INDOOR AIR QUALITY ASSESSMENT

Ware District Court
70 South Street
Ware, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

In response to a request from Christopher McQuade of the Administration Office of the Trial Court (AOTC), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH), Bureau of Environmental Health Assessment (BEHA) conducted an indoor air quality assessment at the Ware District Court (WDC), 70 South Street, Ware, Massachusetts. Employee reports of water pooling in the lock-up area prompted the assessment.

On September 22, 2004 Michael Feeney, Director of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, visited the WDC. The WDC was constructed as a school at sometime prior to 1940. The red-brick building consists of three floors with an occupied basement. The WDC moved into the building in 1983. It appears that the first floor and basement were renovated to accommodate court activities. Mechanical ventilations systems, separated office spaces and suspended ceilings were installed in first floor areas. Offices and a holding area were constructed in the basement. An access ramp was installed on the exterior of the building, above the holding area (Picture 1). Windows are openable throughout the building.

Methods

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, model 8551.

Results

The courthouse has a population of approximately 15 employees and an estimated 50 to 100 other individuals visit the court on a daily basis. The tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million [ppm] of air in seven of twelve areas surveyed, which is indicative of an inadequate fresh air supply in the majority of areas in the building.

The WDC has a number of mechanical heating, ventilating, air-conditioning systems/components. Fresh air in rooms throughout the building is provided by unit ventilators (univents) (Figure 1, Picture 2). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and heating coil and is then provided to the room from the univent by motorized fans through an air diffuser on the top of the unit. Univents were obstructed and/or deactivated in a number of areas during the assessment. To function as designed, univent diffusers and returns must remain free of obstructions. Importantly, these units must be activated and allowed to operate.

A mechanical exhaust ventilation system was installed to remove stale air from the building when originally constructed. The exhaust vent in each room is located in a coat closet (Picture 3). It appears that this system is not in use. The upper floors are not occupied and the vent in the clerk's office was sealed with plastic to prevent cold air

backdraft. If not activated, air can backdraft though these exhaust vents into the building, depending on wind and weather conditions. Drafts can also introduce any particulates that may have accumulated in the airshaft into the building. Since an alternate exhaust system appears to have been retrofitted into the first floor court areas (see below), sealing these vents would be appropriate.

As part of the renovations a newer HVAC system for cooling was installed for the court session. This equipment was installed in the basement below the court session, and is connected to air intakes and diffusers by ductwork. It appears that an exhaust ventilation system was also installed for the clerk of courts office and first floor hallway, which serves as the waiting area for the court session. Court staff report that the fan for this system is not used due to the noise that results when it is activated. Other offices and the holding area have window-mounted air conditioners (WACs) (Picture 4), to temper indoor air during hot weather. The WACs observed do not seem likely to have the means to introduce fresh air.

It appears that an exhaust fan was installed in the holding cell to remove odors (Picture 5) when the holding area was built. No transfer vents or undercuts exist in the doors to allow for the draw of air. Without a means to draw air from another area, the exhaust vent efficiency is reduced, resulting in a lack of air exchange, which can result in lingering odors.

The building was originally designed to use cross-ventilation in the summer to provide comfort for building occupants. The WDC is equipped with windows on opposing exterior walls. This design allows for airflow to enter an open window, pass through a room, pass through the open door, enter the hallway, pass through the opposing room door and exit the building on the leeward side (opposite the windward side) (Figure

2). With all windows and doors open, airflow can be maintained in a building regardless of the direction of the wind. The system fails if the windows or doors are closed (Figure 3). Windows and doors were closed in most areas closed during the assessment, which can inhibit airflow.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a univent and exhaust system, these systems must also be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time

weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 73° F to 77° F, which were within the BEHA recommended guidelines. The BEHA recommends that indoor air temperatures be maintained in a range between 70° F to 78° F in order to provide comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is also difficult to control temperature without the mechanical ventilation systems functioning properly.

The relative humidity ranged from 42 to 52 percent, which were also within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. It is important to note however, that relative humidity measured indoors exceeded outdoor measurements (range +3 to 6 percent). This increase in relative humidity indicated a lack of exhaust ventilation that would remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and

relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The WDC has a history of water penetration problems. Water damage was evidenced by third and second floor ceiling materials (Picture 6), walls (Picture 7) and flooring (Pictures 8 and 9), which have been attributed to roof leaks. A small amount of water damage to ceiling tiles was observed in the clerk's office, possibly attributed to these roof leaks. While the water damage to the second and third floors is extensive, it does not appear to be causing the problem that prompted the assessment (e.g., water pooling in the holding area). According to AOTC staff, funding was obtained for roof repairs and action was pending by the Town of Ware.

Porous materials (e.g., ceiling tiles, carpet and wood) that are wet repeatedly can serve as media for mold growth. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

The holding cell area was reported to accumulate standing water after rainfall. An examination of the holding area indicates that water most likely penetrates through the foundation (Picture 10). The roof is unlikely to be the source of water in the holding cells due to the absence of water staining on the walls and floors of the office immediately above this area. These areas would be stained if the leak originated from the roof that is three stories above the holding area. The following conditions indicate that the most likely source of water pooling in the holding cells is through the foundation:

- The water damage to the wall where the pooling begins is near the floor/wall junction. This type of pattern is typical of water penetration through the foundation rather than a roof leak. If a roof leak were the source, water damage would be likely creating stains from the origin of the leak to the basement.
- Two windows in the holding area were sealed externally with plywood (Picture 11). The plywood appeared to be heavily water damaged and splaying. In this condition, water can easily penetrate between the window frame and plywood.
- The access ramp provides a water impermeable surface that under wind driven rain conditions, can direct water towards the foundation.
- A plastic material was placed under mulch outside this area to keep the soil moist, therefore keeping the ground next to the foundation wet. (Picture 12).
- Shrubbery was located immediately against the foundation. Roots/plants growing against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

- The door for the access ramp was severely water damaged at its base (Picture 13). This condition indicates that rain-driven water has penetrated through the door/threshold.

Based on these observations, ensuring appropriate drainage outside the holding areas and re-establishing the integrity of the sealed windows and access door frame should prevent further water penetration.

Installation of window mounted air conditioners (WACs) can also provide a possible means for water penetration into the building. A number of WACs were installed through exterior walls (Picture 14). It appears that the casing for some of these units are not of sufficient width, since fixed vent vanes used to cool the WAC compressor are partially enclosed by the exterior brick wall. In this condition, rainwater may pass around the sealant installed over the fixed vanes. Spaces were also seen around materials used to install WACs in windows (Picture 15), which can allow water, outdoor pollutants and insects into the building.

Other Concerns

Several other conditions that can affect indoor air quality were noted during the assessment. As discussed, several areas contained WACs. This equipment is normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter. The interior of the univent in the clerk's office was examined. This univent did not have any filters installed in either the return air or fresh air intake vents. Filters are necessary to remove airborne particulates and to prevent debris accumulation on the heating coil.

Damaged fiberglass insulation was noted in one office (Picture 13). Fiberglass insulation can be a source of skin, eye and respiratory irritation to sensitive individuals.

An examination of the attic found animal wastes on flat surfaces, which is an indication of bat and/or bird infestation. CEH staff observed birds entering holes in the west gable and soffit of the roof (Pictures 16 and 17). Animal wastes and dander can be a source of disease. Roosting of bats and/or birds inside the building should be prevented.

Conclusions/Recommendations

1) Continue with plans to replace roof. Roof repair should include repair of holes.
2) Install passive vents or undercut doors in the holding area by at least 1-inch to provide transfer air.
3) Operate the retrofitted exhaust ventilation system during hours of operation. Install a timer to activate/deactivate this ventilation system.
4) Seal the closet exhaust vents to prevent backdrafting.
5) Consider the following actions as a means to prevent moisture penetration into the basement:
    a) Repair/replace water damaged doors and plywood plugs in windows.
    b) Install gutters along the access and downspouts to direct rainwater at least five feet away from the foundation.
    c) Remove plastic beneath mulch along the edge of the building.
    d) Remove mulch and accumulated debris to a level below basement windowsills.

e) Remove foliage to no less than five feet from the foundation.

f) Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek & Brennan, 2001).

g) Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek & Brennan, 2001).

6) Consult a ventilation engineer to maximize the operation of the HVAC system and make repairs as necessary. An increase the amount of fresh air drawn by univents may be necessary to increase comfort.

7) Consult a ventilation engineer concerning re-balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

8) For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. An increase in filter efficiency in the HVAC system may also be advisable. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

9) Replace WAC cases with casings that extend vent louvers for the compressor beyond the exterior brick wall. Establish water tight installation for WACs.

10) Change filters in WACs as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.

11) Install filters in univents.

12) Have the attic examined by a licensed pest control company in order to ascertain whether a bat and/or bird infestation exists. Seal all means of ingress/egress into the attic to prevent bat infestation. Clean bat and bird waste from attic space.

13) Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

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SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning

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Figure 2 **Cross Ventilation in a Building Using Open Windows and Doors**

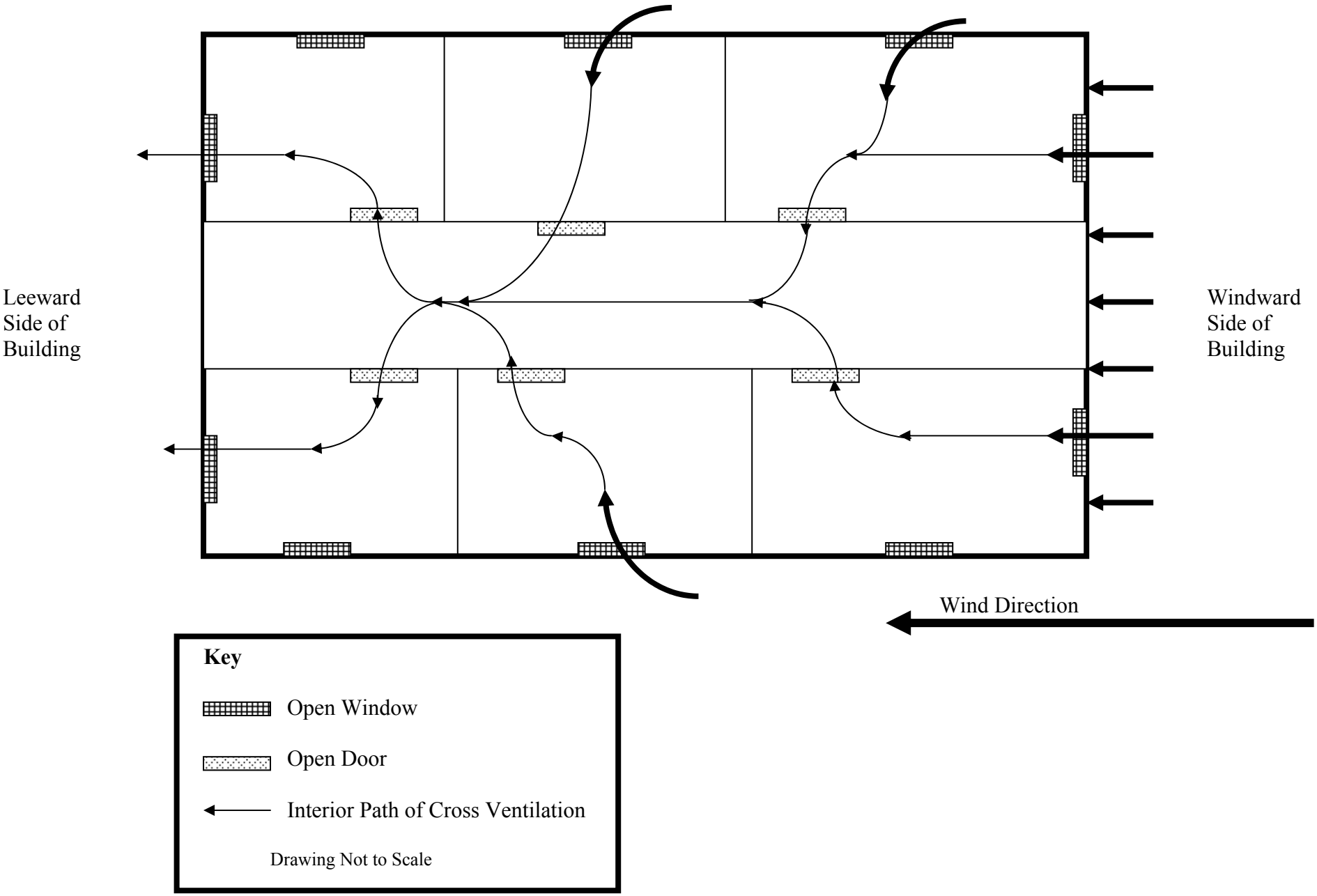
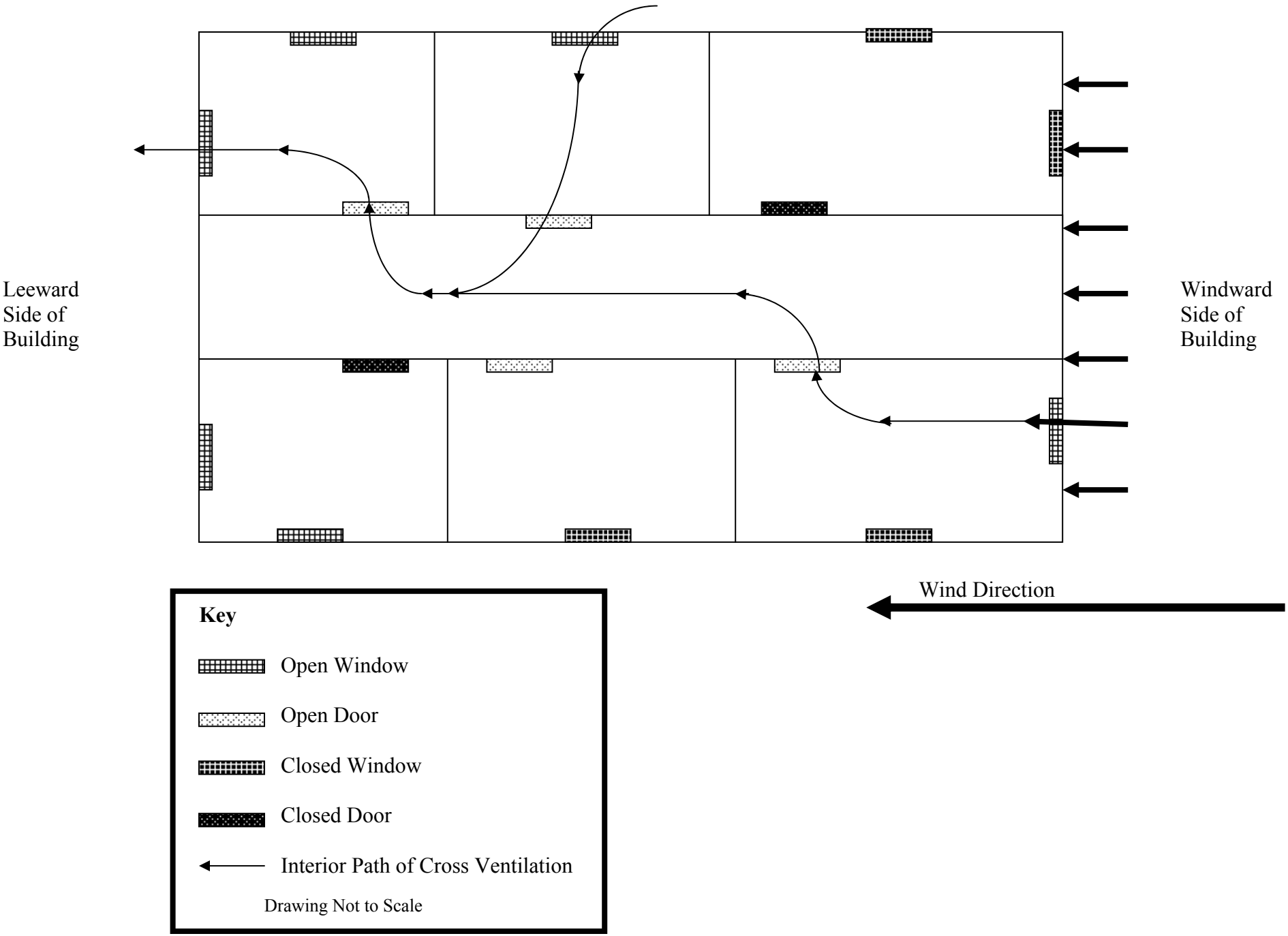
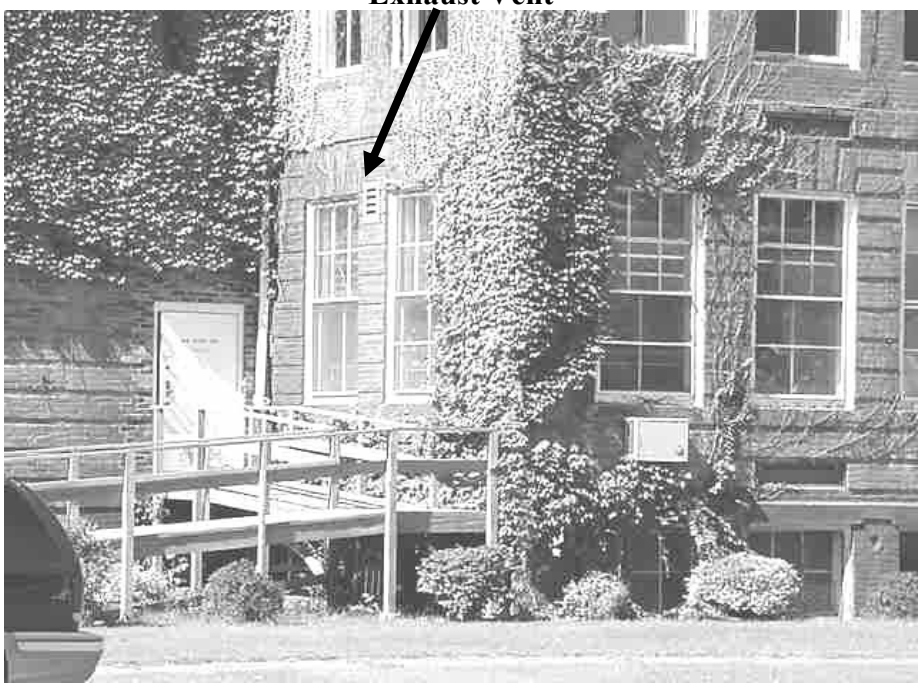


Figure 3 **Inhibition of Cross Ventilation in a Building with Several Windows and Doors Closed**



Picture 1

Exhaust Vent



Access Ramp Was Installed On the Exterior of the Building, Immediately Outdoors above the Holding Area, and Note Exhaust Vent for First Floor

Picture 2

Univent

Picture 3

Original Exhaust Vent System in Closets

Picture 4

Window Mounted Air-Conditioner

Picture 5

Exhaust Vent, Holding Cell

Picture 6

Water Damage to Ceiling, Third Floor

Picture 7

Water Damaged Floor, Third Floor

Picture 8

Water Damaged Carpet, Second Floor

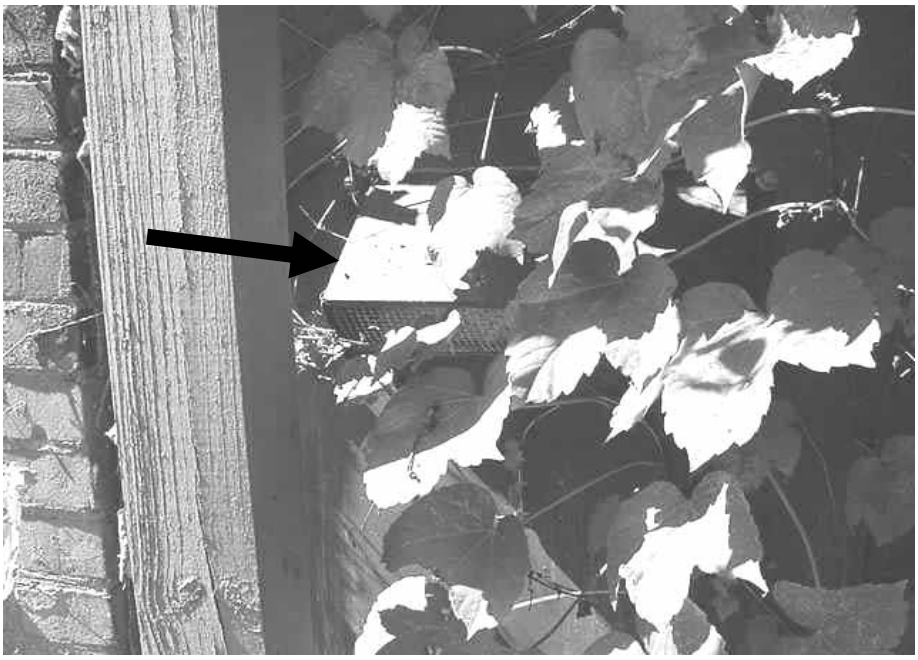
Picture 9

Water Damage Floor Tile in Hallway, Second Floor

Picture 10

Water Damage to Holding Area Base of Wall, In an Area of the Foundation below Grade

Picture 11



Basement Windows Sealed With Plywood, Note Holding Cell Exhaust Vent

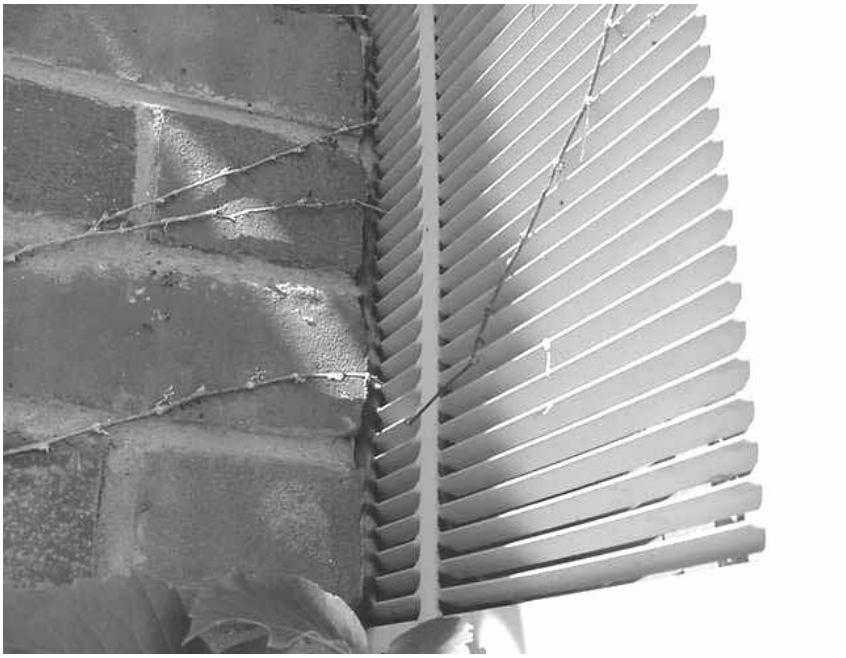
Picture 12

Plastic Material beneath Wood Chips

Picture 13

Water Damage to Access Ramp Door, Above the Holding Cell

Picture 14



Air Conditioner Cabinet with Fixed Louvers Inside Building Envelope

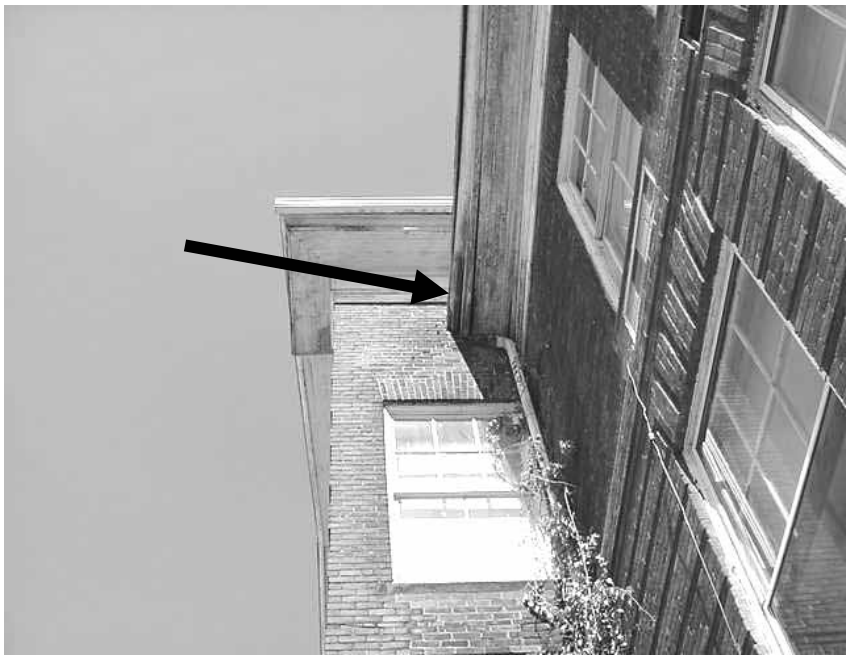
Picture 15

Spaces around WAC

Picture 16

Holes in Gable of WDC, West Roof

Picture 17



Hole in Soffit of WDC, West Roof

TABLE 1

Indoor Air Test Results – Ware District Court — September 22, 2004

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	372	75	46					
Clerk's office	1121	77	51	2	Y	Y	Y	Supply vent off Exhaust vent off Windows open Plastic covering exhaust vent 2 window-mounted air conditioners 1 water damaged ceiling tile
Break room	1080	77	46	0	Y	Y	N	Supply vent off Exhaust vent off Windows open Window-mounted air conditioner Door open Separated from juvenile probation by partial wall
Juvenile Probation	1132	76	47	2	N	N	Y	Door open
Clerk Magistrate	1045	75	50	0	Y	N	N	Door open Window-mounted air conditioner

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Table 1-1

TABLE 1

Indoor Air Test Results – Ware District Court — September 22, 2004

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Hallway, first floor, north end	935	75	48	22 (entire hallway)	N	N	Y	Exhaust vent off
Hallway, first floor, outside clerks office	1086	73	51	22 (entire hallway)	N	N	Y	
Security desk at entrance, first floor	656	73	49	1	N	N	N	Outside door opened periodically during sampling
Probation, Main Office	625	74	52	0	Y	N	N	2 window-mounted air conditioners
Probation, corner office	576	75	51	0	Y	N	N	window-mounted air conditioner
Probation, private office	551	75	42	1	Y	N	N	window-mounted air conditioner
Courtroom 1	444	76	45	1	Y	Y	Y	Univent And Ceiling Mounted Air Diffusers
Holding cell	1230	73	51	3	N	N	Y	Exhaust vent off

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