POE

POST OCCUPANCY EVALUATION

LEARNING FROM TODAY TO PROVIDE A BETTER TOMORROW

Conducted By:

GREEN BUILDING ASSOCIATION OF CENTRAL PENNSYLVANIA

For:

W. S. Cumby & Son

BUILDERS & CONSTRUCTION MANAGERS

938 Lincoln Ave
Springfield, PA 19064

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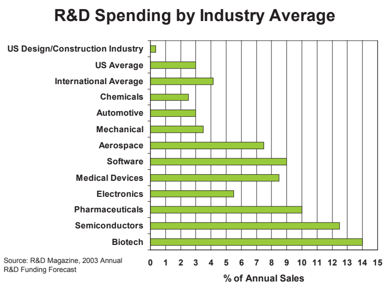
In September of 2007, Todd Reed and Cam Fitzgerald of Energy Opportunities visited W.S. Cumby's office and conducted a POE study.

This study is only a snap shot of the project's actual indoor environment since all but the IAQ test were conducted on one day. The intention of this POE is to provide a general overview of the indoor conditions of the project. This information will allow the owner to see an overall condition and identify any areas or issues of concern or exemplary performance.

This report was made possible to throught the generous support of The Reinvestment Fund's Sustainable Development Fund.

WHAT IS THE PROBLEM.........



"You can only manage what you measure." This adage applies to building performance as well. The building "industry" does a very poor job of connecting the design and construction of a building project to its performance. The current system lacks feedback loops so that designers can learn from how their building performs and make adjustments to improve that performance. Using tools like LEED during design can provide guidance to the design team on incorporating high performance features into the project. Ultimately, however, the proof is not in the paperwork submitted for LEED but how the building performs in the real world. The reality is that many of our buildings do not perform up to expectations. The building "industry" spends a paltry 0.4% of gross sales on research and development compared the US industry average of 3%. We can do better - Building commissioning, Measurement & Verification and POE studies are all attempts to provide feedback to designers and building owners so that we can produce buildings that perform at a higher level and according to prediction.

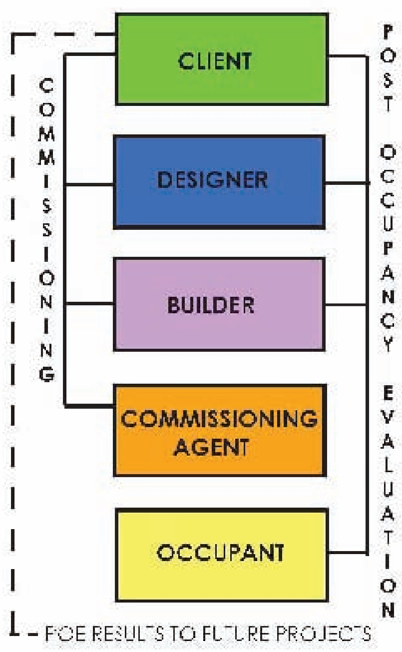
WHAT IS POE........................

Post occupancy evaluation is a method used to evaluate the performance of existing buildings as compared to their initial concepts and analyses. It is a systematic gathering, analysis, and comparison of information collected from within the building and from the occupants. This information can consist of water and electric bills, indoor air quality, day/electric lighting, occupant surveys and other metrics. Information from the surveys provides data on thermal comfort, air quality, acoustics, lighting, cleanliness, spatial layout, and office furnishings. By using both data and surveys, we can better understand the relation between the conceptual and actual performance along with identifying other performance aspects. It is not the intent of POEs to find mistakes but rather to determine the performance of the building and its materials, and occupant satisfaction. A common sense approach to continuous product improvement would dictate that the "industry" consistently strive to produce better buildings which perform well relative to the building's occupants and the broader environment.

WHAT ARE THE BENEFITS......

Ultimately, the benefits are better buildings. Bridging the gaps between design, construction and operations of buildings is necessary if we are to develop a system that focuses on improving building performance. Building performance needs to positively influence the productivity of the building occupants and reduce operating costs. Following up the design and construction of a building with POE gathers the data which enables learning and feedback. Not only can we begin to understand how buildings perform but also how the occupants respond to a space and various construction materials. By comparing POE data with conceptual predictions, we can begin to improve existing guidelines and the overall performance of buildings. The goal is to gather the "lessons learned" from high performance green building projects so that we can improve the design and construction process to improve current practice.

WHAT IS THE METHOD........



Conventional design, construction and operations practice provides little opportunity for feedback from the building occupants. The purpose of a POE is to provide information on building performance parameters in the follow areas:

-Indoor Environment Quality (IEQ) Survey
 -Completed on the web by building occupants
 -Includes evaluation of thermal comfort, air quality, acoustics, lighting, cleanliness, spatial layout, and office furnishings

-Electric & Water Bill Monitoring
 -One year cost and consumption data
 -Comparisons to similar building types using regional data
 -Comparison to predicted results

-Indoor Air Quality Monitoring
 -Monitor typical space in building
 -Independent lab analyzes and reports

-Lighting Analysis
 -Daylight and electric light
 -Quality and quantitative analysis

-Other Metrics
 -Acoustics

THE GOAL..........................

The goal is to provide the information needed to improve building performance. By examining how our buildings perform relative to occupant productivity, operating costs, and the environment, we can learn how to improve upon current practice. In addition, this information needs to be disseminated as widely as possible and made available to the entire building community.

By learning from today we can create a better, greener tomorrow.

The Green Building Association of Central Pennsylvania is a non-profit, membership-based organization and the regional affiliate of the US Green Building Council. Our mission is to promote environmentally responsible design, planning, construction, and operation of the built environment through education, outreach, and networking.

PROJECT DATA

-The project is a major renovation to an existing 14,000 SF building that was once used as a retirement home.

-Located on a 2.5 acre heavily wooded lot with storm water management & treatment.

-Use of low flow fixtures and waterless urinals.

-100% Building Shell Reuse.

-87% of Construction Waste diverted from landfills.

-Over 45% of materials by cost contain recycled content.

-Operable windows.

-Daylighting strategies.

LEED — LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

W. S. Cumby Office Complex, LEED® Project # 0301
LEED Version 2 Certification Level: CERTIFIED
September 24, 2004

30 Points Achieved — Possible Points: 69

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

8	Sustainable Sites		Possible Points: 14
Y			
Y	Prereq 1	**Erosion & Sedimentation Control**	
1	Credit 1	**Site Selection**	1
	Credit 2	**Urban Redevelopment**	1
	Credit 3	**Brownfield Redevelopment**	1
1	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
	Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations	1
1	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
1	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
1	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
1	Credit 6.2	**Stormwater Management**, Treatment	1
1	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
	Credit 8	**Light Pollution Reduction**	1

4	Water Efficiency		Possible Points: 5
Y			
1	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
1	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
	Credit 2	**Innovative Wastewater Technologies**	1
1	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
1	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

	Energy & Atmosphere		Possible Points: 17
Y			
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	
	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing	2
	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing	2
	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing	2
	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing	2
	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing	2
	Credit 2.1	**Renewable Energy**, 5%	1
	Credit 2.2	**Renewable Energy**, 10%	1
	Credit 2.3	**Renewable Energy**, 20%	1
	Credit 3	**Additional Commissioning**	1
	Credit 4	**Ozone Depletion**	1
	Credit 5	**Measurement & Verification**	1
	Credit 6	**Green Power**	1

8	Materials & Resources		Possible Points: 13
Y			
Y	Prereq 1	**Storage & Collection of Recyclables**	
1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
1	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Shell	1
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	**Construction Waste Management**, Divert 50%	1
1	Credit 2.2	**Construction Waste Management**, Divert 75%	1
1	Credit 3.1	**Resource Reuse**, Specify 5%	1
	Credit 3.2	**Resource Reuse**, Specify 10%	1
1	Credit 4.1	**Recycled Content**	1
1	Credit 4.2	**Recycled Content**	1
1	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	Credit 6	**Rapidly Renewable Materials**	1
	Credit 7	**Certified Wood**	1

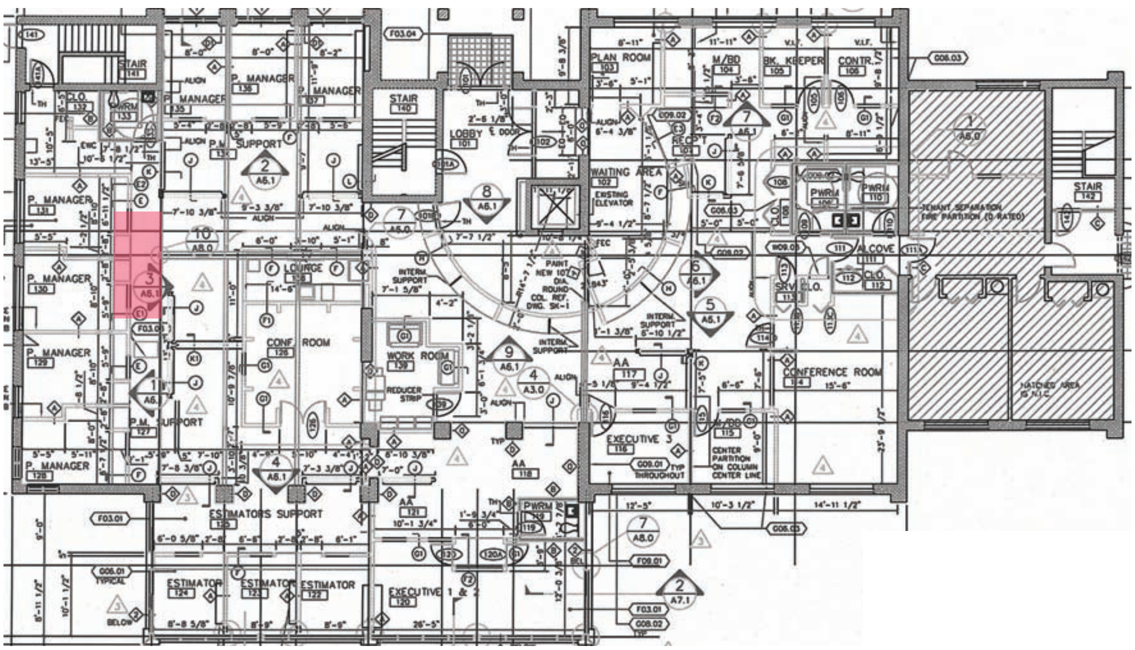
7	Indoor Environmental Quality		Possible Points: 15
Y			
Y	Prereq 1	**Minimum IAQ Performance**	
Y	Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	
	Credit 1	**Carbon Dioxide (CO_2) Monitoring**	1
	Credit 2	**Increase Ventilation Effectiveness**	1
	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1	Credit 4.2	**Low-Emitting Materials**, Paints	1
1	Credit 4.3	**Low-Emitting Materials**, Carpet	1
	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
1	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1	Credit 6.1	**Controllability of Systems**, Perimeter	1
	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
1	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

3	Innovation & Design Process		Possible Points: 5
Y			
1	Credit 1.1	**Innovation in Design**: Work at Home Plan	1
1	Credit 1.2	**Innovation in Design**: Exemplary Performance SSc6.1	1
	Credit 1.3	**Innovation in Design**:	1
	Credit 1.4	**Innovation in Design**:	1
1	Credit 2	**LEED® Accredited Professional**	1

IAQ

An indoor air quality test was performed at the project's location. The test kit used was from Air Quality Sciences, Inc. (Please See Appendix for complete test kit information and results.) Each test kit was capable of testing for VOCs, formaldehyde, and mold spores. There were limitations with these kits, as they could only effectively test 1,000 sq ft of space. An atypical space was chosen for the placement of the kit. The testing tubes were left in place for one week's time and dust samples were taken from the headers to the work spaces shown in the picture.

The test demonstrated good air quality for the space tested. The VOC levels were below the compararable standards and the formaldehyde levels were slightly above the LEED standard by .038. Typical mold spores were found, but the lab report states that these are typical. Workers at the office commented that they had no issues with the air quality since they are able to open the windows.

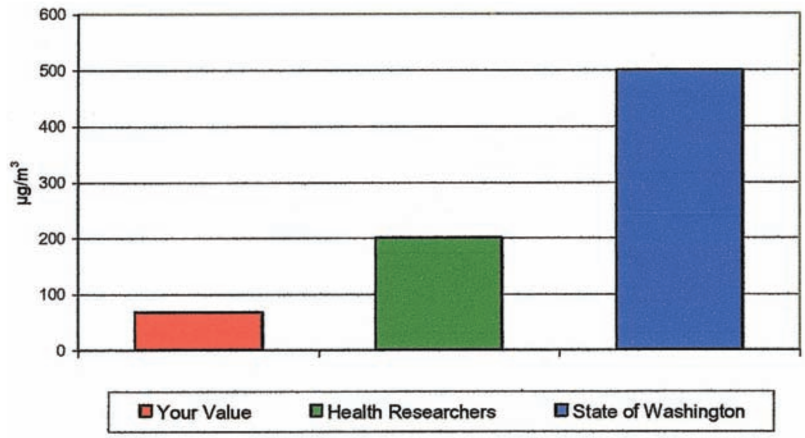


The highlighted area shows the location for the IAQ Test conducted. This occurred in the vaulted open office area.

This image shows the location of the IAQ test tube locations and where the dust samples were taken.

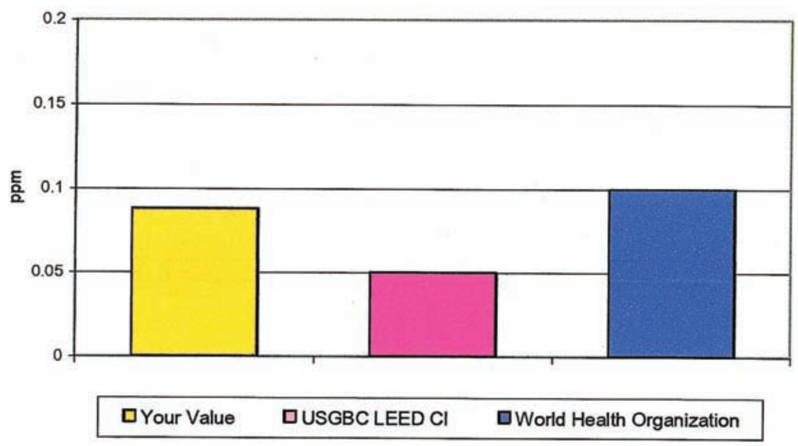
VOC

SAMPLE RESULTS	
Total Volatile Organic Compounds (TVOC)	67.4 $\mu g/m^3$
Primary Individual VOCs Found	Decamethylcyclopentasiloxane; Acetone; Toluene



FORMALDEHYDE

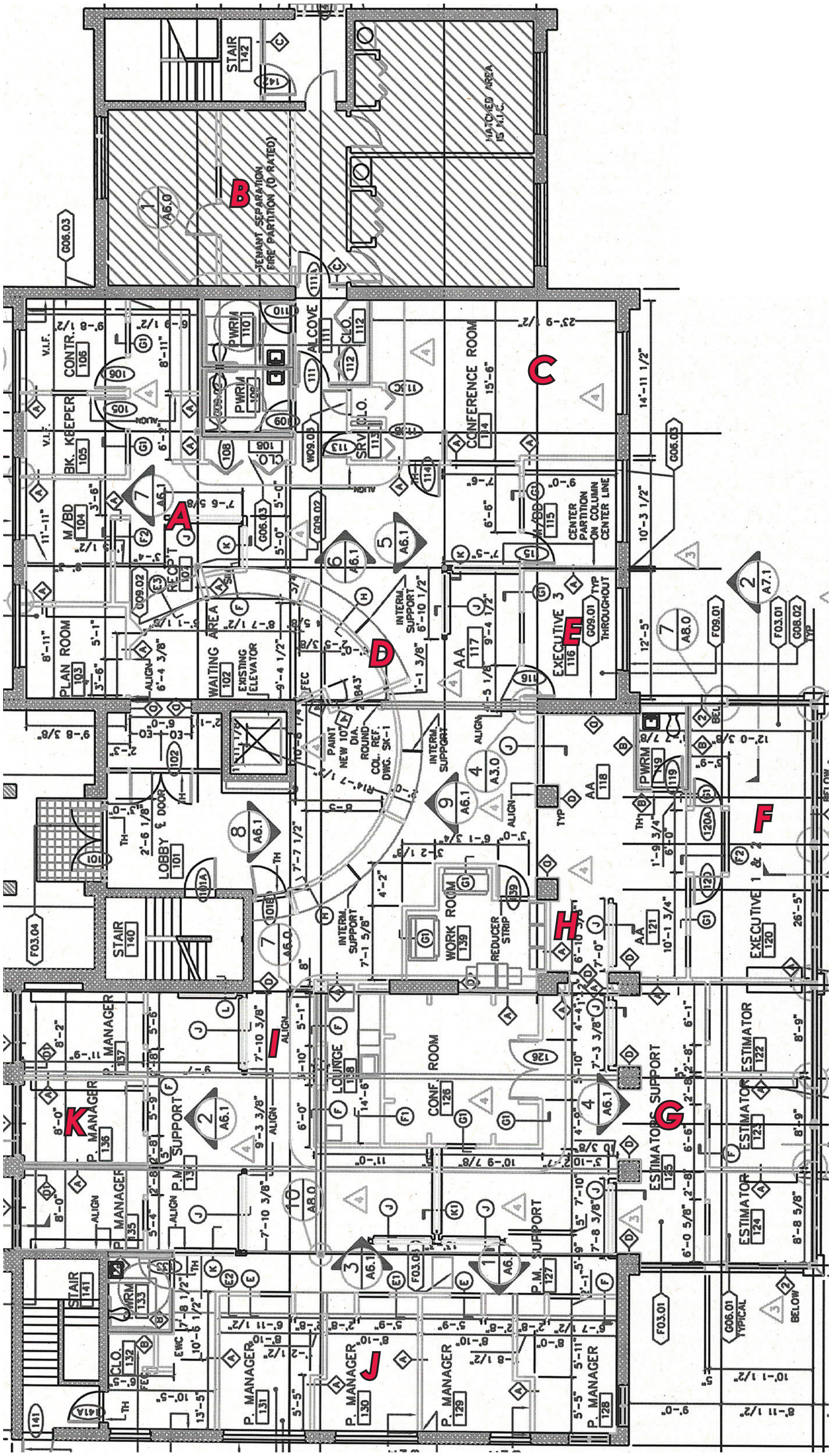
SAMPLE RESULTS	
Formaldehyde	0.088 ppm



MOLD

SAMPLE RESULTS		
	Tape 1	**Tape 2**
Location	Reception	Support
Did the Sample Contain Mold?	___ No (no mold seen) _X_ Yes; only scattered spores seen (typical on non-problem surfaces) ___ Yes; evidence of *growth* seen (undesirable)	___ No (no mold seen) _X_ Yes; only scattered spores seen (typical on non-problem surfaces) ___ Yes; evidence of *growth* seen (undesirable)
What was the evidence of mold *growth*?	_X_ None ___ Mold structures (hyphae) ___ Numerous/clumped spores ___ Reproductive structures (such as conidiophores)	_X_ None ___ Mold structures (hyphae) ___ Numerous/clumped spores ___ Reproductive structures (such as conidiophores)
Kinds of mold seen	Epicoccum Cladosporium ascospores Pithomyces	Cladosporium ascospores Epicoccum

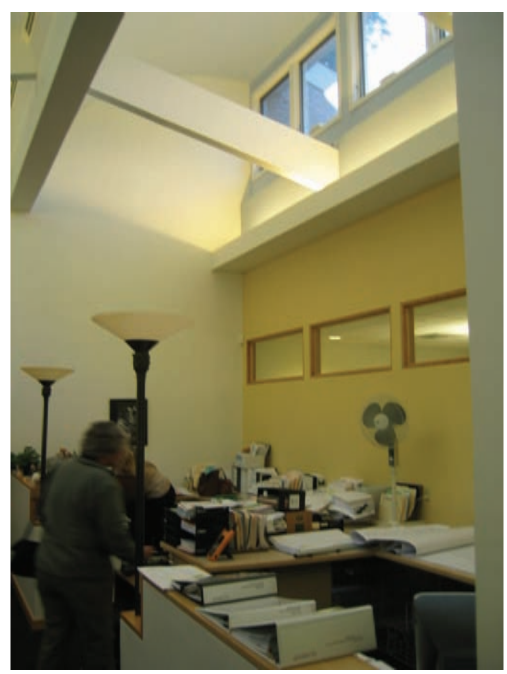
Readings were taken throughout the building for CO_2, temperature, and relative humidity. The office had about 20 people inside at the time of the readings with the outside measurements being 68.9 F, 57.3% relative humidity, and 662 ppm of CO_2. The windows were closed at the time of the readings. The CO_2 levels were on average 19% more than the outside readings. No indications from the occupant survey show any complaints of air quality. The project did not attempt CO_2 monitoring or increased ventilation.



Average CO_2 levels in typical atmospheric conditions are 330-350ppm.

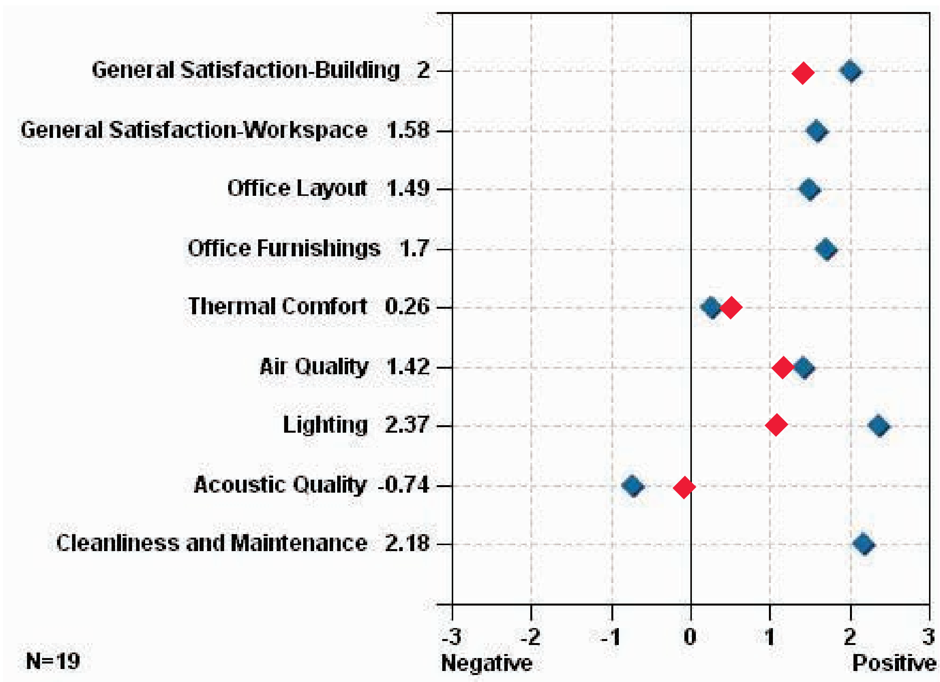
30-50% relative humidity is a typical comfort range.

	Temp	Humidity	CO_2	Occupied
A	74.3	48%	782	yes
B	74.3	49%	923	yes
C	73.4	50%	902	no
D	74.3	48%	814	no
E	73.4	49.60%	762	no
F	73.4	48%	786	no
G	73.4	47.40%	843	yes
H	73.4	47.80%	832	no
I	73.4	49.30%	762	yes
J	73.4	48.90%	781	no
K	73.4	49.50%	804	yes



IEQ

An indoor environmental survey was conducted via the web through the Center for the Built Environment. The survey had a 66% response rate which is above the average of 60% as reported by the CBE.
Overall, the majority of the occupants that took the survey were satisfied.



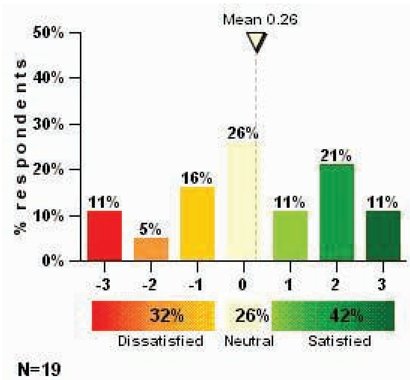
The chart above shows the project's overall results (blue diamonds) from the survey. The red diamonds represent the average results of 15 surveyed LEED certified buildings. (See Appendix for full report) The report titled "Occupant Satisfaction with Indoor Environmental Quality in Green Buildings" was conducted by the Center for the Built Environment which surveyed 215 different buildings. The survey consisted of LEED certified, green designed, and ungreen designed buildings.

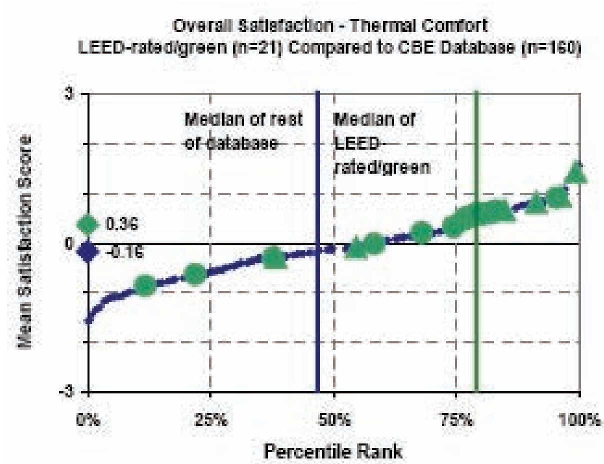
As summarized in the report, acoustics and lighting were among the two lowest amongst green buildings. The reason for this is that most green buildings implement open floor plans to increase the overall penetration of daylight into the space. These open floor plans can have poor acoustical qualities, resulting in the low ratings.

The reason for the lower ratings for lighting was due to the lack of controls for both electric lighting and daylighting.

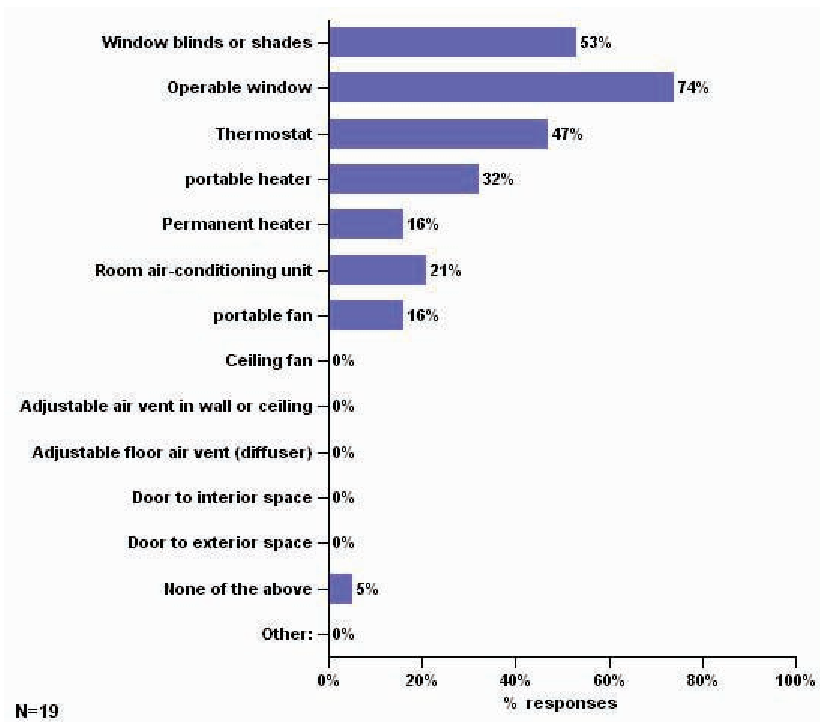
Thermal comfort in the space was relatively low. Reported issues include that the space is too cold in the winter and too hot in the summer. The project does have operable windows, however a comment was made that there is an uneven distribution of treated air throughout the space.

9.2 How satisfied are you with the temperature in your workspace?





9.1 Which of the following do you personally adjust or control in your workspace? **(check all that apply)**



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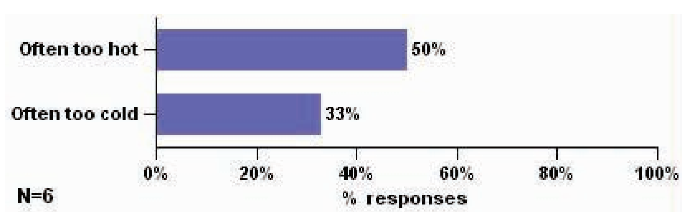
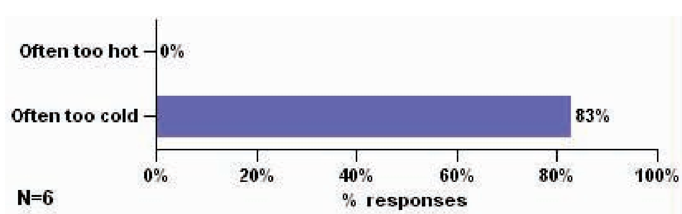
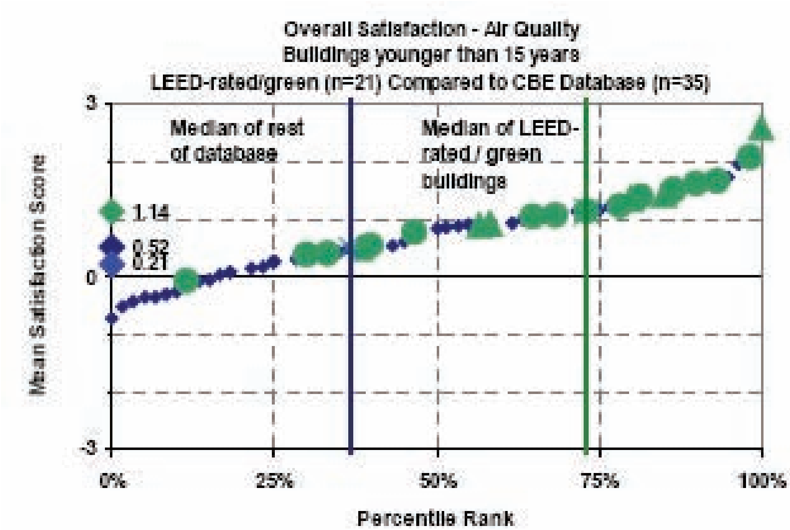
10.1 In warm/hot weather, the temperature in my workspace is: **(check all that apply)**



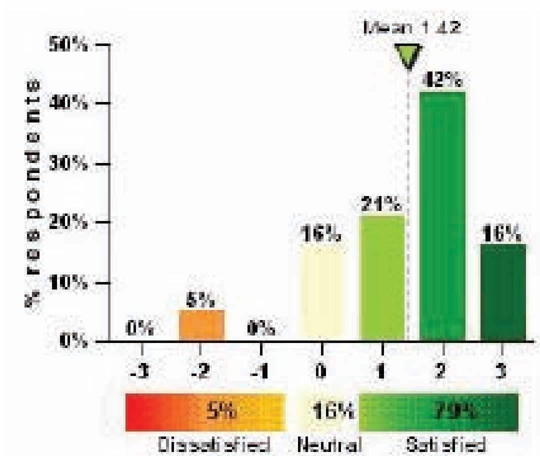
10.2 In cool/cold weather, the temperature in my workspace is: **(check all that apply)**



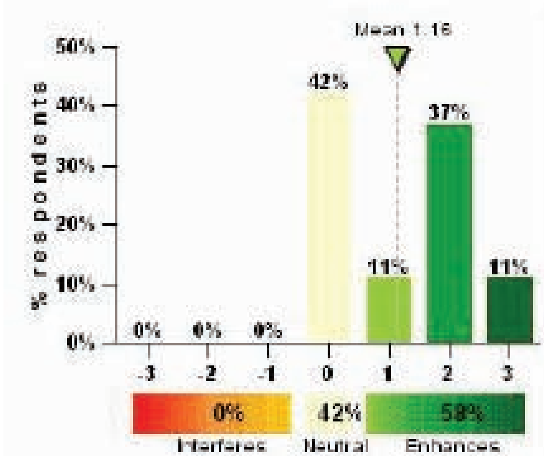
Air quality in the project was reported as goodl. The project earned EQc4.1, 4.2, 4.3 and EQc5. Occupants also have the ability to open the windows when the weather allows.



11.1 How satisfied are you with the air quality in your workspace (i.e. stuffy/stale air, cleanliness, odors)?

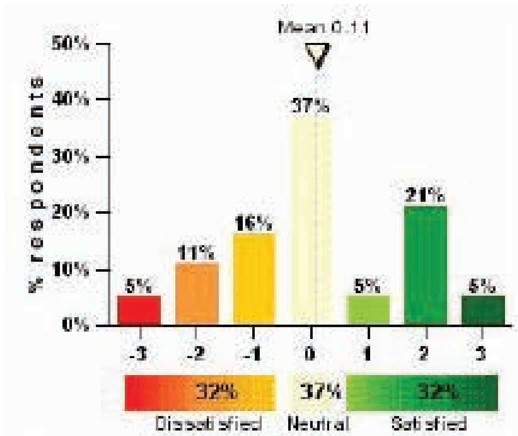


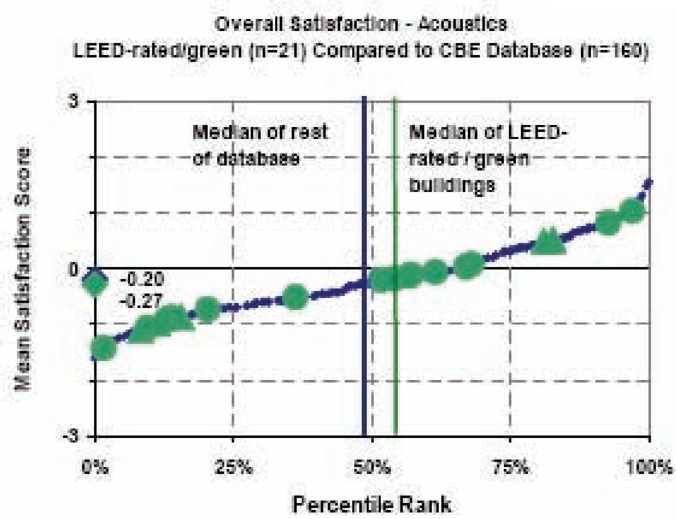
11.2 Overall, does the air quality in your workspace enhance or interfere with your ability to get your job done?

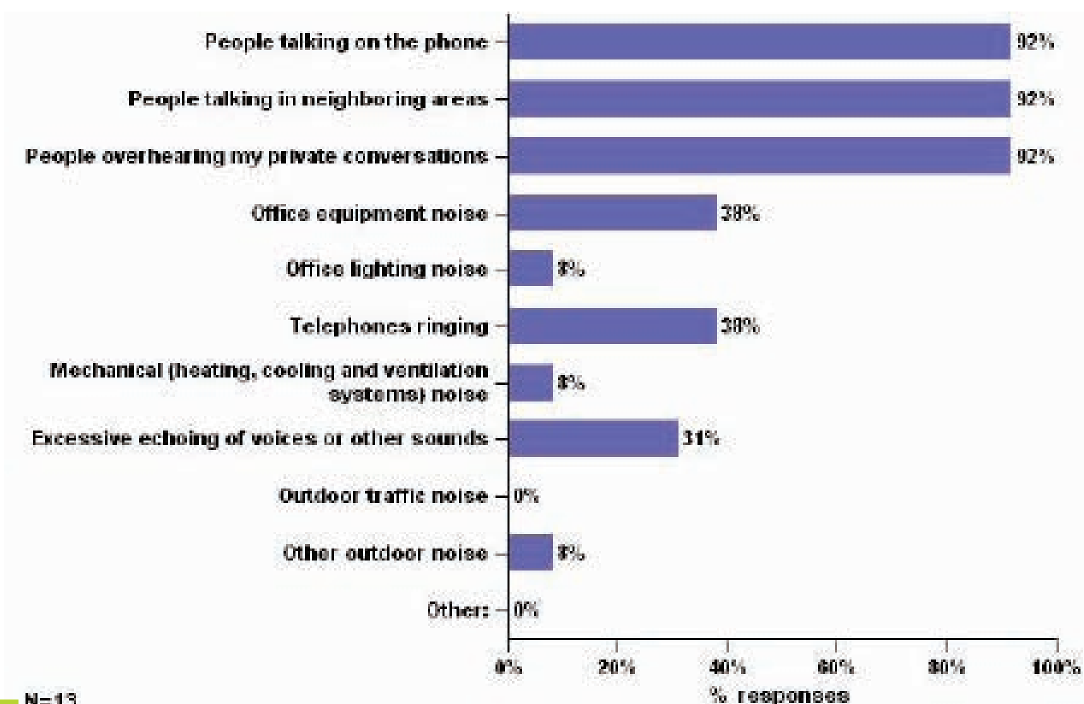


Acoustics in the project had a lower rating than average levels for LEED certified buildings due to the project's space layout. Except for a few offices, the majority of them do not have any windows or doors to isolate noise in these spaces.

15.1 How satisfied are you with the noise level in your workspace?

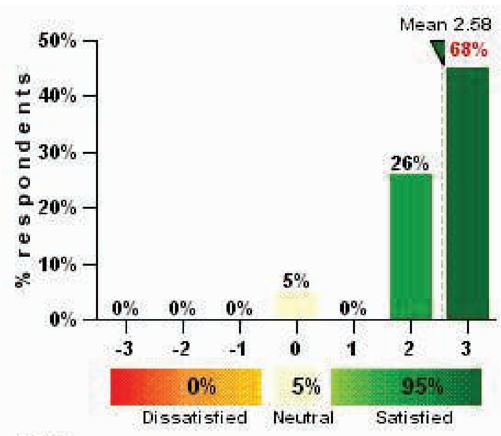


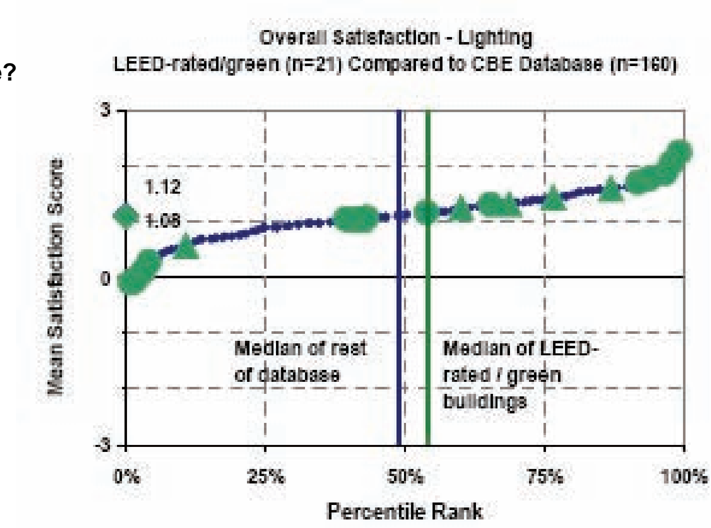




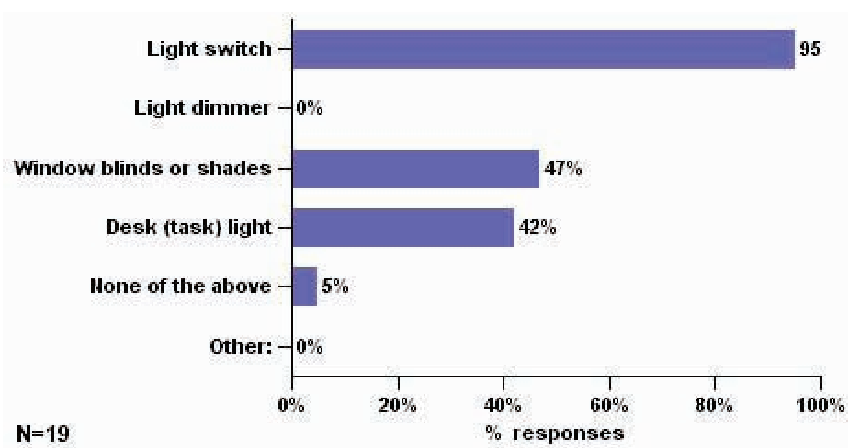
Overall, the occupants were satisfied with the lighting levels in the building. Occupants either have control of window blinds or task lighting. The daylighting levels are not as even as one would like them to be, however, the project sits on a wooded site which provides a large amount of shade.

13.2 How satisfied are you with the amount of light in your workspace?





13.1 Which of the following controls do you have over the lighting in your workspace?
that apply)



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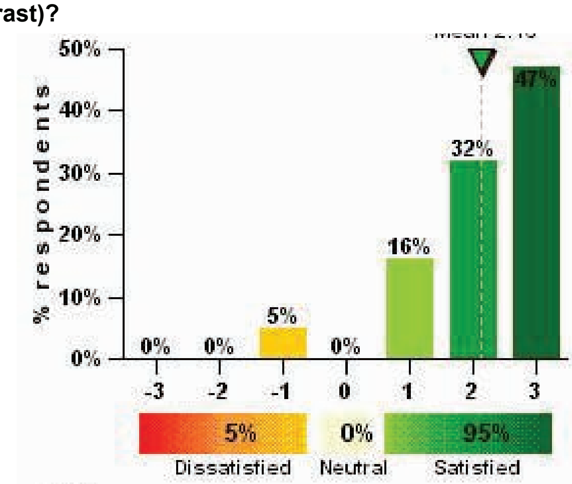
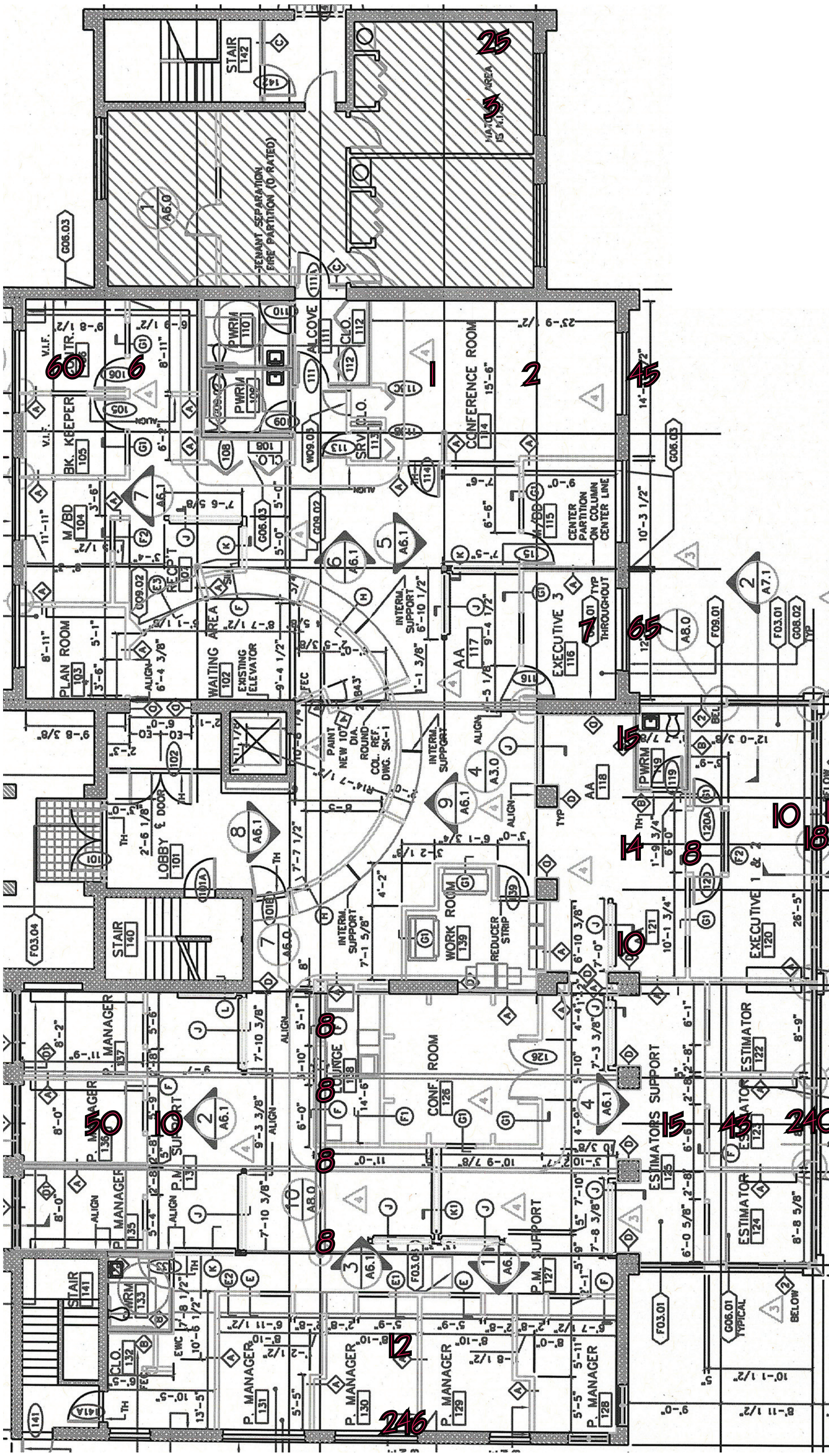
13.3 How satisfied are you with the visual comfort of the lighting (e.g., glare, reflections, contrast)?



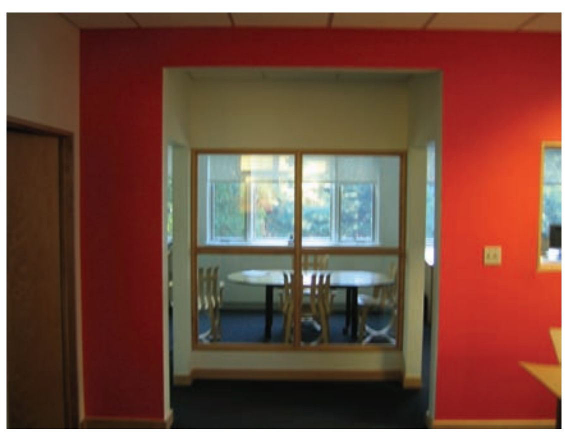
LIGHTING



Overall, the occupants were satisfied with the lighting levels in the building. Below are the measured lighting levels throughout the project on September 19th at 10:30am. 30 fc = a daylight factor of 2.

A typical daylighting zone is usually 1.5 to 2 times the window head height. The project is surrounded by a large amount of vegetation, which results in considerable shade. This is good for the reduction of solar heat gain, but is detrimental to the daylight levels in the space.

Typical lighting levels for an office space are, at a minimum, 20-30 fc. The majority of the spaces adjacent to the window wall have sufficient levels of daylight. Some of the spaces on the northern side of the project are lower than optimum.



Energy Performance Benchmarking

An energy model was not fully completed as part of the original LEED submission, so a comparison to predicted performance is not possible.

The utility bills for the period August 2006 through July 2007 were evaluated against two benchmarks of actual building energy performance. The Target Finder analysis resulted in a score of 88, placing the building in the top 12 percentile of actual energy consumption for commercial office space. This Target Finder score qualifies the project as an Energy Star Building.

The other benchmark that the facility was evaluated against was the 2030 Challenge targets. The current 2030 target is a 50% reduction in energy use relative to an average office building. The actual energy use of the facility is currently 66% below the national average for an office building.

The overall energy performance of the facility is very good in comparison to available existing building energy data.

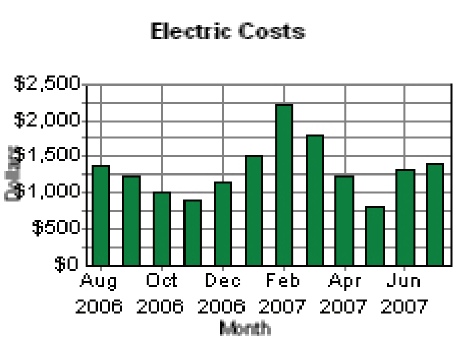
Energy Performance Comparison

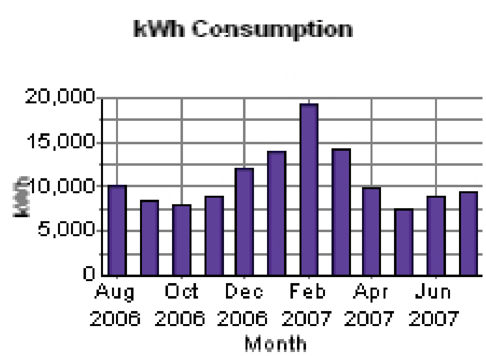
Annual Building Energy Consumption

	Building		Electricity		
Year	Total Btus Consumed	Btu/Sqft	kWh Used	% of Total Bldg Btus	Btu/SqFt
2006-2007	444,683,183	31,763	130,291	100%	31,763

Annual Building Energy Costs

	Building		Electricity		Water	
Year	Cost ($)	$/SqFt	Cost($)	$/SqFt	Cost ($)	$/SqFt
2006-2007	17,599	1.26	15,973	1.14	1,626	0.12





Evaluating Building Energy Performance - W.S. Cumby & Son

Energy Star Target Finder

The US EPA's Energy Star Target Finder is a tool used to assist the design team in setting an energy performance target and evaluating a building's actual energy performance in terms of site energy use intensity and estimated and actual total annual energy consumption. The database used by Target Finder is the US Department of Energy's Commercial Building Energy Consumption Survey (CBECS). By entering a few of the project's facility characteristics (i.e. location of project for local climate and weather data, building type, area, occpancy levels, and hours of operation), the CBECS data can be accessed and normalized. The normalized data is then ranked on a scale of 1-100. As the design progresses, estimated annual energy use can be compared to the normalized CBECS data to monitor the design's energy performance. After occupancy the actual data can be entered and compared to the database to evaluate final building energy performance.

Building Characteristics

Zip Code	19064	City	Springfield	State	Pennsylvania
Space Type (see Notes below)	**Gross Floor Area**	**Number of Occupants**	**Number of PCs**	**Operating Hours / Week**	
Office	14,000	29	29	60	

Utility Rates

Electricity	$0.1225948/kWh	Natural Gas	NA

Energy Star Target Finder Results

Energy Data	Actual Performance	Target Finder 75	Target Finder 90	Target Finder 100		
Target Finder Rating	88	75	90	100		
Site Energy Use Intensity (kBtu/Sq./yr)	31.8	40.8	30.6	16.4		
Estimated Total Annual Energy (kBtu)	444,553.0	571,545.0	428,225.0	230,221.0		
Total Annual Energy Cost ($)	$15,973	$20,536	$15,386	$8,272		
Site Energy Cost Intensity ($/Sf)	$1.14	$1.47	$1.10	$0.59	$0.00	$0.00

Based on the data provided the project would qualify as an Energy Star rated building.

Notes:

The US DOE's CBECS database used in Target Finder has a limited number of building types.

Energy Star Target Finder Disclaimer:

"An incomplete energy use profile could result in a high but inaccurate rating. Total annual estimated energy use must include plug, process, and all non-regulated loads: equipment loads specified on drawings: and all fuel sources."

Evaluating Building Energy Performance - W.S. Cumby & Son

US Department of Energy - Energy Information Administration
Commercial Buildings Energy Consumption Survey, 2003

CBECS data is produced by the US DOE every four years based on a survey of thousands of commercial building from all over the United States. The data is based on actual building energy consumption and cost. This data represents the average of thousands of buildings of various size, age, types of construction, location, and energy sources. It is useful to compare the modeling results to these values as a reality check and to enable realistic goal setting of project energy performance. In addition it is useful for making comparisons to actual building energy use to gauge building energy performance.

Energy Intensity (kBTU/square foot)					Energy Cost ($/square foot)		
Building Type	**National Average**	**Northeast**	**Middle Atlantic**	**Climate Zone 3**	**Building Type**	**National Average**	**Northeast**
All	89.8	98.5	98.3	98.5	All	$1.43	$1.65
Education	83.1	101.6	103.1	93.5	Education	$1.22	$1.49
Food Service	258.3	272.8	290.2	247.6	Food Service	$4.15	$4.84
Health Care	187.7	212.2	219.0	191.4	Health Care	$2.35	$2.82
Retail	73.9	65.0	72.3	97.1	Retail	$1.39	$1.33
Office	92.9	101.2	98.0	95.4	Office	$1.71	$2.07
Public Assembly	93.9	89.2	98.0	87.3	Public Assembly	$1.47	$1.27
Public Order & Safe	115.8	132.5	NA	NA	Public Order & Safe	$1.76	$2.09
Religious Worship	43.5	52.1	58.1	52.8	Religious Worship	$0.65	$0.68
Warehouse	45.2	41.6	49.2	49.5	Warehouse	$0.68	$0.69

The 2030 Challenge

The American Institue of Architects, the US Conference of Mayors, US Green Building Council and many other organizations have adopted the 2030 Challenge to eliminate fossil fuel energy use in buildings by 2030. All projects are challenged to obtain an immediate 50% reduction in energy intensity relative to the national average figures above. The reduction is scheduled to increase over time according to the following schedule:

60% in 2010 70% in 2015 80% in 2020 90% in 2025

Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate).

These targets may be accomplished by implementing innovative sustainable design strategies, generating on-site renewable power and/or purchasing (20% maximum) renewable energy and/or certified renewable energy credits. For more information visit - http://www.architecture2030.org

Actual Energy Performance	**31.8 kBTU/sf-year**	**2030 Challenge target**	**46.45 kBTU/sf-year**

Actual performance exceeds the 2030 Challege by 31.5%

Water Performance Benchmarking

The predicted water performance contained in the LEED submission was 66,638 gallons per year. This prediction only included water use due to standard flush and flow fixtures within the building. Since the building does not irrigate its landscape and the cooling equipment appears to be air-cooled, these fixtures should account for the vast majority of water use in the facility.

The actual water usage during the period September 2006 through August 2007 was 124,000 gallons. During this period, there were four months of anomalous data. September, October and December 2006 all exceeded 23,000 gallons per month. April 2007 was 14,000 gallons. None of the remaining eight months exceeded 7,000 gallons of usage. It is unclear why the consumption during these four months is so much higher than the norm. Averaging the non-anomalous months results in a usage of 4,500 gallons per month. Extrapolating for a year equals 54,000 gallons which is significantly closer to the prediction.

According to the PA Department of Environmental Protection, the average water use in office buildings amounts to 10 gallons per person per day. A total of 29 employees working 260 days per year would amount to 75,400 gallons.

Water billing should be closely tracked to ensure that the causes for the high usage can be identified and addressed to ensure continued water savings in the future.