Woods Hole Research Center

'A' Team

‘A’ Team:

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Indoor air quality is lower at the upper level than at the basement level during occupied hours when the building is naturally ventilated.

- Indoor Air Quality - as determined using CO_2 levels as a surrogate indicator of contaminants, with acceptable limit of 1000 ppm max
- Natural Ventilation - ventilation by means of openings in the building envelope

Upper Level

- Used indoor air exfiltrates

Basement

- Fresh outdoor air infiltrates

Equipment List

- Onset Hobo data loggers (temp, CO_2)
- Engelhard CO_2 meter
- Testo velocity stick (anemometer)
- ‘Tiny’ bubbles
- Scott’s single-ply toilet paper

Methodology

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HOBO Placement:

- HOBOs launched to collect temperature and relative humidity readings every 5 minutes
- HOBOs placed on a string at 6 foot increments from basement to 2nd floor in the open stairwell.

CO_2 Meters:

- Connected to HOBOs collecting CO_2 readings every 5 minutes
- CO_2 meters placed in 3 positions: basement conf. rm, 2nd floor office, and common area in first floor.

Methodology & Equipment List

Methodology

Velocity Stick:

- Took air velocity measurements at open windows.

Toilet Paper:

- Held in front of open windows and at cracked-open doorways.

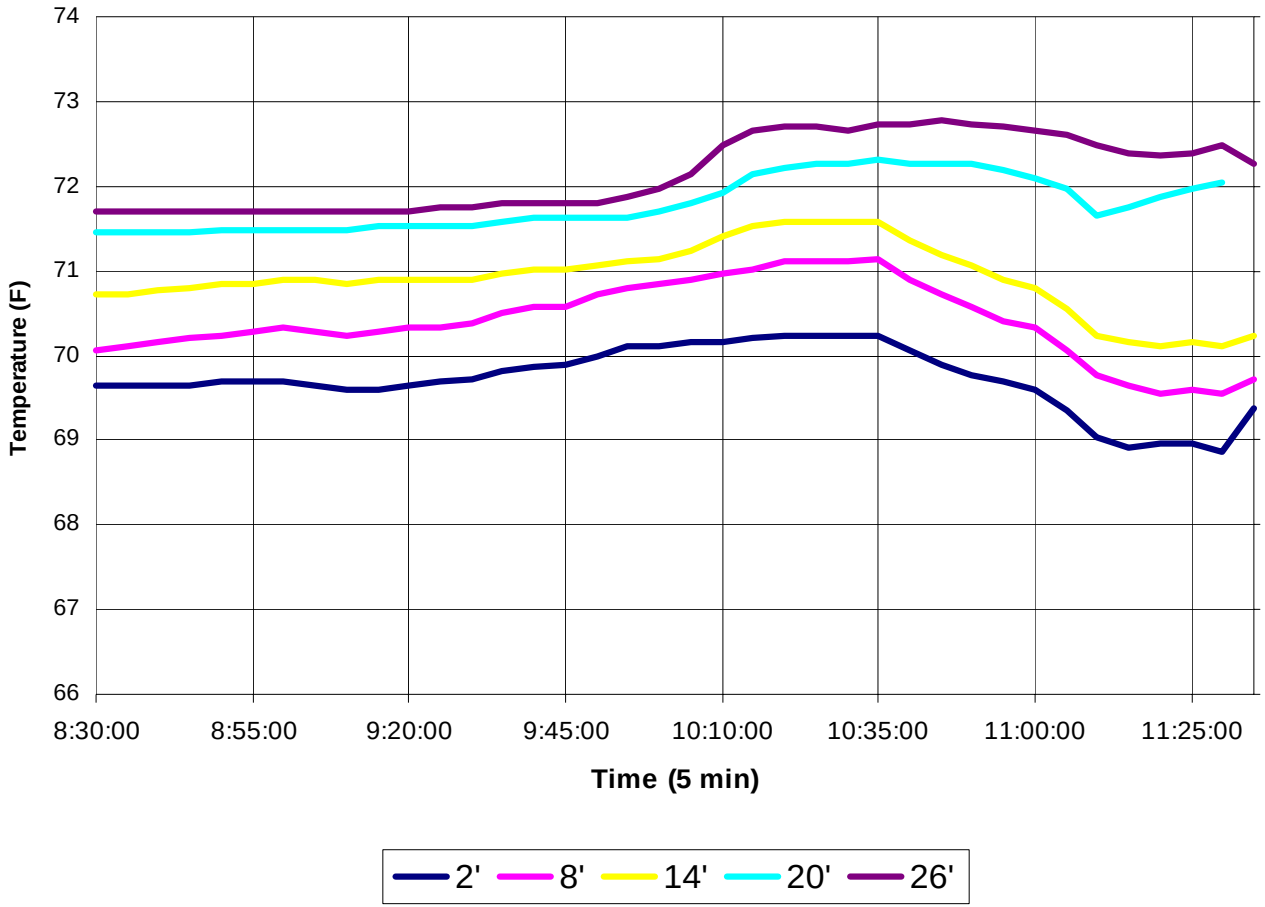
Building Operations

- ERU's for Basement Conf Rm & Floors 1/2/3 are not operating.
- Bathroom exhaust fans are operating.
- Doors at stairwell are typically propped open.
- At the beginning of the work day during the case study, windows were not opened by the building occupants. In order to test the hypothesis, Team A opened various windows.

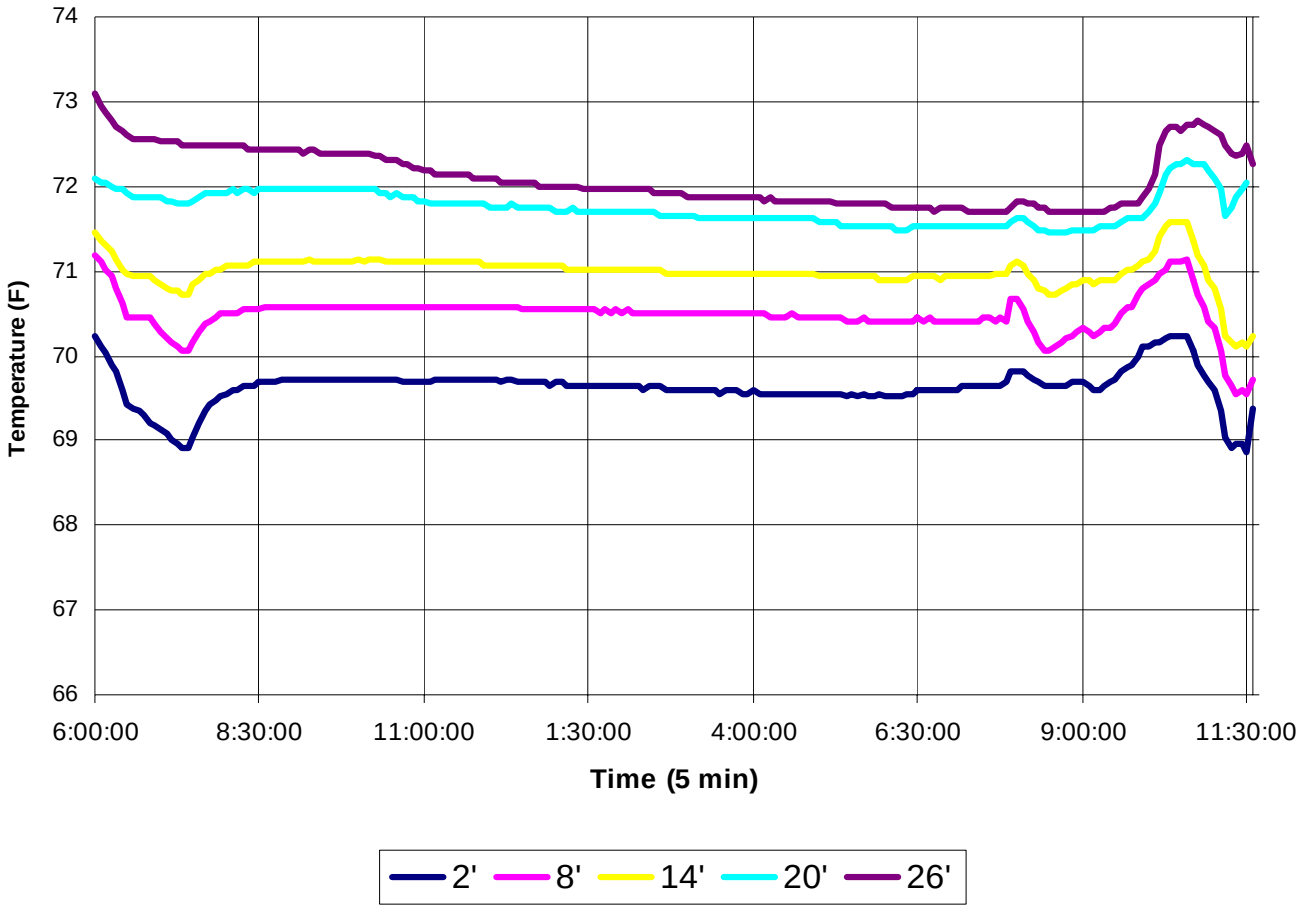
Measured Data

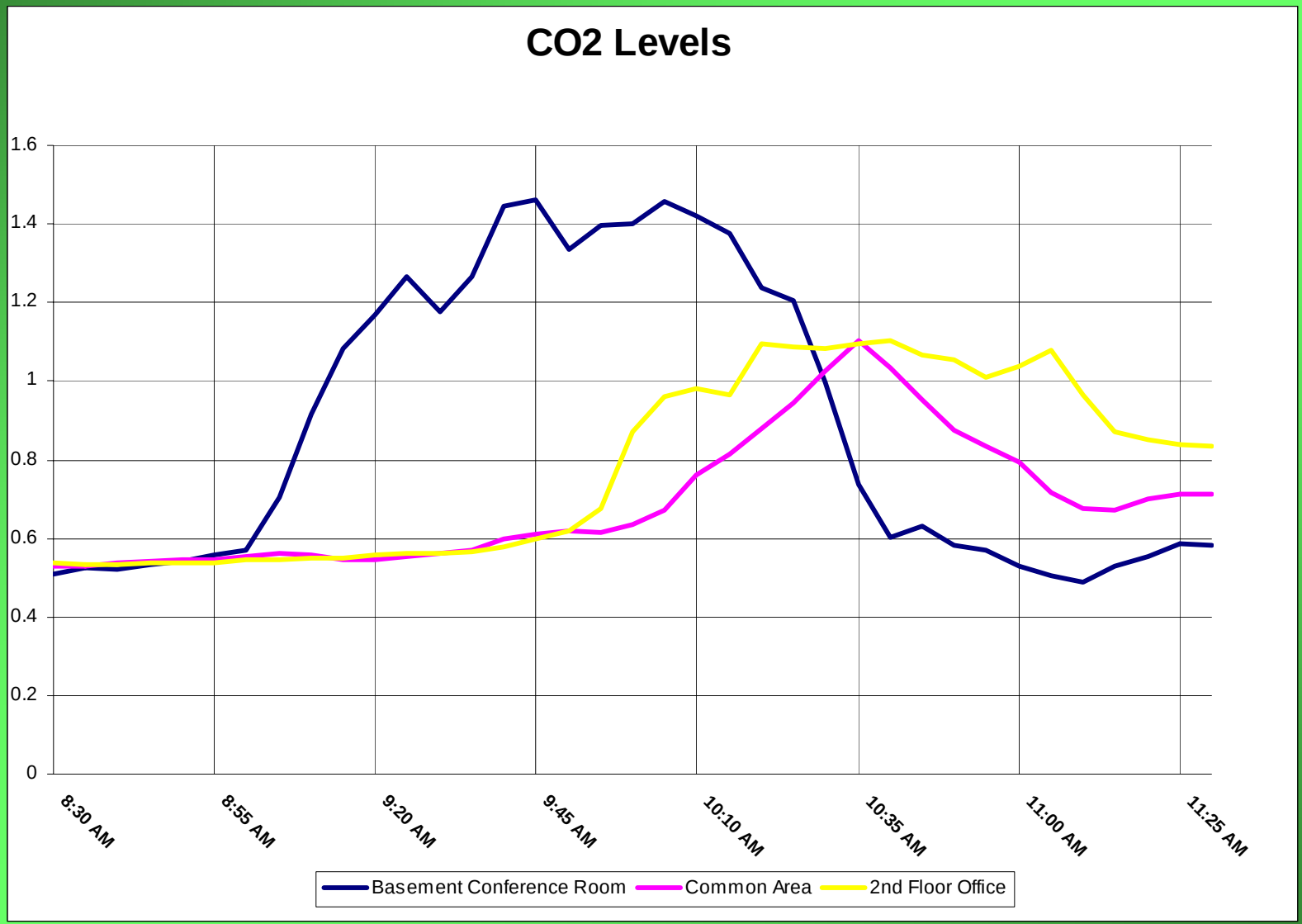
- Temperature gradients in the stairwell
- CO_2 levels
- Velocity readings
- 'Tiny' bubbles
- Direction of airflow

Temp Gradient Profile in Stairwell



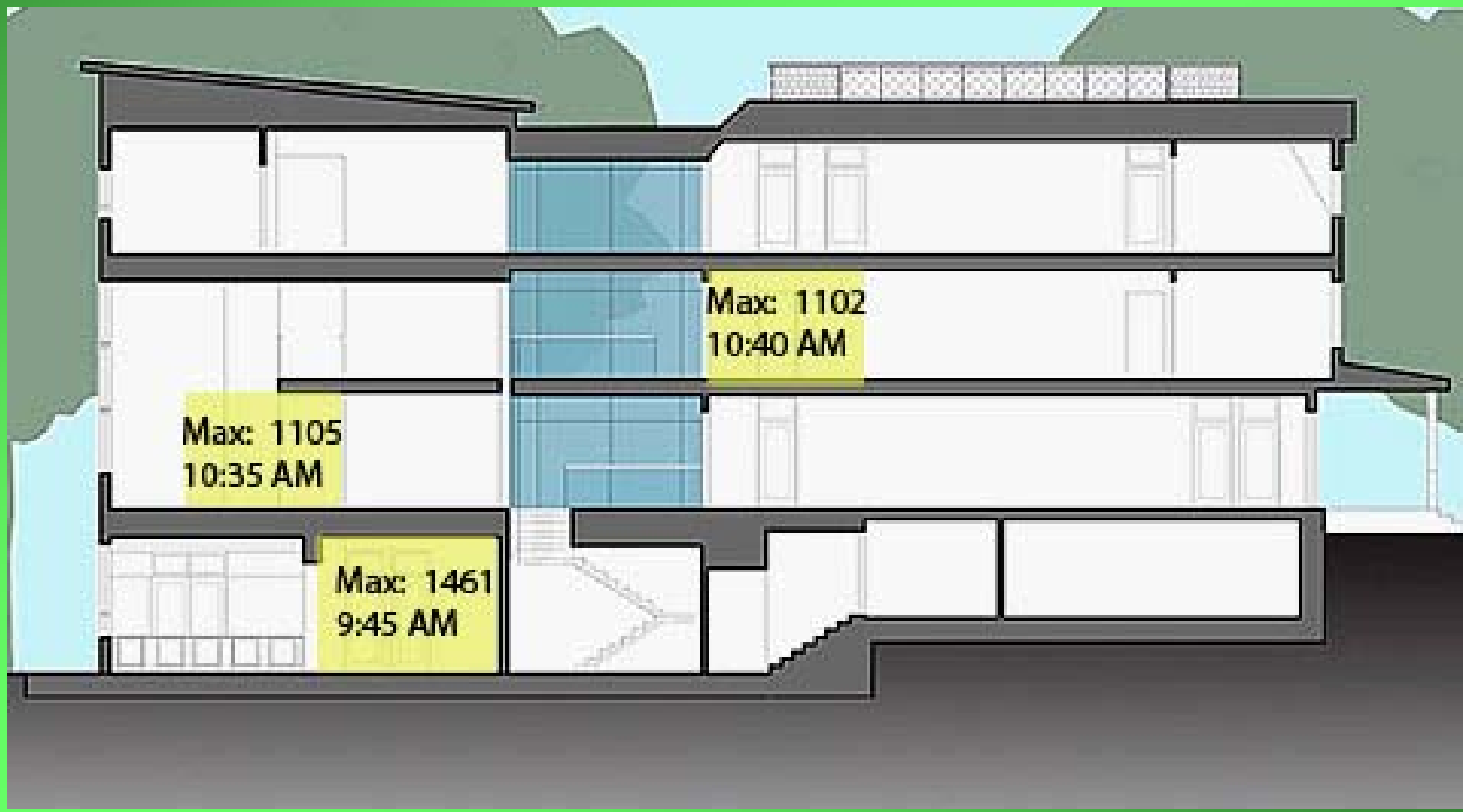
Overnight Temp Gradient Profile in Stairwell




CO2 Levels
ppm x 1000
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
8:30 AM
8:55 AM
9:20 AM
9:45 AM
10:10 AM
10:35 AM
11:00 AM
11:25 AM
Basement Conference Room
Common Area
2nd Floor Office

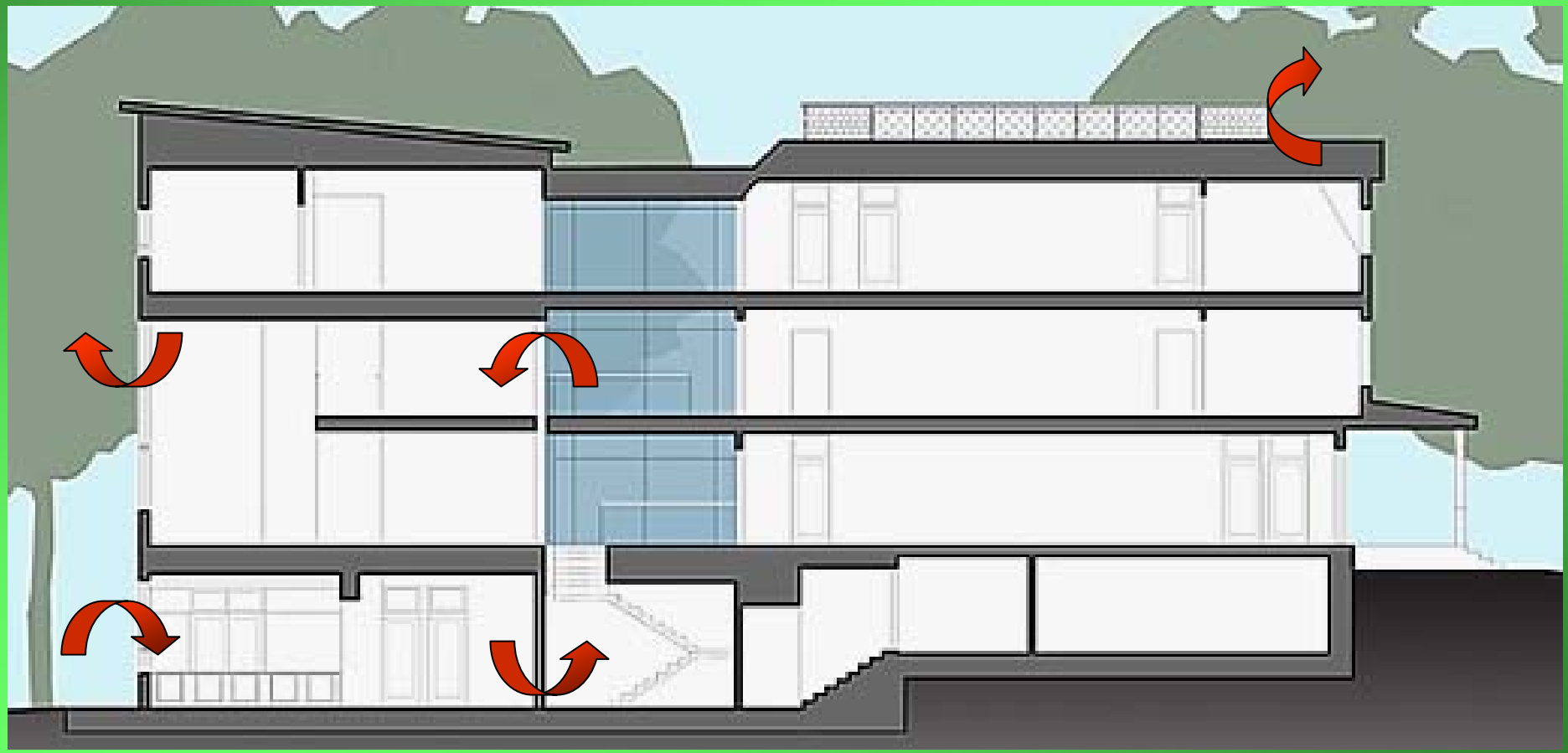
CO_2 Levels:

- Max levels occurred successively from the basement conf rm to the 2nd floor office.



Airflow:

- We confirmed that air flows through the building in the direction we originally thought.



Airflow:

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Data & Analysis

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Data & Analysis

Summary

- A temperature gradient exists.
- Temperatures in the stairwell remain stable overnight.
- A stack effect brings air in at the basement and out the 2nd floor window.
- CO_2 levels can exceed 1000 ppm.
- Opening windows lowers CO_2 levels.

Conclusions:

- Temperature gradients in the addition stairwell seem to provide sufficient inducement for stack effect
- The flow of natural ventilation air was inward at the basement conference room and outward at the 2nd floor office.
- CO_2 levels fall to near outdoor ambient levels overnight when the building is unoccupied, windows are closed, and ventilation systems are de-energized.
- CO_2 levels quickly climb above the recommended 1000 ppm level when the building is occupied and windows are closed.
- Upper floor occupants may not benefit from open windows.

The Design Lesson Learned:

- Natural ventilation is a complex process to model and monitor (as Walter predicted).

Other Design Lessons Learned:

- Natural ventilation can be effective for providing comfortable environments with good air quality.
- Openings at the top of the building really enhance the flow-through of natural ventilation.
- People do not necessarily notice or are bothered by high CO_2 levels.
- Given the choice, people do not necessarily open their windows for natural ventilation. This might be affected if overhangs at the windows were provided.
- They do enjoy the views afforded by the windows.