HUD's Fiscal Year (FY) 2009 Healthy Homes Technical Studies Program

APPENDIX A – Key Residential Health and Injury Hazards

The following briefly describes the residential health and injury hazards HUD considers key targets for intervention:

Allergens and asthma: In 2005, the CDC estimated that over 22.2 million Americans have asthma with an associated annual cost of more than $13 billion. Asthma is now recognized as the leading cause of school and work absences, emergency room visits, and hospitalizations. For sensitized children, exposure to antigens from dust mites, certain pets, and cockroaches has been associated with more severe asthma. There is a preponderance of evidence showing a dose-response relationship between exposure and prevalence of asthma and allergies; some evidence also indicates that exposure to antigens early in life may predispose or hasten the onset of allergies and asthma. Dust mites have been identified as the largest trigger for asthma and allergies. A recently published study of children with atopic (allergic) asthma from seven major U.S. cities reported that over half of the children were allergic to cockroach and dust mite allergen (approximately 70% and 63%, respectively), with approximately 50% of the children allergic to mold (Morgan et al. 2004). Significant fractions of children also tested positive for allergy to cat, rodent and dog allergens. This is consistent with other studies that have found that cockroach tends to be the dominant allergen among asthmatic children living in the inner-city, whereas allergy to dust mite allergens appears to dominate among children living in most suburban environments. While children are the population most at risk for developing asthma, there is a growing need to address the onset of new cases in older adults, and to examine how their risk factors might differ from those of children (Selgrade et al. 2006).

Interventions known to have beneficial effects include the installation of impervious mattress and pillow covers, which can reduce allergen exposure by 90 percent. Other dust mite control measures include dehumidification, laundering bedding in hot water, specialized cleaning (dry steam or use of a HEPA vacuum), and removal of carpets and other materials that accumulate dust and are difficult to clean (e.g., dust sinks). Providing residents with education and instruction on cleaning with repeat visits by outreach workers has been shown to result in significant reduction in levels of dust mite and cockroach allergens in floor dust (Takaro et al. 2004; Morgan et al. 2004). For these same studies, researchers also reported significant reductions in asthma symptoms among children living in the intervention group when compared to the control group. A recent meta-analysis found that dust control interventions can also have a preventative effect. Based on five longitudinal studies, the researchers reported an approximately twenty percent decrease in risk of physician-diagnosed asthma for individuals in homes with dust control interventions, compared to those in control homes (Russell et al. 2007).

In a HUD-supported study, asthmatic children living in homes in which nontrivial mold growth was identified, were randomized into two groups, with one group receiving interventions to address the residential mold/moisture problems. The remediation group showed statistically significant reductions in symptom days, symptom score, and acute care visits (Kercsmar et al. 2006). The mean cost of home interventions was $3,458 per home, including the cost of addressing lead-based paint hazards.

Asbestos: Asbestos is a mineral fiber that has been used commonly in a variety of building construction materials and household products for insulation and as a fire-retardant.

The Environmental Protection Agency (EPA) and the Consumer Product Safety Commission (CPSC) have banned most asbestos products. Manufacturers have also voluntarily limited uses of asbestos. Today, asbestos is most commonly found in older homes in pipe and furnace insulation materials, asbestos shingles, millboard, textured paints and other coating materials, and floor tiles. Elevated concentrations of airborne asbestos can occur when asbestos-containing materials (ACMs) are disturbed by cutting, sanding or other remodeling activities. Improper attempts to remove these materials can release asbestos fibers into the air in homes, increasing asbestos levels and endangering the people living in those homes. The most dangerous asbestos fibers are too small to be visible. After they are inhaled, they can remain and accumulate in the lungs. Asbestos can cause lung cancer, mesothelioma (a cancer of the chest and abdominal linings), and asbestosis (irreversible lung scarring that can be fatal). Most people with asbestos-related diseases were exposed to elevated concentrations on the job; some developed disease from exposure to clothing and equipment brought home from job sites. As with radon, dose-response extrapolations suggest that lower level exposures, as may occur when asbestos-containing building materials deteriorate or are disturbed, may also cause cancer.

Intact asbestos-containing materials are not a hazard; they should be monitored for damage or deterioration and isolated if possible. Repair of damaged or deteriorating ACMs usually involves either sealing (encapsulation) or covering (enclosure) it. Repair is usually cheaper than removal, but it may make later removal of asbestos more difficult and costly. Repairs should only be done by a trained professional certified to handle asbestos safely and can cost from a few hundred to a few thousand dollars; removal can be more expensive.

Combustion products of heating and cooking appliances: Burning of oil, natural gas, kerosene, and wood for heating or cooking purposes can release a variety of combustion products of health concern. Depending upon the fuel, these may include carbon monoxide (a chemical asphyxiant), oxides of nitrogen (respiratory irritants), polycyclic aromatic hydrocarbons (e.g., the carcinogen benzo[a]pyrene), and airborne particulate matter (respiratory irritants). Exposure to carbon monoxide, an odorless gas, can be fatal. Nitrogen dioxide can irritate or damage the respiratory tract, and sulfur dioxide can irritate the eyes, nose and respiratory tract. Improper venting and poor maintenance of heating systems and cooking appliances can dramatically increase exposure to combustion products. As the principles of "green" construction and rehabilitation become more popular, and homes become increasingly airtight to improve energy efficiency, there are concerns about potential indoor air quality trade-offs (Selgrade et al. 2006).

Experts recommend having combustion heating systems inspected by a trained professional every year to identify blocked openings to flues and chimneys, cracked or disconnected flue pipes, dirty filters, rust or cracks in the heat exchanger, soot or creosote build-up, and exhaust or gas odors. Installing a carbon monoxide detector is also recommended; however, such a detector will not detect other combustion by-products.

Insect and Rodent pests: The observed association between exposure to cockroach antigen and asthma severity has already been noted above. In addition, cockroaches may act as vehicles to contaminate environmental surfaces with certain pathogenic organisms. Rodents can transmit a number of communicable diseases to humans, either through bites, arthropod vectors, or exposure to aerosolized excreta. In addition, humans can become sensitized to proteins in rodent urine, dander and saliva. Such sensitization may contribute to asthma severity among

sensitized individuals. Insect and rodent infestation is frequently associated with substandard housing that makes it difficult to eliminate. Treatment of rodent and insect infestations often includes the use of toxic pesticides that may present hazards to occupants (see below). Integrated pest management (IPM) for rodents and cockroaches is the recommended control strategy because it minimizes the use of toxic pesticides and instead emphasizes environmental controls such as elimination of harborages, and removing access to food and water.

Lead-based paint and its hazards: Exposure to lead, especially from deteriorating lead-based paint, remains one of the most important and best-studied of the household environmental hazards to children. Although blood lead levels (BLLs) have fallen nationally, a large reservoir of lead remains in housing. Recent results from CDC's Fourth National Health and Nutrition Examination Survey (NHANES 2002) demonstrate that the national geometric mean blood lead concentration of children aged 1-5 years has decreased from 2.3 μg/dL in 1991 to 1.6 μg/dL in the period 1999-2002 (CDC 2005). During the 1999-2002 survey period, children aged 1-5 years had the highest prevalence of elevated BLLs (1.6%), so that approximately 310,000 children aged 1-5 years remained at risk for exposure to harmful lead levels. Overall, by race/ethnicity, non-Hispanic blacks and Mexican Americans had higher percentages of elevated BLLs (1.4% and 1.5%, respectively) than non-Hispanic whites (0.5%). Among subpopulations, non-Hispanic blacks aged 1-5 years and aged ≥60 years had the highest prevalence of elevated BLLs (3.1% and 3.4%, respectively). As BLLs have dropped over the years, recent analyses have examined the relationship between relatively low blood lead concentrations (<10 μg/dL) and cognitive functioning in representative samples of U.S. children and adolescents, and have found evidence that suggests that deficits in cognitive and academic skills associated with lead exposure have no threshold (Lanphear et al., 2000; Canfield et al. 2003). These findings clearly support the importance of primary prevention with respect to childhood lead exposure.

Despite dramatic reductions in blood lead levels over the past 15 years, lead poisoning continues to be a significant health risk for young children. Based on results from the HUD- and NIEHS-funded National Survey of Lead and Allergens in Housing (Jacobs et al., 2002), it is estimated that approximately 40 percent of housing units (38 million) in the United States contain lead-based paint. It is further estimated that 25 percent of the nation's housing stock (24 million housing units) have one or more significant lead-based paint hazards (i.e., deteriorated lead-based paint, lead-contaminated dust, or lead-contaminated soil). 1.2 million housing units were found to pose the highest risk of lead poisoning because they housed low-income families with children under six years of age.

Among HUD grantees, lead hazard control (LHC) costs tend to range from $500 to $15,000 per unit, with an median cost of $5,960. Corrective measures include paint stabilization, enclosure and removal of certain building components coated with lead paint, cleanup and "clearance testing," which ensures the unit is safe for young children. In addition, acute injuries to children have been well documented, most notably in instances involving sanding or stripping of lead-based paint or visible deterioration of lead-based painted residential building components combined with children who exhibit pica tendencies.

Evaluation of lead hazard control interventions conducted by recipients of HUD's lead hazard control grants found that interventions were effective in significantly reducing pre-intervention dust-lead levels on floors and window surfaces up to six years following intervention (Wilson et al. 2006). More intensive treatments were found to significantly reduce

dust lead loadings on window sills and troughs compared to lower level treatments, however, no significant differences in dust-lead loadings on floors were reported.

Mold and moisture: An analysis of several pulmonary disease studies estimates that 25 percent of airways disease, and 60 percent of interstitial lung disease may be associated with moisture in the home or work environment. Moisture is a precursor to the growth of mold and other biological agents, which is also associated with respiratory symptoms. An investigation of a cluster of pulmonary hemosiderosis (PH) cases in infants showed PH was associated with a history of recent water damage to homes and with levels of the mold *Stachybotrys atra* (SA) in air and cultured surface samples. Associations between exposure to SA and "sick building" symptoms in adults have also been observed. Other related toxigenic fungi have been found in association with SA-associated illness and could play a role. For sensitive individuals, exposure to a wide variety of common molds may also aggravate asthma. A recent review by an expert committee convened by the Institute of Medicine found sufficient evidence for an association between exposure to mold and other agents in damp indoor environments and asthma symptoms in sensitized persons, upper respiratory tract symptoms, cough, and wheeze (IOM 2004). The committee also found limited or suggestive evidence for an association between damp indoor environments and the development of asthma. Addressing mold problems in housing requires coordination among the medical, public health, microbiological, housing, and building science communities.

The cost of mold/moisture-related intervention work (e.g., IPM, clean and tune furnace, remove debris, vent clothes dryer, cover dirt floor with impermeable vapor barrier) is a few hundred dollars, unless major modification of the ventilation system is needed. For example, in Cleveland, mold interventions, including repairs to ventilation systems and basement flooring, in the most heavily contaminated homes range from $500 to $5,000, with some costs also being dedicated to LHC simultaneously through its lead and asthma program.

Pesticide residues: According to the EPA, 75 percent of U.S. households used at least one pesticide product indoors during the past year. Products used most often are insecticides and disinfectants. Another study suggests that 80 percent of most people's exposure to pesticides occurs indoors and that measurable levels of up to a dozen pesticides have been found in the air inside homes. The amount of pesticides found in homes appears to be greater than can be explained by recent pesticide use in those households; other possible sources include contaminated soil or dust that migrates in from outside, stored pesticide containers, and household surfaces that collect and then release the pesticides. Pesticides used in and around the home include products to control insects (insecticides), termites (termiticides), rodents (rodenticides), molds and fungi (fungicides), and microbes (disinfectants). In 2005, the American Association of Poison Control Centers reported that some 1.6 million children were involved in common household pesticide poisonings or exposures (AAPCC 2005). In households with children under five years of age, almost half stored at least one pesticide product within the reach of children. Exposure to high levels of cyclodiene pesticides, commonly associated with misapplication, has produced various symptoms, including headaches, dizziness, muscle twitching, weakness, tingling sensations, and nausea. In addition, the EPA is concerned that cyclodienes might cause long-term damage to the liver and the central nervous system, as well as an increased risk of cancer.

There are available data on hazard evaluation methods and remediation effectiveness regarding pesticide residues in the home environment.

Radon progeny: The National Academy of Sciences estimates that approximately 15,000 cases of lung cancer per year are related to radon exposure. Epidemiologic studies of miners exposed to high levels of radon in inhaled air have defined the dose response relation for radon-induced lung cancer at high exposure levels. Extrapolation of these data has been used to estimate the excess risk of lung cancer attributable to exposure to radon gas at the lower levels found in homes. These estimates indicate that radon gas is an important cause of lung cancer deaths in the U.S. Excessive exposures are typically related to home ventilation, structural integrity and location.

Radon measurement and remediation methods are well developed, and the EPA recommends that every home be measured for radon. EPA estimates that materials and labor costs for radon reduction in an existing home are $800-$2,500. Including radon resistant techniques in new home construction costs $350-$500, and can save up to $65 annually in energy costs, according to the EPA.

Take-home hazards from work/hobbies and work at home: When the clothing, hair, skin, or shoes of workers become contaminated with hazardous materials in the workplace, such contaminants may inadvertently be carried to the home environment and/or an automobile. Such "take-home" exposures have been demonstrated, for example, in homes of lead-exposed workers. In addition, certain hobbies or workplaces located in the home may provide an especially great risk of household contamination.

Control methods include storing and laundering work clothes separately, and showering and changing clothes before leaving work or immediately after arriving home. Once a home becomes contaminated, cleaning floors and contact surfaces and replacing furnishings may be necessary to reduce exposures.

Unintentional injuries/fire: Unintentional injury is now the leading cause of death and disability among children younger than 15 years of age. In 1997, nearly 7 million persons in the U.S. were disabled for at least one full day by unintentional injuries received at home. A recent HUD-supported study of deaths among US children and adolescents from 1985 to 1997 found that an average of 2,822 unintentional deaths occurred annually from residential injuries (Nagaraja et al., 2005). The highest death rates were attributable to fires, submersion or suffocation, and poisoning. Black children were two times more likely to die from residential injuries than white children. The elderly are also at an elevated risk for residential injuries. Home visitation protocols have been shown to be effective in reducing exposure to injury hazards. The "add-on" cost of injury prevention measures, when combined with other housing interventions are estimated at about $100 per unit. This includes the cost of some injury prevention devices (e.g., smoke alarms, electrical socket covers, etc.).