

# “Sick Buildings” and Indoor Air Quality

Claim Association of Greater Chicago

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**Robson Forensic**

Engineers, Architects, Scientists & Fire Investigators

# Your Presenter

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CVs can be viewed on our web site at  
[www.robsonforensic.com](http://www.robsonforensic.com)

# Agenda

- Introduction
- The Problem of IAQ
- Health Effects and Causative Agents
- Sources and Defective Conditions Contributing to Indoor Air Pollution
- Potentially Responsible Parties
- Evaluation and Control Methodologies
- Standards of Care

# Why Do Buildings Get “Sick”?



*“I’m sick of work & I’m sick at work!”*



# Benefits of IAQ Programs

- Boosts morale, productivity, PR
- Limit future costs of
  - WC & health insurance payments
  - Replacement workers
  - Missed opportunities due to replacement workers
  - Employee turnover, productivity
- Reduced energy consumption
- Enhanced property values

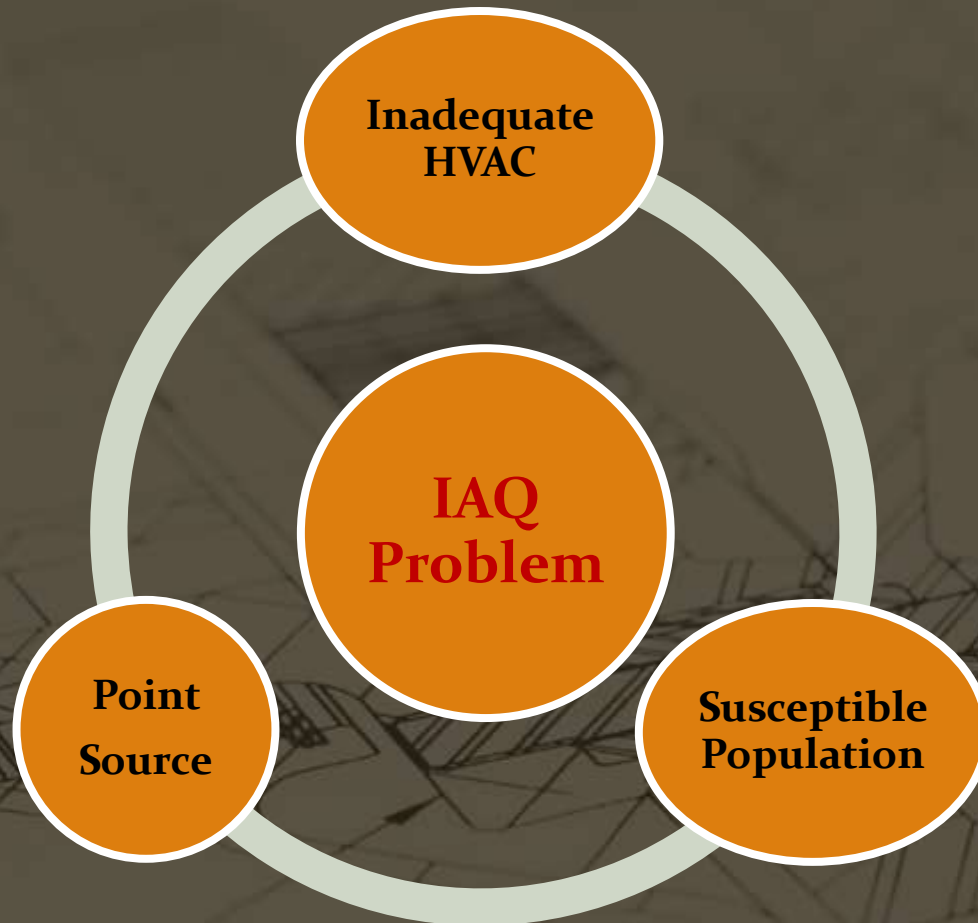
# Physical Factors Affecting Perception of IAQ

- Thermal acceptability
- Humidity
- Normal concentrations of respiratory gases
- Contaminants below health or odor discomfort levels
- Artificial lighting
- Vibration
- Noise

# Preventing IAQ Problems

- Sources inside/outside the building
- Microbial contamination
- Building components & furnishings
- HVAC equipment maintenance
- Ventilation appropriate to occupancy
- Other sources & considerations

# Lowest Common Denominator of IAQ Problems

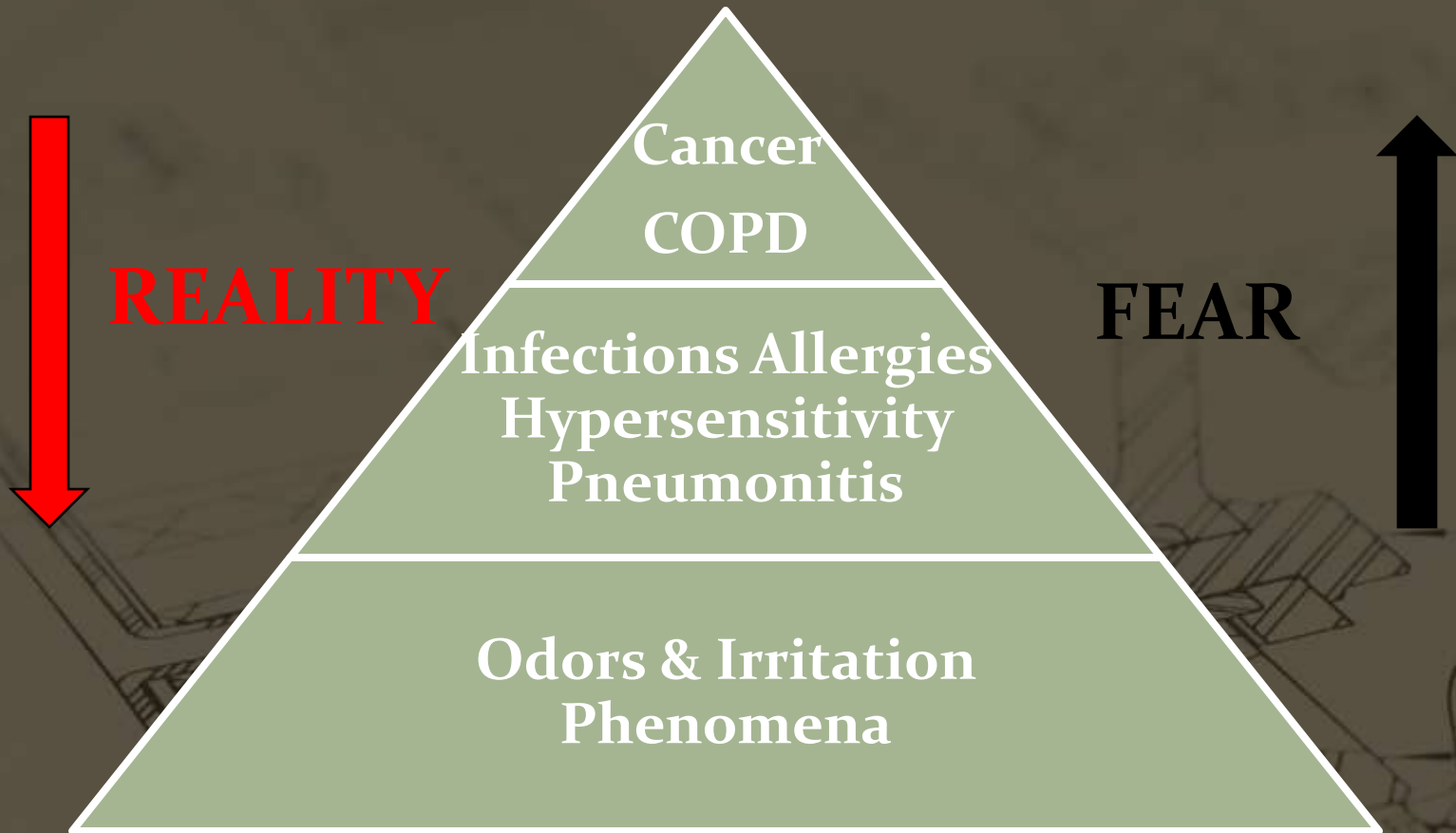


Source: Bradford O. Brooks and W.F. Davis. *Understanding Indoor Air Quality*. CRC Press. 1992. P. 168.

# Health Effects & Causative Agents



# IAQ Health Effects Paradigm



Source: Bradford O. Brooks and W.F. Davis. *Understanding Indoor Air Quality*. CRC Press. 1992. P. 90.

# Comparison of IAQ Health Issues

- **Sick Building Syndrome (SBS)**
  - Widespread persistent symptoms (eye, nose, throat irritation; nose bleeds; nausea; headache; fatigue; difficulty concentrating; irritability)
  - Numerous affected people (> 20% pop.)
  - Symptoms present while in building; less prominent after leaving building
  - No specific recognizable etiology
  - Usually nonspecific health complaints

# Comparison of IAQ Health Issues

- **Building Related Illness (BRI)**
  - Affected persons only ones exposed to source (typically only a few persons)
  - Typically isolated to specific locations
  - Specific, recognizable air pollutants identifiable in building
  - Clinically diagnosable illnesses (Asthma, Allergies, COPD, Pontiac Fever, *Legionella spp.*, Legionnaire's Disease, Humidifier Fever, Hypersensitivity Pneumonitis)

# Comparison of IAQ Health Issues

- **Multiple Chemical Sensitivity (MCS); a/k/a Idiopathic Environmental Intolerances (IEI)**

- Few affected persons
- Associates with low concentrations of chemicals, pathogens, foods &/or drugs
- Symptom-based diagnosis without supportive laboratory tests or agreed-upon clinical manifestations
- Not currently supported by scientific knowledge (AAAAI Position Statement)  
([http://www.aaaai.org/members/academy\\_statements/position\\_statements/ps35.asp](http://www.aaaai.org/members/academy_statements/position_statements/ps35.asp). Last accessed 11/14/08).

# Top Building IEQ Issues

- Arsenic
- Asbestos
- Environmental Tobacco Smoke (ETS)
- Formaldehyde
- Lead
- Mold & Bacteria
- Nuisance Birds
- Radon
- Clandestine Drug Labs
- Trauma Scenes

*... not necessarily ranked by importance*

# Causative Agents by Type

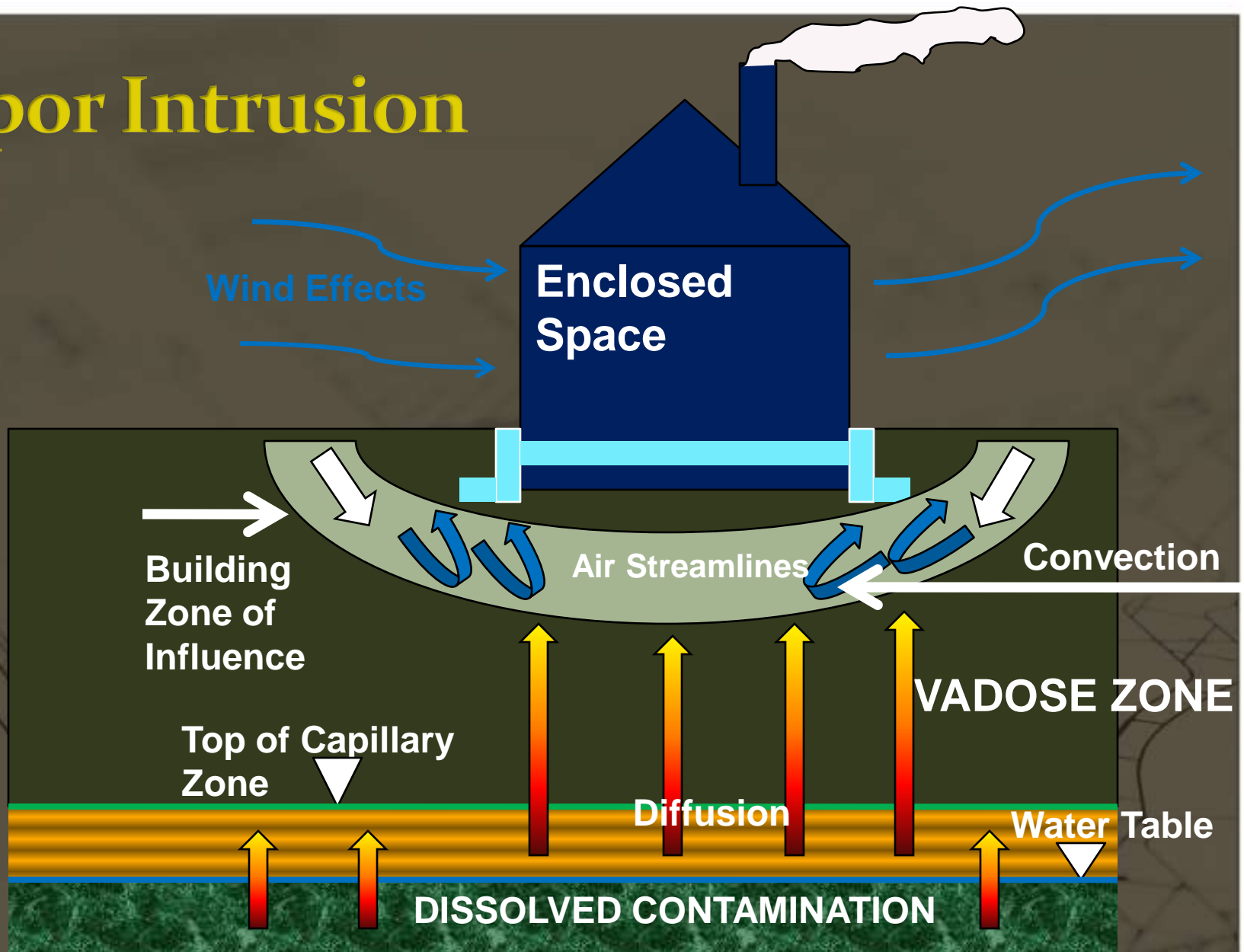
- **Combustion products**
  - CO, CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, PAH, Tobacco smoke
- **Volatile chemicals**
  - Alcohols, HCHO, ethyl acetate, hydrocarbons
- **Respirable particulates**
  - Asbestos, fiberglass, inorganic mineral dusts, lead dust, paper dust, pollen
- **Bioaerosols**
  - Mold, fungi, bacteria, viruses
- **Radionuclides**
  - Radon and radon daughters
- **Odors**

# EPA Radon Guidelines (OPA-86-004)

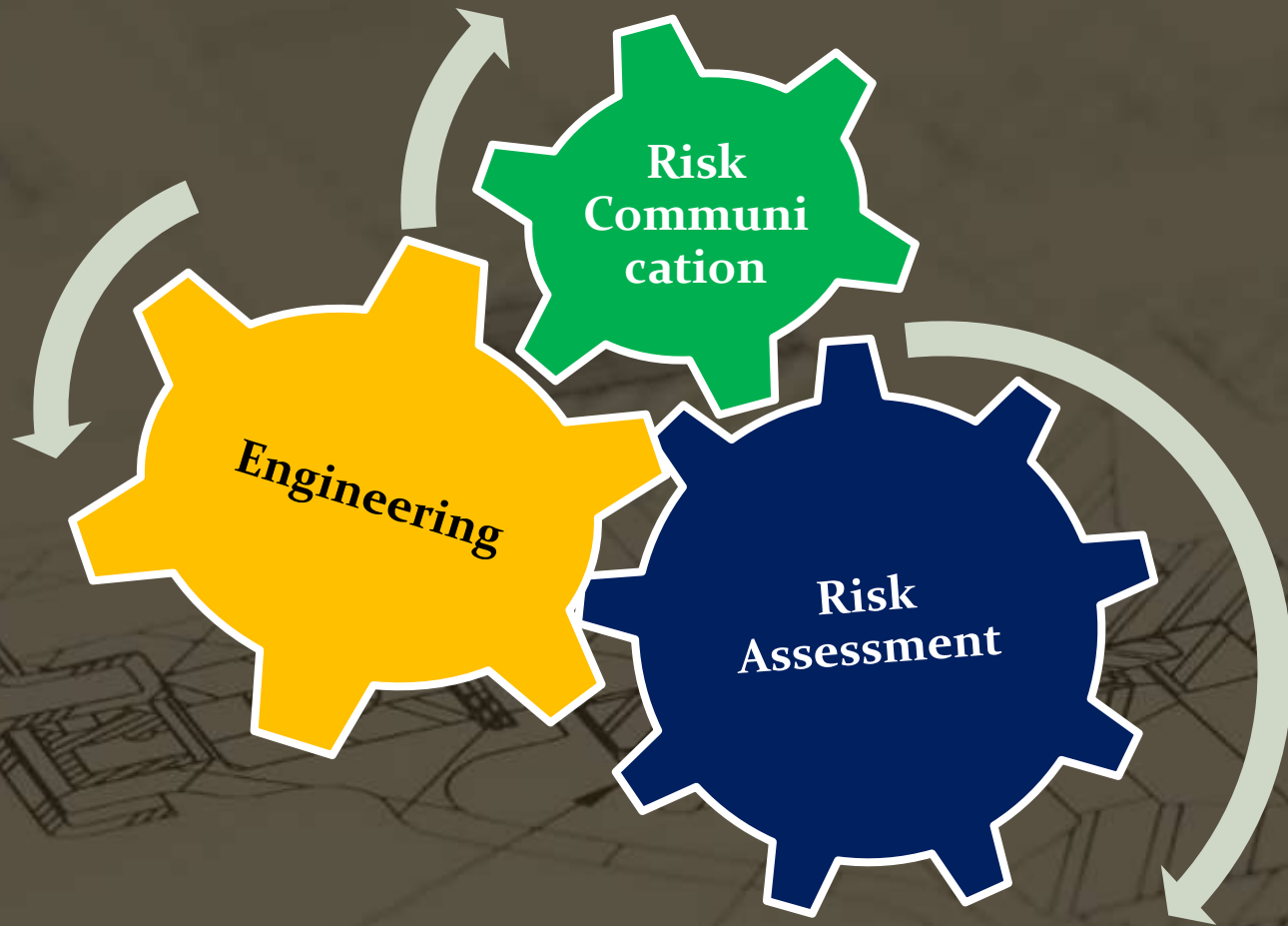
< 4	No action required
4-20	Perform follow up seasonal measurements
20-200	Perform 3 month follow up measurements
> 200	Perform 1 week follow up measurements; take immediate remedial action

**Note: all units in picocuries per liter (pCi/l)**

# Vapor Intrusion



# Evaluation & Control Methodologies



# IAQ Control: General Guidelines

- **Engineering Controls**
  - Regulations (OSHA) & Standards
  - Ventilation
  - Filtration of Contaminated Air
  - Isolate During Renovations
- **Administrative Controls**
  - Restrict Pesticide Use
  - Monitor Occupancy Rates
  - Communicate With Occupants
- **Training/Instruction/Warnings**
  - Train Maintenance Personnel
- **Personal Protective Equipment (PPE)**

# Hierarchy of Exposure Opinion Bases

- Codes or laws
- Voluntary Consensus Standards
- Industry Custom and Practice
- Guidelines in Professional Handbooks
- Scientific Literature
- Empirical Studies
- Professional Judgment



Decreasing

# Occ. and Env. Health Criteria

<b>PEL</b>	<b>OSHA</b>	<b>Statutory</b>
AQS	EPA	Statutory
TLV	ACGIH	Recommended
REL	NIOSH	Recommended
WEEL	AIHA	Recommended
ERPG	AIHA	Recommended

# Exposure Concentration

- Time-Weighted Average (TWA)
- Short-Term Exposure Limit (STEL)
- Ceiling Value (C)

**... none of which have meaning in non-occupational environments!**

# Consensus Standards

- American National Standards Institute (ANSI)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
- ASTM International (ASTM)
- Institute of Inspection Cleaning and Restoration (IICRC)
- EPA re: property assessments

# ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality

- Minimum make-up air rate
- Design documentation required
- Outside air filtration meeting federal air quality standards
- Source control of IAQ pollutants
- Design HVAC systems for maintainability
- Design & operation of HVAC systems in response to IAQ loads, not exclusively thermal loads

# IAQ Indicators

Guideline	Relationship to IAQ	Comment
Carbon Dioxide	Combustion, respiration	< 1000 ppm*
Carbon Monoxide	Combustion, TS	< 9 ppm (24 hrs)*
Methane	Biologicals, fuel gases	Should not be elevated
Total Gaseous Hydrocarbons	Fuels, TS, paints, man-made products, etc.	Identify VOC source
Oxygen	Normal component of air	19.5% - 21%
Temperature	Comfort for 80% of population	68 - 80 F*
Humidity	Comfort	30% - 60%*
Air flow	Distribute clean air uniformly (no drafts)	Verify with smoke tubes

# Sources

- **Combustion products**
  - Kerosene heaters, loading docks, wood stoves, unvented stoves, vehicle traffic
- **Volatile chemicals**
  - Adhesives, caulking compounds, carpeting, drapery, particle board, floor and wall coverings, paints varnishes and stains, upholstery
- **Respirable particulates**
  - ETS, construction debris, plants and plant parts, industrial processes
- **Bioaerosols**
  - HVAC systems, cooling towers, animals, stagnant water, humidifiers
- **Radionuclides**
  - Soil, water, natural gas, building materials

# Environmental Site Assessments

## Tier 1

- Qualitative screening: Vapor intrusion potential based on setting & site history, proximity to contamination, & other bright line criteria & professional judgment.

## Tier 2

- Quantitative screening: Compare site-specific groundwater &/or soil vapor concentrations to generic & specific risk-based concentrations.

## Tier 3

- Site-specific investigations: Use interior & exterior measurements & predictive modeling or attenuation factors as determined by authority having jurisdiction.

## Tier 4

- Select mitigation alternative.

# Public Perception of IAQ Risk

Source: Risk comparisons and indoor air quality. (Modified from: Comparing Risks & Setting Environmental Priorities: Three Regional Projects. U.S. Environmental Protection Agency, Office of Policy, Planning & Evaluation, Washington, DC)

## High Health Risk

- Indoor radon
- Indoor air pollution
- Pesticides
- Drinking water contamination

## High Ecological Risk

- Habitat modification
- Nonpoint sources
- Discharges to surface water

## Low Health Risk

- UST
- Active haz. waste sites
- Abandoned waste sites
- Solid waste sites

## Low Ecological Risk

- Active haz. waste sites
- Solid waste sites
- Non-radon radiation
- UST

# Solving IAQ Problems: Crisis Control & Risk Communication



# Mold Headlines...

*\$32 Million  
Awarded In  
Mold Case*



*Cheaper To Burn  
Home Than  
Repair It!*

*Mold Forces School  
Closure. Health Effects  
to Students Unknown*



# The Basics

- The presence of mold *spores* is normal.
- The presence of mold *growth* indoors is not normal & may pose health/comfort risks to the occupants.
- Mold growth requires spores, temperature, food, & moisture. *We can only really control moisture.*
- Mold growth leads to disseminated spores, both of which may pose health &/or comfort risks.
- Mold growth can result from inadequate design, installation, operation, &/or maintenance of the site, building envelope, HVAC system, &/or building.

# Mold Math

MOISTURE  
+ NUTRIENTS  
+ FAVORABLE TEMPERATURE

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= ***MOLD!*** (in 24-48 hours)

# Conditions Necessary for Fungal Growth

- **Moisture**
  - Water reservoirs or building materials.
  - Wet more than 24 - 48 hours.
  - <30% RH: little growth; >70% RH: optimal growth.
- **Nutrients**
  - Dust, dirt, soiled surfaces; organic building materials - wood, latex paint, drywall, carpet.
- **Temperature & Ventilation**
  - Between 40 F - 100 F.

# Conditions Necessary for *Stachybotrys* Growth

- Moisture
  - Bldg materials w/ > 15% moisture & RH > 90%
- Nutrients
  - Building materials containing cellulose - hay, straw, paper, cotton, wood pulp, plant debris
- Lack of ventilation
  - Low air movement. Means lack of competing molds, especially *Aspergillus* & *Penicillium*.
- ...Which is why *Stachy* is commonly found behind walls and baseboards!

# “Players” in the Mold Arena

- CDC
- EPA
- OSHA
- NIOSH
- NYC DOH
- EEOC/ADA
- AIHA - 5/01 Microbial Growth Task Force

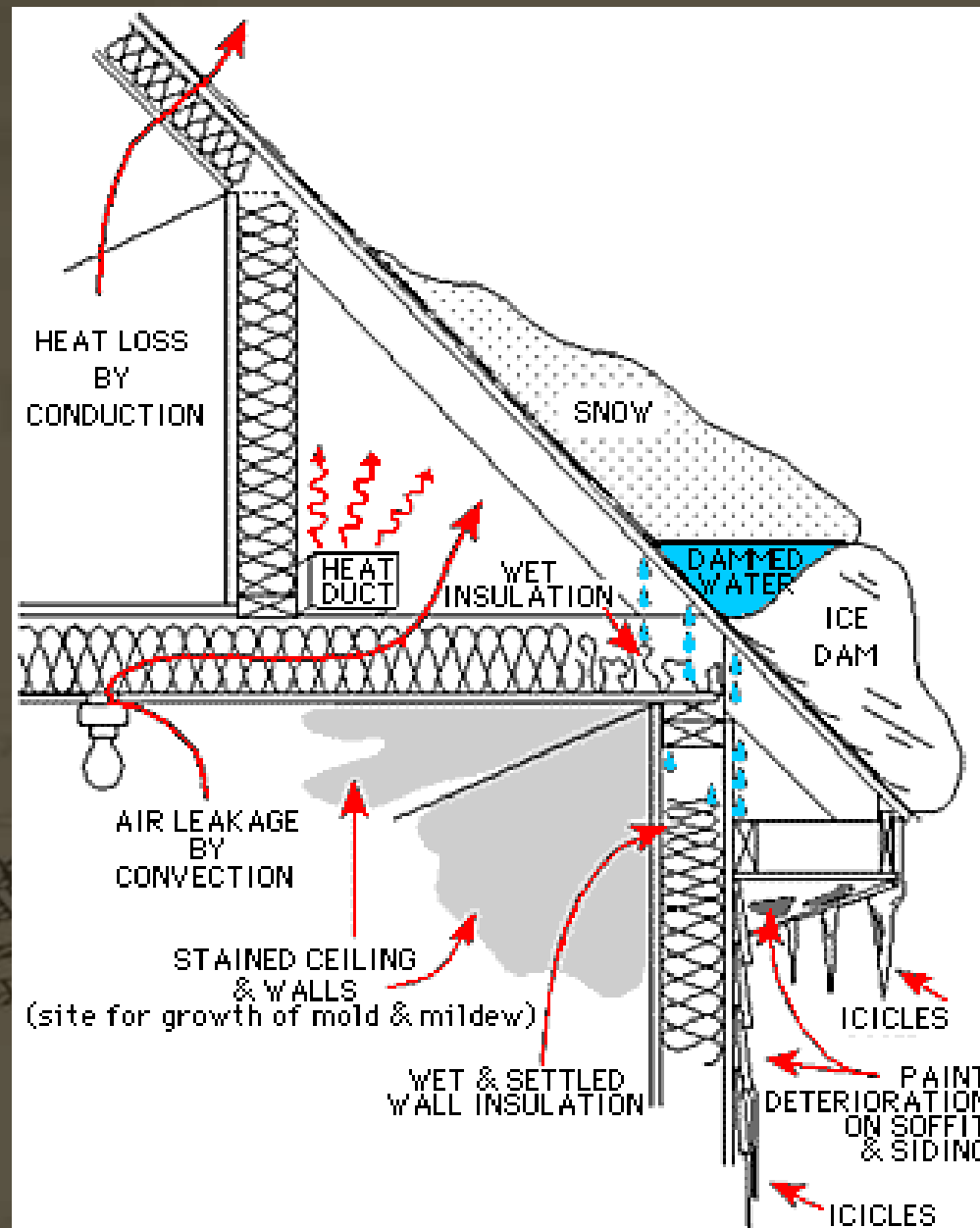
# Existing Standards

- “Standards of Practice for the Assessment of Indoor Environmental Quality” (IESO, April, 2002).
- IICRC S500, *Standard and Reference Guide for Professional Water Damage Restoration, 2nd Edition (1999) & Third Edition (2006)*.
- IICRC S520, *Standard and Reference Guide for Professional Mold Remediation, 1<sup>st</sup> Edition (2003)*.
- *ACR 2002, Assessment, Cleaning, & Restoration of HVAC Systems*. NADCA. 2002.
- ASTM E50.02 XXXX-2004, *Standard Guide for Limited Survey of Observable Mold in Commercial Buildings: Transaction Screen Process*

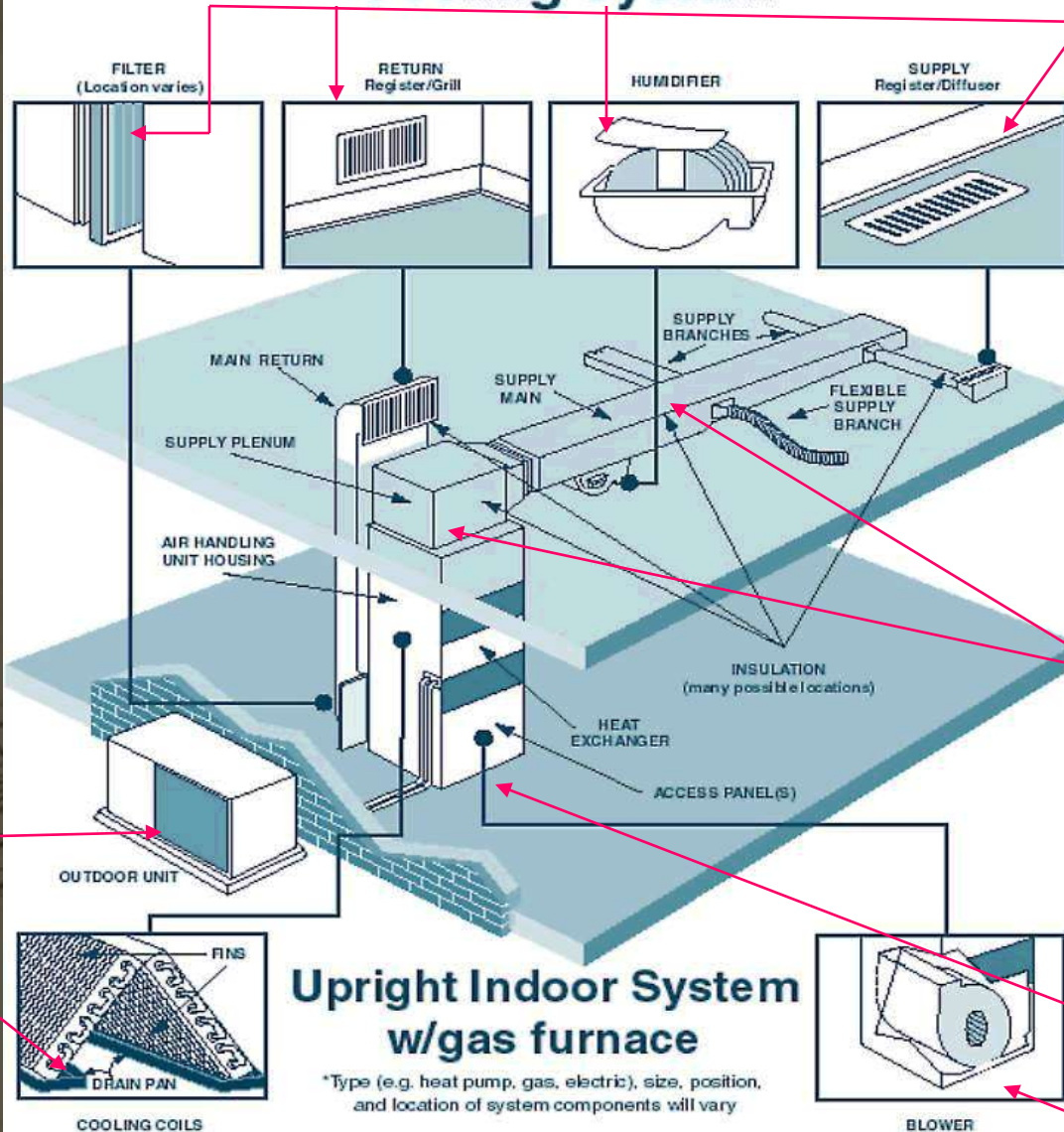
# Common Defects

- **Non-continuous vapor retarder installation**
- **Flashing installation**
- **Roofing/waterproofing installation**
- **Window installation**
- **Poor wall waterproofing**
- **Storage/handling of construction materials**
- **Construction debris**

# Ice Dams



# Components of a Typical\* Residential Heating and Cooling System



Wipe/bulk samples of diffusers, grilles, etc.

Bulk samples if internally lined ducts

Test

Wipe samples of coils

Visual

## Upright Indoor System w/gas furnace

\*Type (e.g. heat pump, gas, electric), size, position, and location of system components will vary

# A Contaminated Duct



# A Victim Of Poor Maintenance



# Could This Be Your Problem?



# Why Does It Seem So Hard To Get It Right?

*...Because Everybody Has To Get It Right!*

**DESIGNERS**

Integrate the Building Envelope with HVAC/Mechanical Systems

**CONTRACTORS**

Keep the Building Dry... Before It's Built

**OPERATORS**

Balance Moisture Control with Energy Conservation Measures

# Potentially Responsible Parties



- Construction Manager
- Project Architect
- Mechanical Engineer
- Subcontractors
- Product Manufacturer
- Landlords
- Property Mgm't. Co.
- Tenants
- HVAC Maintenance Contractors
- Water Extraction Companies
- Real Estate Brokers, Owners
- Property Inspection Companies
- Pest Control Companies
- Employers
- Insurance Companies
- Consultants

# Evaluating a Mold Case

- Engineer's report should be able to state:
  - The origin of the water intrusion.
  - The cause of the water intrusion.
  - Potentially Responsible Party(ies)(PRP) who caused or allowed the condition.
  - What statute, ordinance, code or standard was violated.
- Need to medically determine:
  - If the plaintiff's condition was the result of mold exposure.
  - If the plaintiff was allergic to the identified mold types found during the investigation.

# Possible Health Effects of Fungal Exposure

- Sensitization
- Infection
- Irritating effects
- Organic Dust Toxic Syndrome (ODTS)
- Toxic health effects



# Health Studies

- Science related to mold and certain health effects is not well developed.
- Causation, especially as it relates to toxic effects via inhalation, is largely unproven.
- Lack of dose response data, and time variability of exposure, makes it difficult to establish exposure limits.
- However, several studies associated dampness with cough, wheeze, asthma, & respiratory infection.
- Recommended text: *Damp Indoor Spaces and Health*. Institute of Medicine of the National Academies. The National Academies Press, Washington, DC. 2004.

# Environmental Testing



*Not this!*

**Proven.  
Accurate.  
Trusted.**

Man's best friend is the latest weapon in the war on mold. Similar to finding bombs and drugs, a dog's amazing sense of smell enables an inspector to pinpoint exact areas of mold which leads to more accurate remediation.

Five years ago, the rising concern among homeowners about mold inspired scientists to train and certify dogs to find hidden mold in sick buildings.

Call to buy a dog and significantly increase your business potential, today!



# Why Sample?

- One Widely Held School of Thought: *“No need to test if mold is visible.”*
- Inspection ≠ Investigation
- Typical and Worst-Case Exposure Assessments.
- Maintain acceptable levels while remediation project is on hold.
- To challenge a remediation project.
- To develop or challenge a building baseline.
- ...Are random grab samples at best.

# Guidelines

- Tentatively identify bioaerosol sources, predict their source strengths, and spatial and temporal concentration gradients.
- Identify zones with expected differences in bioaerosol kind or concentration.
- Identify occupants anticipated to receive highest & lowest exposures, and show the strongest and weakest reactions based on proximity to sources, activities conducted, & medical condition.
- Identify areas to which investigators will be allowed access, & without disrupting typical occupant activities.

# Practical Considerations

- **Conditions: Are the Sampling Actions Repeatable?**
- **Time: Inter- & Intra-Day Variations**
- **People: Young, Elderly, Immunocompromised**
- **Sampling equipment – Not mold dogs!**
- **Viable or nonviable organisms?**
- **Genus or species level?**
- **Laboratory services**
- ***Money!***

# Where and When to Sample

- Select at least one (1) sampling location in each of the following areas:
  - Outdoors near air intakes for the building (if possible).
  - An anticipated high-exposure (“complaint”) area.
  - An anticipated low-exposure (“non-complaint”) area.

# Mold Data Interpretation Guidelines

- **General:**

- Indoor levels should be *not significantly greater than* outdoor levels.
- Non-complaint areas should be *less than* complaint areas.
- In complaint areas, species should be consistently present.

- **OSHA**

- 100,000 CFU/M<sup>3</sup> in *workplace air*

# Mold Remediation



# Remediation Recommendations

- **Renovation ≠ Remediation**
- **Standards**
  - IICRC S500, *Standard & Reference Guide for Professional Water Damage Restoration (2<sup>nd</sup> Ed. 1999)*
  - **IICRC S520, *Standard & Reference Guide for Professional Mold Remediation (Dec. 2003)***
- **Guidelines**
  - OSHA  
<http://www.osha.gov/dts/shib/shib101003.html>
  - NYC DOH Fungal Remediation Protocols
  - Health & Safety Canada

# Post-Remediation Validation

- **Testing locations, in sequence**
  - Outside of building
  - Inside building, but outside of containment area(s)
  - Inside building, and inside containment area(s)

# Clearance Criteria

- No visible mold growth or dust remaining.
- All water-damaged materials removed.
- Proper source of negative air.
- HEPA filter used to bring air into the area.
- Time given to purge the air of conidia & spores.
- Good air distribution within containment.
- Containment stays up until testing has been completed, and results known.

# Questions?

**Robson Forensic**  
Engineers, Architects, Scientists & Fire Investigators