

IAQ Summary

7-18-24 through 8-15-24

By Todd DeMonte

tdemonte@madisonair.com

Presentation Overview:

We deployed 10 IAQ sensors on floors 29, 30, and 31

Each sensor monitored the following variables for ~ one month:

- Temperature in °F
- Relative Humidity %
- CO₂ in parts per million (ppm)
- PM 2.5 in µg/m³
- Total Volatile Organic Compounds (TVOC) in µg/m³

Contents

- Explanation of Each IAQ variable: Good, Acceptable, Needs Improvement
- Overall Summary of Readings and What to Do
- Detailed IAQ Results per Sensor per Floor

Temperature (Temp)

Components that Affect IAQ

Temperature is the physical quantity that expresses hot and cold and is measured with a thermometer

Too low Temperature levels can cause

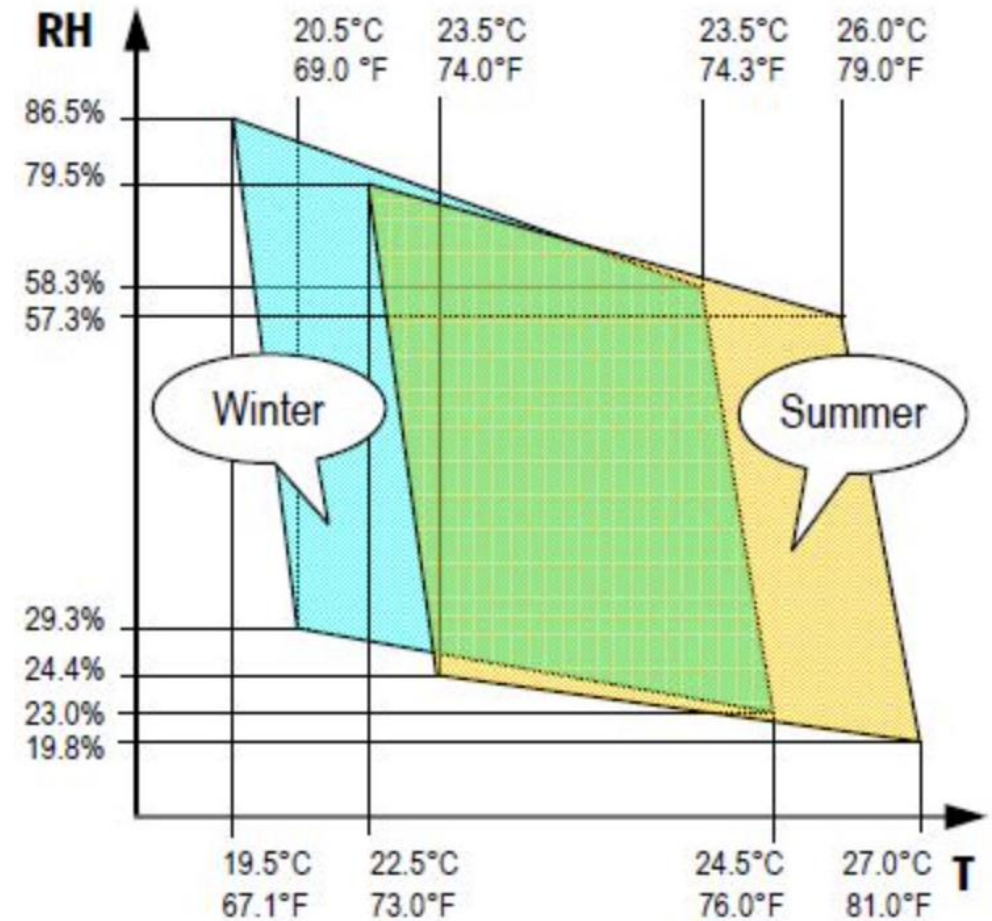
- Discomfort
- Hypothermia in the extreme

Too high Temperature levels can cause

- Discomfort
- Overheating and heat stroke in the extreme

Temperature ranges

- 67°F (winter) - 79°F (summer) – Excellent
- < 67°F (winter) and > 79°F (summer) – Needs improvement



ASHRAE Standard 55 - Thermal Comfort

Relative Humidity (RH)

Components that Affect IAQ

Relative Humidity is the percentage of humidity in the air compared to the amount of humidity in the air when condensation occurs

Relative Humidity at **too low** levels can cause

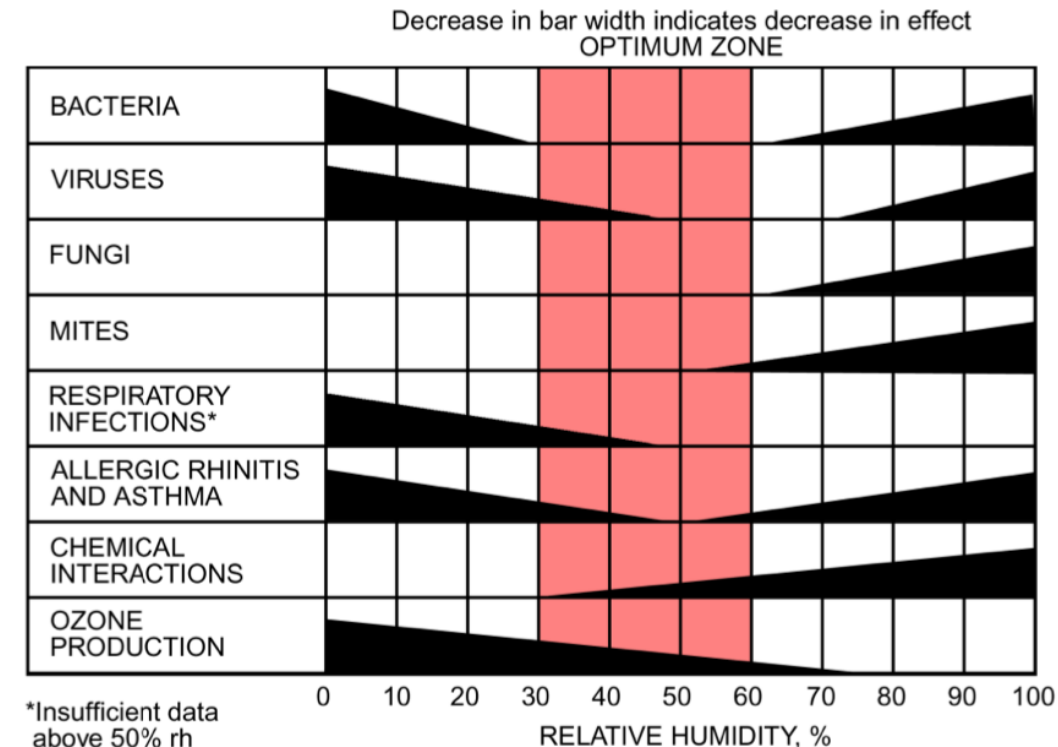
- Dry skin/lips and scratchy throats/noses
- Viruses and bacteria to thrive
- Wood floors and furnishings to shrink and separate

Relative Humidity at **too high** levels can cause

- Condensation on cold surfaces
- Mold/mildew growth
- Dust mites and bugs to thrive

Relative Humidity ranges

- 30% (winter) - 55% (summer) – Excellent
- 25% (winter) - 60% (summer) – Acceptable
- < 25% (winter) and > 60% (summer) – Needs improvement



²2016 ASHRAE HVAC Systems and Equipment Handbook – Ch 22

Carbon Dioxide (CO₂)

Components that Affect IAQ

CO₂ concentration outdoors is ~ 0.04 percent of the air or 400 ppm

Increased CO₂ levels influence

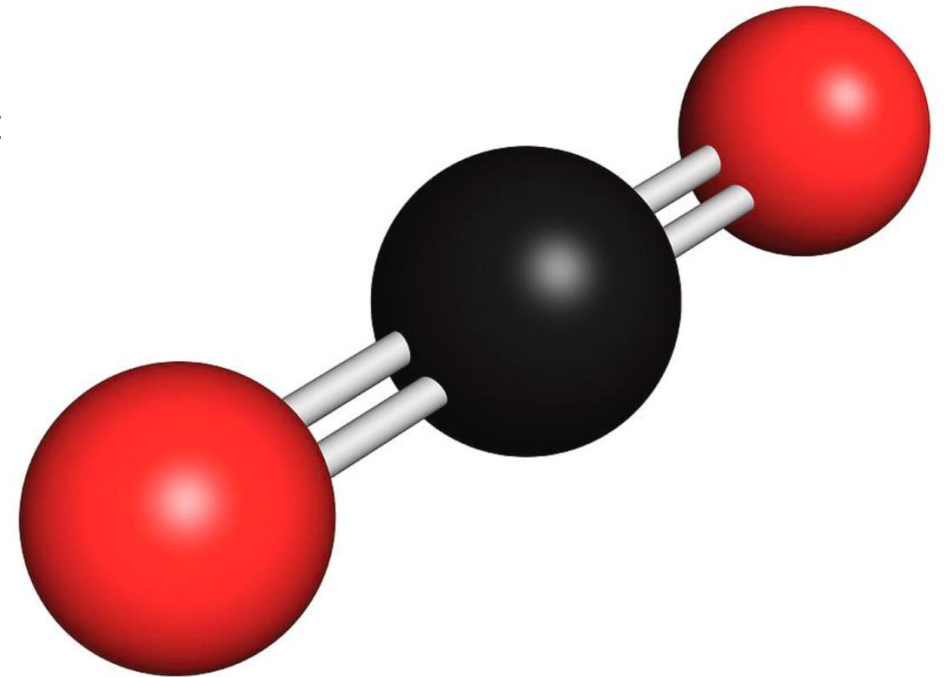
- The control of breathing -> stimulates respiration
- Vascular dilation or constriction -> increases cardiac output
- Body fluid pH -> decreases pH level (increase acidity)

Increased CO₂ levels can cause

- Drowsiness and headaches
- Poor concentration and loss of attention
- Reduced ability to solve complex problems

CO₂ Ranges

- 400-800 ppm – Excellent
- 800-1200 ppm – Acceptable
- > 1200 ppm – Needs improvement



Particulate Matter (PM)

Components that Affect IAQ

PM10 – Inhalable particles with diameters that are generally 10 micrometers and smaller

PM2.5 – Fine inhalable particles with diameters that are 2.5 micrometers and smaller

Sources of PM2.5

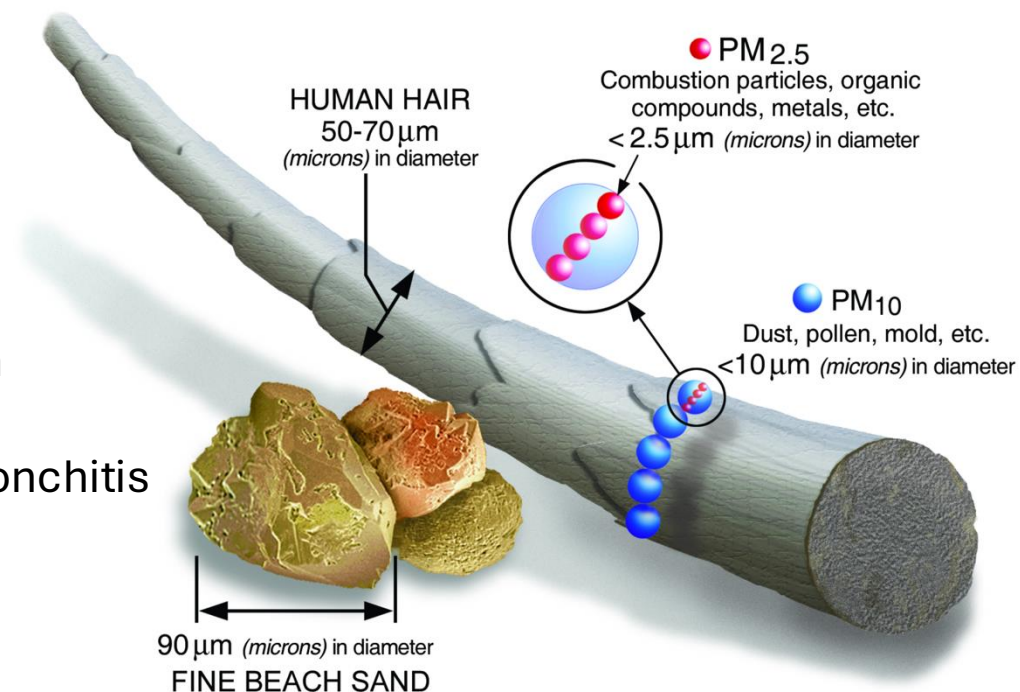
- Construction sites, wildfires, combustion emissions
- Complex reactions in the atmosphere (SO₂ and NO_x)
- Cooking and cleaning (resuspension)

Harmful effects of PM2.5

- Travels deep into the lungs and can enter the bloodstream
- Premature mortality due to heart and lung impact
- Increased hospital admissions for asthma and chronic bronchitis

PM2.5 Ranges

- 0-12 µg/m³ – Excellent, lower is always better
- < 250 µg/m³ – Acceptable
- > 250 µg/m³ – Needs improvement



Volatile Organic Compounds (VOCs)

Components that Affect IAQ

Volatile Organic Compounds (VOCs) – Extremely diverse chemicals with a low boiling point (meaning they easily evaporate) and with a high vapor pressure (meaning they are volatile)

Sources of VOCs

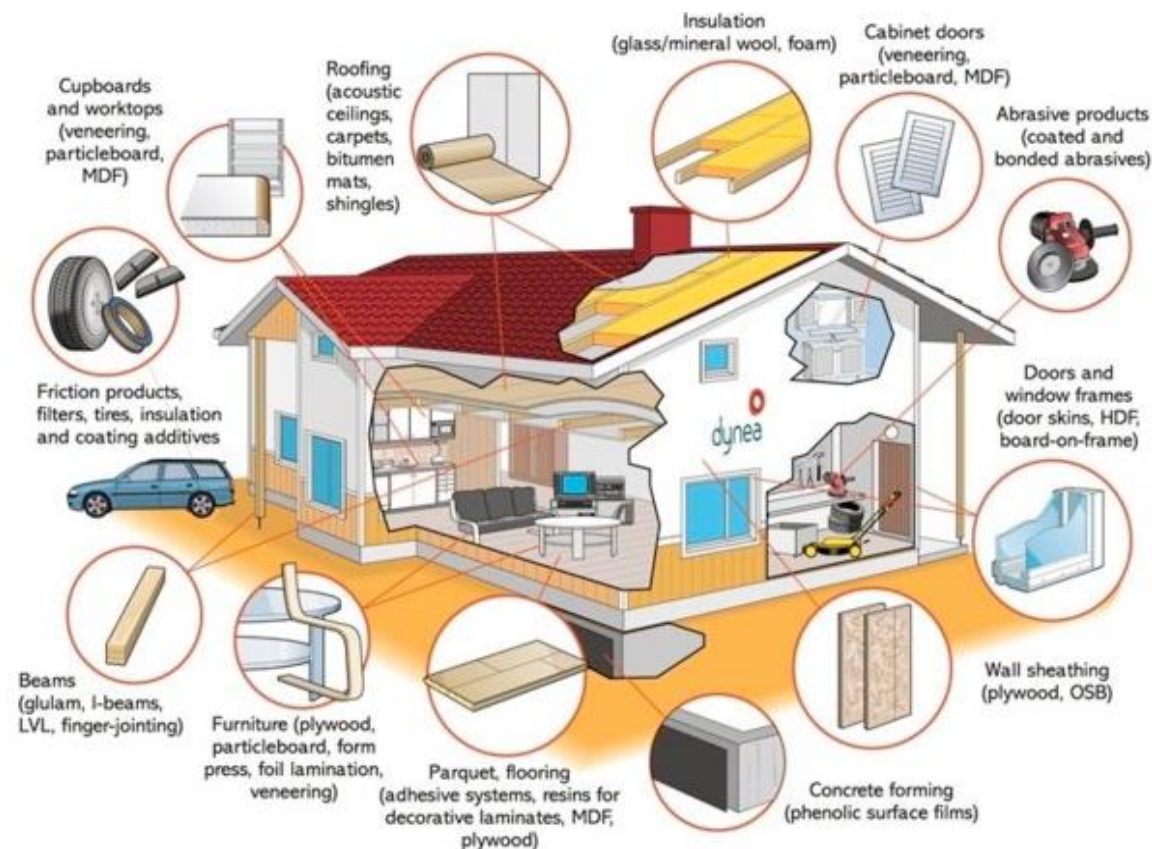
- Paints, solvents, cosmetic and degreasing products
- Odors from scents, perfumes, burnt popcorn

Harmful effects of VOCs

- Some are generally harmless – limonene or pinene
- Some are really bad and cause cancer– formaldehyde

VOC Ranges

- $< 1.0 \mu\text{g}/\text{m}^3$ – Excellent, lower is always better
- $< 10 \mu\text{g}/\text{m}^3$ – Acceptable
- $> 10 \mu\text{g}/\text{m}^3$ – Needs improvement



Overall Summary:

- On Floors 29, 30, and 31, the air quality as indicated by PM 2.5 levels, Carbon Dioxide levels, and Total Volatile Organic Compound (TVOC) levels was overall very good to excellent.
 - These results indicate proper outside air ventilation, proper filtration, and proper use of cleaning agents in the building.
 - These results also indicate that any pollutants caused by cooking, microwaving food, smoking, and/or personal hygiene (perfumes, etc.) were well controlled.
- The Carbon Dioxide levels were not controlled well on ~ 7-24-24, but the ventilation system recovered and worked well afterwards. I am not sure if this was due to an HVAC controls issue or from some company event that involved high occupancy levels.

Overall Summary:

- The Comfort Index, as indicated by Temperature and Relative Humidity levels, was acceptable in some areas but poor in other areas.
 - On Floor 29, the high Relative Humidity Levels were not highly correlated with low temperatures, which makes me believe these high moisture levels were driven by occupant respiration.
 - On Floor 31, the high Relative Humidity Level were correlated with low temperatures, which makes me believe this floor is being over-cooled.
 - Indoor Relative Humidity levels should stay at or below 60% to prevent mold growth.
- Sensor C on Floor 29 was unplugged on 8-8-24

High Relatively Humidity Levels Explained

- During the summer, the absolute humidity levels (dew points) are high outside in Chicago.
- When outside air is brought into buildings for ventilation/make-up air, the outside air contains a lot of moisture.
- On a really hot day, the HVAC system should run long enough to do a good job of dehumidifying the conditioned space and getting it to around 50% RH.
- However, if the conditioned space's cooling load is not high enough - *due to more efficient windows, LED light bulbs, and better building insulation* – then the HVAC system does not have long runtimes and therefore has difficulty removing enough moisture for the conditioned space to reach 50% RH.
- Often facilities managers set the thermostat setpoint lower in an attempt to force the HVAC system to run longer to remove the excess moisture. This usually does not work since the RH will actually increase in colder air. I think we are seeing this on Floor 31.
- Less common reasons would be due to water intrusion/leaks or high moisture loads generated inside from swimming pools, cooking, showers, hydroponics, etc.

What to Do About High Relative Humidity Levels

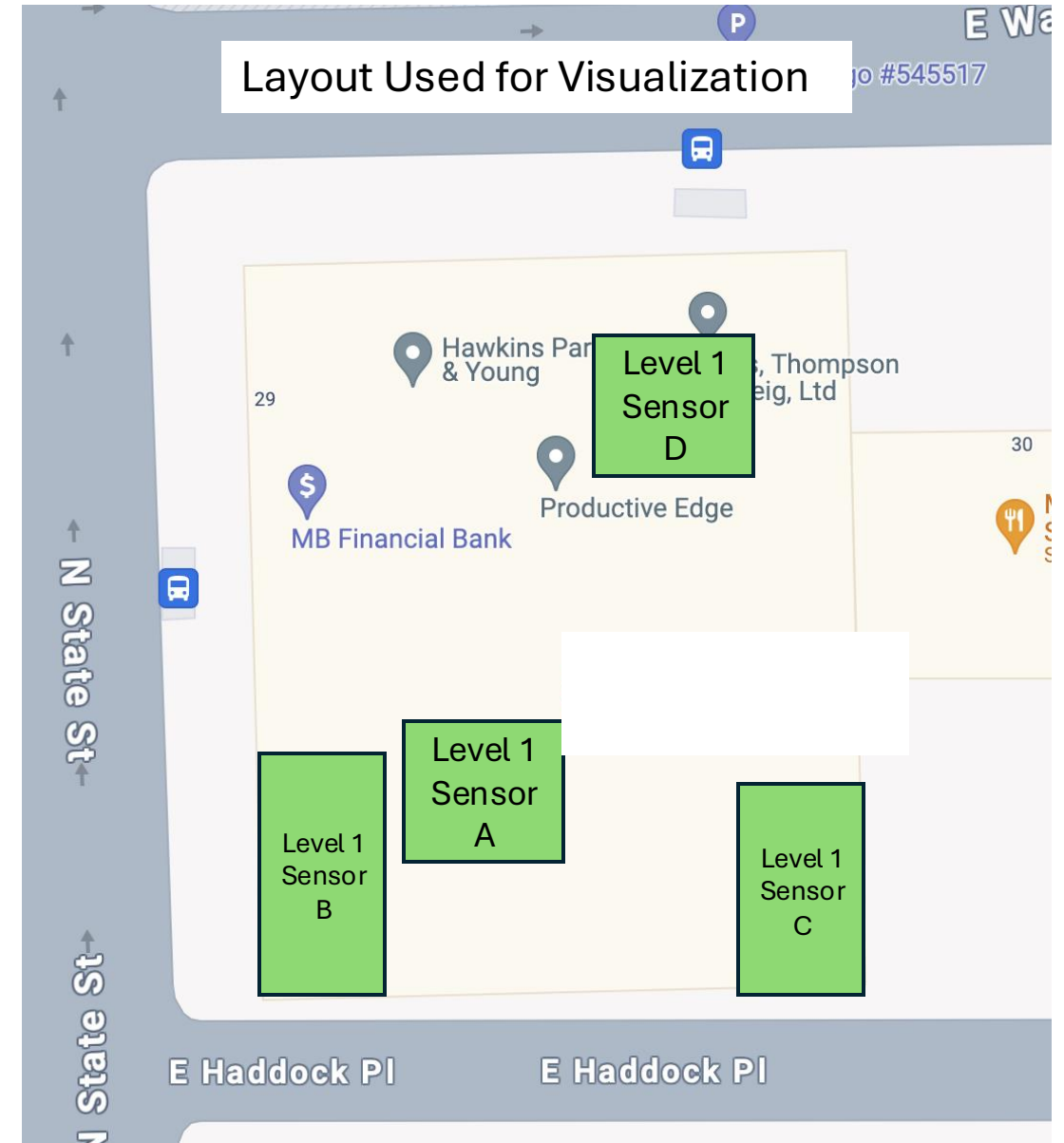
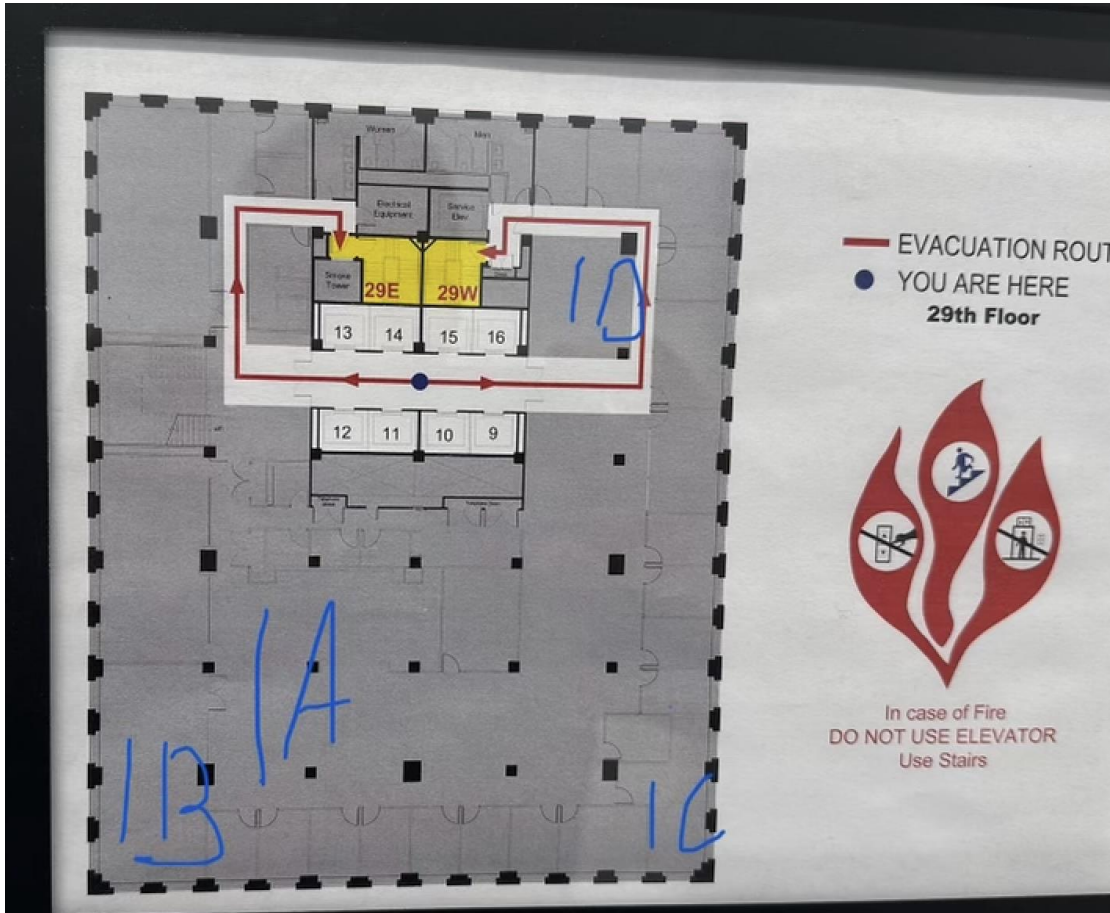
- The facilities manager has a few options to handle high RH levels in the conditioned space. Usually, these options are not taken because they require additional energy costs to remove the excess moisture.
 - Option 1) Add dehumidification capacity to the conditioned space. This can be done by slowing the airflow down across the cooling coils, adding reheat to the HVAC system's processed airflow, running the cooling coil at a colder temperature, and/or by adding dedicated dehumidifiers to the conditioned space.
 - Option 2) Increase the dehumidification of the ventilation air. This can be done by using a Dedicated Outdoor Air System (DOAS), adjusting the setpoints on an existing DOAS system, or using Energy Recovery technology for the ventilation air (by dehumidifying the incoming air using the exhaust air).
- *Most or all of these options increase operating costs, and some require capital expenditures. So, many times the facilities managers cross their fingers and wait for the outdoor weather to change for the better (meaning sustained dew points of 55°F or below).*

Detailed IAQ Results per Sensor per Floor

- Floor Layouts and Sensor Locations
- Floor 29
 - Sensors A-D
 - Temperature, Relative Humidity, Carbon Dioxide, TVCOs, and PM 2.5 Graphs
 - Comments
- Floor 30
 - Sensors A-C
 - Temperature, Relative Humidity, Carbon Dioxide, TVCOs, and PM 2.5 Graphs
 - Comments
- Floor 31
 - Sensors A-C
 - Temperature, Relative Humidity, Carbon Dioxide, TVCOs, and PM 2.5 Graphs
 - Comments

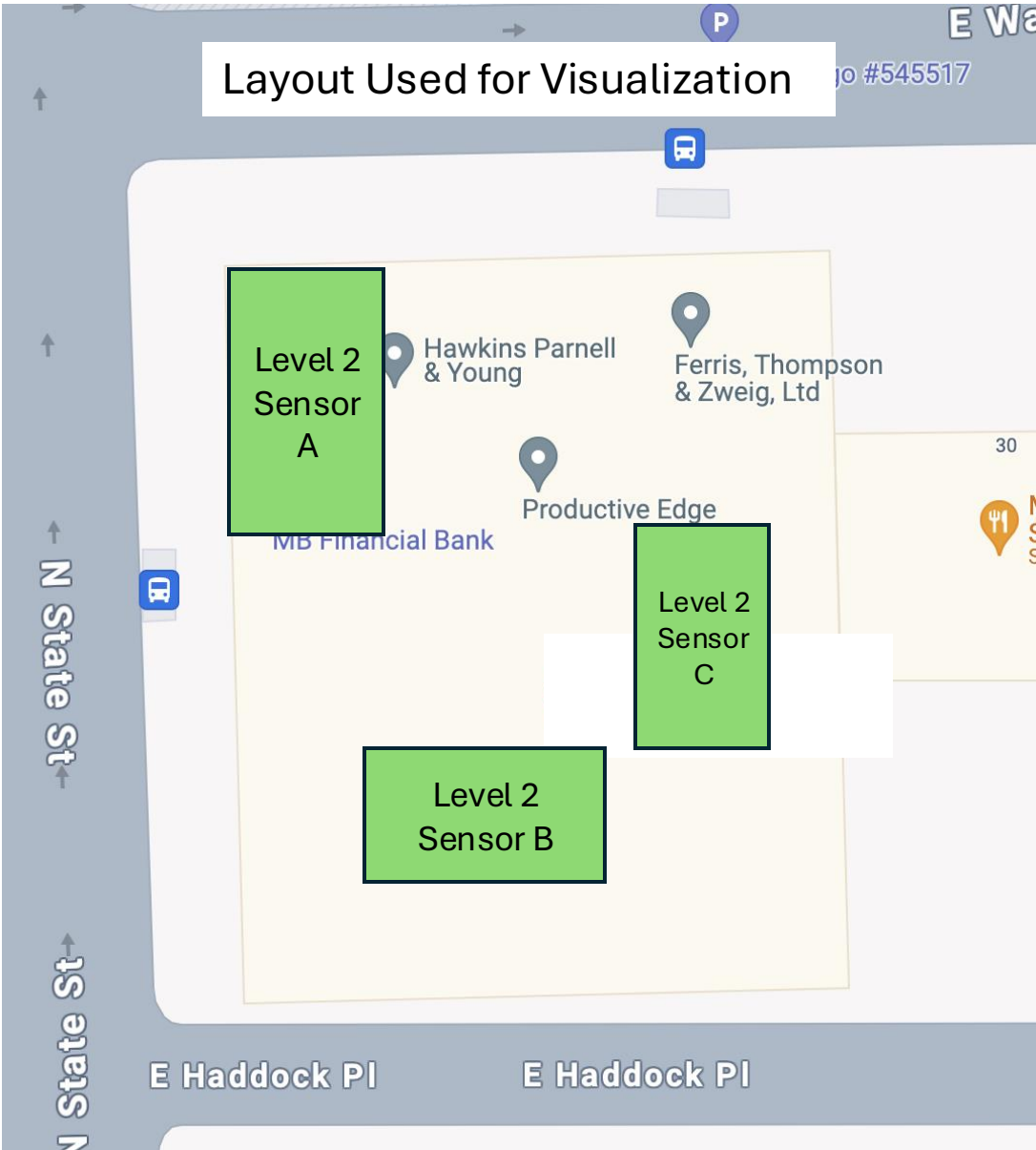
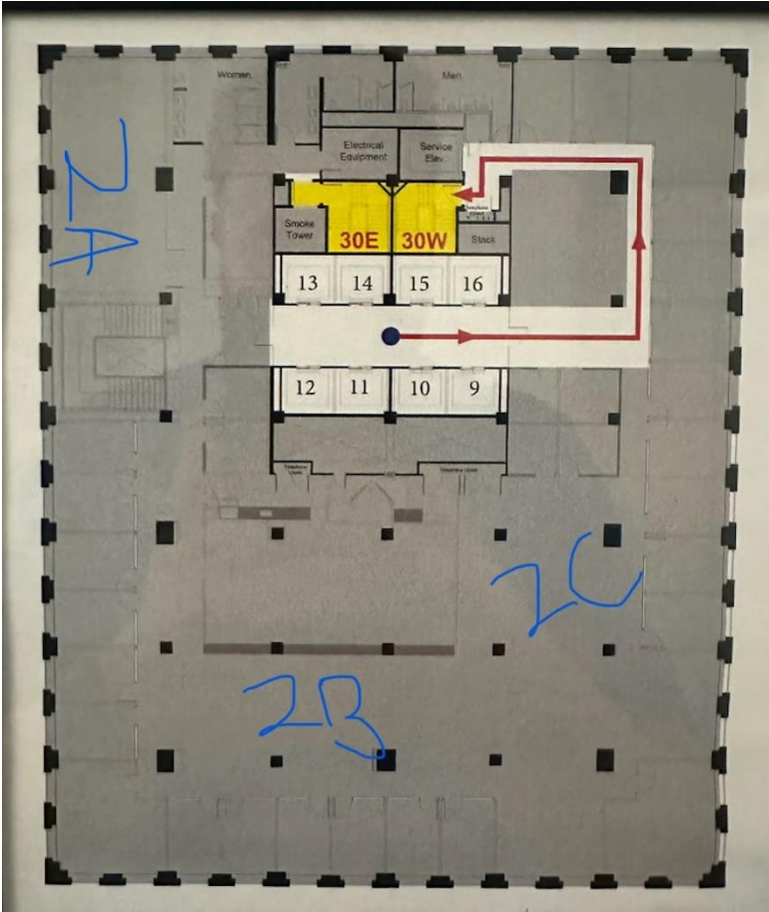
29th Floor

Floor Layout (by Elevators) and Sensor Locations



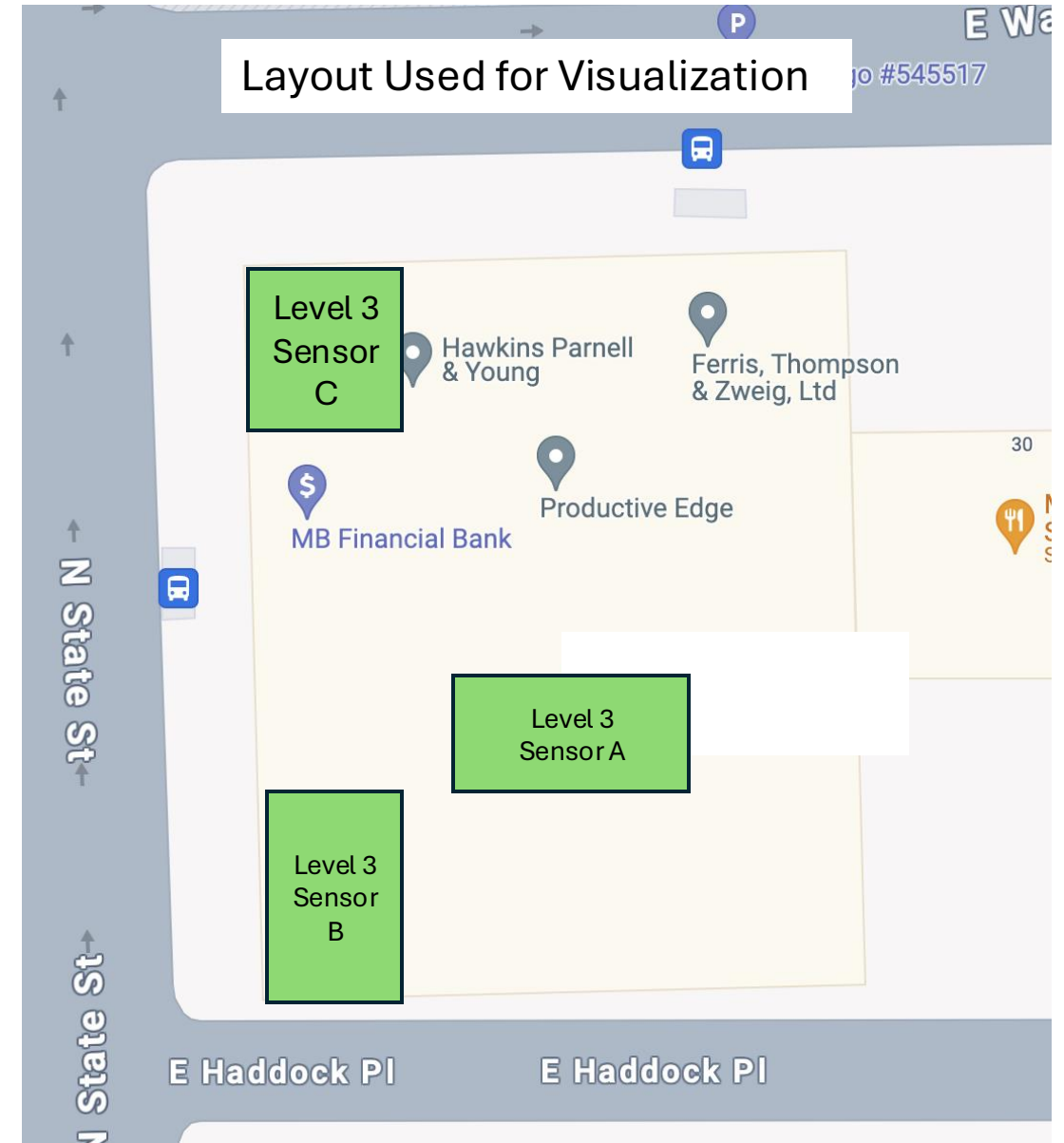
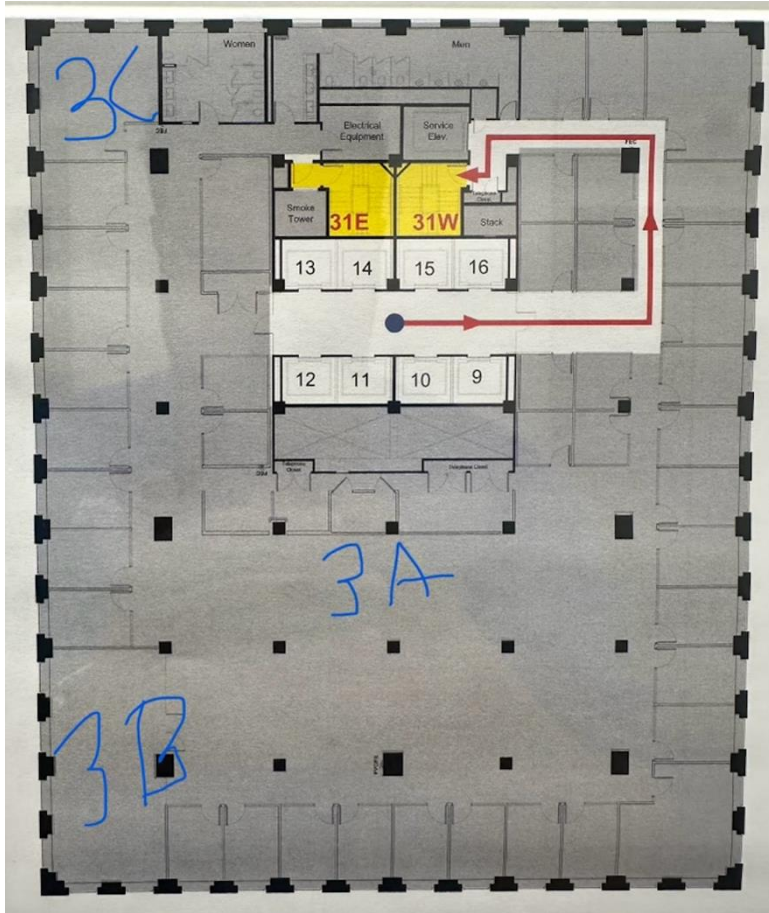
30th Floor

Floor Layout (by Elevators) and Sensor Locations



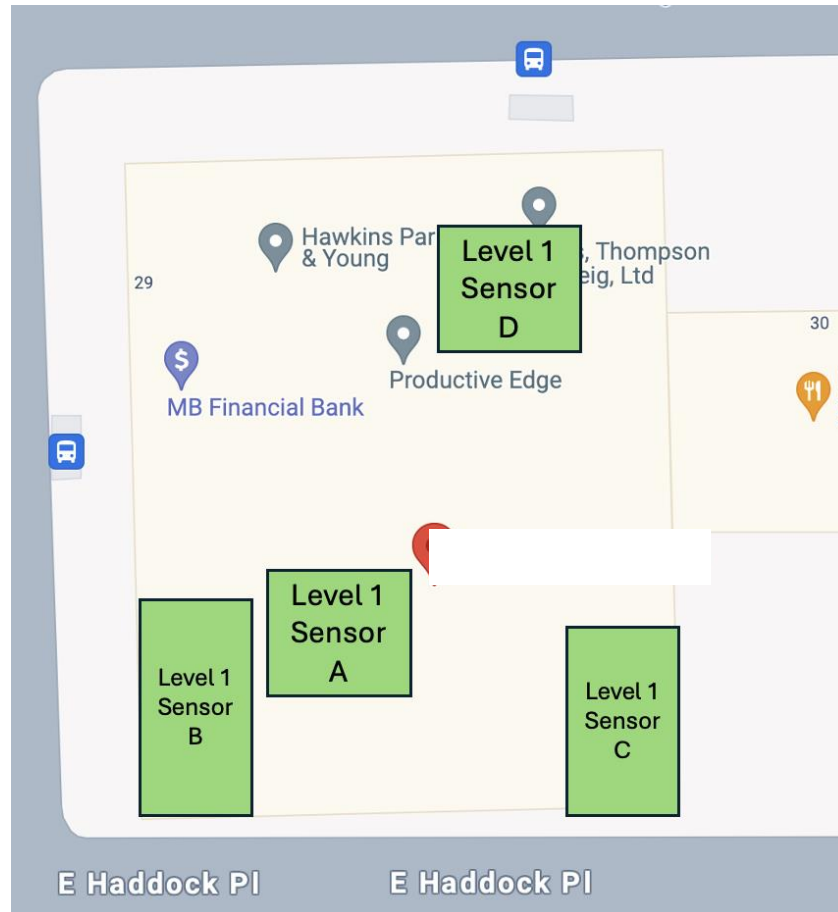
31th Floor

Floor Layout (by Elevators) and Sensor Locations



Floor 29 Results – Sensor A: Temperature

Layout Used for Visualization

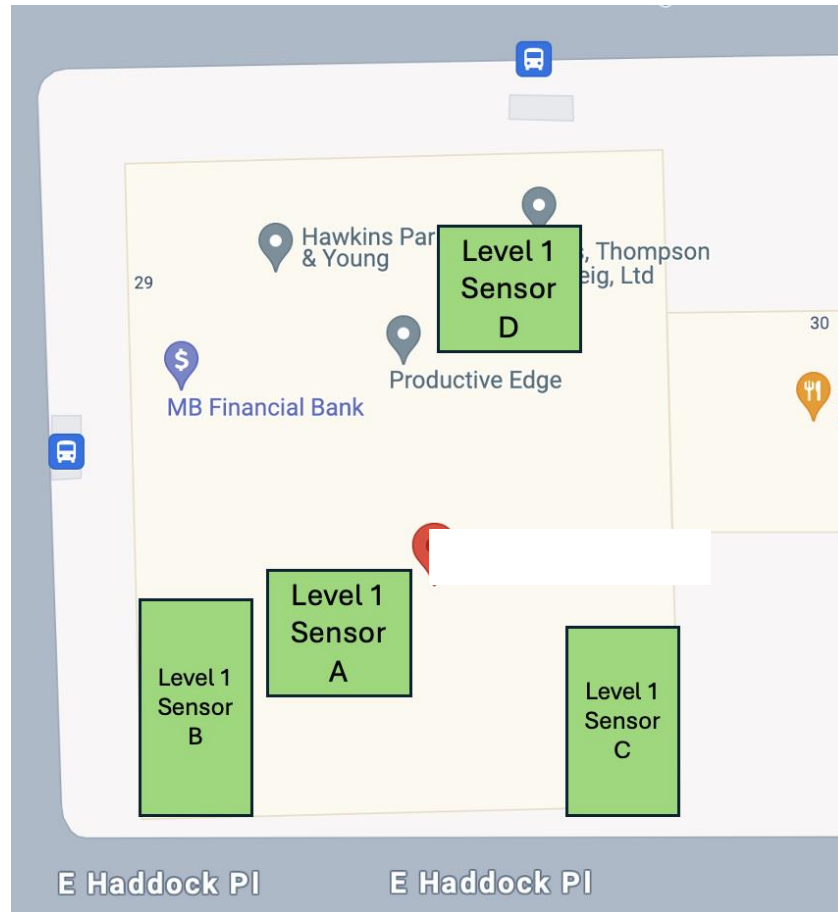


Comments:

- Temperature ranged from ~ 69°F to 75°F during the test, which is good.
- Loss of Wi-Fi signal on ~ 7-30-24.
- The blue line is the actual sensor data.

Floor 29 Results – Sensor A: Relative Humidity

Layout Used for Visualization

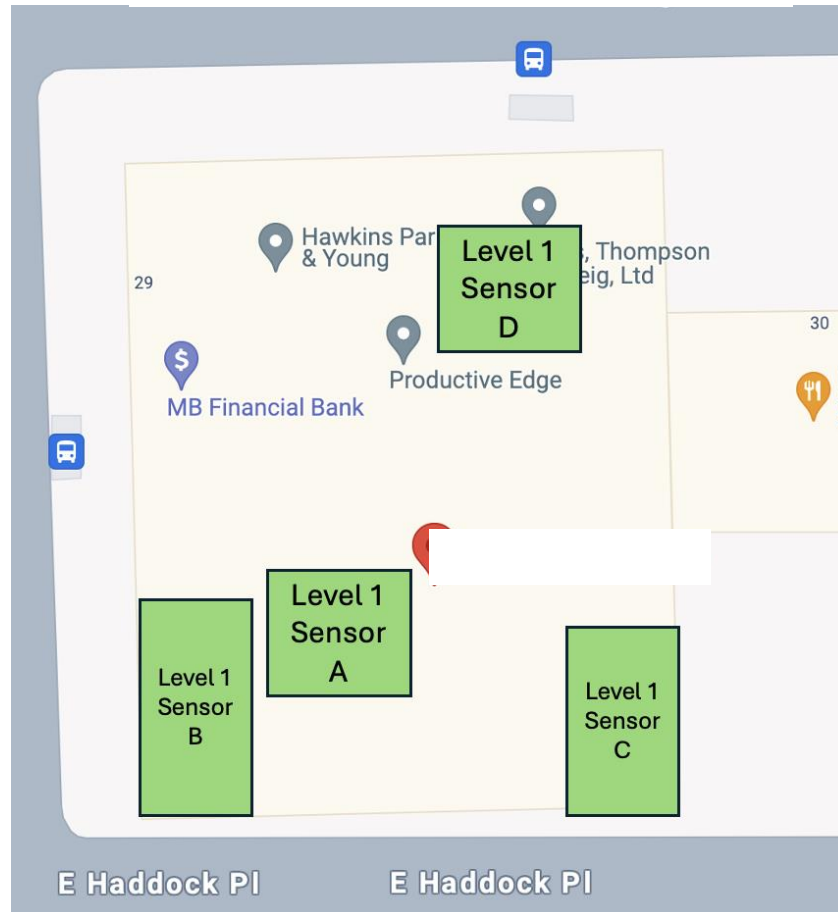


Comments:

- Relative humidity ranged from 50%, which is good, to ~ 70% in late July, which is uncomfortable. RH levels above 60% are not recommended.
- Loss of Wi-Fi signal on ~ 7-30-24.
- The blue line is the actual sensor data.

Floor 29 Results – Sensor A: Carbon Dioxide

Layout Used for Visualization

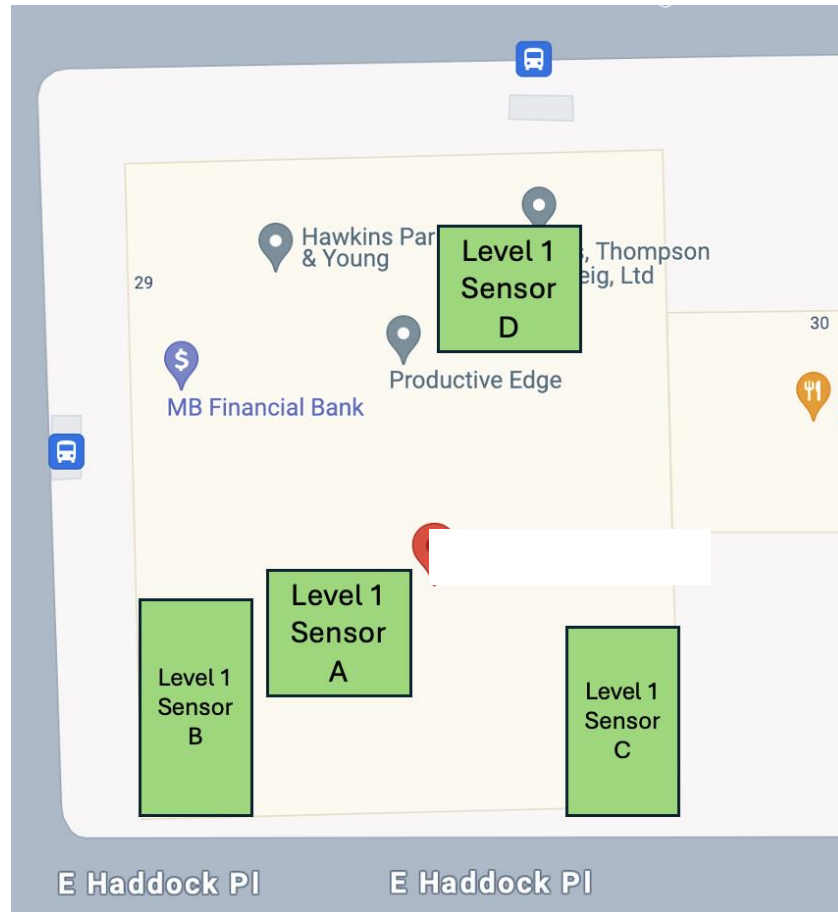


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 750 ppm, which is also excellent.
- The carbon dioxide levels were not controlled well on ~ 7-24-24, but the ventilation system recovered and worked well afterwards.
- Loss of Wi-Fi signal on ~ 7-30-24.
- The blue line is the actual sensor data.

Floor 29 Results – Sensor A: PM 2.5

Layout Used for Visualization

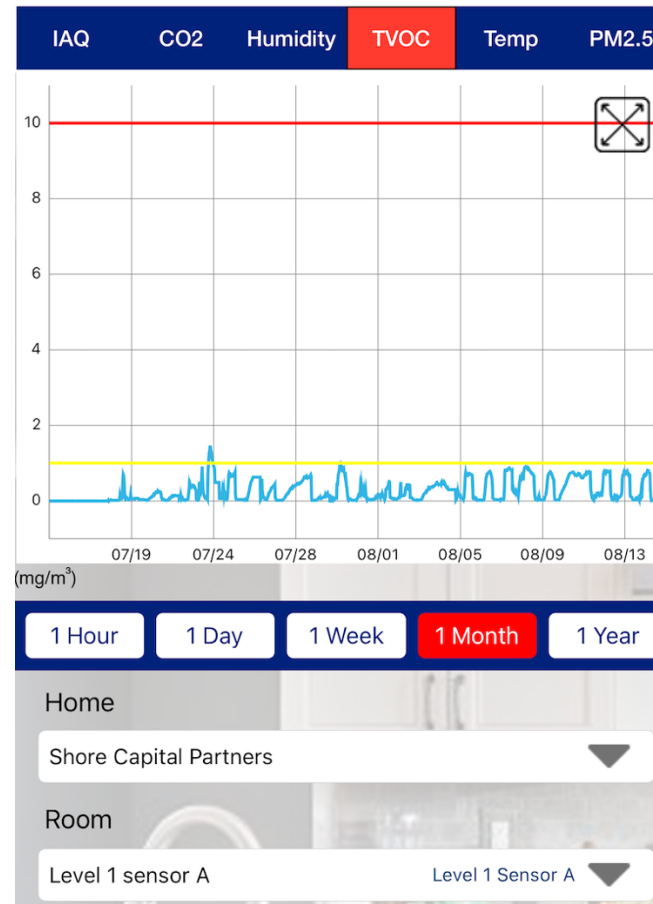
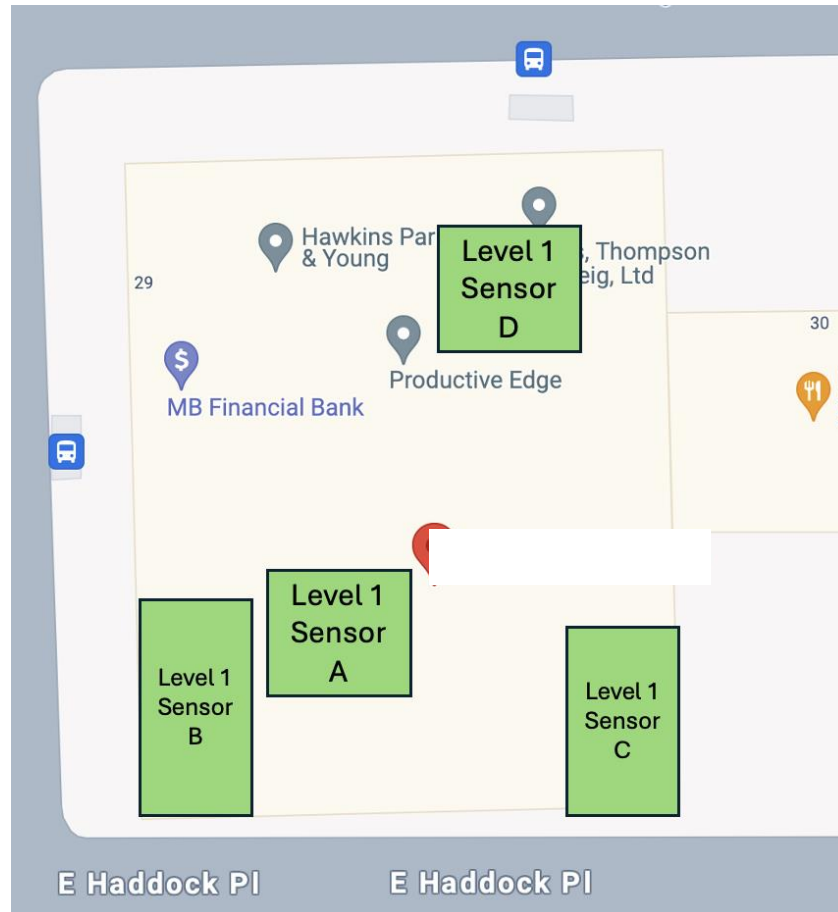


Comments:

- PM 2.5 levels ranged from $\sim 0 \mu\text{g}/\text{m}^3$ to $\sim 10 \mu\text{g}/\text{m}^3$ during the test, which is good.
- The blue line is the actual sensor data.

Floor 29 Results – Sensor A: TVOCs

Layout Used for Visualization

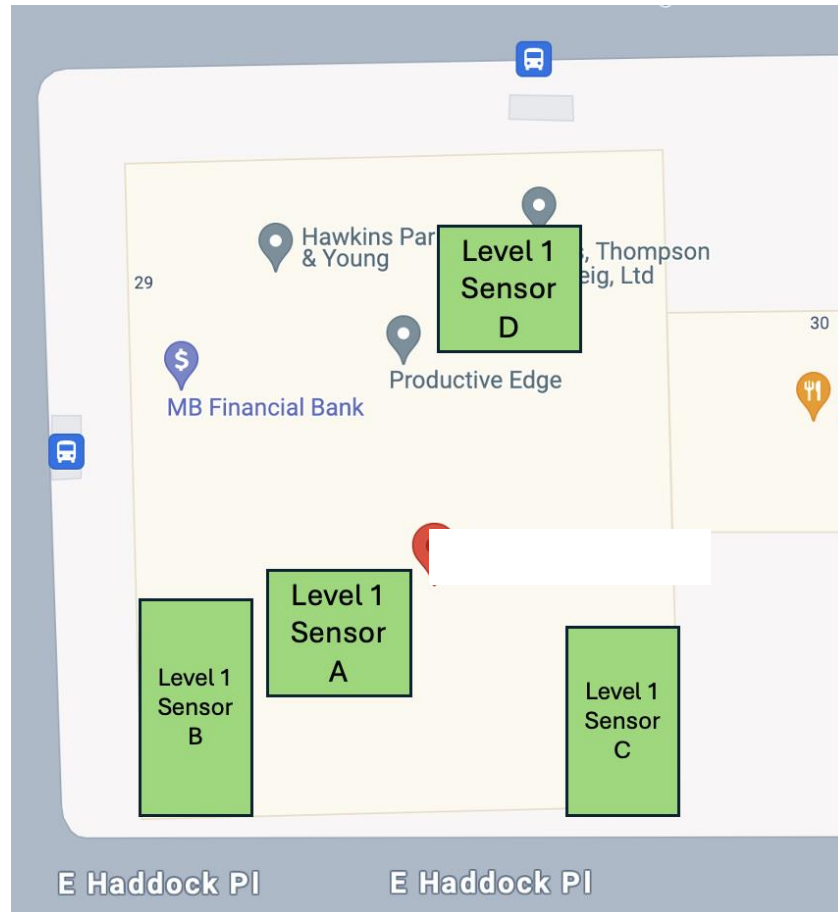


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.
- The blue line is the actual sensor data.

Floor 29 Results – Sensor B: Temperature

Layout Used for Visualization

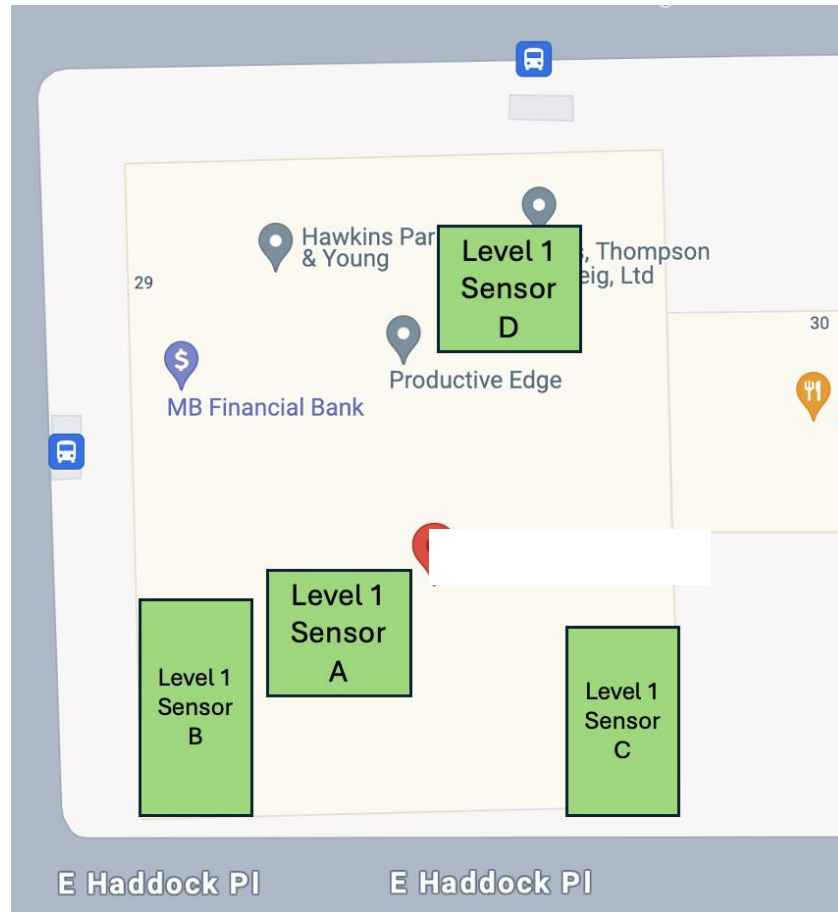


Comments:

- Temperature ranged from ~ 69°F to 75°F during the test, which is good.
- The temperature stayed high on 7-28 and 8-4, both indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 29 Results – Sensor B: Relative Humidity

Layout Used for Visualization

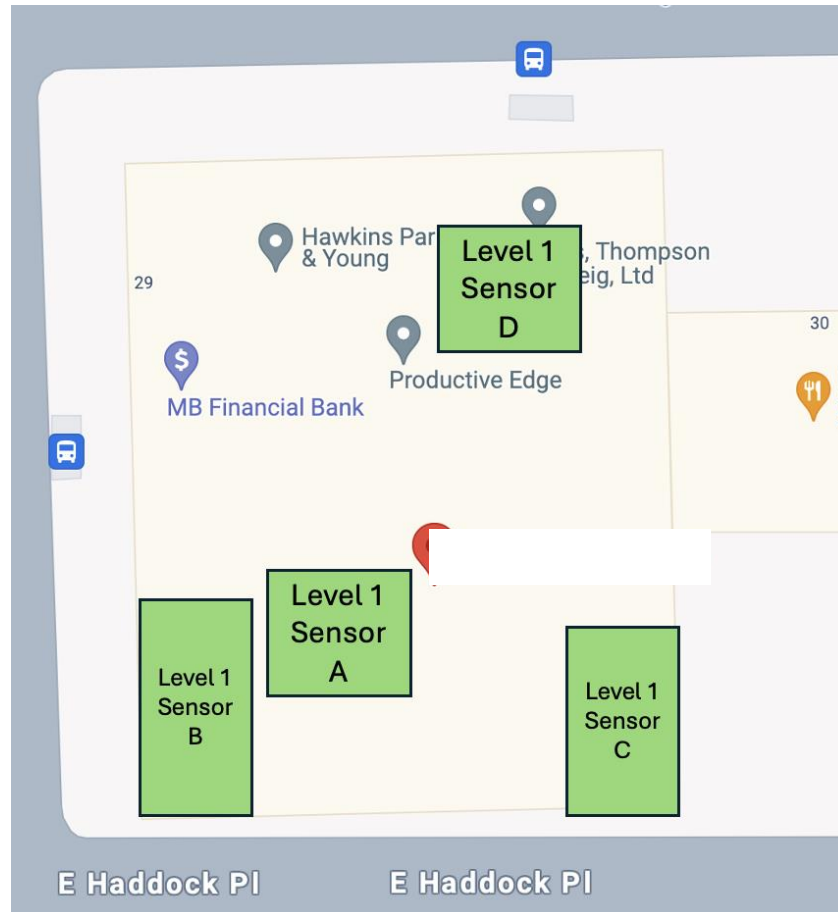


Comments:

- Relative humidity ranged from 45%, which is good, to ~ 75% in late July, which is uncomfortable. RH levels above 60% are not recommended.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 29 Results – Sensor B: Carbon Dioxide

Layout Used for Visualization

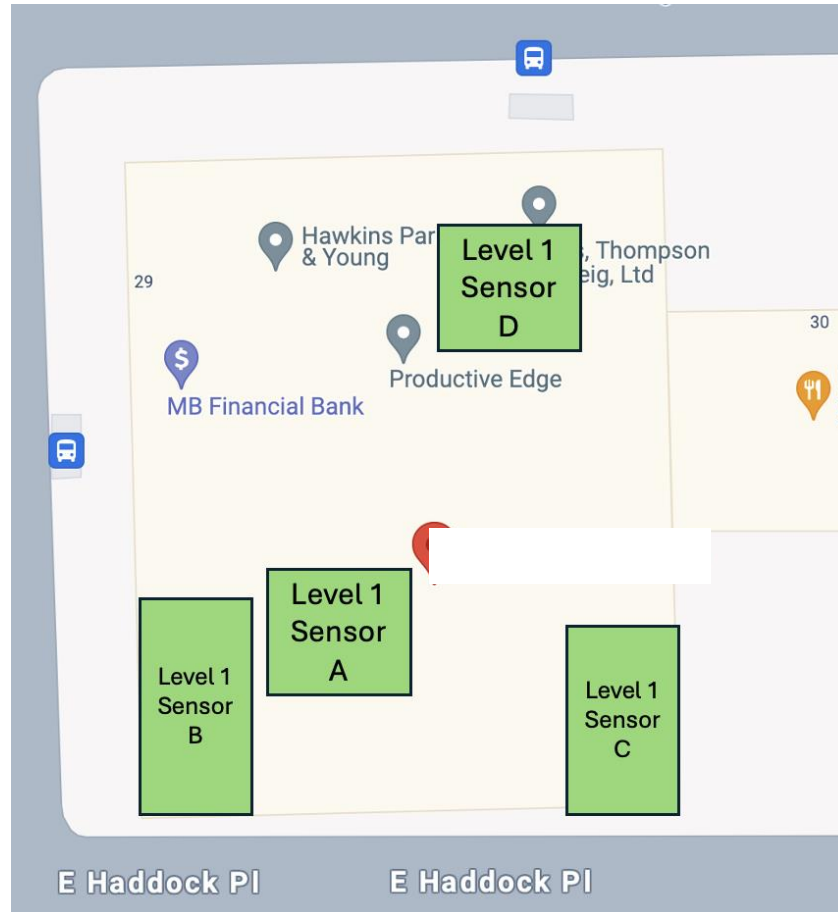


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 750 ppm, which is also excellent.
- The carbon dioxide levels were not controlled well on ~ 7-24-24, but the ventilation system recovered and worked well afterwards.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 29 Results – Sensor B: PM 2.5

Layout Used for Visualization

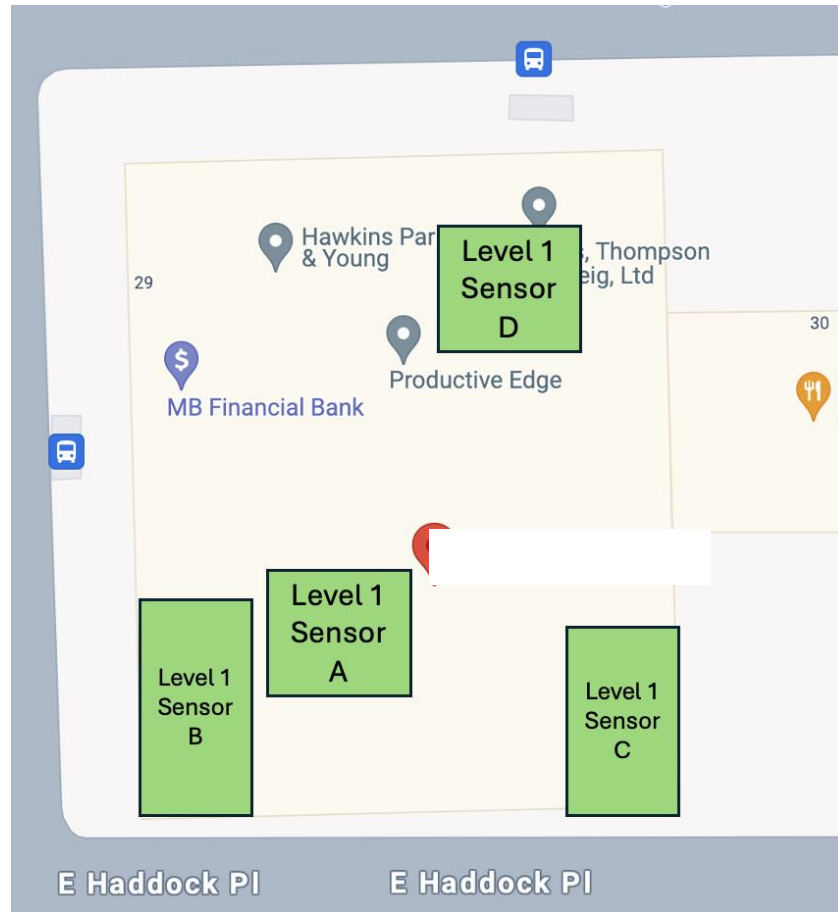


Comments:

- PM 2.5 levels ranged from $\sim 0 \mu\text{g}/\text{m}^3$ to $\sim 10 \mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 29 Results – Sensor B: TVOCs

Layout Used for Visualization

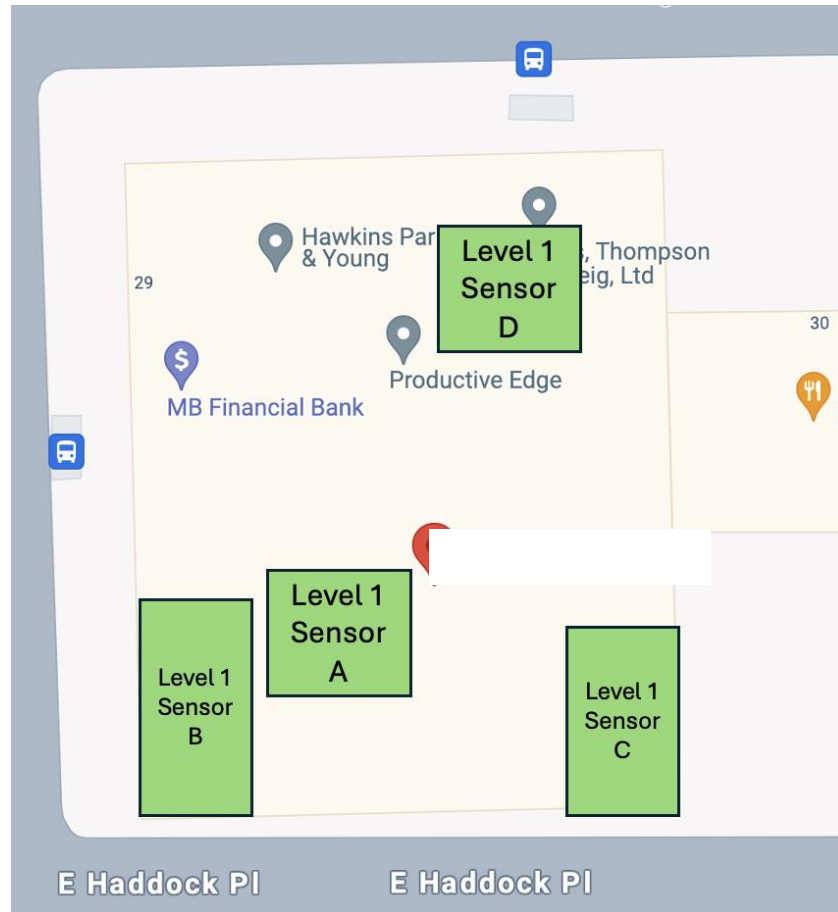


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 29 Results – Sensor C: Temperature

Layout Used for Visualization

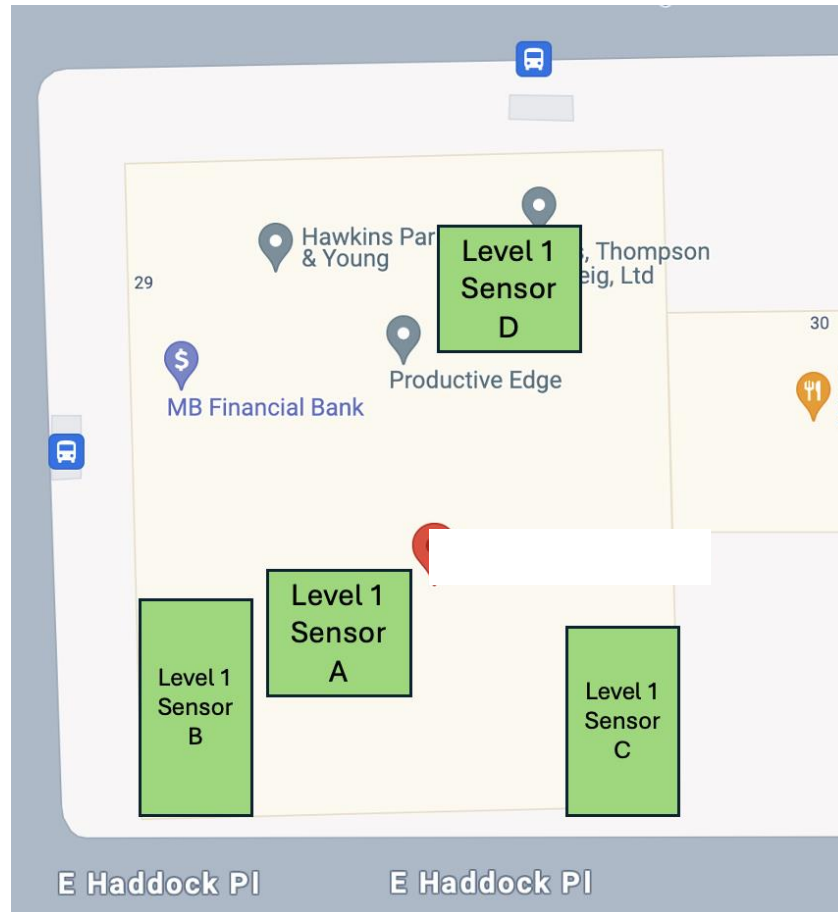


Comments:

- Temperature ranged from ~ 67°F to 73°F during the test, which is good.
- The temperature stayed high on 7-28 and 8-4, both indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.
- Sensor unplugged on ~ 8-8-24.

Floor 29 Results – Sensor C: Relative Humidity

Layout Used for Visualization

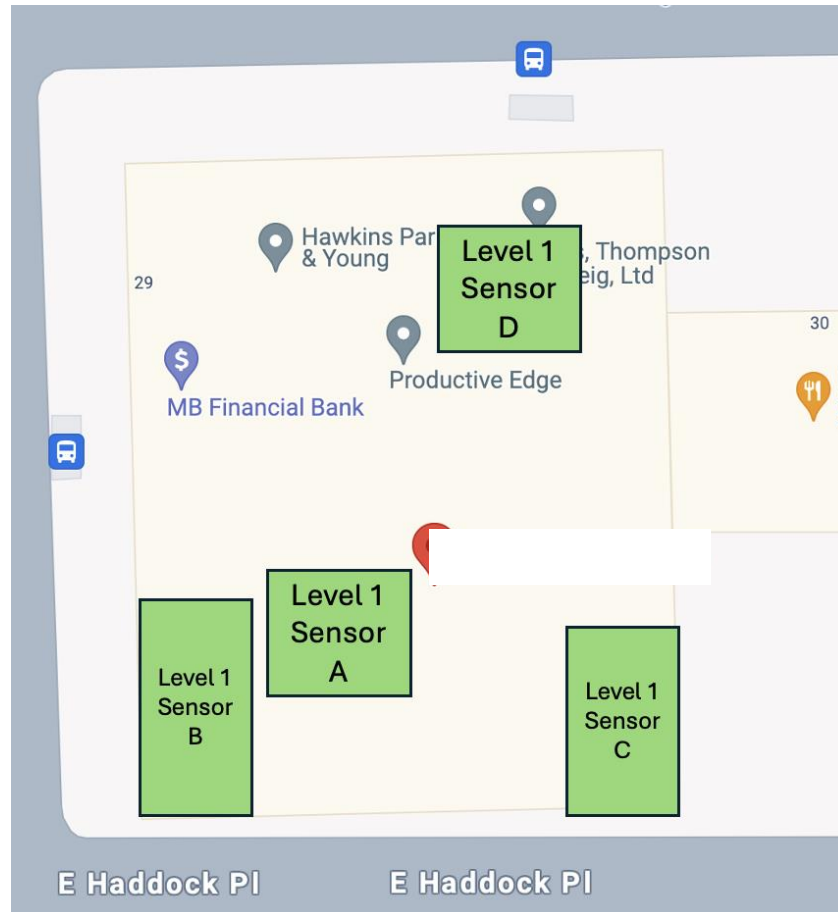


Comments:

- Relative humidity ranged from 55%, which is barely acceptable, to ~ 75% multiple times, which is uncomfortable. RH levels above 60% are not recommended.
- Loss of Wi-Fi signal on ~ 7-30-24.
- Sensor unplugged on ~ 8-8-24.

Floor 29 Results – Sensor C: Carbon Dioxide

Layout Used for Visualization

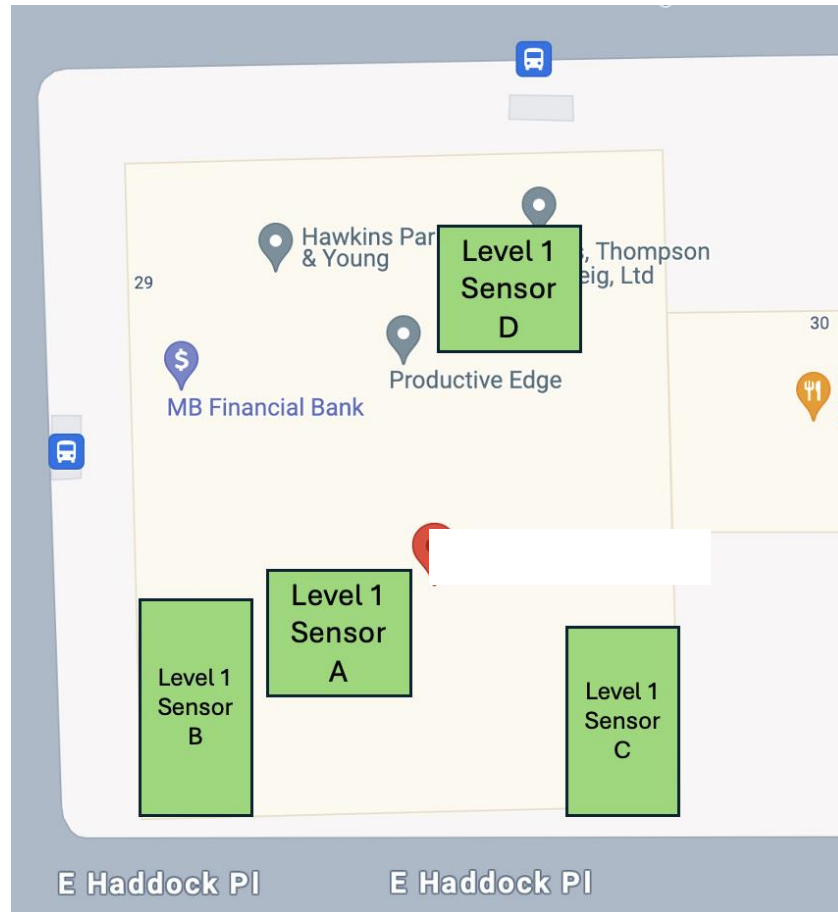


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent, and essentially the outdoors concentration, to ~ 750 ppm, which is also excellent.
- The carbon dioxide levels were not controlled well on ~ 7-24-24, but the ventilation system recovered and worked well afterwards.
- Loss of Wi-Fi signal on ~ 7-30-24.
- Sensor unplugged on ~ 8-8-24.

Floor 29 Results – Sensor C: PM 2.5

Layout Used for Visualization

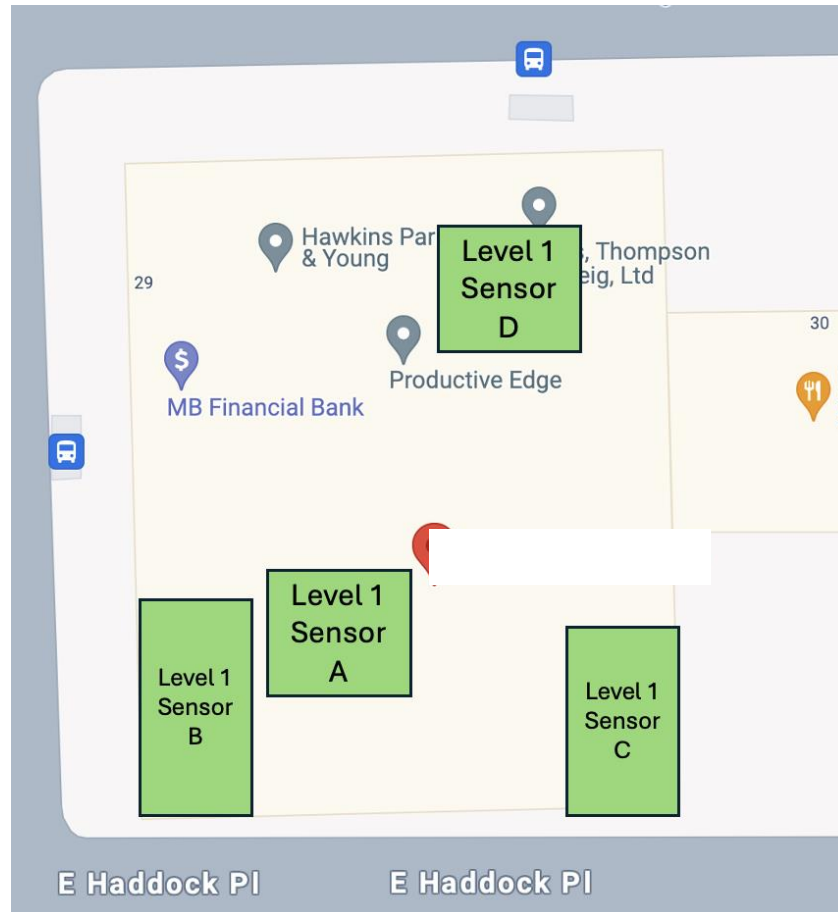


Comments:

- PM 2.5 levels ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 10 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 29 Results – Sensor C: TVOCs

Layout Used for Visualization

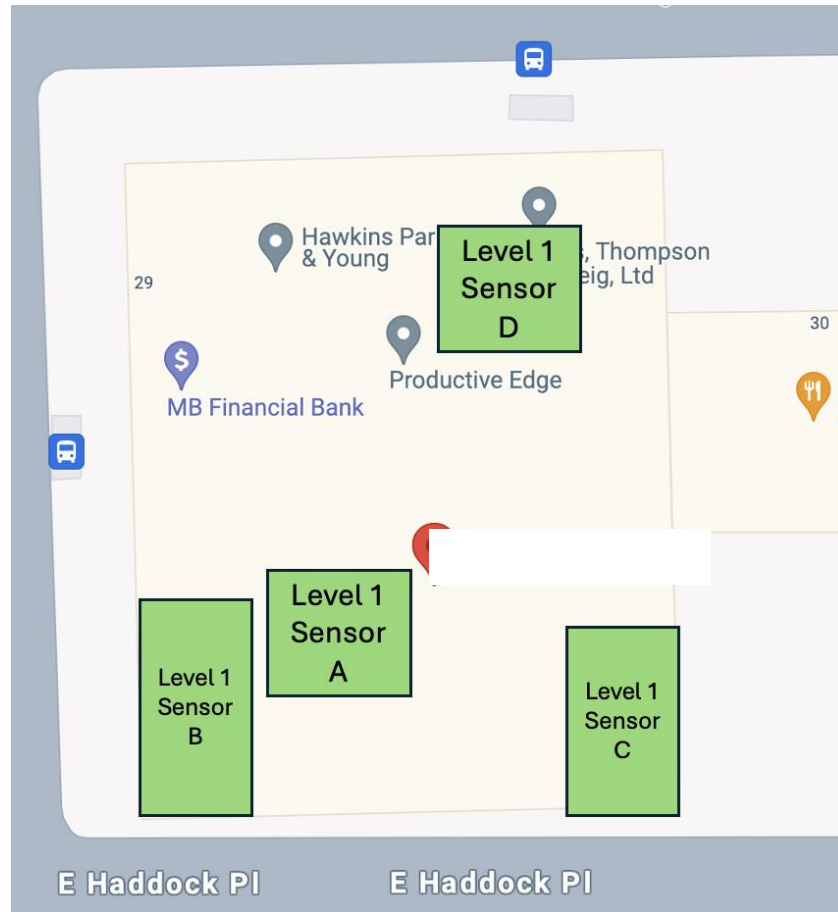


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.
- Sensor unplugged on $\sim 8-8-24$.

Floor 29 Results – Sensor D: Temperature

Layout Used for Visualization

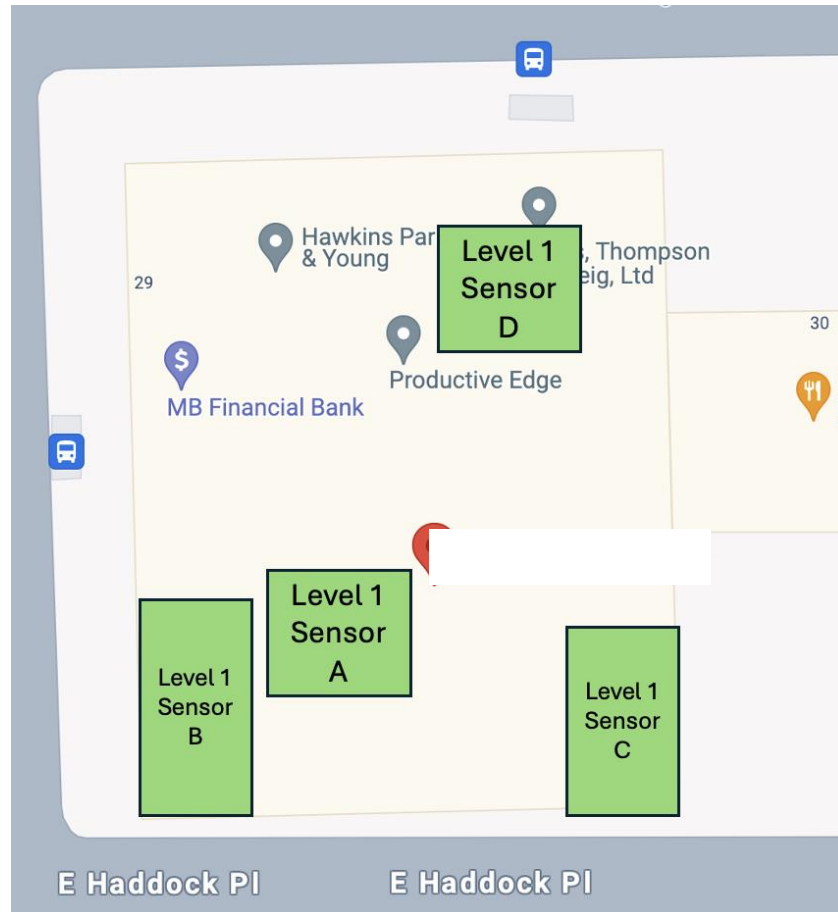


Comments:

- Temperature ranged from ~ 68°F to 74°F during the test, which is good.
- The temperature stayed high on 7-28 and 8-4, both indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 29 Results – Sensor D: Relative Humidity

Layout Used for Visualization

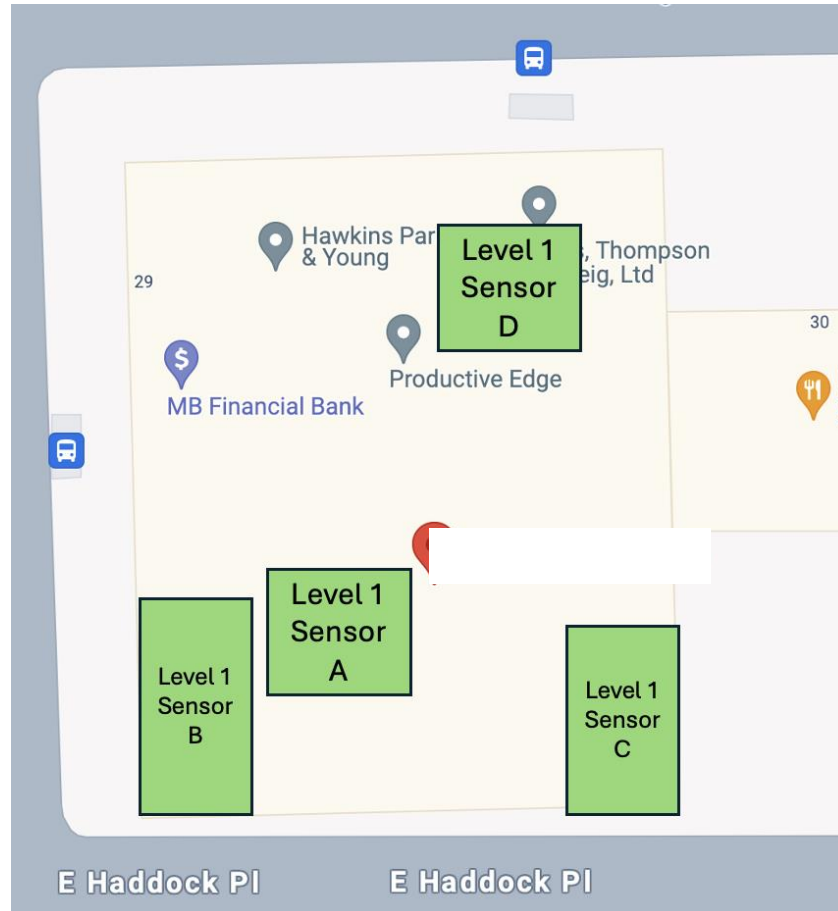


Comments:

- Relative humidity ranged from 45% to ~ 70% multiple times, which is uncomfortable. RH levels above 60% are not recommended.
- This area outperformed the other sensor areas on Floor 29, possibly due to low occupant density or proximity to HVAC supply vents.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 29 Results – Sensor D: Carbon Dioxide

Layout Used for Visualization

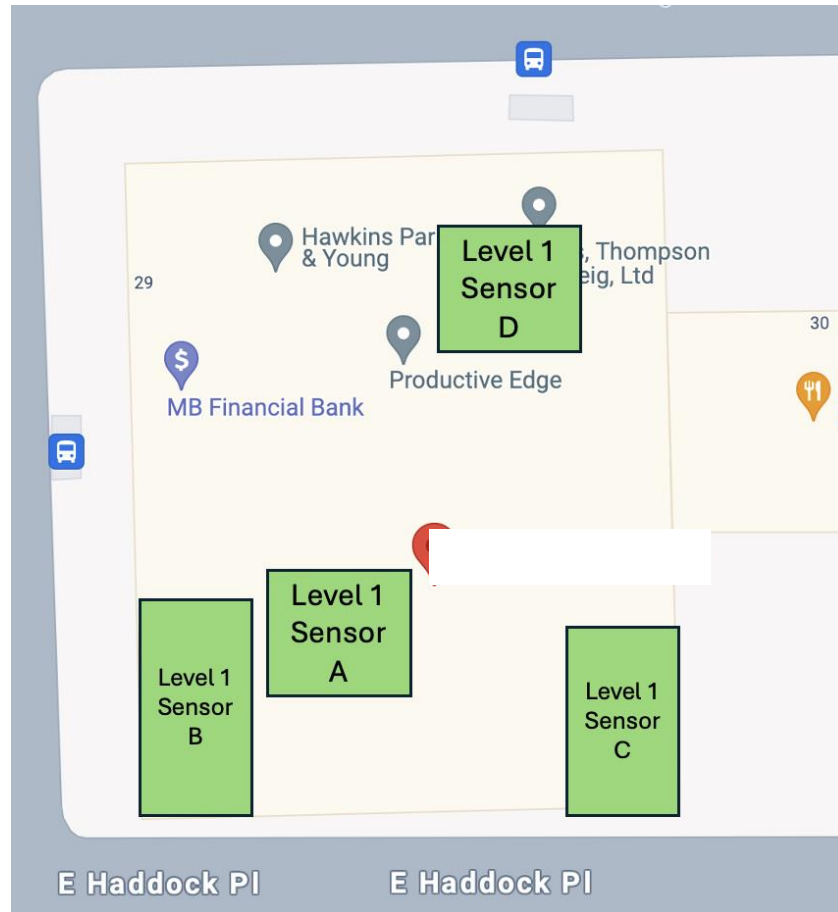


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 600 ppm, which is also excellent.
- This area outperformed the other areas on Floor 29 – probably due to being closer to HVAC supply vents or low occupant density.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 29 Results – Sensor D: PM 2.5

Layout Used for Visualization

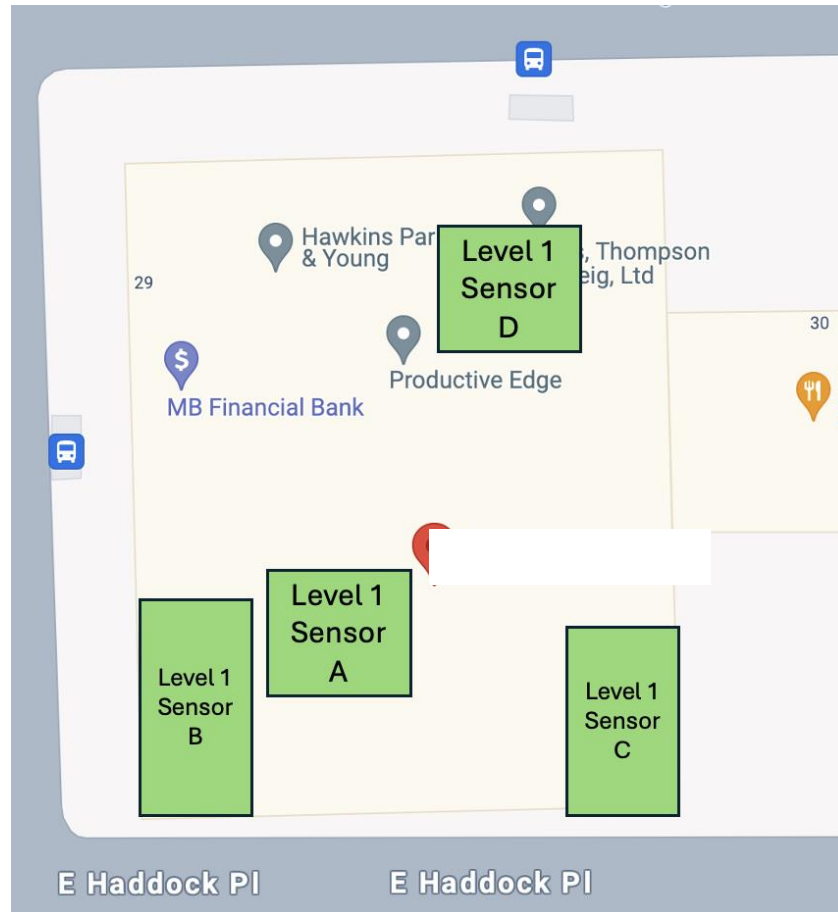


Comments:

- PM 2.5 levels ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 10 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 29 Results – Sensor D: TVOCs

Layout Used for Visualization

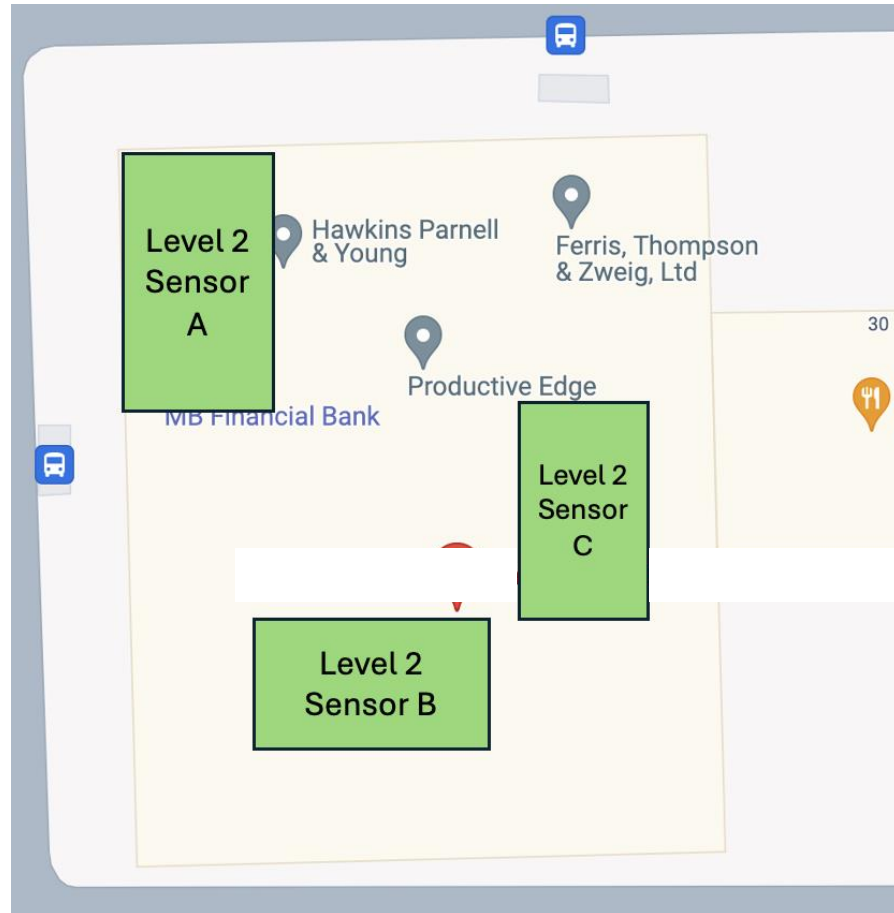


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g/m}^3$ to ~ 1 $\mu\text{g/m}^3$ during the test, which is good.

Floor 30 Results – Sensor A: Temperature

Layout Used for Visualization

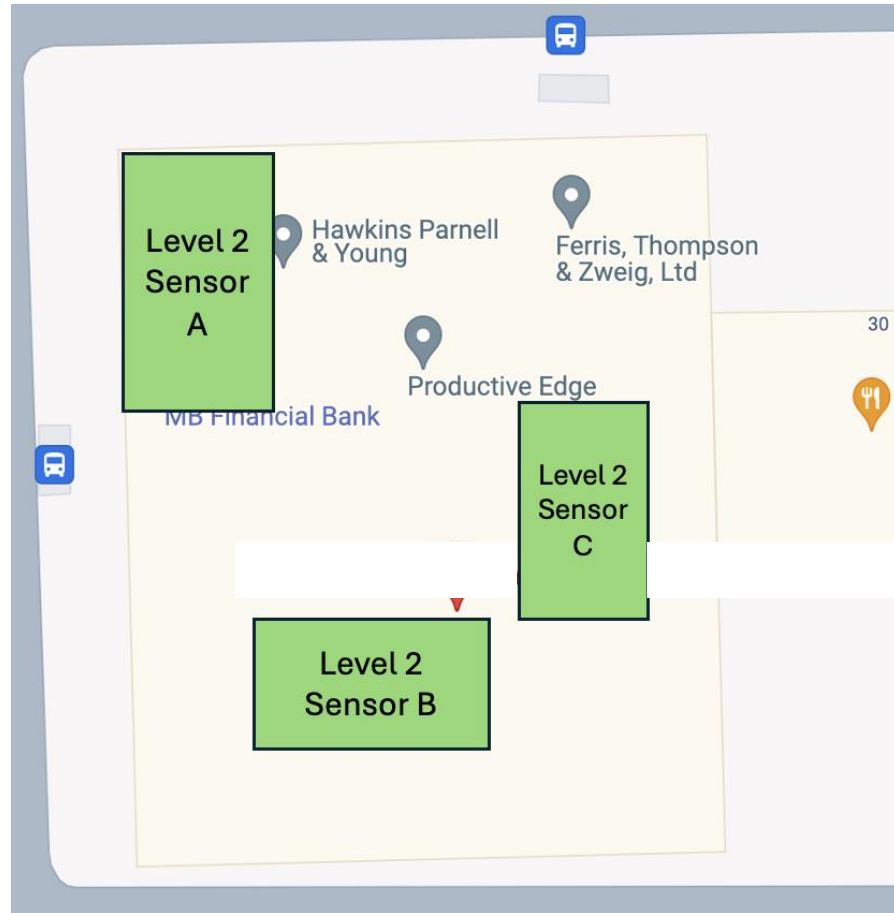


Comments:

- Temperature ranged from ~ 66°F to 73°F during the test, which is good.
- The temperature stayed high on 7-28, 8-4, and 8-11 indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor A: Relative Humidity

Layout Used for Visualization

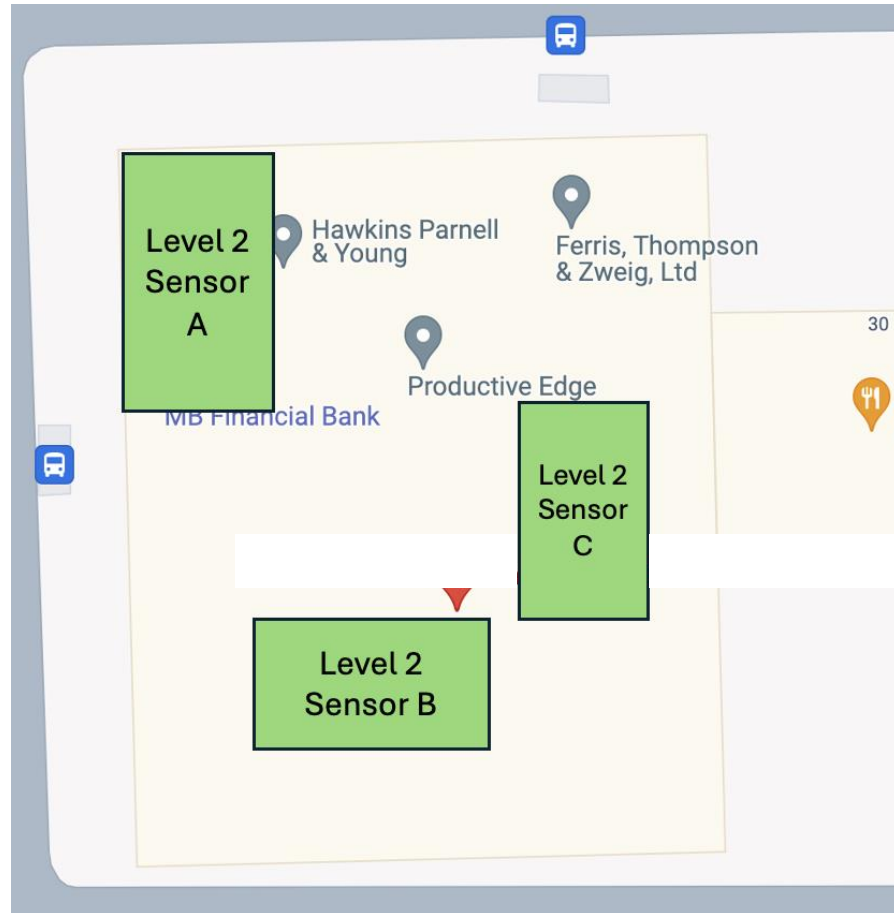


Comments:

- Relative humidity ranged from 45%, which is barely acceptable, to ~ 82% multiple times, which is not acceptable. RH levels above 60% are not recommended.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor A: Carbon Dioxide

Layout Used for Visualization

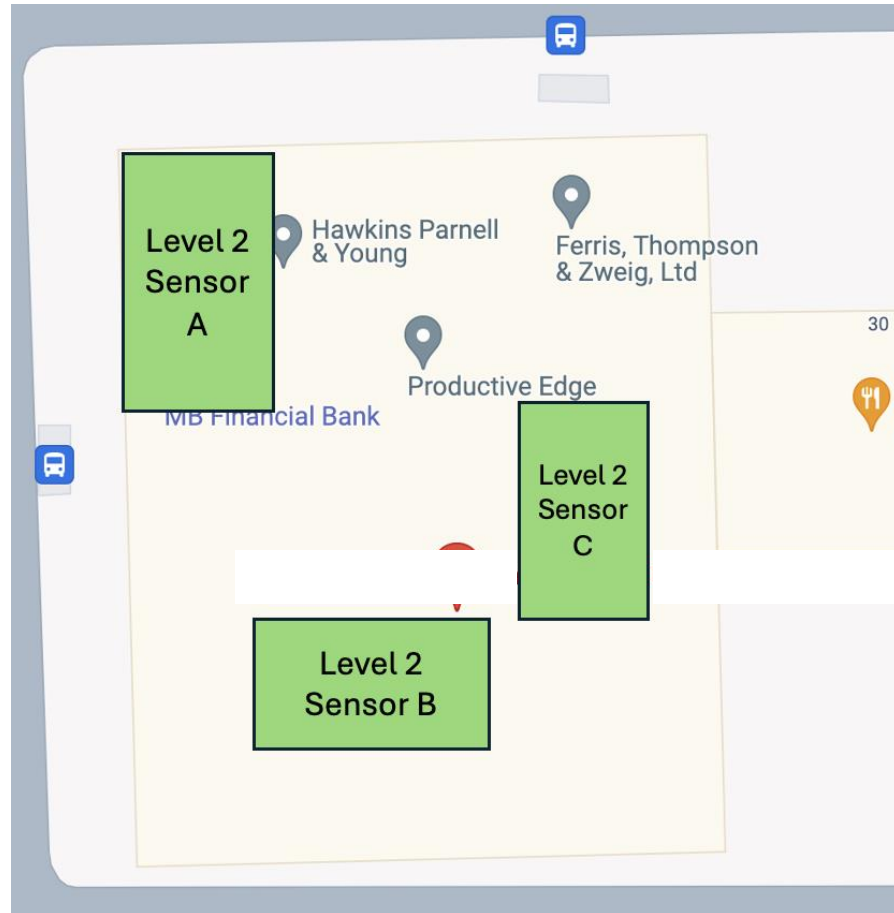


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 800 ppm, which is also excellent.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor A: PM 2.5

Layout Used for Visualization

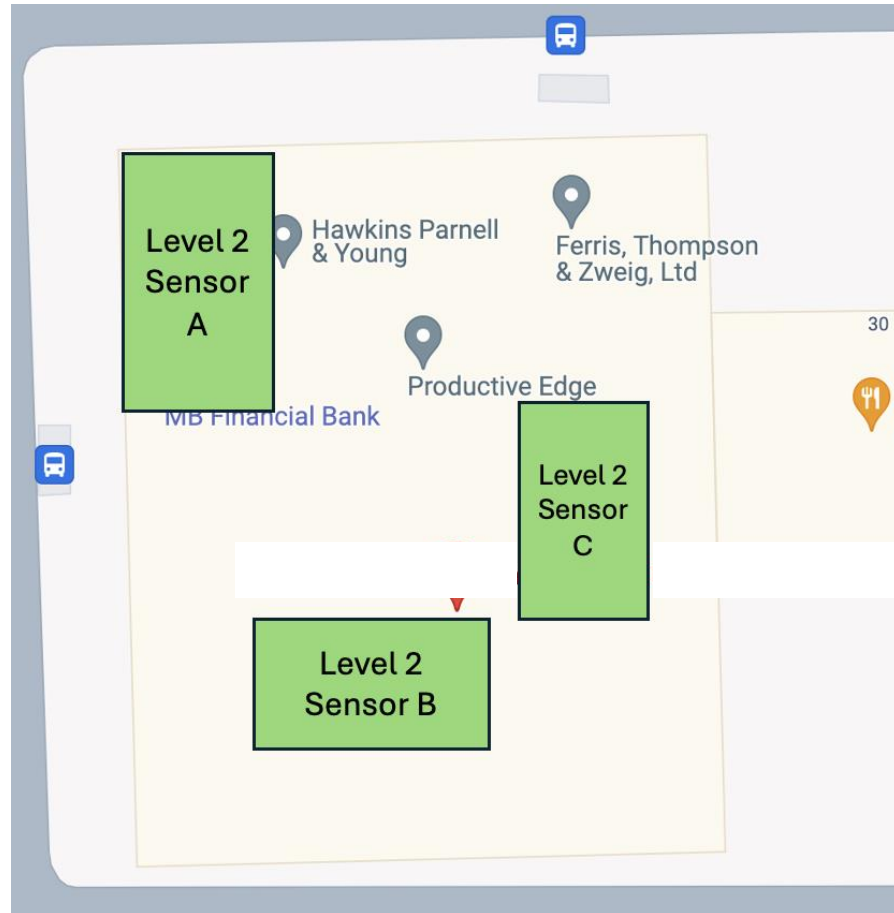


Comments:

- PM 2.5 levels ranged from ~ 0 µg/m³ to ~ 10 µg/m³ during the test, which is good.

Floor 30 Results – Sensor A: TVOCs

Layout Used for Visualization

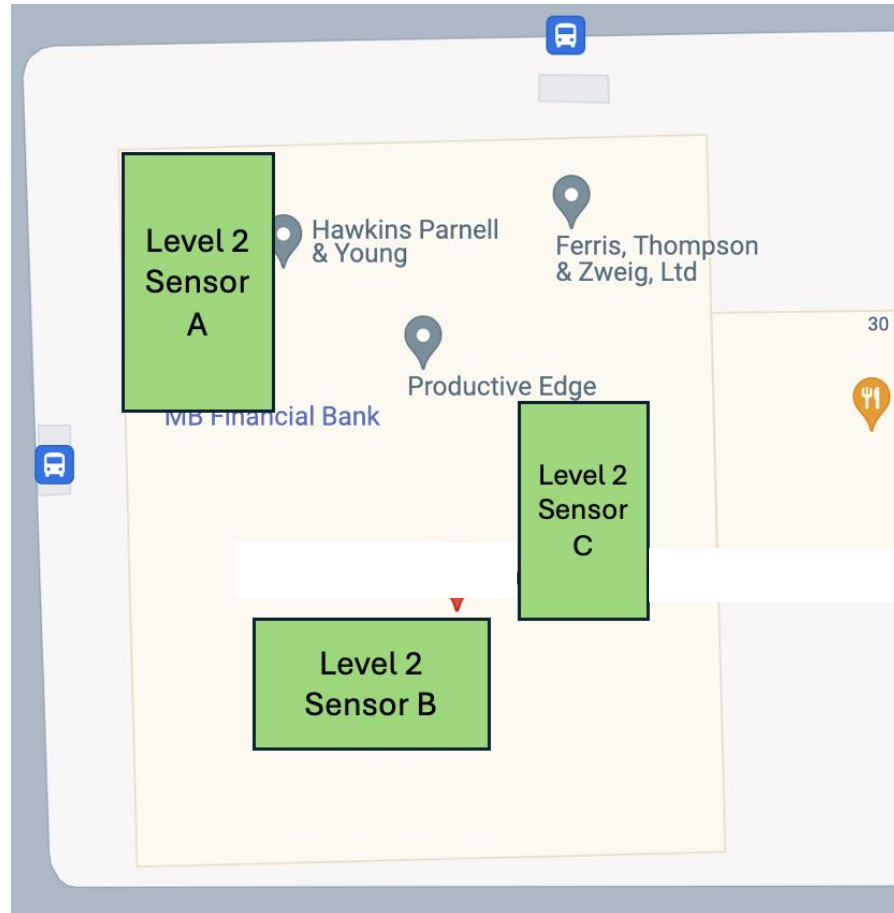


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 30 Results – Sensor B: Temperature

Layout Used for Visualization

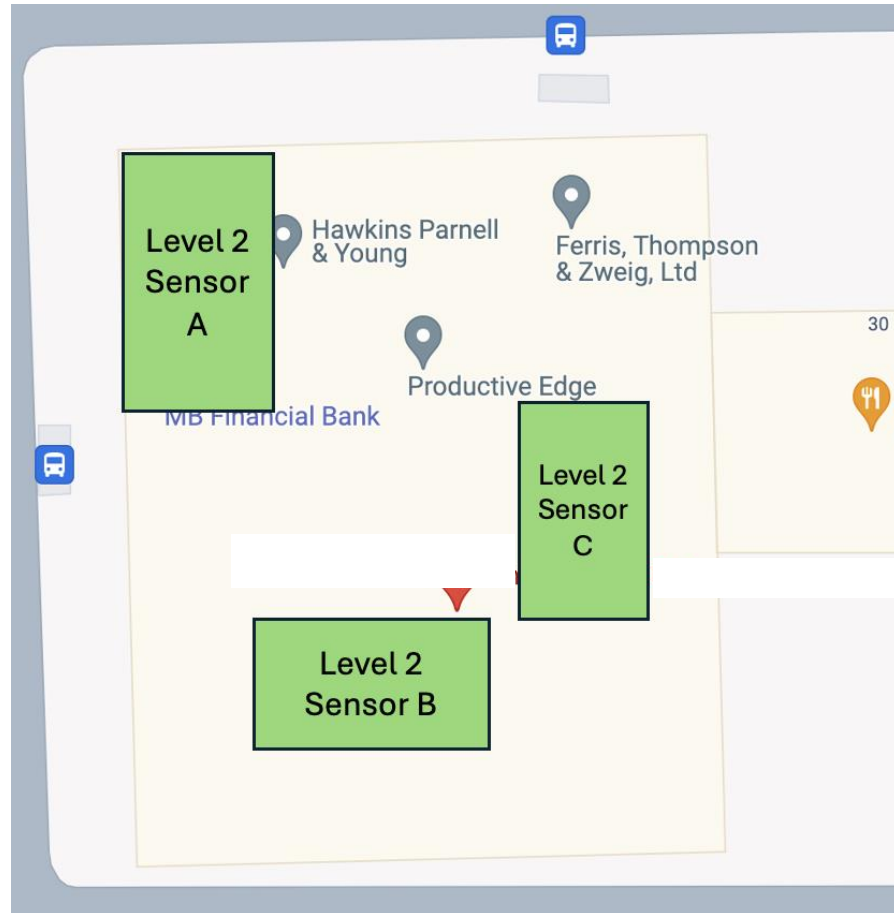


Comments:

- Temperature ranged from ~ 66°F to ~ 72°F during the test, which is good.
- The temperature stayed high on 7-28, 8-4, and 8-11 indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor B: Relative Humidity

Layout Used for Visualization

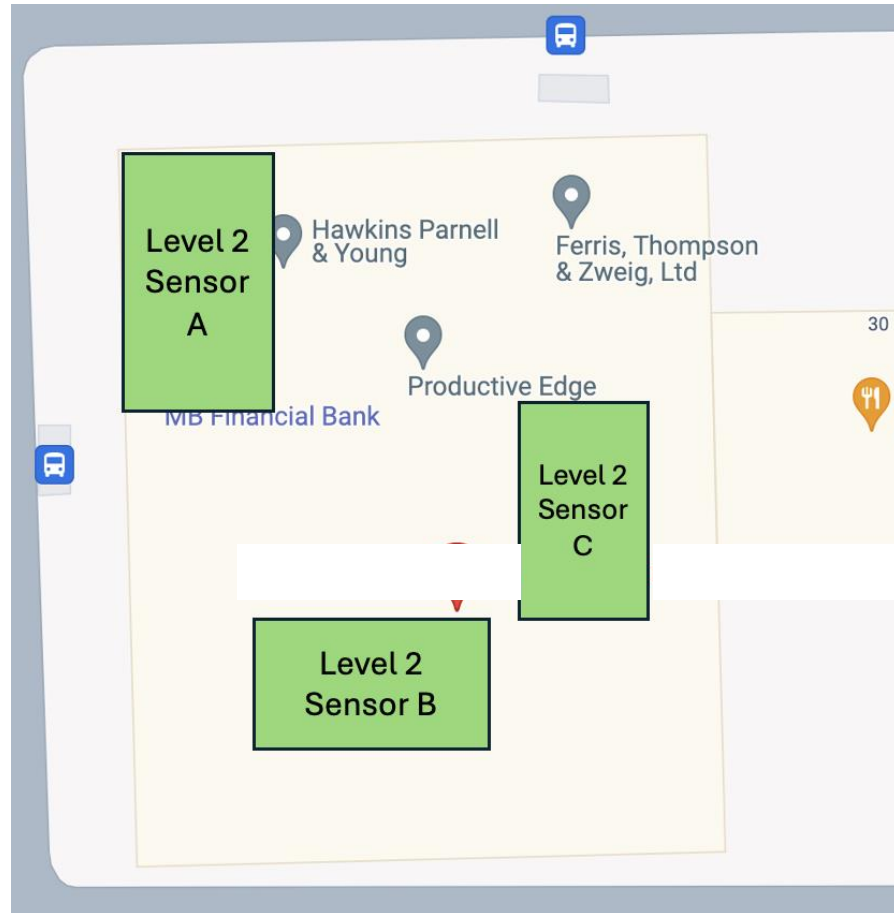


Comments:

- Relative humidity ranged from 50% to ~ 90% multiple times, which is not acceptable. RH levels above 60% are not recommended.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor B: Carbon Dioxide

Layout Used for Visualization

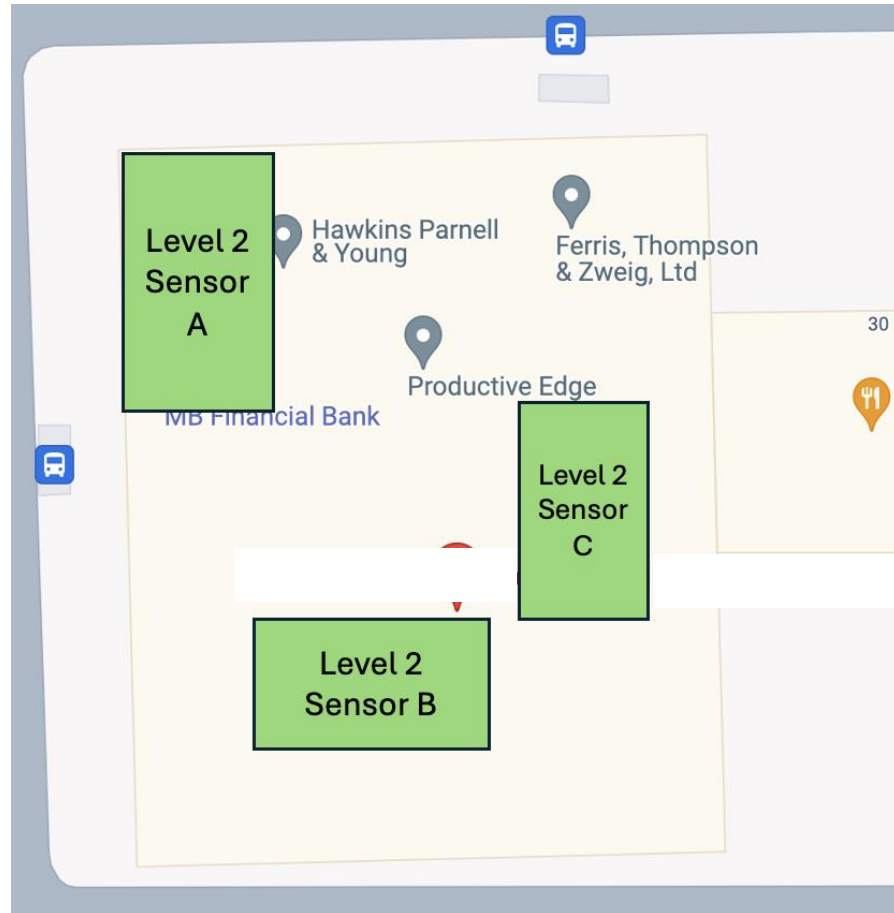


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 700 ppm, which is also excellent.
- The carbon dioxide levels were not controlled well on ~ 7-24-24, but the ventilation system recovered and worked well afterwards.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor B: PM 2.5

Layout Used for Visualization

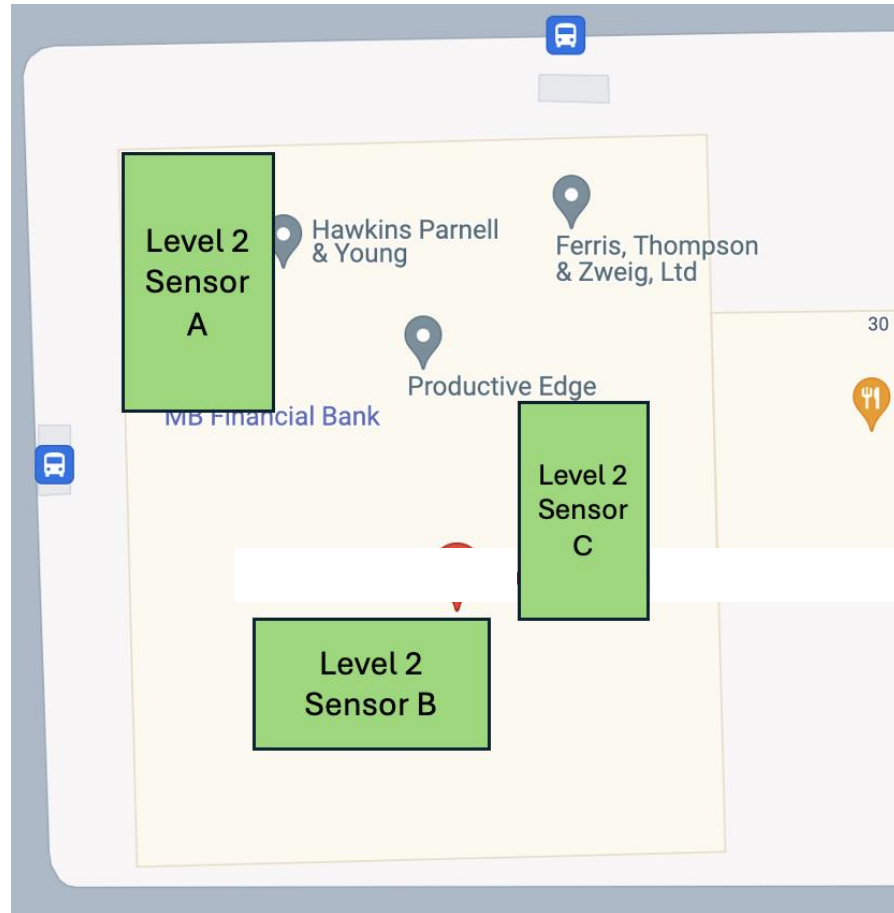


Comments:

- PM 2.5 levels ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 10 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 30 Results – Sensor B: TVOCs

Layout Used for Visualization

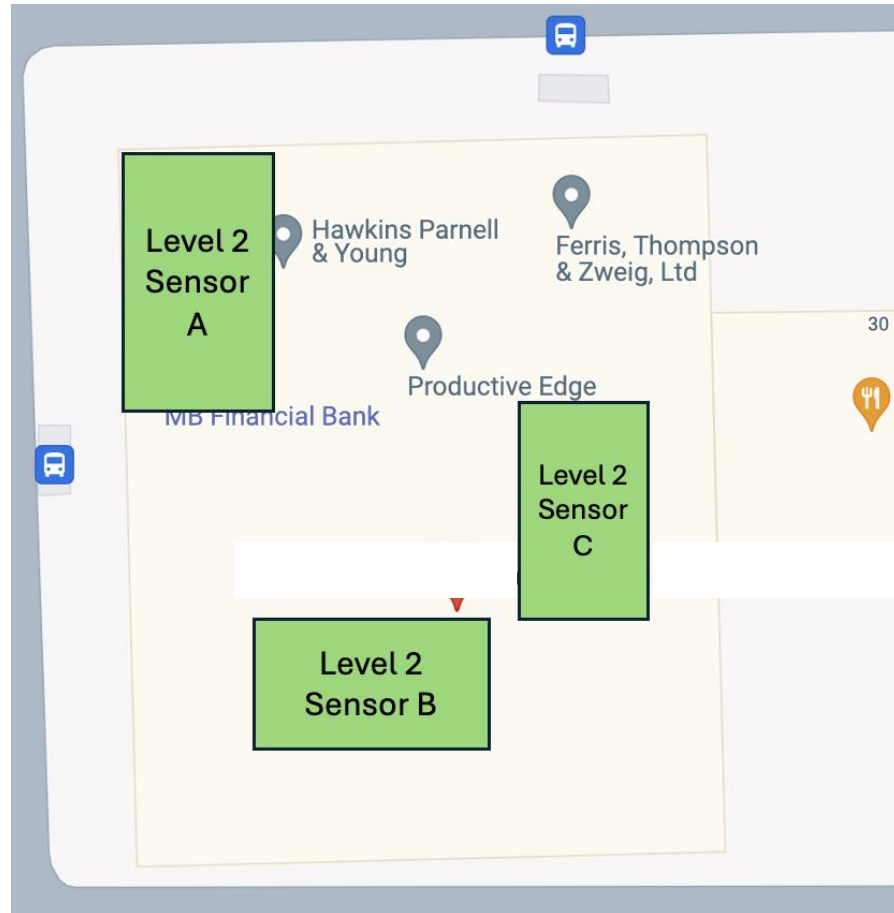


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g/m}^3$ to ~ 1 $\mu\text{g/m}^3$ during the test, which is good.

Floor 30 Results – Sensor C: Temperature

Layout Used for Visualization

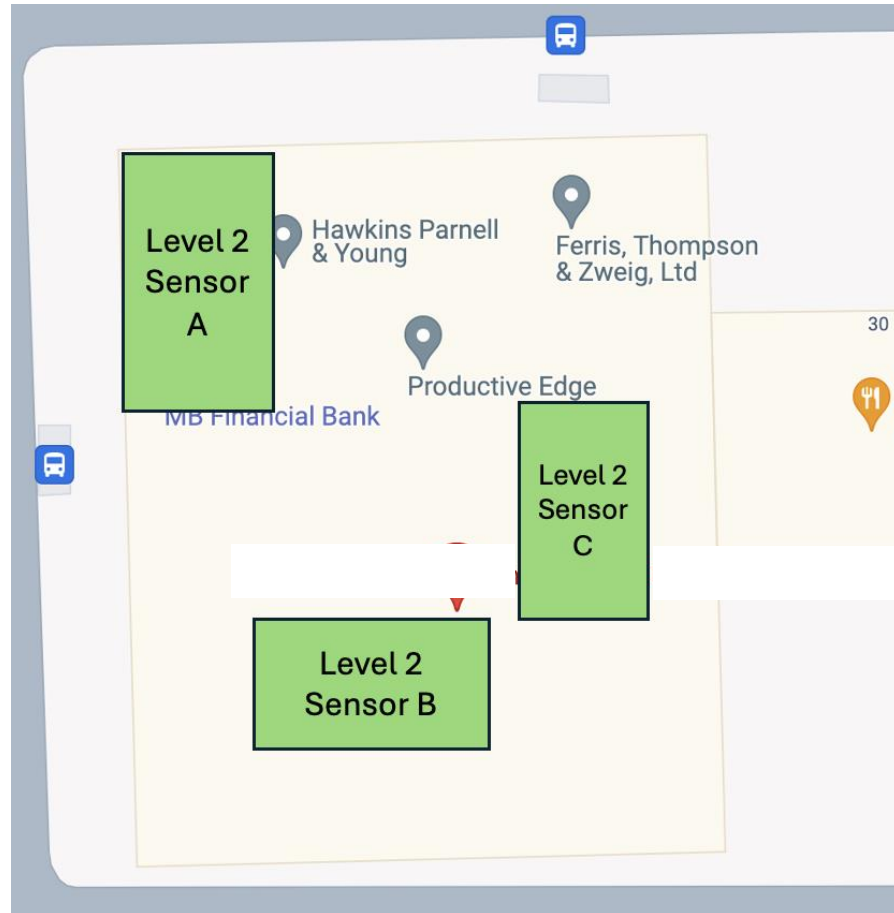


Comments:

- Temperature ranged from ~ 68°F to ~ 72°F during the test, which is good.
- The temperature stayed high on 7-28, 8-4, and 8-11 indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor C: Relative Humidity

Layout Used for Visualization

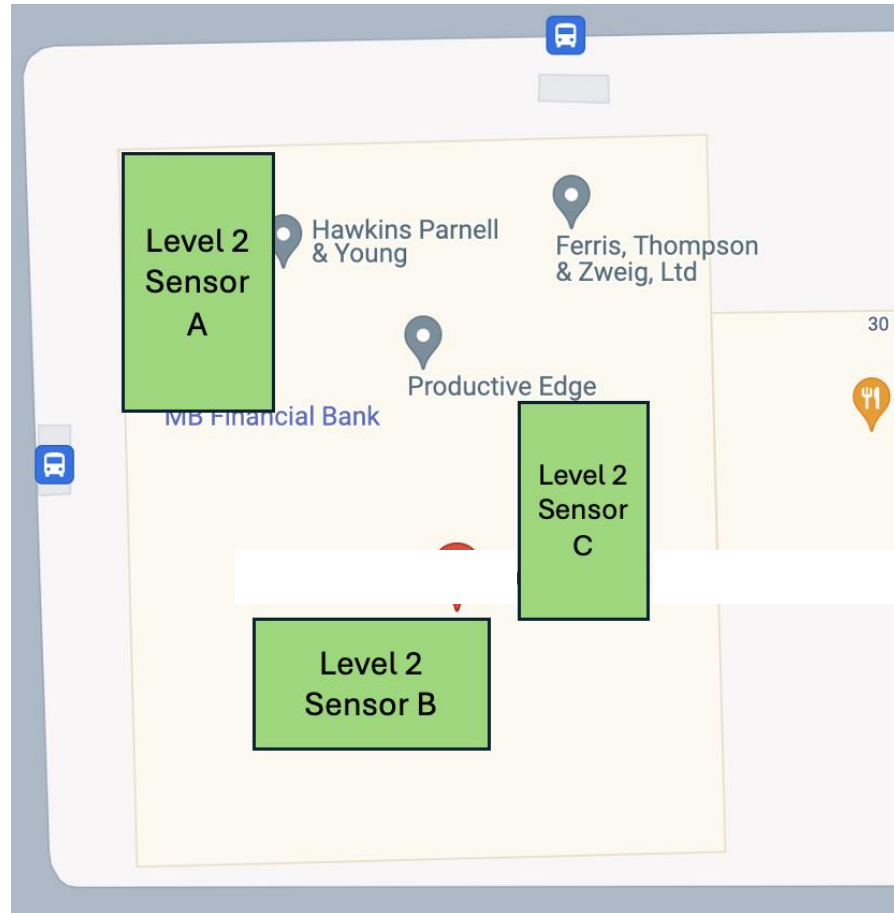


Comments:

- Relative humidity ranged from 40%, which is good, to ~75%, which is not acceptable. RH levels above 60% are not recommended.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor C: Carbon Dioxide

Layout Used for Visualization

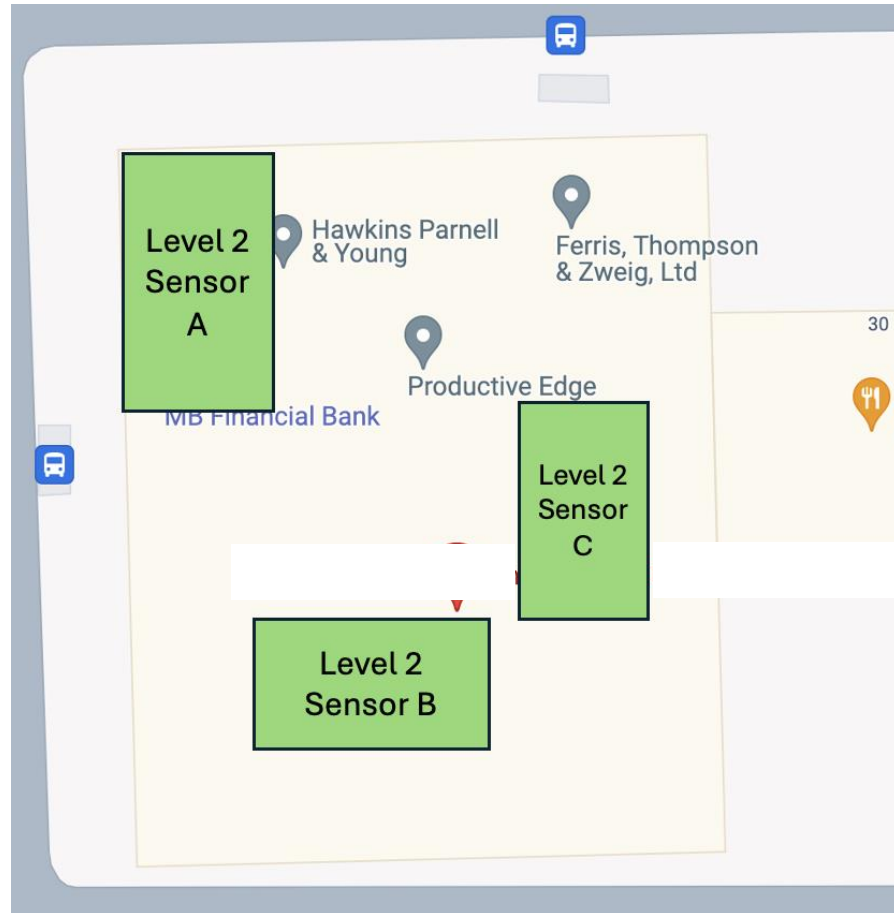


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 600 ppm, which is also excellent.
- The carbon dioxide levels were not controlled well on ~ 7-24-24, but the ventilation system recovered and worked well afterwards.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 30 Results – Sensor C: PM 2.5

Layout Used for Visualization

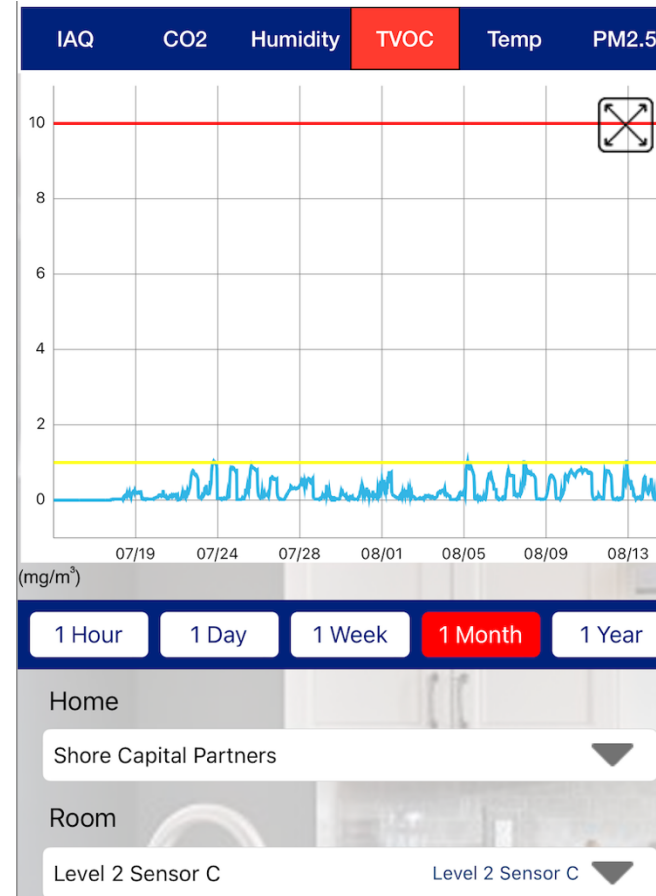
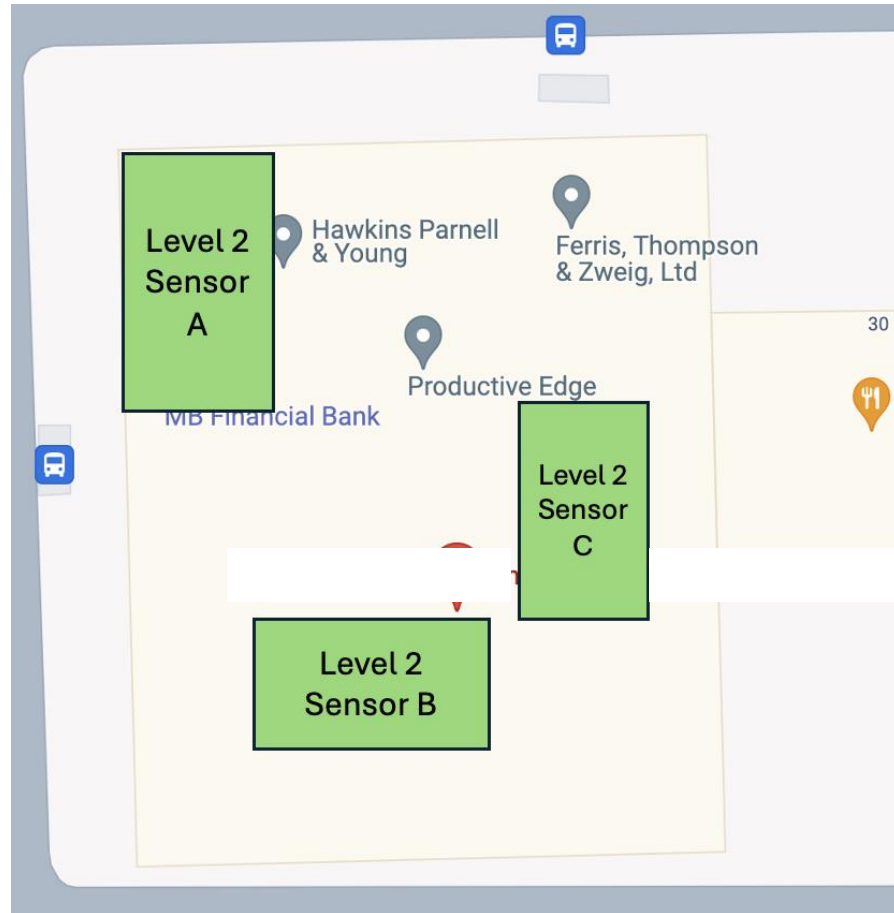


Comments:

- PM 2.5 levels ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 10 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 30 Results – Sensor C: TVOCs

Layout Used for Visualization

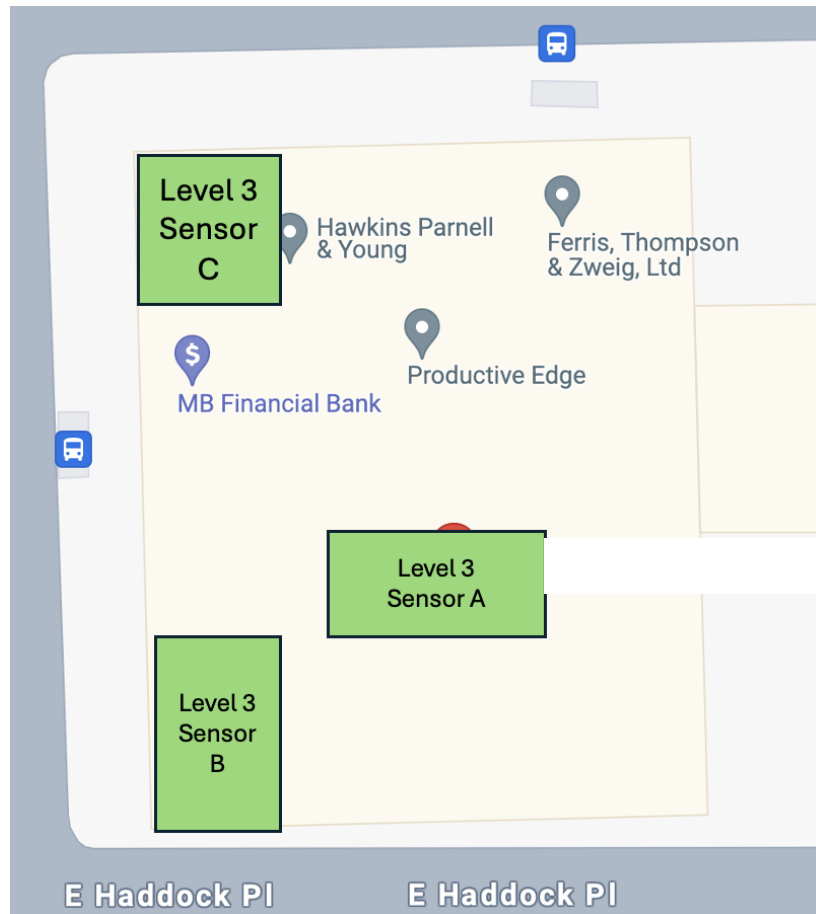


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 31 Results – Sensor A: Temperature

Layout Used for Visualization

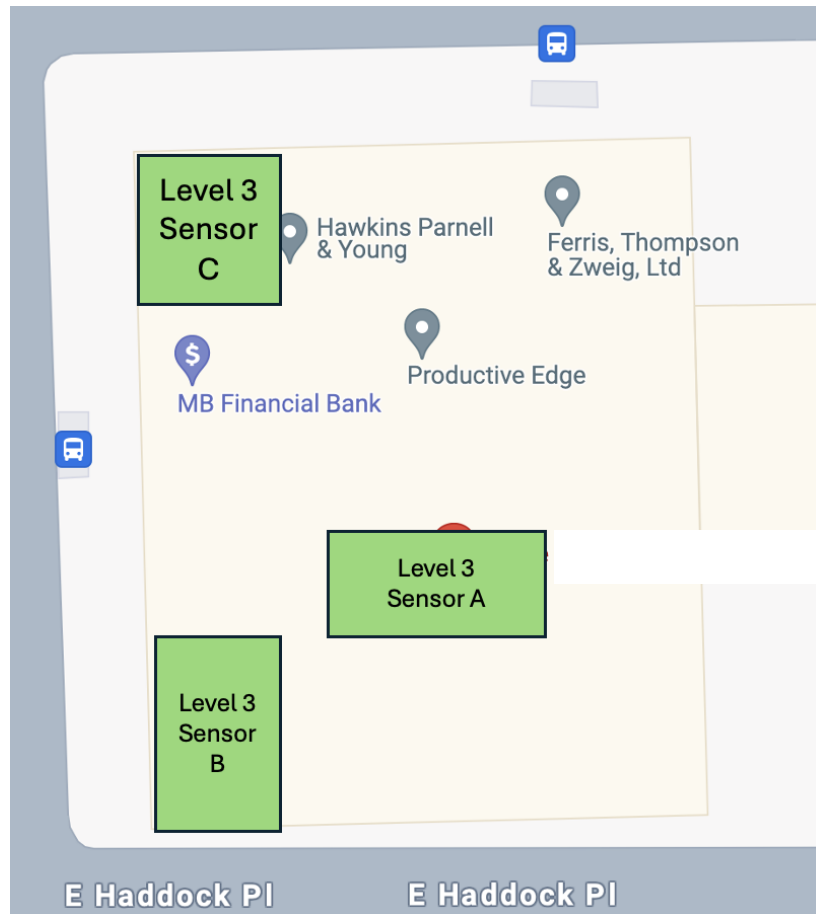


Comments:

- Temperature ranged from ~ 67°F to ~ 70°F during the test, which is cold but acceptable.
- The temperature stayed higher on 7-28, 8-4, and 8-11 indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor A: Relative Humidity

Layout Used for Visualization

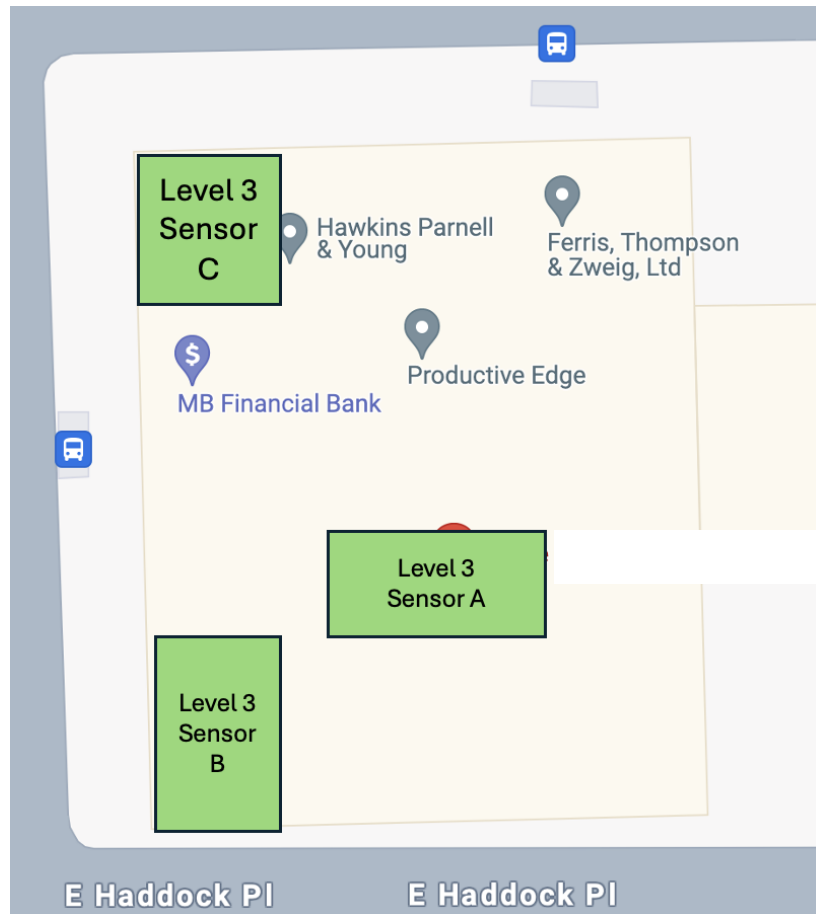


Comments:

- Relative humidity ranged from 50% to ~ 80% multiple times, which is not acceptable. RH levels above 60% are not recommended.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor A: Carbon Dioxide

Layout Used for Visualization

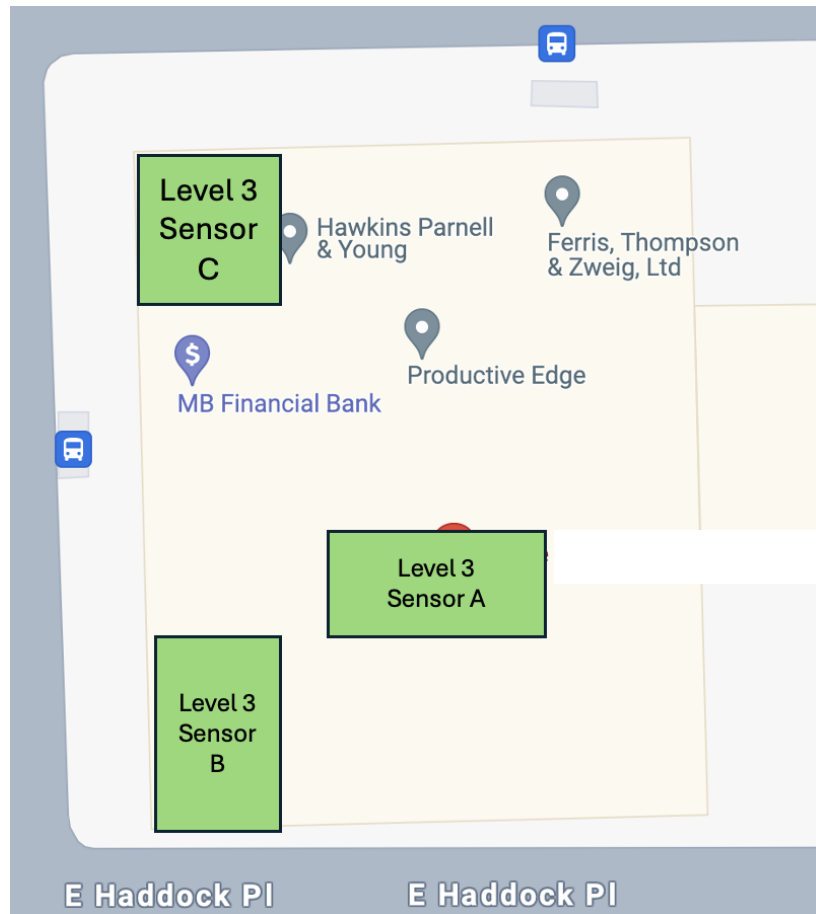


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 700 ppm, which is also excellent.
- Note how you can see the daily workday peaks due to occupancy and the flattening out to 400 ppm on the weekends when there is little to no occupancy.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor A: PM 2.5

Layout Used for Visualization

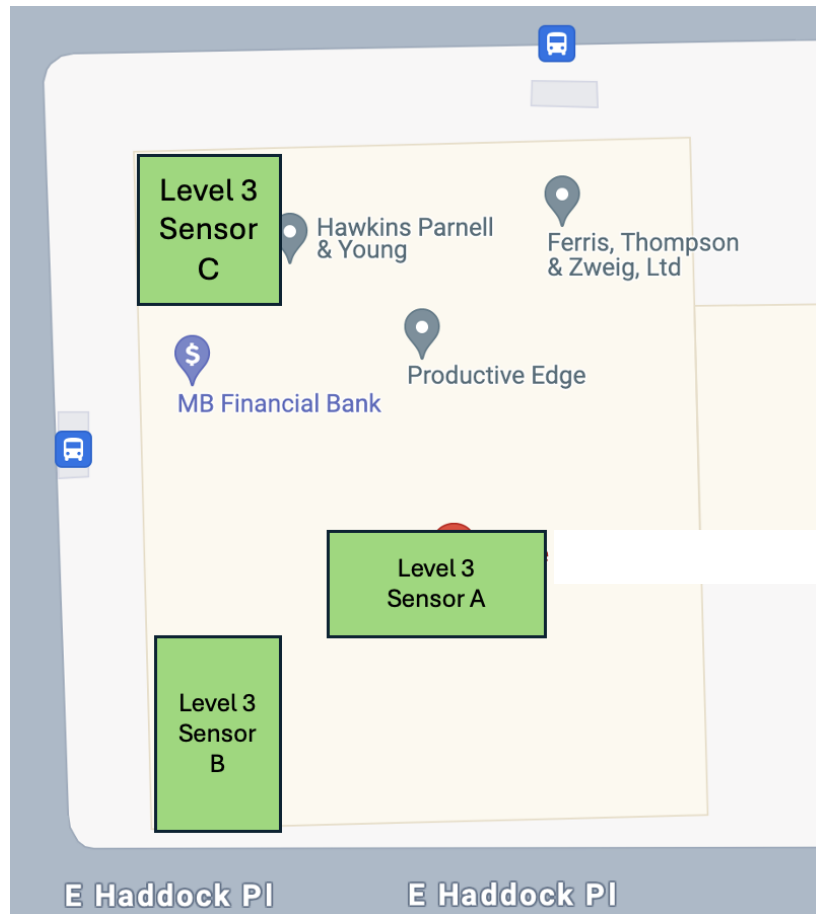


Comments:

- PM 2.5 levels ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 10 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 31 Results – Sensor A: TVOCs

Layout Used for Visualization

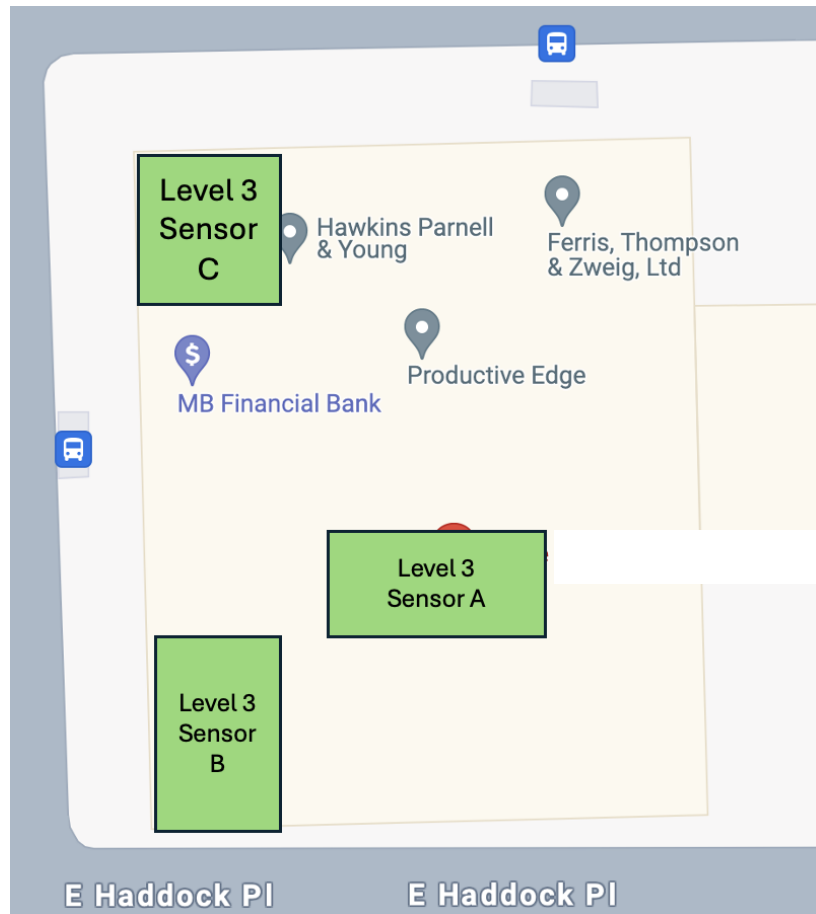


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 31 Results – Sensor B: Temperature

Layout Used for Visualization

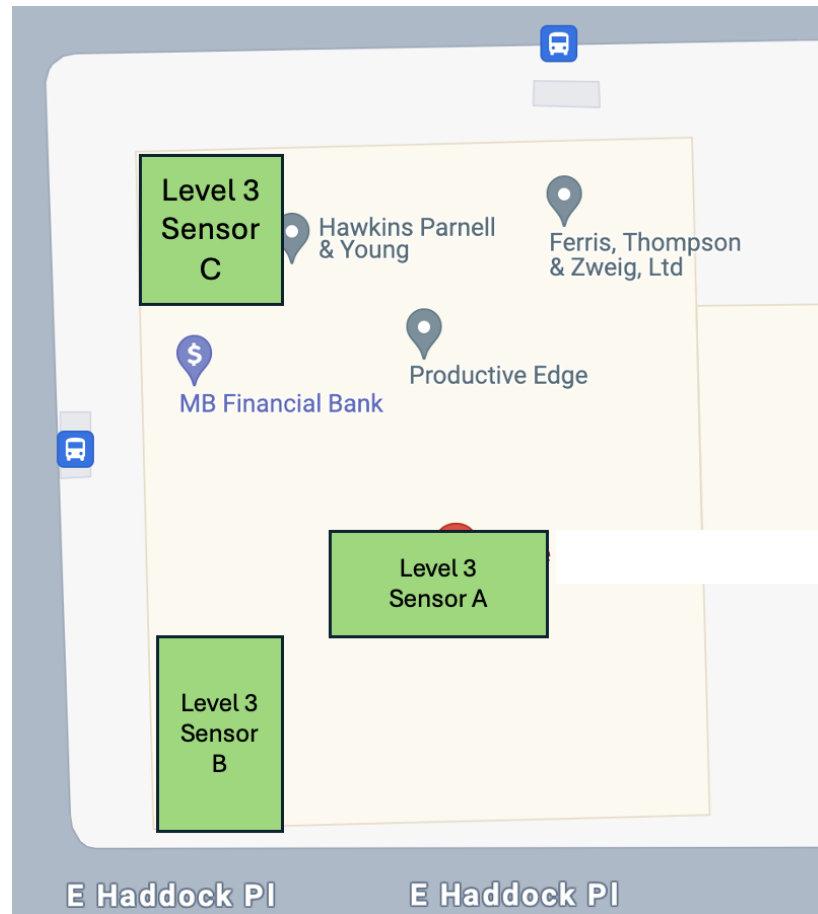


Comments:

- Temperature ranged from ~ 63°F to ~ 66°F during the test, which is colder than the other sensors.
- These cold readings may be caused by the sensor being blown on by a HVAC system supply vent or by the thermostat setpoint being too low.
- The temperature stayed high on 7-28 and 8-4 indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor B: Relative Humidity

Layout Used for Visualization

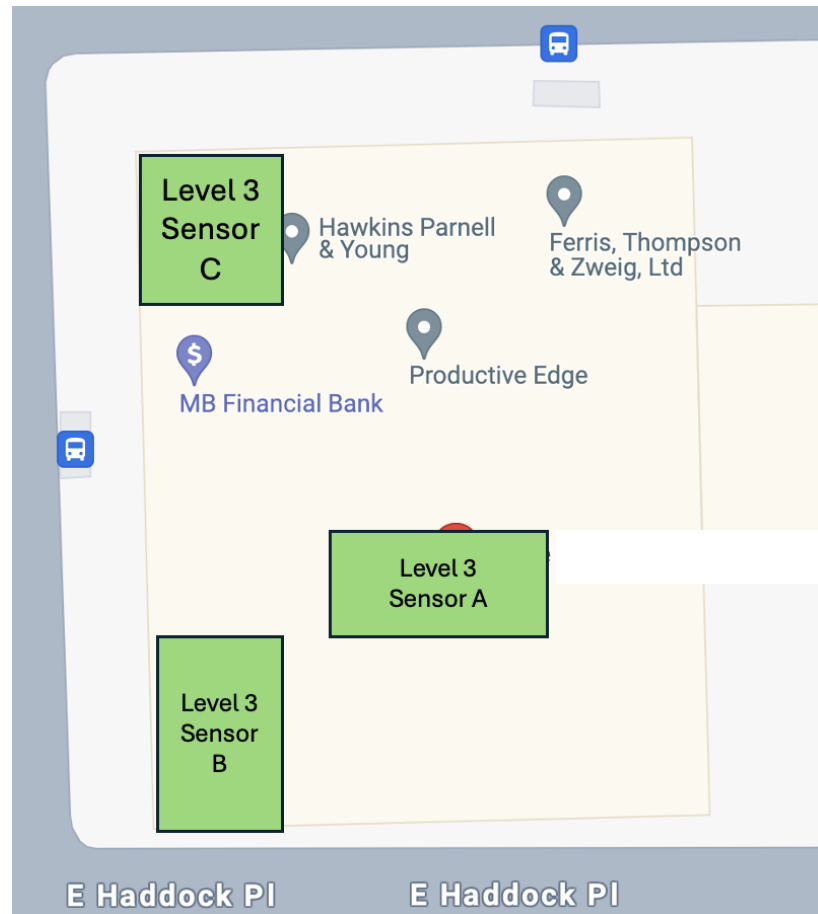


Comments:

- Relative humidity ranged from 50% to ~ 90%, which is not acceptable. RH levels above 60% are not recommended.
- These high RH readings coupled with the lower-than-average temperature readings from this sensor could be due to the sensor being in the airstream from an HVAC vent or a low thermostat setpoint.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor B: Carbon Dioxide

Layout Used for Visualization

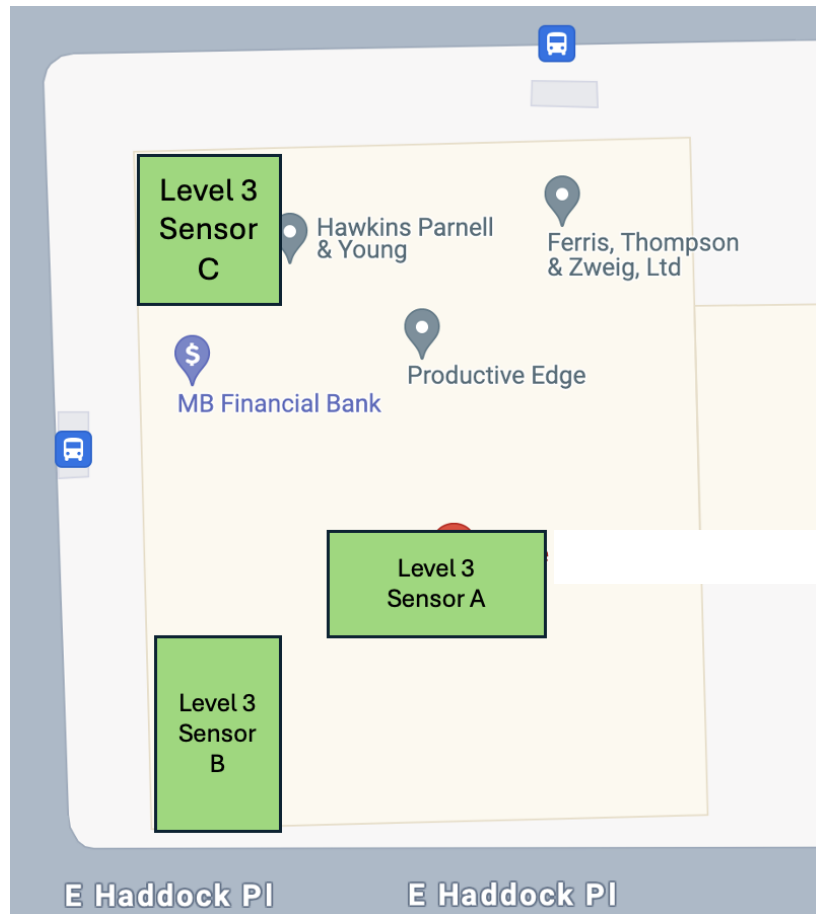


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 700 ppm, which is also excellent.
- Note how you can see the daily workday peaks due to occupancy and the flattening out to 400 ppm on the weekends when there is little to no occupancy.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor B: PM 2.5

Layout Used for Visualization

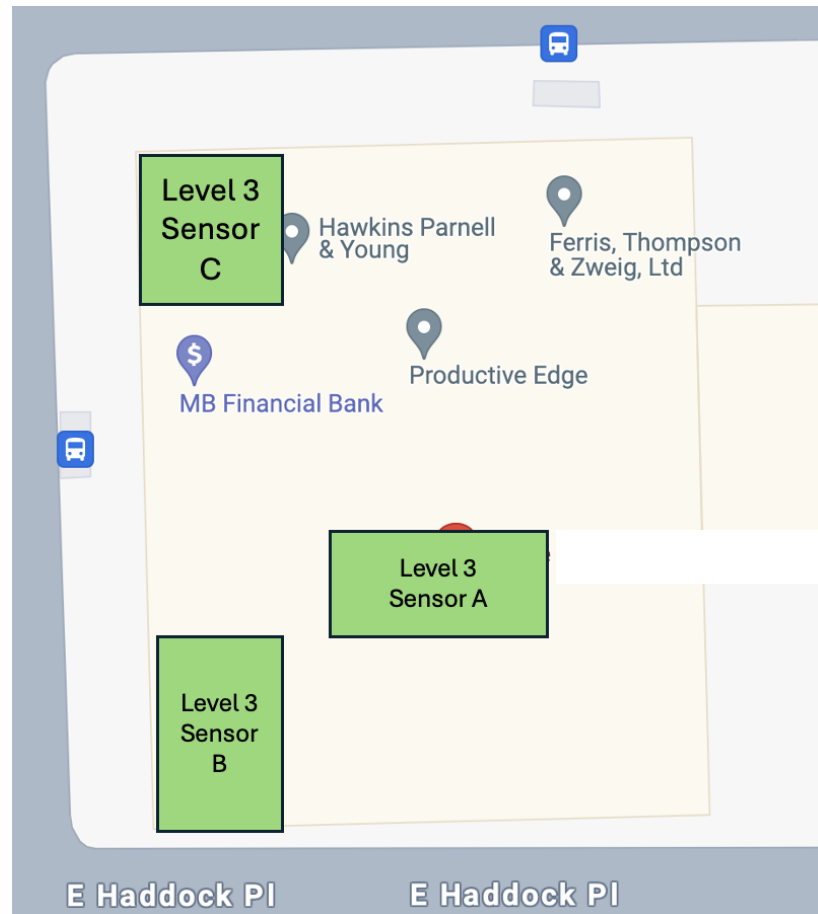


Comments:

- PM 2.5 levels ranged from ~ 0 µg/m³ to ~ 10 µg/m³ during the test, which is good.

Floor 31 Results – Sensor B: TVOCs

Layout Used for Visualization

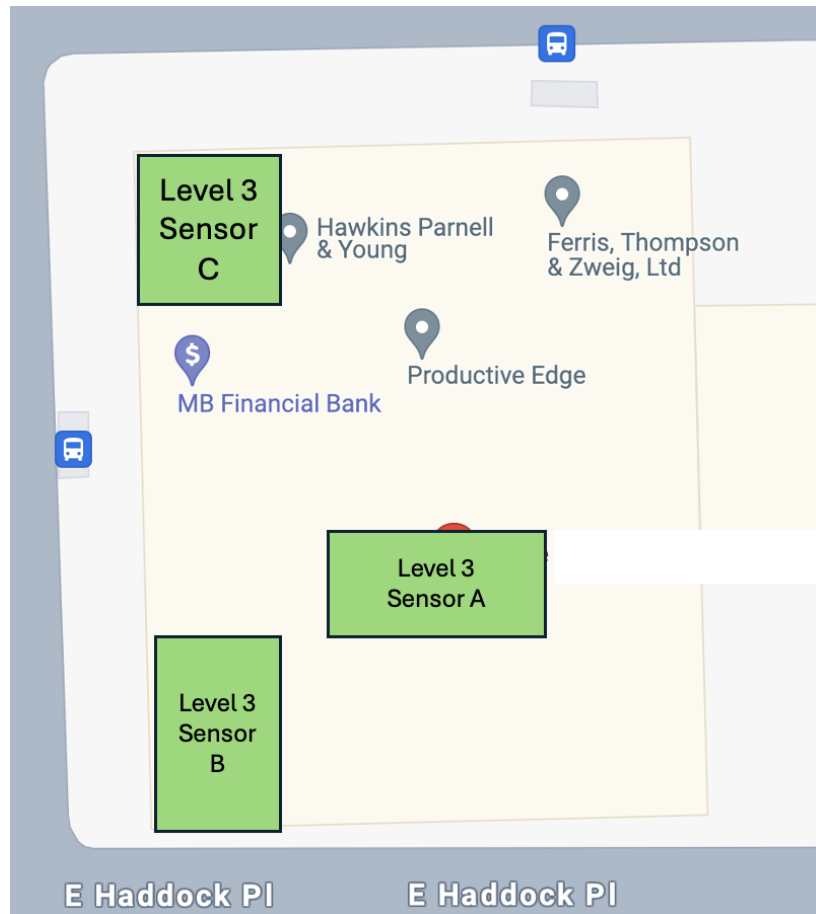


Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Floor 31 Results – Sensor C: Temperature

Layout Used for Visualization

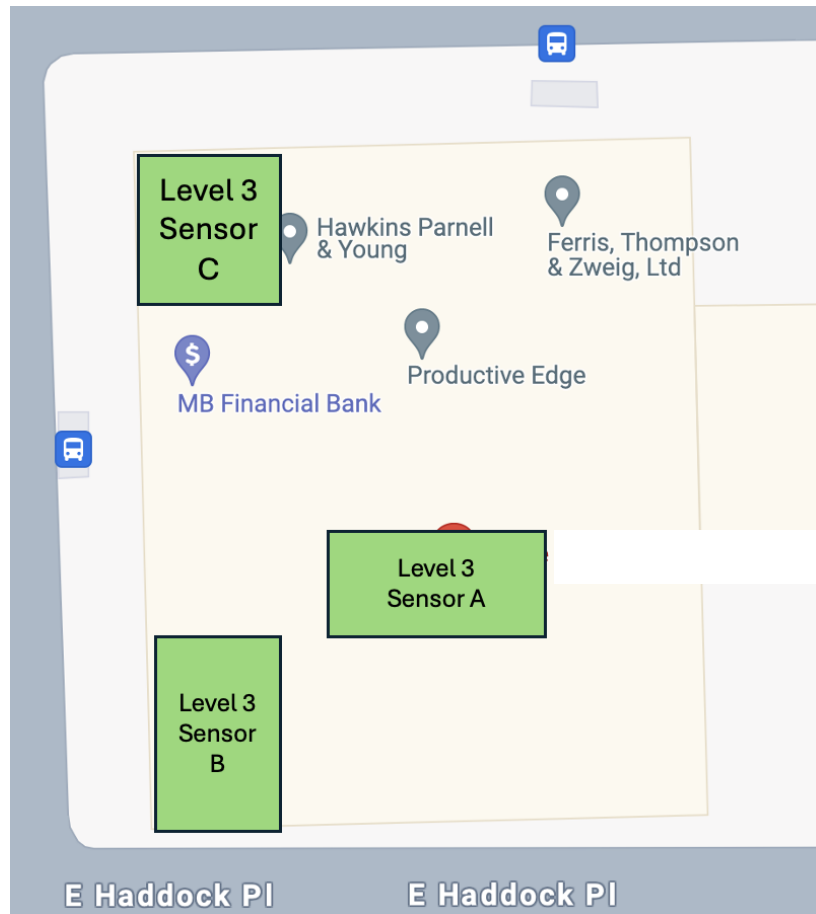


Comments:

- Temperature ranged from ~ 60°F to ~ 66°F during the test. This space is being over cooled.
- These cold readings may be caused by the sensor being blown on by a HVAC system supply vent or by the thermostat placement or malfunction.
- The temperature stayed higher on 7-28 and 8-4 indicating a higher thermostat setpoint for the weekend.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor C: Relative Humidity

Layout Used for Visualization

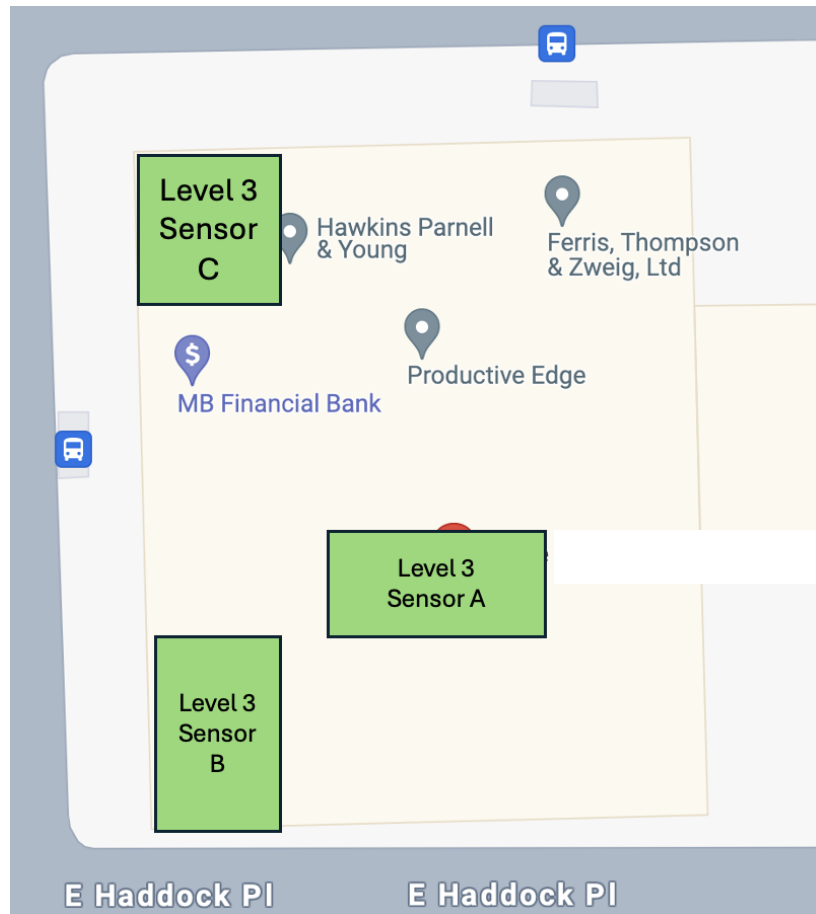


Comments:

- Relative humidity ranged from 50% to ~ 80%, which is not acceptable. RH levels above 60% are not recommended.
- These high RH readings coupled with the lower-than-average temperature readings from this sensor could be due to the sensor being in the airstream from an HVAC vent.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor C: Carbon Dioxide

Layout Used for Visualization

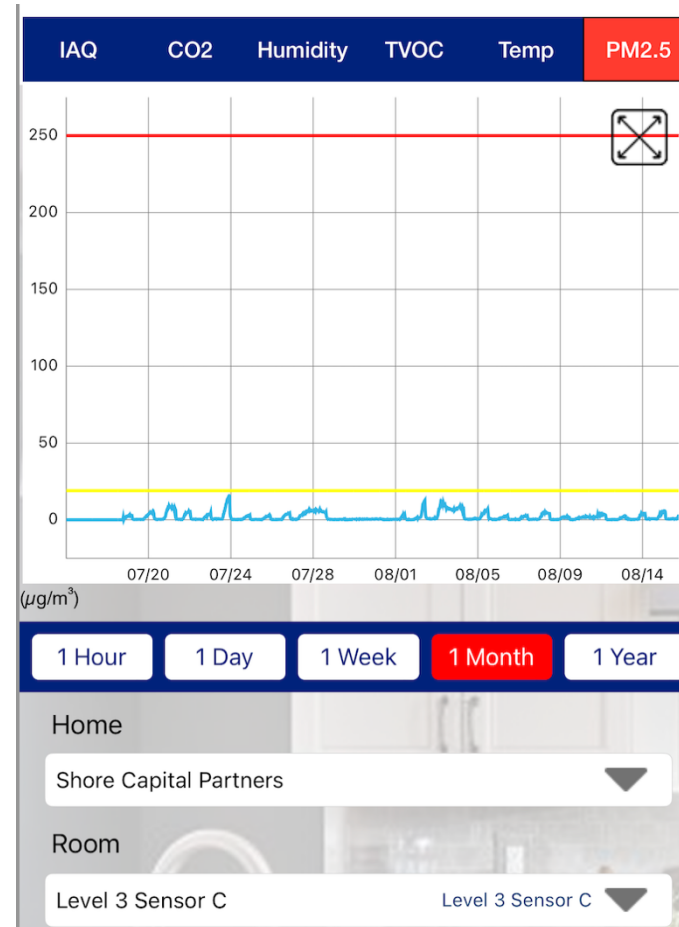
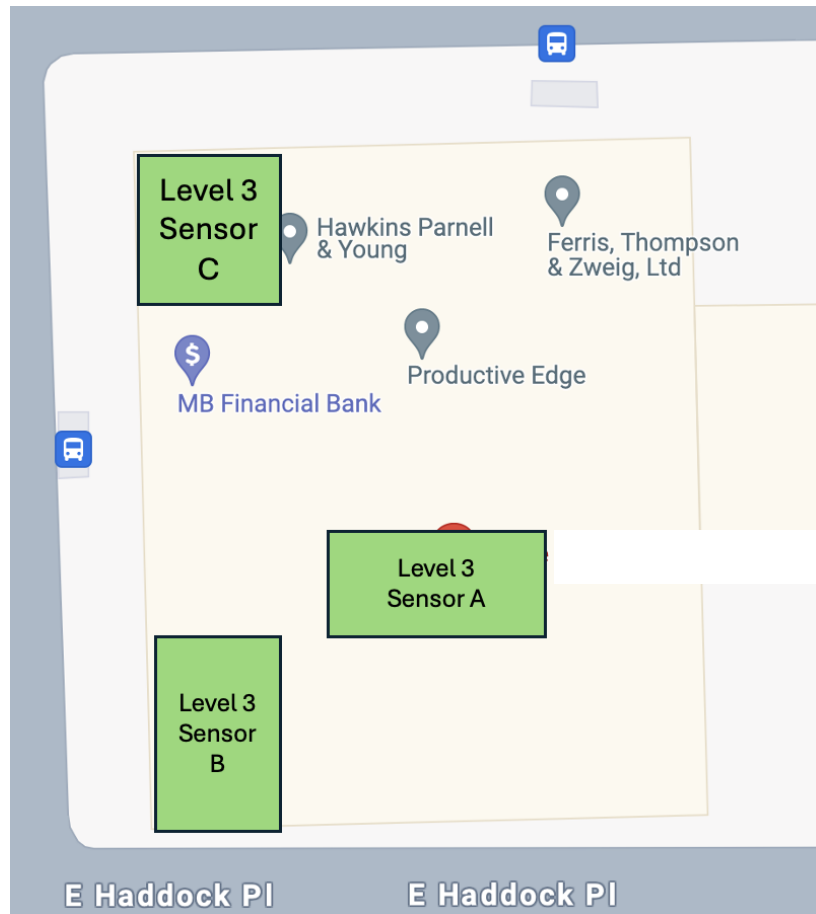


Comments:

- Carbon dioxide levels ranged from ~ 400 ppm, which is excellent and essentially the outdoors concentration, to ~ 700 ppm, which is also excellent.
- Note how you can see the daily workday peaks due to occupancy and the flattening out to 400 ppm on the weekends when there is little to no occupancy.
- Loss of Wi-Fi signal on ~ 7-30-24.

Floor 31 Results – Sensor C: PM 2.5

Layout Used for Visualization

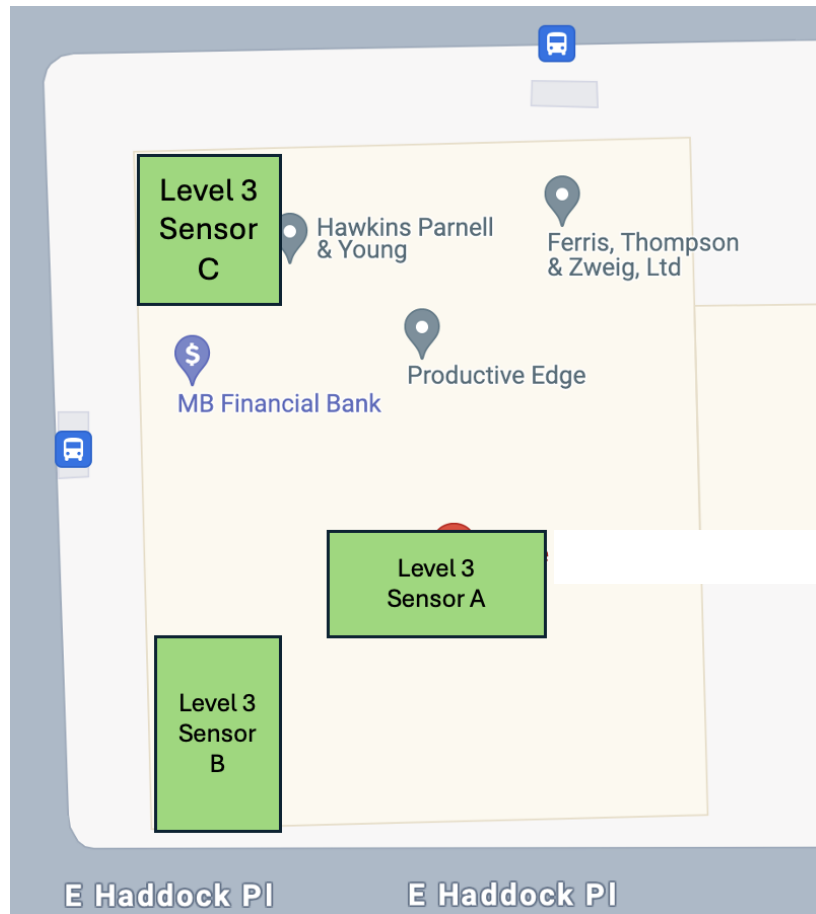


Comments:

- PM 2.5 levels ranged from ~ 0 µg/m³ to ~ 10 µg/m³ during the test, which is good.

Floor 31 Results – Sensor C: TVOCs

Layout Used for Visualization



Comments:

- Total volatile organic compounds ranged from ~ 0 $\mu\text{g}/\text{m}^3$ to ~ 1 $\mu\text{g}/\text{m}^3$ during the test, which is good.

Final Comments

- Overall IAQ (Carbon Dioxide Levels, PM 2.5 Level, and TVOC Levels) were all very good.
- Overall Comfort Levels ranged from acceptable to poor. In general, the Relative Humidity Levels were often higher than 60%, which was likely due to inadequate dehumidification strategies.
- I recommend using enhanced dehumidification strategies (reheat, slowing down the process air flow, colder coils, energy recovery, or dedicated DOAS/dehumidification systems) when the outside air dew point is above 60°F to limit over-wetting the conditioned space from the ventilation air.
- It appears that the southwest conference room (Sensor B) on Floor 29 was the epicenter of the high CO₂ event on 7-24-24 because it recorded the highest CO₂ levels.
- The sensor in the southeast room (Sensor C) on Floor 29 should be plugged back in to ensure continuous IAQ monitoring.
- I am available at tdemonte@madisonair.com or 608-209-3805 if there are further questions or comments.