



**Indoor Environmental Quality + Workplace Environment
UMTC Microbiology Research Facility (MRF)
Minneapolis, MN**

**June 2018, 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 UMTC Microbiology Research Facility (MRF) and occupants' satisfaction with their work environments located in the facility. This report communicates responses from employees about the overall facility and their workplace (WP). The facility was designed using the B3 Guidelines (formerly known as the Minnesota Sustainable Building Guidelines or MSBG), which were in effect at the time that the renovation and addition were funded. It was completed for occupancy in December 2015. The B3 Guidelines track 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 workplace, classroom, and residence hall settings in compliance with the B3 Guidelines project tracking requirements. This is a report of occupants' (hereafter called employees) responses from the survey conducted in January-February 2018.

This SPOES report focuses on employees' satisfaction with the physical environment as related to 26 indoor environmental 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 also are included. Finally, a brief look at employees' commuting and physical activities within the building are 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). 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).

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 each question 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:

- 1.00 - 3.50 dissatisfied (or hinders)
- 3.51 - 4.50 neither dissatisfied (or hinders) nor satisfied (or enhances)
- 4.51 - 7.00 satisfied (or enhances)

An IEQ Score is also calculated for employees' satisfaction with IEQ criteria in their primary workspaces. This is a statistical combination of all category-level (explained below) IEQ scores, which results in a single IEQ score for all respondents and is reported in an IEQ Scorecard.

2.1 Description of the Questionnaire

Employees first rate their level of satisfaction with the facility (site, building, and interior) 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 IEQ criteria from the B3 Guidelines. Additionally, employees' demographic, physical activity, and commuting practice data are collected to provide context for the study.

In the SPOES questionnaire, the 26 IEQ criteria listed below are evaluated. There are two levels of criteria, categories and attributes. As shown in the list, the 'overall' criteria are boldfaced and called 'categories' or 'category level' criteria. A category is broader or more general such as Overall View Conditions or Overall Indoor Air Quality. Some categories have 'attributes' or 'attribute level' criteria and provide greater detail about the category. For example, Overall Thermal Conditions is a category level question, and there are four attribute level questions related to thermal conditions such as adjustability, air velocity (draft), humidity, and temperature. Overall Acoustic Conditions is a category with attributes of employees' ability to hear desired sounds and their ability to limit undesired sounds. There are 12 category-level and 14 attribute level questions. Means are calculated and reported for all category and attribute-level criteria.

An IEQ Satisfaction Score is also calculated for employees' satisfaction with IEQ in their primary workspaces. This is a statistical combination of the 12 category-level criteria only and results in a single, mean IEQ Satisfaction Score for all employees' satisfaction with the physical conditions of their primary workspaces. Attribute-level criteria are not included in the IEQ Score because unequal weight would be given to criteria that have both category and attribute-level questions.

In the following list, **category (boldface)** criteria are listed in alphabetical order. If a category has attributes, they are listed with the category.

Overall Acoustic Quality

- Ability to hear desired sounds
- Ability to limit undesired sounds

Overall Appearance (aesthetics)

Overall Cleaning and Maintenance

Overall Daylighting Conditions

- Amount of daylighting
- Adjustability of daylighting

Overall Electric Lighting Conditions

- Amount of electric lighting
- Adjustability of electric lighting
- Adjustability of task lighting

Overall Furnishings

- Function of furnishings
- Adjustability of furnishings

Overall Indoor Air Quality

Overall Privacy

Overall Technology

- Access to electric outlets

Overall Thermal Conditions

- Adjustability of thermal conditions
- Air velocity (drafty/stagnant)
- Humidity (dry or moist)
- Temperature (hot or cold)

Overall Vibration and Movement

Overall 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. This study is limited to employees' perceptions.

3.0 Sample Description

3.1 Description of Building

The UMTC-MRF is located at 689 23rd Avenue SE, Minneapolis, MN. The building (see Figure 1) is a five-story, 89,004 square foot building (including a 13,746 square foot mechanical penthouse) laboratory research facility. To support staff, the workplace includes office, collaboration, office support, lab support and research support and cores, and additional support areas, circulation space, and storage.



Figure 1. UMTC-MRF. (Photo courtesy of UMTC)

3.2 Project Team

The relevant project team members to the SPOES process for the UMTC-MRF was comprised of the owner, design team, commissioning agent, and general contractor. They are identified below, relative to their capacity and involvement.

| | |
|------------------------------------|-------------------------|
| Owner | University of Minnesota |
| Architect | BWBR |
| Mechanical and Electrical Engineer | MEP Associates |
| Interior Designer | BWBR |
| Landscape Architect | Damon Farber Associates |
| Commissioning Agent | University of Minnesota |
| General Contractor | Mortenson Construction |

3.3 Description of Respondents

This survey was administered to 172 employees with workspace in the facility during January-February 2018. The response rate to the questionnaire was approximately 22%. Of those responding, 44% were male and 56% were female. The mean age of respondents was 41 years, with a range from 19-78 years of age.

The UMTC-MRF was completed and ready for operation in December 2015. Since that time, 63% of the respondents reported that they worked at the UMTC-MRF facility for more than two years, 22% of the respondents reported that they worked at the UMTC-MRF facility for 1-2 years, and 15% of the respondents spent less than one year at this facility. Relating to hours worked during a typical week at the UMTC-MRF, 59% of the employees reported they spend 40+ hours a week in the facility, 22% spend 30-40 hours a week at the UMTC-MRF, less than 4% spend 20-29 hours at the facility, and nearly 15% spend less than 20 hours per week at the facility.

Relating to the time employees spend per week in their primary workspace, 37% of the employees reported they spend more than 75% of their weekly time in their primary workspace; nearly 56% spend 51-75% of their time in their primary workspace; and 7% spend less than 25% of their time in their primary workspace. These responses indicate the amount of time employees are exposed to IEQ conditions in their workplace environment.

The UMTC-MRF is a workplace with private offices; enclosed shared offices; workstations (cubicles) with low partitions, a work area in a lab, or a lounge work area serving as primary workspaces. Nearly 81% of employees indicated that their primary workspaces were located within 15 feet of an exterior window and over 19% of the employees were not within 15 feet of an exterior window.

4.0 Findings and Discussion

4.1 UMTC-MRF Facility (Site, Building, and Interior): Overall Satisfaction, Work Performance, and Health

Employees responded to questions concerning the UMTC-MRF 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 the means and standard deviations of their responses as well as how the responses are interpreted. Figure 2 is a graph that shows the mean for each question, which is identified with a blue mark. The standard deviation is shown by the green/red vertical bar with green representing satisfied (or enhanced) and red representing dissatisfaction (or hindered). Gray represents the 'neither/nor' range of responses. In cases where there were no dissatisfied responses, the bar may be all green or gray and green. This graph is simply a visual image of the findings from Table 1.

Table 1 UMTC-MRF facility - overall satisfaction, work performance, and health

| Overall | Mean | SD | N | Interpretation |
|------------------|------|------|----|----------------|
| Satisfaction | 5.76 | 1.02 | 37 | Satisfied |
| Work Performance | 5.30 | 1.35 | 37 | Enhanced |
| Health | 4.97 | 1.24 | 37 | Enhanced |

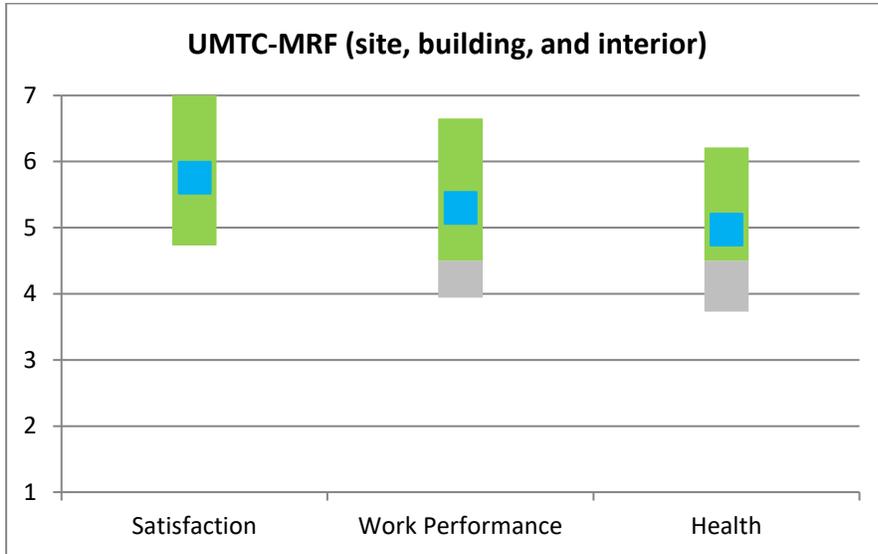


Figure 2. UMTC-MRF facility - overall satisfaction, work performance, and health

Results indicate that employees were **satisfied (M = 5.76)** with the physical environment of the UMTC-MRF facility (building, site, and interior) and reported that their overall work performance was **enhanced (M = 5.30)** by the facility. Employees reported that their overall health was **enhanced (M = 4.97)** 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 shows the means and standard deviations of their responses as well as how the responses are interpreted. Figure 3 is a visual image of the findings from Table 2; an explanation of the graph was given for Figure 2.

Table 2. UMTC-MRF primary workspace – overall satisfaction, work performance and health

| Overall | Mean | SD | N | Interpretation |
|------------------|------|------|----|----------------|
| Satisfaction | 5.03 | 1.52 | 36 | Satisfied |
| Work Performance | 5.00 | 1.47 | 36 | Enhanced |
| Health | 4.64 | 1.00 | 36 | Enhanced |

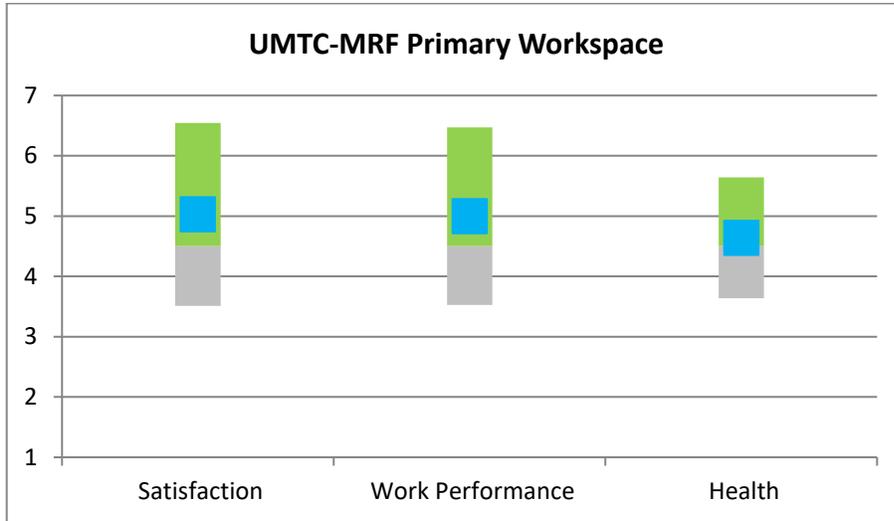


Figure 3. UMTC-MRF primary workspace - overall satisfaction, work performance, and health

Results indicate that employees were **satisfied (M = 5.03)** with their primary workspace, their overall work performance was **enhanced (M = 5.00)** by their primary workspace, and their overall health was **enhanced (M = 4.64)** by their primary workspace.

4.3 Primary Workspace: Satisfaction with Indoor Environmental 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 the means and standard deviations of their responses from highest to lowest mean, as well as how the responses are interpreted. Figure 4 is a visual image of the findings from Table 3; an explanation of the graph was given for Figure 2.

Table 3. UMTC-MRF primary workspace - satisfaction with IEQ criteria

| # | IEQ Criteria (1-26) (Category level criteria are bold face) | Mean | SD | N | Interpretation (D = Dissatisfied) (S = Satisfied) |
|----|--|------|------|----|---|
| 1 | Overall cleaning and maintenance | 6.12 | 1.04 | 33 | Satisfied |
| 2 | Overall appearance (aesthetics) | 6.09 | 1.14 | 33 | Satisfied |
| 3 | Overall vibration and movement | 6.00 | 1.15 | 33 | Satisfied |
| 4 | Overall indoor air quality | 5.79 | 1.18 | 34 | Satisfied |
| 5 | Humidity (dry or moist) | 5.76 | 1.14 | 34 | Satisfied |
| 6 | Overall furnishings | 5.61 | 1.41 | 33 | Satisfied |
| 7 | Amount of daylighting | 5.59 | 1.77 | 34 | Satisfied |
| 8 | Ability to hear desired sounds | 5.56 | 1.19 | 34 | Satisfied |
| 9 | Function of furnishings | 5.55 | 1.39 | 33 | Satisfied |
| 10 | Overall view conditions | 5.45 | 1.78 | 33 | Satisfied |
| 11 | Adjustability of furnishings | 5.39 | 1.61 | 33 | Satisfied |
| 12 | Overall technology | 5.39 | 1.48 | 33 | Satisfied |
| 13 | Overall daylighting conditions | 5.35 | 2.01 | 34 | Satisfied |
| 14 | Air velocity (drafty or stagnant) | 5.32 | 1.57 | 34 | Satisfied |
| 15 | Adjustability of task lighting | 5.21 | 1.77 | 33 | Satisfied |
| 16 | Amount of electric light | 5.21 | 1.97 | 34 | Satisfied |
| 17 | Access to electric outlets | 5.09 | 1.83 | 33 | Satisfied |
| 18 | Adjustability of daylighting | 5.06 | 1.97 | 34 | Satisfied |
| 19 | Overall electric lighting conditions | 4.79 | 1.98 | 34 | Satisfied |
| 20 | Overall thermal conditions | 4.65 | 1.94 | 34 | Satisfied |
| 21 | Overall privacy (sound and visual privacy) | 4.58 | 1.86 | 33 | Satisfied |
| 22 | Temperature (hot or cold) | 4.56 | 1.94 | 34 | Satisfied |
| 23 | Adjustability of task lighting | 4.50 | 2.12 | 34 | Satisfied |
| 24 | Overall acoustic quality | 4.24 | 2.00 | 34 | Neither S or D |
| 25 | Ability to limit undesired sounds | 4.21 | 2.04 | 33 | Neither S or D |
| 26 | Adjustability of thermal conditions | 3.24 | 2.00 | 34 | Dissatisfied |

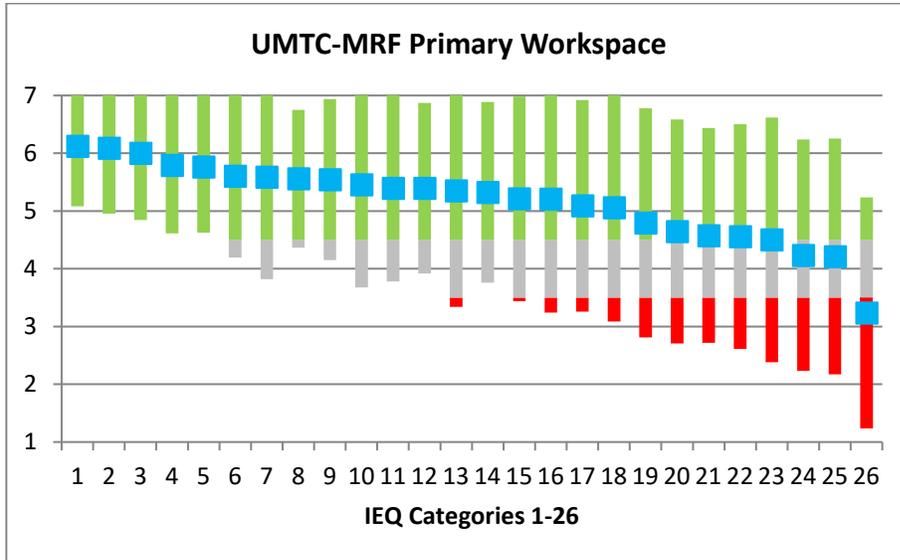


Figure 4. UMTC-MRF primary workspace - satisfaction with IEQ criteria (IEQ 1-26 refer to Table 3)

Results indicate that employees were **satisfied** with 23 of the IEQ criteria in their primary workspaces, i.e., means at or above 4.50. Employees were **neither satisfied nor dissatisfied** with three (3) IEQ criteria, ranging from a mean of 3.24 (adjustability of thermal conditions) to 4.24 (Overall acoustic quality). Employees were not **dissatisfied** with any of the IEQ criteria. The criteria in the ‘neutral’ satisfaction range should be considered for change. Potential for change will be addressed in Section 6.2 Recommendations. Further explanation of these scores also can be found in Appendix A. Open-Ended Responses.

4.4 IEQ Satisfaction Scorecard

The IEQ Satisfaction Score is determined by calculating a mean of the 12 ‘Overall’ category level IEQ criteria. At this time, criteria are weighted equally in this calculation as little evidence exists that provides rationale for weighting some criteria heavier than others. The IEQ mean is representative of a fair overall IEQ score and can serve as a benchmark of employees’ satisfaction with the physical environment of their primary workspace. As shown in Figure 5, the **IEQ Satisfaction Score** for the UMTC-MRF is **5.34**, which falls near the mid-point of satisfied range, i.e., a moderately satisfied IEQ Score.

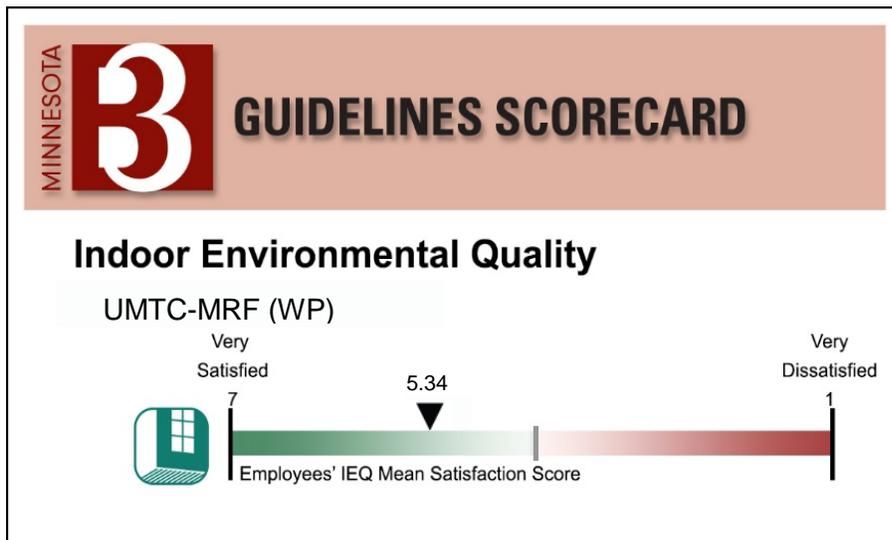


Figure 5. UMTC-MRF primary workspace - IEQ Satisfaction Score

As shown in Table 3, satisfaction with the Overall cleaning and maintenance, Overall appearance (aesthetics), Overall vibration and movement, Overall indoor air quality, and Overall furnishings were the categories with the highest satisfaction means (5.61 or higher) and pulled the IEQ Satisfaction Score in a positive direction. Additionally, three other mean scores were relatively high, with scores between 5.45 (Overall view conditions) and 5.35 (Overall daylighting conditions). The single mean score below 4.5 out of 12 category-level criteria pulled the IEQ Score down, though only a moderate amount. Please note that the IEQ Satisfaction Score only uses the category level criteria (those labeled 'Overall'; see section 2.1, paragraph 3 for explanation).

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 UMTC-MRF (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 UMTC-MRF facility

| UMTC-MRF facility (site, building, and interior) | Mean | SD | N | Interpretation |
|--|------|------|----|----------------|
| Overall physical activity (walking, stair use, etc.) | 5.21 | 1.13 | 29 | Enhanced |

Results indicate that employees felt that UMTC-MRF **enhanced (M = 5.21)** their physical activities (walking, stair use, etc.).

5.2 Commuting Practices

UMTC-MRF is located on the UMTC East Bank Campus area, northeast of TCF Bank Stadium accessible via 23rd Avenue SE and 6th Street SE. The Campus Connector bus stops nearby on 6th Street SE and public and contract parking is available in nearby surface lots.

Table 5 provides results on employees' primary mode of transportation; Table 6 summarizes commuting distances between home and the UMTC-MRF facility; and Table 7 summarizes employees' ability to commute using alternative choices (walk, public transit, bike, van, or carpool, etc.). These results, although not related to IEQ, do offer 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 – UMTC-MRF Primary mode of transportation

| Primary Mode of Transportation (N=28) | Drive Alone (or w/children <16) | Van or Carpool | Public Transit | Walk | Other |
|---------------------------------------|---------------------------------|----------------|----------------|------|-------|
| Commuting to UMTC-MRF | 39% | 18% | 32% | 4% | 7% |

Related to primary modes of transportation, 39% of employees drive alone (or with children under 16), followed by 32% who use public transit, and 18% who use a van or carpool; fewer employees walk (4%) or use other modes of transportation (7%). No employees used a motorcycle/moped or a bicycle.

Table 6. Commuting Practices – UMTC-MRF Commuting distance traveled

| Miles Traveled (N=29) | 0-5 | 6-15 | 16-30 | 46-60 |
|----------------------------|-----|------|-------|-------|
| Home-to-UMTC-MRF (One-way) | 41% | 38% | 17% | 3% |

Results indicate that 41% of employees commuted 0-5 miles one-way between home and the UMTC-MRF, followed by 38% who commute 6-15 miles, 17% who commute 16-30 miles, and 3% who commute 46-60 miles to the UMTC-MRF facility. (These percentages do not add up to 100% due to rounding.) These are one-way miles.

Table 7. Commuting practices – UMTC-MRF location and alternative commuting behaviors

| Alternative Commuting | Mean | SD | N |
|--|------|------|----|
| Ability to commute in alternative ways | 4.72 | 1.72 | 29 |

Results indicate that location of the UMTC-MRF **enhances** (M = 4.72) employees' ability to commute to work in alternative ways, e.g., walk, bicycle, public transit, van or carpool, etc.

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of employees of the UMTC-MRF at approximately 25 months after it was first occupied. This UMTC-MRF facility is used as research lab and office space. This survey reports responses from employees and their satisfaction with the physical environment of the facility and their primary workspace. Results indicate that nearly 81% of employees spend more than 30 hours per week in the UMTC-MRF facility, and approximately 93% of employees spend more than 50% of their time at the UMTC-MRF in their primary work space.

The survey included questions related to employees' satisfaction with the facility (site, building, and interior) and influence of the facility on their work performance and health. Employees were **satisfied**

with the facility (**M = 5.76**); they found the facility **enhanced** their work performance (**M = 5.30**) and **enhanced** their health (**M = 4.97**). In addition, similar results were reported when employees were asked these same questions about their primary workspaces (private office, shared office, workstations, etc.). They reported **satisfaction (M = 5.030)** with their primary workspaces, that their work performance was **enhanced (M = 5.00)**, and their health was **enhanced (M = 4.64)** by their primary workspace. As the range of scores was from 1-7, scores showed a moderate level of satisfaction and enhancement.

Most of the survey questions related to employees' satisfaction with the IEQ criteria in their primary workspaces (private office, workstations, etc.). Employees' responses showed they were **satisfied** with the 23 of the 26 IEQ criteria. The mean satisfaction scores ranged from **4.50** (adjustability of task lighting) to **6.12** (Overall cleaning and maintenance). Again, this shows a moderate positive level of **satisfaction**. Employees responded **neither dissatisfied nor satisfied** to three (3) IEQ criteria. These mean satisfaction scores ranged from **3.24** (adjustability of thermal conditions) to **4.24** (Overall acoustic quality).

From employees' responses, an IEQ Score was developed and shows respondents' satisfaction with the majority IEQ of all category level criteria. For the UMTC-MRF, the IEQ Satisfaction Score was **5.34**. This score reflects the influence of the moderate satisfaction level of 11 of the 12 categories as well as the neither satisfied nor dissatisfied level of a remaining single IEQ category. Finally, employees reported that the UMTC-MRF **enhanced (5.21)** their physical activity, which is one of the sustainable design criteria that influences occupant behavior.

It seems obvious that employees' satisfaction can be improved by addressing the categories that had 'neither dissatisfied nor satisfied' scores. However, the rest of the criteria would benefit from some attention as well. The following recommendations can help address change in these criteria to further improve employees' satisfaction. Exploring these areas in more detail and making adjustments may increase overall satisfaction at the primary workspace. It must be noted that the expense of building and operating a facility is second only to employee-related expenses over the life of the building. Therefore, maintaining or improving employees' satisfaction is a sound investment, which, in turn affects their performance and their health.

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 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.

6.2 Recommendations

Several IEQ criteria satisfaction scores are in the positive direction, however, improvement on the 'neutral' criteria may be possible. For IEQ categories that can be physically measured (e.g., thermal, acoustic, and lighting), it is recommended that these measurements be taken in the primary workspaces. Specific recommendations for the most common areas of occupants' concern follow:

Acoustic Conditions

- Identify acoustic criteria for overall requirements.
- Determine if any task areas differ now from their original spatial layout/use (i.e., collaborative work spaces now located adjacent to focused work areas, individual workstations).
- Develop specialized acoustical performance requirements to support functional programming employees' tasks (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). Identify and apply appropriate acoustics modeling software for the project.
- Measure acoustic performance onsite with full building systems (heating, ventilation, and air conditioning) running.
- Identify employees' privacy concerns via focus groups and/or log complaints relative to acoustical conditions for further evaluation.
- Consider employees' tasks within shared spaces to determine if spatial layout changes can be made for increased acoustic control.

Lighting Conditions

- Identify employees' lighting performance criteria that are to be met to achieve goals by conducting onsite measurements of existing illumination and compare them to standards for employees' tasks as identified by the Illuminating Engineering Society (IES).
- Determine if any task areas differ now from original intent to be sure illumination level and quality of lighting are not impeded by physical changes to the space (i.e., walls, ceilings, furnishings, fixtures, or equipment).
- Develop additional quality lighting criteria as needed for special facility (e.g., influence of daylight quality or quantity) or employee (e.g., age, task duration) issues.
- Log complaints related to lighting conditions for further evaluation.
- Identify poor lighting conditions in the workspace caused by a lack of control over daylighting, which can cause glare and eyestrain.

Personal Adjustability

- Determine what adjustability issues arise with temperature, lighting, or furnishings via a focus group.
- Identify personal, individual problem areas and relate them to other IEQ issues via a log of complaints relative to adjustability.
- Provide education to employees about any existing/achievable adjustment options (e.g., furnishings, air diffusers, lighting, temperature control, etc.)

Privacy Conditions

- Identify employees' privacy concerns via focus groups or log complaints relative to privacy to determine if visual or audio privacy is most affected.
- Determine if any task areas or responsibilities differ from original intent and develop alternatives or modifications.
- Consider adding noise masking equipment and/or visual screening depending on the nature of the complaints.
- Document and compare acoustic privacy problem areas with acoustic measurements to pinpoint specific problem areas.

Thermal Conditions

- Measure thermal performance conditions on site.
- Log complaints related to thermal conditions for further evaluation.
- Determine special thermal comfort requirements or problems that may be encountered in the building due to physicality of work activities, duration of sitting, or design/layout considerations. Focus groups can be useful in identifying problem locations.
- Determine if any employees' task areas differ now from original layout to determine if air flow is meeting systems design intent.
- Review conditions that affect thermal comfort using the applicable version of ASHRAE Standard 55, or Human Factors Design Handbook (see B3 Guidelines). For additional information, consider reviewing Human Factors and Ergonomics Design Handbook, Third Edition (2016), by Barry Tillman, published by McGraw-Hill, NY.

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 survey responses. The UMTC-MRF employees raised very few specific concerns about the following themes: acoustics and privacy, electric lighting and daylighting, furnishings, space planning and amenities, technology, and thermal conditions. These qualitative responses appear as if the employees are a bit dissatisfied with some features; however, it does not mean they represent the overall sentiment from employees. However, the comments do give insight into specific issues that could be addressed by building management. The comments from the employees are provided below.

Overall Positive/Negative

- It is a beautiful building with many fine features.
- The landscaping around the building though is very pleasant and it's nice to see the plants and trees when the weather is good.
- The nearby walking path down to the river is also a plus.
- The location so far away from the Bookstore, restaurants and other conveniences/amenities is a negative.

Acoustics and Privacy

- Poor sound insulation means that private conversations in one office may be overheard in adjacent offices.
- It's impossible to limit the sound of co-workers' conversations or that of people just standing around in the hall and conversing very loudly. The main entry door to our office area closes loudly. I don't care to have my immediate office mate always looking at me when she enters our shared work space. I also feel that my immediate office mate eavesdrops on my conversations with others. There's not a lot of privacy.
- Can hear everything outside of office even when your door is closed.
- The offices are noisy with the door open, due to proximity to common areas.

Electric Lighting and Daylighting

- Automatic lighting is problematic - lights turn off while sitting at desk, turn off too quickly when exit the room, and require a double click of the switch to turn lights on fully (because of view obstruction outside window the lights must be on fully to have sufficient lighting).
- The automatic shut-off of the office lighting is very annoying, because the sensor is in a place where it cannot detect my movements when I am working at the desk, so I have to wave my hand in the air every 10-15 minutes to keep the lights on.
- Our motion lights are wired in a weird way, because they shut off when they shouldn't.
- The lights actually turn off even if you are sitting in your office. Not able to turn them on and be able to have them stay on is extremely annoying.
- With regards to the lab area (which is not my primary area, but which I spend a lot of time in), I do not like that the lights go off so quickly after someone leaves the room (within minutes). I have not been told, if or how this can be adjusted, despite asking building managers on more than one occasion.
- The common spaces near the south windows need some sort of blinds because the sunlight can be unbearable at times and the sun reflecting off the floor is blinding.

- Sunlight from the east side of the building can be very strong in the morning, but there are no blinds (in the lounge areas). This is something that would be an improvement.
- I would like window shades in the lounge areas.

Furnishings

- My office space is very confining and I hated my desk chair. Fortunately, I found a different type of chair elsewhere in the building that is comfortable for me. The small space reduces my physical movement and has created some health issues as a result of extended seating in a cramped space. I regret not asking for a sit/stand desk and may still do so.

Space Planning and Amenities

- Placement of sinks, microwaves and coffee machines directly adjacent to faculty offices seems to be a fundamentally flawed design feature.
- An arbitrary choice of strong colors throughout the building may have satisfied contemporary ideals for interior design but everyday users rather than remote designers could/should perhaps have been more involved in creating an optimal working environment.
- I don't like the overall layout of the office shelving, because it makes it difficult to install a standing desk unless it's facing the window.
- The sinks are an inappropriate size for washing large dishes.
- It is frustrating not having DI water valves at each sink, as the building water is unsuitable for many purposes.
- I wish we had a lounge room, or something, sometimes I want to spend my lunch taking a nap.

Technology

- Telephone lines still having random issues with static on the line.

Thermal Conditions

- The temperature is very low and it is practically freezing inside my office, especially in the evening.
- It will be helpful to have a temperature control unit in every office, so people can adjust the temperature in their room according to their preferences.
- The inability to control office temperature during evenings, weekends and University holidays is a major source of discomfort - frequently the stairwells are noticeably warmer than the office space.
- While there is a thermostat in my office, I cannot adjust it myself and the temperature of the office in the winter varies significantly with sunlight and outside temperature. I'm having to use a space heater to regulate the day-to-day temperature in my office with hands and feet routinely cold in the winter.
- The office has been consistently cold this winter, and there is no way to adjust the thermostat.
- No temperature control in the office. Office can get very cold in the winter.

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.

Frequency

A descriptive statistic that provides information about how many of a particular response or measurement is 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, or a single question, 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).