RISK ASSESSMENT FOR SECTION 403 ANALYSES

Draft Report

VOLUME II

APPENDICES A-E

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APPENDIX A

Glossary

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GLOSSARY

Abatement: The term "abatement" means any set of measures designed to permanently eliminate lead-based paint hazards in accordance with standards established by Federal agencies.

Accessible or Chewable Surface: The term "accessible surface" means an interior or exterior surface painted with lead-based paint that is accessible for a young child to mouth or chew.

Arithmetic Mean: The sum of a set of measurements divided by the number of measurements.

Biokinetics: Processes affecting the movement of molecules from one internal body compartment to another, including elimination from the body.

Blood-Lead Concentration: Blood-lead concentration measures the mass of lead collected per volume of whole blood collected and is usually expressed in terms of micrograms of lead collected per deciliter of blood collected (µg Pb/dL blood).

Blue Nozzle Sampler: The term "blue nozzle sampler" refers to the vacuum sampler used with HUD National Survey and the Baltimore R&M Pilot study.

BRM Sampler: The term "BRM sampler" refers to a device used for the collection of dust over a specified area using a modified HVS-3 vacuum sampler. This vacuum was initially developed and utilized in EPA's Baltimore Repair and Maintenance Study.

Deteriorated Paint: The term "deteriorated paint" means any interior or exterior paint that is peeling, chipping, chalking or cracking or any paint located on an interior or exterior surface or fixture that is damaged or deteriorated.

Dripline Soil: The term "dripline soil" means any soil sample collected from the drip line area about the residence. This is usually approximately 1-3 feet from the side (e.g. foundation) of the house, under the eaves.

Dry Room: (see Wet Room).

Dust-lead concentration: Dust-lead concentration measures the mass of lead collected per mass of dust collected and is usually stated in terms of micrograms of lead collected per gram of dust collected (µg Pb/g dust).

Dust-lead loading: Dust-lead loading measures the mass of lead collected per surface area sampled and is usually expressed in terms of micrograms of lead collected per square foot sampled (µg Pb/ft^2).

DVM Sampler: The term "DVM sampler" refers to a device used to collect dust samples using a vacuum (personal air sampler) operating at a rate of two liters of air per minute.

Efficacy: Refers to the effectiveness of a method of abatement and is defined as the generalized evaluation of several key factors including the usability of a method, its hazard abatement effectiveness, and the the amount of hazardous dust lead generated by a method, measured by air and post-cleanup wipe samples.

Encapsulation: A method of "abatement" that involves the coating and sealing of surfaces with durable coatings formulated to be elastic, long-lasting (e.g., at least 20 years), and resistant to cracking, peeling, algae, and fungus.

Enclosure: The resurfacing or covering of surfaces by sealing or caulking them with mechanically affixed, durable materials so as to prevent or control chalking, flaking, lead-containing substances from being part of house dust or accessible to children.

Entryway Soil: The term "entryway soil" means any soil sample collected immediately adjacent to the entryway of the residence.

EPI Model: A statistical regression model developed from data collected by an epidemiological study. The resulting model which predicts blood-lead concentration as a function of environmental lead levels may be used to predict a national distribution of children's blood-lead levels.

EPI Study: A targeted epidemiology study which measures both children's blood-lead concentrations and environmental lead levels as well as other factors (e.g., behavioral, demographic) influencing a child's blood-lead level.

Exposure: Contact between a chemical, physical, or biological agent (e.g., lead) with the outer boundary of an organism (e.g., a child's skin). Exposure is quantified as the concentration of the agent in the medium in contact integrated over the time duration of that contact.

Exposure Pathway: The physical course a chemical or pollutant takes from its source to the organism exposed.

Exposure Route: The manner by which a chemical or pollutant enters an organism after contact (e.g., by ingestion, inhalation).

Friction Surface: The term "friction surface" means an interior or exterior surface that is subject to abrasion or friction, including certain window, floor, and stair surfaces.

Geometric Mean: The n^{th} root product of n values. Also, the anti-log of the "arithmetic mean" of a set of n natural log-transformed values.

Geometric Standard Deviation (GSD): The anti-log of the "standard deviation" of a set of n natural log-transformed values.

HEPA: A High Efficiency Particulate Accumulator vacuum fitted with a filter capable of filtering out particles of 0.3 microns or greater from a body of air at 99.97 percent efficiency or greater.

IEUBK Model: EPA's Integrated Exposure Uptake Biokinetic Model for Lead is designed to model exposure from lead in air, water, soil, dust, diet, and paint and other sources with pharmacokinetic modeling to predict blood-lead levels in children 6 months to 7 years of age.

Impact Surface: The term "impact surface" means an interior or exterior surface that is subject to damage by repeated impacts, for example, certain parts of door frames.

Interim Controls: The term "interim controls" means a set of measures designed to temporarily reduce human exposure or likely human exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards, and the establishment and operation of management and resident education programs.

Lead-Contaminated Dust: The term "lead-contaminated dust" means surface dust in residential dwellings that contains an area or mass concentration of lead in excess of levels determined by EPA to pose a threat of adverse health effects in pregnant women or young children.

Lead-Based Paint: Lead-based paint is dried paint film that has a lead content exceeding 1.0 mg/cm^2 or 0.5 percent (5,000 parts per million (ppm)) by weight.

Lead-Based Paint Hazard: The term "lead-based paint hazard" means any condition that causes exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-contaminated paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects as established by EPA.

Lead-Contaminated Soil: The term "lead-contaminated soil" means bare soil on residential real property that contains lead at or in excess of the levels determined to be hazardous to human health by EPA.

Percentile: The term percentile refers to a particular value in a set or distribution of numbers that has the property that a specified percentage of the numbers are less than the given value. For instance, the 5th percentile of a set of blood-lead concentrations is the blood-lead concentration value such that 5% of the numbers are less than the value and 95% are greater than it. The 50th percentile is also known as the median.

Perimeter Soil: The term "perimeter soil" usually means any soil sample collected from the perimeter or remote areas of the residence's yard. (Note: in the Rochester Lead-in-Dust study, this terminology referred to samples collected adjacent to the foundation).

Pharmacokinetics: The study of the time course of absorption, distribution, metabloism, and excretion of a foreign substance (e.g., a drug or pollutant) in an organism's body.

PICA: The tendency to mouth or attempt to consume non-food objects.

Playard Soil: The term "playard soil" refers to any soil sample collected at the site where the child usually played. In the National Survey, this was frequently a local playground. In other studies, this refers to an exterior site at the residence.

Probability Samples: Samples selected from a statistical population such that each sample has a known probability of being selected.

Random Samples: Samples selected from a statistical population such that each sample has an equal probability of being selected.

Reduction: The term reduction means measures designed to reduce or eliminate human exposure to lead-based paint hazards through methods including interim contrls and abatement.

Regression Model: A statistical representation of the relationship between a dependent variable such as blood-lead concentration to one or more independent variables such as environmental lead exposures. For example, a regression model could indicate that blood-lead concentration is an additive function of environmental lead levels.

Removal and Replacement: A method of abatement that entails removing substrates such as windows, doors, trim, or soil that have lead-contaminated surfaces and installing new (and presumably lead-free) or deleaded components.

Risk: The probability of deleterious health or environmental effects.

Sample: A small part of something designed to show the nature or quality of the whole. Exposure-related measurements are usually samples of environmental or ambient media, exposures of a small subset of a population for a short time, or biological samples, all for the purpose of inferring the nature and quality of parameters important to evaluating exposure.

Soil-Lead Concentration: Soil-lead concentration measures the mass of lead collected per mass of soil collected and is usually stated in terms of micrograms of lead collected per gram of soil collected (µg Pb/g soil). These units are also sometimes referred to as parts per million (ppm).

Standard Deviation: A measure of the dispersion of a set of values that is the square root of the "arithmetic mean" of the squares of the deviation of each value from the "arithmetic mean" of the values.

Target Housing: The term "target housing" means any housing constructed prior to 1978, except for housing of the elderly or persons with disabilities (unless any child who is less than 6 years of age resides or is expected to reside in such housing for the elderly or persons with disabilities), or any 0-bedroom dwelling.

µ, Microgram: A microgram is 1/1,000,000 of a gram or 1/1,000 of a milligram.

Uptake: The process by which a substance is absorbed into the body.

Vacuum Sample: The term "vacuum sample" refers to collecting dust over a specified area by vacuuming the area. The contents of the vacuum bag are then analyzed for the amount of dust and the amount of lead. Results from vacuum sampling are in the form of "dust-lead loadings" and "dust-lead concentrations".

XRF: "X-ray fluorescence" is a principle used by instruments to determine the lead concentration in substances, usually in milligrams per square centimeter (mg/cm^2).

Wet Room: An interior room in a house which is either a kitchen, bathroom, laundry, or utility room is classified as a 'wet room', otherwise the room may be classified as a 'dry' room.

Window Sill: The term "window sill" is defined as the horizontal board inside the window.

Window Trough: The term "window trough" is defined as the surface below the window sash and inside the screen and/or storm window. This is also sometimes referred to as a window well.

Wipe Sample: The term "wipe sample" refers to collecting dust over a specified area by wiping the area with a moist cloth. The cloth and the dust on the cloth are then analyzed for the amount of lead. Results from wipe sampling are in the form of dust-lead loadings.

APPENDIX B

Health Effects Associated with Exposure to Lead and Internal Lead Doses in Humans

Table B-1. Health Effects Associated with Exposure to Lead and Internal Lead Doses in Humans

Duration of Exposure	System	Effect	Blood Lead Levels at which Effect is Observed (μg/dL)	Reference
< 1 yr (occup)		Increase in death due to hypertension, nephritis, neoplasms	63-80	Cooper et al., 1985, 1988
NS (occup)		Increase in death due to cerebrovascular disease, nephritis, and/or nephrosis	NS	Fanning 1988; Malcolm and Barnett 1982; Michaels et al. 1991
< 3 yr (occup)		No increase in deaths	34-58 (means)	Gerhardsson et al. 1986b
NS		Acute encephalopathy resulting in death in children	125-750	NAS 1972
2 wk - > 1 yr (occup)	Cardiovascular	Increased blood pressure	≥ 30 - 120	deKort et al. 1987; Pollock and Ibels 1986; Marino et al. 1989; Weiss et al. 1986, 1988
> 1 yr (occup)	Cardiovascular	No effect on blood pressure	40 (mean)	Parkinson et al. 1987
> 1 yr (occup)	Cardiovascular	Ischemic electrocardiogram changes	51 (mean)	Kirkby and Gyntelberg 1985
NS (general population)	Cardiovascular	Increased blood pressure	44.9 (mean)	Khera et al. 1980b
NS (general population)	Cardiovascular	Increased systolic pressure by 1-2 mmHg and increased diastolic pressure by 1.4 mmHg with every doubling in blood-lead level; effect most prominent in middle-aged white men	7-38	Coate and Fowles 1989; Harlan 1988; Harlan et al. 1988; Landis and Flegal 1988; Pirkle et al. 1985; Schwartz 1988
NS (general population)	Cardiovascular	No significant correlation between blood pressure and blood-lead levels	6-13 (median) or NS	Elwood et al. 1988; Grandjean et al. 1989; Neri et al. 1988; Staessen et al. 1990, 1991
NS (general population)	Cardiovascular	Degenerative changes in myocardium, electrocardiogram abnormalities in children	6-20	Silver and Rodriguez-Torres 1968

Table B-1. Health Effects Associated with Exposure to Lead and Internal Lead Doses in Humans (Continued)

Duration of Exposure	System	Effect	Blood Lead Levels at which Effect is Observed (µg/dL)	Reference
NS (acute) (occup)	Gastrointestinal	Colic (abdominal pain, constipation, cramps, nausea, vomiting, anorexia, weight loss)	40-200	Awad et al. 1986; Baker et al. 1979; Haenninen et al. 1979; Holness and Nethercott 1988; Kumar et al 1987; Marino et al. 1989; Matte et al. 1989; Muijser et al. 1987; Pagliuca et al. 1990; Pollock and Ibels 1986; Schneitzer et al. 1990
NS (acute) (general population)	Gastrointestinal	Colic in children	60-100	U.S. EPA 1986; NAS 1972
NS (occup)	Hematological	Increased ALAS and/or decreased ALAD	87 or NS (correlated with blood-lead level)	Alessio et al. 1976; Meredith et al. 1978; Wada et al. 1973
NS (general population)	Hematological	Decreased ALAD	3-56 (adult) No threshold (children	Chisholm et al. 1985; Hernberg and Nikkanen 1970; Lauwerys et al. 1978; Roels et al. 1976; Roels and Lauwerys 1987; Secchi et al. 1974
NS (occup)	Hematological	Increased urinary or blood ALA	< 40-50, 87 (mean) or NS	Lauwerys et al. 1974; Meredith et al. 1978; Pollock and Ibels 1986; Selander and Cramer 1970
NS (general population)	Hematological	Increased urinary ALA	> 35 (adult) 25-75 children	NAS 1972; Roels and Lauwerys 1987
NS (general population)	Hematological	Increased FEP	≥ 25-35	Grandjean and Lintrup 1978; Roels et al. 1975
NS (general population)	Hematological	Increased EP	30-40 (males 20-30 (females)	Roels and Lauwerys 1987; Roels et al. 1975, 1976, 1979; Stuick 1974
NS (general population	Hematological	Increased ZPP	≥ 15 (children)	Hammond et al. 1985; Piomelli et al. 1982; Rabinowitz et al. 1986; Roels and Lauwerys 1987; Roels et al. 1976
NS (general population)	Hematological	Increased urinary coproporphyrin	≥ 35 (children) ≥ 40 (adults)	U.S. EPA 1986

Table B-1. Health Effects Associated with Exposure to Lead and Internal Lead Doses in Humans (Continued)

Duration of Exposure	System	Effect	Blood Lead Levels at which Effect is Observed (μg/dL)	Reference
NS (occup)	Hematological	Decreased hemoglobin with or without basophilic stippling of erythrocytes	≥ 40	Awad et al. 1986; Baker et al. 1979; Grandjean 1979; Lilis et al. 1978; Pagliuca et al. 1990; Tola et al. 1973; Wada et al. 1973
NS (general population)	Hematological	Decreased hemoglobin	≥ 40 (children)	Adebonojo 1974; Betts et al. 1973; Pueschel et al. 1972; Rosen et al. 1974
NS (general population)	Hematological	Anemia (hematocrit of < 35%)	> 20 (children)	Schwartz et al. 1990
NS (occup)	Hematological	Decreased Py-5'-N	NS	Buc and Kaplan 1978; Paglia et al. 1975, 1977
NS (general population)	Hematological	Decreased Py-5'-N	7-80 (children)	Angle and McIntire 1978; Angle et al. 1982
NS (acute) (general population)	Hepatic	Decreased mixed function oxidase activity	NS (children)	Alvares et al. 1975; Saenger et al. 1984
NS (chronic) (occup)	Renal	Chronic Nephropathy	40 - > 100	Biagini et al. 1977; Cramer et al. 1974; Lilis et al. 1968; Maranelli and Apostoli 1987; Ong et al. 1987; Pollock and Ibels 1986; Verschoor et al. 1987; Wedeen et al. 1979
1-30 yr (occup)	Renal	No effect on renal function	40-61	Buchet et al. 1980; Huang et al. 1988a
NS (chronic) (general population)	Renal	Renal (impairment with gout or hypertension)	18-26 μg/dL	Batumen et al. 1981, 1983
NS (acute) (general population)	Renal	Aminoaciduria; Fancoi syndrome	> 80 (children)	Chisholm 1962; Pueschel et al. 1972
0.1-20 yr (chronic) (occup)	Other	Decreased thyroxin (T_4)	≥ 56	Tuppurainen et al. 1988
NS (chronic) (general population)	Other	No effect on thyroid function in children	2-77 (levels measured)	Siegel et al. 1989
NS (general population	Other	Negative correlation between blood lead and serum 1,25-dihydroxyvitamin D in children	12-120	Mahaffey et al. 1982; Rosen et al. 1980

Table B-1. Health Effects Associated with Exposure to Lead and Internal Lead Doses in Humans (Continued)

Duration of Exposure	System	Effect	Blood Lead Levels at which Effect is Observed (μg/dL)	Reference
NS (chronic) (general population)	Other	No effect on vitamin D metabolism in children	5-24 (levels measured)	Koo et al. 1991
NS (chronic) (general population)	Other	Growth retardation in children	≥ 30-60; Tooth lead > 18.7 μg/g	Angle and Kuntzelman 1989; Lauwers et al. 1986; Lyngbye et al. 1987
NS (chronic) (general population)	Other	No association between blood-lead levels and growth in children	10-47 (levels measured)	Greene and Ernhart 1991; Sachs and Moel 1989
< 18 yr (occup)	Immunological	Depression of cellular immune function, but no effect on humoral immune function	21-90	Alomran and Shleamoon 1988; Ewers et al. 1982
NS (acute)	Neurological	Encephalopathy (adults)	50 - > 300	Kehoe 1961; Kumar et al. 1987; Smith et al. 1938
NS (acute and chronic) (occup)	Neurological	Neurological signs and symptoms in adults including malaise, forgetfulness, irritability, lethargy, headache, fatigue, impotence, decreased libido, dizziness, weakness, paresthesia	40-80	Awad et al. 1986; Baker et al. 1979; Campara et al. 1984; Haenninen et al. 1979; Holness and Nethercott 1988; Marino et al. 1989; Matte et al. 1989; Pagliuca et al. 1990; Parkinson et al. 1986; Pasternak et al. 1989; Pollock and Ibels 1986; Schneitzer et al. 1990; Zimmerman-Tansella et al. 1983
NS (occup)	Neurological	Neurobehavioral function in adults; disturbances in oculomotor function, reaction time, visual motor performance, hand dexterity, IQ test and cognitive performance, nervousness, mood, coping ability, memory	40-80	Arnvig et al. 1980; Baker et al. 1983; Baloh et al. 1979; Campara et al. 1984; Glickman et al. 1984; Haenninen et al. 1978; Hogstedt et al. 1983; Mantere et al. 1982; Spivey et al. 1980; Stollery et al. 1989; Valciukas et al. 1978; Williamson and Teo 1986
NS (occup)	Neurological	No effect on neurobehavioral function in adults	40-60 (levels measured)	Milburn et al. 1976; Ryan et al. 1987
NS (occup)	Neurological	Peripheral nerve function in adults; decreased nerve conduction velocity	30- ≥ 70	Araki et al.1980; Muijser et al. 1987; Rosen et al. 1983; Seppalainen et al. 1983; Triebig et al. 1984

Table B-1. Health Effects Associated with Exposure to Lead and Internal Lead Doses in Humans (Continued)

Duration of Exposure	System	Effect	Blood Lead Levels at which Effect is Observed (μg/dL)	Reference
NS (occup)	Neurological	No effect on peripheral nerve function	60-80 (levels measured)	Spivey et al. 1980
NS (general population)	Neurological	Neurological signs and symptoms in children and encephalopathy	60-450 (effects other than encephalopathy); > 80-800 (encephalopathy)	Bradley and Baumgartner 1958; Bradley et al. 1956; Chisolm 1962, 1965; Chisolm and Harrison 1956; Gant 1938; Rummo et al. 1979; Smith et al. 1983
NS (general population)	Neurological	Neurobehavioral function in children: lower IQS and other neuropsychologic deficits	40-200	dela Burtde and Choate 1972, 1975; Ernhart et al. 1981; Kotok 1972; Kotok et al. 1977; Rummo et al. 1979
NS (general population)	Neurological	Neurobehavioral function in children: slightly decreased performance on IQ tests and other measures of neuropsychological function	Tooth lead: 6 - > 30 μg/g Blood lead: 6-60	Bellinger and Needleman 1983; Bergomi et al. 1989; Fulton et al. 1987; Hansen et al. 1989; Hawk et al. 1986; Needleman et al. 1979, 1985, 1990; Schroeder et al. 1985; Schroeder and Hawk 1987; Silva et al. 198; Wang et al. 1989
NS (general population)	Neurological	No correlation between blood-lead levels and permanent effects on neurobehavioral development in children	10-15	Cooney et al. 1989; Harvey et al. 1984, 1988; Lansdown et al. 1986; McBride et al. 1982; Ernhart and Greene, 1990; Dietrich et al. 1987a; Bellinger et al. 1989; McMichael et al. 1986; Pocock et al. 1989; Smith et al. 1983; Winneke et al. 1984
NS (general population)	Neurological	Decrease in hearing acuity in children	4-60	Robinson et al. 1985; Schwartz and Otto 1987
NS (general population)	Neurological	Alterations in peripheral nerve function in children	20-30	Erenberg et al. 1974; Landrigan et al. 1976; Schwartz et al. 1988; Seto and Freeman 1964
prenatal (general population)	Developmental	Decreased growth rate	7.7	Shukla et al. 1989

Table B-1. Health Effects Associated with Exposure to Lead and Internal Lead Doses in Humans (Continued)

Duration of Exposure	System	Effect	Blood Lead Levels at which Effect is Observed (µg/dL)	Reference
prenatal (general population)	Developmental	Reduced birth weight and/or reduced gestational age, and/or increased incidence of stillbirth and neonatal death	12-17	Bornschein et al. 1989; McMichael et al. 1986; Moore et al. 1982; Ward et al. 1987; Wibberley et al. 1977
NS (general population)	Developmental	No association between blood-lead levels and birth weight, gestational age, or other neonatal size measures	3-55	Greene and Ernhart 1991; Factor-Litvak et al. 1991
NS (general population)	Developmental	Impaired mental development in children	10-15	Baghurst et al. 1987; Bellinger et al. 1984, 1985a, 1985b, 1986a, 1986b, 1987a, 1987b; Bornschein et al. 1989; Dietrich et al. 1986, 1987a, 1987b; Ernhart et al. 1985, 1986, 1987; McMichael et al. 1988; Rothenberg et al. 1989; Wigg et al. 1988; Winneke et al. 1985a, 1985b; Wolf et al. 1985; Vimpani et al. 1985, 1989
NS (general population)	Developmental	Inverse correlation between blood-lead levels and ALA and ALAD activity	10-33 (mean)	Haas et al. 1972; Kuhnert et al. 1977; Lauwerys et al. 1978
NS (general population	Reproductive	Increased incidence of miscarriages and stillbirths in exposed women	≥ 10 or NS	Baghurst et al. 1987; Hu et al. 1991; McMichael et al. 1986; Nordstrom et al. 1979; Wibberley et al. 1977
NS (general population)	Reproductive	No association between blood-lead levels and the incidence of spontaneous abortion in exposed women	2	Murphy et al. 1990
NS (occup)	Reproductive	Adverse effects on testes	40-50	Assennato et al. 1987; Braunstein et al. 1978; Chowdhury et al. 1986; Cullen et al. 1984; Lancranjan et al. 1975; Rodamilans et al. 1988; Wildt et al. 1983

ALA = δ-aminolevulinic acid; ALAD = δ-aminolevulinic acid dehydratase; ALAS = δ-aminolevulinic acid synthase; EP = erythrocyte protoporphyrins; FEP = free erythrocyte protoporphyrins; IQ = intelligence quotient; mmHg = millimeters of mercury; NS = not specified; (occup) = occupational; Py-5'-N = pyrimidine-5-nucleotidase; wk = week(s); yr = year(s); ZPP = zinc erythrocyte protoporphyrin

APPENDIX C

Supporting Information for Chapter 3

APPENDIX C
SUPPORTING INFORMATION FOR CHAPTER 3

C1.0 CHARACTERIZING BASELINE ENVIRONMENTAL-LEAD LEVELS IN THE NATION'S HOUSING STOCK

As discussed in Section 3.3.1.1, the §403 risk assessment effort used environmental-lead data from the National Survey of Lead-Based Paint in Housing ("HUD National Survey") to characterize baseline environmental-lead levels in the nation's 1997 housing stock. Here, the term "baseline" refers to conditions prior to implementing interventions in response to §403 rules. Data for 284 privately-owned, occupied housing units included in the HUD National Survey were considered in the characterization. In total, these units represented the entire U.S. privately-owned, occupied housing stock built prior to 1980. Due to the complex sampling design employed, the HUD National Survey assigned sampling weights to each unit, which equaled the number of privately-owned, occupied housing units in the national housing stock built prior to 1980 that were represented by the unit.

In order to use the information from the HUD National Survey to represent baseline environmental-lead levels in the 1997 national housing stock, the following steps were taken:

1. Update the sampling weights assigned in the HUD National Survey to reflect the 1997 housing stock (including publicly-owned units).

2. Determine the total number of children residing in the housing units represented by each sampling weight.

3. Summarize the environmental-lead levels within each surveyed unit.

Methods for conducting each of these steps, and the results from implementing these methods, are summarized in the following subsections.

C1.1 UPDATING THE NATIONAL SURVEY SAMPLING WEIGHTS

Characterizing the 1997 national housing stock and its distribution of environmental-lead levels involved updating the sampling weights assigned in the HUD National Survey to reflect the 1997 national housing stock. The tasks performed to update these weights were the following:

1. Identify demographic variables that served to group the housing units by their potential for differing environmental-lead levels.

2. Use information within the National Survey weights and the 1993 American Housing Survey to determine total numbers of 1997 housing units within each of these housing groups.

3. Allocate these 1997 totals among the National Survey units within the housing groups.

The methods developed for each of these tasks are presented in the following subsections.

C1.1.1 Identify Significant Factors Associated With Environmental-Lead Levels. In updating the sampling weights of the 284 National Survey units, the units were classified into housing groups according to a set of demographic factors found to have a statistically significant influence on environmental-lead levels in the units. Then, the number of 1997 housing units in each group was determined. By grouping the housing units according to these factors, units within the same group had relatively similar distributions of environmental-lead levels, while units in different groups had considerably different distributions.

In determining an appropriate housing grouping, a set of candidate factors was identified, where these factors satisfied three criteria: 1) they would be either important in an economic analysis for §403 rulemaking, or they were likely to be significantly associated with environmental-lead levels; 2) their values for National Survey units existed within the National Survey database; and 3) their values were measured within the 1993 American Housing Survey, a national survey conducted by the Bureau of the Census and the Department of Housing and Urban Development (HUD) to characterize the nation's housing stock. Then, a stepwise regression variable selection analysis selected a subset of these factors which explained the largest proportions of house-to-house variability in the following four environmental-lead measurements:

- A mass-weighted arithmetic average floor dust-lead concentration[1] for the unit (i.e., each measurement was weighted by the mass of the sample);

- An area-weighted arithmetic average floor dust-lead loading for the unit (i.e., each measurement was weighted by the square-footage of the sample area);

- A weighted arithmetic average soil-lead concentration for the unit, where results for samples taken from remote locations were weighted twice as much as results for dripline and entryway samples.

- Maximum XRF paint-lead level in the unit (for units containing lead-based paint[2]).

The set of factors included in this analysis are documented in Table C-1.

Table C-1. Demographic Factors Included in the Stepwise Regression Analysis

Factor	How the Factor Categorized Housing Units for the Stepwise Regression Analysis
Year the Unit Was Built	Pre-1940; 1940-1959; 1960-1979
Race of Youngest Child	White/Non-Hispanic; Other
Urbanicity Status	City; Suburb/non-metro
Region of Country	Northeast; Midwest; South; West (U.S. Census regions)
Ownership Status	Owner-occupied; renter-occupied
Number of Units in the Bldg.	One unit; more than one unit
Annual Income of Residents	< $30,000; $30,000 or more

The analysis was performed twice on each endpoint: on data for National Survey units containing lead-based paint (LBP) and for units with no LBP. Table C-2 provides the observed significance levels of each factor considered in the stepwise regression analyses when these levels were below 0.10. Lower significance levels imply a stronger effect on the measurement. The columns in Table C-2 correspond to separate regression analyses. Across all analyses, the

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[1] Prior to calculating the mass-weighted average, dust-lead concentrations were adjusted to reduce bias associated with underestimated sample weights ("low tap weights") reported in the HUD National Survey for dust samples. The adjustment procedure is documented in Appendix Z.

[2] LBP was considered present in a unit if its predicted maximum XRF value (as determined by statistical modeling techniques within the HUD National Survey) in either the interior or exterior was at least 1.0 mg/cm^2.

year in which a unit was built (as categorized by pre-1940, 1940-1959, and 1960-1979) had the strongest and most consistent effect on the environmental-lead level (with floor dust-lead concentration an exception). Statistical significance levels for the effect of year built were consistently less than 0.01. While similar significance levels were occasionally observed for other factors in the table, the extent of significance across the environmental-lead measurements was not as consistent for any other factor. Therefore, the year in which the unit was built was the only factor considered in grouping National Survey units for purposes of updating their weights to 1997.

Table C-2. Demographic Factors Included in Stepwise Regression Analyses, and Significance Levels Associated With These Factors When Less Than 0.10[1]

	Units with predicted maximum XRF value below 1.0 mg/cm² or missing (n=40)			Units with predicted maximum XRF value at 1.0 mg/cm² or above (n=221)			
Demographic Factors[2]	Floor Dust-Lead Loading	Floor Dust-Lead Conc.[3]	Soil-Lead Conc.	Floor Dust-Lead Loading	Floor Dust-Lead Conc.[3]	Soil-Lead Conc.	Max. Observed XRF Value[4]
Year the Unit Was Built	<0.01[5]		<0.01	<0.01		<0.01	<0.01
Race of Youngest Child			0.04				
Urbanicity Status	0.03						
Region of Country							
Ownership Status							
# Units in the Bldg.				0.01	0.01		
Annual Income of Residents							

[1] Column headings for this table identify the environmental-lead measurement being considered in the analysis and the group of National Survey units whose data are included in the analysis. Each column corresponds to a separate regression analysis. The demographic factors included in the regression analyses are included as rows of the table. As the significance level for a demographic factor gets closer to zero, the effect of the factor on the given environmental measurement is considered more highly statistically significant.

[2] See Table C-1 for definitions of these factors.

[3] This analysis was performed on unadjusted dust-lead concentrations (i.e., no adjustment was made for bias due to underestimated sample weights).

[4] Regression performed on units where the observed maximum XRF value was at least 1.0 mg/cm².

[5] In the regression analysis of floor dust-lead loading in units without LBP, the effect of the year in which the unit was built was statistically significant with a p-value of less than 0.01 (i.e., significance can be concluded at the 0.01 level).

The stepwise regression analysis assumed that the predicted maximum XRF value is an accurate indicator of whether or not a unit contains LBP. Also, those units with no predicted maximum XRF value were assumed not to contain LBP.

C1.1.2 Estimating Numbers of Housing Units in 1997 Within Year-Built Categories. In this second task, the number of occupied housing units in 1997, both privately- and publicly-owned, was estimated for each of four categories denoting when the unit was built: pre-1940, 1940-1959, 1960-1979, and post-1979. These categories are hereafter referred to as "year-built categories." The results of this task are presented in Table 3-3 within Chapter 3 of this document.

The primary data source for determining the number of units within each year-built category was the 1993 American Housing Survey (AHS), the most recent survey with available data on estimated numbers of units in the national housing stock. Data from the 1993 AHS provided estimates of the number of housing units in each year-built category in 1993. However, it was of interest to obtain estimates for 1997, not 1993. Therefore, the 1993 estimates were augmented to reflect additions to and removals from the national housing stock from 1994 to 1997. Once the 1997 estimate of the total within each year-built category was obtained, the total was distributed among the National Survey units in the group using information within the National Survey weights. Details on each of these procedures are now provided.

Characterizing the 1993 National Housing Stock

As in the National Survey, each unit in the 1993 AHS was assigned a weight that was interpreted as the number of units in the national housing stock represented by the given unit. Therefore, placing the AHS units among the four year-built categories and summing the weights of the units within each category yielded the estimated number of units in 1993 for each category.

Only occupied housing units in the 1993 AHS (either publicly-owned or privately-owned) were considered in updating to 1997. The definition of an "occupied" unit was one which was occupied by at least one resident who was classified as not having his/her usual residence elsewhere. Data for 40,931 occupied housing units were available from the 1993 AHS.

Updating the 1993 Housing Stock to 1997

Once the number of housing units in 1993 was determined for each of the four year-built categories, these totals were updated to reflect the 1997 housing stock. Updating the 1993 totals to 1997 was done in the following way:

1. For the post-1979 category, the total number of housing constructed from 1994 to 1997 and occupied in 1997 was estimated and added to the 1993 total.

2. For all four year-built categories, the total number of housing occupied in 1993 and lost from the housing stock from 1994 to 1997 was estimated and subtracted from the 1993 total.

In the first step, numbers of new, privately-owned housing units completed in 1994 and 1995 were obtained from Bureau of the Census and HUD (1996). This publication reported estimates of 1,346,900 such units completed in 1994 and 1,311,300 units in 1995. For this analysis, the 1995 estimate was also used in estimating totals for both 1996 and 1997. Therefore, the 1993 estimate for the post-1979 housing category was incremented by 1,346,900 + 3*1,311,300 = 5,280,800 units. Note that this approach assumes that new housing units are completed and occupied within the same year. In addition, no provision was considered for adding new publicly-owned units.

The second step, subtracting the number of housing units occupied in 1993 and lost from the housing stock from 1994 to 1997 within each of the four year-built categories, was more complex. Information on losses was not available by considering only the 1993 AHS. To obtain such information, the 1989 and 1991 AHS databases were obtained. As the AHS retains the same units from survey to survey, it was possible to determine those units that were occupied in one survey and lost from the housing stock by the next. Units were considered lost from the housing stock in a given survey if they were labeled as a "Type C non-interview" in the survey, meaning the unit no longer exists and is dropped from consideration for future surveys. Such losses include demolition, disaster loss, abandoned permit, or the unit was merged with another unit. While moving a house or mobile home from the site also labels the unit as a Type C noninterview, such an instance was <u>not</u> labeled as a loss from the housing stock for this effort, as it is assumed that the unit remains habitable in its new location. Using this definition of a loss, all occupied units in the 1989 AHS were labeled as whether or not they were considered lost from the housing stock by the 1991 AHS. Similarly, all occupied units in the 1991 AHS were labeled as whether or not they were considered lost from the housing stock by the 1993 AHS.

It is recognized that the probability of removal from the housing stock is a function of the age of the unit (in years). However, each of the year-built categories represent units of varying ages. For this approach, it was necessary to assign a single age (in years) to each category. For the 1940-1959, 1960-1979, and 1980-1997 categories, this age corresponded to the age of a unit built in the middle year of the category (48, 28, and 9 years, respectively). The single age assigned to all units in the pre-1940 category was equal to the age of a unit built in 1939 (58 years).

Because each AHS was separated by two years, a two-year period was considered when determining the probability of a unit in a given year-built category being lost from the housing stock. In this approach, each unit in the 1989 AHS and in the 1991 AHS was assigned an age in years (as of 1989 and 1991, respectively) according to the year-built category in which they were classified (different year-built categories from the four considered here were used in the AHS). This information was combined across the two surveys, and a logistic regression analysis was used to predict the probability of a loss over a two-year period as a function of age (in years). This regression analysis was weighted by the sample weights assigned to the units in their respective surveys (1989 or 1991). The resulting prediction model was

$$P[\text{loss over a two-year period}] = \frac{1}{1 + e^{5.82 - 0.0094 \cdot \text{age}}} \qquad (1)$$

where "age" is the age of the unit in years. The probability for a one-year period is roughly one-half of the probability for the two-year period. Table C-3 provides the predicted probabilities of losses over a one-year period for every five years of age.

Table C-3. Estimated Probability of an Occupied Housing Unit Becoming Lost from the Housing Stock Over a One-Year Period, Given the Age of Unit

Age of Unit (yrs)	Probability of Loss	Age of Unit (yrs)	Probability of Loss
5	0.0013	45	0.0023
10	0.0014	50	0.0025
15	0.0015	55	0.0026
20	0.0016	60	0.0028
25	0.0017	65	0.0031
30	0.0018	70	0.0033
35	0.0020	75	0.0036
40	0.0021	80	0.0038

Note: These probabilities were estimates from equation (1) and adjusted to cover a one-year period.

Table C-4 illustrates how reductions were determined from 1993 to 1995. First, an age (in years) associated with each of the four year-built categories was determined for 1993 and 1995. Then, the probability of loss for both ages was determined from equation (1); these probabilities are labeled as $p_{1993\text{-}95}$ and $p_{1995\text{-}97}$ in Table C-4. The total number of units in the category in 1993 was then reduced by multiplying the total by the product $(1-p_{1993\text{-}95})*(1-p_{1995\text{-}97})$ (i.e, the last column of Table C-4).

Table C-4. Determining Losses from the Housing Stock from 1993-1997

Year-Built Category	Age of units in 1993 (yrs.)[1]	Prob. of loss from 1993-1995 ($p_{1993\text{-}95}$)[2]	Age of units in 1995 (yrs.)[1]	Prob. of loss from 1995-1997 ($p_{1995\text{-}97}$)[2]	Proportion of 1993 Total That Remains in 1997 [3]
Pre-1940	54	0.0052	56	0.0054	0.989
1940-1959	44	0.0045	46	0.0046	0.991
1960-1979	24	0.0034	26	0.0034	0.993
Post-1979	7	0.0026	9	0.0027	0.995

[1] A single age is assigned to all units in a given category according to the approach indicated in the text.
[2] Determined from equation (1).
[3] Equal to $(1-p_{1993\text{-}95})*(1-p_{1995\text{-}97})$

Besides additions and removals, changes in the number of occupied homes in the national housing stock from 1993 to 1997 are also affected by the number of units that are occupied in 1993 and vacant in 1997, as well as by the number of units that are vacant in 1993 and occupied in 1997. However, in this approach, it was assumed that the number of occupied units in 1993 that become vacant in 1997 was approximately equal to the number of vacant units in 1993 that become occupied in 1997, thereby canceling each other out.

C1.1.3 Determining the Number of 1997 Units Represented by Each National Survey Unit. The procedures outlined in the previous subsection provide a method for estimating total numbers of housing units in 1997 within each of the four year-built categories. The results are displayed in Table 3-3 in Chapter 3 of this report. The housing units were grouped within year-built categories to facilitate the linking of numbers of units with estimated environmental-lead levels. The linking process consisted of classifying the National Survey units among the four categories, then distributing the 1997 total among the National Survey units within each category. This distribution yielded an updated weight for each National Survey unit, reflecting changes in the numbers of units in the year-built category from the time the National Survey was conducted to 1997. A unit's updated weight represented the number of units in the 1997 housing stock associated with the National Survey unit (and therefore with its environmental-lead levels).

The 1997 totals include both privately-owned and publicly-owned housing units, while the 284 National Survey units were privately-owned. Therefore, the revised 1997 weights for the National Survey units represent publicly-owned as well as privately-owned units.

Updating the Weights to Reflect the Pre-1980 Housing Stock

To update the sampling weights for the 284 National Survey units to reflect the pre-1980 housing stock, the units were grouped according to the three pre-1980 year-built categories. (Recall that all National Survey units were built prior to 1980). For these three categories, the updated 1997 weight for each unit in the category was calculated as follows:

$$\text{1997 weight} = (\text{National Survey weight}) * (\text{Updating factor for the category}) \qquad (2)$$

where the updating factor was determined as follows:

$$\text{Updating factor} = \frac{\text{\# units in the category in 1997}}{\text{Total National Survey weights in the category}} \tag{3}$$

(The sampling weights assigned in the National Survey were determined according to when the unit was built, whether the unit existed in a single- or multiple-unit building, the Census region in which the unit was located, and whether or not a child less than aged seven years resided in the unit).

Table C-5 contains the updating factors applied to the National Survey units according to year-built category. As an example, Table C-5 indicates that the updated 1997 weight for each of the 77 National Survey units in the pre-1940 category equaled the weight assigned in the National Survey multiplied by 0.936.

Table C-5. Number of National Survey Units in the Pre-1980 Year-Built Categories, and the Multiplicative Factor Used to Update National Survey Weights to 1997

Year-Built Category	# National Survey Units	Sum of National Survey Weights	Updating Factor
Pre-1940	77	21,020,019	0.936
1940-1959	87	20,472,997	0.963
1960-1979	120	35,686,004	0.980

Updating the Weights to Reflect the Post-1979 Housing Stock

Despite the fact that no HUD National Survey units were built after 1979, it was of interest to use the HUD National Survey to characterize the entire occupied national housing stock, including those units built after 1979. Therefore, methods were developed to determine how to use environmental-lead information from the HUD National Survey to represent the post-1979 occupied housing stock.

As the post-1979 housing stock was built after the Consumer Product Safety Commission's 1978 ban on the sale of LBP and its use in residences, the post-1979 housing stock was assumed to be free of LBP. This same assumption was made in the HUD National Survey and is the reason for not including post-1979 housing in the survey. Therefore, only National Survey units not containing LBP were considered in representing post-1979 housing.

To determine whether the entire set of National Survey units without LBP should be considered in representing post-1979 housing or only a subset of these units, data on dust-lead and soil-lead concentrations for units having maximum and minimum XRF measurements below 0.7 mg/cm^2 were investigated. As the top two plots in Figure C-1 illustrate, a noticeable relationship exists between lead concentrations and the age of the unit, with higher concentrations associated with older units. In contrast, the bottom two plots in Figure C-1 show less of a relationship between concentration and age of unit when only units built from 1960-1979 were considered. This finding suggests that older units may be free of LBP, but dust and soil are more likely to remain contaminated with lead than for newer units, either due to previous renovation work on the units or from outside contamination.

As a result of the conclusions made from Figure C-1, only the 28 National Survey units built between 1960 and 1979 and containing no LBP were selected to represent the post-1979 housing stock. As a result, it was assumed that the environmental-lead levels for these 28 units represented levels that exist in the post-1979 housing stock. These units also were included among those representing the 1960-1979 housing stock. Therefore, the total 1997 sampling weight for these 28 units consisted of two parts: that representing the 1960-1979 housing stock, and that representing the post-1979 housing stock. That portion representing the post-1979 housing stock was determined by dividing the total number of post-1979 units in 1997 by 28.

C1.2 POPULATING HOUSING UNITS WITH CHILDREN

To characterize health benefits associated with §403 interventions, it was necessary to estimate numbers of children of specific age groups who reside within the national housing stock. This section documents the methods for populating the 1997 national housing stock with children.

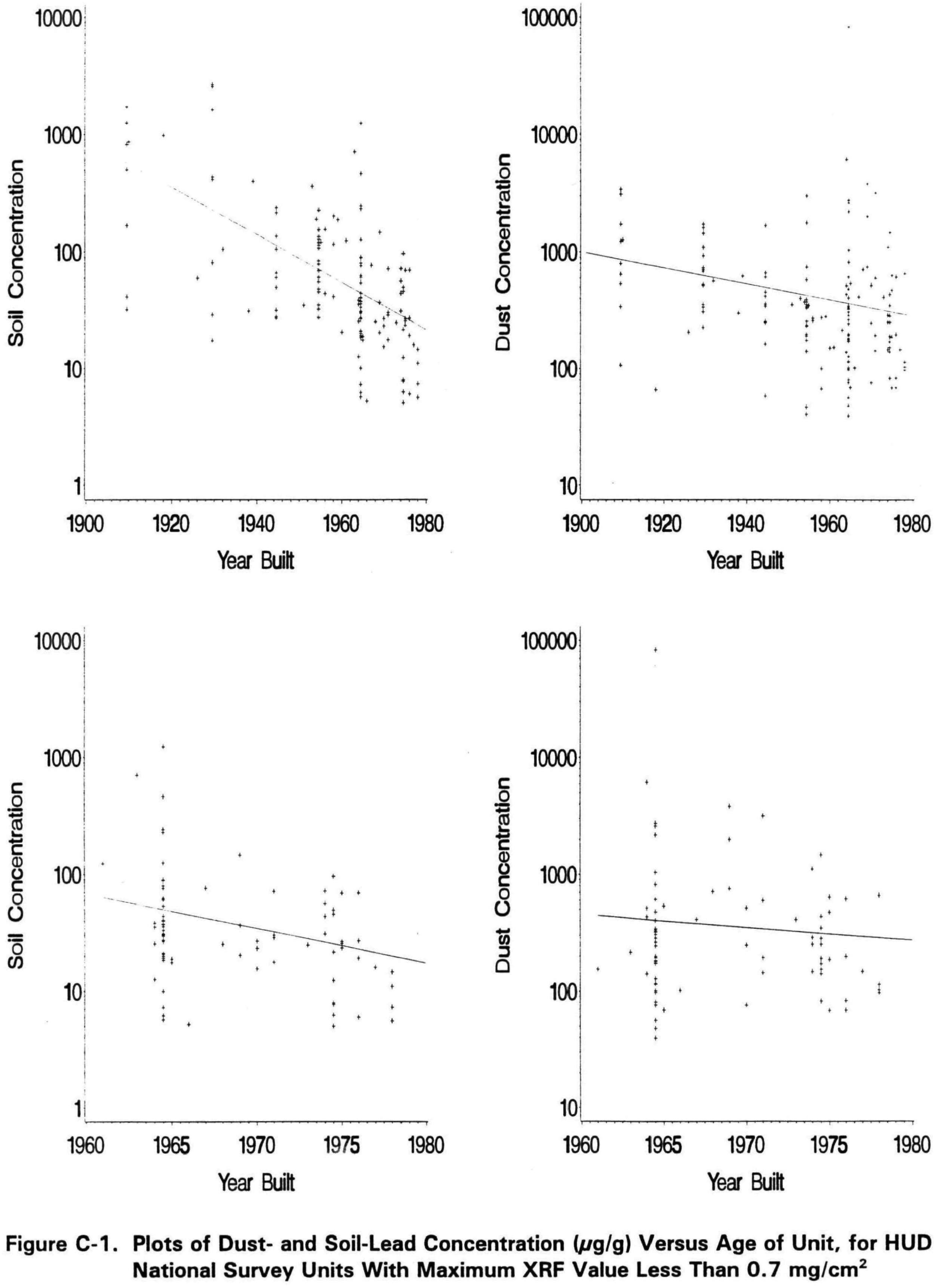

Figure C-1. Plots of Dust- and Soil-Lead Concentration (µg/g) Versus Age of Unit, for HUD National Survey Units With Maximum XRF Value Less Than 0.7 mg/cm²

Section C1.1 presented methods to revising the sampling weights for HUD National Survey units to reflect the 1997 national housing stock of occupied units. Therefore, each weight represents a subset of the national housing stock. It was desired to link numbers of children with each weight. Two age groups of children were of interest:

- Children aged 12 to 35 months (1 to 2 years)
- Children aged 12 to 71 months (1 to 5 years)

The 1-2 year age group was the primary group of interest in the §403 risk assessment effort, while the 1-5 year age group was considered in the sensitivity analysis.

For a given age group of children, the estimated number of children associated with the units represented within a 1997 sampling weight was the product of three statistics:

$$\text{\# children} = (\text{1997 weight}) * (\text{Average \# residents per unit}) * (\text{\# children per person}) \quad \textbf{(4)}$$

As the 1997 weight was determined for each National Survey unit using the methods in Section C1.1, it was necessary to obtain estimates for the latter two statistics in equation (4).

The factor "average # residents per unit" in equation (4) was calculated for the housing group based on information obtained in the 1993 AHS. The 1993 AHS database provided information on up to 15 residents within each housing unit in the AHS. Once these units were placed within the four year-built categories, the average number of people residing in a unit (regardless of age) was calculated for each group. This average ranged from 2.5 to 2.7 across the four year-built categories. A common average of 2.7 residents per unit was used for all units in the national housing stock. While this average was based on 1993 data, it is assumed to also hold for the 1997 housing stock.

The third factor in equation (4), "# children per person," represented the average number of children (of the given age group) per person residing in units within the housing group. This factor was calculated from information presented in Day (1993). This document provided two types of information necessary to calculate average number of children per person:

1. Predicted numbers of births per 1,000 people in the general population within selected years from 1993 to 2050

2. Predicted numbers of people in the general population of specific ages for these selected years.

For 1997, Day (1993) predicted a total of 14.8 births predicted per 1,000 people in the U.S.[3] Therefore, it was assumed that in any subset of occupied housing in 1997, the units within this subset will contain 14.8 children less than one year of age for every 1000 residents.

Day (1993) also provided a predicted number of children of various age groups in the nation in 1997. A total of 3,907,000 children aged 0-11 months, 7,835,000 children aged 12 to 35 months, and 20,066,000 children aged 12 to 71 months were predicted. By dividing each of these latter two statistics by 3,907,000, approximately 2.01 children aged 12 to 35 months and 5.14 children aged 12 to 71 months are predicted in 1997 for every child aged 0-11 months. Thus, using the birth rate in the previous paragraph, a total of 2.01 x 14.8 = 29.7 children aged 12 to 35 months, and 5.14 x 14.8 = 76.1 children aged 12 to 71 months, are predicted in 1997 per 1000 people in the U.S.

Table C-6 contains estimates of average number of children per unit in the 1997 national housing stock, according to age group. These numbers are the product of the final two factors in equation (4). Therefore, these numbers are multiplied by the 1997 sampling weights for each National Survey unit to obtain an estimated number of children residing in units represented within the weight. By summing the estimates across National Survey units, the total number of children aged 12-35 months and 12-71 months residing within the 1997 national housing stock is obtained by year-built category and for the nation. These results are presented in Table 3-24 in Chapter 3 of this report.

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[3] This is a "middle series assumption" birth rate, indicating the level at which assumptions are placed on fertility, life expectancy, and yearly net immigration.

Table C-6. Estimated Average Number of Children Per Unit in the 1997 National Housing Stock, by Age of Child

Age Group	Estimated Average Number of Children Per Unit
12-35 months	2.7*0.0297 = 0.080
12-71 months	2.7*0.0761 = 0.205

C1.3 SUMMARIZING ENVIRONMENTAL-LEAD LEVELS WITHIN THE HUD NATIONAL SURVEY UNITS

The methods of Sections C1.1 and C1.2 were used to link each of the 284 units in the HUD National Survey with an estimated number of units in the 1997 national housing stock and an estimated number of children residing within these units. In this final step, it is necessary to summarize the environmental-lead levels within each National Survey unit.

The following statistics were calculated for each National Survey unit, summarizing the unit's dust-lead loadings and dust-lead concentrations from floors and window sills, and soil-lead concentrations:

- A mass-weighted arithmetic average floor dust-lead concentration[4] for the unit (i.e., each measurement is weighted by the mass of the sample);
- An area-weighted arithmetic average floor dust-lead loading for the unit (i.e., each measurement is weighted by the square-footage of the sample area);
- A mass-weighted arithmetic average window sill dust-lead concentration[4] for the unit (i.e., each measurement is weighted by the mass of the sample);
- An area-weighted arithmetic average window sill dust-lead loading for the unit (i.e., each measurement is weighted by the square-footage of the sample area);
- A weighted arithmetic average soil-lead concentration for the unit, where results for samples taken from remote locations were weighted twice as much as results for dripline and entryway samples. If a unit has no soil-lead results for a particular

Prior to calculating the mass-weighted average, dust-lead concentrations on floors and window sills were adjusted to reduce bias associated with underestimated sample weights ("low tap weights") reported in the National Survey for dust samples.

location, the arithmetic average was unweighted (i.e., results for the remaining locations were not weighted).

- An unweighted arithmetic average soil-lead concentration, considering only the dripline and entryway samples for the unit.

- The maximum paint-lead concentration in the interior and the exterior of the unit, as measured by XRF techniques in selected rooms and on selected components within these rooms.

- The amount of damaged lead-based paint measured in the interior and the exterior of the unit.

These summary values were used in the statistical models to represent environmental-lead levels in the national housing stock, in determining health benefits associated with intervention.

In the HUD National Survey database, some units have unrecorded (or "missing") values for dust-lead loadings or concentrations, or soil-lead concentrations, preventing values for one or more of the first six summary statistics above from being calculated. As the values of certain statistics were used as input to the HUD/IEUBK and EPI models to predict health benefits due to §403 interventions, it was necessary that every housing unit have values for these statistics, even if no data existed for a particular unit. Therefore, an imputation scheme was devised to obtain summary values for units having no data in the National Survey database for the given parameter. In this approach, if a unit did not have data to allow the value of a summary statistic from being calculated, the value assigned to the unit equaled the weighted arithmetic average of those values for units within the same year-built category and having the same indicator for the presence of LBP, with each value weighted by the 1997 weight for the respective unit. For example, a total of eight National Survey units were built prior to 1940 and contained no LBP. If one of these units had no floor dust-lead loadings, then the summary value of floor-dust-lead loading for this unit would equal the weighted average of the summary values across the other seven units.

Table C-7 contains a listing of National Survey units within the three year-built categories in which they are classified. Also note that the 28 National Survey units built from 1960-1979 and containing no LBP were listed within a fourth category within Table C-7, representing the national housing stock built after 1979. The dust-lead concentrations summarized in Table C-7 were initially adjusted for underestimated sample weights; see Appendix Z for methods used to conduct this data adjustment. Also, dust-lead loadings summarized in Table C-7 were initially adjusted to reflect loadings that would be obtained if wipe collection techniques were used, rather than the Blue Nozzle vacuum method employed in the National Survey. The method to converting from vacuum to wipe loadings is presented in Chapter 4.

Table C-7 also contains the updated 1997 sampling weights for each unit (as calculated in Section C1.1) and the estimated numbers of children aged 12-35 months and 12-71 months that reside within the units (as calculated in Section C1.2). For the 28 units listed in both the 1960-1979 and post-1979 categories, the sampling weights and numbers of children are only that portion representing units within the category.

Table C-7. Estimated Environmental Lead Levels in the 1997 Housing Stock, As Determined from National Survey Units

Year Built	National Survey ID	LBP Present?	Floor Dust-Lead Loading (ug/ft2)	Floor Dust-Lead Conc. (ug/g)	Window Sill Dust-Lead Loading (ug/ft2)	Window Sill Dust-Lead Conc. (ug/g)	Soil-Lead Conc. (ug/g)	Dripline/Entry Soil-Lead Conc. (ug/g)	Obs. Max. Interior XRF (mg/cm2)	Obs. Max. Exterior XRF (mg/cm2)	Damaged Interior LBP (ft2)	Damaged Exterior LBP (ft2)	1997 Weight	# Children 12-35 mo.	# Children 12-71 mo.
<1940	0320408	No	17.7	317.	3.26	1740. *	36.5	19.7	0.60	--	0.0	0.0	183,864	14,744	37,779
	0320507	No	32.9	340.	50.0	762.	113.	88.1	--	--	0.0	0.0	183,864	14,744	37,779
	1210806	No	46.8	978.	29.7	618.	305. *	432. *	--	--	0.0	--	121,752	9,763	25,016
	1921709	No	39.1	448.	56.6	579.	504.	504.	--	--	0.0	--	199,528	16,000	40,997
	1932300	No	158.	412.	1440.	1880.	305. *	432. *	--	--	0.0	0.0	199,528	16,000	40,997
	1942606	No	59.2	246.	2500.	10900.	413.	413.	0.60	0.00	0.0	0.0	199,528	16,000	40,997
	1953009	No	3.02	112.	2.84	103.	305. *	432. *	0.60	--	0.0	0.0	199,528	16,000	40,997
	2022507	No	142.	589.	243.	881.	326.	544.	0.60	--	0.0	0.0	1,140,935	91,492	234,428
	0211102	Yes	41.2	781.	0.36	6700. *	84.2	66.5	2.8	8.7	0.0	0.0	183,864	14,744	37,779
	0221101	Yes	5.90	157.	1.71	6700. *	394.	424.	0.60	5.1	0.0	0.0	95,766	7,679	19,677
	0221507	Yes	44.5	979.	484.	1740.	2020.	1080.	10.	6.0	0.0	4.8	183,864	14,744	37,779
	0310102	Yes	27.2	297.	5.12	108.	138.	124.	0.60	0.60	0.0	0.0	183,864	14,744	37,779
	0310607	Yes	7.19	64.1	548.	835.	1240.	439.	3.4	--	0.0	--	183,864	14,744	37,779
	0310706	Yes	8.15	212.	90.4	1250.	534.	932.	7.1	14.	0.0	0.0	95,766	7,679	19,677
	0311100	Yes	220.	1600.	5.93	423.	711.	653.	5.3	5.8	0.0	57.6	183,864	14,744	37,779
	0320705	Yes	15.2	399.	1 86	6700. *	274.	263.	0.70	27.	0.0	0.0	183,864	14,744	37,779
	0350801	Yes	54.2	2120.	39.9	855.	25.9	34.1	--	--	0.0	0.0	95,766	7,679	19,677
	0411207	Yes	397.	1810.	25.0	396.	805.	843.	0.40	0.40	0.0	0.0	244,799	19,630	50,299
	0520106	Yes	10.5	87.0	9.24	153.	59.6	59.0	0.60	0.40	0.0	0.0	244,799	19,630	50,299
	0520403	Yes	198.	299.	322.	286.	102.	113.	0.70	1.8	0.0	0.0	114,632	9,192	23,553
	0520700	Yes	127.	938.	4970.	1050.	258.	296.	0.60	2.8	0.0	0.0	199,528	16,000	40,997
	0520908	Yes	28.4	630.	156.	319.	17.4	23.1	0.70	0.60	0.0	0.0	114,632	9,192	23,553
	0711002	Yes	53.3	537.	14.9	242.	157.	1100. *	0.20	13.	0.0	0.0	111,365	8,930	22,882
	0720300	Yes	27.2	340.	2790.	8710.	1460.	1930.	12.	0.60	0.0	0.0	111,365	8,930	22,882
	0720706	Yes	30.2	535.	345.	2310.	830. *	1100. *	8.0	5.0	0.0	24.6	111,365	8,930	22,882
	0721001	Yes	52.9	328.	1780. *	6700. *	80.4	93.7	3.3	0.60	0.0	0.0	60,761	4,872	12,485
	0730606	Yes	74.4	527.	33400.	10200.	372.	262.	10.	8.8	9.4	28.0	111,365	8,930	22,882
	0820506	Yes	14.5	126.	23.0	300.	1110.	1110.	0.70	3.6	0.0	226.8	111,365	8,930	22,882
	0911800	Yes	6.38	96.9	141.	111.	49.8	34.7	0.60	0.80	0.0	0.0	111,365	8,930	22,882
	0920900	Yes	10.7	188.	2.71	6700. *	162.	283.	0.60	54.	0.0	0.0	111,365	8,930	22,882
	0941005	Yes	10.8	245.	1080.	4650.	1620.	260.	0.80	3.8	0.0	0.0	773,094	61,994	158,848
	0950402	Yes	32.6	644.	2200.	3460.	2000.	4000.	0.30	0.30	0.0	0.0	773,094	61,994	158,848
	0951004	Yes	17.9	527.	126.	1890.	1170.	2290.	0.60	6.5	0.0	457.3	773,094	61,994	158,848
	1010909	Yes	51.3	1240.	38.4	1130.	851.	1480.	10.	51.	0.0	0.0	244,799	19,630	50,299
	1011303	Yes	71.5	1100.	1780. *	6700. *	717.	1150.	0.80	--	0.0	--	244,799	19,630	50,299
	1011501	Yes	32.4	623.	65.3	1090.	4620.	8960.	0.40	38.	0.0	0.0	114,632	9,192	23,553
	1011600	Yes	78.1 *	487.	1780. *	6700. *	392.	589.	0.30	29.	0.0	182.0	244,799	19,630	50,299
	1041607	Yes	7 14	0.09	2.38	6700. *	39.5	44.4	0.30	0.30	0.0	0.0	244,799	19,630	50,299
	1221902	Yes	191.	6320.	9640.	56500.	444.	701.	6.4	11.	0.0	8.4	1,140,935	91,492	234,428
	1250406	Yes	53.5	2370.	139.	949.	628.	888.	6.2	4.9	0.0	0.0	121,752	9,763	25,016
	1251107	Yes	136.	1760.	126.	1840.	1030.	1660.	5.0	0.00	0.0	0.0	121,752	9,763	25,016
	1251404	Yes	22.4	662.	54.1	698.	569.	535.	20.	4 0	0.0	0.0	1,140,935	91,492	234,428
	1352608	Yes	276.	2070.	1780. *	6700. *	679.	968.	7.0	10.	0.0	141.4	111,365	8,930	22,882
	1353705	Yes	10.9	491.	13.2	6700. *	109.	116.	13.	1.8	11.5	0.0	111,365	8,930	22,882
	1411909	Yes	443.	4340.	12.5	738.	586.	1040.	0.60	7.9	0.0	0.0	95,766	7,679	19,677
	1531201	Yes	192.	831.	681.	1090.	251.	283.	0.90	14.	0.0	585.7	773,094	61,994	158,848
	1531300	Yes	35.6	303.	55.3	481.	105.	179.	3.3	4.4	0.0	112.0	111,365	8,930	22,882
	1631209	Yes	30.6	215.	286.	1180.	830. *	1100. *	1.4	1.6	0.0	0.0	199,528	16,000	40,997
	1631308	Yes	12.7	123.	310.	701.	524.	524.	1.2	1.6	0.0	0.0	199,528	16,000	40,997
	1740901	Yes	117.	860.	1780. *	6700. *	137.	221.	9.4	15.	89.8	0.0	121,752	9,763	25,016
	1751304	Yes	30.0	198.	0.05	1.44	358.	466.	2.9	9.5	17 6	0.0	121,752	9,763	25,016
	1820802	Yes	9.58	106.	1.61	6700. *	1430.	2330.	0.60	--	0.0	0.0	60,761	4,872	12,485
	1830801	Yes	17.8	279.	6.01	74.3	830. *	1100. *	6.6	--	18.7	--	60,761	4,872	12,485
	1830900	Yes	492.	3630.	13.9	6700. *	830. *	1100. *	4.7	--	0.0	--	199,528	16,000	40,997
	1840503	Yes	213.	1970.	32.6	526.	830. *	1100. *	1.2	--	0.0	--	60,761	4,872	12,485
	1851104	Yes	71.6	316.	532.	2880.	212.	212.	0.60	4.6	0.0	0 0	121,752	9,763	25,016
	1931906	Yes	33.3	193.	908.	5840.	830. *	1100. *	4.4	2.7	0.8	0 0	199,528	16,000	40,997
	1951904	Yes	68.1	627.	394.	2080.	830. *	1100. *	6.0	--	0.0	0.0	60,761	4,872	12,485
	1952506	Yes	23.6	328.	0.87	39.9	830. *	1100. *	1.9	2.4	0.0	0.0	60,761	4,872	12,485
	2121507	Yes	53.3	281.	1780 *	6700. *	1170.	1170.	1.7	7.1	6.2	25 1	199,528	16,000	40,997
	2240406	Yes	279.	781.	21700.	8480.	335.	270. -	0 60	3.5	0.0	604.8	244,799	19,630	50,299
	2311108	Yes	119.	1280.	1720.	500.	830. *	1100. *	8.6	0.70	21 9	0.0	1,140,935	91,492	234,428
	2343002	Yes	13.4	292.	102.	4720.	256.	242.	2 3	5.7	0.5	1.7	121,752	9,763	25,016

Table C-7. Estimated Environmental Lead Levels in the 1997 Housing Stock, As Determined from National Survey Units (Continued)

Year Built	National Survey ID	LBP Present?	Floor Dust-Lead Loading (ug/ft2)	Floor Dust-Lead Conc. (ug/g)	Window Sill Dust-Lead Loading (ug/ft2)	Window Sill Dust-Lead Conc. (ug/g)	Soil-Lead Conc. (ug/g)	Dripline/Entry Soil-Lead Conc. (ug/g)	Obs. Max. Interior XRF (mg/cm2)	Obs. Max. Exterior XRF (mg/cm2)	Damaged Interior LBP (ft2)	Damaged Exterior LBP (ft2)	1997 Weight	# Children 12-35 mo.	# Children 12-71 mo.
<1940 (cont.)	2410801	Yes	18.5	641.	101.	1320.	290.	378.	5.9	7.6	238.6	77.3	121,752	9,763	25,016
	2441608	Yes	13.0	370.	503.	6250.	609.	1010.	9.4	3.9	0.0	0.0	121,752	9,763	25,016
	2521300	Yes	28.0	150.	2.18	77.6	35.0	24.1	0.50	0.60	0.0	0.0	244,799	19,630	50,299
	2541209	Yes	77.4	161.	329.	2050.	28.6	38.0	1.5	0.50	7.0	0.0	114,632	9,192	23,553
	2542009	Yes	20.5	276.	549	1660.	125.	113.	8.2	0.90	139.9	0.0	114,632	9,192	23,553
	2550309	Yes	3.34	61.6	34.3	408.	76.4	132.	0.60	6.6	0.0	0.0	244,799	19,630	50,299
	2551802	Yes	36.5	142.	24.2	61.1	159.	184.	1.3	0.50	0.0	0.0	244,799	19,630	50,299
	2651800	Yes	42.6	399.	10.0	75.7	47.4	49.4	0.60	0.30	0.0	0 0	244,799	19,630	50,299
	2710101	Yes	17.0	265.	2.36	6700. *	613.	1110.	2.6	5.0	0.0	0.0	244,799	19,630	50,299
	2721009	Yes	29.5	316.	1220.	1980.	110.	183.	2.9	0.50	0.0	0.0	244,799	19,630	50,299
	2931608	Yes	153.	814.	517.	2060.	1160.	1150.	3.9	7.7	28.8	0.0	183,864	14,744	37,779
	3011103	Yes	120.	1310.	950.	9040.	1500.	425.	12.	6.9	0.9	0.0	111,365	8,930	22,882
	3011905	Yes	21.8	821.	958.	13200.	2750.	5340.	10.	3.3	6.6	0.0	773,094	61,994	158,848
	3020401	Yes	17.4	330.	206.	2710.	1390.	702.	0.60	5.3	0.0	16.5	773,094	61,994	158,848
													19,676,320	1,577,844	4,042,893
1940-1959	0340406	No	7.73	60.6	2.89	47.4	25.2	31.8	0.60	0.60	0.0	0.0	258,519	20,731	53,118
	0341107	No	10.6	44.7	9.37	318.	47.6	9.55	0.60	--	0.0	0.0	273,941	21,967	56,287
	1312701	No	2.11	62.2	4.30	316. *	36.3	51.3	0.60	0.00	0.0	0.0	227,108	18,212	46,664
	1722206	No	75.6	373.	15.4	183.	39.3 *	45.8 *	--	--	0.0	--	108,151	8,673	22,222
	2230100	No	15.1	32.2	2.46	67.5	42.8	80.6	--	0.60	--	0 0	213,598	17,128	43,888
	2611101	No	2.45	57.0	9.76	337.	75.1	90.0	0.30	0.30	0.0	0.0	181,223	14,532	37,236
	2731503	No	18.9	137.	161.	1050.	5.40	7.96	0.20	0.20	0.0	0.0	181,223	14,532	37,236
	3040706	No	6.37	196.	26.0 *	316. *	43.5	61.9	--	0.60	--	0.0	227,108	18,212	46,664
	0120105	Yes	25.7	116.	80.8	300.	34.6	55.8	1.6	3.7	0.0	0.0	273,941	21,967	56,287
	0131102	Yes	190.	812.	66.4	596.	60.4	63.9	1.5	1.8	0.0	0.0	273,941	21,967	56,287
	0131201	Yes	23.3	144.	117.	589.	109.	57.4	0.60	1.9	0.0	10.3	108,151	8,673	22,222
	0251900	Yes	14.0	278.	21.4	194.	198.	245.	0.60	0.60	0.0	0.0	273,941	21,967	56,287
	0310201	Yes	17.1	120.	15.1	277.	214.	178.	0.60	0.60	0.0	0.0	273,941	21,967	56,287
	0320101	Yes	17.9	342.	5.84	302.	209.	284.	1.0	3.1	0.0	0.0	273,941	21,967	56,287
	0321307	Yes	14.7	162.	0.04	1360. *	146.	107.	--	8.4	0.0	0.0	273,941	21,967	56,287
	0351205	Yes	58.4	706.	1400.	6530.	81.4	135.	3.2	3.3	0.0	33.7	258,519	20,731	53,118
	0410100	Yes	28.1	18.6	11400.	43800.	43.2	63.0	2.9	1.4	0.0	0.0	108,151	8,673	22,222
	0411306	Yes	292.	1240.	4990.	6570.	122.	126.	0.50	7.8	0.0	0.0	213,598	17,128	43,888
	0411603	Yes	22.1	215.	64.3	521.	115.	152.	7.0	0.60	0.0	0.0	213,598	17,128	43,888
	0520809	Yes	134.	543.	2310.	19900.	347.	609.	0.40	--	0.0	0.0	108,151	8,673	22,222
	0531301	Yes	67.3	241.	35.9	183.	160.	145.	0.40	0.60	0.0	0.0	181,223	14,532	37,236
	0612002	Yes	19.4	740.	18.5	244.	135.	199.	0.50	10.	0.0	0.0	213,598	17,128	43,888
	0651901	Yes	3.88	84.1	141.	417.	70.9	87.4	0.90	0.60	0.0	0.0	108,151	8,673	22,222
	0710103	Yes	13.4	243.	271. *	1360. *	60.2	366. *	0.60	0.60	0 0	0.0	227,108	18,212	46,664
	0750406	Yes	125.	667.	18.7	378.	52.4	61.9	0.70	1.4	0.0	0.0	227,108	18,212	46,664
	0821009	Yes	6.36	101.	50.4	608.	90.5	131.	1.1	--	0.0	0.0	227,108	18,212	46,664
	0911503	Yes	72.2	259.	48.6	989.	21.7	37.6	0.40	0.30	0.0	0.0	227,108	18,212	46,664
	0920801	Yes	5.93	80.1	0.19	1360. *	9.26	11.6	0.50	0.30	0.0	0.0	227,108	18,212	46,664
	0921304	Yes	6.02	138.	271. *	1360. *	75.8	54.4	0.50	0.00	0.0	0.0	227,108	18,212	46,664
	1010503	Yes	240.	1560.	152.	1920.	7030.	14E3.	11.	30.	6.3	5.1	213,598	17,128	43,888
	1030204	Yes	7.98	105.	271. *	1360. *	65.7	89.6	0.50	0.50	0.0	0.0	213,598	17,128	43,888
	1051200	Yes	3.95	118.	8.31	1.02	142.	178.	0.30	0.40	0.0	0.0	213,598	17,128	43,888
	1120401	Yes	81.0	248.	12.5	132.	99.0	75.2	0.90	2.6	0.0	6.5	181,223	14,532	37,236
	1121300	Yes	6.45	63.0	3.04	61.4	144.	145.	0.70	17.	0.0	0.0	213,598	17,128	43,888
	1130806	Yes	26 5	258.	3.22	61.1	81.0	98.4	7.3	8.3	0 0	0.0	213,598	17,128	43,888
	1140508	Yes	58.9	775.	33.8	1230.	90.0	64.2	1.1	4.8	0.0	0.0	181,223	14,532	37,236
	1332402	Yes	23.2	276.	11.9	276.	182.	309.	0 60	0.60	0.0	0.0	291,118	23,345	59,816
	1333806	Yes	52.9	322.	12 7	195.	61.1	87.9	0.60	2.2	0.0	0 0	227,108	18,212	46,664
	1352806	Yes	9.34	95.7	4.55	48.1	71.3	92.9	1.9	0 50	0.0	0 0	227,108	18,212	46,664
	1410406	Yes	11.3	174.	7.47	183.	130.	179.	0.60	1 9	0.0	0 0	273,941	21,967	56,287
	1440205	Yes	43.7	236.	83 6	772.	24.9	32.4	1.4	2.2	0.0	0 0	273,941	21,967	56,287
	1450907	Yes	68.7	73.5	0.57	41.6	26.0	31.2	0 60	0 50	0 0	0.0	258,519	20,731	53,118
	1521400	Yes	53.5	173.	182.	350.	145.	142.	2 4	2 8	6.3	0.0	227,108	18,212	46,664
	1521509	Yes	45.7	396.	39.7	1360. *	132.	219.	1.5	13	0 0	278 5	227,108	18,212	46,664
	1530500	Yes	8.98	166.	262.	1080.	264.	249.	1.8	3.7	0.0	56 0	227,108	18,212	46,664
	1550102	Yes	26.5	288.	4.39	112.	209.	336.	3 5	2 1	12.5	3.0	227,108	18,212	46,664
	1550607	Yes	37.5	419.	271. *	1360. *	145.	155.	1 2	2 0	73.5	0 0	227,108	18,212	46,664
	1551704	Yes	58.4	314.	77.5	1360. *	136.	241.	2 9	2 6	0.0	0 0	227,108	18,212	46,664

Table C-7. Estimated Environmental Lead Levels in the 1997 Housing Stock, As Determined from National Survey Units (Continued)

Year Built	National Survey ID	LBP Present?	Floor Dust-Lead Loading (ug/ft2)	Floor Dust-Lead Conc. (ug/g)	Window Sill Dust-Lead Loading (ug/ft2)	Window Sill Dust-Lead Conc. (ug/g)	Soil-Lead Conc. (ug/g)	Dripline/Entry Soil-Lead Conc. (ug/g)	Obs. Max. Interior XRF (mg/cm2)	Obs. Max. Exterior XRF (mg/cm2)	Damaged Interior LBP (ft2)	Damaged Exterior LBP (ft2)	1997 Weight	# Children 12-35 mo.	# Children 12-71 mo.
1940-1959 (cont.)	1730407	Yes	32.4	162.	395.	504.	63.9	73.5	1.8	2.3	4.8	0.0	108,151	8,673	22,222
	1730704	Yes	13.8	224.	13.5	1360. *	77.3	83.7	2 1	1.5	0.0	0.0	108,151	8,673	22,222
	1730803	Yes	15.7	88.4	94.2	938.	77.3	83.7	1.8	1.5	0.0	0.0	108,151	8,673	22,222
	1731603	Yes	2.86	17.5	271. *	1360. *	88.0	88.0	1.5	1.4	0.0	0.0	108,151	8,673	22,222
	1750108	Yes	17.3	316.	9.74	323.	53.8	70.6	1.2	1.8	0.0	0.0	433,850	34,790	89,143
	1831106	Yes	66.4	839.	240.	1760.	2570.	2570.	2.0	--	0.0	--	111,336	8,928	22,876
	1831304	Yes	33.4	445.	602.	2930.	2570.	2570.	0.60	--	0.0	--	108,151	8,673	22,222
	1840305	Yes	31.7	244.	232.	1040.	322. *	366. *	20.	--	0.0	--	108,151	8,673	22,222
	1841105	Yes	40.4	286.	258.	1130.	322. *	366. *	1.0	--	0.0	--	111,336	8,928	22,876
	2022705	Yes	29.0	94.4	25.5	338.	60.1	75.2	0.70	1.5	0.0	0.0	433,850	34,790	89,143
	2030302	Yes	11.7	102.	10.2	1360. *	33.7	47.7	0.60	0.60	0.0	0.0	433,850	34,790	89,143
	2110906	Yes	299.	1680.	560.	4480.	491.	491.	0.60	6.3	0.0	7.3	108,151	8,673	22,222
	2141505	Yes	2.08	32.6	0.34	1360. *	58.9	102.	1.7	1.5	1.4	2.5	291,118	23,345	59,816
	2142107	Yes	15.3	93.7	271. *	1360. *	123.	99.5	1.2	--	0.0	--	227,108	18,212	46,664
	2211902	Yes	41.5	61.7	17.1	246.	22.0	33.1	0.70	0.90	0.0	0.0	213,598	17,128	43,888
	2332005	Yes	53.3	755.	81.1	1270.	322. *	366. *	8.0	5.0	0.0	77.1	433,850	34,790	89,143
	2343606	Yes	11.3	144.	3.55	148.	225.	246.	0.80	2.5	0.0	0.0	433,850	34,790	89,143
	2421709	Yes	23.8	169.	142.	159.	52.4	90.9	0.60	1.4	0.0	0.0	433,850	34,790	89,143
	2441509	Yes	75.8	1700.	78.0	1510.	4320.	1680.	0.60	3.9	0.0	118.3	411,982	33,037	84,650
	2451805	Yes	9.11	201.	424.	3230.	34.1	35.9	0.60	0.60	0.0	0.0	433,850	34,790	89,143
	2520906	Yes	73.6	321.	68.0	287.	55.8	45.5	0.80	0.70	0.0	0.0	213,598	17,128	43,888
	2540102	Yes	133.	254.	315.	31.6	102.	116.	2.7	1.5	201.9	20.0	213,598	17,128	43,888
	2540201	Yes	12.6	271.	41.1	178.	33.0	44.0	0.60	1.2	0.0	0.0	213,598	17,128	43,888
	2541407	Yes	147.	378.	29.6	413.	485.	109.	0.60	0.50	0.0	0.0	181,223	14,532	37,236
	2541902	Yes	3.65	65.4	143.	1140.	116.	89.7	0.70	0.50	0.0	0.0	213,598	17,128	43,888
	2610103	Yes	18.7	284.	28.5	341.	43.5	44.7	0.20	0.20	0.0	0.0	213,598	17,128	43,888
	2651206	Yes	12.7	16.8	60.5	342.	26.3	43.8	0.60	0.30	0.0	0.0	213,598	17,128	43,888
	2652303	Yes	12.4	275.	271. *	1360. *	49.0	38.4	0.50	0.30	0.0	0.0	213,598	17,128	43,888
	2711505	Yes	40.4	210.	795.	4000.	218.	292.	1.7	7.6	0.0	0.0	181,223	14,532	37,236
	2730703	Yes	6.45	87.0	16.5	149.	119.	237.	0.40	0.20	0.0	0.0	213,598	17,128	43,888
	2731800	Yes	49.9	114.	345.	510.	12.1	21.2	0.40	1.0	0.0	0.0	213,598	17,128	43,888
	2812204	Yes	32.0	484.	25.5	345.	162.	242.	2.8	0.60	0.0	0.0	213,598	17,128	43,888
	2840403	Yes	51.4	1070.	16.1	145.	52.1	62.5	6.1	8.7	0.0	0.0	213,598	17,128	43,888
	2841203	Yes	90.7	1270.	1250.	2760.	61.9	78.7	9.6	13.	0.0	0.0	213,598	17,128	43,888
	2841500	Yes	14.8	118.	1.46	1360. *	41.4	31.8	1.0	1.8	0.0	0.0	213,598	17,128	43,888
	2910107	Yes	24.0	232.	6.70	1360. *	51.8	78.1	1.4	0.50	0.0	0.0	273,941	21,967	56,287
	2931202	Yes	39.1	316.	62.8	698.	188.	188.	0.80	0.50	0.0	0.0	108,151	8,673	22,222
	2940708	Yes	11.3	232.	12.1	261.	44.3	53.8	1.7	1.5	0.0	0.0	273,941	21,967	56,287
	3011509	Yes	10.5	358.	20.6	344.	346.	689.	0.60	1.4	0.0	0.0	227,108	18,212	46,664
													----------	----------	----------
													19,717,970	1,581,184	4,051,451
1960-1979	0130708	No	10.6	88.5	46.9	203.	29.7	31.5	0.60	0.60	0.0	0.0	658,726	52,823	135,348
	0131003	No	19.4	110.	13.6	170.	5.35	7.87	0.60	0.00	0.0	0.0	291,351	23,363	59,864
	0150201	No	46.9	68.8	20.4	16.6	6.16	9.49	0.60	0.50	0.0	0.0	291,351	23,363	59,864
	0330308	No	8.41	54.7	3.46	48.1	61.6	105.	0.60	0.60	0.0	0.0	291,351	23,363	59,864
	0350306	No	7.98	116.	7.17	261.	14.2	24.7	--	--	0.0	0.0	658,726	52,823	135,348
	0420901	No	28.9	20.2	1820.	287.	21.0	27.6	0.40	0.60	0.0	0.0	291,351	23,363	59,864
	0430108	No	13.2	68.8	21.9	172.	21.3	37.3	0.30	0.60	0.0	0.0	116,364	9,331	23,909
	0440305	No	42.1	245.	5.98	101.	97.4	144.	0.50	0.60	0.0	0.0	116,364	9,331	23,909
	0440602	No	18.1	144.	12.0	154.	79.3	128.	--	--	0.0	0.0	316,764	25,401	65,085
	0541201	No	5.85	22.2	6.21	562.	17.9	28.9	0.60	0.60	0.0	0.0	116,364	9,331	23,909
	0940700	No	5.63	48.2	99.4 *	541. *	7.23	7.52	0.30	0.30	0.0	0.0	291,351	23,363	59,864
	0940809	No	18.2	458.	2.15	533.	17.7	20.3	0.30	0.30	0.0	0 0	291,351	23,363	59,864
	1020205	No	7.88	167.	25.6	406.	49.2	70.0	0.30	0.50	0.0	0.0	316,764	25,401	65,085
	1020502	No	9.89	161.	26.4	1250.	58.3	90.8	0.30	--	0 0	0.0	316,764	25,401	65,085
	1021005	No	5.64	198.	8.70	541. *	25.5	35.0	0.50	0.30	0.0	0.0	316,764	25,401	65,085
	1040500	No	11.7	210.	17.1	156.	24.5	21.3	0.40	--	0.0	0.0	116,364	9,331	23,909
	1323609	No	5.69	108.	99.4 *	541. *	20.4	35.5	0.60	--	0.0	--	312,998	25,099	64,312
	1441302	No	4.17	92.6	0.05	541. *	13.0	11.0	0.60	0.50	0.0	0.0	658,726	52,823	135,348
	2220507	No	18.7	123.	99.4 *	541. *	14.1	19.9	0.60	0.60	0.0	0.0	316,764	25,401	65,085
	2230209	No	6.10	70.4	7.94	124	5.58	5.61	0.60	0.60	0 0	0.0	316,764	25,401	65,085
	2511806	No	6.20	52.9	1.81	26.0	11.6	9.94	0.60	0.50	0.0	0.0	116,364	9,331	23,909
	2521201	No	39.9	182.	180.	4930.	73.4	67.4	0.60	0 10	0.0	0.0	316,764	25,401	65,085
	2551000	No	4.28	52.8	4.10	64.3	22.6	12.7	0.60	0.50	0.0	0.0	316,764	25,401	65,085

Table C-7. Estimated Environmental Lead Levels in the 1997 Housing Stock, As Determined from National Survey Units (Continued)

Year Built	National Survey ID	LBP Present?	Floor Dust-Lead Loading (ug/ft2)	Floor Dust-Lead Conc. (ug/g)	Window Sill Dust-Lead Loading (ug/ft2)	Window Sill Dust-Lead Conc. (ug/g)	Soil-Lead Conc. (ug/g)	Dripline/Entry Soil-Lead Conc. (ug/g)	Obs. Max. Interior XRF (mg/cm2)	Obs. Max. Exterior XRF (mg/cm2)	Damaged Interior LBP (ft2)	Damaged Exterior LBP (ft2)	1997 Weight	# Children 12-35 mo.	# Children 12-71 mo.
1960-1979 (cont.)	2552107	No	4.53	39.6	1.18	77.0	27.2	35.9	0.60	0.50	0.0	0.0	316,764	25,401	65,085
	2822005	No	8.03	66.3	176.	895.	82.5	123.	0.60	0.00	0.0	0.0	316,764	25,401	65,085
	2831006	No	3.67	34.5	0.31	541. *	21.1	14.5	0.60	0.60	0.0	0.0	316,764	25,401	65,085
	2831709	No	9.88	65 1	11.3	134.	40.8	30.7	0.60	0.60	0.0	0.0	116,364	9,331	23,909
	3050101	No	11.8	487.	99.4 *	541. *	6.68	10.5	0.60	0.60	0.0	0.0	312,998	25,099	64,312
	0130906	Yes	16.0	68.2	10.1	97.9	39.5	34.3	0.60	0.60	0.0	0.0	126,372	10,134	25,966
	0150102	Yes	24.7	188.	5.22	87.1	4.79	7.49	0.80	0.60	0.0	0.0	658,726	52,823	135,348
	0250902	Yes	12.3	207.	7.10	534.	180.	335.	0.60	0.60	0.0	0.0	352,318	28,252	72,391
	0252404	Yes	28.7	225.	394.	481.	604.	910.	1.0	0.60	0 0	0.0	291,351	23,363	59,864
	0311209	Yes	17.6	330.	1070.	2470.	186.	337.	0.80	0.60	0.0	0.0	352,318	28,252	72,391
	0331009	Yes	10.5	27.6	15.4	169.	15.3	15.9	0.60	0.60	0.0	0.0	352,318	28,252	72,391
	0340505	Yes	28.2	15.8	1.12	45.5	23.7	26.6	0.60	0.60	0.0	0.0	658,726	52,823	135,348
	0340802	Yes	58.4	652.	12.4	241.	31.8	36.5	0.90	0.60	0.0	0.0	352,318	28,252	72,391
	0341404	Yes	10.5	34.3	45.3	138.	20.0	21.7	1.0	0.60	0.0	0.0	658,726	52,823	135,348
	0410605	Yes	20.0	61.0	753.	520.	127.	123.	1.4	0.00	0.0	0.0	291,351	23,363	59,864
	0421206	Yes	139.	643.	821.	331.	22.8	21.6	0.50	1.7	0.0	0.0	291,351	23,363	59,864
	0430207	Yes	36.6	87.3	26.8	102.	35.2	65.2	0.50	0.80	0.0	0.0	316,764	25,401	65,085
	0430306	Yes	51.2	7.04	12.7	0.79	27.2	49.2	0.40	0.70	0.0	0.0	316,764	25,401	65,085
	0430702	Yes	54.2	318.	227. *	1540. *	26.4	40.0	0.40	0.40	0.0	0.0	116,364	9,331	23,909
	0440107	Yes	52.6	319.	176.	296.	34.7	38.3	0.60	0.50	0.0	0.0	316,764	25,401	65,085
	0441105	Yes	13.3	75.7	18.8	191.	5.22	5.22	0.50	0.60	0.0	0.0	116,364	9,331	23,909
	0441204	Yes	55.1	177.	286.	230.	87.4	91.7	0.40	0.60	0.0	0.0	316,764	25,401	65,085
	0530105	Yes	20.8	246.	59.3	492.	50.9	52.1	1.4	0.70	0.0	0.0	116,364	9,331	23,909
	0530600	Yes	13.4	193.	227. *	1540. *	215.	303.	1.0	0.60	0.0	0.0	291,351	23,363	59,864
	0531400	Yes	93.6	143.	145.	339.	56.1	32.4	0.70	1.7	0.0	0.0	116,364	9,331	23,909
	0540203	Yes	28.7	59.9	227. *	1540. *	14.8	15.6	0.80	0.70	0.0	0.0	316,764	25,401	65,085
	0541300	Yes	23.2	179.	177.	397.	7.52	8.10	0.90	0.60	0.0	0.0	316,764	25,401	65,085
	0621607	Yes	7.26	64.1	1.04	1540. *	39.4	53.2	0.70	0.30	0.0	0.0	126,372	10,134	25,966
	0631408	Yes	12.3	221.	42.6	273.	85.4	79.3	0.40	--	0.0	0.0	126,372	10,134	25,966
	0840702	Yes	9.92	81.9	2.54	1540. *	30.6	37.0	0.80	1.2	0.0	5.9	291,351	23,363	59,864
	0911404	Yes	4.97	104.	3.26	1540. *	29.8	31.8	0.30	0.30	0.0	0.0	173,719	13,931	35,694
	0930701	Yes	12.9	388.	3.13	58.7	19.7	24.3	0.60	0.30	0.0	0.0	312,998	25,099	64,312
	1011709	Yes	10.1	368.	1.04	1540. *	996.	1710.	11.	0.40	28.8	0.0	116,364	9,331	23,909
	1020304	Yes	7.05	159.	227. *	1540. *	26.6	36.3	0.80	0.70	0.0	0.0	316,764	25,401	65,085
	1020403	Yes	6.84	111.	1.78	1540. *	25.0	27.0	0.70	0.30	0.0	0.0	316,764	25,401	65,085
	1020700	Yes	2.22	52.4	0.47	1540. *	23.8	20.3	0.60	0.70	0.0	0.0	316,764	25,401	65,085
	1020809	Yes	7.98	285.	17.1	1540. *	25.4	29.4	0.40	--	0.0	0.0	316,764	25,401	65,085
	1050509	Yes	3.15	48.1	227. *	1540. *	116.	206.	3.0	0.60	0.0	0.0	316,764	25,401	65,085
	1050608	Yes	4.40	134.	0.30	1540. *	57.5	72.3	0.30	0.30	0.0	0.0	316,764	25,401	65,085
	1051408	Yes	5.05	135.	227. *	1540. *	143.	259.	0.30	1.7	0.0	0.0	116,364	9,331	23,909
	1150200	Yes	15.0	242.	91.8	705.	35.3	40.5	1.0	9.1	0.0	0.0	291,351	23,363	59,864
	1150705	Yes	11.5	183.	574.	1650.	81.6	105.	1.6	0.40	0.0	0.0	291,351	23,363	59,864
	1241801	Yes	7.29	116.	2950.	18400.	196.	207.	0.60	1.4	0.0	0.0	451,561	36,211	92,782
	1311505	Yes	5.08	82.8	3.32	120.	20.8	19.4	0.60	0.00	0.0	0.0	173,719	13,931	35,694
	1312800	Yes	57.8	251.	0.93	53.4	13.8	10.1	0.90	--	0.0	--	312,998	25,099	64,312
	1322601	Yes	4.08	104.	1.60	1540. *	33.3	39.9	0.60	--	0.0	--	312,998	25,099	64,312
	1353309	Yes	2.40	16.7	0.57	12.3	51.6	18.7	0.60	0.00	0.0	0.0	291,351	23,363	59,864
	1441005	Yes	5.81	48.1	1.82	28.7	18.8	20.3	1.5	0.50	0.0	0.0	658,726	52,823	135,348
	1510403	Yes	13.5	246.	227. *	1540. *	4.63	5.79	0.50	0.60	0.0	0.0	173,719	13,931	35,694
	1510908	Yes	29.7	188.	3.66	70.7	14.8	23.7	0.30	0.20	0.0	0.0	312,998	25,099	64,312
	1520204	Yes	18.9	228.	13.3	1540. *	35.9	33.6	0.30	10.	0.0	0.0	312,998	25,099	64,312
	1530104	Yes	21.1	204.	78.9	170.	78.7	50.5	3.3	0.10	0.0	0.0	312,998	25,099	64,312
	1530302	Yes	19.1	327.	515.	855.	68.4	84.3	0.90	1.5	0.0	0.0	312,998	25,099	64,312
	1530807	Yes	34.6	239.	65.3	404.	40.5	61.9	0.60	2.5	0.0	0.0	312,998	25,099	64,312
	1531607	Yes	37.0	290.	5940.	51200.	105.	100.	22.	11	12 5	27.5	173,719	13,931	35,694
	1531706	Yes	20.3	159.	547.	180.	23.4	28.4	0.00	1.3	0.0	0.0	312,998	25,099	64,312
	1540202	Yes	7.52	149.	227. *	1540. *	15.9	14.5	0.00	0.70	0.0	0.0	173,719	13,931	35,694
	1540400	Yes	32.4	159.	28.1	87.3	49.9	31.7	0.60	0.20	0.0	0 0	312,998	25,099	64,312
	1540806	Yes	44.0	175.	227. *	1540. *	30.1	32.5	0 70	0.30	0.0	0 0	312,998	25,099	64,312
	1541200	Yes	10.6	187.	227. *	1540. *	17.1	26.0	0.70	0.70	0.0	0 0	173,719	13,931	35,694
	1741701	Yes	152.	141.	227. *	1540. *	54.7	60 8	1.0	0 80	0.0	0 0	243,025	19,488	49,934
	1741800	Yes	31.9	143.	227. *	1540 *	95.7	85.3	2.5	0.90	9.5	0 0	451,561	36,211	92,782
	1743103	Yes	3.79	29.6	0.20	1540. *	28.6	23.7	1.0	3.3	0.0	0.0	451,561	36,211	92,782
	2040301	Yes	16.4	124.	36.3	472	14.8	20.6	0.60	3 6	0.0	0.0	451,561	36,211	92,782
	2122000	Yes	85.5	395.	155.	494.	355	685.	1.4	0.60	0.0	0.0	291,351	23,363	59,864

Table C-7. Estimated Environmental Lead Levels in the 1997 Housing Stock, As Determined from National Survey Units (Continued)

Year Built	National Survey ID	LBP Present?	Floor Dust-Lead Loading (ug/ft2)	Floor Dust-Lead Conc. (ug/g)	Window Sill Dust-Lead Loading (ug/ft2)	Window Sill Dust-Lead Conc. (ug/g)	Soil-Lead Conc. (ug/g)	Dripline/Entry Soil-Lead Conc. (ug/g)	Obs. Max. Interior XRF (mg/cm2)	Obs. Max. Exterior XRF (mg/cm2)	Damaged Interior LBP (ft2)	Damaged Exterior LBP (ft2)	1997 Weight	# Children 12-35 mo.	# Children 12-71 mo.
1960-1979 (cont.)	2130706	Yes	27.2	127	17.0	149.	13.7	15.8	1.5	1.3	57.3	0.0	173,719	13,931	35,694
	2131902	Yes	8.19	76.4	77.1	291.	21.1	21.4	0.60	1.6	0.0	0.6	312,998	25,099	64,312
	2141604	Yes	29.1	87.0	7.12	1540. *	39.2	58.9	1 1	0.60	0.0	0.0	173,719	13,931	35,694
	2151207	Yes	30.3	327.	53.4	59.4	17 5	27.5	1.2	0.50	0.0	0.0	312,998	25,099	64,312
	2211308	Yes	14.6	89.6	603.	879.	20.4	33.0	0.70	1.3	0.0	8.0	316,764	25,401	65,085
	2230506	Yes	8.73	77.6	19.3	562.	6.11	5.84	0.90	--	0.0	0.0	316,764	25,401	65,085
	2351500	Yes	16.4	136.	270.	13000.	115.	141.	1.2	0.10	1.1	0.0	243,025	19,488	49,934
	2352201	Yes	12.6	180.	227. *	1540. *	42.5	35.3	1.1	0.10	0.0	0.0	243,025	19,488	49,934
	2430403	Yes	16.7	480.	6.62	10.7	69.7	97.8	0.60	3.4	0.0	72.4	451,561	36,211	92,782
	2431807	Yes	22.1	215.	11.3	131.	41.1	57.9	0.90	5.1	0.0	0.0	451,561	36,211	92,782
	2452605	Yes	15.4	320.	227. *	1540. *	121.	119.	1.0	0.60	0.0	0.0	451,561	36,211	92,782
	2520609	Yes	28.7	818.	0.54	1540. *	15.7	12.4	0.60	0.50	0.0	0.0	116,364	9,331	23,909
	2521102	Yes	17.0	117.	208.	200.	26.8	34.7	0.60	1.0	0.0	0.0	316,764	25,401	65,085
	2531804	Yes	4.07	59.8	0.97	1540. *	66.4	82.9	1.2	0.50	0.0	0.0	316,764	25,401	65,085
	2541506	Yes	124.	2200.	380.	1300.	45.2	71.7	4.6	0.50	12.8	0.0	116,364	9,331	23,909
	2620508	Yes	6.78	142.	227. *	1540. *	49.5	49.5	0.40	0.60	0.0	0.0	126,372	10,134	25,966
	2621704	Yes	15.5	191.	2.93	103.	53.0	83.9 *	0.40	8.8	0.0	0.0	126,372	10,134	25,966
	2622603	Yes	4.15	2.11	5.89	55.5	54.6	59.8	0.50	1.1	0.0	0.0	291,351	23,363	59,864
	2623007	Yes	3.69	141.	3.53	105.	26.0	28.2	0.60	0.60	0.0	0.0	126,372	10,134	25,966
	2650208	Yes	8.85	94.4	24.9	92.8	52.7	83.9	0.50	3.0	0.0	6.0	116,364	9,331	23,909
	2711109	Yes	24.3	128.	51.2	171.	32.0	21.2	0.70	0.80	0.0	0.0	316,764	25,401	65,085
	2751402	Yes	398.	54300.	28.8	89.6	27.3	27.3	0.30	0.60	0.0	0.0	291,351	23,363	59,864
	2810307	Yes	9.82	146.	227. *	1540. *	23.2	29.1	0.50	0.00	0.0	0.0	291,351	23,363	59,864
	2812105	Yes	9.68	141.	227. *	1540. *	91.3	126.	1.2	1.5	0.0	0.0	291,351	23,363	59,864
	2830602	Yes	19.5	170.	20.0	519.	32.1	33.0	0.60	1.5	0.0	0.0	116,364	9,331	23,909
	2832004	Yes	19.0	287	0.72	1540. *	20.8	18.5	0.60	0.60	0.0	0.0	116,364	9,331	23,909
	2832103	Yes	5.11	94 4	227. *	1540. *	75.6	30.8	0.20	0.20	0.0	0.0	316,764	25,401	65,085
	2840106	Yes	26.6 *	786. *	227. *	1540. *	63.1 *	83.9 *	0.80	5.1	0.0	20.7	126,372	10,134	25,966
	2840205	Yes	26.6 *	786. *	227. *	1540. *	63.1 *	83.9 *	0.70	2.0	0.0	25.7	316,764	25,401	65,085
	2841401	Yes	8.94	59.9	234.	1190.	35.6	34.1	0.60	1.6	0.0	0.0	116,364	9,331	23,909
	2940401	Yes	4.13	66.4	2.76	1540. *	27.2	26.6	1.2	--	0.0	--	658,726	52,823	135,348
	3051000	Yes	5.99	152.	227. *	1540. *	31.1	48.1	0.70	0.60	0.0	0.0	312,998	25,099	64,312
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													34,984,547	2,805,411	7,188,275
>1979	0130708	No	10.6	88.5	46.9	203.	29.7	31.5	0.60	0.60	0.0	0.0	889,038	71,292	182,671
	0131003	No	19.4	110.	13.6	170.	5.35	7.87	0.60	0.00	0.0	0.0	889,038	71,292	182,671
	0150201	No	46.9	68.8	20.4	16.6	6.16	9.49	0.60	0.50	0.0	0.0	889,038	71,292	182,671
	0330308	No	8.41	54.7	3.46	48.1	61.6	105.	0.60	0.60	0.0	0.0	889,038	71,292	182,671
	0350306	No	7.98	116.	7.17	261.	14.2	24.7	--	--	0.0	0.0	889,038	71,292	182,671
	0420901	No	28.9	20.2	1820.	287.	21.0	27.6	0.40	0.60	0.0	0.0	889,038	71,292	182,671
	0430108	No	13.2	68.8	21.9	172.	21.3	37.3	0.30	0.60	0.0	0.0	889,038	71,292	182,671
	0440305	No	42.1	245.	5.98	101.	97.4	144.	0.50	0.60	0.0	0.0	889,038	71,292	182,671
	0440602	No	18.1	144.	12.0	154.	79.3	128.	--	--	0.0	0 0	889,038	71,292	182,671
	0541201	No	5.85	22.2	6.21	562.	17.9	28.9	0.60	0.60	0.0	0.0	889,038	71,292	182,671
	0940700	No	5.63	48.2	101. *	503. *	7.23	7.52	0.30	0.30	0.0	0.0	889,038	71,292	182,671
	0940809	No	18.2	458.	2.15	533.	17.7	20.3	0.30	0.30	0.0	0.0	889,038	71,292	182,671
	1020205	No	7.88	167.	25.6	406.	49.2	70.0	0.30	0.50	0.0	0.0	889,038	71,292	182,671
	1020502	No	9.89	161.	26.4	1250.	58.3	90.8	0.30	--	0.0	0.0	889,038	71,292	182,671
	1021005	No	5.64	198.	8.70	503. *	25.5	35.0	0.50	0.30	0.0	0.0	889,038	71,292	182,671
	1040500	No	11.7	210.	17.1	156.	24.5	21.3	0.40	--	0.0	0.0	889,038	71,292	182,671
	1323609	No	5.69	108.	101. *	503. *	20.4	35.5	0.60	--	0.0	--	889,038	71,292	182,671
	1441302	No	4.17	92.6	0.05	503. *	13.0	11.0	0.60	0.50	0.0	0.0	889,038	71,292	182,671
	2220507	No	18.7	123.	101. *	503. *	14.1	19.9	0 60	0.60	0.0	0.0	889,038	71,292	182,671
	2230209	No	6.10	70.4	7.94	124.	5.58	5.61	0.60	0.60	0 0	0 0	889,038	71,292	182,671
	2511806	No	6.20	52.9	1.81	26.0	11.6	9.94	0 60	0.50	0.0	0 0	889,038	71,292	182,671

Table C-7. Estimated Environmental Lead Levels in the 1997 Housing Stock, As Determined from National Survey Units (Continued)

Year Built	National Survey ID	LBP Present?	Floor Dust-Lead Loading (ug/ft2)	Floor Dust-Lead Conc. (ug/g)	Window Sill Dust-Lead Loading (ug/ft2)	Window Sill Dust-Lead Conc. (ug/g)	Soil-Lead Conc. (ug/g)	Dripline/Entry Soil-Lead Conc. (ug/g)	Obs. Max. Interior XRF (mg/cm2)	Obs. Max. Exterior XRF (mg/cm2)	Damaged Interior LBP (ft2)	Damaged Exterior LBP (ft2)	1997 Weight	# Children 12-35 mo.	# Children 12-71 mo.
>1979	2521201	No	39.9	182.	180.	4930.	73.4	67 4	0.60	0.10	0.0	0.0	889,038	71,292	182,671
	2551000	No	4.28	52.8	4.10	64.3	22.6	12.7	0.60	0.50	0.0	0.0	889,038	71,292	182,671
	2552107	No	4.53	39.6	1.18	77.0	27.2	35.9	0.60	0.50	0.0	0.0	889,038	71,292	182,671
	2822005	No	8.03	66.3	176.	895.	82.5	123.	0.60	0.00	0.0	0.0	889,038	71,292	182,671
	2831006	No	3.67	34.5	0.31	503. *	21.1	14.5	0.60	0.60	0.0	0.0	889,038	71,292	182,671
	2831709	No	9.88	65.1	11.3	134.	40.8	30.7	0.60	0.60	0.0	0.0	889,038	71,292	182,671
	3050101	No	11.8	487.	101. *	503. *	6.68	10.5	0.60	0.60	0.0	0.0	889,038	71,292	182,671
													24,893,064	1,996,175	5,114,778
										TOTALS ACROSS ALL UNITS:			99,271,901	7,960,614	20,397,397

* As no data for this parameter existed in the National Survey database for the given housing unit, this value is the average of the values across all units in the same year-built category and having the same value for the LBP indicator that had reported data. The average is weighted using the 1997 weights.

Note: Dust-lead loadings are area-weighted arithmetic averages for the unit, with the loadings converted from Blue Nozzle vacuum loadings to wipe loadings (see Chapter 4). Dust-lead concentrations are mass-weighted arithmetic averages of individual sample concentrations for the unit that have been adjusted for low tap weights (see Appendix Z). Two summaries of soil-lead concentration are presented: one represented a weighted arithmetic average for the unit, with remote sample results weighted twice that of entryway and dripline samples; and one an unweighted average of dripline and entryway sample results only.

APPENDIX D1

Assumptions and Scientific Evidence to Account for the Effect of Pica for Paint

APPENDIX D1

ASSUMPTIONS AND SCIENTIFIC EVIDENCE TO ACCOUNT FOR THE EFFECT OF PICA FOR PAINT

The scientific evidence on paint chip ingestion is scant and can be contradictory. It is well known that pica for paint and plaster is associated with lead poisoning [1]. However, survey data and blood-lead concentrations collected in the Rochester Lead-in-Dust Study [3] indicated that children whose parents responded that they have a tendency to eat paint chips had blood-lead levels only slightly more elevated, on average, than those who do not exhibit pica. The scientific evidence and assumptions required to estimate the percentage of children who exhibit pica for paint and their blood-lead levels are summarized in this section.

PERCENTAGE OF CHILDREN WHO INGEST PAINT CHIPS

In a study involving 2,402 children attending the Child Development Center of the University of Virginia, de la Burde and Reames [1] reported that 9% of mothers of children between eight months and seven years of age responded that their child exhibited pica for paint or plaster. The children in the University of Virginia study were generally from low income families and lived in substandard housing, where flaking paint or falling plaster were accessible. Use of this data in the risk assessment assumes that the homes in the de la Burde study represent the HUD National Survey homes where damaged lead-based paint is present. For the risk assessment, the incidence of paint pica is assumed to be 9% for children living in homes with damaged lead-based paint. Both children with recent paint chip ingestion and those who ingested paint chips at some time are included in the 9%.

For HUD National Survey homes where no damaged lead-based paint is present, the IEUBK model and EPI model, with the effect of pica set to zero, predicted values are used to estimate blood-lead concentrations for all children represented by the home. When damaged lead-based paint is present, the same predicted values are used to estimate blood-lead concentrations under each model for 91% of the children, who are assumed not to ingest paint chips. The modeling approaches differ for the remaining 9% of children, who are assumed to ingest paint chips. Because the EPI model incorporates the effect of pica for paint, EPI model predicted values are used to estimate blood-lead concentrations for children who ingest paint chips. The IEUBK model does not include a direct mechanism for estimating the effect of pica for paint. The assumptions utilized in the risk assessment, to account for the effect of paint pica under the IEUBK model, are described in the sections that follow.

Although the University of Virginia study was used to estimate the percentage of children who ingest paint chips, children in this study would have been exposed to lead from sources, such as automobile exhaust, no longer present in the environment. Thus their blood-lead levels, if available, would not be comparable to those of present-day children. A current estimate of the effect of pica for paint may be derived from a study conducted by the University of Rochester [3]. In that study, 20 of 205 children (10%) were reported to exhibit pica for paint. The geometric mean blood lead for children who were reported to have ingested paint chips was 9.1 µg/dL, while the geometric mean blood lead for children who were reported to have never ingested paint chips was 6.1 µg/dL. This geometric mean blood-lead concentration for children who ingested paint chips at some time is assumed to be 3.0 µg/dL greater than the IEUBK model predicted geometric mean for children who do not ingest paint chips..

BLOOD-LEAD CONCENTRATION FOR CHILDREN WITH RECENT PAINT CHIP INGESTION (IEUBK MODEL)

When the IEUBK model is used, the blood-lead concentration is set equal to 63 µg/dL for children who have recently ingested paint chips. The basis underlying this blood-lead concentration and the percentage of children assumed to have recently ingested paint chips are discussed in this section.

Because the opportunity for pica arises only when paint chips are available, the effect of pica for paint will be applied only for HUD National Survey homes where damaged lead-based paint is present. Forty-one of the 284 homes in the HUD National Survey have damaged lead-based paint. These homes represent 15.2% of U.S. housing, based on 1997-projected weights used in the risk assessment.

Of the 924 children ages 1-2 years in the NHANES III Survey [4], just one child had a blood-lead level greater than 40 µg/dL. The percentage of children ages 1-2 with blood lead greater than 40 µg/dL, adjusted for sampling weights, is 0.03%.

It is assumed that blood-lead levels greater than 40 µg/dL are extremely rare in homes with no damaged lead-based paint. Thus the entire 0.03% of children nationwide with blood lead greater than 40 µg/dL are assumed to reside in the 15.2% of homes with damaged lead-based paint. Combining these figures, we estimate that 0.20% of children in homes with damaged lead-based paint have blood-lead levels greater than 40 µg/dL.

A St. Louis study [2] found that 13 of 90 (14.4%) children less than age 3 years with blood-lead levels greater than 40 µg/dL, or less than seven years with blood lead levels greater than 50 µg/dL, had radiographic evidence of recent paint chip ingestion. This information, combined with the preceding estimate, leads us to conclude that 0.03% of children in homes with damaged lead-based paint have blood lead greater than 40 µg/dL due to recent paint chip ingestion. Table D1-1 shows step by step the methodology for computing the percentage of children living in homes with damaged lead-based paint who have blood-lead levels greater than 40 µg/dL and have recently ingested paint chips. The underlying assumptions of this approach are that 1) blood-lead concentrations are greater than equal to 40 for children who have recently ingested paint chips containing lead and 2) only children who reside in homes with damaged lead based paint can ingest paint chips containing lead. The 13 children in the St. Louis study, who were confirmed to have ingested paint chips, had a mean blood-lead level of 63 µg/dL. The blood lead levels of children with recent pica (0.03% of children in homes with damaged lead-based paint) will be mapped to 63 µg/dL.

BLOOD-LEAD CONCENTRATION FOR CHILDREN WHO INGESTED PAINT CHIPS AT SOME TIME (IEUBK)

For HUD National Survey homes with damaged lead-based paint, 9% of the children represented by those homes are assumed to ingest paint chips, with 0.03% of children assumed to have recent paint chip ingestion, as described above. The remaining 8.7% of children are assumed to have ingested paint chips at some time, but not recently. The geometric mean blood-lead concentration for the 8.7% of children in homes with damaged lead-based paint, who have ingested paint chips at some time, is estimated to be 3 μg/dL greater than the IEUBK predicted value for children who do not eat paint chips. The basis for this adjustment is presented in this section.

Table D1-1. Calculation of Percentage of Children Who Have Recently Ingested Paint Chips.

Variable Name	Variable Definition	Method of Calculation	Value
PC_EAT	Percentage of children with blood lead concentration ≥ 40 μg/dL, living in homes with damaged lead-based paint, who have recently ingested paint chips containing lead.	(PbB ≥ 40 μg/dL| Damaged LBP) * (PC_EAT | PbB ≥ 40 μg/dL)	.197% x .144 = .028%
(PbB ≥ 40 μg/dL| Damaged LBP)	Percentage of children with blood-lead concentration ≥ 40 μg/dL, living in homes with damaged lead based paint.	(PbB ≥ 40 μg/dL) / (Damaged LBP)	0.03% / 0.152 = 0.197%
Damaged LBP	Percent of US housing units with damaged lead based paint.	Percentage of housing units with damaged lead-based paint, estimated in the HUD National Survey.	15.2%
PbB ≥ 40 μg/dL	Percentage of children aged 1-2 with blood-lead concentration ≥ 40 μg/dL.	Taken from NHANES III for children 1-2 years of age.	0.03%
(PC_EAT | PbB ≥ 40 μg/dL)	Percentage of children with blood-lead concentration ≥ 40 μg/dL who have recently ingested paint chips.	Taken from McElvaine's St. Louis study.	13/90 = 14.4%

APPENDIX D2

Results of Three Published Meta-Analyses on the Relationship Between IQ Point Loss and Childhood Blood-Lead Levels

APPENDIX D2

RESULTS OF THREE PUBLISHED META-ANALYSES ON THE RELATIONSHIP BETWEEN IQ POINT LOSS AND CHILDHOOD BLOOD-LEAD LEVELS

INTRODUCTION

The association between blood-lead levels and low IQ scores has been consistently reported in the scientific literature. The estimates of the dose-response relationship published in the literature have been combined via meta-analysis and reported in the three articles listed below. This appendix provides a summary of each article and a discussion of the key results, relative to the §403 Risk Assessment. The studies cited in these articles are summarized in Tables D2-1 and D2-2.

PRIMARY REFERENCES

Schwartz, J., 1993, Beyond LOEL's, p Values, and Vote Counting: Methods for Looking at the Shapes and Strengths of Associations, Neuro Toxicology 14(2-3):237-246.

Schwartz, J., 1994, Low-Level Lead Exposure and Children's IQ: A Meta-analysis and Search for a Threshold, Environmental Research 65:42-55.

Pocock, S. J., Smith, M., and Baghurst, P., 1994, Environmental Lead and Children's Intelligence: A Systematic Review of the Epidemiological Evidence, BMJ 309:1189-1197.

SUMMARY OF SCHWARTZ, J., 1993

This paper uses examples from the lead literature to illustrate statistical methods for determining the shape of dose-response relationships, including the possible existence of thresholds, and for assessing the strengths of associations within a study and for the literature as a whole. Of interest to the §403 Risk Assessment is a meta-analysis of the results from 7 studies that estimated a slope for the relationship between children's blood-lead levels and IQ scores. These studies used linear, or log-linear, regression models to fit the relationship between IQ scores and PbB in children. Up to 17 additional covariates were included in the models. The weighted mean regression slope over the 7 studies, weighted by the inverse of the estimated variance, was -0.245 (±0.039). That is, a 1 μg/dL increase in PbB was associated with a 0.245 decrease in IQ score.

SUMMARY OF SCHWARTZ, J., 1994

This article focuses on the relationship between blood lead and IQ scores, while the earlier paper by Schwartz used this relationship to illustrate a statistical method. The 1994 paper presents a meta-analysis of 7 studies, some of which had been cited in the earlier paper, that estimated a slope for the relationship between children's blood-lead levels and IQ scores. Three longitudinal and four cross-sectional studies were included in the analysis. The studies used linear, or log-linear, regression models to fit the relationship between IQ scores and PbB in children. Additional covariates were included in the models. The weighted mean regression slope over the 7 studies, weighted by the inverse of the estimated variance, was -0.257 (±0.041). That is, a 1 μg/dL increase in PbB was associated with a 0.257 decrease in IQ score.

The paper also presents a sensitivity analysis, summarized as follows:

Revised Analysis: resulting slope (± 1 standard error of the mean)
Study with Largest Effect Size Removed: -0.243 (±0.034)
Study with Most Significant Effect Removed: -0.252 (±0.058)
Add 8 Studies with No Effect (each with average weight of the 7 studies): association still significant, but slope reduced to about half of original estimate
Longitudinal vs. Cross-sectional: -0.296 (±0.125) vs. -0.269 (±0.051)
Disadvantaged vs. Nondisadvantaged Lifestyle: -0.185 (±0.092) vs. -0.289 (±0.050)
Add 2 Studies that Included Younger Children: -0.239 (±0.031)

The question of whether a threshold exists in the relationship between IQ scores and PbBs was examined through a meta-analysis that compared studies with different mean blood lead levels. In studies with mean blood lead levels of 15 μg/dL, the estimated slope was -0.323

(±0.126) compared to -0.232 (±0.040) for studies with means above 15 μg/dL. Thus, if anything, a trend toward a higher slope at lower concentrations was observed.

An alternative approach to the threshold issue examined the data from the Boston study (Bellinger, 1992) more thoroughly. The Boston study was chosen because it had the lowest mean PbB. For this analysis, separate regression models for IQ score and PbB were fit using the same set of covariates. A nonparametric smoothed curve (LOESS) was fit to the relationship between the two sets of residuals. Based on this analysis, the author concludes that the relationship between blood lead and IQ continues at PbB below 5 μg/dL in this study, i.e. no threshold was evident.

SUMMARY OF POCOCK, S. J., SMITH, M., AND BAGHURST, P., 1994

This paper presents a systematic review and meta-analysis of 26 epidemiological studies: 5 prospective studies, 14 cross-sectional studies of blood-lead, and 7 cross-sectional studies of tooth-lead. The three types of studies are considered in separate meta-analyses. The results are summarized follows:

Analysis: resulting slope (± 1 standard error of the mean)
Prospective Studies, PbB at Birth: 0.018 (±0.062)
Prospective Studies, PbB around 2 Years: -0.185 (±0.051)
Prospective Studies, Postnatal Mean PbB: -0.088 (±0.058)

Cross-Sectional Blood-Lead Studies: -0.253 (±0.041)
Cross-Sectional Blood-Lead Studies, Excluding Shanghai: -0.174 (±0.043)
Cross-Sectional Tooth-Lead Studies: -0.095 (±0.025)

Only the analysis of cross-sectional blood-lead studies had a statistically significant slope.

DISCUSSION

There was considerable overlap in the studies cited by the three meta-analysis papers. Two studies, Fulton et al. (1987) and Yule et al. (1981), were cited in all three papers, while several others were cited in two of the three papers. In addition, some studies cited by Schwartz (1993) or Pocock were used by Schwartz (1994) in the sensitivity analysis.

The three papers are directly comparable in that a common endpoint was used for all meta-analyses. For the meta-analysis endpoint, the regression coefficients and standard errors calculated by the original authors were used to estimate the change in IQ for an increase in blood-lead from 10 to 20 µg/dL. This was necessary, because some of the original authors worked with log-transformed data, while others did not transform the data. In most cases, the regression coefficients were adjusted for other covariates included in the model. The other covariates varied from study to study. For §403 decision-making, we have converted the estimated change in IQ back to a slope value for untransformed blood-lead data.

The Schwartz (1993) paper focuses on introducing the statistical methods to a non-technical audience. The Schwartz (1994) and Pocock papers focus on the relationship between IQ and blood-lead levels. The Schwartz (1994) paper includes a sensitivity analysis and search for threshold in the relationship. These topics are not covered in the Schwartz (1993) and Pocock papers. However, in the meta-analysis of prospective studies, the Pocock paper does include separate analyses for blood-lead measures at three ages. Also, one of the studies (Schroeder, 1985) used in the Schwartz (1993) paper included approximately 50 children under 30 months of age. This study and another (Ernhart, 1989) with younger children were included in the sensitivity analysis in Schwartz (1994).

The Pocock paper analyzes prospective and cross-sectional studies separately, while the Schwartz papers include both types of studies in the same meta-analysis. In the analysis of prospective studies, Pocock includes an analysis of how PbB at approximately age 2 affects IQ measured at school age. The slope for this analysis (-0.185) is less than the values (approximately -0.25) from Schwartz (1993 and 1994) and the Pocock cross-sectional studies analysis.

Both Schwartz (1994) and Pocock included "full scale IQ score" in school-age children as a selection criteria for studies used in the meta-analysis. Most of the studies cited used the Wechsler Intelligence Scale for Children - Revised (WISC-R) test. The 1993 Schwartz paper includes one study, Schroeder (1985), that uses the Bayley Scales of Infant Development (BSID), for children less than 30 months of age. The BSID score is not directly comparable with the IQ scores, as this test measures developmental endpoints as well as cognitive ability.

Table D2-1. Design Information for Studies that Investigate the Relationship Between Child's IQ and Blood-Lead Level

Primary References That Cite the Study	Study	Type of Study	Year(s) of Study	Location of Study Participants	Age of Study Participants		IQ Test Instrument	Sample Size	Other Study Information
					Blood Lead Measure	IQ Measure			
Schwartz (1993) Schwartz (1994)	Hatzakis et al. (1987)	Prospective	1985	Lavrion, Greece (a lead smelter city; soil lead levels of 1,300-18,000 ppm)		Primary school age	WISC-R	509	Study participants enrolled in one of four schools in the town in 1984-85.
Pocock	Hatzakis et al. (1989)	Prospective		Lavrion, Greece (a lead smelter city)		6-12 yrs	WISC-R	509	
Schwartz (1993)	Bellinger et al. (1991)	Prospective	Mid- to late-1980s	Boston, MA		Approx. 57 mos	GCI	150	Middle and upper-middle class families, not in inner-city or housing projects. Children born at Brigham and Women's Hospital from 1979-1981
Schwartz (1994) Pocock	Bellinger et al. (1992)	Prospective	1979(Aug.) - 1981(April)	Boston, MA	24 months	School Age	WISC-R	147	Middle class, advantaged
Schwartz (1994) Pocock	Baghurst et al. (1992)	Prospective	1979-1982	Port Pirie, Australia	0 - 3 yrs	7 yrs	WISC-R	494	Smelter town and rural surroundings, middle class families
Pocock	Ernhart et al. (1989)	Prospective		Cleveland, OH	at 2yrs	5 yrs	WPPSI	212	Inner city, disadvantaged, 50% of mothers alcoholic
Pocock	Cooney et al. (1991)	Prospective	1983-1990	Sidney, Australia	1 and 2 yrs	7 yrs	WISC-R	175	Mixed urban
Schwartz (1993)	Schroeder et al. (1985)	Prospective	1977-1978	Wake County, NC		10 mos - 6.5 yrs (half < 30 mos)	BSID (<30 mos) SBIS (≥ 30 mos)	104	Low income families
Schwartz (1993) Schwartz (1994)	Hawk et al. (1986)	Replication of Schroeder Study		Lenoir & New Hanover counties, NC		3-7 yrs	SBIS	75	Black study participants from low income and SES families, at high risk of exposure to deteriorated LBP
Schwartz (1994) Pocock	Dietrich et al. (1993)	Prospective		Cincinnati, OH	0 - 3 yrs	Approx. 6.5 yrs	WISC-R	231	Inner city, black, disadvantaged

Table D2-1. Design Information for Studies that Investigate the Relationship Between Child's IQ and Blood-Lead Level (Continued)

Primary References That Cite the Study	Study	Type of Study	Year(s) of Study	Location of Study Participants	Age of Study Participants: Blood Lead Measure	Age of Study Participants: IQ Measure	IQ Test Instrument	Sample Size	Other Study Information
Schwartz (1993) Schwartz (1994) Pocock	Yule et al. (1981)	Pilot Study	Summer 1980 (PbB taken 9-12 months earlier)	Outer London, England		6-12 yrs	WISC-R	166	Results for younger children are reported elsewhere.
Schwartz (1993) Pocock	Lansdown et al. (1986)	Replication of Yule Study		Within 1 km of a factory in London, England		6-12 yrs	WISC-R	166	Mostly middle class families with homes near a main road
Pocock	Winneke et al (1990)	Multi-Center, Cross - Sectional Study		Bucharest		9.2 yrs (mean age)	WISC-Short Form	301	General population
				Budapest		8.5 yrs (mean age)	WISC-Short Form	254	General population
				Moden		7.8 yrs (mean age)	WISC-Short Form	216	Industrial city, lead industry
				Sofia		7.3 yrs (mean age)	WISC-Short Form	142	General population
				Dusseldorf		6.5 yrs (mean age)	WISC-Short Form	109	Industrial city, near smelter
				Dusseldorf		8.3 yrs (mean age)	WISC-Short Form	109	Industrial city, near smelter
Schwartz(1994) Pocock	Silva (1988)	Cross - Sectional	1972-1973	Dunedin, New Zealand		11 yrs (mean age)	WISC-R	579	Mixed urban and rural
Pocock	Harvey et al (1988)	Cross - Sectional	Late 1979-early1981	Birmingham, England		5.5 yrs (mean age)	WPPSI	177	Mixed, inner city
Pocock	Wang et al (1989)	Cross - Sectional		Shanghai, China		6-14 yrs	WISC-R	157	Near battery plant, rural control
Pocock	Winneke et al (1985)	Cross - Sectional		Nordenham, Germany		7 yrs	WISC-R	122	Smelter town, rural surroundings
Schwartz (1993) Schwartz (1994) Pocock	Fulton et al. (1987)	Cross - Sectional	1983-1985	Edinburgh, Scotland		6-9 yrs	BAS	501	Study participants enrolled in one of 18 primary schools Mixed Urban - previously hish water lead

Table D2-2. Summary of Results from Studies that Investigate the Relationship Between Child's IQ and Blood-Lead Level

Primary References That Cite the Study	Study	PbB of Study Participants[1] (µg/dL)		IQ of Study Participants[2]		Measure of Association Between IQ and Blood-Lead Levels[3]			
		Range	Summary Statistics	Endpoint Type	Range/Summary Statistics	Measure	P-Value	Covariates	Other Information
Schwartz (1993) Schwartz (1994)	Hatzakis et al. (1987)	7.4 - 63.9	AM = 23.7 STD = 9.2 10%ile = 13.9 50%ile = 21.5 90%ile = 36.0	WISC-R		-0.270 change in IQ per unit increase in PbB (-0.403, -0.137)	<0.001	17 potential confounders or IQ correlates[4] (called the "optimal" model)	Dose-response investigation showed no PbB effect on IQ when PbB < 25 µg/dL.
Pocock	Hatzakis et al. (1989)	7.4-63.9	AM=23.7 STD=9.2		AM=87.7 STD=14.8	-2.7 change in IQ for increase from 10-20 µg/dL in PbB	<0.001	Up to 24, including mother's IQ	Dose-reponse curve showed evidence of a threshold at the level of about 25 µg/dL PbB
Schwartz (1993)	Bellinger et al. (1991)	0.0 - 23.3	AM = 6.4 STD = 4.1 19% were >10µg/dL 4% were >15µg/dL	GCI	80-150 AM = 115.5 STD = 14.5	-2.28 change in IQ per unit increase in Log(PbB) (-6.0, 1.4) --- -0.250 change in IQ per unit increase in PbB from 5-15 µg/dL PbB	0.23	13 covariates[5]	Regression diagnostics were used to check the robustness of estimates. These results reflect only PbB data at age 57 months.
Schwartz (1994) Pocock	Bellinger et al (1992)		AM=6.5 STD=4.9	WISC-R	71-147 AM=119.1 STD=14.8	-5.8 change in IQ for increase from 10 to 20 µg/dL in PbB	0.007	HOME mother's IQ, 8 other covariates[6]	Slightly elevated blood lead levels around the age of 24 months are associated with intellectual and academic performance deficits at age 10 years.
Schwartz (1994) Pocock	Baghurst et al (1992)		AM=20	WISC-R	AM=104.7	-3.3 change in IQ for an increase from 10-20 µg/dL in PbB	0.04	HOME, mother's IQ, 11 others[9]	Found low-level exposure to lead during early childhood is inversely associated with neuropsychological development through first seven years of life.
Pocock	Ernhart et al (1989)		AM=16.7 STD=6.45	WPPSI	AM=87.5 STD=16.6	-1.1 change in IQ for an increase from 10-20 µg/dL in PbB	<0.01	HOME , mothers IQ, and 11 others[11]	
Pocock	Cooney et al (1991)		AM=14.2	WISC-R		0.39 change in IQ for an increase from 10-20 µg/dL in PbB		HOME ,mothers IQ, and 4 others[12]	

Table D2-2. Summary of Results from Studies that Investigate the Relationship Between Child's IQ and Blood-Lead Level (Continued)

Primary References That Cite the Study	Study	PbB of Study Participants[1] (µg/dL)		IQ of Study Participants[2]		Measure of Association Between IQ and Blood-Lead Levels[3]			
		Range	Summary Statistics	Endpoint Type	Range/Summary Statistics	Measure	P-Value	Covariates	Other Information
Schwartz (1993)	Schroeder et al. (1985)	6 - 58		BSID (<30 mo.) SBIS (≥30 mo.)	45-140	-0.199 change in IQ per unit increase in PbB	<0.01	7 covariates[6] plus interaction with PbB. Quadratic and cubic components of PbB also considered.	Unforced stepwise regression. SES was only other significant covariate.
Schwartz (1993) Schwartz (1994)	Hawk et al. (1986)	6.2 - 47.4	AM = 20.9 STD = 9.7	SBIS	59-118	-0.255 change in IQ per unit increase in PbB (-0.554, 0.043)	<0.05	Gender, HOME score, maternal IQ	
Schwartz (1994) Pocock	Dietrich et al (1993)		AM = 15.2 STD = 11.3	WISC-R	AM = 86.9 STD = 11.3	1.3 esimated loss in IQ for an increase from 10 to 20 µg/dL in PbB	<0.10	HOME score, maternal IQ, birth weight, birth length, child sex, cigarette consumption during pregnancy	Postnatal PbB concentrations were inversely associated with Full Scale IQ.
Schwartz (1993) Schwartz (1994) Pocock	Yule et al. (1981)	7 - 33	AM = 13.52 STD = 4.13 80% were >10µg/dL 4.8% were >20µg/dL	WISC-R	AM = 98.21 STD = 13.44	-8.08 change in IQ per unit increase in Log(PbB) (4.63) -0.560 change in IQ per unit increase in PbB from 10-20 µg/dL	0.084	Age, social class	Social class was considered a crude measure.
Schwartz (1993) Pocock	Lansdown et al. (1986)	7 - 24	AM = 12.75 STD = 3.07 77% were >10µg/dL 1.5% were >20µg/dL	WISC-R WISC-R	AM = 105.24 STD = 14.20	2.15 change in IQ per unit increase in Log(PbB) 0 149 change in IQ per unit increase in PbB from 10-20 µg/dL	0.63	Age, social class	N = 86 for regression analysis. Social class was also a significant factor.

Table D2-2. Summary of Results from Studies that Investigate the Relationship Between Child's IQ and Blood-Lead Level (Continued)

Primary References That Cite the Study	Study	PbB of Study Participants[1] (μg/dL)		IQ of Study Participants[2]		Measure of Association Between IQ and Blood-Lead Levels[3]			
		Range	Summary Statistics	Endpoint Type	Range/Summary Statistics	Measure	P-Value	Covariates	Other Information
Pocock	Winneke et al (1990) Bucharest		GM=18.9 STD=1.3	WISC-Short Form			<0.1	Gender, age, social class, mother's education	
	Winneke et al (1990) Budapest		GM=18.2 STD=1.7	WISC-Short Form			<0.1	Gender, age, social class	
	Winneke et al (1990) Moden		GM=11.0 STD=1.3	WISC-Short Form			<0.1	Gender, age, social class, mother's education	
	Winneke et al (1990) Sofia		GM=18.2 STD=1.6	WISC-Short Form			<0.1	Gender, age, social class, mother's education	
	Winneke et al (1990) Dusseldorf		GM=8.3 STD=1.4	WISC-Short Form	AM=116		<0.1	Gender, age, social class, mother's education	
	Winneke et al (1990) Dusseldorf		AM=7.4 STD=1.3	WISC-Short Form			<0.1	Gender, age, social class, mother's education	
Schwartz (1994) Pocock	Silva (1988)	4 - 50 μg/dL	AM=11.1 STD=4.91	WISC-R	AM=108.9 STD=15.12	Loss of 1.51 in IQ for an increase in PbB of 10-20μg/dL		None	
Pocock	Harvey et al (1988)	0.2-1.4 mol/L	AM=12.3 STD=0.2	WPPSI	AM=105.9 STD=10.6			None	No significant relationship was found between overall IQ and PbB

Table D2-2. Summary of Results from Studies that Investigate the Relationship Between Child's IQ and Blood-Lead Level (Continued)

Primary References That Cite the Study	Study	PbB of Study Participants[1] (μg/dL)		IQ of Study Participants[2]		Measure of Association Between IQ and Blood-Lead Levels[3]			
		Range	Summary Statistics	Endpoint Type	Range/Summary Statistics	Measure	P-Value	Covariates	Other Information
Pocock	Wang et al (1989)	4.5 - 52.8 μg/dL	AM=21.1 STD=10.11	WISC	AM=89	A decrease of IQ of 9 per 10μg/dL increase in PbB		Mother's education and 4 others [10]	Found a dose - effect relation between PbB and IQ even after confounding variables were controlled for by stepwise regression analysis
Pocock	Winneke et al (1985)	4.4 - 23.8 μg/dL	AM=8.2 STD=1.4	WISC-R	AM=120.2 STD=10.3		<0.1	Age, sex and hereditary background	
Schwartz (1993) Schwartz (1994) Pocock	Fulton et al. (1987)	3.3 - 34	GM = 11.5 1.2% were >25μg/dL	BASC	AM = 112 STD = 13.4	-3.70 change in IQ per unit increase in Log(PbB) (1.31) -0.256 change in IQ per unit increase in PbB from 10-20 μg/dL	0.003	13 covariates[7] + school attended ("optimal" regression model)	Adjusted R^2 = 45.5%

Notes for Table D2-2:

[1] "Range" indicates the observed range of PbB levels among the study participants. Among the summary statistics, AM = arithmetic mean; GM = geometric mean; STD = standard deviation; x%ile = x percentile of observed distribution.

[2] "Type" indicates the type of IQ endpoint measured in the study. WISC-R = Wechsler Intelligence Scale for Children - Revised (full-scale IQ measurement); GCI = McCarthy Scales of Children's Abilities: General Cognitive Index; BSID = Bayley Scales of Infant Development; SBIS = Stanford-Binet Intelligence Scale; BASC = British Ability Scales: Combined Score. Among the summary statistics, AM = arithmetic mean; STD = standard deviation.

[3] Results are the outcome of a regression analysis to predict IQ endpoint based on PbB level and other covariates. "Measure" is the estimated slope parameter indicating the change in IQ measurement associated with a unit change in the (possibly transformed) PbB level. If the PbB level is transformed, the change in IQ measurement over a given range of the untransformed PbB level is also given. When available, a 95% confidence interval associated with the slope estimate is given, or a standard error associated with the estimate. "P-value" is for the test that the slope parameter is equal to zero versus an alternative that it is not zero. "Adjusted covariates" indicates the number of covariates included in the regression model; these covariates are named if the number is small. "Other information" indicates specifics associated with the regression fit (e.g., method used, whether a log-transformation was taken on the PbB level prior to analysis, information on the covariates).

[4] Covariates include parental IQ, birth order, family size, father's age, parental education, alcoholic mother, age, bilingualism, birth weight, length of child's hospital stay after birth, walking age, history of CNS disease, history of head trauma, illness affecting sensory function, parent's divorce.

[5] Covariates include family social class, material IQ, preschool attendance, HOME total score, # hours per week of "out-of-home" care, # changes in family residence since birth, medication use in preceding month, # adults in household, gender, race, birth weight, material marital status, birth order.

[6] HOME score, maternal IQ, child's age, child's sex, SES of parents, type of IQ test, presence of father in home, number of siblings.

[7] Parent's vocabulary and matrices tests, child's interest score, age, father's qualifications, length of gestation, parental involvement with school score, class year, # days absent from school, sex, standardized height, car/telephone ownership, employment status of father.

[8] Child stress, maternal age, race, SES, sex, birth order, martial status, number of residence changes prior to age 57 months

[9] Sex, parents' level of education, maternal age at delivery, parents' smoking status, socio-economic status, quality of the home environment, birth weight, birth order, feeding method (breast feeding, bottle, or both), duration of breast - feeding, and whether the child's natural parents were living together

[10] Age, sex, father's education, father's occupation, father's daily smoking quantity

[11] Sex, race, birth weight, birth order, gestational age at birth, parental education, maternal variables like PPVT-R, AFI, MAST SCORE, AA/day in pregnancy, cigarettes per day, and use of marijuana and other drugs in pregnancy, medical problems and psychosocial problems.

[12] Gestational age, education of the mother, education and occupational status of the father.

APPENDIX E1

Generating Distribution of Blood-lead Concentrations Based on Model-predicted Geometric Mean and Geometric Standard Deviation

APPENDIX E1

GENERATING DISTRIBUTION OF BLOOD-LEAD CONCENTRATIONS BASED ON MODEL-PREDICTED GEOMETRIC MEAN AND GEOMETRIC STANDARD DEVIATION

Geometric mean blood-lead levels predicted for specific conditions are not sufficient to characterize the national distribution of children's blood-lead levels, nor are they sufficient to estimate the arithmetic average blood-lead level in the nation. This section discusses how the geometric mean blood-lead concentrations predicted at each housing condition were combined to characterize the national distribution of children's blood-lead levels for children aged 1-2.

First, as described above, either the EPI or the IEUBK model was used to predict the geometric mean blood-lead concentration for specific housing conditions defined by the demographic and environmental-lead variables. If blood-lead concentrations have a log-normal distribution, then the geometric mean represents the predicted median blood-lead concentration for the distribution of childhood blood-lead concentrations. Rather than lumping the population of children associated with each specific housing condition to a single blood-lead concentration represented by the predicted geometric mean they were allocated to seven blood-lead concentrations distributed about the predicted geometric mean. This approach allowed us to account for the variability in blood-lead concentrations that is expected to take place for children with similar environmental exposures.

We now present how the distribution of childhood blood-lead concentrations associated with each specific housing condition were allocated to the seven blood-lead concentrations. Blood-lead concentrations are usually assumed to have a log-normal distribution. Under this assumption, the distribution of blood-lead concentrations associated with each specific housing condition may be characterized by two numbers: the geometric mean and the geometric standard deviation. The geometric mean was taken to be that predicted by either the EPI or IEUBK model and the geometric standard deviation was set equal to 1.6. The default geometric standard deviation of blood-lead concentrations for children at similar environmental-lead levels for the IEUBK model is 1.6 (EPA, 1994c). Note that for the EPI model fitted to the Rochester data, the geometric standard deviation of observed blood-lead levels from the model was 1.63.

If blood-lead concentrations have a log-normal distribution with a geometric mean GM and geometric standard deviation 1.6, then the logarithms of the blood-lead concentrations have a normal distribution with mean M = log(GM) and standard deviation S = log(1.6) =0.47. The distribution of log blood-lead concentrations was partitioned into the seven intervals about the log of the geometric mean shown in Table E1-1. Figure E1-1 graphically illustrates the partitioning of the log blood-lead concentrations. The first row of the table represents the lower tail of the distribution, log blood-lead concentrations more than 2.5 standard deviations below the mean. The percentage of the distribution assigned to this interval is based on the area under a standard normal curve for x-values less than -2.5, 0.62%. The assigned log blood-lead concentration for this interval is the expected value of a standard normal random deviate lying in the interval $-\infty$ to -2.5. The assigned blood-lead concentration for this interval was obtained by exponentiation:

$$e^{M-2.82 \cdot S} = e^{M} * e^{-2.82 \cdot S} = GM/GSD^{2.82}.$$

If N children were associated with the specific housing condition then 0.62 percent of the N children were assigned a blood-lead concentration of $GM/GSD^{2.82}$. The remaining 99.38 percent of the N children were assigned to the other six blood-lead concentrations presented in Table E1-1 using the percentages given in second column of the table. A similar procedure was used to determine the log blood-lead concentration and relative frequency for each of the six remaining intervals. In this manner, the distribution of blood concentration of the N children were allocated to a distribution of blood-lead concentrations centered around the GM predicted by the EPI model with a GSD of 1.6.

Table E1-1. Allocation of Blood-Lead Distribution to Seven Blood-Lead Concentrations

Log Blood-Lead Concentrations			
Interval for Log Blood Lead[a]	Percentage of Distribution in Interval	Assigned Log Blood Lead for Interval	Assigned Blood Lead Concentration for Interval
[-∞, M-2.5*S]	0.0062	M - 2.82*S[b]	$GM/GSD^{2.82}$
[M-2.5*S, M-1.5*S]	0.0606	M - 1.85*S[c]	$GM/GSD^{1.85}$
[M-1.5*S, M-0.5*S]	0.2417	M - 0.92*S[d]	$GM/GSD^{0.92}$
[M-0.5*S, M+0.5*S]	0.3830	M[e]	GM
[M+0.5*S, M+1.5*S]	0.2417	M + 0.92*S[f]	$GM*GSD^{0.92}$
[M+1.5*S, M+2.5*S]	0.0606	M + 1.85*S[g]	$GM*GSD^{1.85}$
[M+2.5*S, ∞]	0.0062	M + 2.82*S[h]	$GM*GSD^{2.82}$

[a] Blood-lead concentrations were assumed to have a log-normal distribution with the geometric mean (GM) predicted by the EPI model and a geometric standard deviation (GSD) of 1.6. The default geometric standard deviation for the IEUBK model is 1.6. The distribution of log blood-lead concentrations was assumed to be normal; with mean M given by the log of GM and standard deviation S = log(GSD) = log(1.6).

[b] The expected value of a normal random deviate known to lie in the interval [-∞, -2.5] is -2.82.

[c] The expected value of a normal random deviate known to lie in the interval [-2.5,-1.5] is -1.85.

[d] The expected value of a normal random deviate known to lie in the interval [-1.5,-0.5] is -0.92.

[e] The expected value of a normal random deviate known to lie in the interval [-0.5, 0.5] is 0.00.

[f] The expected value of a normal random deviate known to lie in the interval [0.5, 1.5] is 0.92.

[g] The expected value of a normal random deviate known to lie in the interval [1.5, 2.5] is 1.85.

[h] The expected value of a normal random deviate known to lie in the interval [2.5, ∞] is 2.82.

The predicted distributions at each housing condition were then combined to generate a distribution of childhood blood-levels over all of the housing conditions present in the HUD National Survey.

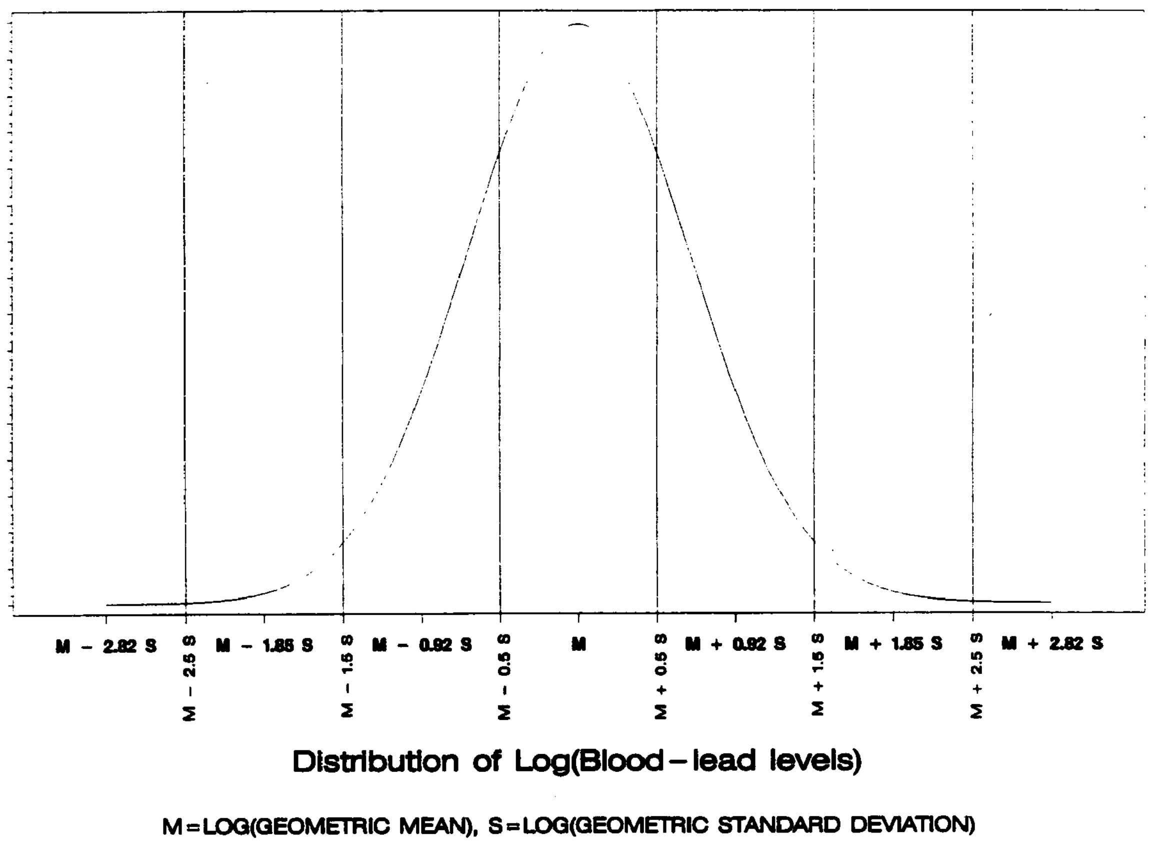

Figure E1-1. Distribution of Blood-Lead Levels About Geometric Mean on Log Scale.

APPENDIX E2

Methodology for Estimating Health Benefits Associated with Interventions Resulting from Proposed §403 Rules

APPENDIX E2

METHODOLOGY FOR ESTIMATING HEALTH BENEFITS ASSOCIATED WITH INTERVENTIONS RESULTING FROM PROPOSED §403 RULES

This appendix details the procedures used to compute the health risks associated with lead exposure to children. The approach to conducting risk characterization in the §403 rulemaking effort is focused around characterizing the national distribution of blood-lead (PbB) concentrations in children aged 1-2 years in 1997 under two scenarios:

- Immediately prior to initiating any intervention strategies under the proposed §403 rules.
- Immediately after performing the relevant intervention strategies on the nation's housing stock under the proposed §403 rules.

Once these two blood-lead concentration distributions are characterized, predicted health benefits associated with various options for the §403 standards are obtained by calculating a series of health endpoints (e.g., P[PbB > 10 µg/dL], P[IQ < 70]) and comparing the values of these endpoints between the two distributions.

Outline of the Methodology

This methodology characterizes the pre-§403 blood-lead distribution for children aged 1-2 years using reported information from NHANES III. A model-based procedure (either the EPI or IEUBK model) is used to characterize the distribution of blood-lead concentrations at both pre-§403 and post-§403, and the observed differences between the two distributions are identified. Then, a post-§403 distribution that is comparable to the pre-§403 NHANES III distribution is derived based on the differences between the two model-based estimates and the pre-§403 NHANES III distribution.

The methodology consists of the following five steps:

#1. Use blood-lead concentration data reported in the NHANES III to estimate the geometric mean (GM), the geometric standard deviation (GSD), and the 10th percentile associated with the baseline (i.e., pre-§403) distribution of blood-lead concentration for children aged 1-2 years (i.e., 12-35 months).

#2. Use the environmental-lead levels for HUD National Survey units as input to either the IEUBK or EPI model to estimate the geometric mean, the geometric standard deviation (GSD), and the 10th percentile associated with the baseline (i.e., pre-§403) distribution of blood-lead concentration for children aged 1-2 years (i.e., 12-35 months).

#3. Use adjusted (post-§403) environmental-lead levels for HUD National Survey units as input to the model used in Step #2 to estimate the geometric mean, the geometric standard deviation (GSD), and the 10th percentile associated with the post-§403 distribution of blood-lead concentration for children aged 1-2 years (i.e., 12-35 months).

#4. Estimate the geometric mean, 10th percentile, and GSD of a post-§403 blood-lead distribution that is derived from pre-§403 NHANES III distribution determined in Step #1 and the changes in the blood-lead distributions estimated in Steps #2 and #3.

#5. Calculate values for the health endpoints of interest using information from the final post-§403 distribution in Step #4.

Details of the Revised Methodology

A key assumption in this methodology is that blood-lead concentrations are assumed to be lognormally distributed, regardless of whether they represent pre- or post-§403 concentrations or whether the distribution is based on NHANES III data or is model-based. With this assumption and by estimating the geometric mean and GSD of the distribution, the entire distribution is characterized.

All five steps of the methodology are now discussed in detail. Following this discussion, applications of the revised methodology are illustrated for two intervention strategies.

#1. Use NHANES III to characterize the pre-§403 distribution.

The NHANES III database includes blood-lead concentration data for 924 children aged 12-35 months at the time of their survey interview. Each child in the survey was assigned a sampling weight corresponding to the number of children in the country being represented by the child. In Step #1, a weighted geometric mean and weighted geometric standard deviation of the blood-lead concentration data are calculated across these children, where the weights correspond to the sampling weights assigned at the time that the child was examined in the survey (variable WTPEXMH1 in the NHANES III database). Call these variables GM_1 and GSD_1, respectively. These values are calculated as follows:

$$GM_1 = 4.046\ \mu g/dL; \quad GSD_1 = 2.057\ \mu g/dL\ .$$

Thus, the pre-§403 blood-lead distribution characterized using NHANES III data is assumed to be lognormally-distributed with geometric mean = 4.046 µg/dL and geometric standard deviation = 2.057 µg/dL. The 10th percentile of this distribution is

$$P10_1 \ = \ GM_1\ (GSD_1)^{-1.282} = 4.04*(2.057)^{-1.282} = 1.60\ \mu g/dL\ ,$$

where -1.282 is the 10th percentile of a standard normal distribution.

#2, #3. <u>Obtain pre- and post-§403 distributions that are model-based.</u>

Because interventions under §403 have not yet occurred, thereby precluding post-§403 blood-lead concentrations from being directly measured, the blood-lead distribution resulting from the proposed §403 rules must be estimated. For this reason, this methodology characterizes pre- and post-§403 blood-lead distributions that are model-based (i.e., predicted blood-lead concentrations as a function of environmental-lead levels are obtained using either the IEUBK or EPI model).

This approach uses the information on environmental-lead levels in the HUD National Survey database as input to the model. The result of the modeling is a series of blood-lead concentrations and the number of 1997 children aged 1-2 years associated with each concentration. A weighted geometric mean and weighted geometric standard deviation of these concentrations are calculated, where the weights correspond to the numbers of children associated with each concentration. Call these variables GM_2 and GSD_2, respectively. Thus, the model-based pre-§403 blood-lead distribution is assumed to be lognormally-distributed with geometric mean GM_2 and geometric standard deviation GSD_2. The 10th percentile of this distribution is

$$P10_2 = GM_2 (GSD_2)^{-1.282}$$

where -1.282 is the 10th percentile of a standard normal distribution.

The same method used in Step #2 is also used to characterize a model-based post-§403 distribution (Step #3). Step #3 differs from Step #2 in that the environmental-lead levels from the HUD National Survey are initially adjusted to reflect the effects of intervention. This adjustment is documented in Table 5-3. Let GM_3 and GSD_3 be the weighted geometric mean and geometric standard deviation, respectively, of the predicted post-§403 blood-lead concentrations. Thus, the model-based post-§403 blood-lead distribution is assumed to be lognormally-distributed with geometric mean GM_3 and geometric standard deviation GSD_3. The 10th percentile of this distribution is

$$P10_3 = GM_3 (GSD_3)^{-1.282}$$

where -1.282 is the 10th percentile of a standard normal distribution.

#4. Derive a post-§403 distribution from NHANES III and Steps #2 and #3.

The three distributions calculated in Steps #1 through #3 are used to characterize a post-§403 blood-lead distribution that is directly comparable with the pre-§403 distribution determined in Step #1. This distribution is assumed to be lognormal with geometric mean GM_4, 10th percentile $P10_4$, and geometric standard deviation GSD_4 calculated by the formulas provided in Table E2-1. Note that while GSD_4 is expressed in (3) as a function of the 10th percentile $P10_4$, it could have been calculated from any of the distribution's percentiles, provided that the denominator in (3) is replaced by the same percentile for the standard normal distribution, multiplied by -1.

Table E2-1. Formulas to Calculate the Geometric Mean, 10th Percentile, and Geometric Standard Deviation for the Post-§403 Blood-Lead Distribution in Step #4

Statistic	Formula
GM_4 (geometric mean)	$GM_4 = GM_1 * (GM_3/GM_2)$ (1)
$P10_4$ (10th percentile)	$P10_4 = P10_1 * (P10_3/P10_1)$ (2)
GSD_4 (geometric S.D.)	$GSD_4 = \exp[(\ln(GM_4) - \ln(P10_4))/1.282]$ (3)

#5. Calculate post-§403 health and blood-lead effects.

The procedure for calculating health and blood-lead endpoints for the nation's children aged 1-2 years, based on the post-§403 blood-lead distribution obtained in Step #4, is as follows:

a. P[PbB > X], where X=10 µg/dL or 25 µg/dL

Because it is assumed that the post-§403 blood-lead concentration distribution is lognormally distributed, the probability of observing a blood-lead concentration greater than X is expressed as

$$P[PbB > X] = 1 - \Phi\left(\frac{\ln(X) - \ln(GM_4)}{\ln(GSD_4)}\right) \quad (4)$$

where $\Phi(z)$ is the probability of observing a value less than z under the standard normal distribution. Therefore, setting X=10 and X=25 in equation (4) will provide estimates of the probability of observing a post-§403 blood-lead level exceeding 10 µg/dL and 25 µg/dL, respectively. Note that these probabilities under the pre-§403 distribution can be calculated by replacing GM_4 and GSD_4 in equation (4) with GM_1 and GSD_1, respectively.

b. P[IQ < 70]

As indicated in Table E2-2, the estimated probability that a child will have an IQ score less than 70 given the child's blood-lead concentration (PbB) is expressed as a piecewise linear function of PbB. To estimate the probability that a child in the national population has an IQ score less than 70 following §403 interventions, the post-§403 blood-lead distribution derived in Step #4 is used with the information in Table E2-2.

Table E2-2. Formulas for Estimating the Probability of Observing IQ Score Less Than 70, Given a Child's Blood-Lead Concentration

Interval # (i)	Range of PbB (x_{i-1} < PbB ≤ x_i)	P[IQ < 70 $\mid$ PbB] (= $\alpha_i + \beta_i$*PbB)
1	0 < PbB ≤ 5.0	0.00360 + 0.000204*PbB
2	5.0 < PbB ≤ 7.5	0.00218 + 0.000488*PbB
3	7.5 < PbB ≤ 10.0	-0.00217 + 0.001068*PbB
4	10.0 < PbB ≤ 12.5	-0.00193 + 0.001044*PbB
5	12.5 < PbB ≤ 15.0	-0.00108 + 0.000976*PbB
6	15.0 < PbB ≤ 17.5	-0.00534 + 0.001260*PbB
7	17.5 < PbB ≤ 22.5	-0.00653 + 0.001328*PbB
8	22.5 < PbB ≤ 25.0	-0.01112 + 0.001532*PbB
9	25.0 < PbB < ∞	-0.00942 + 0.001464*PbB

Source: Wallsten, T.S., and Whitfield, R.G. "Assessing the Risks to Young Children of Three Effects Associated with Elevated Blood-lead Levels." *Report by Argonne National Laboratory.* Report No. ANL/AA-32. Sponsored by the U.S. EPA Office of Air Quality Planning and Standards. 1986.

Using the notation x_i, α_i, and β_i (i=1,...,9) introduced in the column headings in Table E2-2, and letting $LGM_4 = \ln(GM_4)$ and $LGSD_4 = \ln(GSD_4)$, the expected value of the probability of observing an IQ score less than 70, given the post-§403 blood-lead distribution derived in Step #4, is

$$P[PbB < 70] = \sum_{i=1}^{9} \alpha_i \cdot \left[\Phi\left(\frac{\ln(x_i) - LGM_4}{LGSD_4} \right) - \Phi\left(\frac{\ln(x_{i-1}) - LGM_4}{LGSD_4} \right) \right] + K \cdot \sum_{i=1}^{9} \beta_i \cdot \left[\Phi\left(\frac{\ln(x_i) - LGM_4 - (LGSD_4^2)}{LGSD_4} \right) - \Phi\left(\frac{\ln(x_{i-1}) - LGM_4 - (LGSD_4^2)}{LGSD_4} \right) \right] \tag{5}$$

where $K = \exp(LGM_4 + (LGSD_4)^2/2)$ and $\Phi(z)$ is the probability of observing a value less than z under the standard normal distribution. In calculating (5) use the following conventions: $\ln(0)=-\infty$, $\ln(\infty)=\infty$, $\Phi(-\infty)=0$, and $\Phi(\infty)=1$. Equation (5) is equivalent to

$$\sum_{i=1}^{9} \int_{x_{i-1}}^{x_i} (\alpha_i + \beta_i x)\, \phi(x)\, dx \tag{6}$$

where $\phi(x)$ is the probability density function of the lognormal distribution with parameters LGM_4 and $LGSD_4$. Note that the expected probability under the pre-§403 distribution can be calculated by replacing LGM_4 and $LGSD_4$ in equation (5) with $LGM_1 = \ln(GM_1)$ and $LGSD_1 = \ln(GSD_1)$, respectively.

c. P[IQ decrement > x] for x=1, 2, 3

In this risk characterization, it is assumed that each μg of lead per dL of blood corresponds to a 0.257 decline in IQ score (see Chapter 4 of the §403 Risk Assessment report). Therefore, an IQ decrement exceeding 1 is associated with blood-lead concentrations exceeding 1/0.257 = 3.9 μg/dL. Similarly, blood-lead concentrations exceeding 2/0.257 = 7.8 μg/dL are associated with an IQ decrement exceeding 2, and concentrations exceeding 3/0.257 = 11.7 μg/dL are associated with an IQ decrement exceeding 3. Therefore,

$$P[\text{IQ decrement} > 1] = P[\text{PbB} > 3.9\ \mu g/dL]$$

$$P[\text{IQ decrement} > 2] = P[\text{PbB} > 7.8\ \mu g/dL]$$

$$P[\text{IQ decrement} > 3] = P[\text{PbB} > 11.7\ \mu g/dL]$$

where the right-hand side of each of these equations is calculated using equation (4) with X=3.9, 7.8, or 11.7.

d. Average IQ points lost (and associated standard deviation)

The (arithmetic) average IQ points lost in the population of children aged 1-2 years is calculated using the properties of the lognormal distribution. If X corresponds to a child's blood-lead concentration and Y is the associated decline in IQ for the child due to the presence of the blood-lead, then it is assumed in this risk assessment that Y = 0.257*X. As X is assumed to be lognormally distributed, it can be shown that Y is also lognormally distributed. Furthermore, under the post-§403 blood-lead distribution in Step #4, estimates of the expected value of Y (average # IQ points lost) and the standard deviation of Y (S.D. of # IQ points lost) are as follows:

$$\text{Avg. \# IQ points lost} = 0.257 * GM_4 * \exp(\ln(GSD_4)^2/2) \qquad (7)$$

$$\text{S.D. of \# IQ points lost} = 0.257 * GM_4^2 * \sqrt{\exp(2 * \ln(GSD_4)^2) - \exp(\ln(GSD_4)^2)} \qquad (8)$$

Note that if 0.257 is excluded from the formulas in equations (7) and (8), the result would be the arithmetic average and standard deviation associated with the distribution of blood-lead concentrations.

Example of Applying the Methodology

The values of the geometric mean, geometric standard deviation, and 10th percentile for the pre-§403 blood-lead distributions determined from the NHANES III data (Step #1) and the

IEUBK model (Step #2) are provided in Table E2-3. Table E2-4 documents three §403 intervention strategies upon which the above methodology is applied. These strategies cover a wide range of expected benefits, from minimal benefit (low) to substantial benefit (severe). With these strategies are the values of GM_i, GSD_i, and $P10_i$ for i=3 and 4 (i.e., the post-§403 distributions generated in Steps #3 and #4).

The health endpoints calculated in Step #5 under the NHANES III pre-§403 distribution (Step #1) and the final post-§403 distributions associated with the three intervention strategies in Table 3 (Step #4) are presented in Table E2-5. These numbers are calculated from the entries in Tables E2-3 and E2-4, using the equations found in Step #5.

Table E2-3. Values of Geometric Mean, Geometric Standard Deviation, and 10th Percentile (µg/dL) for the Pre-§403 Blood Lead Distributions in Steps #1 and #2

NHANES III Pre-§403 Distribution (Step #1)			HUD/IEUBK Pre-§403 Distribution (Step #2)		
GM_1	GSD_1	$P10_1$	GM_2	GSD_2	$P10_2$
4.05	2.06	1.60	3.94	2.23	1.41

Table E2-4. Intervention Strategies and Values of Geometric Mean, Geometric Standard Deviation, and 10th Percentile (µg/dL) for the Pre-§403 Blood Lead Distributions in Steps #3 and #4

Intervention Strategy							HUD/IEUBK Post-Intervention Distribution (Step #3)			Final Post-Intrvention Distribution (Step #4)		
	Triggers for Dust-Cleaning											
Strategy Name	Floors	Window Sills	Trigger for Soil Cover	Trigger for Soil Abatement	Trigger for Paint Maint.	Trigger for Paint Abate.	GM_3	GSD_3	$P10_3$	GM_4	GSD_4	$P10_4$
Low	--	--	--	--	5 ft²	20 ft²	3.89	2.20	1.41	3.99	2.03	1.61
Mid	100 µg/ft²	500 µg/ft²	400 µg/g	3000 µg/g	5 ft²	20 ft²	3.51	1.90	1.54	3.60	1.75	1.76
Severe	25 µg/ft²	25 µg/ft²	50 µg/g	1500 µg/g	0 ft²	5 ft²	3.23	1.79	1.53	3.32	1.65	1.74

Table E2-5. Values of Health Endpoints Under the NHANES III Pre-§403 Distribution and Under the Post-§403 Distributions of Three Intervention Strategies

Health Endpoint	NHANES III Pre-§403	Post-§403[1]		
		Low Intervention Strategy	Mid Intervention Strategy	Severe Intervention Strategy
P[PbB > 10 μg/dL]	0.1048	0.0965	0.0336	0.0141
P[PbB > 25 μg/dL]	0.0058	0.0047	0.00026	0.00003
P[IQ < 70]	0.0057	0.0055	0.0048	0.0045
P[IQ decrement > 1]	0.5216	0.5142	0.4444	0.3756
P[IQ decrement > 2]	0.1822	0.1719	0.0836	0.0449
P[IQ decrement > 3]	0.0709	0.0641	0.0175	0.0062
Avg. IQ Point Loss	1.35	1.32	1.08	0.968
S.D. of IQ Point Loss	1.11	1.06	0.65	0.519

[1] See Table 4 for definitions of the three intervention strategies.

APPENDIX E3

Estimation of Primary Prevention Efficacy Using Model of Bone-Lead Mobilization

APPENDIX E-3

ESTIMATION OF PRIMARY PREVENTION EFFICACY USING MODEL OF BONE-LEAD MOBILIZATION

Though the scientific literature documents the effectiveness of a range of behavioral and environmental intervention strategies on their ability to reduce childhood lead exposure, efficacy is measured only among already exposed children *[1]*[5]. Specifically, declines in children's blood-lead concentration on the order of 25% as measured 6 to 12 months following a variety of intervention strategies were reported *[2-7]*. This secondary prevention intervention effectiveness is likely not representative of the effectiveness being sought from the promulgation of §403. The §403 standards for lead in dust, soil, and paint are mostly intended to prevent childhood lead exposure before it occurs and, therefore, their effectiveness will be assessed by measures of primary prevention efficacy.

Secondary prevention efficacy results are not necessarily representative of those expected from primary prevention because lead present in blood is a combination of current environmental exposure and internal sources of lead. A significant internal source of lead is bone tissue. After prolonged exposure to lead, bone tissue retains much more lead than the other body tissues *[8-12]*. Nordberg et al. *[13]* suggest that bone can become an internal source of lead during periods of reduced external exposure to lead; see also *[10,14-16]*. The reported declines in blood-lead concentration, therefore, may underestimate the primary prevention effectiveness of the associated intervention strategy.

Unfortunately, there is limited empirical evidence regarding the extent to which bone-lead stores are able to keep blood-lead levels elevated following an intervention, especially concerning children. One study *[17]* measured bone-lead levels in children before and after an intervention, but found no significant decline in the levels over a period of six weeks. Despite the lack of studies concerning children, Nordberg et al. *[13]* claim that "skeletal turnover is highest among children under 10 years of age." Several studies have been conducted to study bone-lead mobilization in adults *[14-15, 18-29]*. For example, Gulson et al. *[29]* show that 45% to 70% of

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[5] The references for this appendix in this draft report are provided at the end of this appendix. The format will be revised to agree with the rest of the document in the next revision.

lead in the blood of adult women comes from long-term tissue stores, primarily the bone tissue. A similar result was observed in another study on five adult subjects undergoing knee and hip replacement *[30]*.

If the contribution of mobilized bone-lead stores can be characterized, however, it would be possible to translate the documented secondary prevention results into estimated primary prevention results. An approach is presented here for estimating the efficacy of a primary prevention intervention given an observed effectiveness for a secondary prevention intervention. The approach is based on a bone-lead mobilization model developed to estimate the degree to which bone-lead stores could mask the full effectiveness of an intervention by mobilizing into the child's blood. This model is extensively discussed and its basis documented elsewhere *[31]*, though a summary is provided below.

A Model for Bone-Lead Mobilization

To evaluate the potential for continuing elevated blood-lead levels due to bone-lead mobilization, a two-compartment model (see Figure E3-1) was adopted for the transfer of lead between the blood and bone tissues within the body and elimination of lead from the body.

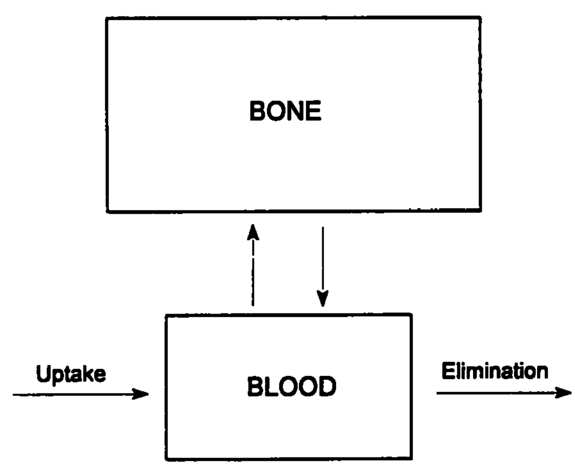

Figure E3-1. Two Compartment Model of Bone-Lead Mobilization.

In this model, lead is taken into the body (from the gastrointestinal tract and lungs) via the blood, transfers between the blood and bone tissue, and is eliminated from the body via the blood. It is assumed that the transfer of lead between the blood and bone tissues, and elimination of lead from the blood follows a first-order kinetic relationship.

While the adopted model is most certainly an oversimplification, model results will approximate those of other more complicated models involving additional tissue compartments for two reasons:

- While lead does mobilize from non-bone tissues following a decrease in environmental lead uptake, the effects are believed to be limited to a period of days or weeks due to the lower concentrations of lead amassed in these tissues, and
- While all lead elimination from the body does not occur via a direct pathway from the blood, the kinetic parameters used in the model properly include these other pathways (endogenous fecal and via other soft tissues) as if they were directly from the blood.

Based on the model illustrated in Figure E3-1, blood-lead concentrations (PbB) after intervention would follow the relationship illustrated in Figure E3-2. More specifically, immediately after intervention there would be an initial drop from the pre-§403 PbB level (PbB_{Pre}) to achieve an immediate post-§403 PbB level ($PbB_{ImmPost}$). $PbB_{ImmPost}$ represents the blood-lead concentration that can be supported by the amount of lead being transferred from the bone. After this initial drop, blood-lead concentrations would follow an exponential decline toward the long-term post-§403 PbB level ($PbB_{LongTerm}$). $PbB_{LongTerm}$ is the blood-lead level that can be supported by the post-§403 exposure level, with no additional lead from the bone. At any a particular length of time following the intervention, illustrated by the symbol "T" on the horizontal axis in Figure E3-2, a target post-§403 PbB level ($PbB_{Observed}$) will be observed. The original analysis using this model *[31]* estimated the maximum length of time (T) the bone-lead stores would be capable of keeping the blood-lead concentration above the targeted observed level ($PbB_{Observed}$) for a given value of $PbB_{LongTerm}$. For the purposes of the sensitivity analysis for §403, the maximum long-term effectiveness is estimated instead. As the long-term percent decline reflects the post-§403 PbB that can be support by the post-§403 exposure level, it is assumed this decline is equal to the primary prevention effectiveness of the intervention.

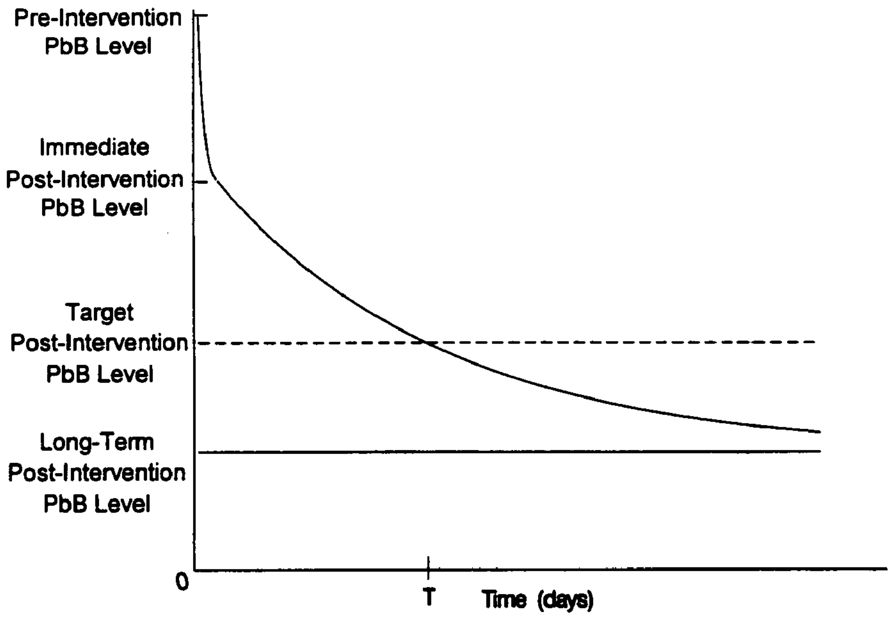

Figure E3-2. Blood-Lead Concentration Versus Time Following a Reduction in Lead Uptake

The child's blood-lead concentration at t days post-§403 is given by the equation

$$PbB = PbB_{LongTerm} + (PbB_{ImmPost} - PbB_{LongTerm}) \cdot \exp(-t \cdot KBONEBL_{Net}) \tag{1}$$

where $KBONEBL_{Net}$ is the net rate of lead flow from bone to blood to elimination. This rate is a function of the blood-lead level following the initial drop ($PbB_{ImmPost}$) as well as other kinetic parameters (e.g., the lead mass ratio of bone to blood and the elimination rate of lead from the blood) which can be estimated from existing scientific literature *[31]*. As portrayed in Figure 2, the blood-lead concentration follows an exponential decline toward $PbB_{LongTerm}$. Setting PbB in Equation (1) equal to $PbB_{Observed}$ and solving for the long-term percent decline in blood-lead concentration ($R_{LongTerm}$) results in the following equation:

$$R_{LongTerm} = \frac{PbB_{LongTerm}}{PbB_{Pre}} = \frac{R_{Observed} - R_{ImmPost} \cdot \exp(-t \cdot KBONEBL_{Net})}{1 - \exp(-t \cdot KBONEBL_{Net})} \tag{2}$$

where

$$R_{Observed} = \frac{PbB_{Observed}}{PbB_{Pre}} \quad \text{and} \quad R_{ImmPost} = \frac{PbB_{ImmPost}}{PbB_{Pre}} .$$

The maximum efficacy of an intervention, then, may be calculated given two parameters:

1. the observed percent decline ($R_{Observed}$) in an exposed child's blood-lead concentration following an intervention (i.e., the observed secondary prevention efficacy); and
2. the length of time (t) following the intervention when the decline was observed.

Note that this process estimates the maximum value of $R_{LongTerm}$ that might have yielded the inputed values of $PbB_{Observed}$ and t based on Equation (1). The specific value may lie between $R_{Observed}$ and $R_{LongTerm}$. The estimated primary prevention efficacy is a maximum in that $R_{ImmPost}$, and therefore $KBONEBL_{Net}$, cannot be estimated from available data *[31]*. It is necessary to estimate the maximum efficacy over a range of possible values for $R_{ImmPost}$.

Results of Modeling Bone-Lead Mobilization

To illustrate the efficacy of primary prevention, values of 25%, 50%, and 75% are considered for the observed secondary prevention efficacy and values of 6, 12, 18, and 24 months are considered for the lengths of time. Table E3-1 presents the maximum primary prevention efficacy for these scenarios for children 1 to 7 years of age. The standard error of the estimated efficacy—calculated by propagating, through the model, the standard errors of the underlying model parameters—is enclosed in parentheses.

As an example of the results in Table E3-1, note that if the observed effectiveness of a secondary intervention is assumed to be 25% (i.e., PbB decline to 75% percent of the pre-§403 level) at 6 months post-§403 for a 2 year old, then the implied effectiveness of primary prevention will be at most 47%. The scientific literature reports secondary prevention efficacy of approximately 25% declines in blood-lead concentration 12 months following dust abatements, lead-based paint abatements, elevated soil lead abatements, and intensive educational efforts *[1]*.

Depending upon the age of the child benefitting from the intervention, the results in Table E3-1 would suggest these interventions would prompt primary prevention efficacy of between 30% and 59% (column: "Length of Time, 12 Months"; row: "Observed Efficacy of Secondary Prevention, 25%").

Empty cells in Table E3-1 indicate that those scenarios cannot possibly occur based on Equation (1). For example, for a 7 year old, the impact of mobilized bone-lead stores would result in less than a 25% decline in blood-lead concentration at 6 months, even for a 100% effective intervention. Estimates of primary prevention efficacy under these "impossible" scenarios are not meaningful and are therefore not shown.

Consistent with the limited data available on bone-lead mobilization, the standard errors in Table E3-1 are quite large. By incorporating the 95% upper confidence bounds on the maximum primary prevention efficacy, the resulting bounded estimates are 1.2 to 1.9 times larger than the mean estimates reported in the table.

As described above, this analysis estimates the maximum efficacy of primary prevention interventions. Consideration was also given to obtaining the minimum efficacy. It was determined that the present model can provide a meaningful solution for the maximum case only, and that additional empirical data and extensive model enhancement are required to solve the minimum case. Only the maximum efficacy, therefore, is reported.

Table E3-1. Maximum Efficacy of Primary Prevention For Blood-Lead Levels (PbB) Observed at 25%, 50%, and 75% of Pre-§403 Levels at 6, 12, 18, and 24 Months

Observed Efficacy of Secondary Prevention[1]	Child's Age (years)	Length of Time[2] (months)			
		6	12	18	24
25%	1	0.39 (0.16)	0.30 (0.05)	0.28 (0.03)	0.27 (0.02)
	2	0.47 (0.18)	0.33 (0.08)	0.30 (0.04)	0.28 (0.03)
	3	0.56 (0.21)	0.36 (0.14)	0.31 (0.07)	0.29 (0.04)
	4	0.67 (0.25)	0.41 (0.19)	0.34 (0.10)	0.31 (0.06)
	5	0.79 (0.27)	0.47 (0.19)	0.37 (0.14)	0.33 (0.08)
	6	0.91 (0.32)	0.53 (0.21)	0.40 (0.19)	0.35 (0.12)
	7		0.59 (0.22)	0.44 (0.19)	0.37 (0.15)
50%	1	0.78 (0.32)	0.60 (0.09)	0.56 (0.05)	0.55 (0.04)
	2	0.94 (0.36)	0.65 (0.16)	0.59 (0.08)	0.56 (0.06)
	3		0.73 (0.27)	0.63 (0.13)	0.59 (0.08)
	4		0.83 (0.37)	0.68 (0.21)	0.62 (0.13)
	5		0.93 (0.38)	0.73 (0.29)	0.66 (0.17)
	6			0.81 (0.37)	0.70 (0.24)
	7			0.89 (0.37)	0.75 (0.31)
75%	1		0.90 (0.14)	0.84 (0.08)	0.82 (0.05)
	2		0.98 (0.25)	0.89 (0.13)	0.85 (0.09)
	3			0.94 (0.20)	0.88 (0.13)
	4				0.93 (0.19)
	5				0.98 (0.25)
	6				
	7				

Note: An empty cell means that the scenario is not possible according to model predictions.

[1] This is equivalent to the observed percent decline in an exposed child's blood lead levels at a specified time point following the intervention.

[2] This is equivalent to the length of time following the intervention when the decline was observed.

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