



**Indoor Environment Quality + Workplace Environment
Center for Magnetic Resonance Research, (CMRR)
Minneapolis, MN
Report 1**

**November 2013, 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 Center for Magnetic Resonance Research facility (CMRR) and employees' satisfaction with their work environments. The Center for Magnetic Resonance Research facility was designed using the B3 Guidelines (formerly known as the Minnesota Sustainability Guidelines or MSBG) and completed for occupancy in 2011. The B3 Guidelines tracks specific state-funded, B3 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. This is a report of occupants' (hereafter called employees) responses at 24 months post-occupancy. The survey was conducted in November 2013.

This SPOES report focuses on employees' satisfaction with the physical environment as related to 15 indoor environment quality (IEQ) criteria (hereafter called categories) 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** (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)

An IEQ Score is also calculated for employees' satisfaction with IEQ in their primary workspaces. 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 categories. The questionnaire uses 15 IEQ categories from the B3 Guidelines and relates each of them to employees' satisfaction with their physical environment.

Categories include (in alphabetical order):

1. Acoustic Conditions
2. Appearance
3. Cleaning and Maintenance
4. Daylighting Conditions
5. Electric Lighting Conditions
6. Function
7. Furnishings
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

Employees' 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 Description of Building

The CMRR facility is located at 2021 Sixth Street SE Minneapolis, MN. The building (see Figure 1) is part of the University of Minnesota's Biomedical Discovery District on the East Bank campus. The CMRR houses the largest and most powerful imaging magnet in the world. Offices, laboratories, seminar rooms, common spaces, and a courtyard are distributed across two floors and 102,400 square feet. A 41,000 square foot renovation and a 61,400 expansion were completed in 2011.



Figure 1. Center for Magnetic Resonance Research Building (Photo: Shawn Sullivan)

3.2 Description of Respondents

The CMRR houses 142 employees. The response rate to the questionnaire was approximately 18%. Of those responding, 62.5% were male and 37.5% were female. Relating to hours worked in CMRR, 45.8% of the employees spend 40+ hours in their primary workspace; 50% spend 30-40 hours in their primary workspace; 4.2% spend 20-29 hours in their primary workspace; and no one spends less than 20 hours in their primary workspace. The mean age of respondents was 48 years, with a range of 25 to 59 years.

CMRR is a research facility with offices and laboratories serving as primary workspaces. Results indicated 4.2% of the employees work in laboratories, 20.8% work in private offices, 29.2% share private offices, 8.3% work at a desk in an open area with no partitions, and 37.5% work in a cubicle with partitions. Results also indicated that 62.5% of the primary workspaces were located within 15 feet of an exterior window, 33.3% of the employees were not within 15 feet, and 4.2% were uncertain of the distance to an exterior window.

The CMRR was housed in its facility since 1991, however the renovation and expansion were completed in 2011. Of those years, 66.7% of the respondents reported that they had worked at this location for more than 3 years, 12.5% had been there 2-3 years, 20.8% had been there for 1-2 years, and no respondents 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 CMRR Facility (Site, Building, and Interior): Overall Satisfaction, Work Performance, and Health

Employees responded to questions concerning the CMRR 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 and Figure 2 show a summary and interpretation of their responses.

Table 1. CMRR facility - overall satisfaction, work performance, and health

CMRR Facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	5.67	0.96	24	Satisfied
Overall work performance	5.46	1.18	24	Enhances
Overall health	4.63	1.13	24	Enhances

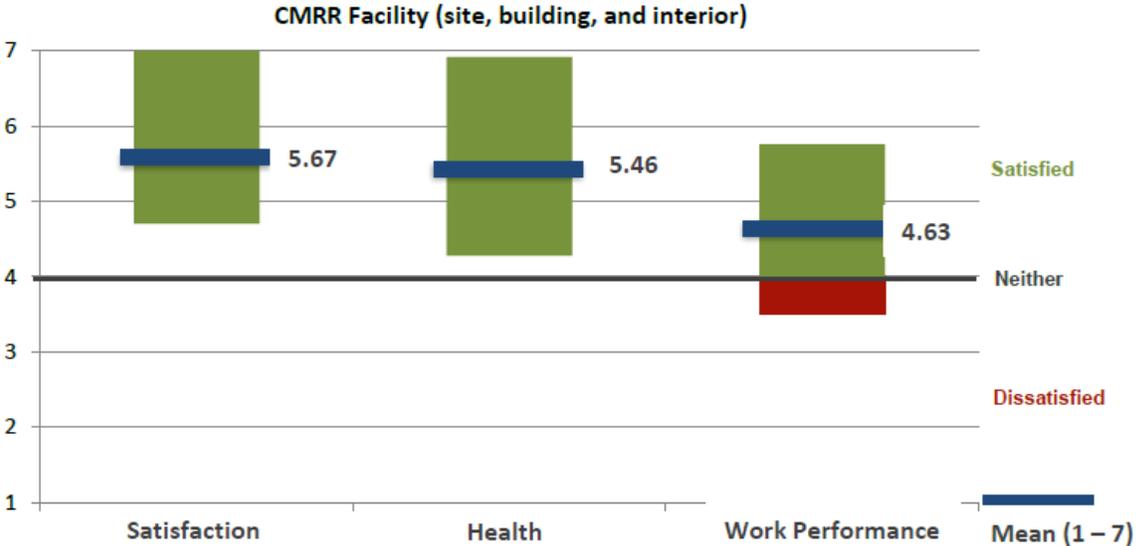


Figure 2. CMRR facility - overall satisfaction, work performance, and health

Results indicated that employees were **satisfied (M = 5.67)** with the CMRR facility (building, site, and interior) and reported that their overall work performance was **enhanced (M = 5.46)** by the facility. Employees reported that their overall health was **enhanced (M = 4.63)** by the facility.

**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 their primary workspace (e.g., private office, workstation, or other primary workspace). Table 2 and Figure 3 show a summary and interpretation of their responses.

Table 2 Primary workspace – overall satisfaction, work performance and health

Primary Workspace	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	4.71	1.73	24	Satisfied
Overall work performance	4.71	1.65	24	Enhances
Overall health	4.25	1.07	24	Neither enhances nor hinders

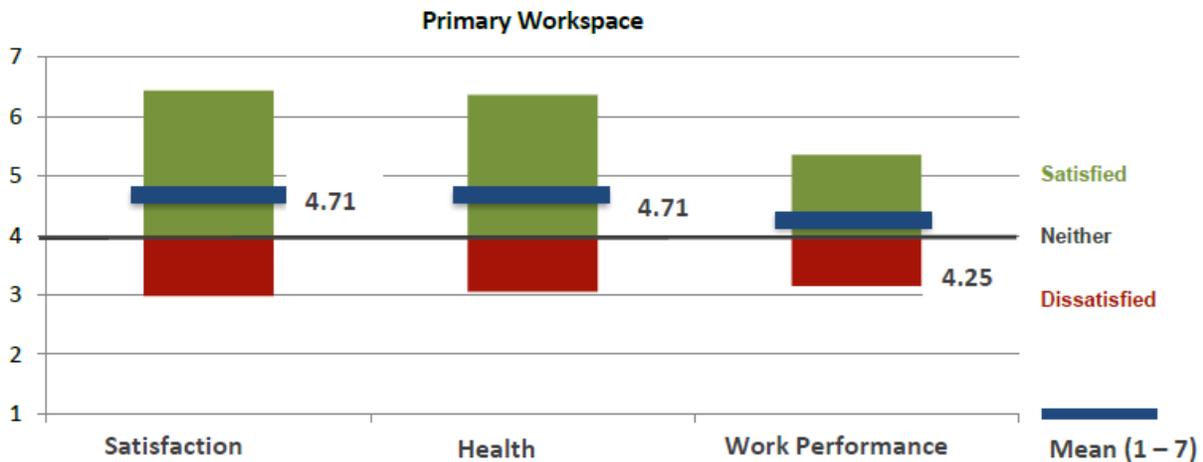


Figure 3 Primary workspace - overall satisfaction, work performance, and health

Results indicated that employee were **satisfied (M = 4.71)** with their primary workspace, their overall work performance was **enhanced (M = 4.71)** by their primary workspace, and their overall health was **neither enhanced nor hindered (M = 4.25)** by their primary workspace.

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 and Figure 4 show a summary of the means, the standard deviations, and interpretation of their responses.

Table 3. Primary workspace - satisfaction with IEQ conditions

Primary Workspace	Mean (1-7)	SD	N	Interpretation
1. Vibration and movement	5.67	1.37	24	Satisfied
2. Humidity	5.58	1.25	24	Satisfied
3. Electric lighting conditions	5.42	1.50	24	Satisfied
4. Technology	5.42	1.34	24	Satisfied
5. Air velocity	5.38	1.50	24	Satisfied
6. Cleaning and maintenance	5.17	1.66	24	Satisfied
7. Function	5.13	1.65	24	Satisfied
8. Daylighting conditions	5.00	2.24	24	Satisfied
9. Lighting conditions (electric & daylighting)	4.92	1.79	24	Satisfied
10. Adjustability of task lighting	4.92	1.79	24	Satisfied
11. Furnishings	4.88	1.42	24	Satisfied
12. Thermal conditions	4.88	1.75	24	Satisfied
13. Appearance (aesthetics)	4.79	1.84	24	Satisfied
14. Indoor air quality	4.75	1.67	24	Satisfied
15. Temperature	4.63	1.81	24	Satisfied
16. Ability to hear desired sounds	4.58	1.69	24	Satisfied
17. Adjustability of daylighting conditions	4.42	2.01	24	Neither S / D
18. View Conditions	4.42	2.04	24	Neither S / D
19. Adjustability of electric lighting	4.38	1.97	24	Neither S / D
20. Acoustic conditions	4.08	1.58	24	Neither S / D

21. Ability to limit undesired sounds	3.88	1.85	24	Dissatisfied
22. Privacy	3.71	1.92	24	Dissatisfied
23. Adjustability of thermal conditions	3.13	1.70	24	Dissatisfied

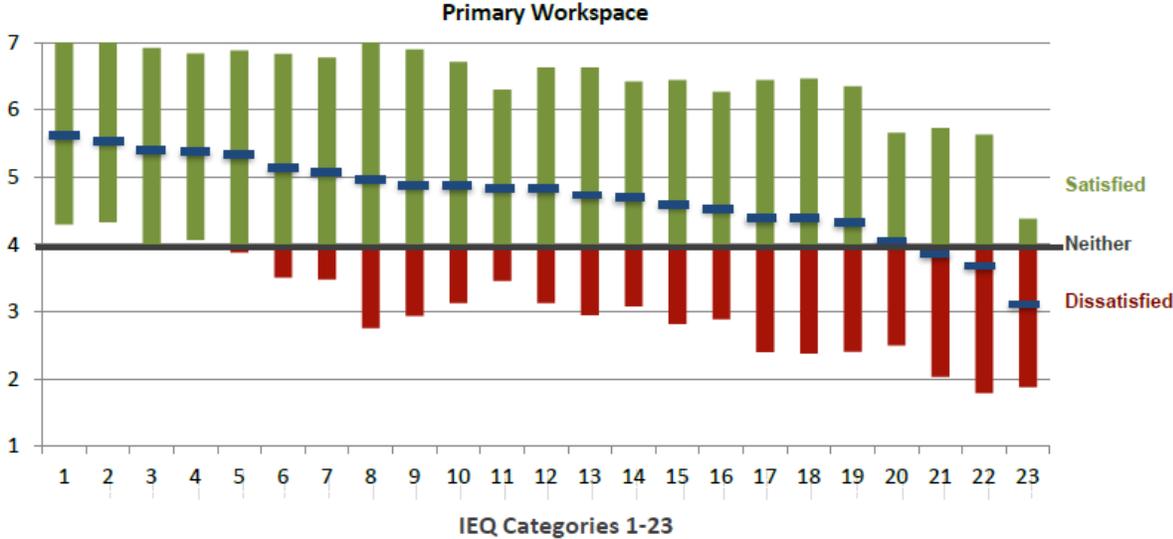


Figure 4. Primary workspace - satisfaction with IEQ categories (IEQ 1-23 are listed in Table 3 above)

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

- Vibrations and movements
- Humidity
- Electric lighting conditions
- Technology
- Air velocity
- Cleaning and maintenance
- Function
- Daylighting Conditions
- Lighting conditions (electric and daylighting)
- Adjustability of task lighting
- Furnishings
- Thermal conditions
- Appearance
- Indoor air quality
- Temperature
- Ability to hear desired sounds

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

- Adjustability of daylighting
- View conditions
- Adjustability of electric lighting
- Acoustic conditions

Employees were dissatisfied with IEQ conditions for the following:

- Ability to limit undesired sounds
- Privacy
- Adjustability of thermal conditions

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 low 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 5, the **IEQ satisfaction score** for CMRR is **4.84**.



Figure 5. Primary Workspace - IEQ Satisfaction Score

Overall, the occupants showed a positive response but low level of satisfaction with IEQ as indicated by the weighted mean score of **4.84**. Satisfaction with **Appearance (Aesthetics)** of employees' primary workspace was identified as the category that contributed most to the IEQ Satisfaction Score, followed by **Function** of the primary workspace. They determine IEQ satisfaction more strongly than other categories. Overall **Thermal Conditions** was the least contributing category to the IEQ Satisfaction Score.

This score of **4.84** validates the overall satisfaction score in Table 2 (**M = 4.71**). They are similar but the IEQ Score is slightly higher because it may reflect some other factors beyond IEQ such as location or size of primary workspace. The IEQ Score gives us 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 CMRR (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 CMRR facility

CMRR facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall physical activity (walking, stair use, etc.)	5.38	.92	24	Enhances

Results indicated that employees felt that CMRR **enhanced (M = 5.38)** their physical activities (walking, stair use, etc.). Further, of the 24 respondents to this set of questions, 87.6% said they were **satisfied** with the facility’s influence on their overall physical activity; 12.5% said they were **neither dissatisfied nor satisfied**; and no employees were **dissatisfied**.

5.2 Commuting Practices

CMRR is located on the northeastern 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 CMRR facility.

Table 5 provides results on employees’ commuting mode of transportation. 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 Practices - Primary mode of transportation for daily commute

Commuting Practices	Drive alone (or with children < 16)	Carpool or vanpool	Public transit	Bicycle	Walk
Primary mode of transportation	58.3 %	8.3%	16.7%	12.5%	4.2%

The most frequent mode of transportation to CMRR was driving alone (or with children under 16) (58.3%), followed by public transit (16.7%), bicycle (12.5%), carpool or vanpool (8.3%), and walking (4.2%). No employees drove motorcycles/moped, telecommuted, or stated other modes of transportation.

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of employees of CMRR at approximately two years after it was first occupied. Nearly 100% 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 = 5.67**); they found the facility **enhances** their overall work performance (**M = 5.46**) and **enhances** their overall health (**M = 4.63**). 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 = 4.71**) with their primary workspaces and that their overall work performance was **enhanced** (**M = 4.71**) by their primary workspaces. However, their overall health was **neither enhanced nor hindered** (**M = 4.25**) by their primary workspace. As the range of scores was from 1-7, scores that showed satisfaction are in a low to mid-level range, 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' responses showed they were **satisfied** with the majority of the IEQ categories. The mean satisfaction scores ranged from **4.58** (Ability to hear desired sounds) to **5.67** (Vibration and movement). Again, this shows a positive but moderate level of **satisfaction**. Employees responded **neither dissatisfied nor satisfied** with Acoustic conditions, Adjustability of daylight, View conditions, and Adjustability of electric lighting with scores ranging from **4.08** to **4.42**. Lastly employees were **dissatisfied** with their Ability to limit undesired sounds, Privacy, and Adjustability of thermal conditions with scores ranging from **3.13** to **3.88**.

From the employees' responses, an IEQ Score was developed and shows respondents' satisfaction with all categories and the contribution of each category to that satisfaction score. For CMRR, the IEQ Satisfaction Score was **4.84**, with **satisfaction** with appearance (aesthetics) and function of their workspaces as the two categories that influenced employees' satisfaction level most. This score reflects the moderate satisfaction level of the other categories. Finally, employees reported that CMRR **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 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 need to be controlled, special user populations that may have distinct auditory performance limitations, or multiple uses of building spaces that 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 'dissatisfied' or 'neither dissatisfied nor satisfied' scores. The above recommendations can help address change in these categories. The areas employees were dissatisfied with (ability to limit undesired sounds, overall privacy, and adjustability of thermal conditions) can all be addressed by the above recommendations. Exploring these areas in more detail and making adjustments may increase overall satisfaction at the primary workspace.

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

Appendix A. Open-Ended Responses

Employees had the opportunity to raise specific concerns on the overall facility and their primary workspaces. Important information can be gleaned from the open-ended responses. CMRR employees raised specific concerns about the following themes: appearance (aesthetics), building services amenities, furnishings, indoor air quality (IAQ), lighting, space organization/layout/function, thermal conditions, and vibration and movement/acoustics (noise). There were positive comments as well, which included an overall satisfaction with the building and the building services amenities, specifically the unisex bathrooms. Though these qualitative responses overall appear as the employees are dissatisfied; it does

not mean they represent the overall sentiment from employees. For example thermal conditions, appearance, IAQ, vibrations/movement, and function reflected positive employees' satisfaction in their primary workspaces making the case that the open-ended responses reflect a small sample of the population. The following are qualitative responses to the above noted themes.

Appearance (Aesthetics)

- The wall color along with the lack of natural lighting in places inside CMRR is depressing;
- especially considering most of the building is well lit with natural light and accents of color.
- Interior Paint Colors on 2nd floor...why?

Building Services Amenities

- PA system is insufficient, and individual speaker + control in offices would have been better.
- The automatically opening sanitary napkin disposers open much too often.
- Unisex bathroom/showers are outstanding for supporting bike commuting (which I do ~30%) and other physical activities (lunch/pre-work workouts).

Furnishings

- Half-cubicle desk surfaces are not deep enough - they should be extended 8-12 inches.

IAQ

- Lack of good ventilation near food preparation areas makes for at times unpleasant smells near offices.

Lighting

- Entirely lighting bathrooms with motion sensitive lighting is a horrible idea.

Space Organization Layout and Function

- One area is very poorly done: the rooms without windows on the second floor of the new extension. (By opposition, the rooms with external windows on the same story are just so great!). Two big problems with these no-windows, multi-seating rooms (4 to 6 seats per room): 1) their walls go up to the ceiling with no window completely blocking light and view to everyone and completely isolating all people working on this floor, with all room doors distributed on long uniform corridors. This is a recipe to block communication between people who are just a few feet apart and to kill the great sources of light that otherwise would exist without the tick and tall walls of these center rooms with no windows.

2) This carries the risk of sterilizing an immensely vivid and dynamic traditional source of brainstorming in a research lab: high level of communication between post-docs, grad students or early-stage researchers that are typically hosted in this category of rooms seating multiple people together. Any sort of cubical arrangement, including with glass walls or with mid-height walls to limit each areas to a few people would be so much better. To make things worse, the thick tall walls are so constraining that people are actually more cramped against each other than they would be in smart cubical arrangement (no way, however, to consider a completely open shared cubical space like in a telephone company).

- The atrium space is in the way and useless, particularly since we are not allowed to set up picnic tables in it. Let us at least make use of it! Additionally, the door out of the breakroom needs a window, people are constantly running into others coming the opposite direction.

Thermal

- I run my space heater all year. My office is always too cold. The lack of thermal control in individual offices is a problem, since different offices have different amount of heat sources.

Vibration and Movement / Acoustics (Noise)

- Changes that would reduce the frequency and volume of door slams would be nice - there are many doors and few people close them quietly. It's startling and disruptive to hear the doors slamming all day.

Overall Positive

- It's a great and modern building, with some weaknesses.

Appendix B. 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).