3 Lead in Soil: Why is it a Problem?

This chapter provides an overview of the problems posed by lead in soil. Section 3.1 discusses lead poisoning, its health effects and prevalence, and the pathways through which children and others are exposed to lead. Section 3.2 describes the most common sources of lead in residential soil and summarizes soil-lead levels found in the United States. Section 3.3 reviews evidence indicating that soil is one important pathway for childhood lead exposure. Finally, Section 3.4 describes the national strategy for reducing hazardous exposures to lead and identifies standards and regulations that may affect a lead-safe yard program.

The information in this chapter should be useful to any person interested in soil-lead hazards and mitigation, whether that person be a community organizer responsible for implementing a lead-safe yard program or a homeowner concerned about elevated soil-lead levels in his or her own yard.

3.1 Lead and Lead Poisoning

Lead is a heavy, soft, malleable metal. Due to its physical and chemical properties, industry has found countless uses for lead in our daily lives. While certain uses of lead are banned, lead is still found in a myriad of products. Important sources of lead in the environment today include:

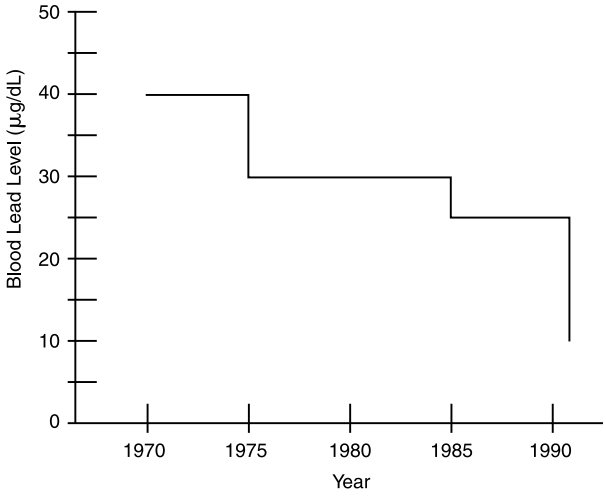
- Lead paint, and resulting lead dust, found in and around homes built before 1978 (lead-based paint was banned in 1978). Lead dust from deteriorated lead-based paint is the most significant contributor to childhood lead poisoning.
- Lead from automobile emissions (before leaded gasoline was finally banned in 1986) that has been deposited on land and surface water.
- Lead in occupational settings (often brought home on clothes or skin).
- Lead from industrial emissions, such as lead smelters, lead mining, hazardous waste sites, and battery-recycling plants.
- Lead in drinking water caused by lead-containing plumbing.
- Lead-containing tableware, such as leaded-crystal glassware and lead-glazed pottery.
- Certain hobbies and activities that use lead (e.g., car radiator repair, target shooting, stained-glass making, glass or metal soldering).
- Certain folk remedies that contain lead (e.g., azarcon, greta).

3.1.1 What Is Lead Poisoning?

Lead poisoning is entirely preventable. However, according to the Centers for Disease Control and Prevention (CDC), nearly 1 million children living in the United States in the early 1990s had lead in their blood at levels high enough to cause irreversible damage to their health.

CDC defines elevated blood lead in children as blood lead levels of 10 micrograms of lead per deciliter of blood (µg/dL) or higher. Until the early 1970s, CDC's blood lead levels of concern were 60 µg/dL for children and 80 µg/dL for adults. As the adverse effects of lead became better known,

Blood lead levels considered elevated by the Centers for Disease Control and the Public Health Service.



Source: Centers for Disease Control, 1991, *Preventing Lead Poisoning in Young Children*

CDC lowered the level at which it recommends medical attention, also known as the "blood lead intervention level," on three separate occasions. After research showed that cognitive and developmental damage occurs at blood lead levels as low as 10 µg/dL, CDC lowered the blood lead level of concern to the current 10 µg/dL value in 1991. There is no known safe level of lead in blood.

3.1.2 Health Effects of Lead Poisoning

Lead poisoning affects nearly every system in the body, and often occurs without noticeable symptoms. Although lead can affect adults, children under the age of six are especially vulnerable to the adverse effects of lead. The incomplete development of the blood-brain barrier in fetuses and very young children (up to 36 months of age) increases the risk of lead's entry into the nervous system. Low but chronic exposure can affect the developing nervous system in subtle but persistent ways. In children, blood lead levels as low as 10 to 15 µg/dL can stunt growth rates, affect attention span, cause learning disabilities, lower IQ scores, impair hearing acuity, and cause behavioral problems. In addition, fetuses exposed to elevated levels of lead can suffer from low birth weight, impaired hearing, and altered gestational age, which can lead to further complications.

In addition to damaging the nervous system, elevated blood lead levels can also affect the kidneys and reproductive system and cause high blood pressure. Very high levels (greater than 80 µg/dL) can cause convulsions, coma, or death. Levels greater than 150 µg/dL are fatal if not treated quickly. Fortunately, exposures resulting in such high levels of lead are rare.

The literature on the health effects of lead is extensive. For more information, see CDC's *Preventing Lead Poisoning in Young Children* (http://aepo-xdv-www-epo.cdc.gov/wonder/prevguid/p0000029/p0000029.htm) and the Agency for Toxic Substances and Disease Registry's *Case Studies in Environmental Medicine: Lead Toxicity* (http://www.atsdr.cdc.gov/HEC/caselead.html). Additional resources and links listed at the end of this chapter provide a wealth of information on this and other lead-related topics.

3.1.3 How Does Lead Enter the Body, and What Happens to Lead in the Body?

Lead enters the body through either ingestion or inhalation. Young children tend to ingest more lead than adults do in a given environment, mainly because of their normal hand-to-mouth behavior. They also take in more food and water per kilogram of body weight. The most common way for a child to ingest lead is by putting objects in the mouth (e.g., toys or hands) that have lead-contaminated dust or dirt on them. Children may also mouth surfaces having lead-based paint (such as window sills) or ingest lead-paint chips or soil (especially children who exhibit pica, a pattern of eating dirt or other non-food substances). Children may also ingest lead if their drinking water contains lead. (Lead in drinking water usually comes from lead-containing pipes, faucets, and solder in the plumbing of older buildings.) Children can also inhale lead via dust from deteriorating paint, dust on clothing brought home by parents exposed to occupational lead sources, or fumes from hobbies or industries that use lead.

The rate at which the body absorbs lead, once it has been ingested, depends on the chemical and physical form of the lead and on the physiological characteristics of the exposed person. Nutritional status and age are the factors having the greatest influence on absorption rates. Adults typically absorb 10 to 15 percent of ingested lead through the gastrointestinal tract, while children and pregnant women can absorb as much as 50 percent. Children are also at higher risk when their nutritional needs are not being adequately met. Calcium, iron, zinc, and protein deficiencies, in particular, increase lead absorption rates. Fasting conditions in adults have a similar impact on the absorption of lead. Lead dust inhaled and deposited into the lower respiratory tract is completely absorbed by both adults and children.

Since lead is an inorganic metal, it is not metabolized and is distributed throughout the body by the bloodstream. Over time, a portion of the lead may be eliminated from the body. The majority, however, remains in the bloodstream, or is absorbed by soft tissue (kidneys, bone marrow, liver, and brain), or mineralizing tissue (bones and teeth). In adults, 95 percent of the lead present in the body is found in teeth and bones, where it remains inert. When the body experiences physiological changes, however—such as pregnancy, lactation, or chronic disease—this inert lead can leach into the bloodstream and raise blood lead levels to dangerous levels. During pregnancy, this mobilized lead can also be transferred to the fetus, which has no defense mechanism against it. This can result in developmental and neurological damage.

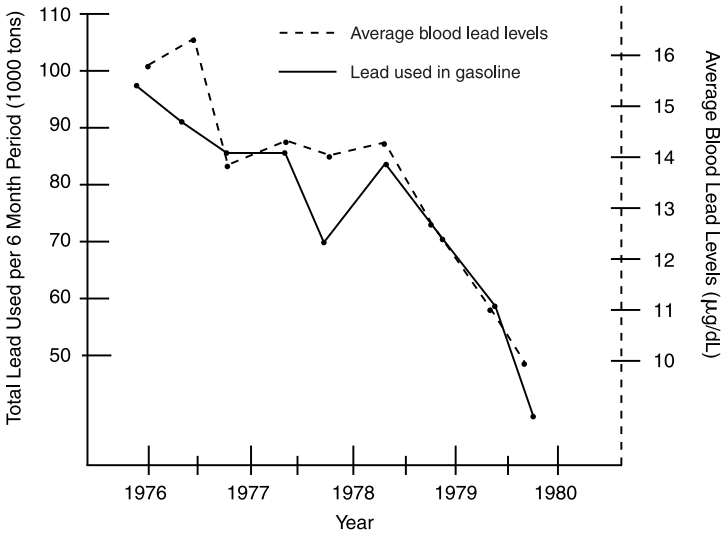
In addition to absorbing a greater proportion of the lead to which they are exposed, children also tend to retain a greater percentage of lead in their blood than do adults. This is partly because a child's body is not as efficient as an adult's at absorbing lead into mineralizing tissue. Consequently, a greater fraction of the lead absorbed remains in the bloodstream and has a toxic effect on internal organs.

3.1.4 How Common Is Lead Poisoning in Children?

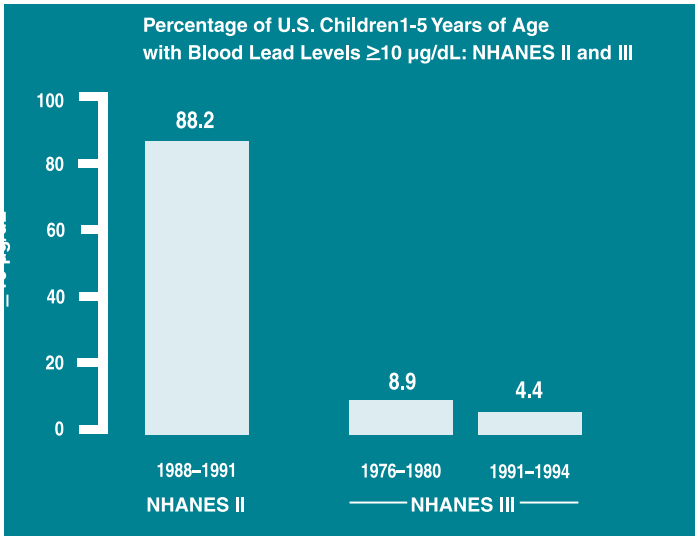
The Second National Health and Nutrition Examination Survey (NHANES II), released in 1980, showed that as recently as 1976, the average blood lead level of the typical American child was 12.8 µg/dL. The survey also revealed that at that time 88.2 percent of American children ages one through five were suffering from some degree of lead poisoning (i.e., over CDC's current level of concern of 10 µg/dL).

In the 1970s, the federal government banned the use of lead-based paint in residential buildings and houses, and phased out the use of lead as an additive in gasoline. These two actions had an immense impact on the blood lead levels of children nationwide. NHANES III reported that by 1988, the national average blood lead level in children had dropped to 2.8 µg/dL and the percentage of children suffering from lead poisoning had dropped to 8.9 percent. By the early 1990s, the average blood lead level of

Change in blood lead levels in relation to a decline in use of leaded gasoline, 1976-1980.



Source: Centers for Disease Control, 1991, *Preventing Lead Poisoning in Young Children*



children ages one through five was 2.3 µg/dL.[1] A fourth NHANES report has recently been completed; though the report has not yet been made public, the survey data apparently suggest that average blood lead levels continue to decrease among children in this age range.

While childhood lead exposure has diminished over the past 25 years, the problem is far from solved. In particular, minority, low-income, inner-city populations continue to lag behind in improvement, relative to national averages:

- 8 percent of impoverished children suffer from lead poisoning compared to only 1 percent of children from high-income families.[2]
- 11.2 percent of all African-American children are lead poisoned compared to 2.3 percent of all white children.[3]
- 50 to 70 percent of the children living in the inner cities of New Orleans and Philadelphia have blood lead levels above 10 µg/dL.[4]

Poor nutrition, deteriorating housing, lack of access to medical care, and language barriers all contribute to placing poor and minority children at risk for lead poisoning. It is important to note, however, that no economic or ethnic/racial group is free from the risk of lead poisoning. A sizable number of affluent families renovating older homes, for example, have placed their children at risk through unsafe lead paint removal techniques.

3.2 Sources and Levels of Lead in Soil

When lead is deposited in soil from anthropogenic sources, it does not biodegrade or decay and is not rapidly absorbed by plants, so it remains in the soil at elevated levels. Lead is estimated to have a half-time of residence in soil of 1,000 years.[5] In soils with a pH of greater than or equal to 5 and with at least 5 percent organic matter (which immobilizes the lead), atmospheric lead is retained in the upper 2 to 5 centimeters of undisturbed soil.[6] Urban soils or other soils that have been turned under or otherwise disturbed may be contaminated to much greater depths.

EPA estimates that 23 percent, or 18 million, of the privately owned homes in the United States built before 1980 have soil-lead levels above 400 parts per million (ppm); that 3 percent, or 2.5 million, have levels exceeding 2,000 ppm; and that 3 percent, or 2.5 million, exceed 5,000 ppm.[7]

[1] Natural Resources Defense Council, *Our Children at Risk: The 5 Worst Environmental Threats to Their Health,* Chapter 3: Lead, Washington, DC, 1997. Available at http://nrdc.org/health/kids/ocar/ocarinx.asp
[2] Ibid.
[3] Ibid.
[4] Mielke, H.W., "Lead in the Inner Cities," *American Scientist,* vol. 87, no. 1, Jan/Feb 1999.
[5] Benninger et al., *The Use of Natural Pb-10 as a Heavy Metal Tracer in the River-Estuarine System,* ACS Symposium Series #18, Marine Chemistry and the Coastal Environment, 1975.
[6] U.S. Environmental Protection Agency, *Air Quality Criteria for Lead,* Research Triangle Park, NC, EPA600-8-83-018F, 1986.
[7] U.S. Environmental Protection Agency, *Distribution of Soil Lead in the Nation's Housing Stock,* 1996.

Lead in residential soil comes from several different sources, including lead-based exterior paint and automobile tailpipe emissions from vehicles burning leaded gasoline. Industrial emissions are also a source of residential soil contamination in some areas. These sources of contamination are discussed in more detail below.

3.2.1 Lead-Based Paint

EPA has found building age to be the strongest statistical predictor of soil lead, with soil around private homes built before 1940 having significantly higher levels of lead in soil than homes built between 1960 and 1979.[8] While the use of lead paint in residential buildings was federally banned in the United States in 1978, many homes built prior to 1978 still contain lead-based paint. Paint used in homes built between 1950 and 1978 contained between 0.5 and 50 percent lead, and the paint used prior to 1950 contained higher concentrations. One estimate is that more than 3 million tons of lead-based paint remain in the 57 million homes built prior to 1980.[9]

Since a large portion of this lead-based paint covers building exteriors, it continues to be a significant source of soil contamination. Lead-based paint contaminates soil as the paint film weathers and reaches the soil in the form of chips and dust. Renovating, remodeling, and performing routine home maintenance will also mobilize this lead if proper precautions are not taken. As the paint on a building's exterior deteriorates, lead paint chips and dust concentrate in the surrounding soil. Dry scraping, sanding, and blasting of lead-based paint can mobilize large amounts of lead in a short time and significantly increase lead concentrations in soil. Lead concentrations in soil are typically highest in the drip zone, or dripline, the area surrounding and extending out about 3 feet from the perimeter of a building.

3.2.2 Leaded Gasoline

The use of lead as a gasoline additive was phased out during the 1970s and banned in the United States in 1986. It has been estimated that 4 to 5 million metric tons of lead, emitted from automobile tailpipes as fine dust particles, remain in the environment in dust and soil.[10] This represents approximately 75 percent of the total amount of lead added to gasoline. The remaining 25 percent was deposited on internal engine surfaces or ended up in the oil. The lead dust that became airborne would migrate until hitting a barrier such as the side of a house or some other structure, to which it would adhere. Subsequent rains washed this lead dust down into the surrounding soil, where it accumulated over time.

Scientists estimate that 4 to 5 million metric tons of lead emitted from automobile tailpipes prior to 1986 remain in the environment in dust and soil.

Soil-lead levels within 25 meters of roadways are typically 30 to 2,000 ppm higher than natural levels, and can sometimes be

[8] Ibid.
[9] Centers for Disease Control, *Preventing Lead Poisoning in Young Children,* 1991.
[10] Ibid.

as high as 10,000 ppm.[11] Some researchers have found that soil-lead concentrations typically are highest in older, inner-city neighborhoods, especially those near high-traffic routes, and that soil-lead concentrations diminish with distance from the city center. Another study found that soil-lead concentrations are 10 to 100 times higher in old communities in large cities than in comparable neighborhoods in smaller cities, perhaps because traffic volume is higher and vehicles remain inside the city longer.[12]

A back yard in Dorchester, Massachusetts, with areas of bare, contaminated soil. When children play outdoors, lead-contaminated dirt and dust can get on hands, clothes, toys, and food.

3.2.3 Industrial Emissions

Communities near industrial and mining activities that release lead (or released lead in the past) may also have elevated levels of lead in residential soils. Examples of such industries and activities are lead smelting or refining plants, lead mining, auto repair, battery recycling or manufacturing, bridge and water tank repainting and reconstruction, plastic manufacturing, shipbuilding, glass manufacturing, printing, and hazardous waste sites. EPA has found lead levels in soils next to smelters as high as 60,000 ppm.[13]

3.3 Soil as an Exposure Pathway for Lead

While deteriorated lead-containing paint in housing is generally accepted as the leading source of lead exposure to children, outdoor activities where individuals come into contact with lead-contaminated soil also represent an exposure pathway that can be significant. When children play outdoors, lead-contaminated dirt and dust can get on hands, clothes, toys, and food. Putting these items in the mouth can lead to ingestion of lead.

Children can also breathe lead dust or lead-contaminated dirt stirred up by the wind or by outdoor play activities. During dry periods, dust from bare patches of contaminated soil can readily become airborne, increasing the chance that it will be inhaled. Also, airborne lead dust and lead-contaminated dirt can settle on play clothes and shoes and can be tracked into homes, further increasing exposure. Pets, as well, can track lead-contaminated soil into homes on their coats and paws.

The relative contribution of lead-contaminated soil versus lead-based paint and house dust is the subject of research and debate. Although there are differing opinions among researchers and experts as to the degree of significance of exposure to lead-contaminated soil, evidence does exist that soil is one important pathway for lead exposure among children. Some researchers have shown an asso-

[11] Ibid.
[12] Mielke, H.W., "Lead in the Inner Cities," American Scientist, vol. 87, no. 1, Jan/Feb 1999.
[13] U.S. Environmental Protection Agency, *Air Quality Criteria for Lead.*

ciation between increases in blood lead and increases in soil or dust concentrations. Factors that influence this relationship include access to soil, behavior patterns, presence of ground cover, seasonal variation of exposure conditions, and the particle size and chemical form of the lead. Others have found an association between time spent outdoors and children putting soil or dirt in their mouths, which, in turn, is associated with elevated blood lead levels.[14]

In 1996, EPA published the Integrated Report of the Urban Soil Lead Abatement Demonstration Project. This report assessed the scientific data from studies in three cities (Boston, Baltimore, and Cincinnati) to determine whether abatement of lead in soil could reduce blood lead levels of inner-city children. The report concludes that when soil is a significant source of lead in the child's environment, the abatement of that soil will result in a reduction in exposure that will, under certain conditions, cause a reduction in childhood blood lead concentrations. Important factors in reducing blood lead levels were thought to be (1) the past history of exposure of the child to lead, as reflected in pre-abatement blood lead levels; (2) the magnitude of the reduction in soil-lead concentrations; (3) the magnitude of other sources of lead exposure; and (4) a direct exposure pathway between soil and the child.[15]

CREATING A LEAD-SAFE RESIDENCE

As the various pathways for lead exposure in young children become better understood, the importance of addressing all of the sources of lead in and around the home has also become clearer. For example, even if the interior of a home is certified as deleaded, a lead-contaminated yard can remain a dangerous source of lead exposure for children living there. Conversely, soil mitigation work will be ineffective if nothing is done about heavily leaded exterior paint on a home, because recontamination of the yard is likely to occur.

Because lead in yard soil is only one aspect of a multi-layered problem, the EMPACT Lead-Safe Yard Project decided in Phase 3 to address yards only for residences where structural lead abatement had been completed. Even in such homes, however, some lead probably remains, and precautions must be taken (e.g., using lead-safe renovation techniques) to prevent recontamination of the yard.

Howard Mielke, a leading researcher on lead poisoning and prevention, reviewed other evidence for soil lead as an important exposure pathway in a 1999 article.[16] Mielke demonstrated a strong correlation between soil lead and blood lead in several studies.

3.4 Standards and Guidelines for Lead Poisoning Prevention

This section provides an overview of federal guidelines and standards that may affect a lead-safe yard program. When determining the requirements that apply to your program, it is important to check with the state or tribal agency that addresses lead poisoning prevention. For example, many states have requirements for training and certification of contractors performing lead hazard evaluation and abatement work. For a list of state/tribal lead poisoning prevention agencies, see http://www.ncsl.org/programs/ESNR/pbdir.htm.

3.4.1 The Federal Regulatory Infrastructure

Title X of the 1992 Housing and Community Development Act (available online at http://www.epa.gov/lead/titleten.html), otherwise known as the Residential Lead-Based Paint Hazard Reduction Act (Public Law 102-550), mandated the creation of an infrastructure that

[14] Bruce Lanphear and Klaus Roghmann, "Pathways of Lead Exposure in Urban Children," *Environmental Research,* vol. 74, 63–73, 1997.
[15] U.S. Environmental Protection Agency, *Integrated Report of the Urban Soil Lead Abatement Demonstration Project,* EPA600-P-93-001aF, Office of Research and Development.
[16] Mielke, H.W., "Lead in the Inner Cities," *American Scientist,* vol. 87, no. 1, Jan/Feb 1999.

would correct lead paint hazards in housing. Title X also redefined "lead paint hazards" and how they can be controlled, and created Title IV of the Toxic Substances Control Act (TSCA), under which EPA sets lead hazard standards, work practice standards, and training requirements for lead abatement workers. Based on scientific research in the 1980s, Congress defined "hazard" to include deteriorated lead paint and the lead-contaminated dust and soil it generates. The infrastructure has been developed and includes the following:

- Grant programs to make homes lead safe, now active in over 200 cities.
- Training of thousands of workers doing housing rehabilitation, remodeling renovation, repainting, and maintenance to help them do their work in a lead-safe way.
- Licensing of inspectors and abatement contractors.
- Compliance with and enforcement of lead safety laws and regulations.
- Disclosure of lead paint problems before sale or lease.
- National and local education and outreach programs.
- Promulgation of federal standards of care.
- Worker protection regulations.

The box below lists federal agencies and their programs related to lead poisoning prevention. For a more detailed overview of these federal programs, see "Current and Ongoing Federal Programs and Activities" in *Eliminating Childhood Lead Poisoning: A Federal Strategy Targeting Lead Paint Hazards* (http://www.epa.gov/children/whatwe/leadhaz.pdf).

FEDERAL AGENCY ROLES IN LEAD POISONING PREVENTION

Agency	Programs and Duties
Department of Housing and Urban Development **http://www.hud.gov/lea/leahome.html**	Lead Hazard Control Grant Program, enforcement of Disclosure Rule (with EPA and DOJ) and federally assisted housing lead paint regulations, National Survey of Lead Paint in Housing, Lead Hotline (with EPA), Internet listing of lead paint professionals, public education and training of housing professionals and providers and others, technical assistance, research.
Department of Health and Human Services: Centers for Disease Control and Prevention **http://www.cdc.gov/nceh/lead/lead.htm**	Blood Lead Screening Grant Program, public education to medical and public health professionals and others, National Health and Nutrition Examination Survey, quality control for laboratories analyzing blood lead specimens, research.
Health Care Financing Administration **http://www.hcfa.gov**	Covers and reimburses for lead screening and diagnosis, lead poisoning treatment, and follow-up services for Medicaid-eligible children.

FEDERAL AGENCY ROLES IN LEAD POISONING PREVENTION

Agency	Programs and Duties
National Institute of Child Health and Human Development **http://www.nichd.nih.gov**	Conducts and supports laboratory, clinical, and epidemiological research on the reproductive, neurobiologic, developmental, and behavioral processes, including lead poisoning related research.
Health Resources and Services Administration **http://www.hrsa.gov**	Directs national health programs to assure quality health care to under-served, vulnerable, and special need populations including children with lead poisoning.
Agency for Toxic Substances and Disease Registry **http://www.atsdr.cdc.gov**	Studies blood lead in populations near Superfund sites and funds state health agencies to undertake this type of work.
Food and Drug Administration **http://www.fda.gov**	Enforces standards for lead in ceramic dinnerware; monitors lead in food.
National Institutes of Health **http://www.nih.gov**	Conducts basic research on lead toxicity.
Environmental Protection Agency **http://www.epa.gov/opptintr/lead/index.html**	Licenses lead paint professionals (or delegates this responsibility to states); environmental laboratory accreditation; enforcement of Disclosure Rule (with HUD and DOJ) and Pre-Renovation Notification Rule; hazardous waste regulation; public education to parents, environmental professionals, and others; training curriculum design; Lead Hotline (with HUD); research; addresses lead contamination at industrial waste sites, including drinking water and industrial air emissions.
Department of Justice **http://www.usdoj.gov**	Enforces Federal Lead Paint Disclosure Rule (with HUD and EPA); defends federal lead paint regulations; enforces pollution statutes, including hazardous waste laws.
Consumer Product Safety Commission **http://www.cpsc.gov**	Enforces ban of lead paint; investigates and prevents the use of lead paint in consumer products; initiates recalls of lead-containing products that present a hazard; conducts dockside surveillance and intercepts imported products that present a risk of lead poisoning; recommends elimination of lead from consumer products through Guidance Policy on lead.

FEDERAL AGENCY ROLES IN LEAD POISONING PREVENTION

Agency	Programs and Duties
Occupational Safety and Health Administration **http://www.osha-slc.gov/SLTC/lead/index.html**	Enforces worker protection regulations.
Department of the Treasury **http://www.ustreas.gov**	Evaluates financial incentives (such as tax credits) for lead hazard control.
Department of Energy **http://www.energy.gov**	Conducts weatherization activities in a lead-safe manner.
Department of Defense **http://www.defenselink.mil**	Administers lead-based paint/lead hazard management programs in 250,000 family housing and child-occupied facilities worldwide, administers childhood lead poisoning prevention programs on installations worldwide, administers research and development programs to develop new cost-effective technologies for lead paint management and abatement, partners with other federal agencies to develop policies and guidance for lead hazard management on a national level.

3.4.2 The Federal Strategy To Eliminate Lead Poisoning

The interagency President's Task Force on Environmental Health Risks and Safety Risks to Children has proposed a coordinated federal strategy to eliminate childhood lead poisoning, focusing on lead paint hazards (*Eliminating Childhood Lead Poisoning: A Federal Strategy Targeting Lead Paint Hazards,* available at http://www.epa.gov/children/whatwe/leadhaz.pdf). The goals of the Strategy are:

- By 2010, to eliminate lead paint hazards in housing where children under six live.
- By 2010, to eliminate elevated blood lead levels in children.

To accomplish these goals, the Task Force makes the following recommendations:

Act before children are poisoned:

- Increase the availability of lead-safe dwellings by increasing federal grants for low-income housing and leveraging private and other non-federal funding.
- Promote education for universal lead-safe painting, renovation, and maintenance work practices.
- Ensure compliance with existing lead paint laws.

Identify and care for lead-poisoned children:

Improve early intervention by expanding blood lead screening and follow-up services for at-risk children, especially Medicaid-eligible children.

Conduct research:

Improve prevention strategies, promote innovative ways to drive down lead hazard control costs, and quantify the ways in which children are exposed to lead.

Measure progress and refine lead poisoning prevention strategies:

Implement monitoring and surveillance programs.

The Strategy notes that research is needed to help develop, evaluate, and market new products, such as x-ray fluorescence technologies. It also notes that research is needed to test the effectiveness of specific actions to reduce exposure to lead in soil and dust. These are areas in which the EMPACT Lead-Safe Yard Project and other similar programs can make significant contributions through their data and experience.

3.4.3 Federal Regulations and Guidelines Affecting Lead-Safe Yard Programs

EPA and the Department of Housing and Urban Development have issued regulations governing lead contamination in residential buildings and soil. EPA regulates lead contamination in homes and yards from lead-based paint under Title IV of TSCA. EPA's Resource Conservation and Recovery Act (RCRA) regulations also regulate lead-contaminated soil in certain situations. HUD's regulations parallel the TSCA regulations and apply to residential buildings that are either federally owned or receive federal assistance under HUD programs.

3.4.3.1 Proposed Rule Under TSCA (40 CFR Part 745)

EPA is currently preparing a final rule under TSCA Section 403, "Lead; Identification of Dangerous Levels of Lead," which will establish standards for lead-based paint hazards, including a hazard level for lead-contaminated residential soils. The pending rule is being designed to contribute to the lead hazard identification and abatement mandates specified under Title X, "The Residential Lead-Based Paint Hazard Reduction Act of 1992."

The Section 403 rule is expected to directly affect HUD and other federal agencies that own residential property by requiring soil abatement (such as soil removal or paving) before property sale if soil-lead hazards are identified. It will also indirectly affect property owners who receive federal housing assistance by potentially requiring hazard abatement or reduction. However, this pending rule will not by itself require residential soil abatement, but will instead provide standards for use in other regulations currently being implemented under Title X.

3.4.3.1.1 Are the Treatments in This Handbook Consistent With Federal Regulations?

The EMPACT LSYP was designed before the Section 403 rule was drafted; however, it can be considered to be complementary to the pending Section 403 rule. The project complements the "focus on prevention" objective of TSCA Title IV and the pending Section 403 rule by providing residents (particularly low-income urban minority residents) with practical low-cost yard improvements and landscaping measures that will reduce exposure to lead-contaminated soils. These low-cost measures may be used, in the case of federally owned or assisted properties, as interim shorter-term solutions until permanent, higher-cost solutions are employed. In addition, these low-cost measures may also provide longer-term, but not permanent, protection at non-federally and if needed, federally owned/assisted properties so long as homeowners and/or residents carefully and conscientiously follow specific maintenance procedures developed by the LSYP.

The tables below show the actions recommended for different soil levels by the EMPACT LSYP and the pending Section 403 rule. Following the tables is a discussion of the context for the two sets of recommended actions, as well as a comparison of the sampling plans used in each approach.

EMPACT LEAD-SAFE YARD PROJECT

Soil-Lead Level (parts per million)*	Recommended Interim Action
> 5,000 (very high)	If soil removal or permanent barriers are not possible: • Install semi-permanent barrier, such as a wood-framed dripbox filled with gravel or mulch. • Relocate gardens—unsafe for all types of gardening.
2,000–5,000 (high)	• Relocate gardens—unsafe for all types of gardening. • Relocate children's play area, pet area, and picnic area, if possible. If not, install wood platform or wood-framed raised play and picnic area filled with woodchips. • Install path of walking stones for high-traffic areas. • Seed and fertilize grassy areas, or cover with mulch or woodchips if not suitable for grass.
400–2,000 (moderately high)	• Install raised-bed garden and supplement with clean topsoil. • Install wood-framed raised play and picnic area filled with woodchips. • Install path of walking stones for high-traffic areas. • Seed and fertilize grassy areas, or cover with mulch or woodchips if not suitable for grass.
< 400 (urban background)	• No treatment necessary.

*Based on in situ XRF analysis of surface soils (typically 15 to 25 samples per yard) and lead concentration mapping of the entire yard to include areas of special concern (play areas, gardens, outside eating areas, pet runs, etc.).

PROPOSED SECTION 403
BARE SOIL-LEAD HAZARD IDENTIFICATION

Soil Lead Level (parts per million)**	Recommended Interim Action
> 1,200 (hazard standard)	Eliminate hazard: • Remove contaminated soil or install permanent covering.
400–1,200 (level of concern)	Implement interim controls: • Cover bare soil • Use doormats in entryways. • Wash hands, toys, etc., more frequently.
< 400	• No action

** For the yard, concentration is derived from an arithmetic mean of two composite samples, one from the drip line and one from mid-yard. For identified play areas, a single composite sample is used.

The EMPACT LSYP's mitigation strategy currently focuses on application of interim controls, though some permanent measures (blacktop) have been used for car park areas. Clearly, permanent controls are desirable where the resources are available to implement them. The EMPACT LSYP targeted its mitigation measures toward low-cost/no-cost options to address neighborhoods and homes where hazards exist and resources for mitigating these hazards are limited.

It also must be noted that the EMPACT LSYP approach to soil measurement is different from the proposed standard in several respects:

1) The EMPACT LSYP maps the entire yard with 15 to 25 field screening XRF analyses; this results in clear identification of hazard areas and the detailed information needed to apply controls in a cost-effective manner.

2) Surface soils are analyzed in situ to provide data on the soil material most likely to come into contact with the residents. Standard protocols would use field collection and offsite analysis of composite grab samples.

3) The proposed 403 rule applies to bare soil, while the EMPACT LSYP measures all yard surfaces.

4) The proposed 403 rule relies on average measurements (composites) rather than the discrete in situ measurements used to map yards in the EMPACT LSYP.

For these reasons, the proposed 403 standards and the action levels used for the EMPACT LSYP may not be directly comparable. Nonetheless, before applying the EMPACT project's model to your situation, you will need to consult local regulatory authorities to determine the requirements you must meet. State/tribal and local government regulations may be more restrictive than existing federal guidance.

3.4.3.2 Resource Conservation and Recovery Act (40 CFR Parts 240–299)

RCRA regulates the disposal of solid and hazardous waste. EPA's interpretations of RCRA regulations state that soils contaminated with lead-based paint as a result of routine residential maintenance and/or natural weathering or chalking of lead-based paint fall under the household waste exclusion and are not regulated as hazardous waste. This means that material may be disposed of off site in accordance with the regulations governing solid (non-hazardous) waste, known as RCRA Subtitle D, as well as applicable state and local regulations. Lead-contaminated soil that falls under the household waste exclusion need not be tested to determine if it is hazardous waste; if it is tested and found to be hazardous waste, it is still exempt from the RCRA hazardous waste regulations. You should check with state and local authorities, however, to see what testing they require.

3.4.3.3 Lead-Based Paint Poisoning Prevention in Certain Residential Structures (40 CFR Part 35)

This HUD rule establishes procedures to eliminate, as far as practicable, lead-based paint hazards in residential properties that are federally owned or receive federal assistance under HUD programs. The rule requires lead inspection and screening to be performed at all federally owned or assisted target housing, or any time a child under six years of age is found to exhibit an environmental intervention blood lead level ($\geq$20 µg/dL for a single test or 15 to 19 µg/dL in two tests taken at least three months apart). Target housing is defined as any residence built prior to 1978, excluding housing for the elderly or those with disabilities (unless children under the age of six are expected to reside there) or zero bedroom dwellings. Where a soil-lead hazard is found to exist, action is required to reduce the hazard.

The rule establishes six levels of protection: abatement of the lead-contaminated soil, abatement of the lead soil hazards, interim controls, paint stabilization, ongoing lead-based paint maintenance, and safe work practices during rehabilitation.

- When abatement (the permanent elimination of lead) is required for soil, the standards promulgated under TSCA must be followed. Abatement can be achieved through either soil removal and replacement with uncontaminated soil or permanent covering of the contaminated area (e.g., with pavement or concrete).
- Interim controls are steps taken to temporarily reduce lead exposure or hazards. They include impermanent surface coverings (e.g., sod, gravel, bark, artificial turf) and land use controls (e.g., fencing, warning signs, landscaping).
- The remaining actions (paint stabilization, ongoing lead-based paint maintenance, and safe work practices during rehabilitation) are not directly applicable to soil, but can help reduce the potential for increased soil contamination.

The specific level of protection required depends on the type of housing and the type of federal ownership or assistance. Once the required remedial action has been completed, the soil must pass the clearance examinations outlined in the regulations or further action will be required.

3.5 For More Information

3.5.1 Additional Resources

Agency for Toxic Substances and Disease Registry. 1992. *Analysis Paper: Impact of Lead-Contaminated Soil on Public Health.* Available online at http://www.atsdr.cdc.gov/cxlead.html.

Agency for Toxic Substances and Disease Registry. *Philadelphia Neighborhood Lead Study, Philadelphia, Pennsylvania. Report of Lead Exposure Pilot Study.* Division of Health Studies. Atlanta, GA. Available from NTIS (order # PB92-123777INZ).

Agency for Toxic Substances and Disease Registry. 1999. *Toxicological Profile for Lead (draft)*. Atlanta: U.S. Department of Health and Human Services, Public Health Service.

American Academy of Pediatrics Committee on Drugs. 1995. "Treatment Guidelines for Lead Exposure in Children." *Pediatrics.* 96:155–160. Available online at http://www.aap.org/policy/00868.html.

Center for Bioenvironmental Research at Tulane and Xavier Universities. 1996. *Lead's Urban Legacy.* Available online at http://www.tmc.tulane.edu/ecme/leadhome/soil.html.

Centers for Disease Control and Prevention. 1997. *Screening Young Children for Lead Poisoning: Guidance for State and Local Public Health Officials.* Available online at http://www.cdc.gov/nceh/lead/guide/1997/guide97.htm, or call (toll-free) 1-888-232-6789.

Department of Housing and Urban Development. 1995. *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing.* Available online at http://www.hud.gov/lea/learules.html.

Department of Housing and Urban Development. 2000. *Residential Lead Desktop Reference, 2nd Edition.* CD-ROM containing more than 140 documents, including ASTM scopes, screening guidance, community outreach materials, lead resources, scientific studies and reports, lead statutes and regulations, lead training materials, regulation support documents, reports to Congress, HUD guidelines, and other resources. Available for $10 by calling HUDUSER at 1-800-245-2691.

Lead-Based Paint Hazard Reduction and Financing Task Force. 1995. *Putting the Pieces Together: Controlling Lead Hazards in the Nation's Housing.* Available online at http://www.hud.gov/lea/leadwnlo.html.

Mielke, H.W. 1990. "Lead Dust-Contaminated Communities and Minority Health: A New Paradigm," *The National Minority Health Conference: Focus on Environmental Contamination.* B.L. Johnson, R.C. Williams and C.M. Harris, Eds. Princeton, New Jersey: Princeton Scientific Publishing Co., Inc.

Mielke, H.W. 1994. "Lead in New Orleans Soils: New Images of an Urban Environment." *Environmental Geochemistry and Health.* 16:123–128.

Mielke, H.W. 1997. "Leaded Dust in Urban Soil Shown To Be Greater Source of Childhood Lead Poisoning Than Leaded Paint." *Lead Perspectives.* 28–31 (March/April).

Mielke, H.W. 1999. "Lead in Inner Cities." *American Scientist.* Vol. 87, No. 1 (January-February).

Mielke, H.W., and J.L. Adams. 1989. "Environmental Lead Risk in the Twin Cities." Center for Urban and Regional Affairs. CURA 89-4. 22 pp.

Mielke, H.W., J.C. Anderson, K.J. Berry, P.W. Mielke, R.L. Chaney, and M. Leech. 1983. "Lead Concentrations in Inner-City Soils as a Factor in the Child Lead Problem." *American Journal of Public Health.* 73:1366–1369.

Mielke, H.W., S. Barroughs, R. Wade, T. Yarrow, and P.W. Mielke. 1984/1985. "Urban Lead in Minnesota: Soil Transect Results of Four Cities." *Journal of the Minnesota Academy of Science.* 50:19–24.

National Research Council. 1993. *Measuring Lead Exposure in Infants, Children and Other Sensitive Populations.* Washington, D.C. National Academy Press. Order online at http://books.nap.edu/catalog/2232.html.

U.S. Congress. 1992. *Residential Lead-Based Paint Hazard Reduction Act of 1992.* Title X (42 USC 4851). Available online at http://www.epa.gov/lead/titleten.html.

U.S. Environmental Protection Agency. 1994. *EPA Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil.* EPA540-F-94-045. Order online at http://www.epa.gov/ncepihom/ordering.htm.

U.S. Environmental Protection Agency. 1995. *EPA Residential Sampling for Lead: Protocols for Dust and Soil Sampling.* EPA747-R-95-001.

U.S. Environmental Protection Agency. 1996. *Distribution of Soil Lead in the Nation's Housing Stock.* Available online at http://www.hud.gov/lea/lealead.pdf.

U.S. Environmental Protection Agency. 1997. *Reducing Lead Hazards When Remodeling Your Home.* EPA747-K-97-001. Order online at http://www.epa.gov/ncepihom/ordering.htm.

U.S. Environmental Protection Agency. 1997. *Risk Analysis To Support Standards for Lead in Paint, Dust, and Soil, Volumes 1 & 2.* EPA747-R-97-006. Available online at http://www.epa.gov/ncepihom/ordering.htm.

3.5.2 Links

U.S. Environmental Protection Agency

National Lead Information Center
http://www.epa.gov/lead/nlic.htm
A federally funded hotline and clearinghouse that provides information on lead hazard reduction and exposure prevention. To speak with one of the Center's clearinghouse specialists, call 1-800-424-LEAD Monday through Friday, 8:30 a.m. to 6:00 p.m. EST.

Office of Pollution Prevention and Toxics (OPPT)
http://www.epa.gov/opptintr/lead/index.html
Responsible for EPA programs related to lead poisoning prevention and lead regulation. OPPT also provides educational packets for parents, teachers, daycare providers, and librarians, as well as technical information and publications.

Integrated Risk Information System (IRIS)
http://www.epa.gov/iris
An electronic database containing information on human health effects that may result from exposure to various chemicals in the environment. The information in IRIS is intended for those without extensive training in toxicology, but with some knowledge of health sciences.

Lead Poisoning Prevention Outreach Program
http://www.nsc.org/ehc/lead.htm
Funded through a cooperative agreement between EPA and the Environmental Health Center.

Department of Housing and Urban Development,
Office of Lead Hazard Control
http://www.hud.gov/lea/leahome.html
Sets standards for evaluation and management of lead in federally assisted housing, and promotes efforts to reduce lead hazards in privately owned housing. In addition, provides grants to communities to reduce lead hazards in housing.

Centers for Disease Control and Prevention
Childhood Lead Poisoning Prevention Program
http://www.cdc.gov/nceh/lead/lead.htm
Promotes state and local screening efforts and develops improved treatments for lead exposure. CDC also provides a database, 1990 Census Data on Housing and Population—Interactive Query, that allows you to search by county or zip code to find the percentage of houses built before 1950.

Agency for Toxic Substances and Disease Registry (ATSDR)
http://www.atsdr.cdc.gov
An agency of the U.S. Public Health Service established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund. ATSDR is required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List to determine if people are being exposed to hazardous substances, which includes lead. The public can search by region to see which health assessments are currently available in an online database located at http://www.atsdr.cdc.gov/HAC/PHA.

National Conference of State Legislatures
http://www.ncsl.org/programs/ESNR/pbdir.htm
Contains NCSLnet Search—a directory of state lead poisoning prevention contacts.

Consumer Product Safety Commission
http://www.cpsc.gov
Identifies and regulates sources of lead exposure in consumer products.

Occupational Safety and Health Administration
http://www.osha-slc.gov/SLTC/lead/index.html
Develops work practice standards and worker exposure limits to protect workers from occupational lead exposure.