



Indoor Environment Quality + Workplace Environment Wallin Medical Biosciences Building (WMB) Report 1

**March 2012, Minneapolis, MN
Sustainable Post-Occupancy Evaluation Survey (SPOES)
B3 Guidelines**

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1.0 Overview

The purpose of this report is to examine the connection between sustainable design criteria used in the design of the Wallin Medical Biosciences Building (WMB) and employees' satisfaction with their work environments. The WMB facility was designed using the B3 Guidelines (formerly known as the Minnesota Sustainability Guidelines or MSBG) and completed for occupancy in December 2009. The B3 Guidelines track specific state-funded buildings as a means of demonstrating real outcomes aimed at the conservation of energy resources, creation and maintenance of healthy environments, and occupants' satisfaction with their work environments. The Sustainable Post-Occupancy Evaluation Survey (SPOES) was developed to assess human outcomes in classroom and workplace settings in compliance with the project tracking requirements for the B3 Guidelines goals. The survey was conducted in March 2012 and serves as the first of two required POE events.

This SPOES report focuses on employees' satisfaction with the physical environment as related to 15 overall indoor environment quality (IEQ) criteria such as lighting, thermal, and acoustic conditions in their primary workspaces, i.e., offices. Employees' satisfaction with the facility (site, building, and interior) and the effect of the facility's physical environment on their perceptions of their work performance and health are included. Finally, a brief look at employees' commuting and physical activities within the building are also reported. The report provides descriptive information about employees' perceptions of the IEQ of their work environments. In addition, this information serves the broader development of knowledge regarding the influence of IEQ on employees.

2.0 Method

SPOES consists of a self-administered, Internet-based, questionnaire submitted to and completed by employees. The SPOES questionnaire has been tested for **validity** (measures what it is intended to measure) and **reliability** (repeatability or replicability of findings) in studies involving similar facilities and employees. Employees rate their level of satisfaction on a **Likert-type scale** (measurement scale) from 1 (very dissatisfied) to 7 (very satisfied) with IEQ of the facility and their primary workspaces. They also rate the influence of their physical environment on their perception of their work performance and health on a scale from 1 (hinders) to 7 (enhances). There were no physical measurements taken of environmental conditions such as temperature or acoustic level. This study is limited to employees' perceptions.

The report provides a descriptive summary of the results stated as a **mean** (M = average of all responses), **standard deviations** (SD) (how different scores are from each other and the mean), and **number of responses** (N) for questions analyzed. The mean for a 7-point scale is 4.00. Lower or higher means reflect stronger tendencies towards dissatisfaction/satisfaction and hinders/enhances. Means that are close to the center of the scale (4) are considered to be neither dissatisfied/hinders or satisfied/enhances.

When interpreting **mean** responses, the following labels were used:

- 1-3.99 dissatisfied (hinders)
- 4-4.49 neither satisfied (enhances) or dissatisfied (hinders)
- 4.5-7 satisfied (enhances)

For some of the results, more detail was provided by giving the **frequency** (descriptive statistic typically stated in percentages) of responses for each level of satisfaction or performance/health. The frequency of responses (N) is reported as percentages. For the satisfaction questions, the numbers are associated with the following labels:

- 1 very dissatisfied
- 2 dissatisfied
- 3 somewhat dissatisfied
- 4 neither satisfied or dissatisfied
- 5 somewhat satisfied
- 6 satisfied
- 7 very satisfied

Performance and health responses were collapsed into fewer levels of interpretation, again, for ease in reporting the results. For the performance questions, the numbers are associated with the following labels:

- 1 hinders
- 2-3 somewhat hinders
- 4 neither hinders or enhances
- 5-6 somewhat enhances
- 7 enhances

An IEQ Scorecard is also calculated for employees' satisfaction with IEQ in their primary workspace. This is a statistical combination of all IEQ scores, which results in a single IEQ score for all employees on all IEQ variables and is reported in an IEQ Scorecard.

2.1 Description of the Questionnaire

Employees first rate their level of satisfaction with the facility and the influence of their physical environment on their perception of their work performance and health. Then they respond to questions about their satisfaction with their primary workspaces in relation to the IEQ criteria. The questionnaire uses the IEQ criteria from the B3 Guidelines and relates each of them to employees' satisfaction with their physical environment. Additional questions are also asked to delve deeper into

IEQ conditions at the primary workspace.

Categories include (in alphabetical order):

1. Acoustic Conditions
2. Appearance
3. Cleaning and Maintenance
4. Daylighting Conditions
5. Electric Lighting Conditions
6. Function
7. Furnishing
8. Indoor Air Quality
9. Lighting Conditions
10. Personal Adjustability Conditions

11. Privacy
12. Technology
13. Thermal Conditions
14. Vibration and Movement
15. View Conditions

2.2 Limitations

Employee participation is voluntary, and responses are self-reported. As is true with all survey research, the responses indicate employees' perceptions. There were no physical measurements, e.g., temperature, humidity, or lighting levels, of the environment taken.

3.0 Sample Description

3.1 Building Description

The Winston and Maxine Wallin Medical Bioscience building (WMB) is located at 2102 6th St. SE, Minneapolis, Minnesota. The building (see Figure 1) is comprised of 40 private and shared offices, 25 research laboratories, eight conference rooms, and animal holding facilities. These areas are distributed across five floors and 118,858 square feet. Departments at this site include the Center for Immunology and the Paul and Sheila Wellstone Muscular Dystrophy Center.



Figure 1. WMMB (Photo credit: <http://www1.umn.edu/twincities/maps/WMB/>)

3.2 Description of Respondents

The WMB has 426 employees, which can vary slightly over the year. The response rate was approximately 12%. Of those responding, 50% were male and 50% were female. Relating to hours worked in WMB, 54% of the employees spend 40+ hours in their primary workspace, 19% spend 30-40 hours in their primary workspace, 8% spend 20-29 hours in their primary workspace, and 17% spend less than 20 hours in their primary workspace. The mean age of respondents was 37 years, with a range of 22 to 64 years.

WMB is a research facility with offices and laboratories serving as primary workspaces. Results indicated 57% of the employees work in laboratories, 27% work in private offices, 8% share private offices, 4% work at a desk in an open area, and 4% worked in unassigned building spaces. Results also indicated that 64% of the primary workspaces were located within 15 feet of an exterior window, 25% of the employees were not within 15 feet, and 11% were uncertain of the distance to an exterior window.

WMB has been occupied since December, 2009. Of those years, 57% had been there 2-3 years, 19% had been there for 1-2 years, and 25% spent less than 1 year at this site. (Note: all percentages reported may not add to 100% due to rounding.)

4.0 Findings and Discussion

4.1 WMB Facility (Site, Building, and Interior): Overall Satisfaction, Work Performance, and Health

Employees responded to questions concerning the WMB facility (site, building, and interior) and their overall satisfaction with the facility, overall perceptions of their work performance in relation to the facility, and their overall perception of their health in relation to the facility. Table 1 shows a summary and interpretation of their responses.

Table 1. Overall satisfaction, work performance, and health related to the WMB facility.

WMB Facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	5.33	.95	51	Satisfied
Overall work performance	4.78	1.26	51	Enhances
Overall health	4.53	1.19	51	Enhances

Results indicated that employees were **satisfied (M = 5.33)** with the WMB facility (building, site and interior) and reported that their overall work performance was **enhanced (M = 4.78)** and their overall health was **enhanced (M = 4.54)** by the facility.

Further, employees responding to questions regarding their overall satisfaction, work performance and health with the WMB facility (site, building, and interior) are summarized below:

- 78% indicated they were satisfied, 16% said they were neither dissatisfied nor satisfied, and 6% were dissatisfied;
- 55% indicated their overall work performance was enhanced, 37% stated their performance was neither hindered nor enhanced, and 8% stated their work performance was hindered by the facility;
- 35% indicated their health was enhanced, 61% stated their health was neither enhanced nor hindered, and 4% stated their health was hindered.

4.2 Primary Workspace: Overall Satisfaction, Work Performance, and Health

Employees responded to questions concerning their overall satisfaction and overall perceptions of their work performance and health as related to with their primary workspace (e.g., private office,

workstation, or other primary workspace). Table 2 shows a summary and interpretation of their responses.

Table 2. Overall satisfaction, work performance, and health related to primary workspace.

Primary Workspace	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	4.98	1.44	47	Satisfied
Overall work performance	4.98	1.31	49	Enhances
Overall health	4.53	1.10	49	Enhances

Results indicated that employees were **satisfied (M = 4.98)** with their primary workspace, their overall work performance was **enhanced (M = 4.98)**, and their overall health was **enhanced (M= 4.53)** by their primary workspace.

Further, employees responding to questions regarding their overall satisfaction, work performance, and health with their primary workspace are summarized below:

- 66% indicated that they were satisfied, 15% said they were neither dissatisfied nor satisfied, and 19% were dissatisfied;
- 70% indicated that their overall work performance was enhanced, 16% was neither enhanced nor hindered, and 14% stated their work performance was hindered by their primary workspace; and
- 41% indicated their overall health was enhanced, 45% stated their overall health was neither enhanced nor hindered, and 14% stated their overall health was hindered.

4.3 Primary Workspace: Satisfaction with Indoor Environment Quality (IEQ)

Employees responded to questions concerning their satisfaction with IEQ categories (thermal conditions, indoor air quality, acoustic conditions, etc.) related to their primary workspace (e.g., private office, workstation, or other primary workspace). Table 3 shows a summary of the means, the standard deviations, and interpretation of their responses.

Table 3. Satisfaction with IEQ as related to primary workspace.

Primary Workspace	Mean (1-7)	SD	N	Interpretation
1. Electric lighting conditions	5.43	1.7	47	Satisfied
2. Indoor air quality	5.40	1.3	48	Satisfied
3. Function	5.35	1.2	46	Satisfied
4. Cleaning and maintenance	5.19	1.5	48	Satisfied
5. Technology (e.g., computer, telephone, etc.)	5.15	1.1	48	Satisfied
6. Appearance (aesthetics)	5.06	1.3	47	Satisfied
7. Lighting conditions (electric and daylighting)	5.06	1.8	48	Satisfied
8. Daylighting conditions	4.94	2.0	48	Satisfied
9. Furnishings	4.88	1.4	48	Satisfied
10. Vibrations and movements	4.83	1.5	48	Satisfied
11. View conditions (outdoor or distant interior views)	4.63	1.9	48	Satisfied
12. Acoustic conditions	4.44	1.5	48	Neither S/ D
13. Thermal conditions	4.13	1.8	48	Neither S/D
14. Privacy conditions (sound and visual privacy)	4.00	1.5	48	Neither S/D
15. Personal adjustability (temp, lighting, furnishings)	3.83	1.7	48	Dissatisfied

Results indicate that employees were **satisfied** with the following IEQ conditions in their primary workspaces:

- Electric lighting conditions
- Indoor air quality
- Function
- Cleaning and maintenance
- Technology
- Appearance
- Lighting conditions (electric and daylighting)
- Lighting conditions
- Furnishings
- Vibrations and movements
- View conditions

Employees were **neither dissatisfied nor satisfied** with IEQ conditions for the following:

- Acoustic conditions
- Thermal conditions
- Privacy

There was only one IEQ category with a mean score resulting in a **dissatisfied** rating:

- Personal adjustability conditions (**3.83**).

The frequency of employees' responses to questions regarding their satisfaction with IEQ categories associated with their primary workspace is summarized below:

- **Electric lighting conditions** in the primary workspace: 77% are satisfied, 10% are neither dissatisfied nor satisfied, and 13% are dissatisfied.
- **Indoor air quality** (free of odors, staleness, chemicals or irritants) in the primary workspace: 75% are satisfied, 12.5% are neither dissatisfied nor satisfied, and 12.5% are dissatisfied.
- **Function** with the primary workspace: 74% are satisfied, 20% are neither dissatisfied nor satisfied, and 6% are dissatisfied.
- **Cleaning and maintenance** in the primary workspace: 56% are satisfied, 13% are neither dissatisfied nor satisfied, and 21% are dissatisfied.
- **Technology** (e.g., computer, telephone, etc.) with the primary workspace: 65% are satisfied, 31% are neither dissatisfied nor satisfied, and 4% are dissatisfied.
- **Appearance** (aesthetics) of the primary workspace: 60% are satisfied, 30% are neither dissatisfied nor satisfied, and 10% are dissatisfied.
- **Lighting conditions** (electric and daylighting) in the primary workspace: 67% are satisfied, 12% are neither dissatisfied nor satisfied, and 11% are dissatisfied.
- **Daylighting conditions** in the primary workspace: 60% are satisfied, 17% are neither dissatisfied nor satisfied, and 23% are dissatisfied.
- **Furnishings** in the primary workspace: 56% are satisfied, 29% are neither dissatisfied nor satisfied, and 15% are dissatisfied.
- **Vibrations and movements** in the primary workspace: 48% are satisfied, 37% are neither dissatisfied nor satisfied, and 15% are dissatisfied.
- **View conditions** (outdoor or distant interior views) from the primary workspace: 52% are

satisfied, 15% are neither dissatisfied nor satisfied, and 33% are dissatisfied.

- **Acoustic conditions** (ability to hear desired sounds and limit undesired sounds) in the primary workspace: 39% are satisfied, 23 % are neither dissatisfied nor satisfied, and 29% are dissatisfied.
- **Thermal conditions** [temperature (hot or cold), air velocity (drafty or stagnant), and humidity (dry or moist)]: 40% are satisfied, 14% are neither dissatisfied nor satisfied, and 46% are dissatisfied.
- **Privacy conditions** in the primary workspace: 35% are satisfied, 31% are neither dissatisfied nor satisfied and 34% are dissatisfied.
- **Personal adjustability** of your primary workspace (e.g., adjustable temperature, lighting, furnishings, etc.): 31% are satisfied, 25% are neither dissatisfied nor satisfied, and 44% are dissatisfied.

4.4. IEQ Satisfaction Scorecard

The IEQ Satisfaction Score is determined by developing weighted factors of all categories, which is more representative of a fair overall IEQ score. For example, it might be more important for an employee to have satisfying thermal conditions than to have satisfying indoor air quality. Thus, if the employee gives a high thermal satisfaction score and a lower indoor air quality satisfaction score, the overall IEQ satisfaction will be scored much higher than one with the inverse statistics.

The weighted scoring system was developed by employing the following procedures:

1. **Factor analysis** (a multivariate statistical procedure) was conducted to determine the importance of various IEQ categories.
2. The factor loading of each IEQ category was regarded as the individual weight.
3. The weighted sum score was used to calculate the final mean score illustrating how well a particular building performed in terms of satisfying its occupants' IEQ needs. This becomes the IEQ Score

As shown in Figure 2, the **IEQ satisfaction score for WMB is 4.91.**

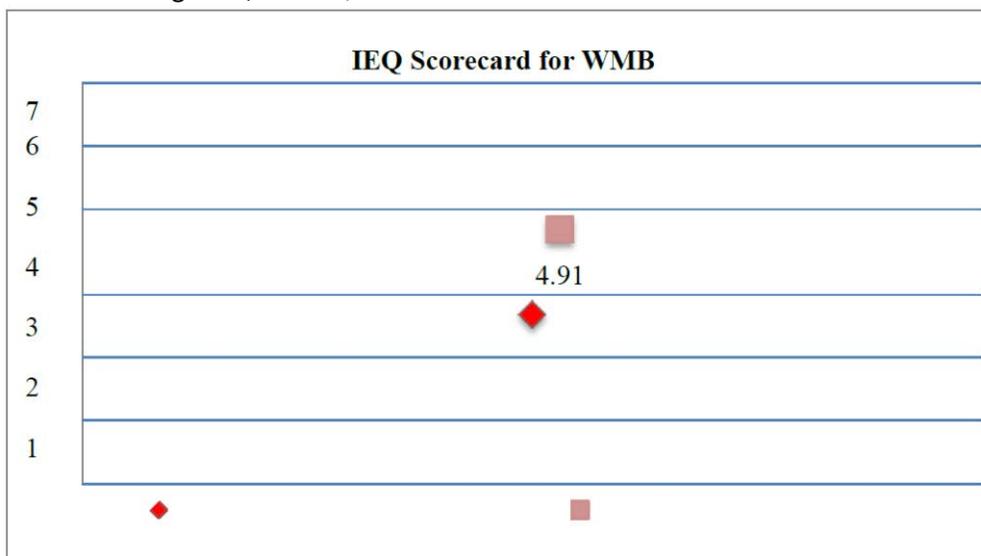


Figure 2. IEQ Satisfaction Score associated with the primary workspace 4.91

Overall, employees showed a positive but low level of satisfaction with IEQ as indicated by the **weighted mean score of 4.91**. Satisfaction with **Furnishings** of primary workspace was identified as the category that contributes most to the IEQ Satisfaction Score, followed by satisfaction with **Function** of the primary workspace. They determine IEQ satisfaction more strongly than other categories. Satisfaction with **Daylighting Conditions** was the least contributing category to the IEQ Satisfaction Score.

This score of **4.91** validates the overall satisfaction score in Table 2 (**4.98**). They are similar but the IEQ Scorecard is slightly lower because it may reflect some other factors beyond IEQ such as location or size of primary workspace. The IEQ Scorecard gives more refined knowledge.

5.0 Physical Activity Engagement and Commuting Practices

In the final section of the survey, employees responded to questions regarding their overall physical activity while at WMB (site, building, and interior) and their commuting practices.

5.1 Physical Activity Engagement

Providing employees with opportunities for alternative paths of travel around the workplace, e.g., taking stairs as opposed to the elevator, provides opportunities to engage in additional types of physical activities. Engaging in physical travel throughout the work environment can be associated with healthier lifestyles.

Table 4. Overall physical activity (walking, stair use, etc.) affected by the WMB facility.

WMB facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall physical activity (walking, stair use, etc.)	4.94	1.14	49	Enhances

Results indicated that employees felt that WMB **enhanced** (Mean = 4.94) their physical activities (walking, stair use, etc.). Further, of the 49 respondents to this set of questions: 59% said they were satisfied with the facility's influence on their overall physical activity, 33% said they were neither dissatisfied nor satisfied, and 8% were dissatisfied.

5.2 Commuting Practices

WMB is located on the northern side of the East Bank of the University of Minnesota. The East Bank campus is located north of metropolitan hub providing bus and light rail transit service through the campus environment. The University provides several parking facilities, bike paths, and sidewalks throughout the campus and adjacent to the WMB facility.

Tables 5-7 provide results on employee commuting mileage, mode of transportation, commuting distances, and use of alternative modes of commuting. These results, although not related to IEQ, do offer the University insight into employees' commuting behaviors and opinions. These data can provide important information about commuting practices that can reduce transportation energy consumption.

Table 5. Commuting mileage to WMB (one way).

Commuting mileage to WMB	0-5 miles	6-15 miles	16-30 miles	31-59 miles	61-75 miles
Daily home-to-work commuting mileage, one way	36.7%	38.8%	22.4%	2.0%	2.0%

Results indicated that over 38.8% of the employees commuted from 6-15 miles one way, followed by 36.7% percent commuted from 0-5 miles, and 22.4% commuted from 16-30 miles. Only 4% of the employees commuted distances greater than 31 miles.

Table 6. Primary mode of transportation.

Primary Commute Mode	Drive alone (or with children < 16)	Carpool vanpool	Public transit	Bicycle	Walk	Other
Primary mode of transportation	53.1 %	6.1%	14.3%	14.3%	8.2%	4.1%

The most frequent mode of transportation to WMB was driving alone (or with children under 16) (53.1%), followed by public transit (14.3%), bicycle (14.3%), walking (8.25%), and carpool or vanpool (6.1%). Other mode of transportation (4.1%) included “50/50” combinations of driving and biking and ‘a combination of carpooling, biking and taking the bus.”

Table 7. Alternative commuting choices.

WMB facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Alternative Commuting Options	4.27	1.3	49	Neither hinders or enhances

Results indicated that employees felt that WMB neither hinders nor enhances their ability to commute to work in an alternative way with a mean of 4.27. Further, 35% of the employees indicated that WMB enhances their ability to commute in alternative ways, followed by 45% who felt that WMB neither hinders nor enhances alternative commuting options, and 20% felt WMB hinders their ability to commute in alternative ways.

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of employees of WMB at approximately three years after it was first occupied. Approximately 12% of the employees responded to the survey.

The survey included questions related to employees’ overall satisfaction with the facility (site, building, and interior) and influence of the facility on their overall work performance and health. Employees were **satisfied** with the facility (**M = 5.33**); they found the facility **enhances** their overall work performance (**M = 4.78**) and **enhances** their overall health (**M = 4.53**). In addition, similar results were reported when employees were asked these same questions about their primary workspaces (private office, shared office, laboratory, etc.). They reported **overall satisfaction** (**M = 4.98**) with their primary workspaces, and that their overall work performance (**M = 4.98**) and their overall health were **enhanced** (**M = 4.53**) by their primary workspace. However, as the range of scores was from 1-7, this is a **low level of satisfaction**, although still positive.

Most of the survey questions related to employees' satisfaction with the IEQ categories in their primary workspaces (private office, laboratory, etc.). Employees were **satisfied** with 11 of the IEQ categories. The mean satisfaction scores ranged from **4.63** (View conditions) to **5.43** (Electric lighting conditions). Again, this shows a positive but **moderate level of satisfaction**. Four of the categories received **neither dissatisfied nor satisfied** scores from **4.00** (Privacy conditions) to **4.44** (Acoustic conditions). Finally, one category, Personal adjustability, received a **dissatisfied** score of **3.83**.

From the employees' responses, an IEQ Scorecard was developed and shows respondents' satisfaction with all categories and the contribution of each category to that satisfaction score. For WMB, the IEQ Satisfaction Score was **4.91**, with **satisfaction** with furnishings and function of their workspaces as the two categories that influenced their satisfaction level most. This score reflects the **moderate satisfaction** level of the other categories. Finally, employees reported that WMB **enhances** their physical activity, which is one of the sustainable design criteria that influences occupant behavior.

6.2 Recommendations

The satisfaction scores are certainly in the positive direction, however, improvement may be possible. For IEQ categories that have physical measurement possible, e.g., thermal, acoustic, and lighting, it is recommended that these measurements be taken in both overall workspaces and primary, individual workspaces. Recommendations follow:

Thermal Conditions

- Determine special thermal comfort requirements or problems that may be encountered in the building due to work activities or sitting or design considerations.
- Determine if any task areas differ now from original intent.
- Review conditions that affect thermal comfort using ASHRAE Standard 55-2004 or Human Factors Design Handbook.
- Measure performance variables on site.
- Log complaints related to thermal conditions.

Lighting Conditions

- Identify performance criteria that are to be met to achieve goals.
- Determine if any task areas differ now from original intent.
- Develop additional quality lighting criteria as needed for special facility issues such as employees' ages, duration of task, influence of daylight quality or quantity Conduct onsite measurements using
- Conduct onsite measurements using Illuminating Engineering Society standards for employees' tasks.
- Log complaints related to lighting conditions.

Acoustic Conditions

- Identify acoustic criteria for overall requirements.
- Determine if any task areas differ now from original intent.
- Develop any additional special acoustical performance requirements to support functional programming of building. (E.g. sources of recurrent noise that needs to be controlled, special user populations which may have distinct auditory performance limitations, multiple uses of building spaces which may have different acoustic criteria. Investigate and choose appropriate acoustics modeling software for the project

- Measure acoustic performance onsite with full systems running.
- Log noise and other sonic environment complaints.

Privacy Conditions

- Identify employees' privacy concerns via focus groups or log complaints.
- Determine if any task areas or responsibilities differ from ordinal intent.
- Consider adding noise masking equipment and/or visual screening depending on nature of complaints.
- Compare acoustic privacy problem areas with acoustic measurements to pinpoint specific problem areas.

Personal Adjustability

- Determine if adjustability issues arise with temperature, lighting, or furnishings via focus group.
- Identify personal, individual problem areas and relate to other IEQ issues via log of complaints.
- Provide education to employees about adjustability of any applicable adjustment options, e.g., furnishings, air diffusers, lighting, temperature control, etc.

It seems obvious that employees' satisfaction can be improved by addressing the categories that had the 'dissatisfied' or 'neither dissatisfied nor satisfied' scores. The above recommendations can help address change in these categories. However, what is not quite so obvious is that because furnishings and function of the primary workspace are the two IEQ categories that contribute most to employees' satisfaction, and these two categories did not receive highly satisfied mean scores individually, employees' satisfaction could be increased with greater attention paid to furnishings and function.

This study investigated employees' satisfaction with the facility and primary workspaces. IEQ satisfaction is individual, but the results of the survey show a central tendency of **moderate satisfaction to satisfaction** with the facility and most of the IEQ categories. The results can be used as a diagnostic tool to aid in improving IEQ conditions for employees and to set the benchmarks from which improvement can be measured in the future.

7.0 Glossary

Descriptive statistics

Statistics used to summarize large sets of data (i.e., means, frequencies, medians). Descriptive statistics describe only the sample under consideration and are not intended to infer results to the larger population.

Factor analysis

A multivariate statistical procedure that is used to identify and group together general dimensions or factors that underlie a large number of variables in a set of data. The procedure transforms the variables into new principal components or orthogonal factors. Variables within each factor are related to each other but have no relationship to variables in other factors.

Frequency

A descriptive statistic that provides information about how many of a particular response or measurement are observed.

Likert-type scale

A measurement technique, employed in questionnaires and interviews, that utilizes a range of standardized response categories such as strongly agree, agree, etc.

Mean

The average score of a set of data calculated by adding all scores together, then dividing by the number of scores.

N

The number of subjects or participants responding to the questions in the study

Reliability

The repeatability or replicability of findings; the same results are produced each time. Instruments and procedures should produce the same results when applied to similar people in similar situations, or on a second occasion.

Standard deviation

A statistic used to measure the variability of a group of scores (how different scores are from each other and the mean). For example, if the range of scores is 1-7 and the mean (average) is 5.0 with a standard deviation of 1.0, then the scores are closely clustered around the mean, i.e., there is one unit of variation among all scores. If the mean was 5.0 and the SD was 3.0, there is a broader range of variation among the scores...a smaller SD means the scores are similar and the mean score is likely to be more accurate and more useful (this is better!).

Validity

The extent to which an instrument or procedure measures what it is intended to measure (internal validity). The generalizability of results to another population (external validity).