The literature suggests that deteriorated or disturbed lead-based paint constitutes a major source of leaded dust in residential environments and that children are commonly exposed to the lead through normal hand-to-mouth contact. Uncontrolled removal of old paint and inadequate cleanup has caused numerous cases of child and adult lead poisoning in the past. Today, methods to safely remove or treat leaded surfaces exist and dust clearance procedures are standardized and feasible. This ensures that children do not move back into dwellings contaminated with lead by the treatment process itself. However, it is important to know which methods are most effective in controlling lead hazards in the home over the short- and long-term. The following sections present numerous studies to illuminate our current state of knowledge on this subject.

3. Measuring the Impact of Lead Hazard Control Interventions

While each study contributes to our understanding of the impact of lead hazard control interventions, each study has strengths and limitations that influence the interpretation of the findings. Before reviewing the studies, it is important to understand the difference between the primary and secondary prevention of lead poisoning, and some of the problems with using blood or dust lead levels to measure the effect of lead hazard control activities.

3.1 Primary Versus Secondary Prevention of Lead Poisoning

Except for one EPA study (Weitzman 1993), all of the currently published blood lead studies available measured blood lead levels among already poisoned children (above 25 µg/dL) to evaluate the impact of lead hazard control activities. The studies measure the effectiveness of secondary prevention of childhood lead poisoning. The effectiveness of lead hazard control interventions on the primary prevention of childhood lead poisoning may differ. In fact, lead hazard control activities may work better for the primary prevention of lead poisoning among siblings or future residents than as an intervention for already-poisoned children.

Children who are chronically exposed to lead may have large body burdens of lead. The internal lead burdens may slow the reduction of blood lead levels even after a child is moved into a lead-free environment. One study showed that chronically exposed children who were placed in lead-free housing following chelation for blood lead levels of 50 µg/dL or greater had an average blood lead level of 28 µg/dL one year after chelation (Chisolm, 1985). The study highlights that even in a relatively lead-free environment, the blood lead levels of chronically exposed children may not go below 25 µg/dL during the year following diagnosis. However, children born into environments free from lead hazards usually do not have large body burdens of lead. The increase in blood lead levels prevented by lead hazard control interventions may be larger than the decrease measured among already-poisoned children.

3.2 Using Dust or Blood Lead Levels as an Outcome Measure

The general assumption behind abatement and interim controls is that by eliminating or controlling the sources of lead in an environment, the dust lead level will be reduced, which will in turn reduce blood lead levels. Therefore, samples of both house dust and blood are typically collected to assess the short- and long-term efficacy of lead hazard control interventions.

It can be argued that lead levels in house dust are a more direct measure of efficacy than are lead levels in blood. Consider the following simplified pathway of lead exposure from a primary lead source (e.g., old paint) to a child's blood.
Sampling house dust for lead provides an estimate of the amount of lead present in the environment. Blood lead sampling provides an estimate of the biological impact of the absorbed dose of lead, after exposure has taken place. Lead hazard control work typically targets the primary sources of lead and/or house dust directly. Therefore, house dust is a more direct measure of efficacy than measuring blood lead levels alone because the presence of lead can be measured before the uncertainties associated with exposure and biological impact occur.

When using dust lead measurements to determine if an intervention is effective in reducing lead-based paint hazards, it is important that dust lead levels are measured both before and after the intervention takes place. Although dust lead levels after an intervention may be below the HUD clearance levels, they may in fact be higher than they were prior to the intervention. Without pre-intervention dust lead levels, this will not be recognized.

Dust lead measurements are also influenced by many factors not associated with lead hazard control interventions. For example, the dust lead loading level, which measures the amount of lead on a surface, is directly affected by the cleaning methods used and the frequency of cleaning in relation to the timing of sampling. In addition, the dust sampling method itself, and the laboratory analysis procedure, may influence estimates of environmental dust lead levels. Standardized dust wipe sampling procedures have been established by the Federal government and ASTM (American Society for Testing and Materials) to minimize the variation in dust lead measurements (HUD, 1994a) (ASTM, 1994). These standardized procedures should be followed by persons conducting efficacy studies.

Measuring a child's blood lead level may show whether the intervention made a difference for the child for whom the intervention was initiated. However, blood lead levels can be influenced by numerous factors that are not associated with the hazard control activities. First, they can be influenced by the levels of lead stored in the bone, which reflect the child's past exposure to lead. Second, they can be influenced by exposure to lead hazards outside the home environment, such as hazards at the home of a relative or babysitter. Third, they can be influenced by behavioral changes that are independent of the environmental changes. For example, as children age, their mouthing behaviors change which may increase or decrease their exposure to the existing lead hazards. Children's blood lead levels tend to peak around two to three years of age. Fourth, they may be influenced by metabolic changes. Finally, blood lead levels may be influenced by seasonal changes which may result from increased exposure to leaded soil or dust, possibly due to opening windows more frequently and playing more out-of-doors during the warmer months of the year. Among 14,033 children screened in Milwaukee from 1990-1994, the average blood lead levels decreased approximately one-third from summer to winter. The seasonal fluctuations were especially keen among children with higher blood lead levels (personal communication, Brad Schultz).

In summary, when the blood lead levels of lead-poisoned children are evaluated over time, the levels can be affected by the season the child was tested, the child's past exposure to lead, the increasing age of the child, as well as any educational or other interventions that coincide with the environmental intervention. Similarly, dust lead measurements can be affected by numerous events not related to the environmental interventions.

### 4. Definitions