# DESIGNING A SUSTAINABLE LIGHTING SOLUTION FOR OLDER ADULTS IN A CONTINUING CARE RETIREMENT CENTER

**By**

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# CHAPTER I

## STATEMENT OF THE PROBLEM

### Background

The aged population is increasing fast in the United States, and one of the major consequences of it is the growing demand for long-term care facilities. With increased life expectancy, more people will need wellness care in their final years. In this case, what can interior designers do to create a comfortable illuminated environment for older adults? What lighting do older adults actually need in their environment?

People of different ages require different conditions to support their daily lives. Older adults have special visual needs related to their environment. Lighting can illuminate surroundings according to the user needs and ensure their safe mobility. Thus, lighting can play an important role in meeting the challenges of older adults' physical conditions, such as changes in their vision and eye diseases.

In this context, appropriate lighting can improve the quality of life of older adults and maximize their personal independence while promoting health, well-being, and safety (IES, 2007). In addition, all retirement centers, and long-term care facilities should view good lighting as a preventative measure and give it priority (IES, 2007). For interior designers, it may be a challenge to utilize proper lighting in care facilities for older

adults. Appropriate lighting solutions for older people are usually more complicated than lighting for the younger generations due to the need to compensate for the age-related changes occurring in the eyes of older adults (Noell-Waggoner & Dupuy, 2010). However, the available lighting techniques for potential design solutions differ in their abilities to optimize older adults' vision. Sustainable lighting is one type of available illumination which may contribute to lighting solutions for older adults (Boyce, 2003).

The World Health Organization (1998) reported that due to the aging world of the population there will be more than one billion people aged 60 and above by 2020. This makes senior housing facilities a large market for interior designers. A Continuing Care Retirement Center (CCRC) is one kind of facility targeted toward older adults. In such a facility, individuals may or may not need some assistance, but do not need continual medical care (Piotrowski & Rogers, 2007). As an alternative housing option for older adults, a CCRC offers different kinds of living units, activities, and continuing care services suited to individuals' health and social needs (PrivateCommunities, 2010). Achieving sustainability in a CCRC is important since the ultimate goal is to promote and protect the health and well-being of the community and its inhabitants. Sustainable lighting can be adopted for housing in order to "substantially save energy costs, reduce greenhouse gas emissions (particularly carbon dioxide), reduce solid waste in landfills and conserve scarce resources" (Stall-Meadows & Hebert, 2011, p.164).

**Purpose**

The purpose of this study is to gather and apply evidence at an existing CCRC site to inform the design of a sustainable lighting solution. This study will be produced in

order to improve the interior lighting in public spaces for older adult independent living residents at the CCRC.

Sustainable lighting suggests a way to save energy and protect eco-environment (LIU & WENG, 2002). Nowadays, sustainable lighting has been widely applied in the market. For example, as a relatively newer lighting technology, light emitting diodes (LED) features high contrast and minimal glare. LED technology also offers high lumens per watt and long life, and is poised to be a leader in sustainable lighting sources. LED is a semiconductor diode that emits visible light when electricity is applied. The study will determine whether LED is an appropriate choice for older adults in the interior public spaces at a CCRC. In this study, independent living residents are those who do not require regular assistance in the performance of daily activities, such as eating and getting around. Although many older adults are healthy and able to live independently in private homes, some who are healthy will need some type of living assistance. Many older adults may prefer to live in a CCRC. Properly addressing lighting issues relevant to the older population will help to sustain their well-being during their life (Noell-Waggoner, 2010).

However, research concerning the interior public areas' lighting at CCRC is limited and study results have rarely been applied to design. If interior designers are to create interior lighting for older adults, it is important that they identify the existing problems of interior lighting in the public spaces at the CCRC. In this study, the researcher will choose one CCRC to be the site and redesign the interior lighting of several public spaces. Because residents who are living in the facility are affected by interior lighting, it is important to gather evidence of their perceptions to improve the

overall environment. The results are anticipated to lead the researcher to select the proper sustainable lighting that suits older adults.

**Definition of Terms**

The following terms are used in this study and are defined as follows:

1. Semiconductor: It is a material with electrical conductivity between that of a conductor and an insulator.
2. Illuminance: Light level or amount of illumination.
3. Glare: A very harsh, bright, dazzling light. Glare (vision) is difficulty seeing in the presence of very bright light (IES, 2007).
4. Luminance: Brightness of a surface per unit area of its source. (IES, 2007).
5. Footcandle: The unit for the amount of illumination. It means the inside lighting a 1-foot radius sphere would be receiving if there were a central point source of one candela (lighting unit) in the sphere (Niesewand, 1999).
6. Direct: 90-100% of light output is directed down. Wide/narrow beam direct lighting can be used for emphasis and highlighting (Kilmer & Kilmer, 2003).
7. Indirect: 90-100% of light output is directed up toward the ceiling. Can create a feeling of height and prevent dark ceiling (Kilmer & Kilmer, 2003).
8. Ambient lighting: Uniform lighting throughout an area, which is a combination of light reflections from various surfaces (Whitehead, 2004).
9. Color Rendering Index (CRI): Evaluating color rendering quality of light sources in comparison with an ideal or natural light source (Yaguchi, Takahashi, & Shioiri, 2001).

# CHAPTER II

## Summary of Surveyed Related Work

This chapter will present basic information about this proposed study. Thus, the purpose of this literature review is to introduce related frameworks; to provide insights into older adults' visual systems and issues; to explore sustainable lighting solutions; and to present industry recommendations for interior lighting in public spaces. This literature review will contain five sections. The first section will introduce the frameworks of Wellness and Evidence Based Design. The second section will present the common challenges to older adults' vision as well as this age group's specific preferences for lighting. Then, the characteristics and recent applications of LED will be addressed. The next section will focus on the lighting survey instruments and the field study instruments. Lastly, the current lighting industry recommendations for interior lighting in public spaces specifically designed for older adults will be presented.

### Related Frameworks

Wellness Framework

The term of wellness was first introduced by Dr. Halbert Dunn in 1961. He defined wellness as "an integrated method of functioning that is oriented toward maximizing the potential of which the individual is capable within the functioning environment" (Dunn, 1961, p. 4). The National Wellness Institute later expanded the

wellness concept as six-dimension wellness model. Dimensions that embody personal wellness include, but are not limited to, emotional wellness, social wellness, intellectual wellness, physical wellness, spiritual wellness, and vocational wellness (See Figure 2-1).

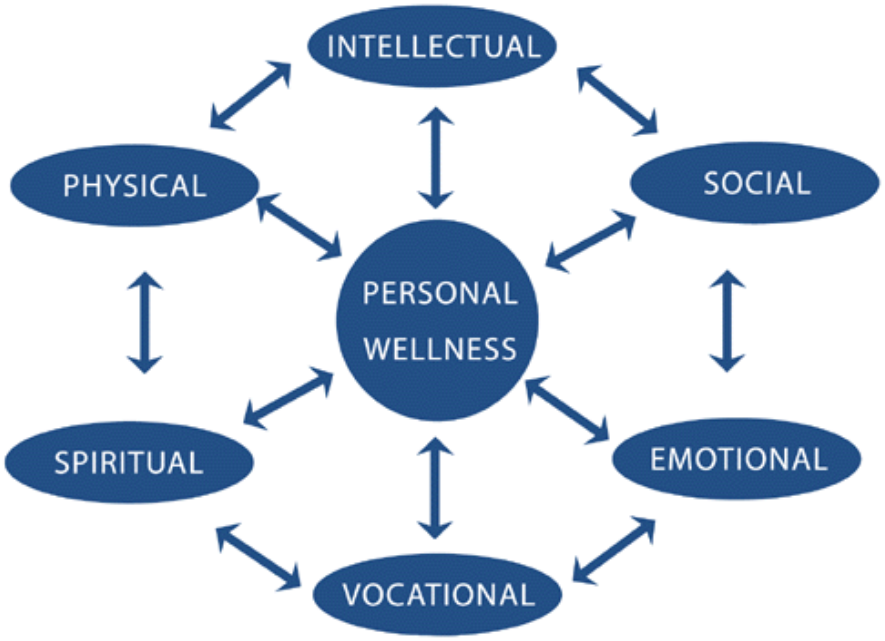



Figure 2-1. Whole Person Wellness Model

The emotional wellness promotes an awareness and acceptance of one's feelings. The social wellness emphasizes the creation and maintenance of healthy relationship. The intellectual dimension encourages creating a better understanding and expanding knowledge. The physical dimension promotes the need for physical activity. The spiritual wellness recognizes seeking the meaning and purpose in life. The vocational dimension emphasizes personal enrichment and development through work. The whole person wellness model embodies a holistic and comprehensive perspective to wellness. This study proposed appropriate interior lighting to promote older adults' wellness through another dimension, environmental dimension of wellness.

Evidence Based Design Framework

Evidence Based Design (EBD) framework is the method by which designers use the highest quality of research that leads them to the best possible design solutions (Nussbaumer, 2009). It is defined as "a process for the conscientious, explicit, and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project" (Stichler & Hamilton, 2008, p. 3). In other word, EBD is an approach to inform design base decisions on researches. Based on the EBD framework, this study will apply findings to the proposed design solutions.

Furthermore, a design process involves synthesis and analysis (Nussbaumer, 2009), since designers should use a systematic and logical method to solve the problem. EBD is divided into phases: programming, schematic design, design development, and construction document. The programming phase consists of information gathering. Then, the schematic design stage continues to analyze the evidences and brainstorming possibilities. The next step is to determine the best solution in the design development phase. At last, the construction drawings will be produced. In this study, the methodology will use the EBD's design process to inform a sustainable lighting solution for older adults.

**Older Adults' Vision**

Outward appearances alter with age. The eyes, too, experience changes. Typically with advancing age, the tissues of the eyes become more fragile, and the pupils become smaller. Older adults may need greater amounts of lighting to compensate for the reduction in the amount of light reaching their eyes (IES, 2007). The goal of lighting is to

ensure that people have sufficient illumination to perform visual tasks safely, effectively, and accurately (IES, 2008). Interior tasks in a CCRC's public spaces may include walking through the building entries, hallways, and lobby, as well as the performance of reading and related visually intensive activities. Additionally, pastimes such as swimming and dining may be considered visual tasks. These visual tasks associated with daily living, need special lighting consideration for older adults (IES, 2007). For example, aging population needs even lights, higher illumination without glare, and greater contrast because of the effect of their age-related vision changes (Noell-Waggoner & Dupuy, 2010).

Physiological changes occurring in the visual system with increasing age lead to degradation in "visual acuity, contrast sensitivity, color discrimination, and absolute sensitivity to light" (IES, 2007, p.3). Color preferences cause some reduction in the ability to discriminate blues and blue-greens. Thus, older people are more sensitive to yellow, orange, and red than other colors (Goodman & Smith, 1992). The yellowing of the lens is believed to be responsible for this effect. (The Eye Digest, 2009). Because some colors will appear dull or even gray to older eyes, they require greater intensities of color for the visual system to perceive stimuli. Thus, appropriate Color Rendering Index (CRI) will help older adults see their environments more clearly.

Aging also can result in a reduction in eyes' ability to adjust to sudden changes in lighting. Part of the reason is that pupils have lost size adjustability and also due to changes in the retina (Boyce, 2003). Consequently, when older people move from a very bright environment (such as being outdoors on a sunny day) to a darker one (such as inside an interior room), their eyes will need longer time to adapt than those of younger

adult. Finally, older adults' sensitivity to glare is increased by age-related changes in the lens (IES, 2007). While many experience glare when confronted with high levels of illumination, older adults can find it debilitating to simply look at a brightly illuminated objects (The Eye Digest, 2009). This increased sensitivity to glare can have a blinding effect.

Moreover, contrast sensitivity declines as people get older which lead to the poor vision quality especially in the dark (The Eye Digest, 2009). Contrast sensitivity is influenced by the condition of eye's adaptation and by the rate of luminance's change across the visual space (IES, 2007). Thus, it is more difficult for older people to read low-contrast, grey-on-white letters than higher-contrast, black-on-white ones. But much of the world is composed of low-contrast objects: surfaces, sidewalks, escalators, and sometimes newsprint, so how older adults function becomes important. However, these age-related challenges to the visual system could be compensated for, to a certain extent, by improvements to the environment, the task, the eye system, and the lighting in the area (IES, 2007).

In addition, as people age, many become dependent on their environment, and good design directly impacts older adults' quality of life. Quality of life is used to reflect personal satisfaction or dissatisfaction with the cultural or intellectual condition (Campbell, Converse, & Rodgers, 1976). Some researchers found a close relationship between lighting and quality of life in relation to older people (Sörensen & Brunnström, 1995). They also suggested that studies, which encourage older people to improve their interior lighting, should be focuses in future efforts.

## Existing sustainable lighting technologies

Today, there are many choices in lighting technologies including compact fluorescent (CFL), metal halide (HID), high-pressure sodium, induction, and light emitting diodes (LED) (Hubbell Lighting, 2008). The advantages of CFL are high luminous efficacy and durability (Cook, 1998). However, like all fluorescent lamps, CFL contains mercury that release poisonous emissions from their disposal (Tunnessen Jr, McMahon, & Baser, 1987). HID also could provide high light levels, but needs to be operated under high temperature and pressure (Cook, 1998). Thus, most HID lamps have been applied for the outdoor applications (Rea, Bullough, & Akashi, 2009). As a relatively newer lighting technology, LED features high contrast and minimal glare. LED technology also offers high lumens per watt, long life, and is poised to be a leader in sustainable lighting sources. LED may be appropriate for spaces frequented by older adults. The literature review mainly focuses on this kind of sustainable lighting.

### Light Emitting Diodes － LED

The development of LED is an important event in industry lighting history. LED is the electrical light source that holds great potential for the future lighting applications. LED, also known as solid-state lighting (SSL) is an extremely efficient source appropriate for many interior applications (Winchip, 2007). The U.S. Department of Energy (DOE) has released their findings of the energy savings of LED sources for general illumination applications as compared to other conventional light sources (e.g., incandescent). Some key findings include: 1) In the future twenty years, the estimation of total energy conservation will be about 1,488 terawatt-hours, which are equivalent to $120 billion at today's energy prices (EERE, 2010). 2) Millions of metric tons of carbon

could be reduced by these savings (EERE, 2010). In addition, older adults are finding that they need three to four times as much light and that the glare is hard on the eyes (The Eye Digest, 2009). Thus, LED lights are being used more than other lighting sources for their reduced glare (Sammarco, Mayton, Lutz, & Gallagher, 2009).

What makes LED different from other light sources? LED is a semiconductor device, while incandescent, fluorescent, and high-intensity discharge lamps are all based on glass enclosures containing filaments or electrodes (EERE, 2008). As illumination sources in their infancy stage, LED has some advantages when used as interior lighting at a CCRC for older adults.

First, well-designed LED luminaries can save significant energy compared to traditional light sources. For example, one currently-available 12-watt LED recessed downlight provides equivalent light output and quality to a 65-watt incandescent lamp (Illuminating Engineering Society, 2010). Second, a single LED is very small, allowing fixture designers to make light fixtures into shapes and sizes suited for many interior applications. Light distribution can be controlled by sophisticated optical elements to direct the light with greater precision than is possible with traditional light sources (Illuminating Engineering Society, 2010). Third, LED can provide very long service. According to the report, the lifetime of LED can have more than 100,000 hours, as compared to 1,000 hours for the traditional tungsten bulb. However, the reports from University of California campuses in Irvine and Davis have revealed (2011) the existence of hazardous materials, such as lead and arsenic, in some LED products. The issue about toxic metal in lighting products will continue to be investigated by DOE (Brodrick, 2011).

Based on the documented characteristics and performances, LED applications are anticipated to save energy and reduce the negative impacts that other traditional lighting products produced relative to humans and their environments. LED as the interior lighting has been widely applied in the market. For example, in the Shanghai Expo, the Urban Best Practices Area have applied LED technology, and about 80 percent of the interior lighting equipments of the pavilions adopted LED sources (He & Wu, 2010). In addition, well-designed LED indoor luminaires can provide the required surface luminance， using less energy， and with improved uniformity compared to traditional lighting sources (EERE, 2008).

**Lighting survey instruments and field study instruments**

For older adults, it is important to provide high light levels with a limited amount of glare in CCRC environments. Interior designers and facility managers should make sure that the physical environment protects the safety and health of older adults. One study performed an assessment of lighting in independent living facilities and gathered residents' perceptions (Hegde & Rhodes, 2010). The researchers gained quantitative measurements of light levels in two independent living facilities and conducted a survey about residents' perceptions regarding their environment in these facilities. When compared to the suggested lighting recommendations for senior living, the results indicated that the light levels were low and inadequate for daily activities. However, the residents rated the interior lighting as "average"， "good" or "comfortable". According to Bakker, Iofel, and Lachs (2004), residents' familiarity with their environments may explain their satisfactions with the inadequate illuminance levels. The researchers

suggested that a larger study should be performed due to the limited number of facilities (2) and participants (40 seniors) in their two facilities study. The results of this study also suggested that design teams should pay attention to lighting standards.

One built lighting project (Delta, 2000) for an independent living facility provided six interior lighting design objectives in order to compensate for the reduced visual capabilities of older adults. The first objective was to increase overall light levels 25 to 50 percent higher than illuminance recommended for the general population. The next was to significantly raise task lighting illuminance. It is important to improve lighting uniformity among spaces for older adults. Therefore, providing gradual transitions in brightness between spaces was appropriate for older adults in the independent living facility. The third was to minimize direct and reflected glare. The last was to use good color-rendering lamps to improve color discrimination. The project's new electric lighting has been designed to meet the special visual needs of the older residents, while keeping maintenance costs and energy usage low. Delta used manufacturers' data to calculate lighting power densities (LPDs) for the independent living facility. After the completion of this project, residents, management, and staff also were interviewed about their experiences with the new interior lighting. The responses to the lighted environment were very positive.

These studies provided examples of methodologies for the proposed interior lighting solution at the CCRC in the current study. The results reflect the problems with existing interior lighting, opinions of independent living participants' regarding current lighting, and potential improvements to the environment using sustainable lighting.

**Industry recommendations for interior lighting in public spaces for older adults**

Tasks in a CCRC's public interior spaces may include walking through the building entries, hallways, and lobby, as well as the performance of reading and related visually intensive activities. Additionally, pastimes such as swimming and dining may be considered visual tasks. The visual tasks associated with the activities of daily living of older adults in public areas need special lighting consideration (IES, 2007). Comparisons of the recommendations for visual tasks' minimum light levels (Rea & America, 2000; IES, 2007) between older adults and the general population are shown in Table 2-1. The following industry recommendations for interior lighting in six public interior spaces show how application-specific lighting solutions can help older adults to preserve independence especially if they have limited vision.

Table 2-1.

*Recommendations for visual task's minimum light levels*

| Activity | Recommended Illumination (footcandles) | |
|---|---|---|
| | General population | Older adults |
| Public spaces | 3 | 10 |
| Simple orientation for short visit | 5 | 30 |
| Working spaces where simple visual tasks are performed | 10 | 30 |
| Performance of visual tasks of high contrast and large size | 30 | 50 |

1) Hallways

The primary function of hallways and other circulation spaces is to make traffic circulation safe in public spaces. While some other rooms use task lighting to meet the needs for more specific work tasks, hallways need to provide a constant level of light (De Chiara, Panero, & Zelnik, 1991). Thus, poor lighting in a hallway may allow for hazards such as collisions (Chartered Institution of Building Services Engineers, 1997). The illumination of these circulation spaces can also play an important transitional role since it can help older adults to adapt to changes in lighting levels between activity areas linked by the circulation areas. As mentioned earlier, older eyes adapt to different light levels more slowly than younger eyes. In order to compensate for reduced adaptation, even illumination makes hallways easier to guide older adults (IES, 2007). Adequate light levels in hallways help create "secure feelings" for individuals within the space (IES, 2007, p. 34). Moreover, hallway lighting for older adults should be indirect if possible to alleviate glare for aging eyes (Elia, 2011). To compensate for reduced illuminance, IESNA suggests a minimum of 30 footcandles (fc) for general light in the hallways and lobby/waiting areas during the active hours.

2) Lobby

In a CCRC, the lobby is the main public space where people chat, read, and wait for friends to arrive or activities to begin. Thus, general lighting in the lobby should be permanently installed for those common tasks (IES, 2007). Providing higher light levels near the lobby area during the day can help aging eyes adapt when coming inside from outdoors. Additionally, appropriate task lighting must be provided in the

lobby for detail-intensive activities, such as reading or needlework (Boyce, 2003). The purpose of task lighting is to illuminate a relatively small area for specific task. Selected task lighting must allow flexible positioning to protect users from direct glare and burns. The use of LED in adjustable task-specific light fixture can generate less heat than incandescent or halogen light sources and may be sufficient to illuminate a small area in the lobby (IES, 2007). In addition to task lighting, ambient light levels in a lobby should be adjustable for older adults to adapt to their various activities (Arditi, 2005).

3) Dining rooms

In dining rooms, good lighting with minimum glare helps people clearly see the food on the table and also each other's faces. Because dining rooms are also used as places for paying bills and reading letters, ambient light in dining rooms should be maintained (IES, 2007). According to the recommendations of Illuminating Engineering Society, dining rooms' ambient lighting should be at least 10 footcandles during active hours. Furthermore, obvious shadows in dining rooms should be avoided since they affect how people look and can generate visual distractions (Arditi, 2005). Also, "dimmable light sources with high color rendering indices are recommended for dining areas" (IES, 2007, p. 39).

4) Activity rooms

Activity rooms are the spaces in which participants perform activities that provide them with pleasure, success, and a sense of usefulness. Providing adequate, even, and diffused lighting without glare for older adults are the guiding principles for illuminating activity rooms (IES, 2007). Appropriate lighting should be supplied to

support the specific requirements of various activities (IES, 2007). The task light recommendation for activity rooms is 30 fc.

5) Chapel

As well as providing enough illumination to read, walk, eat and play, it is also important to create a proper atmosphere for worship in a continuing care retirement center. Reading is one of the most basic functions that occur in a CCRC chapel. Ideally, the general lighting should come from directly above the reader at all times, so that shadows are not created that could make reading difficult (Shook and White, 2009). It is also important to use frontal lighting that assists people in clearly seeing the worship leaders during services. Thus, the greater the distance to the back row in a chapel, the brighter the frontal lighting will need to be. Moreover, the exact light level required depends largely on the architecture and size of chapel, as well as the type of congregation (Manning, 2011). In general, a level of 20 to 40 footcandles is recommended for comfortable reading in a chapel (IES, 2007).

6) Swimming pool

Selection of appropriate luminaires is critical to ensure proper light levels in a CCRC's natatorium, as well as to control glare for its older adult occupants. Placing interior lighting around the perimeter of the pool is the preferred method (Flaherty, 2010). For an indoor swimming pool, light levels and uniformity play key roles in establishing a safe environment (Arditi, 2005). In natatoria where the pools are to be used at night, proper lighting should also be provided on the pool deck areas so that people walking on the decks can identify hazards. The deck areas are required to be illuminated to a 30 fc level by either artificial or natural lighting.

## Conclusions

CCRCs are committed to providing the continuing care for older adults, and to providing housing and activities that are suited to an individual's health. Because of the special visual needs of a CCRC's older residents, it is important to design appropriate interior lighting for them. The interior lighting in public spaces at CCRC should be designed to provide a visual environment that helps the residents see comfortably and easily, making them feel safer and more confident in their daily activities. Due to the advances in sustainable lighting technologies and the associated emerging research, it is postulated that the light levels, energy consumption, lamp life, and older adults' safety in a CCRC may be improved through the selection of appropriate LED solutions for their interior public environments. According to the Evidence Based Design framework, it is important to gather evidence of older residents' perceptions to improve a CCRC's overall environment. The results are anticipated to lead the researcher to select the proper sustainable lighting that suits older adults.

# CHAPTER III

## Methodology: Summary of the Design Process

The methodology section will contain the development of five stages of the design process for the lighting design of the public interior spaces of a CCRC based on the EBD framework. These stages including: 1) programming, 2) schematic design, 3) design development and 4) evaluation and 5) construction documents.

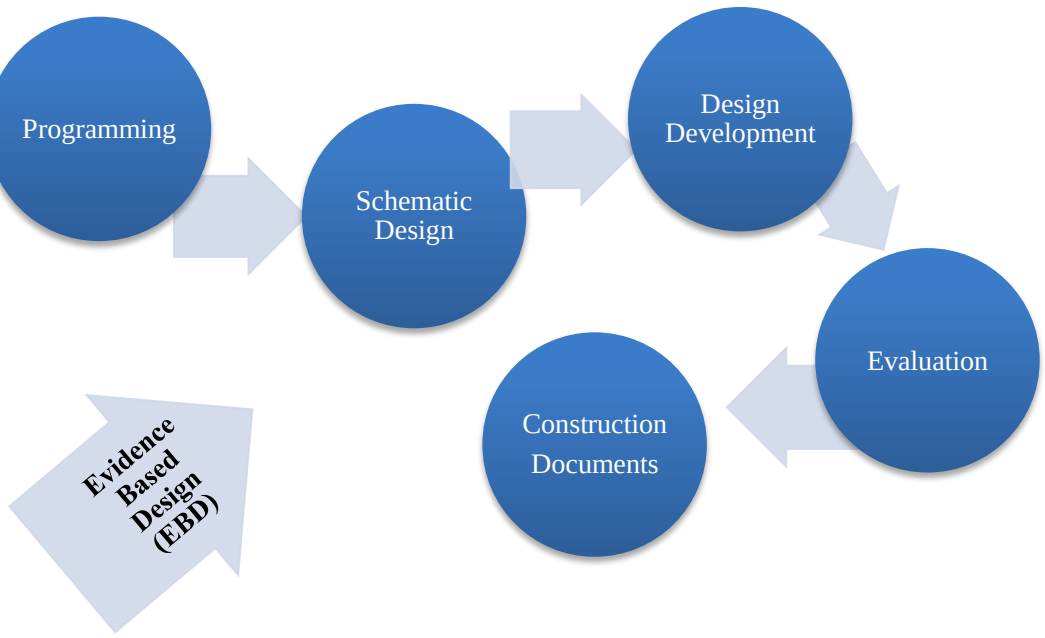



Figure 3-1. Modified Stages of Design Process based on EBD Framework

**1) Programming**

Programming is the first phase of the traditional design process and can be informed by EBD framework. Programming is the stage in which designers begin to identify the problems and the design is formed (Nussbaumer, 2009). It is important to collect information regarding various components of the design project, such as the site of a project, existing environmental conditions, human factors, interior products, codes, and regulation at this stage. In this study, there are several steps under the programming phase.

Preliminary Case study of existing lighting in public interior spaces at a CCRC site

Convenience sampling was utilized to select one existing operational CCRC site in the mid-western United States of America. The preliminary field study at this site was conducted on July 24, 2011.

Preliminary lighting measurements were taken at the CCRC site in a lobby, a hallway, a dining room, an activity room, a chapel, and an indoor swimming pool. The researcher examined the sites' existing lighting fixtures, noted their overall styles, and determined if they were direct or indirect through visual inspection. In this study, the researcher measured 2'-0" or 4'-0" square grids on horizontal and vertical work plane surfaces using masking tape. On vertical surfaces the bottom of the grids were 2'-6" above finished floor level, such as walls, doors and windows according to the recommendations of IES. Beginning at 12:30pm ending at 6:00pm, the researcher visited the selected public spaces and examined and documented the existing lighting fixtures and effects. The researcher measured the visible light in footcandles (fc) with a General Electric (GE) lighting model 217 "triple range" light meter. The researcher recorded

different light level measurements in the selected interior public spaces at CCRC, the numbers of measurements could be found in the Table 3-1.

Table 3-1.

*Quantities of light level measurements taken in six interior public spaces at CCRC*

| Area Name | Horizontal Surfaces (floor level) | Vertical Surfaces (height aff=30in) |
|---|---|---|
| Lobby | 21 | - |
| Hallway | - | 42 |
| Dining Room | - | 16 |
| Activity Room | 16 | 15 |
| Chapel | - | 33 |
| Swimming Pool Deck | 16 | - |

*Note.* The light level measurements on horizontal or vertical surfaces were recorded according to Illuminating Engineering Society (IES) recommendations.

The means for each public space's light levels were calculated. The results of the calculations will later be compared to industry recommendations for minimum light levels for older adults in the Chapter of Results. With the exception of the hallway, where there were no windows, all of the existing window coverings were open during the light level measurements. The windows of the CCRC allowed daylight contributions into the lobby, dining room, activity room, chapel, and swimming pool. The physical features of these spaces were recorded by the researcher in field sketches. The researcher also documented the overall site, relevant spaces, light fixtures and effects, and measurement procedures with a digital camera. The following figures showed the conditions of these different interior public spaces at the CCRC site.

Lobby

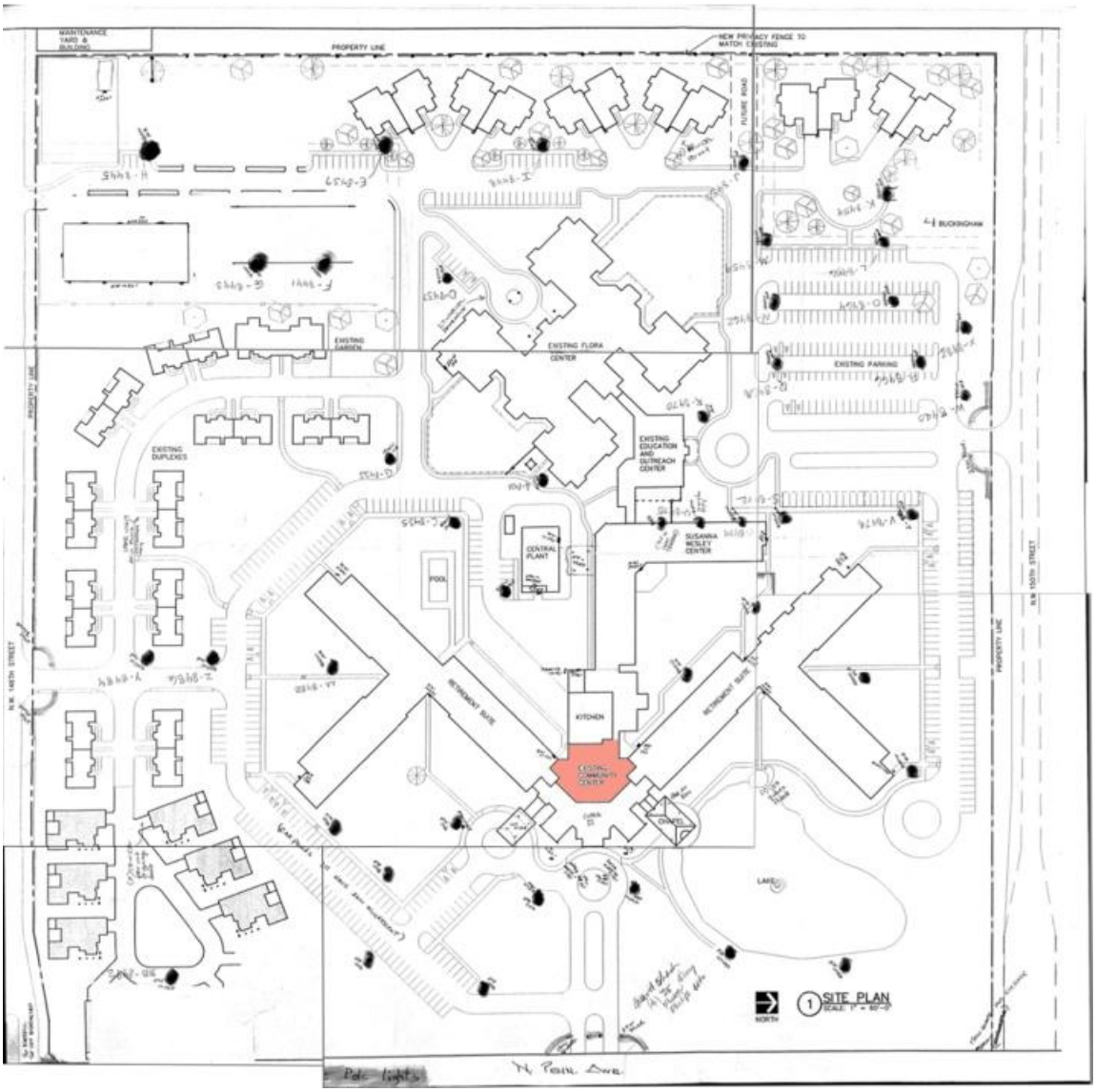



Figure 3-2A*. Location of Lobby at CCRC site

* This floor plan was created by others and provided to the researcher by the CCRC

Figure 3-2B

In this West view of the Lobby, the space had both windows and a large chandelier.

Figure 3-2C

In this Southeastern corner of the Lobby, the space had windows, a desk lamp and several down lights.

Figure 3-2D

The researcher recorded the horizontal light meter readings in the Lobby.


Figure 3-2E

These interior down lights were located close to the main entrance of Lobby.

Hallway

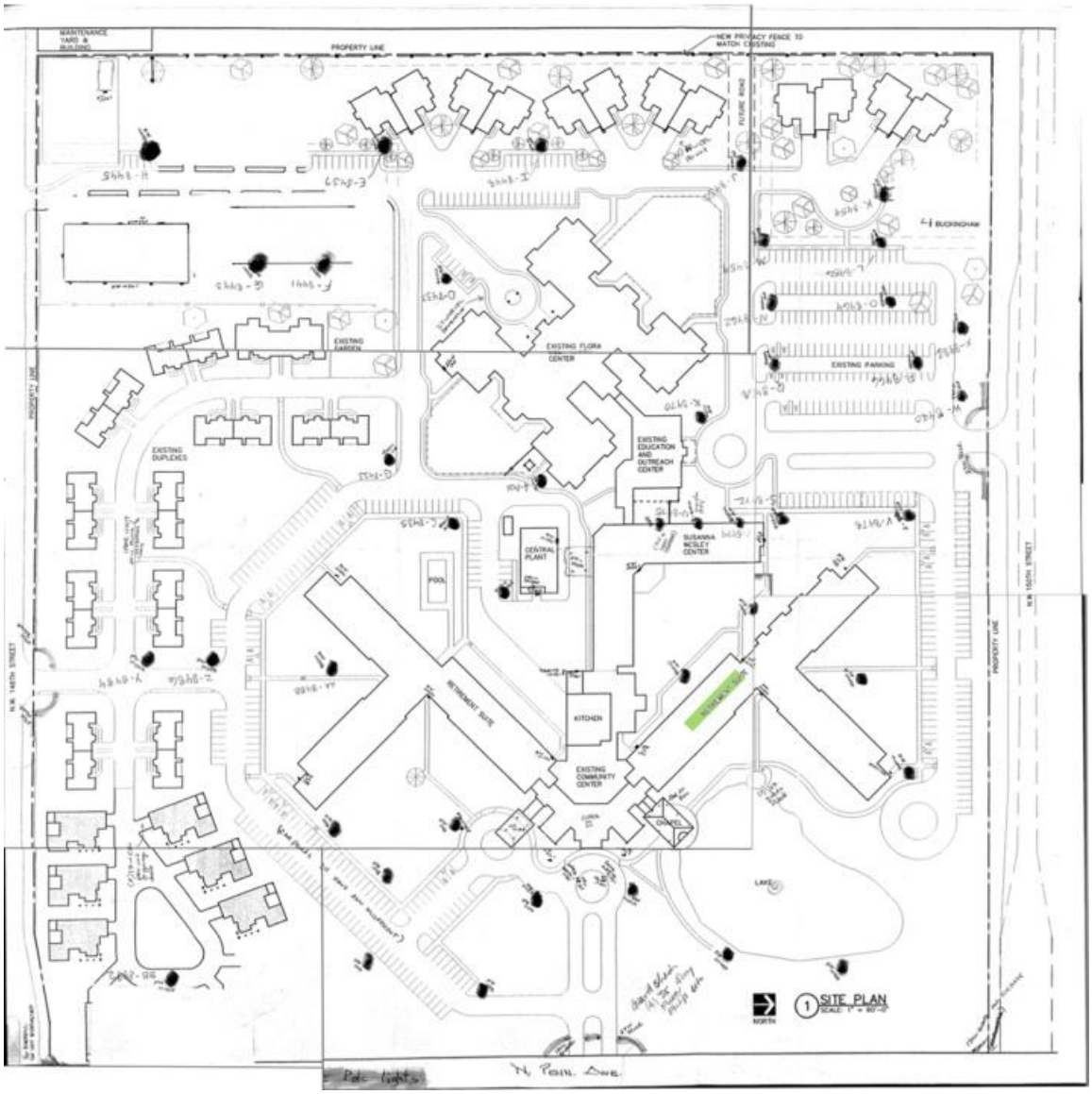



Figure 3-3A*. Location of Hallway at CCRC site


Figure 3-3B

In this hallway in the Northwestern independent living apartments, there were no windows.

Figure 3-3C

The researcher marked the vertical grids on the hallway's wall in preparation to measure existing lighting levels.

Figure 3-3D

There were recessed fluorescent lighting fixtures in the hallway.

Dining Room

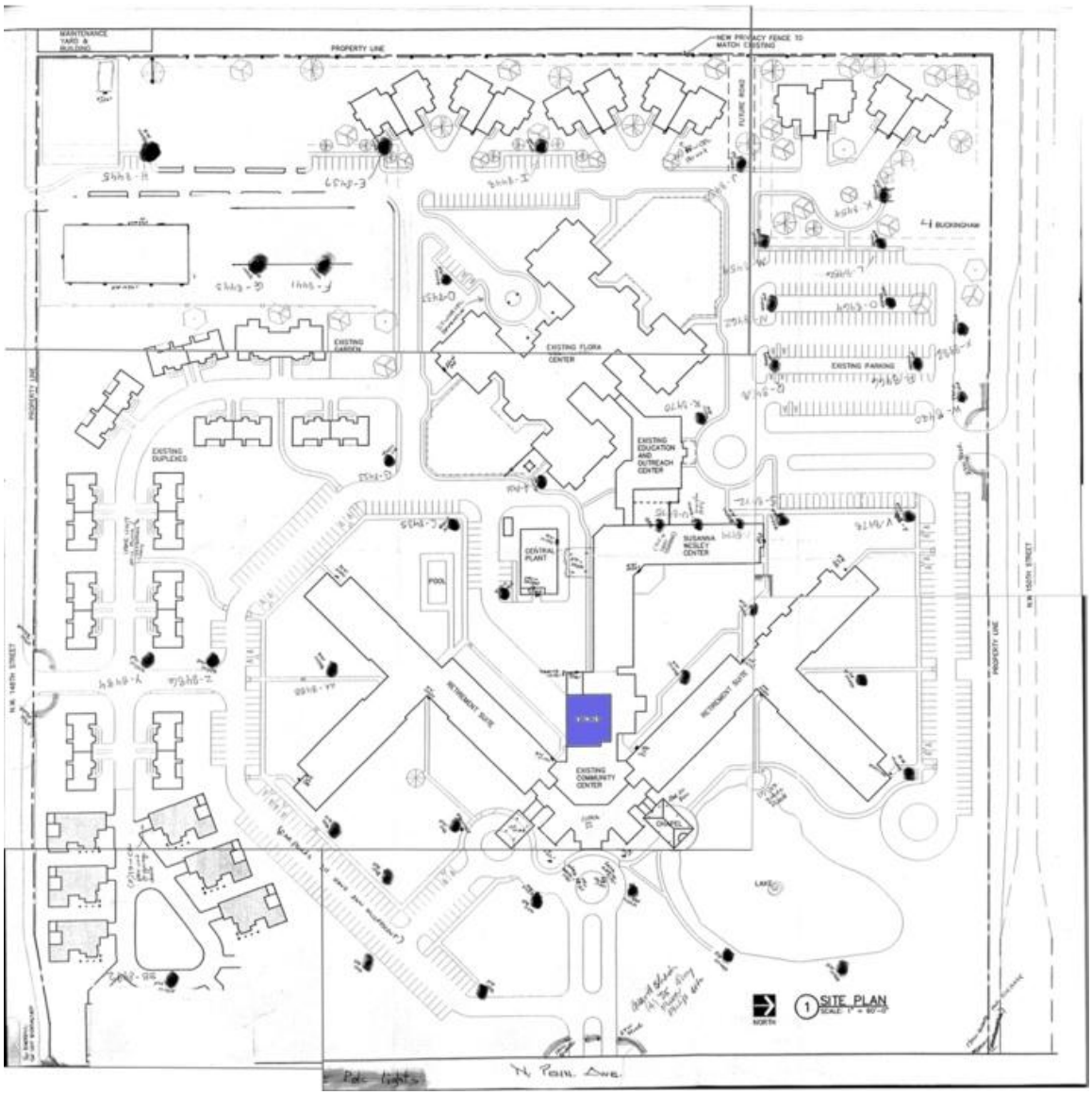



Figure 3-4A*. Location of Dining Room at CCRC site

Figure 3-4B

The independent living dining room located on the East side of the CCRC, had windows, down lights, and chandeliers.

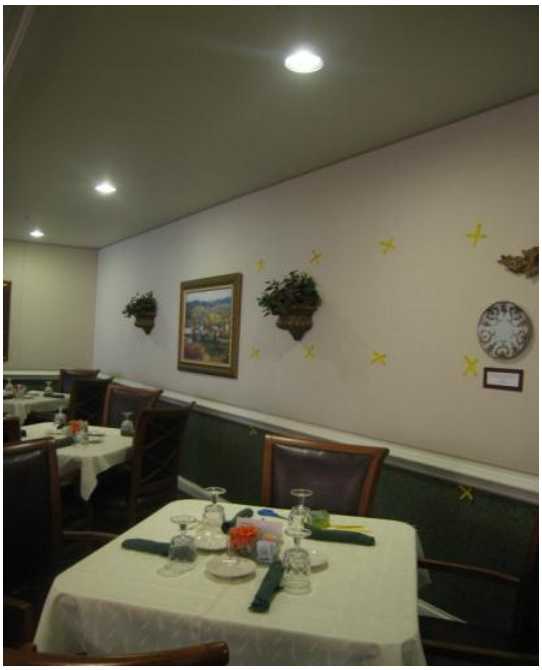


Figure 3-4C

The researcher marked the vertical grids on the dining room's wall.

Figure 3-4D

The middle of dining room had a large incandescent chandelier.

Activity Room

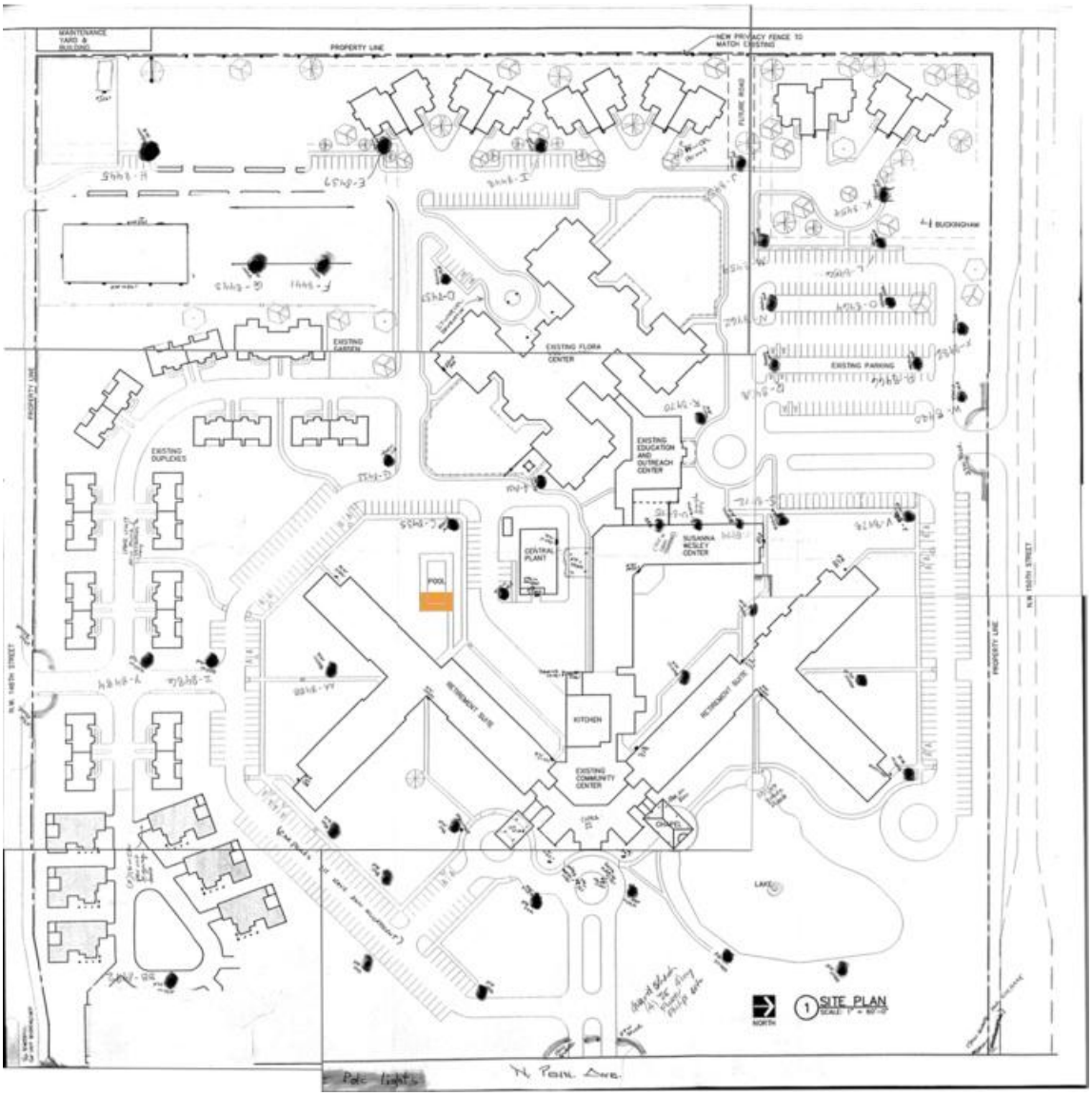



Figure 3-5A*. Location of Activity Room at CCRC site

Figure 3-5B

Outside the activity room was the indoor swimming pool.

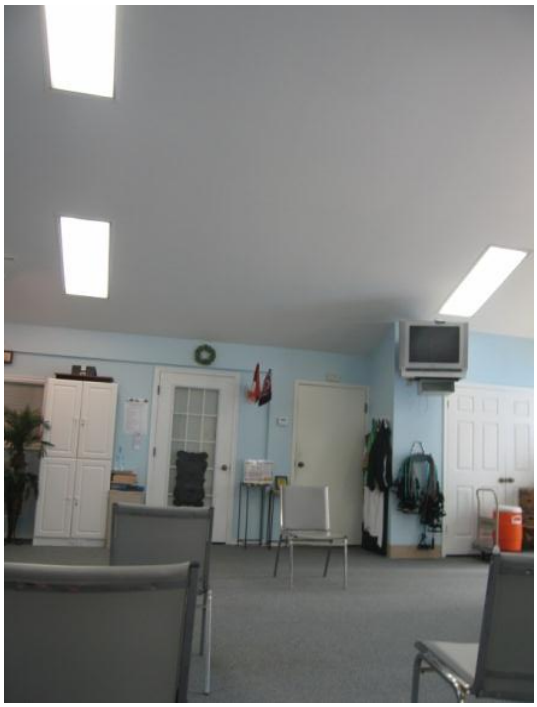


Figure 3-5C

The activity room, located in the middle of the CCRC, had both windows and compact fluorescent lighting.

Figure 3-5D

These recessed fluorescent lighting fixtures were found in the activity room.

Chapel

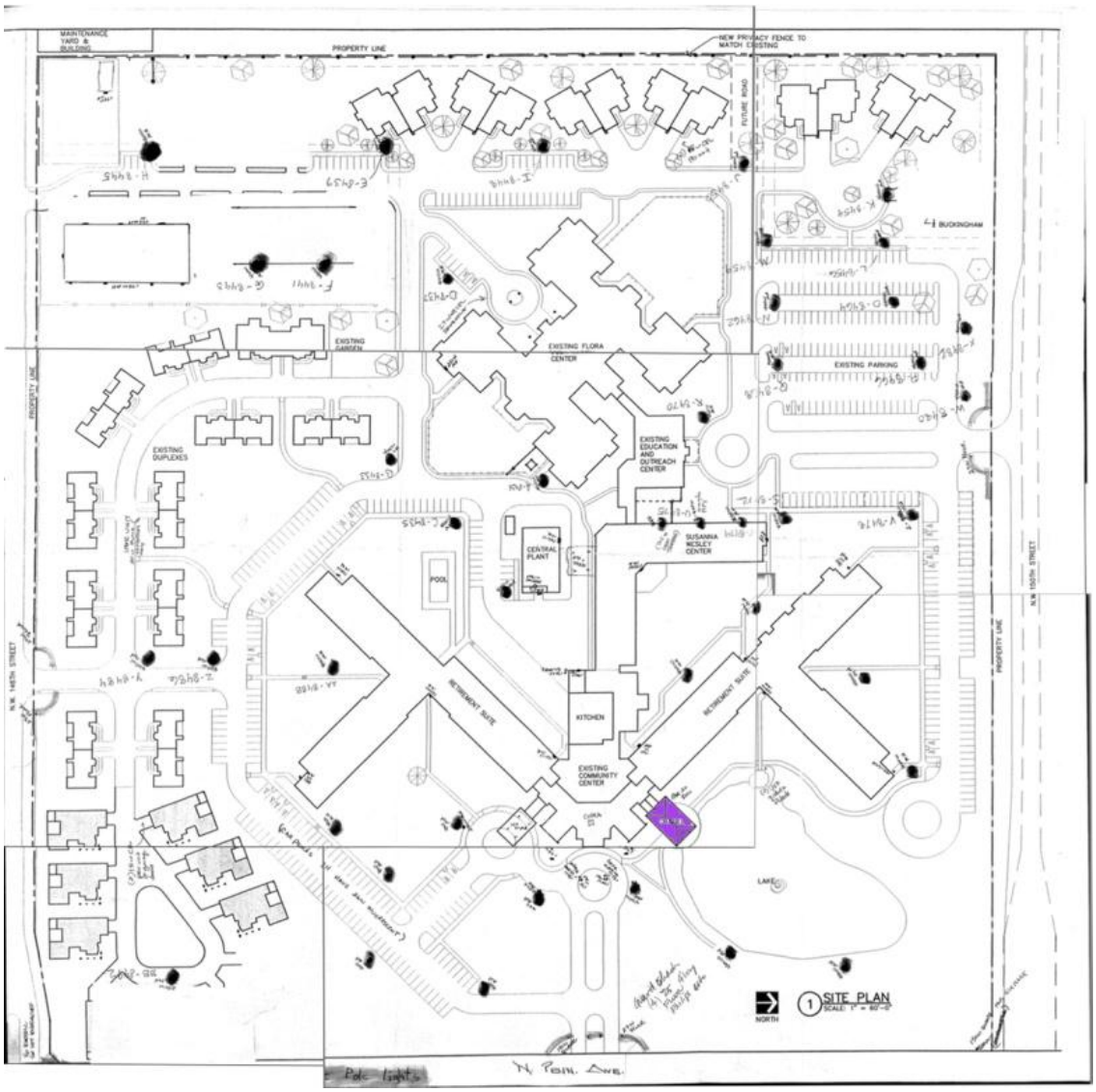



Figure 3-6A*. Location of Chapel at CCRC site

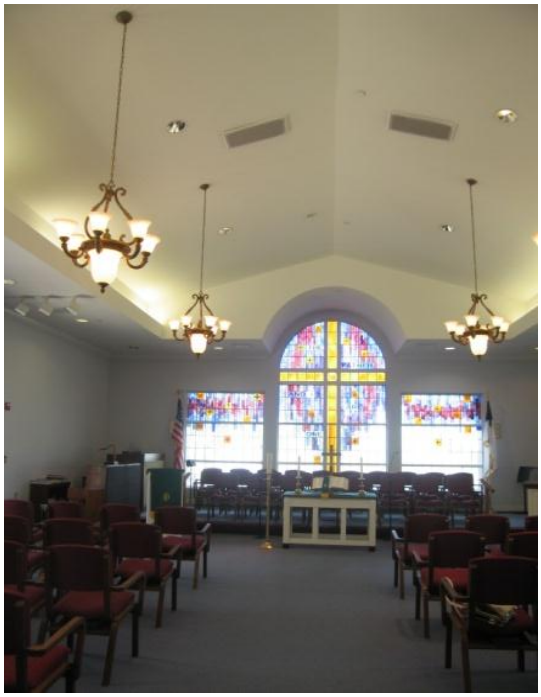


Figure 3-6B

The chapel, located in the Northeast of CCRC, had windows, down lights, and incandescent chandeliers.

Figure 3-6C

The researcher marked the vertical grids on the chapel's wall in preparation to measure light levels.

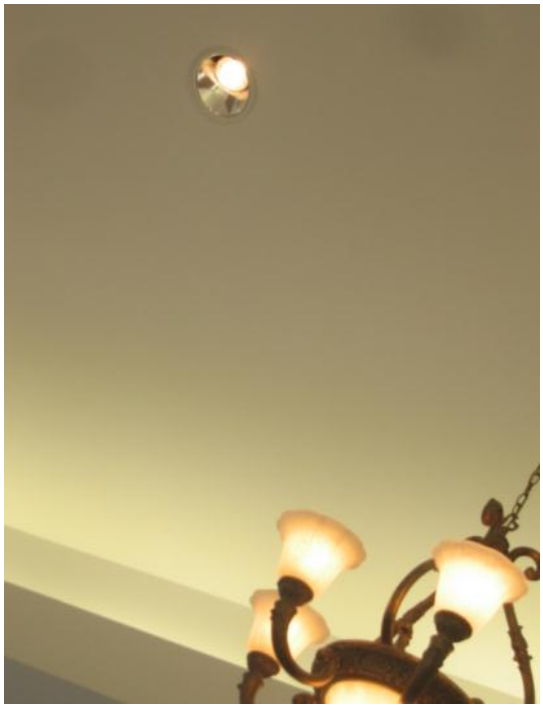


Figure 3-6D

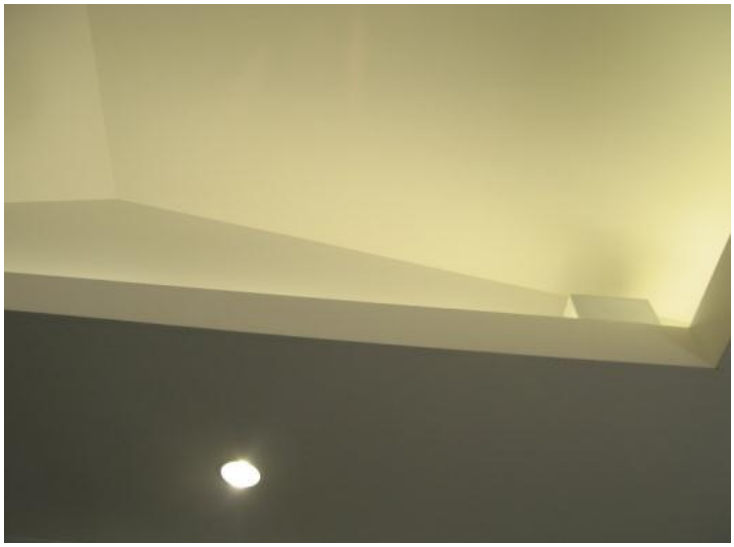


Figure 3-6E

Different lighting fixture styles were represented in the chapel.

Swimming Pool Deck

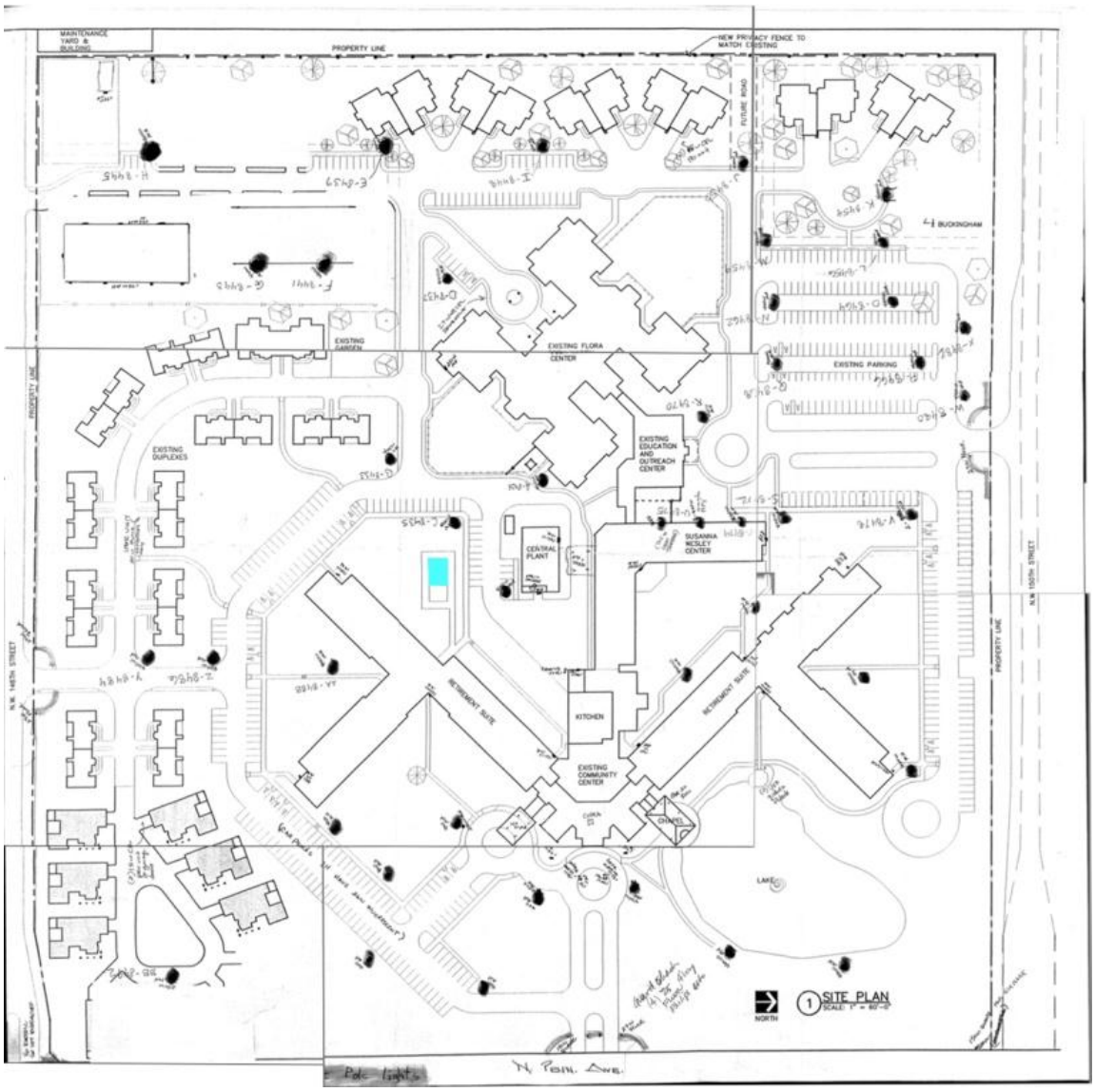



Figure 3-7A*. Location of Chapel at CCRC site


Figure 3-7B

The indoor swimming pool, located in the middle of the CCRC, had both windows and fluorescent lighting.


Figure 3-7C

These fluorescent lighting fixtures were on the wall mounted near the swimming pool.

Figure 3-7D

The swimming pool was located close to the activity room, with a great amount of daylight contributions.

*Follow-up Field Study at the CCRC*

A second field study was conducted in early Spring 2012 to determine the wattage of the existing lighting fixtures in the selected interior public areas of the CCRC site. The results will later be compared to the proposed new lighting design at the schematic design phase.

*Survey*

An interior lighting survey of adult independent living CCRC residents at CCRC site was developed in order to gather current perceptions of the existing lighting. The lighting perception survey queried residents regarding the quantity and quality of existing lighting in six public interior rooms and was conducted in Spring 2012. The independent residents' opinion survey was a questionnaire consisting of two parts. Part 1 addressed the residents' opinion of "overall lighting" in their interior spaces, such as 1) The lights in the chapel are glaring; 2) Overall, the lights in the dining room are pleasing, whereas Part 2 focused on basic demographics. Subjects were informed that participation in the study was voluntary and the surveys had no identification marks linking them to individual subjects. The questionnaires were sent to older independent living adults' mailboxes that were located in the Lobby. All of this study's methods and instruments were approved by the researcher's university's Institutional Review Board (IRB) and the management of the CCRC. Because residents who were living in the facility were influenced by the interior lighting, it is important to gather evidence of their perceptions to improve the overall environment. The results of the survey led the researcher to select sustainable lighting that suited older adults.

**2) Schematic Design**

Based on the information collected during the programming phase, the schematic design phase synthesizes the program into a defined, feasible design (Nussbaumer, 2009). The designers continue to analyze the facts and also develop alternative solutions to the design problems. This is the stage to create different design possibilities and not be limited to one possible solution.

At this stage in the current study, the researcher produced a design concept, ideas for light sources, and lighting fixture selections. The design concept was not only based on the data from field studies and survey, but was also based on meeting older, independent living adults' visual needs. The selections of lighting fixtures provided alternative lighting solutions for the different public spaces at the CCRC.

**3) Design Development**

The next stage in the design process, design development, is refining and defining the design (Nussbaumer, 2009), and then determining the best possible solutions for each particular area, including the selection of products to be used. At this stage in the current study, more detailed and refined drawings of the six interior public spaces with lighting fixtures were developed using the software of AutoCAD, Photoshop, and Sketchup. The aim of this phase was to complete all design decisions before proceeding with construction documents.

At this stage in the current study, the researcher calculated the lighting quantity, lifetime of lamp, and an initial uninstalled lighting cost estimate. To calculate the lighting quantities, there were two main formulae. One was the calculation of Room Cavity Ratio

(RCR), which determined the volume between the fixture and height. In this first formula, the room width, room length, and height of the room cavity needed to be determined. The second formula determines the number of luminaires required to, the maintained illuminance (fc) desired the area in square feet, the lamp lumens per luminaire and the coefficients of utilization (CU). The room ceiling reflectance was 80 percent, the reflectance of the wall was 50 percent and the reflectance of the floor was 20 percent. The results of calculation for lighting fixtures' quantity will be used to produce the reflected ceiling plan.

In order to calculate the lifetime for a lamp, the researcher assumed the lamp would work 10 hours per day in an activity room, dining room, and lobby, and would work 24 hours per day in a hallway. Researching the prices of proposed lighting fixtures, an initial uninstalled lighting cost estimate could be calculated for each public interior space. The proposed lighting fixtures were inserted into the existing public interior spaces using Photoshop, in order to show the lighting effects.

**4) Evaluation**

In addition to completing the traditional design phases through Construction Documents, an evaluation phase was also performed. Experts with experience working with the independent older adult residents at the CCRC were invited to evaluate the proposed lighting design, based on their professional recommendations. The researcher used PowerPoint to develop a presentation of the proposed lighting design which was given to the facility managers and executives at the CCRC. Four experts participated: one expert in the area of plant operation, two administrators of living facility, and one expert

in the area of nursing home unit. This process helped the researcher to determine whether the initial goals of the design were met. Oral feedback was solicited and recorded through written notes and a recorder. This input has been incorporated into the final thesis project.

**5) Construction Documents**

In the construction documents phase, the construction drawings for light fixtures were assembled to describe in detail all of the proposed lighting for the CCRC's public interior spaces. The construction drawings included: a lighting fixture schedule, a lighting legend, and reflected ceiling plans.

# CHAPTER IV

## Results: Illustrations and Explanations

### Programming

### Preliminary Study Results

In this preliminary field study, the light levels measured within the examined CCRC spaces: lobby, activity room, hallway, and dining room were consistently lower than industry lighting recommendations for the tasks expected to be performed in these areas as shown in Table 4-1, and Table 4-2.

In the lobby, from which residents depart for walks during the daytime (where high levels of daylight exist) and then return, they currently encounter a relatively low light level (11.95 fc). IES recommended 30 fc as the minimum light level on horizontal surfaces in a lobby. In the hallway, measured illuminance levels ranged from 10.0 fc to 43.0 fc on vertical surfaces. According to the IES, the light level recommended for a hallway is 30 fc (minimum) on vertical surfaces during active hours and 10 fc during sleeping hours. In the dining room, illuminance levels ranged from 2.0 fc to 14.0 fc on vertical surfaces. According to the IES, the light level recommended for a group dining room is 10 fc (minimum) on vertical surfaces. In the activity room, where visual attention to detail is important, the mean light level was found to be 18 fc which the IES recommended minimum light level was 30 fc on vertical surfaces. In the both the chapel

(on vertical surfaces) and the indoor swimming pool deck (on horizontal surfaces), measured light levels were much higher than these of industry recommendations and somewhat uneven (82.3 to 446.88 fc). In these spaces much of the measured light could be attributed to daylight entering through the windows and skylights. Per the IES, general visibility requires only a minimum of 30 fc in these areas to meet the needs of aging eyes.

Table 4-1.

*Case Study Existing Light levels Measurements at CCRC*

| | Horizontal (floor level)-Footcandles | | | Vertical-Footcandles (height aff=30in) | | |
|---|---|---|---|---|---|---|
| Area Name | Min | Max | Mean | Min | Max | Mean |
| Lobby | 4 | 20 | 11.95 | NA | NA | NA |
| Hallway | NA | NA | NA | 10 | 43 | 18.6 |
| Dining room | NA | NA | NA | 2 | 14 | 8 |
| Activity room | 16 | 58 | 36.27 | 10 | 27 | 18 |
| Chapel | NA | NA | NA | 19 | 400 | 82.3 |
| Swimming pool Deck | 380 | 850 | 446.88 | NA | NA | NA |

Table 4-2.

*Illuminance Levels for CCRC*

| | Illuminance level – Footcandles by Area Name | | | | | |
|---|---|---|---|---|---|---|
| | Hallway | Lobby | Dining room | Activity room | Chapel | Swimming pool deck |
| Case Study Existing Light Level Means | 18.6 | 11.95 | 8 | 18 | 82.3 | 446.88 |
| ANSI/IESNA minimum Light Level Recommendations | 10-30 | 30 | 10 | 30 | 30 | 30 |

*Note*. ANSI/IESNA RP-28-07: Recommended practice for lighting and the visual environment for senior living. (Prepared by the IESNA lighting for the Elderly and Partially Sighted Committee). Approved by IESNA May 7, 2007, a recommended practice; approved as American National Standard July 6, 2007.

**Follow-up Field Study Results**

The information about the CCRC's existing interior lighting fixtures in the selected public spaces is shown in the Table 4-3. It includes: lighting fixtures' manufactures, catalog numbers, volts, mounting, and mounting heights; lamps' number, life, lumens, and types. The results will later be compared to the proposed lighting solution at the schematic design phase and design development phase.

Table 4-3.

*Existing Lighting Fixture Schedule of CCRC Site*

| | | | Lamps | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Room Name | Manuf. | Catalog# | No | Watts | Life (Hours) | Lumens | Type | Volts | Mounting | Mounting heights above finished floor |
| Lobby | NA | NA | 42 | 9 | 8,000 | 425 | Compact Fluorescent (CFL) | 120 | Surface | 14’ |
| | TCP | 4R3014A | 1 | 14 | 8,000 | 650 | CFL | 120 | Ceiling | 9’ |
| | TCP | 801014 | 1 | 14 | 10,000 | 900 | CFL | 120 | Surface | 3’10” |
| Dining Room | Cooper | DULUX D 20691 | 1 | 13 | 10,000 | 780 | CFL | 120 | Ceiling | 8’5” |
| | NA | NA | NA | 40 | 4,000 | 270 | Incandescent | 120 | Surface | 6’6” |
| Chapel | NA | NA | 7 | 60 | 20,000 | 560 | Incandescent | 120 | Surface | 6’2” |
| | Cooper | PL-T 841/4P/XEW | 1 | 27 | 20,000 | 1,875 | CFL | 120 | Ceiling | 10’ |
| | Cooper | CF42DT/E/IN/841/ECO | 1 | 42 | 12,000 | 3,200 | CFL | 120 | Ceiling | 12’ |
| Hallway and Activity Room | Cooper | F32T8/ADV841/XEW/ALTO25W | 2 | 25 | 30,000 | 2,500 | Fluorescent | 120 | Ceiling | 5’10”/12’ |
| Swimming Pool Deck | TCP | 1014 | 1 | 14 | 10,000 | 900 | CFL | 120 | Surface | 5’10” |

Conclusions from Case Studies

Based on comparison to industry standards, some existing lighting levels measured in the CCRC were not adequate to compensate for the anticipated reduced retinal illuminance or for the adaptation capacity expected for the older adult residents. For example, the light level was found to be 18 fc in the activity room. That was not adequate for residents' visual needs and below the 30 fc industry standard. Public interior spaces surveyed in the CCRC ranged from 8 fc to 446.88 fc. The non-uniform illumination found at the CCRC's facilities created problematic areas of bright spots and dark areas, resulting in deep shadows and glare. Some existing lighting fixtures were too old to collect their information in the selected interior public spaces. Also, each area has applied some compact fluorescent lamps for the existing lighting fixtures.

**Survey Results**

Conducting a survey was the last step in the programming stage. The Table 4-4 showed the participants' basic demographic characteristics in this survey, including the number of participants, their average age, percentages of sex, marital status, race, and employment. The survey was developed as a self-administered instrument, using a five-point, likert-type scale with a sixth "don't know" opinion. The results of each question for six selected interior public spaces: lobby, hallway, dining room, activity room, chapel, and swimming pool deck, using the pie charts, could be found in the following figures.

Table 4-4.

*Demographics*

| Participants | n=55 |
|---|---|
| Sex | 64% female, 36% male |
| Marital Status | 51% widowed, 44% married, 4% divorced, 1% no response |
| Race | 91% white, 2% native American, 7% no response |
| Employment | 95% retired, 5% no response |
| Average Age | 84.5 years |

## 1. Lobby

1.1. The ***lobby*** is poorly lighted.

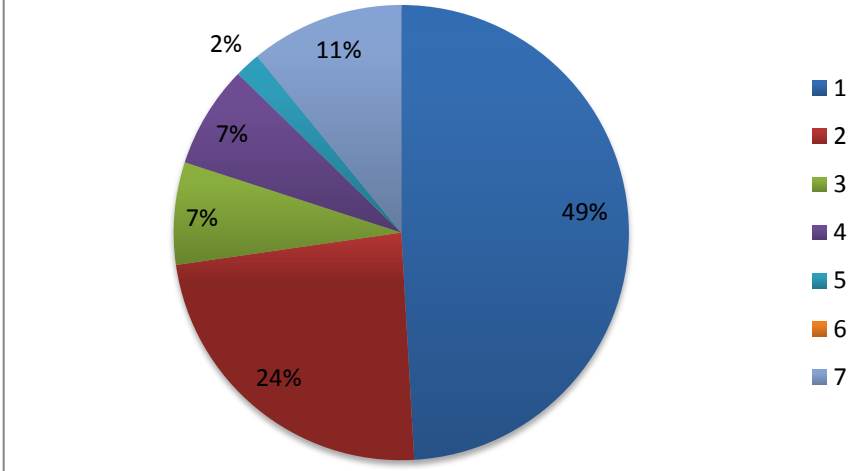



Figure 4-1.1. Survey results for question 1.1

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

1.2. The lights in the ***lobby*** are glaring.

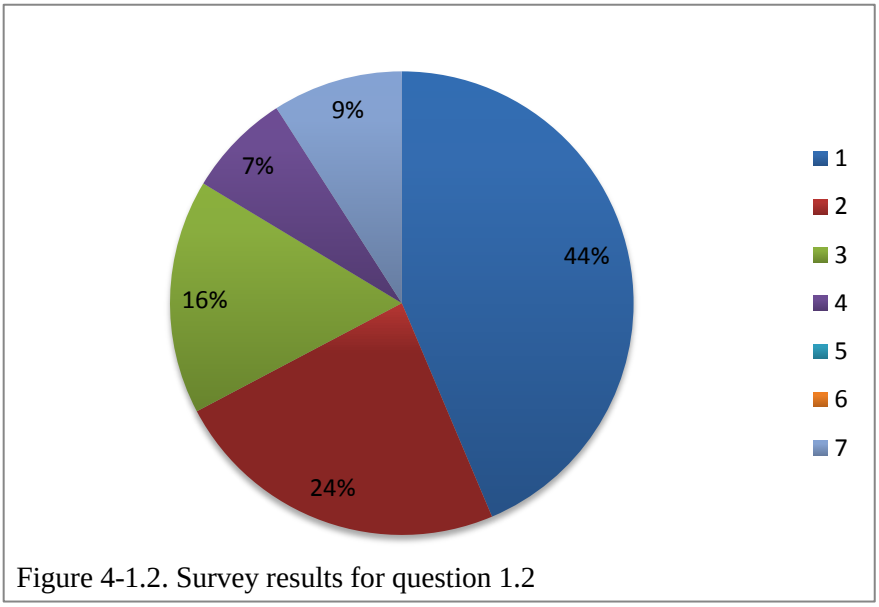



Figure 4-1.2. Survey results for question 1.2

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

1.3. Overall, the lights in the ***lobby*** are pleasing.

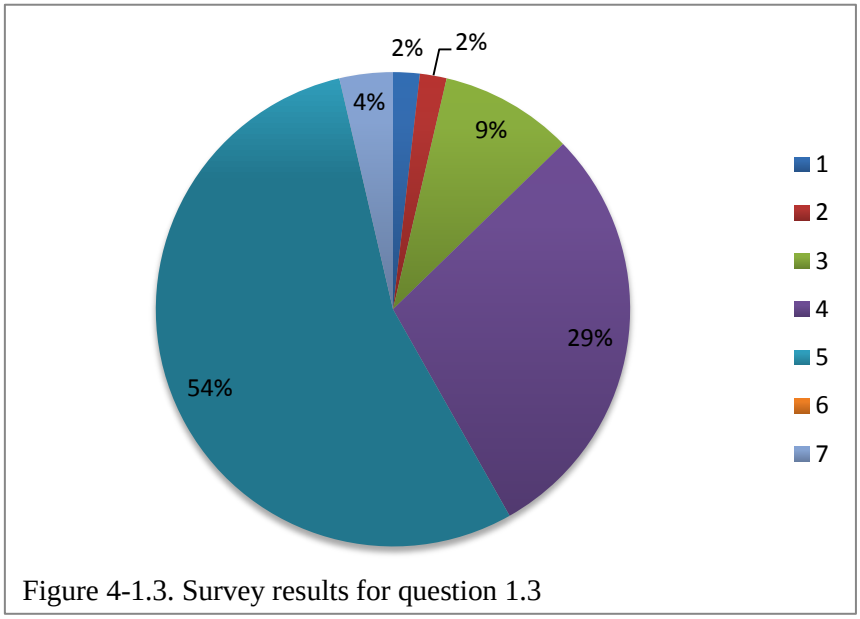



Figure 4-1.3. Survey results for question 1.3

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

## 2. Hallway

2.1. The ***hallway*** is poorly lighted.

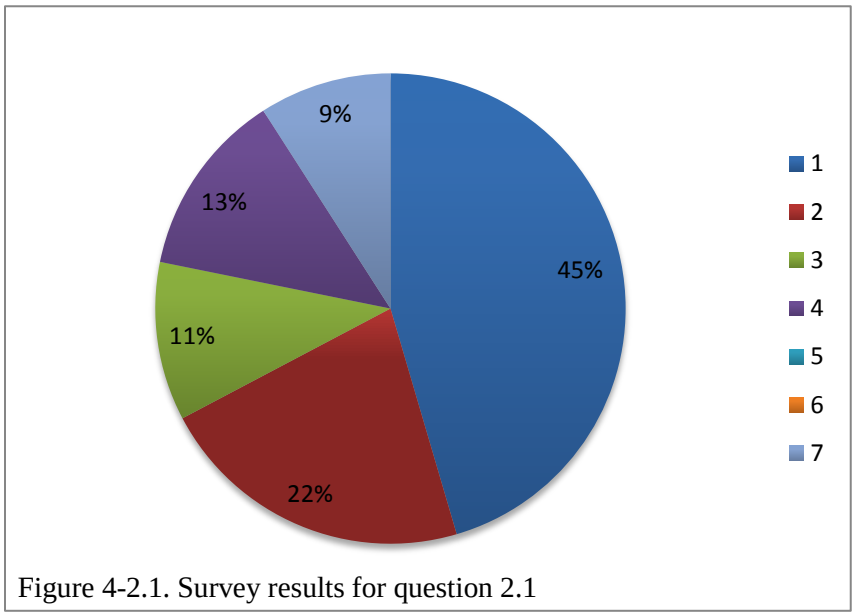



Figure 4-2.1. Survey results for question 2.1

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

2.2. The lights in the ***hallway*** are glaring

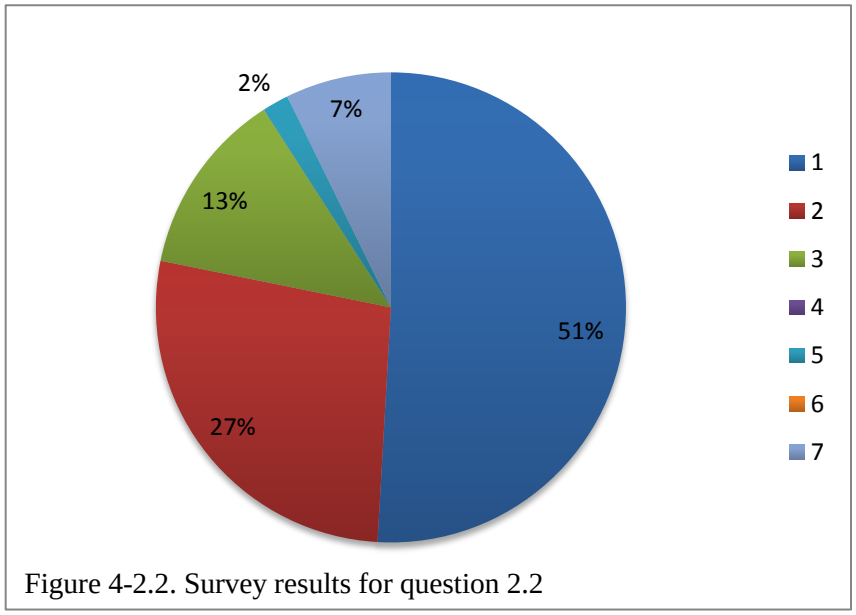



Figure 4-2.2. Survey results for question 2.2

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

2.3.Overall, the lights in the ***hallway*** are pleasing.

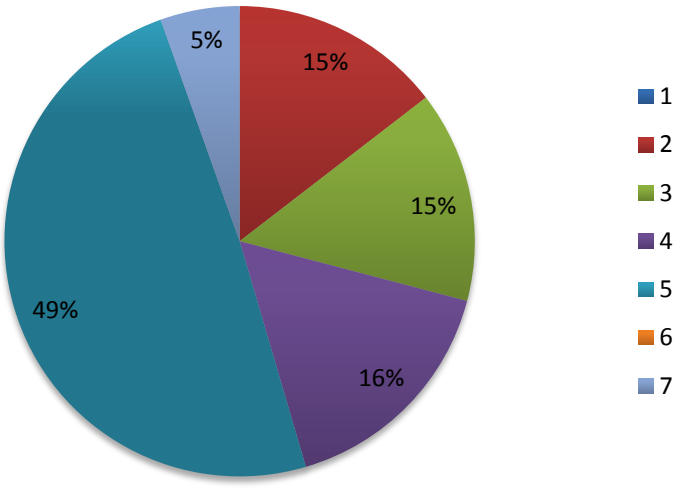



Figure 4-2.3. Survey results for question 2.3

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

## 3. Dining Room

3.1. The ***dining room*** is poorly lighted.

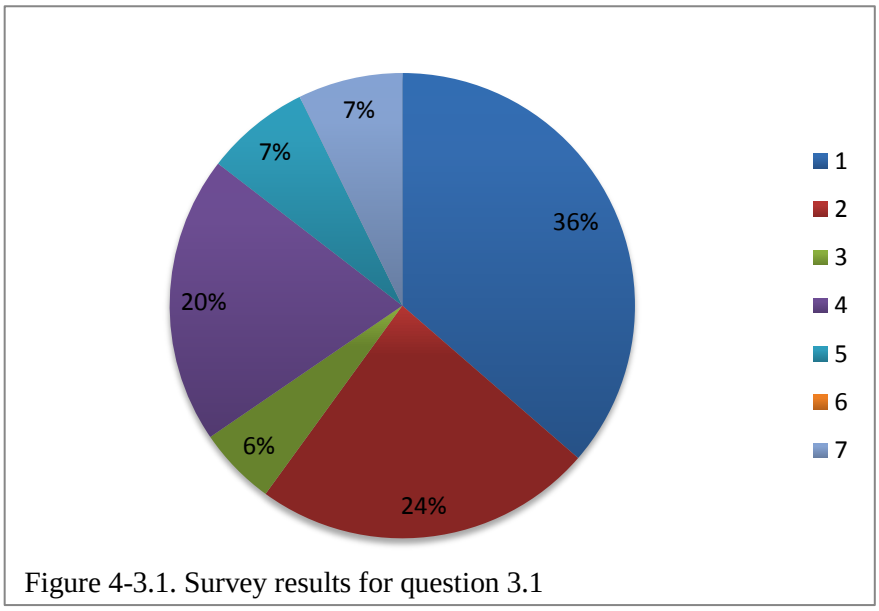



Figure 4-3.1. Survey results for question 3.1

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

3.2. The lights in the ***dining room*** allow me to see clearly to eat my meal.

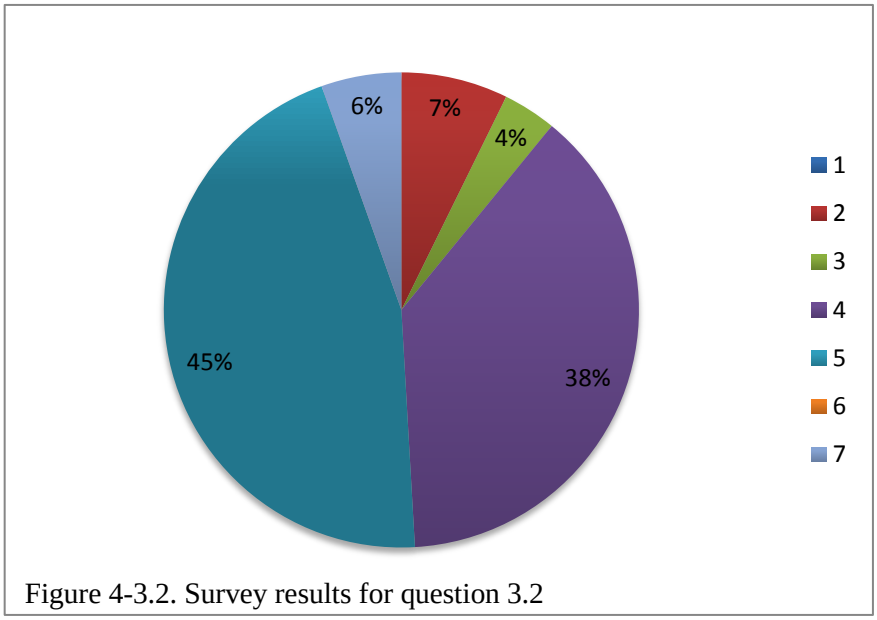



Figure 4-3.2. Survey results for question 3.2

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

3.3. Overall, the lights in the ***dining room*** are pleasing

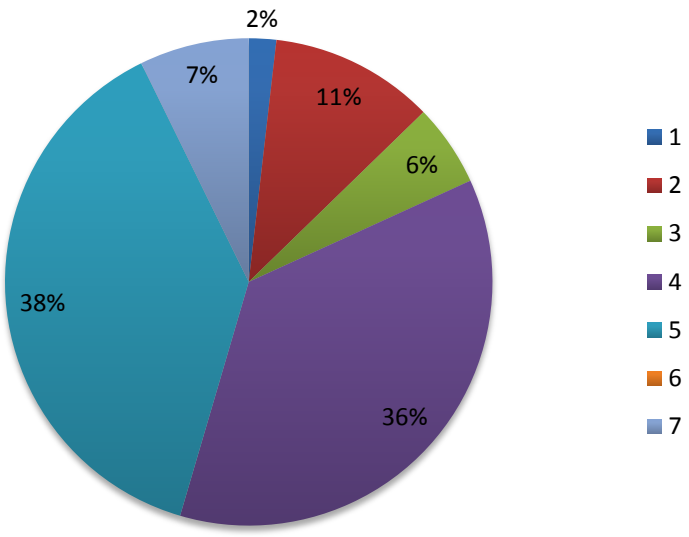



Figure 4-3.3. Survey results for question 3.3

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don’t Know, 7= Blank.

## 4. Activity Room

4.1. The ***Wellness center*** is poorly lighted.

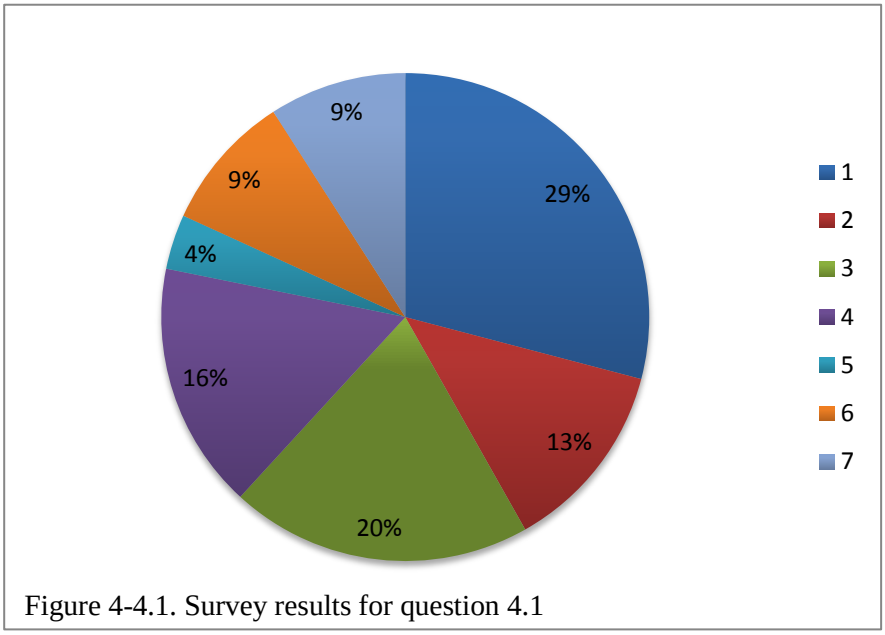



Figure 4-4.1. Survey results for question 4.1

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

4.2. I would like to turn some lights off in the ***wellness center***, since they are bright.

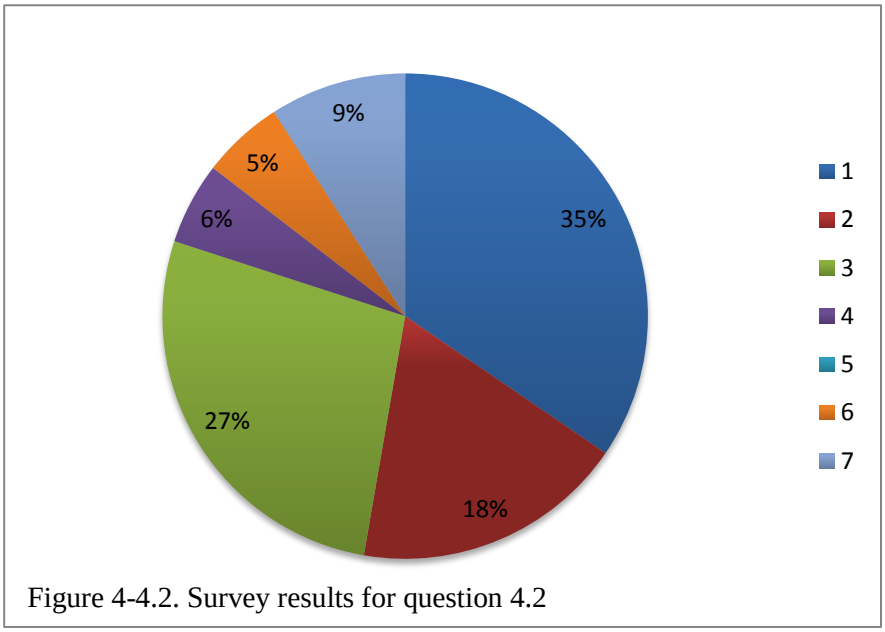



Figure 4-4.2. Survey results for question 4.2

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

4.3. Overall, the lights in the ***wellness center*** are pleasing.

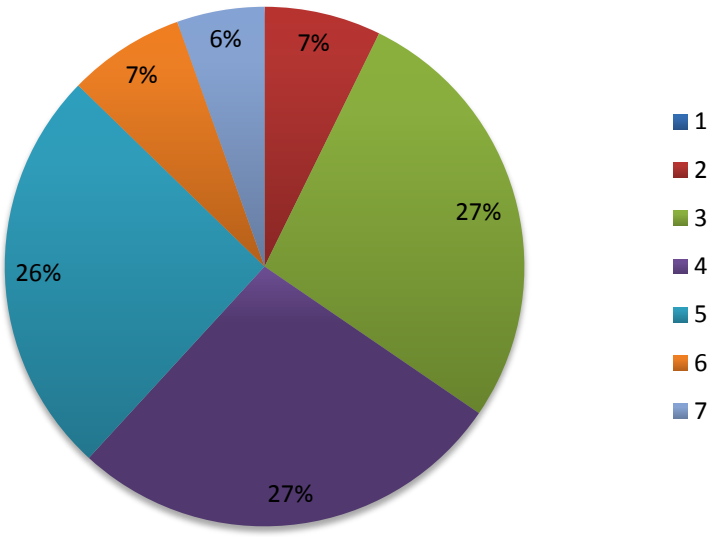



Figure 4-4.3. Survey results for question 4.3

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

## 5. Chapel

5.1. The ***chapel*** is poorly lighted.

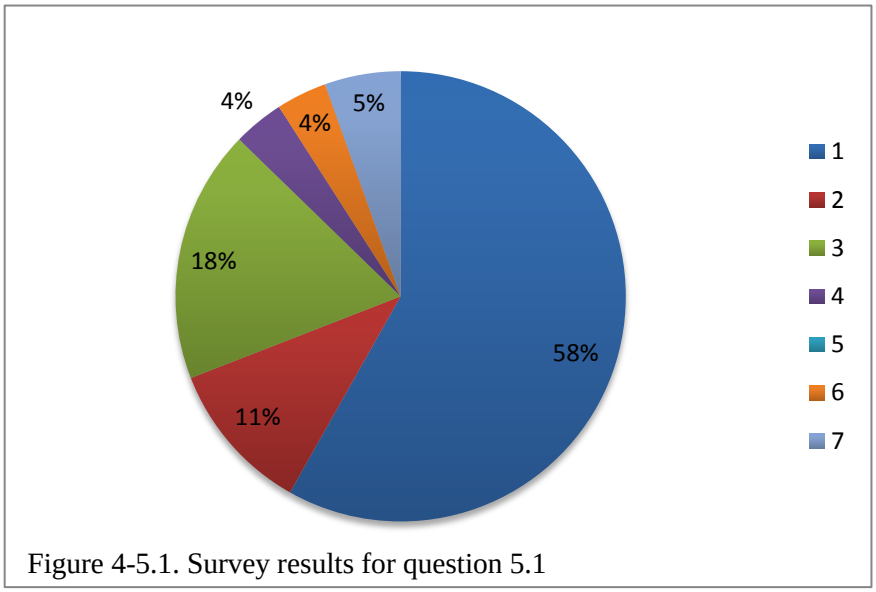



Figure 4-5.1. Survey results for question 5.1

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

5.2. I would like to turn some lights off in the ***chapel***, since they are bright.

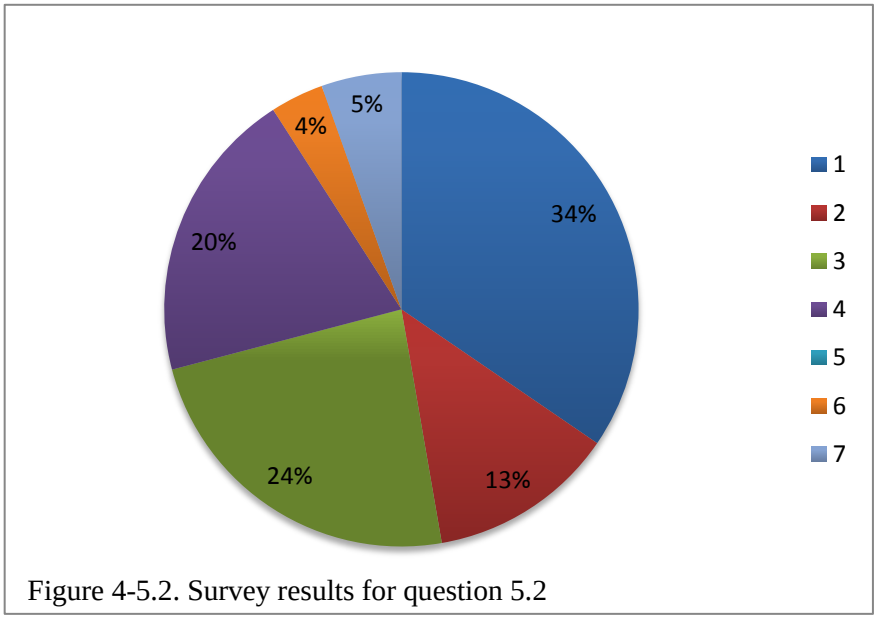



Figure 4-5.2. Survey results for question 5.2

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

5.3. Overall, the lights in the ***chapel*** are pleasing.

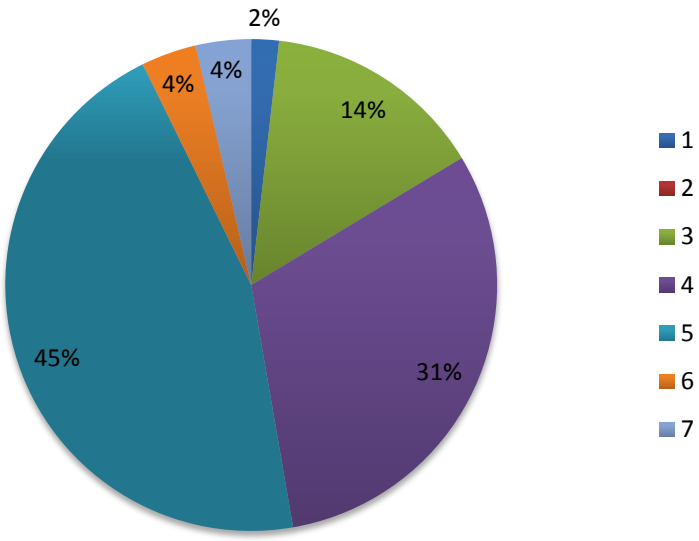



Figure 4-5.3. Survey results for question 5.3

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

## 6. Swimming Pool Deck

6.1. The ***swimming pool deck*** is poorly lighted.

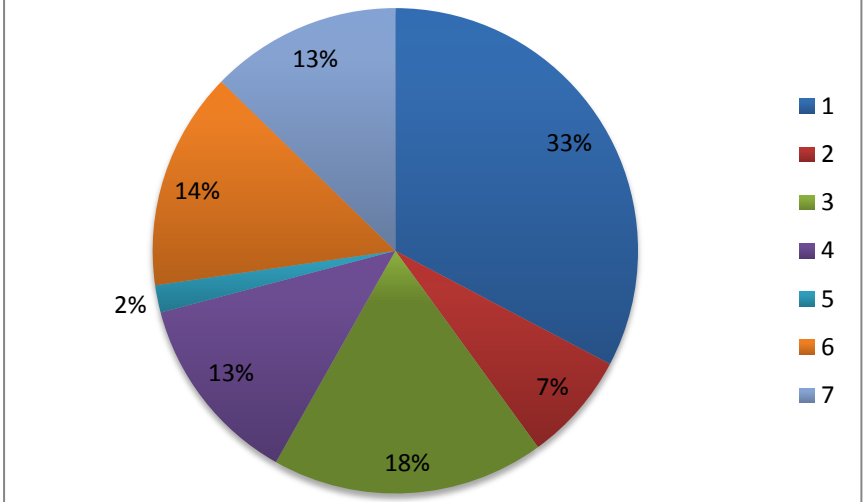



Figure 4-6.1. Survey results for question 6.1

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

6.2. The lights in the ***swimming pool deck*** area are glaring.

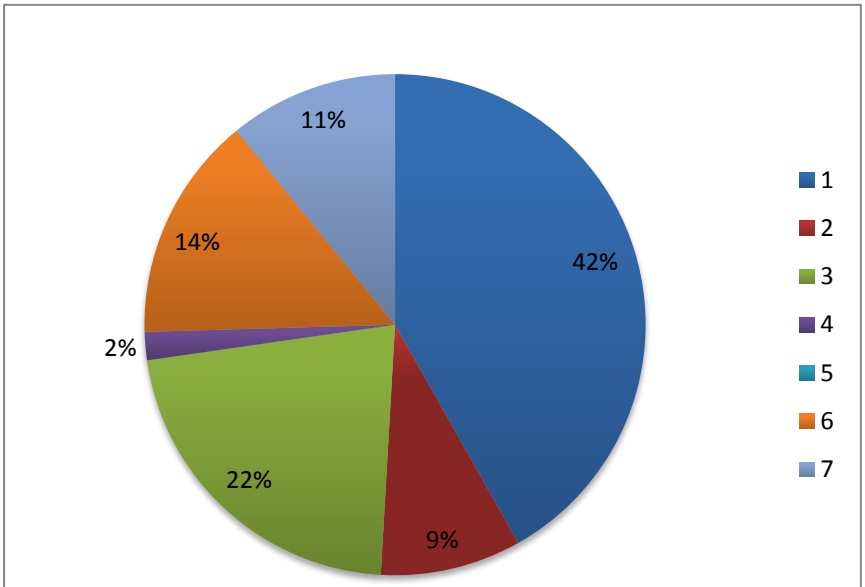



Figure 4-6.2. Survey results for question 6.2

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion, 4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

6.3. Overall, the lights in the ***swimming pool deck*** area are pleasing.

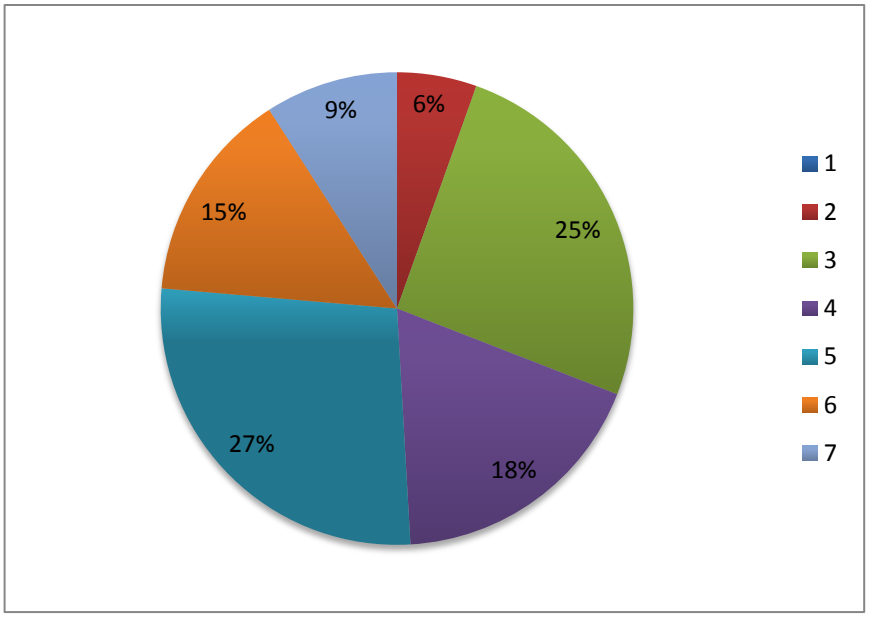



Figure 4-6.3. Survey results for question 6.3

1= Strongly Disagree, 2= Somewhat Disagree, 3= Neutral/No Opinion,

4=Somewhat Agree, 5= Strongly Agree, 6= Don't Know, 7= Blank.

Participant Comments:

- "Interior lighting is adequate. But would like to see more outdoor lights."
- "More lights could be turned off at night in common areas."
- "The overhead lights on the balcony are not replaced when needed and more lights are needed over the puzzle table."
- "Some of the spotlight at outside entrance (front) are blinding as you walk in and out."
- "The biggest problem seems to be in getting lights turned off when areas such as the chapel, wellness center, restrooms, living room, etc are not in use."
- "Do not turn lights to "dim" in Redbud Dining Room in area next to stage."
- "The lighting is 20 years old and out of date."

Summary of Survey

The coded survey data were analyzed, by examining the percentages of responses. Some key findings are shown in Figure 4-7, Figure 4-8, Figure 4-9, and Figure 4-10.

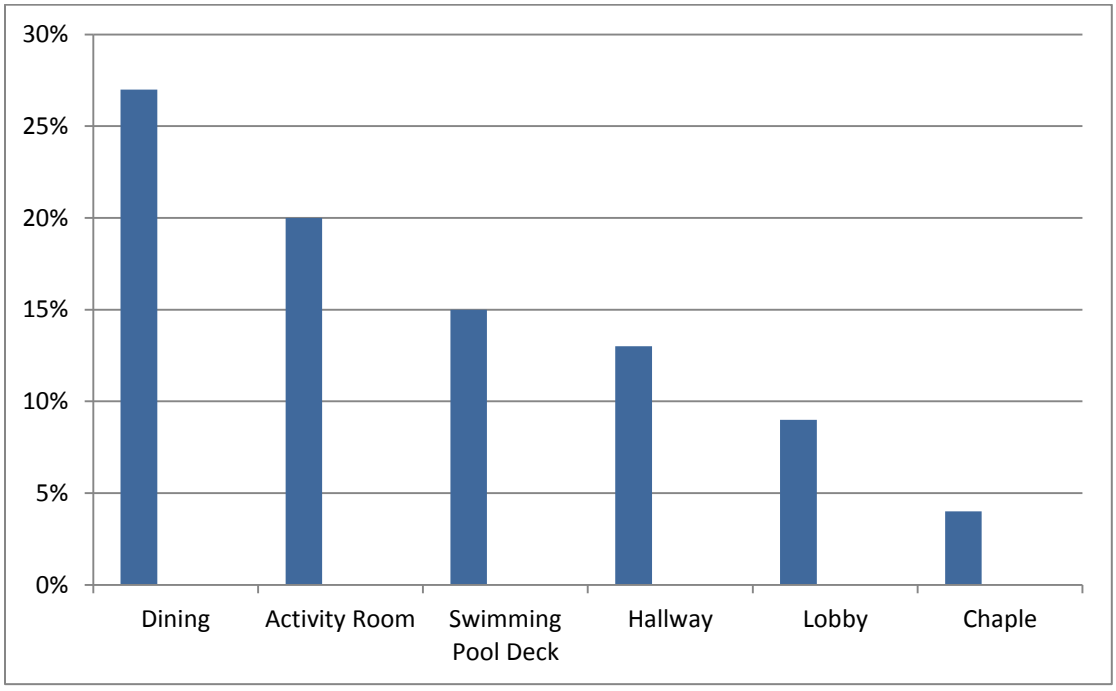



Figure 4-7. Percentages of responses indicating space was poorly lighted

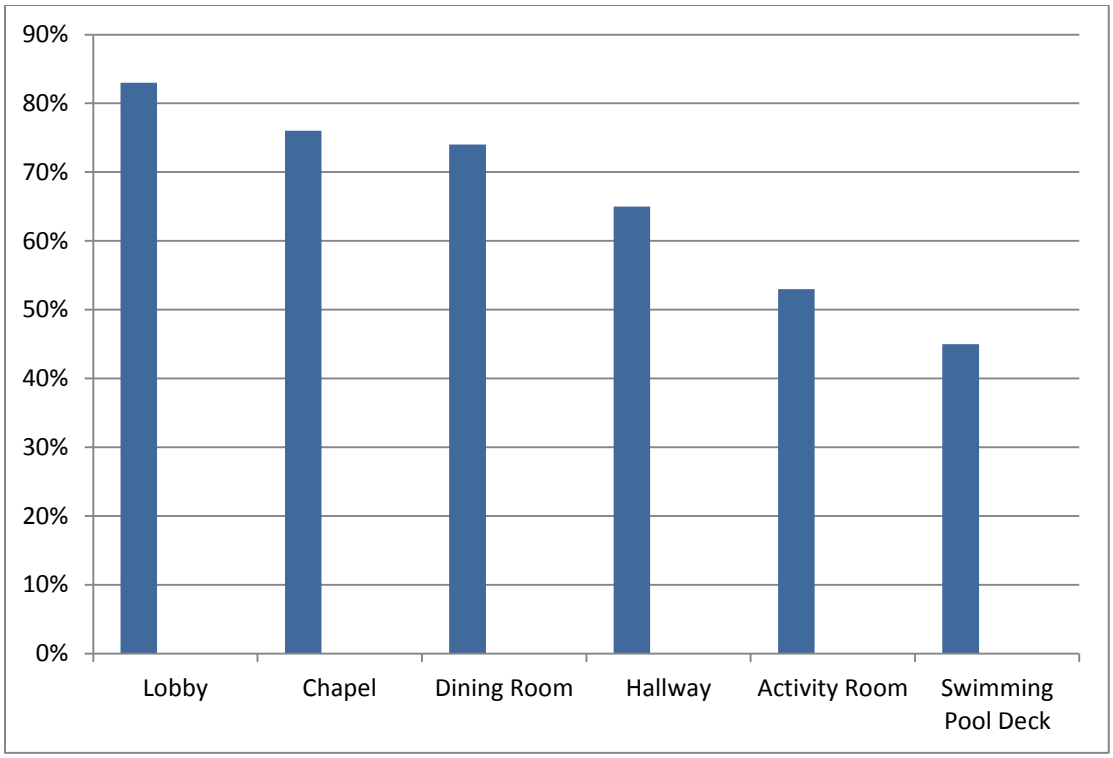



Figure 4-8. Percentages of responses indicating space had pleasing lights

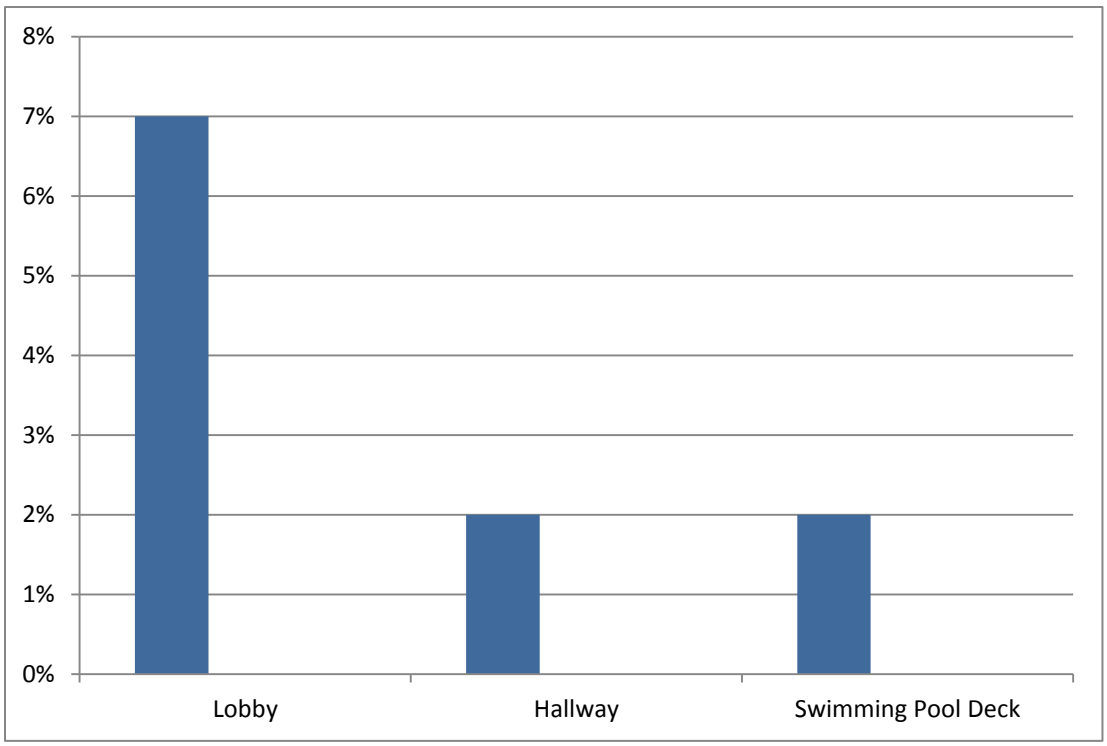



Figure 4-9. Percentages of responses indicating space had glaring lights

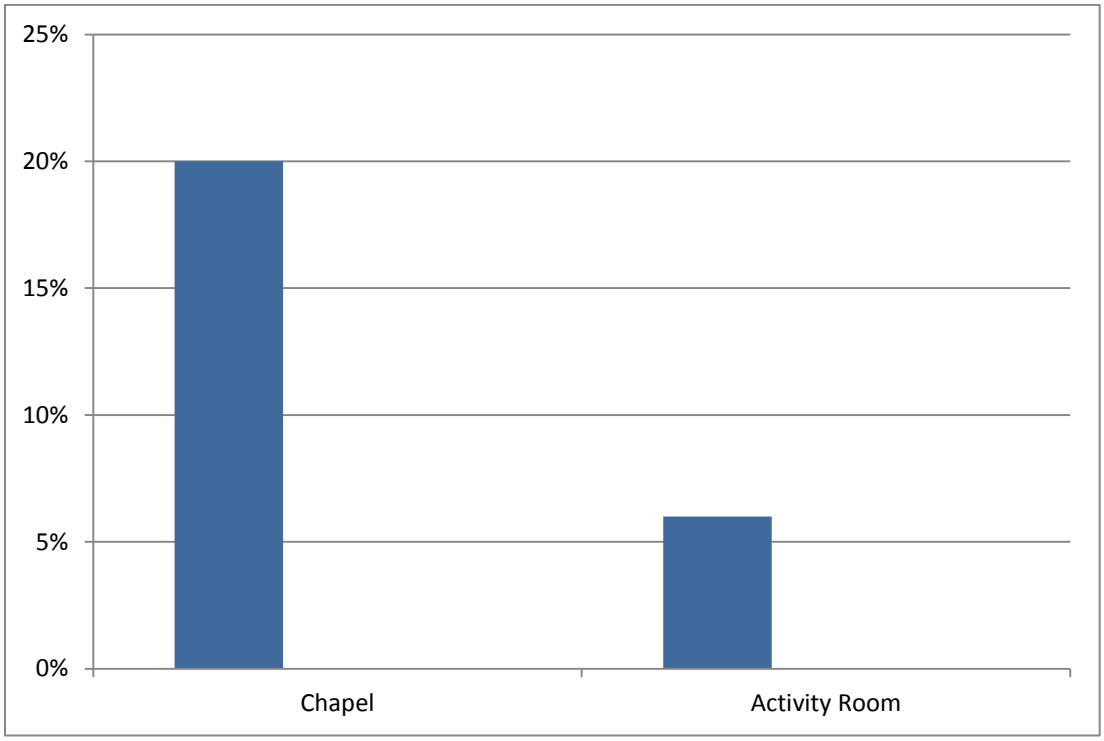



Figure 4-10. Percentages of responses indicating space had bright lights

**Schematic Design**

**Design Concept: Whole Person Wellness**

The Continuing Care Retirement Center was willing to create an environment conducive to positive outcomes for residents. This study is also trying to design conformable interior lighting solution to promote and protect the older adults' wellness and health. The design process was based on this concept, to improve whole person wellness in the CCRC.

**Lighting Fixture Selections**

The comparison of different interior lighting fixtures between existing lights and new sustainable lights are shown in the Table 4-5, and Table 4-6. This is also a process of

selecting different lighting fixtures that provide alternative lighting solutions for the selected public spaces at CCRC site. Design criteria used to compare different lighting solutions included: lumen, watts, efficacy, light source life, glare reduction, and dimmable. Using dimmers is a useful strategy, since it allows residents to adapt light levels to accommodate different situations and personal preferences.

Table 4-5.

*Proposed selection of Down Lights*

| Condition | Manuf. | Type | Lumens | Watts | Efficacy (Lm/W) | Lamp life hours | Glare reduction | Dimmable |
|---|---|---|---|---|---|---|---|---|
| Existing | TCP (Dining room) | CFL | 650 | 14 | 46.42 | 8,000 | NA | No |
| | Philips (Chapel) | CFL | 1,875 | 27 | 69.44 | 20,000 | NA | Yes |
| Proposed | TCP | LED | 850 | 14 | 60.71 | 2,500 | NA | Yes |
| | Philips | LED | 1,500 | 27 | 55.55 | 60,000 | Yes | Yes |
| | Cooper | LED | 900 | 14 | 64.29 | 50,000 | NA | Yes |
| | Cree | LED | 1,000 | 12.5 | 80 | 50,000 | Yes | Yes |

*Note.* The detailed product information was based on the manufactures' printed catalogs and websites.

Table 4-6.

*Proposed selection of Linear Recessed Lights*

| Condition | Manuf. | Type | Lumens | Watts | Efficacy (Lm/W) | Lamp life hours | Glare reduction | Dimmable |
|---|---|---|---|---|---|---|---|---|
| Existing | Philips (Activity room and Hallway) | CFL | 2,500 | 25 | 100 | 30,000 | NA | No |
| Proposed | Philips | LED | 1,650 | 22 | 75 | 40,000 | NA | Yes |
| | Cooper | LED | 4,500 | 52 | 64.29 | 50,000 | NA | Yes |
| | Cree | LED | 4,000 | 36 | 110 | 75,000 | Yes | Yes |

## Design Development

### 1). Activity Room

Proposed Products

The activity room was not bright enough based on the results of this study's light level measurements and residents' survey perceptions. According to IES, providing adequate, even, and diffused lighting without glare for older adults are the guiding principles for the activity room. Through the comparison of seventeen LED and eleven CFL lighting catalog, Cree Cr24 LED light (See Figure 4-11) was selected in the activity room. Occupancy sensor is proposed (See Figure 4-12) to switch off some lighting when no one is present.

Figure 4-11. Cree Cr24 LED*

*4000 Lumens, 36 Watts, 110 Lm/W, 50000 Hours, glare reduction, and dimmable.

Figure 4-12. Cooper Dual Tech Line Voltage Ceiling Sensor*

*A ceiling mounted occupancy sensor to monitor a room for occupancy to deliver maximum energy savings and ensure the greatest sensitivity.

Calculations

Several lighting formulae were required to determine the quantity of fixtures needed for a target light level in the activity room.

$$Room\ Cavity\ Ratio(RCR) = \frac{5h(L+W)}{L \times W} \approx 3$$

$$Number\ of\ Luminaires = \frac{[Maintained\ Illuminance(FC)\ Desired] \times (Area\ in\ Square\ Feet)}{(Lamp\ Lumens / Luminaire) \times (CU)}$$

$$\approx 10$$

(h= height of room cavity; L= room length; W= room width; CU= coefficient of utilization)

Initial Reflected Ceiling Plan and Lighting Effects

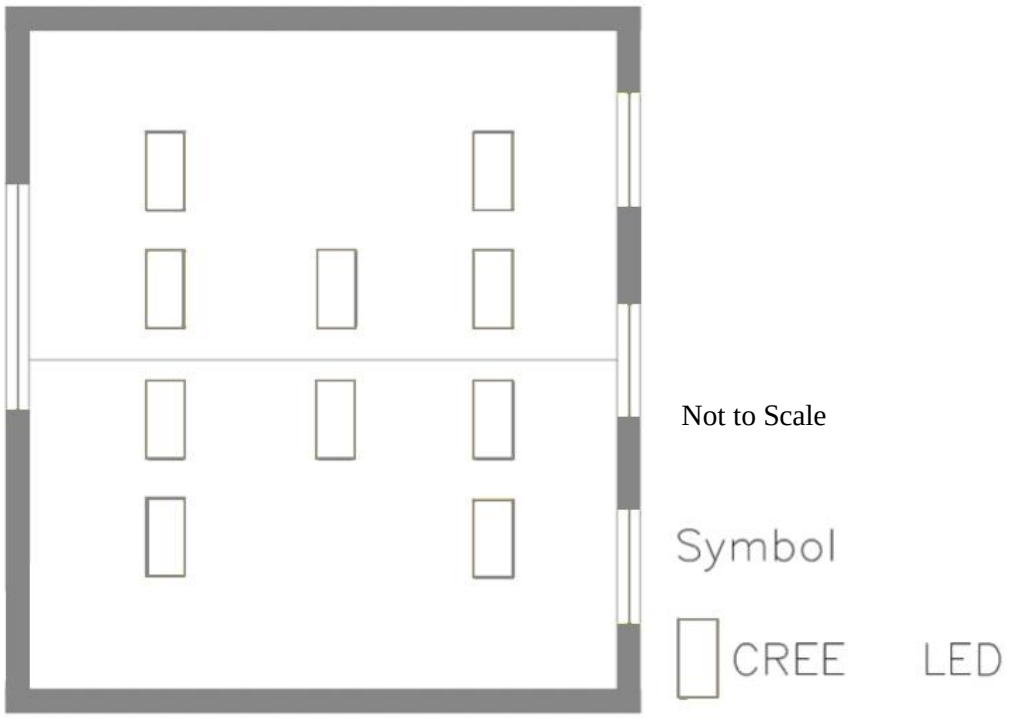



Figure 4-13. Initial Reflected Ceiling Plan of Activity Room

Figure 4-14. Lighting Effects in Activity Room

Estimated initial uninstalled lighting cost for the proposed lighting solution: $2,750.00

Comparison

Table 4-7 showed the comparison between existing lighting and proposed lighting. The design criteria used to compare these two different lighting solutions included: number of fixtures, watts, total watts, lifetime in years, glare reduction, and dimmable. The new lighting solution not only provided high efficiency, but also improved the older adults' wellness.

Table 4-7.

*Comparison between Existing Lighting and Proposed Lighting in Activity Room*

| Type | Number of fixtures | Watts per fixture | Total watts | Lifetime in years | Light level (fc) | Glare reduction | Dimmable |
|---|---|---|---|---|---|---|---|
| CFL (existing) | 8 (16 tubes) | 25 | 400 | 3.4 | 18 | No | No |
| LED (proposed) | 10 | 36 | 360 | 8.6 | 30 | Yes | Yes |

**2). Dining Room**

Proposed products

According to the survey, the dining room is the most poorly lighted public interior space, but 74% residents are satisfied with the lighting. It is important to apply appropriate lighting with minimum glare to help people clearly see the food on the table and each other's faces. The window side had sufficient light level in the dining room. Thus, the researcher chose the side without windows that did not meet the industry recommended light level for a dining room. Through the comparison of seventeen LED and eleven CFL lighting catalog, a Philips' LED down light (See Figure 4-15) was

selected for the dining room. A Cove light, a kind of indirect light, provides even, low glare illumination for older adults. Cooper LED cove lighting (See Figure 4-16) was selected for older adults in dining room.


Figure 4-15. Philips Calculite Solid-State LED*

*1500 Lumens, 27 Watts, 55.55 Lm/W, 60000 Hours, glare reduction, and dimmable.

Figure 4-16. Cooper Line Symmetric .75*

*34 lms/ft, 2.1w/ft, 50000 Hours.

Calculations

Several lighting formulae were required to determine the quantity of fixtures needed for a target light level in the dining room.

$$Room\ Cavity\ Ratio(RCR) = \frac{5h(L+W)}{L \times W} \approx 2.92$$

$$Number\ of\ Luminaires = \frac{[Maintained\ Illuminance(FC)\ Desired] \times (Area\ in\ Square\ Feet)}{(Lamp\ Lumens / Luminaire) \times (CU)} \approx 6$$

(h= height of room cavity; L= room length; W= room width; CU= coefficient of utilization)

Initial Reflected Ceiling Plan and Lighting Effects

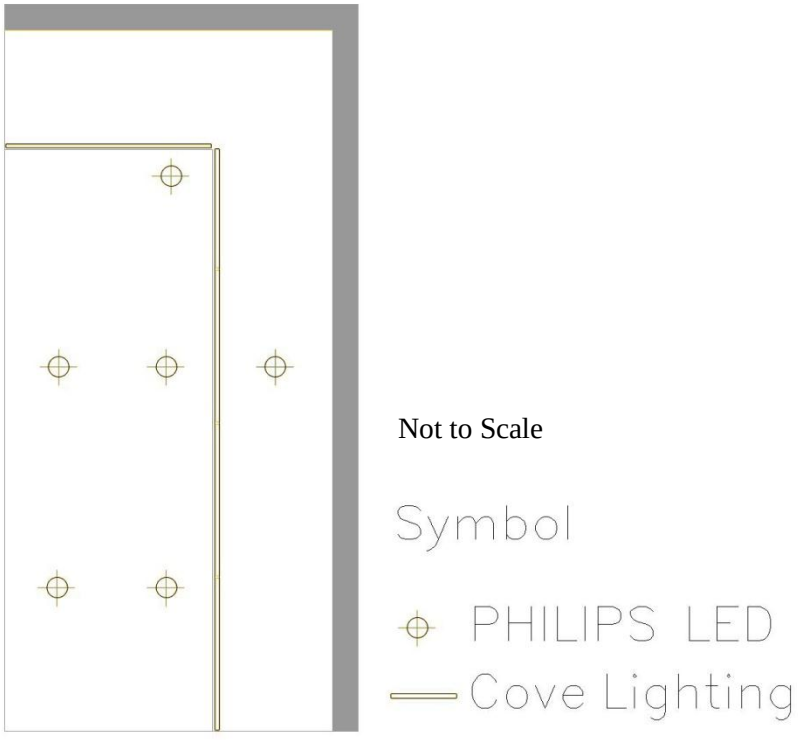



Figure 4-17. Initial Reflected Ceiling Plan of Dining Room

Figure 4-18. Lighting Effects in Dining Room

Estimated initial uninstalled lighting cost for the proposed lighting solution: NA

Comparison

Table 4-8 showed the comparison between existing lighting and proposed lighting. The design criteria used to compare these two different lighting solutions included: number of fixtures, watts, total watts, lifetime in years, glare reduction, and dimmable. The new lighting solution not only provided high efficiency, but also improved the older adults' wellness.

Table 4-8.

*Comparison between Existing Lighting and Redesigned Lighting in Dining Room*

| Type | Number of fixtures | Watts per fixture | Total watts | Lifetime in years | Light level (fc) | Glare reduction | Dimmable |
|---|---|---|---|---|---|---|---|
| CFL (existing) | 12 | 14 | 168 | 0.9 | 8 | No | No |
| LED (proposed) | 6 | 27 | 162 | 6.8 | 10 | Yes | Yes |

**3). Hallway**

Proposed products

The light level in the hallway is lower than industry standards. Although not so many residents are satisfied with the lighting in the hallway, only 13% participants thought it is poorly lighted. Even light distribution makes hallway easier to guide older adults. Thus, it is necessary to improve lighting uniformity in the hallway. The existing lights in the hallway have two different color temperatures that make the environment look non-uniform. Since wall sconce lamp was compact fluorescent, it had high luminous efficacy. Changing its color temperature was a better way to improve lighting uniformity

in the hallway. Through the comparison of seventeen LED and eleven CFL lighting catalog, Cree Cr24 LED light (See Figure 4-11) was selected in the hallway. CR24 is a dimmable light that can be adjusted for the light level of 30 fc during the active hours and 10 fc during the sleeping hours. The lamp with 3500k color temperature can be used for the wall sconce instead of the existing 2700k. The proposed wall sconce lamp had the same color temperature as the proposed down light, which made the environment look uniform.

Calculations

Several lighting formulae were required to determine the quantity of fixtures needed for a target light level in the dining room.

$$Room\,Cavity\,Ratio(RCR) = \frac{5h(L+W)}{L \times W} \approx 6$$

$$Number\,of\,Luminaires = \frac{[Maintained\,Illuminance(FC)\,Desired] \times (Area\,in\,Square\,Feet)}{(Lamp\,Lumens/Luminaire) \times (CU)} \approx 2$$

(h= height of room cavity; L= room length; W= room width; CU= coefficient of utilization)

Initial Reflected Ceiling Plan and Lighting Effects

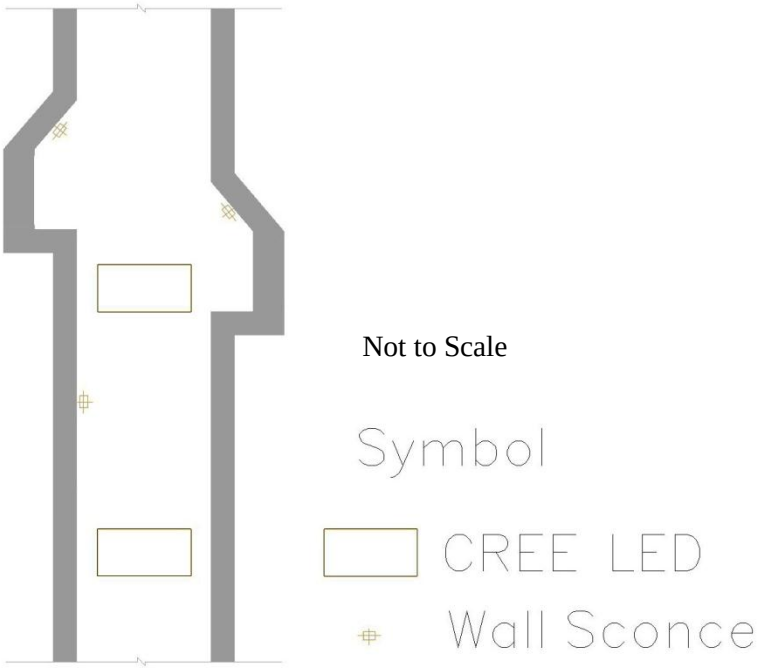



Figure 4-19. Initial Reflected Ceiling Plan of Hallway

Figure 4-20. Lighting Effects in Hallway

Estimated initial uninstalled lighting cost for the proposed lighting solution: $557.50

Comparison

Table 4-9 showed the comparison between existing lighting and proposed lighting. The design criteria used to compare these two different lighting solutions included: number of fixtures, watts, total watts, lifetime in years, glare reduction, and dimmable. The new lighting solution not only provided high efficiency, but also improved the older adults' wellness.

Table 4-9.

*Comparison between Existing Lighting and Redesigned Lighting in Hallway*

| Type | Number of fixtures | Watts per fixture | Total watts | Lifetime in years | Light level (fc) | Glare reduction | Dimmable |
|---|---|---|---|---|---|---|---|
| CFL (existing) | 2 (4 tubes) | 25 | 100 | 3.4 | 18.6 | No | No |
| LED (proposed) | 2 | 36 | 72 | 8.6 | 10-30 | Yes | Yes |

**4). Lobby**

Appropriate products

As for Lobby, 83% residents are satisfied with the lighting, although the light level is lower than recommendation. A chandelier is the main lighting fixture in the lobby. Based on the high satisfaction with lobby from participants, the existing chandelier can be kept. In this case, the lamp with more lumens needs to be applied for chandelier in order to improve the light level in the lobby. Through the comparison of seventeen LED and eleven CFL lighting catalog, Philips LED lamp (See Figure 4-21) was selected in the lobby.


Figure 4-21. Philips LED Lamp*

*940 Lumens, 10 Watts, 94 Lm/W, 30000 Hours, glare reduction, and dimmable.

Initial Reflected Ceiling Plan and Lighting Effects


Figure 4-22. Initial Reflected Ceiling Plan of Lobby

Figure 4-23. Lighting Effects in Lobby

Estimated initial uninstalled lighting cost for the proposed lighting solution: $2,014.74

Comparison

Table 4-10 showed the comparison between existing lighting and proposed lighting. The design criteria used to compare these two different lighting solutions included: number of fixtures, watts, total watts, lifetime in years, glare reduction, and dimmable. The new lighting solution not only provided high efficiency, but also improved the older adults' wellness.

Table 4-10.

*Comparison between Existing Lighting and Redesigned Lighting in Lobby*

| Type | Number of fixtures | Watts per fixture | Total watts | Lifetime in years | Light level (fc) | Glare reduction | Dimmable |
|---|---|---|---|---|---|---|---|
| CFL (existing) | 42 | 9 | 378 | 0.9 | 11.95 | No | No |
| LED (proposed) | 42 | 10 | 420 | 3.4 | 30 | Yes | Yes |

**5). Chapel**

The chapel was bright enough (based on the light level measurements in this current study) and 76% residents are satisfied with the lighting. According to the documents of existing lighting fixtures in the chapel, the down lights were compact fluorescent that have high luminous efficacy (70 lm/w and 76 lm/m) and also dimmable. The chapel had five different types of lights that would greatly benefit residents since they could be adjusted to their specific needs. Overall, the existing interior lighting in the chapel created a proper atmosphere for worship in the CCRC and also improved the older adults' wellness. In this case, adding the occupancy sensor (See Figure 4-12) was the

only lighting solution for the chapel. The sensor can switch off some lighting when no one is present.

**6). Swimming Pool Deck**

The swimming pool deck had adequate natural lights from windows. Although there were several wall sconces, they were not used when the researcher visited on four separate days apparently because of the natural light. Also, the staff did not recommend that residents swim after dark. Obviously, it is dangerous to walk on the deck in the dark environment that may affect older adults to see clearly and result in some accidents, such as fall. According to Sec. 3114B from *The design, construction, operation and maintenance of public swimming pools* (County, 1998), "where the pool is to be used at night, pool deck areas shall be provided with lighting so that persons walking on the deck can identify hazards". In this case, removing the existing lighting fixtures in the swimming pool may be a better lighting solution. It would not only save energy, but also reduce residents' risk by avoiding dangerous situations during the nighttime.

**Focus Group Comments**

- What if we could have bright (correct) lighting for one day? What responses will be from residents?
- The sustainable lighting solution is great.
- What is the estimated cost for the new lighting solution?
- The reason for the low light with high satisfaction may because some other outside factors, like in the dining room, because residents get food and meets need.
- The study provides lots of useful information.
- What is the average age of participants?

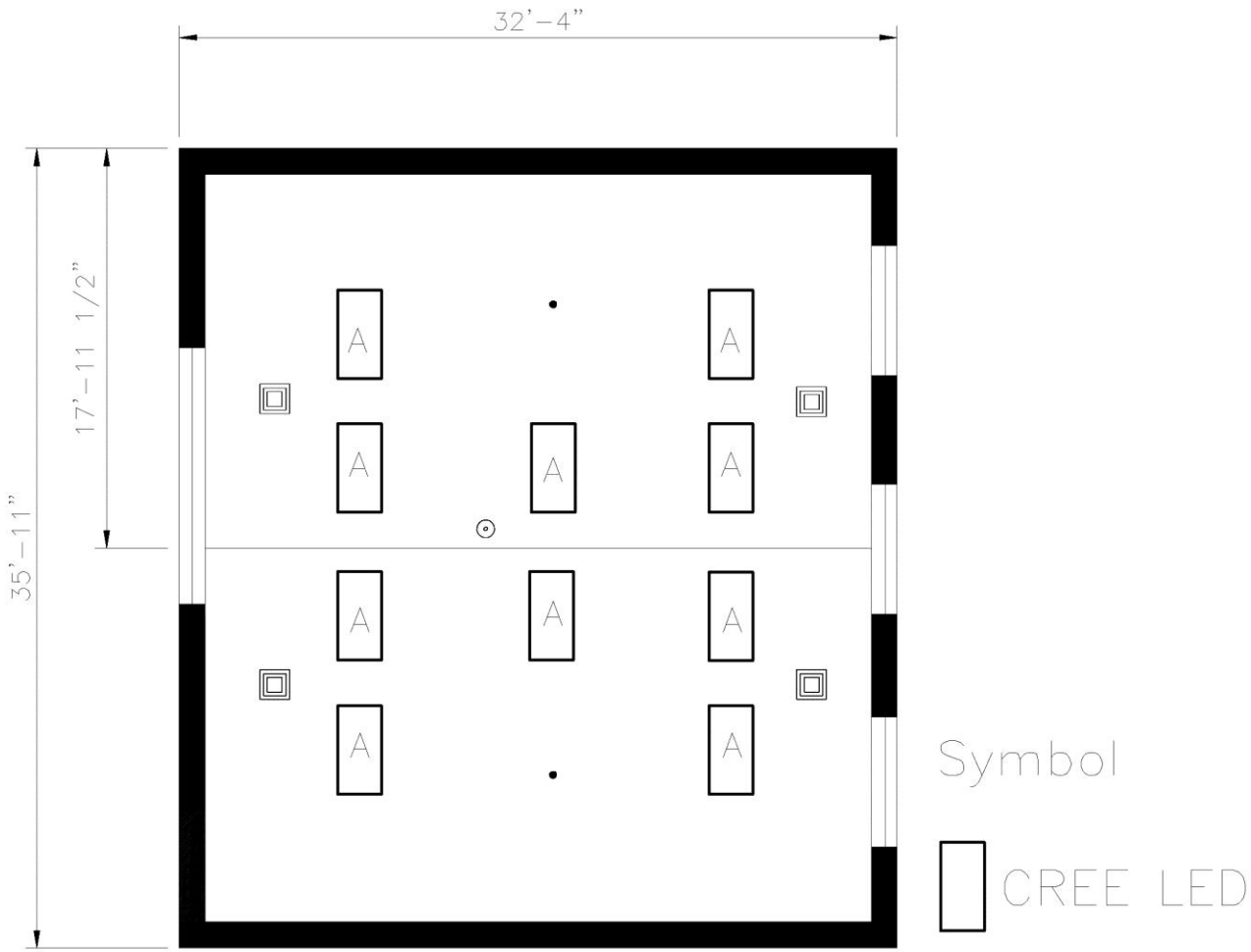
**Discussions**

- Chapel: bright enough and 76% residents are satisfied with the lighting.
- Lobby: 83% residents are satisfied with the lighting, although the light level is lower than recommendation.
- Hallway: not so many residents are satisfied with the lighting and only 13% participants thought it is poorly lighted.
- Swimming pool deck: few residents use it.
- Activity room: not bright enough.
- Dining room: most poorly lighted room from survey, but 74% residents are satisfied with the lighting.

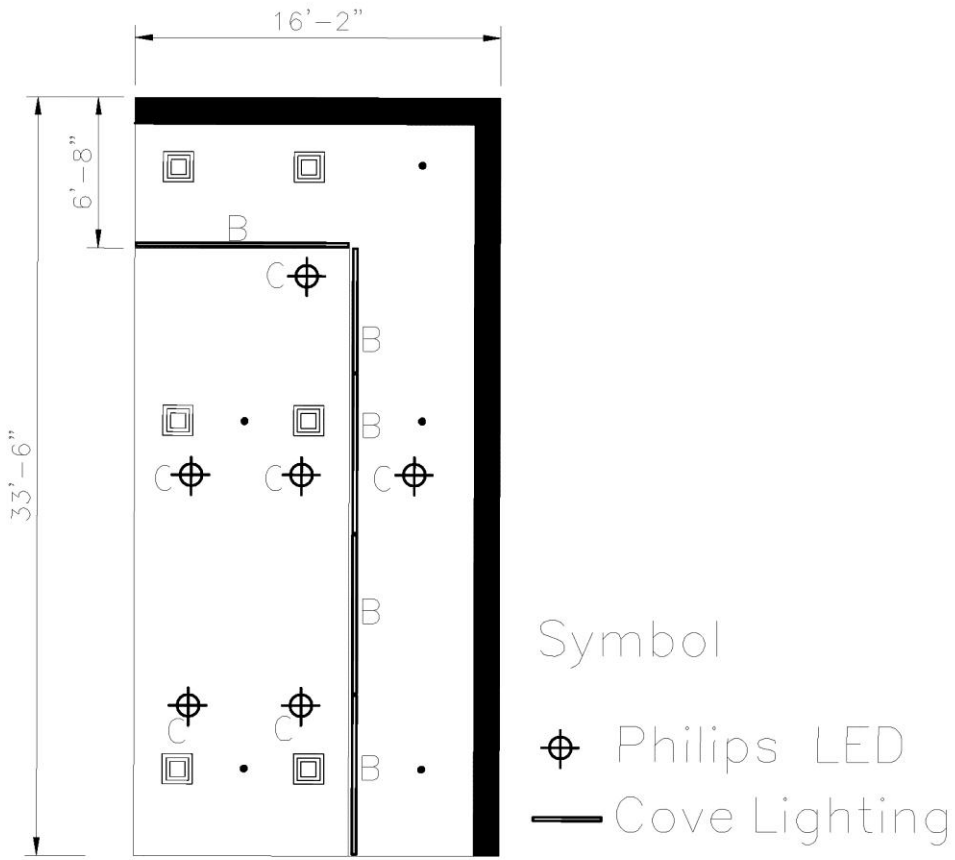
Although some selected public spaces' light levels were lower than recommendations, the satisfactions for the interior lighting were still high from participants in the survey. According to Bakker, Iofel, and Lachs (2004), residents' familiarity with their environments may explain their satisfactions with the inadequate illuminance levels. Moreover, some experts pointed out that the reason for the low light with high satisfaction may be some other outside factors. They mentioned like in the dining room, residents were satisfied with the lighting because they got food and met need. In the evaluation stage, the expert panel asked the average age of the participants and suggested to add the estimated costs for the proposal lighting solution. Their suggestions were incorporated into this study in the design development phase.

**Final Design: Construction Documents**

| Legend | | |
|---|---|---|
| Symbol | Key | Description |
|  | A | Linear Recessed Light |
|  | B | Cove light |
|  | C | Ceiling–mounted Downlight |
|  | D | Wall Sconce |
|  | E | Chandelier |
|  | | HVAC |
|  | | SPRINKLER HEAD |
|  | | OCCUPANCY SENSOR |

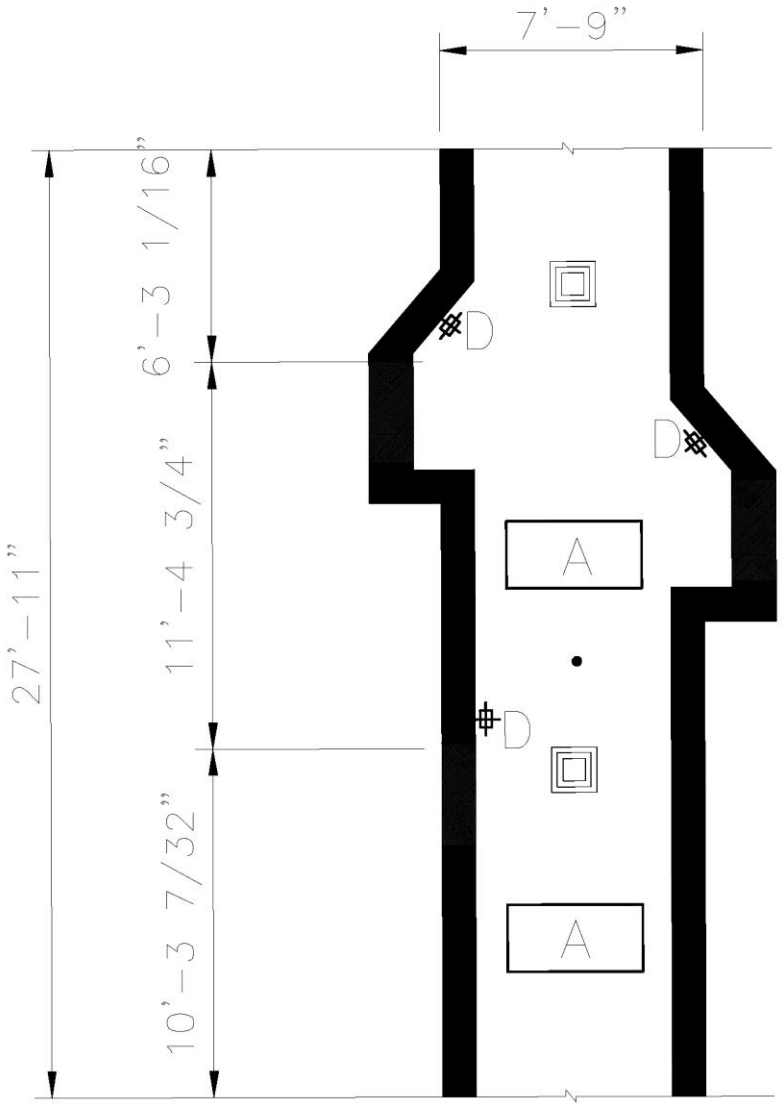



| Room | Page Title | Scale |
|---|---|---|
| Activity Room | Lighting and Reflected Ceiling Plan | 1/8"=1'-0" |




Key Plan

| Room | Page Title | Scale |
|---|---|---|
| Dining Room | Lighting and Reflected Ceiling Plan | 1/8"=1'-0" |

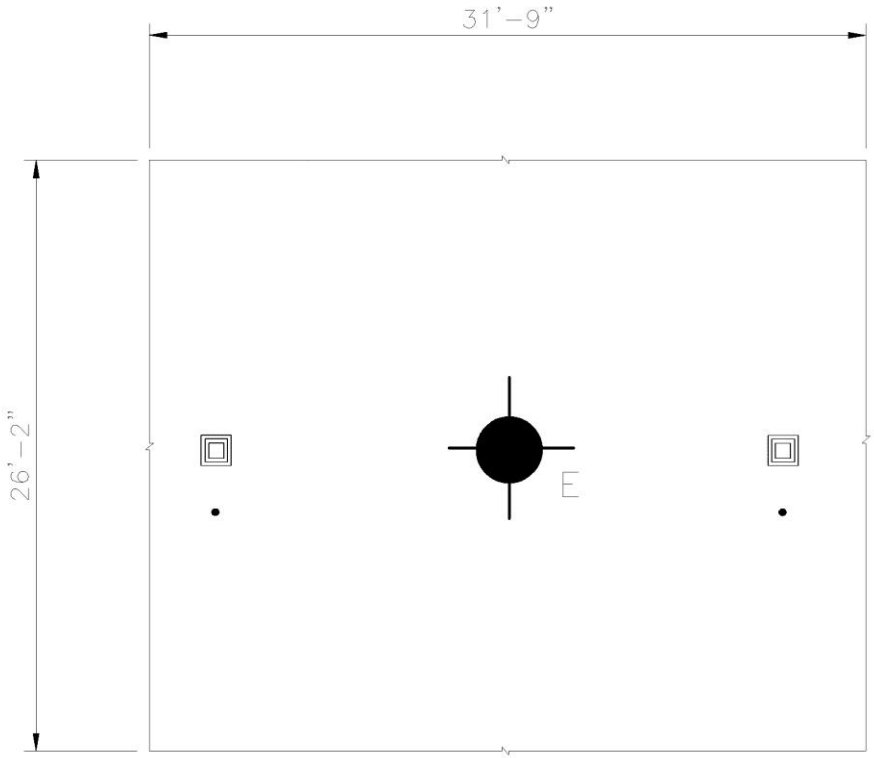


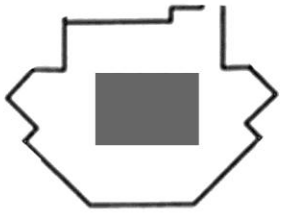

Symbol

CREE LED

Wall Sconce

| Room | Page Title | Scale |
|---|---|---|
| Hallway | Lighting and Reflected Ceiling Plan | 3/16"=1'-0" |



Key Plan

Symbol

CHANDELIER

| Room | Page Title | Scale |
|---|---|---|
| Grand Lobby | Lighting and Reflected Ceiling Plan | 1/8"=1'-0" |

Table 4-11.

*Lighting Fixture Schedule*

| | | | Lamps | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Key | Manuf. | Catalog# | No | Watts | Life (Hours) | Lumens | Type | Color Temperature | CRI | Finish | Volts | Mounting | Mounting heights above finished floor |
| A | Cree | CR24 | 1 | 36 | 75,000 | 4000 | LED | 3,500k | 90 | White | 120 | Ceiling | 12’ |
| B | Cooper | Line Symmetric.75 | 1 | 2.1 w/ft | 50,000 | 34 lms/ft | LED | 3,000k | NA | Aluminum | 120 | Surface | 6’6” |
| C | Philips | C6L15200DL | 1 | 27 | 60,000 | 1500 | LED | 3,000k | NA | Sliver | 120 | Ceiling | 8’5” |
| D | NA | NA | 1 | 14 | 10,000 | 900 | CFL | 3,500k | 82 | NA | 120 | Surface | 5’10” |
| E | NA | NA | 42 | 10 | 30,000 | 940 | LED | 2,700k | 92 | Gold | 120 | Ceiling | 14’ |

# CHAPTER V

## CONCLUSIONS AND IMPLICATIONS

This study was designed for interior lighting in selected public spaces, including lobby, hallway, activity room, dining room, chapel, and swimming pool deck, for older adults in independent living at a Continuing Care Retirement Center in the state of Oklahoma. Since the sustainable lighting can be adopted to improve light levels, reduce energy consumption, increase lamp life, and promote the older adults' wellness, the study applied this technology in order to benefit the whole environment for older adults at the CCRC.

According to Evidence Based Design framework, the methodology developed five phases: programming, schematic design, design development, evaluation, and construction documents. In the programming phase, results of the field study showed that light levels in some interior public spaces, such as the lobby, hallway, dining room, and activity room were insufficient compared to industry recommendations. The follow-up field study gathered the information of existing interior lighting fixtures so that the results could be used to compare the proposed lighting solution in the development phase. In order to collect residents' perceptions for the existing interior lighting at CCRC site, the survey was conducted by researcher. Survey results varied but indicated participants' high satisfactions with the inadequate light levels in some areas. Participants' familiarity

with their environment and the fact that their needs were met may contribute these responses. However, responses related to the quantity of interior lighting showed results consistent with the light level measurements from field study. Selections of proposed sustainable lighting products for public spaces were based on the results of field study and survey, as well as the design concept under the schematic phase and design development. The evaluation phase examined whether the initial goals of this study were met and gathered some suggestions from expert panel. At last, the final design was produced in the construction documents stage.

In the design process, the design criteria developed to compare different lighting solutions included: number of fixtures, watts, lifetime in years, glare reduction, and dimmable. The number of fixtures in the selected interior public space was produced according to recommended light level for older adults. Total watts and lifetime in years of lamps can be used to determine the lamp energy efficiency. Since minimizing glare was another important consideration for older adults, it was necessary to provide lamps which can reduce glare. Using dimmers allows residents to adapt light levels to accommodate different situation and personal preferences. Thus, the purpose of creating design criteria was to select the best solution through comparison of these different lighting factors in this study.

The design supports the wellness of older adult residents through the use of lights with even, uniformity, glare reduction, and which were dimmable. The proposed lighting solution supports not only energy savings and environmental friendliness, but also the special lighting considerations regarding residents' health, which also has the potential to greatly improve the quality of life enjoyed by these individuals. This project represents a

progressive design, because of its inclusion of resident surveys regarding interior public lighting and the incorporation of design features intended to reflect the results of the survey.

However, the limitation of this study is that only six interior public spaces in one CCRC were selected for study. Further studies are needed to utilize more randomly selected sites, which will be hard to achieve. In addition, since this study only addresses lighting design, and not lighting construction, it is not anticipated that this proposal will be built or applied at this particular CCRC site. An actual post-occupancy evaluation will not be conducted and perceptions of CCRC's residents of the new installed lighting cannot be collected or compared to the existing interior illumination. Research concerning the interior lighting in public spaces is limited and study results have rarely been applied to the design. However, this study added the body of literature of light level measurements in the existing CCRC site, and the responses from older independent living adults regarding the interior public lighting. Also the results of field study and survey had been applied to the proposed lighting design, which filled a research gap.

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APPENDIX A
IRB APPROVAL FOR THE SURVEY

## Oklahoma State University Institutional Review Board

| | |
|---|---|
| Date: | Friday, February 17, 2012 |
| IRB Application No | HE1211 |
| Proposal Title: | Designing a Sustainable Solution to Improve the Interior Lighting in Public Places for Older Adults in a Continuing Care Retirement Center |
| Reviewed and Processed as: | Exempt |

**Status Recommended by Reviewer(s): Approved  Protocol Expires: 2/16/2013**

Principal Investigator(s):


Xiaofei Zhang
76 S. Univ. Place Apt. 6
Stillwater, OK 74075

Paulette Hebert
431 HES
Stillwater, OK 74078


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The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia H. Kennison

Shelia Kennison, Chair
Institutional Review Board

APPENDIX B
CONSENT FORM FOR PARTICIPANTS

**Survey Participant Information Sheet**
**Interior Lighting Survey**

You are being invited to participate in a research study being conducted by Oklahoma State University's Department of Design, Housing and Merchandising.

**Purpose of the study:**
The following survey is part of a study that seeks to gather your perceptions of interior lighting in some public spaces at Epworth Villa. The results will be used to make general recommendations in order to potentially improve interior lighting in public places located within Continuing Care Retirement Centers.

**What you will be asked to do in the study:**
You will be asked to rate different interior lighting conditions currently found in Epworth Villa's public spaces. This questionnaire is expected to take no more than 10-20 minutes to complete.

**Risks:** There are no expected risks associated with the study.

**Compensation:** There is no compensation for participating in this study. There are no direct benefits to you in completing this survey.

**Confidentiality:**
You will NOT be asked to give your name or contact information. Any personal demographic information will only be used to compare your answer to other participants. Your responses will be anonymous. Data from the survey will be stored in the Faculty Advisor's locked office, in a locked filing cabinet, with access only by authorized research investigators. Data from the survey will be held for 7 years and then destroyed. No results from the survey will be tied directly to individual respondents.

**Voluntary Participation:**
Participation is voluntary and you are under no obligation to complete this questionnaire.

If you have any questions about this research project, please feel free to contact Professor Paulette R. Hebert Ph. D. at (405) 744-5035 (paulette.hebert@okstate.edu) or graduate student Xiaofei Zhang at (405) 744-5035 (xiaofez@okstate.edu). If you have questions about your rights as a research volunteer, you may contact the Oklahoma State University Institutional Review Board (IRB) Chair, Dr. Shelia Kennison at 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

**After reading this participant information sheet, you may voluntarily agree to participate in this study. If you decide to participate, please complete the attached survey. By completing the survey, you are giving your consent to participate. You may retain this survey participant information sheet. Please return completed survey to Survey Collection Box located in the Grand Lobby after you are finished before March 03, 2012.**

APPENDIX C
IRB APPROVAL FOR THE PRESENTATION

## Oklahoma State University Institutional Review Board

| | |
|---|---|
| Date: | Friday, March 16, 2012 |
| IRB Application No | HE1223 |
| Proposal Title: | Designing a Sustainable Solution to Improve the Interior Lighting in Public Places for Older Adults in a Continuing Care Retirement Center |
| Reviewed and Processed as: | Exempt |

**Status Recommended by Reviewer(s): Approved  Protocol Expires: 3/15/2013**

Principal Investigator(s):


Xiaofei Zhang
76 S. Univ. Place Apt. 6
Stillwater, OK 74075

Paulette Hebert
431 HES
Stillwater, OK 74078


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The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia H. Kennison

Shelia Kennison, Chair
Institutional Review Board

APPENDIX D
CONSENT FORM FOR FOCUS GROUP

**PARTICIPANT INFORMATION**

**Title:** Designing a sustainable solution to improve the interior lighting in public places for older adults in a continuing care retirement center (CCRC)

**Investigators:** Xiaofei Zhang, Graduate student, Principal Investigator
Paulette Hebert, PhD, Advisor/Co-Principal Investigator

**Purpose:**
The presentation is part of a research study that seeks to gather your opinions of proposed interior lighting in some public spaces at Epworth Villa to help inform the design of a sustainable lighting solution for CCRCs.

**What to expect:**
You are asked to attend a presentation and provide recommendations about the proposed redesigned interior lighting in Epworth Villa's existing public spaces. Your recommendations will be audio recorded and then incorporated into the final thesis project of the principal investigator. This presentation will take place at Epworth Villa and is expected to take no more than two hours.

**Risks:**
There are no expected risks associated with the study with this project which are expected to be greater than those ordinarily encountered in daily life.

**Benefits:**
Your recommendations will contribute to the final thesis project of the principal investigator which is intended to expand the current body of knowledge about interior lighting design for an older adult facility. The design developed from this research also will be anticipated to promote the well-being of older adults at the CCRC.

**Your Rights:**
Your participation in this research study is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this study at any time, without penalty.

**Confidentiality**:
Your recommendations will be anonymous in that although they will be audio recorded the researcher will not attach identifiers to the recordings. No results from your recommendations will be tied directly to individual respondents. Recordings will be transcribed by the researcher and the recording destroyed as soon as this is complete.

**Contacts:**
If you have any questions about this research project, please feel free to contact Professor Paulette R. Hebert Ph.D. at (405) 744-5035 (paulette.hebert@okstate.edu) or graduate student Xiaofei Zhang at (405) 744-5035 (xiaofez@okstate.edu). If you have questions about your rights as a research volunteer, you may contact the Oklahoma State University Institutional Review Board (IRB) Chair, Dr. Shelia Kennison at 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

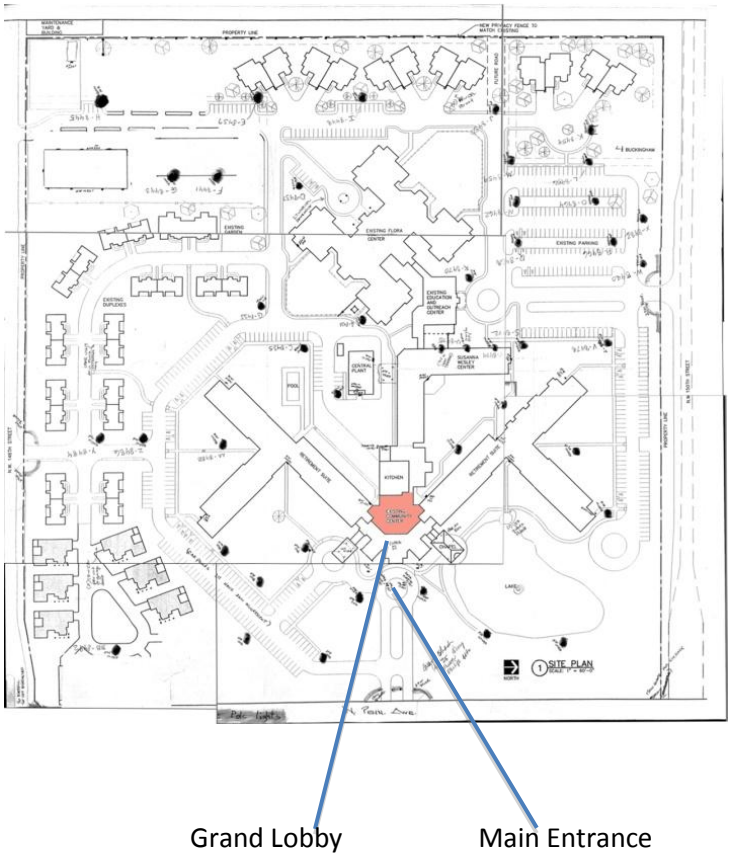
**If you choose to participate:** Your participation in the presentation and discussion indicates your voluntary consent to participate in this research.

APPENDIX E
SURVEY INSTRUMENT

***OPINION OF OVERALL LIGHTING WITHIN INTERIOR PUBLIC SPACES AT EPWORTH VILLA***

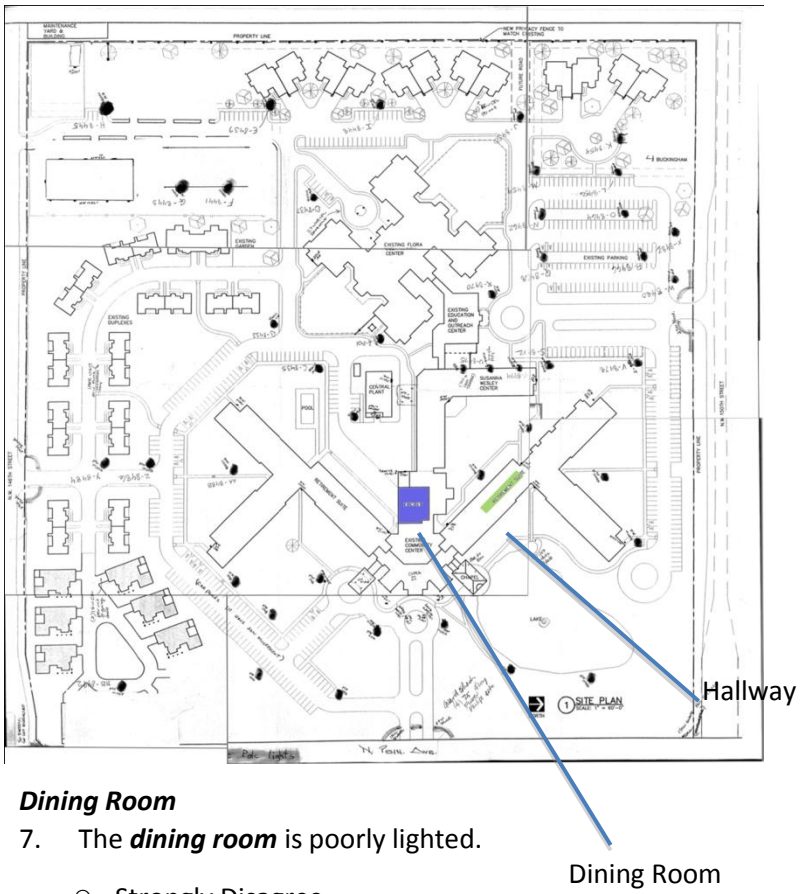
Please fill in the circle next to your answer.

***Grand Lobby***




1. The ***lobby*** is poorly lighted.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know
2. The lights in the ***lobby*** are glaring.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know
3. Overall, the lights in the ***lobby*** are pleasing.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know

For a larger Site Map, Please see the Last Page

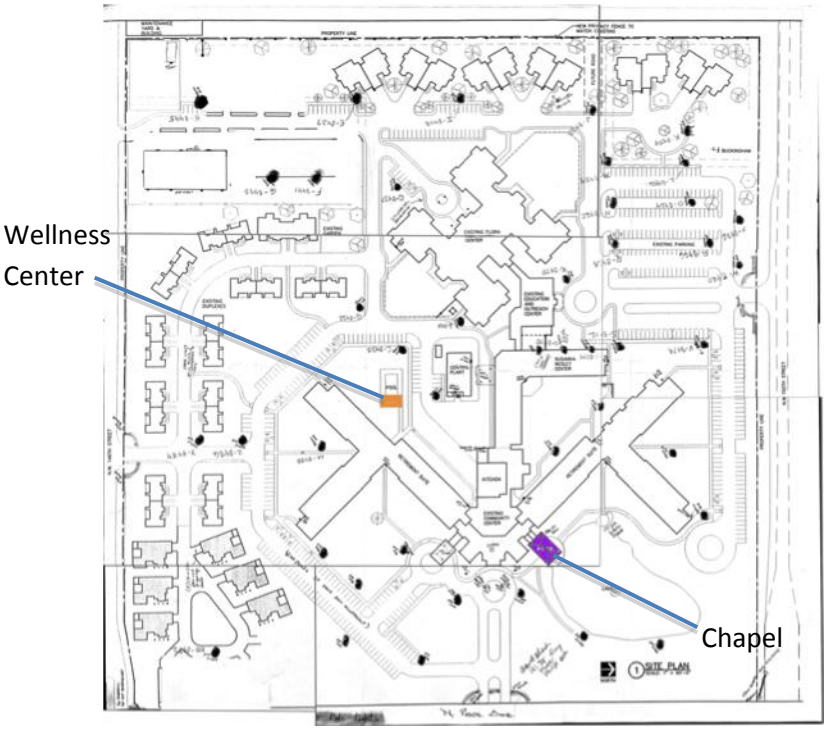



***Dining Room***

7. The ***dining room*** is poorly lighted.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know
8. The lights in the ***dining room*** allow me to see clearly to eat my meal.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know
9. Overall, the lights in the ***dining room*** are pleasing.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree

***Hallway***

4. The ***hallway*** is poorly lighted.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know
5. The lights in the ***hallway*** are glaring.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know
6. Overall, the lights in the ***hallway*** are pleasing.
   - ○ Strongly Disagree
   - ○ Somewhat Disagree
   - ○ Neutral/No Opinion
   - ○ Somewhat Agree
   - ○ Strongly Agree
   - ○ Don't Know



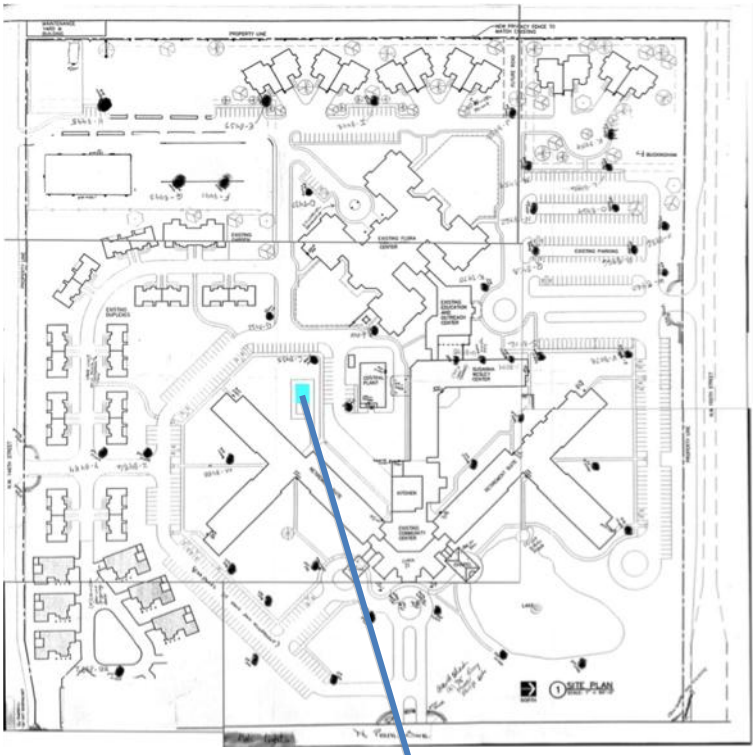

***Kenneth & Evelyn Brill Chapel***

13. The ***chapel*** is poorly lighted.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree
    - ○ Don't Know
14. I would like to turn some lights off in the ***chapel***, since they are bright.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree
    - ○ Don't Know
15. Overall, the lights in the ***chapel*** are pleasing.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree

***Wellness Center***

10. The ***Wellness center*** is poorly lighted.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree
    - ○ Don't Know
11. I would like to turn some lights off in the ***wellness center***, since they are bright.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree
    - ○ Don't Know
12. Overall, the lights in the ***wellness center*** are pleasing.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion

***Swimming Pool Deck***




16. The ***swimming pool deck*** is poorly lighted.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree
    - ○ Don't Know
17. The lights in the ***swimming pool deck*** area are glaring.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree
    - ○ Don't Know
18. Overall, the lights in the ***swimming pool deck*** area are pleasing.
    - ○ Strongly Disagree
    - ○ Somewhat Disagree
    - ○ Neutral/No Opinion
    - ○ Somewhat Agree
    - ○ Strongly Agree
    - ○ Don't Know

**Comments / Suggestions**

If you have any comments or suggestions for the interior lighting in these six public spaces, please feel free to write here:

**Please take a moment to tell me a little bit about you. Fill in the circle next to your answer.**

1. I am…
   - ○ Male
   - ○ Female

2. I was born in the year 19_____.

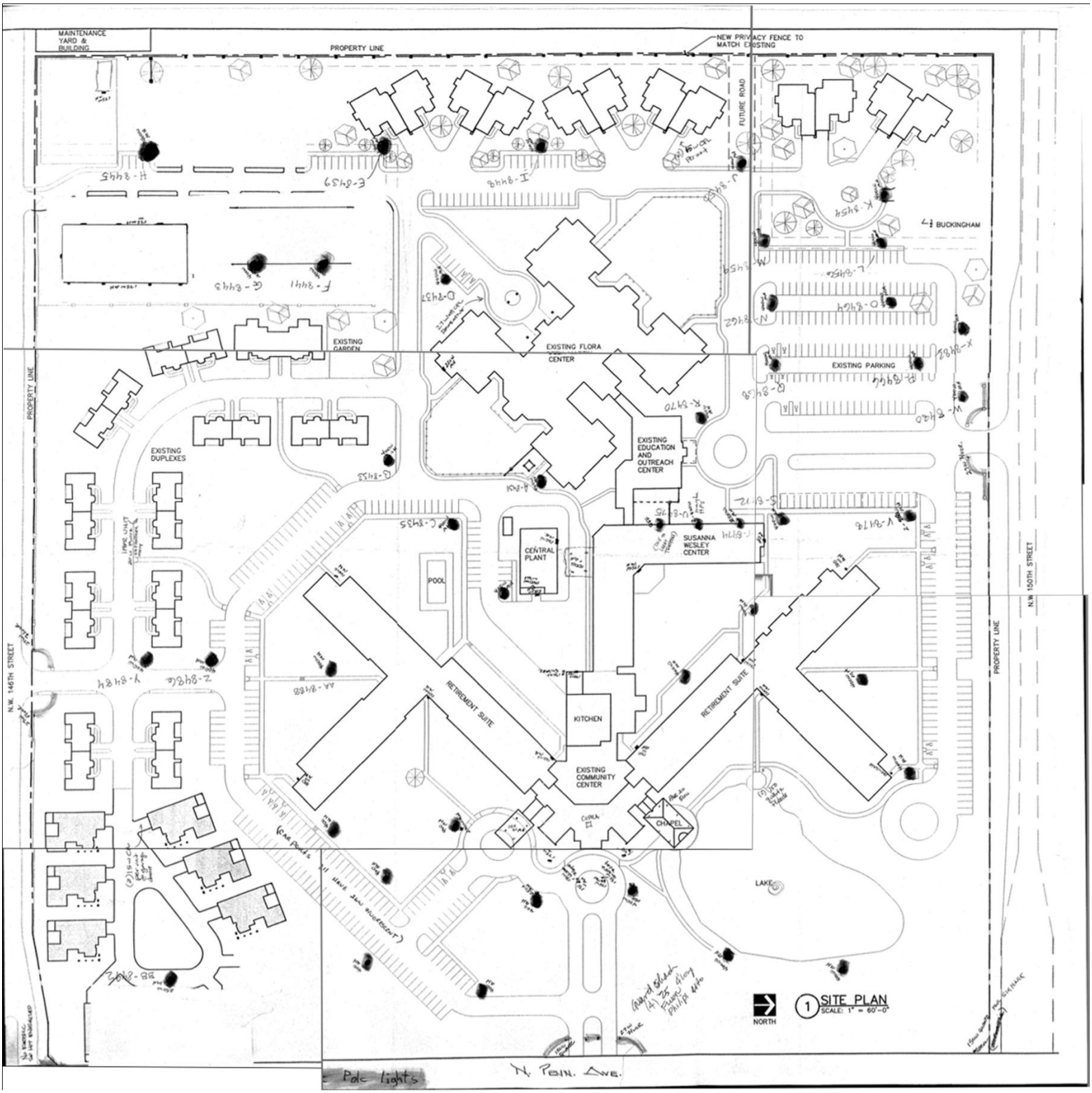
3. I am…
   - ○ Married
   - ○ Divorced
   - ○ Widowed
   - ○ Never Married

4. I am…
   - ○ White American
   - ○ Black American
   - ○ Native American
   - ○ Asian American
   - ○ Other: _____
   - ○ Choose Not to Answer

5. I am…
   - ○ Retired
   - ○ Employed Part-Time
   - ○ Employed Full-Time
   - ○ Other: _____

***Thank you for taking the time to participate in this survey!***

## SITE MAP


MAINTENANCE YARD & BUILDING
PROPERTY LINE
NEW PRIVACY FENCE TO MATCH EXISTING
FUTURE ROAD
BUCKINGHAM
EXISTING GARDEN
EXISTING FLORA CENTER
EXISTING PARKING
EXISTING DUPLEXES
EXISTING EDUCATION AND OUTREACH CENTER
SUSANNA WESLEY CENTER
CENTRAL PLANT
POOL
RETIREMENT SUITE
RETIREMENT SUITE
KITCHEN
EXISTING COMMUNITY CENTER
CHAPEL
LAKE
N.W. 148TH STREET
N.W. 150TH STREET
PROPERTY LINE
PROPERTY LINE
NORTH
1 SITE PLAN
SCALE: 1" = 60'-0"
N. Penn. Ave.
Pole lights

VITA

Xiaofei Zhang

Candidate for the Degree of

Master of Science

Thesis: DESIGNING A SUSTAINABLE LIGHTING SOLUTION FOR OLDER ADULTS IN A CONTINUING CARE RETIREMENT CENTER

Major Field: Design, Housing, and Merchandising; Specialization in Interior Design

Biographical:

Education:

Completed the requirements for the Master of Science in Design, Housing, and Merchandising with a Specialization in Interior Design at Oklahoma State University in Stillwater, Oklahoma, in May, 2012.

Completed the requirements for the Bachelor of Arts in Architecture at the Southwest Jiaotong University in Chengdu, China, in June 2010.

Experience:

August 2010 – May 2011. Teaching assistant, Oklahoma State University.

Taught undergraduate students to learn AutoCAD in DHM 2073. Graded and organized the assignments from undergraduate students in DHM 1003, 2003, and 2073. Assisted faculty to organize the data from researches' surveys using SPSS.

October 2010 – January 2010. Oklahoma State University.

Participated in a research project entitled *"An evaluation of the existing exterior conditions of the Epworth Villa facility"* .

Conferences:

March 2012. Oklahoma Association of Family and Consumer Sciences

Oral presentation entitled *"Case study of existing lighting in public interior spaces at a Continuing Care Retirement Center"* in Edmond, Oklahoma.

January 2012. Graduate Teaching Conference

Successfully completed the conference on teaching at Oklahoma State University.

April 2011. 7th National Sustainable Design Expo

Oral presentation entitled *"The pros and cons of light and dark in my backyard"* in Washington D.C.

Name: Xiaofei Zhang Date of Degree: May, 2012

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: DESIGNING A SUSTAINABLE LIGHTING SOLUTION FOR OLDER ADULTS IN A CONTINUING CARE RETIREMENT CENTER

Pages in Study: 105 Candidate for the Degree of Master of Science

Major Field: Design, Housing, and Merchandising; Specialization in Interior Design

Scope and Method of Study:

This study explores the sustainable lighting suited for older adults and proposed an interior lighting solution for the six public spaces in a Continuing Retirement Center (CCRC). The research includes five stages of the process for the lighting design based on Wellness and Evidence Based Design frameworks. In the programming stage, a preliminary case study measured the existing light levels at a CCRC site; in a follow-up field study interior lighting fixtures' information was collected in selected public spaces; and in a survey of older adults (n=55), participants were asked to evaluate the quantity and quality of existing lighting in six public interior rooms at a CCRC. The design decisions, under schematic stage and design development stage, were based on the field studies and survey results, which was refined after evaluation by a focus group of exerts in the area of older adults and older adult living.

Findings and Conclusions:

Survey results varied but indicated participants' high satisfaction levels with the inadequate light levels in some areas. Participants' familiarity with their environment and the fact that their other needs were met may contribute to these responses. However, responses related to the quantity of interior lighting showed results consistent with the light level measurements from the field study. The proposed design supports the wellness of older adult residents through the use of lights with even uniformity, glare reduction, and which were dimmable. The proposed lighting solution supports not only energy savings and environmental friendliness, but also the special lighting considerations regarding residents' health, which also has the potential to greatly improve the quality of life enjoyed by these individuals. This project represents a progressive design, because of its inclusion of resident surveys regarding interior public lighting and the incorporation of design features intended to reflect the results of the survey.

ADVISOR'S APPROVAL: Paulette R. Hebert, Ph, D.