FIELD INSPECTION PROTOCOL
FOR INVESTIGATION OF MOLD DAMAGED BUILDINGS

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Field Inspection Protocol for Investigation of Mold Damaged Buildings

ABSTRACT

The evolution of building technology and construction products has resulted in widespread use of materials and techniques which are more susceptible to moisture damage than more traditional building materials and methods. There is increasing scientific knowledge and growing public awareness of the relationship between water damaged building materials and the potential health impact on building occupants, particularly related to microbial growth and indoor air quality. Building moisture problems have been widely studied and information is available to aid responsible design. Many protocols for investigation of indoor air quality are available. Guidelines for remediation of mold damage have also been developed and generally accepted. Methods of field inspection for microbial growth problems have been less well documented. However, the association of fungal contamination with occupant health and resulting publicity has created an urgent need for a systematic, rational and appropriate response to occupant complaints, and the establishment of a framework for problem investigation. This paper was written for the field inspector, from the perspective of a forensic architect with experience in the investigation and remediation of mold and moisture problems. It reviews reasons for present concern, reviews some of the currently available protocols and guidelines, and proposes standardized procedures and protocols for field inspectors involved in the identification, investigation, and remediation of fungal contamination in building structures.

Field Inspection Protocol for Investigation of Mold Damaged Buildings

BACKGROUND

It has been estimated that approximately 1/4 of the earth's total biomass is composed of fungi (Miller 1992). About 200,000 species of fungi have been described worldwide (Reed and Farr 1993), but an estimated 1-1.5 million species may exist (Hawksworth 1991). Leaf litter and soil fungi are indispensable to our natural ecology, as they decompose organic material to provide the nutrients for the continued life and growth of other species. Fungal colonization is therefore essential to our survival, and an essential part of soils, forest, grassland, mangrove and salt marsh ecology. Fungal colonization is only considered "damage" and undesirable when it occurs in our dwellings and food stores. Of the major fungal groupings, the fungi of primary interest in indoor air quality (IAQ) are Deuteromycetes, more commonly known as "molds". Mold species produce spores which are often globally distributed on the wind, seeking only nutrients and an appropriate range of temperature and moisture conditions to colonize and propagate. An understanding of the potential impact of building molds on the health of occupants has been demonstrated as early as biblical times (Leviticus: 14:33-59), but a stronger association with a wide variety of adverse health conditions is presently being drawn, resulting in heightened awareness and public concern. The recent focus on health and mold damage may be attributed to the advance of knowledge in the fields of science and medicine, but is likely also prompted by changes in the way buildings are constructed.

Traditional Building Techniques

Traditional building materials and techniques evolved to provide structures that were suited to their climate and resistant to air quality problems. Where climate permitted outdoor living with open and well ventilated living spaces, materials were able to dry quickly and mold growth was unlikely. Wood framed structures commonly incorporated wide roof overhangs to protect exterior walls from the weather, and shingled materials on walls kept water out while allowing passage of air. In more temperate climates, the use of plaster and masonry resulted in surfaces that did not encourage mold growth. The thickness of masonry walls provided a buffer against moisture intrusion, and frequently incorporated a damp course (horizontal moisture barrier in the wall) to prevent wicking of moisture from below, and drainage cavities to the building exterior to redirect rain water which entered and saturated masonry. The use of moisture barriers behind exterior plaster walls provided internal drainage and weeps to control water that entered plaster materials. Buildings were naturally cooled or heated by combustion (increasing ventilation), were not tightly constructed or heavily insulated, and relied on natural ventilation for outdoor air. Materials were relatively plentiful and construction techniques were labor intensive by current standards. Development of construction technology was gradual, and built upon time-tested materials and techniques that were suited to the geographical location for which they were developed.

Though older buildings were certainly not immune to indoor air quality problems, building envelopes were highly porous to air movement by today's standards, and indoor pollutants were continuously diluted by either deliberate or incidental infiltration of outside air. Construction of building envelopes that "breathe", together with the use of inherently mold resistant natural materials and long established construction principles provided resilient and forgiving structures that likely maintained relatively stable indoor air quality over the life of the building.

Building Trends

Social and economic pressures have resulted in rapid change in the built environment, and in the use of new materials and conditions which pose new challenges. Increasing population growth has pushed construction upward and outward. Urbanization of favorable locations, and pressures to develop less hospitable environments has led to greater reliance on indoor spaces and mechanical conditioning of these spaces for comfort. At the same time, natural resources are becoming more scarce. Industrialized cultures have become increasingly reliant on synthetic and man-made materials, and on materials that are more readily renewable. Thin skinned buildings lack the thermal buffering, and the redundancy in moisture protection provided by older construction. Manufactured wood products, and paper faced gypsum board are in common use, and both are much more susceptible to mold growth than solid wood or plaster. The labor saving practice of constructing building assemblies from panels has resulted in fewer joints and tighter construction. Architectural styles, materials and techniques have been utilized in geographical locations where they are less suited. Energy conservation has resulted in tight building envelopes for conditioned spaces. Moisture problems have resulted where mechanical systems and building envelope design are not carefully integrated to prevent leaks and condensation.

Building technology is evolving to accommodate these recent construction trends. Thoughtful and well considered design and construction can produce modern structures which are both healthful and efficient, but there is a large inventory of existing buildings and continued construction of inappropriate structures. Strong parallels can be drawn between recent trends in construction and twentieth century health trends.

Recent Health Trends

Large epidemiological studies have confirmed a relationship of respiratory health with moisture and mold. The Harvard University Six-Cities Program evaluated the health of 4,600 children in relation to mold and dampness in their homes. Thirty communities were studied in Canada involving 15,000 children and another 18,000 adults. Another study included 13,000 children in 24 cities in the U.S. and 5 cities in Canada. A further study of 400 homes in Wallaceburg, Ontario, was conducted to analyze exposures to dust, fungi, dust mites, lipopolysaccharide (LPS) endotoxin, and ergosterol (a measure of fungal biomass). Each study reported an association between self-reported symptoms and home dampness or mold (Miller and Day 1997). Another Finnish study of 630 randomly selected dwellings suggests that homes with more than one observed patch of moisture damage, or homes with moisture damage which require replacement of building materials were more likely to be associated with adverse health effects (Haverinen et al. 2001).

Fungal exposure can exacerbate asthma symptoms, trigger allergic reactions, elicit an immune system response, cause invasive and opportunistic infection, and might cause toxic disease (IOM 2000). Fungal by-products including glucans, allergens, and toxins may act in concert, affecting health through a complex interrelationship. Variability in the susceptibility of individuals also poses difficulties in drawing conclusions.

Asthma:

Building-associated fungal asthma has been known since the 8th century (Miller and Day 1997), but recent trends have heightened our awareness and concern. The U.S. Center for Disease Control (CDC) estimates that asthma affected 17.3 million individuals in the U.S. in 1998. The asthma mortality rate has doubled in the United States since the 1970s. The self reported prevalence of cases has increased 75% from 1980 to 1994 (IOM 2000). Asthma is more common in urban than rural dwellers and reactions are more severe in persons over 30 years old. Because the average age is increasing and a greater percentage of our population now lives in urban centers, these morbidity and mortality trends can be expected to continue (Brenner 1991). The escalation of asthma prevalence prompted the U.S. Environmental Protection Agency (EPA) to seek guidance from the Institute of Medicine (IOM) to evaluate scientific data related to indoor air and the occurrence of asthma. It is known that house-dust mites cause asthma, and there are a number of other agents, including fungi, that are thought to cause asthma on a population basis. The IOM committee found sufficient evidence of a relationship or association of building associated fungi with exacerbation of asthma symptoms, and increased upper respiratory symptoms (IOM 2000).

Allergies:

Spores and mycelial fragments contain allergens. Repeated or prolonged exposure to fungal allergens can lead to sensitization, and allergic symptoms in susceptible people. Fungi excrete enzymes to evaluate food availability and digest complex carbon compounds. These enzymes are some of the major fungal allergens. Though few have been chemically characterized, these proteins (serine proteases) are concentrated in spores, and can cause allergic reaction in sensitized individuals.   Allergens have been described primarily from phylloplane species and *Aspergillus fumigatus* (Horner et al., 1994), but all fungal species are potentially allergenic (IOM 2000, NYC 2000).

Immune response:

Antigens are substances that induce an immune response. An antigen is called an allergen when it stimulates production of immunoglobulin E (IgE) antibodies. Fungi produce a variety of compounds that are potentially antigenic and allergenic. Sensitization normally occurs through airborne exposure. Two types caused by airborne fungal antigens are allergic disease (asthma and rhinitis) and hypersensitivity pneumonitis. Some fungi can grow in the thick secretion that builds up in the lungs of some asthmatic patients. These fungi do not actually invade the human tissue, but grow in the mucous and produce antigens (and possibly toxins) that cause disease. The most common fungus causing this disease is *Aspergillus fumigatus* (Burge 1990). Mayo Clinic researchers report that most chronic sinus infections are caused by an immune system response to fungus (Ponikau 1999). An estimated 37 million people suffer from chronic sinusitis in the U.S., making it the most common chronic disease in the United States (Straus and Kirihara 1996).

Infection:

A healthy immune system normally prevents infection, but infancy (less than one year old), old age, disease (CF, AIDS and some forms of cancer) and immuno-suppressive medication (e.g., corticosteroids, cyclosporin) can decrease immune function and increase the risk of infection. Some molds such as *Aspergillus fumigatus* have caused infection in people with allergic disease, those with compromised immune systems, and often in individuals with pulmonary forms of cystic fibrosis (Burge 2000). Specific immunologic markers have been clinically linked to fungal exposure and respiratory disease, including elevation of the total serum IgE levels and presence of aspergillus IgE antibodies (Vlahakis 2001).

Inflammation:

Fungal spores may induce inflammatory reactions in the lung independent of allergy or sensitization depending on the type of fungus and concentration of spores. Fungal cell walls contain (1→3)-β-D-glucan, a compound with inflammatory properties. Fungal glucans are known to cause inflammation in rodent and human lungs (Rylander and Lin 2000). Glucans may also be involved in the development of fungal-induced hypersensitivity pneumonitis and organic dust toxic syndrome.

Mycotoxins:

The effect of air borne fungal toxins on human health is presently under scrutiny. While digesting organic material, some fungi produce highly toxic metabolites to help them compete with other fungi for the food source. Mycotoxins produced by fungi such as *Penicillium*, *Aspergillus*, *Fusarium*, and *Stachybotrys* species can be toxic to animals or humans. Mycotoxins are found not only in spores, but also in the mycelium and in the substrates on which toxigenic fungi grow. Because mycotoxins are chemicals, their presence is not eliminated by the death of fungal cells (Morey et al. 2000). Fungal toxins may play a role in affecting the immune response or cause lung damage resulting in pulmonary diseases other than asthma. Spores of some species contain low molecular weight compounds which may be cytotoxic or have other toxic properties (e.g. satratoxins produced by *Stachybotrys chartarum*). Most mycotoxins are cytotoxic and interfere with protein synthesis causing cell death. Some mycotoxins are potent carcinogens. Others affect cell division (cytochalasins) or are estrogenic (zearalenone) or vasoactive (ergot alkaloids). Some mycotoxins cross the blood-brain barrier and affect the central nervous system. Others selectively kill macrophages. *Aspergillus fumigatus* inhibits macrophage functioning and may facilitate the colonization of airways of asthmatics. Gliotoxin (another *A. fumigatus* toxin) causes fragmentation of DNA and may facilitate tissue invasion and aspergillosis in immuno-suppressed patients (IOM 2000).

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Building-associated medical conditions fall into two broad categories: Building-Related Symptoms (BRS) and Building-Related Illness (BRI). BRS is more commonly referred to as Sick Building Syndrome (SBS), manifested by non-specific symptoms which usually cannot be linked to a specific cause but appear linked to time spent in a building. BRI is a diagnosable illness that can be attributed to a specific chemical, biological, or physical agent.

Sick Building Syndrome:

Building-Related Symptoms may include mucous membrane reactions, irritation erythema, inflammation, pain, and neurocognitive effects. Because these symptoms are non-specific and may be due to a variety or combination of factors, bioaerosols have not been conclusively associated with SBS but are a probable cause. Building-Related Symptoms normally tend to diminish once occupants leave the building.

Building Related Illness:

Building Related Illness can be directly linked to a specific cause that occurred in a building. BRI symptoms may improve, or remain with occupants after they have left an affected building. Examples related to fungal exposure include asthma, allergic rhinitis or sinusitis, hypersensitivity pneumonitis (a lung inflammation), and nosocomial infections (affecting hospital patients). Aspergillosis (caused by *Aspergillus* species) is a serious threat to some patients and other immunocompromised individuals. Moisture related diseases caused by other (non-fungal) bioaerosols include asthma and allergy from cockroach or dust mite allergens, exposure to endotoxins produced by gram-negative bacteria, bacterial infection such as Legionnaires disease and humidifier fever (from microorganisms or their products aerosolized from humidifiers).

Moldy Buildings

Exposure to fungi in buildings has been associated with both SBS and BRI. Many fungal species have been associated with moisture damaged building materials and with occupant health. A few of the most commonly encountered species are shown in the following table.

Table 1. Common Fungi from Mold-damaged Building Materials

Chaetomium globosum	*Aspergillus sydowii*
Penicillium viridicatum	*Penicillium commune*
Eurotium herbariorum	*Paecilomyces variotii*
Penicillium aurantiogriseum	*Eurotium repens*
Penicillium citrinum	*Memnoniella echinata*
Stachybotrys chartarum	*Aspergillus versicolor*

(adapted from Miller & Flannigan 2001)

The species present depends on moisture, temperature, and food source, but primarily on moisture. Humidity of room air is less important than the available moisture in the substrate, which is measured as an equilibrium relative humidity at the surface of the material, or water activity (a_w). At an a_w of 0.65, no significant fungal growth can occur. Damp materials (a_w 0.65 to 0.85) which are subject to bio-deterioration can support growth of relatively xerophilic (dry-loving) fungi such as *Eurotium* spp., *Aspergillus versicolor* or *Wallemia sebi*. Materials that are chronically wet (a_w >0.9) are dominated by hydrophilic fungi such as *Ulocladium*, *Stachybotrys*, *Chaetomium*, and *Fusarium* spp., which are sometimes referred to as “signature flood fungi” (Morey et al. 2000, Morey 1997). Control of building moisture is the key to control of mold colonization and resultant health considerations.

The association of moisture, fungal contamination, and health effects has been clearly established, though symptoms have not yet been linked to a specific cause. Regardless of the present difficulties with drawing specific conclusions, scientists are in general agreement that people should not live in damp buildings, and that obvious fungal growth on building surfaces should be considered a potential risk for disease.

It is important to note that dampness in buildings (and resulting mold colonization) is not limited to damp climates. Condensation problems can occur in cold climates if cool surfaces are not protected from normal occupant moisture loads. In warm, humid environments (or even normally arid climates) condensation can occur due to air conditioning equipment and insulation defects, cooling of building surfaces, or improper pressurization of building interiors. Plumbing, flooding, building envelope leaks, or even moisture resulting from the construction itself may be a source of moisture problems. Building use and construction methods can dramatically influence the likelihood of moisture problems in buildings in any climate.

The recent increase in incidence of SBS and BRI symptoms in building occupants and their association with moisture problems and fungal contamination has resulted in high-profile litigation, news reports on “toxic mold”, several building closures, and a dramatic increase in the demand for investigation and remediation of mold related problems. The number and variety of individuals presently involved in mold investigations and the relative infancy of this field underscores the need for training, for building a common knowledge base, and for consensus on standardized protocols for investigation.

In many cases, the cause and extent of a mold problem may be open and obvious, and remediation can proceed immediately based on limited training or experience, following established guidelines discussed below. In more complex cases, an understanding of health risks, investigation methods, construction techniques, engineering, and specialty areas of building science may be required. The field inspector is not likely to be trained in all aspects of investigation and remediation, but they can develop an understanding of the issues, and recognize when involvement of other team members is appropriate.

It may be useful for the investigator to review common elements of existing IAQ investigation protocols, to become aware of the limitations and benefits of mold sampling, and to appreciate the need for special training in the collection and interpretation of sample data. Appropriate methods for clean-up and quality control must be reviewed and understood.

EXISTING IAQ INVESTIGATION PROTOCOLS

A number of protocols have been developed for investigation of a wide variety of indoor air quality problems, including microbial contamination. Some examples from the United States, Canada, and Western Europe are summarized by Godish (1995).

United States Protocols

Protocols for IAQ investigations have been developed by government agencies, professional associations and private consulting firms in the United States. The National Institute of Occupational Safety and Health (NIOSH) developed a protocol for its investigation teams, which typically include an industrial hygienist, an epidemiologist, and a professional familiar with the operation of heating, ventilation and air conditioning (HVAC) systems. Procedures include an opening conference, a walk-through survey, personal interviews, phase I environmental monitoring, and a closing conference (Gorman and Wallingford 1989).

The United States EPA developed a protocol in cooperation with NIOSH, for investigation of complaints by building managers. This approach involves a cycle of information gathering, hypothesis formation, and hypothesis testing. Procedures include notification of occupants of the investigation, identification of key individuals for communication, identification of complaint areas and HVAC zones, evaluation of HVAC system deficiencies, and evaluation of pressure differences and pathways that might allow cross-contamination. Under this protocol, air samples are recommended only after other investigative work has failed to identify problems (USEPA/NIOSH 1991).

The California Protocol includes both elements of the NIOSH protocol and the protocol developed by the Ontario Interministerial Committee on Indoor Air Quality. The procedure involves collection of background information on affected individuals, the building environment, and contact information, followed by an initial site visit and a more detailed medical and environmental evaluation. Data is analyzed and compared with other populations, and a report is prepared to include observations, a summary of questionnaire results, interpretation of environmental measurements, and specific remediation recommendations (Quinlan et al. 1989).

A protocol developed by the American Industrial Hygiene Association (AIHA) incorporates elements of other protocols and the experience of industrial hygienists who have conducted problem-building investigations. The procedure involves intensive review of health complaints, time and location patterns of affected occupants and comparison with potential sources, deficiencies in ventilation and HVAC systems, and medical opinions about the causes of health complaints. A checklist is used to collect background information on the facility, its maintenance, and use. The AIHA protocol focuses on HVAC system design, operation and maintenance (Rafferty 1993).

Private consulting firms have also developed IAQ investigation protocols, with some designed to evaluate air quality in buildings where no health problems have been reported. The Building Diagnostics (BD) protocol, developed by Honeywell Indoor Air Quality Diagnostics, emphasized building performance rather than causation. This approach seeks to identify factors which deviate from acceptable standards, including HVAC system design and measurements of airborne contaminants (Woods et al. 1989, Lane et al. 1989). An investigative protocol developed by Environmental Health and Engineering involves a detailed walk-through, screening questionnaire, interviews with occupants, and survey for potential contaminants. A building history is developed, and problem assessment provided if possible. If necessary, second and third stage investigations are conducted to evaluate systems, micro-environments, and environmental screening in more detail (McCarthy et al. 1991).

Canadian Protocols

Various Canadian protocols have been developed for use by federal investigators in different provincial regions. Public Works Canada (PWC) has developed a comprehensive and standardized approach for investigation of all federal government buildings (Davidge et al. 1992, Public Works Canada 1984). The PWC strategy involves two stages; information collection (plan review, complaint records, occupant interviews, walk-through inspection) and the measurement and assessment of a variety of indoor air contaminants. The PWC protocols address individual differences in sensitivity, and differences between industrial and office work spaces. The Ontario Interministerial Committee (OIC) protocol suggests that the first priority should be inspection of the problem building. Then, if necessary, symptoms and exposures of occupants are evaluated and measurements of airborne contaminants are conducted. The OIC protocol includes four stages: 1) Preliminary assessment, 2) Questionnaire, 3) Simple measurements, 4) Complex measurements. If the problem is not identified at the initial stage, subsequent evaluation stages are incorporated as needed.

European Protocols

European protocols for investigation of air quality complaints by public agencies include the Danish Building Research Institute (DBRI) protocol (Valbjorn et al. 1990), and Nordic Ventilation Group (Nordtest) protocol (Kukkonen et al. 1993). DBRI recommends a stepwise investigation involving up to five stages if required: 1) Evaluation of the ventilation system and thermal comfort, 2) Occupant questionnaire, 3) Technical investigation of the building and its use including CO_2, temperature and air flow, 4) Thorough analysis of the ventilation system and environmental factors, 5) Additional evaluations are recommended if problems persist after remedial measures have been implemented, including clinical assessment of affected individuals. The Nordtest protocol includes elements of the DBRI protocol, but includes eight stages: 1) Evaluating building operation, 2) Occupant questionnaire survey, 3) Technical description of building design, 4) On-site building inspection, 5) Measurement of indicator values including CO_2 and CO levels, 6) Evaluation of the ventilation system, 7) Additional measurement of indoor climate affects and sources, and 8) Specific medical examination of individual persons and effects.

Common Elements

Existing air quality evaluation methods and protocols have certain elements in common. Most include more than one stage of investigation, though the relative importance of various stages differs. Some emphasize information gathering or an initial walk-through. Others prefer initial assessment of occupant symptoms and complaints. Elements such as site visits are common to all protocols. Assessment of occupant symptoms and complaints, and use of questionnaires and checklists, and assessment of HVAC system operation and maintenance are common to most. The use of environmental measurements and air quality testing varies. The only U.S. federal agency to regulate indoor air quality for indoor environments is the Occupational Safety & Health Administration which applies only to the industrial work place (EPA 1989). The American Conference of Governmental Industrial Hygienists (ACGIH) has developed exposure limits for some indoor air contaminants in the work place, but threshold limit values (TLVs) for mold exposure have not yet been established due to the variability of fungal species, variability in methods for collection and culturing samples for measurement, and variability in the susceptibility of individuals (Macher, 1999). For these reasons, interpretation of air sampling results remains problematic.

The relative effectiveness of various IAQ investigation protocols is difficult to evaluate, as systematic follow-up studies are not commonly conducted or reported. Many of the common elements of IAQ investigation protocols have been adapted for the proposed mold investigation procedures which follow. Emphasis has been placed on visual observation of interior surfaces by the field investigator. Visual inspection should be supplemented with analytical testing when health claims or litigation require more thorough documentation, or when problems are complex, or if inspection fails to identify the location or extent of contamination. Environmental samples may also be warranted when the location and extent of contamination and duration of exposure appears to pose a health risk to building occupants, based on the observations of a qualified inspector.

WHEN TO SAMPLE

Mold sampling is generally discouraged in buildings where contamination can be identified by visual means, unless litigation is pending or health complaints must be assessed or if there are reasons to conclude that the mold is hidden. Sampling may also be appropriate for an occupied building where extensive mold colonization has been identified, or when individuals with elevated risk may be exposed (e.g. schools or elderly care facilities), or where a large number building occupants increases the risk that exposure will adversely affect one or more occupants. If the nature and location of contamination cannot be identified by visual inspection, additional information and testing may also be useful to help direct the inspection. Testing is costly if done properly, and results can be misleading. Current remediation guidelines are based on visible growth and recommend removal or cleaning for all mold species. Identification of species or the concentration of fungal propagules is only useful for specific projects.

The results of sampling and analysis will take time, and proper interpretation of results requires a high degree of skill and experience. No current test or single choice of medium can detect all types of mold, and findings can be misleading if they return false negative results. It is much more difficult to rule out exposure than to establish that it exists using current sampling methods.

An expertly designed testing protocol might roughly estimate the amount of mold present at the time the samples were collected (Miller et al. 2000) but only if the sampling effort is large, and results are expertly interpreted. Even a properly conceived testing protocol cannot conclusively establish a health risk, as the effect on individuals is highly subjective. Nevertheless, testing is needed when identification and documentation of mold species is required, or when it is necessary to confirm that indoor contamination is present, or to help identify the general location and nature of concealed contamination when visual inspection fails. Sampling and analysis are presently the only available tools for documenting indoor exposure levels before and after remediation, but sampling should not be considered “clearance testing” for a number of reasons:

Air Sampling

There are several problems associated with sampling for airborne fungi in indoor air. Uneven results can be obtained by differences in air sampling methods and equipment, and in the choice of agar media used in the sampling. Hourly and weekly variations in levels of airborne propagules may vary by several orders of magnitude, as the release of spores is affected by relative humidity, temperature, and mechanical disturbances or changes in ventilation. A single sample will often underestimate fungal contamination because of this variation.

Another problem with air testing lies in the viability of the spores. Non-viable spores may be equally toxic or allergenic but not culturable as viable spores. Other sampling methods have been developed which might detect fungal growth, but not species. A quantitative measurement of ergosterol or (1→3) β-D-glucan concentration may yield a reasonable appreciation for the quantity of spores present (living or dead) and allow an estimation of the total fungal mass present. Volatile organic compounds (VOCs) may be measured, but VOCs are generally produced only during periods of active fungal growth and may not be a good indicator of contamination.

When sampling is required to meet project specific goals, indoor air should be compared with outdoor air. Generally, mechanically ventilated buildings should have lower fungal counts indoors than in outdoor air, and naturally ventilated interiors should show counts comparable to outdoor air that is sampled at the same time. Outdoor samples should not be taken during or immediately after precipitation, and comparison with indoor samples may not be valid during some winter months in cold climates (e.g. snow cover) when outdoor counts are usually below those taken indoors. Species identified indoors should be similar to those outside. If the predominant organism in indoor samples is different than outdoors, further investigation may be warranted. Consistent indoor presence of spores from "indicator species" such as *Stachybotrys chartarum*, *Chaetomium*, *Aspergillus versicolor, A. fumigatus*, and some species of *Penicillium* over and above background outdoor levels should be considered unusual, and an indication of water damage (Morey et al. 2000). Interpretation of air sampling results should be left to those with particular expertise in this area.

Air sampling alone may or may not confirm contamination, and should never be relied on to rule out colonization. Air samples may not accurately reflect levels of contamination or exposure, but a balanced sampling protocol prepared by an expert can be a valuable tool in predicting areas of fungal colonization. If required by the project, the safest way to determine fungal problems is to combine sampling protocols with a thorough building inspection, and the most useful sampling protocols combine air sampling with a thorough particulate matter (dust) sampling (Miller 1992).

Bulk Sampling

When mold testing is warranted, samples of settled dust should be collected along with air samples. Fungal spores settle on surfaces over relatively long periods of time, the variability in concentrations of airborne spores is of less concern. Culturing of dust samples is still limited with regard to viability of spores and choice of culture medium. Interpretation of results is further complicated by variability in methods and frequency of cleaning activity. Surfaces which come in contact with shoes (particularly carpets) may be expected to show a higher incidence of soil borne fungi than on above floor surfaces.

Settled dust can be vacuumed from measured areas of smooth surfaces with residues collected in filter canisters, or wiped from measured areas with sterile swabs. Other forms of bulk sampling may be useful to identify mold species encountered during inspection. Visibly contaminated surfaces can be sampled by sterile swab, tape lift, or cutting of material. The sampling protocol, collection methods, proper handling of samples, and interpretation of results must be conducted by individuals with appropriate training and experience. In all cases, samples must be analyzed by a qualified analytical laboratory that participates in a proficiency testing program to assure accurate identification.

Air and dust sampling is not warranted when the location and extent of contamination can be identified by visual means, unless conditions must be documented. Sampling is warranted in situations where mold contamination is suspected but cannot be confirmed by visual inspection, or if there are significant health complaints, or to evaluate exposure of immune compromised individuals or individuals with elevated sensitivity to molds. Gravimetric sampling for quantities of settled dust after remediation clean-up is warranted as a useful and inexpensive indicator of quality assurance, to measure the effectiveness of the cleaning effort (AIHA 2001).

Sampling Protocols

Chapters 5-7 of *Bioaerosols: Assessment and Control* (Macher et al. 1999) include detailed information on development of a sampling plan, sample analysis and data interpretation. A certified industrial hygienist is typically the most qualified to develop a plan and interpret the results. The field inspector may not be trained in sample collection or analysis, but should become familiar with the work done by others, with appropriate collection and storage procedures for bulk samples, and with information that should be included on sampling forms. Bulk samples should be carefully removed to minimize disturbance to surfaces, and stored under air-dry conditions in air-tight containers. Written records for sampling should include unique sample ID numbers, a form detailing the numbers, sources and types of samples collected, and the requested analyses. Forms should include a space for chain-of-custody records.

EXISTING MOLD REMEDIATION GUIDELINES

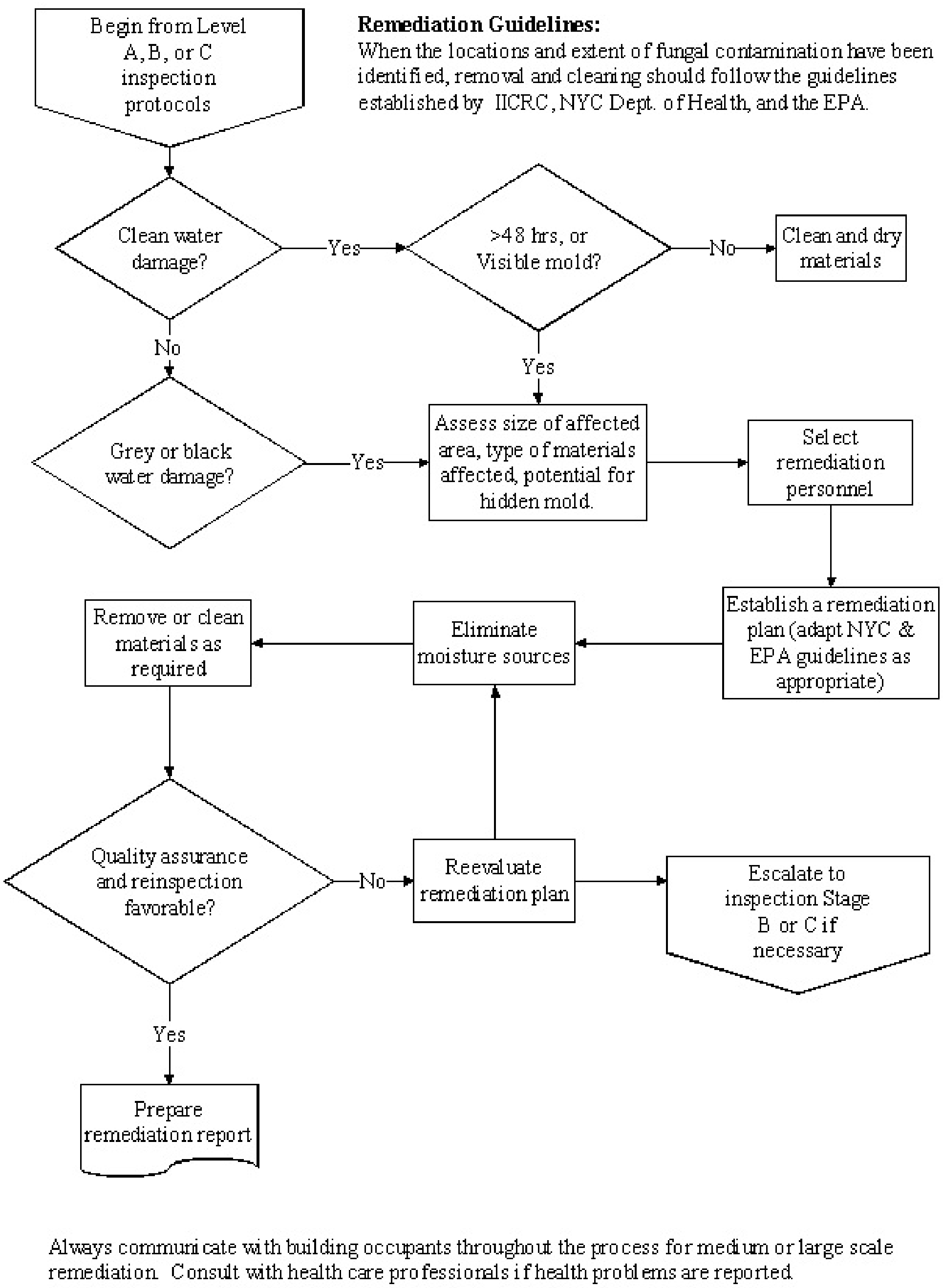
The field inspector should become familiar with existing guidelines for removal, personal protection, and clean-up. Guiding principles have been established to aid those with less experience and to help establish consensus among those with experience in this field. "Guidelines on Assessment and Remediation of Fungi in Indoor Environments" (NYC Guidelines) were initially developed in 1993 for remediation of *Stachybotrys atra*, recommending levels of personal protection for workers and building occupants based on the surface area of visible growth. The standards have since been expanded to include all mold species, increase area thresholds for levels of protection, and add levels of protection recommended for remediation of mold contamination in HVAC systems (NYC 2000). An estimate of the extent of visible growth is primary to consideration of appropriate levels of containment and personal protection during removal.

Health Canada published guidelines for remediation and preventive maintenance (Health Canada 1995), followed by the International Society of Indoor Air Quality (ISIAQ 1996). Chapter 15 of *Bioaerosols: Assessment and Control* (Macher et al. 1999) develops the guidelines for remediation, and provides a more detailed description of appropriate procedures for containment.

In March, 2001, the Environmental Protection Agency (EPA) published guidelines for mold assessment and remediation in schools and commercial buildings, including information on health risks, cleanup methods and a checklist for mold remediation (EPA 2001). The EPA recommendations for containment and personal protection mirror the NYC Guidelines, and describe cleanup methods adapted from various remediation documents including *Bioaerosols: Assessment and Control* (Macher et al. 1999) and *IICRC S500* (IICRC 1999).

The mold remediation guidelines are not standards or regulations. Various combinations of population, climate, and building construction create unique conditions for problem assessment and abatement of mold problems. Project specific protocols must be prepared to suit individual conditions based on the professional judgement of the remediation consultants, but guidelines and references should be reviewed and understood before attempting to establish remediation protocols for specific projects.

Figure 1. Remediation Guidelines Flowchart



Summary of Remediation Guidelines

Mold remediation guidelines generally recommend drying out materials as soon as possible (within 24 to 48 hours) to limit the possibility of mold growth, and eliminate the moisture source to prevent re-growth. Contractor personnel should be advised of health risks, and susceptible individuals should not be involved in the remediation process. For others, appropriate levels of personal protective equipment (PPE) should be provided. For mold damage caused by clean water, current guidelines for PPE and containment fall into three broad categories based on the area of visible contamination. Professional judgement is recommended to determine appropriate levels of protection and containment for specific projects. Full containment with negative pressurization of the remediation area is recommended for cleanup involving large areas of visible mold (total surface area over 100 sq. ft.), with workers fully protected by full-face positive air purifying respirators equipped with High Efficiency Particulate Air filters (HEPA filters), and disposable clothing. For medium sized areas between 10 and 100 sq. ft., personal protection may be similar, or limited to half-mask HEPA filtered respirators with eye protection, goggles, gloves, and disposable paper coveralls. Containment can be limited to a single 6 mil layer of fire-rated polyethylene sheet, but should still be maintained under negative pressure to prevent the flow of contaminated air to surrounding spaces. Small areas (less than 10 sq. ft.) do not require containment of the work area though dust control and proper clean-up methods should be maintained. Personal protection for small areas can be limited to a N-95 respirator, gloves and goggles. Typically, remediation of small to mid-sized areas (less than 30 sq.ft.) can be conducted by regular building maintenance staff if they receive training on proper clean up methods, personal protection, and potential health hazards. For larger areas, a health and safety professional experienced with performing microbial investigations should be consulted prior to remediation activities, to provide oversight for the project.

Containment

Levels of containment include source containment for small areas of contamination (encapsulating the source upon removal), local containment for medium sized areas (enclosure and negative pressurization using a HEPA filtered vacuum with the cannister located outside the enclosure) or full-scale containment (similar to that used for asbestos abatement) for large areas of contamination.

Full-scale containment requires a critical barrier consisting of two layers of polyethylene sheeting to isolate the contaminated area from clean or occupied building zones. All openings, fixtures, and HVAC components must be blocked, and barriers constructed to avoid disturbing the contaminated materials. Negative pressure is provided by a HEPA filtered air filtration device to maintain a pressure differential of greater than or equal to 5 Pa (0.02 in. w. g.). Higher pressure differences may be appropriate in some cases (7Pa or 0.028 inches). A decontamination unit should be constructed for entry and exit, consisting of a single or multiple chambers. A multiple chamber unit may consist of a work room, equipment room, and airlock. Contaminated debris is double bagged (6 mil polyethylene bags) and passed through the decontamination unit where bagged surfaces are HEPA vacuumed before transport through occupied spaces. Direct transport to the outdoors is preferred, through a window or door connected to the decontamination unit. Before critical barriers are removed, the contaminated space should be cleaned by a combination of HEPA vacuuming and damp wiping using a minimum of water (Macher et al. 1999).

Clean-up Methods

Mold remediation guidelines provide recommended clean-up methods for various types of building materials, primarily based on porosity. Dense, non-porous materials such as tile, metal and glass, or semi-porous materials like concrete or wood can usually be cleaned and reused. Cleaning consists of damp wiping with water or detergent solution and thorough drying, followed by HEPA vacuuming. Porous materials like wallboard, acoustical tile, insulation, paper products and fabrics can be reused if they can be effectively cleaned, but should otherwise be discarded (ISIAQ 1996, NYC 2000, EPA 2001). Surface cleaning of porous materials does not remove hyphae from the substrate, which will promote more rapid regrowth if moisture conditions allow.

The goal of a remediation project is not to create a sterile environment, but to restore healthful conditions for building occupants. Professional judgement should be exercised when determining the method of cleaning and requirements for removal. For example, a small patch of mold found in a wall cavity should be removed where practical, but may not warrant tearing out difficult to replace finishes if they can be effectively cleaned and the moisture source controlled. Cleaning may be more appropriate than removal for certain fungi (eg. lumber yard stain fungi, paint or fabric mildews). Testing might be required to confirm that the observed species are not particularly toxigenic or opportunistic pathogens. The tolerance of building occupants might also be taken into consideration, along with the probability that future occupants may have a greater or lesser tolerance.

Use of biocides as a substitute for removing microbial growth is not recommended (Sampson et al. 1994, EPA 2001). Biocides are toxic and must be used with great care in occupied environments. They should only be used when other means of controlling contamination are not possible and only after careful consideration of the risk, or in remediation of sensitive occupancies (e.g. health care facilities) where infection is a risk. Most disinfectants are approved for use on clean rather than soiled surfaces. Biocides may kill microorganisms without eliminating their toxigenic or allergenic byproducts. The goal of remediation is removal of all microbial growth, therefore the use of a biocide serves no purpose that cannot be accomplished with detergent cleaning (Macher 1999).

Following remediation, the types and concentrations of biological agents in air samples should be similar to that found in outdoor air. Surface samples should be similar to those found in well-maintained buildings. After remediation, a long term prevention plan should be established to include routine inspections, preventive maintenance on the structure as well as HVAC and plumbing systems, and adequate housekeeping with emphasis on proper and routine cleaning.

Communication Strategy

Continuous communication with owners and occupants is important throughout the investigation and remediation process. Procedures should be established for handling occupant reports or complaints, and key people identified to maintain clear lines of communication. Effective communication should include:

- A definition of the problem area and description of the nature of complaints, which may be revised from time to time.
- Contact information for key persons on the inspection and remediation team.
- A system for registering complaints and written record of communications.
- Notification of building occupants of the scope and purpose of upcoming investigation or remediation work.
- Provide building occupants with progress reports and final investigation or remediation reports.

(Nathanson 1995)

Remediation Specifications

Written protocols or technical specifications for remediation should be prepared for large scale mold remediation projects, or where remediation might affect sensitive occupancies (e.g. health care facilities). The protocol should be reviewed and understood by all parties, including the clean-up contractor or staff, the occupational health professional monitoring the clean-up work, and those responsible for building management. The specification should include, at a minimum:

- A description of the condition of fungal colonization observed or identified in the building, including a description of affected materials, their location, and extent.
- A floor plan showing the locations where remediation is to occur.
- An description of the general protocol to be followed for removing mold-contaminated materials, control of dust during remediation and for cleaning surfaces after moldy materials have been removed.
- Specific containment practices for clean-up or dust control required at the specific project including locations of barriers and seals at plenums or HVAC

equipment openings.

- Specific practices required to prevent cross-contamination between contaminated and clean areas including filtration requirements, required pressure differential, monitoring procedures needed to verify that work areas are depressurized, and administrative controls to ensure that contamination is not tracked through occupied areas on materials, tools and equipment.
- PPE and practices to be used to protect clean-up workers, including type of respirator and other personal protective equipment to be used by workers.
- Location of susceptible patient areas (if applicable).
- Qualifications of clean-up personnel, including their training and experience in the proper construction and operation of depressurized containment areas and dust control during remediation.
- Guidelines to be followed by the occupational health and safety professional monitoring clean-up activities for quality assurance and documentation that removal and clean-up was performed according to the specifications and for follow up sampling (if required).

(Morey 2002)

QUALITY ASSURANCE

Several quality assurance measures have been outlined to document the key elements for successful remediation. The principal performance indicator is documentation showing that contributing moisture sources have been identified and eliminated, and that all affected areas have been physically inspected for mold. Other indicators include documentation that appropriate containment was maintained during the work, that mold removal was in accord with the approved remediation plan, that cleaning was performed according to specifications, that remediated areas were checked for remaining mold or water damage revealed during remediation, that quantities of remaining surface dust do not indicate a need for re-cleaning; and that the remediated space has been HEPA vacuumed (AIHA 2001).

If containment and negative pressurization is required, a certified industrial hygienist or microbial remediation supervisor should ensure that specified or recommended remediation procedures are followed. Cleanup and containment should be performed by appropriately trained crews, and monitored by an independent consultant to ensure that every area is cleaned according to specifications.

A digital recording micro-manometer is useful to document that recommended negative pressure has been maintained during the course of work. Surrounding surfaces must be inspected during and after remediation work for moisture sources and any contamination that might have been missed.

All surfaces must be thoroughly HEPA vacuumed after materials are removed and surfaces are cleaned. While the value of preliminary air testing may be questioned in relation to its cost, testing for quantities of settled dust after remediation can be an inexpensive and effective measure of the success of clean-up efforts after remediation. Dust samples should be taken from measured areas of non-porous surfaces throughout the remediation area and weighed to evaluate effectiveness of the cleaning effort.

Surfaces with residues weighing less than 100 mg/m^2 of settled dust can generally be considered "clean", although high concentrations of fungal contaminants in smaller quantities of settled dust may still be cause for concern. The need to culture dust samples for microbial analysis must be judged on a case-by-case basis.

Air quality samples might be taken for project documentation after remediation, if recommended by the health care professional or to identify if mold contamination might have been missed in adjacent spaces. Air samples might help identify additional hidden mold that was missed during remediation, but cannot establish that all mold has been removed.

THE ROLE OF THE FIELD INSPECTOR

A visual inspection is normally conducted as the initial response to a moisture or mold problem report. Familiarity with issues outlined in the preceding sections may help the investigator make more informed decisions and appropriate choices. Minimum qualifications for field inspection and remediation work for simple jobs include a general understanding of the health effect issues, a knowledge of personal protective equipment requirements and remediation guidelines, an ability to recognize mold contamination, and an ability to trace the mold to moisture sources. Inspectors involved in more complicated problems might also benefit from a familiarity with principles behind IAQ investigation protocols, sampling procedures, and methods of data collection and interpretation. Complex problems may require a number of specialists.

The inspection process and effective communication of observations to others requires an understanding of local building materials and how buildings are constructed, and an ability to graphically depict observations. Training and experience with investigation and remediation of water intrusion and moisture migration problems are especially helpful, since mold contamination in buildings is directly related to available moisture. Failure analysis might require knowledge of roofing systems, walls and cladding, fenestration, below grade waterproofing, climate control systems, plumbing, building materials, construction techniques, and interior finishes. The list of available resources for building failure analysis is lengthy and the subject is beyond the scope of this study, but water infiltration and moisture migration problems are an integral part of most mold remediation projects. Inspection will be most effective if the inspector has experience with investigation and remediation of moisture problems.

Architects as Field Inspectors

Architects might become valuable participants in the investigation process if they develop an understanding of principles associated with microbial investigations and adopt appropriate procedures. Their training in graphic depiction and traditional roles as the designer of building envelope systems, as the coordinator of work by consulting engineers, and as facilitator of communication between owners, consultants and contractors provides valuable work experience that can benefit the investigation and remediation process.

When to Seek Help

The responsible field inspector will evaluate each project based on observations, recognize their limitations, and request assistance from specialists when appropriate. If the source of moisture problems is not readily apparent, or if the inspector does not know how to correct the source of moisture problems, a qualified architect, engineer, or building contractor should be contacted. When health claims or litigation are involved, a health care professional and microbiologist/mycologist are needed to specify appropriate documentation. When claims are involved or visual inspection fails to locate the location and extent of contamination, an appropriate sampling protocol may be required to document or locate the source and nature of contamination, usually involving a mycologist to specify the sampling method and interpret sampling results, an industrial hygienist for sampling, and a qualified analytical laboratory to culture and identify collected microorganisms. When HVAC systems are involved, a mechanical engineer may be needed to evaluate system design. If extensive contamination is encountered, a qualified remediation contractor may be needed. Responsibility for organization and selection of the remediation team may fall to the first person on-site, the field inspector. The following field inspection protocol is proposed for achieving project goals in an organized and responsible manner.

PROPOSED INVESTIGATION PROTOCOL

Important goals of every mold investigation include notification of persons with particular health risks, identification and correction of moisture sources causing fungal growth, and a determination of the extent and location of fungal amplification sites. No inspection can identify 100% of concealed conditions unless the structure is methodically and completely disassembled, but the goals can be adequately met without such extreme measures.

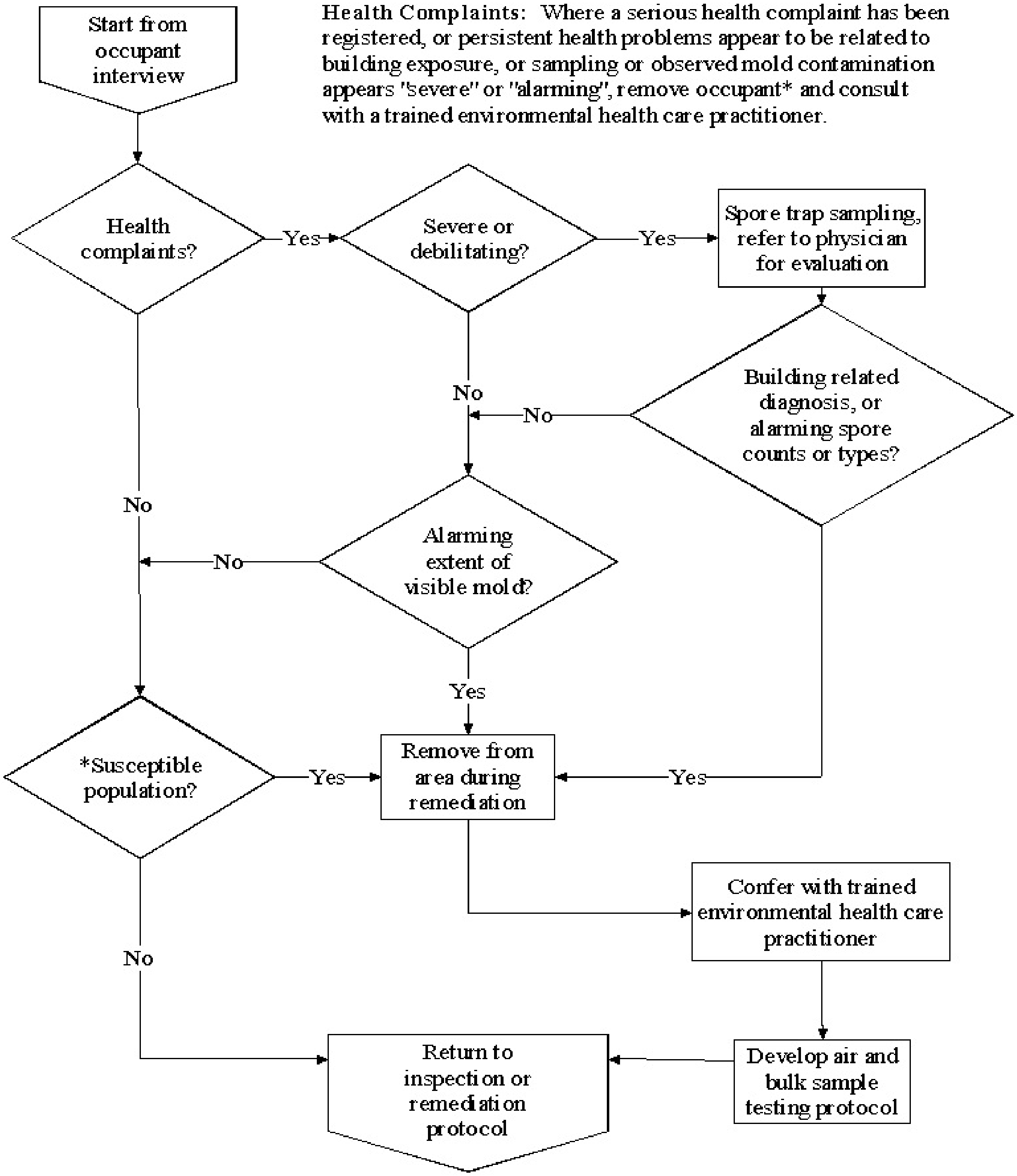
The level and degree of investigation required for each project will vary, but investigation levels might be broadly categorized into three stages depending on the situation. An investigation may progress through one or more of these stages sequentially, until the investigation goals are achieved and remediation can be undertaken. The three levels are characterized as “A”, “B” and “C” in the descriptions which follow. Flowcharts are provided as a simplified outline of some of the decision processes at each stage.

Stage A - Walk-through Inspection

Stage A involves a visual, non-destructive inspection, to identify if there is reason to suspect mold colonization or a need to perform a more detailed inspection. An interview of building occupants should be conducted before the inspection, to notify persons who may have particular health risks and to collect information useful to the inspection. A proposed sample occupant interview form is appended (page 60-61). It includes elements from NIOSH and AIHA IAQ investigation forms, and from a resident questionnaire developed for the Canada Mortgage & Housing Corporation (CMHC unpublished). The occupant interview form includes information on the term of occupancy, a check-box to ensure communication of potential health risks to building occupants, questions to document their knowledge of the building, and a form for recording occupant observations of moisture or mold problems.

The initial interview includes notification of the building occupants of the potential health risks (see Health Notification Form, appendix p. 74). Occupants who are at risk or have debilitating health symptoms should be referred to their physician or a health care professional for evaluation and possible removal from the space. Those at highest risk include infants less than 12 months old and individuals with suppressed immune systems or with severe allergies or asthma. A mold sampling protocol, and more detailed (Stage B) inspection is warranted to evaluate the exposure of occupants who report significant health complaints or particular health risks, or if concealed contamination is likely but cannot be located by visual inspection of exposed surfaces.

Figure 2. Health Concerns Flowchart



*Special Health Risks: Relocation during remediation is recommended for infants less than 12 months old, persons recovering from recent surgery, or people with immune suppression, asthma, hypersensitivity pneumonitis, severe allergies, sinusitis, or other chronic inflammatory lung diseases.

Field Inspection Protocol for Investigation of Mold Damaged Buildings

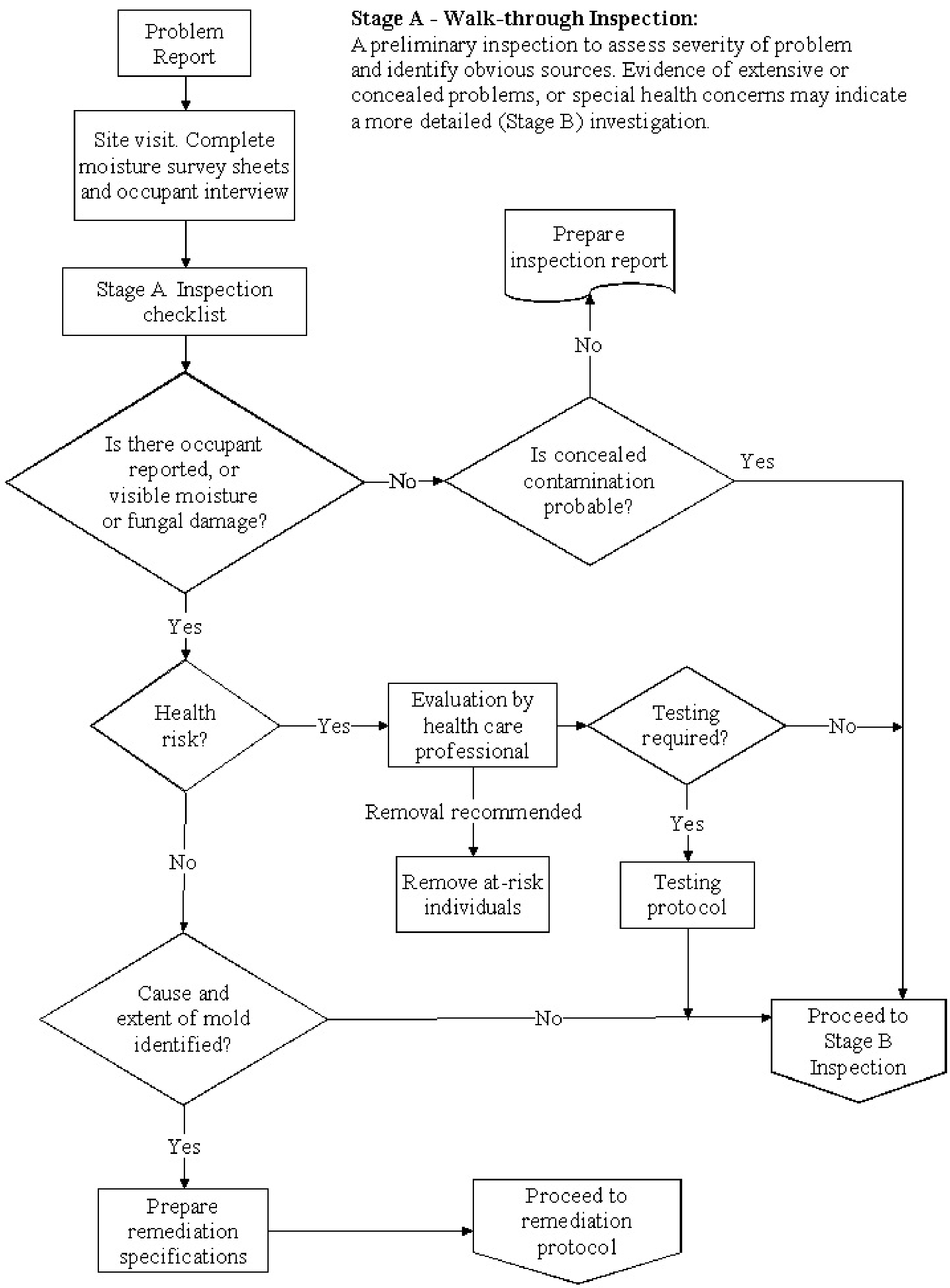
Procedures for Stage A Inspection:

Environmental conditions on the day of inspection should be recorded, along with a cursory evaluation of the type and condition of exterior building envelope components and a quick walk-through of interior spaces to identify interior odors before becoming odor adapted.

Interview a knowledgeable representative of the building occupants to collect contact information, building history, and the history of any known moisture problems. Locations of any persistent odors should be recorded. Each reported “moisture event” (leak, flood, seepage, condensation, etc) should be documented as a potential clue, and to direct the focus of more careful inspection. A moisture report form is provided in Appendix A (page 62), suggesting appropriate questions regarding the owner’s experience with moisture problems. The location of musty odors or moisture reported by occupants must be also be carefully investigated, as higher mold counts in settled dust have been correlated with reported water damage and occupant reports of musty odors (Lawton et al. 1998). If it smells moldy, it probably is moldy.

A systematic visual inspection of each interior space included in the scope of the inspection assignment must be conducted to help ensure that other problem areas are not overlooked. Advise the owners if access to adjacent spaces is helpful or needed to complete the inspection. Note types of building materials and finishes present and any observed damage, distinguishing between materials that are porous and non-porous. Observe damage for clues on the source of water or moisture problems. Consider that moisture problems may be seasonal, for example condensation problems that may occur only during humid or cold weather. A careful walk-through inspection will include close observation of accessible interior surfaces using common inspection tools, notes and photographs. Investigate any noticeable odors or visible evidence of fungal growth, and any blisters, stains, corrosion, deterioration, or discoloration that might indicate water intrusion or condensation problems. A proposed checklist for “Stage A” inspections is appended (page 63-65).

Figure 3. Stage A Inspection Flowchart



Where to Look:

All surfaces should be closely inspected, especially seams and crevices along the base of walls, edges of carpets, seams of wall fabrics, the base of all window and door jambs, tops of walls, joints in ceiling materials, exposed surfaces in attics or crawl spaces, and airstream surfaces of accessible air conditioning or humidification equipment (when present).

Mold growth is dependant on moisture, so predicting and identifying moisture sources is key to finding mold and to preventing its re-growth. Organic substrates wetted by water are the most common amplification sites, but even elevated relative humidity or dust on hard surfaces might support growth. The inspector should first look for any evidence of liquid water from leaks or condensation.

Figure 4. Wall cavity at leaky window

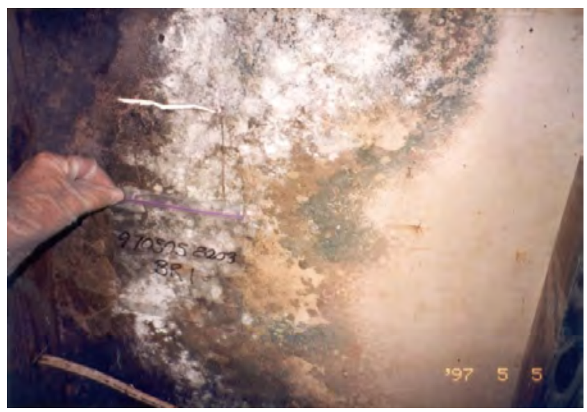


Figure 5. Closeup of heavy growth under window sill

Sometimes moisture sources are obvious (flooding, fire damage). If leaks into a building are severe, evidence is usually visible on interior finishes (stains, discoloration, corrosion, efflorescence, blistered paint). Any locations of apparent or suspected moisture damage must be more closely examined, and the source of moisture determined. Leak testing, or disassembly of building materials my be required to identify the problem source. Observed stains and discoloration might be far removed from the point of entry, as water can travel through concealed spaces and between layers of construction materials. Slow or intermittent leaks can make detection difficult if moisture does not penetrate to interior finishes or cause visible discoloration. Condensation problems might be visible on surfaces or may be concealed in cavities. Condensation can be particularly difficult to trace to a source since it results from migration of water in its gaseous form, and the source is typically not visible.

Figure 6. Colonization from condensation behind mirror.

An understanding moisture problems in buildings is central to effective mold inspection and remediation, but is beyond the scope of this discussion. In simplest terms, water (or water vapor) invariably enters a building through pressure differential (Botsai 2000). Pressure differences may be driven by gravity, wind, or capillary action. Vapor pressure differences result from a difference in relative humidity, or may be temperature driven. A review of psychrometric principles is needed to understand relationships of dewpoint, temperature, relative humidity and vapor pressure. A knowledge of appropriate roofing, flashing, and expansion joint details is important. Practical experience with remediation of moisture problems is most valuable, but many useful references are also available on the subject for those who wish to read. Inspectors should become familiar with the work of experts in the field (Lstiburek and Carmody 1993, Trechsel 1994, Kubal 2000).

Susceptible Materials:

Particular attention should be given to materials that are susceptible to mold growth, particularly when environmental conditions are likely to encourage growth. Many building materials provide nutrients for fungi: wood products, cotton, wool, hemp, organic dust and lint, soap, oil, paint, adhesives, certain plastics and vinyls (Lstiburek and Carmody 1993). Optimum growth depends on temperature and moisture. The optimum relative humidity for most fungal growth is in the range of 70% and above, at temperatures between 75° and 95° Fahrenheit. Different species prefer different temperature and moisture ranges, but in general, surfaces exposed to conditions which are suitable for human habitation are susceptible if moisture is available. Natural wool and cotton fibers used in carpets and drapes are more prone to microbial contamination than synthetic fibers (Levin 2001). Cellulose materials (wallboard surfaces, acoustical tiles, paper products) and pressed wood products are particularly susceptible to contamination, though any carbon source (dust or organic material) may support growth. Wood should be maintained below 30% moisture content at temperatures between 32° and 140° Fahrenheit (0°-40 ° C) to avoid fungal attack and decay. Gypsum wallboard is particularly susceptible to contamination because its hygroscopic gypsum core can maintain a water activity level at the paper face which promotes mold growth even at relatively low moisture content. Wallboard should be maintained below 0.6% in the same temperature range to prevent mold growth (Connolly 1993). Acoustical ceiling tiles, paper faced insulation, particle board, oriented strand board and hardboard products, stored paper and cardboard, and most processed cellulose products are good nutrient sources for mold growth.

Surface condensation must be considered during inspection. In either warm or cold climates, the wall cavity may be susceptible to concealed condensation. In cold climates with heated interior spaces, the inside face of exterior wall sheathing is usually the first condensing surface. In a warm climate where air-conditioning (cooling) is provided, the exterior face of interior gypsum wallboard is normally the first condensing surface. Application of impermeable wall coverings (vinyl wallpaper) in warm, humid

Figure 7. Behind vinyl wall fabric.

climates can result in condensation behind the vinyl between wall covering and gypsum board finishes, with either the glue or paper face of gypsum board providing nutrients for mold growth. Chilled air blown on building surfaces, or improper insulation of chilled water pipes or ducts can result in condensation on ducts, pipes, or adjacent building surfaces. Windows may provide a condensing surface in either warm or cold climates, and adjacent surfaces must be carefully inspected.

What to Look for:

The body of mold growth consists of hyphae; fine filaments which grow along the surface or into the substrate. The hyphae are normally not visible without strong magnification (though they may luminesce in ultraviolet light). The visible portion of mold growth consists of the fruiting structures of the fungus. Spores may appear in a variety of colors and patterns, though mold growth most often appears black, tan, or a light olive green.

Figure 8. Black mold growth

Figure 9. Tan growth

Figure 10. Green growth

Figure 11. Brown and tan growth

Figure 12. Pink and tan growth

Figure 13. Orange growth

Figure 14. Yellow, black and tan growth

Figure 15. Red growth

Patterns of growth may follow moisture stains, radiate from spots, or "bloom" around or above flood damaged materials.

Figure 16. **Radial pattern of colonization, before overgrowth**

Figure 17. Radiating patterns of overlapping growth in "dirty" wall cavity.

Shining a focused “grazing” light parallel with the surface can reveal a texture which is typical of mold growth, differentiating it from soil or stains. A “smudge” test (rubbing the suspect discoloration with a gloved finger or swab) can help differentiate the growth of fungal spores from other pigmented stains, as spores will smear. An eyedropper of concentrated sodium hypochlorite solution (full strength household bleach) can be used to differentiate organic material (mold) from minerals (dirt, paint, stains) when the source of discoloration is indeterminate. Organic material will become colorless after a few moments of contact, while mineral stains will not.

Simple Tools:

Inspection equipment should include a good flashlight and inspection mirrors, and may also include meters for measuring moisture and relative humidity. Any areas of discoloration should be more closely inspected. Moisture meters are useful for identifying damp materials that look dry, which may be an indicator of concealed contamination. Moisture meter readings are relative, allowing comparison with adjacent surfaces but not a precise measurement of actual moisture content in most materials. Temperature and humidity readings may be useful for identifying potential condensation problems. More intrusive equipment and methods may be required if the cause and scope of the problem cannot be determined by inspection of visible surfaces alone.

Report and Remediation:

The inspection report for a Stage A inspection might consist of a copy of the inspection check list with recommendations for remediation, or include a narrative, or a plan view drawing keyed to observation notes and photographs similar to that recommended for Stage B inspections (see appendix p. 67). The report should include a record of the types of finishes present, and any observed mold growth or evidence of moisture damage. If the extent and location of mold contamination can be quantified and moisture sources identified, the project can proceed to development of a remediation plan, funding, and organizing its execution. Otherwise, a more detailed and invasive inspection protocol may be warranted. Pending health or legal claims might also warrant more complete investigation and documentation of existing conditions. Remediation must include elimination of moisture sources and cleaning or removal of contaminated materials. Personal protective equipment and containment requirements for remediation can be based on guidelines developed by the ACGIH, New York City Department of Health, and Environmental Protection Agency (Macher et al. 1999, NYC 2000, EPA 2001), as modified based on the professional judgement of the field inspector or other remediation consultants.

Stage B - Invasive Inspection and Investigation:

An invasive, slightly destructive inspection should be performed when mold contamination is suspected but concealed, when the source of moisture is not apparent, when health problems have been associated with mold, and perhaps when litigation or public health concerns require more complete documentation of contamination. Air and dust sampling may be needed to document occupant exposure if health risks are of concern, or to help inform the inspection effort. A sample checklist proposed for Stage B inspections is provided in the appendices (page 66-68).

Procedures for Stage B Inspection:

Available building plans should be reviewed in advance to identify building assemblies and locations of insulation, vapor (or air) barriers, flashing details, plumbing locations, type and distribution of HVAC systems, and all building envelope penetrations. A small scale plan drawing, prepared in advance, is useful as a visual reference sheet for keeping inspection notes. The process is similar to the walk-through inspection described for Stage A, but attention might be focused on areas of interest generated by the occupant interview and Stage A inspection, and any suspect locations suggested by review of building plans. The inspection may also include a sampling protocol requiring collection of samples before and during the inspection, if sampling is required.

Locations for invasive inspection are chosen where mold colonization is most likely, based on visual evaluation of exposed surfaces, experience with similar construction, and review of building plans. Other locations should be selected to view representative conditions where mold is not expected, to confirm its absence or identify the unexpected. Care should be taken to avoid cutting into plumbing and electrical wiring. A large hole saw (min. 4 inches or 100 mm), with small inspection mirror and flashlight is useful for removal of building materials and inspection at selected locations. Replacement plugs of similar materials can be pre-cut to the same diameter allowing expedient repair if cores need to be saved as bulk samples, or existing materials can be replaced where mold colonization is not found. Structural framing, plumbing, electrical conduits, and insulation may limit the view into cavities. Larger openings can be cut where improved visibility is desirable.

Cutting larger openings allows removal of materials layer by layer, inspection between layers of material, and a better view into wall openings to identify the limits of visible contamination. Remediation might be performed at the time of inspection if the problem is not extensive and the inspector is equipped with appropriate materials and equipment. If wall cavities are found to be clean, repair of the inspection opening can be performed immediately after inspection . Edge support for replacement of wallboard or materials of similar thickness can be provided by metal dry wall repair clips for backing, which have tabs that can be removed from the exposed face after materials are securely fastened into place (Sheetrock brand Drywall Repair Clips, manufactured by United States Gypsum Co).

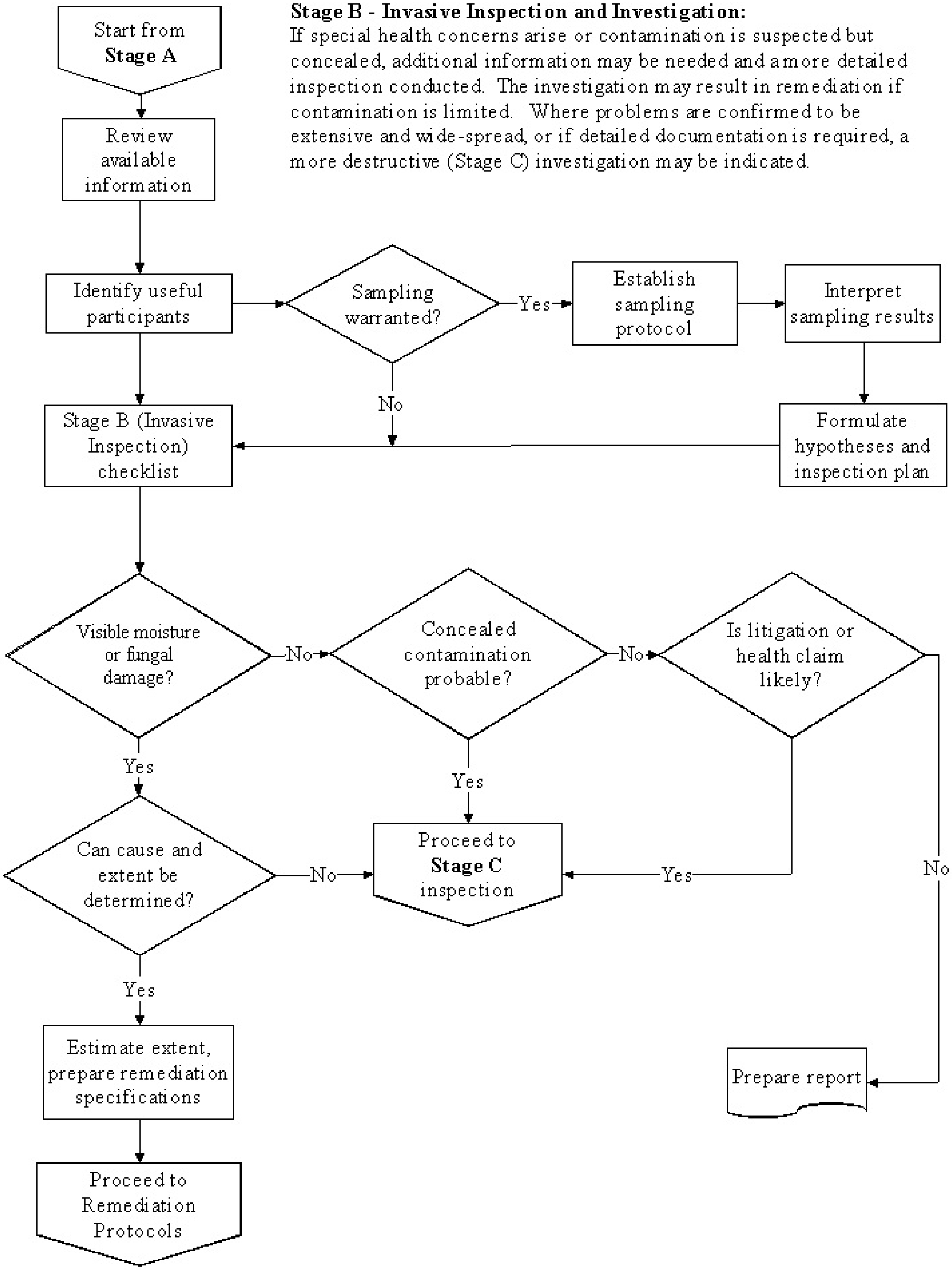
Figure 18. Larger opening where indicated by inspection hole

Care must be taken when opening wall cavities to control dust and minimize the potential for release of biological particulates into occupied spaces. The AIHA recommends use of a HEPA filter equipped vacuum to catch gypsum dust and particles, and a HEPA equipped negative air machine near the hole during inspections (AIHA 2001). If pressurization equipment is not practical, at least spread plastic sheet over surrounding surfaces and keep a HEPA equipped vacuum at the opening or inserted into the wall cavity to maintain the cavity under negative pressure. Materials should be disturbed as little as possible, to minimize particle release. Inspection openings should be patched or sealed after inspection. Where contamination is observed, inspection should continue in adjacent cavities and spaces until its limits can be identified and documented.

Visual inspection of concealed spaces can also be performed with a borescope (with integral light source) where space limitations make access for cutting openings difficult, or to minimize disturbance and damage to surfaces while allowing limited observation of concealed conditions. Penetrations can be as small as 3/8" (10 mm). Borescope inspection can reveal concealed contamination in building cavities or locate areas for further inspection, but might not permit identification of the limits and extent of contamination. Lens distortions make judgement of distances and locations difficult, and the limited range of instrument movement and building obstructions make complete inspection impossible. A rigid borescope with high quality optics will provide a clearer view than flexible fiberoptic instruments. Borescopes are not effective for identifying mold colonization sandwiched between layers of adjacent materials, or for inspection of cavities filled with insulation.

If warranted, visual inspection might be augmented with a more comprehensive space sampling protocol to identify the mold colonizing species present and suggest conditions that would support fungal growth, or to identify fungal byproducts such as (1→3) β-D-glucans or volatile organic compounds that confirm their presence. Some inspectors have reported results locating the general area of concealed contamination using a laser particle counter, set to identify particles in the spore size range (generally 2-10 microns) to identify walls requiring destructive inspection, but false positive indications are likely. Others have collected air samples from wall cavities, drawn through filters or impaction devices, to identify spore concentrations in concealed locations. Wall surfaces may be vibrated by pounding during cavity sampling to reduce the probability of false negative indications, but interpretation of data is still difficult as with all air sampling methods. Infrared cameras have been used to find temperature differences in wall cavities resulting from active leaks. Sampling might help identify where to look, but no sampling method can be relied on to the exclusion of visual inspection. Any method, device, or instrument that proves useful in identifying probable locations of concealed contamination is a valid tool, but the eye and nose of the inspector are the most effective tools.

Figure 19. Stage B Inspection Flowchart



Stage B - Invasive Inspection and Investigation:
If special health concerns arise or contamination is suspected but concealed, additional information may be needed and a more detailed inspection conducted. The investigation may result in remediation if contamination is limited. Where problems are confirmed to be extensive and wide-spread, or if detailed documentation is required, a more destructive (Stage C) investigation may be indicated.

Inspection of HVAC Equipment:

A variety of health problems have been linked with fungal contamination of heating, ventilating and air-conditioning (HVAC) equipment, including hypersensitivity pneumonitis (Morey et al. 1984) and allergic symptoms (Elixmann et al. 1990). HVAC equipment may be directly or indirectly responsible for exposure to fungal byproducts.

Inspection should include HVAC systems where present. HVAC equipment might be the source of contamination, or the means of its distribution between spaces, or might indirectly contribute to the concentration of indoor air contaminants by providing inadequate ventilation. A sample checklist for preliminary HVAC inspection is provided in the appendices (page 73). A preliminary inspection might be performed by the field inspector, though complex systems or problems may require a mechanical engineer or equipment specialist. Inspection should include all major components of the air distribution system, with particular attention to cooling coils, condensation drip pans, condensation drains, humidifiers, air intake locations, duct insulation, and surfaces near air diffusers. Moist surfaces, bird or bat droppings near air intakes (which can harbor disease causing fungi), and any standing water or observed microbial growth in HVAC equipment should be recorded. If microbial contamination is suspected or confirmed in occupied spaces and the source of contamination cannot be identified by visual inspection of building or HVAC components, dust sampling from filters and return and supply ducts may be warranted to help determine if the HVAC system may be a source of contamination or the means of its distribution. Evaluation of ventilation rates, balancing, or the adequacy of system design normally requires the involvement of a mechanical engineer or specialty contractor. A sample checklist for HVAC equipment inspection is included in Appendix D (page 73).

Air conditioning systems should be sized for their latent loads rather than sensible loads. Over sizing equipment can lead to intermittent operation and reduced dehumidification. In small residential systems (less than 10 tons) thermostats commonly cycle the coils off before moisture can be removed from interior spaces.

These systems are generally more effective at removing moisture if they are undersized so they will work harder and operate more or less continuously at part load. Small systems (below 5 tons) without dehumidification equipment are particularly problematic for controlling indoor humidity in warm, humid climates (Keeler 1994).

HVAC equipment can spread contamination throughout a building whether or not it is the source of colonization. Where problems are not apparent, air and dust sampling may help identify the type of contamination present and suggest probable locations. Cultures from dust samples taken from ducts, filters, and registers might help to determine if the HVAC system is colonized by mold, and if the species identified are consistent with conditions observed in the system. Consultation with a mycologist can help determine if more destructive inspection of the system is needed or whether to look elsewhere.

Figure 20. Moldy chilled water pipe insulation

Fungal contamination may occur where dust or other organic food sources are moistened by air conditioning or humidification equipment. The basic HVAC inspection should include coils, drip pans and drains, filters, insulation, air intake locations, and surfaces around diffusers. Fleecy surfaces exposed to the air stream (duct liners, fibrous insulation) are of particular concern, as they can collect dust and moisture, resulting in microbial amplification sites within the ventilation system (Levin 1990). Any visible mold growth, standing water, wet surfaces, water spray into the air stream, dust accumulation, stains or discoloration on surfaces near diffusers, condensation or dampness on porous surfaces such as insulation or air filters, inoperable (or intentionally defeated) intake air dampers, or intake of contaminated air should be noted. Damp or wet niches may occur where access for cleaning and inspection is difficult, and provide sites for fungal amplification.

Bacterial growth is likely to occur in standing water or on wet surfaces, and some of the health complaints may be similar to those for mold exposure. Bacteria can be introduced into the airstream by recycled water from humidifiers, air intakes near cooling towers, or bubbles from improperly sized P traps in condensate pan drains. When bacterial growth is encountered, the cause must be eliminated and reservoirs of contamination removed, as with mold contamination. Bacteria found in settled dust samples typically arise from the outdoors, reflect housekeeping practices, and are not generally of concern to health.

Measuring Ventilation Rate:

If necessary, seek assistance for measurements to determine if there is unbalanced air flow within the building or improper control of temperature, relative humidity, air velocity or ventilation rate. Proper ventilation (introduction of outdoor air) is important for dilution of a variety of contaminants, and a specialist may be needed to determine ventilation rates. Several methods have been developed to study air flow within buildings. One relies on direct measurement of the air flow required to induce a positive or negative pressure differential between spaces. Another determines the outdoor air ventilation rate indirectly, measuring concentrations of tracer gasses (e.g. SF_6), and using equations for conservation of mass to study air flow (Lagus 1994). Estimates are also possible from measurement of CO_2 concentrations or temperature differences.

Direct measurement of air flow uses external fans to pressurize or evacuate a structure to much higher pressure differentials than would be induced by naturally existing conditions. In large mechanically ventilated structures, the air handling units may be used as the pressurization fans (assuming the building is relatively tight). ASTM E 779-87 describes this measurement procedure. Where pressure measurements are not feasible or are undesirable, indirect measurements of gas concentrations may be used.

The three principal tracer gas techniques include the tracer dilution method, the constant injection method, and the constant concentration method. The tracer dilution method involves direct measurement of the decay of an initial concentration of gas to determine ventilation rate under ambient flow conditions, and forms the basis for ASTM E 741-83 (1990). The constant injection method measures equilibrium tracer concentration within a ventilated area, during a steady release of gas at a pre-determined rate. The gas concentration can be related to air flow rate if the tracer release rate is known. The constant concentration method measures the tracer gas release rate required to maintain a constant concentration within a ventilated zone. The quantity of tracer injected can be used to calculate the ventilation rate (Godish 1995).

Because human respiration produces carbon dioxide gas, CO_2 concentrations can be also be measured while the building is in full occupancy, with supply and return air readings compared with CO_2 in outdoor air to estimate the ventilation rate. CO_2 might also be monitored after hours when the building is unoccupied, measuring the decay of its concentration between the time the building is full and empty. Thermal balance techniques measure temperature of outdoor, return, and mixed air to estimate ventilation rate. Access problems may make thermal measurement difficult or impossible for some systems (Godish 1995).

Report and Remediation:

The Stage B inspection report may be similar to or supplement the Stage A (non-destructive) report, with additional notes for observation of concealed spaces. Documentation should include specific reference to the extent, location, and cause of observed fungal growth. Photographs and videotape are possible with an adapter for the borescope, or using mirrors and lights through cut openings. Bulk samples may be collected during the inspection to aid in documenting the nature of contamination. If the moisture source cannot be identified and eliminated, leak testing or additional destructive examination is warranted. If air and dust sampling has been conducted in advance of the inspection, visual observations should be compared for consistency with the sampling analysis and interpretation before planning remediation. If the extent and location of mold contamination can be estimated with reasonable assurance, the project can proceed to remediation. Personal protection and containment requirements for remediation can be based on existing ACGIH, NYC and EPA guidelines (Macher et al. 1999, NYC 2000, EPA 2001), with modifications based on the professional judgement of the field inspector or other remediation consultants.

Stage C - Destructive Investigation and Remediation:

A complete and systematic inspection is fairly destructive, and involves opening representative building cavities and/or HVAC components so that the extent, location, and nature of concealed mold contamination can be observed and documented with reasonable accuracy. This inspection level might be warranted if 1) concealed contamination is probable but cannot be identified using less intrusive inspection methods, 2) the need for remediation is confirmed but the location and extent cannot otherwise be determined, 3) moisture sources cannot be identified by less intrusive observation or testing, or 4) building owners wish to proceed with remediation but potential legal claims or serious health concerns require highly detailed study or documentation of existing conditions.

Careful documentation requires an orderly opening and removal process and preparation of scaled drawing notes showing the locations and allowing estimation of areas of contamination. It may also be useful to record the appearance of the colonization as well as the extent, both in photographs and field notes. Density and unusual appearances may be noted for more complete records.

Figure 22. “Light” growth

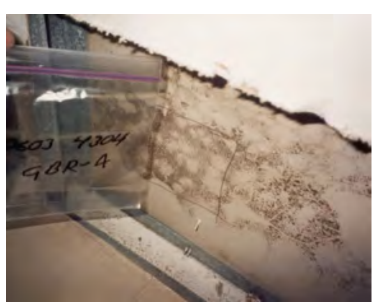


Figure 23. “Moderate”

Figure 21. “Heavy” growth

An example of field notes and photographs for a Stage C inspection is provided in Appendix F (page 75).

Procedures for Stage C Inspection:

A team of participants is likely to be required for a large scale investigation involving any significant portion of an occupied building. Detailed advanced planning is required to coordinate the work effort and anticipate project requirements in advance. Occupants should be interviewed to collect building history information. Preliminary site visit inspection must be performed to gauge the scope of the problem and problems that might be anticipated. A review of available building plans should initially be conducted to identify wall assemblies, plumbing locations, and roof or floor penetrations which might provide a path for moisture migration. Review mechanical drawings to identify HVAC system operation and locations of ducts and registers.

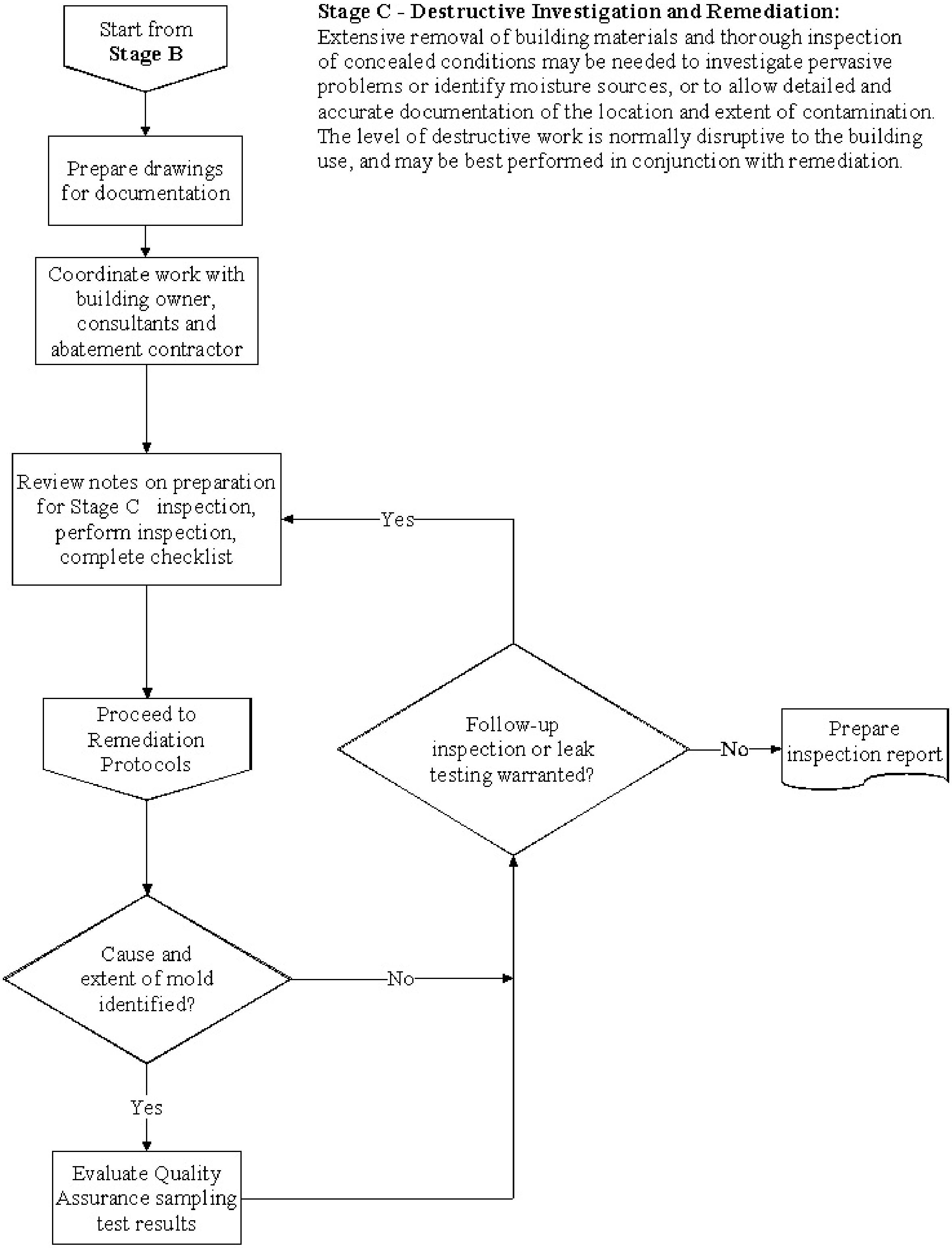
All soft materials (fabrics, carpets, etc.) should be removed from the space in advance of the inspection if possible, or covered by fire rated polyethylene sheet plastic during the inspection. HVAC diffusers and registers should be sealed. Naturally ventilated spaces should be opened to the outdoors unless adjacent occupancies prohibit ventilation. If adjacent spaces are occupied, determine if containment and negative pressurization will be required. Air in containment areas can be cleaned by air-washers, and/or exhausted through HEPA filter equipped fans. Bulk sample bags can be prepared in advance with labels, date & space designations. Blank drawings for keeping field notes should be prepared in advance if possible. The building owner and occupants must be notified of the purpose of the upcoming work and its schedule.

Care must be taken during any destructive inspection so as not to expose occupants to mold uncovered during the evaluation. Contractor activity therefore should be minimized to limit disturbance of settled dust and fungal spores, if present. The remediation team should recommend appropriate containment and protection for workers and building occupants, as the investigation assumes that mold contamination will be encountered. Review and understand ACGIH Chapter 15, NYC and EPA guidelines for remediation (ACGIH 1999, NYC 2000, EPA 2001).

The level of destructive work can be disruptive to building use, and is often best performed in concert with the remediation effort. If the inspection is performed in conjunction with remediation, the level of personal protection and containment should be based on a conservative estimate of the anticipated extent of contamination. PPE and containment should follow established ACGIH, NYC and EPA guidelines for remediation, or as otherwise indicated by the professional judgement of the field inspector.

Checklists for Stage C inspection (appendix page 69-70) and HVAC inspection (appendix, page 73) are attached. Contractor personnel working on the investigation-remediation project should also be advised of potential health risks and be cleared for use of personal protection equipment (Health Notification Form, Appendix E, page 74).

Figure 24. Stage C Inspection Flowchart



Previous inspections or testing may have established that the destructive investigation might be limited to specific areas or locations within the building. An appropriate air and settled dust sampling protocol may be useful in directing the focus of the inspection, if data is expertly interpreted. Procedures for conducting a limited inspection are similar to those for a complete building, using localized containment and depressurization to prevent the spread of contamination from the work area.

Procedure for Inspection of Wall Cavities:

The goal is to inspect every wall cavity in the area under investigation, identify the location and extent of mold growth in each wall cavity, and delineate areas requiring remediation. During the process, bulk samples may be collected and observed conditions documented as a record of the nature and extent of contamination. It is important to proceed methodically (especially when you are late or tired) so that each area receives the same level of attention, with the same procedures followed in the same way.

Figure 25. Stage C openings in wall cavities allow more thorough inspection.

Wall cavities are opened in advance of the inspection, and may be opened from either the interior or exterior side, whichever is more practical. Typically, interior wallboard repairs are more cost effective but also result in greatest occupant exposure. For inspection from the interior, one side of each wall cavity is cut along a line approx. 1 foot (.3 m) from the floor. Straight, measured cuts facilitate replacement with new materials. The bottom (cut) section should be carefully pried from supporting studs, rotated as if hinged at the floor, and laid cavity side up for inspection and documentation. The procedure allows close inspection of the base of walls where water inundation is most likely to collect and cause mold colonization. Opening the wall may permit a relatively unobstructed view of the full height of the wall cavity depending on the wall construction, and allow detailed drawings and observation notes, and photographs or videotape if necessary. Where visible contamination extends up into the wall cavity above, and where leaks from overhead roofs, decks, windows, or pipes are suspected, smaller openings should be made high on walls or ceilings, so that the leak source and extent of contamination can be identified. At wall cavities which cannot be opened from either side but are accessible through built-in cabinets or fixtures, it may be necessary to resort to inspection by borescope or cored openings. Move or remove insulation at inspection openings to perform a reasonable inspection of insulated wall cavities.

Field Notes & Samples:

Prepare drawing notes while marking locations for bulk samples on drywall. If detailed documentation is desired, drawings should include wall elevations as well as plan view drawings (see sample drawings, appendix pages 75 & 76). The extent and location of mold colonization should be sketched on wall elevation drawings with reasonable accuracy, on drawings that are prepared to scale. The relative density of observed growth can be indicated by the density of marks on drawings to assist other team members with interpretation of observations. Clean areas can remain unmarked, with light, moderate, and heavily colonized areas indicated with stippling, diagonal lines, and cross-hatching respectively. Light, medium and heavy marks indicate the density of growth, not extent. The extent of visible growth is important in estimating the affected area, and should be indicated with a line surrounding the area of visible growth, regardless of apparent density. Prepare blank drawing/note sheets in advance if possible, to minimize delay of the work.

Bulk samples typically include cuttings of removed wallboard, or removal of the paper face peeled from wallboard on the opposing wall. Photograph samples in place, with labels, before cutting. Both an overall photo for context, and close-up photo to document the in situ appearance of the sample area should be taken. An assistant is useful for cutting and bagging samples after their location has been documented.

Leave sample bags in place initially, until documentation and sampling of the area is complete. Afterward, the assistant and inspector can collect the samples together; with the assistant packing samples while the inspector checks them off on field notes, verifying that all have been properly labeled, noted on survey sheets and accounted for. Mark the limits of additional removal with a lumber crayon or marking pen for follow-up removal work if the area is to be remediated at the time of inspection.

Remediation During Inspection:

Additional removal efforts can begin as soon as inspection locations are documented and delineated by the inspector. Additional surfaces should be marked for removal to a boundary approximately 2 feet (.6 m) beyond the limits of visible contamination to assure removal of hyphal (non-sporulating) growth. If detailed documentation is required, all removal work must be done methodically and carefully, so that additional sample locations can be selected, and additional appearance notes and boundaries can be mapped on drawings. Materials must be placed so that it is immediately obvious where each piece of wallboard came from, until observations, sampling and documentation of that portion of the work is completed. Further inspection may again lead to instructions for additional removal, following the same procedures.

After sampling and documenting are complete, contaminated porous materials can be bagged, removed, and disposed of where normal construction debris is discarded. Care should be taken during handling, storage, and transport to prevent accidental exposure. All exposed surfaces in the remediation area should be cleaned by broom and brush cleaning, followed by thorough vacuum cleaning utilizing High Efficiency Particulate Air filters (HEPA filters). Vacuum cleaning should be methodical, covering every vertical or upward facing surface with at least two sets of overlapping strokes in perpendicular directions. Cleaning should proceed from the top down, and toward negative pressurization exhaust fans to avoid re-contaminating cleaned areas. Do not clean "soft" or porous surfaces (wallboard, fabrics) with water based solutions or biocides. However, "hard" and “semi-porous” surfaces (tile, glass, metal, concrete, wood) should be damp-wiped with a detergent solution and allowed to dry thoroughly before vacuuming. In critical locations (hospitals, elderly care facilities), it may be appropriate to clean hard surfaces with a 20% solution of household chlorine bleach and water, as long as occupants are isolated from exposure and workers are appropriately protected. After clean-up, settled dust may be collected and weighed to judge the effectiveness of the HEPA vacuuming effort. This quality assurance measure is particularly important if the project is large or the extent of contamination was extensive.

Report:

The inspection/remediation report should include a copy of the remediation plan, completed checklists, a compilation of field observations, laboratory analysis of any collected samples with interpretation of results by qualified professionals, results of any quality assurance testing, and recommendations for any additional required investigation or remediation of moisture problems identified during the inspection.

CONCLUSIONS

Maintaining healthful and comfortable conditions for building occupants is the primary purpose of shelter and is of primary concern to the public and to those in the construction industry. Scientific studies have shown an association between damp buildings and adverse health effects. Public agencies have recommended removal of mold colonization from occupied spaces, and have developed guidelines for its removal. All remediation efforts require identification of the extent and location of mold growth based on visual inspection. Litigation and news reports involving toxic molds has created public alarm and an increase in the demand for trained inspection services.

Responsible and effective problem evaluation will depend on the skill and experience of the inspector, but might also benefit from the establishment of standard protocols that can be adapted to individual project needs. Various stages of inspection and investigation may be required, depending on the complexity and extent of the problem. Protocols for three levels of inspection have been described for consideration or adaptation by remediation specialists, with checklists and forms to assist the inspection effort and suggested formats for field notes and documentation. Comment and revision is invited, to achieve standard protocols which are responsible and appropriate to project needs, to encourage consistent methods and procedures, and to collect data the might be useful to others. The author can be contacted by e-mail at haisley@architecturaldiagnostics.com.

Further work is needed toward collecting useful data, and on improving inspection methods for finding concealed fungal growth. An accessible database of collected health and inspection information might help inform the public and building professionals of systems and materials that require special attention during manufacture, design, inspection or remediation, and to help establish causal relationships between construction methods, moisture problems, and adverse health effects. Collected data might also help establish exposure limits for specific fungi. Affordable and improved testing techniques for locating concealed microbial growth are also needed, to improve effectiveness of inspections and reduce the disruption of more destructive methods.

ACKNOWLEDGMENTS

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APPENDIX A. OCCUPANT INTERVIEW FORM [Page 1]

Project name: ____

Address: ____

Name of Occupant: ____

Form applies to evaluation of: ☐ Home ☐ Workplace Date:________________

Interviewer name: ____

1. OCCUPANT HISTORY:

Full name: ____

Address/department: ____

____

Phone: ________________(H) ________________(W)

Fax: ____________________ e-mail:__________________________________

Age: _______ Sex: ☐ M ☐ F Occupation: __________________________

Ages of family members (if home evaluation): ______________________________

Length of occupancy: _______ years

Where do you spend the most of your time in the building? ______________________

Smoke tobacco? ☐ Yes ☐ No Contact lenses? ☐ Yes ☐ No

2. OCCUPANT HEALTH NOTIFICATION:

☐ Distribute health notification form to building occupants

3. BUILDING HISTORY:

a. Approximate age of building: ___________ years

b. Aware of any renovations or change in use? ☐ Yes ☐ No

Approximate year and nature of renovation:

Year: ________ Change: ____

Year: ________ Change: ____

Year: ________ Change: ____

Year: ________ Change: ____

c. Are drawings available for the building design? ☐ Yes ☐ No

Source or location: ____

OCCUPANT INTERVIEW FORM

d. Building is: ☐Heated ☐Air conditioned ☐Naturally ventilated

Type of HVAC system: ____

Who maintains HVAC? ____

e. Is your building often too hot? ☐ Yes ☐ No Too cold? ☐ Yes ☐ No

Description: ____

f. Thermostat setting ☐Constant ☐Changed at night ☐Off when away

g. Spaces are ☐Maintained at same temperature

☐Some are kept cooler (List)

____

____

4. Observed Moisture and Mold or Mildew Problems

a. Have you ever observed any leaks or moisture problems? ☐ Yes ☐ No

If yes, complete Moisture Event Sheet for each occurrence (page 62)

b. Have you ever observed any mold or mildew in the building? ☐ Yes ☐ No

If related to a moisture event, describe on the attached Moisture Event Sheet.

Otherwise, If <u>not</u> apparently related to a Moisture Event, describe exact location:

____

____

____

____

c. Are there any unpleasant odors in the building? ☐ Yes ☐ No

☐Musty ☐Earthy ☐Smoky ☐Dusty ☐Stale

☐Rotten ☐Chemical ☐Petroleum

Other: ____

Locations: ____

When last noticed? ____

5. When and where is it convenient to contact you if further questions arise?

☐Day ☐Evening ☐Work ☐Home ☐Phone ☐Fax ☐e-mail

☐Do not contact me again

Field Inspection Protocol for Investigation of Mold Damaged Buildings

(complete a <u>separate sheet</u> for each event) Project: ______________________________

Date: ______________________________

APPENDIX A: OCCUPANT'S MOISTURE EVENT REPORT Sheet No.:_____

Consider all locations: Bathrooms, kitchen, basement, attic, crawl space, office, mechanical equipment, bedrooms, living/dining/family rooms, windows, walls, floors, ceilings, carpets, etc.
Detailed Occupant Description:

Where was it wet? (Exact location and area affected)	

Was mold observed? (Exact location and area affected, note if cleaned by owner)	

Amount of water: ☐Damp ☐Dripping / puddles ☐standing water

Probable source of moisture (occupant's opinion):

☐ leaks through walls, decks, roofing ☐ sewage backflow
☐ condensation on building surfaces ☐ condensation on pipes, ducts
☐ leaking bath, shower, plumbing ☐ wicking of moisture from soil
☐ improperly drained yard ☐ underground water table
☐ other: ____

Frequency of Wetting

☐ Almost all the time, regardless of weather
☐ Frequently, for example on most rainy days
☐ Occasionally; for example only after heavy rains
☐ Rarely or not at all
☐ Seasonal: ☐Winter ☐Spring ☐Summer ☐Fall
☐ Don't know

For how many days was it wet/damp in the past twelve months?

☐ 0-2 days ☐ 3-7 days ☐ 8-30 days ☐ More than 30 days ☐ Don't know

If currently wet, for how many days has moisture been present? ☐ not currently wet

☐ 0-2 days ☐ 3-7 days ☐ 8-30 days ☐ More than 30 days ☐ Don't know

APPENDIX A. STAGE A - INSPECTION CHECKLIST [Page 1]

Project name: ____

Address: ____

Inspector's name: ____

Date of inspection: __________________________ Time: ________ am pm

Weather conditions: ☐Clear ☐Overcast ☐Precipitation Soil: ☐Wet ☐Damp ☐Dry

Outdoor temperature ___________°F °C Outdoor relative humidity ____________%

Building exterior

Surroundings: ☐Urban ☐Suburb ☐Rural ☐Woods/forest

Building type: ☐Single family ☐Apartment/Condominium ☐Commercial

Building age: _________ yrs. Source: ☐Owner ☐Estimate

Stories: ☐1 ☐2 ☐3 ☐4-10 ☐>10

Foundation: ☐Basement- ☐(finished) ☐(unfinished)

☐Crawl space- ☐(exposed soil) ☐(vapor barrier)

☐Retaining walls- ☐(masonry) ☐(concrete) ☐(stone)

☐Concrete slab on grade

Site slope towards building: ☐Flat ☐Sloping ☐Steep

Structural frame: ☐Wood ☐Steel ☐Concrete

Roofing: ☐Flat ☐Low slope ☐Steep

Type(s) ____

Apparent condition ☐Good ☐Poor ☐Visible damage

Siding: Type(s) ____

Apparent condition ☐Good ☐Poor ☐Visible damage

Windows: Type(s) ____

Apparent condition ☐Good ☐Poor ☐Visible damage

Occupant interview form ☐Completed ☐Not completed

Owner requests inspection for ☐Entire building ☐Selected spaces

Limits of inspection ____

Fast interior pass-through inspection (check for odors before becoming acclimated)

Noted odors ☐Yes ☐No

Location ________________________ description _________________

Location ________________________ description _________________

Location ________________________ description _________________

Location ________________________ description _________________

Project:____ **Date:** ____________________

Systematic interior walk-through (and site visit notes)

Notes on separate sheets: ☐N/A ☐Narrative by room ☐Summarized on plan drawings

Proceed in repetition through each room on each floor, in sequence from ground floor, second floor, upper floors, attic, basement/crawl space, or to limits requested by owner. Extent and location of any noted moisture stains or fungal contamination should be included in field notes.

Repeat for each room/space:

Moisture Event History ☐Yes ☐No ☐Survey sheet completed (occupant interview)

Room name: ____________________________ Use: ______________________

Finish Floor ☐Wood ☐Carpet ☐Vinyl ☐Stone ☐Ceramic tile

☐Other: ____

Wall ☐Gyp. Bd. ☐Wood ☐Plaster ☐Masonry

☐Other: ____

☐Paint ☐Vinyl ☐Fabric ☐Paper ☐Tile

☐Other: ____

Clg. ☐Gyp. Bd. ☐Wood ☐Plaster ☐Acoustical tile

☐Other: ____

Inspect ☐Floor edges ☐Carpet tack strip ☐Door sills

☐Wall base ☐Window sills & jambs ☐Ceiling/wall joints

☐Ceiling ☐Air diffusers/registers ☐Behind furnishings & drapes

☐Seams in vinyl wall coverings

Observed Damage ☐Yes ☐No (skip to next room/space)

Surface ☐Stains ☐Blisters/peeling ☐Mold / Mildew

Moisture ☐Dry ☐Damp ☐Wet

Description ____

____

Location ____

Surface area of observed fungal growth __________sf / m^2

Sampling ☐No ☐Yes Types:______________________________________

ID labels: ____

Photos ☐No ☐Yes Photo Numbers: ________________________________

Project:____ **Date:** ___________________

Kitchens	Range hood, vented to outdoors	☐Yes ☐No		
	Cooking:	☐Electric	☐Gas	
Bathrooms	☐Natural ventilation		☐Continuous fan	☐Fan on demand
Laundry	Dryer ☐Yes ☐No	vented to outdoors	☐Yes ☐No	
Firewood	☐None	☐Indoors	☐Outdoors	
Indoor plants	☐None	☐Potted	☐Indoor garden	
Mechanical	☐None	☐Yes (See HVAC Equipment Inspection Checklist)		

Prepare inspection report and recommendations:

Concealed damage ☐Probable ☐Not likely ☐Cannot determine

Inspector's estimate of extent of fungal growth in each affected room or zone:

_________________________ ___________sf / m^2 ☐Cannot estimate

_________________________ ___________sf / m^2 ☐Cannot estimate

_________________________ ___________sf / m^2 ☐Cannot estimate

_________________________ ___________sf / m^2 ☐Cannot estimate

_________________________ ___________sf / m^2 ☐Cannot estimate

Recommend	☐Proceed with remediation	☐Invasive inspection (Stage B)
	☐Additional testing	☐Destructive inspection (Stage C)

Recommended additional investigation: ____

____

____

Probable cause of damage: ____

____

____

Recommendations for prevention: ____

____

____

Recommendation for remediation: ____

____

____

Recommended quality assurance: ____

____

____

APPENDIX B. **STAGE B - INSPECTION CHECKLIST** [Page 1]

Project name: ______________________________

Address: ______________________________

Inspector's name: ______________________________

Date of inspection: ____________________ Time: _________ am pm

Weather conditions: ☐Clear ☐Overcast ☐Precipitation Soil: ☐Wet ☐Damp ☐Dry

Outdoor temperature ___________°F °C Outdoor relative humidity ____________%

This level of inspection involves a visual evaluation of concealed wall cavities and building envelope components by borescope or cutting inspection openings. Proceed in locations of observed surface staining or mold contamination identified in Stage A inspection, or where mold contamination is suspected but unconfirmed, or where contamination may be likely, based on sampling results. Evaluate all exterior walls and interior plumbing walls in areas under investigation. The extent and location of any noted moisture stains or fungal contamination should be included in field notes.

Occupant interview forms completed? ☐Yes ☐No

Stage A inspection completed? ☐Yes ☐No

Sample analytical report available? ☐Yes ☐No

Locations of interest: ______________________________

Sampling required before inspection? ☐Yes ☐No

☐Establish sampling protocol ☐Interpret results

Building Plans available? ☐Yes ☐No Reviewed? ☐Yes ☐No

Roof assembly (list materials from exterior surface to interior)	______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________

Exterior wall assembly (list materials from exterior surface to interior)	______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________

HVAC equipment ☐Yes ☐No cross contamination possible? ☐Yes ☐No

HVAC inspection checklist completed ☐Yes ☐No

APPENDIX B. STAGE B - INSPECTION CHECKLIST [Page 2]

Project:____ **Date:** __________________

Field Notes Label and sketch plan view of space on left, note observations and sample designations on right. Draw lines to connect notes with location on plan. Inspect minimum two stud spacings beyond limits of any observed contamination.

Room / space name ____________________	Notes:

APPENDIX B. STAGE B - INSPECTION CHECKLIST [Page 3]

Project:____ **Date:** ___________________

Can cause and extent be identified? ☐Yes ☐No

Prepare inspection report and recommendations:

Additional concealed damage ☐Probable ☐Not likely ☐Can't determine

Inspector's estimate of extent of fungal growth in each affected room or zone:

__________________________ ____________sf / m^2 ☐Cannot estimate

__________________________ ____________sf / m^2 ☐Cannot estimate

__________________________ ____________sf / m^2 ☐Cannot estimate

__________________________ ____________sf / m^2 ☐Cannot estimate

__________________________ ____________sf / m^2 ☐Cannot estimate

__________________________ ____________sf / m^2 ☐Cannot estimate

__________________________ ____________sf / m^2 ☐Cannot estimate

Recommend ☐Proceed with remediation

☐Additional testing ☐Destructive inspection

Probable cause of damage: ____

____

____

Recommendations for prevention: ____

____

____

Recommendation for remediation: ____

____

____

Recommended additional investigation: _______________________________________

____

____

Recommended quality assurance: ____

____

____

APPENDIX C. STAGE C - INSPECTION CHECKLIST [Page 1]

Project name: ____

Address: ____

Inspector's name: ____

Date of inspection: ____________________________ Time: ________ am pm

Weather conditions: ☐Clear ☐Overcast ☐Precipitation Soil: ☐Wet ☐Damp ☐Dry

Outdoor temperature ___________°F °C Outdoor relative humidity ____________%

This level of inspection may be warranted if significant mold growth is confirmed by testing but its cause or location cannot be identified by less destructive means, or if potential legal or health claims require detailed documentation, or if investigation is performed as part of an extensive remediation effort.

Completed occupant interview form ☐Yes ☐No Stage A or B inspection ☐Yes ☐No

Consultants ☐ Industrial hygienist ☐ Mycologist ☐ Mechanical engineer

☐ Remediation contractor ☐ HVAC contractor ☐ Building envelope specialist

☐ Health care specialist ☐ Other: ______________________________________

☐ Establish protocols for sampling ☐Before ☐During ☐After

☐ Establish detail of required project documentation

Inspection involves ☐Entire building ☐Part of occupied building

Will remediation be performed during the inspection? ☐Yes ☐No

A preparation checklist for Stage C inspections is provided in appendix pages 71, 72.

Owner contact: ________________________________ Phone: ____________________

Contractor contact: ________________________________ Phone: ____________________

☐ Occupants notified of the purpose and schedule for investigation

☐ Establish requirements for containment and levels of personal protection

Negative pressurization ☐Required ☐Not required

☐½ mask respirators ☐Full face positive air pressure respirators (PAPR)

☐Plan entry & egress ☐Plan ventilation & exhaust filtration

☐Plan decontamination ☐Plan barriers

☐Seal HVAC registers ☐Evaluate impact of opening wall cavities

☐ Distribute Health Notification Form for remediation personnel

☐ Prepare separate blank drawing sheets for field notes ☐Plans ☐Elevations

☐ Walk through with contractor to review work requirements and check work preparation

☐ Mark wall locations for cutting and inspection

Project:____ **Date:** ____________________

☐ Establish critical barriers for containment

☐ Check pressure differential in containment area

☐ Open wall cavities for inspection - initial phase

☐ Remove vinyl wall coverings from air-conditioned spaces

☐ Document locations of moisture or mold contamination and bulk sample locations

☐ Mark surfaces for additional removal or inspection

- ☐ At locations where inspection suggests additional growth
- ☐ To 2 feet (.6 m) beyond limits of visible growth

☐ Remove contaminated materials and open additional areas for inspection

☐ Repeat opening, inspection, documentation, and marking until visible growth is removed

☐ Identify probable cause of damage

Prepare inspection report and recommendations:

Estimated total extent of fungal growth: ____________sf / m^2

Probable cause of damage: ____

Recommended additional investigation: ____

Recommendations for problem prevention: ______________________________________

Recommendation for remediation (if not part of inspection): _______________________

Recommended quality assurance: ____

NOTES ON PREPARING FOR A STAGE C INSPECTION [Page 1]

Inspector's Preparation Checklist:

☐ Identify list of inspection spaces
☐ Review building plans, if available
☐ Coordinate inspection/remediation goals with other consultants
☐ Get room, air, car reservations if needed
☐ Prepare blank survey drawing sheets in advance, if possible
  minimum: floor plans for each space
  preferred: interior elevations showing one side of each wall
☐ Provide contractor with health notification form regarding health risks

Check supplies for sampling

☐ (1) ½ mask HEPA filtered respirator (cutting samples)
☐ (1) eye protection (cutting samples)
☐ (5) disposable gloves (handling drywall)
☐ (1) utility knife or drywall saw (cut samples)
☐ (125) Ziplock sandwich bags (bag samples)
☐ (125) index cards (to label samples)
☐ (3) felt marking pens (to mark labels)
☐ (2) #2 lead pencils or lumber crayons (to mark drywall)
☐ (1) sample bag (carry samples)

Check supplies for inspection & documentation (supplies for 1 day)

☐ (?) blank survey sheets, min. 2 copies for ea. condition
☐ (1) mech. pencil w/ soft lead & eraser (notes)
☐ (1) camera & spare batteries
☐ (5) film rolls or additional digital memory cards
☐ (1) flashlight & spare batteries
☐ (1) small inspection mirror w/ handle
☐ (1) large inspection mirror
☐ (1) extension cord & drill
☐ (1) HEPA filter equipped vacuum cleaner
☐ (1) sheet plastic and tape
☐ (1) borescope
☐ (1) borescope bulb (spare)
☐ (1) video camera w/ light & spare battery (if video required)
☐ (4) blank video cassettes (unwrapped, w/ sequence labeled on tape)
☐ (1) video battery charger

Notes on Field Notes: Prepare survey sheets in a useful size before the inspection. Use pencil, not pen. On plan views (non-destructive examinations), hash marks can indicate the observed mold locations, as well as the side of the wall cavity where mold was observed. Relative density of marks on drawings approximate the density of observed mold growth. On plan views, keep notes outside the drawing area to the extent possible, with a lines or arrows to indicate location. Notes can be taken from one side or the other of each wall, and placed on a single wall elevation. Notation on interior elevation drawings can be made in two different colors of pencil to signify the inboard side or outboard side of the wall cavity, or separate sheets can be labeled and used for each side of the wall cavity. Each sample must be located on either an elevation drawing, or on a plan view with it's elevation above floor level noted. "Clean" samples (if required) should have CLN written after the sample designation. A description of "dirty" samples is optional but may be useful if describing something the camera will not. A short wavy line can be used to indicate walls which are filled with insulation.

Notes on Photos: Photograph with flash. Steady the camera for focused shots. Photograph the building address or room number before entry, to key the photos to the location. Photograph any interesting conditions observed which may be useful to illustrate or understand damage, such as mold concentrated below pipes or electrical slab penetrations, under windows, around electrical outlets, behind wall coverings, in plumbing or duct enclosures, or any apparent sources of water. Mark the camera location on a plan view drawing for each photo, indicating photo number for each shot. (note: photos which include legible sample labels do not need to be marked on plans, as the location can be identified in the sample location field notes) Take an overall photo paired with close up photos, to clarify the location and the surrounding context of each close-up shot. Close up photos should clearly show the appearance of each sample, together with the sample label or labeled sample bag. Photos are cheap and there will never be an opportunity to return and shoot conditions again. Don't shoot indiscriminately, but don't scrimp on film (or memory for digital cameras). Aim for completeness, clarity, and balance between overview shots and close up shots.

Notes on Video Tape: Videotape unit with video light on. Narrative comments on observations are useful to orient viewers and supplement observations with descriptions of what can be seen where the video camera can't record. Commentary should include description of observations only, unless final conclusions and opinions can be drawn. Avoid speculation about cause and effect of observed conditions.

> Start videotape at one entry door. Tape each overall space upon entering, including wallboard on floors. Tape all wall cavities at every wall, in sequence, following the perimeter of each space, beginning at the entry door of each space and proceeding in logical sequence through each space. A consistent and predictable sequence for the videotaping is critical, so that you or other viewers can later tell where the video camera is at all times. It is best to start at the entry door and continuously tape each space following one wall around every corner and along the base of every wall and into each inspection opening, moving slowly either clockwise or counter-clockwise, until you eventually end up back at the starting point.

Notes on Bulk Samples: Choose an identification method that suits the project, and allows each sample to be uniquely identifiable and keyed to notes. Date/Building/UnitNo. or Room/sample number codes can work well for sample bags, while Room/Sample No. is usually adequate for location notes on drawings which already include dates, building and unit numbers. Include a chain-of-custody record with samples during transport.

APPENDIX D. HVAC EQUIPMENT INSPECTION CHECKLIST

Project name: ______________________________

Address: ______________________________

Inspector's name: ______________________________

Date of inspection: ____________________ Time: ________ am pm

Weather conditions: ☐Clear ☐Overcast ☐Precipitation Soil: ☐Wet ☐Damp ☐Dry

Outdoor temperature __________°F °C Outdoor relative humidity __________%

Indoor temperature __________°F °C Indoor relative humidity __________%

Type of system: ☐Heating ☐Cooling ☐Heating & cooling

☐All air distribution: ☐Constant air volume ☐Variable air volume

☐Supply air to fan coil units ☐Water only, to fan coils in rooms

Located: ☐Plans ☐Balancing reports ☐Number & location of zones

☐Air duct configuration ☐Locations of supply diffusers & return grills

☐System controls ☐Outdoor air intakes

Inspected: ☐Cooling coils ☐Condensate pans ☐Drains ☐Humidifiers

☐Outdoor air intake ☐Outdoor air dampers

☐Filters: ☐Dust spot efficiency: ______% ☐Fractional efficiency: ______%

Condition/comment: ______________________________

Controls: ☐Thermostat ☐Humidistat ☐Both

Ducts: ☐Rigid ☐Flexible ☐Lined (inside) ☐Insulated (outside)

Airstream: ☐Note locations of porous insulation on airstream surfaces:

____

____

Outdoor air ventilation rate: __________ ☐CF/min/person, ☐L/s/pers, ☐Air changes/hour

Method: ☐Fan ☐CO_2 ☐Tracer gas ☐Temperature ☐Not determined

Observations: ______________________________

____

____

____

Recommendations: ______________________________

____

____

____

APPENDIX E. HEALTH NOTIFICATION FORM

Hazards from Excess Inhalation Exposure to Molds

People are normally and continuously exposed to fungi through inhalation and ingestion without apparent ill effect, but unusual exposure or sensitivity increases the risk of adverse health effects. Susceptibility to the effects of mold exposure varies from person to person depending on the individual. Allergic responses or allergy-like symptoms, such as irritation of eyes, nose and throat, runny nose, and rashes, are the most commonly reported problems in sensitized persons. Development of an allergy depends on the persons genetic ability to respond to a fungal antigen, the exposure level, and the duration of exposure. An otherwise healthy individual might therefore develop a mold allergy after sufficient or prolonged exposure.

Although rare, more severe health effects such as asthma attacks, infections, or toxic reactions are also possible. People with respiratory problems such as allergies or asthma, and those with compromised immune systems are at greater than normal risk of developing illness.

Fungi which are able to grow at body temperatures can cause infection. Several species of *Aspergillus* are known to cause aspergillosis. Other fungi found in bird or bat droppings can cause disease. A healthy immune system normally prevents infection, but immuno-suppressed persons are at risk. Building occupants such as the elderly, and those who are being treated for cancer, cystic fibrosis, HIV infection, diabetes mellitus, renal dysfunction, splenic disorders, alcoholism, cirrhosis, or organ transplant, and those receiving immunosuppressive medications (e.g. corticosteroids or chemotherapy) should consult with their physician about potential health effects of exposure. Pregnant women and infants may also be at increased risk. Such persons may need to be removed from moldy areas before or during remediation, and their health condition evaluated before and after returning.

Ingestion of toxic species of molds (e.g. *Stachybotrys chartarum*) can induce toxicosis, resulting in mucous membrane irritation , skin rash, dizziness, nausea, immuno-suppression, birth defects, or cancer. Inhalation of mycotoxins produced by these species has not been demonstrated to cause serious illness, but is currently under scrutiny. Because of the severity of potential health effects, a conservative approach is recommended for limiting exposure.

People performing remedial cleaning of widespread fungal contamination who are exposed to very large concentrations of spores risk developing organic dust toxic syndrome (ODTS) or hypersensitivity pneumonitis (HP) unless properly protected. Except in remediation of very heavily contaminated indoor environments, such high level exposures are not expected to occur while performing remedial work. Construction personnel with asthma or known mold allergies should receive clearance from their personal physicians, or not be engaged in mold remediation projects. Others should be properly fit-tested and familiar with respirator use, and wear appropriate personal protective equipment.

More complete information on mold exposure and health effects can be found in:

Macher, J., Amman, H.A., Burge, H.A., Milton, D.K., and Morey, P.R. (Editors) (1999) *Bioaerosols: Assessment and Control*, Cincinnati, OH, American Conference of Governmental Industrial Hygienists. (Chapters 8 and 19)

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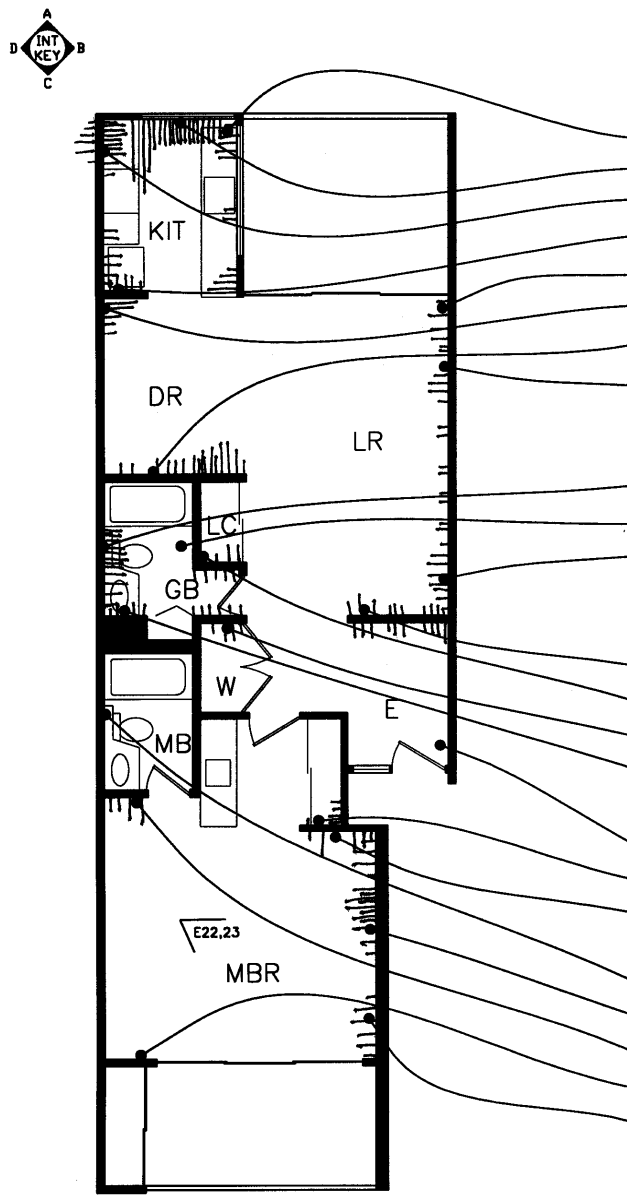
APPENDIX F. SAMPLE FIELD INSPECTION NOTES & PHOTOS [Page 1]

SAMPLE FIELD NOTES - PLAN DRAWING

FIELD NOTES FOR INVESTIGATION AT: SAMPLE PROJECT

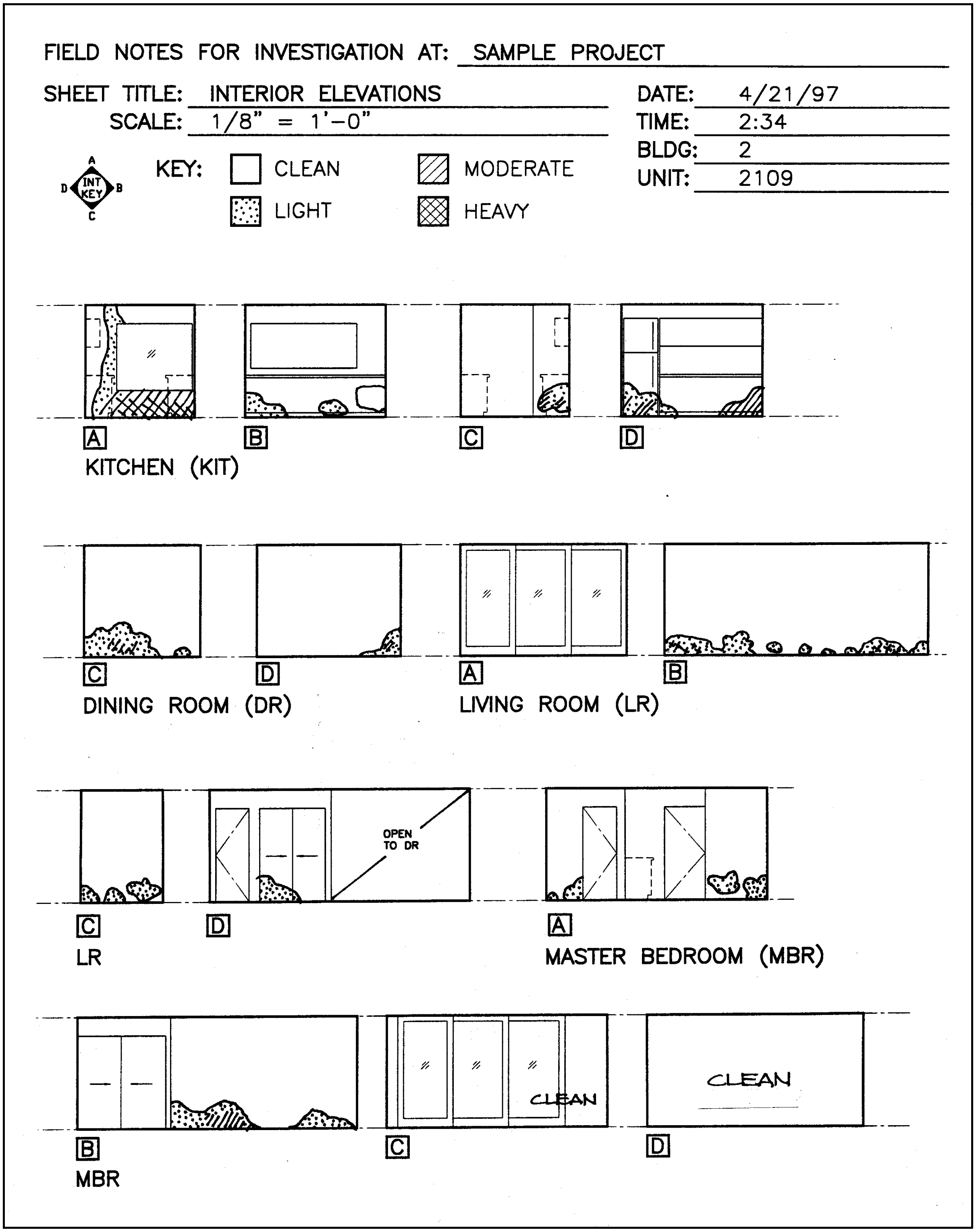
SHEET TITLE: SAMPLE PLAN DRAWING
SCALE: 1/8" = 1'-0"

DATE: 4/21/97
TIME: 2:34 P.M.
BLDG: 2
UNIT: 2109



	(PHOTOS)
K1, 8", LT SPOTS	(F3)
K2, 12", HVY	(F4)
K3, 8", BLK	(F5)
K4, 10", BLK	(F6)
L1, 0", BLK SPOTS	(F2)
D1, 6", BRN/TAN	(F7)
D2, 6", SPECKLED	(F8)
L4, 0", LT SPOTS	(F24)
GB2, 8"	(F11)
GB1, 0", HVY BLK, GRN	(F10)
L3, 0", BLK SPOT	(F23)
L2, 6", LT SPECKLED	(F22)
LC1, 10", LT SPECKLED	(F9)
W1, 0", LT	(F13)
GB3, 40", SHAFT	(F12)
E1, 0", CLN	(F21)
MBC1, 6", LT SPOTS	(F20)
MBR5, 6" UNDER OUTLET	(F19)
MB1, 8", CLN	(F14)
MBR4, 0", UNDER OUTLET	(F18)
MBR1, 0", BLK SPOT	(F15)
MBR2, 12", CLN	(F16)
MBR3, 0", UNDER OUTLET	(F17)

SAMPLE PAGE FROM FIELD NOTE ELEVATIONS



APPENDIX F. SAMPLE FIELD INSPECTION NOTES [Page 3]

PHOTOS FROM SAMPLE INSPECTION (visible interior surfaces had been previously cleaned and painted; all growth was hidden prior to this Stage C inspection)

Photo E21 - Label film in sequence, and photograph door numbers on entry to aid in later identification.

Photo E22 - Shoot overall view of each room. Wallboard is cut in advance to allow inspection of back side.

Photo E23 - Closer view of moderate growth along base of bedroom wall.

Photo E25 - Overall view of light growth in a wall cavity.

Photo F2 - Light to moderate spots of black mold, near living room door jamb (non-viable *Stachybotrys chartarum*).

Photo F3 - Light growth was found in kitchen wall cavity by borescope inspection, after coring through back of kitchen cabinet.

Photo F4 - Sample taken at heavy growth under kitchen window (*Stachybotrys, Penicillium, Aspergillus*).

Photo F5 - Wallboard sample from core. Inspection through back of kitchen cabinet revealed heavy black growth.

Photo F6 - Moderate to heavy black growth, by refrigerator at kitchen.

Photo F7 - Light to moderate growth in dining room demising wall cavity (non-viable *Stachybotrys*, culturable *Aspergillus* and *Penicillium* spp.)

Photo F8 - Moderate to heavy growth in dining room wall at sample location (non-viable *Stachybotrys* with culturable *Cladosporium, Eurotium*)

Photo F9 - Speckled pattern of light growth in living room closet wall. (*Cladosporium, Eurotium*)

Photo F10 - heavy black and green growth in guest bath wall. (*Stachybotrys, Cladosporium*)

Photo F11 - Core sample for inspection where access is difficult.

Photo F12 - Core from duct shaft enclosure revealed mold between layers

Photo F13 - Light growth in washing machine/dryer closet. (*Eurotrium, Talaromyces, Penicillium, Stachybotrys*)

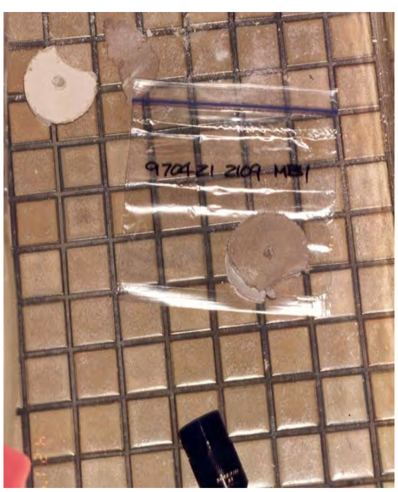


Photo F14 - Clean core from master bath wall.

Photo F15 - Black spots in light growth, master bedroom wall. (*Penicillium, Cladosporium, Eurotrium*)

Photo F16 - Clean wall cavity & sample at master bedroom.

Photo F17 - Light mold growth under flooded electrical conduit. (*Cladosporium*, yeast, *Eurotrium, Penicillium*)

Photo F18 - Moderate growth under flooded electrical conduit at master bedroom. (*Cladosporium, Aspergillus, Eurotrium*, yeast)

Photo F19 - light growth around flooded electrical conduit at master bedroom.

Photo F20 - Sample taken at light growth in master bedroom closet wall.

Photo F21 - Sample taken at clean location by entry door.

Photo F22 - Sample from light, speckled growth pattern in living room wall. (*Cladosporium, Penicillium*)

Photo F23 - Isolated black spots (*Stachybotrys*) in field of very light growth (*Talaromyces flavus, Penicillium citrinum*) in living room wall.

Photo F24 - Light patches in living room wall cavity (sample contained only non-sporulating isolates)

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