FOUR SCHOOLS
LIGHTING STUDY

Preface

This is a report of a study of the luminous environments of the libraries of four elementary schools in Columbus, Indiana. The schools are Clifty Creek, Fodrea, Lincoln and Parkside

The study was undertaken by the Center for Energy Research/Education/Service (CERES) at Ball State University as part of the nationwide Vital Signs Project. The Vital Signs Project is managed through the Center for Environmental Design at the University of California, Berkeley and is funded by the Energy Foundation, the National Science Foundation, Pacific Gas and Electric Company and the University of California.

The Research Team

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ABSTRACT

This report describes a six-month instrumented field study of the luminous environments of the libraries of four elementary schools in Columbus, Indiana. The schools, administered by the Bartholomew [County] Consolidated School Corporation, are Clifty Creek, Fodrea, Lincoln and Parkside. Columbus, located in the southern half of Indiana approximately 40 miles south of Indianapolis, has become well-known for its concentration of buildings "by famous architects". These four schools are among a concentration of almost fifty buildings or building additions designed by architects with national, often international, reputations.

The four schools -- the earliest occupied in 1962, the latest in 1982 -- were selected from a shortlist of seven which in turn was narrowed down from the total of ten elementary schools in the corporation. The final selection of the four study candidates was based on three criteria. These were: 1.) the appropriateness of the school as a candidate for a study of its luminous environment; 2) the potential provided by the school for future studies; and, 3) how true the building had remained to the architect's original design intent. All of the ten schools were commissioned under the auspices of a Cummins Engine Foundation program initiated by Cummins Engine CEO J. Irwin Miller. Under this program, now a half-century old, the foundation pays the architectural fees for a building if the architect is selected from an independently created list of nationally prominent architects furnished by the Foundation. The design firms and designers for the four schools included in the study were:

School	Firm	Designer
Clifty Creek	Richard Meier and Associates	Richard Meier
Fodrea	Caudill, Rowlett and Scott	Paul Kennon /Truitt Garrison
Lincoln	Gunnar Birkerts	Gunnar Birkerts
Parkside	The Architects Collaborative	Norman Fletcher

The study was conducted according to a protocol for post-occupancy evaluation utilized by Professor Wolfgang Preiser, among others. This protocol involves an indicative stage, an investigative stage and a diagnostic stage.

ABSTRACT

During the indicative stage, the selection of the study candidates took place and visits to the four schools were made. During these initial visits, physical characteristics and measurements of the libraries were verified, sample lighting measurements were taken and library users were interviewed.

During the investigative stage, instantaneous light level readings at a task height of 29" and at floor height were taken at registration points using a five foot plan grid. Floor level readings as well as task height readings were taken for two primary reasons: 1) in elementary schools, it is not unusual for students to use the floor as an activity surface; and, 2) books are routinely shelved, and book spines must be read, at or near the floor. Moreover, the floor would probably also represent the worst case condition as all of the schools have an overhead, or downlighting-dominated electric lighting scheme. Also, because it was observed while taking the instantaneous readings that low light levels existed in the bookshelf areas of all of the libraries, supplemental readings were taken at the faces of selected bookshelves. Long-term readings utilizing Hobo[tm] and StowAway[tm] light intensity loggers were taken in all four school libraries at three to five locations at the 29" task height. These long-term readings were used primarily to determine light levels contributed by electric lighting only. Arrangements were made with the school corporation facilities management office to leave the library lights on for the nights when loggers were placed, thus providing readings in the absence of daylight.

During the diagnostic stage the data acquired during the investigative stage were reduced, displayed and evaluated. The criteria used as a basis upon which to evaluate the adequacy of the lighting levels were those recommended by the Illuminating Engineering Society (IES) of North America for “Performance of visual tasks of high contrast or large size”. The range of illuminances for this category -- category D -- is 20-30-50 footcandles (fc).

Two of the libraries, those of Fodrea and Lincoln, are single floor libraries; the other two, located in Clifty Creek and Parkside, utilize two floors. However, only at Parkside is the upper floor a major use space; Clifty Creek's upper floor is a small "story telling" space. Daytime instantaneous light readings showed that the light levels were predominantly above the IES recommended optimum level of 30 footcandles at both the 29" task height and the floor in the libraries of Clifty Creek (both floors) and Fodrea. In the Lincoln library, light level readings were mostly at or above the IES optimum level of 30 fc at 29", but mostly below 30 fc at the floor. Parkside's results were quite mixed; light level readings in the upper space were mostly above the 30 fc optimum level at 29" but below this level for about one-half the space at the floor. And in the lower Parkside space, light level readings were below the optimum 30 fc level at both the 29" height and the floor for almost the entire space. In some areas of this space, light levels were below the IES recommended minimum level of 20 fc; in a few instances readings were in single digits. Long-term readings yielded nighttime levels all below the IES recommended minimum of 20 fc for the libraries of Clifty Creek, Fodrea and the lower floor of Parkside; for the upper floor of Parkside, four of the five readings were below 20 fc. At Lincoln, all four readings were above the IES recommended optimum level of 30 fc. Moreover, nighttime readings at Lincoln were, at most, only 15 fc below daytime readings. One can conclude from these readings the following:

1. for Clifty, Fodrea and Parkside,

    a. the designers relied heavily on daylight to achieve adequate light levels in the libraries;

    b. this approach is largely successful for daytime operation for both floors at Clifty Creek, for Fodrea and for the upper floor at Parkside;

    c. for the lower floor of Parkside, this approach does not yield adequate light levels;

2. for Lincoln, while daylight increased the quantity and enhanced the quality of the lighting, it was not essential to the achievement of acceptable light levels in the space; and,

3. with the exception of Lincoln, nighttime light levels in the school libraries were inadequate for normal library operations.

During the diagnostic stage of the study, two situations were noted that were judged worthy of more detailed investigation. The first situation was found in the libraries of Clifty Creek, Fodrea and Parkside (on the upper floor). Although the majority of measurements were taken on the horizontal plane, it was noticed that lighting of the libraries' bookshelves -- important for tasks such as searching and reshelving -- was greatly influenced by bookshelf orientation relative to window surfaces. In these areas, the book shelves are oriented parallel to the primary source(s) of daylight and as a result the "downstream" sides of the shelves are in their own shadow and "downstream" shelves are in the shadow of the shelves closer to the daylight source. As a consequence, bookshelf surface lighting levels at the floor between shelves were below the IES recommended minimum in many areas. The question this situation posed is whether the reorientation of the shelves to an alignment perpendicular to the natural light source would produce light levels at all points on the shelves, both vertical and horizontal planes, including at the floor, consistently above the IES recommended optimum level.

The second situation was at Parkside only. In order to localize heat gain at the window surface and, possibly, reduce glare, heavy fabric shades were being utilized inside the large upper south windows of the Parkside library. The question here, especially given the low light levels on the first floor of the library, is whether external "egg crate" sunscreens would be a better alternative to the shades, in that the sunscreens would perform the same function as the shades of reducing solar heat gain in the space, but could admit more light.

Context

This report describes a six-month instrumented field study, initiated in the summer of 1996, of the lighting environments of the libraries of four elementary schools in Columbus, Indiana. These schools were selected for study from a total of ten elementary schools in the Bartholomew [County] Consolidated School Corporation. The four schools are Clifty Creek, Fodrea, Lincoln and Parkside.

Cummins Engine Foundation Subvention Program

These schools, as well as many other public buildings in Columbus were commissioned under the auspices of the Cummins Engine Foundation's subvention program. This program was initiated just after World War II by J. Irwin Miller, then the CEO of Cummins Engine Company, Inc. During the years after the war, the Columbus community doubled in size necessitating construction of a number of new schools. Miller is reported to have stated that the first two were, "prefab, hurriedly erected [and] obviously weren't going to last any time at all, and equally, obviously were very bad places for young people to go to school," (Architecture, June, 1984, p.63). Unhappy with the prospect of more schools of this genre, Miller volunteered funding from his firm's philanthropic arm, the Cummins Engine Foundation, to pay the architect's fees for the next school if the school board would, "select a designer from an independently created list of nationally prominent architects furnished by the foundation," (Architecture, June, 1984, p.63). Originally the offer was for a specific school building, but was extended to a second school with Miller's stipulation that a different architect be chosen. After this second building came a third, and a "program" was born.

Companion Studies

This study is companion to a previous investigation also conducted under the aegis of the Vital Signs Project: a study of the lighting environment of the Cleo Rogers Memorial County Library in Columbus, Indiana. The Cleo Rogers Study was the vehicle for a course mounted by the Center for Energy Research/Education/Service (CERES) during the spring semester of the 1995-96 school year. And, a separate study of these four schools, a field-based study of the indoor air quality of the four schools, was the focus of a semester-long course also offered by faculty and staff of CERES in the fall of 1996.

INTRODUCTION

Study Protocol

This lighting study was conducted under the protocol for post-occupancy evaluation utilized by Professor Wolfgang Prieser of the University of Cincinnati, among others. Under this protocol, the study is advanced in three stages with each successive research stage becoming more exact in its level of measurement and analysis. (See Figure I.1) The three levels are the indicative stage, the investigative stage and the diagnostic stage and typically are applied as in the description which follows.

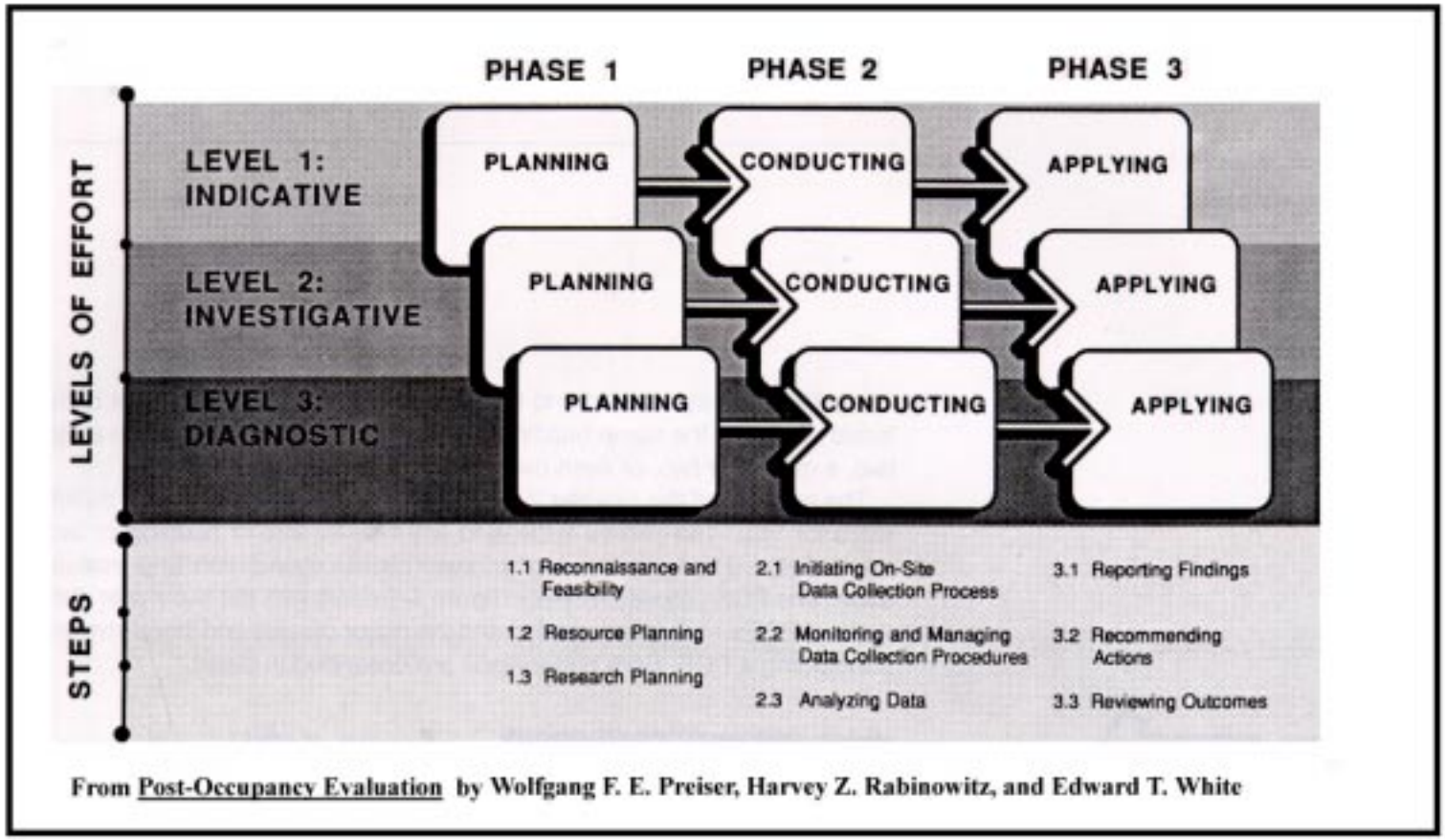


Figure I.1 : Post-Occupancy Evaluation Protocol

The Indicative Stage

The "indicative" stage is the reconnoitering stage of the assessment process. This stage is used isolate points of interest, generate questions and hypotheses, and give direction to more detailed investigations.

Selection of the Study Subject Schools

The indicative portion of the study took place during trips to Columbus paced over the course of three weeks. The initial trips focused on documenting the features and aspects of the pool of ten schools with the goal of reducing the number to a maximum of four. Two of the ten were quickly eliminated: one school, Mabel McDowell was found to have been converted to an Adult Education Center and another, W.D. Richards, was undergoing extensive renovation that involved gutting the library. Videotapes were made in the library spaces of the eight remaining candidates, they were graded according to criteria the research team had developed and the study schools were chosen. The final selection of the four study candidates was based on three criteria. These were:

1. the appropriateness of the school as a candidate for a study of its luminous environment, with special emphasis given to whether daylighting was included as a component of the environment;

2. the potential provided by the school for future studies; the intention at the time was to utilize the same schools for further studies of lighting as well as other environmental aspects; and,

3. how true the building was to the architect's original intent; only one of the final four, Parkside, had undergone major change, but the expansion/renovation was designed and supervised by the original designer, Norman Fletcher. (Late in the evaluatory process, it was discovered that Southside, although now an elementary school, was originally designed to be a middle school. Consequently, it was eliminated from further consideration.)

Figure I.2 summarizes the major aspects of the selection process.

Clifty Creek	●
Fodrea	●
Lincoln	●
Mabel McDowell	1
Mt. Healthy	○
Parkside	●
W.D. Richards	2
Lillian C. Schmidt	
L. Frances Smith	○
Southside	③

Shortlist ○ Final Choice ●

1 - Converted to an Adult Education Center

2 - Undergoing extensive renovation

3 - Converted Middle School

Figure I.2 : Study Schools Selection Process Summary

Quantitative Measures

After the final four candidates were selected, they were visited and studied in greater detail. For these visits, four quantitative objectives were established: 1) to take instantaneous illuminance measurements using GE^{tm} hand-held meters at several points to get a general feel for the lighting in the spaces; 2) to take instantaneous luminance (brightness) readings in several of the same locations using a Minolta LS-100^{tm} Luminance Spot Meter; 3) to confirm the reflected ceiling plans found in the construction documents and, 4) to obtain a detailed furniture layout of each space, including precise measurements of all the furniture.

Qualitative Measures

During those same trips, with the intent of obtaining qualitative data vis á vis the lighting, interviews were conducted with the library staff and principal of all four schools and the custodial/maintenance staffs responsible for the libraries. In one school, two faculty members were also interviewed. In an effort to reduce bias in responses, the staff and principal of each school were asked a series of prepared, branching questions about the thermal and acoustical environments as well as the luminous environments and about their general perception of the physical aspects of the school. It was felt that if questions focused only on the luminous environment, the interviewees -- depending on their point of view -- might feel pressured to find non-existent problems or to make extravagant claims regarding the quality of the lighting. The custodial staff was also asked a series of questions, but these focused the maintenance of the lighting systems. The interview protocol is included as Appendix AP1.

Literature Review

A literature search was done during this portion of the study to find information in four areas: 1) the design and lighting of school libraries; 2) the design of the four schools themselves; 3) the lighting philosophies of the architects involved; and, 4) the Cummins Engine Foundation and Columbus, Indiana. A complete bibliography is included in Appendix AP2.

The Investigative Stage

The "investigative" portion of the study concentrated on obtaining detailed, exact measurements of the luminous environments of the libraries.

Imstantaneous Measurements

A primary activity of this stage was obtaining instantaneous measurements of light levels in the spaces. The process used to obtain these measurements was as follows: a five foot grid was drawn on the floor plans of the libraries of each of the schools; then, using the gridded floor plan drawing as a guide, the grid was marked in the field; and, finally, two measurements were taken at each grid intersection using a GE^{tm} hand meter, one at floor level and one at 29" above the floor. The 29" height was chosen because it equaled the 26 ½" height of many of the work surfaces plus the height of the meter. Many of the grid points fell on these surfaces. Where they did not, a 26 ½" high pedestal was used to support the 2 ½" high meter, yielding the same 29" measurement height . The floor measurements were taken for two primary reasons: 1) in elementary schools, the floor is often used for academic activities and, 2) in all of the libraries, books were shelved, and consequently the titles must be read, at or near the floor. In order to avoid casting shadows on the meter, the meter was placed and then readings were taken from approximately fifteen feet away using low-powered binoculars.

Bookshelves Lighting

Moreover, when it was discovered that low light levels existed on many surfaces of bookshelves, especially near the floor, supplemental vertical plane readings were taken on bookshelf faces for selected bookshelves.

Long-Term Measurements

A second primary set of data was obtained in the four libraries via long-term measurement. These measurements were taken using programmable data gathering light level data loggers --HOBO's^{tm} and Stowaways ^{tm}. These instruments were placed in the buildings and programmed to take footcandle readings of five minutes intervals over a period during which arrangements had been made with school administrators to leave the lights on overnight. This information was used primarily to determine light levels provided by electric light only.

The Diagnostic Stage

The "diagnostic" stage of the study involved producing and analyzing a number of diagnostic drawings and diagrams. These included isometric drawings of the library spaces, isolux diagrams of the lighting patterns in the spaces -- using the data from the instantaneous measurements -- and graphs of the long-term data.

The analysis of this data as well as personal observations from the numerous visits to the libraries resulted in the observations and conclusions contained in the following individual school library reports.

IES Guidelines

In developing these observations and conclusions, the adequacy of lighting levels in the spaces was compared against those recommended by the Illuminating Engineering Society (IES) of North America for "Performance of visual tasks of high contrast or large size." The range of illuminances for this category -- Category D -- is 20-30-50 footcandles (fc): 20 fc, minimum ; 30 fc, optimum ; 50 fc, maximum. (Figure I.3)

Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

Type of Activity	*Illuminance Category*	*Ranges of Illuminances*	
		Lux	*Footcandles*
General lighting throughout spaces			
Public spaces with dark surroundings	A	20–30–50	2–3–5
Simple orientation for short temporary visits	B	50–75–100	5–7.5–10
Working spaces where visual tasks are only occasionally performed	C	100–150–200	10–15–20
Illuminance on task			
Performance of visual tasks of high contrast or large size	D	200–300–500	20–30–50
Performance of visual tasks of medium contrast or small size	E	500–750–1000	50–75–100
Performance of visual tasks of low contrast or very small size	F	1000–1500–2000	100–150–200
Illuminance on task, obtained by a combination of general and local (supplementary) lighting			
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000–3000–5000	200–300–500
Performance of very prolonged and exacting visual tasks	H	5000–7500–10000	500–750–1000
Performance of very special visual tasks of extremely low contrast and small size	I	10000–15000–20000	1000–1500–2000

Courtesy of Illuminating Engineering Society of North America.

Figure I.3 : IES Recommended Lighting Levels

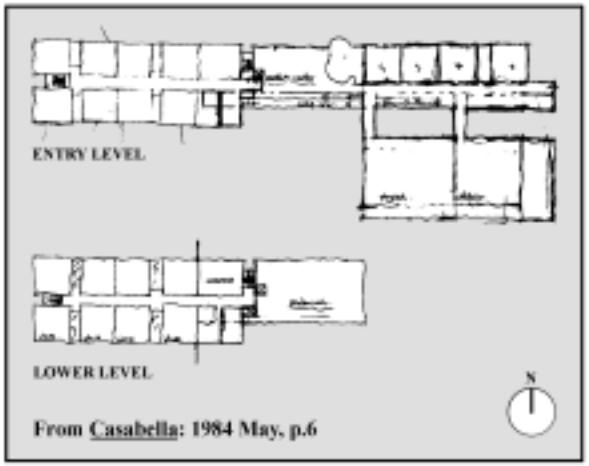
THE SCHOOLS

Clifty Creek

Building Design

Organizationally, Clifty Creek's floor plan falls within the "linear" category of circulation pattern typologies, but the linear organization is obscured by the bending of the linear plan into a "J" configuration. Bending the linear plan back on itself gives the appearance of two major blocks: on the west, a monolithic general classroom block and, on the east, an "eroded" block containing the administrative suite, cafeteria, gymnasium, kindergarten, special use classrooms, and -- the focus of this study -- the library. (See Figure C.1)

It appears that at one point Meier considered a purely linear scheme for Clifty Creek. Evidence supporting this supposition is a Meier sketch (shown below) of an early study of a straightforward linear organization.



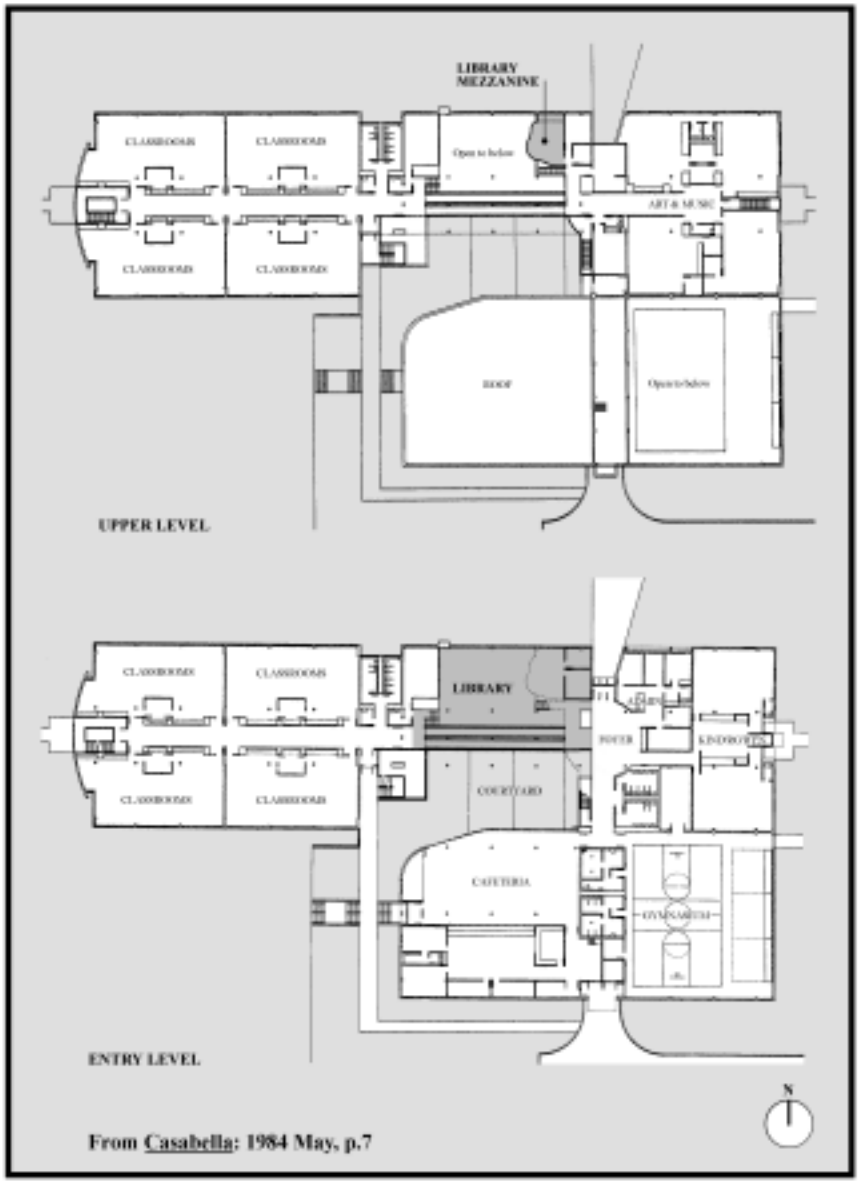


Figure C.1 : Floor Plans

The main circulation spine of the school passes through the library, on the south side, via a set of scissor ramps (See Figure C.2). The library is the only space in the school that sustains this degree of non-destinational traffic. Apparently, Meier's intent was to make the library visibly important to the school's users. He is quoted as saying "The central location of the double-height north-lit library, adjacent to the classroom wing is designed to encourage students' use" (Columbus Republic, November 8, 1982, p.A-9).

Although Meier departed from his signature white metal panel cladding in this project, his color palette remained monochromatic. Predominantly, the materials of the exterior are white glazed brick and gray concrete block and on the interior, white painted drywall and gray carpeting.

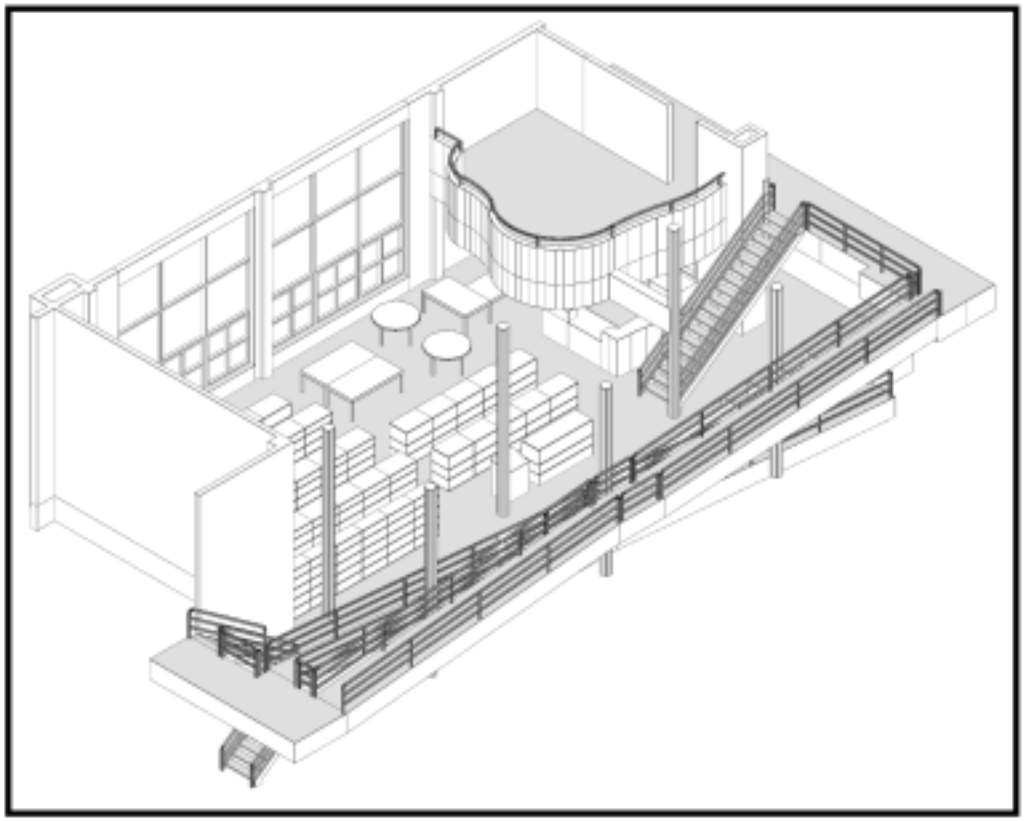


Figure C.2 : Isometric of Library

The Luminous Environment

Meier makes extensive use of daylighting in the library. A large window occupies most of the north wall (Figures C.2, C.3a and C.3b) and a combination of Kalwall and glass window panels make up virtually all of the south wall (Figures C.4a and C.4b). Electric lighting is provided by recessed 1' x 4' fluorescent fixtures with two 34W cool white supersaver lamps (Figure C.6b) and recessed 4" diameter incandescent fixtures with 100W PAR lamps (See Figure C.6a).

Figure C.3a : North Window, Exterior

Figure C.3b : North Window, Interior

Main Floor Light Levels

In combination with the white surfaces, these daylight and electric light sources provide very high light levels for almost the entire space during the daytime hours; on an overcast summer early afternoon -- an outside reading at 1:30 P.M. was 3100 fc -- light levels exceeding 500 fc were measured at the 29" work surface height five feet from the north window. From this highest foot-candle level, light levels fell off steeply, but the lowest levels readings were, predominantly, still above the IES 30 fc optimum level (See Figure C.5a). At the floor, the general lighting pattern was similar to the pattern at 29", high light levels near the north window decreasing rapidly as one moved farther from the window (See Figure C.5b).

Figure C.4a : South Wall, Exterior

Figure C.4b : South Wall, Interior

There were two general areas in the library main space that were exceptions to these high light levels. One was deep under the mezzanine “cloud”, where readings under 20 fc were taken. The other was the bookshelves area, where floor level readings of under 30 fc were recorded in areas that are shaded from the north window and the south Kalwall by bookshelves (Figures C.5a and C.5b).

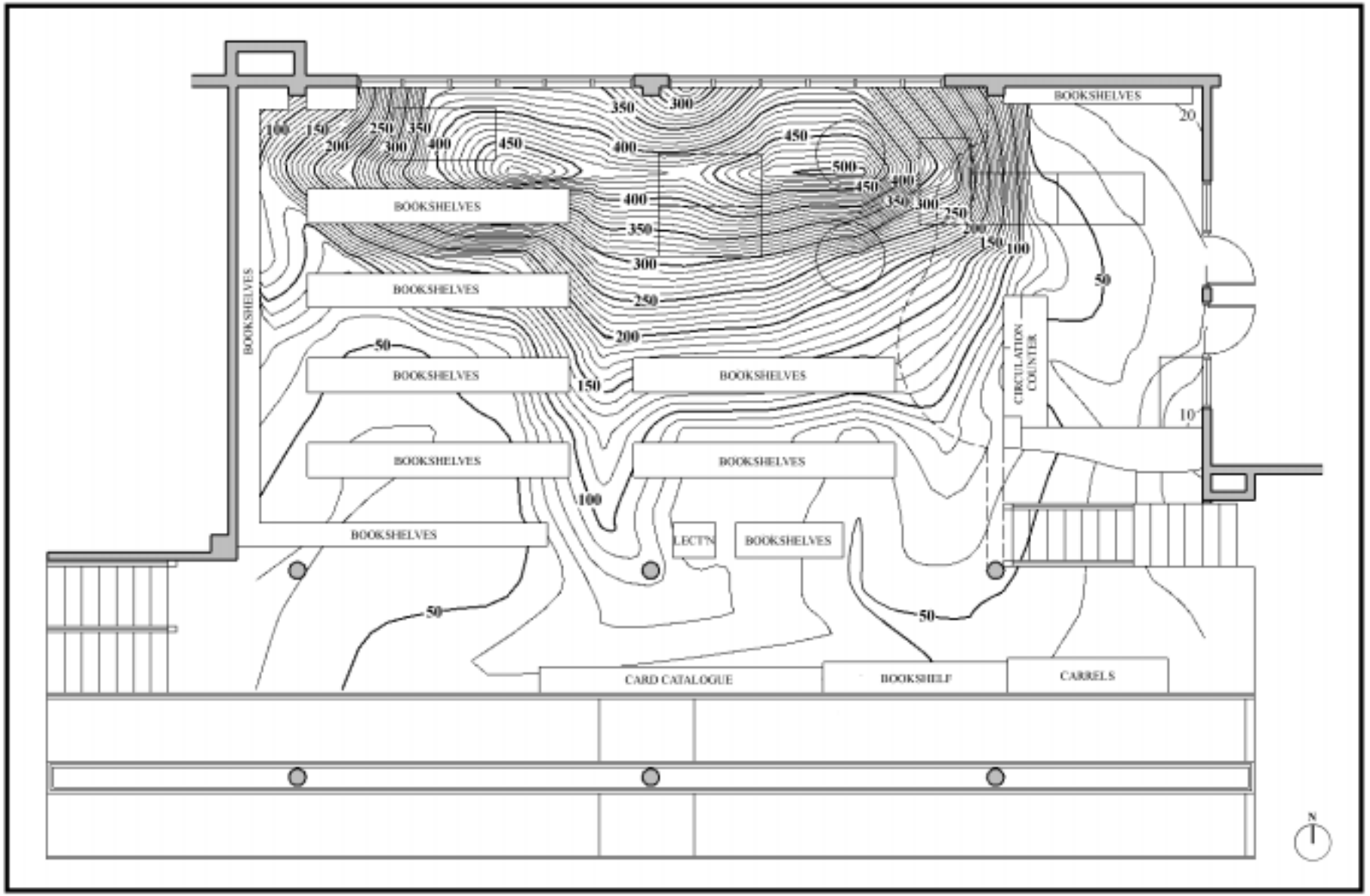


Figure C.5a : Isolux Diagram of Library Main Floor Illumination in Footcandles Measured at 29" Above the Floor

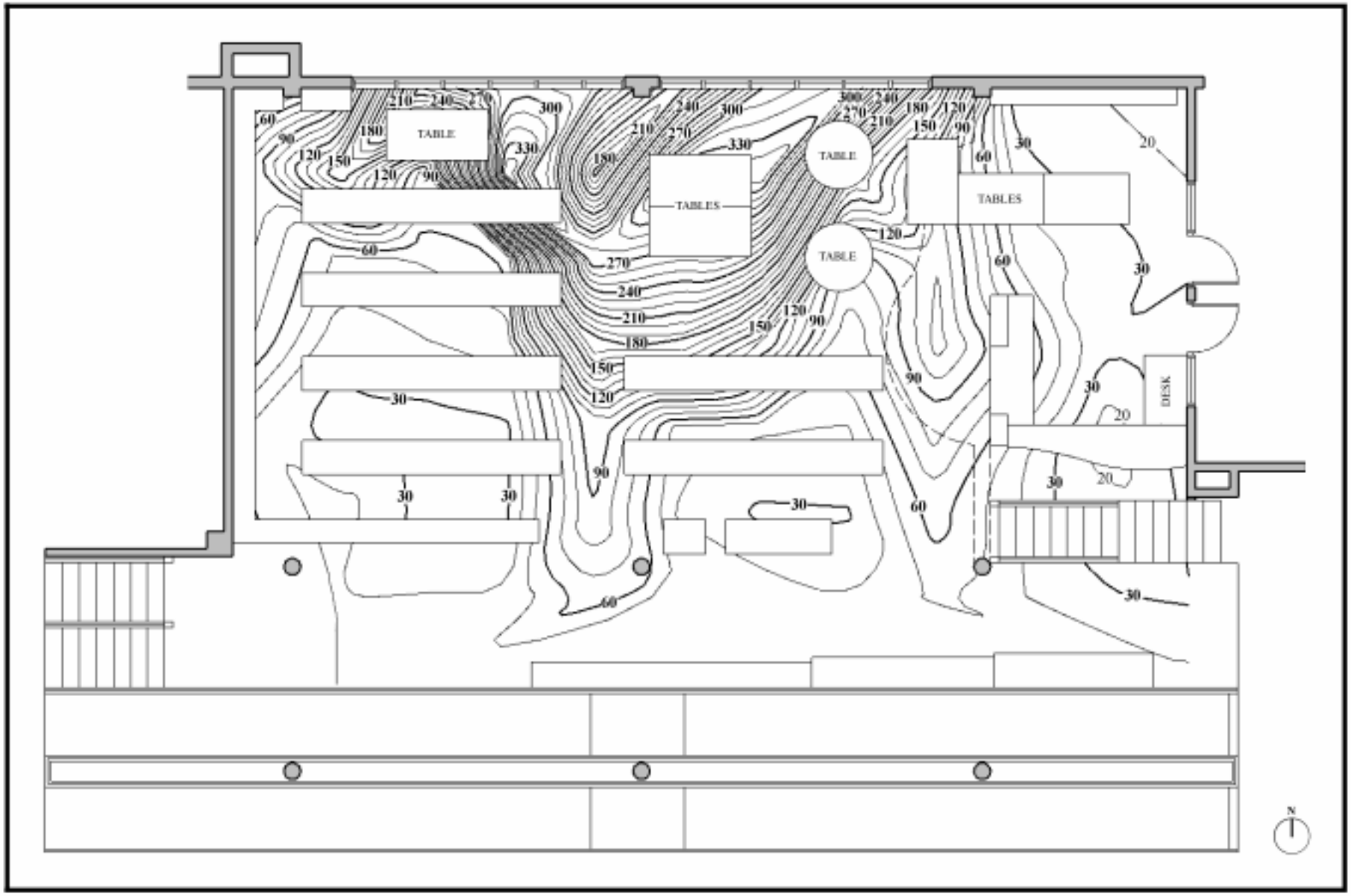


Figure C.5b : Isolux Diagram of Library Main Floor Illumination in Footcandles Measured at Floor Level

Clifty Creek

Bookshelves Lighting

To further investigate the condition of low light levels in the bookshelves area, additional vertical plane readings were taken at the faces of the bookshelves. These readings were taken on the westernmost set of shelves. Three "cross-sections" were taken; one at the west end of the shelves, one in the middle and one at the east end. For each cross-section, four readings were taken on the faces of the four 5'-0" shelves and three readings were taken on the faces of the 3'-6" shelf. This produced 38 readings for each of the three cross-sections. Readings varied from a high of 440 fc at an upper face of the north side of a 3'-6" shelf facing the north window to a low of 8 fc at a shelf face at the floor between two 5'-0" shelves. It is noteworthy that 18 of the 24 readings taken nearest the floor on the interior faces of the shelves -- interior faces being those bookshelf surfaces not directly exposed to the north window and south Kalwall/window -- were below 20 fc. Moreover, only 19 of the 48 readings nearest the floor on these interior faces -- the two readings nearest the floor at eight faces for the three cross-sections -- were 20 fc or higher (See Figure C.7).

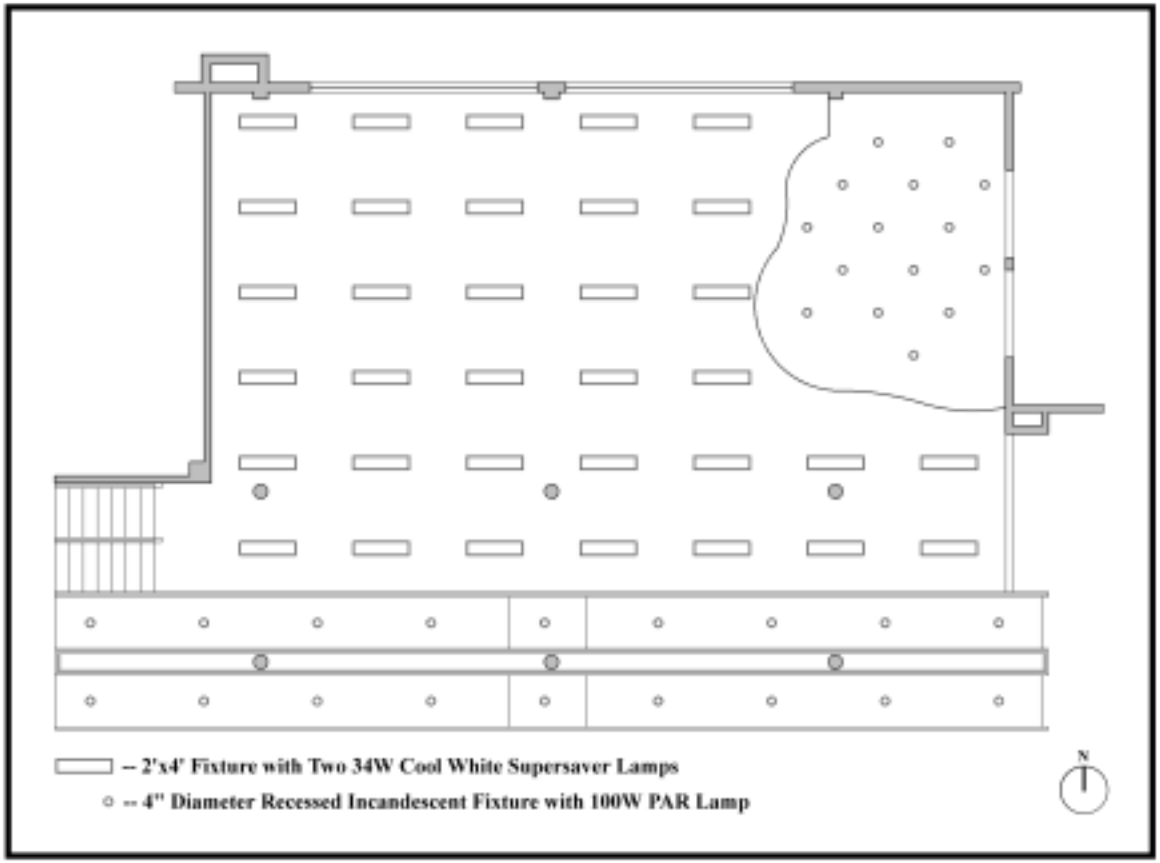


Figure C.6a : Reflected Ceiling Plan

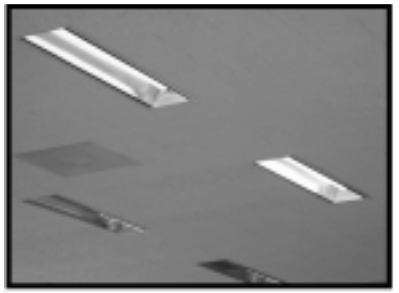


Figure C.6b

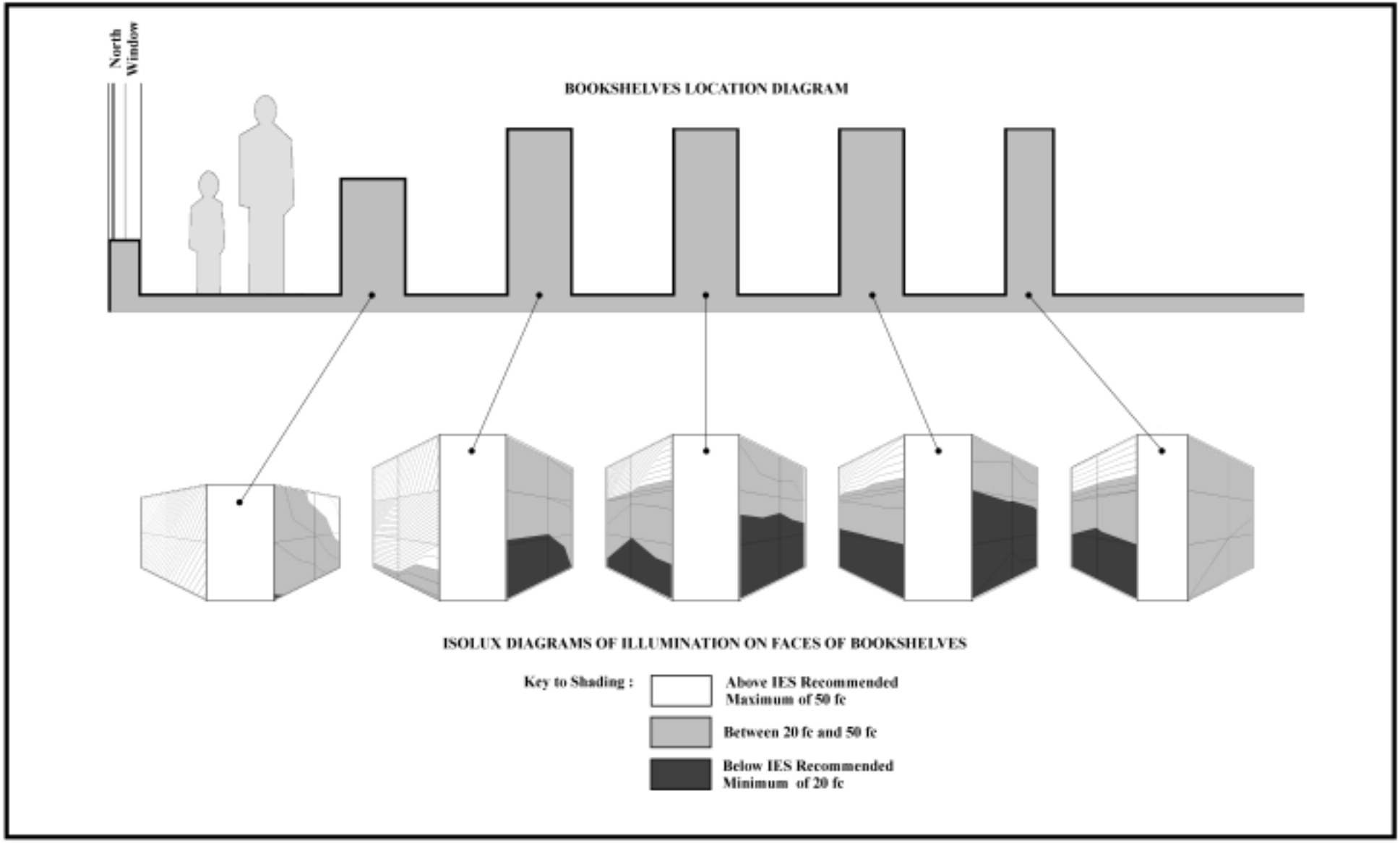


Figure C.7 : Isolux Diagrams of the Illumination on the Faces of the Westernmost Rank of Bookshelves

Mezzanine Light Levels

In the mezzanine, “story-telling”, space, lighting levels were much lower and much more uniform than in the main space: at 29" the lowest reading was 15 fc and the highest 65 fc and at the floor the range was from 12 fc to 46 fc (See Figures C.8a and C.8b).

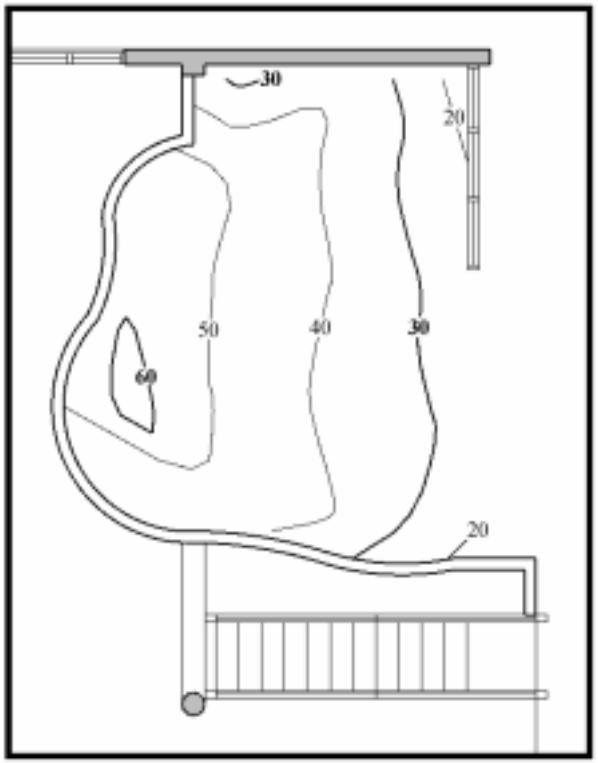


Figure C.8a : Isolux Diagram of Library Mezzanine Illumination in Footcandles Measured at 29" Above the Floor

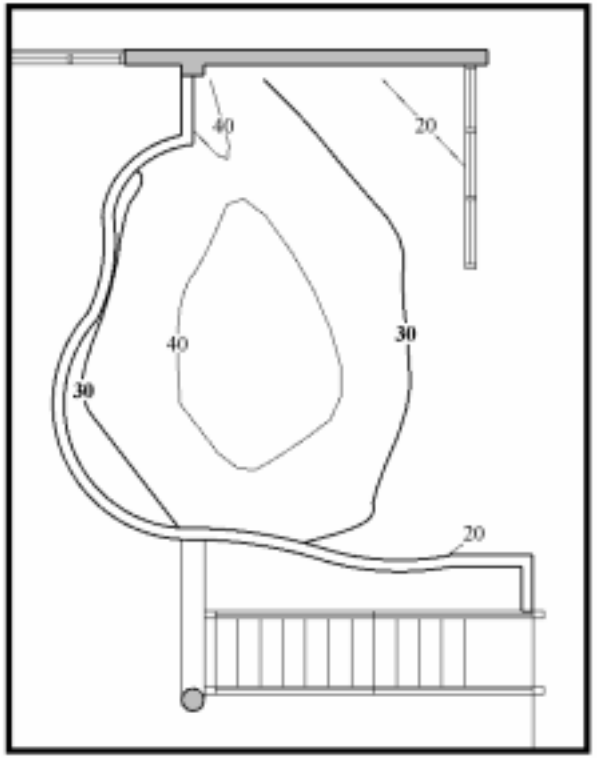


Figure C.8a : Isolux Diagram of Library Mezzanine Illumination in Footcandles Measured at the Floor

Nighttime Readings

Nighttime light levels differed markedly from the daytime lighting condition. Long-term measurements yielded average nighttime light levels of under 20 fc at all four locations monitored. These readings strongly indicate that the architect and his lighting designers relied heavily on daylighting to provide satisfactory light levels in the space.

Library Users' Comments

Library users commented that under the current mandate to conserve energy by turning off one-half of the "fluorescent lights", it "sometimes is difficult to see underneath the 'cloud'" and "at the bottom shelves" of the bookshelves, especially "on a darker day". But the users further noted that with all of the lights on, they "never noticed a problem" with light levels under the "cloud" but the problem of seeing the print on the spines of the books between the shelves remained.

Veiling Reflections

The users noted one additional problem related to the luminous environment of the library. Predictably, they commented that veiling reflections on computer or VCR monitor screens facing the north windows were a problem.

Findings

In summary, the following points regarding the luminous environment of the Clifty Creek library can be made:

1. Lighting levels in the main library space varied widely, from a lowest reading of 13 fc at the floor in the northeast corner under the mezzanine to a highest reading of over 500 fc near the north window (Figures C.5a and C.5b).

2. Lighting levels in the mezzanine space varied within a much narrower range, from a low of 12 fc at the floor in the northwest corner to a high of 65 foot candles at the 29" level at the west railing (Figures C.8a and C.8b).

3. Except for three areas in the library, light levels were substantially above the IES recommended optimum level of 30 fc. In these three areas, light levels fell below the IES recommended optimum level of 30 fc and were at or below the IES minimum of 20 fc. These areas were:

   a. at two points under the mezzanine: at the northeast corner of the space and at the east wall near the stair;

   b. at most of the interior faces of the bookshelves at the floor; over 60% of the readings nearest the floor on the eight interior faces of the four east-west bookcase ranges were under 20 fc.

4. Nighttime readings were under the IES recommended minimum of 20 fc.

5. Users expressed general satisfaction with the library lighting -- with all of the lights on -- with the exception of two aspects:

   a. the lighting levels "between the shelves" near the floor were cited by users as inadequate for reading the print on the spines of the books, especially on "darker days"; and,

   b. "glare" (veiling reflections) on the television/monitor screens facing the north window was cited as a problem that limits the placement and orientation of these devices in the space.

The following conclusions can be reached regarding the luminous environment of the library:

1. With all lights turned on, the daytime lighting levels in the library are adequate for the tasks to be performed with the exception of reading the print on book spines between the book shelves, especially near the floor.

2. Light from the north window produces veiling reflections on television and computer monitor screens facing the window.

3. The architect and lighting designers relied on daylight as the primary producer of light for the space, with electric light as a secondary component. The all-white color scheme that was used was integral to the overall lighting scheme by virtue of its importance in reflecting the daylight into and around the space.

4. Nighttime light levels produced by only electric light were below the IES recommended minimum level of 20 fc for the "Performance of visual tasks of high contrast" and consequently below the level recommended for the majority of tasks performed during the normal operation of a library. However, since Clifty Creek is not an extended hours school, low nighttime light levels may not be viewed as a problem except during special after-hours activities.

Potential for Further Study

The orientation of the bookshelves, parallel to the north window and south window/Kalwall produces a lighting-related problem; it produces a condition where the interior sides of the shelves are shaded from the two major daylight sources. It would appear that reorienting the bookshelves perpendicular to the daylight sources would eliminate much of this problem and would thereby significantly improve lighting levels between the shelves. A scale model lighting study could be performed to test the influence of bookshelf reorientation.

Fodrea

Building Design

Fodrea Elementary School, completed in 1973, was one of the first schools in the nation to function also as a community center. This additional role as a community center appears to have been the parameter that shaped much of the thinking of the Paul Kennon-led five-member "squatter" design team. The design that the team developed after a series of meetings with students who would be attending the school and members of the community who would be utilizing the school as a community center featured what Kennon called a "Community Concourse". This "Community Concourse" was intended to "invite people to come in and interact, to exchange ideas, to read, to play" (Columbus Republic, December 29, 1972) and was the most important organizing element of the design; more conventionally titled an "atrium" or "courtyard", it was the element about which the school's other uses were grouped.

The community concourse was not the only idea that came out of the "squatter" meetings. The children of State Street School, who would be the Fodrea attendees, had a number of suggestions for the architects. Those suggestions that didn't make the cut or were vetoed by school administrators were: robot teachers, ropes to climb on and firemen's poles to slide down, automatic supermarket type doors, push-button desks, a bedroom with water beds, sprinklers to run through, places to play outdoors even when it is raining, pool tables, and a tunnel-of-love where bigger people can go to kiss their girls. Those that were included, albeit sometimes in a moderated form, were: air conditioning, carpeting, stairs, ramps, basketball courts, a place for skits, gracious dining with small tables and outdoor dining, places to bring pets to school, names and numbers to know where you are, tunnels, charts and posters, padded chairs, lots of flags, cubicles for reading and being alone, slides inside and brightly decorated furniture. The slides that were included were half-level slides from the upper classroom level down to the library and from the library down to the lower classroom level (See photographs, right). The, perhaps apocryphal, story being told in the school is that just after Fodrea opened, an assistant principal tried one of these slides, injured an ankle and as a consequence the slides were declared too hazardous and never used. For whatever reason, the slides are not currently in use.

The resulting floor plan of the school (See Figure F.1) is roughly a "hollowed-out" pinwheel, comprised of the L-shaped (open-plan) classroom block, the multipurpose/art/music block and the cafeteria/ kitchen block with an administration/community education element spanning the main entrance area and joining the multipurpose wing with the classroom wing. These elements enclose a rectangular area which contains the "Community Concourse" and is also occupied in part by the triangular Material Resources Center that rests in the internal vee of the L-shaped classroom wing. This "sharing" of the same area by the Material Resource Center and the "Community Concourse" coupled with floor-to-ceiling glass between the two uses makes them visually co-occupants of the same space (See Figures F.2a and F.2b).

Figure F.2a : Wall Between Library and Community Concourse, Interior

Figure F.2b : Wall Between Library and Community Concourse, Exterior

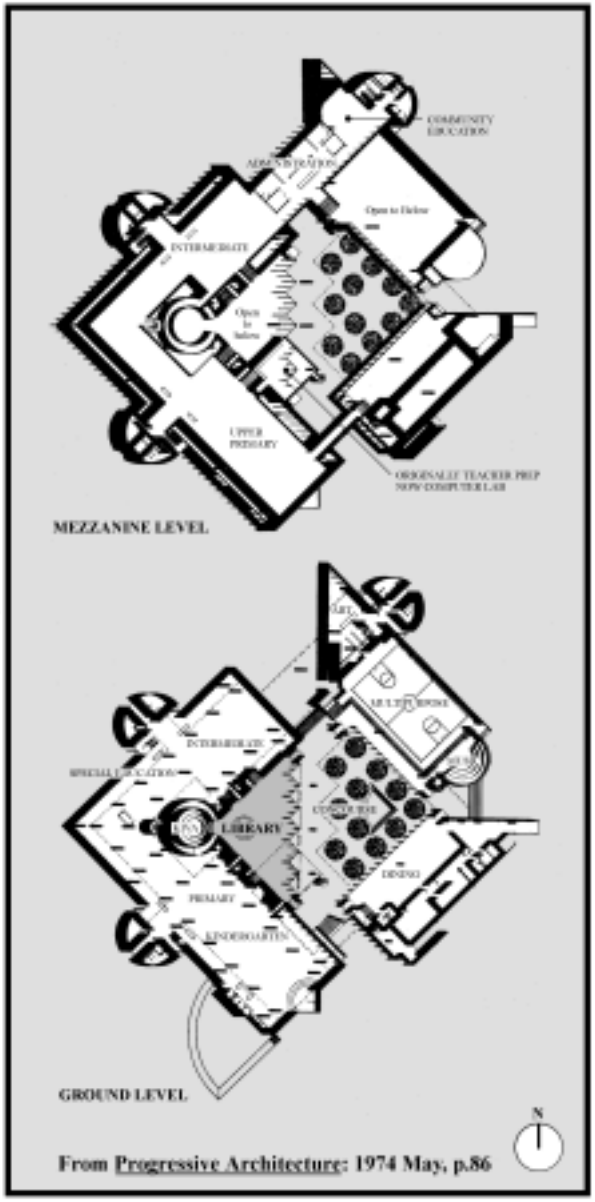


Figure F.1 : Floor Plans

The Luminous Environment

The largely windowless exterior provides few hints of the inner court or of a classroom wing that is light-filled and expansive. This ambiance is produced by the combination of: the open plan classrooms, walls of glass on the courtyard and copious use of clerestories and skylights. The Material Resource Center (hereafter called the "Library") especially is a beneficiary of those daylight sources; the long side of the triangular shaped space is the aforementioned glass wall onto the "community concourse" and the other two sides are skylighted (See Figure F.3).

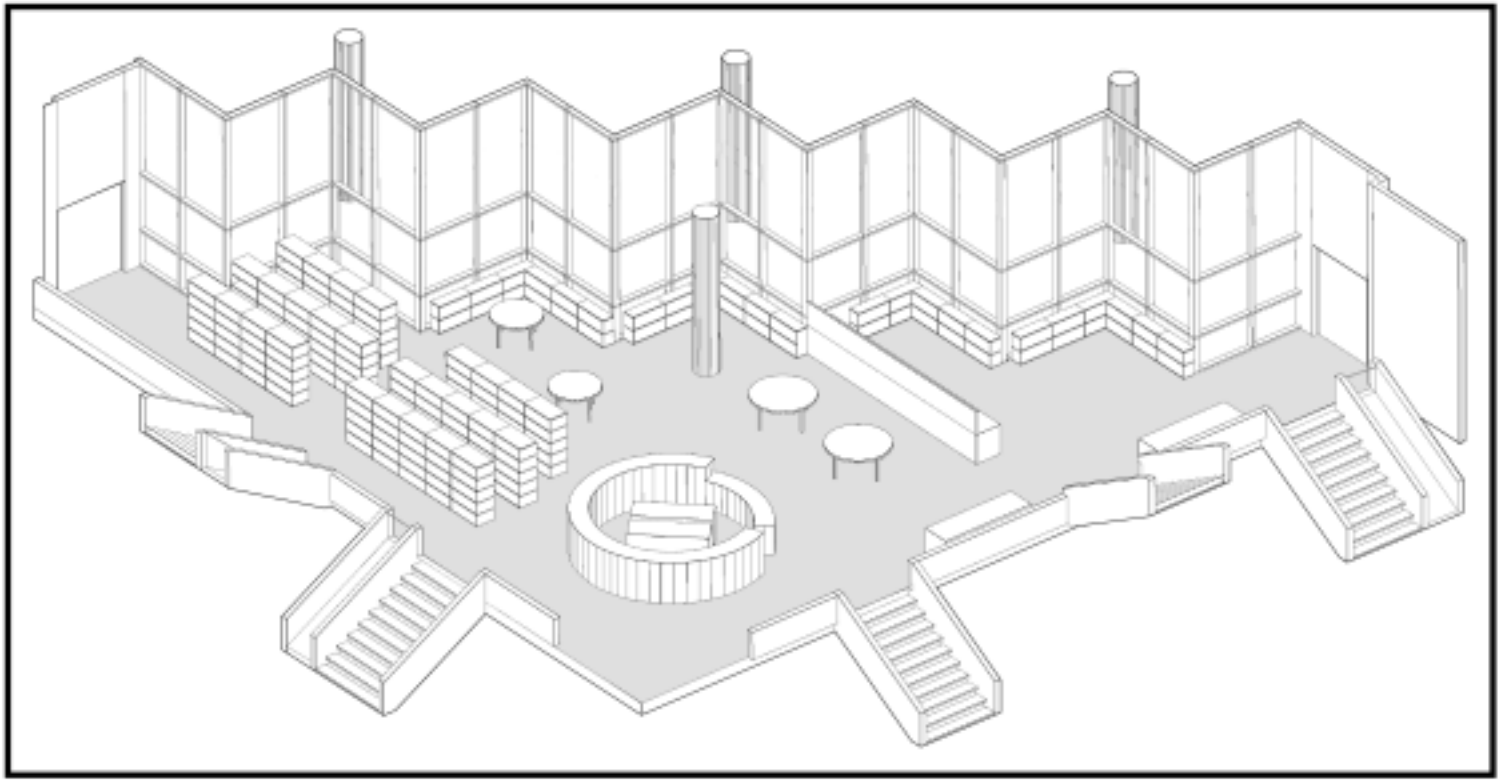


Figure F.3 : Isometric of Library

Electric Lighting

Electric light is provided predominantly by 400W HID lamps in lensed, parabolic reflector fixtures placed within the Unistrut roof structure at every second module, a spacing yielding luminaires ten feet on center within the five foot structural grid (See Figure F.4a). The only exception to this pattern is where a column occurs at a module where a light should have been located. In this case, four 75W metal halide lamps in parabolic reflector fixtures arranged in a square pattern around the column replace the large luminaire (See Figure F.4b). Under the mezzanine, electric lighting is provided by recessed two lamp fluorescent fixtures and can fixtures with 50W lamps. (See Figure F.5).

Figure F.4a

Light Levels

On a partly cloudy June mid-afternoon, the combination of electric lighting and daylighting sources provided light levels in the main area of the library significantly above the IES recommended maximum of 50 fc. With the exception of two “pockets” created by bookshelf shadows -- where readings were between 30 and 50 fc -- readings at the 29" task height ranged from a low of 80 fc to a high of 260 fc. The higher light levels within the main area occurred generally at the perimeters of the space, with readings at the 29" height ranging from 120 to 250 fc along the north edge, from 150 to 260 fc along the two story portion of the west edge and 100 to 220 fc along the portion of the courtyard window edge not under the mezzanine. Lower readings, in the 80 to 90 fc range, occurred in the center of the space and readings as low as 30 fc occurred in the bookshelf area. However, under the mezzanine computer room -- in the original design, a “teachers prep” area -- where the courtyard windows are only one story in height, and shaded by the mezzanine, light levels at the 29" task level dropped to as low as 10 fc, with several other readings in the 12 to 16 fc range. (See Figure F.6a).

Figure F.4b

The pattern of readings at the floor approximated those at the 29" task height: high readings around the perimeter of main space, lower readings in the center of the space, a lower light level “pocket” in the bookshelf area and low levels under the mezzanine. (See Figure F.6b).

Bookshelves Lighting

The lower readings recorded in the bookshelf area suggested that there might be a problem of inadequate light on the vertical surfaces of bookshelves. Consequently, two sets of supplemental readings were taken at the vertical surfaces of the shelves: a total of 48 readings in two "cross-sections" of 24 each, 4 readings for each of the six faces of the three tiers of shelves. One "cross-section" was taken on the line of the lights and one was taken midway between lines of lights. These readings clearly show the shadow producing effect of the bookshelves oriented parallel to the major daylight source. Vertical plane readings at the surfaces of the shelves exposed to the exterior windows or to the skylight ranged from 90 fc to 155 fc at the top of shelves to 70 fc to 100 fc at the bottom. On the interior surfaces, those shaded from the windows and skylights, readings ranged from a high of 78 fc at the top of the shelves to a low of 9 fc at the bottom. Readings at the floor were predominantly in the 9 fc to 14 fc range; seven of the eight "near-floor" readings were below the IES 20 fc recommended minimum. These readings verify the users' concerns regarding light levels between the shelves; users noted that they experienced difficulty reading the splines of books at the bottom of the shelves (See Figure F.7).

Nighttime Readings

Nighttime spot readings stood in stark contrast to daytime readings. All night readings at the 29" task height were below the IES recommended minimum of 20 fc, with readings as low as 6 fc being recorded. These readings were taken in areas of the main library space where daytime light levels ranged from 90 fc to 130 fc.

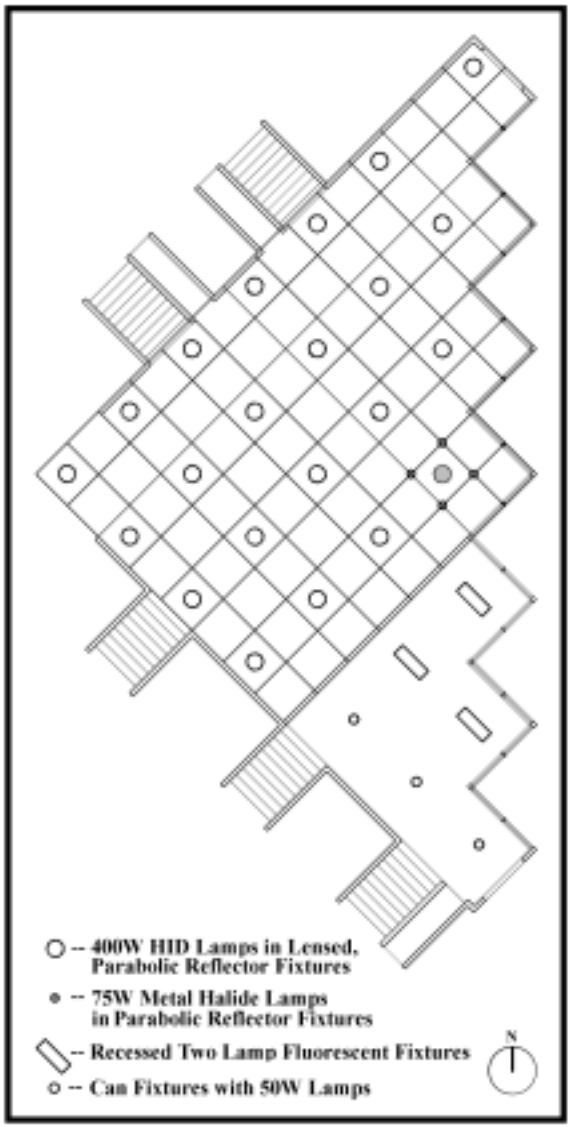


Figure F.5 : Reflected Ceiling Plan

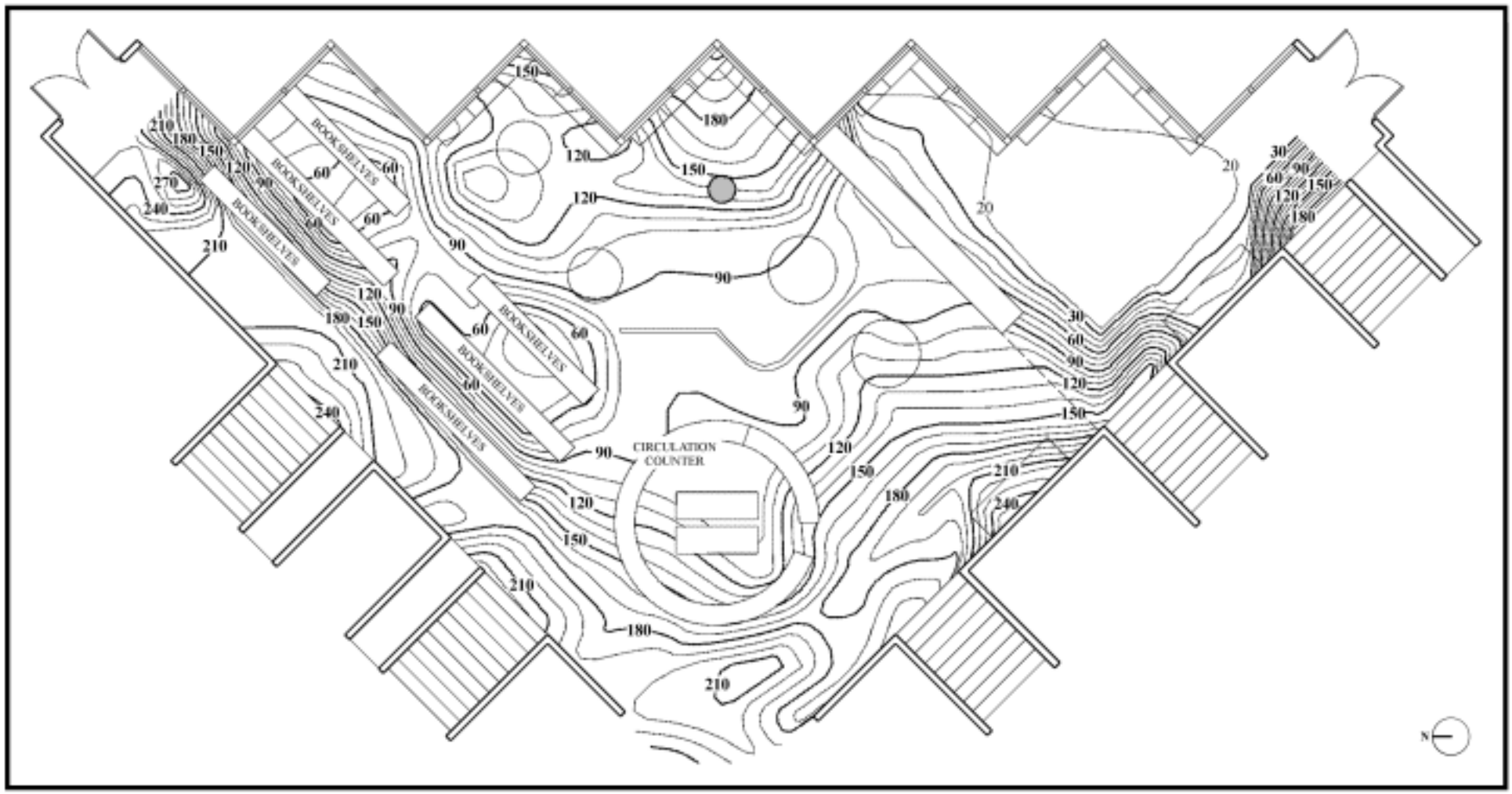


Figure F.6a : Isolux Diagram of Library Illumination in Footcandles Measured at 29" Above the Floor

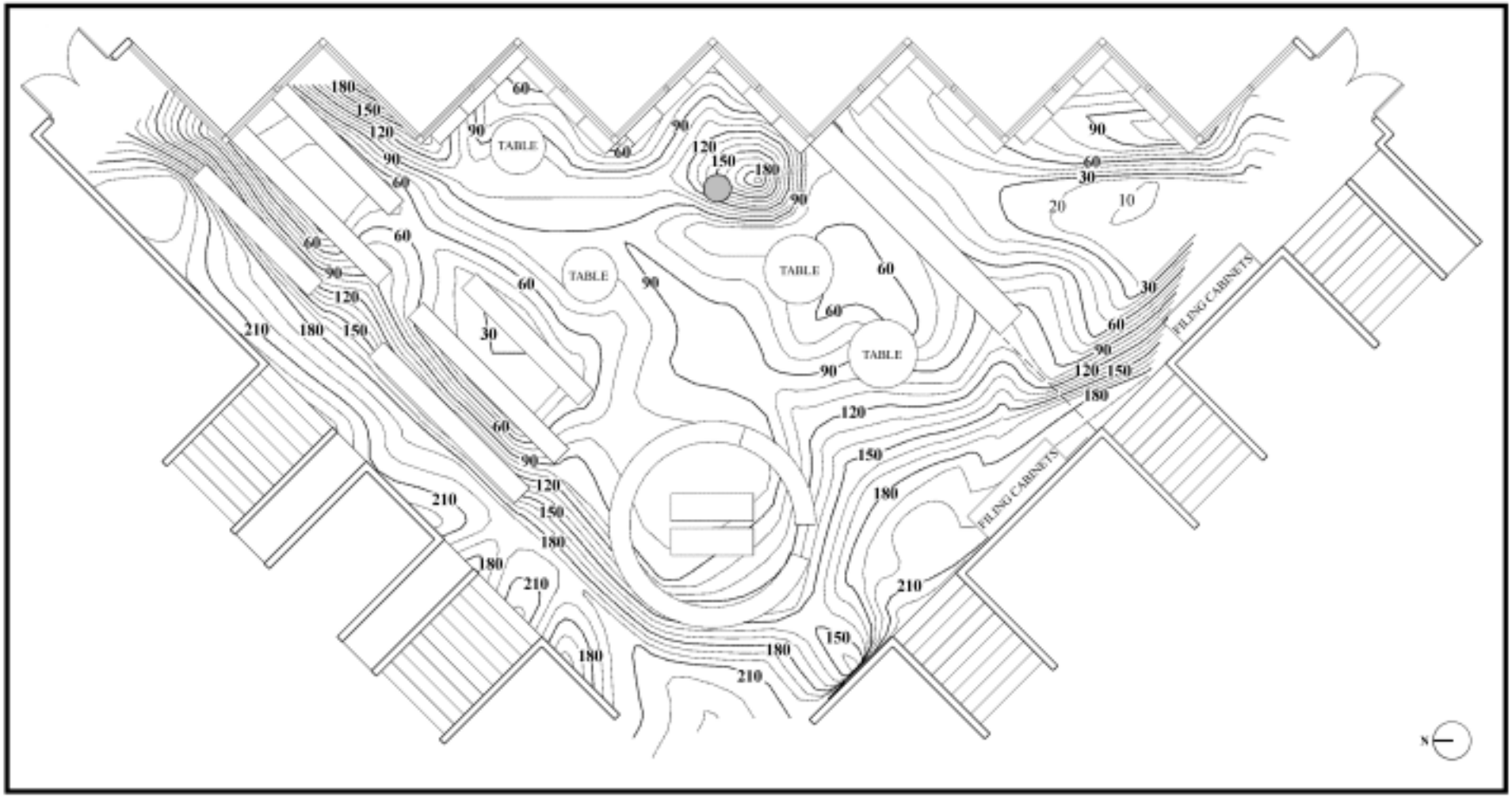


Figure F.6b : Isolux Diagram of Library Illumination in Footcandles Measured at the Floor

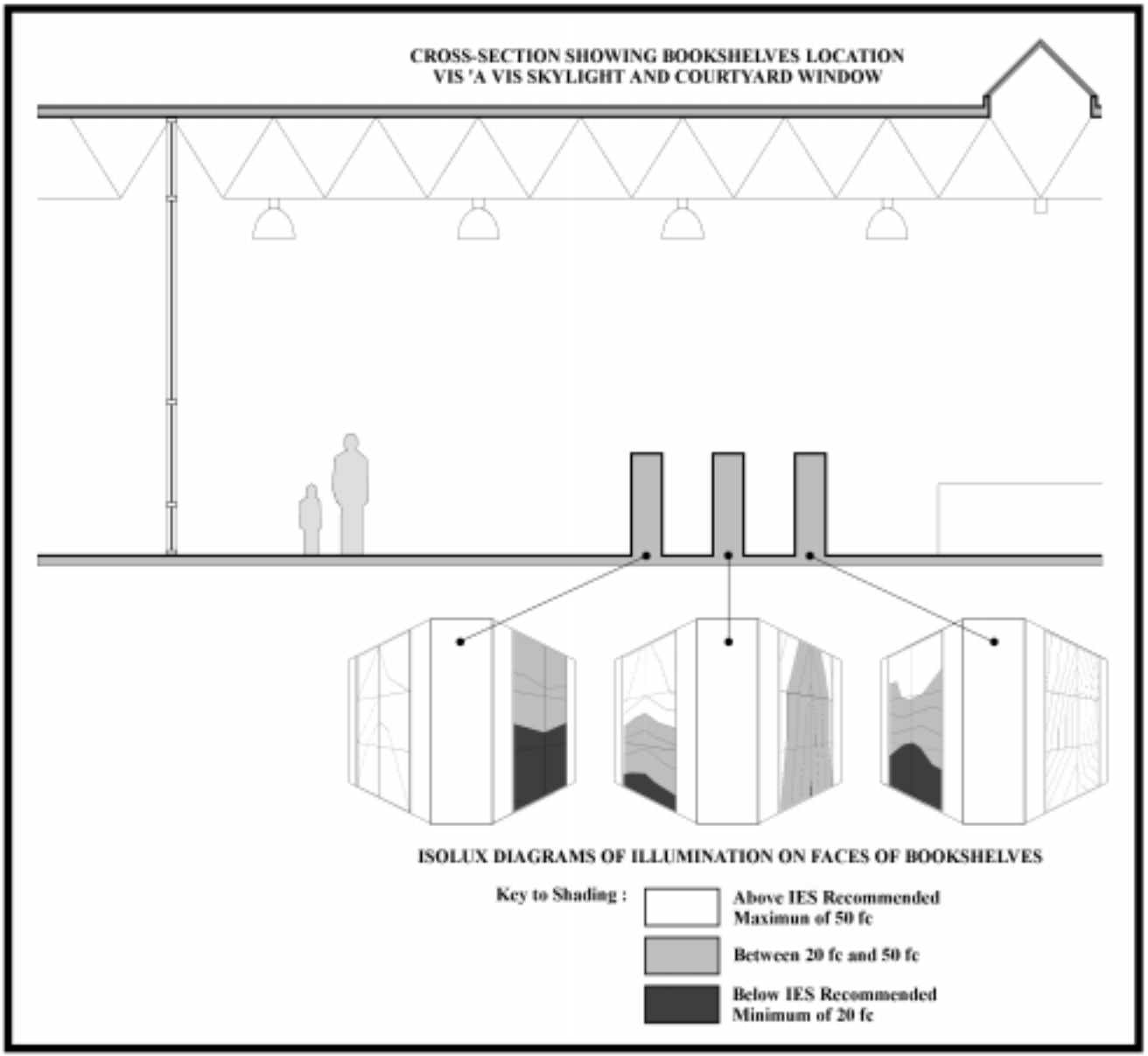


Figure F.7 : Isolux Diagrams of the Illumination on the Faces of the South Rank of Bookshelves

Glare

Because daytime illumination levels in the Fodrea library are significantly above the IES recommended maximum, the question of problems of glare or veiling reflections arises. In the interviews, the users noted that there was a serious problem with glare from sunlight before Venetian blinds were installed. Now, however, there is a problem for only a few areas for "an hour or two" early in the morning and for "the rest of the day its nice to have the extra lighting".

Findings

In summary, the following can be noted about the luminous environment of the library of Fodrea Elementary School:

1. Daytime lighting levels are significantly above IES maximum recommended levels of 50 fc for most of the main area of the library, with light levels ranging from a high of 260 fc at the perimeter of the space to a low of 80 fc at the center of the space.

2. The two areas where daytime light levels fell below IES minimum recommended levels were:

   a. Between bookshelves, where several readings between 9 fc and 11 fc were recorded near the floor at the interior surfaces of the three tiers of shelves.

   b. Under the mezzanine in the audio-visual storage area where several readings under 20 fc were recorded.

3. Users reported that there was a serious problem with sunlight glare before Venetian blinds were installed on the courtyard window. Now the problem exists for a few areas for a short period early in the morning.

4. At night, light levels were below the IES recommended minimum level of 20 fc at all four locations monitored.

The following can be concluded from this information:

1. The Fodrea library is dependent upon daylighting for the achievement of lighting levels above IES recommended optimum levels.

2. The orientation of the bookshelves parallel to the major sources of daylighting creates a situation whereby shelves closer to the daylighting sources shade shelves farther away.

3. Although a deep (20') overhang was provided over the "courtyard" window, glare from sunlight was a serious problem before Venetian blinds were installed. Now, with Venetian blinds down to seven feet above the floor, the problem exists for only "an hour or two" early in the morning. For the rest of the day the users enjoyed the abundance of -- sunlight-glare free -- daylight.

4. If the library is used during the evening hours, light levels are inadequate for many activities.

Potential for Further Study

The orientation of the bookshelves parallel to the major daylighting sources appears to limit daylight distribution over the bookshelf faces. It would seem that orienting the bookshelves perpendicular to the daylighting sources would allow daylight to penetrate more uniformly between the shelves and thereby increase light levels to an appropriate level.

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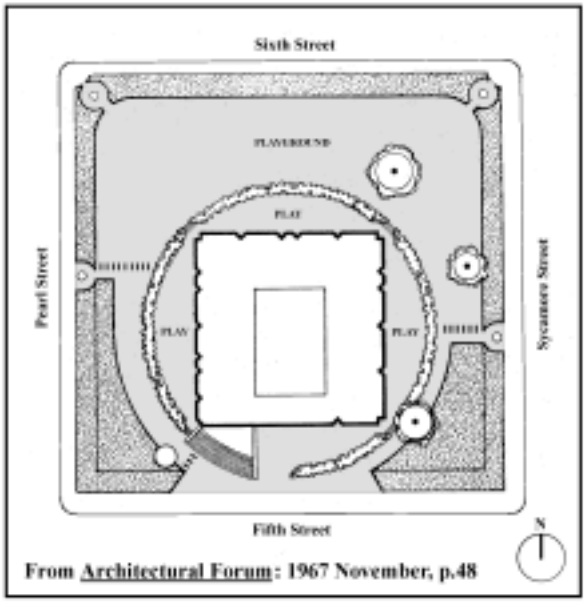
Lincoln

Building Design

Gunnar Birkerts' design for Lincoln Elementary School is a compact two-story structure utilizing the "racetrack" floor plan that typified primary and junior high schools during the first half of the century: the gymnasium (now called the multipurpose room) in the center surrounded by classrooms and the administrative offices and other supporting spaces (See Figure L.1). In the two-story traditional plan the multipurpose space was often accessed at both levels: the gymnasium floor from the first level and the top of stepped seating from the second level. In Birkerts' plan, the multipurpose room can be accessed from only the lower level, but activities in the space can be viewed from the second level corridor.

The resemblance of Birkerts' design for Lincoln elementary to traditional school designs ends with a similarity in floor plan configuration. Birkert's site plan (See right) is a lesson in the efficient and ingenious use of a tight urban site. The school, square in footprint, sits within a circle (defined by a berm topped by closely spaced Linden trees) and this circle in turn sits within the square of the block.



Site Plan

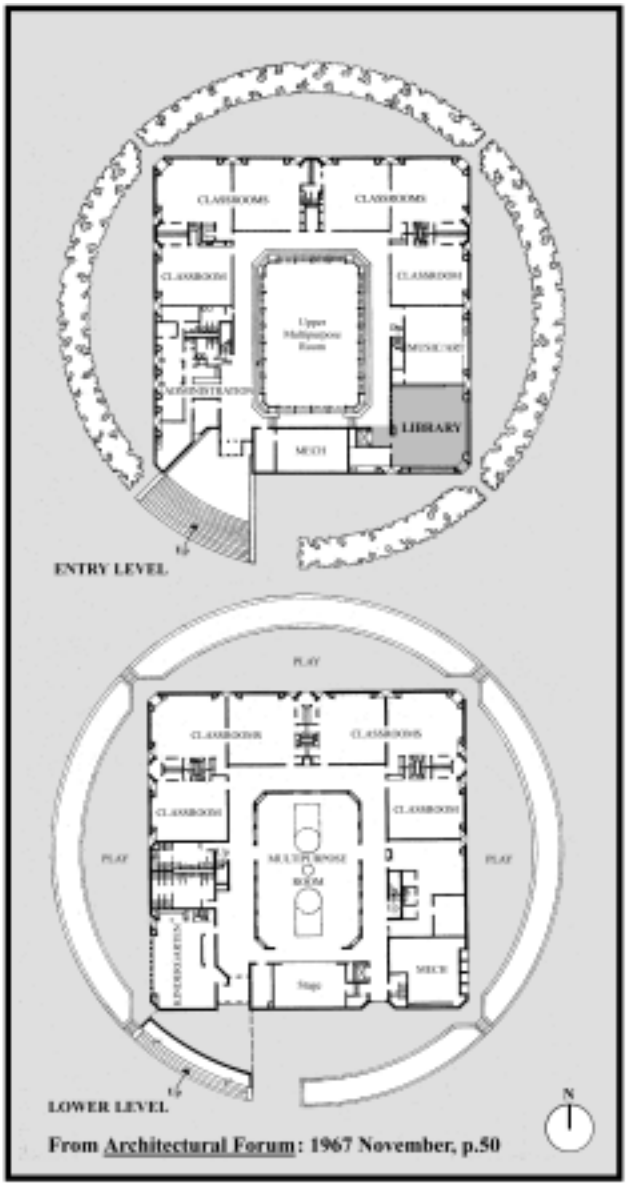


Figure L.1 : Floor Plans

Unlike the school itself, which is sited precisely in the center of the circle, the bermed circle around the school is almost contiguous to the south -- entrance -- edge of the site. The remainder of the site on the north is used for recess activity, sports for older children and as a playground for the community. Younger children's play area is located in the space between the school building and the berm . The school was a winner of a 1970 AIA Honor Award. The awards jury commented: "This building has a tightly controlled and formalized design attitude which extends completely into a small site, to the extent that the building and site are individually self-supporting and dependent. Neither could succeed without the other. Plan, section, general development and detailing are very original in quality, and the building succeeds admirably both as a school and in the self-effacing way in which it fits into a domestic-scaled environment."
(AIA Journal, June 1970, p.82)

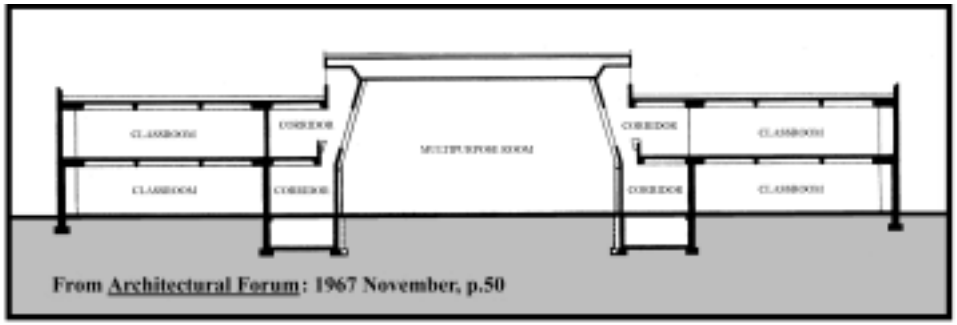


Figure L.2 : East-West Cross-Section Looking North

The building is structured in two parts with the outer ring of rooms and corridor structured separately from the multipurpose room. This approach allowed Birkerts to insert a continuous clerestory between the two structures, a device that is used to maximum effect to provide daylighting to the multipurpose room, both corridor floors and, in some cases, to the outer ring of rooms (See Figure L.2). Daylighting at the exterior of the building is provided almost exclusively via recessed windows; recessed windows that, in some locations, are more inventively configured than in others. In these locations, what appears from the exterior to be a single window conceals two windows configured in a concave vee at the wall between two rooms, with one window of the vee lighting each room (See Figure L.3).

Figure L.3 : Exterior of "Vee" Window

The Luminous Environment

Lincoln's library is on the southeast corner of the second floor of the school (Figure L.1). It is daylit by windows on three corners of the space. It also has windows facing onto the clerestory-lighted corridor (See Figure L.4).

Electric Lighting

Electric lighting is provided in a straightforward fashion by 1'x4', two 40W lamp, fluorescent fixtures set in the rectangular coffers of the concrete waffle slab (See Figures L.5a and L.5b).

Light Levels

Daytime light levels at the 29" work surface level were relatively uniform for most of the space. With the exception of high light levels at the window locations and low readings at the north and east walls, foot-candle readings were predominantly between 20 fc and 40 fc. The lowest levels were along the east wall with four readings of 9 fc and one of 6 fc being recorded (See Figures L.6a and L.6b). These low readings at the walls leads one to question the architects assertion that the "windows were placed in such a way that...light is admitted into the classrooms and is further used to illuminate the side walls", especially given the fact that readings were taken on a mostly sunny mid-June mid-morning when an outside readings of 2100 fc was recorded. However, there exists the possibility that the placement of tall furniture at these windows has the effect of excluding light from the adjacent wall surfaces. Also in the context of windows/daylighting, it is worth noting that users commented favorably on the windows, one noting that "one of the things [she] really likes about the library is

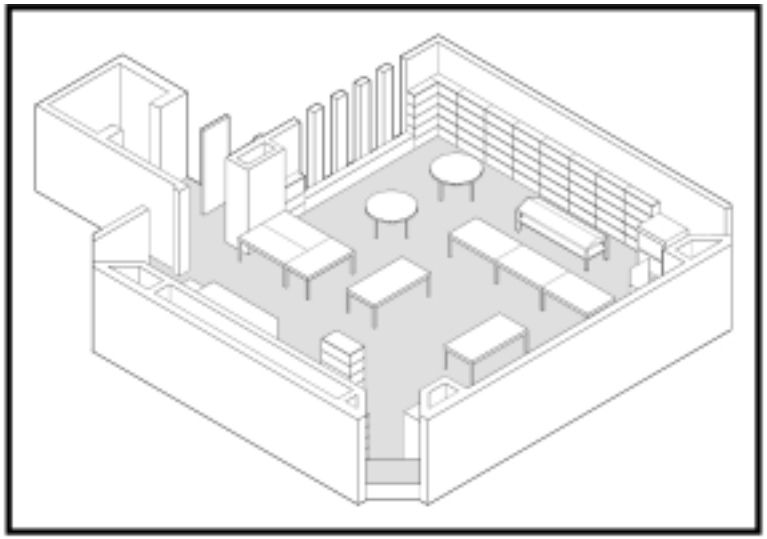


Figure L.4 : Isometric of Library

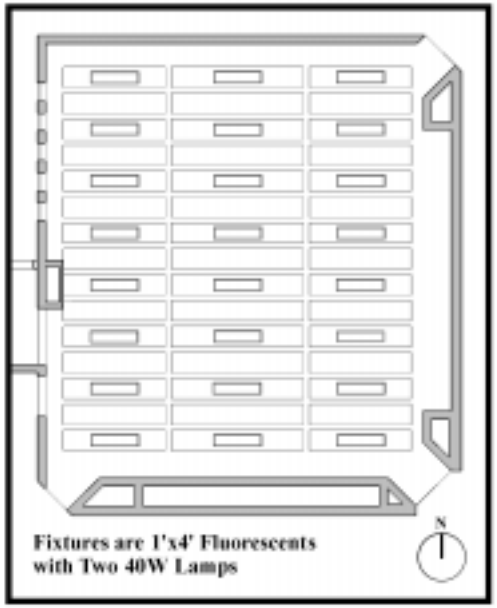


Figure L.5a : Reflected Ceiling Plan

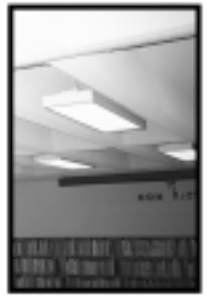


Figure L.5b

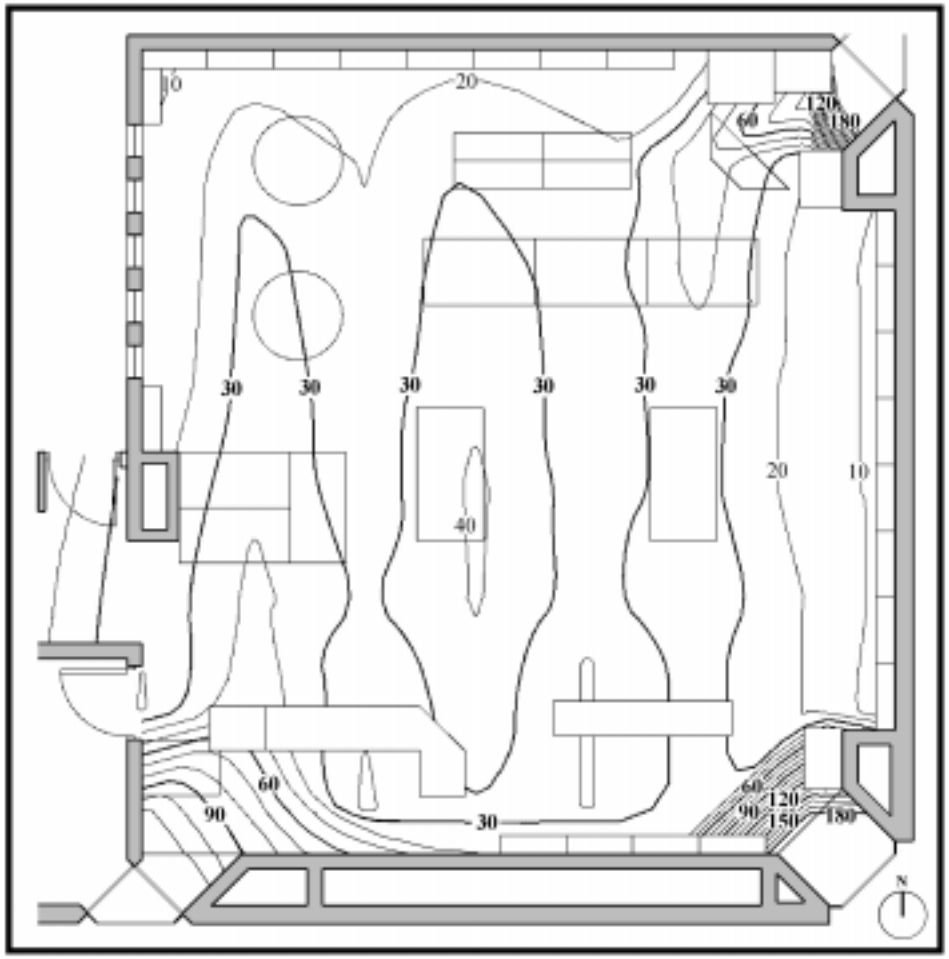


Figure L.6a : Isolux Diagram of Library Illumination in Footcandles Measured at 29" Above the Floor

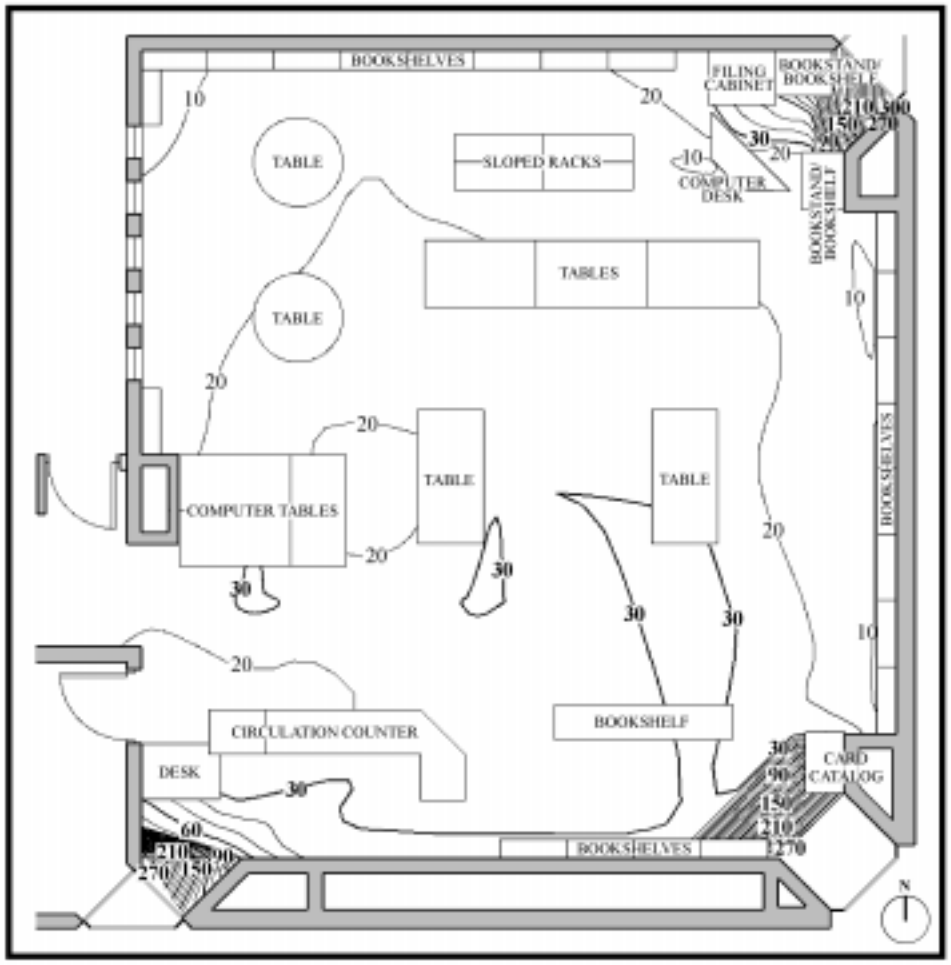


Figure L.6b : Isolux Diagram of Library Illumination in Footcandles Measured at Floor Level

the availability of natural light [through]...three very large windows...and windows to the hallways" and another saying she "loved the windows, the openness".

Floor surface readings follow the same pattern as the readings at the 29" work surface height, but with lower light levels, with footcandle readings ranging from highs of 30 footcandles or more at the center of the room to lows of 4 and 5 footcandles at the two perimeter wall locations (See Figure L.6b).

Bookshelves Lighting

Low light level readings at the walls where book shelving is located gave rise to suspicions that lighting of the shelves was inadequate. To test this hypothesis, vertical plane readings were taken on the faces of the north wall shelves at 40 points, ten profiles of four top-to-bottom readings. Readings ranged from a low of 9 fc to 11 fc at 10" from the floor to highs of 18 fc to 20 fc at the top shelf. All but one of the readings were below the IES recommended minimum of 20 fc, strongly indicating that reading the titles on book splines probably is a problem (See Figure L.7).

Nighttime Readings

Nighttime readings at the 29" work surface height in four locations at the room's interior closely follow daytime readings, with levels in the 35 fc to 50 fc range, indicating that electric light as opposed to daylight is the major source of illumination for the space.

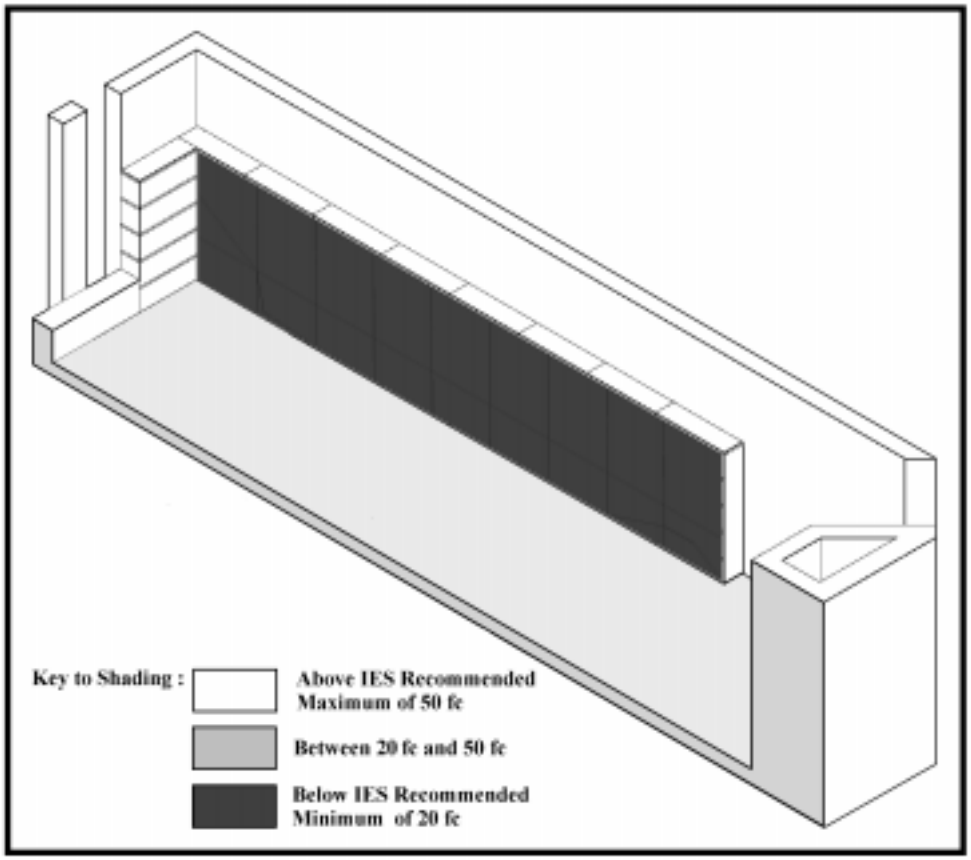


Figure L.7 : Isolux Diagram of the Illumination on the Face of the North Wall Bookshelves

Findings

In summary, the following points regarding the luminous environment of the Lincoln Elementary School library can be made:

1. Lighting levels at the 29" work surface height were:

   a. above the IES recommended minimum level of 20 footcandles for about 75% of the space and at or above the IES 30 footcandles optimum for about 40% of the space; and,

   b. below the IES minimum recommended level on the perimeter at three of the walls: the north, east and west walls. Readings at the east wall were recorded at 9 footcandles for four of five points and 6 footcandles at the fifth.

2. At the floor level, light level patterns were similar to those of the 29" work surface height: above the IES minimum recommended level of 20 footcandles for most of the room, at the IES recommended optimum level of 30 footcandles for a significant portion of the room, and below the IES recommended minimum along every wall of the room except the south wall.

3. At the 29" level there were three clearly defined north-south "ridges" in the light level pattern for the room. These ridges were coincident with the lines of the luminaires. The average light levels of these three ridges were as high as 15 footcandles above the average light levels of the contiguous troughs; a typical difference was a "ridge" reading average of 39 footcandles versus a "trough" average of 24 footcandles.

4. Vertical plane light level readings at the face of the book shelves on the north wall revealed light levels below the 20 footcandles IES recommended minimum for all but one of the forty readings. Over one-half of the readings were below 12 footcandles.

The following conclusions can be reached regarding the luminous environment of the library.

1. Despite the architect's assertion that the intention was to have light from the corner windows "illuminate the side walls", this does not appear to be occurring; there are strong light level "bubbles" at the windows but no significant penetration of light from the windows into the space along the walls. However, it was noted that the placement of tall furniture items at the northeast and southeast corner windows could have the effect of partially shading adjacent walls from light from these windows.

2. There is no evidence of significant penetration of daylight from the corridor clerestory into the space.

3. Electric light is the primary source of lighting for the space, and is adequate for tasks performed in a library for most of the space.

4. Light levels are inadequate for most of the perimeter of the room, most notably at the east wall where footcandle readings were in single digits and the north wall with readings ranging from 9 fc to 20 fc. These two walls are where almost all of the library's books are shelved and light levels on these shelves make it difficult to read the print on the spines of book, a significant shortcoming in the design of lighting for a library.

Parkside

Building Design

Parkside was originally occupied in 1962. It was remodeled and expanded in 1989. Both the original building and the remodel/expansion were designed by Norman Fletcher.

Norman Fletcher's design for the original Parkside featured a trifurcated organization with a one unit for the lower grades (kindergarten through grade two), one unit for the middle and upper grades (grades three through six)-- and the administrative offices-- and a multipurpose unit for the auditorium, cafeteria and gymnasium functions. These three units were organized in a u-shape around an entry courtyard and were connected by covered walkways. The resulting floor plan typology was basically a linear one in which all circulation between units moved along the u-shaped walkway (See Figure P.1).

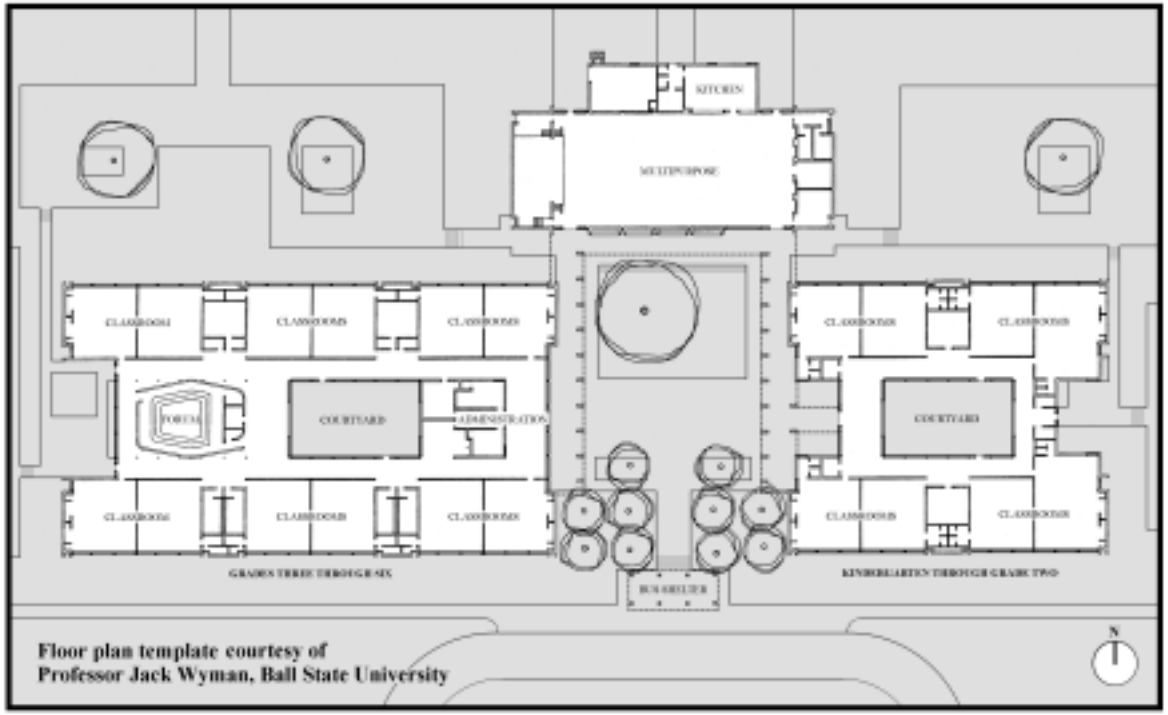


Figure P.1 : Floor Plan of Original School

Three-dimensionally, the original building was three single-story "pavilions" set on two foot high earthen podiums and featuring flat roofs with deep, four foot, overhangs or barrel-vaulted roofs. Flat roofs were used over the classroom units while multiple barrel vaults roofed the multipurpose wing and the bus shelter located on the open south side of the entry courtyard (See Figure P.2).

Figure P.2

Parkside

Fletcher's design for the expanded Parkside preserved most of the original features of the school while doubling its size. The remodeled and enlarged school features a polynodal arrangement of six "pavilions". Two of the three pavilions are classroom additions to the original classroom units and the third is a new gymnasium; the original auditorium/gymnasium/cafeteria unit became a cafeteria/ library unit with the cafeteria on the west end and the library/computer lab on the east end (See Figure P.3).

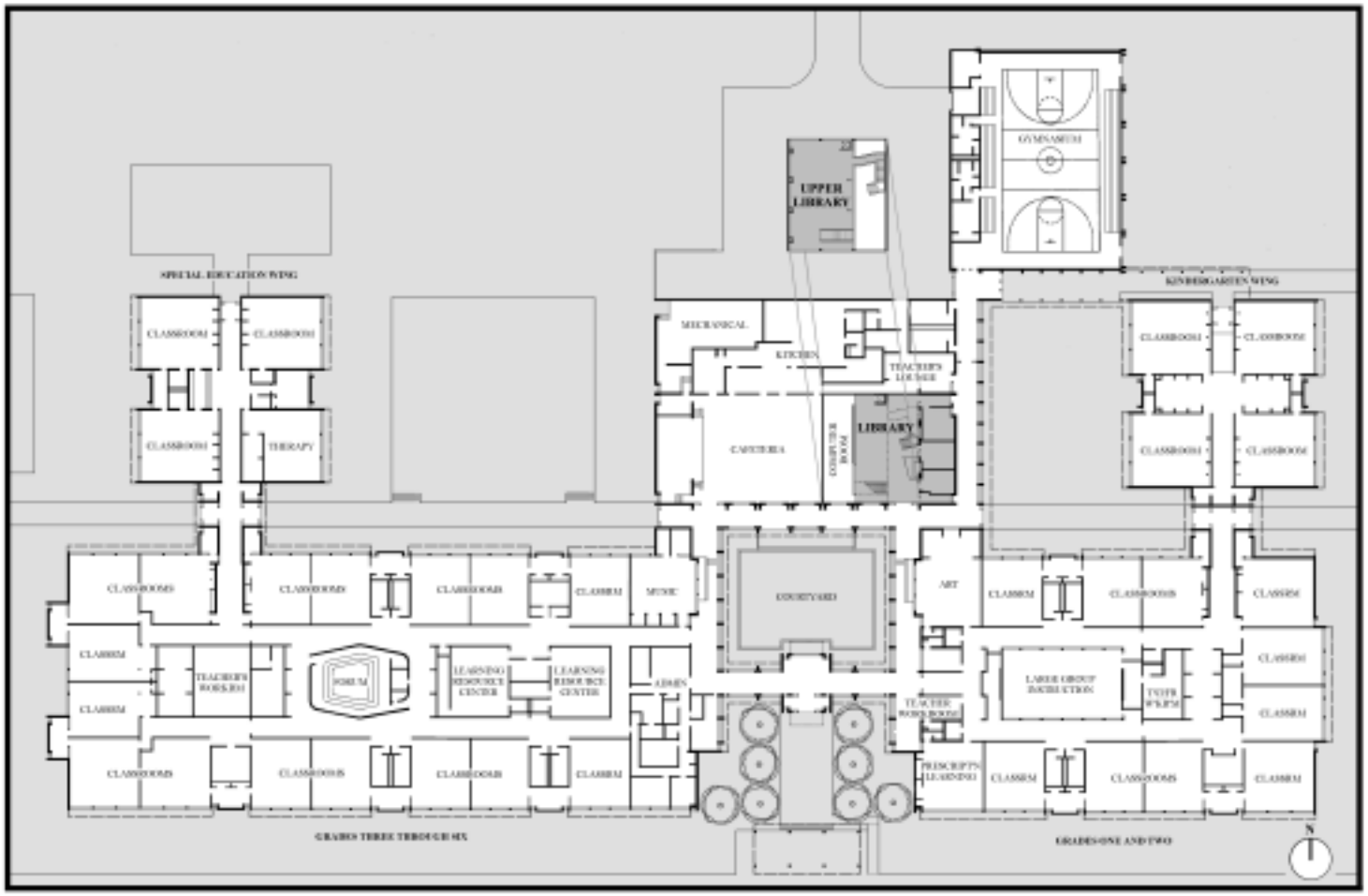


Figure P.3 : Floor Plan of Remodeled School

The library is organized into three sections functionally and four parts spatially. The three functional sections are: the lower library, the upper library and the computer laboratory. The four spatial parts are: the two-story section of the lower library, the mezzanine (upper) library, the part of the library under the mezzanine and the enclosed computer laboratory (See Figure P.4). This organization fits the library into the former gymnasium in a way that is both efficient and spatially interesting.

The Luminous Environment

The original school was designed to make extensive use of daylighting. The separation of the school into three units provided each with four exterior sides. Moreover, each classroom wing had its own interior court. Extensive fenestration of these facades provided copious amounts of daylight to the classrooms. This classroom daylighting was complemented by indirect cornice fixtures developed by lighting consultant William Lam which utilized high-output, grooved fluorescent lamps. Fletcher's intention was that daylighting would be the primary light source with the electric strip lighting supplementing and replicating, to the degree possible, the effect of the daylighting through the windows.

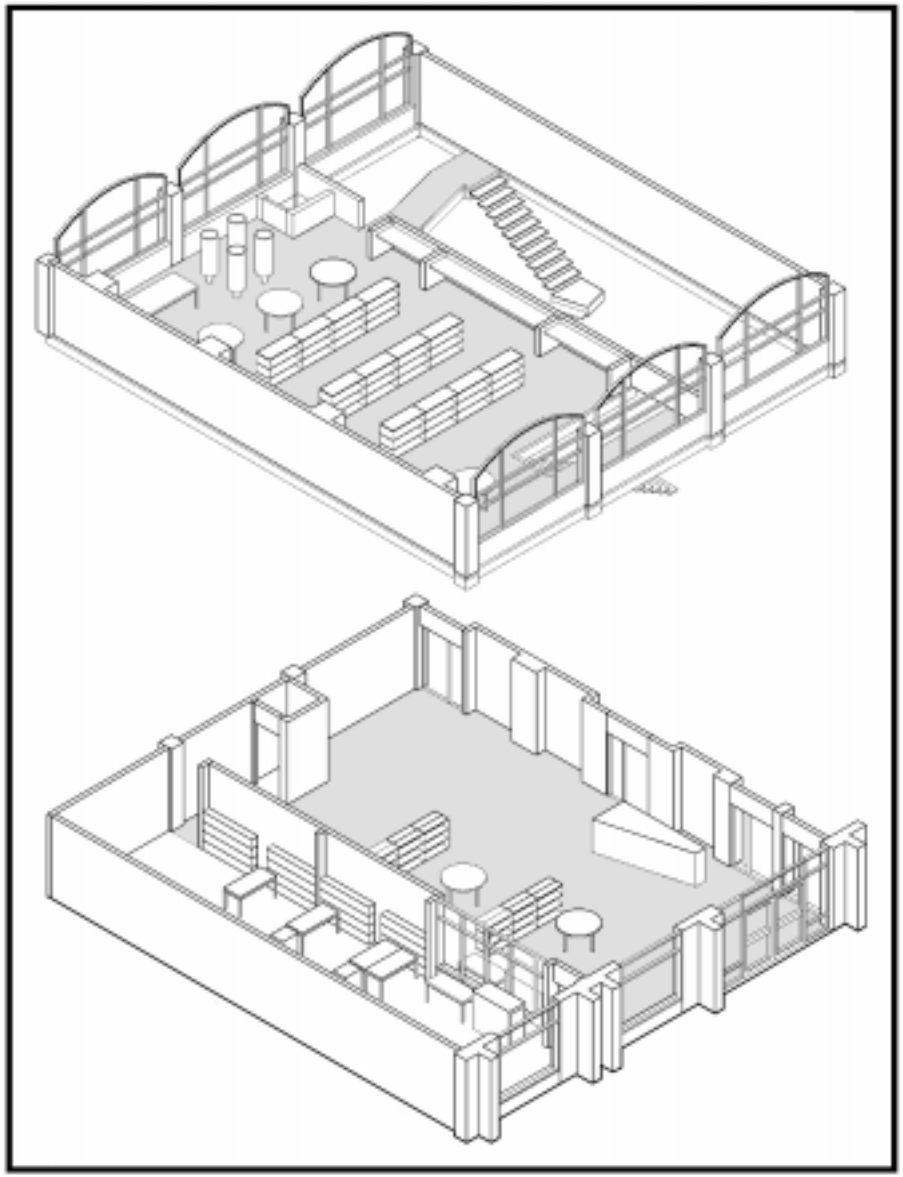


Figure P.4 : Exploded Isometric of Library

Parkside

Light Levels

By virtue of being inserted into a space originally designed for a different function, the library benefits only partially from Fletcher's original daylighting intentions. Also, electric lighting in areas on the ground floor not benefitting from access to daylight appears to be inadequate.

Daylighting

The only direct daylight into the library is via second floor windows which span the entire width of the north and south ends of the library. However, the south window has been covered by opaque interior fabric shades for all but the bottom four feet of its height apparently in order to exclude penetration of south sun and to localize the concomitant heat gain and glare at the glass (See Figures P.5a and P.5b). The north windows are left unshaded. These two sets of large windows, even with the shades on the south windows, provide large amounts of daylight to the second floor of the library, but little of this daylight reaches the ground floor.

Electric Lighting

Electric light is provided by a variety of means. On the second floor, ten paired four foot fluorescent fixtures, each containing two 32W fluorescent lamps, are hung in continuous 40' long rows in the center of each of the three barrel vaults that form the ceiling/roof of the space; these three strips of luminaires provide light to the library mezzanine level, and one of the three -- the row over the two-story space -- apparently is intended to provide lighting for the first floor as well. (See Figures P.5c and P.6b). Electric lighting for the first floor of the library under the mezzanine is provided by two means: surface mounted fixtures, paired four foot fixtures with prismatic lenses containing two 32W lamps, and six recessed can fixtures containing 9W compact fluorescent lamps (See Figure P.6a).

Figure P.5a : Interior of South Window

Figure P.5b : Exterior of South Window

Figure P.5c : Interior View: North Window and Ceiling Fixtures

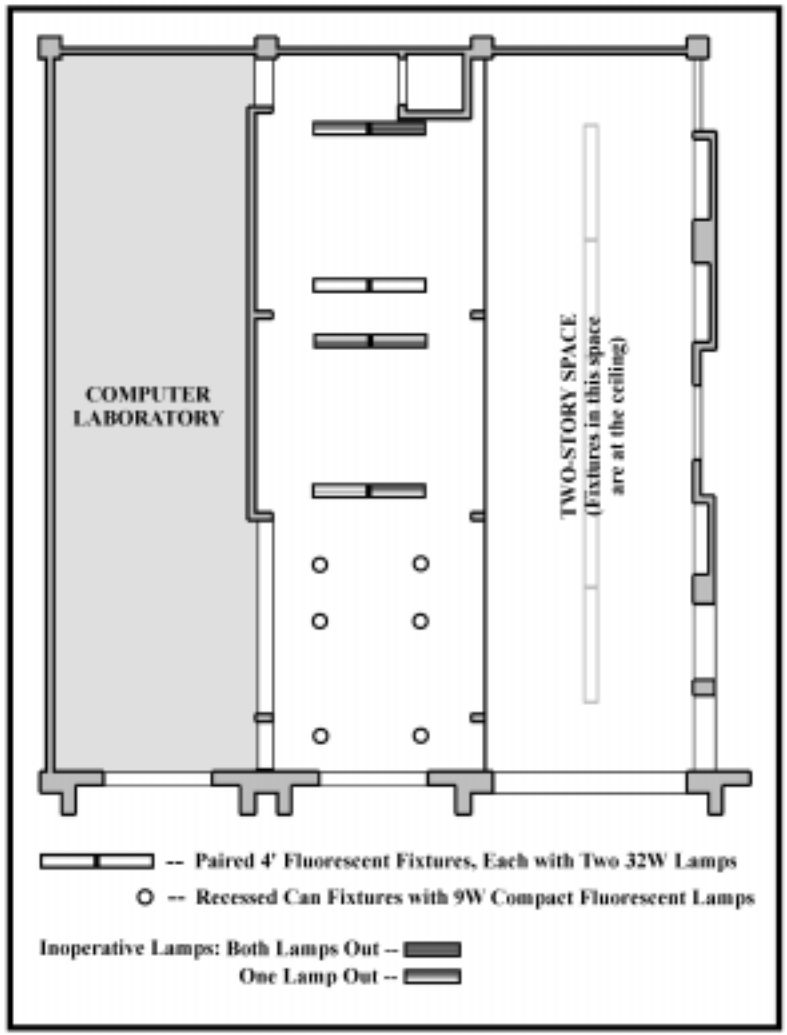


Figure P.6a : First Floor Reflected Ceiling Plan

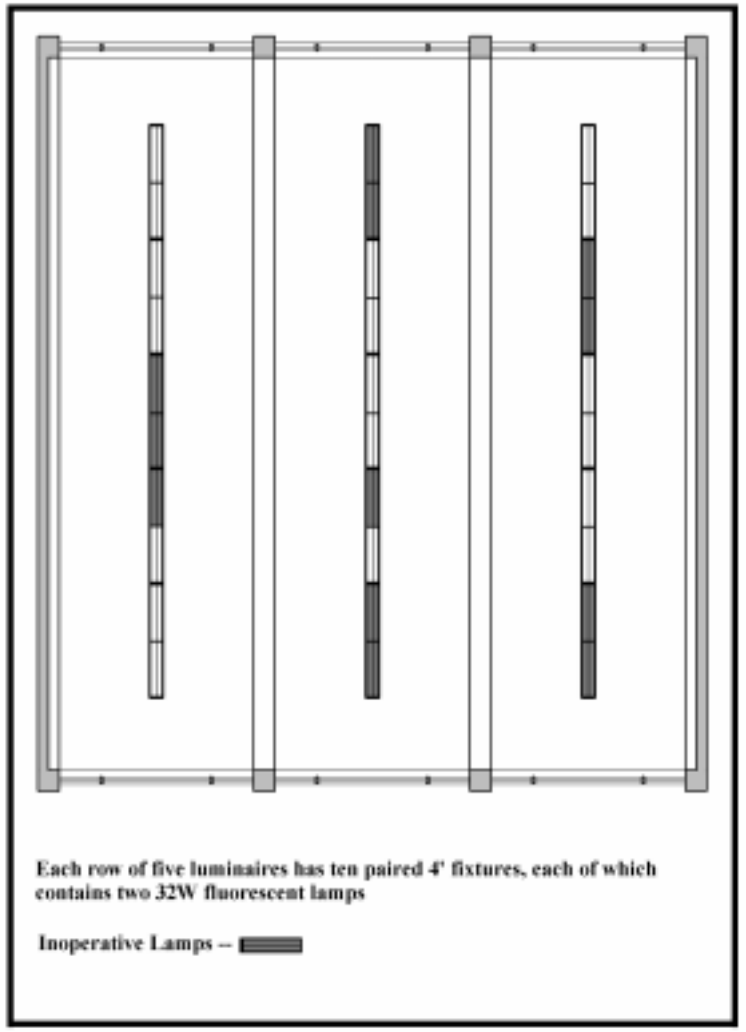


Figure P.6b : Second Floor Reflected Ceiling Plan

Ground Floor Light Levels

The lighting distribution for this hybrid system is uneven. In the lower library space at the 29" work surface height, over 75% of the readings were below the IES recommended minimum 20 fc level and at the floor in the lower space the pattern was the same, over 75% of the readings below 20 fc. Moreover, many of the readings were quite low; at the 29" task height, many readings were in single digits, between two and nine footcandles, and at the floor, several readings were under 10 fc. For both heights, a total of ten readings, seven percent of the total, were above the IES recommended optimum of 30 fc (See Figure P.7a and P.7b). It must be noted that at the time the readings were taken, several fluorescent lamps were not operating; eight of the twenty lamps (in ten fixtures) in the barrel vault over the two-story space and six of the sixteen lamps in the eight two lamp fluorescents were out (See Figures P.6a and P.6b). Obviously this had an effect on light levels; directly under the lower floor fluorescent luminaires that were fully operational, footcandle readings were in the high thirties and middle forties, while under the two-luminaire (four lamp) row that had lost three lamps, readings were 20 fc and 13 fc. However, light levels fell off rapidly between the fluorescent fixtures; six feet from a fully operational luminaire -- under which readings of 37 fc and 45 fc were recorded -- readings were as low as 14 fc. Moreover, under fully operational recessed can fixtures as well as under the upper fluorescent fixtures in the two-story space, footcandle readings were almost all below 20 fc. In fact, readings under the inoperative upper fluorescent lamps were in some areas higher than under fixtures that were fully operational, suggesting that these upper luminaires have little effect on lower-floor light levels.

N.B.: Light level readings were also taken in the Computer Laboratory. The readings in this area were much higher overall than those in the Library's first floor. For example, of a total of 40 readings taken, only two were below 20 fc and over one-half were over 50 fc, with one-half of these -- one-quarter of the total -- being over 100 fc. However, even though readings were taken, it was felt that since the focus of this study is on school libraries and computer labs are not normally included therein, no in-depth analysis of the lighting in this area would be offered.

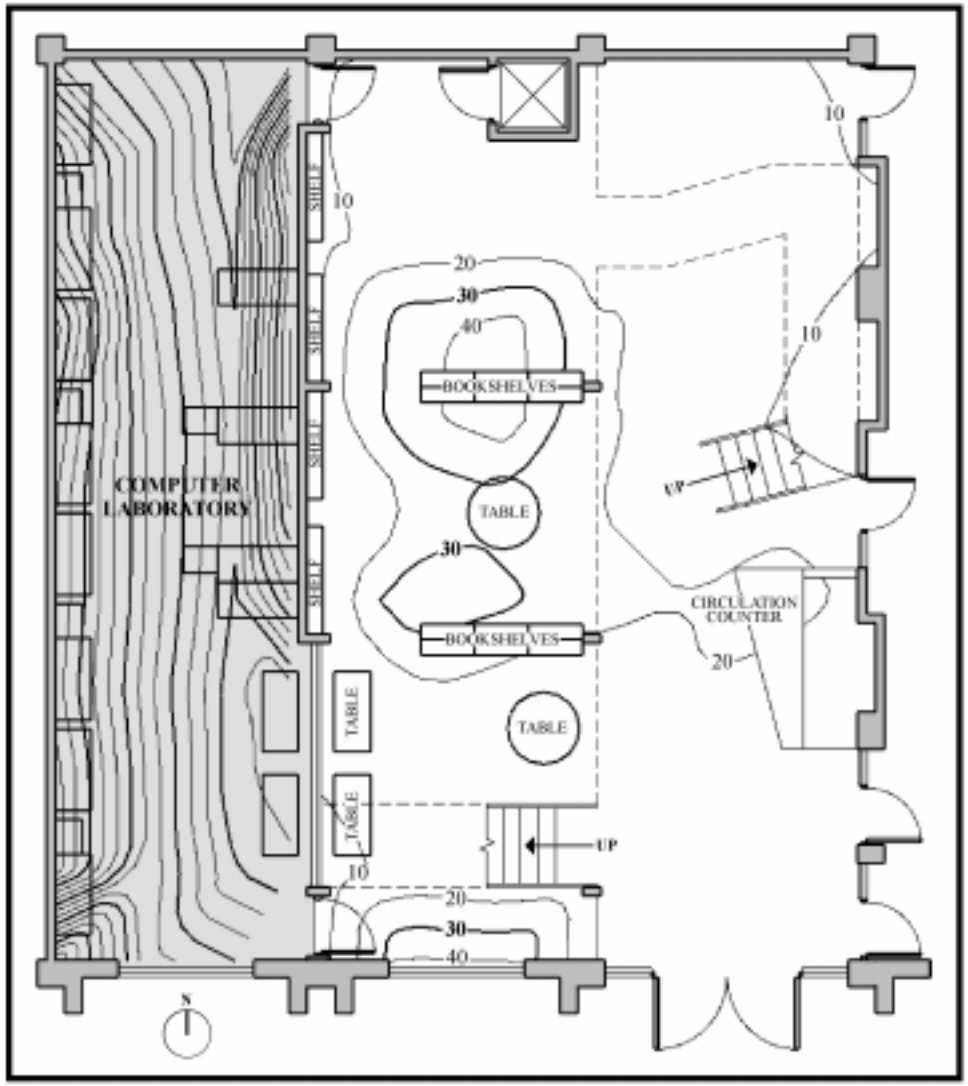


Figure P.7a : Isolux Diagram of Ground Floor Illumination in Footcandles Measured at 29" Above the Floor

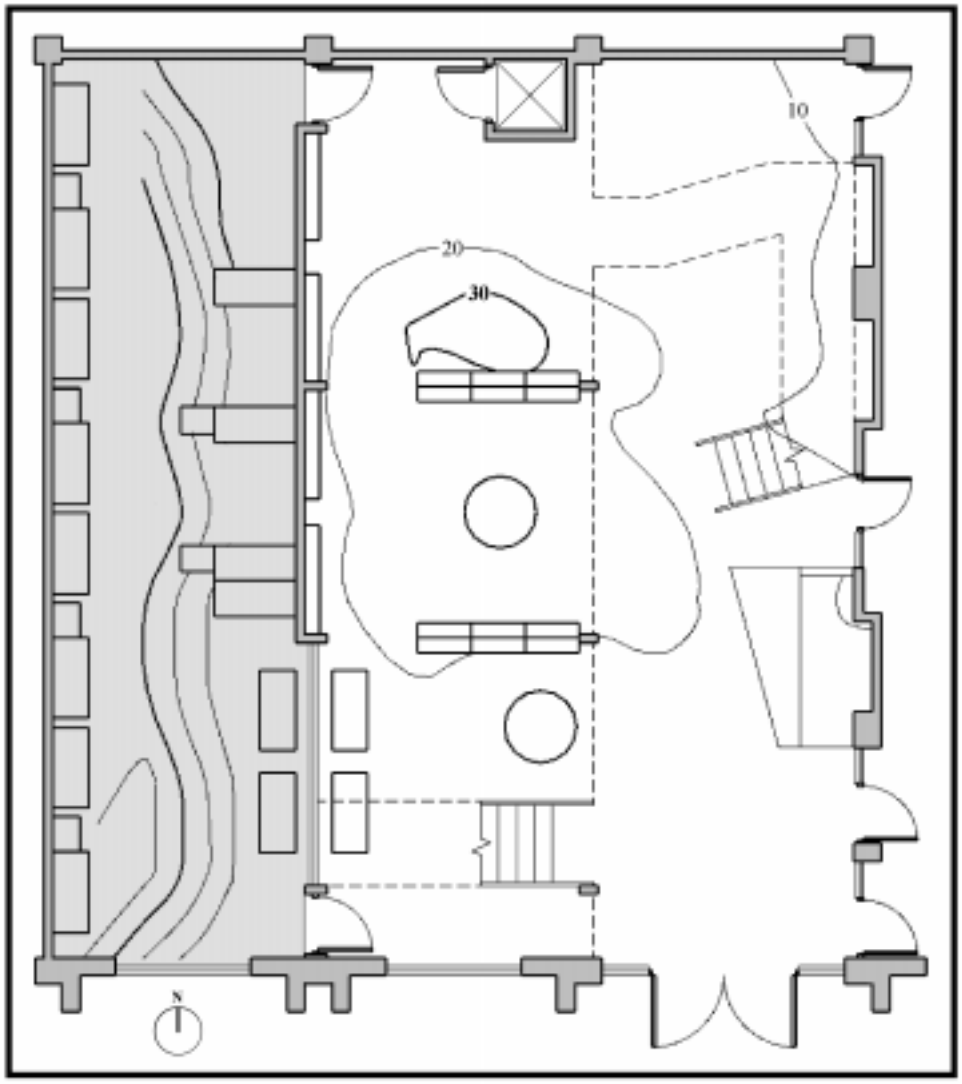


Figure P.7b : Isolux Diagram of Ground Floor Illumination in Footcandles Measured at Floor Level

Second Floor Light Levels

In the upper library space -- the mezzanine -- light levels were significantly higher than in the lower space. Due to the large expanses of windows on the north and south ends of the space, over 80% of the readings were over the IES 20 fc recommended minimum and readings of 180 fc at the south window and 200 fc at the north window were recorded at the 29" work surface height. However, there was a significant “trough” in the west center portion of the space, where light levels were between 13 fc and 18 fc (See Figure P.8a). These lower readings appear to be the result of: a) the area being shaded from the light from the windows by the bookshelves; and, b) three of the four foot fluorescent luminaires (six lamps) not being in operation over this area (See Figure P.6b).

At the floor, the pattern was, predictably, the same as that at 29": high readings at the windows and lower readings in the center of the room. At the windows, readings of 65 fc on the south and 75 fc on the north were recorded. In the center of the room, readings closely resembled those recorded at 29" with readings between 13 fc and 19 fc and in almost the identical location as the low readings at 29" (See Figure P.8b).

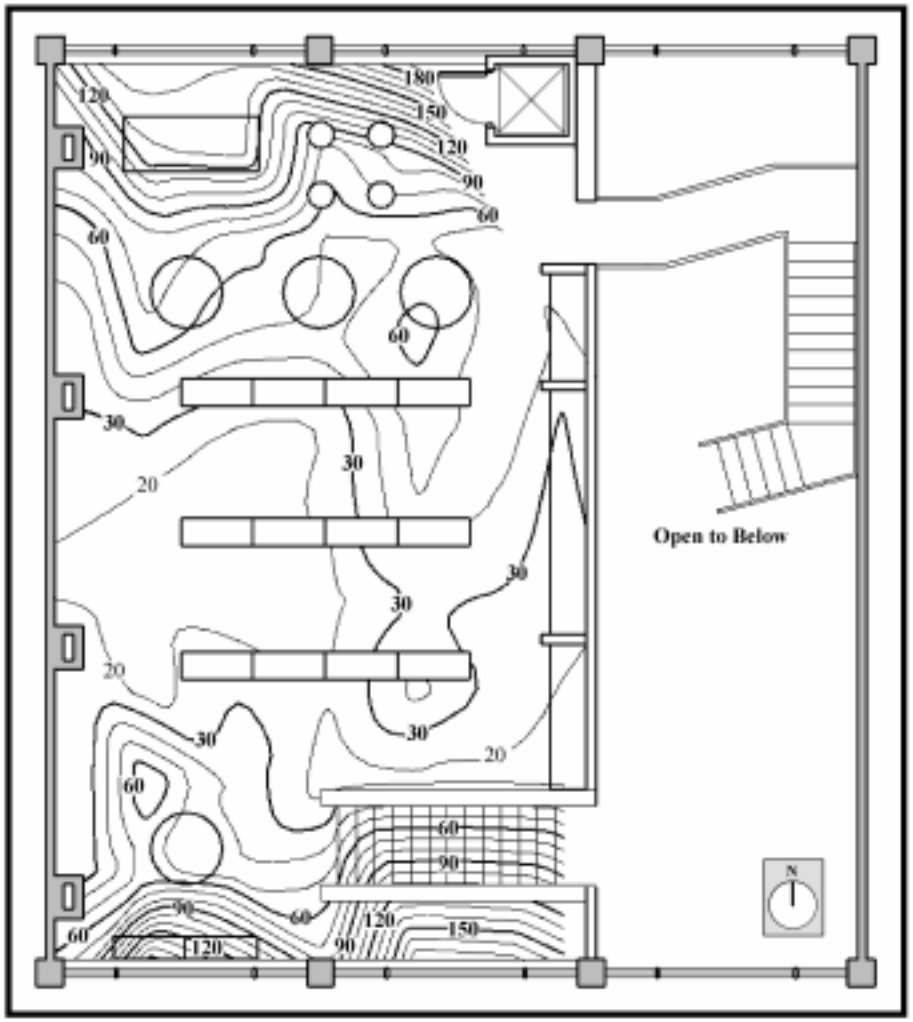


Figure P.8a : Isolux Diagram of Second Floor Illumination in Footcandles Measured at 29" Above Floor Level

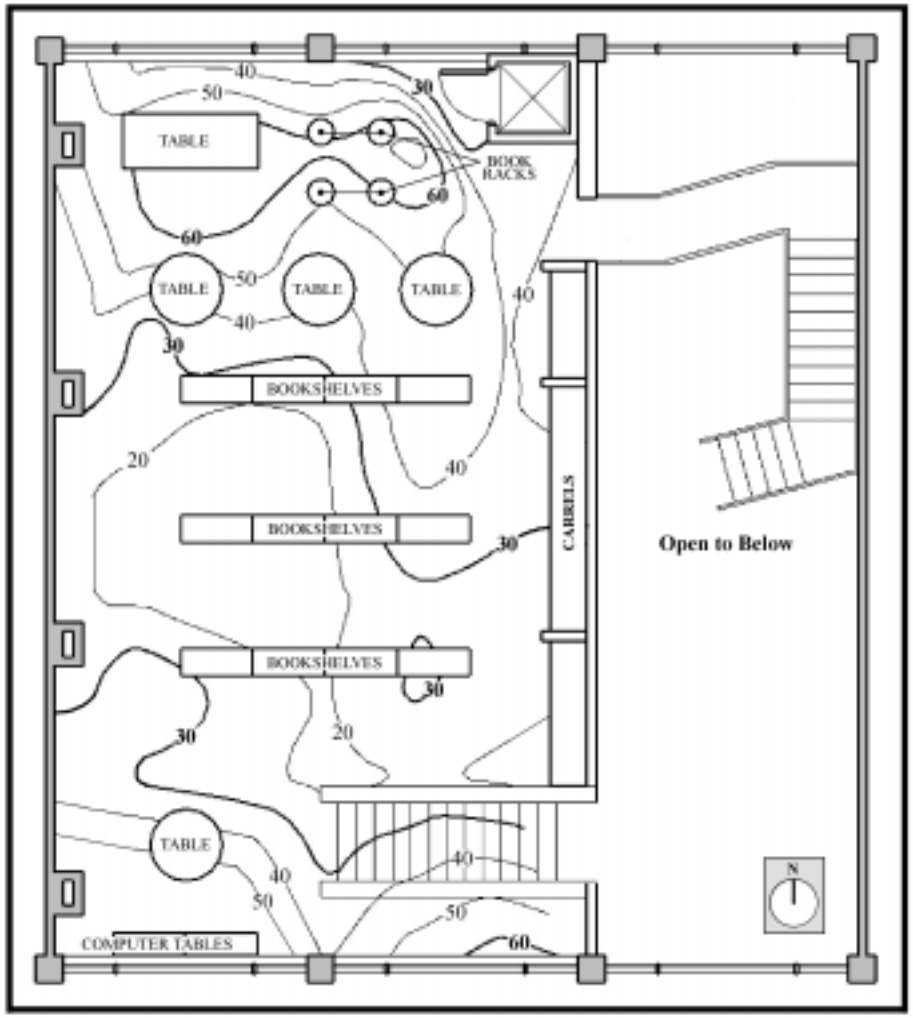


Figure P.8b : Isolux Diagram of Second Floor Illumination in Footcandles Measured at Floor Level

Parkside

Bookshelves Lighting

The low light levels in the bookshelves area gave rise to questions of adequacy of light for the reading of the splines of books. Consequently, supplemental readings were taken on the surfaces of the shelves. Four "cross-sections" of readings were taken across the three shelves; 72 readings were taken, three readings on each of the six shelf faces for each of the four cross-sections. These readings showed that light levels on the exterior faces of the shelves, i.e., the faces facing the north window or the south window were almost all above the IES recommended minimum of 20 fc; only 3 of the total of 24 readings were under 20 fc. However, on the interior surfaces of the shelves -- those shielded from the windows -- 32 of the 48 readings were below 20 fc (See Figure P.9). These readings indicate that the legibility of book splines is probably a problem because of low light levels "within" the bookshelves

Nighttime Readings

Nighttime readings at Parkside were low for both floors of the library. With the exception of one reading of 50 fc under a recessed luminaire, all readings were under 20 fc, ranging from a low of 7 fc to a high of 18 fc.

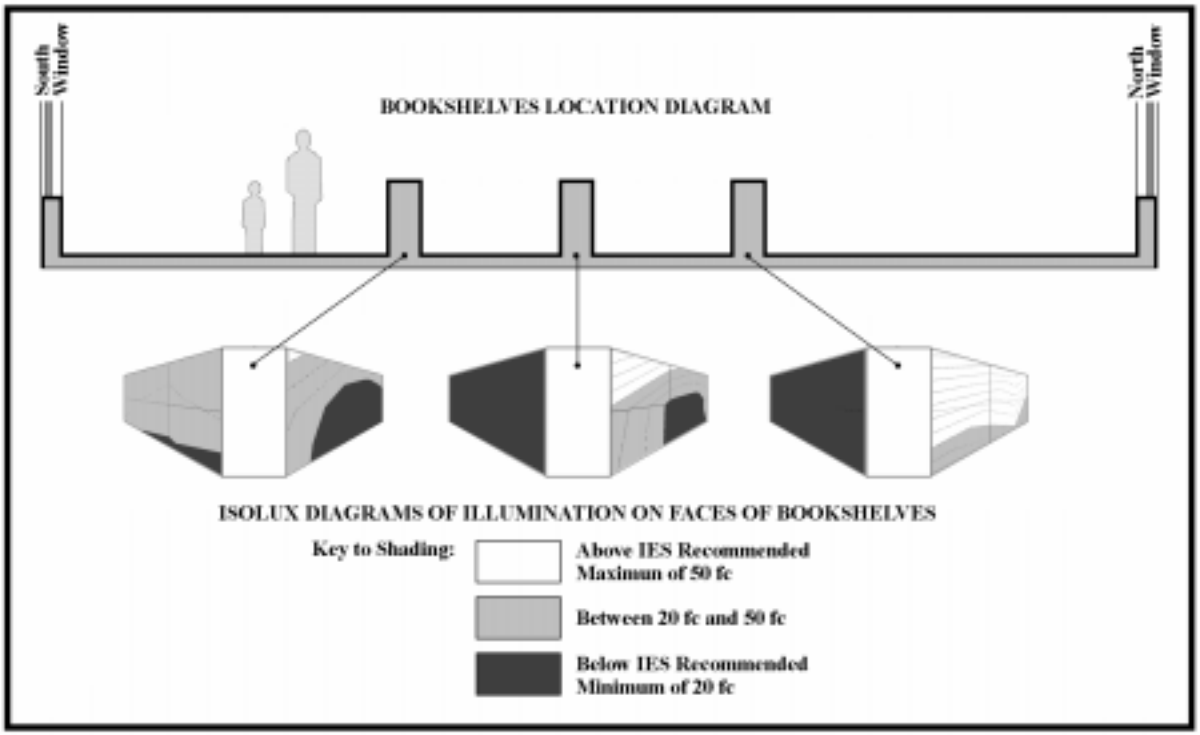


Figure P.9 : Isolux Diagrams of Illumination on Faces of Second Floor Bookshelves

Findings

In summary, the following points regarding the luminous environment of the Parkside library can be made:

1. Daytime light levels recorded in the first floor area were:
   a. barely above or below the IES recommended level of 20 fc for most of the space, and
   b. significantly below the IES 20 fc minimum for most of the northeast corner of the space.

2. Daytime light levels recorded on the mezzanine were:
   a. above IES recommended optimum 30 fc level for all but approximately 200 square feet -- under 15% -- of the space.
   b. significantly above the IES recommended maximum level of 50 fc for the areas near the windows at the 29" work surface height.

3. Nighttime light levels were generally below the IES recommended 20 fc minimum for both levels.

The following conclusions can be reached regarding the luminous environment of Parkside:

1. On the lower floor, if all of the luminaires were fully operational, the light levels would be above the 20 fc IES recommended minimum for the area under the mezzanine but at or below this minimum in the two-story portion of this level.

2. On the upper floor, if all luminaires were operational, light levels for the entire space would be above IES recommended level of 30 fc.

3. Nighttime light levels are too low for many library operations.

Potential for Further Study

Two conditions were observed at Parkside that appeared to be candidates for further study. These were:

1. The orientation of the three bookshelves on the mezzanine level creates a situation whereby the sides of the outer bookshelves away from the windows and both sides of the middle shelves are shadowed from the windows, creating low light levels on these surfaces; 75% of the readings on these surfaces were below 20 fc. It is possible, even probable, that if the bookshelves were oriented north/south rather than east/west, the quantity of light between the bookshelves contributed by daylight would increase significantly and daytime light levels would thereby be increased in these areas to the recommended level.

2. Heavy fabric shades are being utilized inside the large upper windows in order to reduce glare and localize heat gain at the window. Given the low light levels on the first floor of the library, the speculation is whether the installation of an external "egg crate" sunscreen, which would admit reflected daylight while largely excluding heat gain and glare, would provide more light for both floors of the library and thereby be a better solution to the heat gain and glare problem than are the fabric shades.

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APPENDICES

Interview Protocol

School Principal and Library Staff Interview

Do you find the (acoustic/thermal/luminous) environment of the library satisfactory?

- Yes
  - What do you feel is he most important contributor to the satisfactory (acoustic/thermal/luminous) environment?
- No/Mostly/Sometimes/Etc.
  - What are the problems with the (acoustic/thermal/luminous) environment?
    - What are the sources of these problems?
      - How do you believe that these problems could be alleviated or eliminated?

Do you have any other observations about the (acoustic/thermal/luminous) environment?

Do you have any other observations about the physical environment of the library?

School Custodian Interview

What problems do you have with the lights and lighting system in the school?

↓

Do you have any problems that are specific to the library?

↓

How would you solve these problems?

↓

Do you have any other observations about the physical environment of the library?

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