A POST-OCCUPANCY EVALUATION: TO WHAT DEGREE DO LEED CERTIFIED BUILDINGS MAINTAIN THEIR SUSTAINABLE INTEGRITIES OVER TIME?

By

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To all who nurtured my passion for sustainable design and encouraged me to pursue my academic interests in spite of adversity. This milestone will forever be a reminder to treat every obstacle as a step closer to success

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LIST OF ABBREVIATIONS

BCN	Building Construction
CBE	Center for the Built Environment
CBECS	Commercial Building Energy Consumption Survey
DOE	U.S. Department of Energy
EA	Energy & Atmosphere
EPA	Environmental Protection Agency
ETS	Environmental Tobacco Smoke
FP&C	Facilities, Planning & Construction
FTE	Full-Time Equivalent
GSA	General Services Administration
HVAC	Heating, Ventilation and Air-Conditioning
IEQ	Indoor Environmental Quality
ID	Innovation in Design
KGAL	Kilo-Gallons
KWH	Kilowatt Hour
LEED	Leadership in Energy and Environmental Design
MBTU	Million British Thermal Unit
MR	Materials & Resources
NC	New Construction
OHSU	Oregon Health & Science University
POE	Post-Occupancy Evaluation
PPD	Physical Plant Division
REC	Renewable Energy Certificate
RP	Regional Priority

SS	Sustainable Sites
USGBC	United States Green Building Council
WE	Water Efficiency
WHO	World Health Organization

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This study aimed to investigate to what degree LEED certified buildings maintain their sustainable integrities over time. In order to do so, two specific research questions were examined: 1) Do the buildings consume water and energy at the levels predicted in their LEED applications? 2) Do the buildings meet the Indoor Environmental Quality (IEQ) occupant satisfaction levels recommended by the Center for the Built Environment (CBE) and the USGBC? A post-occupancy evaluation (POE) was conducted for two LEED certified education buildings, Rinker Hall (Building A) and Steinbrenner Band Hall (Building B) at the University of Florida in Gainesville, Florida. With the help of the university's Physical Plant and Facilities, Planning and Construction divisions, LEED documents, metered energy, and water records were collected and compared to reveal current performance levels. Additionally, an adaptation of the University of California, at Berkeley's Occupant IEQ Survey (Center for the Built Environment [CBE], 2006) was created and distributed to building users through the use of an online survey tool. Finally, after analyzing the survey responses, full-time and transient occupants from each building were interviewed to better understand the user satisfaction with their building's design, operation, and IEQ.

The results from the water and energy consumption analysis indicated that on average; both buildings deviated by 39% from their predicted levels of performance. In most cases, this variation was in a more efficient direction, indicating that the consumption of each resource was lower than suggested by the original LEED documentation. Additionally, responses to the Indoor Environmental Quality Satisfaction Survey indicated that both buildings averaged a 79% overall satisfaction rating. However, only 63% of occupants provided satisfactory scores for thermal comfort; this is approximately 17% lower than the levels recommended by the USGBC. When compared to the less stringent CBE standard, which seeks for ratings above the 50th percentile, both buildings demonstrated acceptable scores in all of the IEQ categories.

Subsequent interviews with building occupants were therefore focused on identifying factors that may have contributed to the deviation from predicted water consumption, energy performance levels, and the unsatisfactory scores for thermal comfort. Interviews revealed that occupants were generally aware of their water saving features and felt confident they could use them correctly without receiving formal instruction. However, both buildings experienced issues where water saving features did not function properly. With regard to energy consumption, Building A users were well aware of the energy saving feature, but frequently cited that they did not work properly. Conversely, Building B users were satisfied with their standard lighting controls and often made use of the natural daylight that entered through the clerestory windows. Finally, users from both buildings were generally unsatisfied with their thermal comfort. Typical responses indicated that temperatures were inconsistent throughout both buildings and ranged to the extremes of hot and cold.

Overall, the green features in both buildings appear to be maintaining their sustainable integrities and in some cases, have exceeded the expectations of the design teams. Additionally, with the exception of thermal comfort, building users indicated they were generally satisfied with the design and operation of each building. However, research findings still support the need for a variety of procedural and operational improvements including the installation of independent meters, better communication of sustainable goals, and more frequent assessments of building users' satisfaction with indoor environmental factors. Additionally, improvements to the LEED system itself would include the use of more accurate prediction tools during the application process and to require that Optimized Energy Performance points be awarded based on the savings of energy consumption and not utility costs.

CHAPTER 1
INTRODUCTION

Leadership in Energy and Environmental Design (LEED) is a third party certification program that has long been perceived as the benchmark for the design, construction, and operation of high performance buildings. Developed by the United States Green Building Council (USGBC) in 1998, LEED serves as a tool for buildings of all shapes and construction types (USGBC, 2011). Since 2005, the market for green building has steadily gained support and is predicted to represent 20-25% of non-residential construction by 2013 (USGBC, 2008, Green Building Facts). However, despite the exponential growth in LEED certifications, recent studies have suggested that early modeling data used for estimating performance may not consistently predict the consumption of an operating building (Fowler & Rauch, 2008). For example, "the council's own research suggests that a quarter of the new buildings that have been certified do not save as much energy as their designs predicted and that most do not track energy consumption once in use" (Navarro, 2009, p.2). How then could the degree to which LEED buildings maintain their expected efficiency over time be accurately determined?

Statement of Purpose

As the USGBC pushes the green market forward, it too has pushed for an integrated design approach. "The concept of an integrative approach has emerged as a new paradigm that emphasizes connections and communication among professionals throughout the life of a project" (USGBC, 2009, Green Building LEED Core Concepts Guide). This collaborative cooperation between architects, interior designers, engineers, contractors, and building owners thus lends to the development of efficient and innovative solutions.

During the preliminary design phase of sustainable construction, these stakeholders begin to make selections regarding materials, systems, building operation and other major components. Part of a designer's challenge when implementing sustainable strategies is to balance the additional 2 to more than 5% (USGBC, 2009, Green Building LEED Core Concepts Guide) in construction costs with the expected life-cycle cost savings from improved building performance. Therefore it is essential for designers to thoroughly understand the longevity of each specified strategy if they truly intend to make environmentally conscious decisions and provide a lasting service to their clients.

The goal of this research is to define how implemented sustainable features are performing in certified buildings and identify the factors, which may impact the long-term success of these investments. By sharing actual consumption data of two LEED certified structures on the campus of the University of Florida, this study intends to explore the degree to which LEED certified buildings maintain their sustainable integrities and ultimately inform the field of sustainable design.

Definitions

This study explores the degree to which LEED certified higher education buildings maintain the sustainable integrities. For the purpose of this study, the term "sustainable integrity" is defined as the longevity and soundness of the attributes inherent of green building. Additionally, the terms "green" and "environmentally friendly" are used interchangeably, and are defined as "an approach to building that minimizes harmful effects on human health and the environment" (Craven, 2010, Definition section, para.

1). This building type is the result of synergizing multiple building strategies and regular maintenance by building staff and users. This definition of “sustainable” does not refer to any one particular building feature or manufactured material, but rather the result of multiple features operating harmoniously at the environmental, social and economic levels.

The energy and water consumption data in this study is based on the comparison of current building performance figures to those of a baseline and design case. The current or actual building performance figures are those which were collected by the university’s Physical Plant Division on a monthly basis. A baseline case is the amount of energy or water used by a conventional facility of similar size and built to meet code standards. Alternatively, a design case is the as-designed levels of energy or water use that are predicted during the LEED application process (USGBC, 2009, Green Building Design and Construction). For the purpose of this study, the terms “design case” and “predicted case” are used interchangeably. Both the baseline and design case information in this study were collected from the LEED documents approved by the USGBC.

Assumptions

For the purpose of this study, all water and energy consumption figures collected from the university’s Physical Plant Division are assumed to be accurate and up to date. Should a system reading be inaccurate due to a malfunction or human error, it was averaged based on similar monthly readings from previous years (Appendix F). Additionally, all LEED documentation figures collected from the university’s Facilities, Planning and Construction Division are assumed to be accurate and supersedes information posted in other sources. Any figure found to be inaccurate due to a miscalculation or other human error, was corrected after initial findings could be established and documented.

Similarly, it is assumed that all buildings were constructed to reflect the proposed intent of each property's design team. For the purpose of this studies data analysis, subsequent building performance was not considered to be a result of improper installation of systems or building construction elements.

Limitations

Similar to limitations found in “after the fact” (Sommer & Sommer, 2002, p.209) case studies, this POE takes place several years after the application process and thus leaves room for possible distortions. With the exception of information collected through the Occupant IEQ Satisfaction Survey, the findings of this study heavily rely on the measured consumption figures and LEED documents calculated by the university's Physical Plant and Facilities, Planning and Construction divisions. With consumption data and LEED documents ranging from three to six years old, some limitations arose when LEED documents were difficult to acquire. Once all the documents were finally located, there was still the possibility that calculation and consumption reading may have been produced by older, less precise technology, which could also leave room for error. In order to get the most accurate reading of each buildings performance, research would need to have taken place during the LEED application process and follow-up with several years of trending on each building's operating systems.

Further described in the Chapter 3, a questionnaire was used in order to evaluate the users satisfaction with their building's IEQ. This form of research method, however, is known for having its own set of limitations. “Questionnaires are notorious for their low response rates; that is, people fail to return them” (Kumar, 2005, p. 130). Without collecting surveys from every building user, the sample group is limited to providing a snap shot of the overall occupant satisfaction. Thus this study relied on the occupant interviews in order to gain a deeper understanding of trends that emerged from the IEQ survey and potentially mitigate some of these limitations.

Finally, a generalization of the performance of higher education LEED buildings was limited to the performance of two LEED Gold buildings, or approximately 33% of the Gold certified buildings on this university's campus. With a small sample size it may be difficult to make an accurate assessment of the performance of higher education LEED buildings as a whole. Additionally, only three years of consumption data were available for Building B, thus narrowing the length of time for identifying trends in performance for one of the studied buildings.

CHAPTER 2
LITERATURE REVIEW

The USGBC and the Intent of the LEED System

In 1998, the USGBC launched its first LEED Pilot Project Program, better known as LEED Version 1.0. Originally intended to be a measure of sustainability, the program has since evolved into LEED Version 3.0 and now undertakes a variety of initiatives. In addition to being an evaluation system specifically devoted to building operational and maintenance issues, LEED addresses different project development procedures that exist in the urban planning market. LEED is a third party certification program that serves as a design and construction tool for new and existing institutional, commercial and residential establishments. To date, the LEED system has experienced an exponential growth in registered projects across the globe including the United States, Canada, Mexico, Spain, France, Italy, China, Japan, India, and Australia (Scribd, 2008).

LEED versions 1.0-2.2 are organized into six environmental categories: Sustainable Sites (SS), Water Efficiency (WE), Energy & Atmosphere (EA), Materials & Resources (MR), Indoor Environmental Quality (IEQ) and Innovation in Design (ID); the current LEED 3.0 version has also been expanded to include a Regional Priority (RP) category (USGBC, 2009, *Green Building LEED Core Concepts Guide*). Each category in a LEED rating system is divided into prerequisites and credits. Prerequisites are required green building practices that must be included in all LEED certified projects. Credits are optional strategies that a project may elect to pursue to gain certification. Together the prerequisites and credits help to provide a common foundation of performance and a flexible set of strategies to accommodate a variety of project types. Finally, “each credit is allocated points based on the relative importance of the building-related impacts that it addresses" (USGBC, 2009, *Green Building Design and Construction,* p. 14). As a project progresses through construction or renovation, design teams will submit documentation to demonstrate their compliance with each of the credit requirements. The more credits and points a project achieves, the higher their building will be graded on the LEED measure of sustainability. Platinum is the highest level of certification, followed by Gold, Silver and Certified. Table 2-1 illustrates the matrix of points required to reach each of the four levels of certification within LEED Versions 1.0 -2.2.

Table 2-1. LEED 1.0-2.2 for New Construction (NC) point matrix (USGBC, 2006)

Total possible points: 64 base points, 5 points for Innovation in Design (ID)	
Certified	26 - 32 points
Silver	33 - 38 points
Gold	39 - 51 points
Platinum	52 and above

Water Efficiency (WE) Category

The Water Efficiency (WE) category in all LEED systems "encourages and recognizes efficiency measures that significantly reduce the amount of potable water used by buildings while still meeting the needs of the systems and the occupants" (USGBC, 2009, Green Building LEED Core Concepts Guide, p. 41). As a LEED certified building, it is suggested that measures have been taken to track and conserve water usage associated with restrooms, landscaping and process water for building systems. Some suggested methods for reducing potable water include the use of low-flow fixtures, composting toilet systems, waterless urinals and recycling graywater. By reducing potable water usage, building are able to moderate the demand on our natural resources, reduce the amount of water that must be treated and even lower energy costs associated with water use. Therefore, design teams are often encouraged to strategically plan conservative water systems early in the design process and to continue to monitor water use after the building has been occupied.

One of the most significant contributors to water consumption is a building's irrigation system. Thus, one goal of the WE category is to achieve a 50% minimum reduction in potable water used for landscaping. Early in the landscape design process, all LEED buildings are encouraged to specify water-wise foliage and water-efficient irrigation systems. Xeriscaping or a method of landscaping that makes regular irrigation unnecessary (USGBC, 2009, *Green Building Design and Construction*) and native plant use are methods that can help to eliminate the need for regular irrigation. For areas that are particularly arid the installation of a high-performance system could be an efficient solution. "High-performance irrigation systems include efficient water supply and control technology, such as drip and bubbler distribution systems and water-based irrigation controllers, which respond to weather conditions" (USGBC, 2009, Green Building LEED Core Concepts Guide, p. 44). Finally, for projects that may not be able to specify adapted plants or efficient irrigation systems, LEED suggests less invasive methods such as harvesting rainwater, graywater, or using municipal reclaimed water.

In order to heat and cool commercial spaces, buildings use a series of cooling towers, boilers, chillers, and heating, ventilation and air-conditioning (HVAC) systems. Each of these systems typically uses potable water and therefore has the potential to contribute towards water consumption and costs. The LEED rating system suggests a variety of strategies to reduce process water needs, which would allow this equipment to work more efficiently. Some such strategies include specifying water efficient cooling equipment and integrating harvested rainwater or other nonpotable water sources. By redirecting water from municipal sources, it reduces the burden on our freshwater reserves. Finally, the USGBC highly recommends that all water-using systems be submetered so that leaks can be detected and repaired as soon as possible (2009, Green Building LEED Core Concepts Guide).

According to the USGBC (2009, Green Building Design and Construction), these combined measures can help to reduce the consumption of potable water in commercial buildings by 30%. However, it should be noted that only under the currently LEED version 3.0 are buildings required, by means of a prerequisite, to apply water reducing strategies. Buildings certified prior to version 3.0 could do so without addressing any of their indoor, outdoor or process water consumption. Table 2-2 illustrates the total number of points which may be awarded for each of the credits within the LEED 1.0-2.2 WE category.

Table 2-2. LEED 1.0-2.2 Water Efficiency (WE) category (USGBC, 2006)

	Total possible points: 5 Points	
Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1 point
Credit 1.2	Water Efficient Landscaping, Reduce by 100%	1 point
Credit 2	Innovative Wastewater Technologies	1 point
Credit 3.1	Water use Reduction, Reduce by 20%	1 point
Credit 3.2	Water use Reduction, Reduce by 30%	1 point

Energy and Atmosphere (EA) Category

“Generating electricity from fossil fuels, such as oil, natural gas, and coal, negatively affects the environment at each step of production and use, beginning with extraction and transportation, followed by refining and distribution, and ending with consumption” (USGBC, 2009, Green Building Design and Construction, p. 240). For example, the harvesting of coal disrupts natural ecosystems, creates sludge ponds and devastates landscapes. Since the late 1960’s the processes associated with refining fossil fuels have been linked to the generation of carbon dioxide, nitrogen oxide and sulfur dioxide. Each gas is not only dangerous to occupant health but is also a contributor to greenhouse gas emissions and climate change. Green buildings are intended to address these issues in four primary ways: by improving energy efficiency, reducing the amount of energy required, using more benign energy forms, and by monitoring energy performance (America's Energy Future Panel on Energy Efficiency Technologies, 2010).

In order to improve upon energy efficiency, designers must first look at a building's construction. The specification of a building's "massing and orientation, materials, construction methods, building envelope, water efficiency as well as the [HVAC] and lighting systems determine how efficiently the building uses energy" (USGBC, 2009, Green Building Design and Construction, p. 240). The best means of effectively addressing each of these building factors is to use an integrated design approach, as previously described in this study. During a traditional design approach, professionals such as an architects, interior designers, engineers and contractors, work relatively independently of each other (Prowler, 2008). Often times, this linear method of planning and design can lead to inefficient system solutions. By contrast, the integrated design approach allows all members of the design team to work through an interactive process of observation and analysis, which allows the building team to develop synergistic solutions in which the output of one system can become the input of another.

To save on energy consumption a project may also look at reducing its energy demands. Programs such as Energy Star, "a joint program of the U.S. EPA and the U.S. Department of Energy that promotes energy-efficient buildings, products, and practices"

(USGBC, 2009, *Green Building Design and Construction,* p. 210), can help to identify equipment that requires less power to operate. Thus, their incorporation into a project can help to reduce the lifetime energy load of a building. However, since the cost of energy efficient equipment can at times be higher than conventional equipment, these strategies may be out of reach for some projects. As a result, the USGBC identified some inexpensive architectural features that can easily be incorporate in any project such as light shelves and awnings, which help to reduce the demand for artificial lighting, heating in the winter and cooling in the summer. These effects may also be achieved by orienting the building properly on a site. Finally, the USGBC recommends sizing a building appropriately for its function to help reduce maintenance costs, energy consumption and insulation requirements.

With many of the technological advancements in renewable energy options today, it is now more feasible to meet a building's energy needs through the use of clean energy sources. Some of the available sources across the globe include solar, wind, wave, biomass, geothermal power and hydropower (Alsharafi, 2009). Use of these energy sources avoids the countless environmental impacts associated with the production and utilization of traditional fuels, such as coal, nuclear power, oil, and natural gas. As an alternative solution for projects that may not have the space or budget for the above stated strategies, there is now the option to purchase offsite renewable energy from local utility providers in the form of a renewable energy certificate (REC) (USGBC, 2006) REC's are " tradable, non-tangible energy commodities in the United States that represent proof that one megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource" (Renewable

Energy Certificates, 2010). In addition to supplementing a building's fossil fuel use, the purchase of RECs also promotes the continued generation of renewable energy.

Finally, similar to the submetering strategy described in the WE category, it is highly recommended that all energy systems be monitored throughout the life of the building. In doing so, facility managers are able to verify that systems are meeting energy performance goals and can quickly identify any problems should they arise over time. Additionally, LEED recommends that all operating staff be properly trained on how to use the energy saving systems, such as sensored lights, dimmers and adapted lighting systems. Table 2-3 illustrates the total number of points which may be awarded for each of the credits within the LEED 1.0-2.2 EA category.

Table 2-3. LEED 1.0-2.2 Energy and Atmosphere (EA) category (USGBC, 2006)

Total possible points: 17 points		
Prereq. 1	Fundamental Commissioning of the Building Energy System	Required
Prereq. 2	Minimum Energy Performance	Required
Prereq. 3	Fundamental Refrigerant Management	Required
Credit 1	Optimize Energy Performance	1-10 points
Credit 2	On-Site Renewable Energy	1-3 points
Credit 3	Enhanced Commissioning	1 point
Credit 4	Enhanced Refrigerant Management	1 point
Credit 5	Measurement & Verification	1 point
Credit 6	Green Power	1 point

Indoor Environmental Quality (IEQ) Category

As stated by the USGBC, "Americans spend on average 90% of their time indoors where the Environmental Protection Agency (EPA) reports that levels of pollutants may run two to five times – and occasionally more than 100 times – higher than outdoor levels" (USGBC, 2006, p. 293). In light of the prevalence of harmful indoor pollutants, the primary purpose of the LEED IEQ category is to minimize building-related health problems by providing the occupants with a stimulating, healthy and comfortable environment. In order to accomplish this goal, a designer is required to address the indoor air quality, thermal comfort, lighting and acoustic properties of a building (USGBC, 2009, Green Building LEED Core Concepts Guide).

According to a recent study by the World Health Organization (2008), most of an individual's exposure to air pollutants comes from the inhalation of indoor air. Unbeknownst to buildings users, indoor pollutants are estimated to cause health reactions in as many as 17 million American who suffer from asthma and 40 million who have allergies From a business perspective, building-related illnesses can be translated into the loss of productivity and money spent on health benefits and sick days (World Health Organization [WHO], 2008). Throughout the Indoor Environmental Quality category, the USGBC sought to alleviate indoor air problems in addition to creating strategies that enhanced the lives of building occupants, increase the investment value of buildings, and reduce the liability for building owners. Thus, in order to receive any points under this category a building must adhere to three prerequisites, which require that a project employ strict environmental tobacco smoke (ETS) controls and exceed the current building standards for air quality and acoustic performance. In this manner, LEED certified buildings intend to raise the standards for indoor spaces and provide healthier environments for occupants.

"Thermal comfort, lighting and acoustics are other major aspects of indoor environmental quality that have a significant impact on occupants" (USGBC, 2009, Green Building LEED Core Concepts Guide, p. 65). Studies have shown that user access to natural daylight and views, comfortable temperatures, and appropriate acoustics can directly affect their sense of satisfaction, health and productivity (Fisk, 2000). Thus, several of the credits within this category have been designed to provide building users with controls over these environmental aspects. For example, some potential strategies may be to install operable windows, temperature and lighting controls within all regularly occupied spaces and provide users with natural views to the outdoors (USGBC, 2009, Green Building Design and Construction). Finally, the USGBC encourages all certified buildings to conduct a thermal comfort survey within 18 months of occupancy. This protocol allows both users and maintenance staff with an opportunity to express their concerns with regards to their indoor environmental quality satisfaction. Additionally, this continued maintenance might inform building operators where to make adjustments and potentially identify any system failures throughout the life of the property. Table 2-4 illustrates the total number of points which may be awarded for each of the credits within the LEED 1.0-2.2 IEQ category.

Table 2-4. LEED 2.2 Indoor Environmental Quality (IEQ) category (USGBC, 2006)

Total possible points:15 points		
Prereq. 1	Minimum IAQ Performance	Required
Prereq. 2	Environmental Tobacco Smoke (ETS) Control	Required
Credit 1	Outdoor Air Delivery Monitoring	1 point
Credit 2	Increased Ventilation	1 point
Credit 3.1	Construction IAQ Management-During Construction	1 point
Credit 3.2	Construction IAQ Management- Before Occupancy	1 point
Credit 4.1	Low-Emitting Materials- Adhesives & Sealants	1 point
Credit 4.2	Low-Emitting Materials- Paints & Coatings,	1 point
Credit 4.3	Low-Emitting Materials- Carpet Systems	1 point
Credit 4.4	Low-Emitting Materials-Composite Wood & Agrifiber Products	1 point
Credit 5	Indoor Chemical & Pollutant Source Control	1 point
Credit 6.1	Controllability of Systems- Lighting	1 point
Credit 6.2	Controllability of Systems- Thermal Comfort	1 point
Credit 7.1	Thermal Comfort- Design	1 point
Credit 7.2	Thermal Comfort- Verification	1 point
Credit 8.1	Daylight & Views- Daylight 75% of Spaces	1 point
Credit 8.2	Daylight & Views- Views for 90% of Spaces	1 point

Failures in the System

Over the past decade billions of dollars have been spent on projects seeking a LEED certification, one of the most recognized seals of sustainable building. Currently, there are approximately 34,000 LEED projects across all 50 states and 106 countries (USGBC, 2011). It is estimated that "the overall green building market (both non-residential and residential) is likely to more than double from today's $36-49 billion to $96-140 billion by 2013" (McGraw Hill Construction, 2008, p. 20). Even federal and state government agencies have made a push for sustainability by adopting plans requiring that new construction projects meet the principles of the LEED system (USGBC, 2008, LEED Public Policies). However, if one takes a step back from the wave of the green market does research yet support that certified buildings consistently maintain higher performance levels beyond that which is documented during the application and award ceremony? For example, in 2008 the USGBC assessed 121 certified buildings and found that 53% did not qualify for the EPA's Energy Star label, which ranks buildings after looking at a year of utility bills. Additionally, 15% scored below a 30 in the Energy Star program, indicating that they used more energy per square foot than at least 70% of comparable buildings built to code (Navarro, 2009). An Energy Star rating "score of 50 represents average building performance" (USGBC, 2009, *Green Building Design and Construction,* p. 286).

With the exception of projects registered under LEED version 3.0, once a building is certified, it is certified for life. Though many steps are carefully taken to ensure that these buildings meet the required standards during the application process, none are taken to verify that they are still maintaining their efficient performance levels after certification. In fact, several credits including SS Credit 7.1 Heat Island Effect: Non-

Roof, WE Credit 1- Water Efficient Landscaping, WE Credit 3- Water Use Reduction, EA Credit 1- Optimized Energy Performance, EA Credit 3- Enhanced Commissioning, EA Credit 5- Measurement & Verification, and IEQ Credit 7.2- Thermal Comfort: verification, either allow applicants to make predictions on their building system performance or assume that building owners will follow through on prescribed steps after the certification process has been completed.

For example, the intent of SS Credit 7.1 Heat Island Effect: Non-Roof is to reduce heat islands that may impact human and wildlife habitats. One acceptable strategy for this credit is to predict the amount of shade that will be provided by trees or other landscape features within five years from the date of installation. However, neither the USGBC nor an acceptable representative is scheduled to verify that recipients of this particular credit met their shading requirements as documented. Similarly, WE Credit 3- Water Reduction and EA Credit 1- Optimized Energy Performance, both credits seeking to reduce the amount of water and energy used in buildings, allow engineers to predict the resource savings their buildings will have above a baseline or code compliant case. Up until the release of LEED 3.0, many certified buildings did not track their own usage of these resources. Although LEED 3.0 now requires the submission of these consumption figures, the USGBC has not yet released a plan for those buildings that do not meet their predicted savings or worse, perform below a baseline case. Finally, credits such as WE Credit 1- Water Efficient Landscaping, EA Credit 3- Enhanced Commissioning, EA Credit 5- Measurement & Verification, and IEQ Credit 7.2- Thermal Comfort: verification all require that actions be taken anywhere from six to eighteen months after the certification process has been completed. However, the USGBC does not currently verify that the building owners take these additional steps and has not indicated any plans for auditing these types of credits with the release of the newest LEED 3.0 system.

This particular aspect of the LEED certification process has been under attack from designers, architects, engineers, and energy experts who argue that because building performance is not tracked, certified buildings may be falling short of their goals. In a recent New York Times article, Mireya Navarro describes how many industry experts feel “that [certification] should be withheld until a building proves itself efficient, which is the cornerstone of what makes a building green, and that energy-use data from every rated building should be made public” (2009, p. 2).

Underestimating Water Consumption

As previously described, the WE category in all LEED systems “encourages and recognizes efficiency measures that significantly reduce the amount of potable water used by buildings while still meeting the needs of the systems and the occupants” (2009, Green Building LEED Core Concepts Guide, p. 41). Design teams are often encouraged to strategically plan conservative water systems early in the design development process and to monitor water use closely after the building has been occupied. According to the USGBC, early planning of water efficient measures can help to reduce the consumption of potable water in a commercial building by 30% (USGBC, 2009, Green Building Design and Construction). However, despite the encouragement from the USGBC, evidence has suggested that the water conservation strategies employed in certified buildings need further development to be consistently beneficial.

In order to receive points under the LEED 2.2 WE category, a building must demonstrate a 50% minimum reduction in potable water use for Credit 1- Water Efficient

Landscaping, a 50% reduction for Credit 2- Innovative Wastewater Technology, and a 20% minimum reduction for Credit 3- Water Use Reduction (USGBC, 2006). However, in a building performance assessment conducted by the General Services Administration (GSA), researchers Kim Fowler and Emily Rauch (2008) reviewed the monthly water use of twelve certified office buildings across the country. Of the studied buildings, eight of the buildings in the study excluded their landscaping and process water consumption. However, despite the handicap on 2/3rd of the study group, the findings still indicated that 50% of the buildings were performing above the baseline of a code compliant building. On average all of the buildings combined only manage to produce a 3% improvement below the expected baseline predictions, a far cry from the LEED minimum standard of 20%. Three water hogs in particular; the Robert E. Coyle United States Courthouse and Federal Building in Fresno, CA; the Santa Ana Federal Building in Santa Ana, CA; and the Alfred A. Arraj United States Courthouse in Denver, CO; were found to have consumed approximately 40% more than an equivalently sized building built to code. Worse still, the researchers agreed that “when landscape and process water uses are included, the buildings use significantly more water” (Fowler & Rauch, 2008, p. 39). Based on the collected information it was decided that the struggling water conservation efforts were due to a combination of inaccurate water load calculations, higher than average occupant use, low water costs which created a disincentive to minimize use, and maintenance and operation challenges such as leaks or clogs (Fowler & Rauch, 2008).

Underestimating Energy Consumption

The USGBC describes sustainability as “a series of events with no crisp beginning or end […] rather, it is the process of meeting the needs of the present without compromising the ability of future generations to meet their own needs" (USGBC, 2009, Green Building LEED Core Concepts Guide, p. 6). Recent studies are evaluating sustainability through the analysis of building characteristics including a project's design, system specification, and the resulting building energy performance.

One such study, conducted by Newsham, Mancini, and Birt (2009), extensively monitored the yearly energy flow, light loads, and HVAC loads of six certified buildings. Calculations were taken every 15 minutes and uploaded into an energy simulation model for evaluation. The results of the simulation indicated that the buildings did manage a savings in energy use when compared to a code-compliant building, however, all of the buildings performed less efficiently than predicted during their applications. This study concluded that the building designers were optimistic about the behavior of the end users and that deviation from the predicted savings was a result of the actual building operation practices.

In the GSA study previously described, the researchers also reviewed the energy consumption levels of their twelve case studies. Building contacts helped to provide utility bills for twelve consecutive months. These findings were then compared to "industry baselines developed [by] the GSA, the U.S. Department of Energy (DOE), International Facility Management Association, Building Owners and Managers Association International, U.S. Environmental Protection Agency, University of California at Berkeley's Center for the Built Environment, and the Energy Information Administration" (Fowler & Rauch, 2008, p. ix). As a result, they found the LEED NC-Certified, Federal Building in downtown Youngstown, Ohio to be of particular concern. Some identified issues during the assessment included its lack of structural energy-saving features and its gas guzzling cooling system (Navarro, 2009). Subsequently, it did not score high enough to qualify for the Energy Star label and did not meet the minimum Optimized Energy Performance credits that the LEED 3.0 system now requires. Thus, “Youngstown would not receive certification under the current system” if they were to reapply (Fowler & Rauch, 2008, p. 46).

Similarly, in a study by Turner and Frankel (2008), the measured energy performance for 121 LEED NC buildings were collected and analyzed. Each building provided at least one full year of measured post-occupancy energy usage data, which was then compared to that of the national building stock database. “National EUI data comes from the Commercial Building Energy Consumption Survey (CBECS), a national survey of building energy characteristics completed every four years by the federal Energy Information Administration” (Turner & Frankel, 2008). Results from this study indicated that over half of the projects deviated from their predicted performance levels by 25%. Of these buildings, 30% did perform higher than expected but 25% performing significantly lower. Researchers also noted, that of the original 552 LEED certified buildings contacted for this study, only 22% were either able or willing to provide their energy consumption figures; suggesting that very few LEED buildings track their energy consumption after occupancy. This study concluded that due to the scattered performance results, improvements would need to be made to current energy prediction tools in order to obtain more accurate results in the future.

Issues with Indoor Environmental Quality

Similar to the discrepancies noted for the energy and water consumption of LEED buildings, case studies suggest that the IEQ category may not be an exception. In light of the indoor pollutants identified by the EPA, the primary purpose of the LEED IEQ category is to minimize building-related health problems by providing the occupants with a stimulating, healthy and comfortable environment. Design teams accomplish this goal by addressing a variety of factors including indoor air quality, thermal comfort, lighting, and acoustic building properties (USGBC, 2009, Green Building LEED Core Concepts Guide).

Currently, an industry metric standard for occupant satisfaction with IEQ is the CBE’s Occupant Indoor Environmental Quality core survey. The survey questions require a participant to provide a numeric representation of their satisfaction with each of the following key elements: Office, Layout, Office Furnishings, Cleanliness and Maintenance, Thermal Comfort, Air Quality, Lighting and Acoustic Quality. A researcher may then collect an average satisfaction rating for each element and then compare them to the CBE’s database, which contains results from over 51,000 completed surveys. A good response rating according to the CBE is a score greater than the 50th percentile.

In the same case study mentioned before, the GSA researchers created a modified version of the CBE survey. Users from all twelve buildings under study provided survey responses from which the researchers were able to draw the following results: participant responses indicated that 50% of the buildings in the study received scores that were lower than that accepted by the CBE. The key elements most frequently found below the 50th percentile include Thermal Comfort, Lighting, and Acoustic Quality. Although on average these buildings did still report a higher score than the industry baseline cases within the CBE database, in comparison to other LEED certified buildings, the Air Quality category was found to be below standards. (Fowler & Rauch, 2008).

Factors Affecting Building Performance

For over a decade designers have pushed the envelope of cooling, heating and operating systems in an effort to create more efficient buildings. As an added bonus to certification seekers, all LEED systems propose a variety of strategies that can be used to reach each credit goal. As research has shown, however, some of these efforts have been successful but an alarming percentage of certified buildings have missed their marks. What then are some of the identified factors affecting even the most cutting-edge of sustainable technologies?

Building Occupants

In an issue of the Oregon Environmental News publication, author Len Reed (2009) pinpoints what he believes is the main culprit: building occupants. The desktop computers that get left on during lunch hour, the line up of power-hogging photocopiers, and the space heaters under every other desk are all noted examples of the fallible human behaviors affecting efficiency. All too often, it seems that building occupants are unaware of their own energy use, and without the committed participation of everyone such actions can negate the benefits of sustainable design elements. A case in point is the highly acclaimed Oregon Health & Science University's (OHSU) Center for Health & Healing, which was the first medical and research facility anywhere to achieve LEED Platinum. In order to reach this level of certification a variety of sustainable solutions needed to be applied including the use of sunshades that doubled as solar power generators, efficient chilling beams in lieu of central air-conditioning, and the first on-site micro-turbine plant in Oregon (Gerding Edlen Development, 2010). However, according to a recent POE conducted by the university, the actual energy cost savings was approximately 10% lower than that predicted during the certification process (Rdesinski et al., 2009). Once again the finger was pointed to building users who managed to consume twice as much energy than engineers originally anticipated (Reed, 2009).

But OHSU is not the only party guilty of underestimating building user's energy consumption. Pacific Lutheran University's (PLU) Morken Center for Learning and Technology received a LEED Gold certification under version 2.0 for allegedly optimizing their energy performance by 49% (Peter Li Education Group, 2008). Some of the applied strategies to reach his goal included the following:

> The structure's east-west elongation and slender form allow for significant use of on-site resources of sun, wind and light. An optimized envelope design allows the designed building systems to achieve remarkable efficiency. A ground source heat pump system, which circulates water through pipe coiling 300 feet down into the site offsets the need for grid power to heat and cool the facility, and provides occupants with individual controls over their thermal environment. […] Motion sensors control the lights and shut them off when rooms are unoccupied [and] the light fixtures used emit 25% more light and are 33% more efficient than standard fixtures (Peter Li Education Group, 2008, p. 2).

Despite its structural design and intended efficiency, once occupied researchers found that users consumed more than four times the energy from plugged-in electronics, otherwise known as plug loads, than forecasted by the Portland based engineers. Investigating engineers suspect that a miscalculation in the number of user computers could be one of the problems (Reed, 2009).

Building occupant behavior has also been found to affect the intended reduction in potable water use. In the same LEED Platinum OHSU building introduced above, a variety of initiatives were taken to reduce their demands on local water sources. For example, "all non-potable water usage for the building [was] provided through rainwater collection, reclaimed wastewater and groundwater from the parking garage dewatering system" (Rdesinski et al., 2009 p. 40). Documentation of these strategies during the LEED application process resulted in an estimated potable water savings of 56%. However, metered data collected for a university-run POE, indicated that the water consumption volume was 61% more than originally estimated. Researchers attributed part of this increase to the underestimation of both the fixture use per building occupant and the total number of patients visiting the building (Rdesinski et al., 2009).

Building Systems and Operation

Although underestimating occupant behavior is frequently cited as a factor affecting green building performance, it is not the only identified issue with sustainability. Research may suggest that the specified systems themselves may also be at fault. For example, many high performance buildings utilize a series of state of the art operating systems as a means of achieving anticipated efficiency goals. While these systems are theoretically the best choice from a design perspective, they are often accompanied by a set of complex controls that can be difficult to operate. "Complex building systems (in any building, not just green or high performance buildings) often require improvements and iterative adjustments" (Hinge, Taneja, & Bobker, 2008 p. 3) to ultimately operate as designed. In fact, it can often take buildings several years or seasonal cycles to be calibrated to optimal performance settings. The complexity of these systems is only made worse by the disconnect that exists between building managers and building designers. After construction is complete and the building is occupied it is often difficult for managers to approve the added expense of a POE; preventing an opportunity for designers to identify systems failures that may have been the result of underestimation, miscalculation, improper installation, and more.

How the USGBC is Bridging the Gap

As the evidence challenging the long-term effectiveness of green design continues to compound, the pressure has been placed on the USGBC to make improvements to its rating system. Coincidentally, at the start of this study and soon after the release of the new LEED version 3.0, the USGBC issued a press release announcing several new strategies for tackling building performance head on. Projects now seeking LEED certification under version 3.0 are required to report 5 years of energy and water use data to the USGBC for analysis. Building owners may meet these requirements in one of three ways: 1) provide the data to the USGBC on an annual basis, 2) sign a release to authorize the USGBC to access the building's consumption data directly, or 3) recertify the building on a biannual cycle using the LEED for Existing Buildings rating system (Pulsinelli, 2009). With this information the USGBC may monitor the actual performance of their certified buildings, provide building owners with useful feedback, and continue to improve performance gaps that may exist between predicted building performance and actual performance. In summation of this new commitment, USGBC Senior Vice President, Scot Horst, states "this initiative is about gathering knowledge about building performance in a way no one has ever done before. The information that we collect from our certified projects is a workable, holistic approach for achieving better performing buildings" (USGBC, 2009, *Press Release: USGBC Tackles Building Performance Head On,* p. 1*).*

It should be noted, that despite the leap the USGBC has made in the right direction, the evolution of its systems is still not complete. Currently, the requirement for reporting energy and water data has been added to the LEED 3.0 Reference Guide in the form of a web based addendum. Although the requirements clearly state that projects must commit to sharing this data, the USGBC has not yet determined how they will address projects that use more resources than originally predicted or worse, more than those built to code standard. “Although some critics have suggested that certification be revoked if an individual building ever fails to live up to its claims, the USGBC has not yet taken that draconian step” (Stetz, 2009).

Building Occupant Needs in High Performance School Buildings

Beyond the sustainable requirements set by the USGBC’s LEED systems, a series of design elements are necessary in order to meet the needs of modern day classroom users. In Nair and Fielding’s book (2007) *The Language of School Design*, researchers begin to define these fundamental features and better understand the complexity of human behaviors that take place within learning environments. Based on their own research and experience with educational environments, Nair and Fielding’s found that successful designs often balance four realms of human experience: spatial, psychological, physiological, and behavioral experience. In three dimensions these experiences can manifest into a variety of design elements. For example, designers are encouraged to create studios that allow for both large and small group learning sessions. This method helps to provide for a variety of student learning types and can instill a sense of community in building users. In recent studies, researchers have begun to link a number of user benefits, including improved health and class performance, to environments with natural light and a connection to the outdoors (Heschong Mahone Group, 1999). Thus, it is also suggested that classrooms have welcome entries, views to the outdoors and access to natural ventilation. Finally, the modern day classroom must also be flexible in its layout and technology devices and installation. More often than not, users require their environments to be as dynamic as they are. With the ability for a classroom and its technology to be flexible, users can most easily shape the room to best suit their needs and update technology and equipment when necessary.

CHAPTER 3
RESEARCH METHODOLOGY

Research Design

In order to capture a picture of each building's overall performance, a POE was used to assess the physical qualities as well as the occupants' satisfaction with three categories of LEED certified buildings: water consumption, energy consumption, and indoor environmental quality (IEQ). Prior to collecting data, however, participating buildings were carefully selected based on their ability to meet a series of criteria. Each building had to be occupied and LEED certified for at least one year prior to this study. With the current LEED 3.0 system still under development and open to additions to its requirements, this investigation only reviewed occupied buildings that had been certified under LEED versions 1.0-2.2. At a minimum, each building had to have achieved WE Credit 3.0 for Water Reduction, EA Credit 1.0 for Optimized Energy Performance, and 50% of the credits within the IEQ category. Each of these LEED documents was used to establish the initial design intent and sustainable goals for each building. Also, all of the buildings needed to be able to provide their energy and water consumption figures from independent meters; a criteria that proved to be the most difficult to achieve on a campus setting were buildings often share meters. Finally, it was important to select buildings that were located within a single climate zone in order to eliminate any building performance variation that may have occurred due to climate changes such as temperature, humidity and precipitation. Based on this criteria only two buildings, Rinker Hall (Building A) and Steinbrenner Band Hall (Building B), qualified from the initial list of certified buildings. Building A and Building B, however, still represent 1/3 of the LEED Gold certified projects on the university campus at the time of this study.

Under the LEED WE, Credit 1- Water Efficient Landscaping, Credit 2- Innovative Wastewater Technology, and Credit 3- Water Use Reduction, the USGBC allows applicants to predict the total annual volume of water consumption from regulated fixtures in gallons (USGBC, 2006). Therefore, this study collected a minimum of one year of consumption data for the metered indoor water systems and the predicted water LEED documents from the university's Physical Plant and Facilities, Planning and Construction divisions. The predicted water consumption, the present water consumption data, and the baseline case were all translated into line graphs to illustrate the annual water use trends. These consumption trends were then compared in order to identify any significant differences between the consumption types. This direct comparison helped to quickly capture how the buildings water conservation strategies were functioning over time as well as indicate if the buildings were performing at the LEED standard.

Similarly, under the LEED Energy and Atmosphere (EA), Credit 1- Optimized Energy Performance, energy simulations models are often used to "demonstrate a percentage improvement in the proposed building performance rating compared to the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2004" (USGBC, 2006, New Construction Reference Guide, p. 173). In other words, the higher the percentage a building saves in energy as compared to a similar code compliant building, the more points the project earns under this specific credit. This study collected a minimum of one year of consumption data for the metered mechanical systems and the predicted energy LEED documents from the university's Physical Plant and Facilities, Planning & Construction Division, respectively. Similar to an electric bill, the metered consumption information itemizes the month-by-month energy use of the building's steam, chilled water and electrical systems. The predicted energy consumption submitted for EA Credit 1, the present energy consumption data, and the consumption for a baseline case were all translated into line graphs to allow for easy comparison. Using the same methods as described for water use, all three consumption types were compared in order to identify significant differences. These findings quickly indicate if the building's energy systems are performing as predicted on an annual basis.

Finally, an IRB reviewed adaptation of the CBE's Occupant Indoor Environmental Quality survey was used to assess the building users' satisfaction with the overall building design, operation, and IEQ (Appendix A). This survey utilized a qualitative methodology to estimate how a building was performing from the perspective of the building occupants (CBE, 2006). Using a Likert scale, building users evaluated the following key aspects of their environment: Workspace Layout, Workspace Furniture, Thermal Comfort, Indoor Air Quality, Lighting Levels, Acoustic Quality, Water Efficiency, and Cleanliness/Maintenance. As previously mentioned, the CBE suggests that participant responses fall above the 50th percentile. With regard to thermal comfort in particular, however, the USGBC recommends that corrective action be taken should more than 20% of the occupants be unsatisfied (USGBC, 2006). This study compared its survey responses to both of these industry standards.

Building users were selected based on their qualifications as full-time or transient occupant (refer to Chapter 3 for a complete description of both user types). All participants had to be eighteen years or older, and either work full-time, part-time or have been transient occupants for a minimum of three months in each respective LEED building. After a minimum of 100 surveys were collected from each building, a random sampling of 20 building users were asked to participate in personal interviews. These interviews were used as a tool to further understand any trouble areas that had been identified in the surveys.

Research Setting

Climate Condition on Site

In order to best qualify the findings presented by this study, it was necessary to characterize the site and climate in which each LEED building is found. According to The National Climatic Data Center (2010), each building has been located in the north central part of the Florida peninsula. Their terrain is relatively level and shares a close proximity to several lakes in the east and south direction. Rainfall can be expected every month, however, it is noted as most abundant from showers and thunderstorms in summer. The average number of annual thunderstorm hours is approximately 160 and monthly precipitation values range from an average of 1.9 inches in October to 6.7 inches in August (Figure 3-1).

During the summer months, generally thought to be between June 1st and September 30th, temperatures can range from the low 70 °F (21 °C) in the evening to 90 °F (32 °C) during the day. By contrast the winter months, generally between early-October and late May, can see temperatures drop below 30 °F (-1 °C) in the evening and rise to 69 °F (20.5 °C) during the day. Occasionally this area can reach freezing temperatures between 15 °F and 20 °F (-8.5 °C) and sustained freezes have occurred every few years. Cold temperatures, however, are almost always accompanied by high-pressure systems and clear skies (The National Climatic Data Center, 2010).

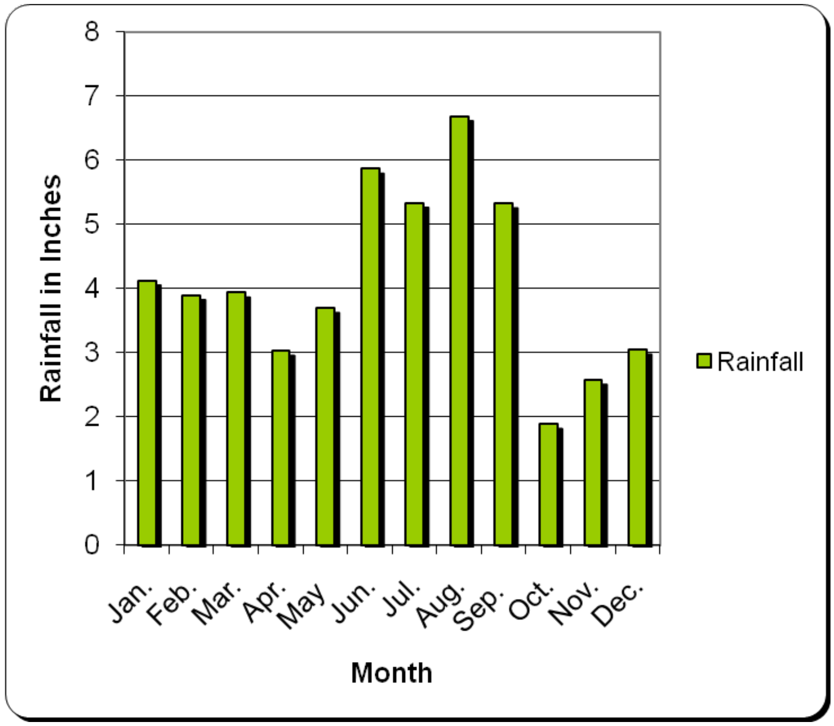

Figure 3-1. Average rainfall for building sites. (Adapted from National Climatic Data Center, 2010)

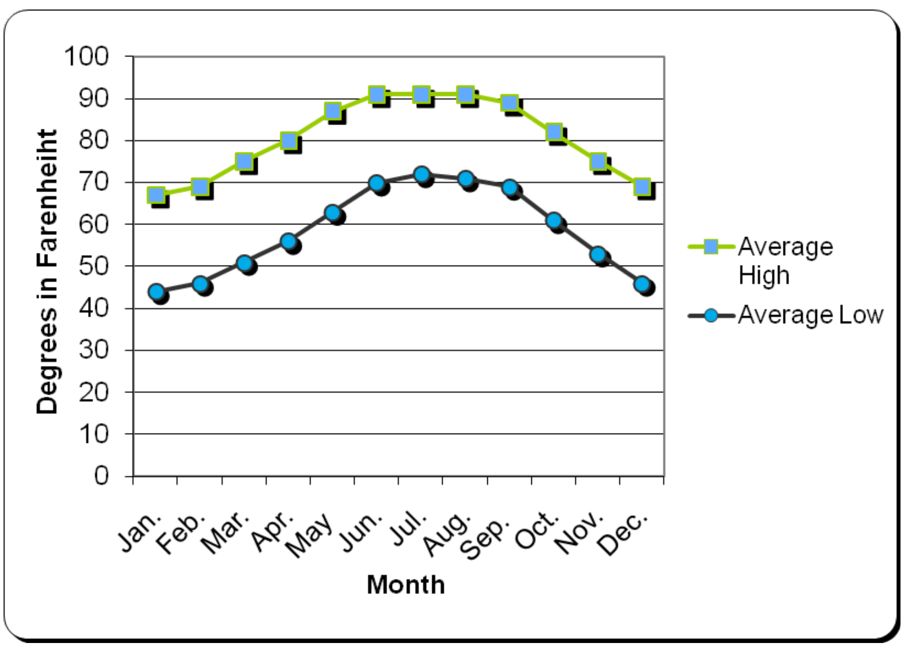

Figure 3-2. Average temperature for building sites. (Adapted from National Climatic Data Center, 2010)

LEED Building Overview

Prior to collecting consumption figures and user satisfaction levels, it was important to establish each building's design intent and the user needs the design teams sought to satisfy. After creating these descriptions, it is clear that each building was tailored to meet the needs of two very different occupant types. For example, Building A (Rinker Hall) focused on providing appropriate lighting levels and flexible floor plans for classroom users and laboratory technicians, whereas Building B (Steinbrenner Band Hall) focused on creating a space that could serve the acoustic and thermal requirements of musicians. These profiles illustrate the goals each building set out to meet and help to provide a basis of comparison for this study's IEQ survey.

Building A (Rinker Hall): User Needs and Construction Profile

A B

Figure 3-3. Series of Building A views. A) taken from the interior, B) taken from the exterior (USGBC,2008, Rinker Hall at the University of Florida)

Located in the northeast quadrant of the university campus, Building A was intended to be a leadership facility for the university's College of Design, Construction and Planning. More specifically this building's design focuses on the needs of the students enrolled in the School of Building Construction, the nation's oldest and most recognized program of its type. This new construction project, completed in March of 2003, accommodates a variety of work environments including 46,530 square feet of classrooms, teaching labs, construction labs, faculty and staff offices, and student facilities. In a project description on the USGBC website, Building A focused on addressing user environmental comfort and lighting needs in a variety of ways. For example, the building features an 8,000-gallon cistern for collection of rainwater and is oriented on a north-south axis to naturally utilize low-angle light. Additionally, much effort went into creating what the design team referred to as “access mapping/flexibility” (USGBC, 2008, Rinker Hall at the University of Florida). This design approach allowed for the consolidation of all support systems such as the mechanical, telephone, data systems, and sprinklers, in anticipation of future upgrades. Similarly, classrooms were arranged to provide unobstructed servicing and maximum flexibility for future retrofitting (USGBC, 2008, Rinker Hall at the University of Florida). Table 3-1 and Figure 3-5 summarize the construction profile and illustrate the floorplans for Building A.

Table 3-1. Building A (Rinker Hall): construction profile (University of Florida, Division of Facilities, Planning and Construction, 2009, UF LEED Certified Project Scorecard Compilation)

Building A: construction profile	
College:	School of Building Construction
GSF:	46,530 (New Construction)
Project Description:	This project scope included the construction of classrooms, teaching laboratories, office/computer rooms and campus support services.
Year Built:	2003
Architect:	Gould Evans & Croxton
Mechanical, Electrical And Plumbing Engineer:	Lehr Associates
General Contractor:	Centex-Roony Construction Company
Structural Engineer:	Walter P. Moore Associates

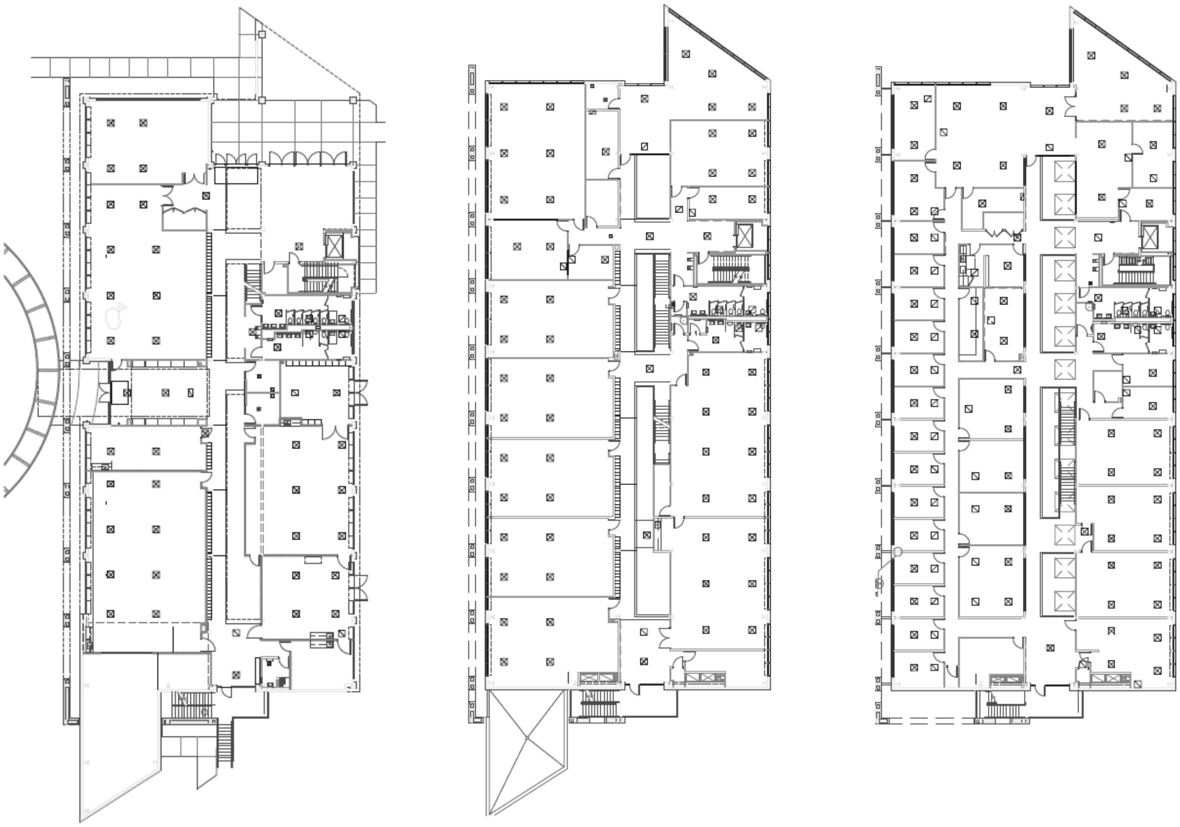

Figure 3-4. Building A ground, second, and third floor plans (USGBC,2008, Rinker Hall at the University of Florida)

Building B (Steinbrenner Band Hall): User Needs and Construction Profile


A


B

Figure 3-5. Series of Building B views. A) taken from the exterior, B) taken from the interior (University of Florida, Division of Facilities, Planning & Construction, 2009, LEED Brochure: George Steinbrenner Band Hall)

Located in the northeast quadrant of the university campus, Building B was intended to be the primary rehearsal hall for the collegiate marching band. Completed in

2008, this freestanding, 18,082 square foot facility accommodates the needs of both the student performers and faculty alike. The project was located on a sloped site, which allowed designers to imbed the building into the terrain and create a new outdoor terrace space with may also be used as a staging area. On the building's lower level the students were provided with ample storage room for large instruments, sound equipment, sheet music, uniforms, and a music hall that comfortably seats up to 300 performers. This building's use as a rehearsal hall naturally required that special attention be paid to the acoustic and thermal characteristics of several systems. For example, the mechanical systems were designed to be virtually silent so as not to disturb the musicians. Additionally, with the potential to have 300 students blowing hot air into their musical instruments at once, the engineers needed to focus on designing an HVAC system that could successfully regulate the indoor humidity levels. With student and storage facilities located on the lower level, the designers were able to utilize the upper level as an administrative suite for faculty and staff. A large open lobby was included to provide both a welcoming entry space as well as an additional gathering space for large events. Due to this building's location in the southeast region its enhanced envelope design and construction materials were selected to withstand hurricane force winds. Thus, as an added bonus to building users and community members, this building may also double as a public shelter in the event of severe weather conditions. Finally, the exterior of the building offers new seating, landscaping, bike racks, and a loading dock outfitted with an electric car charging station (University of Florida, Division of Facilities, Planning & Construction, 2009, LEED Brochure: George Steinbrenner Band Hall). Table 3-2 summarizes the construction profile for Building B.

Table 3-2. Building B: construction profile (University of Florida, Division of Facilities, Planning and Construction, 2009, UF LEED Certified Project Scorecard Compilation)

Building B: construction profile	
College:	College of Music
GSF:	18,082 (New Construction)
Project Description:	This project scope included the construction of a rehearsal hall for the university's band, offices, instrument storage/issue room, and band library.
Year Built:	2008
Architect:	Zeidler Partnership Inc.
Mechanical, Electrical And Plumbing Engineer:	Affiliated Engineers SE Inc.
General Contractor:	MM. Parrish Construction Co.
Structural Engineer:	Walter P. Moore Associates

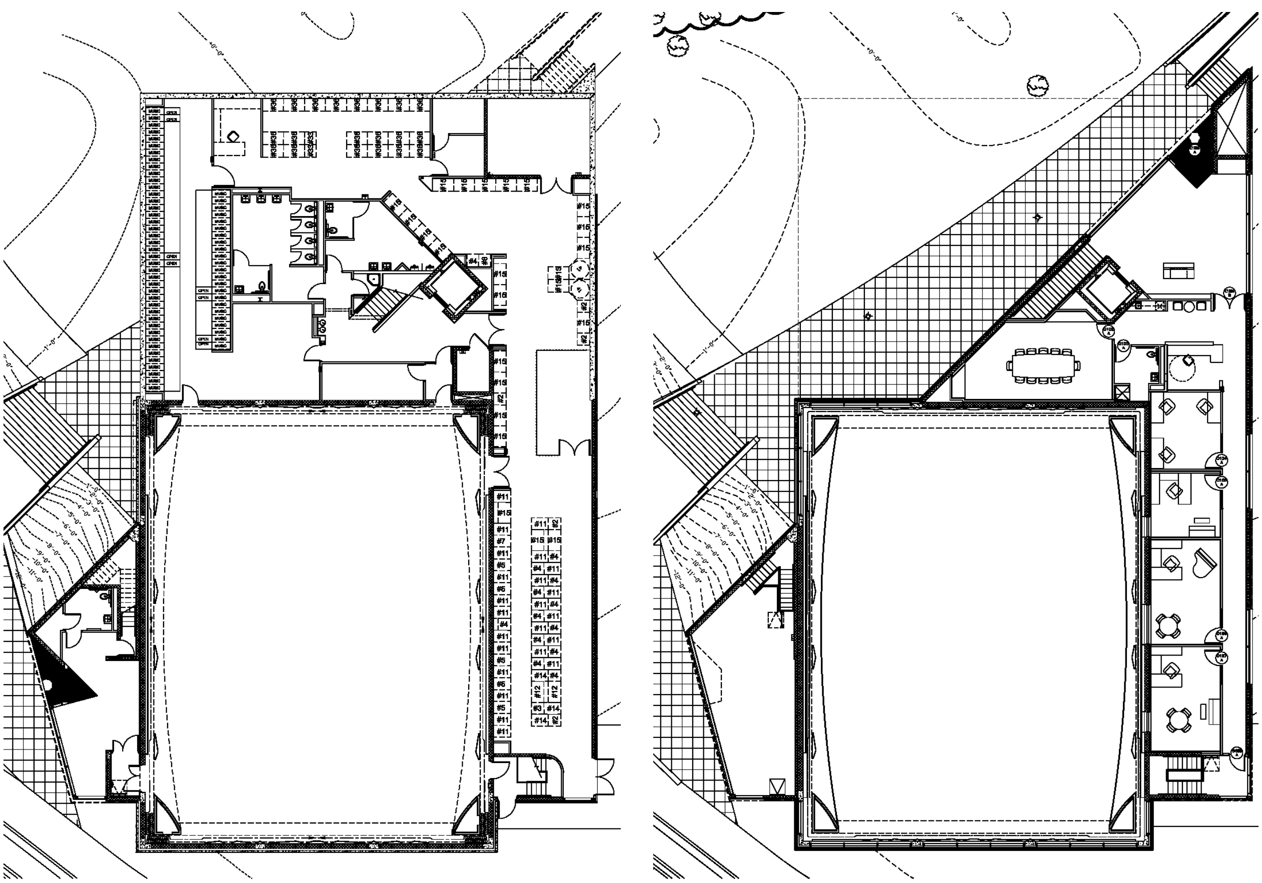

Figure 3-6. Building B ground and second floor plans (University of Florida, Division of Facilities, Planning & Construction 2011)

LEED Point Matrixes per Category

In order to establish the point matrix illustrated in Table 3-3, this study collected and analyzed the original LEED documentation submitted to the USGBC during each building's certification process. From this information, the number of credits and subsequent points each building successfully earned was confirmed. Therefore, any information collected from the LEED documents supersedes that which may have been found on other resources such as websites, press releases or department marketing brochures. As indicated in table 3-3, Building A was certified under LEED version 2.0 for new construction. Overall Building A received a total of 39 points; 4 were obtained within the WE category, 9 from the EA category, and 8 from the IEQ category. Alternatively, Building B was certified under the LEED version 2.2 for new construction. In total Building B received 41 points; 5 were obtained within the WE category, 6 from the EA category, and 11 from the IEQ category.

Table 3-3. LEED building point matrix per category (University of Florida, Division of Facilities, Planning and Construction, 2009, UF LEED Certified Projects Scorecard Compilation)

Building Name	Certification Type	Certification Level	Total Points Earned	WE Category Points Earned	EA Category Points Earned	IEQ Category Points Earned
Build. A	NC-v2.0	Gold	39	4	9	8
Build. B	NC-v2.2	Gold	41	5	6	11

Table 3-4 indicates the individual credits and points earned by each building under the WE category. It should be noted that Building B received an exemplary performance point under ID credit 1.2 for predicting reduction in water use by 40%. Thus, the projected water savings is 10% beyond what the USGBC ordinarily requires under WE Credit 3-Water Use Reduction. In such cases, it is suggested that water saving strategies were carefully selected and specified early in the design process. Credit 3-Water Use Reduction also helps to provide a direct correlation between the indoor water consumption that was predicted during the LEED certification process and the actual water consumption later found for each building.

Table 3-4. Water Efficiency point matrix per credit (University of Florida, Division of Facilities, Planning and Construction, 2009, UF LEED Certified Projects Scorecard Compilation)

Building Name	Credit 1: Water Efficient Landscaping	Credit 2: Innovative Wastewater Technologies	Credit 3: Water Use Reduction
Building A	2	0	2
Building B	2	1	2 + 1ID

Table 3-5 indicates the individual credits and points earned by each building under the EA category. Note that the majority of points earned for Building B and all of the point for Building A under this category are earned under EA credit 1- Optimized Energy Performance. This credit helps to provide a direct correlation between the energy consumption that was predicted during the LEED certification process and the actual energy consumption later found for each building.

Table 3-5. Energy and Atmosphere point matrix per credit (University of Florida, Division of Facilities, Planning and Construction, 2009, UF LEED Certified Projects Scorecard Compilation)

Building Name	Credit 1: Optimized Energy Performance	Credit 2: Renewable Energy	Credit 3: Enhanced Commissioning
Building A	9	0	0
Building B	4	0	1
	Credit 4: Enhanced Refrigerant Management	Credit 5: Measurement and Verification	Credit 6: Green Power
Building A cont.	0	0	0
Building B cont.	0	0	1

Table 3-6 indicates the individual credits and points earned by each building under the IEQ category. These credits help to identify the measures taken during the LEED certification process to improve the quality of each buildings indoor environment. It should be noted that both buildings qualified for IEQ Credit 7-Thermal Comfort, which suggests that thermal comfort strategies were carefully selected and specified in the early stages of design. Thus we should expect to find that both buildings meet the minimum 80% thermal satisfaction rating recommended by the USGBC.

Table 3-6. Indoor Environmental Quality point matrix per credit (University of Florida, Division of Facilities, Planning and Construction, 2009, UF LEED Certified Projects Scorecard Compilation)

Building Name	Credit 1: Carbon Dioxide Monitor	Credit 2: Increased Ventilation	Credit 3: Construct. IAQ Manage	Credit 4: Low-Emitting Material
Building A	0	0	1	3
Building B	1	0	2	4
	Credit 5: Indoor Chem. & Pollutant	Credit 6: Control. of Systems	Credit 7: Thermal Comfort	Credit 8: Daylight & Views
Building A cont.	0	1	1	2
Building B cont.	1	1	2	0

Total Building Occupancy

In order to complete many of the credits during a LEED application process, design teams must first determine their total building occupancy. This is calculated using two figures: the number of transient occupants and the Full-Time Equivalent (FTE) number. Transient users are defined as “occupants who do not use a facility on a consistent, regular, daily basis” (USGBC, 2009, Green Building Design and Construction, p. 670). For this study, student users or visitors to each building were considered transient occupants. It is important to note that transient occupant estimates are generally generated for peak hours of building operation (USGBC, 2006). However, WE Credit 3- Water Use Reduction specifically calls for the use of a “transient occupancy number that is a representative daily average”. For this reason, both of these original estimates were compared to current building use.

Finally, the FTE is defined as the number of “regular building occupants who spend 40 hours per week in the project building. Part-time or overtime occupants have FTE values based on their hours per week divided by 40” (USGBC, 2009, Green Building Design and Construction, p. 657). For this study, faculty and staff in each building were considered in the calculation of the FTE number.

Collection of Occupancy Data

As described in Chapter 2, occupants are documented as having a large impact on building performance (Reed, 2009). Thus, prior to collecting water, energy and IEQ data, it was important to establish if any changes had occurred between the predicted and actual occupant volumes for each building. The predicted FTE and transient figures for each building were collected from the LEED documents submitted and accepted by the USGBC. Quantities for current FTE users were obtained from the directors of each building and compared to salary reports for each department for accuracy. Transient quantities were then collected from the university’s Space Tracking and Reporting System (University of Florida, Division of Facilities, Planning & Construction, 2010). This system tracks all of the courses scheduled for each classroom throughout the week and records the number of students registered for each class (Appendix G). Table 4-1 illustrates the predicted number of transient and FTE users versus an approximation of actual users found within each building throughout the year 2010.

Study Instrument and Procedures

The Center for the Built Environment (CBE) Survey Description

The CBE's Occupant IEQ core survey is often used as a metric for indoor occupant satisfaction. This survey is a tool for building operators and researchers to obtain unbiased information on building systems and design techniques. Ultimately, the information gathered through the CBE's survey helps to improve the design, operation and environmental quality of buildings. As described on the CBE website, the organization of their studies falls into two categories. "First, our research team and industry partners are developing ways to "take the pulse" of the occupied buildings-looking at how people use space, asking them what they like and don't like about their indoor environments, and linking these responses to physical measurements of IEQ" (CBE, 2006). This is then coupled with the study of "technologies that hold promise for making buildings more environmentally friendly, more productive to work in, and more economical to operate" (CBE, 2006). The Occupant IEQ core survey applies these two organizational factors by testing and addressing issues occupants identify in each of the following areas; Office Layout, Office Furnishings, Cleanliness and Maintenance, Thermal Comfort, Air Quality, Lighting, and Acoustic Quality. The Occupant IEQ core survey is a web-based instrument that allows users to use a Likert scale to qualify how their building is performing in each of these areas. Researchers may then compare the collected responses to the averages in the CBE's database. A desirable score for each building area falls above the 50th percentile. As of October 2009, the CBE had implemented its survey in over 475 buildings and had collected over 51,000 individual occupant responses (CBE, 2006). Notably, under the LEED IEQ category, applicants' may be awarded points for successfully implementing and addressing issues similar to those found in the CBE's survey.

Occupant IEQ Satisfaction Survey Instrument

For the purpose of this study, a web-based adaptation of the CBE's Occupant IEQ core survey was created and named the Occupant Indoor Environmental Quality Satisfaction Survey. First, the questions from the CBE's original survey were analyzed and formatted to best fit the full-time and transient user groups who occupied the buildings in this study. Similar to the CBE's original survey, this study's research tools used a 5 point Likert scale (1 being very dissatisfied; 5 being very satisfied) for participants to qualify their satisfaction with the following eight aspects of their environment; Workspace Layout, Workspace Furniture, Thermal Comfort, Indoor Air Quality, Lighting Levels, Acoustic Quality, Water Efficiency, and Cleanliness/Maintenance. A copy of the Occupant Indoor Environmental Quality Satisfaction Survey can be found in Appendix C.

Sample and Procedure

Upon completion of the Occupant IEQ Satisfaction Survey, building users were targeted based on their qualifications as full-time or transient occupant. For example, faculty and staff members who had designated offices and were actively on the payroll for each building were identified as full-time occupants. Whereas, transient occupants were individuals who registered for courses within each building but did not have a designated office and were not actively on each respective department's payroll. All survey participants were eighteen years old or older, and either work full-time, part-time or have been transient occupants for a minimum of three months in each respective LEED building. Surveys were emailed to faculty, staff, and students through an online resource which allows users to create their own web-based assessment tools. Survey volunteers generally completed the assessment in approximately 30 minutes and then submitted an online response which could be tracked and analyzed for trends.

Interview Instrument and Procedure

Data collection for IEQ was then followed by a series of personal interviews with 10 randomly selected full-time and transient users from Building A and Building B. Interview questions focused on addressing and solving the issues identified in each buildings survey responses. For example, Building A’s users indicated a 65% satisfaction rating under the Thermal Comfort category. Thus, several interview questions focused on documenting the major issues that contributed towards the dissatisfaction with the thermal environment. Additionally, participants were asked to suggest solutions that could mitigate user discomfort. A copy of the interview questions can be found in Appendix E.

The intent of the interviews was to provide occupants an opportunity to elaborate on issues that were identified in the full-time and transient Occupant Indoor Environmental Quality Satisfaction Survey. Each interview lasted approximately 30 minutes and took place November of 2010-March 2011 in a private office on the University of Florida campus. In preparation for each interview, participants were asked to sign an Informed Consent form, which helped to describe the procedures and format of the interview. They were then informed of the study purpose and its goal to identify the degree to which LEED buildings maintain their sustainable integrities. Participants were asked open-ended questions which specifically addressed the identified issues for each building. It was important to ensure that questions and the interviewer remained unbiased. Therefore, questions were formatted so as not to lead the participant. Finally, upon permission all interviews were recorded in order to accurately capture the exchange of information between the participant and the interviewer.

CHAPTER 4
FINDINGS AND DISCUSSIONS

This research focused on answering two specific questions: 1) Do the buildings consume water and energy at the levels predicted during their LEED application process? 2) Do the buildings meet the Indoor Environmental Qualities (IEQ) occupant satisfaction levels recommended by the CBE and the USGBC? In answering these questions, this chapter reviews the findings for the three different building features analyzed in this POE: water consumption, energy consumption, and indoor environmental quality (IEQ). The collected data for each building is first described separately and then compared to one another for an additional layer of analysis. Finally a synopsis is provided for each of the three building features in order to summarize the performance results for Building A (Rinker Hall) and Building B (Steinbrenner Band Hall).

Building Occupancy Findings: Predicted vs. Actual

As previously described, occupants and their use of building environments can impact the efficient performance of water, energy and HVAC systems. Therefore it was important to establish if any changes had occurred between the predicted and actual quantities of building occupants at the time of this POE study. Table 4-1 illustrates the predicted number of transient and FTE users versus an approximation of users found within each building throughout the year 2010. This approximation of users is referred to in Table 4-1 as the “Actual Quantity at Time of Study”. The predictions made for each building’s FTE users proved to be within 13% of actual quantities. For example, Building A underestimated their FTE total by 13% and Building B overestimated their FTE totals by 13%. Additionally, the daily and peak transient occupants were underestimated by

92% and 79% respectively, for Building A. Conversely, the daily and peak transient occupants were overestimated by 32% and 47% respectively, for Building B.

Table 4-1. Predicted vs. actual occupant quantities for Building A and Building B.

Building Name	Occupant Type	Predicted Quantity	Actual Quantity at time of study (2010)	Percentage Variation
Building A	Full-Time Equivalent	40	45	13%
	Daily Transient	500	962	92 %
	Peak-hour Transient	500	894	79%
Building B	Full-Time Equivalent	8	7	-13%
	Daily Transient	300	204	-32%
	Peak-hour Transient	300	158	-47%

Water Consumption Findings

Building A: Rinker Hall

Consumption readings from Building A were collected for the years 2004-2010, starting with July of 2004 and ending in Jun of 2010. During this period actual water consumption averaged 104.08 kgals. Additionally, figures collected from the LEED documents for this building indicated that the baseline and predicted consumption values were 1090.25 kgals and 743.37 kgals, respectively. These initial findings for Building A indicated that actual consumption was 87% below a baseline case and 81% below the predicted case (Table 4-2 and Figure 4-1). This irregularly high variation from the prediction line prompted further investigation into the consumption and LEED documentation for this particular building. It was determined that one cause for this deviation could lie in the calculation of the original baseline and design cases. As described in Chapter 3, Building A is primarily occupied by students and university faculty and staff. Based on the 2010 Spring and Fall classroom schedules obtained from the university's Facilities, Planning & Construction Division, the average class time in

Building A is 1.3 hours and there are approximately 8 peak course periods throughout the year (University of Florida, Division of Facilities, Planning & Construction, 2010, Classroom Schedules: Rinker). Approximately, 500 students are registered with the Building Construction Department and attend several class periods throughout the day in this particular building. Additionally, approximately 462 students and instructors from other departments visit this building to attend or teach one class period per day throughout the week.

Upon further review of the LEED documents it was discovered that the default fixture-use values, or three conventional toilet flushes for every female and one conventional toilet flush/ two urinal flushes for every male (USGBC, 2006), were used for both full-time and transient users. This may imply that all occupants, even transient students or instructors who participate in a single class period in the building, were calculated as producing three flush types a day. Additionally, janitorial sinks and showers were both indicated as being used by all full-time and transient occupants. As a result of this overestimation, both the baseline and design case lines were skewed when compared to actual consumption rates.

In order to mitigate this effect, the USGBC asks applicants to "provide fixture use values for different occupancy types" (USGBC 2006, p. 140). Additionally, students and visitors are not intended to be users of showers or sinks dedicated to maintenance staff. Since LEED version 2.2, the USGBC has provided some suggested fixtures use values for a variety of user types including FTE's, student/visitors, retail customers and residents. Being certified under LEED system 2.0 in 2003, these values may not have been readily available for this project team's reference.

To obtain a more accurate comparison between the actual, baseline, and predicted case, the web-based WE LEED template for Building A was adjusted using the full-time and transient occupant fixture-use values recommended by the USGBC. When these values were adjusted for the baseline and predicted case, estimates for the 2004-2010 academic years dropped to 921.61 kgals and 183.17 kgals, respectively. These final findings for Building A indicated that actual consumption was 85% below a baseline case and 24% below the predicted case (Table 4-3 and Figure 4-2). It should be noted that between the years 2008-2010, consumption has begun to rise above the adjusted prediction line. This may be an indication that the 92% variation of daily transient occupants has begun to affect overall water consumption.

Table 4-2. Initial water consumption findings for Building A (Rinker Hall)

Year	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	Average
Actual (kgal)	51.00	71.00	117.00	180.00	198.00	221.47	140.08
Pred. (kgal)	743.37	743.37	743.37	743.37	743.37	743.37	743.37
Base. (kgal)	1090.25	1090.25	1090.25	1090.25	1090.25	1090.25	1090.25
% From Base.	95% Below	93% Below	89% Below	83% Below	82% Below	80% Below	87% Below
% From Pred.	93% Below	90% Below	84% Below	76% Below	73% Below	70% Below	81% Below

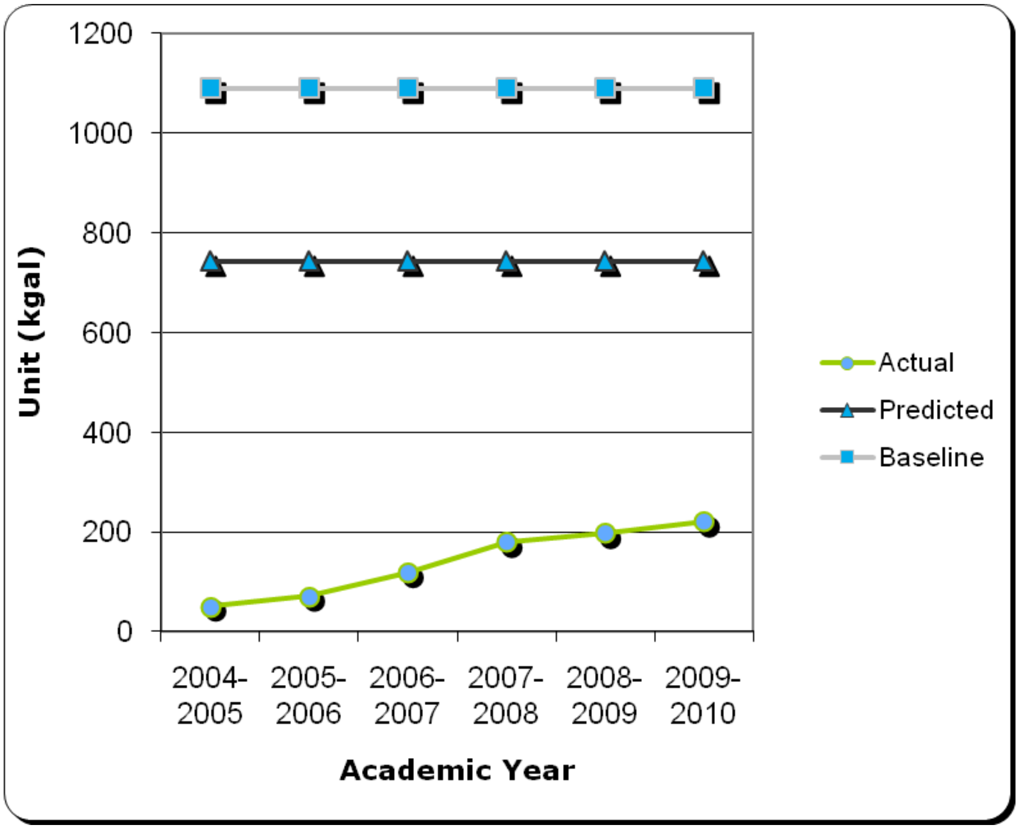

Figure 4-1. Initial actual, predicted and baseline water consumption levels for Building A between 2004-2010

Table 4-3. Adjusted water consumption findings for Building A (Rinker Hall)

Year	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	Average
Actual (kgal)	51.00	71.00	117.00	180.00	198.00	221.47	140.08
Pred. (kgal)	183.17	183.17	183.17	183.17	183.17	183.17	183.17
Base. (kgal)	921.61	921.61	921.61	921.61	921.61	921.61	921.61
% From Base.	94% Below	92% Below	87% Below	80% Below	79% Below	76% Below	85% Below
% From Pred.	72% Below	61% Below	35% Below	2% Below	8% Above	21% Above	24% Below

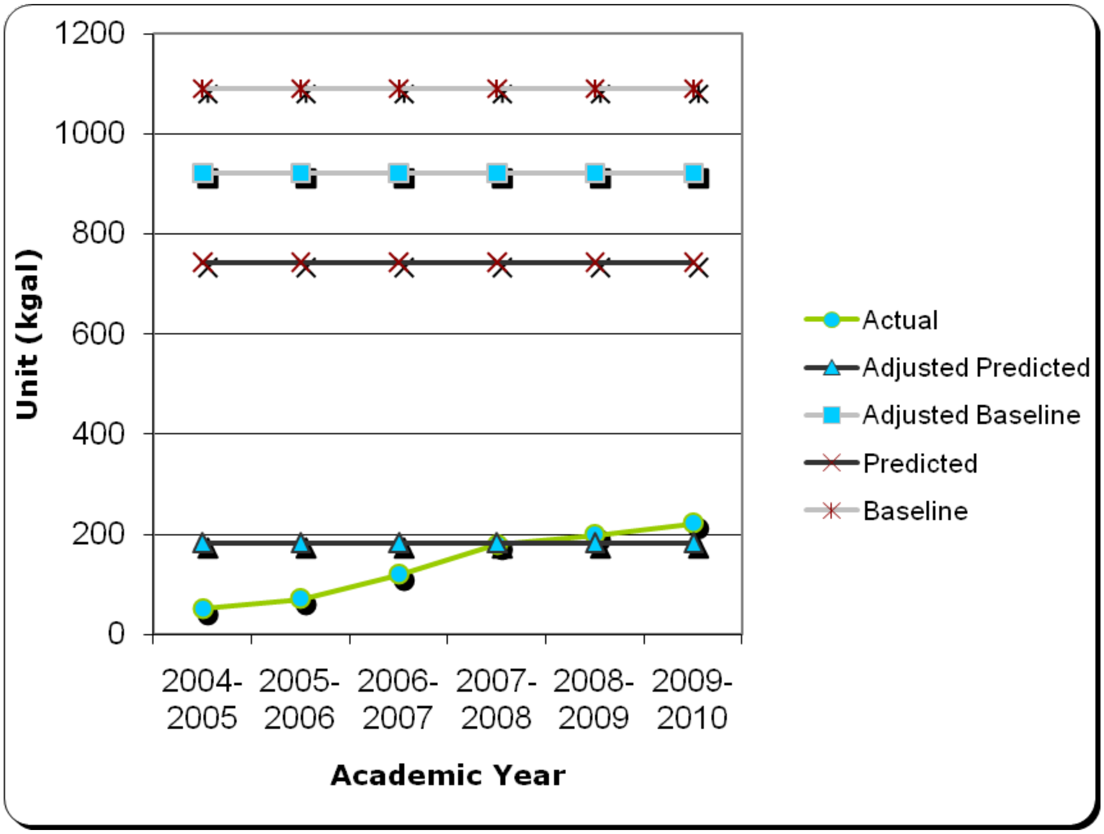

Figure 4-2. Actual, adjusted predicted, and adjusted baseline water consumption levels for Building A between 2004-2010

Building B: Steinbrenner Band Hall

Consumption readings from Building B were collected for the years 2008-2011, starting with April of 2008 and ending in March of 2011. During this period actual water consumption averaged 26.14 kgals. Additionally, figures collected from the LEED documents for this building indicated that the baseline and predicted consumption values were 95.33 kgals and 57.33 kgals, respectively. These initial findings for Building B indicated that actual consumption was 73% below a baseline case and 54% below the predicted case (Table 4-4 and Figure 4-3). This high variation from the prediction line prompted further investigation into the consumption and LEED documentation for this particular building. Similar to Building A, it was determined that one cause for this deviation could have originated in the calculation of the original baseline and design cases. As described in Chapter 3 of this study, Building B is primarily occupied by the students, faculty and staff from the Music Department. Based on classroom schedules obtained from the university's Facilities, Planning & Construction Division, the average class time in Building B is 1.5 hours and there are approximately 5 peak courses periods throughout the year (University of Florida, Division of Facilities, Planning & Construction, 2010, Classroom Schedules: Steinbrenner). Approximately, 204 students attend orchestra related classes throughout the day in this particular building.

Since WE Credit 3- Water Use Reduction is based on annual water consumption, the USGBC asks applicants to provide "a transient occupancy number that is a representative daily average" (USGBC, 2006, p. 140). However, upon further review of the LEED documents it was discovered that the project team assumed the number of daily transient occupants and peak transient occupants would be the same value. This implies that Building B would experience a consistent volume of transient occupants throughout its hours of operation; 7:25am-9:20pm. Contrary to this assumption, class schedules from the Spring and Fall semesters of 2010 indicate that there are 204 daily transient occupant in Building B. This is 32% less than the predicted 300 daily occupants. As a result of this overestimate, both the baseline and design case lines are skewed when compared to actual consumption rates.

Similar to Building A, the web-based WE LEED template for Building B was adjusted using the actual daily occupant value. When this was adjusted for the baseline and predicted case, estimates for the 2008-2011 academic years dropped to 70.30 kgals and 42.48 kgals, respectively. These final findings for Building B indicated that actual consumption was 63% below a baseline case and 38% below the predicted case (Table 4-5 and Figure 4-4).

Table 4-4. Initial water consumption findings for Building B (Steinbrenner Band Hall)

Year	2008-2009	2009-2010	2010-2011	Average
Actual (kgal)	26.50	24.00	27.92	26.14
Pred. (kgal)	57.33	57.33	57.33	57.33
Base. (kgal)	95.56	95.56	95.56	95.56
% From Base.	72% Below	75% Below	70% Below	73% Below
% From Pred.	54% Below	58% Below	51% Below	54% Below

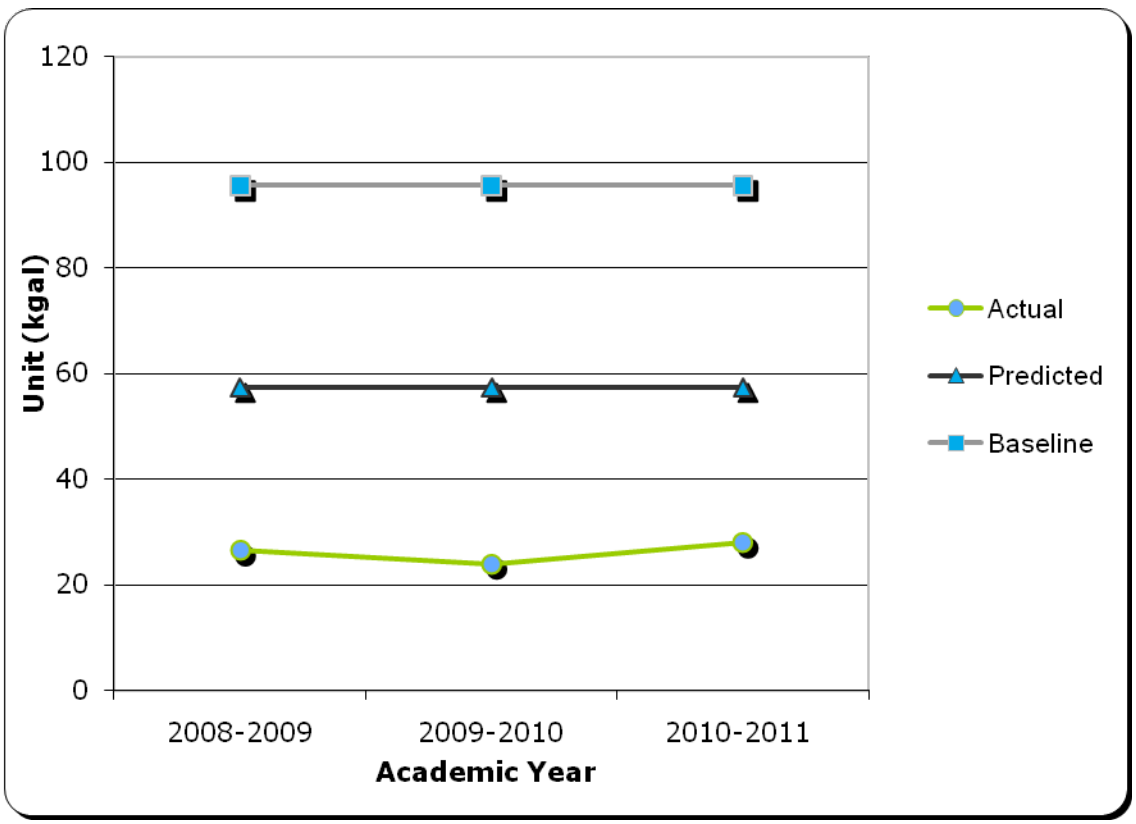

Figure 4-3. Initial actual, predicted, and baseline water consumption levels for Building B between 2008-2011

Table 4-5. Adjusted water consumption findings for Building B (Steinbrenner Band Hall)

Year	2008-2009	2009-2010	2010-2011	Average
Actual (kgal)	26.50	24.00	27.92	26.14
Pred. (kgal)	42.48	42.48	42.48	42.48
Base. (kgal)	70.30	70.30	70.30	70.30
% From Base.	62% Below	66% Below	60% Below	63% Below
% From Pred.	38% Below	43% Below	34% Below	38% Below

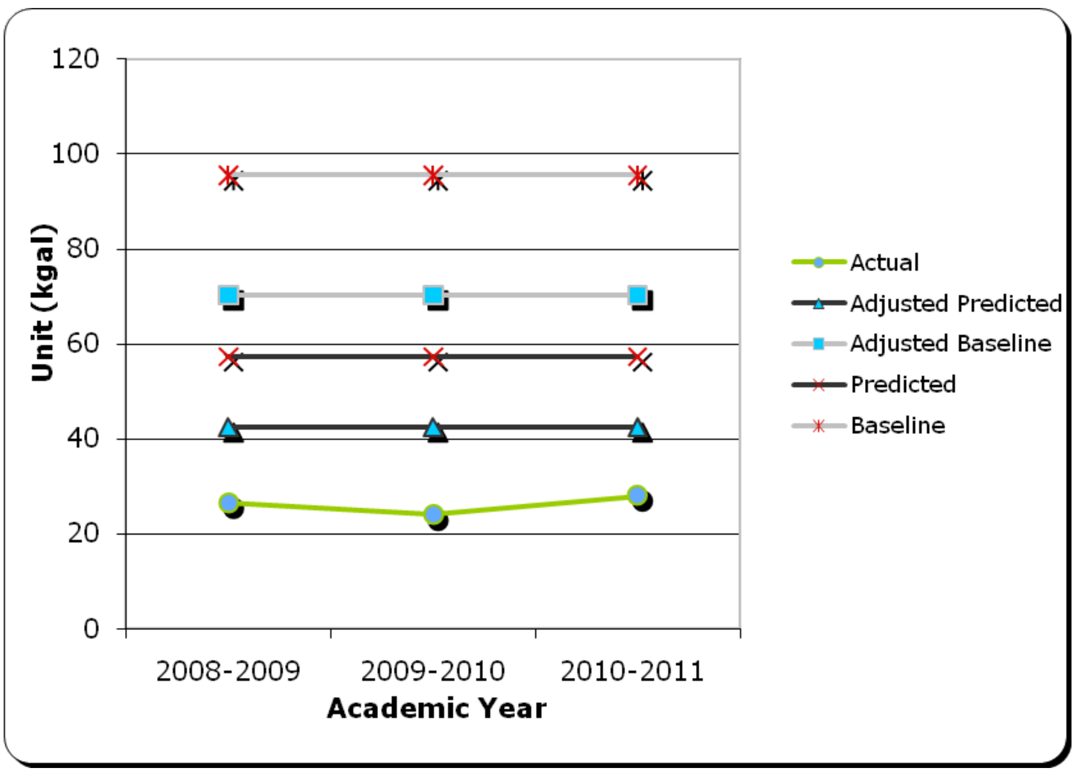

Figure 4-4. Actual, adjusted predicted and adjusted baseline consumption levels for Building B between 2008-2011

Water Consumption Summary

Overall, both buildings were found to be performing below their design cases and their baseline cases. Initial results indicated that Building A was approximately 87% below the baseline and 81% below the design case. Similarly, Building B's initial findings indicated that performance was 73% below the baseline and 54% below the designed estimate. However, once the miscalculations in the LEED templates were corrected and the subsequent baseline and design case lines were adjusted, both buildings performed within 31% of their predicted lines. For example, Building A performed 85% below its baseline case and 24% below its design case. Alternatively, Building B was 63% below its baseline case and 38% below its design case. Current LEED documents indicate that for WE credit 3-Water Use Reduction both buildings received two points and Building B received an additional bonus point under the ID category for exemplary performance in water reduction. If, however, both buildings were to reevaluate these points based on this study's findings, Building A would earn an additional point under the ID category for exemplary performance and Building B would retain its current points in the WE category.

Energy Consumption Findings

Building A: Rinker Hall

Energy consumption data for Building A averaged 2145.62 Mbtus for the metered readings taken between July of 2004 and June of 2010 academic years. Additionally, figures collected from the LEED documents for this building indicated that the baseline and predicted consumption values were 2732.10 Mbtus and 1424.60 Mbtus, respectively. These findings for Building A indicated that actual consumption was 21% below a baseline case and 51% above the predicted case (Table 4-6 and Figure 4-5). Upon review of the LEED documentation, it was determined that one cause for this deviation could be an underestimation of total building occupants. During the LEED application process, it appears the project team assumed that a total of 540 full-time and transient users would occupy Building A on a daily basis. However, over time the number of full-time users has risen by approximately 13% and the number of daily transients has risen by approximately 92%. This increase in occupant use indicates that energy loads from facility systems and equipment such as HVAC, lighting, projectors, and computers are nearly twice as much as predicted. As energy performance is base on operation cost in the LEED rating systems, it should be noted that this increase is the equivalent of approximately $12,744 more per year than predicted when calculated at the rates provided in the LEED documents.

Table 4-6. Energy consumption findings for Building A (Rinker Hall)

Year	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	Average
Actual (Mbtu)	2264.71	2130.52	2019.67	2230.88	1839.99	2387.92	2145.62
Pred. (Mbtu)	1424.60	1424.60	1424.60	1424.60	1424.60	1424.60	1424.60
Base. (Mbtu)	2732.10	2732.10	2732.10	2732.10	2732.10	2732.10	2732.10
% From Base.	17% Below	22% Below	26% Below	18% Below	33% Below	13% Below	21% Below
% From Pred.	59% Above	50% Above	42% Above	57% Above	29% Above	68% Above	51% Above

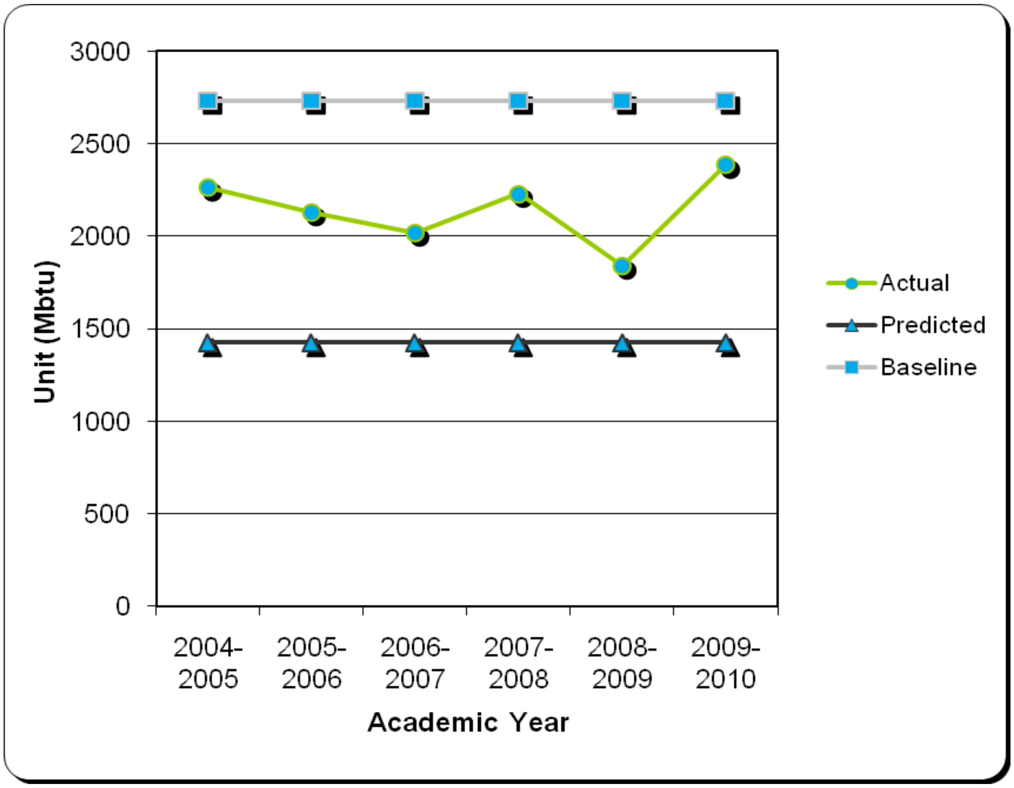

Figure 4-5. Actual, predicted, and baseline, energy consumption levels for Building A between 2004-2010

Building B: Steinbrenner Band Hall

Energy consumption data for Building B averaged 1005.93 Mbtus for the metered readings taken between April of 2008 and March of 2011. Additionally, figures collected from the LEED documents for this building indicated that the baseline and predicted consumption values were 1345 Mbtus and 1764 Mbtus, respectively. These findings for Building B indicated that actual consumption was 25% below a baseline case and 43% below the predicted case (Table 4-7 and Figure 4-6). However, as described previously in this study, it was determined that Building B's project team overestimated the total building occupants. Initial occupancy estimates indicated that Building B would operate under conditions for 308 full-time and transient users. However, over time this quantity has fallen by 32% for daily full-time and transient occupants. This indicates that energy loads from facility systems and equipment are all 1/3 less than engineers estimated.

It should also be noted that Building B's prediction line was 419 Mbtus (31%) above the baseline case. With a documented savings of 21.3% in the original LEED application, it was important to establish how this building earned 4 points under EA Credit 1- Optimized Energy Performance while predicting it would consume more energy than a code-compliant building. According to the LEED v2.2 Reference Guide the intent of this credit is to achieve increasing levels of energy performance above a baseline case to reduce environmental impacts associated with excessive energy use (USGBC, 2006). However, as previous described, current LEED templates will base a building's energy performance on operation cost and not energy consumption. Additionally, projects are permitted to purchase RECs in order to offset proposed design energy costs. So in a case such as Building B, although their predicted energy use, was 31.2% or $64,192 (if calculated at the rates provided in the LEED documents) higher than its baseline case, the purchase of RECs for the first two years of operation offset 70% of the predicted energy costs on the LEED template. Therefore, although actual use is 43% below the design case as initially stated, this current performance is only 25% below a baseline case.

Table 4-7. Energy consumption findings for Building B (Steinbrenner Band Hall)

Year	2008-2009	2010-2011	2008-2009	Average
Actual (Mbtu)	1047.57	795.33	1174.88	1005.93
Predicted (Mbtu)	1764.00	1764.00	1764.00	1764.00
Baseline (Mbtu)	1345.00	1345.00	1345.00	1345.00
% From Baseline	22% Below	41% Below	13% Below	25% Below
% From Predicted	41% Below	55% Below	33% Below	43% Below

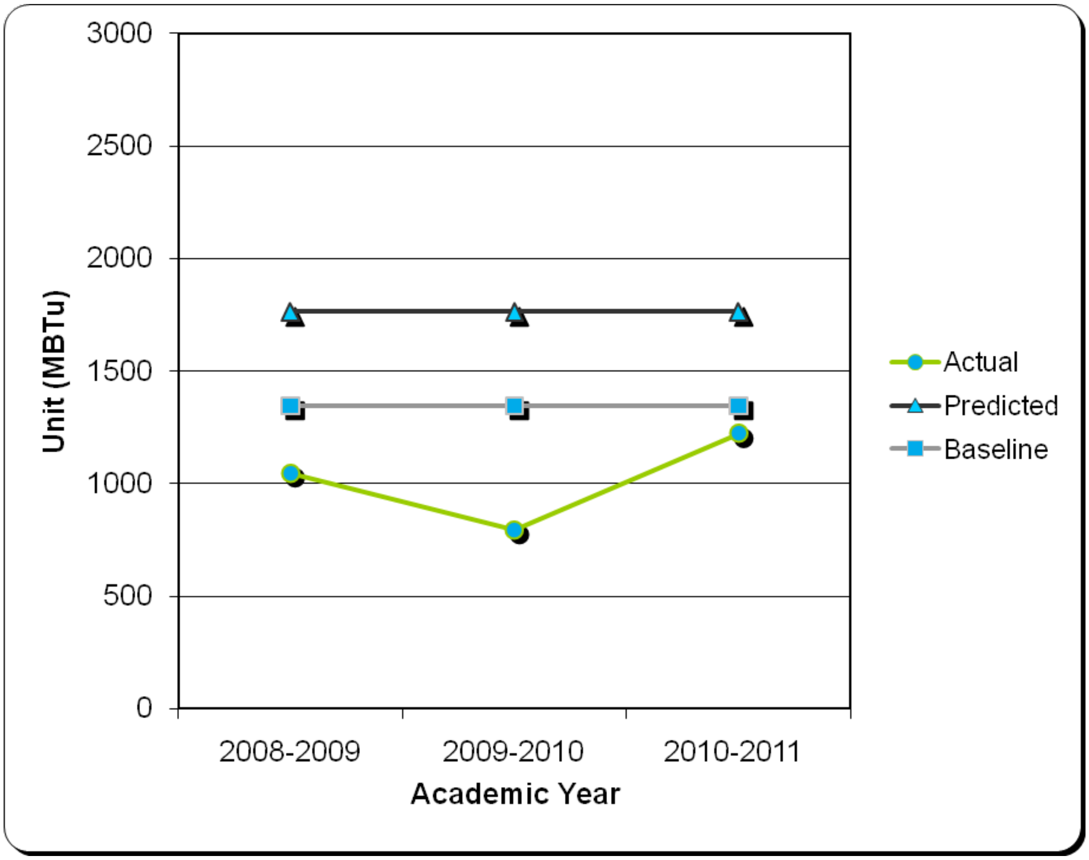

Figure 4-6. Actual, predicted and baseline energy consumption levels for Building B between 2008-2011

Energy Consumption Summary

Overall, both buildings are performing below their baseline cases, however, only Building B performed below its design cases. Results for this category indicated that Building A was approximately 21% below the baseline and 51% above the design case. Conversely, Building B's findings indicated that performance was 25% below the baseline and 43% below the designed estimate. Current LEED documents indicate that for EA credit 1-Optimized Energy Performance Building A received nine points and Building B received four. However, if the points previously awarded by the USGBC were reevaluated for both buildings and their energy performance measured on consumption, Building A would lose seven point under EA Credit 1-Optimized Energy Performance and Building B would earn two point under the same credit. Additionally, Building B would not have required the additional purchase associated with the Renewable Energy Credits.

Indoor Environmental Quality Findings

Participant Demographics Analysis

Prior to reviewing the Occupant IEQ Satisfaction Survey responses it was important to define a profile for the average transient and full-time occupants within Building A and Building B. This information helped to provide a context for the occupant types in each building. Thus, each survey participant was asked to provide information regarding his or her age and the length of time they spent in their building. This demographic information was then compiled and was presented in Table 4-8 and Table 4-9.

Of the 117 survey respondents for Building A (Rinker Hall), 17 (14.5%) were full-time occupants and 100 (85.5%) were transient users. The average age in years for full-time and transient users was 54 and 25 respectively. It is also noted that 9 (53%) of full-time occupants had maintained their current workspaces for over six years and all transient respondents had occupied their workstations for a minimum of three months. The gender ratios for Building A as a whole indicated that 53 (45%) of the occupants were male and 64 (55%) of them were female. Gender ratios for the full-time occupants alone demonstrated that 12 (71%) of full-time users were male and 5 (29%) of them were female. Conversely, 41 (41%) of the transient users in Building A were male and 59 (59%) of them were female (Table 4-8).

Table 4-8. Demographic characteristics for Building A (Rinker Hall)

Occ	Age Range	Gender By User Type	Gender For Building	Occupancy Length in Months	Occupancy Length in Hours
Full -Time	18-21 (0, 0%) 22-32 (2, 11.7%) 32-41 (2, 11.7%) 42-51 (3, 18%) 52-61 2, 11.7%) >62 (8, 47%)	Male (12,71%) Female (5,29%)	Male (53,45%) Female (64,55%)	0-3 (0, 0%) 4-12 (0, 0%) 13-24 (2, 11.7%) 25-48 (3, 17.6%) 49-72 (3, 17.6%) >73 (9, 52.9%)	All full-time users are factored on an 8 hours work day
Transient	18-21 (31, 31%) 22-32 (62, 62%) 32-41 (0, 0%) 42-51 (4, 4%) 52-61 (1, 1%) >62 (2, 2%)	Male (41,41%) Female (59,59%)		All transient users occupied this building for a minimum of 3 months.	< 5 (50, 49.5%) 5-10 (5, 4.9%) 11-25 (25, 24.7%) 26-35 (9, 8.9%) >36 (2, 1.9%) Unsure (10,9.9%)

Total Full-time Occupants: 17 Total Transient Occupants: 100

Of the 111 survey respondents from Building B (Steinbrenner Band Hall), 2 (1.8%) were full-time occupants and 109 (98.2%) were transient users. Additionally, the average age in years for full-time and transient users was 44.5 and 19.5, respectively. Full-time occupants documented that 1 (50%) had maintained their workspaces for eighteen months while the other 1 (50%) had maintained theirs for five months. It should be noted that this building did not complete construction until June of 2008, so all seven of the full-time users were expected to have occupancy lengths that were less than two years at the time of this study. All transient respondents had occupied their workstations for a minimum of three months. Gender ratios for Building B as a whole indicated that 39 (35%) of the occupants were male and 72 (65%) were female. The gender ratios for the full-time occupants generated separately demonstrate that 2 (100%) were male. Finally, 37 (34%) of the transient users in Building B were male and 72 (66%) were female.

Table 4-9. Demographic characteristics for Building B (Steinbrenner Band Hall)

Occ	Age Range	Gender By User Type	Gender For Building	Occupancy Length in Months	Occupancy Length in Hours
Full Time	18-21 (0, 0%) 22-32 (0, 0%) 32-41 (1, 50%) 42-51 (1, 50%) 52-61 (0, 0%) >62 (0, 0%)	Male (2,100%) Female (0, 0%)	Male (39, 35%) Female (72, 65%)	0-3 (0, 0%) 4-12 (1, 50%) 13-24 (1, 50%) 25-48 (0, 0%) 49-72 (0, 0%) >73 (0, 0%)	All full-time users are factored on an 8 hours work day
Transient	18-21(103,95%) 22-32 (6, 5.5%) 32-41 (0, 0%) 42-51 (0, 0%) 52-61 (0, 0%) >62 (0, 0%)	Male (37,34%) Female (72,66%)		All transient users occupied this building for a minimum of 3 months.	< 5 (71, 66.1%) 5-10 (30, 27.5%) 11-25 (3, 2.7%) 26-35 (0, 0%) >36 (0, 0%) Unsure (5, 4.5%)

Total Full-time Occupants: 2 Total Transient Occupants: 109

Building A: Rinker Hall

The IEQ survey utilized a 5-point Likert scale in order to estimate how their building was performing from the perspective of the building occupants (CBE, 2006). IEQ surveys were distributed and analyzed from 17 full-time and 100 transient occupants in Building A (Rinker Hall). According to the survey responses, Building A received the following satisfaction ratings: 81% for Workspace Layout, 78% for Workspace Furniture, 60% Thermal Comfort, 84% for Indoor Air Quality, 80% for Lighting Levels, 76% for Acoustic Quality, 77% for Water Efficiency, and 87% for Cleanliness/Maintenance. Overall building occupants rated Building A as 77% satisfactory (Table 4-10). In this particular building, occupants were the most satisfied with the Cleanliness and Maintenance, which received a rating of 87%. However, occupants were the least satisfied with their thermal comfort, which received a rating of 60%. Under IEQ Credit-7.2 Thermal Comfort: Verification, the USGBC asks that project teams verify a minimum of 80% of occupants are satisfied with their thermal comfort. Therefore, Building A is approximately 20% below this recommendation. However, when compared to the less stringent CBE standard, which seeks for ratings above the 50th percentile, this building demonstrated acceptable scores in all of the IEQ categories. Figure 4-7 illustrates the satisfaction rating of both the full time and transient occupants for Building A.

Table 4-10. Indoor Environmental Quality findings for Building A (Rinker Hall)

Building Name	Workspace Layout	Workspace Furniture	Thermal Comfort	Indoor Air Quality	Lighting Levels	Acoustic Quality	Water Efficiency	Cleanliness and Maintenance	Overall Score:
Building A	81%	71%	60%	84%	80%	76%	77%	87%	77%

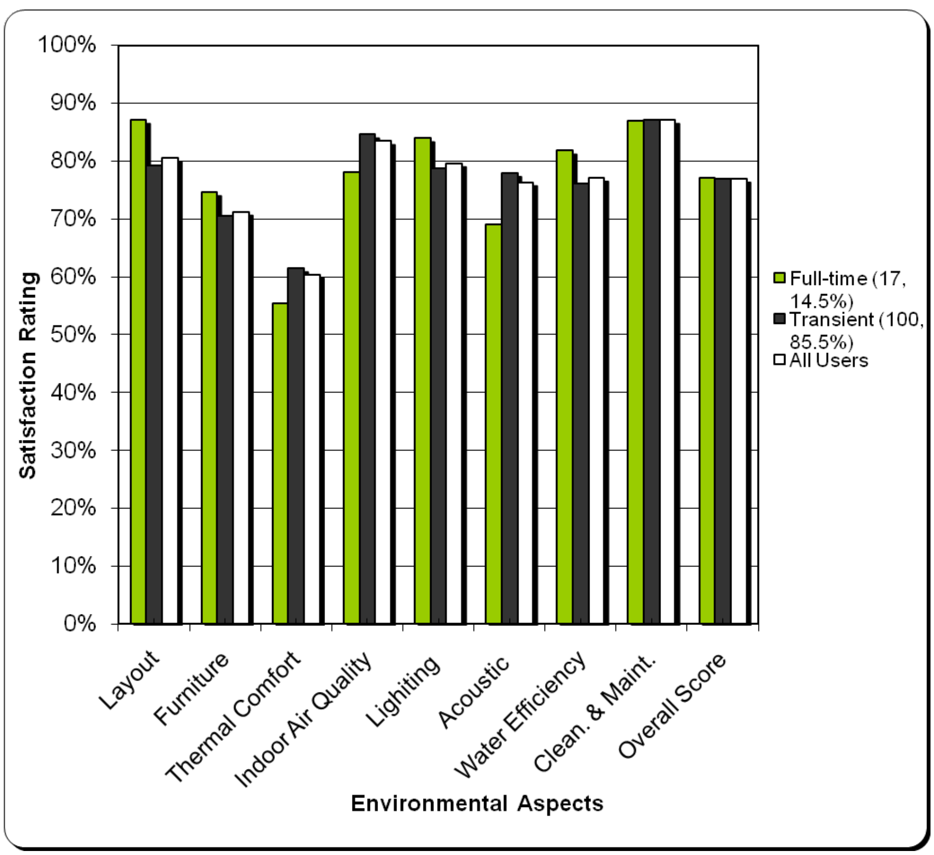

Figure 4-7. Full-time and transient occupant satisfaction ratings for each IEQ category in Building A (Rinker Hall)

Building B: Steinbrenner Band Hall

IEQ surveys were analyzed from 2 full-time and 109 transient occupants in Building B. According to the survey responses, this building received the following satisfaction ratings: 83% for Workspace Layout, 80% for Workspace Furniture, 66% Thermal Comfort, 87% for Indoor Air Quality, 76% for Lighting Levels, 87% for Acoustic Quality, 81% for Water Efficiency, and 86% for Cleanliness/Maintenance. Overall building occupants rated Building A as 81% satisfactory (Table 4-11). In this particular building, occupants were the most satisfied with the Indoor Air Quality and Acoustic Quality, which received ratings of 87%. However, occupants were the least satisfied with their thermal comfort, which received a rating of 66%. Similar to Building A, this building is approximately 14% below the satisfaction levels recommended by the USGBC. However, when compared to the less stringent CBE standard, which seeks for ratings above the 50th percentile, this building demonstrated acceptable scores in all of the IEQ categories. Figure 4-8 illustrates both the full-time and transient occupant satisfaction ratings in each IEQ category.

Table 4-11. Indoor Environmental Quality findings for Building B (Steinbrenner Band Hall)

Building Name	Workspace Layout	Workspace Furniture	Thermal Comfort	Indoor Air Quality	Lighting Levels	Acoustic Quality	Water Efficiency	Cleanliness and Maintenance	Overall Score:
Building B	83%	80%	66%	87%	76%	87%	81%	86%	81%

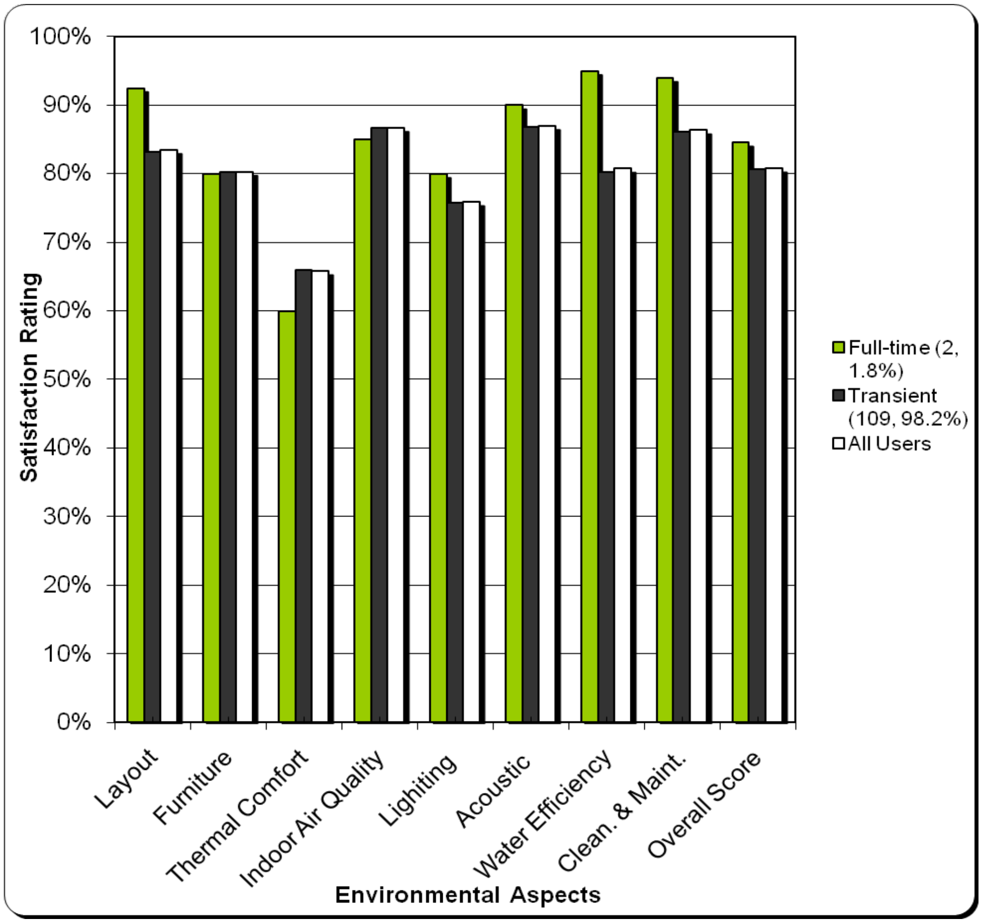

Figure 4-8. Full-time and transient occupant satisfaction ratings for each IEQ category in Building B (Steinbrenner Band Hall)

Indoor Environmental Quality Summary

Overall, both buildings produced acceptable scores when compared to the standards set by the CBE. On average, Building A was 27% above the CBE standard and Building B was 31% above the standard. Both buildings, however, did not meet the thermal comfort levels recommended by the USGBC. For this particular area, Building A was 20% below the USGBC standard and Building B was 14% below the standard. If the points previously awarded by the USGBC were reevaluated for both buildings, Building A would not be eligible to receive a point under IEQ Credit 7-Thermal Comfort; Design and Building B would lose a point for this same credit.

Personal Interviews

Subsequent interviews with building occupants focused on identifying factors that may have contributed towards the deviation from the predicted water consumption, predicted energy performance, and the unsatisfactory scores for thermal comfort. Ten participants were selected at random from each building and included a wide variety of user types. For Building A (Rinker Hall), two professors, two doctoral students, five master's students, and one undergraduate student were selected. Additionally, one professor, one staff, and eight undergraduate students were selected from Building B (Steinbrenner Band Hall). Interviews were generally 30 minutes in length and were conducted in private offices on the University of Florida campus. After finishing interviews for both buildings, the collected responses were transcribed and analyzed for using content analysis. Finally, each interview participant was coded 1-10 for either Building A or Building B. Tables 4-12 to 4-17 illustrate the themes that emerged from each interview question and provides a number of example responses from participants.

Interview Responses Regarding Water Consumption

Building A: Rinker Hall

Final water consumption findings indicated that Building A was an average of 24% below its predicted case. Additionally, as previously noted, between the years of 2008 and 2010, consumption had risen above the adjusted prediction line. Therefore, interviews sought to identify factors that may have contributed towards the early success of water conservation as well as the later rise in resource use.

As a testament to the general success of Building A's water conservation, responses suggested that the building users were well aware of their building's low-flow fixtures and were often reminded of them throughout the semester. For example, one participant noted that “an instructor in a sustainability course used the cistern and waterless urinals at Rinker Hall as an example during a lecture” (2A). Additionally, users indicated that proper fixture use was intuitive and additional instruction would not be required. Each interviewee’s ability to speak knowledgably about these features suggests that they were comfortable using them on a daily basis and could make a conscious effort to reduce their personal water consumption.

Alternatively, the waterless urinals, although cited as an affective water saving feature, were also noted for needing constant maintenance. Similarly, the sensored faucets were cited as the least effective water saving feature due to their long running time. One participant even stated that “at one point [the faucets] were changed with a 2.2 gpm aerator. So I don’t believe these are saving water anymore” (7A). Subsequently, participants often suggested that the staff receive instruction on how to maintain the waterless urinals and the faucets be replaced as ways of improving the water consumption in Building A.

These responses may lend some insight to the deviation from the expected water consumption for Building A. As interviewee’s indicated, users of this building are frequently educated about the benefits of low-flow fixtures. So much so, that interviewees were often able to identify items that needed improvements, such as the waterless urinals and sensored faucets. This level of awareness is consistent with the general success of the building’s water saving features. Also, these comments may shed some light on the areas that could be updated in order to maintain or potentially improve building water performance. Table 4-12 illustrates the themes that emerged from each interview question that referred to water consumption.

Table 4-12. Summary of interview responses for water consumption in Building A

Rinker Hall

Question Category: Deviation from predicted water consumption
Question: Have you been informed of the water saving features in your building?
Interview Code - Interview Response Theme

- 1A - The professors talk about the water saving features during several of the BCN classes.
- 2A - Yes, an instructor in a sustainability course used the cistern and waterless urinals at Rinker Hall as an example during a lecture.
- 4A - Several of the professors have discussed the low-flow options at Rinker during class. I have also given tours of Rinker to donors and learned about many of the fixtures at that time.
- 5A - I have noticed them through my own observations.
- 8A - Yes, the professors brag about it and there is signage over the waterless urinals.

Question: Have you been informed on how to use the water saving features in your building?
Interview Code-Interview Response Theme

- 3A - Not officially, but I have learned through experience how to use the faucets and toilets.
- 6A -No one has ever told me specifically how to use any of the features.
- 7A - We have not been provided information on how to use them, but you just push a button.
- 8A - No, it seems self explanatory though.
- 10A - No, but I don’t think it’s necessary.

Question: Which water saving features do you feel are the most affective?
Interview Code-Interview Response Theme

- 2A – The waterless urinals and cistern seem to be affective.
- 5A – The automatic faucets are a good thought, however they are timed poorly.
- 7A – The waterless urinals, strictly on the fact that there is no water to use.
- 8A – The water saving urinals seem to work well, until they are broken.
- 9A – The low flow fixtures and the waterless urinals.

Question: Which water saving features do you feel are the least affective?
Interview Code-Interview Response Theme

- 1A – The waterless urinals break a lot and can really smell. Also the faucets run too long.
- 4A – The waterless urinals tend to break often and the “supposed” water sensored faucets aren’t well timed. They run even when not in use.
- 7A - All of the faucets. The faucets at one point they were changed with a 2.2 gpm aerator. So I don’t believe these are saving water anymore.
- 9A – Sometimes when I flush the toilet it keeps going and going. I have to tell the office that the toilet won’t stop flushing. So there may be some faulty fixtures.
- 10A – Waterless urinals ostensibly save 40,000 gallons of water per year and yet, the lavatories are set where the water runs for 30 seconds. So is there really a savings in water usage?

Question: How do you think the water saving features of your building could be improved?
Interview Code-Interview Response Theme

- 4A - They could have motion sensored faucets. Also, I’m unsure if there is a real pay back on the cistern.
- 5A – Adjusting the timing on the automatic faucets would be helpful.
- 6A – Use better faucets in the restrooms. Perhaps time them better or replace with manual fixtures.
- 7A- Use aerators with less gpm’s. Then you could keep the faucets but save on water.
- 10A- The timing on the lavatories needs to be reset.

Building B: Steinbrenner Band Hall

Final water consumption findings indicated that Building B was an average of 38% below its predicted case. Therefore, user interviews sought to identify themes that would be consistent with this exemplary water performance.

Interviews for Building B revealed that users were well aware of the sustainable features that were labeled, such as the dual-flush toilets, but were unfamiliar with the environmental benefits of items such as the sensored faucets. However, although users did not feel as though they received formal instruction on how to use these water-saving features, they were confident that they could use both fixtures properly. Similar to Building A, this level of awareness suggests that users are able to make a conscious contribution towards water conservation. Additionally, several users also mentioned that the bathrooms were difficult to find and suggested that this may be contributing to additional water savings. For example one use stated “It’s hard to find the restrooms, so that certainly deters people from using them.” (5B). Therefore, it may be possible that the exemplary water conservation in Building B may also be due in part to the building’s design.

A frequently suggested improvement for Building B included the adjustment of water pressure for all of the dual-flush toilets. For example, several of the interviewee’s noted that the toilets often required two flushes in order to clear them of sanitary paper. Similar to Building A, participants also noted that the faucets were timed poorly and ran longer than necessary. One such participant suggested that the faucets only “turned on and off when in use and not depend on the timer” (1B). Therefore, it may be possible for Building B to save even more water if the pressure of the dual-flush toilets and the timing of the faucets were adjusted.

These responses may lend some insight to the deviation from the expected water consumption for Building B. As interviewee's indicated, users of this building frequently noticed the signage that described the water-saving features, perhaps suggesting that more signage be integrated in future designs as a means of improving water consumption. Also, these comments may help to identify the areas, such as the pressure of the toilets and timing of the faucet, which could be updated in order to improve building water performance. Table 4-13 illustrates the themes that emerged from each interview question that referred to water consumption.

Table 4-13. Summary of interview responses for water consumption in Building B

Steinbrenner Band Hall
Question Category: Deviation from predicted water consumption Question: Have you been informed of the water saving features in your building? Interview Code - Interview Response Theme • 1B – There is a sign on the dual flush toilets. But that is the only information I have received about any of the features that save water. • 3B – The restrooms have signage on the toilets, but no one has informed us directly. I didn't know that the faucets were water saving. • 4B – Yes, there is a sign in the restrooms. • 6B – Yes, signage/color coded handles in the toilets. • 7B – The toilets have a sign that have information about saving water. Question: Have you been informed on how to use the water saving features in your building? Interview Code-Interview Response Theme • 1B – The sign in the bathroom was the only indication of how to use this feature. • 2B – The first year in Marching Band the professors had mentioned the toilets and faucets saved water. • 3B – No, just the signage in the restrooms. • 7B – The sign itself in the restroom, but there has never been any other form of explanation. • 8B – No. Question: Which water saving features do you feel are the most affective? Interview Code-Interview Response Theme • 3B – Now that I know the faucets are water saving, I would have to say those. • 4B – The low flush urinals and motion sensored faucets appear to work fine. • 5B – It's hard to find the restrooms, so that certainly deters people from using them. • 6B – I think the toilets are working well. • 10B – I'm not really sure. I don't really know of any other water saving feature except for the toilets. Question: Which water saving features do you feel are the least affective? Interview Code-Interview Response Theme • 2B – The toilet paper does not go down on the first flush and the water fountains taste like paint.

Table 4-13. Continued

Steinbrenner Band Hall
• 3B – The toilets are not doing a very good job. You have to flush twice to get any of the paper to go down. • 5B – Water is really not used a lot. There are the hidden bathrooms and that's about it. Not sure if any other features are more or less affective. • 6B – I wasn't even aware that the faucets were water saving, perhaps signage would make these more affective. • 9B – The toilets. They don't really work because you have to flush twice in order for the toilet to flush all the way.
Question: How do you think the water saving features of your building could be improved? Interview Code-Interview Response Theme • 1B – Allowing the faucets to get turned on/off when in use and not depend on the timer. • 2B – Better toilet pressure and water fountains that work (one is broken). • 3B - Getting the toilets to work with one flush would be a huge improvement. • 7B – Fix the toilets so that they have more pressure. • 10B – Not really sure of any of the water saving features to determine if they need to be improved.

Interview Responses Regarding Energy Consumption

Building A: Rinker Hall

Energy consumption findings for Building A indicated that actual consumption was 21% below a baseline case and 51% above the predicted case. Therefore, interviews sought to identify factors that may have contributed towards the increase from that which was initially demonstrated by the simulation model.

Interviews for Building A revealed that users were well educated on the location of sustainable features, such as the occupancy sensors, light sensors, dimmable switches, and shading devices. However, participants rarely stated that they had received any formal instruction on how to use these controls. In fact, it was often noted that the fixture controls were cumbersome and avoided if possible. For example, one user stated “the dimmers are really confusing and you have no information on how to use them. So I just refer to the on/off switch” (7A). This suggests that without the proper knowledge to use these items, occupants may be reverting to less efficient options as a means of making their workspaces functional.

Additionally, many of the interviews revealed that the occupant sensors and light sensors were not calibrated correctly. As a result, these fixtures appeared to stay on when occupants were not in the room and turn off while classes were in session. User 5A suggests that "perhaps it's useful to train the upper echelon of occupants on how to use the lighting sensors so that they can be used more efficiently". These statements may indicate that the fixtures themselves are not working properly and could be using more energy than expected.

Collectively, these responses provide some perspective on the energy use in Building A. As interviewees indicated, users of this building frequently noticed the energy saving features, but were often daunted by how to use them. Additionally, it seems that improvements may be needed to some of the sensors themselves so as to optimize their efficiency. Thus it may be possible to reduce a portion of Building A's energy consumption if these items were to be addressed and corrected. Table 4-14 illustrates the themes that emerged from each interview question that referred to energy consumption.

Table 4-14. Summary of interview responses for energy consumption in Building A

Rinker Hall
Question Category: Deviation from predicted energy consumption Question: Do the occupants of Building A have the ability to adjust the lighting levels? Interview Code - Interview Response Theme • 1A – You can try, but it may not do what you want it to do. The switch panels are not very easy to use. • 2A – Yes. Lighting sensors and light dimmers. • 5A – The shades are useful in most of the rooms. • 7A – Yes. There are light switches and there is a button pad at the front of the room that can dim different lights. • 10A – We have light switches and window blinds/shades

Table 4-14. Continued

Rinker Hall
Question: Have you been informed on how to use the lighting controls in your workspace? Interview Code-Interview Response Theme • 2A– It seems more of a self taught process, where one will have to experiment with the lights to find a comfortable lighting level. • 3A – No. • 4A – No. • 7A – Nope. • 8A - There has never been a formal tutorial.
Question: Which lighting features do you like the most? Interview Code-Interview Response Theme • 1A – The theory of the adjustable lighting is good, BUT, they are cumbersome and not very accurate. These need some improvement. • 2A – I like that there are options for the lights, but it takes time to figure out how they work. • 3A – I like the motions sensors…when they work. • 5A – I like the shades because they are easy to adjust. • 7A – The on/off switch. The dimmers are really confusing and you have no information on how to use them. So I just refer to the on/off switch.
Question: Which lighting features do you like the least? Interview Code-Interview Response Theme • 1A – The daylight sensors don't work and change the light levels at random during class. • 6A – You can't operate the "operable windows" and the occupancy sensors don't work. • 7A – The motion sensors. They have a 15 minute delay, so they will stay on for 15-20 extra minutes before turning off. So these are wasting money because no one is in the rooms and the lights are still on. • 8A – Poor daylight controls. In some rooms they flicker and other rooms they keep the shades closed so they are rendered useless. • 10A – The blinds are not very effective AND lights turn on even when no one is in the room
Question: How do you think the lighting conditions could be improved? Interview Code-Interview Response Theme • 1A – The occupancy sensors and adjustable lights need to be more accurate. • 5A - Perhaps it's useful to train the upper echelon of occupants on how to use the lighting sensors so that they can be used more efficiently. • 6A – More people should make use of the natural light. I have seen lights on even when there is ample day light. • 7A – Yes. Putting the controls back in the people's hands and requiring that users are more responsible about turning off lights. Or reduce the time after which people leave the room and the lights turn off by means of the sensor. • 8A – It would be nice to have better sensors or a way to control the lighting.

Building B: Steinbrenner Band Hall

Energy consumption findings for Building B indicated that actual consumption was 25% below a baseline case and 43% below the predicted case. Therefore, interviews sought to identify factors that may have contributed towards the decrease from that which was initially demonstrated by the simulation model.

Although it did not appear as though Building B users were provided lighting controls, they were aware of the standard light switch locations and were confident they could use them correctly. Additionally, participants often noted their affinity to the natural daylight that came through the clerestory windows. For example, one participant stated "I like the natural light during the day. It's nice to be able to see the sun going down and have a sense of the time" (2B). Interviews often suggested that the users in Building B could often rely on the natural daylight alone to read their sheet music, hereby, allowing them to turn the artificial lights off if they were not required. This type of energy conservation is consistent with the exemplary energy performance for Building B and may be partially responsible for the deviation from the predicted consumption.

However, one caveat to the clerestory windows was the inability for users to control the amount natural daylight that filtered into the room. Therefore, users frequently suggested that shading devices be introduced in order to make these feature more functional for classes that were in session later in the afternoon. For example, user 3B stated "there isn't anything to control the amount of light that comes in and at times it can be blinding". This may suggest that too much light is allowed to enter the building, which contributes to heat gain and consequently to the excessive use of air conditioning. Therefore, in addition to creating a more suitable environment for the building users, shading devices may also be an opportunity to reduce the energy consumption of Building B even more.

These responses may shed some light on the deviation from the expected energy consumption for Building B. As interviewees indicated, users of this building were knowledgeable of switch locations and confident of using them properly. Additionally, although shading devices would be an improvement, interviewees noted their frequent use of natural daylight throughout the day. This level of awareness is consistent with the exemplary performance of the building's energy performance. Also, these comments may help to indicate areas that could be updated and further improve overall energy performance. Table 4-15 illustrates the themes that emerged from each interview question that referred to energy consumption.

Table 4-15. Summary of interview responses for energy consumption in Building B

Steinbrenner Band Hall
Question Category: Deviation from predicted energy consumption Question: Do the occupants of Building B have the ability to adjust the lighting levels? Interview Code - Interview Response Theme • 2B – I know where the light switches are, but I'm not sure if there are dimmers or not. • 4B – Only an on/off switch. There aren't even shades on the windows. • 5B – An on/off switch is there, but that is it. There is some kind of lighting control used on the weekends. All of the lights are turned off and you are not really able to turn them back on. • 9B – I've never seen any lighting controls or window blinds and it doesn't look like the windows are tinted. • 10B – It can be turned on/off, but there aren't other options. Question: Have you been informed on how to use the lighting controls in your workspace? Interview Code-Interview Response Theme • 1B – None. • 2B – No. • 6B – No. • 7B – Its not explained in any way, but it's a pretty typical control. • 9B – Nothing had been explained in a formal way. Question: Which lighting features do you like the most? Interview Code-Interview Response Theme • 1B – I really like the natural light, there are clerestory windows along two sides of the room. • 2B – I like the natural light during the day. It's nice to be able to see the sun going down and have a sense of the time. • 3B – I really like the natural light that we get in the room. • 4B – It's well lit enough with just the natural light to see our sheet music. • 6B – It's nice to play here at night. The lighting doesn't seem so harsh. Question: Which lighting features do you like the least? Interview Code-Interview Response Theme

Table 4-15. Continued

Steinbrenner Band Hall
• 3B – There isn't anything to control the amount of light that comes in and at times it can be blinding. • 4B – There are times when the natural light is blinding throughout the day. • 6B – It would be better to have brighter light for seeing the sheet music. • 7B – The lack of natural light is a negative in the music library. • 8B – The artificial lights buzz a bit. So when we are trying to record something, this background noise can be problematic. Question: How do you think the lighting conditions could be improved? Interview Code-Interview Response Theme • 2B – Nothing, I like it in general. • 3B – It would be nice to add shades to the windows. • 4B – It would be nice to be able to control the sunlight that comes into the room. • 6B – It would be nice to have better interior lighting. • 7B – No, its fine except for the buzzing background noise of the artificial lights.

Interview Responses Regarding Thermal Comfort

Building A: Rinker Hall

The IEQ survey for Building A indicated that occupants were the least satisfied with their thermal comfort, which received a rating of 60%. As previously mentioned, this is approximately 20% below the recommended levels of the USGBC. Therefore, interviews sought to identify factors that may have contributed towards the unsatisfactory scores for thermal comfort.

Interviews revealed that although many of the regularly occupied spaces in Building A contained a thermostat or operable window, the temperatures were generally uncomfortable. Consistent with the low score for thermal comfort, users were not authorized to adjust the thermal settings and often did not feel comfortable using the windows as a means of controlling their thermal environment. For example, occupant 2A stated “the windows are operable, but no one has ever used them and teachers do not inform students that they can be used”. Thus, it was often suggested that the thermostats be more accessible and that the thermal set points be adjusted in order to provide a more consistent temperature throughout the building.

In addition to the temperature being perceived as uncomfortable, interviews suggested that the classroom finishes appeared to be cold as well. For example one participant noted “there are so many hard surfaces that it just feels cold. The counters are all grey, the floors are grey concrete, and the walls are white. Perhaps if they brought in a warmer carpet it wouldn’t feel so cold” (1A). This type of response evidences of how occupants may be responding to the building’s appearance. Therefore, it addition to addressing the thermal properties of the building, it may be useful to address the perceptual properties of the building so that the perceived thermal comfort can increase.

Overall, the interviews with Building A users supported the results of the IEQ survey. Occupants generally noted that the thermal set points in the building did not provide a consistent temperature in each room. Additionally, interviews revealed the occupants’ reluctance to use the operable windows as a means of controlling their thermal comfort. Some suggested improvements included the ability to access the thermal controls and to finish the rooms with materials that would promote a sense of warmth. These comments illustrated in Table 4-16 may help to indicate areas that could be updated in order to improve the scores received for thermal comfort.

Table 4-16. Summary of interview responses for thermal comfort in Building A

Rinker Hall
Question Category: Unsatisfactory Scores for Thermal Comfort Question: Do the occupants of Building A have the ability to control their thermal environment? Interview Code - Interview Response Theme • 1A – Students do not have the ability to adjust the thermal environment. • 2A – The windows are operable, but no one has ever used them and teachers do not inform students that they can be used. There also are no thermostats that can be adjusted. • 4A – Students don’t have the ability to change the temperature. • 7A – No. We don’t have control • 9A - Slightly, we have the operable windows on the first floor. Question: Have you been informed on how to use the thermal controls in your workspace? Interview Code-Interview Response Theme

Table 4-16. Continued

Rinker Hall
Question: Have you been informed on how to use the thermal controls in your workspace? Interview Code-Interview Response Theme • 1A – I have not been informed. • 2A – No, but there doesn't seem to be the need for these users. • 4A – I have not. • 6A – None come to mind. • 10A – Not formally.
Question: Which features of your thermal environment do you like the most? Interview Code-Interview Response Theme • 1A – The operable windows are good in theory, but no one uses them. • 6A – It is usually at a comfortable temperature, but there are rooms that have reputations for being uncomfortable. • 7A – Nothing. The building is consistently uncomfortable. Some rooms are too cold and some are too hot. • 8A – My workspace has a good baseline. Its generally comfortable, but there are a number of rooms that are reliably uncomfortable • 9A – I like the operable windows
Question: Which features of your thermal environment do you least like? Interview Code-Interview Response Theme • 1A – The students cannot control the thermostats and there are so many hard surfaces that it just feels cold. The counters are all grey, the floors are grey concrete and the walls are white. Perhaps if they brought in a warmer carpet it wouldn't feel so cold. • 2A – Certain seating is right under the vent, which requires that you move around in order to maintain a thermal comfort • 4A - I would want more control of the temperature. • 7A - The temperature settings. The classrooms are set too cold and when the heat is on, it is only set to 68 degrees. So generally uncomfortable. • 10A – It's cold in the winter and hot in the summer. UF HVAC guys know about the problem and can't seem to fix it. In the winter it can be as cold as 62 degrees – I work from home during these days. This problem is mostly confined to the 2nd floor, north corner and is much less of a problem in the rest of the building.
Question: How do you think your thermal environment could be improved? Interview Code-Interview Response Theme • 1A – It would be nice to have more consistent temperatures in the rooms. Some are very hot and others are very cold. • 2A – It would be nice if users could have the option of controlling the temperature. • 6A – Some of the rooms get MUCH colder than others. It would be nice if this could be fixed. • 7A –Narrow the range of the set points so that it can be more comfortable. • 9A – Add controls that are accessible to the occupants

Building B: Steinbrenner Band Hall

The IEQ surveys for Building B indicated that occupants were the least satisfied with their thermal comfort, which received a satisfaction rating of 66%. Given its scoring

14% below the levels recommended by the USGBC, interviews sought to identify factors that may have contributed towards the unsatisfactory scores for thermal comfort.

Users revealed that many of the regularly occupied spaces did not provide a thermal control, such as a thermostat, fan, or operable window. Consistent with the low scores for thermal comfort, this lack of thermal control made it difficult for adjustments to be made within the most frequently used performance rooms. For example, occupant 1B noted "I do not have the ability to adjust the temperature and I'm not even sure the director or upper administration does either. I've heard the director call the building "the ice box" because it gets so cold". Therefore, it was often suggested that the thermostats be installed in order to provide a method of adjusting the temperature when necessary.

In general, it appeared as though Building B could, at times, provide a comfortable indoor environment. In fact, several interviewees noted their satisfaction with the humidity levels. However, there were an overwhelming number of complaints that the temperature ranged to the extremes, specifically at the peaks of summer and winter. Several interviewees noted that they would often shiver in class if they were not well prepared with a sweater. For example occupant 3B stated "it just isn't very constant. In the summer it is really cold and in the winter it is very hot". These types of responses further support the need for individual controls and may provide some insight to the factors which contributed to the unsatisfactory score in thermal comfort.

Overall, the interviews responses for Building B supported the results of the IEQ survey. Occupants often noted that they did not have a method to adjust their thermal set points. Additionally, occupants were the least satisfied with the extreme temperatures experienced in the winter and summer seasons. Therefore, the most frequently cited suggestion was the need for individual controls in the regular occupied spaces. The comments provided in Table 4-17 illustrates the themes that emerged from the interviews with building users and may help to identify the target areas for improving the IEQ thermal comfort score.

Table 4-17. Summary of interview responses for thermal comfort in Building B

Steinbrenner Band Hall

Question Category: Unsatisfactory Scores for Thermal Comfort

Question: Do the occupants of Building B have the ability to control their thermal environment?

Interview Code - Interview Response Theme

- 1B – I do not have the ability to adjust the temperature and I'm not even sure the director or upper administration does either. I've heard the director call the building "the ice box" because it gets so cold.
- 3B – There aren't any thermostats, I suppose they don't want everyone to have access to them.
- 4B – No personal control.
- 5B – No. You can ask the professors but they don't change it.
- 8B – No. We are able to go to the Director but that is about it.

Question: Have you been informed on how to use the thermal controls in your workspace?

Interview Code-Interview Response Theme

- 1B – No.
- 3B – None.
- 4B – No.
- 9B – No.
- 10B – Not sure.

Question: Which features of your thermal environment do you like the most?

Interview Code-Interview Response Theme

- 1B – At the moment it is at a comfortable temperature, but it can get REALLY cold. At least it's not humid, mildew, or smelly.
- 2B- Pretty constant temperature most of the time.
- 5B – It's not humid and most of the time it's comfortable. But the summers are a real problem because they blast the air.
- 6B – It's a constant temperature and usually comfortable. It tends to keep the body heat down when there are so many people in the rooms at once.
- 8B – It's comfortable now, but it was very cold for a period of time.

Question: Which features of your thermal environment do you least like?

Interview Code-Interview Response Theme

- 2B - I am not a fan of the fluctuating temperatures during the seasons.
- 3B – It just isn't very constant. In the summer it is REALLY cold and in the winter it is VERY hot.
- 4B – When the temperature does vary, it is to the extreme. I think the professors put it on full blast.
- 5B – In the summer time it is way too cold. You see people shivering if they don't have a sweater.
- 9B – It was really cold for a period of time in the fall. It was way too cold and there was nothing we could do to change that except speak to the Director.

Question: How do you think your thermal environment could be improved?

Table 4-17. Continued

Steinbrenner Band Hall
Interview Code-Interview Response Theme • 1B – When it is not comfortable, it would be nice to be able to adjust the temperature. • 3B – It would be nice to have more control of the temperature. • 5B – It is generally fine, but perhaps the set points in the summer are not well placed. • 6B – Every room should have a thermostat so that we can control the temperature better. • 10B- It would be nice to have more control of the temperature and be able to adjust it when necessary.

Summary of Findings

In summary, the findings from the water and energy consumption analysis indicated that both buildings demonstrated varying levels of deviation from their predicted performance during the LEED application process. In most cases, this variation was an average of 35% more efficient than predicted by the original LEED documentation. In the case of Building A, however, energy consumption levels were approximately 51% higher than its simulation model. Additionally, initial water consumption data for both buildings lead to the discovery of computation errors in the LEED documents which subsequently skewed initial results. For example, Building A data initially suggested that performance was 81.16% below the design case. Upon further inspection of the LEED documentation, a miscalculation was discovered with regards to the fixture use values for transient occupants. Once corrected, the actual consumption of water averaged 24% below the design case. Similarly, water consumption figures for Building B initially demonstrated a 54% decrease from that which was predicted. However, a miscalculation was identified with regards to the daily average calculation for transient occupants. Once this figure was adjusted to reflect daily occupancy trends, the consumption of water averaged 38% below the prediction line.

IEQ surveys were distributed and analyzed from 117 occupants in Building A and 111 occupants in Building B. Participant responses indicated that both buildings averaged an 79% overall satisfaction rating. However, only 63% of occupants provided satisfactory scores for thermal comfort; this is approximately 17% lower than those recommended by the USGBC. However, when compared to the less stringent CBE standard, which seeks for ratings above the 50th percentile, both buildings demonstrated acceptable scores in all of the IEQ categories.

Subsequent interviews with building occupants were therefore focused on identifying factors, which may have contributed to the deviation of predicted water consumption, the deviation of predicted energy performance, and the unsatisfactory scores for thermal comfort. Participants were selected at random and included a wide variety of users including professors, graduate and undergraduate students from each building. Interviews revealed that occupants were generally aware of their water saving features and felt confident they could use them correctly without receiving formal instruction. However, both buildings experienced issues where water saving features did not function properly. With regard to energy consumption, Building A users were well aware of the energy saving feature, but frequently cited that they did not work properly. Conversely, Building B users were satisfied with their standard lighting controls and often made use of the natural daylight that entered through the clearstory windows. Finally, users from both buildings were generally unsatisfied with their thermal comfort. Typical responses indicated that temperatures were inconsistent throughout both buildings and ranged to the extremes of hot and cold. Additionally, regularly occupied spaces in each building either did not have thermal comfort system controls, or occupants were not capable of accessing them.

CHAPTER 5
RECOMMENDATIONS AND CONCLUSION

Overall, the green features in both buildings appear to be maintaining their sustainable integrities and in most cases, have exceeded the expectations of the design teams. Additionally, with the exception of thermal comfort, building users indicated they were generally satisfied with the design and operation of each building. However, research findings still support the need for a variety of procedural and operational improvements including the installation of independent meters, better communication of sustainability-related goals, and more frequent assessments of building users' satisfaction with indoor environmental factors. Additionally, improvements to the LEED system itself would include the use of more accurate prediction tools during the application process and to require that Optimized Energy Performance points be awarded based on the savings of energy consumption and not utility costs.

Recommendations for Future Building Design and Maintenance

Independent Meters for Building Systems

Early in this study, it was discovered that many of the LEED certified buildings on the University of Florida campus were not metering their consumption of resources in a way that would allow for the continued assessment of building performance. For example, in order to be eligible for this study, the energy and water consumption figures for each building needed to be provided from an independent meter. This particular criterion proved to be very difficult to achieve on the University of Florida campus were buildings often share meters. Thus, of the preliminary list of eight buildings selected for this study only two met this particular standard.

At a smaller scale, when the final findings for Building A (Rinker Hall) indicated that there was a drop from the predicted water consumption and prior to investigating the LEED documents, it was first believed that the 8,000-gallon cistern located on the building's site could be a possible factor. Designed to collect rainwater, this system helps to supplement potable water used for municipal functions such as toilet and urinal flushing. While the original LEED documents indicated that this system was predicted to supply 174.065 kilo-gallons (kgal) a year for indoor water use; the utility figures found for Building A suggested that the cistern could be providing more. However, after requesting consumption data from the university's Physical Plant Division, it was indicated that the cistern itself was not metered. Therefore, measured figures for the cistern alone could not be obtained and could not be used to determine the viability of this conjecture.

These scenarios suggest that post-occupancy metering is either not a focus or that the meters are not being budgeted into the construction costs for this particular campus. Either way, submetering resource consumption is an essential step for every building who wishes to remain sustainable over time. In doing so, the campus occupants are more conscious of their own use of resources and maintenance staffs are able to quickly identify if a system is malfunctioning or leaking. It is recommended that the campus and the USGBC require that buildings submeter their systems and maintenance staff establish a schedule of anticipated system checks.

Communication of Sustainable Features

Interviews frequently revealed that users were generally not provided instruction on how to use the green features of their buildings. Often times, this lack of knowledge lead to maintenance issues and perhaps the reduction in efficient building performance.

For example, it was found that although Building A users were well aware of their sustainable features, very few of them, including the facility staff, had been formally informed of their proper use and maintenance. For items, such as the waterless urinals in the men's restrooms, this lack of instruction has been problematic. IEQ surveys revealed that on several occasions, facility staff had made the mistake of cleaning these fixtures in the same fashion as they clean standard urinals. As a result of adding harsh cleansers to these fixtures, the liquid sealant that creates a thin layer over the vertical trap is compromised and results in the release of gasses that are perceived as offensive smells (Reichardt, 2006). In order to prevent such occurrences, it may be useful to have training sessions for facility staff and building owners. This type of protocol would update current staff of specialty items and inform new staff of specific maintenance procedures. Additionally, with this knowledge, owners would be more capable of identifying a malfunctioning piece of equipment, and mitigate any cost associated with inefficient performance.

Similarly, Building B users were only aware of sustainable features that were labeled, such as the dual-flush toilets. However, many did not know of the water saving benefits of a sensored faucet, were unfamiliar with the LEED rating system, and were unaware that their building was LEED certified. In this case, it may be difficult for some users to make a conscious contribution towards conserving resources. By educating these users on the available sustainable features they can be more aware of their consumption of resources and even help to identify equipment that is malfunctioning. Additionally, they will have the ability to share this knowledge with other buildings users and thereby encourage a wider population to be more sustainable.

In addition to educating users on water saving features, it would be useful to inform users of the energy saving features of the building as well. For example, Building A energy findings indicated that users consumed more than initially predicted. When occupants were questioned during personal interviews it was found that many were reluctant to use the energy-saving lighting controls, such as dimmers, occupancy sensors and lighting sensors, because they were too cumbersome. As a result, occupants often relied on standard lighting switches and bypassed this energy saving feature all together. By educating the students, faculty, and staff the building owners could encourage the use of installed controls and ultimately benefit from the addition saving in energy costs.

Finally, IEQ surveys indicated that users from both buildings either did not have access to thermal comfort controls or were not informed of how to use the ones that were provided. As a result, approximately 63% of the users from both buildings were unsatisfied with their thermal comfort and lack of thermal comfort controls. In both of these cases, a higher score in thermal comfort may have been achieved if building owners were to have properly instructed users on how to use the provided thermal controls. In this way, building occupants could adjust their thermal environment as needed and building owners could benefit from users who were more focused and productive while in their building.

More Frequent Assessment of User's Satisfaction

As previously described, users often provided valuable feedback with regards to desired and some time required improvements to the buildings and their sustainable features. For example, Building A users suggested that the sensored faucets ran too long, the waterless urinals frequently required maintenance, and the lighting and occupancy sensors were poorly calibrated. It may then be possible for Building A's water and energy performance to improve even more if these issues were addressed. Therefore, it would be an added benefit to building owners to more frequently assess users' satisfaction and, in particular, evaluate their feedback on potential building improvements.

Similarly, Building B users most frequently cited that the dual-flush toilets did not work properly. As revealed by the interviews, occupants frequently had to flush multiple times, in order to clear the toilets of any sanitary paper. Consequently, Building B users are required to consume more water than necessary. Had the building owners conducted a user satisfaction assessment, this issue could have been identified sooner and building owners may have benefited from an additional savings in water consumption and costs.

Ultimately, these issues may be contributing to maintenance costs and higher consumption in resources, as was the case with Building A's energy use. Therefore, it may be a benefit to users and a method of cost savings for building owners, to more frequently assess the satisfaction of their building users and evaluated their suggested improvements.

Recommendations for the LEED System

Prediction Tools during the LEED Application Process

For both buildings, prediction tools used for calculating water and energy savings appeared to be inaccurate. For water saving predictions, fixture use values and occupancy totals were both based on assumptions of how the buildings would be used and thus were skewed when compared to actual use. Currently, the USGBC allows applicants to create predictions prior to the completion of building construction. These types of over and underestimations will continue to exist for as long as the USGBC continues to use the present submittal process. Additionally, there is always the possibility that a LEED reviewer would not be able to detect an erroneous value input, such as in the case of Building A. Therefore, without the ability to reference actual consumptions values, human errors are bound to slip through the cracks. It is recommended that for this category, projects receive anticipated points for the first 2 years of operation and only be awarded points and certification after performance has been verified. This probation period thus allows building owners to adjust and improve water systems as necessary. As an added bonus, the USGBC could use this data to further their own understanding of sustainable building and expand upon their current rating systems.

Similar to water consumption predictions, energy simulation models are created and submitted to the USGBC prior to the completion of a project. As a result, energy simulation modelers for new construction have no choice but to make a variety of assumptions for items such as occupant quantities, equipment loads, and schedules for operation, lighting, heating, cooling, and fans. Additionally, modelers are limited to the capabilities of the software they use to create the energy models. As demonstrated in this study, these assumptions and limitations can result in a model that does not accurately represent the actual performance of a building. As recommended previously, it may be beneficial if projects were to receive anticipated points for the first 2 years of operation and only be awarded points and certification after efficient energy performance has been confirmed. This probation period would then provide building owners with an opportunity to track annual energy consumption and make adjustments to electrical systems as necessary.

Energy Savings vs. Utility Costs

Building B provides a unique case in which its energy prediction line was estimated to fall above an equivalent baseline case. As previously described, the EA Credit 1-Optimized Energy Performance is accessed on the reduction of energy costs, not energy consumption. Therefore, as a way of encouraging the use of clean energy sources, the USGBC allows applicants to purchase REC's in order to offset their projects energy costs on the submitted LEED template. However, this essentially allows designers to create a building without the use of energy saving features and purchase a desired number of points once a simulation model has been developed. Evident with how Building B was predicted to perform, this method is discouraging the production of energy efficient buildings and diminishes the credibility of the LEED rating system. As previously noted in Chapter 2, the USGBC has taken a preliminary step in addressing this issue. All projects registered under LEED version 3.0 are now required to report 5 years of energy and water use data to the USGBC for analysis. However, despite the requirements clearly stating that projects must commit to sharing this data, the USGBC still bases this analysis on energy costs. USGBC has not announced how they will address projects that use more resources than originally predicted or worse, more than those built to code standard. It is recommended that the USGBC continue to amend this policy in order to more accurately access the efficiency of building systems and create a clear set of consequences for buildings that do not perform sustainably. Ultimately, the goal for the EA category should be to first reduce the consumption of energy and subsequently the cost.

Need for Future Research

By providing the post-occupancy performance of two LEED buildings, this study contributes to the body of knowledge that exists on sustainability and LEED certified buildings. However, there is always a need for future research due to the exponential growth of this field of design. As mentioned in Chapter 1 of this study, due to a lack of metered data, this research was limited to only two buildings on the university campus. Therefore, a natural next step for future research would be to collect data from a larger sample of buildings and expand the analysis to include several campuses, a variety of certification levels, and different construction type. At that time, the correlation between building use and overall performance can more thoroughly be investigated for annual trends. Finally, a larger sample size would also provide the opportunity to test new prediction tools and aid in improving their accuracy. With this level of analysis, a researcher would be better poised to draw a conclusion on the population of LEED buildings and how they maintain their sustainable integrities over time.

Conclusion

Based on the review of literature and the analysis of data collected from the LEED buildings in this study the following conclusions have been drawn. Although LEED buildings do not consistently perform as predicted or meet the standards set by both the USGBC and the CBE, they do appear to maintain their sustainable integrities over time and in some instances, exceed the expectations of their design teams. Additionally, with the exception of thermal comfort, building users have indicated they are satisfied with the design and operation of their building.

. However, research findings still support the need for a variety of procedural and operational improvements including the installation of independent meters, better communication of sustainable goals, and more frequent assessments of building users' satisfaction with indoor environmental factors. Additionally, improvements to the LEED system itself would include the use of more accurate prediction tools during the application process and to require that Optimized Energy Performance points be awarded based on the savings of energy consumption and not utility costs.

Part of a designer's challenge when specifying sustainable materials and systems is to balance the additional 2 to more than 5% in green construction costs (USGBC, 2009, Green Building LEED Core Concepts Guide) with the presumed life-cycle cost savings from improved building performance. Therefore it is essential for designers to thoroughly understand each strategy's rate of success if they intend to provide a lasting service to their clients. By sharing actual performance data of LEED buildings and user responses to interior building environments, this study intends to inform the field of sustainable design and help its advocates learn from past projects.

APPENDIX A
UNIVERSITY OF FLORIDA INSTITUTIONAL REVIEW BOARD

UF | Institutional Review Board
UNIVERSITY *of* FLORIDA

PO Box 112250
Gainesville, FL 32611-2250
352-392-0433 (Phone)
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irb2@ufl.edu

December 16, 2009

TO: Pamela Cotera
PO Box 115705
Campus

FROM: Ira S. Fischler, PhD; Chair
University of Florida
Institutional Review Board 02

SUBJECT: **Exemption of Protocol #2009-U-1273**
Occupant Indoor Environmental Quality (IEQ) Satisfaction Survey

SPONSOR: None

The Board has determined that your protocol is exempt from review. This exemption is issued because this protocol does not involve the use of human participants in research in accordance with 45 CFR 46. Human participants are defined by the Federal Regulations as living individual(s) about whom an investigator conducting research obtains (1) data through intervention or interaction with the individual; or (2) identifiable private information.

Should the nature of your study change or if you need to revise this protocol in any manner, please contact this office before implementing the changes.

IF:di

APPENDIX B
INFORMED CONSENT

Protocol Title: Occupant Indoor Environmental Quality (IEQ) Satisfaction Interview

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study:
The goal of this study is to investigate to what the degree LEED buildings are maintaining their sustainable integrities.

What you will be asked to do in the interview:
The intent of this interview is to provide you, as a building occupants, an opportunity to elaborate on issues that were identified during the *Occupant Indoor Environmental Quality Satisfaction Survey's.* Prior to this interview, questions were formatted to address some specific problem areas with your building. You will be asked to provide details on each issue and are welcome to suggest solutions that could mitigate user discomfort.

Time required:
30 minutes

Risks and Benefits:
There are no direct benefits or risks to the participants associated with this study.

Compensation:
There is no foreseen compensation for participants.

Confidentiality:
Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file in my faculty supervisor's office. When the study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

Voluntary participation:
Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study:
You have the right to withdraw from the study at anytime without consequence.

Whom to contact if you have questions about the study:
Pamela Cotera, Graduate Student, Department of Interior Design, 346 Architecture Building, Gainesville, FL 32611, phone 352.392.0252 x333

Nam-Kyu Park, PhD, Department of Interior Design, 354 Architecture, P.O. Box 115705 Gainesville, FL 32611, phone 352.392.0252 x338

Whom to contact about your rights as a research participant in the study:

IRB02 Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; phone 392-0433.

Agreement:
I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: ____ Date: _________________

Principal Investigator: ___________________________________ Date: _________________

APPENDIX C
OCCUPANT INDOOR ENVIRONMENTAL QUALITY (IEQ) SATISFACTION SURVEY
(FULL-TIME OCCUPANT/TRANSIENT OCCUPANT)

Occupant Indoor Environmental Quality (IEQ) Satisfaction Survey (Full Time Occupant)

This adaptation of the Center for the Built Environment's (CBE) Occupant Indoor Environmental Quality (IEQ) survey, has been developed to qualify the performance of a building in terms of occupant satisfaction and comfort. This survey contains two basic background sections and nine primary screening sections. Utilizing a Likert scale from 1 to 5, 1 being the most dissatisfied and 5 being the most satisfied, you will be asked to evaluate your degree of satisfaction with a variety of building factors. If you respond that you are "very dissatisfied" with a particular feature of your building, please follow-up with and explanation in order to accurately determine the cause of your dissatisfaction.

For Researcher Use Only

Subject Code #: ______________________________

Date: ____

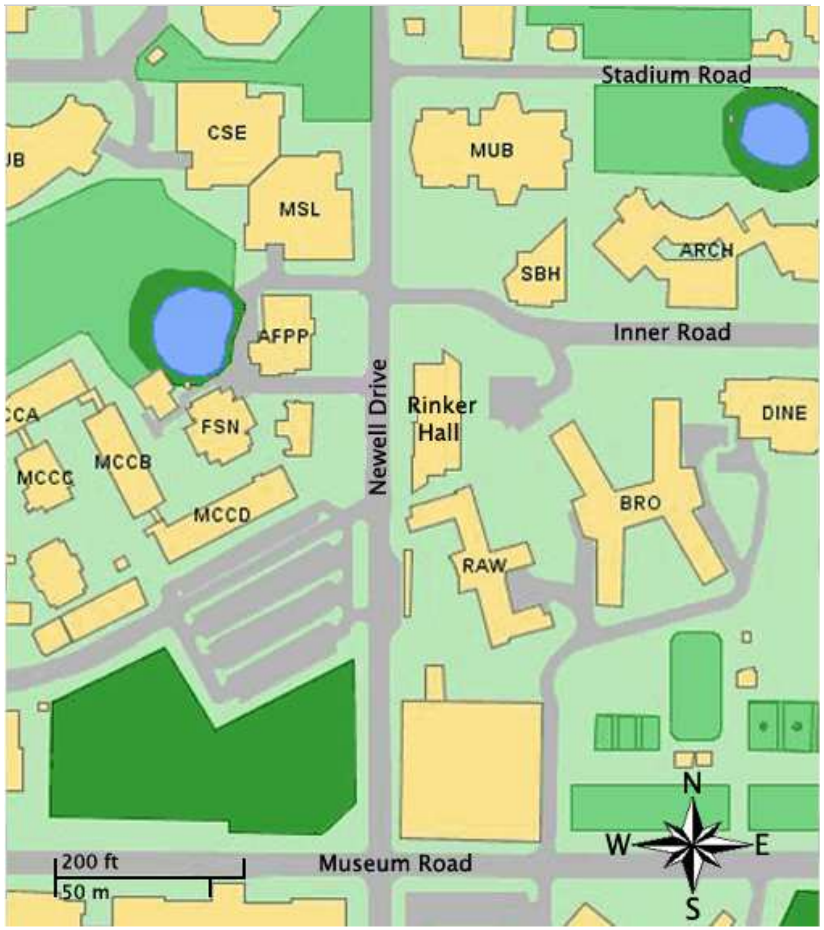

Figure 1. Adapted Map of Rinker Hall.
Source:http://campusmap.ufl.edu/

Thank you for participating in the Occupant Indoor Environmental Quality (IEQ) Satisfaction Survey. A random sampling of building users will be selected for a brief interview regarding their responses. Please indicate below if you can be contacted should you be selected.

Email Address:_________________________________

○ **Yes**, you may contact me should my survey be selected

○ **No**, you may not contact me should my survey be selected

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Part 1 - Occupant Background Information

1. What department do you work for?

2. What is your position and job title:

3. How many days, months, or years have you worked in this building?

4. How long have you worked in your current workspace (A workspace is the office, workstation or touch down desk, you frequently work at) ?

5. Please state your age in years.

6. Please indicate your gender.

○ Male ○ Female

Part 2 - Occupant Workspace Location

1. Which floor of the building is your workspace located?

2. Which area of the building is your workspace located (refer to map on page 1) **?**

○ North
○ East
○ South
○ West
○ Core (the center of the building)
○ Don't know
○ Other____________________

3. Are you near an exterior wall (within 15 feet)**?**

○ Yes
○ No
○ Don't know

4. Are you near a window (within 15 feet)**?**

○ Yes
○ No
○ Don't know

5. What direction does your window face (refer to map on page 1) **?**

- ○ North
- ○ East
- ○ South
- ○ West
- ○ Don't know

6. Describe your workspace.

Part 3 - Workspace Layout

This next section will ask you to rate your level of satisfaction with the attributes of your workspace layout. Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

1. How satisfied are you with the amount of personal space available for your work tasks and/or storage needs?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

2. How satisfied are you with your ability to communicate/interact with others within your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

3. How satisfied are you with the level of visual privacy provided within your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

Part 11 - General Feedback

1. How satisfied are you with the overall function of your personal workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

2. How satisfied are you with the overall function of your general office?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

3. How satisfied are you with the overall environmental conditions of your building?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

4. Please describe any other issues you may be experiencing that were not addressed above.

2. How satisfied are you with the maintenance service provided for your building (this question is referring to the quality of the company that provides your general maintenance. Are they timely, efficient, experienced, etc.)**?**

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

3. How satisfied are you with the general cleanliness of your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

4. How satisfied are you with the cleaning service provided for your building?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

5. Does the cleanliness and maintenance of your building enhance or hinder your ability to do your job efficiently?

Greatly Hindered	○ 1	○ 2	○ 3	○ 4	○ 5	Greatly Enhanced

If dissatisfied, please indicate why:

6. Please describe any issues you may be experiencing with the cleanliness or maintenance of that may not have been addressed above.

4. Does the layout of your workspace enhance or hinder your ability to do your job efficiently?

Greatly Hindered	○ 1	○ 2	○ 3	○ 4	○ 5	Greatly Enhanced

If hindered, please indicate why:

5. Please describe any issues you may be experiencing with your workspace layout that may not have been addressed above.

Part 4 - Workspace Furniture

This next section will ask you to rate your level of satisfaction with the attributes of your workspace furniture. Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

1. How satisfied are you with your workspace furniture (seating, desk, computer, etc.)**?**

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

2. How satisfied are you with the ability to adjust your furniture to meet your individual needs?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

3. Does your workspace furniture enhance or hinder your ability to do your job efficiently?

Greatly Hindered	○ 1	○ 2	○ 3	○ 4	○ 5	Greatly Enhanced

4. How satisfied are you with the aesthetics of your furniture (color, texture, finish material)**?**

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

5. Please describe any issues you may be experiencing with your personal workspace furniture that may not have been addressed above.

Part 5 - Thermal Comfort

This next section will ask you to rate your level of satisfaction with your thermal comfort. Thermal comfort is defined as "a condition of mind experienced by building occupants expressing satisfaction with the thermal environment" (USGBC, 2006). Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

1. Which of the following do you have the ability to adjust in your workspace (check all that apply)**?**

- ○ Operable Windows
- ○ Thermostat
- ○ Adjustable air vent in floor
- ○ Permanent Heater
- ○ Door to interior space
- ○ Door to exterior space
- ○ Window blinds/shades
- ○ Portable Fan
- ○ Portable Heater
- ○ Ceiling Fan
- ○ Adjustable air vent in wall/ceiling
- ○ None of the above
- ○ Other____________________

1. Which of the following do you use while in your building (check all that apply)**?**

- ○ Sensored sink faucet
- ○ Dual toilet flush
- ○ Low flow toilet
- ○ Waterless urinal
- ○ Not Sure
- ○ None of the above
- ○ Other____________________

2. Please describe how satisfied/dissatisfied you are with the effectiveness of the features you indicated above.

3. How well informed do you feel about using the features you indicated above?

Not well Informed	○ 1	○ 2	○ 3	○ 4	○ 5	Well Informed

4.How satisfied are you with the amount of water saving features available in your building?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

Part 10 - Cleanliness and Maintenance

This next section will ask you to rate your level of satisfaction with the operation and maintenance of your workspace. Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

1. How satisfied are you with the general maintenance (this refers to the maintenance of everyday items such as replacing light bulbs, general repairs, changing of air filters, etc.) **of your building?**

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

Part 8 - Acoustic Quality

This next section will ask you to rate your level of satisfaction with your workspace acoustics. Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

1. How satisfied are you with the acoustic qualities of your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

2. How satisfied are you with the acoustic privacy of your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

3. Does the acoustics of your workspace enhance or hinder your ability to do your job efficiently?

Greatly Hindered	○ 1	○ 2	○ 3	○ 4	○ 5	Greatly Enhanced

If hindered, please indicate why:

4. Please describe any issues you may be experiencing with your acoustics that may not have been addressed above.

Part 9 - Water Efficiency

This next section will ask you to rate your level of satisfaction with the water efficiency of your building. Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

2. Please describe how satisfied/dissatisfied you are with the effectiveness of the features you indicated above.

3. How well informed do you feel about using the features you indicated above?

Not well Informed	○ 1	○ 2	○ 3	○ 4	○ 5	Well Informed

4. How satisfied are you with the thermal comfort of your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

5. Does your office thermal comfort enhance or hinder your ability to do your job efficiently?

Greatly Hindered	○ 1	○ 2	○ 3	○ 4	○ 5	Greatly Enhanced

If hindered, please indicate why:

6. Please describe any issues you may be experiencing with your workspace/office thermal comfort that may not have been addressed above.

Part 6 - Indoor Air Quality

This next section will ask you to rate your level of satisfaction with your indoor air quality. Indoor air quality is defined as "the nature of air inside the space that affects the health and well-being of building occupants" (USGBC, 2006). Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

1. How satisfied are you with the indoor air quality of your workplace (i.e. dusty, stuffy/stale, cleanliness, odors)**?**

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

2. Does your indoor air quality enhance or hinder your ability to do your job efficiently?

Greatly Hindered	○ 1	○ 2	○ 3	○ 4	○ 5	Greatly Enhanced

If hindered, please indicate why:

3. Please describe any issues you may be experiencing with your indoor air quality that may not have been addressed above.

Part 7 - Lighting Levels

This next section will ask you to rate your level of satisfaction with your workspace lighting. Please follow-up with an explanation if you have indicated that you are "very dissatisfied" with a particular item.

1. Which of the following do you have the ability to adjust in your workspace (check all that apply)**?**

- ○ Light switch
- ○ Window blinds or shades
- ○ Under cabinet light
- ○ Light dimmer
- ○ Task (desk) light
- ○ None of the above
- ○ Other____________________

2. Please describe how satisfied/dissatisfied you are with the effectiveness of the features you indicated above.

3. How well informed do you feel about using the features you indicated above?

Not well Informed	○ 1	○ 2	○ 3	○ 4	○ 5	Well Informed

4. How satisfied are you with amount of artificial light available in your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

5. How satisfied are you with amount of natural light available in your workspace?

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

6. How satisfied with the visual quality of the lighting in your workspace (i.e. glare, reflection, contrast)**?**

Very Dissatisfied	○ 1	○ 2	○ 3	○ 4	○ 5	Very Satisfied

If dissatisfied, please indicate why:

7. Does your workspace lighting enhance or hinder your ability to do your job efficiently?

Greatly Hindered	○ 1	○ 2	○ 3	○ 4	○ 5	Greatly Enhanced

If hindered, please indicate why:

8. Please describe any issues you may be experiencing with your lighting that may not have been addressed above.

APPENDIX D

EMAIL TO RANDOMLY SELECTED PARTICIPANTS FOR IN-DEPTH INTERVIEWS

Dear__________________________,

Thank you for participating in the recent Occupant Indoor Environmental Quality (IEQ) Satisfaction Survey. I have taken a random sampling of the IEQ surveys and you were selected as a potential candidate for an interview. This follow-up interview is intended to expand on the areas that many participants indicated were unsatisfactory with BUILDING NAME. Your opinion and feedback is very valuable and can help to clarify the cause for these problematic areas.

The interview will take approximately 30 minutes and will be tape recorded for my records. Your involvement is voluntary and your responses will be kept confidential. There are no potential risks or compensation for your participation.

If you would like to participate, please let me know if you could be available on DATE. If not, please let me know a time that would be most convenient for your schedule.

Thank you again for your participation and I look forward to hearing from you.

Pamela N. Cotera | LEED® AP, BD+C | NCIDQ

APPENDIX E
INTERVIEW QUESTIONS FOR BOTH BUILDING A AND BUILDING B

Follow-up to Occupant Indoor Environmental Quality (IEQ) Satisfaction Survey

This follow-up is intended to expand on the areas that participants indicated they were dissatisfied with. The goal of this follow-up is to clarify and identify the cause of each participant's dissatisfaction.

Screen Section 1 - Occupant Background

1. Occupant Name:

2. Occupant Major:

3. How long have you been a user of (Building A)?

4. What course(s) do you have in (Building A)

Screen Section 2 - Thermal Comfort

1. Do the occupants of (Building A) have the ability to control their thermal environment?

2. Have you been informed on how to use the thermal controls in your workspace?

3. Which features of your thermal environment do you like the most?

4. Which features of your thermal environment do you least like?

5. How do you think your thermal environment could be improved?

Screen Section 3 - Lighting Levels

1. Do the occupants of (Building A) have the ability to adjust the lighting levels?

2. Have you been informed on how to use the lighting controls in your workspace?

3. Which lighting features do you like the most?

4. Which lighting features do you least like?

5. How do you think the lighting conditions could be improved?

Screen Section 4 - Water Efficiency

1. Have you been informed of the water saving features in your building?

2. Have you been informed on how to use the water saving features in your building?

3. Which water saving features do you feel are the most affective?

3. Which water saving features do you feel are the least affective?

5. How do you think the water saving features of your building could be improved?

APPENDIX F
BUILDING PERFORMANCE FIGURES FOR BUILDING A AND BUILDING B

Calculations for Building A (Rinker Hall)									
	Energy Consumption							Water Consumption	
	Electrical Consumption	Chilled Water		Steam		Total	Year Totals	Indoor Wate	Year Totals
Meter ID	#0272E01	#0272C01		#0272H01				#0272W01	
Units	kWh	ton hours	kWh	kLbs	kWh	kWh	Mbtu	kgal	kgal
Date									
Jul-04	40568	18	63.29	17	5882.51	46513.80		5	
Aug-04	39724	24	84.38	19	6574.57	46382.95		5	
Sep-04	38113	21	73.83	17	5882.51	44069.34		5	
Oct-04	43973	17	59.77	19	6574.57	50607.34		3	
Nov-04	41248	22	77.35	53	18339.59	59664.94		9	
Dec-04	40444	22	77.35	87	30104.61	70625.96		2	
Jan-05	40351	22	77.35	95	32872.85	73301.20		1	
Feb-05	36697	19	66.80	70	24222.1	60985.90		7	
Mar-05	45329	20	70.32	62	21453.86	66853.18		0	
Apr-05	44044	15	52.74	24	8304.72	52401.46		2	
May-05	41172	14	49.22	22	7612.66	48833.88		2	
Jun-05	41054	20	70.32	7	2422.21	43546.53	2264.71	10	51
Jul-05	42627	33	116.02	7	2422.21	45165.23		1	
Aug-05	42060	51	179.31	9	3114.27	45353.58		2	
Sep-05	39450	35	123.06	6	2076.18	41649.24		5	
Oct-05	48630	32	112.51	14	4844.42	53586.93		7	
Nov-05	29243	20	70.32	24	8304.72	37618.04		15	
Dec-05	37623	17	59.77	48	16609.44	54292.21		4	
Jan-06	56008	20	70.32	79	27336.37	83414.69		2	
Feb-06	41846	18	63.29	65	22491.95	64401.24		7	
Mar-06	45113	21	73.83	36	12457.08	57643.91		10	
Apr-06	45541	23	80.87	21	7266.63	52888.50		14	
May-06	42364	27	94.93	8	2768.24	45227.17		2	
Jun-06	41725	30	105.48	4	1384.12	43214.60	2130.52	2	71
Jul-06	45636	32	112.51	1	346.03	46094.54		1	
Aug-06	43130	36	126.57	2	692.06	43948.63		2	
Sep-06	43489	33	116.02	6	2076.18	45681.20		5	
Oct-06	45464	26	91.41	9	3114.27	48669.68		19	
Nov-06	42701	18	63.29	46	15917.38	58681.67		12	
Dec-06	35179	20	70.32	53	18339.59	53588.91		11	
Jan-07	31012	17	59.77	58	20069.74	51141.51		5	
Feb-07	37035	14	49.22	71	24568.13	61652.35		10	
Mar-07	40084	21	73.83	39	13495.17	53653.00		24	
Apr-07	36654	22	77.35	27	9342.81	46074.16		18	
May-07	38061	25	87.90	12	4152.36	42301.26		8	
Jun-07	37261	29	101.96	9	3114.27	40477.23	2019.67	4	119
Jul-07	39524	47	165.25	4	1384.12	41073.37		2	
Aug-07	38343	49	172.28	8	2768.24	41283.52		2	
Sep-07	37377	43	151.18	5	1730.15	39258.33		6	
Oct-07	40395	39	137.12	7	2422.21	42954.33		26	
Nov-07	38206	25	87.90	33	11418.99	49712.89		21	
Dec-07	41009	25	87.90	41	14187.23	55284.13		22	
Jan-08	37704	21	73.83	67	23184.01	60961.84		11	
Feb-08	39106	23	80.87	57	19723.71	58910.58		25	
Mar-08	43387	30	105.48	144	49828.32	93320.80		18	
Apr-08	42369	34	119.54	125	43253.75	85742.29		23	
May-08	43417	6	21.10	14	4844.42	48282.52		15	
Jun-08	34688	26.3333333	92.59	6.666666667	2306.86667	37087.45	2230.88	9	180
Jul-08	28195	54	189.86	5	1730.15	30115.01		8	
Aug-08	27383	40	140.64	9.5	3287.285	30810.92		8	
Sep-08	31868	40	140.64	8.5	2941.255	34949.89		16	
Oct-08	34716	48	168.76	4	1384.12	36268.88		24	
Nov-08	33399	24	84.38	25	8650.75	42134.13		21	
Dec-08	35126	19	66.80	65	22491.95	57684.75		20	
Jan-09	29506	16	56.25	62	21453.86	51016.11		9	
Feb-09	30884	19	66.80	92	31834.76	62785.56		25	
Mar-09	31831	23	80.87	62	21453.86	53365.73		19	
Apr-09	32349	25	87.90	61	21107.83	53544.73		22	
May-09	36663	26	91.41	37	12803.11	49557.52		14	
Jun-09	32129	27	94.93	14	4844.42	37068.35	1839.99	12	198
Jul-09	41614	38	133.60	15	5190.45	46938.05		14.8	
Aug-09	34569	38	133.60	20	6920.6	41623.20		12.06	
Sep-09	41393	54	189.86	67	23184.01	64766.87		17.2	
Oct-09	46536	44	154.70	57	19723.71	66414.41		27.3	
Nov-09	38569	28	98.45	55.8	19308.474	57975.92		25.5	
Dec-09	34988	21	73.83	71	24568.13	59629.96		21.25	
Jan-10	34255	16	56.25	171	59171.13	93482.38		11.16	
Feb-10	34465	18	63.29	92	31834.76	66363.05		22.2	

Mar-10	28352	16	56.25	81	28028.43	56436.68		17.1	
Apr-10	36075	25	87.90	54	18685.62	54848.52		24.4	
May-10	34908	30	105.48	36	12457.08	47470.56		14.5	
Jun-10	35526	34	119.54	24	8304.72	43950.26	**2387.92**	14	**221.47**
Jul-10	35500	35	123.06	19	6574.57	42197.63		15.4	
Aug-10	29300	43	151.18	12	4152.36	33603.54	**258.62**	14.8	**30.2**

Note: Text in "RED" was based on an average of previously recorded years due to a missed reading in PPD's original records.

Calculations for Building B (Steinbrenner Band Hall)

	Energy Consumption							Water Consumption	
	Electrical Consumption	Chilled Water		Steam		Total	Year Totals	Indoor Water	Year Totals
Meter ID	#0110E01	#0110C01		#0110H01				#0110W01	
Units	kWh	ton hours	kWh	kLbs	kWh	kWh	Mbtu	kgal	kgal
Date									
Apr-08	27820	11.5	40.43	122	42215.66	70076.09		2.5	
May-08	30260	4	14.06	35	12111.05	42385.11		2	
Jun-08	37150	12	42.19	15	5190.45	42382.64		1	
Jul-08	14297	23	80.87	18	6228.54	20606.41		2	
Aug-08	19307	33	45.71	19	6574.57	25927.28		1	
Sep-08	15892	25	87.90	2	692.06	16671.96		2	
Oct-08	12610	8	45.71	5	1730.15	14385.86		4	
Nov-08	12367	8	28.13	3	1038.09	13433.22		3	
Dec-08	11342	11	38.67	19	6574.57	17955.24		3	
Jan-09	9813	7	24.61	10	3460.3	13297.91		1	
Feb-09	11586	8	28.13	7	2422.21	14036.34		3	
Mar-09	9624	9	31.64	18	6228.54	15884.18	**1047.57**	2	**26.5**
Apr-09	12391	13	45.71	10	3460.3	15897.01		2	
May-09	11571	13	45.71	2	692.06	12308.77		2	
Jun-09	10399	15	52.74	2	692.06	11143.80		1	
Jul-09	10010	14	49.22	1	346.03	10405.25		2	
Aug-09	10385	13	45.71	19	6574.57	17005.28		1	
Sep-09	11543	16	56.25	3	1038.09	12637.34		3	
Oct-09	11441	15	52.74	35	12111.05	23604.79		3	
Nov-09	11688	12	42.19	43	14879.29	26609.48		3	
Dec-09	10551	7	24.61	41	14187.23	24762.84		1	
Jan-10	9341	3	10.55	47	16263.41	25614.96		1	
Feb-10	10531	4	14.06	48	16609.44	27154.50		3	
Mar-10	9693	3	10.55	47	16263.41	25966.96	**795.33**	2	**24**
Apr-10	12219	10	35.16	234	80971.02	93225.18		3	
May-10	11089	13	45.71	68	23530.04	34664.75		2	
Jun-10	10294	16	56.25	28	9688.84	20039.09		1	
Jul-10	10527	16	56.25	1	346.03	10929.28		3	
Aug-10	9664	18	63.29	19	6574.57	16301.86		1	
Sep-10	13680	18	63.29	20	6920.6	20663.89		3	
Oct-10	9740	12	42.19	39	13495.17	23277.36		2	
Nov-10	11010	10	35.16	44	15225.32	26270.48		4	
Dec-10	10760	6	21.10	48	16609.44	27390.54		2	
Jan-11	8650	6	21.10	54	18685.62	27356.72		3	
Feb-11	12610	10	35.16	61	21107.83	33752.99		3	
Mar-11	9810	12	42.19	42	14533.26	24385.45	**1222.30**	1	**28**

Note: Text in "RED" was based on an average of previously recorded years due to a missed reading in PPD's records.

APPENDIX G
CLASS SCHEDULES FOR BOTH BUILDING A AND BUILDING B

Building A (Rinker Hall) Occupancy Schedule - Spring 2010														
Room 106														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday			25	23	23	23	8	8		20				
Tuesday		25	25			17	17	17	17					
Wednesday			25	29	29	8	26	26	20					
Thursday			25	3	3	17	29	29						
Friday			25			23			20					
Saturday														
Sunday														
Room 110														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday		68	82	62	42	97	36	75	103	68				
Tuesday		64	64	93	93		46	60	60					
Wednesday		68	82	62	42	97	36	75		68				
Thursday			82				46	46						
Friday			82		68	97	36	75		68				
Saturday														
Sunday														
Room 125														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday														
Tuesday														
Wednesday														
Thursday					21		23							
Friday		30		32	20									
Saturday														
Sunday														
Room 140														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday		55	55	63	23	61								
Tuesday				3	3			12	12					
Wednesday		20	20			23	20	20						
Thursday							21	21	12					
Friday			38	38	38	23								
Saturday														
Sunday														
Room 206														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday														
Tuesday														
Wednesday														
Thursday														
Friday														
Saturday														
Sunday														
Room 210														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday		33	41	41		25	17	17						
Tuesday			15	15	15	11	17	13	13					
Wednesday		33	24	24	24	25	17	17						
Thursday		32	32	32	32	11	8	8	13	13				
Friday		33	7	18	18	25	16	16						
Saturday														
Sunday														
Room 215														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday		21	22	23	23	8			41	41	41			
Tuesday					19	19	11	11						
Wednesday		21	22	23	23	8		9	9	42	42	42		
Thursday		29	29	32	32	19	17	17	11	11				
Friday			22	21		8								
Saturday														
Sunday														
Room 220														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday			20	21	28	28	8	8	8					
Tuesday		37	37		12	12	29	29	13	13	13			
Wednesday			20	21	28	28	4	4						
Thursday		37		23	23	7	21	21	32	32				
Friday			8	21	21	20	20							
Saturday														
Sunday														
Room 225														
	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday				23			24	24						
Tuesday			17	17			15	15	15					
Wednesday		33	33	30	30	29	29	24	24					

Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room 230														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	35	21	21	19	11	20	19	0	0	0	0	0	0
Tuesday	0	16	16	15	15	15	10	40	40	0	0	0	0	0
Wednesday	0	31	21	21	19	0	20	19	0	0	0	0	0	0
Thursday	0	35	35	29	29	0	10	0	19	18	18	0	0	0
Friday	0	31	21	21	19	19	29	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room 238														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	49	0	41	49	0	30	30	0	0	0	0	0	0
Tuesday	0	38	38	0	40	0	0	0	0	0	0	0	0	0
Wednesday	0	49	0	41	49	0	0	30	0	0	0	0	0	0
Thursday	0	38	0	0	0	40	0	0	0	0	0	0	0	0
Friday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room 240														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	11	11	11	11	24	24	0	0	0	0	0	0	0
Tuesday	0	23	23	0	23	23	24	24	0	0	0	0	0	0
Wednesday	0	11	11	11	11	24	24	0	0	0	0	0	0	0
Thursday	0	23	23	0	0	0	23	24	0	0	0	0	0	0
Friday	0	13	13	13	0	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Building A (Rinker Hall) Occupancy Schedule - Spring 2010

Room 106

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	0	25	23	23	23	8	8	0	20	0	0	0	0
Tuesday	0	25	25	0	0	17	17	17	17	0	0	0	0	0
Wednesday	0	0	25	29	29	8	26	26	20	0	0	0	0	0
Thursday	0	0	25	3	3	17	29	29	0	0	0	0	0	0
Friday	0	0	25	0	0	23	0	0	20	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 110

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	68	82	62	42	97	36	75	103	68	0	0	0	0
Tuesday	0	64	64	93	93	0	46	60	60	0	0	0	0	0
Wednesday	0	68	82	62	42	97	36	75	0	68	0	0	0	0
Thursday	0	0	82	0	0	0	46	46	0	0	0	0	0	0
Friday	0	0	82	0	68	97	36	75	0	68	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 125

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tuesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wednesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thursday	0	0	0	0	21	0	23	0	0	0	0	0	0	0
Friday	0	30	0	32	20	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 140

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	55	55	63	23	61	0	0	0	0	0	0	0	0
Tuesday	0	0	0	3	3	0	0	12	12	0	0	0	0	0
Wednesday	0	20	20	0	0	23	20	20	0	0	0	0	0	0
Thursday	0	0	0	0	0	0	21	21	12	0	0	0	0	0
Friday	0	0	38	38	38	23	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 206

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tuesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wednesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thursday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Friday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 210

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	33	41	41	0	25	17	17	0	0	0	0	0	0
Tuesday	0	0	15	15	15	11	17	13	13	0	0	0	0	0
Wednesday	0	33	24	24	24	25	17	17	0	0	0	0	0	0
Thursday	0	32	32	32	32	11	8	8	13	13	0	0	0	0
Friday	0	33	7	18	18	25	16	16	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 215

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	21	22	23	23	8	0	0	41	41	41	0	0	0
Tuesday	0	0	0	0	19	19	11	11	0	0	0	0	0	0
Wednesday	0	21	22	23	23	8	0	9	9	42	42	42	0	0
Thursday	0	29	29	32	32	19	17	17	11	11	0	0	0	0
Friday	0	0	22	21	0	8	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 220

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	0	20	21	28	28	8	8	8	0	0	0	0	0
Tuesday	0	37	37	0	12	12	29	29	13	13	13	0	0	0
Wednesday	0	0	20	21	28	28	4	4	0	0	0	0	0	0
Thursday	0	37	0	23	23	7	21	21	32	32	0	0	0	0
Friday	0	0	8	21	21	20	20	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 225

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	0	0	23	0	0	24	24	0	0	0	0	0	0
Tuesday	0	0	17	17	0	0	15	15	15	0	0	0	0	0
Wednesday	0	33	33	30	30	29	29	24	24	0	0	0	0	0

Thursday	0	0	0	30	30	32	32	31	29	0	0	0	0	0
Friday	0	0	20	20	20	20	24	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room 230														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	19	21	0	21	0	33	13	13	0	0	0	0	0
Tuesday	0	0	25	25	13	13	14	14	14	0	0	0	0	0
Wednesday	0	19	21	23	21	33	33	13	13	13	0	0	0	0
Thursday	0	0	25	19	19	13	21	21	21	21	0	0	0	0
Friday	0	21	21	21	21	33	33	33	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room 238														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	40	0	44	45	45	0	0	0	0	0	0	0	0
Tuesday	0	44	44	0	44	0	19	19	0	49	49	49	0	0
Wednesday	0	40	0	44	45	0	0	0	0	0	0	0	0	0
Thursday	0	44	0	0	0	44	19	19	0	0	0	0	0	0
Friday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room 240														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	0	0	34	34	34	34	32	32	0	0	0	0	0
Tuesday	0	0	0	23	23	29	20	20	0	0	0	0	0	0
Wednesday	0	0	0	34	34	32	0	0	0	0	0	0	0	0
Thursday	0	0	0	23	23	0	20	20	0	0	0	0	0	0
Friday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Building B (Steinbrenner Band Hall) Occupancy Schedule - Fall 2010														
Room G005														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	0	0	0	0	0	45	45	82	82	287	287	0	0
Tuesday	0	0	0	0	27	0	0	0	287	287	0	0	0	0
Wednesday	0	0	0	0	0	0	45	45	82	82	0	0	0	0
Thursday	0	0	0	0	27	0	0	0	287	287	0	0	0	0
Friday	0	0	0	0	0	0	21	21	287	287	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room 110														
	7:25	**8:30**	**9:35**	**10:40**	**11:45**	**12:50**	**1:55**	**3:00**	**4:05**	**5:10**	**6:15**	**7:20**	**8:20**	**9:20**
Monday	0	0	4	4	0	0	0	0	0	0	0	0	0	0
Tuesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wednesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thursday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Friday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Building B (Steinbrenner Band Hall) Occupancy Schedule - Spring 2010

Room G005

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	0	0	0	0	0	44	44	88	88	0	73	73	73
Tuesday	0	0	0	0	0	0	67	67	16	16	0	0	0	0
Wednesday	0	0	0	0	0	20	44	44	88	88	0	0	0	0
Thursday	0	0	0	0	0	0	67	0	16	16	0	0	0	0
Friday	0	0	0	0	0	0	0	0	16	16	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room 110

	7:25	8:30	9:35	10:40	11:45	12:50	1:55	3:00	4:05	5:10	6:15	7:20	8:20	9:20
Monday	0	0	0	3	3	0	0	0	0	0	0	0	0	0
Tuesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wednesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thursday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Friday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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BIOGRAPHICAL SKETCH

In 2006, Pamela N. Cotera graduated from the University of Florida with a Bachelor of Design and a keen interest in sustainability. Whether by luck or fate, she started working for an Atlanta based firm that not only embraced environmentally conscious design; but had adamantly encouraged their clients to do the same since 1999. While surrounded by United States Green Building Council (USGBC) members and avid green designers, her college-founded interests were quickly nurtured into a budding passion for sustainable practices. She quickly became a LEED Accredited Professional and worked closely with clients and design teams on a series of certified projects. Sometime after becoming a licensed designer and the LEED Administrator for her office, she felt it was important to share the knowledge she had gained while crafting sustainable interiors. In 2008 she decided to start her own business, Leaping for GREEN, and began to instruct LEED courses for a wide client base including designers, architects, and engineers.

It was at this time that Pam realized how much she loved teaching and decided to pursue a career in sustainable design education. In 2009, she returned to UF where she could further enrich her knowledge of LEED-building performance and pursue a master’s and doctoral degree in design. Since her enrollment, she has worked as a Graduate Teaching Assistant for several upper-division studios, has competed in the Department of Energy’s Solar Decathlon in Washington D.C., presented her master’s research at the 2011 IDEC conference in Denver, Colorado, and was a winner of the Witters design charrette competition. Ultimately, Pam hopes to refine her knowledge of sustainable design and start her career as a Professor at an esteemed university.