3.0 EXPOSURE ASSESSMENT

According to Chapter 3 of the §403 risk analysis report, the goal of the exposure assessment was to document the important sources of lead in the environment, to document the major pathways by which children are exposed to lead, to characterize the current (baseline) distribution of environmental-lead levels in the nation's housing stock, and to characterize the current distribution of average blood-lead concentration among the nation's children.

In particular, Chapter 3 introduced those data sources used to characterize environmental-lead levels in the nation's housing stock and presented summaries of household average lead levels in dust and soil as reported in these studies. The U.S. Department of Housing and Urban Development (HUD)'s National Survey of Lead-Based Paint in Housing ("HUD National Survey", Section 3.3.1.1 of the §403 risk analysis report) was selected as the data source for characterizing baseline environmental-lead levels in the nation's housing stock. Pre-intervention data from other selected studies, such as the Rochester Lead-in-Dust study and the ongoing Evaluation of HUD Lead-Based Paint Hazard Control Grant Program ("HUD Grantees") were also summarized in Section 3.3.1 of the §403 risk analysis report to provide supporting information on environmental-lead levels and to obtain information on the relationship between these levels and blood-lead concentration in children.

Since the §403 risk analysis report was published, additional data on environmental-lead levels in the nation's housing stock have been made available to EPA. These data include interim data from the National Survey of Lead and Allergens in Housing, and additional data from the HUD Grantees evaluation. In addition, updated data from the U.S. Census Bureau are available on numbers of young children associated with the various types of lead exposures found in the national housing stock. Some comments on the §403 proposed rule suggested that EPA use these additional data when available. Therefore, EPA has investigated these new data to document additional, more recent information on lead levels in the nation's housing stock and, when available, blood-lead levels in children exposed to these lead levels. For example, it was of interest to document more recent information on the distribution of lead levels in dust deposited on interior uncarpeted floors and window sills (i.e., the surfaces included in the proposed §403 standards), as well as on other types of surfaces (e.g., exterior surfaces, window troughs) to help evaluate their potential contribution to overall lead exposure at a residence. It was also of interest to characterize the national distribution of residential soil-lead levels and percentages of the housing stock whose soil-lead levels exceed specified thresholds. Therefore, this chapter provides additional information on lead exposure within the following sections:

- <u>Section 3.1</u>: Information on the National Survey of Lead and Allergens in Housing (NSLAH), a national survey begun in 1997 of lead levels in dust and soil in U.S. residential housing.

- <u>Section 3.2</u>: Comparison of the HUD National Survey data summaries for dust-lead loading and soil-lead concentration with summaries from other lead exposure studies, including interim data (for 706 households) from the NSLAH and pre-intervention data from the HUD Grantees evaluation that have been revised and augmented since the §403 risk analysis report was published).

- Section 3.3: Information on the prevalence of soil pica tendencies in young children and how such tendencies may occur over and above paint pica tendencies.

- Section 3.4: Updated information on numbers of children in the nation's housing stock, using interim data from the NSLAH.

- Section 3.5: Distribution of dust-lead levels on surfaces other than uncarpeted floors and window sills.

- Section 3.6: Revised summaries of pre-intervention blood-lead concentration based on updated data from the HUD Grantees evaluation.

3.1 THE NATIONAL SURVEY OF LEAD AND ALLERGENS IN HOUSING

The National Survey of Lead and Allergens in Housing (NSLAH) is a currently-ongoing survey sponsored by the U.S. Department of Housing and Urban Development (HUD) and the National Institute of Environmental Health Sciences (NIEHS) to assess the lead and allergen burden in that portion of the regularly-occupied U.S. housing stock that can potentially include young children among its residents. In particular, the survey is assessing lead burden by characterizing levels of lead-contaminated dust, lead-based paint, and lead-contaminated soil in housing and residential areas. HUD initiated this survey in 1997 and has been approved by the Office of Management and Budget to collect information through April 2001 for up to 1000 housing units.

The NSLAH provides a more recent nationally-representative characterization of environmental-lead levels in the U.S. housing stock than the 1989-1990 HUD National Survey and involves sampling in considerably more housing units. In addition, dust samples in the NSLAH are collected using wipe techniques (i.e., the technique assumed in the §403 rule) rather than the Blue Nozzle vacuum method used in the older survey, and the NSLAH did not restrict the sampling frame to only housing built prior to 1980. Therefore, the information collected in the NSLAH is very important for the §403 risk analysis to consider. However, the survey's scheduled completion date and the expected date for finalizing the survey's database do not fall within the time frame necessary to complete the risk analysis. Therefore, in order to utilize data from the NSLAH, the risk analysis could only consider data collected up to an interim point in the survey.

Interim NSLAH data for 706 housing units, collected from 1998-1999, were made available to the §403 risk analysis in August, 1999. This is a preliminary subset of the survey's final database that will represent an expected 825 housing units. To allow the data for these 706 units to be considered a nationally-representative characterization of lead levels in the housing stock, the interim database included sampling weights assigned to each unit based on its set of selection probabilities within each stage of the multi-staged sampling design and adjusted for nonresponse. These are interim sampling weights as they were generated by only considering the 706 units represented in the interim database. As the final sampling weights to be assigned at the end of the survey will reflect all housing units in the survey, and as there is a potential for additional correction of the existing data before the survey database is finalized, any analysis results based on the interim database of 706 housing units will likely differ from those to be based on the final database.

Table 3-1 contains key design specifications and approaches of the NSLAH, such as the types of rooms in which dust samples were collected and paint-lead levels were measured, the approach to taking soil samples, and laboratory analytical methods. Also included for comparison purposes in Table 3-1 are the design specifications and approaches taken in the older HUD National Survey. Note that in both surveys, dust samples were taken from the same types of surfaces (floors, window sills, and window troughs, also known as window wells) and analyzed under similar methods, and soil sampling occurred in the same areas of the yard. The method for analyzing soil samples was changed from ICP-AES in the older survey to FAA in the NSLAH due to the need to reduce detection limits associated with the method. Specific focus was made in the NSLAH to ensure that rooms in which children frequently reside are more dominantly represented in the sampling design.

Various types of data are being collected from housing units participating in the NSLAH. Household questionnaire data are collected at two time points: at the initial contact with the household during recruitment (to screen for eligibility and to perform an inventory on interior rooms) and during an interview with residents during the study (to obtain information on the building, household, and residents). Allergen dust levels are measured by collecting and analyzing vacuum dust samples. Lead levels in the unit are characterized through the following types of measures:

- <u>Dust samples</u>: Dust-lead loadings (µg/ft^2, assuming wipe collection techniques) for floors, window sills, and window troughs (also known as window wells)

- <u>Soil samples</u>: Soil-lead concentrations (µg/g) at entryway, dripline, and mid-yard

- <u>Lead on painted surfaces</u>: X-ray fluorescence (XRF) measurements (mg/cm^2)

To determine the numbers of housing units represented by the interim NSLAH sampling weights within certain housing categories and how these numbers compare with estimates made in the §403 risk analysis and by the U.S. Census Bureau, Tables 3-2 and 3-3 provide estimated numbers of occupied housing within specified housing age categories and the four Census regions, respectively. These totals are presented based on data from the NSLAH as well as from the following additional surveys/analyses:

Table 3-1. Differences in Approaches and Outcomes Between the HUD National Survey of Lead-Based Paint in Housing and the HUD National Survey of Lead and Allergens in Housing

Area	HUD National Survey of Lead-Based Paint in Housing[1]	HUD National Survey of Lead and Allergens in Housing[1]
Types/numbers of housing units selected for the survey and whose data were available to the §403 risk analysis	284 housing units selected from privately-owned, year-round occupied housing in the 48 conterminous states built prior to 1980 and having the potential for containing children. Institutional and group (i.e., housing units with at least 10 unrelated persons) housing were excluded from consideration for the survey.	Interim data for 706 housing units selected from year-round occupied housing in the 50 states and the District of Columbia having the potential for containing children were provided to EPA on August 13, 1999 (out of an expected 825 housing units in the survey). The sample represents 67 of the planned 75 primary sampling units (PSUs). Institutional and group (i.e., housing units with at least 10 unrelated persons) housing were excluded from consideration for the survey.
Breakdown of selected units by year built	Pre-1940: 27% 1940-1959: 31% 1960-1979: 42% Post-1979: 0%	Pre-1940: 18% 1940-1959: 23% 1960-1977: 31% Post-1977: 28% (Percentages are relative to the 640 units with housing age information from either the recruitment or resident questionnaire.)
Dates of environmental sampling	November 1989 to March 1990	August 1998 to February 1999 (according to dates specified in the survey's interim database -- sampling in a small number of units may have occurred earlier in 1998)

Table 3-1. (cont.)

Area	HUD National Survey of Lead-Based Paint in Housing[1]	HUD National Survey of Lead and Allergens in Housing[1]
Selecting rooms for environmental sampling	Telephone household interview provided information on rooms. One room was selected for sampling in each of the following strata: • <u>Wet room</u> -- rooms containing plumbing (e.g., kitchen, bathroom, laundry room, utility room) • <u>Dry room</u> -- all rooms not classified as wet rooms • <u>Main entryway</u> (floor dust samples only)	Room Inventory Form from the Screening/Recruiting Questionnaire was used to obtain information on rooms. One room was randomly selected for sampling in each of the following four strata: • <u>Kitchen</u> • <u>Common living area</u> (e.g., living room, den, family room) • <u>Bedroom</u> in which one or more children aged 17 years or younger regularly slept, or any regularly-occupied bedroom if no such children lived in the unit (occasionally, two such bedrooms were selected) • <u>Other random room</u> among the remaining rooms in the housing unit. (Note: Two rooms were randomly selected from this stratum if the stratum contained at least six rooms. Adult bedrooms were included if a child's bedroom was available for selection in the bedroom stratum.) In addition to the selected rooms, floor dust samples from the main entryway were collected.
Method to assigning sampling weights	Weights reflect the various stages of sampling and were designed to sum to the approximately 77 million pre-1980 homes then in the occupied housing stock. The weights were stratified to control for the number of housing units with children (13.9 million) and without children. Total of the sampling weights within a given census region equaled the estimated number of units with children under age 7 years in the census region.	Interim weights reflect the various stages of sampling and were designed to sum to the estimated 89 million housing units in the occupied housing stock that do not exclude children.
Method for taking dust samples for lead analysis	Blue Nozzle vacuum (a few wipe samples were also collected)	Wipes, collected in accordance with ASTM E1728-95, *Practice for the field determination of settled dust samples using wipe sampling methods for lead determination by atomic absorption spectrometry techniques.*
Number and location of floor-dust samples per room	One sample from each selected room (location not dictated in the protocol)	One sample from each selected room, generally taken from the largest open area.

Table 3-1. (cont.)

Area	HUD National Survey of Lead-Based Paint in Housing[1]	HUD National Survey of Lead and Allergens in Housing[1]
Window sill/trough dust sampling approach	A window was selected within each selected room according to some ranking scheme. Sampling was performed from both the sill and trough of the selected window until "enough" dust was collected or until the entire sill or trough was vacuumed.	Entire sill and trough sampled from a random window in the selected room.
Number and location of sill and trough dust samples per room	One sample from each of the sill and trough of the selected window in the selected wet room and dry room	One sample from the sill and one sample from the trough of the selected window in each selected room
Method of analyzing dust samples	GFAA (with SW-846 digestion method)	FAA (Digestion method: modification of SW-846 Method 3050 or ASTM ES 36-94 -- hot-plate digestions utilizing nitric/perchloric acid and H_2O_2) Method must be that used in proficiency testing within the Environmental Lead Laboratory Accreditation Program (ELLAP)
Soil sampling approach	One composite sample of 3 core samples (the latter two taken within 20 inches of the first), each taken at a depth of 10 cm, was collected at each of the following locations: entryway, drip-line, and remote area (i.e., an area halfway between the unit and its property boundary, or within 25 feet of the unit).	Samples were collected from bare soil when possible. If no bare soil existed, soil samples were collected from covered surfaces if possible. Two sides of the unit were selected for soil sampling: the side containing the major entryway (Wall 1) and a second, randomly-selected side (Wall 2). Samples were collected from the top 0.5 inches of soil at the following three locations: • Main entry – a single sample from Wall 1 • Foundation/drip-line – one sample from each of Walls 1 and 2, each sample being a composite of 3 core samples taken within 3 feet of the foundation • Mid-yard area – one sample from each of Walls 1 and 2, each sample being a composite of up to 4 core samples taken midway between the drip-line and the closer of the boundary line or another building on the property. Soil samples were collected in accordance with core sampling procedures based on ASTM E1727-95 (described in the HUD *Guidelines* and in EPA's *Residential Sampling for Lead: Protocols for Leaded Dust and Soil Sampling*)

Table 3-1. (cont.)

Area	HUD National Survey of Lead-Based Paint in Housing[1]	HUD National Survey of Lead and Allergens in Housing[1]
Method of analyzing soil samples	ICP-AES (with SW-846 digestion method)	ICP-AES Digestion method: modification of SW-846 Method 3050 or ASTM ES 36-94 (hot-plate digestions utilizing nitric acid and/or HCl/H_2O_2), or SW-846 Method 3051 (microwave nitric acid digestion) Method must be that used in proficiency testing within the Environmental Lead Laboratory Accreditation Program (ELLAP)
Handling dust-lead and soil-lead measurements below the detection limit	As log-transformed lead amounts are reported in the database, only positive measurements are represented. No indication is given as to when data may have been truncated due to being below detection limits.	The final results as reported by the instrument are recorded in the database (i.e., not-detected results are not censored), along with detection limits.
Method for taking paint-lead measurements	MAP-3 XRF instrument (single 60-second "spectrum reading" measurement using a 40 millicurie cobalt source). Measurements were adjusted to statistically correct for measurement bias.	XRF (Niton XL-309 running software version 5.1)
Approach to selecting <u>interior</u> painted components for paint-lead measurements	Painted surfaces were categorized into the following four strata: • Walls/ceilings/floors • Metal substrate • Non-metal substrate • Other surfaces Five painted components were selected randomly for testing in each of the selected wet and dry rooms, one from each stratum along with a fifth selected randomly from among all strata. In addition, up to two purposive measurements were taken from paint anywhere in the unit that may be suspected to contain lead.	A list of 25 possible interior components was developed and included: • All four major walls • Ceiling • Floor • Window system components • Doors and doorways • Trim • Porches All components present in a given room were tested.

Table 3-1. (cont.)

Area	HUD National Survey of Lead-Based Paint in Housing[1]	HUD National Survey of Lead and Allergens in Housing[1]
Approach to selecting exterior painted components for paint-lead measurements	Painted surfaces were categorized into the following four strata: • Wall (randomly-selected) • Metal substrate within the selected wall • Non-metal substrate within the selected wall • Other surfaces within the selected wall Five painted components were selected randomly for testing from the side of the unit containing the selected wall, one from each stratum along with a fifth selected randomly from among all strata. In addition, up to two purposive measurements were taken from paint anywhere on the exterior of the unit that may be suspected to contain lead.	A list of 25 possible exterior components was developed and included: • Siding • Window system components • Doors and doorways • Trim • Porches All components present on the sampled wall were tested.

[1] Information reflects only that part of the survey whose data and information were used in the §403 risk analysis.

Table 3-2. Estimated Number of Occupied Housing Units in the U.S. Housing Stock Within Year-Built Categories, According to Four Recent Surveys and/or Analyses

Year in Which the Unit Was Built	Number of Units in the National Housing Stock (and Percentage of Total Units), as Estimated by the ...				# Units Surveyed	
	1995 American Housing Survey[1]	§403 Risk Analysis[2]	1997 American Housing Survey[3]	National Survey of Lead and Allergens in Housing (NSLAH)[4]	1989-90 HUD National Survey	NSLAH (interim)
Prior to 1940	19,308,000 (20%)	19,676,000 (20%)	19,441,000 (20%)	14,412,000 (18%)	77	114
1940-1959	19,885,000 (20%)	19,718,000 (20%)	19,797,000 (20%)	16,886,000 (21%)	87	145
1960-1979 (1960-1977 for NSLAH)	35,300,000 (36%)	34,985,000 (35%)	34,884,000 (35%)	25,688,000 (32%)	120	201
After 1979 (After 1977 for NSLAH)	23,201,000 (24%)	24,893,000 (25%)	25,367,000 (25%)	24,076,000 (30%)	--	180
Not specified[5]	--	--	--	8,089,000	--	66
Total	97,693,000	99,272,000	99,487,000	89,151,000	284	706

[1] Estimates represent only year-round occupied housing in the 1995 national housing stock and were obtained from information within Table 1A-1 of "American Housing Survey for the United States in 1995" (Current Housing Reports H150/95RV, published by the Bureau of the Census and HUD's Office of Policy Development and Research). This national survey was conducted on about 55,000 surveyed units from August 1995 through February 1996. An updated report reflecting the 1997 American Housing Survey data has not yet been published.

[2] Estimates were obtained from Table 3-5 of the §403 risk analysis report. Estimates are based on data from the 1989-90 HUD National Survey of Lead-Based Paint in Housing, augmented by other Census information in order to represent the 1997 housing stock (see the §403 risk analysis report for details).

[3] Estimates were obtained from Table 2-1 of U.S. Census Bureau (1999). The estimates represent total year-round occupied units in the 1997 national housing stock.

[4] This survey, conducted from 1998-1999, characterized only occupied housing in which a young child could reside. Information in this table is based on an interim dataset for 706 surveyed housing units. Year-built information was determined from responses given in the survey's resident questionnaire. If no year-built information was available from the resident questionnaire, any year-built information provided from the recruitment questionnaire (when available) was used. Note differences in how year-built categories were defined in this survey. The specified percentages are relative to the total minus the number of units represented by surveyed units with no year-built information specified (i.e., 89,151,000 - 8,089,000 - 81,062,000).

[5] Total sampling weights for surveyed units where either no housing age information was provided, or responses of "Don't Know" or "Not Ascertained" were given, on both the resident and recruitment surveys.

Table 3-3. Estimated Number of Occupied Housing Units in the U.S. Housing Stock Within Each Census Region, According to Four Recent Surveys and/or Analyses

Census Region	Number of Units in the National Housing Stock (and Percentage of Total Units), as Estimated by the ...				# Units Surveyed	
	1995 American Housing Survey[1]	§403 Risk Analysis[2]	1997 American Housing Survey[3]	National Survey of Lead and Allergens in Housing (NSLAH)[4]	1989-90 HUD National Survey	NSLAH (interim)
Northeast	19,200,000 (20%)	15,878,000 (16%)	19,484,000 (20%)	14,977,000 (17%)	53	109
Midwest	23,662,000 (24%)	22,313,000 (22%)	23,951,000 (24%)	22,202,000 (25%)	69	150
South	34,236,000 (35%)	41,733,000 (42%)	34,808,000 (35%)	32,519,000 (36%)	116	265
West	20,596,000 (21%)	19,348,000 (19%)	21,245,000 (21%)	19,453,000 (22%)	46	182
Total	97,693,000	99,272,000	99,487,000	89,151,000	284	706

[1] Estimates represent only year-round occupied housing in the 1995 national housing stock and were obtained from information within Table 1A-1 of "American Housing Survey for the United States in 1995" (Current Housing Reports H150/95RV, published by the Bureau of the Census and HUD's Office of Policy Development and Research). This national survey was conducted on about 55,000 surveyed units from August 1995 through February 1996. An updated report reflecting the 1997 American Housing Survey data has not yet been published.

[2] Estimates were obtained from Table 3-5 of the §403 risk analysis report. Estimates are based on data from the 1989-90 HUD National Survey of Lead-Based Paint in Housing, augmented by other Census information in order to represent the 1997 housing stock (see the §403 risk analysis report for details).

[3] Estimates were obtained from Table 2-1 of U.S. Census Bureau (1999). The estimates represent total year-round occupied units in the 1997 national housing stock.

[4] This survey, conducted from 1998-1999, characterized only occupied housing in which a young child could reside. Information in this table is based on an interim dataset for 706 surveyed housing units.

- the 1995 American Housing Survey (i.e., the last survey in which estimates of these totals were published in documents issued by the Census Bureau)

- the §403 risk analysis (which characterized the 1997 housing stock by revising the sampling weights from the 1989-90 HUD National Survey)

- the 1997 American Housing Survey (based on information obtained from the HUD web-site)

As noted in these tables, the sum of the interim sampling weights in the NSLAH (89,151,000) is over ten million units lower than the corresponding sums from the §403 risk analysis and the 1997 American Housing Survey. It is possible that this difference is due to the NSLAH's exclusion of housing that forbids resident children (i.e., adult-only housing), while the §403 risk analysis and the 1997 American Housing Survey results reflect the entire regularly-occupied housing stock.

When reviewing the sum of sampling weights by housing age category (Table 3-2), the interim NSLAH data represent a slightly smaller percentage of pre-1940 housing compared to the other surveys. The housing age categories for the NSLAH differ slightly from the categories in which the other surveys are represented and what was used in the 1989-90 HUD National Survey. Approximately eight million housing units in the U.S. housing stock are represented by 66 units in the interim NSLAH dataset that do not have a housing age specified. The final two columns of Table 3-2 present numbers of surveyed units by housing age category in both HUD surveys.

The percentages of housing units within Census regions (Table 3-3) are similar between the interim NSLAH and the 1997 American Housing Survey except for the Northeast, where the percentage in the interim NSLAH was lower than in the 1997 American Housing Survey. Differences relative to the 1997 American Housing Survey were even greater for the §403 risk analysis, where the adjustments made to the sampling weights in the 1989-90 HUD National Survey to represent the 1997 housing stock did not take into account Census region.

Summaries of the interim NSLAH data and comparison to the 1989-90 HUD National Survey data summaries (cited in the §403 risk analysis report) are provided in the next section.

3.2 COMPARISON OF ENVIRONMENTAL-LEAD LEVELS IN THE HUD NATIONAL SURVEY WITH THOSE OF OTHER KEY STUDIES

As discussed in Sections 3.2 and 3.3 of the §403 risk analysis report, the risk analysis used data from the HUD National Survey to represent baseline (pre-§403) environmental-lead levels (paint, dust, soil) in the nation's housing stock. To help evaluate how accurate this representation may be and how environmental-lead levels may have changed since the HUD National Survey was conducted (1989-1990), the survey data were compared with data from other environmental field studies that were conducted more recently and that measured environmental-lead levels in a large number of housing units. This section also summarizes how housing selection, sample collection techniques, laboratory testing practices, and the distribution of environmental-lead levels reported in the HUD National Survey differ from those in these other studies.

The studies whose dust-lead and soil-lead data were used in the comparisons in this section included the ongoing National Survey of Lead and Allergens in Housing (NSLAH, introduced in Section 3.1 above), the Baltimore Repair & Maintenance (R&M) Study, the Rochester Lead-in-Dust Study, and the various portions of the ongoing HUD Grantees evaluation (design information and data for the latter three studies were summarized in Section 3.2.2 of the §403 risk analysis report). These studies were conducted since 1993 in locations within the United States where a specific point source of lead was not necessarily present. The latter three studies provided the §403 risk analysis with the most useful and available data on the relationship between environmental-lead levels (paint, dust, and soil) and childhood blood-lead concentration. In particular, dust samples in these studies were collected from floors and window sills using either a wipe technique or a method whose resulting dust-lead loadings could be converted to wipe-equivalent loadings using methods such as those documented in Section 4.3 of the §403 risk analysis report. Data summaries for the HUD Grantees evaluation were updated from the §403 risk analysis report summaries to reflect data collected through February, 1999.

The risk associated with elevated soil-lead concentrations and intervention practices designed to alleviate that risk are more frequently debated in the scientific literature than are the risk from and the intervention practices targeting elevated dust-lead loadings. As a result, this section supplements the comparison of the HUD National Survey's characterization of soil-lead concentrations to the interim NSLAH and the aforementioned three recent studies with the results of other relevant studies.

Boxplots were used in this section to summarize household average dust-lead and soil-lead levels graphically. A boxplot, also known as a box-whisker plot, portrays the distribution visually by using a box to represent data falling within the 25^{th} and 75^{th} percentiles and using different graphical symbols for the remaining data values according to their distance from the box. The following features are included within the boxplots presented in this section:

- A horizontal line within the box corresponds to the median.
- A dot within the box corresponds to the geometric mean.
- The bottom and top edges of the box correspond to the 25^{th} and 75^{th} percentiles, respectively.
- Central vertical lines ("whiskers") extend to 1.5 interquartile ranges (IQR, equal to the difference between the 75^{th} and 25^{th} percentiles on a log scale) of the box. However, if the data extend to less than 1.5 IQRs of the box, the whiskers extend only as far as the data exist.
- Open circles represent data values that exceed 1.5 IQRs but no more than 3 IQRs from the box.
- Asterisks represent data values that exceed 3.0 IQRs from the box.

The boxplots were plotted on a logarithmic scale to improve the readability of the data distributions, due to the tendency of the data to be skewed toward the lower end of these distributions. Selected information portrayed within the boxplots have also been included within tables of descriptive statistics presented throughout this section.

Dust-lead loading data comparisons are provided in Section 3.2.1, while soil-lead concentration data are addressed in Section 3.2.2.

3.2.1 Characterizing Dust-Lead Loadings on Floors and Window Sills

Household area-weighted average dust-lead loadings (assuming wipe techniques) as calculated in the §403 risk analysis were the basis for the comparisons made in this section. This average, calculated for each building component sampled for dust (i.e., floor, window sill), represented a single dust-lead measure for the component within a housing unit and was calculated by weighting each dust sample's result by the area that was sampled.

While the household average dust-lead loadings assumed wipe collection techniques, the dust collection device differed among the studies:

- HUD National Survey: Blue Nozzle vacuum
- Baltimore R&M study: BRM vacuum
- NSLAH, Rochester study, and the HUD Grantees evaluation: wipes.

To obtain wipe-equivalent dust-lead loadings for samples taken in the HUD National Survey and the Baltimore R&M study, the reported loadings were entered into the conversion equations presented in Sections 4.3.1 (Blue Nozzle vacuum to wipe) and 4.3.2 (BRM vacuum to wipe) of the §403 risk analysis report. Note that dust-lead loadings for samples collected by other collection methods in these studies were not included in determining the area-weighted averages.[7]

In the §403 risk analysis, the household averages were calculated on wipe-equivalent sample loadings associated with the 284 units in the HUD National Survey, with imputed averages assigned to those units having no available data (Section 3.3.1.1 of the §403 risk analysis report). When characterizing the distribution of these averages across units, the §403 risk analysis weighted each unit by its 1997 sample weight as calculated for the §403 risk analysis (Appendix C1 of the §403 risk analysis report), and each unit built between 1960 and 1979 and without lead-based paint also represented post-1979 housing (Section 3.3.1.5 of the §403 risk analysis report). The resulting data distribution was used in the §403 risk analysis to characterize the distribution of average dust-lead loadings in the nation's housing stock.

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[7] The HUD National Survey database included a few wipe dust-lead loadings that were used as reported in determining household area-weighted averages.

3.2.1.1. <u>Data Summaries for the §403 Risk Analysis Versus the Interim NSLAH</u>. Descriptive statistics of household average dust-lead loadings for floors and window sills as calculated in the §403 risk analysis using the HUD National Survey data are presented in this subsection as they compare with the same statistics calculated on interim data for 706 housing units in the NSLAH. Note that these statistics reflect the sampling weights used in the §403 risk analysis and the interim NSLAH sample weights, thereby allowing these summaries to be nationally representative of the 1997 housing stock.

The interim NSLAH summaries include imputed average dust-lead loading data values which are assigned to households when no such data are available for a given surface (floors, window sills). Assigning an imputed dust-lead loading average to a household that has no dust-lead loading data ensures that it (and its corresponding sampling weight representing a given portion of the national housing stock) is represented in the risk analysis. The method used to impute data closely follows the method used in the §403 risk analysis for housing units in the HUD National Survey; this method is detailed in Appendix C. This appendix also gives the imputed data values and how they were assigned to housing units. Summaries of the interim NSLAH dust-lead loading data with imputed data excluded are found in Appendix D1.

When using the interim NSLAH data to calculate a household's average dust-lead loading for floors or window sills, five different approaches were considered for handling individual sample results that fell below the instrument's detection limit. These five approaches, which include censoring the not-detected results, are presented in Appendix D1. The data summaries that exclude imputed data values, found in Appendix D1, were performed and presented for each of these five approaches. Of these five approaches, two were specifically identified as most likely to be applied in the supplemental risk analysis involving the interim NSLAH data:

- making no adjustment to not-detected data values, and
- replacing not-detected data values with one-half of the detection limit.

The first approach eliminates potential bias that can be introduced when an adjustment is made to a reported data value, but it also permits a household's average to be zero or below, preventing the data from being used as input to the empirical model within the §403 risk analysis. (As the survey's analytical method adjusted for potential analytical bias by subtracting a specified amount from a given sample result, reported results of less than zero were possible. Such results were included in the survey database used in this analysis.) The second approach prevents this problem from occurring and represents the best estimate of a sample's actual lead amount value when the analytical result is only known to fall somewhere between zero and the instrument's detection limit. Interim NSLAH data summaries under both approaches are presented in this section to illustrate the impact that any one approach has on the characterized distribution.

<u>National comparisons</u>

Tables 3-4 and 3-5 present descriptive statistics of average household dust-lead loadings for floors and window sills, respectively, for the 1997 national housing stock. These summaries

Table 3-4. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
§403 Risk Analysis (HUD Natl. Survey)		284	16.5	6.27	3.49	0.508	2.65	5.32	12.2	375
Interim NSLAH[3]	No adjustment	633	10.4	1.22	4.57	-1.23	0.300	1.05	2.30	5940
	Replaced by LOD/2	706	10.8	1.82	2.78	0.750	0.950	1.31	2.46	5950

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with floor dust-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no floor wipe dust-lead loading data. The method for imputation is presented in Appendix C.

Table 3-5. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Window Sill Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
§403 Risk Analysis (HUD Natl. Survey)		284	550	23.0	15.8	0.0118	4.35	19.5	198	43700
Interim NSLAH[3]	No adjustment	690	137	14.5	7.83	-9.43	2.90	12.8	51.3	11100
	Replaced by LOD/2	706	137	15.8	6.57	0.445	3.35	13.6	51.0	11100

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with window sill dust-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no window sill wipe dust-lead loading data. The method for imputation is presented in Appendix C.

imply that the average dust-lead loadings for both floors and window sills based on the interim NSLAH data are considerably lower than that reported in the §403 risk analysis (based on the HUD National Survey after converting to wipe-equivalent loadings). For example, the median floor dust-lead loading is less than 2 $\mu g/ft^2$ based on the interim NSLAH data compared to 5.3 $\mu g/ft^2$ from the §403 risk analysis, and the median window sill dust-lead loading is less than 12 $\mu g/ft^2$ based on the interim NSLAH data compared to nearly 20 $\mu g/ft^2$ from the §403 risk analysis.

Median detection limits for dust-lead loadings in the interim NSLAH were 1.5 $\mu g/ft^2$ for floors and 3.6 $\mu g/ft^2$ for window sills. When considering all dust samples in the interim NSLAH that had lead amounts reported, approximately two-thirds of the floor dust-lead samples and one-third of the window sill dust-lead samples had results below the detection limit.

Boxplots of the data distributions presented in Tables 3-4 and 3-5 are found in Figures 3-1 and 3-2, respectively. Appendix D1 contains these tabular summaries and boxplots after excluding imputed data values.

In addition to these data summaries that are based solely on the observed data and the sampling weights, it was desired to characterize the national distribution of household average floor dust-lead loading in such a way that the percentage of housing where this average exceeds a specified threshold could be estimated. This was done for both the HUD National Survey and interim NSLAH data by assuming that these data originate from a lognormal distribution. Then, the fitted distributions and corresponding estimated exceedance percentages were compared between the two surveys. These results are presented in Section 3.2.1.3 below.

<u>Comparisons by housing age category</u>

While the summaries in Tables 3-4 and 3-5 represent the entire nation, Tables 3-6 and 3-7 present descriptive statistics according to the housing age category scheme defined in Table 3-2 above. Considerable declines in the geometric means and medians from the §403 risk analysis to the interim NSLAH data were observed in all four age categories.

Boxplots of the data distributions presented in Tables 3-6 and 3-7 are found in Figures 3-3 and 3-4, respectively. Appendix D1 contains these tabular summaries and boxplots after excluding imputed data values.

<u>Comparisons by Census region</u>

Tables 3-8 and 3-9 present descriptive statistics according to Census region. Declines in the geometric means and medians were observed from the §403 risk analysis to the interim NSLAH data for all regions but the West region, where very slight increases in these estimates were observed. The greatest declines were observed in the Northeast and Midwest.

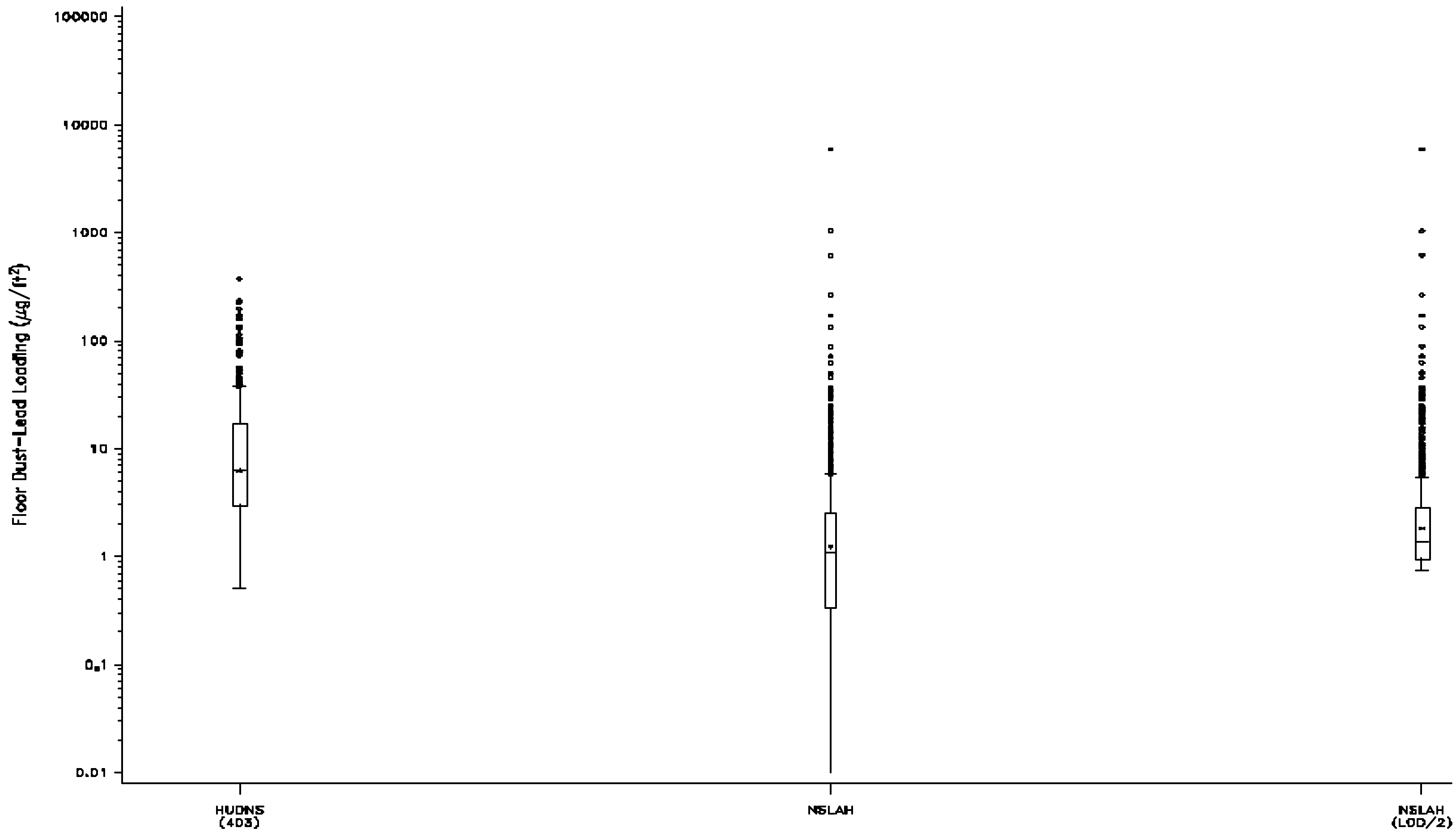

Figure 3-1. Boxplots of Area-Weighted Average Floor Wipe Dust-Lead Loadings (µg/ft²) As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. Boxplots include imputed household averages but not negative averages. See text for definitions of labels along the horizontal axis.)

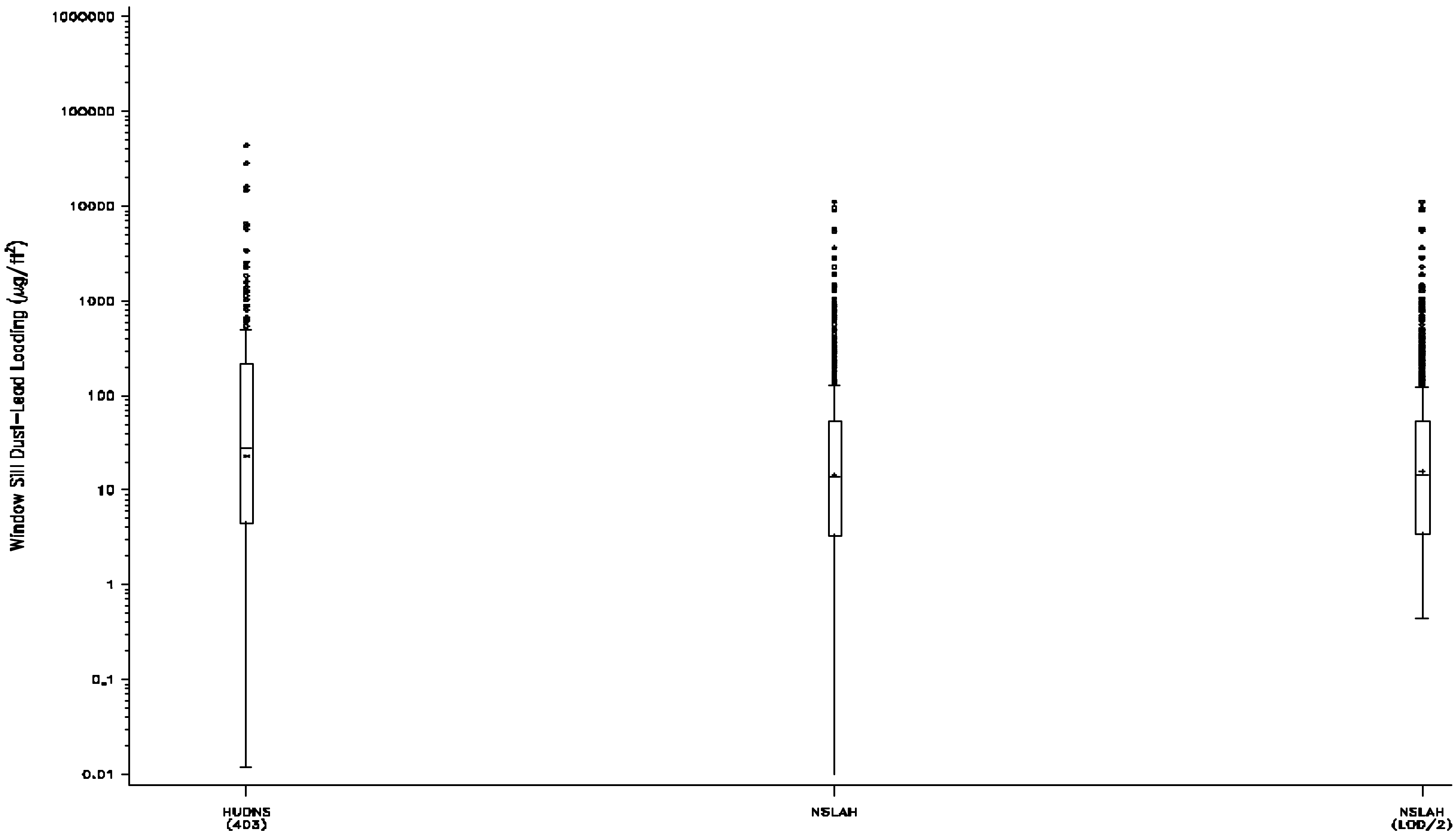

Figure 3-2. Boxplots of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings (µg/ft^2) As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. Boxplots include imputed household averages but not negative averages. See text for definitions of labels along the horizontal axis.)

Table 3-6. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Units Built Prior to 1940										
§403 Risk Analysis (HUD Natl. Survey)		77	47.9	22.6	3.63	0.991	8.84	17.7	79.7	375
Interim NSLAH[3]	No adjustment	111	36.9	3.74	4.53	-0.600	1.30	2.42	9.50	5940
Interim NSLAH[3]	Replaced by LOD/2	114	37.0	4.00	3.97	0.750	1.45	2.71	9.50	5950
Units Built from 1940 - 1959										
§403 Risk Analysis (HUD Natl. Survey)		87	18.1	8.74	3.34	0.508	4.07	7.81	22.4	171
Interim NSLAH[3]	No adjustment	134	4.11	1.90	3.57	-0.720	0.719	1.80	4.00	71.0
Interim NSLAH[3]	Replaced by LOD/2	145	4.38	2.31	2.64	0.750	1.05	1.99	4.00	71.0
Units Built from 1960-1977 (1960 - 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		120	6.74	4.14	2.45	0.657	2.25	3.62	7.59	106
Interim NSLAH[3]	No adjustment	176	1.50	0.912	3.47	-0.733	0.236	0.900	1.68	28.5
Interim NSLAH[3]	Replaced by LOD/2	201	1.96	1.46	1.92	0.750	0.900	1.20	1.92	28.8
Units Built After 1977 (after 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		28	4.16	3.14	2.06	1.06	1.76	2.84	5.66	12.9
Interim NSLAH[3]	No adjustment	151	1.20	0.545	3.35	-1.05	0.146	0.400	1.08	265
Interim NSLAH[3]	Replaced by LOD/2	180	1.71	1.14	1.72	0.750	0.750	1.00	1.35	265
NSLAH Units with Unspecified Year-Built Indicator										
Interim NSLAH[3]	No adjustment	61	31.7	1.37	6.64	-1.23	0.300	1.24	2.72	1040
Interim NSLAH[3]	Replaced by LOD/2	66	32.1	2.20	3.92	0.750	1.00	1.40	2.56	1040

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with floor dust-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no floor wipe dust-lead loading data. The method for imputation is presented in Appendix C.

Table 3-7. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Window Sill Dust-Lead Loading ($\mu g/ft^2$)[1] # Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Units Built Prior to 1940										
§403 Risk Analysis (HUD Natl. Survey)		77	2060	168	16.7	0.0155	35.6	198	1220	43700
Interim NSLAH[3]	No adjustment	113	400	77.5	6.59	-0.152	21.2	79.8	294	11100
Interim NSLAH[3]	Replaced by LOD/2	114	400	76.8	6.44	1.03	21.2	79.8	294	11100
Units Built from 1940 - 1959										
§403 Risk Analysis (HUD Natl. Survey)		87	285	22.0	10.7	0.0118	6.47	19.1	107	16100
Interim NSLAH[3]	No adjustment	144	129	24.5	6.80	-1.73	6.35	23.0	88.6	3630
Interim NSLAH[3]	Replaced by LOD/2	145	129	26.1	5.97	0.923	6.58	22.0	88.6	3630
Units Built from 1960-1977 (1960 - 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		120	184	16.2	14.6	0.0164	2.05	16.6	217	5790
Interim NSLAH[3]	No adjustment	195	36.6	10.7	4.71	-2.32	2.89	9.40	29.0	1390
Interim NSLAH[3]	Replaced by LOD/2	201	36.9	11.3	4.18	1.02	3.17	9.54	29.3	1390
Units Built After 1977 (after 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		28	83.0	8.17	9.94	0.0164	2.58	8.11	57.8	1590
Interim NSLAH[3]	No adjustment	174	15.6	3.56	5.27	-9.43	0.916	3.19	10.3	426
Interim NSLAH[3]	Replaced by LOD/2	180	16.0	4.57	3.79	0.445	1.72	3.67	9.99	427
NSLAH Units with Unspecified Year-Built Indicator										
Interim NSLAH[3]	No adjustment	64	367	39.8	7.32	-0.629	18.6	36.4	118	9030
Interim NSLAH[3]	Replaced by LOD/2	66	367	40.2	6.72	0.720	18.8	36.4	118	9030

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with window sill dust-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no window sill wipe dust-lead loading data. The method for imputation is presented in Appendix C.

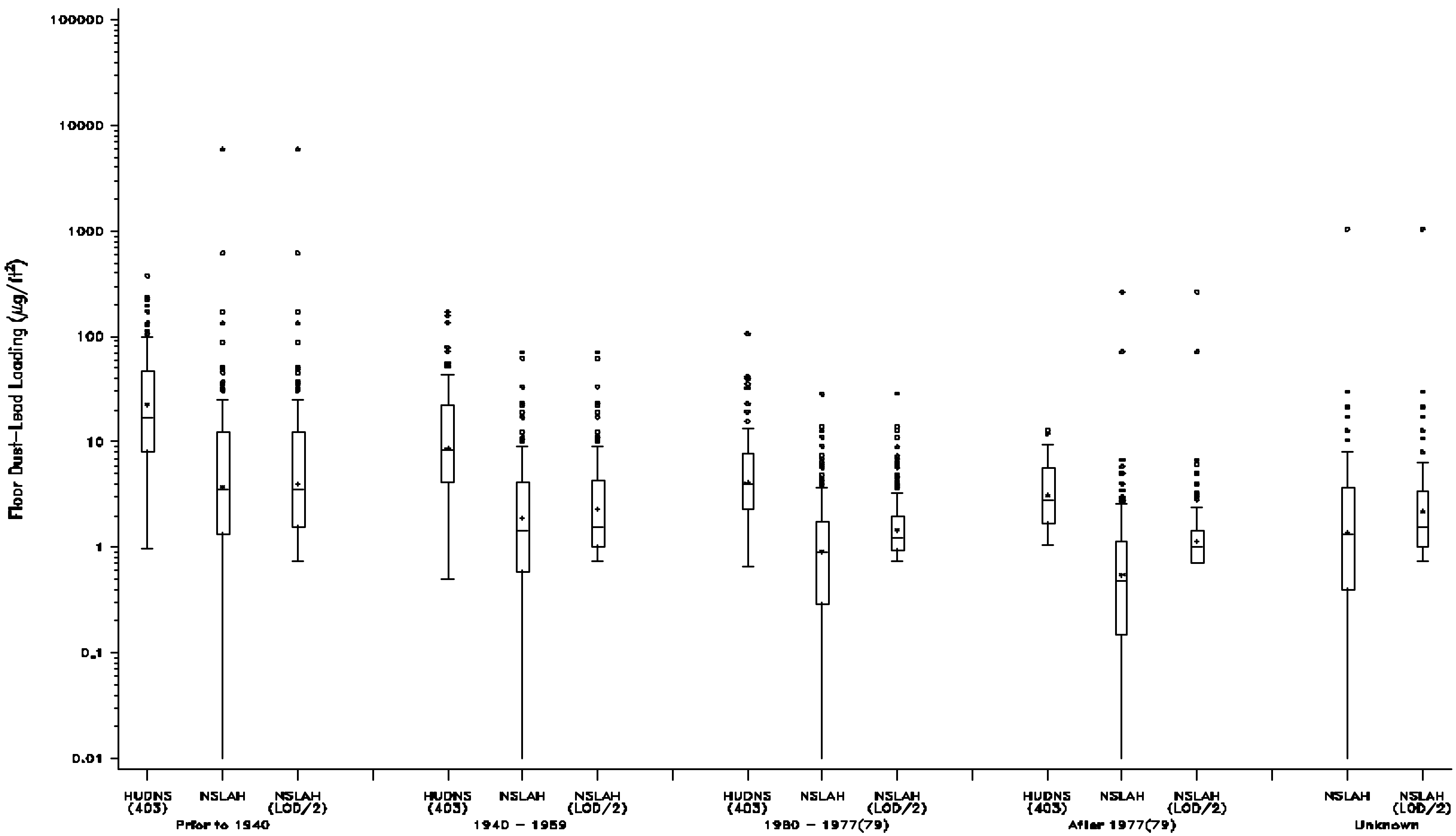

Figure 3-3. Boxplots of Area-Weighted Average Floor Wipe Dust-Lead Loadings (µg/ft^2), by Housing Age Category, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. Boxplots include imputed household averages but not negative averages. See text for definitions of labels along the horizontal axis.)

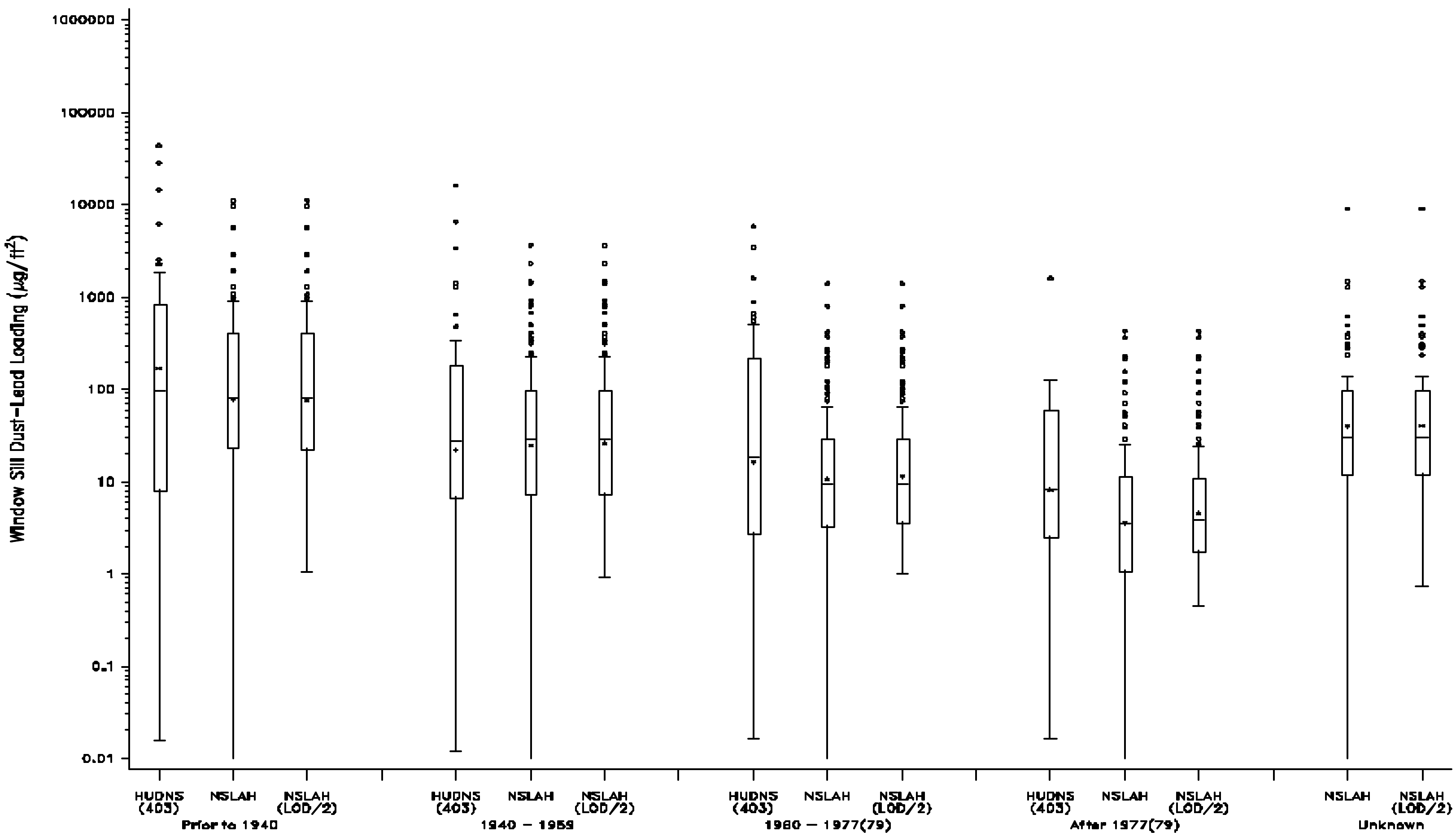

Figure 3-4. Boxplots of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings (µg/ft²), by Housing Age Category, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. Boxplots include imputed household averages but not negative averages. See text for definitions of labels along the horizontal axis.)

Table 3-8. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Northeast										
§403 Risk Analysis (HUD Natl. Survey)		53	35.6	14.9	3.95	0.632	4.79	11.0	76.3	375
Interim NSLAH[3]	No adjustment	103	10.0	2.28	4.42	-0.620	0.800	1.90	6.00	617
Interim NSLAH[3]	Replaced by LOD/2	109	10.3	2.90	3.15	0.750	1.20	2.13	6.00	617
Midwest										
§403 Risk Analysis (HUD Natl. Survey)		73	14.7	6.32	3.26	0.508	2.83	6.32	11.0	173
Interim NSLAH[3]	No adjustment	136	14.7	1.34	5.81	-0.733	0.283	1.20	2.48	1040
Interim NSLAH[3]	Replaced by LOD/2	150	15.0	2.04	3.39	0.750	0.760	1.29	3.25	1040
South										
§403 Risk Analysis (HUD Natl. Survey)		134	13.3	5.01	3.28	0.735	2.00	3.89	10.0	236
Interim NSLAH[3]	No adjustment	235	2.65	0.981	3.94	-1.05	0.254	0.940	1.76	265
Interim NSLAH[3]	Replaced by LOD/2	265	3.07	1.55	2.25	0.750	0.970	1.21	1.94	265
West										
§403 Risk Analysis (HUD Natl. Survey)		52	9.81	4.97	2.75	1.06	2.65	4.01	8.43	197
Interim NSLAH[3]	No adjustment	159	18.7	0.949	3.66	-1.23	0.255	0.800	1.67	5940
Interim NSLAH[3]	Replaced by LOD/2	182	19.1	1.46	2.31	0.750	0.800	1.20	1.88	5950

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with floor dust-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no floor wipe dust-lead loading data. The method for imputation is presented in Appendix C.

Table 3-9. **Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data**

Study	How Not-Detected and Negative Data were Handled	Area-Weighted Average Window Sill Dust-Lead Loading ($\mu g/ft^2$)[1]								
		# Surveyed Units with Positive Averages	Arithmetic Mean	Geometric Mean[2]	Geometric Std. Dev.[2]	Minimum	25th Percentile	Median	75th Percentile	Maximum
Northeast										
§403 Risk Analysis (HUD Natl. Survey)		53	1440	92.2	16.1	0.0155	15.3	173	335	14600
Interim NSLAH[3]	No adjustment	107	172	21.5	8.01	-1.89	5.94	16.0	89.5	5530
Interim NSLAH[3]	Replaced by LOD/2	109	172	22.6	7.06	0.578	5.94	16.0	90.0	5530
Midwest										
§403 Risk Analysis (HUD Natl. Survey)		73	564	48.5	13.2	0.0706	7.76	83.0	309	43700
Interim NSLAH[3]	No adjustment	145	218	21.0	7.25	-2.32	4.00	16.6	60.1	9630
Interim NSLAH[3]	Replaced by LOD/2	150	218	21.6	6.49	1.12	4.75	16.4	60.1	9630
South										
§403 Risk Analysis (HUD Natl. Survey)		134	432	19.6	12.4	0.118	4.60	15.0	127	28400
Interim NSLAH[3]	No adjustment	259	115	13.8	8.11	-9.43	2.88	12.8	53.8	11100
Interim NSLAH[3]	Replaced by LOD/2	265	116	15.6	6.42	0.646	3.06	13.9	53.8	11100
West										
§403 Risk Analysis (HUD Natl. Survey)		52	62.2	4.45	12.7	0.0118	1.68	5.40	28.0	1400
Interim NSLAH[3]	No adjustment	179	54.3	7.73	6.65	-0.115	2.07	7.54	29.0	3630
Interim NSLAH[3]	Replaced by LOD/2	182	54.4	8.72	5.59	0.445	2.30	7.76	29.3	3630

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with window sill dust-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no window sill wipe dust-lead loading data. The method for imputation is presented in Appendix C.

Boxplots of the data distributions presented in Tables 3-8 and 3-9 are found in Figures 3-5 and 3-6, respectively. Appendix D1 contains these tabular summaries and boxplots after excluding imputed data values.

Comparisons by combination of housing age and Census region

Tables 3-10a and 3-10b present descriptive statistics for household average floor dust-lead loadings according to the 16 combinations of Census region and housing age category. Table 3-10a considers no adjustment to the interim NSLAH data when not-detected results were observed, while Table 3-10b summarizes data where not-detected data were replaced by one-half of the detection limit. Tables 3-11a and 3-11b present the same descriptive statistics for household average window sill dust-lead loadings. As the central tendency of the dust-lead loading data was of primary interest to compare across the different combinations, these tables only contain estimates of the arithmetic and geometric means, geometric standard deviation (GSD), and median. Appendix D1 contains these tabular summaries after excluding imputed data values.

Due to the small number of housing units within certain combinations, caution is warranted when making inferences based on the numbers in these tables.

3.2.1.2. Data Summaries for the §403 Risk Analysis Versus Three Other Studies. This subsection provides descriptive statistics of household average dust-lead loadings for floors and window sills for the HUD National Survey (both as collected and as used in the §403 risk analysis), comparing these summaries to those for the three studies identified in the introduction to this section that provided the most useful and available information to the §403 risk analysis on the relationship between environmental-lead levels and childhood blood-lead concentration: the Baltimore R&M study, the Rochester Lead-in-Dust study, and the ongoing HUD Grantees evaluation (data collected through February 1999).

Summaries of the reported dust-lead loadings in the HUD National Survey and the Baltimore R&M study were performed on wipe-equivalent dust-lead loadings using conversion methods presented in the §403 risk analysis report. In addition, the household averages based on HUD National Survey data were summarized in two different ways: by ignoring the sample weights assigned to the surveyed housing units and any imputed data for households with missing data, and by handling the data as used in the §403 risk analysis (described earlier in this section).

Because the HUD Grantees program emphasizes local control of the individual programs, each grantee participating in the HUD Grantee evaluation is responsible for designing and implementing lead-hazard reduction approaches applicable to its specific needs and objectives. These responsibilities include the recruitment methods, enrollment criteria, and intervention strategies. However, to enable comparison of results from the various approaches, grantees participating in the evaluation follow the same sampling protocols and use standard data collection forms developed specifically for this evaluation. Table 3-4 of the §403 risk analysis

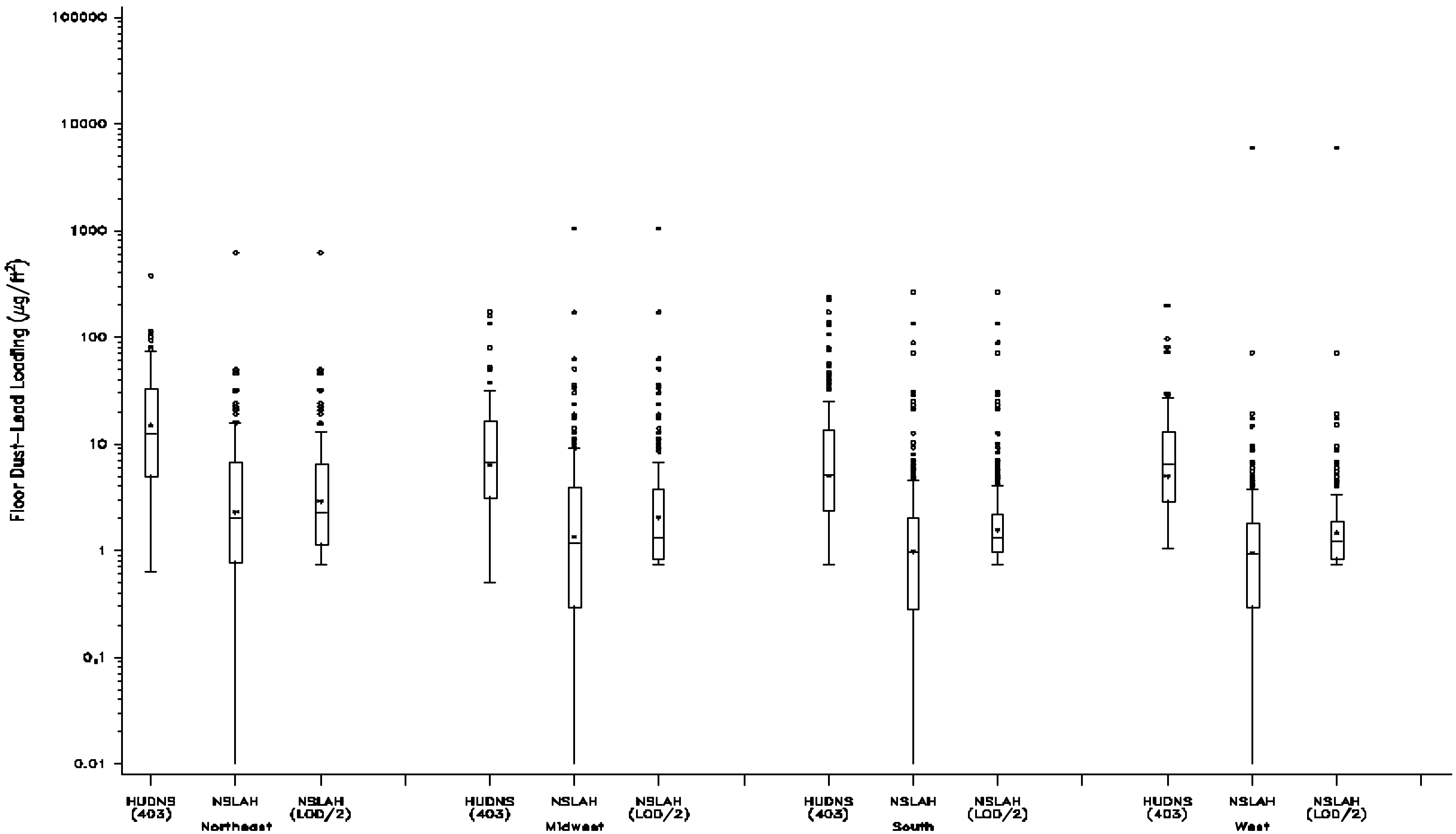

Figure 3-5. Boxplots of Area-Weighted Average Floor Wipe Dust-Lead Loadings (µg/ft^2), by Census Region, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. Boxplots include imputed household averages but not negative averages. See text for definitions of labels along the horizontal axis.)

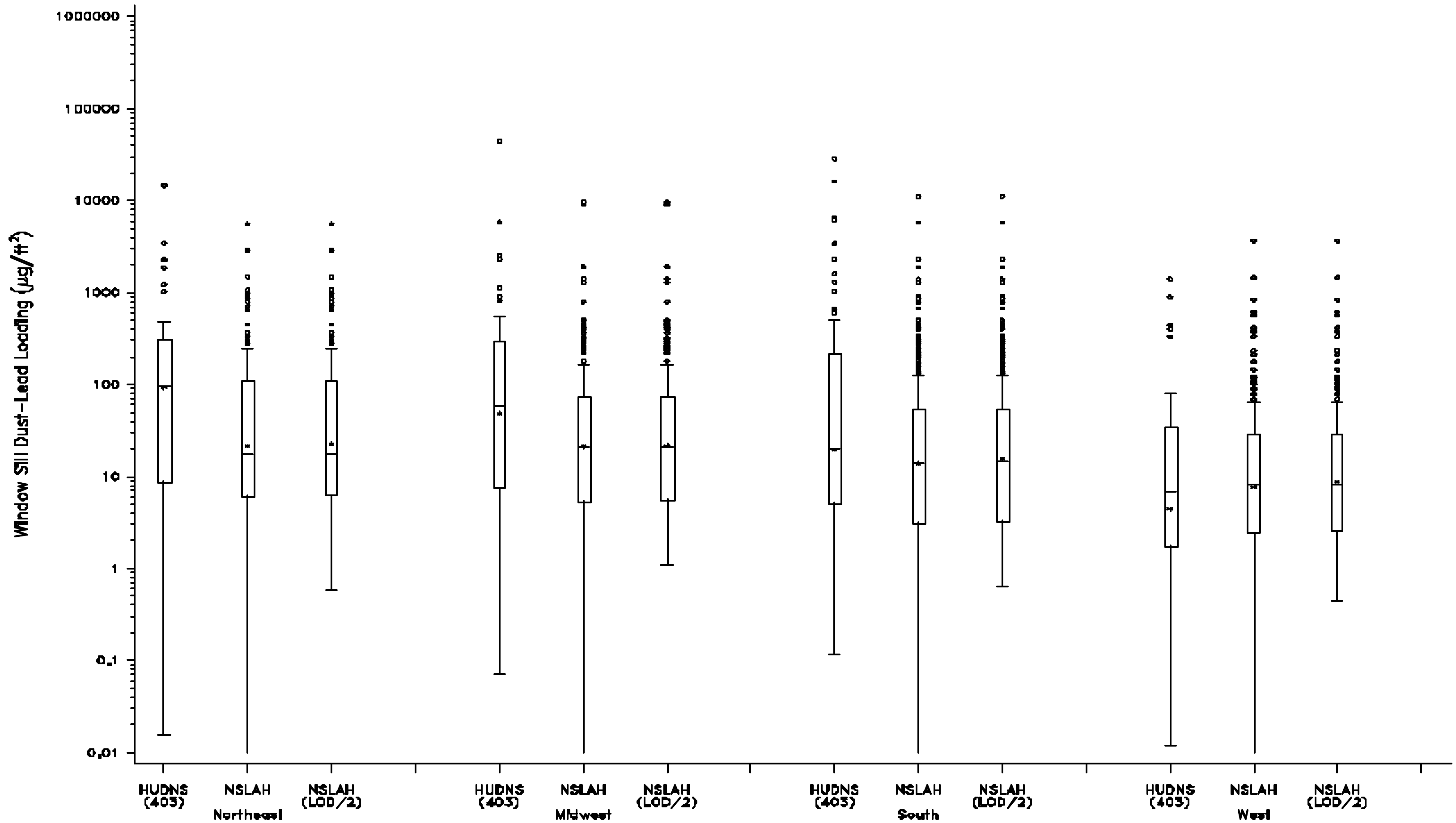

Figure 3-6. **Boxplots of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings (µg/ft²), by Census Region, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)**

(Note: Dust-lead loadings from the HUD National Survey have been converted to wipe-equivalents in the §403 risk analysis using the methods documented in the §403 risk analysis report. Boxplots include imputed household averages but not negative averages. See text for definitions of labels along the horizontal axis.)

Table 3-10a. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where No Adjustments Were Made to Not-Detected Results

Census Region	Study	Housing Age Category	Area-Weighted Average Floor Dust-Lead Loading (μg/ft²)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	63.5	36.5	3.39	76.3
	Interim NSLAH		41	23.7	5.02	4.31	4.20
	§403 Risk Anal.	1940 - 1959	17	13.2	8.84	2.54	7.81
	Interim NSLAH		21	3.75	2.37	3.36	2.38
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	7.00	4.73	2.23	4.76
	Interim NSLAH		19	3.34	1.72	3.76	1.46
	Interim NSLAH	After 1977	15	1.12	0.714	2.78	0.867
Midwest	§403 Risk Anal.	Prior to 1940	19	31.3	14.7	3.01	8.94
	Interim NSLAH		33	8.49	2.62	4.47	2.16
	§403 Risk Anal.	1940 - 1959	21	15.8	6.69	3.95	5.79
	Interim NSLAH		35	5.48	2.05	4.16	1.59
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	6.33	4.58	2.35	4.44
	Interim NSLAH		32	1.52	0.737	4.77	1.12
	§403 Risk Anal.	After 1977 (1979 for §403)	4	3.32	2.77	1.83	2.80
	Interim NSLAH		25	0.913	0.545	3.86	0.320
South	§403 Risk Anal.	Prior to 1940	19	50.7	20.8	4.01	19.0
	Interim NSLAH		26	11.0	3.66	3.93	2.74
	§403 Risk Anal.	1940 - 1959	33	25.4	10.3	3.91	10.0
	Interim NSLAH		42	3.66	1.63	3.40	1.77
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	8.06	4.13	2.74	3.39
	Interim NSLAH		71	1.16	0.825	3.04	0.880
	§403 Risk Anal.	After 1977 (1979 for §403)	18	4.19	3.16	2.05	2.84
	Interim NSLAH		72	1.04	0.549	3.12	0.480
West	§403 Risk Anal.	Prior to 1940	13	34.9	16.2	3.51	17.2
	Interim NSLAH		11	264	3.84	6.17	2.30
	§403 Risk Anal.	1940 - 1959	16	14.6	9.04	2.46	7.47
	Interim NSLAH		36	2.86	1.70	2.92	1.36
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	4.50	3.53	2.03	3.35
	Interim NSLAH		54	1.16	0.949	2.42	0.990
	§403 Risk Anal.	After 1977 (1979 for §403)	6	4.60	3.36	2.21	3.00
	Interim NSLAH		39	1.75	0.454	3.67	0.270

Note: Summaries include imputed data for households having no floor wipe dust-lead loading data. The method for imputation is presented in Appendix C.

Table 3-10b. Descriptive Statistics of Area-Weighted Average Floor Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where Not-Detected Results Were Replaced by LOD/2

Census Region	Study	Housing Age Category	Area-Weighted Average Floor Dust-Lead Loading ($\mu g/ft^2$)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	63.5	36.5	3.39	76.3
	Interim NSLAH		41	23.8	5.47	3.91	4.35
	§403 Risk Anal.	1940 - 1959	17	13.2	8.84	2.54	7.81
	Interim NSLAH		23	4.03	2.86	2.23	2.40
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	7.00	4.73	2.23	4.76
	Interim NSLAH		21	3.58	2.16	2.60	1.68
	Interim NSLAH	After 1977	16	1.68	1.43	1.72	1.29
Midwest	§403 Risk Anal.	Prior to 1940	19	31.3	14.7	3.01	8.94
	Interim NSLAH		36	8.79	2.88	3.41	2.19
	§403 Risk Anal.	1940 - 1959	21	15.8	6.69	3.95	5.79
	Interim NSLAH		36	5.80	2.57	3.20	1.53
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	6.33	4.58	2.35	4.44
	Interim NSLAH		37	2.00	1.50	2.03	1.20
	§403 Risk Anal.	After 1977 (1979 for §403)	4	3.32	2.77	1.83	2.80
	Interim NSLAH		30	1.31	1.09	1.67	0.938
South	§403 Risk Anal.	Prior to 1940	19	50.7	20.8	4.01	19.0
	Interim NSLAH		26	11.1	3.87	3.76	2.70
	§403 Risk Anal.	1940 - 1959	33	25.4	10.3	3.91	10.0
	Interim NSLAH		48	3.94	1.99	2.35	1.54
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	8.06	4.13	2.74	3.39
	Interim NSLAH		81	1.67	1.31	1.73	1.18
	§403 Risk Anal.	After 1977 (1979 for §403)	18	4.19	3.16	2.05	2.84
	Interim NSLAH		84	1.54	1.13	1.57	1.06
West	§403 Risk Anal.	Prior to 1940	13	34.9	16.2	3.51	17.2
	Interim NSLAH		11	264	4.03	5.91	2.19
	§403 Risk Anal.	1940 - 1959	16	14.6	9.04	2.46	7.47
	Interim NSLAH		38	3.07	1.99	2.34	1.52
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	4.50	3.53	2.03	3.35
	Interim NSLAH		62	1.62	1.40	1.65	1.38
	§403 Risk Anal.	After 1977 (1979 for §403)	6	4.60	3.36	2.21	3.00
	Interim NSLAH		50	2.34	1.07	1.95	0.900

Note: Summaries include imputed data for households having no floor wipe dust-lead loading data. The method for imputation is presented in Appendix C.

Table 3-11a. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where No Adjustments Were Made to Not-Detected Results

Census Region	Study	Housing Age Category	Area-Weighted Average Window Sill Dust-Lead Loading ($\mu g/ft^2$)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	2700	265	15.8	176
	Interim NSLAH		40	396	99.4	6.33	91.7
	§403 Risk Anal.	1940 - 1959	17	98.5	32.6	5.55	50.7
	Interim NSLAH		23	62.7	20.1	4.31	18.5
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	499	38.9	20.8	217
	Interim NSLAH		20	13.9	7.88	2.67	6.49
	Interim NSLAH	After 1977	16	18.3	3.28	5.69	2.06
Midwest	§403 Risk Anal.	Prior to 1940	19	1660	435	5.79	542
	Interim NSLAH		36	361	72.5	6.15	67.3
	§403 Risk Anal.	1940 - 1959	21	98.2	17.7	11.6	17.4
	Interim NSLAH		35	103	20.0	6.33	17.1
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	223	20.9	11.6	48.3
	Interim NSLAH		33	27.9	9.94	4.75	9.54
	§403 Risk Anal.	After 1977 (1979 for §403)	4	62.5	27.5	6.78	83.0
	Interim NSLAH		30	21.0	6.57	3.64	5.86
South	§403 Risk Anal.	Prior to 1940	19	2450	64.0	23.1	24.4
	Interim NSLAH		26	600	112	5.87	115
	§403 Risk Anal.	1940 - 1959	33	657	38.9	9.93	26.2
	Interim NSLAH		48	160	30.7	8.58	32.0
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	149	24.0	12.6	32.0
	Interim NSLAH		80	55.4	14.3	5.44	15.4
	§403 Risk Anal.	After 1977 (1979 for §403)	18	112	9.09	8.60	7.58
	Interim NSLAH		80	18.2	3.93	6.00	3.89
West	§403 Risk Anal.	Prior to 1940	13	125	11.5	14.7	7.05
	Interim NSLAH		11	47.6	14.2	5.17	17.1
	§403 Risk Anal.	1940 - 1959	16	107	7.35	13.2	6.96
	Interim NSLAH		38	186	29.0	7.21	33.8
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	58.7	3.83	11.5	4.35
	Interim NSLAH		62	26.1	8.34	4.19	7.51
	§403 Risk Anal.	After 1977 (1979 for §403)	6	9.66	2.65	11.6	5.94
	Interim NSLAH		48	5.64	1.99	4.08	1.63

Note: Summaries include imputed data for households having no window sill wipe dust-lead loading data. The method for imputation is presented in Appendix C.

Table 3-11b. Descriptive Statistics of Area-Weighted Average Window Sill Wipe Dust-Lead Loadings for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where Not-Detected Results Were Replaced by LOD/2

Census Region	Study	Housing Age Category	Area-Weighted Average Window Sill Dust-Lead Loading ($\mu g/ft^2$)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	2700	265	15.8	176
	Interim NSLAH		41	396	90.1	6.91	91.7
	§403 Risk Anal.	1940 - 1959	17	98.5	32.6	5.55	50.7
	Interim NSLAH		23	62.7	19.6	4.49	18.9
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	499	38.9	20.8	217
	Interim NSLAH		21	14.7	8.39	2.55	7.37
	Interim NSLAH	After 1977	16	18.6	4.80	3.80	3.73
Midwest	§403 Risk Anal.	Prior to 1940	19	1660	435	5.79	542
	Interim NSLAH		36	361	75.7	5.65	67.3
	§403 Risk Anal.	1940 - 1959	21	98.2	17.7	11.6	17.4
	Interim NSLAH		36	103	20.9	5.49	17.6
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	223	20.9	11.6	48.3
	Interim NSLAH		37	28.4	10.3	3.81	9.54
	§403 Risk Anal.	After 1977 (1979 for §403)	4	62.5	27.5	6.78	83.0
	Interim NSLAH		30	21.4	7.01	3.54	6.20
South	§403 Risk Anal.	Prior to 1940	19	2450	64.0	23.1	24.4
	Interim NSLAH		26	600	112	5.86	115
	§403 Risk Anal.	1940 - 1959	33	657	38.9	9.93	26.2
	Interim NSLAH		48	160	35.5	6.78	32.0
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	149	24.0	12.6	32.0
	Interim NSLAH		81	55.7	15.3	4.88	15.8
	§403 Risk Anal.	After 1977 (1979 for §403)	18	112	9.09	8.60	7.58
	Interim NSLAH		84	18.8	5.21	3.86	4.00
West	§403 Risk Anal.	Prior to 1940	13	125	11.5	14.7	7.05
	Interim NSLAH		11	47.8	15.9	4.23	17.2
	§403 Risk Anal.	1940 - 1959	16	107	7.35	13.2	6.96
	Interim NSLAH		38	186	30.6	6.51	33.8
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	58.7	3.83	11.5	4.35
	Interim NSLAH		62	26.0	8.77	3.88	7.51
	§403 Risk Anal.	After 1977 (1979 for §403)	6	9.66	2.65	11.6	5.94
	Interim NSLAH		50	5.77	2.57	3.14	1.85

Note: Summaries include imputed data for households having no window sill wipe dust-lead loading data. The method for imputation is presented in Appendix C.

report documented the differences between grantees in their enrollment/recruitment criteria. As a result, the HUD Grantees data summaries in this subsection are presented by grantee.

Overall data summaries

Figures 3-7 and 3-8 present boxplots of the area-weighted household average dust-lead loadings for floors and window sills, respectively. Each of these two figures contains a boxplot for each study, along with separate boxplots for each grantee in the HUD Grantees evaluation[8]. Each figure also includes three boxplots associated with the HUD National Survey data:

- "HUDNS (U)" summarizes the data without regard to sampling weights
- "HUDNS (403)" summarizes the data as used in the §403 risk analysis (e.g., using sampling weights reflecting the 1997 housing stock; incorporating imputed data assigned to housing units with missing data)
- "HUDNS (OW)" summarizes the data weighted according to the original weights assigned in the survey.

Tables 3-12 and 3-13 present values of the statistics presented in the boxplots (geometric mean, minimum, median, maximum, 25th and 75th percentiles), along with other important information not explicitly observable from the boxplots (number of houses whose data enter into these statistics, geometric standard deviation) that is necessary when comparing distributions across studies. The GSD reported for the overall HUD Grantees evaluation is the exponentiation of the square root of the weighted average of log-transformed variances for the different grantees, where the weights correspond to the numbers of units with data.

Comparisons by housing age category

Figures 3-9 and 3-10 contain boxplots on pre-1980 housing data (floors and window sills, respectively) from the HUD National Survey, Baltimore R&M, and Rochester studies, and pre-1978 data from the HUD Grantees evaluation (data combined across grantees) according to three housing age categories (pre-1940, 1940-1959, 1960-1977/79). As in the overall summaries above, the HUD National Survey data are presented within three boxplots for each age category. Caution is warranted when interpreting results in these figures for the Rochester study, as the actual age of certain houses may be older than what was specified in the Rochester study database (see Section 3.3.1.3 of the §403 risk analysis report). Also for this reason, and since the other studies surveyed few, if any, post-1979 homes, boxplots were not created for homes built after 1979. Boxplots for non-control houses in the Baltimore R&M study, all of which were built prior to 1941, are also included in these figures and are displayed in the "pre-1940" category.

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8 "Alam"=Alameda County; "Balt"=Baltimore; "Bos"=Boston; "CA"=California; "Cle"=Cleveland; "MA"=Massachusetts; "MN"=Minnesota; "NJ"=New Jersey; "RI"=Rhode Island; "WI"=Wisconsin; "Milw"=Milwaukee; "Chic"=Chicago; "NYC"=New York City; "VT"=Vermont.

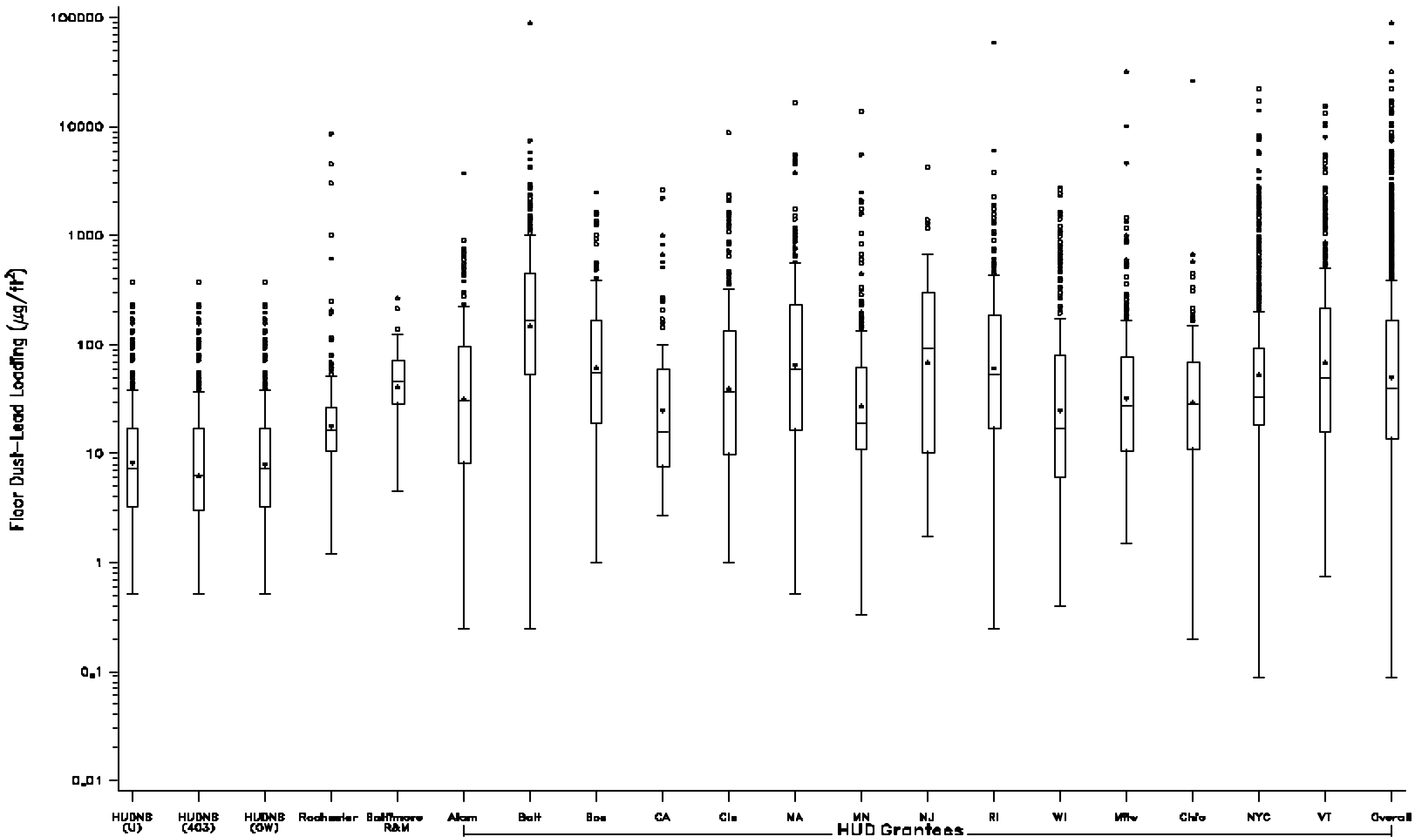

Figure 3-7. Boxplots of Area-Weighted Average Pre-Intervention Floor Wipe Dust-Lead Loadings (µg/ft²) for Houses in the HUD National Survey, Baltimore R&M Study, Rochester Lead-in-Dust Study, and Grantees Within the HUD Grantees Evaluation

(Note: Dust-lead loadings from the HUD National Survey and Baltimore R&M study have been converted from vacuum to wipe-equivalents using the methods documented in the §403 risk analysis report. See text for definitions of labels along the horizontal axis.)

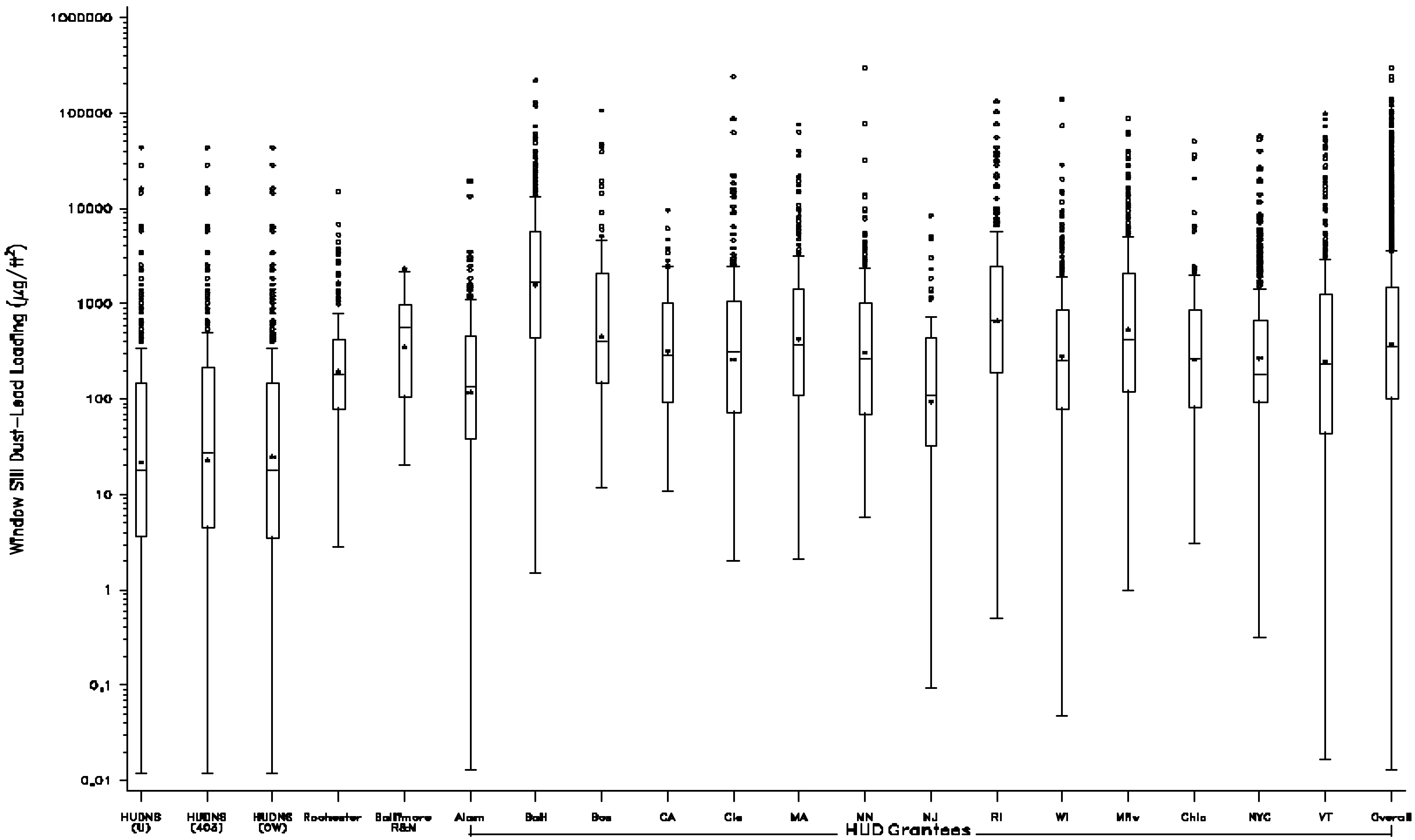

Figure 3-8. Boxplots of Area-Weighted Average Pre-Intervention Window Sill Wipe Dust-Lead Loadings (µg/ft²) for Houses in the HUD National Survey, Baltimore R&M Study, Rochester Lead-in-Dust Study, and Grantees Within the HUD Grantees Evaluation

(Note: Dust-lead loadings from the HUD National Survey and Baltimore R&M study have been converted from vacuum to wipe-equivalents using the methods documented in the §403 risk analysis report. See text for definitions of labels along the horizontal axis.)

Table 3-12. Descriptive Statistics of Area-Weighted Average Pre-Intervention Floor Wipe Dust-Lead Loadings for Households, As Reported in the §403 Risk Analysis, the HUD National Survey, and Other Studies

Study	Approach/ Grantee	Area-Weighted Average Pre-Intervention Floor Dust-Lead Loading ($\mu g/ft^2$)								
		# Units with Data	Arith-metic Mean	Geo-metric Mean	Geo-metric Std. Dev.	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
HUD National Survey	unweighted[1]	281	21.0	8.19	3.66	0.508	3.23	7.27	17.3	375
	orig. weights[2]	281	21.0	7.97	3.70	0.508	3.17	6.94	17.0	375
	§403 RA[3]	284	16.5	6.27	3.49	0.508	2.65	5.32	12.2	375
Rochester Lead-in-Dust		205	110	17.7	3.20	1.21	10.4	16.1	26.6	8660
Baltimore R&M[4]		90	54.3	40.9	2.27	4.48	29.1	45.2	70.4	266
HUD Grantees	Alameda Co.	168	127	31.4	5.78	0.250	8.59	31.0	98.0	3730
	Baltimore	402	642	149	5.48	0.250	53.2	167	456	89100
	Boston	114	205	61.3	4.79	1.00	18.8	55.3	170	2490
	California	90	130	24.6	4.89	2.75	7.95	15.6	59.3	2650
	Cleveland	190	232	39.4	6.51	1.00	10.3	36.4	134	8800
	Massachusetts	229	408	64.4	6.47	0.521	17.0	59.8	234	16600
	Minnesota	212	202	27.3	5.14	0.333	10.9	19.2	62.4	13800
	New Jersey	45	308	68.2	6.71	1.75	10.5	93.4	298	4250
	Rhode Island	203	530	60.6	5.85	0.250	17.7	54.0	187	59200
	Wisconsin	236	172	24.8	6.92	0.400	5.99	16.9	79.1	2780
	Milwaukee	291	247	32.2	4.61	1.50	11.0	27.5	76.3	31900
	Chicago	158	234	29.4	4.40	0.200	11.5	28.2	69.2	26400
	New York City	399	462	52.6	5.90	0.0880	18.5	32.9	94.4	22200
	Vermont	354	515	67.9	6.70	0.750	15.8	49.9	219	15600
	All Grantees	3091	366	50.1	5.76	0.0880	14.3	40.2	165	89100

[1] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized without weighting by sample weights.
[2] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized by weighting each average by the original sample weights assigned in the survey.
[3] Area-weighted average dust-lead loadings, as calculated in Chapter 3 of the §403 risk analysis, are summarized by weighting each average to reflect the 1997 U.S. housing stock and imputing averages for units with missing data.
[4] BRM dust-lead loadings are converted to wipe-equivalent loadings prior to summary in this table.

Table 3-13. Descriptive Statistics of Area-Weighted Average Pre-Intervention <u>Window Sill Wipe Dust-Lead Loadings</u> for Households, As Reported in the §403 Risk Analysis, the HUD National Survey, and Other Studies

Study	Approach/ Grantee	Area-Weighted Average Pre-Intervention Window Sill Dust-Lead Loading ($\mu g/ft^2$)								
		# Units with Data	Arith-metic Mean	Geo-metric Mean	Geo-metric Std. Dev.	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
HUD National Survey	unweighted[1]	245	678	21.7	15.4	0.0118	3.57	17.6	149	43700
	orig. weights[2]	245	721	24.9	17.9	0.0118	5.22	36.3	217	43700
	§403 RA[3]	312	550	23.0	15.8	0.0118	4.35	19.5	198	43700
Rochester Lead-in-Dust		196	558	196	3.96	2.83	80.6	183	416	14900
Baltimore R&M[4]		90	627	356	3.55	20.6	112	576	960	2330
HUD Grantees	Alameda Co.	178	677	118	9.14	0.0016	37.7	134	464	19700
	Baltimore	402	6690	1560	7.39	<0.0001	444	1690	5800	220000
	Boston	95	4090	452	9.87	0.0053	135	385	2040	106000
	California	81	909	316	4.60	11.0	94.2	293	1030	9630
	Cleveland	185	4050	259	16.2	<0.0001	72.8	288	949	241000
	Massachusetts	206	2990	425	7.13	2.15	108	369	1420	76100
	Minnesota	193	3160	308	6.17	5.66	72.6	262	1030	300000
	New Jersey	51	758	93.7	27.8	<0.0001	32.8	104	435	8450
	Rhode Island	192	4930	659	11.9	<0.0001	186	666	2450	132000
	Wisconsin	234	2790	279	8.44	0.0008	80.7	256	845	142000
	Milwaukee	271	3520	536	6.89	1.00	127	424	2110	88000
	Chicago	146	1600	260	5.71	3.02	86.7	267	877	50500
	New York City	382	1580	267	5.58	0.320	97.0	183	670	57100
	Vermont	318	3740	246	14.6	<0.0001	45.0	227	1260	98100
	All Grantees	2934	3360	380	8.68	<0.0001	102	343	1490	300000

[1] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized without weighting by sample weights.
[2] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized by weighting each average by the original sample weights assigned in the survey.
[3] Area-weighted average dust-lead loadings, as calculated in Chapter 3 of the §403 risk analysis, are summarized by weighting each average to reflect the 1997 U.S. housing stock and imputing averages for units with missing data.
[4] BRM dust-lead loadings are converted to wipe-equivalent loadings prior to summary in this table.

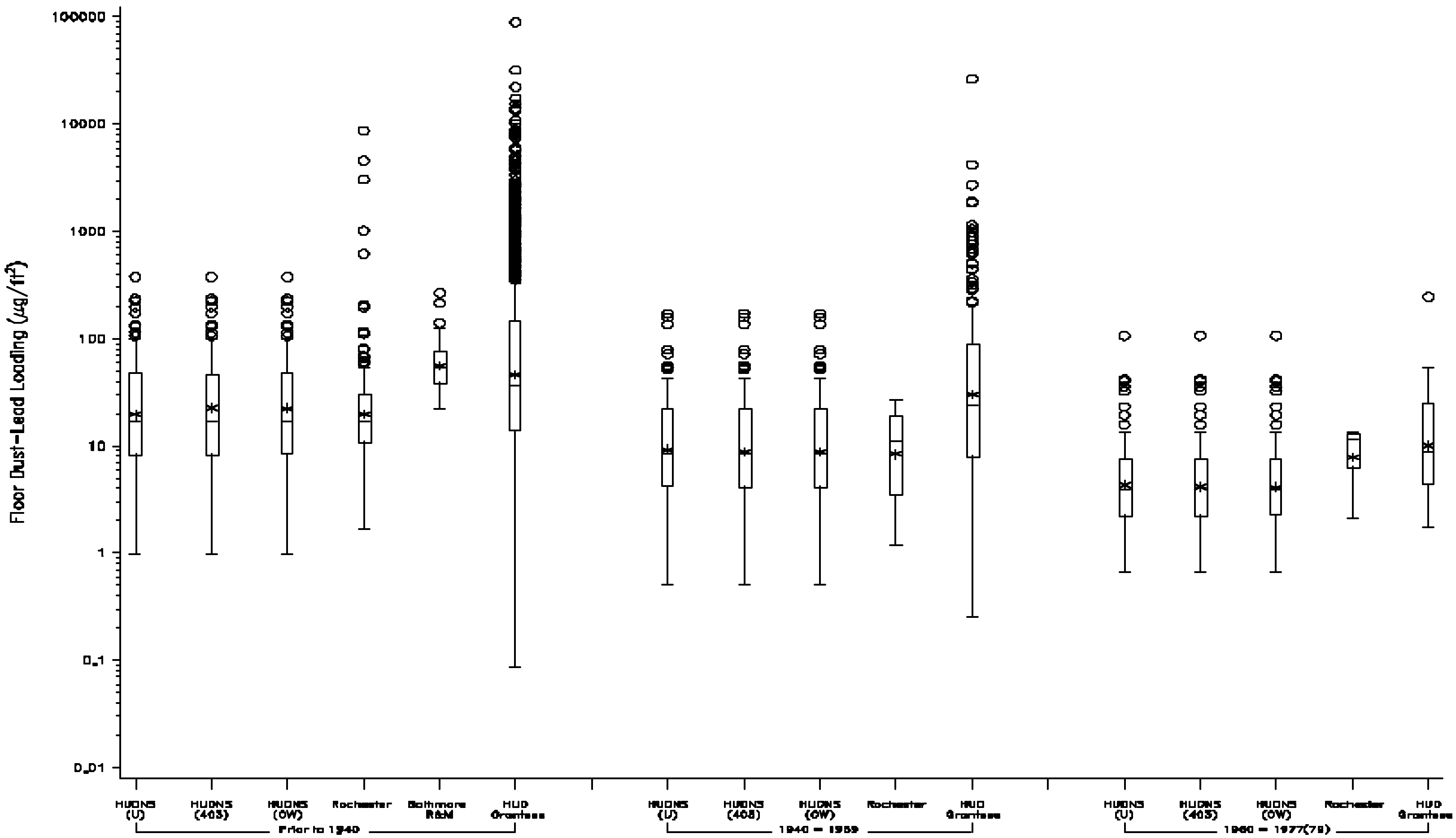

Figure 3-9. **Boxplots of Area-Weighted Average Pre-Intervention Floor Wipe Dust-Lead Loadings (µg/ft²) for Houses in the HUD National Survey, Baltimore R&M Study, Rochester Lead-in-Dust Study, and HUD Grantees Evaluation, by Age of House Category (pre-1979 only)**

(Note: Dust-lead loadings from the HUD National Survey and Baltimore R&M study have been converted from vacuum to wipe-equivalents using the methods documented in the §403 Risk Analysis report. See text for definitions of labels along the horizontal axis. Caution must be taken when categorizing houses in the Rochester study by age of house.)

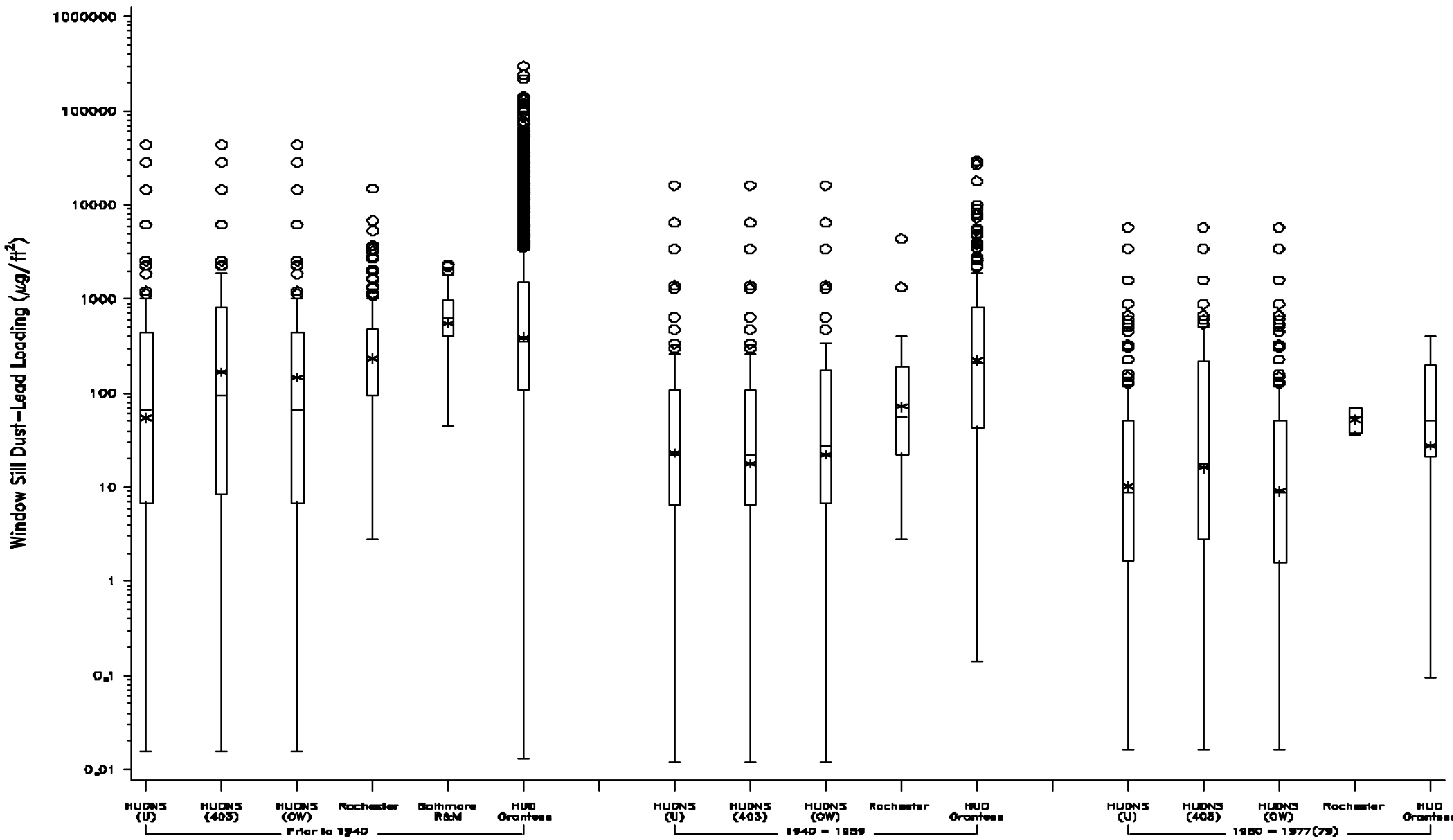

Figure 3-10. Boxplots of Area-Weighted Average Pre-Intervention Window Sill Wipe Dust-Lead Loadings (µg/ft²) for Houses in the HUD National Survey, Baltimore R&M Study, Rochester Lead-in-Dust Study, and HUD Grantees Evaluation, by Age of House Category (pre-1979 only)

(Note: Dust-lead loadings from the HUD National Survey and Baltimore R&M study have been converted from vacuum to wipe-equivalents using the methods documented in the §403 Risk Analysis report. See text for definitions of labels along the horizontal axis. Caution must be taken when categorizing houses in the Rochester study by age of house.)

Values of the statistics entering into the boxplots in Figures 3-9 and 3-10 are included within Tables 3-14 and 3-15. While not included in the figures, these tables include summary statistics for homes labeled as post-1979 (although the Rochester study units may not have actually been built in this time period, as mentioned in the previous paragraph). The post-1979 results labeled as "HUD National Survey (§403 RA)" represent surveyed homes built from 1960-1979 that contain no lead-based paint (Section 3.3.1.5 of the §403 risk analysis report).

3.2.1.3 <u>Calculating National Exceedance Percentages for Household Average Floor Dust-Lead Loading</u>. With respect to the national summaries of household average floor dust-lead loading presented in Section 3.2.1.1 above, it was desired to estimate the percentage of housing with average floor dust-lead loadings at or above specified thresholds (i.e., "exceedance percentage"), with separate estimates originating from data for each of the two national surveys (i.e., HUD National Survey and the interim NSLAH). This was done by fitting a lognormal distribution to the household average floor dust-lead loadings summarized in Section 3.2.1.1 and calculating the exceedance percentages based on this distribution.[9] If the household averages from the two surveys could each be considered a sample from their respective fitted lognormal distributions, with the probability of selection for the sample determined by the sampling weights, then the estimates based on these fitted distributions would be considered representative of actual percentages for the nation. The fitted lognormal distributions and the resulting exceedance percentage estimates are now presented for both surveys.

For both surveys, normal probability plots prepared on the log-transformed average floor dust-lead loadings indicated that a lognormal distribution did not adequately represent data in the upper tails of the distribution (i.e., typically the upper quartile). This was because the fitted distribution was heavily influenced by the considerable amount of data at the lower end of the distribution. Because it was necessary in this exercise to characterize the upper tail of the distribution as accurately as possible (due to calculating exceedance percentages from the distribution), the actual values of the data at the lower end of the distribution did not need to influence the fitted distribution to the extent that they were. Under these considerations, the procedure to fit a lognormal distribution was as follows:

- For values of P from 5 to 50 (in multiples of 5), the value of the log-transformed average floor dust-lead loading (call this value X) was identified for which P% of the (weighted) data fell below.

- For each value of P, log-transformed data values falling below the value X were considered to be *censored* at X. That is, rather than using these actual log-transformed data values, the procedure assumed that each of these values was somewhere at or below X.

[9] For the interim NSLAH, household averages calculated from data where no adjustment was made when below detection limits were used in this exercise.

Table 3-14. Descriptive Statistics of Area-Weighted Average Pre-Intervention Floor Wipe Dust-Lead Loadings for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis, the HUD National Survey, and Other Studies

Study	Approach/ Grantee	Area-Weighted Household Average Pre-Intervention Floor Dust-Lead Loading ($\mu g/ft^2$)								
		# Units with Data	Arith-metic Mean	Geo-metric Mean	Geo-metric Std. Dev.	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Houses Built Prior to 1940										
HUD National Survey	unweighted[1]	76	43.9	19.5	3.68	0.991	8.45	17.1	47.1	375
HUD National Survey	orig. weights[2]	76	47.9	22.4	3.65	0.991	8.84	17.7	79.7	375
HUD National Survey	§403 RA[3]	77	47.9	22.6	3.63	0.991	8.84	17.7	79.7	375
Baltimore R&M[4]		74	63.6	55.5	1.65	22.0	38.7	54.3	76.0	266
Rochester Lead-in-Dust		172	127	19.8	3.18	1.66	11.3	16.9	30.0	8660
HUD Grantees	Alameda Co.	138	118	30.6	5.40	0.250	10.3	31.0	97.7	3730
HUD Grantees	Baltimore	345	672	153	5.10	1.00	54.6	164	456	89100
HUD Grantees	Boston	71	222	55.4	5.11	1.00	16.0	35.0	151	2490
HUD Grantees	California	35	269	48.4	6.75	2.75	8.38	35.0	250	2650
HUD Grantees	Cleveland	173	209	34.7	6.30	1.00	9.50	31.0	121	8800
HUD Grantees	Massachusetts	146	147	31.7	5.03	0.521	11.9	26.5	83.1	4540
HUD Grantees	Minnesota	182	171	21.3	4.72	0.333	10.0	16.8	40.0	13800
HUD Grantees	New Jersey	26	511	215	4.19	10.5	134	239	513	4250
HUD Grantees	Rhode Island	123	197	44.2	4.68	2.00	16.4	38.7	106	6050
HUD Grantees	Wisconsin	214	183	28.4	6.77	0.400	7.26	18.5	99.5	2780
HUD Grantees	Milwaukee	262	254	30.7	4.42	1.50	11.0	26.3	71.0	31900
HUD Grantees	Chicago	144	60.7	25.6	3.92	0.200	10.7	25.4	62.4	668
HUD Grantees	New York City	375	470	50.0	5.93	0.0880	18.1	31.4	84.4	22200
HUD Grantees	Vermont	288	478	63.7	6.81	0.750	15.8	49.0	197	15500
HUD Grantees	All Grantees	2522	328	45.9	5.45	0.0880	13.7	36.1	145	89100
Houses Built From 1940 - 1959										
HUD National Survey	unweighted[1]	87	19.8	9.20	3.53	0.508	4.20	8.32	22.5	171
HUD National Survey	orig. weights[2]	87	18.1	8.74	3.34	0.508	4.07	7.81	22.4	171
HUD National Survey	§403 RA[3]	87	18.1	8.74	3.34	0.508	4.07	7.81	22.4	171
Rochester Lead-in-Dust[5]		19	11.8	8.36	2.61	1.21	3.54	11.1	19.2	26.9
HUD Grantees	Alameda Co.	19	153	32.1	7.15	2.00	5.75	17.0	157	909
HUD Grantees	Baltimore	43	494	120	9.13	0.250	39.5	197	648	4170
HUD Grantees	Boston	4	57.3	26.6	4.46	5.00	10.0	27.0	105	170
HUD Grantees	California	51	41.7	15.4	3.29	2.75	6.25	10.1	33.3	825
HUD Grantees	Massachusetts	5	55.5	46.5	1.93	22.5	30.0	39.8	70.3	115

Table 3-14. (cont.)

Study	Approach/ Grantee	Area-Weighted Household Average Pre-Intervention Floor Dust-Lead Loading ($\mu g/ft^2$)								
		# Units with Data	Arith-metic Mean	Geo-metric Mean	Geo-metric Std. Dev.	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
	Minnesota	1	149	149	--	149	149	149	149	149
Houses Built From 1940 - 1959 (cont.)										
HUD Grantees	Rhode Island	34	81.3	27.3	5.47	0.250	7.60	36.6	77.3	617
	Wisconsin	15	87.0	7.22	6.99	0.800	1.60	5.72	17.1	1050
	Milwaukee	5	14.0	6.78	4.14	1.50	2.25	4.88	22.5	38.8
	Chicago	5	5300	102	23.8	16.4	17.8	19.2	75.8	26400
	Vermont	31	38.4	26.4	2.23	8.00	15.0	17.8	45.5	219
	All Grantees	213	276	30.1	5.39	0.250	8.00	24.3	89.3	26400
Houses Built From 1960 - 1979 (1960 - 1977 for HUD Grantees)										
HUD National Survey	unweighted[1]	118	7.14	4.30	2.50	0.657	2.26	3.85	7.59	106
	orig. weights[2]	118	6.74	4.11	2.46	0.657	2.25	3.62	7.59	106
	§403 RA[3]	120	6.74	4.14	2.45	0.657	2.25	3.62	7.59	106
Rochester Lead-in-Dust[5]		4	9.65	7.84	2.40	2.13	6.38	11.6	12.9	13.2
HUD Grantees	Boston	1	18.8	18.8	--	18.8	18.8	18.8	18.8	18.8
	Cleveland	1	9.25	9.25	--	9.25	9.25	9.25	9.25	9.25
	New Jersey	16	32.6	13.6	3.70	1.75	6.58	10.0	34.6	245
	Wisconsin	6	4.42	4.01	1.61	2.40	2.50	3.84	5.93	8.02
	All Grantees	24	24.0	10.0	3.14	1.75	4.45	8.88	24.6	245
Houses Built After 1979 (After 1977 for HUD Grantees)										
HUD National Survey (§403 RA)[3]		28	4.16	3.14	2.06	1.06	1.76	2.84	5.66	12.9
Baltimore R&M[4]		16	10.9	9.97	1.55	4.48	7.13	10.5	14.7	17.4
Rochester Lead-in-Dust[5]		10	37.2	15.0	3.34	3.48	5.57	16.8	21.2	250
HUD Grantees	Minnesota	1	32.4	32.4	--	32.4	32.4	32.4	32.4	32.4
	Rhode Island	3	984	838	2.00	440	440	763	1750	1750
	All Grantees	4	746	372	2.00	32.4	236	602	1260	1750

[1] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized without weighting by sample weights.
[2] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized by weighting each average by the original sample weights assigned in the survey.
[3] Area-weighted average dust-lead loadings, as calculated in Chapter 3 of the §403 risk analysis, are summarized by weighting each average to reflect the 1997 U.S. housing stock and imputing averages for units with missing data.
[4] BRM dust-lead loadings are converted to wipe-equivalent loadings prior to summary in this table.
[5] Some houses in this housing age category may belong to an earlier age category, as some houses may have actually been built earlier than the year specified within the study's database.

Table 3-15. Descriptive Statistics of Area-Weighted Average Pre-Intervention Window Sill Wipe Dust-Lead Loadings for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis, the HUD National Survey, and Other Studies

Study	Approach/ Grantee	Area-Weighted Household Average Pre-Intervention Window Sill Dust-Lead Loading ($\mu g/ft^2$)								
		# Units with Data	Arith-metic Mean	Geo-metric Mean	Geo-metric Std. Dev.	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Houses Built Prior to 1940										
HUD National Survey	unweighted[1]	71	1610	54.7	19.6	0.0155	7.05	67.1	442	43700
	orig. weights[2]	71	2060	146	16.8	0.0155	35.6	198	1220	43700
	§403 RA[3]	77	2060	168	16.7	0.0155	35.6	198	1220	43700
Baltimore R&M[4]		74	751	555	2.41	44.0	399	628	989	2330
Rochester Lead-in-Dust		164	613	234	3.67	2.85	95.3	223	475	14900
HUD Grantees	Alameda Co.	148	767	138	9.34	0.0016	44.7	164	566	19700
	Baltimore	347	7070	1600	7.69	<0.0001	451	1690	6140	220000
	Boston	71	5150	577	7.89	14.0	135	425	2410	106000
	California	35	1530	506	5.70	28.0	159	524	2440	9630
	Cleveland	172	4120	233	16.9	<0.0001	63.8	270	876	241000
	Massachusetts	146	1770	322	5.81	2.60	93.8	296	1090	63400
	Minnesota	177	3320	282	6.30	5.66	71.0	190	945	300000
	New Jersey	26	1080	328	5.08	21.3	99.6	276	1170	8450
	Rhode Island	123	5780	816	6.49	12.0	192	709	2500	132000
	Wisconsin	211	3020	294	8.91	0.0008	81.4	258	1090	142000
	Milwaukee	261	3610	543	6.89	1.00	127	413	2110	88000
	Chicago	140	1630	259	5.78	3.02	85.0	267	852	50500
	New York City	368	1530	258	5.51	0.320	95.6	175	543	57100
	Vermont	269	3860	272	15.9	<0.0001	72.0	275	1340	98100
	All Grantees	2494	3480	391	8.22	<0.0001	106	351	1470	300000
Houses Built From 1940 - 1959										
HUD National Survey	unweighted[1]	79	430	23.1	11.4	0.0118	6.47	21.7	107	16100
	orig. weights[2]	79	285	17.9	10.5	0.0118	6.47	19.1	107	16100
	§403 RA[3]	87	285	22.0	10.7	0.0118	6.47	19.1	107	16100
Rochester Lead-in-Dust[5]		18	399	72.0	6.16	2.83	23.0	56.0	194	4390
HUD Grantees	Alameda Co.	20	152	47.7	8.04	0.140	14.5	71.1	260	580
	Baltimore	43	4310	1330	5.39	33.0	256	1600	4820	29400
	Boston	4	382	150	5.20	39.4	39.6	160	724	1170
	California	42	395	203	3.41	11.0	89.9	190	565	1850

Table 3-15. (cont.)

Study	Approach/ Grantee	Area-Weighted Household Average Pre-Intervention Window Sill Dust-Lead Loading ($\mu g/ft^2$)								
		# Units with Data	Arith-metic Mean	Geo-metric Mean	Geo-metric Std. Dev.	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
	Massachusetts	4	142	59.7	8.20	2.79	47.9	123	237	321
	Minnesota	1	289	289	--	289	289	289	289	289
Houses Built From 1940 - 1959 (cont.)										
HUD Grantees	Rhode Island	34	1520	416	7.53	0.500	144	617	1120	9970
	Wisconsin	16	497	148	4.24	24.0	47.4	105	338	4750
	Milwaukee	6	552	140	7.09	18.0	28.8	123	797	2220
	Chicago	5	835	449	3.84	111	120	521	1170	2250
	Vermont	30	52.4	40.4	2.08	7.00	31.0	45.0	45.0	212
	All Grantees	205	1350	222	4.94	0.140	45.0	205	814	29400
Houses Built From 1960 - 1979 (1960 - 1977 for HUD Grantees)										
HUD National Survey	unweighted[1]	95	190	10.3	13.3	0.0164	1.68	8.69	51.3	5790
	orig. weights[2]	95	184	9.10	14.5	0.0164	2.05	16.6	217	5790
	§403 RA[3]	120	184	16.2	14.6	0.0164	2.05	16.6	217	5790
Rochester Lead-in-Dust[5]		4	54.4	52.3	1.38	36.2	40.0	55.2	68.7	70.7
HUD Grantees	Boston	1	289	289	--	289	289	289	289	289
	Cleveland	1	409	409	--	409	409	409	409	409
	New Jersey	20	59.8	12.9	63.1	<0.0001	17.8	29.6	72.7	333
	Wisconsin	6	209	153	2.90	21.0	105	240	289	359
	All Grantees	28	112	27.8	39.3	<0.0001	20.9	44.4	179	409
Houses Built After 1979 (After 1977 for HUD Grantees)										
HUD National Survey (§403 RA)[3]		28	83.0	8.17	9.94	0.0164	2.58	8.11	57.8	1590
Baltimore R&M[4]		16	50.8	45.6	1.65	20.6	27.1	52.6	66.5	85.9
Rochester Lead-in-Dust[5]		10	134	113	1.95	26.9	75.7	125	159	320
HUD Grantees	Minnesota	1	2350	2350	--	2350	2350	2350	2350	2350
	Rhode Island	1	816	816	--	816	816	816	816	816
	All Grantees	2	1580	1390	--	816	816	1580	2350	2350

[1] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized without weighting by sample weights.
[2] Area-weighted average dust-lead loadings, as reported in the HUD National Survey but converted to wipe-equivalent loadings, are summarized by weighting each average by the original sample weights assigned in the survey.
[3] Area-weighted average dust-lead loadings, as calculated in Chapter 3 of the §403 risk analysis, are summarized by weighting each average to reflect the 1997 U.S. housing stock and imputing averages for units with missing data.
[4] BRM dust-lead loadings are converted to wipe-equivalent loadings prior to summary in this table.
[5] Some houses in this housing age category may belong to an earlier age category, as some houses may have actually been built earlier than the year specified within the study's database.

- For each value of P, a normal distribution was fitted to the log-transformed data, taking into account the censoring of the lower P% of the data and the sample weights, using the LIFEREG procedure in the SAS® System.

- The value of P (and its corresponding cut-off X) was identified that resulted in the best fit for normality in the upper tail of the distribution (based on review of normal probability plots). The exceedance percentages were estimated based on this final distribution, using normal probability theory.

This procedure was applied separately to HUD National Survey data and interim data from the NSLAH. Exceedance percentages were estimated for each of the following floor dust-lead loading thresholds: 5, 10, 20, 30, 40, and 50 $\mu g/ft^2$.

Figure 3-11 contains the fitted distributions based on the HUD National Survey data (top plot) and the interim NSLAH data (bottom plot). (The top plot is labeled "Section 403 risk analysis" as it reflects sample weights adjusted for the 1997 housing stock and dust-lead loadings converted to wipe-equivalents, both done within the §403 risk analysis.) Each plot contains a bar chart of the observed data, onto which the fitted lognormal distribution curve is superimposed. Note that the same floor dust-lead loading (horizontal) axis is used for both plots, so that the two plots can be directly compared. As can be noted in this figure (and which was seen in the summaries in Section 3.2.1.1), the distribution based on the interim NSLAH data covers a considerably lower range compared to the distribution based on the HUD National Survey data used in the §403 risk analysis. Thus, the estimated exceedance percentages for each of the six thresholds, also annotated within each plot, are considerably lower based on the interim NSLAH data, especially as the threshold increases.

Each estimated exceedance percentage within Figure 3-11 is accompanied by an approximate 95% confidence interval on the number of homes in the U.S. housing stock that exceeds the threshold. These intervals were calculated based on the estimated total number of housing units in the housing stock, as determined by the sum of the sampling weights for the given survey (which is specified within each plot).

In Figure 3-11, the distribution based on the HUD National Survey data used in the §403 risk analysis was determined by censoring data values below 3.81 $\mu g/ft^2$ (i.e., the bottom 40 percent of the data, taking into account the sample weights). The distribution based on the interim NSLAH data was determined by censoring data values below 0.2025 ug/ft^2, which corresponds to the bottom 20 percent of the observed weighted distribution, including negative values.

For both surveys, the estimated exceedance percentages specified within Figure 3-11 for household average floor dust-lead loading, based on the fitted lognormal distribution, are also included within Table 3-16 (columns 2 and 4) for the same six thresholds. Also included in Table 3-16 (columns 3 and 5) are estimated exceedance percentages that were determined solely
by the proportion of total sampling weights in the survey that corresponded to surveyed units

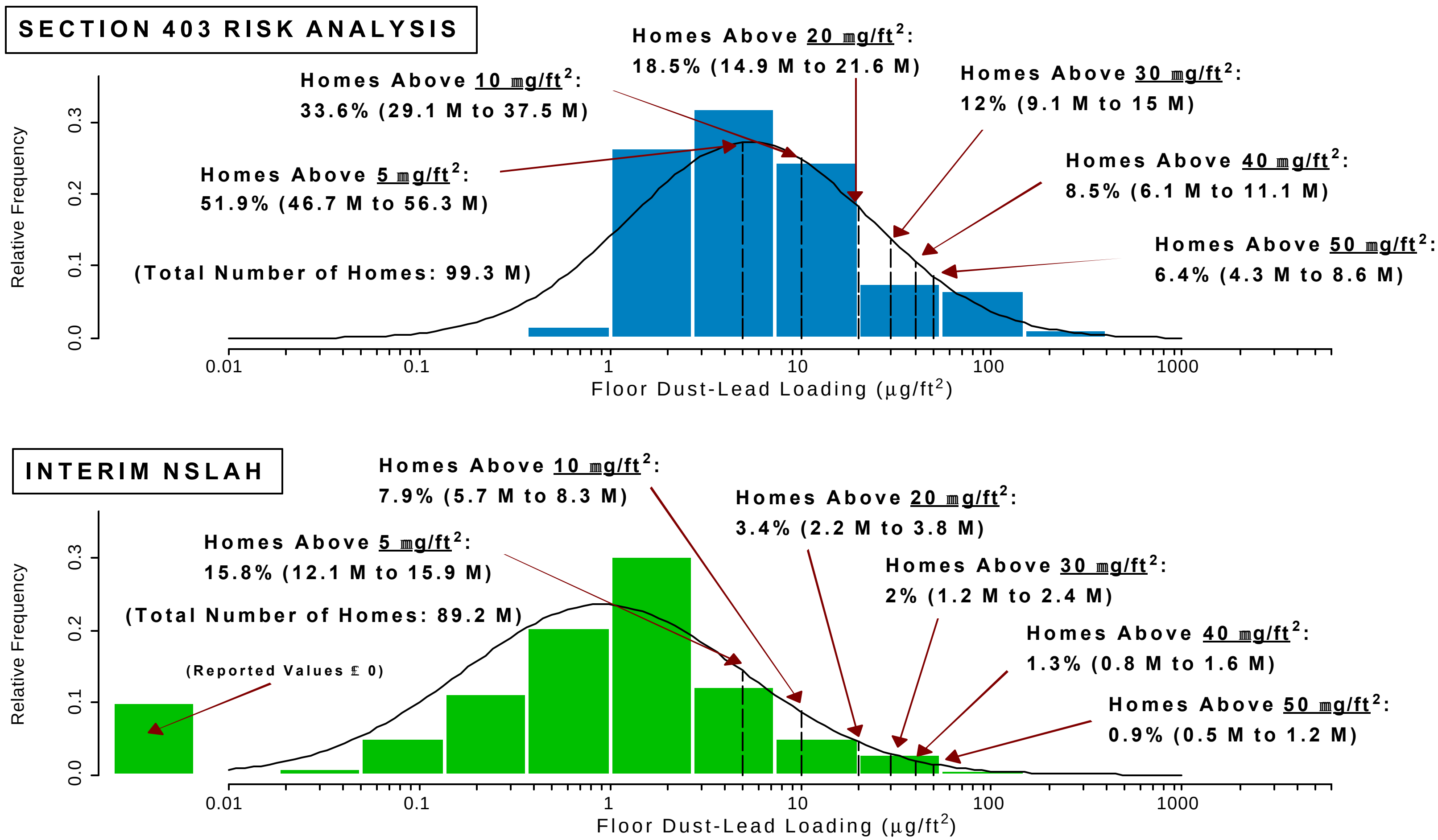

Figure 3-11. Estimated Distribution of Household Average Floor Dust-Lead Loading in the Nation's Housing Stock, and Corresponding Estimates of the Percentage of Homes Exceeding Specified Thresholds (with 95% Confidence Intervals on the Corresponding Number of Homes, in Millions), Based on Data from the HUD National Survey (top plot) and the Interim NSLAH (bottom plot)

Note: The estimated exceedance percentages are calculated based on the fitted distribution (solid curve).

Table 3-16. Estimated Percentages of 1997 U.S. Housing Exceeding Specified Thresholds of Household Average Dust-Lead Loading

Dust-Lead Loading Threshold ($\mu g/ft^2$)	§403 Risk Analysis – Based on Data from the HUD National Survey (n = 284)		Data from the Interim NSLAH (n = 706)	
	Based on the Fitted Lognormal Distribution (i.e., the curve in Figure 3-11)	Based on the Weighted Observed Data (i.e., the bar chart in Figure 3-11)	Based on the Fitted Lognormal Distribution (i.e., the curve in Figure 3-11)	Based on the Weighted Observed Data (i.e., the bar chart in Figure 3-11)
5	51.9%	51.1%	15.8%	13.2%
10	33.6%	30.6%	7.9%	7.2%
20	18.5%	15.6%	3.4%	4.0%
30	12.0%	11.9%	2.0%	2.0%
40	8.5%	9.6%	1.3%	1.4%
50	6.4%	8.3%	0.9%	1.2%

Note: Data are imputed for those surveyed units with missing data prior to calculating the above statistics (3 observations in the HUD National Survey and 9 observations in the interim NSLAH had imputed data). The estimates based on the weighted observed data are simple weighted percentiles that do not originate from a fitted distribution.

whose household average floor dust-lead loadings exceeded the given threshold (i.e., information from the bar charts within Figure 3-11). These results are included to evaluate the similarity between the lognormal-based estimates and those generated from an approach that uses only the observed data without an underlying distribution assumption. As Table 3-16 shows, the lognormal-based estimates are slightly lower for the lower thresholds and slightly higher for the higher thresholds, while the two approaches yield nearly equivalent estimates at the threshold of 30 $\mu g/ft^2$. It should be noted that the lognormal-based estimates for the exceedance percentages (which were also portrayed in Figure 3-11) should be used when making inferences on the nation's housing stock.

3.2.1.4 Interpreting the Observed Differences with Other Studies. In order to make proper interpretations from the results portrayed in this subsection, in particular why differences exist between the studies, one must be aware of how the housing selection procedure and sample collection and analysis procedures differ between the studies and can contribute to the differences observed in the boxplots and tables. For the studies highlighted in the §403 risk analysis report, this information was summarized in Tables 3-3a through 3-3f of that report. Some of the differences among these studies that may contribute to differences in the reported data are as follows:

- All non-control housing units in the Baltimore R&M study, approximately 88 percent of units selected in the HUD Grantees evaluation, and at least 84 percent of the Rochester study units were built prior to 1941. In contrast, only 27 percent of the housing units in the HUD National Survey were built prior to 1940.

- The neighborhoods surveyed within the Baltimore R&M study and HUD Grantees evaluation had a high prevalence of homes with lead-based paint hazards, along with a history of children with elevated blood-lead concentrations and/or considered at high-risk for lead poisoning.

- The HUD National Survey targeted occupied permanent housing throughout the 48 contiguous states. The units were selected via a statistically-based sampling design to represent the national housing stock built prior to 1980. Excluding two grantees from California, the HUD Grantees (as well as the Rochester and Baltimore R&M studies) sampled housing from the Northeast and Midwest census regions. Approximately two out of every five homes sampled in the HUD National Survey were from the South.

- For the HUD Grantees evaluation, 28 percent of the homes were single-family buildings (16 percent were single-family detached, and 12 percent were single-family attached, or rowhouses). All homes in the R&M intervention group within the Baltimore R&M study were urban rowhouses (single-family attached). Eighty percent of the homes in the HUD National Survey were single-family dwellings.

- From 8 percent to 67 percent of the dwelling units for any one Grantee were vacant prior to sampling. Out of the 5,265 dwelling units in total that were enrolled as of January 1999, 1524 units were vacant prior to pre-intervention sampling. Overall vacancy rate was 29 percent for the Evaluation. On the other hand, the HUD National Survey contained dwelling units which were permanent and occupied, with the potential for containing children.

- The dates of environmental sampling were 11/89-3/90 for the HUD National Survey, 12/93-1/99 for the HUD Grantees evaluation (pre-intervention), 8/93-11/93 for the Rochester study, and 3/93-11/94 for the Baltimore R&M study. Therefore, the HUD National Survey performed sampling roughly three years before each of the other studies and during the late fall and winter months.

Section 3.1 discussed differences in approaches and methods between the HUD National Survey and the NSLAH that could impact observed differences in the reported data.

3.2.1.5 Conclusions of the Dust-Lead Data Comparisons. The following conclusions could be made upon review of the dust-lead loading summaries within Tables 3-4 through 3-16 and Figures 3-1 through 3-11:

- For both floors and window sills, the interim NSLAH data are considerably lower than that reported in the §403 risk analysis (and based on the HUD National Survey data), as well as for all other sources of data available to the risk analysis. Household average floor dust-lead loadings had a median of less than 2.0 µg/ft^2 across the interim NSLAH data, while household average window sill dust-lead loadings had a median of approximately 12.0 µg/ft^2. Approximately two-thirds of the floor-dust samples and one-third of the window sill-dust samples had lead measurements below the detection limit in the interim NSLAH. Further investigation is necessary to determine the reasons for such low dust-lead loadings in the interim NSLAH.

- Compared to the other lead exposure studies whose data were considered in the §403 risk analysis (e.g., Rochester study, Baltimore R&M study, HUD Grantees evaluation), geometric mean dust-lead loadings tended to be lower in the HUD National Survey. However, all of these studies had similar ranges of observed dust-lead loading data. This suggests that 1) the conversions to wipe-equivalent dust-lead loadings performed on the HUD National Survey data in the §403 risk analysis did not lead to extreme adjustments overall, and 2) there is not sufficient evidence that data from the HUD National Survey are higher than what is representative of the 1997 housing stock simply because it was performed some years earlier.

- The importance of housing age is evident in the summaries within the four housing age categories. Older housing is more likely to contain higher average dust-lead loadings compared to newer housing. However, within an age category, the summaries were quite consistent across studies (with the exception of the interim NSLAH).

- The percentage of housing units with average floor dust-lead loadings that exceed 50 µg/ft^2 (i.e., the proposed floor dust-lead standard) was 6.4% based on data used in the §403 risk analysis, and 0.9% based on interim data from the NSLAH.

3.2.2 Characterizing Soil-Lead Concentrations

This subsection summarizes observed soil-lead concentrations in the HUD National Survey and how these data were used to characterize soil-lead levels in the §403 risk analysis, and compares these summaries with summaries of the interim NSLAH data (Section 3.1), as well as data for 22 other studies that characterized soil-lead concentrations in urban areas prior to any lead abatement. These 22 studies include the three recent studies included in the dust-lead data summaries of the previous section (Baltimore R&M study, Rochester study, and HUD Grantees evaluation) and other studies dating to the early 1970s (e.g., Omaha, Charleston). Sampling and laboratory protocols for the 22 additional studies are summarized in Table 3-17. The soil-lead data summaries for these 22 studies were either calculated directly from the available data set or culled from the published scientific literature.

Household mass-weighted average soil-lead concentration for a specific portion of the yard was the basis for the comparisons made in this section. This average was calculated by weighting the result for each soil sample taken at that location by the sample's mass. If this

Table 3-17. Information on Soil Sampling and Analysis Protocols for Studies Whose Soil-Lead Data Were Compared to Results from the §403 Risk Analysis and the HUD National Survey

Study [Reference]	Soil Sampling and Analysis Details	Soil-Lead Parameter(s) Used in This Section for Comparison to HUD National Survey
Baltimore R&M (USEPA, 1996c)	1993-94. Three 0.5" core samples per composite, taken from randomly determined areas along the dripline using a 6" stainless steel recovery probe and collected into a polysterene liner. Samples were sieved and homogenized and digested using SW 846-3015 and SW 846-3051. GFAA (SW 846-7421) laboratory analysis method. Only data for occupied units were used.	Soil-lead concentration for each composite sample (one composite sample per housing unit, taken from the dripline).
Baltimore Urban Garden Soil (Mielke et al., 1983)	1982. Samples were from garden soil in random locations within a 30-mile radius of downtown Baltimore. Samples were air-dried and sieved with a 2mm stainless steel mesh screen and digested in nitric acid. Extracts were filtered and analyzed using a Varian atomic absorption spectrophotometer with deuterium background correction.	Soil-lead concentration for each collected sample.
3-City (Baltimore, Boston, Cincinnati) (USEPA, 1996a) (Also known as the Urban Soil Lead Abatement Demonstra-tion Project)	Only round 1 (pre-abatement) measurements were used. <u>Baltimore/Boston</u>: Only results for the top 2 cm of a 15 cm core sample were considered. <u>Cincinnati</u>: Soil samples were collected within neighborhoods, as well as within the yards of surveyed housing units.	<u>Baltimore</u>: Yard-wide average for a unit, equal to the unweighted arithmetic average of the unit's average dripline, average mid-yard and average boundary soil-lead concentrations within a property (set to missing if any of these measurements were missing). The location averages were also summarized. <u>Boston</u>: Yard-wide average for a unit, equal to the average across all samples associated with that unit. <u>Cincinnati</u>: Yard-wide average for a unit, equal to the unweighted arithmetic average of average building and average play area soil-lead concentrations for the unit (set to missing if either of these measurements are missing). These and other location averages were also summarized.
Boston Brigham and Women (Rabinowitz et al., 1985)	3 samples were collected one meter apart and at least 3 meters from any road structure (preference given to obvious play areas). These samples were composited prior to analysis. Soil sampling occurred twice: when the resident child of interest was 18 and 24 months of age. Laboratory analysis method was atomic absorption spectrophotometry (AAS).	Soil-lead concentration for each unit, equal to the unweighted arithmetic average of soil-lead concentrations for composite samples taken at the 18 and 24 month visits.
CAP Study (USEPA, 1996b)	1990. Soil samples taken from Denver units that were abated in 1989 during the HUD Abatement Demonstration Study. Samples were collected from the dripline, entryway, and remote areas of the yard with a soil recovery probe (1" diameter liner and 12" core sampler). At each location, a composite sample consisted of 3 cores, each 0.5" in depth. The sample preparation method was EPA SW846 Method 3050 (included use of nitric acid and hydrogen peroxide for digestion). The laboratory analysis method was ICP-AES.	Soil-lead concentration for the dripline, entryway, and remote areas of the yard. (One composite sample per location per unit.)

Table 3-17 (cont.)

Study [Reference]	Soil Sampling and Analysis Details	Soil-Lead Parameter(s) Used in This Section for Comparison to HUD National Survey
California (Sutton et al., 1995)	1987-91. Older units in Oakland, Los Angeles, and Sacramento. Composite soil samples (of 4 subsamples) were collected at each of the front, side, and rear yards. In addition, units in Oakland and Los Angeles had a composite soil sample collected from a secondary structure (e.g., garage) and a single sample collected from rain drains. All but rain drain samples were composites. Samples were < 1" in depth and were collected using a trowel (visible paint chips removed first). The laboratory analysis method was AAS.	Soil-lead concentration for each collected sample (from 3 to 5 per unit).
Cincinnati Longitudinal (Bornschein et al., 1985a; 1986; Que Hee et al., 1985)	1980-87. Surface scrapings rather than soil cores were taken. Laboratory analysis method was AAS. Enrolled expectant mothers residing in areas with a history of child residents with elevated blood-lead concentrations.	Not determined[1].
Cincinnati Roadside (Tong, 1990)	1990. Samples were collected near highways, boulevards, and cul-de-sacs in two neighborhoods (not industrial areas nor poor neighborhoods with deteriorated housing) within the Greater Cincinnati Metropolitan District. Samples were from a depth of 0-5cm and were analyzed using a Leeman plasma spectrophotometer with background correction.	Not determined[1].
Charleston (Galke et al., 1975)	1973. Soil samples taken from a child's primary play area. Laboratory analysis method was AAS.	Not determined[1].
Corpus Christi (Harrison, 1987)	1984. Samples were collected from parks, schools, and roadside embankments within the city limits of Corpus Christi, Texas from vegetated, non-sandy soil. The top 2 cm of soil was sampled with a Teflon knife. The laboratory analysis method was AAS.	Soil-lead concentration for each collected sample.
I-880 (Alameda County) (Teichmean et al., 1993)	1990. Samples were collected from homes, parks, playgrounds, and public housing developments within one mile east or west of I-880. The top 0.50" to 0.75" of soil was sampled. The laboratory analysis method was AAS.	Soil-lead concentration for each collected sample.
HUD Abatement Demonstra-tion Study (USHUD, 1991)	Dripline samples were taken from 1 to 3 feet from an exterior wall and were composites of 5 subsamples. Soil sampling (and compositing) occurred twice: prior to and following lead-based paint abatements performed in this demonstration. The laboratory analysis method was AAS.	Soil-lead concentration for each dripline composite sample (one composite sample per housing unit collected at pre-intervention, and one sample per unit collected at post-intervention)
HUD Grantees Evaluation (USHUD, 1998)	1994-97. Pre-Intervention phase only. From 5-10 core samples were taken at 0.5-1" depths at a given location and composited. Locations were the dripline (samples taken from all sides of the unit, 2' from foundation and 2' from each other) and play areas (samples collected along x-shaped grids at least 1' from each other).	Yard-wide average for a unit, equal to the unweighted arithmetic average of dripline and play area soil-lead concentrations within a unit (set to missing if either of these measurements were missing).
Maine Urban (Krueger et al., 1989)	1988. Samples collected from units at least 30 years of age and from parks/playgrounds in Portland, Maine. A single composite sample, consisting of 4 cores taken 2' from the foundation, was associated with each housing unit. Laboratory analysis method was AAS.	Soil-lead concentration for each composite sample (housing units) and each sample collected from parks/playgrounds.

Table 3-17 (cont.)

Study [Reference]	Soil Sampling and Analysis Details	Soil-Lead Parameter(s) Used in This Section for Comparison to HUD National Survey
Milwaukee (Pendleton)	Soil samples collected from perimeter and play areas at each housing unit.	Yard-wide average for a unit, equal to the unweighted arithmetic average of perimeter and play area soil-lead concentrations (set to missing if either of these measurements are missing).
Minneapolis Clean-Up (Mielke et al., 1992)	Only pre-cleanup data were considered. Deep scrape samples were taken at a depth of 2.5 cm, air-dried and sieved with a 2 mm stainless steel mesh screen, and digested in nitric acid. Extracts were filtered and analyzed using a Varian atomic absorption spectrophotometer with deuterium background correction.	Not determined[1].
Minnesota (Schmitt et al., 1988; Mielke et al., 1989)	1986-87. Only results for St. Paul and Minneapolis were considered (except results labeled "Whole Study" also included Duluth, Rochester, St. Cloud and rural areas). Foundation samples were taken within 1.5 m of building. Yard samples (front, side, and back) were taken at the midpoint of the yard and at least 1.5 m from the foundation. Street samples were taken within 1.5 m of a curb. Samples were from the top 2 cm of soil. The laboratory analysis method was ICP-AES.	Soil-lead concentration for each collected sample.
New Orleans (Mielke, 1995; 1993)	1983. Samples taken from residential neighborhoods within 283 census tracts in the New Orleans metropolitan area. Foundation samples were taken within 1 m of a house. Streetside samples were taken from within 1 m of a street. Open area samples were from vacant lots or parks. The laboratory analysis method was AAS with deuterium background correction.	Soil-lead concentration for each collected sample.
New Haven, Connecticut (Stark et al., 1982)	1974-77. Samples (5-10 g) collected from homes of children who lived at the same address for at least one year. Only the top 0.5" of soil was analyzed.	Not determined[1].
Omaha (Angle et al., 1979)	1971-77. Soil core samples (2" depth) self-selected from halfway between the building and lot line on four sides of the selected units.	Yard-wide average for a unit, equal to the arithmetic average soil-lead concentration across all collected samples at the unit.
Rochester Lead-In-Dust (USHUD, 1995a; Lanphear et al., 1996a)	1993. Two composite samples, one from the dripline (12 samples per composite) and one from play areas (8-10 samples per composite). Core samples were taken at a depth of 0.5". Composites were mixed and sieved into fine and coarse fractions and analyzed separately. Digestion method was SW 846-3050, and the laboratory analysis method was FAA (method 239.1). Total soil-lead concentrations were computed as 0.25*Fine Soil Fraction + 0.75*Coarse Soil Fraction (see Appendix E).	Yard-wide average for a unit (for both total soil and fine soil only), equal to the unweighted arithmetic average of the unit's dripline and play area soil-lead concentrations (set to missing if either of these measurements was missing). The soil-lead concentration for the dripline sample at each unit was also summarized (for both total soil and fine soil only).
Washington, DC (Elhelu et al., 1995)	Housing units were randomly selected from each of the 8 wards of Washington, DC. Soil samples were collected from unpaved front yards approximately 1 m from the unit and at a depth of 15cm. Average dwelling distance from the road was 4.5 m. Fine soil samples were analyzed with a Perkin Elmer 2100 Atomic Absorption Spectrophotometer, with one result associated with each surveyed unit.	Soil-lead concentration for each collected sample (i.e., each housing unit).

[1] Most likely soil-lead concentration for each collected sample.

average could not be calculated for a given study due to insufficient data, then alternative statistics were calculated. For example, if mass weights were not available, the arithmetic average soil-lead concentration was instead calculated.

When possible, a yard-wide average soil-lead concentration was calculated in a manner that attempted to be consistent with the §403 risk analysis. This involved taking a weighted arithmetic average of the soil-lead concentrations reported at the dripline, unit entryway, and remote areas of the yard, with remote concentrations weighted twice as much as the dripline and entryway concentrations. (When only one of the dripline or entryway concentrations was available at a housing unit, the yard-wide average was the unweighted arithmetic average of that one concentration and the remote soil-lead concentration.) Thus, the yard-wide average was essentially an arithmetic average of two measures: the average soil-lead level at the dripline and unit entryway (i.e., "near" the housing unit) and the soil-lead level at a remote area of the yard (i.e., "far" from the housing unit). It was assumed that "play areas" represented remote areas of the yard. Imputed data values replaced missing values for a housing unit in the §403 risk analysis summaries, where imputation methods discussed in Section 3.3.1.1 of the §403 risk analysis report were used.

3.2.2.1 Data Summaries for the §403 Risk Analysis Versus the Interim NSLAH. Descriptive statistics of yard-wide average soil-lead concentrations as calculated in the §403 risk analysis using the HUD National Survey data are presented in this subsection as they compare with the same statistics calculated on interim data for 706 housing units in the NSLAH. Note that these statistics reflect the sampling weights used in the §403 risk analysis and the interim NSLAH sample weights, thereby allowing these summaries to be nationally representative of the 1997 housing stock. In addition, the interim NSLAH summaries do not include any data that may have been imputed within the revised §403 risk analysis when missing data for key parameters were encountered for a housing unit.

As in the dust-lead loading summaries (Section 3.2.1.1), the interim NSLAH summaries include imputed values of yard-wide average soil-lead concentration for those housing units having no reported soil-lead concentration data. As discussed in Appendix C, the imputation method involved imputing values for average dripline/entryway soil-lead concentration and for average mid-yard soil-lead concentration, then averaging these two imputed values together. If data existed for one of the two locations but not the other, the yard-wide average for that unit equaled the average soil-lead concentration at the location represented by the available data. Appendix C also gives the imputed data values and how they were assigned to housing units. Summaries of the interim yard-wide average soil-lead concentration data from the interim NSLAH excluding any imputed data can be found in Appendix D2.

Also, in the same manner as the dust-lead loading summaries (Section 3.2.1.1), Appendix D2 presents soil-lead concentration summaries for the interim NSLAH under five different approaches (including data censoring) to handling sample results that were below the detection limit. The summaries in this subsection were calculated under two of these approaches:

- making no adjustment to not-detected data values

- replacing not-detected data values with one-half of the detection limit.

These two approaches, the same two used in the dust-lead loading data summaries in Section 3.2.1.1, were included together in the summary tables to illustrate the impact that any one approach has on the characterized distribution of yard-wide average soil-lead concentration.

National comparisons

Table 3-18 presents descriptive statistics of yard-wide average soil-lead concentrations for the 1997 national housing stock. These results indicate that only a slight downward shift in the distribution of soil-lead concentrations was observed from the §403 risk analysis to the interim NSLAH data. (e.g., a decline in the geometric mean from 62 µg/g to approximately 53 µg/g). This decline was much smaller than that observed for dust-lead loadings.

Boxplots of the data distributions presented in Table 3-18 are found in Figure 3-12. When not-detected data in the NSLAH were replaced by one-half of the detection limit, the observed distribution of yard-wide average soil-lead concentration appears similar to what was characterized in the §403 risk analysis. Appendix D2 contains tabular summaries and boxplots after excluding imputed data values.

Table 3-18. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations for Households, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data

Study	How Not-Detected and Negative Data were Handled	Yard-Wide Average Soil-Lead Concentration (µg/g)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
§403 Risk Analysis (HUD Natl. Survey)		284	235	61.9	4.46	4.63	21.3	49.2	142	7030
Interim NSLAH[3]	No adjustment	689	200	53.0	5.09	0.00	16.6	41.8	158	9270
	Replaced by LOD/2	706	200	52.6	4.73	4.62	16.8	41.4	158	9270

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no soil-lead concentration data. The method for imputation is presented in Appendix C.
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

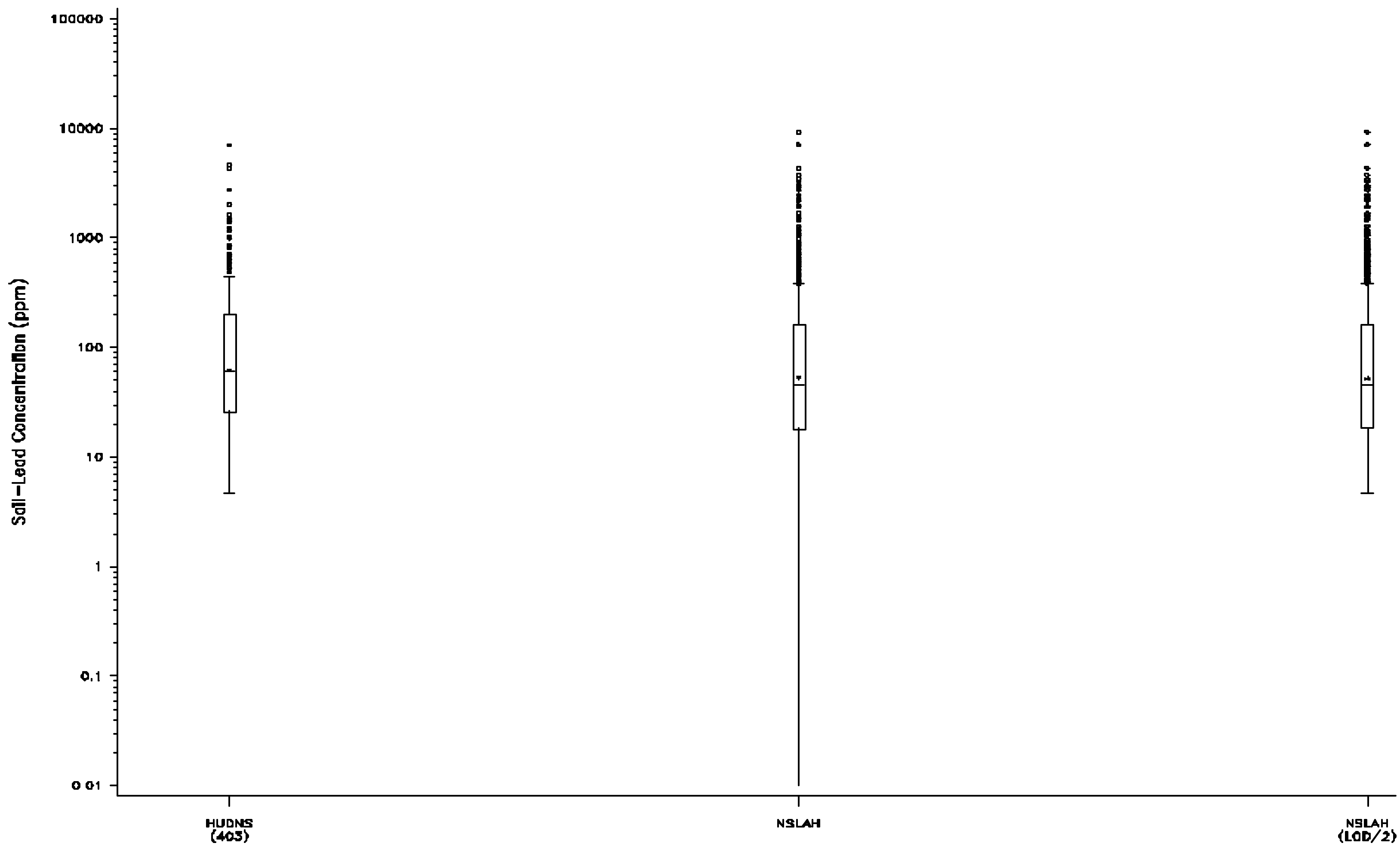

Figure 3-12. Boxplots of Yard-Wide Average Soil-Lead Concentrations (µg/g) As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Boxplots include imputed data but not negative or zero values.)

The detection limit for soil-lead concentrations in the interim NSLAH ranged from 7.2 to 12.4 µg/g, with a mean (and median) of 9.9 µg/g. Of those soil samples in the interim NSLAH with soil-lead concentrations reported, approximately 22% (covering approximately 38% of housing units reporting soil-lead concentrations) had soil results below the detection limit.

In addition to these data summaries that are based solely on the observed data and the sampling weights, it was desired to characterize the national distribution of yardwide average soil-lead concentration in such a way that the percentage of housing where this average exceeds a specified threshold could be estimated. Like what was done in Section 3.2.1.3 above for floor dust-lead loading, this was done for both the HUD National Survey and interim NSLAH data by assuming that these data originate from a lognormal distribution. Then, the fitted distributions and corresponding estimated exceedance percentages were compared between the two surveys. These results are presented in Section 3.2.2.4 below.

Comparisons by housing age category

The distribution of yard-wide average soil-lead concentrations is portrayed for each study according to housing age category in Table 3-19. The importance of housing age on yard-wide average soil-lead concentration is seen in both surveys, as the geometric mean and median concentrations tend to increase with the age of house. The method to handling not-detected values in the interim NSLAH dataset affected the data summaries only slightly, if at all.

Boxplots associated with the data distributions portrayed in Table 3-19 are found in Figure 3-13. Appendix D2 contains tabular summaries and boxplots after excluding imputed data values.

Comparisons by Census region

The distribution of yard-wide average soil-lead concentrations is portrayed for each study according to Census region in Table 3-20. Geometric mean estimates declined from the §403 risk analysis to the interim NSLAH data for each Census region, but the magnitude of the declines were typically small. Observed median values increased from the §403 risk analysis to the interim NSLAH data for the Midwest and West, but these increases were likely due to random chance. No changes from the §403 risk analysis in the pattern of the yard-wide soil-lead concentration distributions across Census regions were observed, with the Northeast continuing to be associated with somewhat higher concentrations compared to the others (although the ranges of observed soil-lead concentrations are comparable across all Census regions).

Boxplots associated with the data portrayed in Table 3-20 are found in Figure 3-14. Appendix D2 contains tabular summaries and boxplots after excluding imputed data values.

Table 3-19. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentration for Households, Presented by Housing Age Category, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data

Study	How Not-Detected and Negative Data were Handled	Yard-Wide Average Soil-Lead Concentration (µg/g)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Units Built Prior to 1940										
§403 Risk Analysis (HUD Natl. Survey)		77	761	463	3.09	17.4	259	569	1030	4620
Interim NSLAH[3]	No adjustment	114	646	297	3.56	12.8	135	294	711	9270
	Replaced by LOD/2	114	646	297	3.56	10.8	135	294	711	9270
Units Built from 1940 - 1959										
§403 Risk Analysis (HUD Natl. Survey)		87	287	92.6	3.15	5.40	44.3	77.3	162	7030
Interim NSLAH[3]	No adjustment	145	264	112	3.43	1.65	45.2	110	273	4340
	Replaced by LOD/2	145	264	114	3.33	4.62	45.2	110	273	4340
Units Built from 1960-1977 (1960 - 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		120	55.0	32.8	2.56	4.63	19.7	29.7	61.6	996
Interim NSLAH[3]	No adjustment	198	76.7	31.8	3.65	0.00	14.0	29.4	58.3	1120
	Replaced by LOD/2	201	77.2	33.3	3.24	4.83	14.7	29.4	58.3	1120
Units Built After 1977 (after 1979 for the §403 risk analysis)										
§403 Risk Analysis (HUD Natl. Survey)		28	31.3	22.4	2.31	5.35	13.6	21.2	45.0	97.4
Interim NSLAH[3]	No adjustment	168	27.4	15.7	3.19	0.00	6.07	16.0	28.7	474
	Replaced by LOD/2	180	28.2	16.2	2.65	4.65	6.34	14.9	28.7	475
NSLAH Units with Unspecified Year-Built Indicator										
Interim NSLAH[3]	No adjustment	64	175	72.9	4.15	0.00	22.3	63.8	211	2290
	Replaced by LOD/2	66	175	68.9	4.13	4.74	22.4	64.4	211	2290

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no soil-lead concentration data. The method for imputation is presented in Appendix C.
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

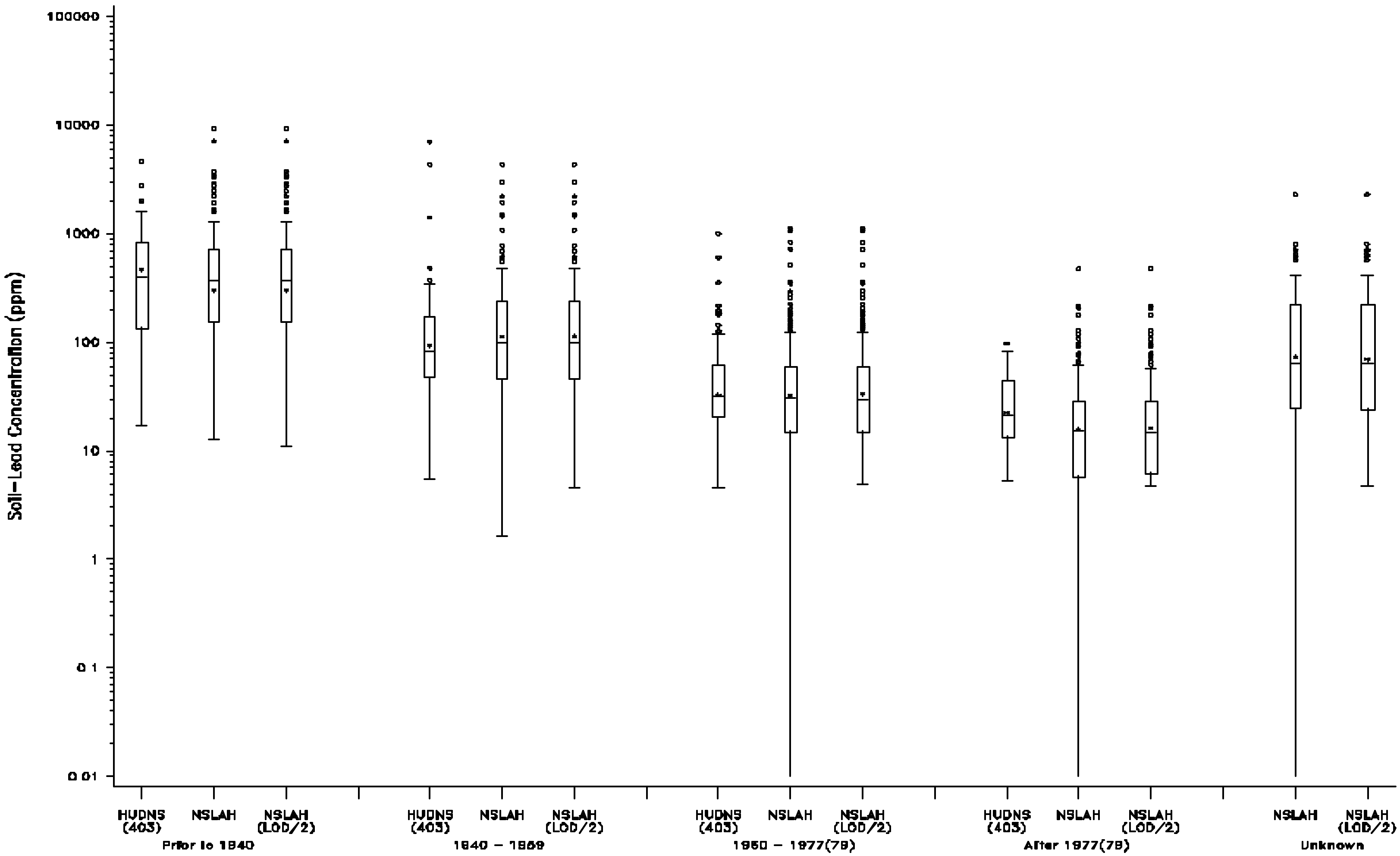

Figure 3-13. Boxplots of Yard-Wide Average Soil-Lead Concentration (µg/g), by Housing Age Category, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Boxplots include imputed data but not negative or zero values.)

Table 3-20. **Descriptive Statistics of Yard-Wide Average Soil-Lead Concentration for Households, Presented by Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data**

Study	How Not-Detected and Negative Data were Handled	Yard-Wide Average Soil-Lead Concentration ($\mu g/g$)[1]								
		# Surveyed Units with Positive Averages	Arith-metic Mean	Geo-metric Mean[2]	Geo-metric Std. Dev.[2]	Minimum	25th Percen-tile	Median	75th Percen-tile	Maximum
Northeast										
§403 Risk Analysis (HUD Natl. Survey)		53	437	206	3.58	14.8	60.1	279	569	4320
Interim NSLAH[3]	No adjustment	109	423	160	4.24	3.92	52.3	176	396	3460
	Replaced by LOD/2	109	423	162	4.16	6.24	52.9	176	396	3460
Midwest										
§403 Risk Analysis (HUD Natl. Survey)		73	404	81.4	6.33	4.63	19.7	51.6	264	2750
Interim NSLAH[3]	No adjustment	149	220	65.5	4.97	0.00	22.1	63.2	206	7070
	Replaced by LOD/2	150	220	65.8	4.71	4.90	22.1	63.2	206	7070
South										
§403 Risk Analysis (HUD Natl. Survey)		134	125	44.5	2.94	5.22	22.6	40.8	79.3	7030
Interim NSLAH[3]	No adjustment	258	162	37.3	4.62	0.00	11.9	27.6	79.2	9270
	Replaced by LOD/2	265	163	36.4	4.38	4.65	13.1	27.9	79.2	9270
West										
§403 Risk Analysis (HUD Natl. Survey)		52	112	34.4	3.92	4.79	14.2	27.2	61.6	2020
Interim NSLAH[3]	No adjustment	173	68.2	30.5	4.36	0.00	12.5	29.4	77.5	776
	Replaced by LOD/2	182	69.0	31.7	3.55	4.62	12.8	29.4	79.3	776

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).
[3] Summaries include imputed data for households having no soil-lead concentration data. The method for imputation is presented in Appendix C.
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

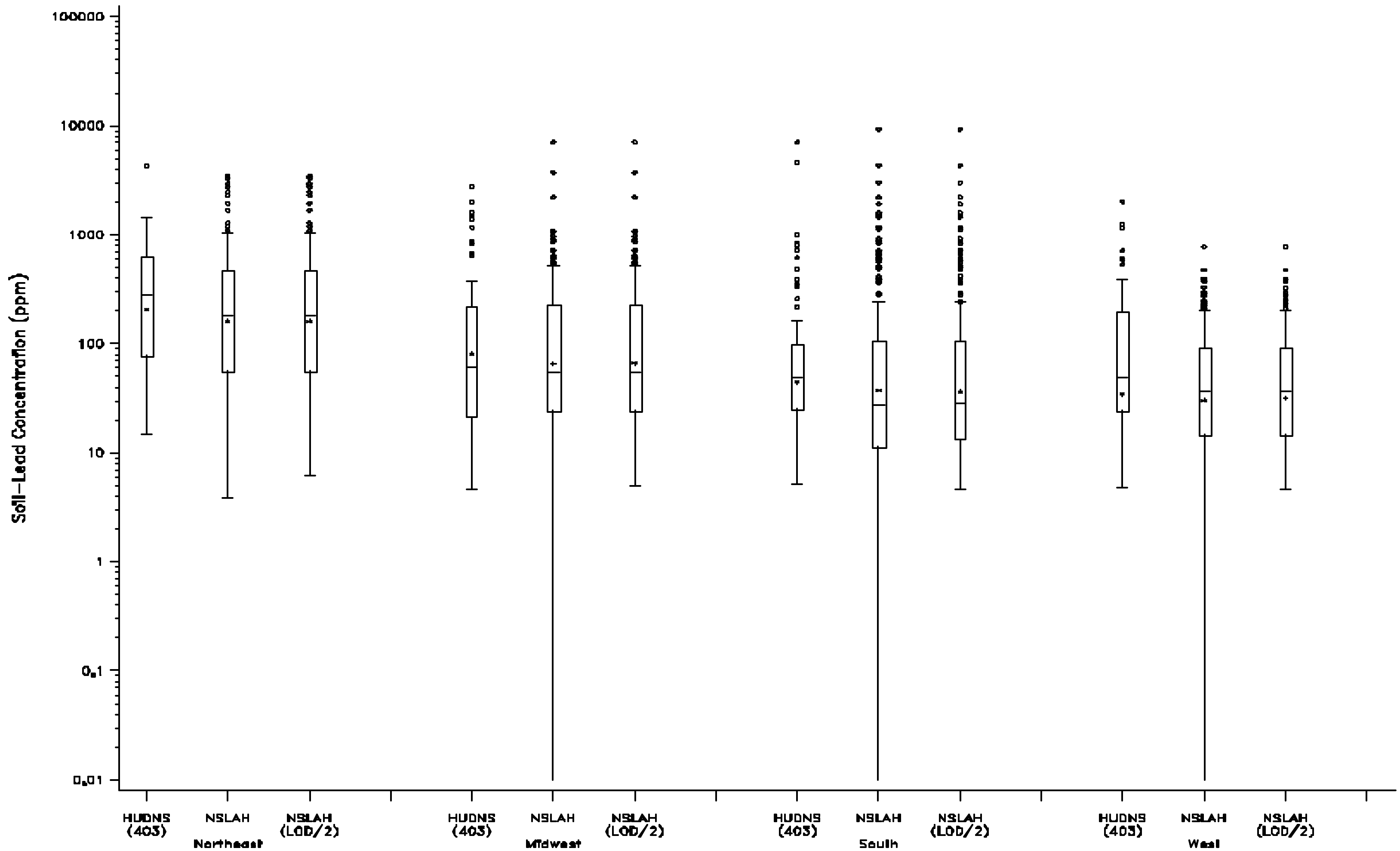

Figure 3-14. Boxplots of Yard-Wide Average Soil-Lead Concentration (µg/g), by Census Region, As Observed in the §403 Risk Analysis (Using HUD National Survey Data) and in the Interim NSLAH (under 2 approaches to handling not-detected values)

(Note: Boxplots include imputed data but not negative or zero values.)

Comparisons by combination of housing age and Census region

Tables 3-21a and 3-21b present descriptive statistics for yard-wide average soil-lead concentration according to the 16 combinations of Census region and housing age category. Table 3-21a reflects the data when no adjustment to not-detected results, while not-detected results are replaced by one-half of the detection limit prior to performing the summaries in Table 3-21b. As the central tendency of the soil-lead concentrations was of primary interest to compare across the different combinations, these tables only contain estimates of the arithmetic and geometric means, geometric standard deviation, and median.

Due to the small numbers of housing units entering into each summary within Tables 3-21a and 3-21b, caution must be taken when making inferences from the results portrayed in these tables. Appendix D2 contains these tabular summaries after excluding imputed data values.

3.2.2.2 Data Summaries for the §403 Risk Analysis Versus Other Studies. This subsection presents data summaries for the 22 studies in Table 3-17 that characterized soil-lead concentrations in urban areas and how these summaries compare to that for the HUD National Survey and to the distribution of yard-wide average soil-lead concentration characterized in the §403 risk analysis. The soil-lead concentration parameters that are summarized in this subsection were specified for each study in Table 3-17.

The 22 studies whose data are considered in this subsection include the three recent studies included in the dust-lead data summaries in Section 3.2.1: Baltimore R&M study (pre-intervention), Rochester Lead-in-Dust study, and HUD Grantees evaluation (pre-intervention data available through 1/99). Figure 3-15 contains boxplots of household average soil-lead concentration for these three studies and the HUD National Survey ("HUDNS"). These boxplots represent yard-wide averages in all cases except the Baltimore R&M study, where only dripline soil samples were collected. Separate boxplots are included for each grantee in the HUD Grantees evaluation[10].

As in Figures 3-7 through 3-10, the left-most three boxplots in Figure 3-15 represent yard-wide average soil-lead concentration data from the HUD National Survey:

- "HUDNS (U)" summarizes the data without regard to sampling weights

- "HUDNS (403)" summarizes the data as used in the §403 risk analysis (e.g., using sampling weights reflecting the 1997 housing stock; incorporating imputed data assigned to housing units with missing data)

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[10] "Alam"=Alameda County; "Balt"=Baltimore; "Bos"=Boston; "CA"=California; "Cle"=Cleveland; "MA"=Massachusetts; "MN"=Minnesota; "NJ"=New Jersey; "RI"=Rhode Island; "WI"=Wisconsin; "Milw"=Milwaukee; "Chic"=Chicago; "NYC"=New York City; "VT"=Vermont.

Table 3-21a. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where No Adjustments Were Made to Not-Detected Results

Census Region	Study[2]	Housing Age Category	Yard-Wide Average Soil-Lead Concentration[1] (μg/g)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean[3]	Geometric Std. Dev.[3]	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	542	491	1.57	444
Northeast	Interim NSLAH	Prior to 1940	41	877	499	3.22	569
Northeast	§403 Risk Anal.	1940 - 1959	17	573	136	4.40	60.1
Northeast	Interim NSLAH	1940 - 1959	23	290	199	2.24	273
Northeast	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	79.1	60.7	2.15	69.7
Northeast	Interim NSLAH	1960 -1977 (1960-79 for §403)	21	132	65.5	2.95	50.9
Northeast	Interim NSLAH	After 1977	16	57.8	40.0	2.63	38.8
Midwest	§403 Risk Anal.	Prior to 1940	19	1310	941	2.68	1390
Midwest	Interim NSLAH	Prior to 1940	36	498	224	3.34	238
Midwest	§403 Risk Anal.	1940 - 1959	21	127	92.6	2.41	123
Midwest	Interim NSLAH	1940 - 1959	36	236	110	3.14	82.0
Midwest	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	42.7	27.1	2.32	23.4
Midwest	Interim NSLAH	1960 -1977 (1960-79 for §403)	37	93.8	38.3	3.34	34.6
Midwest	§403 Risk Anal.	After 1977 (1979 for §403)	4	13.0	11.5	1.66	12.4
Midwest	Interim NSLAH	After 1977 (1979 for §403)	29	34.1	12.9	3.92	9.36
South	§403 Risk Anal.	Prior to 1940	19	417	174	3.68	159
South	Interim NSLAH	Prior to 1940	26	684	278	3.74	186
South	§403 Risk Anal.	1940 - 1959	33	327	83.1	3.27	81.0
South	Interim NSLAH	1940 - 1959	48	364	96.6	4.40	77.9
South	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	54.6	36.5	2.30	34.7
South	Interim NSLAH	1960 -1977 (1960-79 for §403)	79	68.7	26.9	3.60	26.1
South	§403 Risk Anal.	After 1977 (1979 for §403)	18	38.5	29.7	2.11	25.0
South	Interim NSLAH	After 1977 (1979 for §403)	81	22.2	15.7	2.45	15.0
West	§403 Risk Anal.	Prior to 1940	13	594	295	3.76	394
West	Interim NSLAH	Prior to 1940	11	155	122	2.23	158
West	§403 Risk Anal.	1940 - 1959	16	96.8	72.1	2.19	60.4
West	Interim NSLAH	1940 - 1959	38	143	86.9	3.08	90.3
West	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	56.2	23.8	3.02	20.0
West	Interim NSLAH	1960 -1977 (1960-79 for §403)	61	47.4	24.7	3.81	26.9
West	§403 Risk Anal.	After 1977 (1979 for §403)	6	21.7	15.0	2.34	13.6
West	Interim NSLAH	After 1977 (1979 for §403)	42	17.3	10.6	3.54	9.53

1 All statistics are calculated by weighting each household by its sampling weight.
2 Summaries include imputed data for households having no soil-lead concentration data. The method for imputation is presented in Appendix C.
3 Only household averages greater than zero are used to calculate this value (data for all units with soil-lead data are used to calculate the remaining statistics).
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

Table 3-21b. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations for Households, Presented by Housing Age and Census Region, As Reported in the §403 Risk Analysis Versus the Interim NSLAH Data Where Not-Detected Results Were Replaced by LOD/2

Census Region	Study[2]	Housing Age Category	Yard-Wide Average Soil-Lead Concentration[1] (µg/g)				
			# Surveyed Units	Arithmetic Mean	Geometric Mean	Geometric Std. Dev.	Median
Northeast	§403 Risk Anal.	Prior to 1940	26	542	491	1.57	444
	Interim NSLAH		41	877	497	3.26	569
	§403 Risk Anal.	1940 - 1959	17	573	136	4.40	60.1
	Interim NSLAH		23	290	199	2.24	273
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	10	79.1	60.7	2.15	69.7
	Interim NSLAH		21	132	65.4	2.96	50.9
	Interim NSLAH	After 1977	16	58.1	42.0	2.36	38.8
Midwest	§403 Risk Anal.	Prior to 1940	19	1310	941	2.68	1390
	Interim NSLAH		36	498	224	3.34	238
	§403 Risk Anal.	1940 - 1959	21	127	92.6	2.41	123
	Interim NSLAH		36	236	111	3.11	82.0
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	29	42.7	27.1	2.32	23.4
	Interim NSLAH		37	94.1	39.0	3.27	34.6
	§403 Risk Anal.	After 1977 (1979 for §403)	4	13.0	11.5	1.66	12.4
	Interim NSLAH		30	34.7	14.0	3.06	9.67
South	§403 Risk Anal.	Prior to 1940	19	417	174	3.68	159
	Interim NSLAH		26	684	278	3.74	186
	§403 Risk Anal.	1940 - 1959	33	327	83.1	3.27	81.0
	Interim NSLAH		48	364	97.7	4.34	77.9
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	64	54.6	36.5	2.30	34.7
	Interim NSLAH		81	69.4	27.8	3.24	26.1
	§403 Risk Anal.	After 1977 (1979 for §403)	18	38.5	29.7	2.11	25.0
	Interim NSLAH		84	22.7	15.4	2.29	14.7
West	§403 Risk Anal.	Prior to 1940	13	594	295	3.76	394
	Interim NSLAH		11	155	122	2.21	158
	§403 Risk Anal.	1940 - 1959	16	96.8	72.1	2.19	60.4
	Interim NSLAH		38	143	89.8	2.78	90.3
	§403 Risk Anal.	1960 -1977 (1960-79 for §403)	17	56.2	23.8	3.02	20.0
	Interim NSLAH		62	48.0	27.8	2.91	26.9
	§403 Risk Anal.	After 1977 (1979 for §403)	6	21.7	15.0	2.34	13.6
	Interim NSLAH		50	18.9	12.1	2.42	11.2

[1] All statistics are calculated by weighting each household by its sampling weight.
[2] Summaries include imputed data for households having no soil-lead concentration data. The method for imputation is presented in Appendix C.
Note: The yard-wide average for a household is the average of the following two statistics: 1) the average of the mid-yard sample results, and 2) the average of results for the dripline and entryway samples.

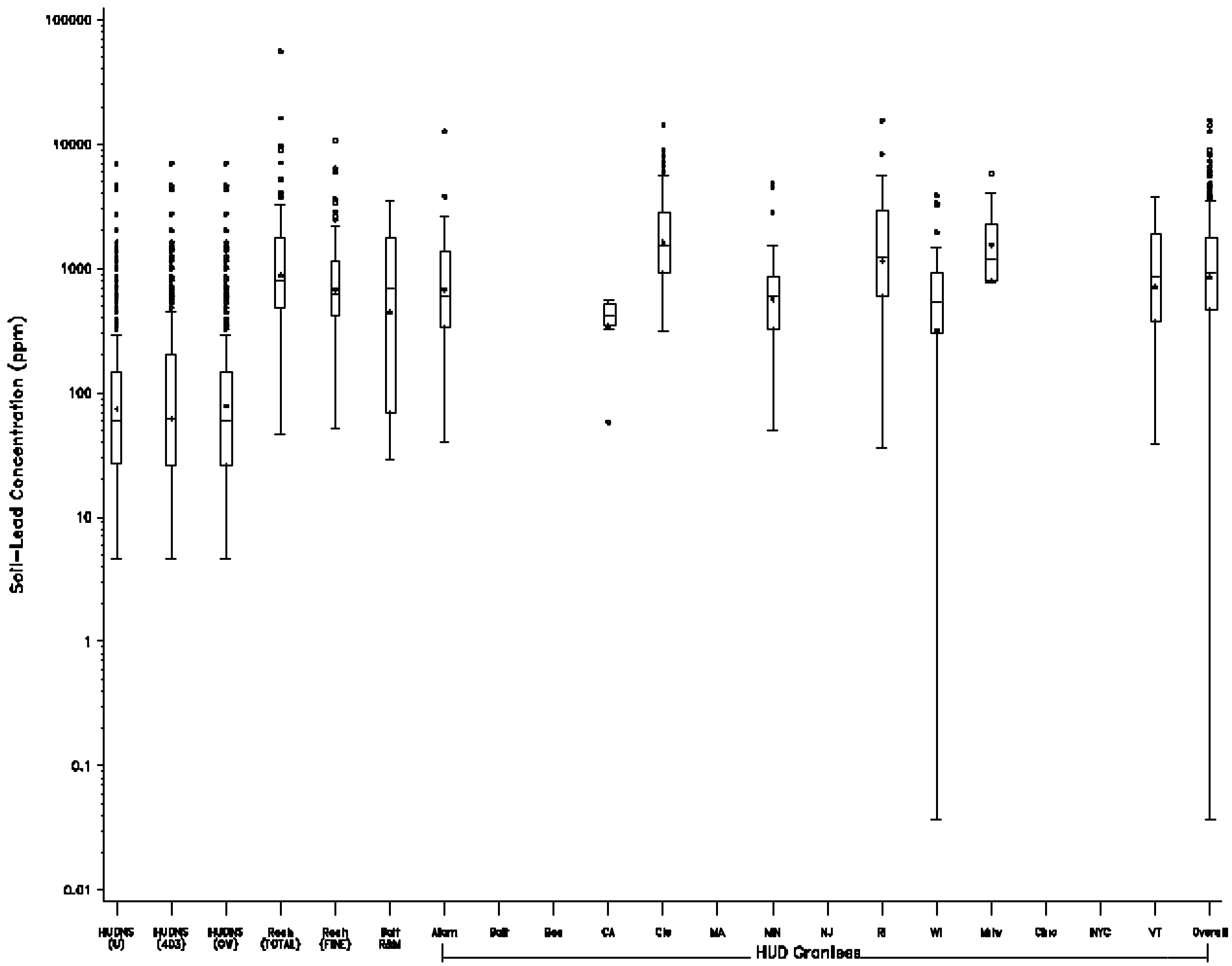

Figure 3-15. Boxplots of Household Average Soil-Lead Concentrations (μg/g) for Houses in the HUD National Survey, Baltimore R&M Study, Rochester Lead-in-Dust Study, and Grantees Within the HUD Grantees Evaluation

(Note: Household averages represent yard-wide averages except for the Baltimore R&M study, where only dripline soil samples were collected. See text for definitions of labels along the horizontal axis.)

- "HUDNS (OW)" summarizes the data weighted according to the original weights assigned in the survey.

As soil samples were sieved into fine and coarse fractions in the Rochester study, Figure 3-15 includes two boxplots for the Rochester soil-lead data. The boxplot labeled "Rochester (FINE)" summarizes household average soil-lead concentration considering only the fine-sieved fraction of the collected soil samples. The boxplot labeled "Rochester (TOTAL)" summarizes estimated household average soil-lead concentration assuming the total soil sample was analyzed. Total soil-lead concentration for each sample was estimated as the average of the reported concentrations for the fine and coarse fractions of the sample, with the coarse fraction result weighted three times that of the fine sample result (see Appendix E for the derivation of this estimate using data from the Milwaukee study). Estimating soil-lead concentration in the total soil sample was intended to allow soil-lead data from the Rochester study to be more comparable to data from the other studies in which no sieve-fractions were calculated.

Figure 3-15 shows that while the ranges of average soil-lead concentrations among the study households tended to overlap from study to study, the distributions based upon the HUD National Survey data (including the §403 risk analysis) tended to be shifted lower than for the other studies.

Figure 3-16 contains a graphical presentation of how the distribution of household average soil-lead concentration in other selected studies listed in Table 3-17 compare with the distributions based upon the HUD National Survey data (i.e., the same three distributions portrayed in the boxplots labeled "HUDNS" in Figure 3-15). The studies selected for Figure 3-15 were among those in which an average soil-lead concentration for a particular area could be determined. As only summary statistics for many of the studies in Table 3-17 were available from the references or prior literature reviews, boxplots like those in Figure 3-15 could not be created for these other studies. Instead, specific descriptive statistics (when cited in the references) are plotted in Figure 3-16 for each study by using plotting symbols that indicate the type of statistic. These statistics, with their plotting symbols following in parentheses, are the minimum (MIN), 25th percentile (25th), median (50th), 75th percentile (75th), maximum (MAX), and geometric mean (GM) soil-lead concentrations. In studies where the arithmetic mean is specified instead of the geometric mean, the arithmetic mean (AVE) was plotted. The vertical dashed line in Figure 3-16 separates results based on the HUD National Survey data from the results for the other studies.

Yard-wide average soil-lead concentration (or an average that is not specific to a given location) were available or could be calculated within eight of these studies (one being the 3-Cities study, which consisted of three sub-studies). Table 3-22a presents values of descriptive statistics (e.g., geometric mean, minimum, maximum, selected percentiles) for yard-wide average soil-lead concentration within these studies. This table also includes the estimated number of averages represented in the descriptive statistics that exceed a given soil-lead concentration threshold (400, 1200, 2000, and 5000 µg/g). The following features can be found within this table:

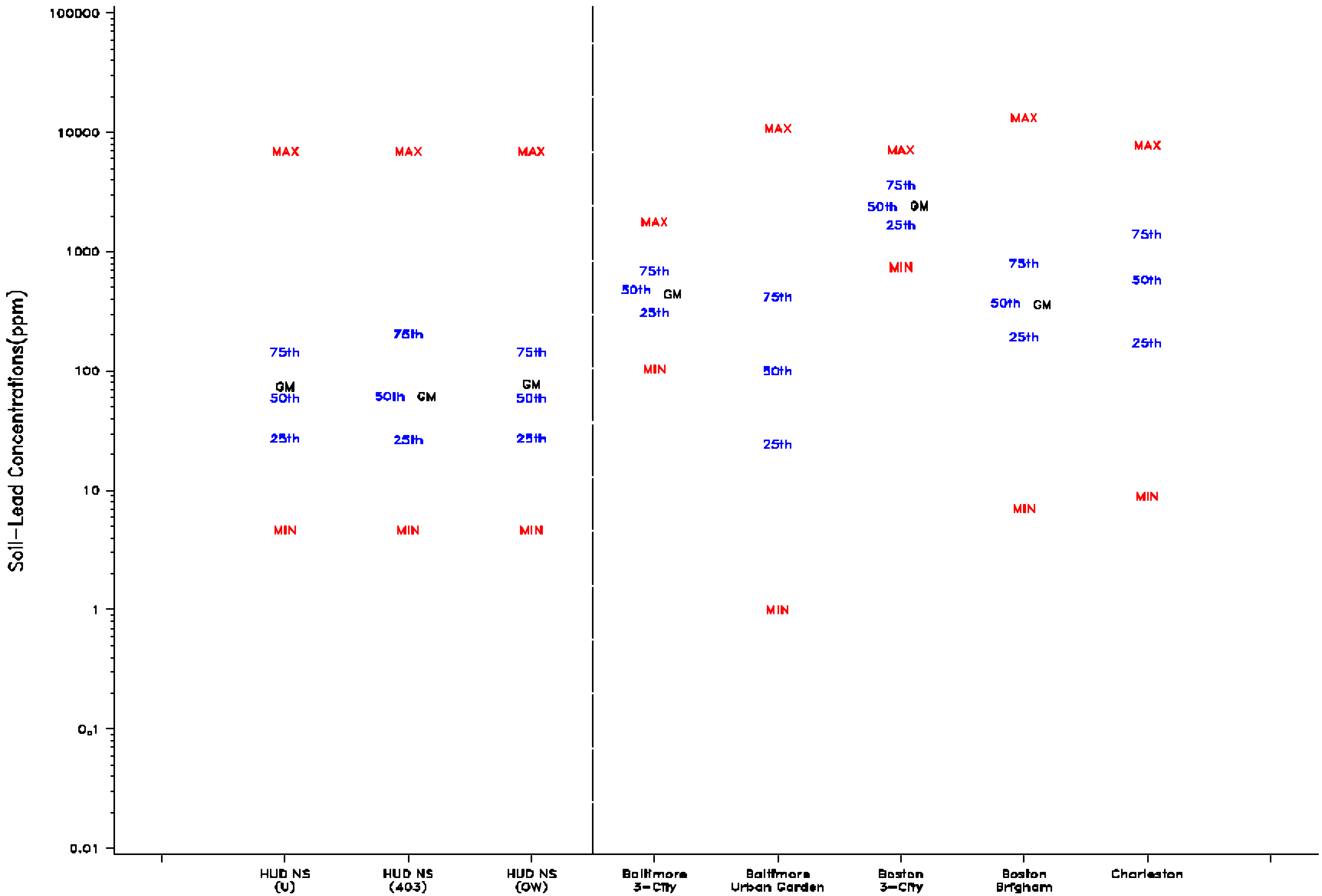

Figure 3-16. Summary Statistics of Average Household Soil-Lead Concentrations ($\mu g/g$) for Selected Studies as Compared to Summaries Based on Data from the HUD National Survey

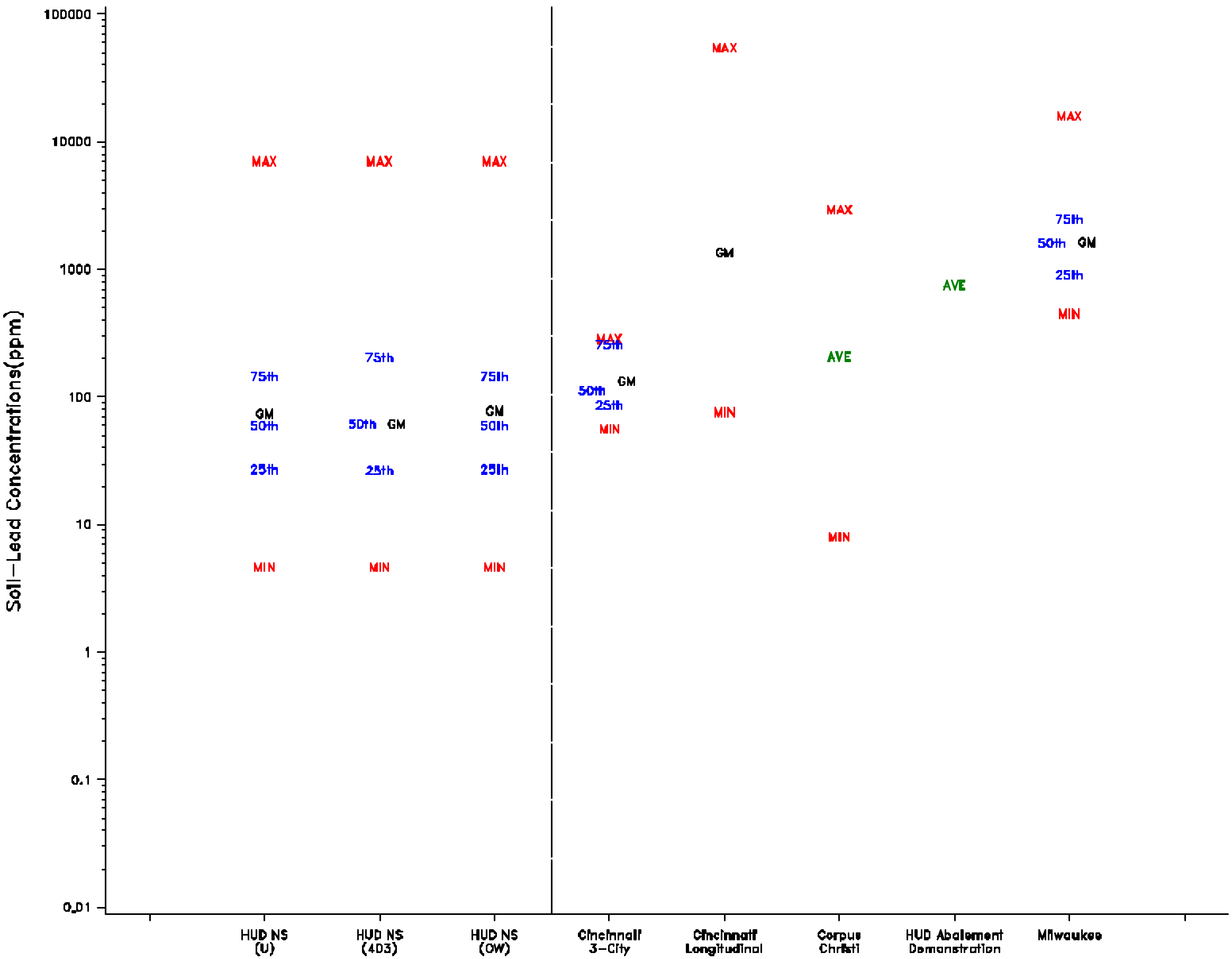

Figure 3-16. (cont.)

Table 3-22a. Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations, According to Study and Within Specific Subsets of the Sampled Housing Within a Study

Study	Subset of Units or Type of Soil/cover	Yard-Wide Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration $			
		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
HUD National Survey (unweighted) [1]	All Units	250	74.0	4.0	4.6	27.2	59.9	145.1	7025	12.0%	4.8%	2.4%	0.4%
	Big City/ Metro	67	80.6	3.3	5.4	35.3	70.9	159.7	1463	10.4%	4.5%	0.0%	0.0%
	Big City/ Suburb	60	72.0	3.6	4.8	30.4	60.6	171.0	2019	10.0%	1.7%	1.7%	0.0%
	Small City/ Metro	42	112.0	6.2	5.2	26.0	93.9	585.6	7025	26.2%	11.9%	7.1%	2.4%
	Small City/ Suburb	24	65.1	3.6	6.7	28.6	50.8	118.4	4318	8.3%	4.2%	4.2%	0.0%
	Non-Metro	57	53.5	3.8	4.6	21.7	45.2	125.2	2002	7.0%	3.5%	1.8%	0.0%
	City	109	91.5	4.3	5.2	32.0	77.3	213.7	7025	16.5%	7.3%	2.8%	0.9%
	Non-City	141	62.8	3.7	4.6	25.9	53.8	135.9	4318	8.5%	2.8%	2.1%	0.0%
	Northeast	31	144.5	3.7	14.8	53.8	115.2	357.6	4318	22.6%	6.5%	3.2%	0.0%
	Midwest	63	75.0	4.6	4.6	21.7	58.9	162.3	2752	12.7%	9.5%	3.2%	0.0%
	South	111	60.6	3.5	5.2	26.3	52.7	115.1	7025	7.2%	1.8%	1.8%	0.9%
	West	45	75.0	4.4	4.8	25.9	60.4	197.9	2019	15.6%	4.4%	2.2%	0.0%
HUD National Survey (§403 RA) [2]	All Units	284	61.9	4.5	4.6	26.5	61.8	203.6	7025	13.2%	4.7%	2.5%	0.2%
	Big City/ Metro	96	87.5	4.2	5.4	43.0	94.5	313.3	1463	17.9%	2.5%	0.0%	0.0%
	Big City/ Suburb	73	56.2	3.8	4.8	28.6	61.1	161.8	2019	10.2%	0.7%	0.7%	0.0%
	Small City/ Metro	50	77.9	5.5	5.2	24.5	83.3	391.9	7025	19.4%	11.7%	6.5%	1.3%
	Small City/ Suburb	28	46.2	3.4	6.7	26.0	49.2	92.9	4318	4.9%	3.8%	3.8%	0.0%
	Non-Metro	65	46.9	4.9	4.6	17.7	35.9	105.0	2002	11.0%	6.8%	3.4%	0.0%
	City	146	83.3	4.7	5.2	34.6	88.7	313.3	7025	18.5%	6.4%	2.7%	0.5%
	Non-City	166	50.5	4.2	4.6	23.4	51.9	123.3	4318	9.5%	3.6%	2.3%	0.0%
	Northeast	53	205.8	3.6	14.8	77.3	278.9	627.9	4318	34.8%	4.4%	2.6%	0.0%
	Midwest	73	81.4	6.3	4.6	21.1	61.1	216.7	2752	21.2%	14.9%	6.9%	0.0%
	South	134	44.5	2.9	5.2	25.4	49.2	97.4	7025	3.8%	0.8%	0.8%	0.5%
	West	52	34.4	3.9	4.8	24.3	49.7	191.8	2019	6.3%	1.9%	1.0%	0.0%

Table 3-22a. (cont.)

Study	Subset of Units or Type of Soil/cover	Yard-Wide Average Soil-Lead Concentration (μg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration ≥			
		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 μg/g	1200 μg/g	2000 μg/g	5000 μg/g
HUD National Survey (original weights)[3]	All Units	250	78.1	4.5	4.6	27.2	59.9	145.1	7025	15.3%	6.8%	3.7%	0.3%
	Big City/ Metro	67	74.0	3.3	5.4	35.3	70.9	159.7	1463	12.6%	2.3%	0.0%	0.0%
	Big City/ Suburb	60	69.1	3.9	4.8	30.4	60.6	171.0	2019	11.3%	1.1%	1.1%	0.0%
	Small City/ Metro	42	121.9	6.5	5.2	26.0	93.9	585.6	7025	29.1%	18.2%	10.1%	1.9%
	Small City/ Suburb	24	60.7	3.6	6.7	28.6	50.8	118.4	4318	7.3%	5.6%	5.6%	0.0%
	Non-Metro	57	77.5	5.1	4.6	21.7	45.2	125.2	2002	16.4%	10.2%	5.1%	0.0%
	City	109	90.9	4.6	5.2	32.0	77.3	213.7	7025	19.4%	8.8%	4.1%	0.8%
	Non-City	141	70.5	4.3	4.6	25.9	53.8	135.9	4318	12.6%	5.4%	3.4%	0.0%
	Northeast	31	150.2	3.6	14.8	53.8	115.2	357.6	4318	27.5%	4.1%	3.5%	0.0%
	Midwest	63	113.3	6.0	4.6	21.7	58.9	162.3	2752	24.1%	19.0%	8.9%	0.0%
	South	111	57.9	3.3	5.2	26.3	52.7	115.1	7025	6.6%	1.3%	1.3%	0.9%
	West	45	47.3	4.0	4.8	25.9	60.4	197.9	2019	9.0%	2.7%	1.4%	0.0%
Baltimore Urban Garden		422	NA	NA	1.0	24.5 [4]	100.0	421.0 [5]	10900	NA	NA	NA	NA
Baltimore 3-City	Top 2 cm	181 [6]	442.3	1.7	103.7	308.4	479.3	688.4	1793	59.7%	2.8%	0.0%	0.0%
Boston 3-City	Top 2 cm	101 [6]	2430.9	1.6	744.3	1678.0	2380.0	3600.0	7070	100.0%	93.1%	65.3%	6.9%
Boston Brigham and Women		195	360.8	3.3	7.0	193.0	374.0	796.0	13237	49.2%	13.8%	6.7%	1.0%
Cincinnati 3-City	Overall	7 [6]	133.1	1.9	55.8	86.4	112.9	257.3	285	0.0%	0.0%	0.0%	0.0%
	Full Grass	4 [6]	138.9	2.4	49.9	73.9	144.9	294.3	397	0.0%	0.0%	0.0%	0.0%
	>1/2 Grass	6 [6]	115.7	1.5	71.5	77.8	126.3	151.6	182	0.0%	0.0%	0.0%	0.0%
	<1/2 Grass	4 [6]	149.6	2.3	56.8	91.6	142.1	300.1	442	25.0%	0.0%	0.0%	0.0%
	All Bare	3 [6]	103.6	1.6	60.8	60.8	118.1	154.7	155	0.0%	0.0%	0.0%	0.0%
HUD Grantees Evaluation	All Grantees	314	857.5	3.8	0.0	479.0	920.5	1730.0	15535	82.8%	40.1%	21.0%	4.1%
	Alameda	58	669.8	2.5	39.5	352.5	588.5	1348.0	12648	70.7%	34.5%	5.2%	1.7%
	California	8	341.8	2.1	58.0	357.5	415.8	512.5	560	62.5%	0.0%	0.0%	0.0%
	Cleveland	99	1620.7	2.2	315.0	940.0	1545.0	2840.0	14180	99.0%	61.6%	38.4%	8.1%
	Minnesota	41	563.1	2.4	49.5	339.5	591.5	857.5	4800	70.7%	17.1%	7.3%	0.0%
	Rhode Island	40	1146.0	3.3	35.5	608.5	1227.8	2875.0	15535	87.5%	52.5%	32.5%	7.5%
	Wisconsin	38	318.3	11.8	0.0	316.0	536.8	917.0	3852	71.1%	15.8%	7.9%	0.0%
	Milwaukee	10	1530.5	2.0	766.0	829.0	1184.8	2287.5	5800	100.0%	40.0%	30.0%	10.0%
	Vermont	20	707.9	3.0	38.5	393.8	850.9	1868.8	3695	75.0%	35.0%	15.0%	0.0%
Milwaukee		92	1640.5	2.1	449.0	903.5	1605.5	2472.0	15814	100.0%	63.0%	32.6%	7.6%
Omaha	Urban Commercial	69	262.0	NA	53.0	NA	NA	NA	1615	NA	NA	NA	NA

Table 3-22a. (cont.)

Study	Subset of Units or Type of Soil/cover	Yard-Wide Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration $			
		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
	Urban Mixed	56	339.0	NA	20.0	NA	NA	NA	4792	NA	NA	NA	NA
	Suburban	51	81.0	NA	16.0	NA	NA	NA	341	NA	NA	NA	NA
Rochester Lead-in-Dust	Total soil	82	880.2	3.5	46.7	487.5	807.8	1736.6	55617	76.8%	32.9%	22.0%	9.8%
	Fine soil only	82	670.8	2.7	51.1	419.0	626.8	1150.5	10721	79.3%	23.2%	12.2%	3.7%

NA = Not Available

1 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized without weighting by sample weights.
2 Mass-weighted arithmetic average soil-lead concentration as calculated in Chapter 3 of the 403 risk analysis; summarized by weighting each average to reflect the 1997 U.S. housing stock.
3 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized by weighting with the National Survey sample weights.
4 20th percentile
5 80th percentile
6 An initial unweighted arithmetic average of soil lead levels at the specified locations was taken prior to calculation of statistics within this table. The number in this column represents the number of properties, not necessarily the number of houses.

- For the HUD National Survey data, which are associated with sampling weights from the original survey and revised sampling weights for the §403 risk analyses, all results in Table 3-22a are portrayed three times: under each of these two sets of weights as well as without regard to weights.

- For the HUD National Survey data, which are associated with sampling weights from the original survey and revised sampling weights for the §403 risk analyses, all results in Table 3-22a are portrayed three times: under each of these two sets of weights as well as without regard to weights.

- In addition to summarizing results across all housing units or samples in a study, results for selected studies are also summarized for specific subsets of housing units, soil types, or soil samples. In particular, HUD National Survey results are portrayed according to urbanicity and Census region, results from the HUD Grantees evaluation are portrayed by grantee, and the Rochester study results are portrayed for the fine soil fraction as well as for total soil.

Refer to Table 3-17 to verify the types of results being summarized in Table 3-22a (i.e., housing unit averages versus averages for single analytical samples).

Table 3-22b contains the same descriptive statistics as those portrayed in Table 3-22a, but they represent average soil-lead concentration for specific locations, such as dripline, play areas, remote areas, geographical areas, and other locations that were considered within the individual studies. As in Table 3-22a, the statistics in Table 3-22b are given over the entire study, as well as for specified sets of units that are determined by urbanicity and other factors.

<u>Summary statistics by housing age category</u>

As housing age category is generally regarded as an important influence on soil-lead concentrations, the above summaries are also presented according to the housing age categories considered in the HUD National Survey (pre-1940, 1940-1959, 1960-1979, post-1979). Figure 3-17 presents boxplots for pre-1980 housing data from the HUD National Survey and the Rochester Lead-in-Dust study (total soil and fine soil), non-control houses in the Baltimore R&M study, and pre-1978 data from the HUD Grantees evaluation (data combined across grantees). As all non-control units in the Baltimore R&M study were built prior to 1941, the only boxplot for this study in Figure 3-17 appears in the "pre-1940" category. Caution must be taken when interpreting results in Figure 3-17 for the Rochester study, as the actual age of certain houses may be older than what was specified in the Rochester study database (see Section 3.3.1.3 of the §403 risk analysis report).

Many of the other studies listed in Table 3-17 did not have information readily available on housing age. Thus, no corresponding figure portraying distributions according to housing age was prepared to represent these other studies.

Table 3-22b. Descriptive Statistics of Average Soil-Lead Concentrations in Specific Yard Areas and/or for Certain Subsets of the Sampled Housing Within a Study

Study	Yard Area/	Subset of Housing Units	Average Soil-Lead Concentration (µg/g)								Percentag of Homes with Soil-Lead Concentration $			
			N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
HUD National Survey (unweighted) [1]	Dripline/ Entryway	All Units	263	91.3	4.3	5.2	32.4	75.2	237.3	13596	16.4%	4.9%	3.0%	1.1%
		Big City/ Metro	76	101.8	3.7	7.9	40.2	81.5	226.9	2571	17.1%	5.3%	3.9%	0.0%
		Big City/ Suburb	62	89.5	4.0	7.5	29.1	82.0	263.3	1661	19.4%	1.6%	0.0%	0.0%
		Small City/ Metro	44	146.9	6.7	5.2	31.8	127.2	695.6	13596	31.8%	11.4%	6.8%	6.8%
		Small City/ Suburb	24	83.5	3.3	10.5	36.1	71.1	148.5	1684	8.3%	4.2%	0.0%	0.0%
		Non-Metro	57	57.9	3.8	5.6	26.0	45.5	131.9	3999	3.5%	3.5%	3.5%	0.0%
		City	120	116.4	4.7	5.2	37.8	85.6	294.0	13596	22.5%	7.5%	5.0%	2.5%
		Non-City	143	74.4	3.8	5.6	29.4	67.4	178.8	3999	11.2%	2.8%	1.4%	0.0%
		Northeast	38	212.5	3.9	20.6	75.2	209.5	534.7	2571	36.8%	13.2%	7.9%	0.0%
		Midwest	66	95.2	4.8	5.8	31.7	73.1	261.6	5336	18.2%	6.1%	4.5%	1.5%
		South	113	70.1	3.8	5.2	31.8	62.5	126.0	13596	8.0%	3.5%	1.8%	1.8%
		West	46	81.8	4.3	7.5	26.6	65.2	263.3	1149	17.4%	0.0%	0.0%	0.0%
HUD National Survey (403 RA) [2]	Dripline/ Entryway	All Units	312	72.7	4.6	5.2	31.8	76.7	245.7	13596	15.5%	4.0%	2.9%	1.1%
		Big City/ Metro	96	102.4	4.4	7.9	44.2	91.9	426.0	2571	0.0%	1.7%	1.2%	0.0%
		Big City/ Suburb	73	68.0	3.9	7.5	28.9	78.7	242.0	1661	16.7%	0.5%	0.0%	0.0%
		Small City/ Metro	50	96.2	6.0	5.2	27.6	124.7	589.2	13596	22.2%	8.7%	6.5%	6.5%
		Small City/ Suburb	28	60.6	2.9	10.5	35.4	70.0	108.2	1684	4.9%	3.8%	0.0%	0.0%
		Non-Metro	65	48.7	4.9	5.6	20.3	37.6	112.9	3999	6.8%	6.8%	6.8%	0.0%
		City	146	99.7	5.0	5.2	37.3	96.1	439.2	13596	22.5%	4.6%	3.4%	2.7%
		Non-City	166	58.5	4.1	5.6	27.5	61.9	131.9	3999	10.7%	3.5%	2.6%	0.0%
		Northeast	53	251.0	3.6	20.6	85.3	373.2	1007.0	2571	48.5%	5.1%	1.8%	0.0%
		Midwest	73	94.5	6.3	5.8	28.4	61.9	283.0	5336	20.6%	10.9%	10.4%	3.5%
		South	134	51.8	3.3	5.2	29.4	59.4	123.3	13596	4.3%	1.7%	0.8%	0.8%
		West	52	40.3	3.7	7.5	24.7	56.6	216.4	1149	6.8%	0.0%	0.0%	0.0%

Table 3-22b. (cont.)

Study	Yard Area/ Subset of Housing Units		Average Soil-Lead Concentration (µg/g) N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	Percentag of Homes with Soil-Lead Concentration $ 400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
HUD National Survey (HUD NS weights) [3]	Dripline/ Entryway	All Units	263	92.8	4.6	5.2	32.4	75.2	237.3	13596	18.5%	5.7%	4.3%	1.6%
		Big City/ Metro	76	90.2	3.7	7.9	40.2	81.5	226.9	2571	16.7%	2.3%	1.6%	0.0%
		Big City/ Suburb	62	86.1	4.1	7.5	29.1	82.0	263.3	1661	22.5%	0.7%	0.0%	0.0%
		Small City/ Metro	44	147.4	7.0	5.2	31.8	127.2	695.6	13596	33.2%	12.9%	9.7%	9.7%
		Small City/ Suburb	24	75.2	3.1	10.5	36.1	71.1	148.5	1684	7.3%	5.6%	0.0%	0.0%
		Non-Metro	57	82.0	5.1	5.6	26.0	45.5	131.9	3999	10.2%	10.2%	10.2%	0.0%
		City	120	109.9	5.0	5.2	37.8	85.6	294.0	13596	23.3%	6.6%	4.9%	3.9%
		Non-City	143	82.5	4.3	5.6	29.4	67.4	178.8	3999	15.1%	5.2%	3.9%	0.0%
		Northeast	38	195.9	3.5	20.6	75.2	209.5	534.7	2571	42.0%	6.5%	2.2%	0.0%
		Midwest	66	132.0	6.0	5.8	31.7	73.1	261.6	5336	24.4%	13.6%	13.0%	4.3%
		South	113	66.9	3.6	5.2	31.8	62.5	126.0	13596	7.2%	2.8%	1.3%	1.3%
		West	46	53.2	3.9	7.5	26.6	65.2	263.3	1149	9.6%	0.0%	0.0%	0.0%
Baltimore R&M	Dripline		28	444.5	5.1	28.9	71.5	686.9	1767.5	3539	60.7%	42.9%	10.7%	0.0%
Baltimore 3-City	Dripline	Top 2 cm	196 [10]	635.9	2.0	96.0	390.2	666.6	1035.6	4400	72.4%	18.9%	2.6%	0.0%
	Midyard	Top 2 cm	183 [10]	287.0	1.9	31.0	199.0	286.0	425.0	2500	29.0%	1.1%	0.5%	0.0%
	Remote	Top 2 cm	197 [10]	337.0	1.7	77.2	230.0	351.8	465.6	1850	35.5%	1.0%	0.0%	0.0%
CAP Study	Dripline	All Homes	117 [7]	182.1	2.7	11.0	97.8	190.4	331.8	3351	20.5%	3.4%	0.9%	0.0%
		Unabated Homes	37 [7]	91.3	2.6	11.0	55.8	112.0	137.0	1016	5.4%	0.0%	0.0%	0.0%
		Abated Homes	80 [7]	250.6	2.3	51.4	122.6	257.1	412.4	3351	27.5%	5.0%	1.3%	0.0%
	Entryway	All Homes	109 [7]	143.5	2.7	4.6	72.9	148.5	265.2	1068	17.4%	0.0%	0.0%	0.0%
		Unabated Homes	37 [7]	101.3	3.3	4.6	47.4	129.5	215.8	655	13.5%	0.0%	0.0%	0.0%
		Abated Homes	72 [7]	171.6	2.3	42.9	88.0	152.8	343.4	1068	19.4%	0.0%	0.0%	0.0%
	Remote	All Homes	120 [7]	120.4	2.1	15.0	70.3	120.0	197.6	1073	5.0%	0.0%	0.0%	0.0%
		Unabated Homes	39 [7]	85.3	2.2	15.0	53.4	87.9	131.3	1073	2.6%	0.0%	0.0%	0.0%
		Abated Homes	81 [7]	142.2	1.9	28.7	79.1	150.2	228.8	615	6.2%	0.0%	0.0%	0.0%
California	Oakland		292	897.0	NA	56.0	NA	880.0	NA	88176	NA	NA	NA	NA
	Los Angeles		327	188.0	NA	30.0	NA	190.0	NA	1973	NA	NA	NA	NA
	Sacramento		227	234.0	NA	26.0	NA	229.0	NA	2664	NA	NA	NA	NA

Table 3-22b. (cont.)

Study	Yard Area/ Subset of Housing Units		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
			Average Soil-Lead Concentration (µg/g)								Percentag of Homes with Soil-Lead Concentration $			
Cincinnati 3-City	Building	Overall	100 [10]	233.9	4.6	7.1	91.3	260.9	842.4	6340	35.0%	17.0%	7.0%	1.0%
		Full Grass	22 [10]	286.7	5.7	16.9	55.4	249.2	1554.0	4533	45.5%	27.3%	13.6%	0.0%
		>1/2 Grass	35 [10]	303.5	4.3	6.2	102.0	290.9	1133.6	4963	34.3%	22.9%	8.6%	0.0%
		<1/2 Grass	56 [10]	184.2	4.8	7.1	57.6	219.9	569.8	4897	33.9%	10.7%	5.4%	0.0%
		All Bare	46 [10]	410.1	3.3	35.0	214.4	296.9	1130.7	7602	43.5%	23.9%	13.0%	2.2%
	Bare Areas	Overall	74 [10]	220.9	5.5	5.4	77.1	223.9	800.2	4552	39.2%	17.6%	12.2%	0.0%
		Full Grass	3 [12]	340.2	17.1	12.9	12.9	1491.3	2047.3	2047	66.7%	66.7%	33.3%	0.0%
		>1/2 Grass	8 [10]	106.7	2.9	42.3	52.1	77.6	153.1	1128	12.5%	0.0%	0.0%	0.0%
		<1/2 Grass	8 [12]	30.1	4.4	7.8	9.7	21.0	70.1	609	12.5%	0.0%	0.0%	0.0%
		All Bare	63 [10]	272.6	4.7	5.4	111.1	256.7	861.6	4552	41.3%	17.5%	12.7%	0.0%
	Play Area	Overall	11 [10]	94.6	1.9	20.0	70.7	103.4	155.4	192	0.0%	0.0%	0.0%	0.0%
		Full Grass	5 [10]	122.1	1.6	69.3	80.2	129.1	164.3	230	0.0%	0.0%	0.0%	0.0%
		>1/2 Grass	7 [12]	86.3	1.4	55.8	68.3	82.0	123.4	124	0.0%	0.0%	0.0%	0.0%
		<1/2 Grass	7 [10]	129.8	1.8	62.0	72.6	155.4	211.4	299	0.0%	0.0%	0.0%	0.0%
		All Bare	8 [10]	60.0	2.3	18.2	32.1	75.7	98.2	192	0.0%	0.0%	0.0%	0.0%
	Other	Overall	9 [10]	107.8	4.0	5.8	61.3	137.5	248.1	743	11.1%	0.0%	0.0%	0.0%
		Full Grass	3 [10]	172.8	1.6	122.6	122.6	139.4	301.7	302	0.0%	0.0%	0.0%	0.0%
		>1/2 Grass	2 [10]	222.7	1.3	180.4	180.4	227.7	274.9	275	0.0%	0.0%	0.0%	0.0%
		<1/2 Grass	6 [10]	95.9	5.1	5.8	59.7	104.4	275.6	743	16.7%	0.0%	0.0%	0.0%
		All Bare	4 [10]	65.4	1.9	35.7	42.8	55.7	114.1	167	0.0%	0.0%	0.0%	0.0%
Cincinnati Longitudinal	Play Area and/or Entryway	All Units	80	1360.3	4.7	76.0	NA	NA	NA	54519	NA	NA	NA	NA
		20th Century Public	14	572.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		19th Century Rehabbed	18	804.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		19th Century Satisfactory	7	2540.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		19th Century Deteriorated	13	2670.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cincinnati Roadside	Pavement Edge	< 1950	60 [9]	1256.0 [8]	1254.3 [8]	NA	NA	NA	NA	NA	NA	NA	NA	NA
		> 1960		752.0 [8]	557.4 [8]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Charleston	Play Area		164	NA	NA	9.0	173.0	585.0	1400.0	7890	NA	NA	NA	NA

Table 3-22b. (cont.)

Study	Yard Area/ Subset of Housing Units		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
			Average Soil-Lead Concentration (µg/g)								Percentag of Homes with Soil-Lead Concentration $			
Corpus Christi	All Samples		485 [7]	208.0 [8]	NA	8.0	NA	NA	NA	2969	NA	NA	NA	NA
	Parks		94 [7]	55.0 [8]	NA	8.0	NA	NA	NA	318	NA	NA	NA	NA
	Schools		12 [7]	57.0 [8]	NA	11.0	NA	NA	NA	258	NA	NA	NA	NA
	All Others		379 [7]	250.0 [8]	NA	8.0	NA	NA	NA	2969	NA	NA	NA	NA
I-880 (Alameda County)	East		116 [7]	594.3 [8]	NA	22.3	NA	NA	NA	3187	NA	NA	NA	NA
	West		22 [7]	263.3 [8]	NA	89.7	NA	NA	NA	862	NA	NA	NA	NA
HUD Abatement Demonstration Study	Dripline		455 [7]	755.0 [8]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dripline - Post-Abatement		455 [7]	867.5 [8]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HUD Grantees Evaluation	Dripline	All Grantees	557	1182.0	3.7	0.1	557.0	1252.0	2580.0	52700	83.7%	53.1%	32.1%	11.3%
		Alameda	97	776.3	2.7	30.0	395.0	710.0	1387.0	21131	73.2%	32.0%	13.4%	4.1%
		California	8	330.7	1.9	94.0	270.0	360.0	460.0	780	37.5%	0.0%	0.0%	0.0%
		Cleveland	99	2380.5	2.3	420.0	1350.0	2140.0	4517.0	16380	100.0%	80.8%	54.5%	20.2%
		Minnesota	44	593.2	2.7	45.0	280.0	559.5	1150.5	8120	59.1%	25.0%	9.1%	4.5%
		Rhode Island	60	1392.4	3.3	66.0	639.5	1500.0	2779.0	26159	88.3%	60.0%	36.7%	15.0%
		Wisconsin	66	563.7	7.3	0.1	400.0	859.0	1500.0	5733	77.3%	37.9%	16.7%	3.0%
		Milwaukee	12	1974.2	2.5	327.0	1166.5	1690.0	3496.0	10300	91.7%	75.0%	33.3%	16.7%
		Vermont	171	1536.5	3.3	25.0	692.0	1560.0	3380.0	52700	88.9%	60.8%	41.5%	14.0%
Maine Urban	Homes		75	1275.0	NA	50.0	NA	NA	NA	10900	50.0% [5]	37.0% [6]	NA	NA
	Parks and Playgrounds		25	205.0	NA	50.0	NA	NA	NA	700	8.0% [5]	0.0% [6]	0.0%	0.0%
Milwaukee	Perimeter		93	2343.7	2.2	587.0	1248.0	1990.0	3655.0	29335	100.0%	77.2%	50.0%	18.3%
	Play Area		92	626.3	2.3	130.0	378.0	556.0	860.0	9459	73.9%	20.7%	9.8%	3.3%
Minneapolis Clean-up	Minneapolis	Foundation	12	NA	NA	34.0	184.0	795.0	1265.0	2240	NA	NA	NA	NA
		Mid-yard	12	NA	NA	6.0	55.0	272.0	411.0	680	NA	NA	NA	NA
		Street	10	NA	NA	96.0	138.0	255.0	282.0	373	NA	NA	NA	NA
	St. Paul	Foundation	10	NA	NA	22.0	178.0	561.0	980.0	2960	NA	NA	NA	NA
		Mid-yard	10	NA	NA	44.0	70.0	108.0	284.0	414	NA	NA	NA	NA
		Street	10	NA	NA	33.0	106.0	153.0	282.0	470	NA	NA	NA	NA

Table 3-22b. (cont.)

Study	Yard Area/ Subset of Housing Units		Average Soil-Lead Concentration (µg/g) N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	Percentag of Homes with Soil-Lead Concentration $ 400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Minnesota	Entire Study, All Samples		2454 [7]	NA	NA	NA	NA	NA	NA	NA	11.0% [5]	5.0% [6]	2.0%	NA
	St. Paul	Foundation	127 [7]	472.0	4.5	3.0	268.0	576.0	1246.0	7994	70.7% [4]	26.3%	NA	NA
		Garden	8 [7]	174.0	6.2	14.0	40.0	147.0	1177.0	2846	NA	NA	NA	NA
		Backyard	114 [7]	119.0	3.8	1.0	65.0	161.0	300.0	1386				
		Front yard	108 [7]	90.0	3.0	1.0	44.0	104.0	192.0	1377	21.0% [4]	2.5%	NA	NA
		Side yard	46 [7]	96.0	6.1	1.0	42.0	133.0	364.0	2385				
		Street side	170 [7]	113.0	2.2	6.0	64.0	127.0	204.0	575	8.3% [4]	0.0%	0.0%	0.0%
		Open	95 [7]	66.0	3.7	2.0	26.0	76.0	177.0	1466	NA	NA	NA	NA
		Play area	164 [7]	24.0	7.0	1.0	4.0	36.0	104.0	607	NA	NA	NA	NA
	Minneapolis	Foundation	199 [7]	665.0	3.5	35.0	305.0	689.0	1496.0	20136	56.60 [4]	32.6%	NA	NA
		Garden	28 [7]	253.0	3.2	34.0	109.0	264.0	445.0	3858	NA	NA	NA	NA
		Backyard	61 [7]	212.0	3.3	4.0	110.0	247.0	520.0	1210				
		Front yard	131 [7]	173.0	2.1	18.0	107.0	185.0	289.0	1345	31.4% [4]	0.8%	NA	NA
		Side yard	170 [7]	177.0	2.2	27.0	106.0	165.0	297.0	1326				
		Street side	119 [7]	186.0	2.6	3.0	108.0	223.0	338.0	1876	25.0% [4]	0.6%	NA	NA
		Open	51 [7]	39.0	3.7	1.0	24.0	34.0	73.0	878	NA	NA	NA	NA
		Play area	139 [7]	22.0	6.9	1.0	4.0	33.0	110.0	788	NA	NA	NA	NA
New Haven, Connecticut	Near (near the house)		260	712.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Far (near the street)		260	597.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
New Orleans	Inner City	Foundation	201 [7]	NA	NA	8.0	249.0	840.0	2370.0	69000	NA	NA	NA	NA
		Streetside	723 [7]	NA	NA	4.0	142.0	342.0	620.0	9450	55.5% [4]	9.1%	NA	NA
		Open Area	74 [7]	NA	NA	10.0	76.0	212.0	460.0	10600	NA	NA	NA	NA
	Mid-City	Foundation	220 [7]	NA	NA	1.0	32.0	110.0	446.0	24400	NA	NA	NA	NA
		Streetside	765 [7]	NA	NA	1.0	30.0	110.0	246.0	6340	21.2% [4]	2.9%	NA	NA
		Open Area	80 [7]	NA	NA	2.0	16.0	40.0	98.0	3960	NA	NA	NA	NA
	Suburban	Foundation	332 [7]	NA	NA	2.0	18.0	50.0	154.0	5650	NA	NA	NA	NA
		Streetside	1195 [7]	NA	NA	2.0	40.0	86.0	171.0	2150	9.2% [4]	0.3%	NA	NA
		Open Area	114 [7]	NA	NA	4.0	14.0	28.0	78.0	540	NA	NA	NA	NA
Rochester Study	Dripline		185	992.6	4.2	17.8	545.8	1117.5	2380.2	110834	79.5%	47.6%	31.4%	11.4%
	Dripline (fine soil only)		185	732.0	3.7	12.3	412.0	959.0	1648.0	21049	76.2%	38.4%	18.4%	3.8%

Table 3-22b. (cont.)

Study	Yard Area/ Subset of Housing Units		Average Soil-Lead Concentration (µg/g) N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	Percentag of Homes with Soil-Lead Concentration $ 400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Washington, D.C.	Front yard	Ward 1	30	NA	NA	36.4	228.0	444.2	1145.0	4905	NA	NA	NA	NA
		Ward 2	30	NA	NA	48.3	344.8	471.4	975.0	4520	NA	NA	NA	NA
		Ward 3	30	NA	NA	10.2	25.1	53.7	105.7	815	NA	NA	NA	NA
		Ward 4	30	NA	NA	32.7	95.5	198.9	294.9	4575	NA	NA	NA	NA
		Ward 5	30	NA	NA	12.0	101.3	221.9	380.4	5056	NA	NA	NA	NA
		Ward 6	30	NA	NA	13.8	125.0	260.4	427.9	1720	NA	NA	NA	NA
		Ward 7	30	NA	NA	36.2	70.3	144.4	274.9	3740	NA	NA	NA	NA

NA = Not Available
1 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized without weighting by sample weights.
2 Mass-weighted arithmetic average soil-lead concentration as calculated in Chapter 3 of the 403 risk analysis; summarized by weighting each average to reflect the 1997 U.S. housing stock.
3 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized by weighting with the National Survey sample weights.
4 Percent of samples that exceed 300 ppm
5 Percent of samples that exceed 500 ppm
6 Percent of samples that exceed 1000 ppm
7 Number of samples (multiple samples taken at many sites).
8 Arithmetic Mean or SD
9 60 houses total; reference used did not provide number of houses by house age.
10 An initial unweighted arithmetic average of soil lead levels at the specified locations was taken prior to calculation of statistics within this table. The number in this column represents the number of properties, not necessarily the number of houses.

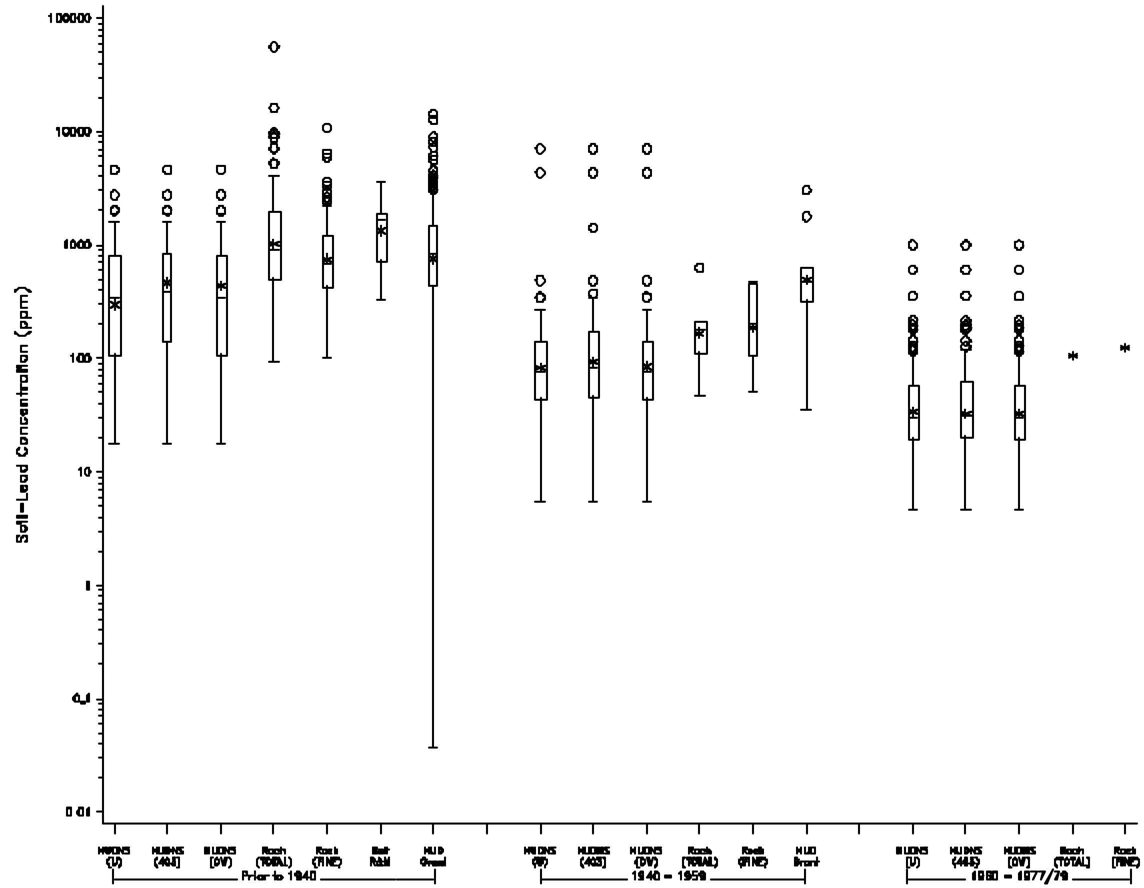

Figure 3-17. Boxplots of Household Average Soil-Lead Concentrations (μg/g) for Houses in the HUD National Survey, Baltimore R&M Study, Rochester Lead-in-Dust Study, and HUD Grantees Evaluation, by Housing Age Category (pre-1979 only)

(Note: Data for the Baltimore R&M study are dripline results. See text for definitions of labels along the horizontal axis. Caution must be taken when categorizing houses in the Rochester study by age of the house.)

The summary statistics found in Tables 3-22a and 3-22b were calculated according to housing age category for relevant studies. These summaries are found in Tables 3-23a (for yard-wide average soil-lead concentration) and 3-23b (for average soil-lead concentration for specific locations). Note that these tables also include summary statistics for housing units built after 1979 (although the Rochester study units may not have actually been built in this time period, as mentioned in Section 3.2.1.2). The post-1979 results labeled as "HUD National Survey (§403 RA)" represent surveyed homes built from 1960-1979 that contain no lead-based paint (Section 3.3.1.5 of the §403 risk analysis report).

3.2.2.3 <u>Calculating National Exceedance Percentages for Yardwide Average Soil-Lead Concentration</u>. The soil-lead data summaries presented above suggest that the distribution of measured soil-lead concentrations as reported for the HUD National Survey are reasonably consistent with the distributions suggested by other studies, including the interim NSLAH data. Thus, these two national surveys are expected to generate similar national distributions for yardwide average soil-lead concentration, from which the estimated percentages of housing units whose yardwide average soil-lead concentrations exceed specified thresholds ("exceedance percentages") could be calculated. These percentages give some indication of the frequency with which intervention activities might be prompted by regulations that target alleviating soil-lead exposure. Soil abatement practices are often recommended both within the literature and by the HUD "Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing" (USHUD, 1995b; pages 12-47 to 12-56).

The methods detailed in Section 3.2.1.3, which were used to fit lognormal distributions to household average floor dust-lead loadings based on data from the two national surveys, were also used to fit lognormal distributions to yardwide average soil-lead concentration data from these two surveys. As discussed in Section 3.2.1.3, the key objective to fitting the lognormal distribution was to use the distribution to estimate exceedance percentages for specified soil-lead concentration thresholds. Therefore, in order to ensure that the upper tail of the distribution was as accurately portrayed as possible within the fitted distribution, this method treated a certain percentage of the lowest data values as censored data when fitting the distribution. In this exercise, four thresholds were of interest for yardwide average soil-lead concentration: 400, 1200, 2000, and 5000 ppm.

Figure 3-18 contains plots of the fitted lognormal distributions (superimposed on bar charts of the observed data) and the estimated exceedance probabilities corresponding to these distributions, for residential yard-wide average soil-lead concentrations, based on the HUD National Survey data (top plot) and the interim NSLAH data (bottom plot). Recall that the sampling weights corresponding to the HUD National Survey data were revised in the §403 risk analysis to reflect the 1997 national housing stock. The same soil-lead concentration (horizontal) axis is used for both plots, so that the two plots can be directly compared. The similarity of the two distributions is noted in this plot, as the fitted distributions are nearly the same shape and cover approximately the same ranges of data. Furthermore, the estimated exceedance percentages for a given threshold differ by less than one percentage point between the two

Table 3-23a. **Descriptive Statistics of Yard-Wide Average Soil-Lead Concentrations, According to Study and Housing Age Category and Within Specific Subsets of the Sampled Housing Within a Study**

Study	Subset of Units or Type of Soil/Cover	Yard-Wide Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration ≥			
		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Houses Built Prior to 1940													
HUD National Survey (unweighted) [1]	All	58	298.3	3.8	17.4	109.4	346.5	805.3	4619	43.1%	17.2%	6.9%	0.0%
	City Only	29	375.6	4.0	17.4	110.2	533.9	1159.2	4619	55.2%	24.1%	6.9%	0.0%
	Northeast	11	453.8	1.9	136.7	289.6	443.6	627.9	1427	54.5%	9.1%	0.0%	0.0%
	Midwest	15	476.9	3.9	49.8	109.4	679.1	1497.0	2752	53.3%	40.0%	13.3%	0.0%
	South	19	166.3	4.3	17.4	47.4	125.2	613.4	4619	26.3%	5.3%	5.3%	0.0%
	West	13	286.2	4.0	25.9	112.7	393.5	711.2	2019	46.2%	15.4%	7.7%	0.0%
	Northeast - City Only	3	545.1	2.4	255.8	255.8	443.6	1427.1	1427	66.7%	33.3%	0.0%	0.0%
	Midwest - City Only	6	794.2	3.7	80.4	371.5	1427.8	1497.0	2752	66.7%	66.7%	16.7%	0.0%
	South - City Only	13	221.4	4.9	17.4	59.6	258.1	717.5	4619	38.5%	7.7%	7.7%	0.0%
	West - City Only	7	449.7	2.8	84.2	137.7	585.6	1159.2	1244	71.4%	14.3%	0.0%	0.0%
HUD National Survey (403 RA) [2]	All	77	462.7	3.1	17.4	137.7	393.5	840.7	4619	59.2%	19.6%	9.4%	0.0%
	City Only	45	509.4	3.0	17.4	258.8	613.4	840.7	4619	67.4%	20.7%	8.6%	0.0%
	Northeast	26	490.7	1.6	136.7	289.6	554.1	840.7	1427	64.7%	0.8%	0.0%	0.0%
	Midwest	19	940.7	2.7	49.8	162.3	834.7	1463.0	2752	77.3%	54.1%	25.2%	0.0%
	South	19	173.6	3.7	17.4	47.4	125.2	613.4	4619	27.7%	2.9%	2.9%	0.0%
	West	13	295.5	3.8	25.9	112.7	393.5	711.2	2019	45.5%	18.0%	9.0%	0.0%
	Northeast - City Only	16	525.4	1.6	255.8	278.9	642.1	840.7	1427	72.0%	1.5%	0.0%	0.0%
	Midwest - City Only	9	1405.1	2.1	80.4	641.9	840.7	1463.0	2752	92.4%	77.8%	34.0%	0.0%
	South - City Only	13	223.8	4.0	17.4	59.6	258.1	717.5	4619	39.8%	4.2%	4.2%	0.0%
	West - City Only	7	434.4	2.8	84.2	137.7	585.6	1159.2	1244	66.9%	16.6%	0.0%	0.0%
Rochester Lead-in-Dust	Total Soil	75	1018.6	3.3	91.7	508.6	911.9	1971.8	55617	81.3%	36.0%	24.0%	10.7%
	Fine Soil Fraction	75	749.3	2.6	102.9	438.5	686.0	1205.0	10721	82.7%	25.3%	13.3%	4.0%

Table 3-23a. (cont.)

Study	Subset of Units or Type of Soil/Cover	Yard-Wide Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration $			
		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Houses Built Prior to 1940 (cont.)													
HUD National Survey (HUD NS weights) [3]	All	58	433.9	3.4	17.4	109.4	346.5	805.3	4619	56.1%	24.2%	11.6%	0.0%
	City Only	29	478.7	3.6	17.4	110.2	533.9	1159.2	4619	67.5%	29.9%	12.5%	0.0%
	Northeast	11	433.3	1.5	136.7	289.6	443.6	627.9	1427	62.5%	1.4%	0.0%	0.0%
	Midwest	15	955.4	2.8	49.8	109.4	679.1	1497.0	2752	75.1%	59.3%	27.7%	0.0%
	South	19	173.6	3.7	17.4	47.4	125.2	613.4	4619	27.7%	2.9%	2.9%	0.0%
	West	13	295.5	3.8	25.9	112.7	393.5	711.2	2019	45.5%	18.0%	9.0%	0.0%
	Northeast - City Only	3	444.9	1.4	255.8	255.8	443.6	1427.1	1427	90.8%	4.6%	0.0%	0.0%
	Midwest - City Only	6	1559.6	2.1	80.4	371.5	1427.8	1497.0	2752	91.1%	91.1%	39.8%	0.0%
	South - City Only	13	223.8	4.0	17.4	59.6	258.1	717.5	4619	39.8%	4.2%	4.2%	0.0%
	West - City Only	7	434.4	2.8	84.2	137.7	585.6	1159.2	1244	66.9%	16.6%	0.0%	0.0%
HUD Grantees Evaluation	All Grantees	181	757.2	4.2	0.0	431.0	835.0	1455.0	14180	79.0%	35.4%	18.8%	3.9%
	Alameda	39	650.9	2.7	39.5	318.0	582.0	1348.0	12648	69.2%	33.3%	7.7%	2.6%
	California	7	325.1	2.2	58.0	325.0	405.0	540.0	560	57.1%	0.0%	0.0%	0.0%
	Cleveland	64	1629.1	2.2	431.0	922.0	1430.0	2857.5	14180	100.0%	59.4%	37.5%	7.8%
	Minnesota	18	442.8	2.6	49.5	265.0	471.8	790.0	4492	61.1%	5.6%	5.6%	0.0%
	Rhode Island	11	835.1	3.6	65.0	281.5	1205.5	1496.0	5648	72.7%	54.5%	18.2%	9.1%
	Wisconsin	28	303.4	11.9	0.0	260.3	556.0	908.5	3852	67.9%	10.7%	7.1%	0.0%
	Milwaukee	6	1085.9	1.5	766.0	804.0	1005.0	1188.5	2288	100.0%	16.7%	16.7%	0.0%
	Vermont	8	395.9	3.6	38.5	178.5	503.8	1033.9	2078	50.0%	25.0%	12.5%	0.0%
Houses Built From 1940-1959													
HUD National Survey (unweighted) [1]	All	77	83.1	2.9	5.4	44.3	75.8	141.6	7025	3.9%	2.6%	2.6%	1.3%
	City Only	37	81.0	3.2	5.4	43.5	77.3	129.6	7025	2.7%	2.7%	2.7%	2.7%
	Northeast	10	96.9	4.2	33.7	52.4	62.0	77.3	4318	10.0%	10.0%	10.0%	0.0%
	Midwest	19	85.2	2.4	9.3	52.4	90.5	145.3	346	0.0%	0.0%	0.0%	0.0%
	South	33	84.1	3.3	5.4	43.5	81.0	135.1	7025	6.1%	3.0%	3.0%	3.0%
	West	15	70.7	2.2	24.9	34.6	60.4	145.5	214	0.0%	0.0%	0.0%	0.0%
	Northeast - City Only	4	96.4	1.8	63.9	70.6	77.3	151.4	225	0.0%	0.0%	0.0%	0.0%
	Midwest - City Only	3	104.3	3.1	36.3	36.3	90.5	345.9	346	0.0%	0.0%	0.0%	0.0%
	South - City Only	20	91.5	4.1	5.4	46.2	94.5	139.5	7025	5.0%	5.0%	5.0%	5.0%
	West - City Only	10	55.0	2.1	24.9	26.0	49.7	108.5	214	0.0%	0.0%	0.0%	0.0%

Table 3-23a. (cont.)

Study	Subset of Units or Type of Soil/Cover	Yard-Wide Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration $			
		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Houses Built From 1940-1959 (cont.)													
HUD National Survey (403 RA) [2]	All	87	92.6	3.2	5.4	47.6	81.4	170.7	7025	5.2%	4.3%	3.2%	1.1%
	City Only	46	101.5	3.4	5.4	49.0	103.7	218.2	7025	4.7%	4.7%	2.3%	2.3%
	Northeast	17	136.4	4.4	33.7	53.8	77.3	313.3	4318	14.3%	14.3%	9.3%	0.0%
	Midwest	21	92.6	2.4	9.3	58.9	123.3	182.0	372	0.0%	0.0%	0.0%	0.0%
	South	33	83.1	3.3	5.4	43.5	81.0	135.1	7025	6.1%	3.3%	3.3%	3.3%
	West	16	72.1	2.2	24.9	39.4	70.9	171.7	220	0.0%	0.0%	0.0%	0.0%
	Northeast - City Only	10	255.8	2.3	63.9	77.3	269.4	313.3	1412	12.6%	12.6%	0.0%	0.0%
	Midwest - City Only	5	140.6	2.4	36.3	90.5	216.7	345.9	372	0.0%	0.0%	0.0%	0.0%
	South - City Only	20	91.8	4.1	5.4	46.2	94.5	139.5	7025	5.7%	5.7%	5.7%	5.7%
	West - City Only	11	56.3	2.1	24.9	26.0	51.8	129.6	220	0.0%	0.0%	0.0%	0.0%
HUD National Survey (HUD NS weights) [3]	All	77	83.9	3.1	5.4	44.3	75.8	141.6	7025	4.4%	3.4%	3.4%	1.2%
	City Only	37	80.8	3.2	5.4	43.5	77.3	129.6	7025	2.8%	2.8%	2.8%	2.8%
	Northeast	10	102.8	4.5	33.7	52.4	62.0	77.3	4318	12.3%	12.3%	12.3%	0.0%
	Midwest	19	85.7	2.4	9.3	52.4	90.5	145.3	346	0.0%	0.0%	0.0%	0.0%
	South	33	83.1	3.3	5.4	43.5	81.0	135.1	7025	6.1%	3.3%	3.3%	3.3%
	West	15	69.9	2.2	24.9	34.6	60.4	145.5	214	0.0%	0.0%	0.0%	0.0%
	Northeast - City Only	4	138.8	1.8	63.9	70.6	77.3	151.4	225	0.0%	0.0%	0.0%	0.0%
	Midwest - City Only	3	104.3	2.5	36.3	36.3	90.5	345.9	346	0.0%	0.0%	0.0%	0.0%
	South - City Only	20	91.8	4.1	5.4	46.2	94.5	139.5	7025	5.7%	5.7%	5.7%	5.7%
	West - City Only	10	53.1	2.0	24.9	26.0	49.7	108.5	214	0.0%	0.0%	0.0%	0.0%
HUD Grantees Evaluation	All Grantees	11	492.0	3.0	35.5	328.0	479.0	640.0	3024	72.7%	18.2%	9.1%	0.0%
	Alameda	2	1059.0	2.1	632.0	632.0	1203.2	1774.5	1774	100.0%	50.0%	0.0%	0.0%
	Rhode Island	5	409.2	5.0	35.5	328.0	509.5	640.0	3024	60.0%	20.0%	20.0%	0.0%
	Wisconsin	3	404.8	1.2	316.0	316.0	450.0	466.5	466	66.7%	0.0%	0.0%	0.0%
	Vermont	1	479.0	.	479.0	479.0	479.0	479.0	479	100.0%	0.0%	0.0%	0.0%
Rochester Lead-in-Dust [4]	Total Soil	5	166.8	2.6	46.7	113.9	180.6	212.8	632	20.0%	0.0%	0.0%	0.0%
	Fine Soil Fraction	5	186.3	2.6	51.1	104.0	198.5	458.5	465	40.0%	0.0%	0.0%	0.0%

Table 3-23a. (cont.)

Study	Subset of Units or Type of Soil/Cover	Yard-Wide Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration $			
		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Houses Built From 1960-1979 (1977 for HUD Grantees Evaluation)													
HUD National Survey (unweighted) [1]	All	115	33.9	2.6	4.6	20.0	30.1	58.3	996	1.7%	0.0%	0.0%	0.0%
	City Only	43	39.2	2.7	5.2	21.1	33.3	79.3	996	2.3%	0.0%	0.0%	0.0%
	Northeast	10	61.2	2.2	14.8	41.1	62.2	115.2	196	0.0%	0.0%	0.0%	0.0%
	Midwest	29	26.5	2.4	4.6	17.1	23.4	39.2	355	0.0%	0.0%	0.0%	0.0%
	South	59	36.4	2.5	5.2	22.6	32.1	66.4	996	1.7%	0.0%	0.0%	0.0%
	West	17	28.4	3.7	4.8	14.2	23.7	39.5	604	5.9%	0.0%	0.0%	0.0%
	Northeast - City Only	3	98.7	2.2	42.5	42.5	115.2	196.2	196	0.0%	0.0%	0.0%	0.0%
	Midwest - City Only	6	19.6	1.4	13.7	13.8	20.6	21.1	33	0.0%	0.0%	0.0%	0.0%
	South - City Only	25	48.5	2.7	5.2	26.4	39.4	81.6	996	4.0%	0.0%	0.0%	0.0%
	West - City Only	9	25.4	2.6	5.4	18.8	23.7	31.8	186	0.0%	0.0%	0.0%	0.0%
HUD National Survey (403 RA) [2]	All	120	32.8	2.6	4.6	20.4	31.5	62.5	996	1.2%	0.0%	0.0%	0.0%
	City Only	46	36.2	2.4	5.2	21.3	34.8	68.5	996	0.9%	0.0%	0.0%	0.0%
	Northeast	10	60.7	2.2	14.8	41.1	62.2	115.2	196	0.0%	0.0%	0.0%	0.0%
	Midwest	29	27.1	2.3	4.6	17.1	23.4	39.2	355	0.0%	0.0%	0.0%	0.0%
	South	64	36.5	2.3	5.2	23.0	35.1	64.9	996	0.8%	0.0%	0.0%	0.0%
	West	17	23.8	3.0	4.8	14.2	23.7	39.5	604	3.7%	0.0%	0.0%	0.0%
	Northeast - City Only	3	115.0	1.9	42.5	42.5	115.2	196.2	196	0.0%	0.0%	0.0%	0.0%
	Midwest - City Only	6	20.1	1.4	13.7	13.8	20.6	21.1	33	0.0%	0.0%	0.0%	0.0%
	South - City Only	28	48.8	2.2	5.2	26.8	42.7	80.4	996	2.0%	0.0%	0.0%	0.0%
	West - City Only	9	23.5	2.1	5.4	18.8	23.7	31.8	186	0.0%	0.0%	0.0%	0.0%
HUD National Survey (HUD NS weights) [3]	All	115	32.4	2.6	4.6	20.0	30.1	58.3	996	1.2%	0.0%	0.0%	0.0%
	City Only	43	35.9	2.5	5.2	21.1	33.3	79.3	996	0.9%	0.0%	0.0%	0.0%
	Northeast	10	60.7	2.2	14.8	41.1	62.2	115.2	196	0.0%	0.0%	0.0%	0.0%
	Midwest	29	27.1	2.3	4.6	17.1	23.4	39.2	355	0.0%	0.0%	0.0%	0.0%
	South	59	35.7	2.3	5.2	22.6	32.1	66.4	996	0.8%	0.0%	0.0%	0.0%
	West	17	23.8	3.0	4.8	14.2	23.7	39.5	604	3.7%	0.0%	0.0%	0.0%
	Northeast - City Only	3	115.0	1.9	42.5	42.5	115.2	196.2	196	0.0%	0.0%	0.0%	0.0%
	Midwest - City Only	6	20.1	1.4	13.7	13.8	20.6	21.1	33	0.0%	0.0%	0.0%	0.0%
	South - City Only	25	49.3	2.3	5.2	26.4	39.4	81.6	996	2.2%	0.0%	0.0%	0.0%
	West - City Only	9	23.5	2.1	5.4	18.8	23.7	31.8	186	0.0%	0.0%	0.0%	0.0%

Table 3-23a. (cont.)

Study	Subset of Units or Type of Soil/Cover	N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
		Yard-Wide Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Yard-Wide Average Soil-Lead Concentration $			
Houses Built From 1960-1979 (1977 for HUD Grantees Evaluation) (cont.)													
Rochester Lead-in-Dust [4]	Total Soil	1	106.2	.	106.2	106.2	106.2	106.2	106	0.0%	0.0%	0.0%	0.0%
	Fine Soil Fraction	1	124.5	.	124.5	124.5	124.5	124.5	124	0.0%	0.0%	0.0%	0.0%
Houses Built After 1979 (1977 for HUD Grantees Evaluation)													
HUD National Survey (403 RA) [2]	All	28	22.4	2.3	5.4	13.6	21.2	45.0	97	0.0%	0.0%	0.0%	0.0%
	City Only	9	24.8	2.3	5.4	20.4	21.3	29.7	97	0.0%	0.0%	0.0%	0.0%
	Midwest	4	11.5	1.7	6.7	7.0	12.4	19.0	20	0.0%	0.0%	0.0%	0.0%
	South	18	29.7	2.1	5.6	21.0	25.0	58.3	97	0.0%	0.0%	0.0%	0.0%
	West	6	15.0	2.3	5.4	6.2	13.6	29.7	62	0.0%	0.0%	0.0%	0.0%
	Midwest - City Only	1	20.4	1.0	20.4	20.4	20.4	20.4	20	0.0%	0.0%	0.0%	0.0%
	South - City Only	5	38.5	2.0	21.0	21.3	24.5	79.3	97	0.0%	0.0%	0.0%	0.0%
	West - City Only	3	12.8	2.0	5.4	5.4	13.0	29.7	30	0.0%	0.0%	0.0%	0.0%
HUD Grantees Evaluation	Minnesota	1	405.5	.	405.5	405.5	405.5	405.5	406	100.0%	0.0%	0.0%	0.0%
Rochester Lead-in-Dust [4]	Total Soil	1	521.9	.	521.9	521.9	521.9	521.9	522	100.0%	0.0%	0.0%	0.0%
	Fine Soil Fraction	1	545.5	.	545.5	545.5	545.5	545.5	546	100.0%	0.0%	0.0%	0.0%

1 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized without weighting by sample weights.
2 Mass-weighted arithmetic average soil-lead concentration as calculated in Chapter 3 of the 403 risk analysis; summarized by weighting each average to reflect the 1997 U.S. housing stock.
3 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized by weighting with the National Survey sample weights.
4 Some houses in this housing age category may belong to an earlier age category, as some houses may have actually been built earlier than the year specified within the study's database.

Table 3-23b. Descriptive Statistics of Average Soil-Lead Concentrations in Specific Yard Areas and/or for Certain Subsets of the Sampled Housing Within a Study, Presented by Housing Age Category

Study	Location		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
			Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Average Soil-Lead Concentration $			
Houses Built Prior to 1940														
HUD National Survey (unweighted) [1]	Dripline/ Entryway	All	64	347.2	4.0	19.7	127.9	418.2	987.6	8960	51.6%	12.5%	7.8%	3.1%
		City Only	33	426.2	4.0	23.1	182.9	504.3	1106.5	8960	60.6%	15.2%	9.1%	6.1%
		Northeast	15	556.9	2.0	211.8	377.9	523.7	887.7	2334	73.3%	13.3%	6.7%	0.0%
		Midwest	17	515.9	4.0	34.7	259.8	424.8	1165.5	5336	52.9%	23.5%	17.6%	5.9%
		South	19	207.5	5.0	23.1	49.4	182.9	842.9	8960	31.6%	10.5%	5.3%	5.3%
		West	13	254.4	4.1	19.7	88.1	423.6	932.3	1149	53.8%	0.0%	0.0%	0.0%
		Northeast - City Only	6	509.3	2.4	211.8	241.9	458.5	700.8	2334	66.7%	16.7%	16.7%	0.0%
		Midwest - City Only	7	702.0	3.8	93.7	261.6	702.0	1932.8	5336	71.4%	28.6%	14.3%	14.3%
		South - City Only	13	299.4	5.7	23.1	59.0	296.3	1106.5	8960	46.2%	15.4%	7.7%	7.7%
		West - City Only	7	428.0	3.1	66.5	123.8	652.8	1038.2	1149	71.4%	0.0%	0.0%	0.0%
HUD National Survey (403 RA) [2]	Dripline/ Entryway	All	77	529.0	3.4	19.7	184.0	466.4	1126.5	8960	68.1%	15.1%	12.7%	4.5%
		City Only	45	622.7	3.3	23.1	261.6	700.8	1126.5	8960	78.7%	12.7%	9.2%	8.6%
		Northeast	26	664.4	1.6	211.8	453.0	622.4	1126.5	2334	93.6%	2.4%	0.8%	0.0%
		Midwest	19	924.7	3.6	34.7	259.8	702.0	1165.5	5336	64.7%	39.7%	37.9%	12.6%
		South	19	215.9	4.3	23.1	49.4	182.9	842.9	8960	33.8%	9.1%	2.9%	2.9%
		West	13	241.4	3.8	19.7	88.1	423.6	932.3	1149	50.2%	0.0%	0.0%	0.0%
		Northeast - City Only	16	743.6	1.6	211.8	453.0	913.7	1126.5	2334	94.1%	1.5%	1.5%	0.0%
		Midwest - City Only	9	1387.1	3.0	93.7	424.8	1114.5	1126.5	5336	92.4%	38.9%	34.0%	34.0%
		South - City Only	13	301.3	4.6	23.1	59.0	296.3	1106.5	8960	48.7%	13.1%	4.2%	4.2%
		West - City Only	7	375.0	2.9	66.5	123.8	652.8	1038.2	1149	66.9%	0.0%	0.0%	0.0%

Table 3-23b. (cont.)

Study	Location		Average Soil-Lead Concentration (µg/g) N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	Percentage of Homes with Average Soil-Lead Concentration $ 400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Houses Built Prior to 1940 (cont.)														
HUD National Survey (HUD NS weights) [3]	Dripline/ Entryway	All	64	481.8	3.7	19.7	127.9	418.2	987.6	8960	62.9%	17.5%	14.7%	5.2%
		City Only	33	545.8	3.8	23.1	182.9	504.3	1106.5	8960	71.7%	16.8%	12.2%	11.4%
		Northeast	15	562.0	1.5	211.8	377.9	523.7	887.7	2334	90.4%	3.6%	1.2%	0.0%
		Midwest	17	917.8	3.6	34.7	259.8	424.8	1165.5	5336	63.3%	41.2%	39.3%	13.1%
		South	19	215.9	4.3	23.1	49.4	182.9	842.9	8960	33.8%	9.1%	2.9%	2.9%
		West	13	241.4	3.8	19.7	88.1	423.6	932.3	1149	50.2%	0.0%	0.0%	0.0%
		Northeast - City Only	6	572.4	1.6	211.8	241.9	458.5	700.8	2334	86.8%	3.3%	3.3%	0.0%
		Midwest - City Only	7	1418.8	3.1	93.7	261.6	702.0	1932.8	5336	91.6%	43.1%	37.7%	37.7%
		South - City Only	13	301.3	4.6	23.1	59.0	296.3	1106.5	8960	48.7%	13.1%	4.2%	4.2%
		West - City Only	7	375.0	2.9	66.5	123.8	652.8	1038.2	1149	66.9%	0.0%	0.0%	0.0%
Baltimore R&M	Dripline		28	444.5	5.1	28.9	71.5	686.9	1767.5	3539	60.7%	42.9%	10.7%	0.0%
California	Oakland, LA, Sacramento		377	NA	NA	NA	NA	NA	NA	NA	66.0% [4]	NA	NA	NA
	Oakland		174	NA	NA	NA	NA	NA	NA	NA	90.0% [4]	NA	NA	NA
HUD Grantees Evaluation	Dripline	All Grantees	266	1025.9	3.9	0.1	534.0	1077.5	2150.0	50600	80.8%	46.2%	29.3%	8.6%
		Alameda	57	733.3	2.8	30.0	370.0	652.0	1317.0	21131	71.9%	28.1%	14.0%	3.5%
		California	7	321.9	1.9	94.0	250.0	350.0	520.0	780	28.6%	0.0%	0.0%	0.0%
		Cleveland	64	2491.7	2.3	540.0	1370.0	2150.0	4638.0	16380	100.0%	79.7%	59.4%	21.9%
		Minnesota	21	455.7	2.8	45.0	275.0	400.0	770.0	8120	52.4%	9.5%	4.8%	4.8%
		Rhode Island	13	1251.5	3.0	112.0	744.0	1511.0	2401.0	10209	84.6%	61.5%	30.8%	7.7%
		Wisconsin	44	504.9	7.6	0.1	353.5	796.5	1205.0	5733	75.0%	29.5%	9.1%	4.5%
		Milwaukee	6	1224.7	2.2	327.0	1070.0	1166.5	1910.0	3727	83.3%	50.0%	16.7%	0.0%
		Vermont	54	1355.8	3.2	28.0	645.0	1425.0	3180.0	50600	88.9%	55.6%	40.7%	5.6%
New Haven, Connecticut	Near (near the house)		112	1252.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Far (near the street)		112	816.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rochester Lead-in-Dust	Dripline		158	1329.8	3.5	29.1	668.8	1322.0	2755.0	110834	88.0%	55.1%	36.7%	13.3%
	Dripline (fine soil only)		158	937.8	3.2	12.3	640.0	1076.5	1816.0	21049	85.4%	44.3%	21.5%	4.4%

Table 3-23b. (cont.)

Study	Location		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	Percentage of Homes with Average Soil-Lead Concentration $: 400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
				Average Soil-Lead Concentration (µg/g)										
Houses Built From 1940-1959														
HUD National Survey (unweighted) [1]	Dripline/ Entryway	All	82	107.7	3.2	8.0	55.8	89.6	179.4	13596	8.5%	4.9%	3.7%	1.2%
		City Only	42	116.8	4.1	8.0	55.8	87.7	187.5	13596	14.3%	7.1%	7.1%	2.4%
		Northeast	13	170.4	4.6	35.9	73.5	83.7	246.0	2571	23.1%	23.1%	15.4%	0.0%
		Midwest	20	121.8	2.6	11.6	61.9	116.7	244.9	689	10.0%	0.0%	0.0%	0.0%
		South	33	97.9	3.4	8.0	45.5	89.6	145.3	13596	6.1%	3.0%	3.0%	3.0%
		West	16	77.2	2.5	9.5	43.1	71.0	178.7	284	0.0%	0.0%	0.0%	0.0%
		Northeast - City Only	7	256.8	5.1	73.5	83.7	88.0	2570.5	2571	28.6%	28.6%	28.6%	0.0%
		Midwest - City Only	4	218.5	3.3	51.3	91.3	311.1	590.0	689	50.0%	0.0%	0.0%	0.0%
		South - City Only	20	114.0	4.4	8.0	53.9	94.2	175.3	13596	10.0%	5.0%	5.0%	5.0%
		West - City Only	11	58.9	2.5	9.5	31.8	57.4	177.9	188	0.0%	0.0%	0.0%	0.0%
HUD National Survey (403 RA) [2]	Dripline/ Entryway	All	87	108.6	3.1	8.0	55.8	90.0	218.9	13596	6.5%	4.3%	2.2%	1.1%
		City Only	46	119.3	3.8	8.0	57.4	94.2	246.0	13596	9.6%	4.7%	4.7%	2.3%
		Northeast	17	152.7	3.6	35.9	73.5	88.0	373.2	2571	14.3%	14.3%	5.0%	0.0%
		Midwest	21	125.3	2.5	11.6	61.9	131.4	249.0	689	7.0%	0.0%	0.0%	0.0%
		South	33	96.8	3.3	8.0	45.5	89.6	145.3	13596	4.9%	3.3%	3.3%	3.3%
		West	16	75.7	2.5	9.5	43.1	71.0	178.7	284	0.0%	0.0%	0.0%	0.0%
		Northeast - City Only	10	294.4	2.8	73.5	83.7	309.6	373.2	2571	12.6%	12.6%	12.6%	0.0%
		Midwest - City Only	5	224.0	2.7	51.3	131.4	373.2	490.7	689	33.0%	0.0%	0.0%	0.0%
		South - City Only	20	114.0	4.4	8.0	53.9	94.2	175.3	13596	8.6%	5.7%	5.7%	5.7%
		West - City Only	11	55.2	2.4	9.5	31.8	57.4	177.9	188	0.0%	0.0%	0.0%	0.0%
HUD National Survey (HUD NS weights) [3]	Dripline/ Entryway	All	82	103.0	3.1	8.0	55.8	89.6	179.4	13596	6.9%	4.5%	2.3%	1.1%
		City Only	42	105.7	3.9	8.0	55.8	87.7	187.5	13596	10.6%	5.2%	5.2%	2.6%
		Northeast	13	134.9	3.8	35.9	73.5	83.7	246.0	2571	17.2%	17.2%	6.0%	0.0%
		Midwest	20	118.7	2.5	11.6	61.9	116.7	244.9	689	7.4%	0.0%	0.0%	0.0%
		South	33	96.8	3.3	8.0	45.5	89.6	145.3	13596	4.9%	3.3%	3.3%	3.3%
		West	16	75.7	2.5	9.5	43.1	71.0	178.7	284	0.0%	0.0%	0.0%	0.0%
		Northeast - City Only	7	255.2	3.5	73.5	83.7	88.0	2570.5	2571	20.2%	20.2%	20.2%	0.0%
		Midwest - City Only	4	193.4	2.9	51.3	91.3	311.1	590.0	689	42.5%	0.0%	0.0%	0.0%
		South - City Only	20	114.0	4.4	8.0	53.9	94.2	175.3	13596	8.6%	5.7%	5.7%	5.7%
		West - City Only	11	55.2	2.4	9.5	31.8	57.4	177.9	188	0.0%	0.0%	0.0%	0.0%

Table 3-23b. (cont.)

Study	Location		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
			Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Average Soil-Lead Concentration $			
Houses Built From 1940-1959 (cont.)														
California	Oakland, LA, Sacramento		163	NA	NA	NA	NA	NA	NA	NA	19.6% [4]	NA	NA	NA
California	Oakland		17	NA	NA	NA	NA	NA	NA	NA	70.6% [4]	NA	NA	NA
HUD Grantees Evaluation	Dripline	All Grantees	17	478.0	3.2	66.0	174.0	530.0	925.0	5389	64.7%	23.5%	11.8%	5.9%
HUD Grantees Evaluation	Dripline	Alameda	4	484.3	2.2	174.0	273.0	645.5	922.0	925	50.0%	0.0%	0.0%	0.0%
HUD Grantees Evaluation	Dripline	Rhode Island	6	509.1	4.8	66.0	140.0	536.0	1217.0	5389	66.7%	33.3%	16.7%	16.7%
HUD Grantees Evaluation	Dripline	Wisconsin	5	516.5	2.7	139.0	400.0	516.0	593.0	2160	80.0%	20.0%	20.0%	0.0%
HUD Grantees Evaluation	Dripline	Vermont	2	317.5	6.6	84.0	84.0	642.0	1200.0	1200	50.0%	50.0%	0.0%	0.0%
New Haven, Connecticut	Near (near the house)		115	534.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
New Haven, Connecticut	Far (near the street)		115	500.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rochester Lead-in-Dust [5]	Dripline		13	282.6	3.5	27.5	170.5	259.0	843.0	1790	38.5%	7.7%	0.0%	0.0%
Rochester Lead-in-Dust [5]	Dripline (fine soil only)		13	276.5	3.4	29.7	146.0	272.0	851.0	1788	30.8%	7.7%	0.0%	0.0%
Houses Built From 1960-1979 (1977 for HUD Grantees and New Haven)														
HUD National Survey (unweighted) [1]	Dripline/ Entryway	All	117	39.1	2.8	5.2	21.3	33.6	70.0	1713	2.6%	0.9%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	City Only	45	44.8	2.9	5.2	21.7	37.3	79.3	1713	2.2%	2.2%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	Northeast	10	66.8	2.1	20.6	35.3	73.1	118.6	207	0.0%	0.0%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	Midwest	29	29.8	2.5	5.8	19.4	28.4	39.9	685	3.4%	0.0%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	South	61	41.7	2.8	5.2	27.0	35.9	72.3	1713	1.6%	1.6%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	West	17	36.2	4.0	7.5	15.9	26.6	36.5	910	5.9%	0.0%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	Northeast - City Only	3	101.1	2.5	35.3	35.3	141.2	207.2	207	0.0%	0.0%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	Midwest - City Only	6	21.3	1.7	10.1	15.8	20.4	35.5	40	0.0%	0.0%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	South - City Only	27	56.1	2.8	5.2	28.2	49.5	91.7	1713	3.7%	3.7%	0.0%	0.0%
HUD National Survey (unweighted) [1]	Dripline/ Entryway	West - City Only	9	28.7	2.9	7.9	20.3	26.6	34.3	337	0.0%	0.0%	0.0%	0.0%

Table 3-23b. (cont.)

Study	Location		N	Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
			Average Soil-Lead Concentration (µg/g)								Percentage of Homes with Average Soil-Lead Concentration $			
Houses Built From 1960-1979 (1977 for HUD Grantees and New Haven) (cont.)														
HUD National Survey (403 RA) [2]	Dripline/ Entryway	All	120	38.0	2.7	5.2	21.4	34.2	75.8	1713	2.0%	0.3%	0.0%	0.0%
		City Only	46	40.9	2.7	5.2	21.7	37.8	83.9	1713	0.9%	0.9%	0.0%	0.0%
		Northeast	10	66.7	2.1	20.6	35.3	73.1	118.6	207	0.0%	0.0%	0.0%	0.0%
		Midwest	29	30.6	2.4	5.8	19.4	28.4	39.9	685	3.7%	0.0%	0.0%	0.0%
		South	64	41.9	2.6	5.2	27.2	36.8	83.4	1713	0.8%	0.8%	0.0%	0.0%
		West	17	29.6	3.3	7.5	15.9	26.6	36.5	910	3.7%	0.0%	0.0%	0.0%
		Northeast - City Only	3	118.6	2.1	35.3	35.3	141.2	207.2	207	0.0%	0.0%	0.0%	0.0%
		Midwest - City Only	6	22.1	1.6	10.1	15.8	20.4	35.5	40	0.0%	0.0%	0.0%	0.0%
		South - City Only	28	57.3	2.5	5.2	30.3	50.8	87.9	1713	2.0%	2.0%	0.0%	0.0%
		West - City Only	9	26.0	2.4	7.9	20.3	26.6	34.3	337	0.0%	0.0%	0.0%	0.0%
HUD National Survey (HUD NS weights) [3]	Dripline/ Entryway	All	117	37.5	2.7	5.2	21.3	33.6	70.0	1713	2.0%	0.3%	0.0%	0.0%
		City Only	45	40.6	2.7	5.2	21.7	37.3	79.3	1713	0.9%	0.9%	0.0%	0.0%
		Northeast	10	66.7	2.1	20.6	35.3	73.1	118.6	207	0.0%	0.0%	0.0%	0.0%
		Midwest	29	30.6	2.4	5.8	19.4	28.4	39.9	685	3.7%	0.0%	0.0%	0.0%
		South	61	40.8	2.6	5.2	27.0	35.9	72.3	1713	0.8%	0.8%	0.0%	0.0%
		West	17	29.6	3.3	7.5	15.9	26.6	36.5	910	3.7%	0.0%	0.0%	0.0%
		Northeast - City Only	3	118.6	2.1	35.3	35.3	141.2	207.2	207	0.0%	0.0%	0.0%	0.0%
		Midwest - City Only	6	22.1	1.6	10.1	15.8	20.4	35.5	40	0.0%	0.0%	0.0%	0.0%
		South - City Only	27	56.8	2.5	5.2	28.2	49.5	91.7	1713	2.0%	2.0%	0.0%	0.0%
		West - City Only	9	26.0	2.4	7.9	20.3	26.6	34.3	337	0.0%	0.0%	0.0%	0.0%
California	Oakland, LA, Sacramento		93	NA	NA	NA	NA	NA	NA	NA	16.1% [4]	NA	NA	NA
	Oakland		12	NA	NA	NA	NA	NA	NA	NA	58.3% [4]	NA	NA	NA
New Haven, Connecticut	Near (near the house)		33	286.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Far (near the street)		33	382.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rochester Lead-in-Dust [5]	Dripline		4	66.3	2.1	27.5	37.9	69.6	125.6	160	0.0%	0.0%	0.0%	0.0%
	Dripline (fine soil only)		4	66.3	1.8	29.0	49.5	78.0	98.5	111	0.0%	0.0%	0.0%	0.0%

Table 3-23b. (cont.)

Study	Location		N	Average Soil-Lead Concentration (µg/g) Geometric Mean	Geometric Std. Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum	Percentage of Homes with Average Soil-Lead Concentration $ 400 µg/g	1200 µg/g	2000 µg/g	5000 µg/g
Houses Built After 1979 (1977 for HUD Grantees and New Haven)														
HUD National Survey (403 RA) [2]	Dripline/ Entryway	All	28	27.4	2.5	5.6	11.9	28.3	52.3	144	0.0%	0.0%	0.0%	0.0%
		City Only	9	32.4	2.5	7.9	21.3	31.5	37.3	144	0.0%	0.0%	0.0%	0.0%
		Midwest	4	15.4	1.8	7.5	9.0	15.4	27.9	35	0.0%	0.0%	0.0%	0.0%
		South	18	34.5	2.5	5.6	19.9	32.8	70.0	144	0.0%	0.0%	0.0%	0.0%
		West	6	20.2	2.4	7.9	9.5	17.9	31.5	105	0.0%	0.0%	0.0%	0.0%
		Midwest - City Only	1	35.5	1.0	35.5	35.5	35.5	35.5	35	0.0%	0.0%	0.0%	0.0%
		South - City Only	5	52.7	2.2	21.3	27.6	37.3	128.3	144	0.0%	0.0%	0.0%	0.0%
		West - City Only	3	14.0	1.8	7.9	7.9	11.0	31.5	31	0.0%	0.0%	0.0%	0.0%
HUD Grantees Evaluation	Dripline	Minnesota	1	330.0	.	330.0	330.0	330.0	330.0	330	0.0%	0.0%	0.0%	0.0%
Rochester Lead-in-Dust [5]	Dripline		10	147.6	3.7	17.8	66.0	125.8	705.0	874	30.0%	0.0%	0.0%	0.0%
	Dripline (fine soil only)		10	135.3	3.1	26.0	72.0	125.5	169.0	876	20.0%	0.0%	0.0%	0.0%

NA = Not Available

1 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized without weighting by sample weights.
2 Mass-weighted arithmetic average soil-lead concentration as calculated in Chapter 3 of the 403 risk analysis; summarized by weighting each average to reflect the 1997 U.S. housing stock.
3 Mass-weighted arithmetic average soil-lead concentration as reported in the HUD National Survey; summarized by weighting with the National Survey sample weights.
4 Percent of samples that exceed 500 µg/g.
5 Some houses in this housing age category may belong to an earlier age category, as some houses may have actually been built earlier than the year specified within the study's database.

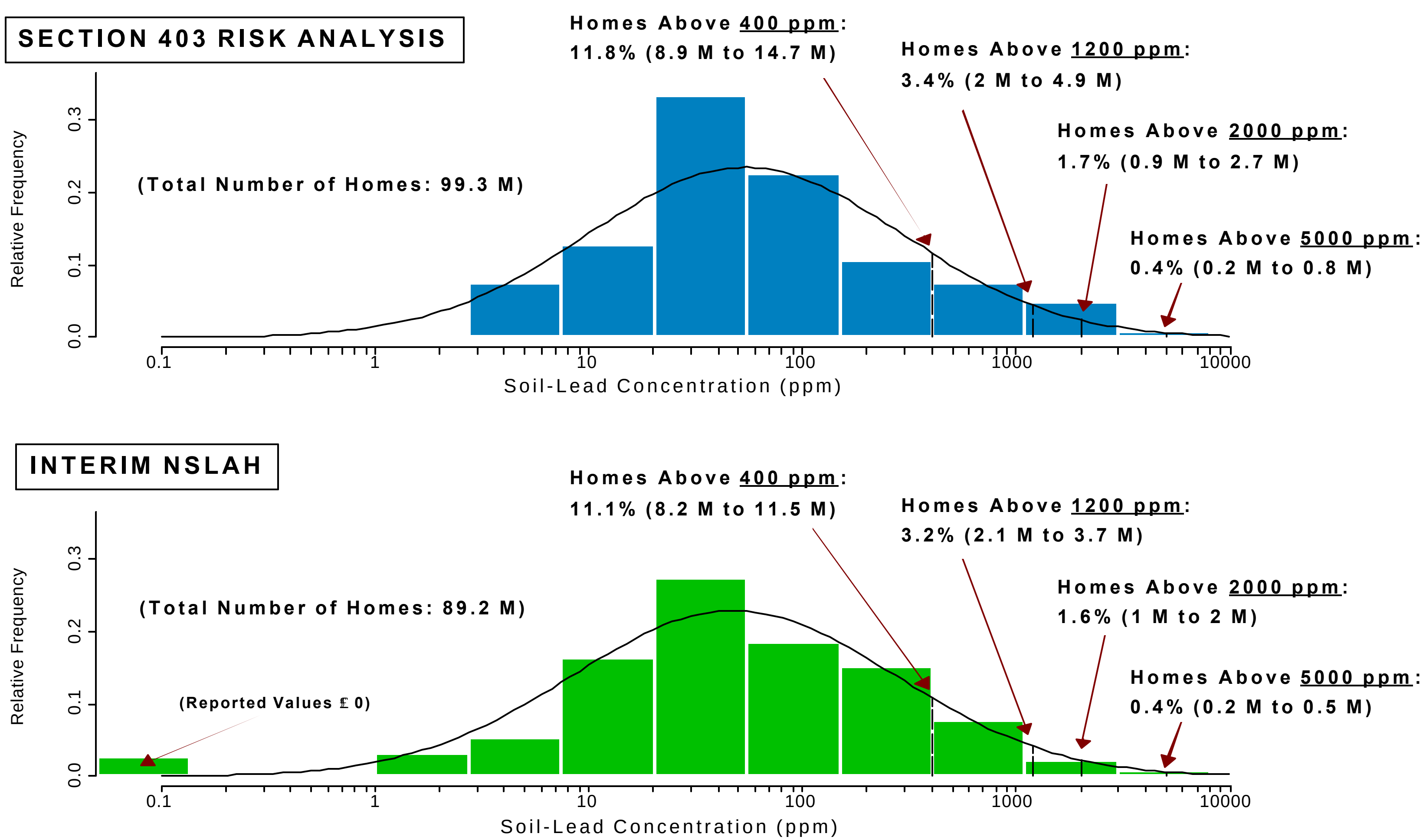

Figure 3-18. Estimated Distribution of Yardwide Average Soil-Lead Concentration in the Nation's Housing Stock, and Corresponding Estimates of the Percentage of Homes Exceeding Specified Thresholds (with 95% Confidence Intervals on the Corresponding Number of Homes, in Millions), Based on Data from the HUD National Survey (top plot) and the Interim NSLAH (bottom plot)

Note: The estimated exceedance percentages are calculated based on the fitted distribution (solid curve).

surveys. Each estimated exceedance percentage is accompanied by an approximate 95% confidence interval on the number of homes in the U.S. housing stock that exceeds the threshold (given in millions).

In Figure 3-18, the distribution based on the HUD National Survey data used in the §403 risk analysis was determined by censoring data values below 24.5 ppm (i.e., the bottom 30 percent of the data, taking into account the sample weights). The distribution based on the interim NSLAH data was determined by censoring data values below 2.01 ppm, which corresponds to the bottom 5% of the observed weighted distribution, including negative values.

Among these four thresholds, the estimated percentage of residences that exceed the threshold vary widely. For a threshold of 2000 ppm, the estimated percentage is 1.6% to 1.7% for the two surveys, while the percentage increases to from 11.1% to 11.8% for the two surveys when the threshold is lowered to 400 ppm.

For both surveys, the estimated exceedance percentages specified within Figure 3-18 for yardwide average soil-lead concentration, based on the fitted lognormal distribution, are also included within Table 3-24 (columns 2 and 4) for the same four thresholds. Also included in Table 3-24 (columns 3 and 5) are estimated exceedance percentages that were determined solely by the proportion of total sampling weights in the survey that corresponded to surveyed units whose household average floor dust-lead loadings exceeded the given threshold (i.e., information from the bar charts within Figure 3-18). The two types of estimates are very similar for the interim NSLAH data except at the highest threshold, while for the HUD National Survey data, differences between the estimates increase as the threshold decreases. It should be noted that the lognormal-based estimates for the exceedance percentages (which were also portrayed in Figure 3-18) should be used when making inferences on the nation's housing stock.

Table 3-24. Estimated Percentages of 1997 U.S. Housing Exceeding Specified Thresholds of Yardwide Average Soil-Lead Concentration

Soil-Lead Conc. Threshold (ppm)	§403 Risk Analysis – Based on Data from the HUD National Survey (n = 284)		Data from the Interim NSLAH (n = 706)	
	Based on the Fitted Lognormal Distribution (i.e., the curve in Figure 3-18)	Based on the Weighted Observed Data (i.e., the bar chart in Figure 3-18)	Based on the Fitted Lognormal Distribution (i.e., the curve in Figure 3-18)	Based on the Weighted Observed Data (i.e., the bar chart in Figure 3-18)
400	11.8%	13.2%	11.1%	11.2%
1200	3.4%	4.7%	3.2%	2.9%
2000	1.7%	2.5%	1.6%	1.7%
5000	0.4%	0.2%	0.4%	0.1%

Note: Data are imputed for those surveyed units with missing data prior to calculating the above statistics (34 observations in the HUD National Survey had either dripline or remote soil-lead concentration imputed prior to calculating a yardwide average; 42 observations in the interim NSLAH had an imputed yardwide average). The estimates based on the weighted observed data are simple weighted percentiles that do not originate from a fitted distribution.

It was also desired to calculate exceedance percentages for only urban residences within the U.S. housing stock, as urban soil has the potential for being more likely to be contaminated by lead than non-urban soil (in the absence of a particular lead source). Thus, the procedure used to fit the distributions in Figure 3-18 was also applied to the HUD National Survey data for only the 146 surveyed homes labeled as being located in urban areas. (The interim NSLAH data were not included in this exercise because homes were not characterized by urbanicity.)

Figure 3-19 plots the distribution and documents the exceedance percentages for urban residential soil-lead concentrations as estimated using the HUD National Survey data. Based on the fitted lognormal distribution, this figure indicates that approximately 2.8 percent of the roughly 40 million homes in urban areas are estimated to exceed a yardwide average soil-lead concentration of 2000 ppm[11]. This corresponds to approximately 1.1 million homes. However, because the sampling weights in the HUD National Survey (and revised in the §403 risk analysis) were not necessarily determined to ensure that the weights assigned to the homes in urban areas would be representative of the entire urban housing stock, caution must be taken in making inferences on the national urban housing stock based on these estimates.

3.2.2.4 Interpreting the Observed Differences with Other Studies. Contrasting the measured soil-lead concentrations from one study to another is complicated by differences in study designs, sampling locations, and sampling and laboratory protocols and practices used by these studies. As areal patterns in the lead concentration of residential soil have long been recognized, different locations within the same yard can have widely different soil-lead concentrations. For example, levels along the foundation of the residence are typically highest, reflecting the presence of deteriorated lead-based paint formerly on the residence or deposited leaded gasoline emissions washed off the roof. Also, distinct sampling protocols may impact the amount of lead measured in a collected sample. The Rochester and Milwaukee studies, for example, partitioned a collected soil sample into fine- and coarse-sieved fractions. Finally, various laboratory practices and procedures can leach more or less lead from the digested soil sample. Some studies seek to mimic "bioavailable" lead by using an acidic digestion meant to mimic human stomach acids.

Unfortunately, insufficient data were available from the various studies in Table 3-17 to consider fully any distinctions in soil-lead concentration that would be prompted exclusively by a study's collection and measurement practices. Undoubtedly, soil collection and measurement practices partially explain the observed differences across the studies, but their effects cannot be quantified at this stage. The data summaries in Section 3.2.2.2 attempted to express soil-lead concentrations in the Rochester study as reflecting the total sample (as is done in many studies) rather than only the fine-sieved portion of the sample by adjusting the data based on relationships observed in the Milwaukee study among fine-, coarse- and total-sieved soil fraction data.

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[11] The sum of the sampling weights (adjusted in the §403 risk analysis to represent the 1997 housing stock) for the 146 urban homes in the HUD National Survey is roughly 40 million. The fitted lognormal distribution in Figure 3-19 treats the bottom 20 percent of the HUD National Survey (based on the sample weights) as censored data at 21.3 µg/g.

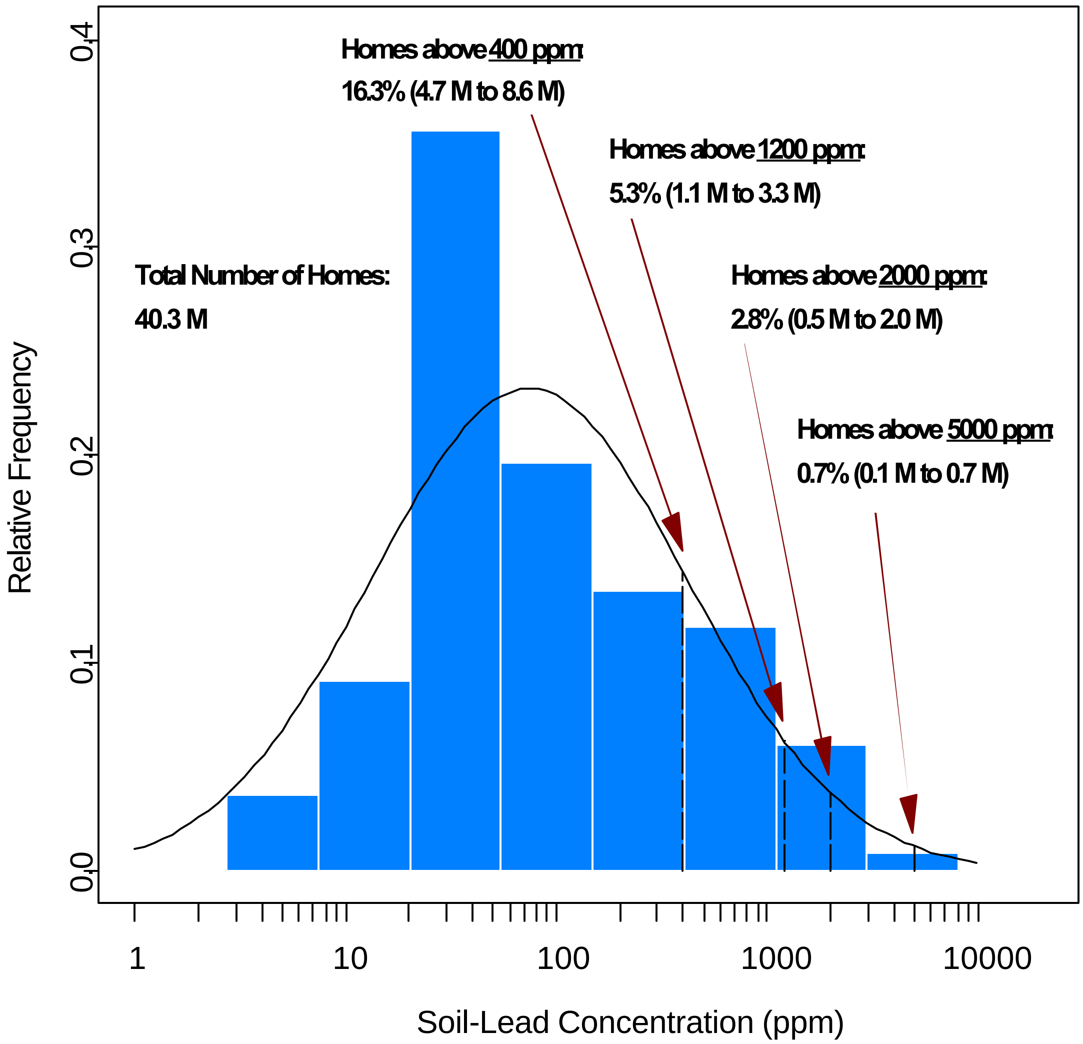

Figure 3-19. Estimated Distribution of Yardwide Average Soil-Lead Concentration Among Urban Housing in the HUD National Survey, and Corresponding Estimates of the Percentage of Urban Homes That Exceed Specified Thresholds (with 95% Confidence Intervals on the Corresponding Number of Urban Homes in the Nation, in Millions)

Note: Because the HUD National Survey was not necessarily conducted in a manner such that the sample weights for urban housing are representative of urban housing in the entire country, caution should be made when attempting to use this information to infer about urban housing for the entire nation.

It is possible to discuss study-specific caveats about how the housing selection procedure and sample collection and analysis procedures differ between the studies and, therefore, can contribute to the differences observed in the plots and tables in Section 3.2.2.2. For the Baltimore R&M, the Rochester, HUD Grantee, and HUD National Survey studies, this information was summarized in Tables 3-3a through 3-3f of the §403 risk analysis report. For the interim NSLAH, this information was summarized in Section 3.1 of this report. Some of the study differences mentioned in Section 3.2.1.4 as possibly contributing to differences in dust-lead loading data would also be contributors to differences in the reported soil-lead concentration data. Other differences among the studies in Table 3-17 include the following:

- The neighborhoods surveyed within the Baltimore R&M study, 3-City study, Cincinnati Longitudinal study, California Lead study, and HUD Grantees evaluation had a high prevalence of homes with lead-based paint hazards, along with a history of children with elevated blood-lead concentrations and/or considered at high-risk for lead poisoning.

- For the HUD Grantees evaluation, 28% of the homes were single-family buildings, 32% were single-family detached, and 12% were single-family attached (rowhouses). All homes in the R&M intervention group within the Baltimore R&M study were urban rowhouses (single-family attached). Eighty percent of the homes in the HUD National Survey were single-family dwellings. In the 3-Cities study, 100% of the Boston homes were single-family detached residences, most of the Baltimore homes were single-family attached dwellings, and the majority of Cincinnati homes were multi-story, multi-family structures.

- The dates of environmental sampling were 11/89-3/90 for the HUD National Survey, 12/93-1/99 for the HUD Grantees evaluation, 8/93-11/93 for the Rochester study, 3/93-11/94 for the Baltimore R&M study, 2/89-2/90 for the Baltimore 3-City study, 7/89-12/89 for the Boston 3-City study, and 1/89-8/89 for the Cincinnati 3-City study. Therefore, the HUD National Survey performed sampling roughly three years before the three major studies in this report, but near in time to others (such as the 3-Cities study).

- The New Orleans, Baltimore Garden, Minneapolis Clean-Up and Minnesota studies have sometimes been identified as using distinct laboratory practices, producing higher soil-lead concentrations than might be otherwise measured. The published literature regarding these studies, however, cites nothing unusual.

Because the HUD Grantees evaluation emphasizes local control of the individual programs, each grantee is responsible for designing and implementing lead-hazard reduction approaches applicable to its specific needs and objectives. These responsibilities include the recruitment methods, enrollment criteria, and intervention strategies. However, to enable comparison of results from the various approaches, grantees participating in the evaluation follow the same sampling protocols and use standard data collection forms developed specifically for this evaluation. Table 3-4 of the §403 risk analysis report documented the differences between grantees in their enrollment/recruitment criteria. As a result, the summaries in Section 3.2.2.2 were also presented by grantee.

3.2.2.5 Conclusions of the Soil-Lead Data Comparisons. The following can be concluded from review of the boxplots and tables within Section 3.2.2 of this report, especially in regard to how the reported soil-lead concentration data for various studies compare with data from the HUD National Survey (as portrayed in the §403 risk analysis):

- Geometric mean (yard-wide) average soil-lead concentration was quite lower for the HUD National Survey relative to the yardwide estimates for most of the other studies cited in Table 3-17. However, the interim NSLAH (Section 3.2.2.1), as well as such studies as the Cincinnati 3-City and Baltimore Garden studies, did report geometric mean soil-lead concentrations that were comparable to that for the HUD National Survey. Otherwise, the distributions of soil-lead concentrations were rather consistent across the studies and available grantees.

- Among the housing age categories, the greatest difference in observed soil-lead concentration between the HUD National Survey (as portrayed in the §403 risk analysis) and the interim NSLAH was for housing built prior to 1940, where nearly a 50% decline in the estimated median was seen from the HUD National Survey to the interim NSLAH. The two sets of results were comparable among the other housing age categories.

- The low geometric mean soil-lead concentration in the HUD National Survey compared to other studies within Table 3-17 was most dramatic for homes built from 1940 to 1959. For homes built prior to 1940, the geometric mean reported in the §403 risk analysis (463 µg/g) was within 150 µg/g of that for three grantees within the HUD Grantees evaluation: California, Minnesota, and Vermont. However, for homes built from 1940 to 1959, the geometric mean soil-lead concentration across all units in the HUD Grantees evaluation (492 µg/g) was over four times higher than that reported in the §403 risk analysis (92.6 µg/g). Insufficient numbers of housing units built after 1959 in the other studies prevent reliable comparisons of soil-lead concentrations with these studies.

- Overall, the importance of housing age is evident in the summaries within the four housing age categories. Older housing is more likely to contain higher average soil-lead concentrations compared to newer housing. However, within an age category, the summaries were reasonably consistent across studies.

- As expected, dripline/entryway soil-lead concentrations consistently exceeded yard-wide average levels for all studies with sampling plans permitting such comparisons. That soil-lead concentrations exhibit an areal pattern is well-known and documented throughout the scientific literature, and suggests caution when comparing the HUD National Survey yard-wide average results to those of other studies.

In general, the soil-lead concentrations observed in the HUD National Survey seem lower than many studies, but not necessarily beyond reason. Several of these other studies were conducted in urban neighborhoods already recognized to either have elevated environmental-lead levels or high incidence rates of elevated blood-lead concentrations among resident children. As such, higher soil-lead concentrations among these residences may be entirely consistent. Furthermore, soil-lead levels in the HUD National Survey were found to be comparable with those reported in the interim NSLAH, which reflects the entire nation's housing stock, and in other studies such as the Cincinnati 3-City and the Baltimore Garden study. Even studies conducted within the same urban area can differ considerably in the reported soil-lead concentrations; for example, the Baltimore 3-City study had levels about five times higher than the Baltimore Garden study.

3.3 EVALUATION OF SOIL PICA IN CHILDREN

This section investigates what has been published in the literature concerning the potential effects that pica for soil may have on children's exposure to lead, over and above the exposure associated with pica for paint that was considered when estimating risks in the §403 risk analysis. While the analysis did not consider the independent impact of soil pica over and above paint pica, it considered the impact of soil pica as part of the relation between soil-lead concentration and blood-lead concentration. While this section does not change the approach taken in the original §403 risk analysis, it documents information obtained on the component of soil-lead exposure that may be attributable to soil pica.

This section summarizes information on pica behavior for soil and paint for the three studies constituting the Urban Soil Lead Abatement Demonstration Project (USLADP) (USEPA, 1996a), the Rochester Lead-in-Dust study (USHUD, 1995a; Lanphear et al., 1996a), and the Baltimore Repair and Maintenance (R&M) study (USEPA, 1996c). The percentage of children who ingest soil, the frequency of soil ingestion episodes, and the amount of soil ingested by children with pica are estimated.

3.3.1 What Is Soil Pica?

Definitions. The literature provides varying definitions of pica. Pica is generally accepted to be the consumption of non-food items and there are at least nine different types of pica, including soil pica (Lacey, 1990). Some authors also consider mouthing of non-food items a pica behavior. Usually, pica is seen as normal behavior in young children, but abnormal in older children and adults. Exceptions occur, however, for some individuals, such as children and pregnant women in certain ethnic groups, the socially disadvantaged, groups of low income and socioeconomic status, developmentally delayed individuals, and the mentally retarded.

The American Psychiatric Association (DSM-III-R) has clinically defined pica as the ingestion of non-nutritive or inedible substances and requires repeated ingestion of a non-nutritive substance for at least one month before pica is considered a diagnosis. However, in practical research, authors tend to use less rigorous definitions of pica. For example, Shellshear et al., (1975) defined pica simply as an unusual appetite for non-food items.

Some authors consider pica a common occurrence in young children while others view pica behavior as abnormal. Sedman (1989) included in his definition of pica the ingestion of foreign substances by children that occurs during the course of normal development. This is consistent with Karam et al., (1990) who stated that pica includes the ingestion of some non-food items and that pica is a relatively common occurrence in small children. Barltrop et al., (1974) defined soil pica as the habitual insertion of soiled fingers or toys into a child's mouth, in addition to the direct consumption of soil. In contrast, Lyngbye et al., (1990) loosely defined pica as a mouthing habit more pronounced than in other children at the same age. Calabrese et al., (1991) defined soil pica as the ingestion of soil in amounts far exceeding those observed in the average child.

Pica for soil is considered by most authors to be the purposeful ingestion of soil. This definition is used throughout this report. Estimates of intentional soil ingestion, such as would occur in an actual "pica" episode, range from 500 to 13,000 mg soil/day, according to the studies cited in Table 3-25. To put this in perspective, quantitative estimates of inadvertent soil ingestion by normal children range from 9 to 246 mg/day (see Table 3-25), which are consistent with the estimates used in the §403 Risk Analysis.

Methods Used to Measure Soil Ingestion. Average daily soil ingestion can be quantified using a mass-balance approach, in which concentrations of tracer elements in fecal matter are measured and used to estimate the amount of soil ingested. The tracer elements typically used in soil ingestion studies include barium (Ba), manganese (Mn), silicon (Si), aluminum (Al), titanium (Ti), vanadium (V), yttrium (Y), and zirconium (Zr). However, in an adult validation study investigating the recovery of different tracer elements, Calabrese et al., (1989) concluded that the most reliable elements for this type of study are Al, Si, and especially Y. In addition, the authors indicated that when using these tracers, 500 mg/day could reliably be detected, and 100 mg/day could also be reliably detected but with a higher degree of variability. These levels are greater than most estimates of average daily soil ingestion in children. Tracer elements are generally selected due to their high concentration in soil relative to food products, and their low level of absorption in the gastrointestinal tract. Thus, the quantities of these tracer elements present in the feces, corrected for "background" or intake levels, can be attributed to the ingestion of soil (assuming there is no other non-food ingestion occurring, e.g., paint). Using the concentration of a tracer element in the bulk soil, the total quantity of soil ingested can be calculated. Concentrations of the tracer elements in the bulk soil are determined from soil samples around the child's home and play area. Samples are typically taken from the upper layers of soil (as this is where children are assumed to play), and finer size fractions may be separated out (as this size fraction is preferentially ingested) (Calabrese et al., 1989; Sheppard,

Table 3-25. Results of Literature Review on Children's Exposure to Lead Through Soil Pica

Author(s) / Publication Date	Methods	Pica Prevalence (% exhibiting soil pica)	Soil Intake Amount (soil ingestion rate mg/day)	Pica Frequency (# days on which soil was ingested)
Mass-Balance / Chemical Tracer Studies				
Calabrese et al., (1989)	64 children, ages 1-4 years; pica measured by fecal analysis using chemical tracers and mass-balance methodology; 8-day study [a]	1.6 % (1 child in 64)	Ç non-pica: 9-40 mg/day Ç pica: 5,000-8,000 mg/day	Information Not Given
Calabrese et al., (1991)	Follow-up study of pica child in Calabrese et al., (1989) [a]	Not Applicable	Ç 5,000-7,000 mg/day over 2 weeks Ç 10,000-13,000 mg/day during week 2	Episodic Ç pica occurred only during week 2 of observation
Calabrese et al., (1993)	Follow-up study of pica child in Calabrese et al., (1989) [a]	Not Applicable	Ç lead consumed in soil: 0.96 Fg/day - 11.6 Fg/day (where soil lead = 22 ppm)	pica occurred on 2 days out of 8
Stanek and Calabrese, (1995)	Re-analysis of Calabrese et al., (1989) [a]	1.6 % (1 child in 64)	Ç 12 mg/day or less for 50% of the children (median) Ç 138 mg/day or less for 95% of the children (median) Ç 10% of subjects ate 1,200 mg/day (n = 64, mean value)	Ç 33% of children are expected to ingest > 10 g soil on 1-2 days/year Ç 16% of children are expected to ingest >1 g soil on 35-40 days/year
Calabrese and Stanek (1993)	Critique of Wong, M.S. (1988) "The Role of Environmental and Host Behavioral Factors in Determining Exposure to Infection With *Ascaris Lumbricoides* And *Trichuris Trichluta*." [Ph.D. thesis], University of the West Indies, Mona, Jamaica. 28 children, ages 1.8-14 years, and 24 children, ages 0.3-7.5 years;[b] ingestion measured by fecal analysis using chemical tracers and correction for "background"; 4 month study (1 day/month) [c]	Ç older group: 3.6% (1 in 28 children; child with pica was mentally retarded) Ç younger group: 20.8% (5 of 24 children)	Ç older group: 58 mg/day based on the mean (mentally retarded child excluded) Ç younger group: mean 470 ± 370 mg/day Ç highly variable for pica episodes: 1,000 - 10,300 mg/day (8 episodes over 5 children, mentally retarded child excluded)	High degree of daily variation Ç 3 of 6 pica children exhibited behavior on only 1 of 4 days, others did more often

Table 3-25. (cont.)

Author(s) / Publication Date	Methods	Pica Prevalence (% exhibiting soil pica)	Soil Intake Amount (soil ingestion rate mg/day)	Pica Frequency (# days on which soil was ingested)
Calabrese et al., (1997)	12 children, ages 1-3 years; children preselected as exhibiting soil ingestion (Stanek et al., 1998); ingestion measured by fecal analysis using chemical tracers and mass-balance methodology; 7-day study [d]	Ç 8.3% (1 child in 12) clearly exhibited pica / high soil ingestion	Ç non-pica: < 10 mg/day (5 children); 10-20 mg/day (4 children) Ç pica: 500-3,050 mg/day (median 1,320 mg/day)	Ç pica child ingested between 0.5-3.0 g/day on 4 of 7 days
Davis et al., (1990)	104 children, aged 2-7 years; ingestion measured by fecal analysis using chemical tracers and mass-balance methodology; study over 7 consecutive days.	0% pica reported	Ç median soil ingestion estimates ranged from 25.3-81.3 mg/day (n= 101), depending on the tracer Ç mean soil ingestion estimates ranged from 38.9±12.2 to 245.5±119.7 mg/day (n = 101), depending on the tracer	Information Not Given
Studies Based on Interviews and Questionnaires				
Stanek et al., 1998	553 children assessed at well-child pediatric visits; presence of pica behavior assessed via parent interview[g]	Reported by age; pica prevalence of 38% at age 1 year declines to 21% at age 2 years and <10 % for ages 3-6 years; overall estimate of 18% for children aged 1 to 6 years	Information Not Given	Ç 38% at least monthly, 24% at least weekly, 11% daily at age 1 year Ç 21% at least monthly, 7% weekly, 0% daily at age 2 years
Abadin et al., (1997)	Discussion of ATSDR method to estimate blood-lead levels in children, where soil ingestion is one predictor	Not Applicable	Ç use assumed soil ingestion rate of 200 mg/day	Not Applicable
Bates et al., (1995)	143 children, aged 12-23 months; soil ingestion assessed via questionnaire [e]	Ç 62% (89 of 143) ate soil Ç 38% (54 of 143) never ate soil	Information Not Given	Information Not Given
Sedman and Mahmood, (1994)	Estimated average daily and lifetime soil ingestion in young children using results of two previous chemical tracer studies (Davis et al., 1990 and Calabrese et al, 1989); age adjusted for a 2 year-old child	Not Applicable	Ç mean estimate (2 year-old): 195 mg/day (std. err. - 53 mg/day) Ç estimated average daily soil ingestion over a lifetime: 70 mg/day (accounting for changes in soil ingestion with age)	Information Not Given

Table 3-25. (cont.)

Author(s) / Publication Date	Methods	Pica Prevalence (% exhibiting soil pica)	Soil Intake Amount (soil ingestion rate mg/day)	Pica Frequency (# days on which soil was ingested)
Greene et al., (1992)	270 socioeconomically disadvantaged children; pica assessed via caretaker interview at ages 2 years, 3 years, and 4 years 10 months [e]	Ç 19% at 2 years of age Ç 13% at 3 years of age Ç 6% at 4 years 10 months of age	Information Not Given	Information Not Given
Annest and Mahaffey (1984)	2,195 children, ages 1-5 years; presence of pica behavior assessed by household interview [e]	Ç 6 month-3 year age group: 11.0% Ç 4-5 year age group: 3.2% Ç annual family income < $10K: 11.9% Ç annual family income ≥ $10K: 6.0%	Information Not Given	Information Not Given
Shellshear et al., (1975)	170 children, ages 1-5 years; pica assessed via parent interview [f]	10.6% (18 children of 170)	Information Not Given	Information Not Given
Barltrop et al., (1974)	119 children in two towns, ages 2-3 years; 48 children in high soil lead area; presence of pica behavior assessed via parent interview [g]	Ç 51 of 119 (43%) conformed to pica definition; 11 of 119 (9%) known to swallow soil Ç 33% (16 of 48) of children had pica for soil (in high soil lead area)	Information Not Given	Information Not Given
Cohen et al., (1973)	230 rural and 272 urban children, mean age of 4 years; history pica assessed via parent questionnaire[e]	Ç 50% of the children had a history of pica at some time for dirt, cigarettes, or other non-food items Ç 10% reported ingestion of paint or plaster	Information Not Given	Information Not Given

[a] soil pica defined as ingestion of soil in quantities far exceeding those observed in the average child
[b] subject population consisted of Jamaican children of normal intelligence in long-term institutional settings, with the exception of one child (i.e., the child exhibiting extreme pica in the older group) who was mentally retarded
[c] pica defined as ingestion of >1 g soil/day
[d] high soil ingestion defined as >0.5 g soil/day on a regular or nearly daily basis
[e] soil pica not quantitatively defined in this study; pica only indicates the occurrence of ingestion
[f] soil pica defined as "an unusual appetite" for soil
[g] definition of pica for soil included children who habitually put fingers, etc., in mouth while playing in their gardens, as well as children who actually put soil directly into their mouths

1998). Most quantitative estimates of the amount of soil ingested that were reviewed in this report were obtained using the mass-balance/tracer element approach.

Incidence rates (i.e., prevalence) of pica for soil in young children may be estimated from parental questionnaires. This approach can yield biased results, however, as it relies on the observation and accurate reporting of pica by the adult. In addition, the response depends on the wording of the question. Various surveys have asked whether the child eats dirt (Annest and Mahaffey, 1984; Bates et al., 1995; USEPA, 1996a - Boston and Baltimore portions), whether the child puts dirt or sand in mouth while playing outside (USEPA, 1996a - Cincinnati portion; USEPA, 1996c), or whether the child puts fingers or toys in mouth while playing outside (Barltrop et al., 1974). Clearly, these questions would elicit different responses from the same caregiver. In addition, response choices may be simply yes or no, may specify a timeframe (e.g., in the past month), or may be open-ended. These choices, too, would result in differing responses. Thus, care must be taken in comparing soil pica prevalence rates originating from parental questionnaire data.

While mass-balance studies provide soil ingestion rates to support prevalence data, these studies are also subject to error and have disadvantages. For example, Calabrese et al., (1989) acknowledge that analyzing chemical tracers without the use of a mass-balance approach (i.e., not correcting for intake) can result in soil ingestion estimates that are increased by factors of 2 to 6. In addition, the particular tracer used, the duration of the study, and the frequency of sampling may also influence reported results (Calabrese et al., 1989; Calabrese et al., 1997). For example, the short duration of most mass-balance studies makes it difficult to determine a "normal" rate of soil ingestion for a child. Approaches using chemical tracers also have disadvantages in that they are more expensive and generally have small sample sizes.

3.3.2 How Does the §403 Risk Analysis Account for Soil Pica?

Within the exposure assessment (Chapter 3) portion of the §403 risk analysis report (USEPA, 1998a), soil was considered an indirect source of lead exposure, although summary information on soil pica frequency from two lead exposure studies was presented in Table 3-3b of the §403 risk analysis report.

An indicator of soil pica was considered as a candidate predictor variable in the development of the empirical model for the §403 risk analysis. The soil pica variable was based on the parental questionnaire administered in the Rochester Lead-in-Dust study. This variable measured the child's tendency to put dirt or sand in the mouth using a scale of 0 (never) to 4 (always). The soil pica variable was borderline significant in single media models, which assessed the relationship between blood-lead concentration and each predictor variable under consideration. These single media models were the first step in developing the empirical model. Variable selection for the multimedia exposure model was based on several properties, including the strength of the relationship with blood-lead concentration as estimated using the bivariate statistical models, predictive power of each variable when included into a model with competing sources of lead exposure, and interpretability of parameter estimates. The soil pica variable was dropped during this phase of the empirical model development. Additional information on the development of the empirical model can be found in Appendix G of the §403 risk analysis report.

Age-dependant soil and dust ingestion rates for the Integrated Exposure, Uptake, and Biokinetic (IEUBK) model were taken from the IEUBK guidance manual (USEPA, 1994) and represent central tendencies within the range of values seen in different studies. Combined soil and dust ingestion amounts ranged from 85 to 135 mg/day, as shown in Table 4-1 of the §403 risk analysis report, of which 45 percent was assumed to be from soil. Thus, soil ingestion was assumed to be between 38 and 61 mg/day for children aged 0 to 7 years, with the maximal ingestion estimated for children aged 1 to 3 years. These ingestion rates are consistent with estimates of inadvertent soil ingestion presented in this report, but are not representative of pica episodes. While IEUBK model predicted blood-lead levels were adjusted in the §403 risk analysis to allow consideration of paint pica in homes with damaged lead-based paint, as described in Section 4.1 and Appendix D1 of the §403 risk analysis report, no such adjustment was made for the effect of soil pica.

It should be noted that while neither model used in the §403 risk analysis had explicitly accounted for soil pica as a separate factor independent of paint pica, the impact of soil pica was included in the analysis as part of the relation between soil-lead concentration and blood-lead concentration which the analysis characterized.

3.3.3 Prevalence of Soil Pica Behavior

Estimates reported in the scientific literature of the percentage of children who ingest soil are summarized in this section. From the literature, it was not possible to estimate the percentage of children who exhibit pica for soil but not paint. The §403 risk analysis did account for the effect of paint pica on blood-lead concentration estimates. For children who ingest both paint chips and soil, it is reasonable to assume that the effect of soil pica is insignificant compared to that of paint pica. Thus, in estimating the percentage of children who ingest soil, it is important to exclude those who also ingest paint chips. It was possible to estimate the percentage of children who exhibit soil pica, but not paint pica, using information from parental questionnaires administered in the USLADP study (USEPA, 1996a), Baltimore R&M study (USEPA, 1996c), and Rochester Lead-in-Dust study (USHUD, 1995a; Lanphear et al., 1996a). This information is also summarized in this section.

3.3.3.1 <u>Literature Review</u>. Most sources in the literature reported prevalence rates for general pica behavior (mouthing or eating non-food items) or for soil pica (eating dirt). One source (Stanek et al., 1998) reported pica rates for a variety of specific non-food items (soil, paint chips, paper, toys, etc), but did not cross-tabulate [e.g., 18 percent of children ages 1 - 6 years, as assessed by parent interview, were reported to ingest/mouth dirt at least monthly and 3 percent to ingest/mouth paint chips, but information was not provided on how many children eat both soil and paint chips (Stanek et al., 1998)]. An overview of selected studies estimating pica prevalence is shown in Table 3-25 above. It is important to note that in the cited studies, various definitions of “pica” were used in reporting the prevalence of pica behavior. For example, Greene et al., (1992) defined soil pica only as the occurrence of soil ingestion and reported the percentage of children who ingest soil based on caretaker interview. In comparison, Calabrese et al., (1997) defined soil pica as consumption exceeding 0.5 grams per day and reported the prevalence of pica behavior as assessed quantitatively by mass-balance methods. It should be noted that only primary research findings are reported in Table 3-25, with the exception of Calabrese and Stanek (1993). Several review articles were also obtained. These were excluded from Table 3-25, as insufficient details of the source studies were provided. General findings of the review articles are cited in the text.

Table 3-25 shows that the estimated percentage of children ingesting soil ranged from 1.6 to 62 percent and varied with definition/criteria for soil pica used, age group of children, and socioeconomic status. In general, 12 of 16 observations in the table report a prevalence of soil ingestion in children of 13 percent or lower (where, at a minimum, limiting criteria are defined as ingesting soil at least once). "Normal" mouthing behavior, however, is typically exhibited more commonly, particularly in the younger age groups. For example, Barltrop et al., (1974) reported that 43 percent of children exhibited pica defined to include mouthing behavior, but that 9 percent were estimated to swallow soil. Stanek et al., (1998) assessed non-food ingestion and mouthing behaviors in 533 children, ages 1 to 6, by parental interview. Results of the survey indicated that 38 percent of 1 year old children and 21 percent of 2-year old children ingest/mouth soil at least monthly. In contrast, at ages 3 to 6 years, less than 10 percent of children were observed to ingest/mouth soil at least monthly. At age 1 year, 11 percent of children were observed to ingest/mouth soil daily compared to one percent or less among children aged 2 to 6 years.

Of the studies that used mass-balance methodology, prevalence of soil pica ranged from 1.6 to 20.8 percent. For studies that employed parent or caretaker interview methodology, soil pica prevalence ranged from 3.2 to 19 percent, although one study reported a rate of 62 percent, which appears to be more consistent with studies that monitored general mouthing behavior. For both methodologies, the prevalence of soil ingestion tended to be higher in the younger age groups and for children in families with lower socioeconomic status. Although, as mentioned in Section 3.3.1 above, techniques utilizing parental interview are generally considered less reliable than quantitative methodologies, the issue of consistently defining "pica" when reporting study results is an issue not only in studies using questionnaire methodology, but also in the mass-balance/chemical tracer studies. Differences in values reported, both between and within the various assessment techniques, may largely be due to differences in how pica behavior is being defined in the study. Thus, many studies estimating soil ingestion prevalence may not consistently monitor the actual overall risk associated with soil pica behavior in children.

3.3.3.2 Prevalence of Soil Pica Separate from Paint Pica. Although the literature review provided several estimates of the prevalence of soil pica behavior, none of the cited sources provided information about concurrent paint pica behavior. For the purpose of this report, the prevalence of soil pica behavior in the absence of paint pica is of interest, as the §403 risk analysis did account for paint pica behavior. For children who ingest both paint chips and soil, it is reasonable to assume that the effect of soil pica is insignificant compared to that of paint pica. Unless there is industrial contamination, or the home is in an area with heavy traffic, where residual leaded gasoline emissions are present, lead in residential soil is usually derived primarily from lead-based paint. Thus, soil pica can be considered an indirect pathway of exposure to leaded paint, whereas paint pica is a direct exposure pathway.

Information on pica behavior for paint, soil, and other objects was collected in the three USLADP studies (USEPA, 1996a), the Rochester Lead-in-Dust study (USHUD, 1995a; Lanphear et al., 1996a), and the Baltimore R&M study (USEPA, 1996c), through parental reporting of observed behaviors. Therefore, it is possible to use these data to estimate the prevalence of soil pica separately from paint pica. This information is summarized in Table 3-26. As can be seen in this table, rates of soil pica only range from 9.1 to 40.9 percent, while rates of both soil and paint pica range from 1.4 to 7.4 percent.

Some of the disparity in the rates reported in Table 3-26 can be explained by the survey questions and other factors associated with the study. For example, in the Rochester Lead-in-Dust, Baltimore R&M, and Cincinnati USLADP studies, parents were asked how frequently the child put dirt or sand in his or her mouth. In contrast, parents in the Boston and Baltimore portions of the USLADP were asked how frequently the child ate dirt or sand. The paint pica questions were more consistent across studies, querying how frequently the child put paint chips in his or her mouth. In the Cincinnati USLADP study, the time-period of observation for both soil and paint was limited to the previous month, whereas the other studies used open-ended time periods. Response rates in Rochester were consistent with literature estimates of soil pica that included mouthing behavior, while the Baltimore R&M and Cincinnati USLADP studies provided substantially lower estimates. Because most homes in the Baltimore R&M study had small or no yards, the low estimates of soil mouthing behavior are not unexpected. The lower response in Cincinnati is probably due to the limited period of observation.

Since inadvertent soil ingestion due to mouthing behavior was included in the IEUBK model analysis for the §403 risk analysis, the prevalence of soil ingestion, rather than mouthing behavior, is of interest in the context of this report. Thus, the Boston and Baltimore portions of the USLADP study provide the best estimates of soil pica behavior in the absence of paint pica. These estimates are 14.4 and 16.3 percent in Boston and Baltimore, respectively. These estimates are greater than those derived from the mass-balance studies, but consistent with other studies that rely on parental reporting methods. The prevalence of pica for both paint and soil was low in Boston (1.4 %), but somewhat higher in Baltimore (6.0 %). Adding these rates to the reported rates for soil pica alone does not substantially increase the estimates, however, which remain in the range of other studies that rely on parental reporting.

Table 3-26. Estimated Rates of Paint and Soil Pica Behavior Reported in the USLADP Studies, the Rochester Lead-in-Dust Study, and the Baltimore R&M Study

Study	Type of Pica Behavior	Study Children Exhibiting Such Pica Behavior		
		Percent (#) of Study Children[1]	Average Age (months)	Geometric Mean, Blood-Lead Conc. (μg/dL)
Boston USLADP (146 children)	Soil only	14.4% (21)	NA	12.5
	Paint only	9.6% (14)	NA	12.7
	Soil and Paint	1.4% (2)	NA	13.4
	neither	74.7% (109)	NA	11.7
Baltimore USLADP (400 children)	Soil only	16.3% (65)	35.7	12.0
	Paint only	10.5% (42)	33.1	11.7
	Soil and Paint	6.0% (24)	26.5	15.2
	neither	67.3% (269)	41.7	10.3
Cincinnati USLADP (220 children)	Soil only	23.2% (51)	35.9	12.8
	Paint only	2.7% (6)	19.7	15.3
	Soil and Paint	2.3% (5)	28.0	14.7
	neither	71.8% (158)	28.1	8.9
Baltimore R&M Pre-intervention (165 children)	Soil only	9.1% (15)	27.5	10.5
	Paint only	7.3% (12)	26.7	15.3
	Soil and Paint	7.3% (12)	24.2	20.7
	neither	76.4% (126)	31.1	9.4
Rochester Lead-in-Dust (203 children)	Soil only	40.9% (83)	21.0	6.1
	Paint only	2.5% (5)	23.0	11.5
	Soil and Paint	7.4% (15)	20.0	8.5
	neither	49.3% (100)	21.4	6.2

[1] A response of "Unknown" was treated as missing and was not included in the calculation of these percentages.
NA = Not applicable

3.3.4 Estimating the Frequency of Ingestion and Amount of Soil Ingested by Children Who Exhibit Soil Pica

As discussed in Section 3.3.3.1 above, studies reporting soil ingestion prevalence have the potential to misrepresent the extent of soil pica behavior in children due to differences in methodology and criteria for defining pica. Therefore, estimates of ingestion quantity and frequency may also be employed to assess the severity of soil pica behavior.

Mass-balance studies provide data on the frequency of ingestion and amount of soil ingested by children who exhibit soil pica. These studies estimate the typical amounts of soil inadvertently ingested by normal children as ranging from 9 to 246 mg/day. The estimated quantities ingested in actual "pica" episodes are between 500 and 13,000 mg/day (Table 3-25). The literature generally reports pica behavior to be episodic in nature, varying both amongst different children and within individual children. In addition, the occurrence (including both frequency and quantity) of soil ingestion was observed to be influenced by the age of the child (Stanek et al., 1998; Annest and Mahaffey, 1984), as well as by variety of factors that may alter the child's access to soil, including seasonal variation and/or climate/vegetation differences (Simon, 1998; Calabrese and Stanek, 1993), socioeconomic status (Annest and Mahaffey, 1984; Bhatia, 1988), and parental supervision (Calabrese and Stanek, 1993; Bhatia, 1988). However, Davis et al., (1990) found that although there was considerable variability in soil ingestion estimates among children, there was no consistent demographic or behavioral factor that was predictive of soil ingestion.

Calabrese et al., (1989) estimated median soil ingestion rates, including those involved in non-pica behavior, between 9 and 40 mg/day (n = 64). Calabrese et al., (1997) also observed median soil ingestion rates under 40 mg/day in 12 children (selected from the population described in Stanek et al., 1998) identified by their parents as likely to ingest soil at a high rate. These levels of soil ingestion typically would not be considered pica behavior. Each of these studies, however, did report observations of a child exhibiting extreme soil pica behavior, with one child ingesting from 5 to 8 grams of soil per day (Calabrese et al., 1989) and another child ingesting between 0.5 and 3.0 grams of soil per day on 4 of 7 days (Calabrese et al., 1997). Calabrese et al., (1991) found that the soil pica behavior for the former child occurred only on two days during the two weeks of observation with an ingestion rate ranging from 10-13 grams of soil per day, suggesting that the issue of variability in soil pica behavior may be very important, meriting further research. Implications of these patterns were demonstrated by Calabrese et al., (1993), who observed that on the two days when the child displayed soil pica behavior, she also displayed striking increases in fecal lead excretory values. In contrast, the pica child reported in Calabrese et al., (1997) consistently ingested large quantities of soil (0.5-3 g soil/day on 4 of 7 days).

Calabrese and Stanek (1993) presented results of a 4-month mass-balance/chemical tracer study performed by M.S. Wong of 52 Jamaican children of generally normal intelligence in an institutional setting. The children were partitioned into a younger (0.3-7.5 years) group and an older (1.8-14 years) group. One of the children in the older group exhibited mental retardation. This was the only child in the older group (of 28 children) that exhibited soil pica exceeding one gram of soil per day. This child had an average ingestion rate of 41 g soil/day over 4 months (observations on 1 day per month). In the younger group, 10.5 percent of total observations (n = 84) included soil pica, and five of the 24 children exhibited soil pica on at least one occasion. The Wong study showed that soil pica occurred more frequently in younger children, and there was a fairly high degree of daily variation in soil ingestion among the children exhibiting soil pica. For example, 3 of 6 children displayed pica on only 1 of 4 days. Furthermore, even for the children who consumed soil more consistently with regards to frequency, the rates were still variable (e.g., 1.0-10.3 g/day). Calabrese and Stanek (1993) suggest that although this study confirms that soil pica, strictly defined as ingestion greater than 1.0 g/day, is likely to be rare in older children, the Wong study is important in that it challenges the idea that pica is a rare event in younger children.

Using daily soil ingestion data from their 1989 study, Stanek and Calabrese (1995) developed annual soil ingestion distribution estimates as follows. First, the mean and variance of daily soil ingestion were estimated for each of the 64 children in the 1989 study, based on 4 to 8 daily estimates for each child. Then 365 daily soil ingestion amounts for each child were calculated as percentiles of a log-normal distribution with the estimated mean and variance, in increments of 1/365. Based on these distributions, Stanek and Calabrese conclude that 33 percent of children are expected to ingest more than 10 grams of soil on 1-2 days per year and that 16 percent of children are expected to ingest more than 1 gram of soil on 35-40 days per year. These ingestion levels are consistent with amounts estimated for soil pica episodes. The median and 95th percentile for average daily soil ingestion resulting from this method were 75 mg/day and 1,751 mg/day, respectively. While the median estimate is similar to previous estimates, the estimated 95th percentile is substantially greater than most other estimates.

Assumptions and limitations of this approach include:

1. The assumption of a log-normal distribution for daily soil ingestion. Insufficient data were available to determine whether this assumption is reasonable.

2. The estimation of the mean and variance for each child based on very small sample sizes. The annual estimates were strongly affected by the tails of the distribution, which are imprecise due to large variability in the estimates of the mean and variance.

3. The extrapolation of daily soil ingestion estimates from a 2-week period in autumn to the remainder of the year, without regard to possible seasonal effects. In addition, the children studied were a nonrandom sample residing in or near an academic community in western Massachusetts. Thus, the soil ingestion behavior of these children may not be representative of those living in other climates, geographic regions, or in inner-city or rural areas.

4. The presence of trace elements in fecal matter was assumed to be entirely due to soil consumption, after correcting for food consumption, with no contribution from indoor dust.

Many of these assumptions and limitations serve to introduce positive bias to the daily soil ingestion estimate, while the effect of others is unclear. Nonetheless, this analysis is at present, the only available source of both frequency of soil pica episodes and amount ingested during soil pica episodes.

3.3.5 Conclusions on Soil Pica

The following conclusions can be made from the findings presented in this section:

- The prevalence of soil pica, exclusive of paint pica, is most likely between 10 and 20 percent in young children. For the purpose of this report, the Boston and Baltimore portions of the USLADP provide the best estimates of soil pica behavior in the absence of paint pica (14.4 and 16.3 percent, respectively).

- Soil pica behavior is episodic in nature. The frequency of soil pica episodes depends on many factors, including climate, access to bare soil, socioeconomic standing, age of child, and parental supervision. In one study of 12 children identified by their parents to be predisposed to pica for soil, only one child displayed soil pica during the two week observation period (Calabrese et al., 1997). Only one study estimated annual rates for pica episodes (Stanek and Calabrese, 1995). This study suggested that 33 percent of children would ingest more than 10 grams of soil on 1-2 days per year, and that 16 percent of children are expected to ingest more than 1 gram of soil on 35-40 days per year.

- Estimates of the amount of soil ingested during pica episodes vary widely among the mass balance studies, from 500 to 13,000 mg/day. The average daily ingestion over a year, however, may be much lower. Assuming the frequencies estimated by Stanek and Calabrese (1995), children who ingest 15 grams of soil on 1-2 days per year and 50 mg/day on remaining days would have an average daily soil intake of 132 mg/day over the course of a year. Children who ingest 1.5 grams of soil on 40 days per year and 50 mg/day on remaining days would have an average daily soil intake of 209 mg/day. A question, however, is whether the amount of lead in soil ingested on the small number of days where pica episodes occurred would be sufficient to elevate the blood-lead concentration to unsafe levels.

3.4 CHARACTERIZING THE POPULATION OF CHILDREN IN THE NATION'S HOUSING STOCK

For the §403 risk analysis, it was necessary to estimate numbers of children of specific age groups who reside within the 1997 national housing stock in order to characterize the extent to which various environmental-lead levels provide exposures to children and to characterize the benefits associated with performing interventions under §403 rules. These estimates were based on numbers of housing units determined by sampling weights within the HUD National Survey (conducted in 1989-1990), revised to represent the 1997 national occupied housing stock and on average numbers of children per housing unit determined from the 1993 American Housing Survey (AHS). The estimates used in the §403 risk analysis were presented in Section 3.3.2 and Appendix C of the §403 risk analysis report. This section provides alternative estimates using more recent data (i.e., interim data from the NSLAH and data from the 1997 American Housing Survey).

The method to calculating the alternative estimates involved determining the numbers of children in a given age group for each of the 706 housing units surveyed within the NSLAH whose interim data were made available to this effort. Methods used to obtain these estimated numbers of children were similar to those presented in Section 1.2 of Appendix C1 of the §403 risk analysis report. For a given age group of children, the estimated number of children associated with a given NSLAH-surveyed unit was determined by the following formula:

$$\#\ \text{children} = (\text{1997 weight}) \times (\text{Average \# residents per unit}) \times (\text{\# children per person}) \qquad \textbf{(1)}$$

The "1997 weight" factor in equation (1) was the interim sampling weight from the NSLAH for the unit. The factor "average # residents per unit" in equation (1) was calculated for the housing group based on information obtained from the 1997 AHS. The 1997 AHS database provided information on up to 18 residents within each housing unit in the AHS. Once units surveyed in the 1997 AHS were placed within the four year-built categories (pre-1940, 1940-1959, 1960-1979, post-1979), the average number of people residing in a unit (regardless of their ages) was calculated for each group. This average ranged from 2.5 to 2.7 across the four year-built categories. Therefore, a common average of 2.6 residents per unit was used for the entire national housing stock. The third factor in equation (1), "# children per person," represented the average number of resident children (of the given age group) in a housing unit. This factor was determined by dividing the total number of residents in the housing stock of a given age group by the total number of residents regardless of age, where both totals were calculated from data in the 1997 AHS. The method for calculating this third factor differed from the approach used in the §403 risk analysis, where forecasted birth rate and population estimates from the Bureau of the Census were used.

Table 3-27 contains estimates of average number of children per unit in the 1997 national housing stock, according to age group. These number are the product of the final two factors in equation (1). Therefore, these number are multiplied by the sampling weights for each housing unit in the interim NSLAH to obtain a revised number of children per housing unit. For children aged 12-35 months, the estimated average of 0.073 children per unit is about 9% lower than the estimate of 0.080 used in the §403 risk analysis.

Table 3-27. Alternative Estimates of the 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	2.6*0.0281 = 0.073
12-71 months	2.6*0.0732 = 0.190

By summing the estimates across surveyed units in the interim NSLAH, the updated 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. Table 3-28 provides these alternative estimates on the number of children residing in the 1997 housing stock according to age of housing unit and age of child. The overall estimate of approximately 6.51 million children aged 1-2 years is approximately 18% lower than the estimate of 7.96 million made in the §403 risk analysis. The lower estimates are due to the lower per-unit estimate from Table 3-27 and on the lower sample weight total in the interim NSLAH data compared to the HUD National Survey (Table 3-2). They are also likely to be underestimates of the numbers of children of the given age category, based upon population projections previously published by the U.S. Bureau of the Census (e.g., Day, 1993).

Table 3-28. Alternative Estimates of the Average Number of Children in the 1997 National Housing Stock, by Age of Child and Year-Built Category, Based on Data Obtained Since the §403 Risk Analysis

Years in Which Housing Units Were Built	Age of Child Within These Housing Units	
	1-2 Years	1-5 Years
Prior to 1940	1,053,000	2,743,000
1940-1959	1,234,000	3,214,000
1960-1977	1,877,000	4,889,000
After 1977	1,759,000	4,582,000
Unknown[1]	591,000	1,540,000
All Housing[2]	6,513,000	16,967,000

[1] There are 66 units in the interim NSLAH which have missing age of house data.
[2] Values in this row may differ from sum of previous rows due to rounding.

3.5 SUMMARIES OF DUST-LEAD LEVELS ON SURFACES OTHER THAN UNCARPETED FLOORS AND WINDOW SILLS

The exposure assessment in Chapter 3 of the §403 risk analysis report concluded that even at low to moderate lead levels, lead-contaminated dust can affect children's blood-lead concentration. The assessment focused on dust-lead found on floor and window sill surfaces, for which §403 regulatory standards were proposed. However, dust found on other surfaces, such as exterior dust and dust in air ducts, carpeted floors, window troughs (also known as window wells), and upholstery, may also potentially present a lead exposure hazard. Many issues concerning potential exposure to dust-lead on these other surfaces were raised throughout the §403 Dialogue Process as well as in comments received on preliminary drafts of the §403 risk analysis and on the proposed rule. For example, there was extensive discussion during the Dialogue Process concerning whether standards were necessary for window troughs (i.e., window wells) as long as there are standards for window sills and the window troughs are thoroughly cleaned. Concern was also expressed about sampling on carpeted and upholstered surfaces.

The purpose of this section is to supplement information in the original exposure assessment by assessing the potential exposure to dust-lead found on surfaces other than floors and window sills. In particular this assessment seeks to answer the following questions:

1. What information is available to assess residential lead exposure resulting from dust on surfaces other than floors and window sills?

2. What does this information say about the distribution of environmental lead levels for dust on these other types of surfaces?

3. Is there evidence of a relationship between these exposures and children's blood-lead concentrations?

4. Is the information sufficient to set a regulatory standard and is a standard necessary?

The exposure assessment is based on a review of the literature to identify studies with potentially useful data for assessing lead hazards due to dust-lead on these other surfaces. It should be noted that this section deals only with several specific surfaces other than uncarpeted floors and window sills. These surfaces include exterior dust, air ducts, window troughs, and upholstery. Hazards associated with lead-contaminated dust from carpeted floors are addressed in Section 6.5 and Appendix I of this report.

The literature review for this assessment drew upon previous literature reviews conducted for the §403 risk analysis and reviews conducted for other EPA published reports (e.g., USEPA, 1997b). Most of the studies that were found that addressed the various surfaces are included here, regardless of whether there is any information specifically relating dust-lead levels and blood-lead levels. For those studies where blood samples were collected from resident children, those results are also presented. Table 3-29 provides a summary of the studies that were examined. The table indicates the surfaces from which dust samples were collected and in the case of exterior dust samples, where those samples were collected.

Table 3-29 indicates that the review of the literature found fourteen studies that have examined exterior dust as a source of lead exposure and seven studies that similarly assessed window troughs. Only four studies were located with significant information on dust-lead levels in air ducts, and four with similar information on upholstery.

3.5.1 Distribution of Dust-Lead on Surfaces Other than Floors and Window Sills

Tables 3-30 through 3-33 present summary information from the studies related to exterior dust samples, air duct samples, window trough samples, and upholstery samples,

Table 3-29. Studies for Which Dust Samples Have Been Collected from Exterior Areas, Air Ducts, Window Troughs, and Upholstery for Lead Analysis

T = medium was sampled in the given study

Study	Exterior Dust (Sampling Location)	Air Ducts	Window Troughs	Uphol-stery	Blood
Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study (USEPA, 1996c, 1997c)	**T** (Entryway)	**T**	**T**	**T**	**T**
University of Rochester Lead-In-Dust Study (USHUD, 1995a)	**T** (Play area, Porch, Entryway?)		**T**		**T**
Urban Soil Lead Abatement Demonstration Project (USEPA, 1996a)	**T** (Entryway, Mat)				**T**
The National Survey of Lead-Based Paint in Housing (USEPA, 1995)			**T**		
The HUD Lead-Based Paint Abatement Demonstration (USHUD, 1991)			**T**		**T**
The Comprehensive Abatement Performance (CAP) Study (USEPA, 1996b)	**T** (Entryway)	**T**	**T**		
Birmingham Urban Lead Uptake Study (Davies et al., 1990)	**T** (Playground, Doormat, Pavement, Roadside)				**T**
Mexico City Study (Romieu et al., 1995)	**T** (Street)				**T**
Butte-Silver Bow Environmental Health Lead Study (Butte-Silver Bow Dept. of Health et al., 1991)	**T** (Entrance)				**T**
Midvale Community Lead Study (Bornschein et al., 1990)	**T** (Entrance)				**T**
Philadelphia Neighborhood Lead Study (USDHHS, 1991)	**T** (Street)				**T**
The Arnhem, Netherlands Lead Study (Brunekreef et al., 1981)	**T** (Street)				**T**
Belgium Lead Smelter Study (Roels et al., 1980)	**T** (School playground)				**T**
Mount Pleasant Household Lead Study (Francek et al., 1994)	**T** (Entrance?)				
Baltimore Experimental Paint Abatement Study (Farfel et al., 1991)			**T**		
Traditional vs. Modified Practices of Lead Abatement in Baltimore (Farfel et al., 1990)			**T**		**T**
Wales Environmental Lead Study (Gallacher et al., 1984)	**T** (Pavement)				**T**
New Orleans Day Care Center Lead Study (viverette et al., 1996)	**T** (Play area)				
Omaha Study of Childhood Lead (Angle et al., 1995)		**T**			**T**
Renovation & Remodeling Study (USEPA, 1997a)		**T**			
HVFS Pilot Study (Roberts et al., 1996)				**T**	
Throop, PA, Superfund Cleanup (Steuteville, 1990)				**T**	

Table 3-30. Summary of Data from Studies Where Exterior Dust Samples Were Collected for Lead Analysis

Study	Environmental-Lead Measurements					Blood-Lead Measurements		
	Group of Homes/ Sampling Location	Sampling Method	N	Concentration Statistics (units)	Loading Statistics (units)	Group of Homes/Children	N	Statistics (units)
Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study (1993-present)				GM [95% CI] (µg/g)	GM [95% CI] (µg/ft²)			GM [95% CI] (µg/dL)
	Entryway:	BRM						
	R&M I, Init. Camp.		25	2219 [1218 - 4043]	242 [109 - 539]	R&M I, Init. Camp.	33	9.9 [7.9 - 12.3]
	R&M II, Init. Camp.		23	4265 [2588 - 7029]	187 [102 - 340]	R&M II, Init. Camp.	32	13.8 [11.2 - 16.9]
	R&M III, Init. Camp.		26	6936 [3549 - 13555]	342 [184 - 637]	R&M III, Init. Camp.	33	14.2 [11.3 - 16.1]
	Pre. Abt., Init. Camp.		15	2073 [1232 - 3488]	227 [76 - 676]	Pre. Abt., Init. Camp.	23	12.8 [10.2 - 16.1]
	Mod. Urb., Init. Camp.		15	137 [75 - 250]	335 [188 - 597]	Mod. Urb., Init. Camp.	19	4.8 [3.8 - 6.1]
University of Rochester Lead-In-Dust Study (1993)				GM [± 2 SD] (µg/g)	GM [± 2 SD] (µg/ft²)			GM [SD] (µg/dL)
	Porch	BRM		1132 [42 - 30150]	548 [7 - 43370]	All Children	205	7.7 [5.1]
		DVM		557 [52 - 6017]	17 [1 - 446]	Levels < 10 µg/dL	157	5.5 [2.2]
		Wipe			57 [4 - 871]	Levels $ 10 µg/dL	48	15.1 [5.0]
	Entryway	BRM		468 [19 - 11243]	88 [0 - 15881]			
		DVM		329 [18 - 5967]	3 [0 - 124]			
		Wipe			18 [2 - 215]			
	External	BRM	145		335 [7 - 17271]			
	Combined	DVM	150		18 [1 - 576]			
The Comprehensive Abatement Performance (CAP) Study (1992)				GM [Range] (µg/g)	GM [Range] (µg/ft²)			
	Entryway	Cyclone vacuum	97	237 [9-16,355]	384 [4.0 - 14021]			
Birmingham Urban Lead Uptake Study (1984-1985)				GM [5th, 95th %] AM [Range] (µg/g)				GM [5th, 95th %] (µg/g)
	Doormat	Vacuum	42	615 [120 - 4300] 1436 [79 - 15000]				
	Pavement	Vacuum	97	360 [127 - 1340] 506 [62 - 5100]				11.7 [6.24]
	Roadside	Vacuum	97	527 [195 - 1170] 805 [80 - 2100]				

Table 3-30. (cont.)

Study	Environmental-Lead Measurements					Blood-Lead Measurements		
	Group of Homes/ Sampling Location	Sampling Method	N	Concentration Statistics (units)	Loading Statistics (units)	Group of Homes/Children	N	Statistics (units)
Urban Soil Lead				Med. (µg/g)				GM (µg/dL)
Abatement								
Demonstration	Cincinnati							
Project (1988-1992)	Mat:	Personal Air						
	Soil, Dust Abt. Rd. 1	Monitoring		109		Soil, Dust Abt. Rd. 1		8.8
	Soil, Dust Abt. Rd. 2	Vacuum		738		Soil, Dust Abt. Rd. 2		-
	Soil, Dust Abt. Rd. 3	Pump		549		Soil, Dust Abt. Rd. 3		6.9
	Soil, Dust Abt. Rd. 4			767		Soil, Dust Abt. Rd. 4		8.8
	Soil, Dust Abt. Rd. 5			659		Soil, Dust Abt. Rd. 5		-
	Dust, (Soil) Abt. Rd. 1			132		Soil, Dust Abt. Rd. 6		8.2
	Dust, (Soil) Abt. Rd. 2			939		Soil, Dust Abt. Rd. 7		8.7
	Dust, (Soil) Abt. Rd. 3			702		Dust, (Soil) Abt. Rd. 1		10.8
	Dust, (Soil) Abt. Rd. 4			722		Dust, (Soil) Abt. Rd. 2		-
	Dust, (Soil) Abt. Rd. 5			889		Dust, (Soil) Abt. Rd. 3		9.3
	No Treatment Rd. 1			100		Dust, (Soil) Abt. Rd. 4		8.6
	No Treatment Rd. 2			373		Dust, (Soil) Abt. Rd. 5		-
	No Treatment Rd. 3			349		Dust, (Soil) Abt. Rd. 6		7.6
	No Treatment Rd. 4			405		Dust, (Soil) Abt. Rd. 7		8.9
	No Treatment Rd. 5			332		No Treatment Rd. 1		8.3
	Cincinnati					No Treatment Rd. 2		-
	Entryway:	Personal Air				No Treatment Rd. 3		5.7
	Soil, Dust Abt. Rd. 1	Monitoring		334		No Treatment Rd. 4		6.8
	Soil, Dust Abt. Rd. 2	Vacuum		606		No Treatment Rd. 5		-
	Soil, Dust Abt. Rd. 3	Pump		433		No Treatment Rd. 6		7.2
	Soil, Dust Abt. Rd. 4			491		No Treatment Rd. 7		7.8
	Soil, Dust Abt. Rd. 5			211				
	Soil, Dust Abt. Rd. 6			382				
	Soil, Dust Abt. Rd. 7			488				
	Dust, (Soil) Abt. Rd. 1			425				
	Dust, (Soil) Abt. Rd. 2			492				
	Dust, (Soil) Abt. Rd. 3			468				
	Dust, (Soil) Abt. Rd. 4			632				
	Dust, (Soil) Abt. Rd. 5			102				
	Dust, (Soil) Abt. Rd. 6			598				
	Dust, (Soil) Abt. Rd. 7			615				
	No Treatment Rd. 1			290				
	No Treatment Rd. 2			367				
	No Treatment Rd. 3			317				
	No Treatment Rd. 4			286				
	No Treatment Rd. 5			84				
	No Treatment Rd. 6			317				
	No Treatment Rd. 7			284				
Mexico City Study (1992-1994)				AM [IQR] (µg/g)				AM [SD] (µg/dL)

Table 3-30. (cont.)

Study	Environmental-Lead Measurements: Group of Homes/ Sampling Location	Sampling Method	N	Concentration Statistics (units)	Loading Statistics (units)	Blood-Lead Measurements: Group of Homes/Children	N	Statistics (units)
	Street	Broom	200	206 [89.5 - 270]		<18 months old	52	7.38 [4.81]
						18-35 months old	55	10.13 [5.92]
						35-49 months old	44	11.07 [5.83]
						50 months old	49	11.40 [5.76]
						Total	200	9.91 [5.78]
Butte-Silver Bow Environmental Health Lead Study (1990)				GM [GSD] (µg/g)				GM [GSD] (µg/dL)
	Entrance:	DVM						
	All Locations		210	541 [2.96]		All Locations	183	3.69 [1.84]
	Location A		141	921 [2.59]		Location A	15	2.27 [1.67]
	Location B		10	302 [1.72]		Location B	12	4.59 [1.89]
	Location C		7	439 [3.56]		Location C	11	4.56 [1.79]
	Location D		9	218 [2.43]		Location D	27	2.72 [1.50]
	Location E		21	188 [2.26]		Location E	17	3.02 [1.52]
	Location F		11	273 [2.56]		Location F	17	3.02 [1.52]
	Location G		11	924 [1.45]		Location G	13	3.81 [1.67]
Midvale Community Lead Study (1989)				GM [[Range] (µg/g)				GM [Range] (µg/dL)
	Entryway	Vacuum	112	466 [[79 - 2984]				5.2 [0.5 - 14.5]
Philadelphia Neighborhood Lead Study (1989)				AM (µg/g)				AM [SD] (µg/dL)
	Street:	Spatula						
	1 Block from Facility			1087		L. Pt. Richm. 0-5 yrs.	122	9.7 (4.8)
	2 Blocks from Facility			1078		Comparison 0-5 yrs.	96	9.5 (3.5)
	3 Blocks from Facility			907		U. Pt. Richm. 0-5 yrs.	55	9.1 (3.7)
	4 Blocks from Facility			882		Manayunk 0-5 yrs.	41	10.0 (3.3)
						L. Pt. Richm. 6-15 yrs.	41	7.8 (3.3)
						Comparison 6-15 yrs.	41	7.4 (2.9)
						U. Pt. Richm. 6-15 yrs.	29	6.7 (2.9)
						Manayunk 6-15 yrs.	12	9.0 (2.4)
						L. Pt. Richm. $16 yrs.	197	6.4 (3.3)
						Comparison $16 yrs.	239	7.3 (4.3)
						U. Pt. Richm. $16 yrs.	142	6.9 (5.0)
						Manayunk $16 yrs.	97	7.7 (3.0)
						L. Pt. Richm. Total	360	7.7 (4.1)
						Comparison Total	376	7.8 (4.1)
						U. Pt. Richm. Total	226	7.4 (4.6)
						Manayunk Total	150	8.4 (3.2)
The Arnhem Netherlands Study (1978)				GM [Range] (mg/kg) AM				GM (µg/dL)
	Street	Vacuum		690 [77 - 2667] 859				16.1

Table 3-30. (cont.)

Study	Environmental-Lead Measurements					Blood-Lead Measurements		
	Group of Homes/ Sampling Location	Sampling Method	N	Concentration Statistics (units)	Loading Statistics (units)	Group of Homes/Children	N	Statistics (units)
Mount Pleasant Household Study (1991)				GM [SD] AM [Range] (µg/g) Med.				
	Entrance?	Wipe	42	12 [105] 53 [0 - 594] 7				
Wales Environmental Lead Study (unknown)	Pavement			AM [95% CI] (µmol)				AM [SD] (µg/dL)
	Area 1 Area 2	Unknown	42 30	2 [0.8 - 3.5] 1 [0.4 - 4.2]		Area1, Children Area1, Mother Area2, Children Area2, Mother	42 42 30 30	16.56 [8.49] 8.90 [2.48] 14.70 [3.73] 8.90 [2.90]
New Orleans Day Care Center Lead Study (unknown)					Med. [Range] (µg/ft^2)			
	Play area Private inner city Private outer city Public inner city Public outer city	Unknown	 5 4 5 5		 412 [44 - 690] 3 [2.2 - 8.0] 11 [8 - 33] 11 [9.5 - 18.4]			

N = Sample size
GM = Geometric mean
AM = Arithmetic mean
Med. = Median
SD = Standard deviation
GSD = Geometric standard deviation
IQR = Interquartile range (75th percentile - 25th percentile)
BRM = Baltimore R&M vacuum method
DVM = Dust vacuum method
Rd = Sampling round

Table 3-31. Summary of Data from Studies Where Air Duct Dust Samples Were Collected for Lead Analysis

Study	Environmental-Lead Measurements					Blood-Lead Measurements			
	Group of Homes/ Sampling Location	Sampling Method	N	Concentration Statistics (units)	Loading Statistics (units)	Group of Homes/Children	N	Statistics (units)	
Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study (1993-present)				GM [95% CI] (μg/g)	GM [95% CI] (μg/ft²)			GM	[SD] (μg/dL)
	R&M I, Init. Camp.	BRM	1	- -	- -	R&M I, Init. Camp.	33	9.9	[7.9 - 12.3]
	R&M II, Init. Camp.		12	1445 [617-3,388]	51405 [33,671-78,480]	R&M II, Init. Camp.	32	13.8	[11.2 - 16.9]
	R&M III, Init. Camp.		15	1491 [945-2,354]	30046 [18,399-49,066]	R&M III, Init. Camp.	33	14.2	[11.3 - 16.1]
	Pre. Abt., Init. Camp.		1	- -	- -	Pre. Abt., Init. Camp.	23	12.8	[10.2 - 16.1]
	Mod. Urb., Init. Camp.		0	- -	- -	Mod. Urb., Init. Camp.	19	4.8	[3.8 - 6.1]
The Comprehensive Abatement Performance (CAP) Study (1992)				GM [Range] (μg/g)	GM [Range] (μg/ft²)				
	Denver Pilot Study	Blue Nozzle	10	749 [363-1,699]	308 [27-3,910]				
	Denver Full Study	CAPS Cyclone	109	427 [59-5,640]	120 [2 - 40,900]				
R&R Study (1993-1995)					GM [Range] (μg/ft²)				
	Baltimore & Denver	Wipe	21		2,900 [205-30,900]				
Omaha Study of Childhood Lead (1995)					AM (μg/g)				
	Omaha City	Unknown	21		383				

N = Sample size
GM = Geometric mean
AM = Arithmetic mean
Med. = Median
SD = Standard deviation
BRM = Baltimore R&M vacuum method
DVM = Dust vacuum method
Rd = Sampling round

Table 3-32. Summary of Data from Studies Where Window Trough Dust Samples Were Collected for Lead Analysis

Study	Environmental-Lead Measurements: Group of Homes/ Sampling Location	Sampling Method	N	Concentration Statistics (units)	Loading Statistics (units)	Blood-Lead Measurements: Group of Homes/Children	N	Statistics (units)	
Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study (1993-present)				GM [95% CI] (µg/g)	GM [95% CI] (µg/ft^2)			GM	[SD] (µg/dL)
	R&M I, Init. Camp.	BRM	43	22144 [15,091-32,495]	7051 [4,896-10,156]	R&M I, Init. Camp.	33	9.9	[7.9 - 12.3]
	R&M II, Init. Camp.		45	20462 [15,106-27,717]	9900 [7,245-13,529]	R&M II, Init. Camp.	32	13.8	[11.2 - 16.9]
	R&M III, Init. Camp.		54	21600 [12,751-36,590]	13916 [10,104-19,167]	R&M III, Init. Camp.	33	14.2	[11.3 - 16.1]
	Pre. Abt., Init. Camp.		31	2251 [1,247-4,062]	802 [501-1,284]	Pre. Abt., Init. Camp.	23	12.8	[10.2 - 16.1]
	Mod. Urb., Init. Camp.		30	338 [239-479]	1021 [515-2,024]	Mod. Urb., Init. Camp.	19	4.8	[3.8 - 6.1]
University of Rochester Lead-In-Dust Study (1993)				GM [± 2 SD] (µg/g)	GM [± 2 SD] (µg/ft^2)			AM	[SD] (µg/dL)
	Rochester, NY	BRM		6114 [65 - 579,533]	11874 [26 - 5,365,819]	All Children	205	7.7	[5.1]
		DVM		1709 [17 - 171,081]	370 [3 - 45,177]	Levels < 10 µg/dL	157	5.5	[2.2]
		Wipe			2759 [29 - 264,752]	Levels $ 10 µg/dL	48	15.1	[5.0]
The National Survey of Lead-Based Paint in Housing (1989-1990)[1]				GM [Range] (µg/g)	GM [Range] (µg/ft^2)				
	Homes Built Prior to 1940	Blue Nozzle	77	8389 [189.8 - 74980]	929 [1.6 - 23798]				
	Homes Built 1940-1959		87	1972 [5.2 - 41429]	140 [0.3 - 5312]				
	Homes Build 1960-1979		120	1016 [19.2 - 17725]	110 [0.04 - 3244]				
	All Surveyed Homes		284	1965 [5.2 - 74980]	177 [0.04 - 23798]				
	Homes Built Prior to 1940	Wipe-Equivalents	77		2017 [8.7 - 33391]				
	Homes Built 1940-1959		87		389 [1.9 - 9446]				
	Homes Build 1960-1979		120		296 [0.4 - 6169]				
	All Surveyed Homes		284		460 [0.4 - 33391]				
The HUD Lead-Based Paint Abatement Demonstration (1990-1993)					> 800 µg/ft^2 [#] [%]				
	Albany	Wet Wipe	98		[2] [2.0%]				
	Cambridge		119		[5] [4.2%]				
	Omaha		161		[0] [0%]				
The Comprehensive Abatement Performance (CAP) Study (1992)				GM [Range] (µg/g)	GM [Range] (µg/ft^2)				
		Cyclone Vacuum	98	1439 [72.9 - 45229]	2515.6 [19.1 - 244581]				

Table 3-32. (cont.)

Study	Environmental-Lead Measurements					Blood-Lead Measurements		
	Group of Homes/ Sampling Location	Sampling Method	N	Concentration Statistics (units)	Loading Statistics (units)	Group of Homes/Children	N	Statistics (units)
Baltimore Experimental Paint Abatement Study (1986-1987)					GM (µg/ft²)			
	New Wndw., Pre-Abt.	Wipe	11		15663			
	New Wndw., Pst.-Abt.		13		2238			
	New Wndw., Pst.-Trt.		13		1212			
	New Wndw., Pst. C.-u.		14		466			
	New Wndw., 1m. Pst.		10		186			
	New Wndw., 3m. Pst.		13		466			
	New Wndw., 6-9m. Pst.		14		466			
	On-sit. C. S., Pre-Abt.		17		44566			
	On-sit. C. S., Pst.-Abt.		16		29462			
	On-sit. C. S., Pst.-Trt.		12		5687			
	On-sit. C. S., Pst. C.-u.		17		1585			
	On-sit. C. S., 1m. Pst.		15		5314			
	On-sit. C. S., 3m. Pst.		15		7179			
	On-sit. C. S., 6-9m. Pst.		10		2984			
Traditional vs. Modified Practices of Lead Abatement in Baltimore (1984-1985)					GM (µg/ft²)			
	Traditional	Wet Wipe			15570			
	Modified				18367			

[1] Area-weighted household averages are summarized in this table for this study, using sampling weights modified in the §403 risk analysis to represent the 1997 housing stock. Wipe-equivalents represent converting the Blue-Nozzle dust-lead loadings to wipe-equivalent loadings as documented in Chapter 4 of the §403 risk analysis report. Data were imputed for surveyed homes without data (see Chapter 3 of the §403 risk analysis report).

N = Sample size
GM = Geometric mean
AM = Arithmetic mean
Med. = Median
SD = Standard deviation
BRM = Baltimore R&M vacuum method
DVM = Dust vacuum method
Rd = Sampling round

Table 3-33. Summary of Data from Studies Where Upholstery Dust Samples Were Collected for Lead Analysis

	Environmental-Lead Measurements					Blood-Lead Measurements		
Study	**Group of Homes/ Sampling Location**	**Sampling Method**	**N**	**Concentration Statistics (units)**	**Loading Statistics (units)**	**Group of Homes/Children**	**N**	**Statistics (units)**
Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study (1998-present)				GM [95% CI] (µg/g)	GM [95% CI] (µg/ft^2)			GM [95% CI] (µg/dL)
	R&M I, Init. Camp. R&M II, Init. Camp. R&M III, Init. Camp. Pre. Abt., Init. Camp. Mod. Urb., Init. Camp.		23 7 0 14 16	699 [493-992] 700 [180-2,722] - - 503 [353-718] 142 [101-200]	95 [49-186] 92 [39-218] - - 101 [55-186] 61 [35-138]	R&M I, Init. Camp. R&M II, Init. Camp. R&M III, Init. Camp. Pre. Abt., Init. Camp. Mod. Urb., Init. Camp.	33 32 33 23 19	9.9 [7.9 - 12.3] 13.8 [11.2 - 16.9] 14.2 [11.3 - 16.1] 12.8 [10.2 - 16.1] 4.8 [3.8 - 6.1]
Mexico City Study (1992-1994)					AM [SD] (µg/ft²)			AM [SD] (µg/dL)
					70 0.11 [0.19]	<18 months old 18-35 months old 35-49 months old 50 months old Total	52 55 44 49 200	7.38 [4.81] 10.13 [5.92] 11.07 [5.83] 11.40 [5.76] 9.91 [5.78]
HVFS Pilot Study (1993)				AM [Range] µg/g	AM [Range] µg/ft²			
	Seattle	HVFS	5	229 [130-380]	27.8 [2.7-94.9]			
Throop, PA Superfund Cleanup (1989-1990)					AM [Range] µg/ft²			
	Throop, PA Pre-Clean	Vacuum (15.2/ min air pump)	5		28.5 [19.9-34.3]			
	Throop, PA Post-Clean	Vacuum (15.2/ min air pump)	5		23.1 [13.7-35.5]			

N = Sample size
GM = Geometric mean
AM = Arithmetic mean
Med. = Median
SD = Standard deviation
BRM = Baltimore R&M vacuum method
DVM = Dust vacuum method
Rd = Sampling round

respectively. Included in the tables are sampling location, dust collection methods used, number of dust samples taken, and distribution statistics available from the literature on dust-lead concentrations and loadings. Also presented in the tables are simple summaries of blood-lead concentrations for those studies which also sampled blood.

Exterior Dust

Table 3-30 summarizes the data from the fourteen studies in which exterior dust samples were collected and analyzed for lead content. In addition, there are also results for several studies in which dust samples were collected inside the home in the entryway. These can occasionally be good representations of exterior dust samples. The summary consists of descriptive statistics for the dust-lead measures and also for blood-lead measures, when available. Summary statistics are presented separately for different study groups and different sampling periods, where appropriate. As indicated in Table 3-29, exterior dust samples were not collected at a consistent location across all studies. Sampled locations included the house entrance (including doormats and porches), street, and the child's play area. Likewise, samples were collected by a variety of methods including surface scraping, vacuum sampling, and wipe sampling. The sampling location and method have a significant impact on the lead loading and concentration estimates.

Overall, even with the variability in sampling location and method, Table 3-30 indicates the potential for significant amounts of lead in exterior dust, with concentrations often exceeding 400 µg/g and loadings often exceeding 100 µg/ft^2.

Air Ducts

As indicated in Table 3-31, only four studies were identified that contained information on lead levels in dust within air ducts in residential housing. While only limited information was encountered, a consensus across studies was that air ducts can contain high amounts of dust and lead. This was due partially to the general lack of cleaning of air ducts over time and the ability of lead particles to enter air ducts from outside of the unit via ventilation filters.

In units with a potential for containing lead hazards, dust-lead loadings in air ducts typically exceeded 100 µg/ft^2, with individual samples often exceeding 1,000 µg/ft^2. Lead levels can vary considerably among dust samples within the same unit and in different units. Older ductwork and HVAC systems, as well as vacant units in which no cleaning is performed and HVAC systems may not be used, tend to have high dust loadings, and therefore, higher dust-lead loadings when a lead source is present. Several methods were used across studies to collect dust in air ducts. As air ducts often have metal surfaces, issues concerning static electricity must be considered when sampling dust from air ducts.

The EPA Comprehensive Abatement Performance (CAP) study involving occupied homes assumed to be free of lead-based paint for at least two years, provided the greatest amount of information on lead in dust within air ducts; levels were relatively low in this study compared to the others. Nevertheless, in a typical housing unit in the CAP study, average dust-lead loadings from air ducts exceeded all other sampled surfaces except for window troughs and entryways. In general, air duct dust-lead levels in the Baltimore R&M study and the Renovation and Remodeling study were considerably higher than in the CAP study, as these studies included older, vacant units in need of repair and maintenance.

The relative sparsity of published information indicates that many open questions exist on the nature of lead contamination of dust within residential air ducts and whether the lead in this dust is available for exposure to residents (especially children). Nevertheless, evidence exists that air ducts can contain some of the highest levels of lead in dust within a housing unit.

Window Troughs

Table 3-32 presents summary information on seven studies that sampled dust-lead levels in window troughs (also known as window wells). The HUD Grantees evaluation is a significant data source on window trough dust-lead levels in high risk housing that is not included in Table 3-32, as these data are still being collected and reported.

In general, partially because of the published data summarized in Table 3-32, and partially because a standard for window troughs has been historically used in risk assessments and to determine clearance (following EPA's Interim Guidance for §403 standards and the HUD Guidelines), window troughs are widely recognized as a major reservoir of dust-lead in residences. As shown in Table 3-32, levels often exceed 800 $\mu g/ft^2$ and it is not uncommon to see levels above 10,000 $\mu g/ft^2$ in high risk housing. However, unlike the other surfaces discussed in this report, national estimates of the distribution of dust-lead in window troughs are available from the HUD National Survey. The estimated national geometric mean dust-lead loading in window troughs from the HUD National Survey (as modified in the §403 risk analysis to reflect the 1997 housing stock and wipe techniques) was 460 $\mu g/ft^2$ (Table 3-32), with 30% of homes estimated to have average window trough dust-lead loadings at or above 800 $\mu g/ft^2$.

Upholstery

Table 3-33 summarizes the data from the four studies which collected dust-lead samples from upholstery. In general, dust-lead loadings for these surfaces averaged below 100 $\mu g/ft^2$. As the sample sizes in all of these studies were small, and sampling techniques, sampling locations, and study goals varied considerably from study to study, more information would be necessary to fully characterize potential lead hazards associated with upholstery.

3.5.2 Evidence of a Relationship Between Children's Blood-Lead Concentrations and Dust-Lead on Surfaces Other Than Floors and Window Sills

The information available to assess children's exposure to dust-lead on surfaces covered in this section is discussed in detail for each surface type below. It should be noted, however, that in general it is difficult to establish the causal link between these surfaces and children's blood-lead concentrations. This is true for many reasons. Often other important sources of lead exposure are not well characterized in the studies that provide data on these special surfaces. Correlations are often estimated based on small sample sizes and without adjusting for other exposure variables such as lead in floor-dust and soil. Moreover, there is often correlation between lead levels on these surfaces and lead levels on floors, window sills, and in soil. For all of these reasons, it must be noted that even significant correlation coefficients should not be interpreted as the degree to which dust-lead on these surfaces causes a change in blood-lead concentration. In almost all cases, in order to characterize the pathway of lead from these surfaces to children's blood, additional data collection or analyses are needed.

Exterior Dust

Table 3-30 (in the previous subsection) contains a summary of the dust-lead data and blood-lead data separately for studies which collected exterior dust. However, it contains no results providing information about the relationship between exterior dust-lead levels and blood-lead levels. The reports describing these analyses were examined to assess the relationship between exterior dust-lead levels and blood-lead levels. In the Repair and Maintenance Study (USEPA, 1996c, 1997c), exterior dust samples were collected at five separate times. The (Pearson) correlation coefficients between blood-lead concentrations and entryway dust-lead concentrations ranged from 0.23 to 0.49, and the correlation coefficients between blood-lead concentrations and entryway dust-lead loadings ranged from 0.10 to 0.46. In most cases, those correlation coefficients were statistically significant at the á=0.01 level. In the Rochester Study (USHUD, 1995a), the University of Cincinnati Dust Vacuum Method (DVM) and Baltimore Repair and Maintenance vacuum method (BRM) were used to collect external dust samples. The correlation coefficients for the BRM and DVM techniques were 0.21 and 0.27 for the correlation between blood-lead concentrations and exterior dust-lead concentrations and 0.34 and 0.18 for the correlation between blood-lead concentrations and exterior dust-lead loadings, respectively. The correlations were all statistically significant at the á=0.05 level, with the correlation for the DVM measured loading significant at the á=0.01 level. On the other hand, the Mexico City Study (Romieu et. al., 1995), Arnhem Study (Brunekreef et. al., 1981) and the Midvale Study (Bornschein et. al., 1990) reported the correlations between external dust measurements and blood-lead levels to be statistically insignificant.

Multivariate regression and structural equation modeling was used in some of the studies to examine how multiple sources of environmental lead exposure and other factors affect blood-lead levels. Regression analyses were carried out in most of the studies where both external dust-lead and blood-lead measurements were collected, but the external dust-lead measurements were not included as an explanatory variable in any of the reported regression models. Reasons for excluding external dust-lead were not clearly stated. Speculatively, such reasons may include a lack of interest in the relationship, poor data quality in the external dust-lead measurements, colinearity of external with internal dust-lead measurements and omission of the variable through step-wise regression. Structural equation modeling was carried out in the (Three Cities) Urban Soil Lead Abatement Demonstration Project (USEPA, 1996a), Butte-Silver Bow Study (Butte-Silver Bow DoH et. al., 1991) and Midvale Study (Bornschein et. al., 1990). In the Three Cities Study, exterior dust was lead considered as a component of the lead exposure pathway in the general structural equation model, but the component was excluded in the actual implementation of the model. In the Butte-Silver Bow Study, external dust-lead was also excluded from the structural equation model, but external dust-lead was observed to be correlated (Pearson correlation r=0.64) with soil lead, which was included as a component of the lead exposure pathway in the model. The Midvale Study was the only one to include external dust-lead in the actual implementation of the structural equation model, but the dust-lead to blood-lead relationship was reported as being statistically insignificant.

In summary, there is much difficulty in distinguishing between direct and indirect exposure in cases where external dust-lead levels is closely related to levels in other sources of environmental lead. Correlation and univariate regressions with external dust-lead and blood-lead fail to account for the possibility that external dust-lead by itself may only play a small part in aggregate lead exposure when other sources of lead and exposure pathways are considered. Multivariate regressions using lead measurements from multiple sources do not solve this problem due to problems with colinearity. The preferred approach would be to use structural equation models, which allow multiple source and exposure pathways to be modeled in a reasonable way, but this approach requires more effort in terms of implementation and interpretation of the model, and is not well-reported in the literature. Therefore, quantitative estimates of the effect of external dust-lead on children's blood-lead concentrations have not been well established in the literature.

Air Ducts

Most of the encountered articles provided only preliminary information on lead exposures associated with air ducts. It is unclear to what extent dust-lead in air ducts is accessible to children. Children would not typically be expected to encounter the dust lodged in air ducts directly. One case study found that dust-lead levels in living areas outside of contaminated air ducts can be orders of magnitude lower than what is found in the air ducts. However, if dust in air ducts is disturbed, it is more likely to be introduced to the air and to nearby surfaces with which children can come into direct contact. In particular, HVAC ductwork removal can yield extensive contamination of surfaces in the general area of the ductwork.

Only one study (the Baltimore R&M Study) estimated (in a quantitative manner) the association between blood-lead concentrations in children and dust-lead levels found in air ducts. This relationship was expressed as a simple correlation coefficient. Unlike correlations between blood-lead concentrations and dust-lead levels on other surfaces, the correlation coefficient involving dust-lead levels from air ducts was not significant at the 0.05 level. However, this analysis was based on a small sample size and did not adjust for the effects of other exposure variables such as lead in floor-dust and soil. Moreover, as evidence of a significant correlation was observed between air duct dust-lead levels and lead levels on other surfaces, such as floors, even significant correlation coefficients should not be interpreted as the degree to which air duct dust causes a change in blood-lead concentration. In order to characterize the pathway of lead from air ducts to children's blood, additional data collection and analyses are needed.

Window Troughs

Of the seven studies listed in Table 3-32 above that collected information on dust-lead in window troughs (also known as window wells), three also collected blood-lead data from resident children. Correlation coefficients between blood-lead levels and window-trough dust-lead concentrations in the R&M study ranged from 0.20 to 0.39, and correlation coefficients between blood-lead levels and window-trough dust-lead loadings ranged from 0.06 to 0.44. The correlations between dust-lead concentrations and blood-lead concentrations were statistically significant in 4 of the 5 sampling campaigns, and the correlation between dust-lead loading and blood-lead concentration was statistically significant only in the pre-maintenance sampling. In the Rochester Study, correlation coefficients between blood-lead concentrations and dust-lead loadings were 0.35 for the BRM samples, 0.31 for the DVM samples, and 0.29 for wipe samples, while correlation coefficients between blood-lead concentrations and dust-lead concentrations were 0.23 for both BRM and DVM samples.

Previous analyses (Battelle, 1996a; Battelle, 1996b) have examined whether the predictive ability of a model improves when adding window trough lead levels to a model which already accounts for dust-lead on floors and window sills. Results of these analyses on the Rochester Lead-in-Dust Study and Baltimore R&M study data indicated that the estimated effect of window trough dust-lead on blood-lead was either not statistically significant or only marginally significant after adjusting for the effects of floor lead, sill lead, and temporal variation. A pathways analysis (USEPA, 1998c) using structural equations modeling concluded that window troughs were a significant pathway for lead exposure, both as a direct pathway of lead to children's blood-lead concentration (seen when Rochester Lead-in-Dust study data were analyzed) and as an indirect pathway through window sills and floors to blood-lead concentrations (seen when both the Rochester and Baltimore R&M study data were analyzed).

In summary, the association between blood-lead concentrations and window trough dust-lead has been well established in the literature. The more difficult question of the degree to which window troughs contribute directly or indirectly to children's lead exposure is not well established.

Upholstery

Table 3-33 in the previous subsection included results for two studies which measured both children's blood-lead concentrations and dust-lead on upholstery. In the Baltimore R&M study, correlation coefficients were calculated between blood-lead concentrations in children and both the loading and concentration of lead in upholstery dust. These correlation coefficients ranged from 0.19 to 0.61 for dust-lead concentrations and from 0.06 to 0.47 for dust-lead loading. These correlations were statistically significant in the pre-intervention sampling. As with most of the other surfaces discussed in this section, upholstery dust-lead levels were not included in any analyses to determine which lead sources were most significantly related to blood-lead levels. In the Mexico City Study, the correlation between upholstery dust-lead levels was not statistically significant, resulting in the absence of upholstery dust-lead levels from models linking blood-lead levels and environmental lead levels.

The results of the two studies assessing the importance of upholstery dust as a source for lead exposure in children differ. In one case, the relationship between blood-lead and upholstery-dust-lead is significant, while in the other it is not. Moreover, as upholstery dust-lead is often correlated with other lead exposure variables, such as floor dust-lead and soil-lead, as cautioned earlier, the positive correlation coefficient should not be interpreted as the degree to which upholstery dust causes a change in blood-lead concentration. In order to characterize the pathway of lead from upholstery to children's blood (and perhaps hands), additional data collection and analyses are needed.

3.5.3 Implications of the Available Information For Regulatory Standards

Two primary questions related to the need and feasibility of regulatory standards for dust-lead on surfaces other than floors and window sills are:

1. Is there sufficient information available on which to base a standard?

2. Is the standard necessary to either identify a lead hazard at a residence or to characterize the risk to determine appropriate corrective actions?

The answers to these questions are discussed for each surface type below.

Exterior Dust

In general, there is a fair amount of data on exterior dust, including studies where exterior dust has been measured along with other lead exposure variables and blood-lead concentrations. The amount of data implies that analyses could be conducted to provide a quantitative basis for an exterior dust standard. However, implementation and interpretation of such analyses for exterior dust will face many difficulties. For example, in many of the studies it is difficult to distinguish between exterior dust and soil samples because of aggregation of the samples or of the measurements. Some external sampling for lead was carried out using surface scrapings which measures lead levels from a mix of both soil and dust-lead and some analyses averaged the external soil and dust measurements and recorded the value as a single external lead measurement. (Hence only studies for which a clear distinction between external soil and dust-lead levels is possible were included in this summary.) It is also difficult to determine what locations for exterior dust should be included. Should the focus be on enclosed spaces or also include unenclosed areas such as sidewalks, stoops, and unenclosed porches? One primary reason to focus only on enclosed areas is because exposures to unenclosed areas are not under the direct control of property owner. Exposure and cleaning scenarios for enclosed versus unenclosed areas are likely to be very different as well. In conclusion, decisions on the specific focus of a standard for exterior dust would impact the feasibility of establishing a good quantitative basis on which to set the standard.

The question of whether a standard for exterior dust is necessary is also a difficult one, for which the literature does not have a clear answer. While it is reasonable to assume that measurements of lead in interior dust and exterior soil might capture a lead hazard if one exists, there is not a strong body of information on which to base this conclusion. A separate standard may not be necessary if risk assessors are aware of the potential hazard from exterior dust, and include testing or corrective actions in cases where it is suspected to be an important pathway of exposure (for example, in the case where a child spends a considerable amount of time on a paved surface, such as a driveway or patio).

Air Ducts

There is insufficient data upon which to develop a hazard standard for lead in air duct dust, or upon which to draw conclusions about the necessity of a standard to either identify a hazard or determine corrective actions.

Window Troughs

The fact that regulatory standards have been proposed for dust-lead on floors and window sills based on data sets (most notably the Rochester Lead-In-Dust Study and the HUD National Survey) that also include window troughs implies that sufficient data exists on which to base a standard for window troughs.

However, while there is sufficient information on which to base a standard, analyses conducted to assess the necessity of a window trough standard given the existence of a floor and window sill standard suggest that a window trough standard may not be necessary to identify a residence with a lead-based paint hazard. These analyses include the sensitivity/specificity analyses included in a companion §403 report as well as the analyses that examine the effect of adding window troughs to a statistical model that already includes floors and window sills (Battelle, 1996a; Battelle, 1996b). Given the correlation between window trough and window sill lead levels, it is likely that if more sampling is to be done beyond a minimal risk assessment, more benefit will be obtained from sampling more windows at the sill rather than sampling fewer windows but at both the sill and trough. Moreover, cleaning of window troughs is recommended for all homes that require a dust intervention, and clearance standards have been proposed to guide assessment of the effectiveness of the cleaning. For these reasons, it does not appear that an additional standard for window troughs is necessary either to identify a home with a hazard or to guide corrective actions.

Upholstery

There is insufficient data upon which to develop a hazard standard for lead in upholstery dust, or upon which to draw conclusions about the necessity of a standard to either identify a hazard or determine corrective actions.

3.6 DISTRIBUTION OF CHILDHOOD BLOOD-LEAD

This section updates the information presented in Section 3.4 of the §403 risk analysis report on the distribution of childhood blood-lead concentration in the United States, with a focus on the 1-2 year (12-35 month) age range as the population of interest. In addition to a national characterization based on data from Phase 2 of the Third National Health and Nutrition Examination Survey (NHANES III), Section 3.4 of the §403 risk analysis report summarized data from other studies (e.g., the Baltimore R&M study, the Rochester Lead-in-Dust study, and the HUD Grantees evaluation) to provide supporting information on the prevalence of elevated blood-lead concentrations in children living in urban locations and in older housing or housing likely to contain lead-based paint. Blood-lead data from these other studies were also considered because the NHANES III did not collect environmental-lead data, despite having the most nationally representative data on blood-lead levels.

Section 3.6.1 below is an update of Section 3.4.4 of the §403 risk analysis report. It contains revised data summaries of pre-intervention blood-lead concentrations in children monitored within the HUD Grantees evaluation and revised regression model fits to predict blood-lead concentration as a function of dust-lead loading for each individual grantee, as well as for the Rochester Lead-in-Dust study (i.e., the study that provided the data used to developed the empirical model developed within the §403 risk analysis. These revisions were possible as additional pre-intervention data from the HUD Grantees evaluation (through 1/99) have been made available to the risk analysis since the report was released.

Section 3.6.2 provides information from the Cincinnati Prospective Lead study (Clark et al., 1985) and summarized by the Centers for Disease Control and Prevention (CDC) on the relationship between children's blood-lead concentration and housing age/condition, and how this relationship may change with the age of the child (CDC, 1991). CDC used this information in their recommendations for blood-lead screenings of young children.

3.6.1 Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program ("HUD Grantees")

Blood-lead concentrations of children residing in households participating in the evaluation phase of the HUD Grantees evaluation (Section 3.2.2.3 of the §403 risk analysis report) were measured, along with environmental-lead levels in various media. The population of children targeted for participation in the program differed among the fourteen grantee recipients, due to the different enrollment criteria among the grantees (see Table 3-4 of the §403 risk analysis report). These criteria included targeting high-risk neighborhoods, enrolling only homes with a lead-poisoned child, and considering unsolicited applications. Pre-intervention data collected through January 1999 are presented in this section; these data provide some of the most recent information on the relationship between children's blood-lead concentration and environmental-lead levels.

Across all grantees, pre-intervention blood-lead concentration data through 1/99 were available for 526 children aged 1-2 years and for 764 children aged 3-5 years. For these children, Table 3-34 summarizes measured blood-lead concentration for each combination of blood collection type (venipuncture, fingerstick) and age of child (1-2 years, 3-5 years, and 1-5 years). Table 3-34 also summarizes measured blood-lead concentration for children aged 1-2 years for each combination of blood collection type and grantee. Note that fingerstick methods were predominant for Wisconsin, Milwaukee, and Vermont, while Rhode Island used both methods for similar numbers of children. The remaining nine grantees (excluding New Jersey) used the venipuncture either exclusively or predominantly.

According to Table 3-34, the geometric mean blood-lead concentration via the venipuncture collection method was 9.3 µg/dL for children aged 1-2 years and 8.0 µg/dL for children aged 3-5 years. In contrast, the geometric means based on data from Phase 2 of NHANES III were 3.1 µg/dL for children aged 1-2 years and 2.5 µg/dL for children aged 3-5 years (Table 3-36 of the §403 risk analysis report). The larger values in the HUD Grantees evaluation reflect the HUD Grantees program's procedure of selecting high-risk children for monitoring. The differing enrollment criteria across grantees also contributed to considerable differences in the geometric mean blood-lead concentration among the grantees.

Under venipuncture, the geometric means of children aged 1-2 years for individual grantees reporting more than three blood-lead results ranged from 4.2 µg/dL (California, which only targeted older units) to 15.9 µg/dL (Cleveland, which targeted units with lead-poisoned children).

The geometric mean blood-lead concentration via the fingerstick collection method was 9.4 µg/dL for children aged 1-2 years and 8.9 µg/dL for children aged 3-5 years. When data were available for more than one child under fingerstick collection methods, the geometric means for children aged 1-2 years ranged from 5.9 µg/dL (Wisconsin) to 13.5 µg/dL (Milwaukee).

Table 3-34. Summary of Children's Pre-Intervention Blood-Lead Concentration in the HUD Grantees Evaluation According to Blood Collection Method, Child Age Category, and Grantee (ages 1-2 years only)

	Number of Children	Blood-Lead Concentration (μg/dL)							
		Arithmetic Mean	Geometric Mean	Geometric Standard Deviation	Minimum	25th Percentile	Median	75th Percentile	Maximum
Age Category	**Blood Collection Method = Venipuncture**								
1-2 Years	361	12.5	9.3	2.3	0.7	5.4	10.0	17.0	53.0
3-5 Years	536	10.6	8.0	2.2	0.0	4.5	8.6	15.0	48.0
1-5 Years	897	11.4	8.5	2.2	0.0	5.0	9.0	16.0	53.0
Grantee	**Blood Collection Method = Venipuncture (Children Aged 1-2 Years only)**								
Alameda County	27	6.5	4.7	2.2	1.4	3.0	4.7	6.6	24.8
Baltimore	25	9.3	7.7	1.9	2.0	6.0	7.0	10.0	26.0
Boston	20	12.7	10.4	2.0	3.0	6.0	14.5	19.0	27.0
California	21	5.3	4.2	2.0	1.4	3.2	3.8	6.0	16.9
Cleveland	64	19.3	15.9	1.9	4.0	11.5	17.0	28.0	53.0
Massachusetts	43	11.2	9.1	1.9	3.0	6.0	9.0	16.0	40.0
Minnesota	75	14.5	10.7	2.4	0.7	6.0	11.0	22.0	43.0
New Jersey	1	3.0	3.0	--	3.0	3.0	3.0	3.0	3.0
Rhode Island	14	10.0	8.1	2.0	2.0	6.0	8.5	14.0	21.0
Wisconsin	9	10.2	8.7	1.8	4.0	6.0	8.0	12.0	24.0
Milwaukee	3	26.0	25.1	1.4	18.0	18.0	25.0	35.0	35.0
Chicago	28	13.9	11.7	2.0	1.0	9.5	12.0	19.0	35.0
New York City	23	5.2	4.7	1.6	2.0	4.0	5.0	7.0	12.0
Vermont	8	13.5	12.4	1.6	6.0	8.5	14.5	17.0	22.0
Age Range	**Blood Collection Method = Fingerstick**								
1-2 Years	164	11.7	9.4	1.9	2.0	6.0	9.0	15.0	48.0
3-5 Years	232	11.5	8.9	2.0	2.0	5.0	9.0	15.0	62.0
1-5 Years	396	11.6	9.1	2.0	2.0	5.0	9.0	15.0	62.0
Grantee	**Blood Collection Method = Fingerstick (Children Aged 1-2 Years only)**								
Cleveland	1	13.0	13.0	--	13.0	13.0	13.0	13.0	13.0
Massachusetts	4	7.8	7.3	1.5	4.0	6.0	8.5	9.5	10.0
Minnesota	1	33.0	33.0	--	33.0	33.0	33.0	33.0	33.0
Rhode Island	9	8.8	8.2	1.5	5.0	7.0	7.0	11.0	15.0
Wisconsin	43	6.2	5.8	1.4	3.5	4.0	6.0	8.0	14.0
Milwaukee	82	16.0	13.2	1.9	2.0	9.0	14.5	20.0	48.0
Vermont	24	7.9	7.0	1.6	3.5	5.0	6.5	11.0	16.0

Note: All pre-intervention blood-lead concentration data available and collected through 1/99 are included in the above summaries.

The percentages of children with elevated blood-lead concentrations (i.e., concentrations at or above 10, 15, 20 or 25 µg/dL) at pre-intervention are summarized in Table 3-35. According to this table, 51 percent of children aged 1-2 years sampled via venipuncture methods had blood-lead concentrations at or above 10 µg/dL, compared to the estimates of 5.88% for Phase 2 of NHANES III, 53.8% for the Baltimore R&M study (pre-intervention), and 23.4% for the Rochester Lead-In-Dust study (Tables 3-37, 3-41, and 3-42, respectively, of the §403 risk analysis report). For individual grantees having more than three children with a measured blood-lead concentration, the percentage of children aged 1-2 years with blood-lead concentrations (venipuncture) at or above 10 µg/dL varied from 4% (New York City, which targeted housing and neighborhoods rather than lead-poisoned children) to 80% (Cleveland). The range of percentages under the fingerstick method were similar to that under the venipuncture method, but less data were available to estimate them.

Figures 3-20 and 3-21 illustrate the nature of the linear relationship observed in the HUD Grantees evaluation between a child's (log-transformed) blood-lead concentration and the household's (log-transformed) area-weighted arithmetic average wipe dust-lead loading for floors and window sills, respectively. The figures portray fitted linear regression models for each grantee, as well as for the Rochester Lead-In-Dust study and, in Figure 3-21, the Baltimore R&M study (for comparison purposes). The regression model used only the log-transformed average dust-lead loading as a predictor variable; the impact of other potentially important predictor variables on blood-lead concentration was not considered in the model fittings. The regression lines span the ranges of the observed area-weighted average dust-lead loadings, except data for five HUD Grantees households (three from Cleveland and one each from Baltimore and Rhode Island) were omitted from Figure 3-21 as their average window sill dust-lead loadings were extremely low (less than 0.05 µg/ft^2) compared to the other households and were considered too influential to the model fittings.

When fitting the regression models in Figures 3-20 and 3-21 to the HUD Grantees data, it was desired to have each household having blood-lead and dust-lead data be represented by only a single data point. This was possible only if blood-lead data were considered for a single child in that household. In situations where data for multiple children were available for a single household, only data for the youngest child older than 12 months of age were considered. This approach resulted in a single blood-lead result for each household with blood-lead data. In addition, only data for children meeting the following criteria were included in the regression modeling:

- Children who lived in the sampled housing unit for at least three months and before dust and soil samples were collected;

- Children whose blood samples were taken within four months of dust and soil sample collection;

- Children not having medical treatment for lead poisoning.

Table 3-35. Percentage of Children with Elevated Blood-Lead Concentration (at Pre-Intervention) in the HUD Grantees Evaluation According to Blood Collection Method, Child Age Category, and Grantee (ages 1-2 years only)

	Number of Children	Percentage of Children with Elevated Blood-Lead Concentration (%)			
		$ 10 µg/dL	$ 15 µg/dL	$ 20 µg/dL	$ 25 µg/dL
Age Range	**Blood Collection Method = Venipuncture**				
1-2 Years	361	51	35	18	12
3-5 Years	536	43	27	12	7
1-5 Years	897	46	30	14	9
Grantee	**Blood Collection Method = Venipuncture (Children Aged 1-2 Years only)**				
Alameda County	27	22	11	4	0
Baltimore	25	36	20	8	4
Boston	20	55	50	15	5
California	21	14	5	0	0
Cleveland	64	80	59	38	30
Massachusetts	43	47	30	9	7
Minnesota	75	61	44	31	21
New Jersey	1	0	0	0	0
Rhode Island	14	36	21	7	0
Wisconsin	9	44	22	11	0
Milwaukee	3	100	100	67	67
Chicago	28	75	39	14	7
New York City	23	4	0	0	0
Vermont	8	63	50	13	0
Age Range	**Blood Collection Method = Fingerstick**				
1-2 Years	164	46	28	13	9
3-5 Years	232	44	26	15	8
1-5 Years	396	45	27	14	9
Grantee	**Blood Collection Method = Fingerstick (Children Aged 1-2 Years only)**				
Cleveland	1	100	0	0	0
Massachusetts	4	25	0	0	0
Minnesota	1	100	100	100	100
Rhode Island	9	33	11	0	0
Wisconsin	43	9	0	0	0
Milwaukee	82	70	50	26	17
Vermont	24	29	13	0	0

Note: All pre-intervention blood-lead concentration data available and collected through 1/99 are included in the above summaries.

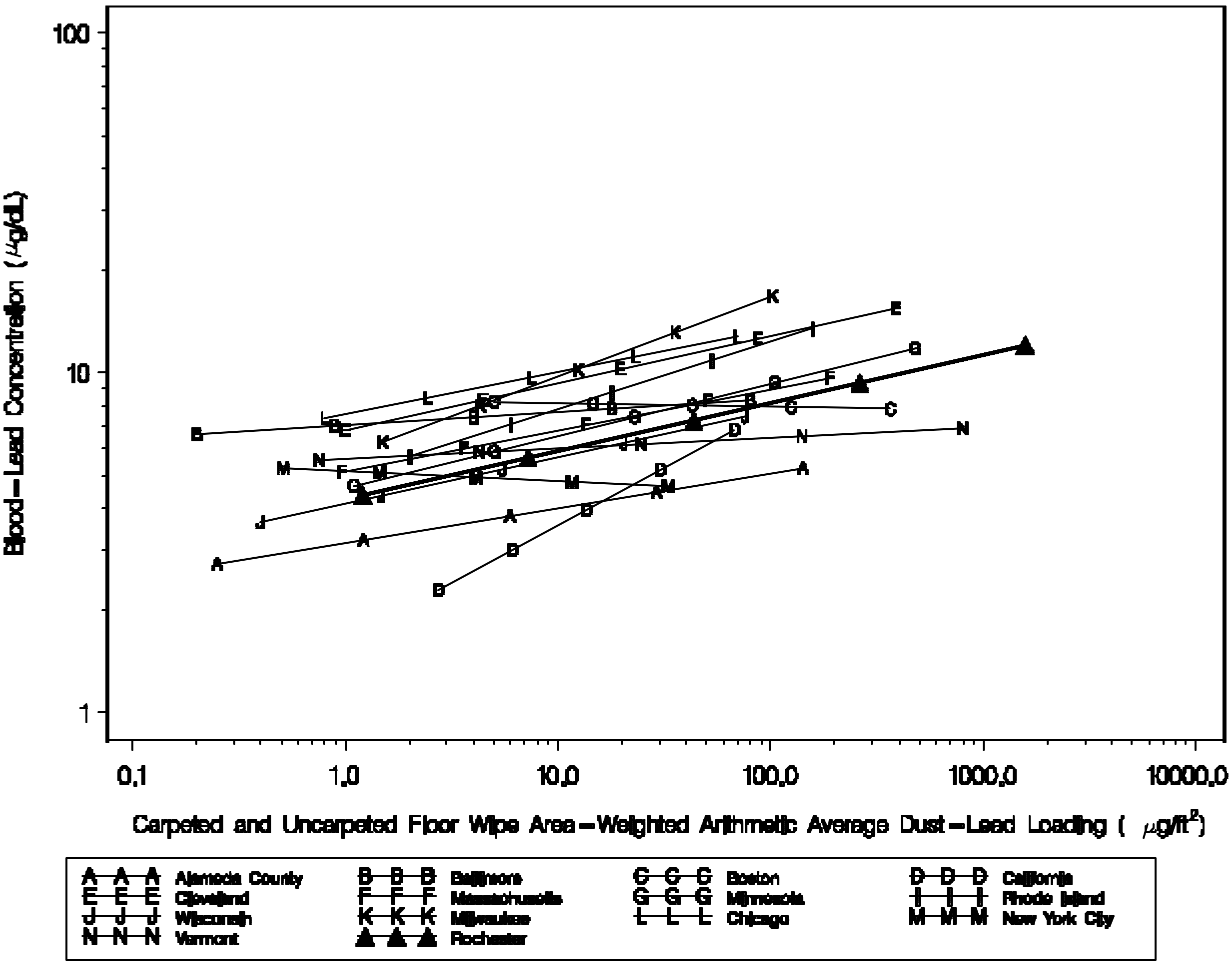

Figure 3-20. Fitted Regression Models Predicting Children's Blood-Lead Concentration as a Function of Area-Weighted Arithmetic Average Floor Dust-Lead Loading (Wipe Collection Method), for the Various Grantees in the HUD Grantees Evaluation and for the Rochester Lead-In-Dust Study

(Note: Venipuncture blood-lead data were exclusively used in each fitting except for Wisconsin, Milwaukee, and Vermont, where fingerprick blood-lead data were exclusively used.)

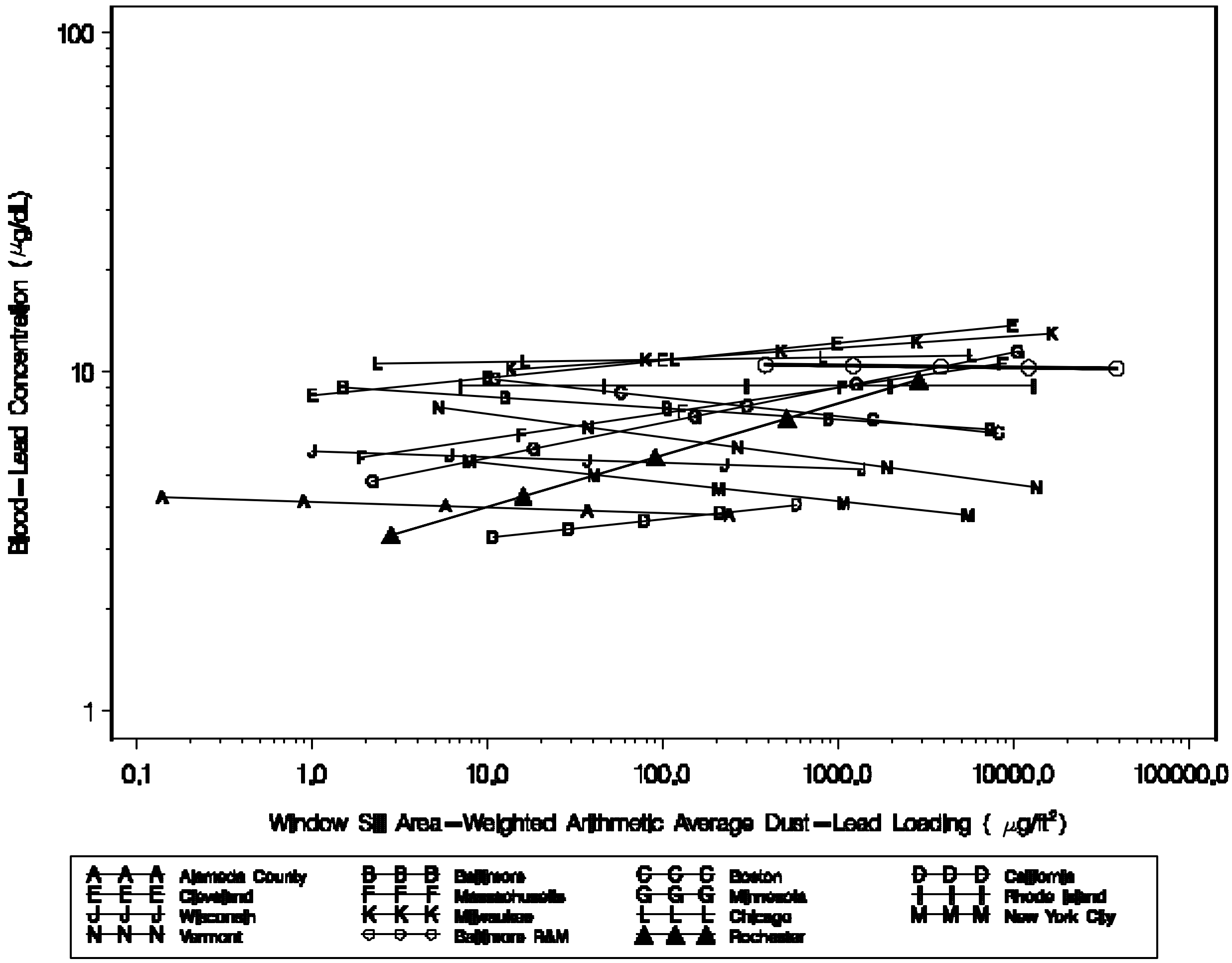

Figure 3-21. Fitted Regression Models Predicting Children's Blood-Lead Concentration as a Function of Area-Weighted Arithmetic Average Window Sill Dust-Lead Loading (Wipe Collection Method), for the Various Grantees in the HUD Grantees Evaluation and for the Rochester Lead-In-Dust Study

(Note: Venipuncture blood-lead data were exclusively used in each fitting except for Wisconsin, Milwaukee, and Vermont, where fingerprick blood-lead data were exclusively used.)

The regression models in Figures 3-20 and 3-21 were fitted to blood-lead concentration data only under the venipuncture method for all but the three grantees (Wisconsin, Milwaukee and Vermont) for which fingerstick sample results were predominant. For these three grantees, only fingerstick blood-lead concentration data were used in the regressions.

Note that the slopes of the fitted regression lines in Figures 3-20 and 3-21 are generally similar in sign and magnitude (given expected ranges of variability) across the grantees and the two other studies. This suggests that the relationships between blood-lead concentration and household average dust-lead loading were relatively consistent across grantees. In particular, these relationships were similar to that observed for data from the Rochester study (i.e., the data used to develop the empirical model presented in Chapter 4 of the §403 risk analysis). This conclusion is important in that the data from the HUD Grantees evaluation reflect a much larger geographical area than the Rochester study and represent several types of exposure conditions.

3.6.2 Evidence of the Impact of Housing Age/Condition on Blood-Lead Concentration

The role that housing age plays in the increased likelihood of a resident child having an elevated blood-lead concentration has been well-documented and is accepted by many experts in residential lead exposure. Older housing is more likely to contain lead-based paint in a deteriorated condition, which contributes to lead in other environmental media within the residence, especially those media that is most likely to come into direct contact with children. In particular, the importance that the level of deterioration plays in the accessibility of lead-based paint hazards implies that housing condition is an additional key factor in predicting blood-lead concentration.

Table 3-39 of the §403 risk analysis report summarized data from Phase 2 of NHANES III to illustrate how geometric mean blood-lead concentration and the percentage of elevated blood-lead concentrations (i.e., percentage exceeding a given threshold) for children are related to housing age category. For example, the percentage of children aged 1-5 years with blood-lead concentration of at least 10 µg/dL increases from 1.6% for children living in post-1973 housing to 8.6% for children living in pre-1946 housing, with a corresponding geometric mean increase from 2.0 to 3.8 µg/dL. The Centers for Disease Control and Prevention (CDC) cited these same results in their 1997 document, *Screening Young Children for Lead Poisoning*, to support their conclusion that older housing (i.e., housing built prior to 1950) contained the greatest risk for lead-based paint hazards.

Figure 6-1 of the CDC's 1991 document, *Preventing Lead Poisoning in Young Children – A Statement by the Centers for Disease Control*, presents results from the Cincinnati Prospective Lead Study (Clark et al., 1985) to illustrate how the combination of housing age and condition is related to children's blood-lead concentration and how this relationship changes with the age of the child. This figure is duplicated in Figure 3-22. This figure shows that children's blood-lead concentration tends to peak at 18-24 months, with the most rapid increase occurring between 6-12 months. The highest blood-lead levels are associated with housing built prior to World War II, as well as older housing (predominantly 19th century) that once contained considerable lead-based paint but which later underwent rehabilitation. Within these groups of housing, children living in units in a deteriorated or dilapidated condition had consistently higher geometric mean blood-lead concentrations through their first three years, with this geometric mean exceeding 20 µg/dL from about 12 to 24 months of age. CDC used the information presented in Figure 3-22 to prepare a recommended screening schedule for testing children's blood-lead levels.

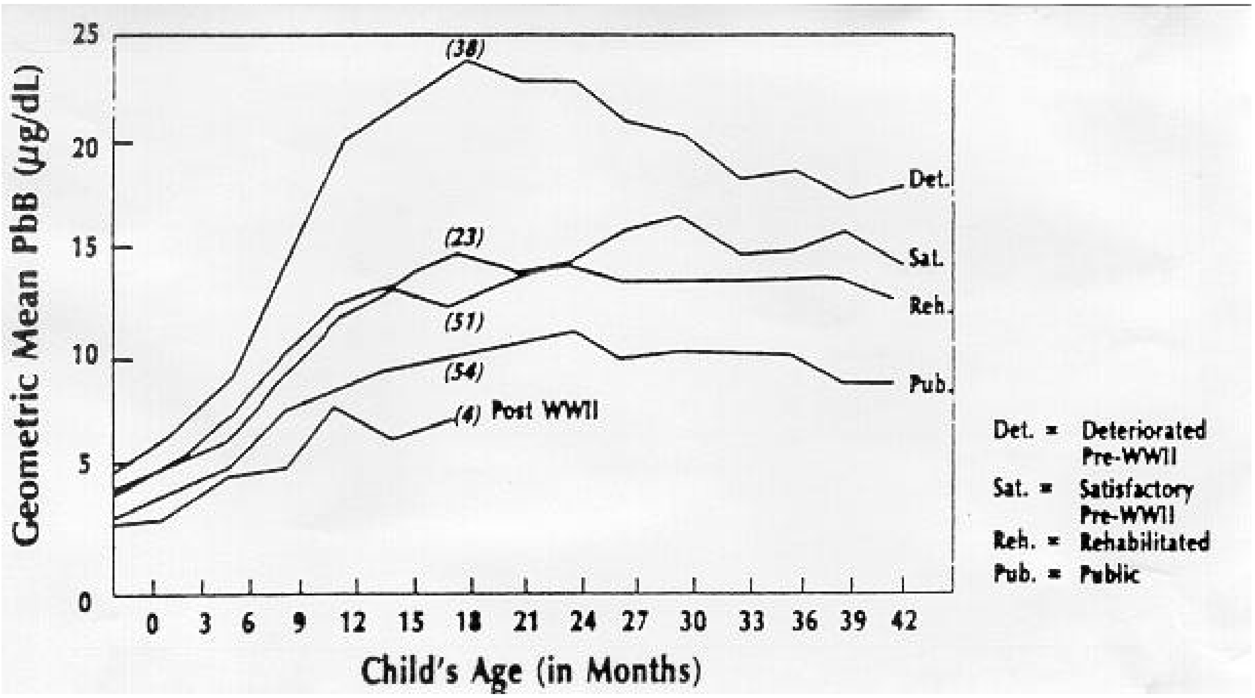

Figure 3-22. Geometric Mean Blood-Lead Concentration Versus Child Age, As Reported Within the Cincinnati Prospective Lead Study and Presented According to Housing Age and Condition

(Note: Duplicated from Figure 6-1 of CDC, 1991. Blood-lead concentrations for the same cohort of children were measured over time. Numbers in parentheses indicate numbers of children with blood-lead information at 18 months of age.)