2007) found evidence of a link between sodium hypochlorite-based bleach exposures and increased risk of illness. Three linked asthma or atopy consistent with asthma to exposures to QACs. Two of these were clinical study reports that attributed exposure to QACs (benzalkonium chloride, dimethylbenzyl ammonium) to the development of four cases of asthma (Burge and Richardson 1994, Purohit et al. 2000). One was an epidemiological study of Dutch pig farmers that linked use of QACs to the development of atopic sensitization (Preller et al. 1996). Note: One additional study (Gorguner et al. 2004) linked RADS with exposure to a mixture of chlorine bleach and hydrochloric acid.

- An epidemiological study identified cleaners, construction workers, laborers, equipment cleaners, and motor vehicle operators as having a high risk of work-related wheezing (***odds ratio*** [OR] > 4.5). Persons employed in protective services occupations and as equipment cleaners were reported as having a high risk of work-related asthma (OR > 9.0) (Arif et al. 2003).

- Henneberger identified the seven most frequently reported agents for RADS as cleaning materials (15 percent), unspecified chemicals (8 percent), chlorine (7 percent), solvents (7 percent), acids-bases (6 percent), smoke (6 percent), and diesel exhaust (6 percent) (Henneberger et al. 2003).

- A case-control study of 521 cases and 932 controls found relationships between asthma and occupations. The link was strongest for men and women in the chemical, rubber, and plastic industries (OR 5.69, 2.61, and 1.72, respectively); for men only as bakers and food processors (OR 8.62), textile workers (OR 4.70), electrical and electronic workers (OR 2.83), laboratory technicians (OR 1.66), and storage workers (OR 1.57); and for women only as dental workers (4.74), wait staff (OR 3.03), and cleaners (OR 1.42) (Jaakkola et al. 2003).

- A large epidemiological study of 2,414 cleaners and 5,235 administrative workers found that the cleaners had a greater risk of adult-onset asthma compared to the administrative workers (***relative risk ratio*** 1.5) (Karjalainen et al. 2002).

- In a ***cross-sectional study*** of 4,521 women, asthma was more prevalent in a group of 593 women then employed in domestic cleaning (OR 1.46). Asthma strongly correlated to a group of 1,170 former cleaning women (OR 2.09) (Medina-Ramón et al. 2003).

- The cases of 160 domestic cleaning women who had contracted asthma, chronic bronchitis, or both were nested in a large population-based survey that included 386 nonsymptomatic women. Women who had asthma, chronic bronchitis, or both used bleach more frequently than did controls (OR 3.3 for intermediate exposures and 4.9 for high exposures). Airborne chlorine levels were measured. Asthma symptoms in domestic cleaning women were associated with exposure to bleach and possibly other irritant agents in a case-control study (Medina-Ramón et al. 2005). This study was a follow-up to an earlier study that found a link between asthma risk and cleaning professions (Medina-Ramón et al. 2003). The earlier study did not collect data that would allow insights into the agents related to asthma risk; however, the follow-up study collected data by suspected agent.

- An epidemiological study of 394 occupational asthma cases found an association between the occupation of cleaner and occupational asthma (Mendonça et al. 2003).

- A pharmacist developed occupational asthma. The reported cause was exposure to a floor cleaner containing dimethylbenzyl ammonium chloride (a QAC). Substituting a different floor cleaner resulted in significant improvement in serial peak flow measurements (Burge and Richardson 1994).

- A ***longitudinal study*** of parents and children determined the frequency with which pregnant women used 11 domestic products. A total chemical burden score was derived based on the sum of the frequency of use for the products; high total chemical burden scores correlated with persistent wheezing during early childhood (OR 2.3). The chemicals and the percentage of women using them included disinfectants (87 percent), bleach (85 percent), aerosols (72 percent), air fresheners (spray, stick, or aerosol) (68 percent), window cleaner (61 percent), carpet cleaner (36 percent), paint or varnish (33 percent), turpentine (23 percent), pesticides (21 percent), stripper (5.5 percent), and dry cleaning fluid (5 percent) (Sherriff et al. 2005).

- A case-control study to investigate the agents in cleaning activities that lead to reported asthma found that the prevalence of asthma was 1.7 times higher among cleaners than referents. The increase in asthma was associated with kitchen cleaning, furniture polishing, and the use of oven sprays and polishes (Zock et al. 2001).

- Rosenman et al. (2003) reported on 1,915 cases of adult-onset or work-related asthma. Exposure to cleaning products across a wide range of occupational settings was linked to 236 cases; the most commonly reported occupations were janitors and cleaners and housekeepers (52) and nurses and nurses' aides (37). The two most commonly reported agents were unspecified cleaning products (107 cases) and bleach (43 cases).

- Three cases of asthma symptoms were reportedly triggered by the handling of a QAC (benzakonium chloride) used as a disinfectant in hospital settings. Reference was made to a Swiss study linking QACs to contact dermatitis and to four asthma case studies associated with QACs (Purohit et al. 2000).

- RADS associated with the use of a mixture of household bleach and hydrochloric acid was reported in a retrospective case study in Turkey (Gorguner et al. 2004).

- A robust longitudinal study found a dose-response relationship between the use of household spray cleaners and asthma and wheeze events. ***Relative risk ratios*** for furniture-polish, glass-cleaning, and air-freshening sprays ranged from 1.54 to 2.0 for these products. Solvent, ammonia, and bleach cleaning products had relative risk ratios ranging from 1.12 to 2.0 (Zock et al. 2007).

- In a follow-up study to Medina-Ramón et al. (2005), 43 domestic cleaners with a recent history of asthma or chronic bronchitis kept diaries recording respiratory symptoms, peak expiratory flow, and respiratory exposures (cleaning products and tasks, smoking status). Regression models found that lower respiratory symptoms were associated with diluted bleach (OR 4.4), degreasing sprays (OR 6.9), and air fresheners (OR 7.8) (Medina-Ramón et al. 2006).

- An epidemiological study of atopic sensitization in 194 Dutch pig farmers found an association between the use of QACs and atopy (OR 6.5) (Preller et al. 1996).

4.2.2 Cases Reporting Exposure to Chlorine Gas or Chloramines After Mixing Products

Five studies and four cases were found that reported injuries occurring because bleach containing sodium hypochlorite was mixed with other compounds, releasing materials more hazardous than the hypochlorite itself. In residential and commercial buildings, the most common occurrences appear to be mixing with sodium hypochlorite with ammonia-based cleaners or drain opener. Figure 5, from the Chlorine Institute, summarizes problem mixtures. Reported symptoms range from minor acute effects to serious health hazards.

- Five episodes of temporary illness were reported among patients performing cleaning chores in a psychiatric hospital who mixed bleach with phosphoric acid cleaner. The symptoms included chest tightness, difficulty breathing, eye and throat irritation, nausea, cough, and headache (CDC 1991).

- An elderly woman with a brain tumor was reported to have died while using a mixture of chlorine bleach and ammonia to clean a bathroom (Cohle et al. 2001).

- A study of construction workers exposed to an accidental release of chlorine gas in a paper mill bleach plant found that 60 percent of 281 workers experienced flu-like symptoms; eye, nose, and throat irritation; cough; and headache. Shortness of breath not associated with age, smoking, or a history of asthma or chronic bronchitis was reported by 54 percent of the workers (Courteau et al. 1994).

- During the course of 1 year, 216 cases of exposure to chlorine or chloramine gas after mixing cleaning products at home were reported to a regional poison control center. The most frequently reported symptom was cough (180 cases); other reported symptoms were shortness of breath, throat irritation, chest pain, wheezing, dizziness, vomiting, eye irritation, and nasal irritation. Symptoms did not persist after 6 hours for 200 cases (Mrvos et al. 1993).

Figure 5. Sodium hypochlorite (bleach) incompatibility chart.

The Chlorine Institute, Inc.
1300 Wilson Boulevard
Arlington, VA 22209
Ph: 703-741-5760 // www.CL2.com

Sodium Hypochlorite Incompatibility Chart

Do NOT mix Sodium Hypochlorite (bleach) with ANY other chemical unless adequate engineering controls and personal protective equipment (PPE) are in place. Accidental mixing may cause dangerous conditions that could result in injury to personnel and/or damage to property or the environment.

Incompatible Material	Mixing May Result In
Acids, Acidic Compounds and Acid Based Cleaning Compounds such as: - Alum (Aluminum Sulfate) - Aluminum Chloride - Ferrous or Ferric Chloride - Ferrous or Ferric Sulfate - Chlorinated Solutions of Ferrous Sulfate - Hydrochloric Acid (HCl) - Sulfuric Acid - Hydrofluoric Acid - Fluorosilicic Acid - Phosphoric Acid - Brick and Concrete Cleaners	- Release of chlorine gas, may occur violently.
Chemicals and Cleaning Compounds containing ammonia such as: - Ammonium Hydroxide - Ammonium Chloride - Ammonium Silicofluoride - Ammonium Sulfate - Quaternary Ammonium Salts (Quats)	- Formation of explosive compounds. - Release of chlorine or other noxious gases.
Organic Chemicals and Chemical Compounds such as: - Solvents and Solvent Based Cleaning Compounds - Fuels and Fuel Oils - Amines - Propane - Organic Polymers - Ethylene Glycol - Insecticides - Methanol	- Formation of chlorinated organic compounds. - Formation of explosive compounds. - Release of chlorine gas, may occur violently.
Metals such as: - Copper - Nickel - Cobalt - Iron Avoid piping and material handling equipment containing stainless steel, aluminum, carbon steel or other common metals.	- Release of oxygen gas, generally does not occur violently. Could cause overpressure/rupture of a closed system.
Hydrogen Peroxide	- Release of oxygen gas, may occur violently.
Reducing agents such as: - Sodium Sulfite - Sodium Bisulfite - Sodium Hydrosulfite - Sodium Thiosulfate	- Evolution of heat, may cause splashing or boiling.

- Two episodes involving 72 soldiers who were exposed to chlorine gas from mixing bleach and ammonia during a "cleaning party" were reported to have resulted in acute respiratory symptoms (Pascuzzi and Storrow 1998).

- Three case studies of toxic pneumonitis caused by exposure to a mixture of bleach and ammonia and resulting in serious long-term injury were reported (Reisz and Gammon 1986).

- Correspondence in the *New England Journal of Medicine* reported a case of exposure to chloramine gas released by mixing household bleach with an ammonia-based cleaner; chest X-rays showed pneumonitis developed over the course of 4 hours (Tanen 1999).

4.3 Irritancy Effects of Cleaners and Disinfectants

Three sources describe irritancy effects associated with cleaners and disinfectants:

- A textbook on irritant dermatitis reports the irritant properties of cleaners and disinfectants: soaps and detergents, antiseptics and disinfectants, and acids and alkalis. Chapping, redness, scaling, and fissuring may result from exposure to soaps and detergents. (The removal of intracellular lipids is described as the mechanism.) Benzalkonium chloride (a QAC) is reported as a known cause of acute contact dermatitis. Acids are reported to denature proteins, and alkalis are reported to denature lipids (Chew and Maibach 2005).

- An overview of risk while cleaning identifies disinfectants as the most hazardous group of agents covered. Sodium hypochlorite is reported to cause allergic contact dermatitis (Wolkoff et al. 1998).

- A study of acute occupational disinfectant-related illness in adolescent workers found that hypochlorites were responsible for 45 percent of the 307 cases. Seventy-eight percent of the illnesses were mild, and there were no fatalities. Two hundred-six cases involved disinfectants whose EPA toxicity category was known; 80 percent were rated Category 1, the highest toxicity level (Brevard et al. 2003).

4.4 Behavior That Leads to Exposure to Cleaners and Disinfectants

Six references were found that provide insight into behaviors that lead to exposures. Two references link increased exposures or health endpoints to the use of sprayers.

- Exposure potential was assessed by watching subjects during cleaning activities; the strength of the warning labels was intended to be used to study the frequency and amount of use by suggested hazard, but only a tiny fraction of subjects read the labels. Thirty-nine percent of women and 15 percent of men reported using protective gloves (Kovacs et al. 1997).

- In a study of consumer behavior to provide a basis for estimating exposures to dishwashing detergents, cleaning products, and hair-styling products, bleach was included as a toilet-cleaning product. Four of 29 subjects wore gloves during toilet cleaning; diaries, observation, and videos were used to assess behaviors. Exposures occurred during mixing, checking suds, rinsing the cap, spills on the package, rinsing the cleaning cloth, wiping with the cloth, and clearing away suds. Subjects were seen to have hand-to-mouth contact during cleaning (Weegels and van Veen 2001).

- A study of dermal exposures during mixing, spraying, and wiping found that exposures for hands during the large-scale disinfection of countertops and fume hoods by wiping for 1 hour per day were more than 100 times greater than the exposures from wiping a small section of countertop for 10 to 15 minutes per day. Although there were essentially no exposures to

head, arms, legs, or chest during the small-scale disinfection, there were significant exposures to these areas during the large-scale disinfection (Hughson and Aitken 2004).

- A longitudinal study of the incidence of eye symptoms, nose or throat symptoms, nose and throat symptoms, asthma, and bronchitis among 1,011 cleaners and former cleaners found that those who began using sprayers to apply cleaning products partway through the study increased the risk of eye irritation (OR 1.3), nose/throat irritation (OR 2.0), asthma (OR 2.4), and bronchitis (OR 1.9) (Nielsen and Bach 1999).

- A study of dermal and inhalation exposures to diisocyanate and oligomers found that increased inhalation and dermal exposures correlate with spraying paint. The use of gloves during spraying reduces dermal exposures (Pronk et al. 2006).

- A longitudinal study examining a hypothesized link between the use of cleaning sprays and adult asthma was conducted as a follow-up to the first phase of the European Community Respiratory Health Survey. A consistent dose-response relationship was found between the frequency of use of cleaning sprays and the relative risk of having asthma events or wheeze within the previous year. The relationship held for a wide variety of sprays as well as for individual sprays (e.g., furniture-polish, glass-cleaning, and air-freshening sprays). Liquid cleaners not used as sprays had significantly lower relative risk ratios than spray-applied products. The authors hypothesize that sprays facilitate respiratory exposures (Zock et al. 2007).

The most comprehensive review of cleaning materials and health-effects literature was found in a research report to the California Air Resources Board (Nazaroff et al. 2006). Exposure mechanisms were grouped into seven categories. Table 8, based on Table 2.2 in Nazaroff et al.'s final report, lists the seven exposure mechanisms and provides examples of each one from previous literature cited in that report.

Table 8. How Cleaning Product Use Can Influence Inhalation Exposure to Air Pollutants

Mechanism	Examples
Volatilization	Formaldehyde from wood-floor cleaning spray (Akland and Whitaker 2000; Figure 4-11); glycol ethers from hard-surface cleaners (Zhu et al. 2001; Gibson et al. 1991)
Production of airborne droplets	Aerosol or pump-spray delivery of surface cleaning products; some spray droplets remain airborne instead of depositing (Fortmann et al. 1999; Roache et al. 2000)
Suspension of powders	Fine particulate matter from carpet freshener (Steiber 1995); sodium tripolyphosphate from carpet cleaner (Lynch 2000)
Suspension of wear products	Surfactants, film formers, complexing agents, acids and bases, and disinfectants (Wolkoff et al. 1998; Vejrup and Wolkoff 2002)

Mechanism	Examples
Inappropriate mixing	Chloramines from mixing household bleach and ammonia-based cleaners; chlorine gas from mixing bleach with acid-containing cleaner (see Table 9 below)
Chemical transformations	Chloroform release from chlorine bleach chemistry in laundry applications (Shepherd et al. 1996); terpene hydrocarbons plus ozone form hydroxyl radical (Weschler and Shields 1997), hydrogen peroxide (Li et al. 2002) and secondary particulate matter (Weschler and Shields 1999; Wainman et al. 2000)
Altered surfaces	Nicotine release from walls following ammonia cleaner use in smoking environment (Webb et al. 2002); enhanced volatile organic emissions from wet linoleum (Wolkoff et al. 1995)

Source: Nazaroff et al. 2006.

Summaries of studies and case reports documenting toxic exposures from the mixing of cleaning products also are provided in Nazaroff et al. (2006). Table 9 is based on Table 2.3 of Nazaroff et al.'s final report. Table 10, which follows, is based on Table 2.4 of that report. The references are to previous literature cited in that report.

Table 9. Documented Inhalation Toxicity Related to Mixing of Cleaning Products

Nature of Study	Products Mixed	Toxic Gases	Outcomes
Case reports (two) (Faigel 1964)	Sodium hypochlorite, vinegar, bleach, and detergent; ammonia and sodium hypochlorite	Chlorine, ammonia	Acute illness with recovery in days
Case report (Dunn and Ozere 1966)	Ammonia type and hypochlorite cleaners	Ammonia	Acute illness with recovery in days
Case report (Jones 1972)	Bleach (5.25% sodium hypochlorite) and powder containing 80% sodium bisulfate	Chlorine gas	Acute illness with recovery after several days
Case report (Murphy et al. 1976)	Several products applied to clear a clogged drain [a]	Uncertain	Severe obstructive airway disease
Case report (Gapany-Gapanavicius et al. 1982a)	Ammonia with household bleach containing hypochlorite	Chloramines	Acute illness with recovery in days
Case reports (two) (Gapany-Gapanavicius et al. 1982b)	Sodium hypochlorite (5%) and hydrochloric acid (10%)	Chlorine gas	Acute illness with recovery in several days

Nature of Study	Products Mixed	Toxic Gases	Outcomes
Case reports (three) (Reisz and Gammon 1986)	Aqueous ammonia (5%–10%) with bleach (5.25% sodium hypochlorite), plus laundry detergent in two cases	Chloramines	Life-threatening toxic pneumonitis requiring prolonged hospitalization and resulting in residual symptoms
Case reports (five episodes at two state hospitals) (CDC 1991)	Bleach (sodium hypochlorite) and phosphoric acid cleaner	Chlorine	Acute poisoning symptoms that abated within hours to days; a few cases required medical treatment
Analysis of 216 cases reported to regional poison information center (Mrvos et al. 1993)	Hypochlorite-containing product with (a) ammonia (50%), (b) acid (29%), and (c) alkali (21%)	Chlorine/ chloramines	Symptom resolution for 93% of patients within 6 hours; 33% received medical care; 1 patient with a pre-existing condition required hospital admission for continued respiratory distress
Case report (Bennion and Franzblau 1997)	Sequential application of numerous cleaning products to remove a bathtub stain [b]	Hydrofluoric acid	Hemorrhagic alveolitis and adult respiratory distress syndrome; month-long hospital care; residual pulmonary deficit
Case reports (two cases each with 36 soldiers) (Pascuzzi and Storrow 1998)	Liquid bleach and ammonia mixed in bowls and buckets	Chloramine gas	Acute symptoms; two patients admitted to hospital, one required several days of intensive care observation
Case report (Tanen et al. 1999)	Liquid ammonia (3%–10% ammonia) and bleach (5% sodium hypochlorite)	Chloramine gas	Upper air compromise and pneumonitis requiring emergency tracheostomy and 7 days of hospital care
Case report (Cohle et al. 2001)	Bleach and ammonia	Cloramine gas	Death

Source: Nazaroff et al. 2006.

References: [a] Products used (selected active ingredients): Liquid Plum-R (NaOCl, 5%; KOH, 2%); Drano (NaOH, 54%; $NaNO_3$, 30%); Clorox (NaOCl, 5%); Sani Flush ($NaHSO_4$, 75%).

[b] Cleaning products used (active ingredient, if reported): cleanser, mildew stain remover (NaOCl, 25–45%), tub and tile cleaner (H_3PO_4, 18%), ammonia cleaner (NaOH, 2–2.5%), bleach (NaOCl, 5.25%), toilet cleaner (HCl, 14.5%), vinegar (CH_3COOH, 5%), rust remover (H_6F_6, 8%). Application of each product was followed by a cold-water rinse.

Table 10. Documented Associations of Asthma, Allergy, and Sick-Building Syndrome Symptoms in Relation to Cleaning Product Use

Key Finding	Reference
Dried detergent residue from carpet shampoo "caused respiratory irritation among most employees in an office building and among all staff members and most children in a day-care center."	Kreiss et al. 1982
Excessive application of carpet shampoo was associated with widespread, transient, mild respiratory illness among conference attendees.	Robinson et al. 1983
Case report of a cleaning worker's occupational asthma caused by inhalation exposure to ethanolamine from a floor-cleaning detergent.	Savonius et al. 1994
Case report of occupational asthma in a pharmacist attributed to indirect exposure to lauryl dimethyl benzyl ammonium chloride from a floor-cleaning product regularly used in his workplace.	Burge and Richardson 1994
With data from 22 offices in 12 buildings in California, researchers found a principal component vector associated with the use of cleaning products and air fresheners was useful in predicting stuffy nose (OR 1.6) and composite irritated mucous membrane symptoms (OR 1.4).	Ten-Brinke et al. 1998
Population-based study of occupational asthma revealed that "cleaners" had the fourth highest OR (1.97) for "bronchial hyper-responsiveness and asthma symptoms or medication."	Kogevinas et al. 1999
Prospective study design indicated increased risk of eye, nose, and throat symptoms; asthma and bronchitis associated with "use of sprayers" among current cleaners compared to former cleaners.	Nielsen and Bach 1999
Case report of anaphylactic shock with respiratory failure secondary to carpet cleaning in a 42-year-old female who was hospitalized for 18 days.	Lynch 2000
Case reports of female nurses who exhibited occupational asthma following exposure to surfaces cleaned with solutions containing benzalkonium chloride. Cases also were occupationally exposed to this chemical as a disinfectant.	Purohit et al. 2000
Asthma prevalence among indoor cleaners in Spain was 1.7 times the rate for office workers. Risk was associated mainly with the cleaning of private homes and "may be explained by the use of sprays and other products in kitchen cleaning and furniture polishing."	Zock et al. 2001
Population study of women in Finland revealed a relative risk ratio of asthma of 1.5 for cleaners compared to administrative workers.	Karjalainen et al. 2002
Twelve percent of confirmed cases of work-related asthma in California, Michigan, Massachusetts, and New Jersey were associated with exposure to cleaning products.	Rosenman et al. 2003
"Janitors, housekeepers, and cleaners" was the occupational group with the highest number of reported cases of occupational asthma in Sao Paulo, Brazil; "cleaning products" were the most commonly reported exposure agent.	Mendonça et al. 2003
"Cleaning materials" are the most frequently reported agents for work-related reactive airways dysfunction syndrome cases in Michigan, New Jersey, Massachusetts, and California.	Henneberger et al. 2003

Key Finding	Reference
In the National Health and Nutrition Examination Survey III survey of U.S. workers, the occupation of "cleaning" was associated with an elevated odds ratio of work-related wheezing (OR 5.4, 95% ***confidence interval*** [CI] 2.4–12.2) and work-related asthma, although not statistically significant for the latter (OR 2.4, 95% CI 0.5–10.6).	Arif et al. 2003
Population-based incident case-control study of relation between occupation and risk of developing asthma showed an association, but not a statistically significant one, for women cleaners (OR 1.42, 95% CI 0.81–2.48).	Jaakkola et al. 2003
Current or former employment as domestic cleaner was associated with a statistically significant increase in the prevalence of asthma in Barcelona, Spain. Symptoms were associated with exposure to bleach and possibly other irritant agents.	Medina-Ramón et al. 2003, 2005
The frequency with which chemical-based household products were used during the prenatal period was associated with persistent wheeze in young children. Among the 11 products in analysis were disinfectant, bleach, carpet cleaner, window cleaner, and air fresheners.	Sherriff et al. 2005

Source: Nazaroff et al. 2006.

Appendices

Appendices

Appendix 1: Comparison of Guidance Documents Identified in Chapter 3

The authors explored in more detail the assessment of the effectiveness and safety of various cleaning and decontaminating methods contained in the different guidance documents identified in the literature search. The literature search included cleanup after floods generally, as well as the use of cleaning and sanitizing methods and materials. This appendix describes guidance selected for review, categorized by agency or organization.

Multi-agency guidance:

- *Homeowner's and Renter's Guide to Mold Cleanup After Disasters*. This 4-page 2015 guide—developed jointly by the U.S. Environmental Protection Agency (EPA), Centers for Disease Control and Prevention (CDC), Federal Emergency Management Agency (FEMA), U.S. Department of Housing and Urban Development (HUD), and National Institutes of Health (NIH)—focuses on protecting individuals who return to, enter, and cleanup a home after a flood. Guidance is provided for hiring mold inspection and cleanup professionals. If a person must do the cleanup themselves, the guide recommends wearing personal protective gear and clothing, getting the liquid water out, opening windows and doors, using fans or dehumidifiers if electricity has been restored, cleaning with water and detergent, *not* mixing cleaning products or bleach and ammonia, and removing items that cannot be cleaned and dried. The guide, which also contains safety tips for using portable generators, also is available in Spanish at www.cdc.gov/mold/cleanup.htm.

FEMA guidance:

- *Repairing Your Flooded Home*. This 56-page document developed by FEMA and the American Red Cross (ARC) has been used by those responding to flooded buildings for many years and was last updated in 1992. The guidance is clear, practical, and prioritizes risks; it is the essential starting point for anyone returning to a flooded building. The guidance recommends cleaning with water and detergents. It does not seem to require the use of disinfectants, but notes that if disinfectants are used, quaternary compounds, phenolics, and pine oil disinfectants should be the first choice and bleach solutions second.

- *Initial Restoration for Flooded Buildings*. This 4-page 2015 Hurricane Katrina Advisory provides five steps for restoring buildings: air out, move out, tear out, clean out, and dry out. It cautions against using bleach on porous or dirty materials, electrical outlets, metals, soil, and materials treated for termites. The advice on cleaning and removing materials is very practical.

- *Dealing With Mold and Mildew in Your Flood Damaged Home*. This undated 7-page document discusses mold growth, health effects, cleaning and disinfecting, and mold prevention. It recommends washing hard surface materials and then disinfecting with a bleach solution. For porous materials, it suggests cleaning and using phenolic or pine oil in an effort to sanitize.

- *Mold and Mildew: Cleaning Up Your Flood Damaged Home*. This 2007 homeowner's guide, written at a simple level for areas of mold up to 25 square feet, includes health cautions, a helpful decision tree and illustrations, and removal and cleanup guidance. It also provides some recommendations for preventing further growth.

- *The ABC's of Returning to Flooded Buildings*. This 2-page fact sheet, published in 2012, is devoted to the initial phase of returning a building to habitability after a flood. It covers tools, entry, assessment, hazards, and removing items intended to be salvaged and contains a list of references for cleaning and decontaminating.

- *Cleaning Flooded Buildings: Hurricane Sandy Recovery Fact Sheet No. 1*. This 5-page fact sheet from 2013 focuses on safety while restoring flooded buildings to occupancy. Coverage of cleaning is limited to the use of foam cleaners and low pressure washing. The use of disinfectants or sanitizers appears to be assumed. A sidebar discourages the use of household bleach.

- *Claims Guidance—Structural Drying and Other Related Items*. This 2013 memorandum provides guidance on what drying activities qualify for coverage by the ***Standard Flood Insurance Policy***. It provides the technical basis and recommendations for drying structural building materials.

- *Mitigation Assessment Team Report: Hurricane Sandy in New Jersey and New York*. This 223-page report published in 2013 covers a variety of topics, including sea level rise; building codes; performance of low-rise, mid-rise, and high-rise buildings; and performance of critical facilities and assets, such as schools, historic buildings, wastewater treatment plants, transportation, and health care facilities. A valuable resource for planning agencies, code organizations, emergency preparedness agencies, and the building design and construction community.

EPA guidance:

- *Flood Cleanup: Avoiding Indoor Air Quality Problems*. This 2-page fact sheet released in 2012 by EPA's Office of Air and Radiation contains guidance on preparing for cleanup, avoiding microbial growth, removing standing water, drying, removing wet materials, avoiding problems with cleaners and disinfectants, and avoiding hazards (e.g., carbon monoxide, asbestos, lead). It has numerous links to other resources (websites). The fact sheet also recommends using household cleaners and disinfectants to clean materials and warns about safety when using disinfectants. (Note: The pdf version of this document does not display all the text found in the online document at www.epa.gov/indoor-air-quality-iaq/flood-cleanup-protect-indoor-air-quality.)

- *Flood Cleanup and the Air in Your Home*. This undated 15-page booklet released by EPA's Office of Air and Radiation contains numerous illustrations accompanied by short, simple sentences in either English or Vietnamese. It identifies reason for concern but is mostly devoted to cleanup methods and safety while cleaning.

- *Mold Remediation in Schools and Commercial Buildings*. This 45-page guide to mold remediation—released in 2001 and reprinted unchanged in 2008—includes assessment,

remediation, and clearance guidance. It is not specifically written for, but is applicable to, mold growth after floods.

CDC guidance:

- *Mold Prevention Strategies and Possible Health Effects in the Aftermath of Hurricanes and Major Floods*. This 2006 27-page document appears to be written for a fairly knowledgeable audience (e.g., public health personnel, emergency responders, restoration professionals). It contains extensive discussion of health effects, worker protection, sampling, cleaning, and restoration. The document recommends cleaning materials with soap and water, then disinfecting them using a solution of bleach and water.

- *Protect Yourself From Mold*. This 2006 2-page fact sheet briefly covers mold risks, recognizing mold, preventing mold growth, and cleaning mold from materials. It recommends using detergent and water or a water and bleach solution to clean mold from materials.

- *Clean Up Safely After a Natural Disaster*. This webpage contains links to CDC guidance on cleanup after floods. It includes information about reentering flooded homes, HVAC (heating, ventilation, and air conditioning) systems, electrical hazards, chemical hazards, food and water safety, heat exposure, carbon monoxide hazards, and respiratory protection links. Many of the links are not available as pdfs.

- *Get Rid of Mold*. This undated, one-page flyer is very direct and has good illustrations. It recommends cleaning mold off materials using a solution of water and bleach. The flyer also is available in Spanish at www.cdc.gov/mold/cleanup.htm.

- *Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers*. This webpage provides specific guidance for cleaning and remediating HVAC equipment after floods. The guidance addresses the ducts, air handler cabinets, insulation, and fans. It does not address hydronic systems or boilers. The webpage recommends removing and discarding HVAC system components that are contaminated with flood water and cannot be effectively cleaned and disinfected, replacing them with new components.

Nongovernmental guidance:

- Institute of Inspection, Cleaning, and Restoration Certification (IICRC)

    - *S500 Standard and Reference Guide for Professional Water Damage Restoration*. The IICRC is the certification body for water restoration professionals. The 2015 S500 standard is a consensus document that forms the basis of certification by the institute. It is the most comprehensive guidance document for cleaning up buildings after a flood. The S500 industry consensus standard includes 88 pages of standard and more than 200 pages of references that explain and reference the science behind the standard. It covers water damage restoration, building physics, safety and health, administration of projects, evaluations, specialized experts, structural restoration, HVAC restoration, building contents, catastrophic events, biocides, and equipment and tools. The IICRC has

published the S500 standard for restoration after water damage since 1994. The fourth edition was published in 2015. The S500 is the only American National Standards Institute (ANSI) standard that specifically addresses cleanup after floods.

  - *S520 Standard for Professional Mold Remediation*. The ANSI/IICRC S520 is a procedural standard for the remediation of mold damaged structures and contents. S520 is based on reliable remediation and restoration principles, includes research and practical experience, and attempts to combine essential academic principles with practical elements of water damage restoration for technicians facing "real-life" mold remediation challenges.

  - *IICRC Storm Damage Restoration Recommendations*. The IICRC released these recommendations as a public service to those who have suffered water-related losses from storm damage. The recommendations are geared toward water-related storm damage to residential or light commercial structures only.

- National Center for Healthy Housing (NCHH)

  - *Creating a Healthy Home: A Field Guide for Cleanup of Flooded Homes*. This 18-page booklet from the NCHH, Enterprise Community Partners, Inc., and NeighborWorks® America covers the cleanup of flooded homes, health risks and worker protection, and lead, asbestos, and carbon dioxide risks. The cleanup itself is covered in eight steps: pre-work inspection, before work begins, site preparation, clean-out, gut tear-out procedure, pre-construction cleaning and treatment, selective tear out and preparation before restoration, and restore possessions. Clear, informative illustrations help with understanding each step.

- Restoration Industry Association

  - *Hurricane Cleanup Guidelines for Volunteers*. This 2006 9-page guide provides practical direction for safely returning to a flooded building, assessing the damage, and conducting removal and cleanup of flood contaminated materials.

	Homeowner's and Renter's Guide to Mold Cleanup After Disasters	***Flood Cleanup: Avoiding Indoor Air Quality Problems***	***Flood Cleanup and the Air in Your Home***
Publisher (Year)	CDC/EPA/FEMA/HUD/NIH (2015)	EPA (2003)	EPA (undated)
Target audience	Owners/renters	Owners/renters	Owners/renters
Number of pages	4	2	15
Safety returning and entering	Recommends wearing personal protective equipment (PPE) when returning to and entering a flooded home.	Recommends consulting the FEMA, ARC, CDC, and American Lung Association websites for safety information, in addition to the safety information offered in the resource itself.	Not discussed.
Call a professional?	Recommends consulting professionals affiliated with or certified by the National Environmental Health Association, American Industrial Hygiene Association, IICRC, or American Council for Accredited Certification to inspect, repair, and restore the damaged parts of the home.	Not discussed.	Recommends calling a professional in situations where the flooded home contains large amounts of mold.
Assessment	Assess the flooded home for signs or scents of mold. There should be no signs of water damage of mold growth post-remediation.	Not discussed.	Not discussed.
Remove standing water	Remove standing water as quickly as possible from the home. Use a wet vacuum to remove water from floors, carpets, and hard surfaces.	Remove standing water as quickly as possible.	Not discussed.
Drying out	Dry all items for 24–48 hours. Open all windows, doors, and cabinets of the home. Remove cabinet drawers to dry, and use fans and dehumidifiers if electricity is safely available.	References the FEMA/ARC 1992 resource *Repairing Your Flooded Home*. Advises inhabitants to be patient and make sure all materials and possessions are dry.	Advises to clean and dry all materials and possessions in the home. Features an illustration showing mopping up liquid water with rags.
Removal of contents and furnishings	Remove wet materials.	Not discussed.	Throw away anything that got wet and cannot be cleaned. Well illustrated.

	Homeowner's and Renter's Guide to Mold Cleanup After Disasters	***Flood Cleanup: Avoiding Indoor Air Quality Problems***	***Flood Cleanup and the Air in Your Home***
Removal of material and built-ins	Remove wet materials and any items that cannot be cleaned and dried within 24–48 hours. Resource includes a detailed graphic illustrating items to remove from a flooded home.	Replace wet fiberboard, insulation, and HVAC filters. References the FEMA/ARC resource *Repairing Your Flooded Home*. Provides guidance on discarding items and links readers to EPA's *Mold in Remediation in Schools and Commercial Buildings*.	Discard all wet items that cannot be sufficiently dried and cleaned. Well illustrated.
Cleaning hard surfaces	Use a wet vacuum to remove water from hard surfaces (material type not specified). Clean hard surfaces with water and detergent, and remove all visible mold.	Details the flood cleanup process and cautions occupants on the use of household cleaners and disinfectants.	Clean and dry all hard surfaces. Well illustrated.
Cleaning porous surfaces	Not discussed.	Not discussed.	Not discussed.
Cleaning cavities	Not discussed.	Not discussed.	Not discussed.
Cleaning HVAC systems and ducts	Not discussed.	Replace all flooded fiberboard, fibrous insulation, and filters in HVAC systems. Ducts should be cleaned with disinfectant or sanitizer. References the FEMA/ARC resource *Repairing Your Flooded Home*.	Not discussed.
Use of biocides	Not discussed.	Not discussed.	Not discussed.
Do not mix bleach and cleaning products	Do not mix bleach with ammonia or any other cleaning products.	Cautions mixing cleaners and disinfectants.	Do not mix cleaning products or add bleach to other chemicals. Well illustrated.
Reoccupancy criteria	No signs or scents of mold present. Ongoing health problems may be a result of hidden mold.	Not discussed.	Not discussed.
Health and safety	Recommends using an N-95 respirator and wearing goggles and gloves.	Not discussed.	Recommends using an N-95 respirator and wearing goggles, gloves, long pants, and sleeves. All illustrations include appropriate PPE.

	Homeowner's and Renter's Guide to Mold Cleanup After Disasters	***Flood Cleanup: Avoiding Indoor Air Quality Problems***	***Flood Cleanup and the Air in Your Home***
Carbon monoxide	Cautions readers about the dangers of carbon monoxide poisoning and fires. Warns against using generators or other combustion devices indoors.	Cautions readers about the dangers of carbon monoxide. Warns against using combustion devices indoors.	Provides good discussion and illustration of generator use.
Asbestos and lead	Not discussed.	Cautions readers about the adverse health effects of both asbestos and lead. Recommends the EPA Toxic Substances Control Act Assistance Information Service and the National Lead Information Center as contacts.	Not discussed.
Health effects	Health effects of mold are discussed, and protective measures are covered.	Not discussed.	Health effects of mold include asthma, allergies and breathing problems. Recommends talking to one's doctor.
Fix moisture problem	Readers are firmly advised to clean up the mold in their home and fix the moisture problem.	Not discussed.	Fix any leaking pipes and other water problems and then dry all items; otherwise, mold will grow again.
Other	Painting over mold does not solve the issue; health effects remain.	NA	NA

	Initial Restoration of Flooded Buildings	***The ABC's of Returning to Flooded Buildings***	***Cleaning Flooded Buildings: Hurricane Sandy Recovery Fact Sheet No. 1***
Publisher (Year)	FEMA (2005)	FEMA (2012)	FEMA (2013)
Target audience	Owners/workers/volunteers restoring flood damaged houses with extensive mold growth	Owners/renters	Owners/workers/volunteers restoring flood damaged houses with extensive mold growth
Number of pages	4	2	5
Safety returning and entering	References *The ABC's of Returning to Flooded Buildings*.	Contains good coverage on PPE, potential entry hazards, and details how occupants should document damage.	References *The ABC's of Returning to Flooded Buildings*. Discusses the dangers of electric shock, mold, asbestos, and lead paint.
Call a professional?	Recommends calling a professional to check the moisture content of all wood materials. This includes drywall (gypsum board) and plywood flooring. It also recommends contacting a local building inspector, structural engineer, or other appropriate professional when in doubt.	Recommends calling pest control professional for termites.	Recommends calling a remediation professional if testing confirms the presence of lead.
Assessment	Assumes that structures that have experienced long-term flooding will have extensive mold growth.	Not discussed.	Assumes mold and contamination when a flooded home has not been cleaned and dried within a few weeks of the event. Floodwaters carry a variety of contaminants, such as bacteria, oil, heavy metals, and pesticides. Safety issues in the home will have to be addressed as well.
Remove standing water	Not discussed.	Not discussed.	Recommends removing all instances of standing water, especially to clean crawlspaces.
Drying out	Air out the structure as much as possible. Advises using fans only if power is safely available. Additionally provides detailed guidance on drying wood framing, walls, floors, and gypsum board. Explains use of moisture meters. Cautions on drying long enough.	Not discussed.	Advises maintaining buildings at 50–70 degrees Fahrenheit in cold weather. Open the building as much as possible to dry if no power is safely available. Once electrical service and HVAC have been safely sanitized and restored, use fans, heaters, air conditioning and dehumidification equipment to dry the structure. Measure moisture levels and continue drying until a moisture reading of less than 15 percent is achieved.

	Initial Restoration of Flooded Buildings	***The ABC's of Returning to Flooded Buildings***	***Cleaning Flooded Buildings: Hurricane Sandy Recovery Fact Sheet No. 1***
Removal of contents and furnishings	Remove salvageable contents and throw out damaged materials that cannot be salvaged.	Extract what is salvageable and focus on high-value items that were not affected by water or that have special significance. Porous items that were not waterlogged or moldy should be second priority.	Not discussed.
Removal of material and built-ins	Tear out or move out building materials and built-ins depending on their condition.	Remove high-value, salvageable items that were not damaged or that can be easily cleaned.	Separate affected from unaffected areas.
Cleaning hard surfaces	To clean hard surfaces, use a shop vacuum with a solution of water and disinfectant in the tank to minimize the spread of dust. Use squeegees and shovels for mucking out spaces. For mold removal, advises using commercial mold removers. Wash, rinse, and pressure-wash to clean contaminated surfaces.	Clean nonporous contaminated items onsite.	Clean and sanitize all materials and contents that got wet. Clean surfaces before sanitizing. Use EPA-registered disinfectants and sanitizers. Recommends foam cleaning, brush cleaning, and pressure-washing combined with high-efficiency particulate air (HEPA) vacuums to collect the residue.
Cleaning porous surfaces	Do not scrub gypsum board until it has dried.	If porous items cannot be saved, recommends saving nonporous pieces of the items as keepsakes.	Water-damaged porous materials should be removed. Semiporous surfaces should be wiped off with disposable towels and not scrubbed.
Cleaning cavities	Remove cabinets and built-ins to access and clean hidden spaces.	Not discussed.	Crawlspaces, once opened, must have all solid contaminants removed, along with any remaining water. Cleaning foam should be used to clean all exposed sides of floor joists, foundation walls, and remaining structural elements. Potential mold growth also must be minimized.
Cleaning HVAC systems and ducts	Not discussed.	Not discussed.	Restore and sanitize electrical service and HVAC.
Use of biocides	Recommends using commercial products for sanitization and cautions against using bleach.	Not discussed.	Not discussed.
Do not mix bleach and cleaning products	Not discussed.	Not discussed.	Cautions against use of bleach. Lists both its convenience and its drawbacks.

	Initial Restoration of Flooded Buildings	***The ABC's of Returning to Flooded Buildings***	***Cleaning Flooded Buildings: Hurricane Sandy Recovery Fact Sheet No. 1***
Reoccupancy criteria	Dry things to less than 15 percent moisture content by weight.	Not discussed.	Not discussed.
Health and safety	Wear PPE.	Not discussed.	References Occupational Safety and Health Administration (OSHA) Hurricane Sandy Cleanup PPE Matrix. Recommends using a disposable N-95 respirator or a full-face respirator, along with gloves and goggles. The N-95 respirator offers the minimum lung protection needed, and the full-face respirator is recommended for mold cleaning to protect both the eyes and respiratory system.
Carbon monoxide	Not discussed.	Not discussed.	Not discussed.
Asbestos and lead	Recommends respiratory protection during the removal of flooring products, as many older pre-1970 materials contain asbestos.	Not discussed.	Both are discussed in this fact sheet. The history behind the use of the materials and the safety issues associated with them are covered. Testing by a professional and remediation are both recommended.
Health effects	Warns that if adequate drying is not achieved, inhabitants may experience health problems in the future.	Recommends inhabitants not return to their residences if they are physically or psychologically unfit and recommends they do not return alone.	Discusses flood-borne bacteria and contaminants, wet mechanical and electrical equipment, and mold growth.
Fix moisture problem	Not discussed.	Not discussed.	Not discussed.
Other	Extensively discusses cleaning crawlspaces and slabs.	Provides advice in the case of a termite infestation.	Provides detailed crawlspace cleaning guidance.

	Mold and Mildew: Cleaning Up Your Flood-Damaged Home	***Repairing Your Flooded House***	***Protect Yourself from Mold***
Publisher (Year)	FEMA (2007; update of earlier document)	FEMA/ARC (1992)	CDC (2006)
Target audience	Owners/renters	Owners/workers/volunteers restoring flood damaged houses	Owners/renters
Number of pages	12	56	2
Safety returning and entering	Recommends having an electrician inspect the home before turning on the power.	Provides extensive guidance for returning to flooded home and restoring it to operation.	Cautions inhabitants to be aware that mold may be present in the home and may be a health risk for the residents.
Call a professional?	Recommends doing it oneself if less than 25 square feet of mold is present. Recommends consulting a professional if the mold spans an area greater than 25 square feet. A professional should be consulted to check the home's HVAC and ducts that have flooded. An electrician must be called to inspect all electrical systems before switching on the power for safety purposes.	Recommends calling a professional if the reader feels any discomfort while addressing a flooded home. If the reader has no experience in construction or electrical repair, professional help is highly recommended. Government disaster programs typically provide a hotline with resources for those affected by severe natural disasters. The ARC is recommended for crisis counseling.	Not discussed.
Assessment	Mold assessment is broken down through a "decision tree" model. This resource recommends checking wall cavities to find hidden mold and to identify the source of the moisture.	Mold and fungus growth is assumed after a flooded home has been unattended for some time. Dampness promotes their growth. This is the only advice offered in this resource on flood damage assessment.	Discusses how to recognize mold growth and assess mold damage.
Remove standing water	Advises on removing standing water as soon as possible as it is a breeding ground for dangerous microorganisms.	Offers advice on removing standing water from basements.	Names standing water as a contributor to mold growth and health issues.
Drying out	Open up the house to let in air flow and dry out the home. Use fans and dehumidifiers if safe access to electricity is available. It is not recommended to use a furnace or an air conditioner if the air handlers or ductwork were flooded. Open all flooded wall cavities to clean and dry.	Provides no timeframe for drying out a flooded home. Recommends lowering the humidity in the home. Provides different options on how to lower the humidity in a flooded building.	Dry the building within 48 hours. Open all windows and use fans.

	Mold and Mildew: Cleaning Up Your Flood-Damaged Home	***Repairing Your Flooded House***	***Protect Yourself from Mold***
Removal of contents and furnishings	Remove wet items (e.g., furniture, rugs, carpeting, bedding, toys, food). If the home's content has been wet for less than 48 hours, clean and salvage the items.	Throw away flood-soaked mattresses, carpets, upholstered furniture, books, paper, fiberglass or cellulous insulation, wallboard, and food.	Remove porous materials that have been wet for more than 48 hours. All items that cannot be dried and thoroughly cleaned (carpeting, upholstery, wallpaper, gypsum board) should be removed from the home. Store salvageable items outside the house. When in doubt, take it out.
Removal of material and built-ins	Remove wet or contaminated gypsum board, ceiling tiles, and composite wood products. Remove wet insulation (foam insulation may be cleaned and salvaged).	Remove and discard flooded wallboard. Soaked wallboard presents a permanent health hazard. Different types of insulation have different reactions to floodwater. This resource explains what to do in each case.	Porous noncleanable items include drywall, floor and ceiling tiles, insulation material, and wood. Remove these items or clean if possible. When in doubt, take it out.
Cleaning hard surfaces	Wash hard surfaces with nonammonia detergent and hot water. Brush rough surfaces. Disinfect with bleach solution (1.5 cups per 1 gallon of water).	Use detergent and water to clean hard surfaces. Disinfect with quaternary, phenolic, or pine oil-based products. Use bleach only as a second choice (with care).	Clean with detergent and water or bleach solution. Refer to EPA's *A Brief Guide to Mold, Moisture and Your Home* for disinfection. Recommends professional help for areas greater than 10 square feet.
Cleaning porous surfaces	For materials that have been wet less than 48 hours, try cleaning and drying the items. When in doubt, throw it out.	Do not scrub gypsum board until it has dried.	Thoroughly clean and dry all porous materials that can be salvaged. To prevent mold growth from occurring, clean wet items with detergent and water. Remove all porous items that have been wet for more than 48 hours and cannot be thoroughly cleaned.
Cleaning cavities	Recommends checking cavities and other areas for hidden mold. Cleaning recommendations are based on the amount of mold found.	Take the backs off of furniture to let air circulate. Do not force open swollen wooden doors and drawers; wait until they have aired out and then ease them open.	Not discussed.
Cleaning HVAC systems and ducts	Flooded HVAC systems and ducts should be inspected by a professional.	Hose out ducts and wash them with disinfectant or sanitizer (quaternary, phenolic, pine oil).	Not discussed.
Use of biocides	Bleach is recommended as a disinfectant, when properly prepared.	Bleach is recommended as a disinfectant, when properly prepared.	Use detergents, soap and water, or bleach solution (1 cup bleach per 1 gallon of water).

	Mold and Mildew: Cleaning Up Your Flood-Damaged Home	***Repairing Your Flooded House***	***Protect Yourself from Mold***
Do not mix bleach and cleaning products	Cautions against mixing bleach and ammonia. Watered-down bleach can be a helpful cleaning tool.	Cautions against mixing bleach and ammonia.	Cautions against mixing bleach and ammonia.
Reoccupancy criteria	Not discussed.	Dry items to less than 15 percent moisture content by weight.	Not discussed.
Health and safety	Recommends wearing gloves and mask or respirator while cleaning or entering the home.	Recommends wearing sturdy shoes and gloves while cleaning or entering the home.	Recommends wearing an N-95 mask (if spending extended periods of time in the building or cleaning mold), gloves, and protective eyewear and practicing proper ventilation.
Carbon monoxide	Not discussed.	Readers are warned to use generators outdoors only as they give off carbon monoxide fumes.	Not discussed.
Asbestos and lead	Not discussed.	Not discussed.	Not discussed.
Health effects	Full-page discussion dedicated to the health effects associated with mold and flooding.	Not discussed.	Briefly discusses health effects.
Fix moisture problem	Identify and fix all moisture sources. Rebuild using water-resistant materials.	Identify and fix moisture source. Rebuild using water-resistant materials.	If there is mold growth in a home, inhabitants are instructed to clean up the mold and fix any water problem, such as leaks in roofs, walls, or plumbing. Controlling moisture in the home is the most critical factor for preventing mold growth.
Other	Provides extensive general advice. Defines disinfectants.	Provides extensive general advice. Defines disinfectants.	NA

	Creating a Healthy Home: A Field Guide for Clean-up of Flooded Houses	***S500 Standard and Reference Guide for Professional Water Damage Restoration***
Publisher (Year)	NCHH (2006)	IICRC (2015)
Target audience	Owners/workers/volunteers restoring flood damaged houses	Water-loss restoration professionals
Number of pages	22	333
Safety returning and entering	Conduct a pre-work inspection before returning or entering. Check for structural damage, have the electric system inspected, have all gas equipment inspected, and have the home's plumbing system inspected. Turn off gas and electricity until they are properly inspected. This resource offers tips to help identify people who should not do this work.	The S500 standard contains an extensive safety and health section directed primarily at hazards encountered while drying, cleaning, decontaminating, and restoring the building. Some of the items covered (e.g., PPE, confined space entry, heat disorders, lockout/tagout for electrical systems, safe work practices in contaminated buildings) apply to the circumstances during the initial re-entry, assessment, cleaning, and stabilization of the house.
Call a professional?	Professional inspections should be conducted for the building's electrical system, gas equipment, and plumbing. Recommends professional help for construction or restoration if the occupants are incapable of completing the tasks alone. Hire a professional if mold growth covers more than 100 square feet. Resource provides tips on how to hire a professional.	As this document is written for water-loss professionals it has no recommendations for hiring professionals.
Assessment	Inspect the home for active rain, plumbing leaks, and standing water. Divide the house into flooded and not-flooded areas. Assess which furnishings and belongings can be salvaged and saved, and make note of damage to windows, doors, and walls.	Contains extensive guidance for assessing the extent of loss, potential contaminants, appropriate work protection, the required drying capacity of dehumidification equipment, containment, and clearance.
Remove standing water	Remove any standing water. Standing water can either be pumped out or mopped out depending on the situation.	Covers pumping, extraction, and follow-up extraction.
Drying out	Open all windows, doors, and crawlspaces. Open up the attic as well.	Begin as soon as safely practical following the initial moisture intrusion. Promote evaporation of remaining water in materials. Remove vapor from air by supplying less humid air and/or dehumidification. Specific advice is provided on drying different materials (e.g., carpets, drywall) and building components (e.g., floor systems, walls).

	Creating a Healthy Home: A Field Guide for Clean-up of Flooded Houses	***S500 Standard and Reference Guide for Professional Water Damage Restoration***
Removal of contents and furnishings	Extensive guidance on salvage/removal of contents. Move salvageable items to designated safety and cleanup areas. All other materials should be placed in the trash removal area. Throw away moldy carpet, furniture, electronics, paper, books, and food in contact with flood waters. Advice is provided on wall removal and tearing out floor tiles and wood. Gut tear-out procedure described in detail. Remove or machine-wash all clothing with detergent and bleach.	Chapter 17 contains extensive guidance on evaluating the restorability of contents and materials. Throw away or clean depending on water category, object's value, and porosity of material. Cleaning, decontaminating, and drying guidance is provided for each kind of material or assembly.
Removal of material and built-ins	Remove plaster/gypsum cabinets, trim, shelves, fibrous insulation, and interior doors. Try to save plaster.	Chapter 17 contains extensive guidance on evaluating the restorability of contents and materials. Throw away or clean depending on water category, object's value, and porosity of material. Cleaning, decontaminating, and drying guidance is provided for each kind of material or assembly.
Cleaning hard surfaces	Use a HEPA vacuum to clean hard surfaces. Wash and disinfect using a bleach and nonphosphate detergent. Wood surfaces should be cleaned with nonphosphate detergent. Treat the wood surface with borate, and avoid bleach. Fungicidal coating is optional.	Contains information on air-based cleaning, such as HEPA vacuuming and air-washing, and liquid-based cleaning with detergent/water, such as ultrasonic cleaning and steam cleaning. Hard surfaced, nonporous materials are considered restorable for all categories of water.
Cleaning porous surfaces	Remove contaminated porous building materials. Save possessions and furnishings.	Chapter 17 contains extensive guidance on evaluating the restorability of contents and materials. Throw away or clean depending on water category, object's value, and porosity of material. Cleaning, decontaminating, and drying guidance is provided for each kind of material or assembly. Many porous materials are consider either not restorable or restorable based on category of water, conditions, and professional judgment.
Cleaning cavities	Wash or mist all wall cavities with a borate solution prepared to the manufacturer's directions for wood fungi.	Contains extensive drying and cleaning guidance for cavities.
Cleaning HVAC systems and ducts	Discard flooded ductwork and air handlers. Fungicidal coatings can be used to keep mold from spreading in the HVAC system.	Inspect for cleanliness and clean using the National Air Duct Cleaners Association's (2006) *Assessment, Cleaning and Restoration of HVAC Systems*. Any insulated ductwork saturated with water, regardless of category, should be removed. When contaminated with Category 2 or 3 water, ductwork with an interior sound/insulation liner, plastic flex duct, and coated fiberboard ducting should be replaced. Use of antimicrobials may be considered but use shall not be substituted for removal of viable microbial bodies.
Use of biocides	Use dilute bleach only on nonporous, hard surfaces.	Provides an extensive discussion of biocides. Refers to the American Conference of Governmental Industrial Hygienists' guidance to avoid biocides except in unusual circumstances.

	Creating a Healthy Home: A Field Guide for Clean-up of Flooded Houses	***S500 Standard and Reference Guide for Professional Water Damage Restoration***
Do not mix bleach and cleaning products	Never mix bleach and ammonia. Use a solution of 1 cup of liquid bleach to 1 gallon of water, plus nonphosphate detergent for cleaning and disinfecting.	Contains warning that chlorine bleach mixed with ammonia or acids produces chlorine gas.
Reoccupancy criteria	Not discussed.	Recommends independent post-remediation verification.
Health and safety during remediation	Resource provides two full pages of discussion on PPE. Recommends wearing a respirator, coveralls, boots, gloves, and eye and head protection. Set up a safety and cleanup area for restoration workers. Plan for dumpster or other trash removal area, and set up a clean-room containment system.	Provides extensive health and safety requirements and references.
Carbon monoxide	Do not have any unvented fuel burning devices in the home (generators mentioned).	Contains warning on the use of space heaters and back drafting atmospherically vented combustion devices (because of negative pressure in the combustion space).
Asbestos and lead	Homes built before 1978 typically have lead-based paint. Recommends using lead-safe practices when disturbing this paint. If the home contains 9 foot x 9 foot or 8 foot x 8 foot floor tiles made before 1970, assume these tiles contain asbestos. Spray these tiles with water and use caution when removing.	Refers to OSHA Standards 29 CFR 1926.62 and 1910.1025.
Health effects	Several pages are dedicated to the major health risks associated with water-damaged homes.	Contains brief descriptions of potential health effects from exposure to Category 2 and 3 water damage.
Fix moisture problem	Identify and fix moisture source. Rebuild using water-resistant materials.	No discussion of underlying moisture problems or floodproofing retrofits.
Other	Resource is comprehensive, easy to understand, and well-illustrated. Defines disinfectants. Discusses paint framing with fungicidal paint.	The book is divided into a standard of practice for responding to water loss problems and an extensive reference section that discusses the topics in detail.

Appendix 2: Selected References From the Literature Search in Chapter 3

The scientific literature search regarding cleaning and sanitizing in buildings yielded a small number of documents related directly to this issue. Highlights from some are listed below:

- Exner M, Vacata V, Hornei B, Dietlein E, Gebel J. 2004. Household cleaning and surface disinfection: New insights and strategies. *Journal of Hospital Infection* 56:S70–S75. This article demonstrates that *Staphylococcus aureus* can be transferred from one portion of a flooring surface to another by mops and found experimentally that:
    - Water and surfactants reduced concentrations by more than a factor of 100 and spread 1 in 10,000 ***colony-forming units*** (cfu) to neighboring floor sections.
    - Glycol derivatives, quaternary ammonium salts, and alkylamines reduced concentrations by more than 1,000 and spread 1 in 100,000 cfu to neighboring floor sections.
    - Aldehydes and peroxides reduced concentrations by greater than 10,000 (essentially eliminating test organism) and spread no measurable levels to neighboring floor sections.
    - Study limitation—mopping was one pass from contaminated site over three other sites and back; no scrubbing, no multiple passes, and no rinse.
- Rutala WA, Weber DJ. 2001. Surface disinfection: Should we do it? *Journal of Hospital Infection* 48(Suppl A):S64–S68. This article reports the following:
    - Cleaning floors with soap and water resulted in an 80 percent reduction in bacteria and a 99 percent reduction using phenolic disinfectant; in either case, levels were back to pre-treatment levels within a few hours (Ayliffe et al. 1966).
    - Detergents become contaminated as floors are mopped, spreading dilute contamination (Ayliffe et al. 1967).
    - ***Nosocomial infection*** rates are the same whether floors are cleaned with detergent or disinfectant (Danforth et al. 1987, Daschner et al. 1980, Dharan et al. 1999).
    - Contamination of noncritical surfaces does not seem to correlate to nosocomial infection rates or profiles (Maki et al. 1982).
    - Use of biocides might lead to organisms resistant to biocides or antibiotics (Levy 1998, McMurry et al. 1998, Moken et al. 1997).
- Wilson SC, Brasel TL, Carriker CG, Fortenberry GD, Fogle MR, Martin JM, Wu C, Andriychuk LA, Karunasena E, Straus DC. 2004. An investigation into techniques for cleaning mold-contaminated home contents. *Journal of Occupational and Environmental Hygiene* 1(7):442–447. This article reported that a combination cleaner/sanitizer was found to be effective at removing and deactivating microorganisms from environmental surfaces.

The authors' search of the literature for studies addressing cleaning or sanitization/disinfection of specific building materials revealed a dearth of citations, strongly emphasizing the need for more applied research in this area.

Although two studies present data relative to the cleaning of gypsum wallboard, it must be re-emphasized that heavily contaminated porous materials such as wallboard should be removed and replaced because fungal growth typically penetrates the material and results in regrowth at a later time. Nonsaturated, intact wallboard, however, may contain mold growth in a surface condensate layer, which then may be removed using a suitable cleaning/sanitizing/disinfecting product.

In one study, sections of unused, nonsterile gypsum board were inoculated with varying concentrations of *Stachybotrys chartarum* and incubated at high relative humidity (86 percent to 92 percent) for up to 12 weeks. Sections then were cleaned with a quaternary ammonium product, a quaternary plus chlorine dioxide, a concentrated oxygen-saline solution, or a quaternary/acrylic treatment and then reincubated. Regrowth of *S. chartarum* occurred within 5 weeks only on those sections cleaned only with the quaternary. Other fungi, mostly species of *Aspergillus, Chaetomium,* and *Penicillium*, slowly colonized (between 9 and 12 weeks) at least some areas of most cleaned/treated surfaces and most control surfaces. Surfaces cleaned/treated with the quaternary/acrylic remained visually free of colonized fungi for more than 90 days, although microscopic examination revealed fungal penetration of the coating after 3 weeks (Price and Ahearn 1999).

Another study used large sections of wallboard wet from immersion of their bottom inch in water for 8 weeks. After drying for 2 weeks, some sections were cleaned by dry brushing, some by spraying with a high-concentration hypochlorite solution and wiping, and some by spraying with a high-concentration hypochlorite solution with detergent surfactants and wiping. On continued incubation for 2 more weeks, the appearance of mold, as determined microscopically by tape-lift and by culturable swab samples, was delayed by at least 1 week on the biocide-treated sections. Other sections treated with commercially available fungicidal/fungistatic coatings remained mold free (Krause et al. 2006).

In a third study, samples of wet ***oriented strand board***, gypsum drywall, and plywood were inoculated with *Aspergillus fumigatus* spores and further incubated for 14 days, after which some were treated separately with one or the other of a high-concentration bleach solution or a commercial sodium hypochlorite/cleaner product. Subsequent sampling and testing showed kill of the *Aspergillus*, although no long-term regrowth studies were conducted. The investigators also tried to assess the capability of the tested solutions to neutralize the antigenic effects of the mold spores, but their sample was too small for meaningful interpretation and calls for further research (Martyny et al. 2005).

Although studies such as these indicate that the use of commercial biocide cleaner/treatments or fungicidal/fungistatic coatings can kill or retard the growth of water-damage molds on porous building materials for varying time periods, growth ultimately can reoccur, and hence the most cost-effective rational approach to remediation is the recommendation to replace such moisture-damaged and mold-contaminated materials, ensure adequate and complete drying of the indoor environment, and implement and maintain sustainable moisture control practices.

The use of detergents in the wet cleaning of surfaces and materials provides for the emulsification of organic residues and thus the removal of associated pathogens, allergens, and chemical pollutants. As most detergent products are formulations of quaternary ammonium compounds, they typically have a sanitizing effect in the killing of microbial contamination as well. A recent study of hospital floor cleaning methods concluded that wet scrub cleaning using detergent solution with hand-hot water was the most efficient, followed by spray cleaning, and then mopping and vacuuming (White et al. 2007). Also, a study investigating the use of detergent cleaning in livestock housing found that detergent use resulted in significant vegetative bacterial reductions on nonporous surfaces such as metal (Hancox et al. 2013), whereas another study showed that wet wiping with a detergent cleaner resulted in 1,000-fold physical reduction of *Clostridium difficile* spores from environmental surfaces (Rutala et al. 2012).

Also, the use of steam as a cleaning and sanitizing method has become more popularized with the availability of a number of commercial equipment products. A most definitive study of the capability of steam to inactivate a broad spectrum of human pathogenic bacterial challenges dried on a hard surface showed complete kill by exposure to steam vapor within 5.0 seconds (Tanner 2009). In that study, the use of bacterial challenges of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus faecalis, Salmonella enterica*, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Shigella flexneri* exposed to a steam device with its head covered with a cotton-terry material showed initial kill beginning at 0.5 seconds and continuing through 1.0 and 2.0 seconds, with complete kill of all challenges by 5.0 seconds. Such results confirmed the fact that steam begins to sanitize and kill vegetative bacteria on contact, and inactivation continues rapidly and logarithmically. The effectiveness of a steam cleaning process also was shown in a veterinary hospital where *S. aureus* and *Pseudomonas* species were reduced on stainless steel tub sinks by 94–98 percent and greater than 99 percent, respectively (Wood et al. 2014).

Once initial wet cleaning and decontamination practices have been completed and the environment sufficiently dried, then high-efficiency particulate air (HEPA) vacuuming can provide an additional measure of physical removal of any remaining residual contaminants prior to the rebuilding process. HEPA vacuuming has been recommended for the cleaning and remediation of indoor environments contaminated with bioterror and other highly infectious agents, such as *Bacillus anthracis*, as a more appropriate alternative to the use of chemical germicides (Cole and Lantrip 2001).

Yet another approach is the use of microfiber cloths for the effective and nonchemical wipe down of various surfaces expected to be contaminated with a variety of microbes, to include human pathogens. An investigation of the ability of 10 different microfiber cloths to remove microbial contamination from three common hospital surfaces (stainless steel, furniture laminate, and ceramic tile) under controlled laboratory conditions (microbial suspensions, automated cleaning device) concluded that "microfiber cloths are an effective way to reduce levels of MRSA, *E. coli*, and *C. difficile"* (Smith et al. 2011).

An interesting study has been published recently examining the effects of flooding and post-flood cleaning on airborne contamination in residential environments following the 2011 flooding of approximately 22,000 homes in Brisbane, Australia (He et al. 2014). Airborne particles, viable fungal and bacterial aerosols, and airborne dusts for elemental composition were

sampled and assessed in flooded (n = 24) and nonflooded (n = 17) homes. Results showed no statistically significant differences in airborne levels for each of the contaminant groups between flooded and nonflooded houses. This was attributed to the fact that all of the flooded homes were remediated and cleaned within 1 week (some within 1 or 2 days) after flood waters had receded. Remediation included removal of flooded materials and drying, while cleaning methods were varied and included the use of water only, water plus detergent, water plus bleach, water plus disinfectant, water plus disinfectant and bleach, detergent and bleach, and water plus insecticide. Although no particular cleaning approach could be advocated, the significance of the study has shown clearly that the key to prevention of poor indoor air quality following flooding is the need to, as rapidly as possible, remove water-damaged materials, institute drying, and employ some type of cleaning method to reduce residual contamination.

In summary, the use of various cleaning methods—as they have been discussed, either individually or in combination—to remove contamination from a variety of surfaces and materials in a home environment exposed to flood conditions appears to be a feasible approach to limiting post-flood contamination of the indoor air, as long as the methods used are in conjunction with the timely removal of affected materials and the rapid drying of the environment.

Further, the literature search also uncovered a number of papers regarding cleaning and sanitizing critical medical and food preparation surfaces but not specifically related to buildings. The major points are summarized below.

- Cases of nosocomial antibiotic resistant bacteria infection correlate to hospital stays longer than 1 week before admission to an intensive care unit (ICU), treatment with vancomycin, use of quinolones before admission to the ICU, and placement in contaminated treatment rooms (which received regular ICU cleaning) (Martinez et al. 2003).

- The concentration of active ingredient in a sanitizer affects efficacy (Bremer et al. 2002).

- The specific organism's tolerance to the sanitizing agent affects efficacy (Bremer et al. 2002, Knowles and Roller 2001, Weber et al. 1999).

- The state of bacteria, planktonic organisms, free cell, or biofilm affects efficacy, with biofilm being the most difficult to inactivate (Bremer et al. 2002, Mafu et al. 1990, Peng et al. 2002).

- Chlorine is more effective at sanitizing surfaces contaminated by a biofilm of *Campylobacter jejuni* than quaternary ammonium compounds or peracetic acid sanitizers in 45-second exposures (Trachoo and Frank 2002).

- Smoother, nonporous materials (e.g., stainless steel, glass, granite) are easier to sanitize, whereas porous, rough ones (e.g., wood, mineral resin, some plastics, scratched or scored smooth surfaces) are more difficult by orders of magnitude; concrete and tile surfaces fall in between (Bremer et al. 2002, Frank and Chmielewski 1997, Mafu et al. 1990, Snyder 1997, Snyder 1999).

- The presence of contaminants on a surface or in a liquid reduces the effectiveness of the sanitizer (which may be compensated for by increased concentration, contact time, or both) (Barker et al. 2003, Barker et al. 2004, Kusumaningrum et al. 2003, Mafu et al. 1990, Peng et al. 2002, Weber et al. 1999).

- Washing with water and detergent is sometimes very effective (Peng et al. 2002, Snyder 1999), whereas other times it is not (Barker et al. 2003, Cogan et al. 1999, Scott and Bloomfield 1993).

- Combination cleaners/sanitizers are effective (Barker et al. 2003, Olson et al. 1994, Peng et al. 2002).

- Inactivating some viruses, even under good conditions, requires high concentrations and long contact time (Allwood et al. 2004, Barker et al. 2004, Jean et al. 2003, Weber et al. 1999).

- Electrolyzed water performs as an effective sanitizer (Park et al. 2002).

- Chlorine bleach must be stored at room temperature in opaque bottles (Frais et al. 2001).

- A solution of sodium hypochlorite can retain 40 to 50 percent efficacy when stored in open, clear containers for 30 days (1:50 and 1:100 solutions), 83 to 85 percent when stored in sealed, nonopaque containers for 30 days (1:5 solutions), and 97 to 100 percent efficacy when stored in dark, sealed containers for 30 days (1:50 and 1:5 solutions) (Rutala et al. 1998).

- Hypochlorite activity is reduced by the presence of heavy metal ions, biofilm, organic material, low temperature, low pH, or UV exposure. Hypochlorite has a long history of use, low toxicity at recommended use concentrations, is effective against most microbes (including viruses), and is less effective against endospore-forming bacteria (Rutala and Weber 1997).

Finally, four papers also reported cleaning or disinfecting compounds as agents that can reduce allergenicity.

- A study of mouse urinary allergen (Mus m 1) found that sodium hypochlorite reduced the allergenicity of the allergen at molar concentrations of 100:1 and fragmented the protein at higher concentrations. Dust mite (Der p 1) and cockroach (Bla g 1) allergens were tested in a mixture with Mus m 1. Much higher concentrations of sodium hypochlorite were needed to reduce the allergenicity (molar ratios of 50,000 to 500,000). It was hypothesized that the higher levels were needed with the mixture than the purified Mus m 1 because of interference by much higher protein levels (Chen and Eggleston 2001).

- A similar study of cat allergen (Fel d 1) found that although Fel d 1 could be fragmented, it required a molar ratio of 7,000. Cat-specific IgG recognition was found at a lower molar ratio of 560 (Matsui et al. 2003).

- In a study of *A. fumigatus* growth on plywood, oriented strand board, and paper-covered gypsum board, sodium hypochlorite was reported to reduce recognition of *A. fumigatus* by ***enzyme-linked immunosorbent assay*** (commonly known as ELISA) and results in a loss of skin test reactivity to the treated mold for people who are allergic to *A. fumigatus* (Martyny et al. 2005).

- In a study of allergic proteins in floor dust tested for denaturing by household cleaners, it was found that soft soap, guanidine hydrochloride, and sodium lauryl sulfate reduced antigenic and allergenic activities but none destroyed them. None of the products used to clean carpets had any effect (Dybendal et al. 1990).

Appendix 3: Glossary

bioaerosol: Short for biological aerosol; a suspension of very small airborne particles that contain living organisms or were released from living organisms.

colony-forming unit: A unit used to estimate the number of viable (able to multiply) bacterial or fungal cells in a sample.

confidence interval: A range of values calculated from observations and so defined that there is a specified probability that the value of a parameter of interest lies within it. In other words, if confidence intervals are constructed in separate experiments on the same population following the same process, the proportion of such intervals that contain the true value of the parameter will match the given confidence level.

cross-sectional study: An observational study that analyzes data collected from a population, or a representative subset, at a specific point in time.

endotoxin: Molecules found on the outer membrane of some bacteria that elicit a strong immune response in mammals. Exposure to endotoxins can lead to septic shock and death.

endotoxin units per cubic meter: A measure of an endotoxin's biological activity (potency).

enzyme-linked immunosorbent assay: Commonly known as ELISA; a biochemical technique used mainly in immunology to detect the presence of an antibody or an antigen.

floodplain: An area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge.

gypsum board: The generic name for a family of panel products that consist of a noncombustible core—composed primarily of gypsum—and paper surfacing on the face, back, and long edges.

hydrophobic particles: Particles that do not carry a charge and, therefore, appear to repel water.

hyphae: Long, branching filamentous structures of a fungus that can cause an allergic reaction in sensitive individuals.

indoor microbiome: The collection of microbial communities that live within human-constructed environments (buildings). These microbiomes are being studied for a variety of reasons, including how they may affect the health of human and animal residents of indoor environments.

longitudinal study: An observational study method in which data are gathered for the same subjects repeatedly over a period of time.

medium-density fiberboard: Commonly known as MDF; an engineered wood product that is formed into panels made with wood fibers combined with wax and a resin binder. When MDF is

cut, sanded, or drilled, a large quantity of dust particles is released into the air; therefore, it is important that a respirator is worn and that the material is cut in a controlled and ventilated environment. Another concern is the slow release of formaldehyde over time, as MDF, particleboard, and oriented strand board have been cited as major sources of formaldehyde emissions.

mycotoxin: Toxic chemical products produced by fungi. Mycotoxins can cause weakened immune systems, allergic reactions, irritation, and death in animals and humans.

nosocomial infection: Hospital-acquired infections caused by viral, bacterial, or fungal pathogens.

odds ratio: Commonly known as OR; a measure of the association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure compared to the odds of the outcome occurring in the absence of that exposure.

oriented strand board: Commonly known as OSB; a type of engineered lumber similar to particle board, formed by adding adhesives and then compressing layers of wood strands. The resins used to create OSB have raised questions regarding the potential for OSB to emit toxic compounds, such as formaldehyde; OSB, particleboard, and medium-density fiberboard have been cited as major sources of formaldehyde emissions.

particleboard: An engineered, pressed wood product manufactured from wood chips, sawmill shavings, or even sawdust combined with a synthetic resin or other suitable binder. Safety concerns include physical (fine dust) and chemical (formaldehyde, carbon monoxide, hydrogen cyanide, phenol) exposure when cut, sanded, or drilled. Another concern is the slow release of formaldehyde over time, as particleboard, medium-density fiberboard, and oriented strand board have been cited as major sources of formaldehyde emissions.

polymerase chain reaction: Commonly known as PCR; a molecular biology technique used to amplify a single copy or a few copies of a piece of DNA. The technique is used for a variety of biological, genetic, and forensic reasons, including the identification and estimation of bacteria and fungi in samples.

reactive airways dysfunction syndrome: An asthma-like syndrome developing after a single exposure to high levels of an irritating vapor, fume, or smoke that includes coughing, wheezing, and shortness of breath.

relative risk ratio: The ratio of the probability of an event occurring (e.g., developing a disease, being injured) in an exposed group to the probability of the event occurring in a comparison, nonexposed group.

spore: A resistant structure used by bacteria, fungi, and other organisms to survive under unfavorable conditions. Mold spores can cause allergic, inflammatory, and toxic responses in sensitive individuals. The verification code for this document is 886215

Standard Flood Insurance Policy: A policy issued to insure a building and/or its contents. The Federal Emergency Management Agency's National Flood Insurance Program offers three

Standard Flood Insurance Policy forms. These forms provide policyholders with a description of their coverage and other important coverage information.

Appendix 4: References

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