ECONOMIC ANALYSIS OF TOXIC SUBSTANCES CONTROL ACT SECTION 403: LEAD-BASED PAINT HAZARD STANDARDS

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Executive Summary

This report presents an economic analysis of final regulations setting standards for lead-based paint hazards. The regulations are being finalized under authority of §403 of the Toxic Substances Control Act (TSCA). This section was established by the Residential Lead-Based Paint Hazard Reduction Act of 1992, also known as "Title X."

TSCA §403 requires that EPA promulgate regulations to "identify ... lead-based paint hazards, lead-contaminated dust and lead-contaminated soil" for purposes of other parts of Title X. The lead-based paint hazards addressed in this economic analysis include residential hazards from deteriorated paint and contaminated dust and soil[1]. These standards apply directly to "target housing" (most housing constructed prior to 1978) and child-occupied facilities. In addition, various parties may also apply the standards to newer residences.

The analysis compares alternative candidate standards in terms of their net benefits. Net benefits are based on the benefits of risk reduction minus the costs of control activities needed to achieve the reduction in risk. The analysis calculates net benefits for a wide range of alternative standards, including the final §403 hazard levels.

The final §403 standards define the level of lead in soil and dust, and the condition of lead-based paint, at which intervention activities should be undertaken. The final standards are listed in Exhibit ES-1 along with their estimated costs, benefits, net benefits, the number of homes affected, and number of children affected. There are two separate estimates of benefits, and thus net benefits, because two models were used to estimate differences in blood-lead levels resulting from differences in environmental lead levels due to the final standards. Since these two models predict different blood-lead levels, they result in different estimates of benefits.

ES.1 Regulatory Background

Lead's advantageous properties, including its malleability, resistance to corrosion, good insulating properties, and low cost, have made it attractive for many applications; lead has been used in gasoline, ceramics, paint, and many other products. These uses have resulted in lead's release to and distribution through all environmental media, which has complicated efforts aimed at reducing lead in the environment.

As our understanding of the negative health effects of lead has increased, a variety of federal, state and local regulations have been developed to reduce exposure to lead. The presence of lead in certain consumer products, such as gasoline, has been prohibited or restricted by regulations. Environmental releases of lead to air and water, and lead concentrations in waste, also have been controlled. OSHA has set limits on allowable workplace concentrations of lead. In addition, regulatory efforts have been made to remediate exposure to lead through drinking water systems.

[1] The final rule also defines "levels of concern." Levels of concern are set at lower levels of contamination than the hazard standards, and are intended for use in risk communication. They were based on health risks only and are not part of this economic analysis.

Exhibit ES-1
Summary of Results for Final §403 Standards Analyzed in this Report

Interior Paint Standard	• More than 2 sq ft of deteriorated lead-based paint in an interior room • Any visible deteriorated or abraded lead-based paint on friction or impact surfaces • Any visible deteriorated lead-based paint on interior window sills up to five feet off the floor
Exterior Paint Standard	More than 10 sq ft of deteriorated lead-based paint on the exterior of a property
Floor Dust Standard	40 µg/sq ft
Window Sill Dust Standard	250 µg/sq ft
Soil Standard	1200 ppm
Total Cost (over 50 year span, discounted at 3%)	$68.9 billion
Total Benefits based on the IEUBK Model (over 50 year span, discounted at 3%)	$192.2 billion
Net Benefits, based on IEUBK Model (over 50 year span, discounted at 3%)	$123.3 billion
Total Benefits, based on Empirical Model (over 50 year span, discounted at 3%)	$48.5 billion
Net Benefits, based on Empirical Model (over 50 year span, discounted at 3%)	$−20.3 billion
Number of Homes that Exceed the Standards	26.7 million
Number of Children who will experience reduced exposure to household lead in soil, dust, and paint	46.0 million

These values correspond to a play area standard of 1200 and a rest of the yard standard of 1200 ppm. An analysis of a play area standard of 400 ppm is presented in Appendix 7A. A play area standard of 400 ppm with a rest of the yard soil standard of 1200 ppm is estimated to have costs of $70.5 billion, IEUBK benefits of $175.6 billion with net benefits of $105.1 billion, and Empirical Model benefits of $44.8 billion with net benefits of −$25.7 billion. The main text of Chapters 5, 6, and 7 addresses play area standards at the same level as the rest of the yard standard, not at a constant level of 400 ppm.

One of the largest remaining lead exposure sources for children is existing reservoirs of lead in paint, dust and soil present in many residential areas. In an effort to reduce exposure to residential lead hazards, regulatory efforts to address these hazards have been increasing for several years.

ES.2 Analytic Approach

As envisioned by Congress, the lead hazard standards to be established under §403 are intended to tell people when they *should act for the safety of their children,* i.e. when interventions should take place. Thus, a normative analysis was conducted to identify lead hazard levels at which the interventions maximize net benefits. More specifically, in defining when intervention actions should occur, the relevant measure is *maximizing net benefits for children* (the population that is both at greatest risk from exposure and the most in need of protection since children are not in a position to protect themselves). Therefore, the birth of a child is used as the event that triggers intervention activities in the analysis used to evaluate alternative standards.

The factors considered in estimating the costs and benefits include:

- The adverse health effects to children from lead exposure -- what they are and how they differ with differing lead-related characteristics of the housing unit, and across demographic, geographic and/or socio-economic groups.

- The costs to individuals and society of interventions which reduce lead exposure.

- The effectiveness and duration of these interventions and the benefits resulting from reduced exposure and reduced adverse health effects.

- The value of these benefits to individuals and society.

By comparing the total present value of net benefits (benefits minus costs) for a reasonable array of standards, it is possible to identify the standard that yields the largest net benefits and to compare standards in terms of their net benefits. For example, as standards become more protective (i.e. more stringent), they also become more costly. By looking at net benefits, the analysis shows how much society is giving up to acquire more protection. Likewise, costs can be reduced by making the standards less stringent. The analysis estimates what benefits society is giving up with this reduction in costs.

The analysis considers children, from birth through the sixth birthday, living in homes that were built in 1997 or earlier.[2] Because the potential for lead exposure in currently contaminated homes may remain for some time, the analysis considers children born during the 50-year period, from 1997 to 2046. Exposure, health effects, and benefits are calculated separately for the cohorts born in each of the 50 model years.

The methodology used to evaluate the economic return from the §403 hazard levels has several linkages with the risk assessment methodology, which in turn relates paint condition and the amount of lead in dust and soil to blood lead levels and health effects. Exhibit ES-2 illustrates the basic linkages between the risk assessment and economic modeling. The primary links are those that connect candidate hazard standards

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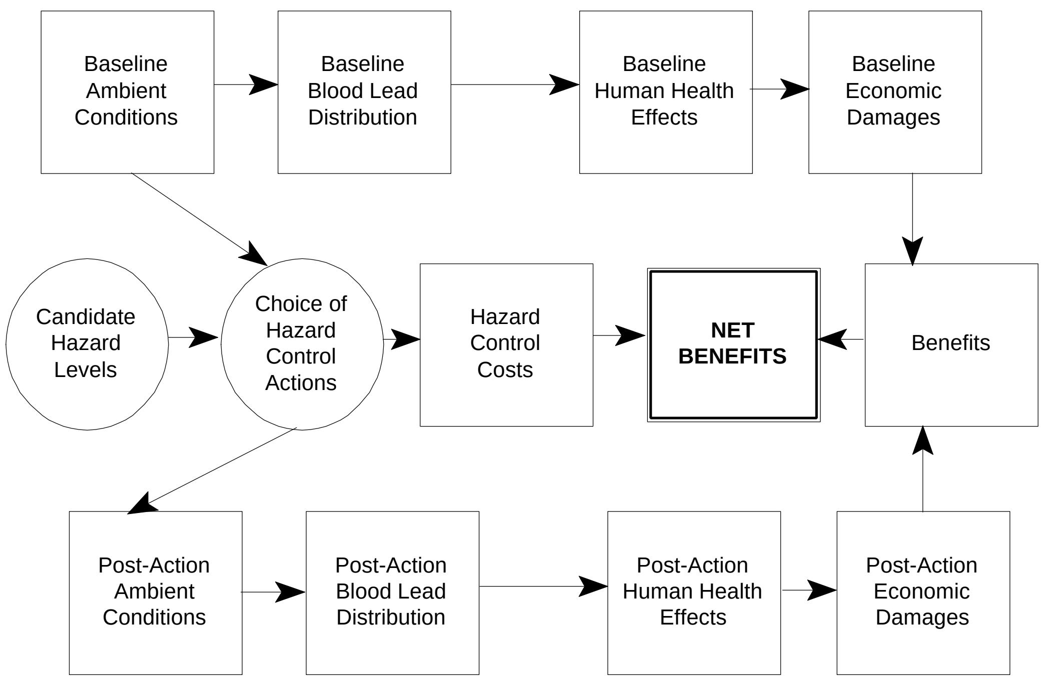
[2] According to Title X, the regulations will apply to housing constructed before 1978. However, the analysis assumes that once EPA promulgates these standards, they will be generally applied to all housing regardless of year constructed. Of the over 25 million homes that exceed the final standards, only an estimated 890,000 (or 3.6 percent) were built after 1978.

and the presence of lead in each housing unit with hazard control choices and costs, and those that connect the presence of environmental lead to blood-lead levels and thus to health effects and economic damages and benefits. The first set of linkages outlines the cost estimation process, while the latter describes the benefit estimation process.

In Exhibit ES-2, the boxes along the top represent the analysis of baseline conditions, yielding an estimate of the economic damages resulting from the baseline residential lead levels. The boxes along the bottom of the exhibit represent the analysis of ex post conditions; each scenario or potential lead hazard definition is analyzed separately. A comparison of the baseline economic damages and the ex post economic damages yields an estimate of the benefits of actions performed under the scenario. This is represented by the far-right box in the middle row of Exhibit ES-2. From these benefits, the analysis subtracts the corresponding costs to get net benefits.

Exhibit ES-2
Linkages Between the Risk Assessment and Economic Methodologies



The evaluation of candidate hazard standards consists of calculating net benefits for a wide range of levels for the candidate standards and then comparing the candidate hazard standards in terms of net benefits. The candidate hazard standard yielding the largest net benefits provides the greatest benefit to society.

ES.2.1 Baseline

The benefit-cost analysis compares alternative futures over a 50-year time span: a baseline or "no-action" alternative for which it is assumed that no changes are made to current ambient lead exposure conditions, and a "post-action" alternative for which it is assumed that the ambient lead exposure conditions are reduced in specific ways in response to the §403 standards. In other words, it is a marginal analysis with a baseline of no intervention. The baseline residential lead conditions are defined by data on dust and soil lead levels, and condition of lead-based paint, collected by the U.S. Department of Housing and Urban Development for a representative sample of homes. The baseline population blood-lead levels are defined by data from the NHANES III Part 2 survey.

ES.2.2 Estimating Costs

Costs of hazard control are calculated using unit costs of individual intervention activities, in combination with the timing and number of interventions. Unit costs are calculated for each of the testing and intervention activities and represent average costs of intervention nationwide. Intervention activities include maintaining, removing or encapsulating deteriorated lead-based paint, removing dust, and removing and replacing soil. Separate cost estimates are developed for single and multi-family housing units; multi-family unit costs are developed by adjusting the single family cost estimates to reflect the smaller size of multi-family units and the smaller yards of multi-family units.

The analysis assumes that when a child is born into a housing unit whose ambient lead levels exceed the candidate standards levels, the appropriate intervention will occur. This initial intervention is repeated as necessary until the child turns six years of age, at which time additional interventions will cease unless an additional child has been born during this time period. If needed, interventions in the home will recommence if another child is born after this period, and will follow the same repeat routine.

Costs incurred after the first year are discounted to the first year using an annual discount rate of 3 percent.[3] The total cost estimate is the sum of the costs of hazard controls in all homes for each year and represents the present value of the assumed stream of intervention costs.

ES.2.3 Estimating Benefits

Benefits of hazard control are calculated using estimates of "avoided" economic damages corresponding to avoided adverse health effects. The model defines "avoided" as the difference between the baseline scenario, which assumes no intervention activity and various intervention or ex post scenarios. Each of the scenarios assumes a different specification of lead hazard standards, and hence intervention activities. In the analysis, benefits are calculated for children whose exposure to lead is reduced for the period from birth to age six.

These avoided economic damages include reductions in IQ, plus increased educational and medical costs connected with high levels of exposure. In each case, the economic value is a proxy for society's willingness to pay to avoid the health effect. Changes in IQ levels make up the vast majority of benefits in this analysis. The economic value of avoiding lost IQ points is approximated by using an estimate of the

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3 The sensitivity analysis presents costs, benefits and net benefits calculated with a discount rate of 7 percent as well.

foregone lifetime income due to IQ point loss. The estimated value per IQ point lost is $8,346 (1995 dollars).

Since lead exposure has been linked to a variety of health hazards for children and adults in addition to those analyzed here, the benefit estimates developed in the analysis understate the societal return from the §403 hazard levels. Furthermore, secondary benefits such as improved energy efficiency due to new windows and increased aesthetic appeal due to repainting are not included.

Benefits accrue over time depending on hazard control choices and assumptions regarding exposure of children. All benefit estimates are discounted to the present using an annual rate of 3 percent. Total benefits are the sum of benefits calculated for each year or cohort of children protected and represent the present value of the stream of benefits from the hazard controls. Net benefits are simply the difference between the total benefits estimate and the total cost estimate. As such, they are an indicator of the societal gains from hazard controls.

ES.2.4 Identifying Hazard Standards that Maximize Net Benefits

The analysis evaluates alternative standards for floor dust, window sill dust and soil, assuming the following responses to the paint standards:

Medium	Amount of Deteriorated Lead-Based Paint	Intervention Activity
Deteriorated Interior Lead- Based Paint	2 sq.ft. or more	Repair
	50 sq.ft. or more	Abate
Deteriorated Exterior Lead- Based Paint:	10 sq.ft. or more	Repair
	100 sq.ft. or more	Abate

The analysis assumes that homes receiving any lead intervention will receive interventions for all media (floor dust, window sill dust, paint and soil) that exceed the standards. This assumption, combined with the fact that there are interactions among the interventions in terms of both costs and benefits, means that standards can not be accurately evaluated one at a time. Instead, the standards for a single medium must be evaluated in the context of specified standards for all other media. To allow for this, the analysis calculated costs, benefits and net benefits for all combinations of standards. For each medium, the alternative standards were defined in terms of incremental changes in the levels of lead. For example, floor dust standards varied by increments of 10 $\mu g/ft^2$ (e.g., 40 $\mu g/ft^2$, 50 $\mu g/ft^2$, 60 $\mu g/ft^2$, 70 $\mu g/ft^2$, etc.). Likewise, soil standards were analyzed in increments of 50 ppm (150 ppm. 200 ppm. 250 ppm, 300 ppm, etc.). All combinations of standards were analyzed.

Two EPA blood-lead models (IEUBK and Empirical) were used in this analysis and they generate different benefit estimates for any given combination of standards. In addition to differences in the overall size of benefits, the benefit estimates vary at different rates under the two models and thus the set of standards that maximize net benefits is different under the two models. As a result, there is no unique answer to the question: which combination of standards maximize net benefits? There is one answer when benefits are estimated using the IEUBK Model and a different answer when the benefits are based on the results of the Empirical Model.

The two blood-lead models differ in several ways, including the incorporation of different variables and very different functional forms relating environmental lead levels to children's blood lead levels. Notably, the functional form of the IEUBK Model is such that it is much more sensitive to changes in environmental lead than the Empirical Model. Also, the IEUBK Model uses lead dust concentrations and the Empirical Model uses dust lead loadings as input variables. Since dust lead concentrations and loadings are not well correlated in the actual housing unit data collected by HUD and used for this analysis, these differences in input variables result in differences in estimated blood-lead changes and thus benefits.

For each of the two blood-lead models, Exhibit ES-3 presents the set of standards that maximize net benefits, along with the costs, benefits and net benefits for each standard. The net-benefit maximizing standards, based on the IEUBK Model, are much more stringent than the net benefit maximizing standards based on the Empirical Model. In addition, the exhibit presents the standards that this report refers to as the final standards, along with their cost, benefit and net benefits. These standards are shown twice, once with benefits calculated using the IEUBK Model and once using the Empirical Model.

Exhibit ES-3
Comparison of Standards Under Alternative Risk Assessment Models

	IEUBK Model Results	
	Standards that Maximize Net Benefits	**Final Standards**
Floor Dust Standard	40 µg/ft^2	40 µg/ft^2
Window Sill Dust Standard	100 µg/ft^2	250 µg/ft^2
Soil Standard*	250 ppm	1200 ppm
Total Cost	$100.6 billion	$68.9 billion
Total Benefit	$274.0 billion	$192.2 billion
Net Benefit	$173.5 billion	$123.3 billion
	Empirical Model Results	
	Standards that Maximize Net Benefits	**Final Standards**
Floor Dust Standard	80 µg/ft^2	40 µg/ft^2
Window Sill Dust Standard	310 µg/ft^2	250 µg/ft^2
Soil Standard*	1,650 ppm	1200 ppm
Total Cost	$51.7 billion	$68.9 billion
Total Benefit	$46.5 billion	$48.5 billion
Net Benefit	−$5.2 billion	−$20.3 billion

* These estimates assume that the play area standard is set equal to the rest of the yard standard.

The IEUBK net benefit maximizing standards are more stringent than the final standards. Because of the large number of homes in the lower range of environmental lead levels, the IEUBK standards would cost nearly 1.5 times as much as much as the final standards and the benefits would be nearly 1.5 times those of the final standards. In addition, the net benefits, at $174 billion, would be substantially higher than the net benefits of the final standards, at $123 billion.

The Empirical Model net benefit maximizing standards, on the other hand, are less stringent than the final standards. Since there are many fewer homes with environmental lead levels in the range of these standards, the Empirical Model net benefits maximizing set of standards would cost less ($52 billion as compared to $69 billion) and would produce smaller benefits ($47 billion as compared to $49 billion) than the final standard. However, its net benefits are somewhat larger than those of the final standard, while still negative.

ES.3 Sensitivity Analysis

To gain a better understanding of the relationships embedded in the analysis, and the impact of certain parameter values, six sensitivity analyses were performed. The particular elements of the model chosen to include in the sensitivity analysis reflect those elements identified as likely to have significant effect on the results or for which there was a particular interest in determining what the potential effects might be. Three of the sensitivity analyses dealt with alternative values for specific parameters:

- Discount rate — 7% in place of 3%;
- Monetary value of an IQ point loss or gain — $6,847 in place of $8,346;
- Elimination of the additional cost of disposing of high-lead soil as a hazardous waste.

The other three sensitivity analyses involved changes in the modeling procedures used in the benefit-cost analysis:

- Exclude from the benefits small changes in IQ;
- Use real estate transactions, rather than pending birth, as the intervention trigger;
- Analyze standards for each medium, assuming there were no standards for other media.

The sensitivity analyses consider the effect on two outcomes of the benefit-cost modeling. The first outcome is the impact on the estimated costs and benefits of the standards. The second outcome is the effect on the determination of the set of standards that produce maximum net benefits. In some cases, both cost and benefit estimates are changed but there is no shift in the standard found to maximize net benefits. In other cases, there are changes in estimated costs and/or benefits that affect which standard maximizes net benefits. In all cases, the sensitivity analyses are conducted separately using the IEUBK and the empirical blood-lead models.

The results of the six sensitivity analyses are summarized in Exhibit ES-4. In the first three analyses costs and/or benefits are decreased; where there are changes in the net benefit maximizing standards, they become less stringent. The largest changes in the standards result from increasing the discount rate; the other two cases experience relatively small shifts in the standards that maximize net benefits.

The impacts of the other three sensitivity analyses are mixed. Excluding small changes in IQ reduces benefits while leaving costs unchanged. The net-benefit maximizing standards become less stringent. Assuming that real estate transactions, instead of births, trigger intervention activities, increases costs and decreases benefits because more actions take place but fewer occur where there is a child to benefit. Again, the impact is to reduce the stringency of the net-benefit maximizing standards. Due to the potential for double counting, neither costs nor benefits can be accurately estimated when standards are analyzed for one medium at a time. The impact on standards that maximize net benefits is to make the floor and soil standards more stringent when the Empirical Model is used to measure benefits, and to leave the rest of the standards unchanged.

Exhibit ES-4
Summary of Results of Sensitivity Analysis

Factor Examined	Impact on Estimation of Costs	Impact on Estimation of Benefits	Impacts on Standards That Maximize Net Benefits
Discount Rate: 7% in place of 3%	Decrease in costs relatively less than decrease in benefits	Decrease in benefits relatively more than decrease in costs	Standards substantially less stringent
Value of IQ Point: decrease from $8,346 to $6,847	No impact on costs	Decrease in benefits	IEUBK: No change in standards Empirical: Standards slightly less stringent
Hazardous Waste Disposal of Soil: not required	Decrease in costs	No impact on benefits	IEUBK: Soil standards slightly less stringent Empirical: Soil standards more stringent
Exclude Small Changes in IQ (i.e., less than 1 IQ point) **from Benefits**	No impact on costs	Decrease in benefits	Standards would become less stringent, with larger impact on Empirical than on IEUBK results
Event That Triggers Interventions: use real estate transaction rates in place of birth rates	Increase in costs (annual transaction rate greater than annual birth rate)	Decrease in benefits (most interventions occur where no child is present to benefit)	IEUBK: Floor dust and soil standards unchanged; window sill dust standard becomes less stringent Empirical: all standards become less stringent
Single Medium Analysis: standard for each medium set assuming no other standards in effect	NA	NA	IEUBK: No change in standards Empirical: Floor dust and soil standards become more stringent

ES.4 Other Impacts of Section 403

Several additional analyses were performed to estimate the impact of the §403 standards on various groups of particular concern. These include its impact on small entities, on minority and low-income households, and on children. The recording keeping and reporting burdens placed on state, local and tribal governments, as well as the private sector, were also estimated. The results of these analyses are presented in the following sections.

ES.4.1 The Regulatory Flexibility Act (RFA) and Small Business Regulatory Enforcement Fairness Act (SBREFA)

As described in the Preamble, the §403 standards do not require or mandate any actions by homeowners, landlords, or personnel performing lead-based paint identifications and interventions. Instead, §403 standards inform decision-makers about what conditions constitute a hazard and recommend potential actions. As a result, EPA is not required to conduct an analysis of small entity impacts under the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA). In situations where RFA requires an analysis of a rule's economic impact on the small entities that will be subject to the rule's requirements, it requires that the analysis identify the types, and estimate the numbers, of small entities "to which the proposed [or final] rule will apply." It also requires that the analysis describe the rule "requirements" to which small entities "will be subject" and any regulatory alternatives, including exemptions and deferrals, which would lessen the rule's burden on small entities. (Sections 603 and 604 of the RFA.) Rules that do not establish requirements applicable to small entities are thus not susceptible to RFA analysis and may be certified as not having a significant economic impact on a substantial number of small entities, within the meaning of the RFA. This is particularly true when the national standards do not themselves require any particular action, as is the case with §403.

Nevertheless, EPA has conducted a more limited analysis of the potential impact on small entities of these standards as they work within the market. Two groups of entities are considered: lead-based paint inspection and abatement firms, and landlords. To the extent that the §403 standards may increase the number of hazard identification and intervention actions, this is likely to help small businesses, who make up the majority of inspection and abatement firms. In terms of impacts on landlords, the analysis found that there would not be a significant economic impact on a substantial number of small firms.

ES.4.2 Unfunded Mandates Reform Act (UMRA)

Under Title II of the Unfunded Mandates Reform Act, the cost to state, local and tribal government or the private sector of compliance with federal regulations must be calculated and considered during the regulatory process. Because §403 is a regulation which provides information to consumers about household lead safety and does not require households or public entities to take any action with respect to that information, no costs are imposed on state, local and tribal governments or the private sector. As such, this action is not subject to the requirements of sections 202 and 205 of (UMRA) because this action does not contain any "federal mandates." Similarly this regulation contains no regulatory requirements that might significantly or uniquely affect small governments, so no action is needed under Section 203 of UMRA.

ES.4.3 Paperwork Reduction Act (PRA)

The Paperwork Reduction Act (PRA) requires EPA to prepare an Information Collection Request (ICR), which estimates the reporting and recordkeeping burden imposed by their regulations. Under the PRA, "burden" means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

Section 403 contains no reporting or recordkeeping requirements, and thus no ICR is necessary for this rule. However, an ICR was previously prepared and filed for the promulgation of regulations for TSCA §402(a) and 404, and these burden estimates were based on estimates of the number of lead-based paint identification and intervention activities anticipated. EPA re-examined the §402(a) and 404 ICR and determined that these estimates would not change due to the §403 standards.

ES.4.4 Executive Order 12898--Federal Actions to Address Environmental Justice

EPA investigated environmental justice related issues with regard to the potential impacts of this action on the environmental and health conditions in low-income and minority communities. African-American households are more likely to live in housing with lead-based paint hazards and a larger proportion of their children will benefit from the standard. Among households performing interventions, non-Hispanic white households face a higher average cost per household to bring their housing units up to the standard. Lower-and upper-income households face roughly the same cost of compliance. This means that lower-income households will have to forego a larger share of their income to comply with §403. Depending on which blood-lead model is used, lower-income households will have either larger or smaller average benefits than higher-oncome households.

ES.4.5 Executive Order 13045--Protection of Children from Environmental Health Risk and Safety Risks

The focus of the §403 regulation is on the protection of children's health. The household lead standards were chosen based on an analysis of the health risks to children. The benefits from §403 outlined in Chapter 5 are a reflection of benefits to children under 6 years old.

Of the estimated 173 million children born between 1997 and 2046, approximately 131 million children will be born into housing built prior to 1979. It is estimated that §403 will result in reductions in exposure to household lead in soil, dust, and paint for 46.0 million children born over that 50 year span. This reduction in exposure, in turn, will result in reductions in the incidence of elevated blood-lead levels and increases in average IQ. Exhibit ES-5 presents blood-lead and IQ statistics for both the baseline and post-compliance scenarios.

Exhibit ES-5
Beneficial Health Impacts on Children Resulting from §403

	Mean blood-lead level (µg/dl)	Number with elevated blood-lead due to pica (millions)	Number with blood-lead greater than 10 µg/dl (millions)	Number with blood-lead greater than 20 µg/dl (millions)	Average IQ point gain	Number avoiding IQ less than 70
Baseline	4.12	2.4	10.0	1.0	NA	NA
Post-§403 IEUBK	3.18	1.1	2.5	0.1	0.90	30,000
Post-§403 Empirical	3.88	1.1	8.0	0.7	0.23	8,000

As shown, the health impacts of §403 are positive and substantial. The reduction in the number of children suffering from elevated blood-lead levels due to pica (direct ingestion of paint chips) is on the order of 1.3 million. The reduction in the number of children with elevated blood-lead levels (greater than 10 µg/dl) from all sources is estimated at 2.0 to 7.5 million. The increase in average IQ depends greatly on which benefits model is used but is between 0.23 and 0.90 points. Similarly the number of children who will avoid an IQ less than 70 points is between 8,000 and 30,000, depending on the benefits model employed.

1. Introduction

This report presents an economic analysis of final regulations setting standards for lead-based paint hazards. The regulations are being promulgated under authority of §403 of the Toxics Substances Control Act (TSCA). This section was established by the Residential Lead-Based Paint Hazard Reduction Act of 1992, also known as "Title X."

Historically, use of lead-based paint in residences has been an important source of lead exposures. Production and sale of lead-based paint for residential use was banned in the United States in 1978. This ban, in combination with a phase-out of lead in gasoline, more stringent standards for lead in drinking water, and reduced use of lead as solder in food cans, has dramatically reduced environmental lead levels. Recent studies have suggested, however, that exposure to lead poses hazards at levels once thought to be safe. In addition, past use of lead-based paint and other sources of lead have resulted in contamination that continues to pose human health hazards. Many older residences (especially those built before 1978) have lead-based paint that has chipped or peeled and become available for ingestion, especially by children. In addition, residential dust and soil are contaminated with lead from past lead-based paint use and other sources.

A variety of both voluntary and mandatory programs have been established at the federal, state and local levels to encourage remediation of these residual hazards. The final rule considered here will support implementation of these programs, either directly or indirectly, by establishing a definition of lead paint-based hazards. By issuing these hazard definitions, EPA hopes to encourage improved targeting of programs that address residential lead problems, thereby enhancing the cost-effectiveness of lead-hazard programs as a whole.

1.1 Purpose of The Rule

TSCA §403 requires that EPA promulgate regulations to "identify ... lead-based paint hazards, lead-contaminated dust and lead-contaminated soil" for purposes of other parts of Title X. This economic analysis evaluates the final §403 standards identifying lead-based paint hazards, which include residential hazards from deteriorated paint and contaminated dust and soil.[1] These standards apply directly to "target housing" (most housing constructed prior to 1978). In addition, various parties may apply the standards to newer residences as well.

Property-owners are not required to take action to address lead-based paint hazards, as defined by this rule. However, it is expected to encourage such interventions by providing a specific definition of hazard, along with guidance on actions that can be taken to address the hazards. The rule should encourage more effective targeting of activities under various federal, state and local programs, by communicating EPA's best judgement about conditions which require intervention.

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[1] The rule also defines "levels of concern." Levels of concern are set at lower levels of contamination than the hazard standards, and are intended for use in risk communication. They were based on health risks only and are not part of this economic analysis.

The lead-based paint hazard standards therefore define conditions of lead-based paint and levels of lead in dust and soil at which EPA believes hazards should be addressed[2]. Paint hazards should be addressed by repairing deteriorated paint, removing or enclosing the paint, or replacing the painted component. Dust-lead hazards should be addressed by intensive cleaning. Soil-lead hazards should be eliminated through soil removal or permanent cover of the soil. EPA is planning to develop a guidance document to describe the recommended responses in more detail.

The standards support implementation of key provisions of Title X, including eligibility criteria for the Department of Housing and Urban Development's (HUD's) abatement grant program and requirements that owners of HUD-associated housing and federal agencies evaluate and control lead-based paint hazards in residential properties being sold. In addition, sellers and lessors of housing built before 1978 are required to disclose known lead-based paint and lead-based paint hazards prior to sale or rental, under Title X §1018. Certified workers must be used for evaluation and cleanup where lead-based paint hazards are present.

The §403 standards will have broader uses, however. The standards communicate the Agency's best judgement about the identification of lead-based paint hazards to property owners, state and local officials, tenants and other decision-makers. EPA expects that public and private institutions may incorporate these standards into state and local laws, housing codes, and lending and insurance underwriting standards.

1.2 Goals of the Economic Analysis

The purpose of this report is to present the economic analysis used by the U.S. Environmental Protection Agency (EPA) in determining what standards should be established under §403 of the Toxic Substances Control Act. The report also meets the requirements for economic analysis in Executive Order 12866 -- *Regulatory Planning and Review*; the Regulatory Flexibility Act (RFA) and Small Business Regulatory Enforcement Fairness Act (SBREFA); Executive Order 12898 -- *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*; Executive Order 13045 -- *Protection of Children from Environmental Health Risks and Safety Risks*; the Unfunded Mandates Act and Executive Order 12875 -- *Enhancing the Intergovernmental Partnership*; and the Paperwork Reduction Act (PRA).

The analysis compares alternative candidate standards in terms of their net benefits. Net benefits are based on the benefits from risk reduction and the costs of hazard control activities needed to achieve the reduction in risk. Using a normative framework, the analysis calculates net benefits for a wide range of alternative standards, including the final §403 hazard levels.

The analysis does not attempt to predict precisely how much remediation of residential lead-based paint hazards will occur as a result of promulgating these standards. Rather, it is designed to provide comparisons of different standards rather than absolute measures of costs and benefits for the different standards.

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[2] The definition of lead-based paint itself has already been established by statute, and is not addressed by this rule. This standard focuses on the conditions under which lead in deteriorated paint surfaces and friction/impact surfaces constitutes a hazard.

The lead hazard standards to be established under §403 are intended to tell people when they *should act*, i.e. when interventions should take place. In the economic literature this is referred to as a normative analysis. As such, the analysis identifies hazard levels at which the interventions maximize net benefits. More specifically, in defining when intervention actions should occur, the relevant measure is *maximizing net benefits for children* (the population that is both at greatest risk from exposure and the most in need of protection since children are not in a position to protect themselves). Therefore, the birth of a child is used as the event that triggers intervention activities in the analysis used to evaluate alternative standards.

The factors considered in estimating the costs and benefits include:

- The adverse health affects from lead exposure -- what they are and how they differ with differing lead-related characteristics of the housing unit, and across demographic, geographic and/or socio-economic groups.

- The costs to individuals and society of interventions which reduce lead exposure.

- The effectiveness and duration of these interventions and the resulting benefits in terms of reduced exposure and reduced adverse health effects.

- The value of these benefits to individuals and society.

By comparing the total present value of net benefits (benefits minus costs) for each potential standard, it is possible to identify the standard that yields the largest net benefits and to compare standards with various levels of costs or benefits in terms of their net benefits. For example, as standards become more protective (i.e. more stringent), they also become more costly. By looking at net benefits, the analysis shows how much society would give up to acquire more protection than that offered by the standard that maximizes net benefits. Likewise, costs can be reduced by making the standards less stringent than the one that maximizes net benefits. The analysis estimates what society gives up with this reduction in costs. In focusing the estimations on interventions that take place at the time of the birth of a child, the analysis identifies the standards that maximize the net benefits to the population of greatest concern -- children.

It is important to emphasize that both the costs and the benefits calculated in this report are subject to substantial uncertainty. While the net benefits measure provides insight into the relationship between costs and benefits for different hazard levels, it does not represent true net social benefits. Important components of the benefits of reduced lead exposure could not be estimated. In addition, there is uncertainty about the relationship between environmental exposures and blood-lead levels. These uncertainties are highlighted by the fact that the two models of children's blood-lead yield very different estimates of risk.

Finally, both costs and benefits reflect simplifying assumptions about how and when property-owners will undertake interventions. Actual costs and benefits will vary, depending on how property-owners actually react to the hazard levels. For instance, if fewer interventions occur or they occur later in time than assumed in the analysis, both costs and benefits will be lower. While there is substantial uncertainty about the absolute estimates of aggregate costs and benefits, however, the estimated relationship between the two for different standards is more reliable. Whenever costs are incurred, benefits also result, although these benefits may occur at some time in the future.

1.3 Organization of this Report

Chapter 2 provides a historical overview of regulations that control lead use and risk. Programs that address residential lead-based paint hazards are described, including both regulations and non-regulatory initiatives. Many of these programs or regulations may be directly or indirectly affected by the lead hazard standards.

Chapter 3 describes the problems presented by lead-based paint hazards in residences, and discusses the rationale for federal action to address these problems. This chapter also describes possible approaches that might be used to address residual lead-based paint hazards.

Chapter 4 provides an overview of the entire economic analysis and its linkages with the risk assessment.

Chapter 5 describes in detail the methods used to calculate costs for different hazard standard levels. It describes the development of unit costs and the methods used to aggregate costs across home types and over time, and reports the predicted number of homes affected and number of interventions for alternative standards.

Chapter 6 describes in detail the methods used to estimate benefits, including the calculation of unit benefits and the aggregation of benefits across home types and over time. Finally, the chapter reports the number of children affected and the predicted differences in blood-lead and IQ distributions for the final standards.

Chapter 7 presents the estimated costs and benefits. Aggregate costs and benefits are shown for different standards for dust and then for soil, holding constant the standards for the other media. The benefits estimated using the two blood-lead models are compared and reasons for their differences discussed. Then net benefits are calculated for both blood-lead models, and these results are used to identify the standards with maximum net benefits.

Chapter 8 discusses the uncertainties of the analysis and estimates the sensitivity of the results to specific assumptions and input values. These include the discount rate, dollar values for lost IQ points, assumptions about hazardous wastes costs, assumptions about the timing of interventions, the valuation of fractional changes in IQ points, and other topics.

Finally, Chapter 9 presents findings relevant to specific rule-making requirements, including small business impacts, unfunded mandates, paperwork burdens, environmental justice, and protection of children.

2. Regulatory Background

2.1 Lead as a Public Health Problem

Exposure to lead is one of the more serious public health problems currently facing the United States (USDHHS, 1988). Lead's advantageous properties, including its malleability, resistance to corrosion, good insulation, and low cost, have made lead attractive for many applications; lead has been used in gasoline, ceramics, paint, and many other products. These uses have resulted in lead's release to and distribution through all environmental media, which has complicated efforts aimed at reducing lead in the environment (USDHHS, 1988). Much of the lead in the environment is accessible to humans through a variety of exposure pathways, and because it does not degrade, continued use of lead results in accumulation in the environment. Human exposure to lead is of concern because lead interferes with the normal functioning of cells, causing a range of toxic effects in the nervous, red blood cell, and kidney systems (USDHHS, 1988). Fetuses and young children exposed to lead are especially at risk from damages to the developing brain and nervous system (CDC, 1991a).

Knowledge of some of lead's negative health effects dates back hundreds of years. In the United States, reproductive and developmental effects of lead were recognized in the 18th and 19th centuries in females working in the lead industry and wives of lead workers. These women demonstrated health problems, including sterility, spontaneous abortion, stillbirth, and premature delivery, and their offspring exhibited high mortality, low birth weight, convulsions and other effects. The recognition of some of the health effects of lead resulted in better industrial hygiene, which in turn reduced reproductive problems (USDHHS, 1988).

The prevalence of direct lead poisoning in children was first examined in Australia in the 1890s and traced to exterior lead-based paint (USDHHS, 1988). In the U.S., physicians eventually defined lead poisoning in children as a clinical entity in the early 20th century after a study reported that lead caused acute encephalopathy in a number of children. In the 1930s and 1940s, epidemiologic data on childhood lead poisoning began to expand, and the accrual of such data accelerated through the 1960s. Rudimentary screening of children in the 1950s and 1960s clearly showed that they were being exposed to excessive amounts of lead. Prevalence of lead poisoning was especially high among inner city youth. Increased screening in the 1970s resulted in the recognition of lead poisoning as a widespread public health problem (USDHHS, 1988).

Lead exposure's prominence as a public health concern is due to the magnitude of population blood lead levels. The average blood lead levels in the U.S. population are estimated to have dropped in the last two decades (USEPA 1989, 1991). However, the current geometric mean blood lead level in children is 3.1 µg/dL (USEPA, 1997), which is still about six times higher than the pre-industrial average of 0.5 µg/dL (USDHHS, 1998).

The recognition of lead's adverse health effects has resulted in a lowering of the blood lead level that triggers medical intervention. In 1970, the U.S. Public Health Service published guidelines that set the level at 60 µg/dL (CDC, 1991b). Shortly thereafter, the CDC set the guidelines at 40 µg/dL, then revised the recommendations to 20 µg/dL, and finally set them at the current level of 10 to 14 µg/dL in 1991.

Levels higher than this range should trigger various remedial actions; a child with a blood lead level between 15 to 19 µg/dL should have nutritional and education interventions; a blood lead level greater than 20 µg/dL should prompt medical evaluations and environmental investigations (CDC, 1991b).

The following two sections focus on existing regulations designed to decrease exposure to lead. Section 2.2 discusses regulations pertaining to lead products, releases of lead in the environment and the workplace, and the concentration of lead in drinking water. Section 2.3 focuses on efforts at the federal, state and local levels to decrease exposure to lead remaining in residential areas (including lead in paint, dust, and soil). Section 2.4 describes a variety of non-regulatory initiatives that have been undertaken by governmental agencies.

2.2 Regulation of Lead Products, Environmental and Workplace Releases of Lead, and Lead in Drinking Water

The presence of lead in some consumer products has been prohibited or restricted by regulations. Environmental releases of lead to air and water, and lead concentrations in waste, also have been controlled. OSHA has set limits on allowable workplace concentrations of lead. In addition, regulatory efforts have been made to remediate exposure to lead through drinking water systems.

2.2.1 Lead in Paint

In the 1950s, the paint industry voluntarily restricted sales of paint with lead content greater than one percent (Mushak and Crocetti, 1990). Subsequently, the Lead-Based Paint Poisoning Prevention Act, enacted in 1971, prohibited the use of paint with greater than one percent lead (by weight of nonvolatile solids) in certain federally-owned or federally-assisted housing (HUD, 1990). As a result of 1976 amendments to this Act, lead paint was redefined as paint containing more than 0.06 percent lead by weight (HUD, 1990). In 1978, the U.S. Consumer Product Safety Commission banned both the sale of lead paint to consumers and the use of lead paint in residences or on other consumer-accessible surfaces (16 CFR 1303).

2.2.2 Lead in Gasoline

The concentration of lead in leaded gasoline decreased significantly in the 1970s and the first half of the 1980s. In addition, the use of leaded gasoline decreased significantly. The Clean Air Act of 1970 (CAA) first indirectly controlled the use of lead in gasoline. Catalytic converters were necessary for automobiles to achieve air standards, but lead rendered catalytic converters on automobiles inoperative. Therefore, beginning in 1974, "unleaded" gasoline was introduced as a fuel for automobiles equipped with catalytic converters. This "unleaded" gasoline contained no more than 10 percent of the lead concentration found in leaded gasoline. The concentration of lead in leaded gasoline for use in vehicles and equipment without catalytic converters went from unlimited, to 2 g/gal in 1978, to 1.1 g/gal in 1983, to 0.5 g/gal in 1985, to 0.1 g/gal in 1986. In 1986, the U.S. acted to phase out the use of lead in gasoline entirely (51 FR 24606).

2.2.3 Other Products Containing Lead

The U.S. canning industry began voluntarily phasing out the use of lead solder in food cans in the 1970s because alternative, affordable processes for sealing the seams of tin containers became available (OECD, 1993). U.S. industry and the U.S. Food and Drug Administration have also undertaken efforts to control lead exposure from ceramic ware (USDHHS, 1991), foil on wine bottles, and crystalware (USDHHS, 1992).

2.2.4 Environmental and Workplace Releases of Lead

Under authority of the Clean Air Act, EPA has established standards of performance designed to limit emissions of air pollutants from lead smelting and processing facilities. In addition, lead emissions from these and other industries are controlled via facility-specific permits written by states. These permits are designed to reduce emissions to the extent needed to meet EPA's national ambient air quality standard for lead of 1.5 $\mu g/m^3$ (quarterly average), established in 1978 (43 FR 46246).

Under the Clean Water Act, federal effluent guidelines and pretreatment limits for lead-containing effluents have been established for over 20 industries. These limits help achieve state-promulgated surface water quality standards (which may be based on water quality criteria published by EPA). The effluent limits are implemented by states through facility-specific permits and, depending on state water quality standards, may be more stringent than federal effluent requirements.

Releases of lead as solid waste are regulated under the Resource Conservation and Recovery Act (RCRA). A waste is defined as hazardous if, when tested, the leachate from the waste contains more than 5 ppm lead (40 CFR 261.24). In addition, certain lead-containing wastes are separately listed as hazardous wastes. All of these wastes must be properly managed and disposed of (40 CFR 260-270).

EPA also initiated a voluntary program to reduce lead emissions, based on the Toxics Release Inventory reporting. This project, called the "33/50 Program", encouraged industry to curtail emissions of 17 high-use toxic chemicals, including lead, which are reportable to the Toxics Release Inventory. The program sought commitments from companies to voluntarily reduce releases and transfers of the 17 pollutants and publicly recognized companies and facilities achieving their goals. The program's reduction goals were broken into two phases -- 33 percent reduction by 1992 and 50 percent by 1995 -- using 1988 as the baseline year. A total of 1300 companies agreed to participate in this program, which ended in mid-September, 1996. Several other similar voluntary toxic emissions reduction programs have been initiated by EPA (Environmental Science &Technology, 1996).

Efforts to reduce exposure to lead in the workplace have included setting permissible workplace air concentrations of lead. The current Permissible Exposure Limit (PEL) is 50 $\mu g/m^3$ for most industries except the construction industry (OECD, 1993). Under the Residential Lead-based Paint Hazard Reduction Act, passed in October 1992, OSHA is required to issue interim regulations lowering the limit for the construction industry (AECLP, 1993). On May 4, 1994, OSHA issued an Interim Final Rule, Lead Exposures in Construction, setting the PEL to an 8-hour time weighted average of 50 $\mu g/m^3$. The interim rule also includes a list of three categories of tasks that are commonly known to produce exposures above the PEL. Performance of these tasks automatically triggers basic protective provisions (USEPA, 1994).

2.2.5 Lead in Drinking Water

Exposure to lead in drinking water has continued because of past use of lead in plumbing. EPA has acted to reduce these exposures through comprehensive measures (Mushak and Crocetti, 1990). In rules promulgated in 1991, EPA outlined new treatment requirements for drinking water systems (56 FR 26460). The regulation requires tap water sampling from high risk homes (e.g., homes with lead service lines or lead soldering installed since 1982). If at least 10 percent of home tap samples exceed 15 µg/l (the "action level"), corrosion control treatment and public education is required. Replacement of lead service lines is required if corrosion control fails to bring water lead levels below the "action level." EPA has also issued a maximum contaminant level goal of zero for lead in drinking water.

2.2.6 Resultant Reduction in Blood Lead Levels

As a result of these regulations, and other efforts, lead exposure and blood lead levels have decreased significantly. The most recent national study (NHANES III Part 2) measured the mean of children's blood lead levels to be 3.14 µg/dL. Thus, average blood lead concentrations have dropped over the last two decades from about 15-20 µg/dL (USEPA, 1991) to approximately 3 µg/dL. In particular, reductions of lead in gasoline have contributed dramatically to reductions in blood lead levels. Several studies have specifically examined the relationship between blood lead and the lead content of gasoline, and have found a strong positive correlation (Schwartz and Pitcher, 1989; Rabinowitz and Needleman, 1983). Annest et al. (1983) noted a 37 percent drop in blood lead levels from 1976 to 1980 correlated with a reduction in gasoline lead. Schwartz and Pitcher (1989) estimated that as much as 50 percent of blood lead in the U.S. in the late 1970s may have been attributable to lead in gasoline.

Reductions in dietary lead have also contributed to declining exposures. Dietary lead intake for a two-year-old child dropped from about 53 µg/day in 1978 to an estimated 13.1 µg/day in 1985; comparable declines have been seen in adults (USEPA, 1989). These trends are attributable to the reduction in gasoline lead emissions (and resulting reductions in deposition of lead from air to soil) and the voluntary phaseout of lead-soldered cans by U.S. manufacturers since the 1970s. It can be calculated that these changes in lead exposure from food have led to reductions of 1 to 2.5 µg/dL in average blood lead levels (USEPA, 1989).

2.3 Regulatory Efforts to Reduce Lead-Based Paint, Dust and Soil in Residential Areas

One of the largest remaining lead exposure sources for children is existing reservoirs of lead-based paint, dust and soil present in many residential areas (USDHHS, 1988). In an effort to reduce exposure to residential lead hazards, regulatory efforts to address these hazards have been increasing for several years.

2.3.1 Current Estimates of Exposure

Although paint containing lead was banned for use in residences in 1978, exposure to existing lead-based paint has continued due to prior use in residential and other buildings. In addition, leaded house paint can contribute to lead in interior dust and soil. There also remains a significant soil burden of lead from leaded gasoline and lead smelter emissions.

Several studies have demonstrated positive correlations between blood lead levels and lead in paint, soil and dust (Charney et al., 1980, Charney et al., 1983, and Bellinger et al., 1986 as cited in HUD, 1990; Clark et al., 1991). Blood lead levels are especially high in children. In a 1988 Report to Congress on the extent of lead poisoning in children, USDHHS stated that the existing leaded paint in U.S. housing and public buildings is "an untouched and enormously serious problem" (USDHHS, 1988). The Centers for Disease Control conveys the seriousness of home lead exposure as a contributor to elevated childhood blood lead by stating that lead poisoning exists in our society primarily because of exposure in the home (CDC, 1991a). Infants and toddlers are especially susceptible to lead in the home because they may ingest lead paint chips, dust and soil and because of the way they metabolize lead. Older children, up to at least eight years old, are also at increased risk (USDHHS, 1988).

Exposure continues mainly from paint in older homes, since houses built after 1978 are presumed to be free of lead paint. Based on a 1987 HUD survey of 284 homes built before 1980, an estimated 64 million (83%) of all pre-1980 private homes have lead-based paint (defined as a measured lead concentration on any painted surface of 1.0 mg/cm^2 or greater) somewhere in the building (USEPA, 1995). Of these units, an estimated 12 million units have families with children younger than seven years old. Seventeen percent of pre-1980 housing have dust lead levels in excess of federal guidelines (listed below). Twenty-one percent of all pre-1980 homes have excessive soil lead levels (USEPA, 1995). Although a large majority of pre-1980 homes have lead-based paint, most have relatively small areas of it. Older homes have the most lead-based paint. Pre-1940 homes have about three times as much lead-based paint as units built between 1960 and 1979.

A significant number of public housing units also contain lead paint. Eighty-six percent of all pre-1980 public housing family units have lead-based paint somewhere in the building (USEPA, 1995). Families of any socioeconomic class may live in older housing, and thus be exposed to lead paint (USDHHS, 1988). However, families with the lowest incomes are disproportionately found in older housing (USDHHS, 1988).

2.3.2 Federal Regulatory Activities to Decrease Exposure to Lead-Based Paint in Existing Housing

Federal regulatory efforts and guidelines to limit exposure to lead-based paint in the existing housing stock have evolved over the past twenty years. The following two sections chronicle these activities in detail.

The Lead-Based Paint Poisoning Prevention Act and Amendments

The Lead-Based Paint Poisoning Prevention Act of 1971 (LBPPPA) and subsequent amendments (1973, 1976, 1987, and 1988) have resulted in a number of federal regulatory activities to reduce exposures and risks from lead paint in housing. In addition to setting limits on the use of lead paint as described above, the Act established grants for lead-poisoning screening and treatment, and required a report to Congress on methods of abatement (HUD, 1990).

Abatement of Lead-Based Paint Hazards in Federally-Associated, Public and Indian Housing. The 1973 amendments required HUD to eliminate, as much as was practical, hazards of lead-based paint poisoning in pre-1950 housing covered by housing subsidies and applications for mortgage insurance and in all pre-1950 federally owned housing prior to sale. HUD acted by issuing regulations to warn tenants and purchasers of HUD-associated housing of the "immediate hazard" of lead-based paint (defined as conditions associated with deteriorating lead paint surfaces). A 1983 court action resulted in broadening the definition of "immediate hazard" to include intact paint; this definition was subsequently signed into law in 1987. In regulations issued by HUD in 1986 and 1987, the construction cutoff date was changed from 1950 to 1973 in most cases. HUD again changed the cutoff date in response to 1987 amendments to the LBPPPA; the new date became 1978 for all programs (HUD, 1990). The 1988 Amendments to the LBPPPA specified the level which defines a lead paint surface as 0.5% by weight or 1.0 mg/cm^2 (AECLP, 1993). HUD has also promulgated rules to eliminate lead paint hazards in public and Indian housing (Mushak and Crocetti, 1990). Where children younger than seven years old are present in these types of units, inspections for defective paint surfaces are required. If a child has an elevated blood lead level, then the house must be inspected for chewable and defective surfaces, and abatement is required in dwellings, common areas, or public child care facilities within the public housing.

Grants. The LBPPPA authorized funding for States and cities to conduct extensive screening programs to identify lead-poisoned children, refer them for medical treatment, investigate their houses for lead, and require abatement (HUD, 1990).

Research and Reports to Congress. The 1971 LBPPPA required a report to Congress on the "nature and extent of the problem of lead-based paint poisoning" and methods of removal. The 1987 amendments required an extensive research and demonstration project on lead-paint testing and abatement technologies in HUD-owned housing, as well as additional reports to Congress (HUD, 1990). In response to another mandate of the 1987 amendments, HUD conducted a survey of the distribution of lead-based paint in the nation's housing stock and submitted a report on the results for privately-owned housing to Congress in a comprehensive plan for abating paint in private housing. Additional amendments in 1988 required a demonstration of abatement techniques in public housing as well as a comprehensive plan to address abatement in public housing (HUD, 1990).

The Residential Lead-Based Paint Hazard Reduction Act

The most recent statutory activity related to the reduction of lead paint hazards is the enactment of the Residential Lead-Based Paint Hazard Reduction Act in October of 1992. Also known as Title X of the Housing and Community Development Act of 1992, this Act amends sections of the LBPPPA and adds a new section (Title IV) to the Toxic Substances Control Act (TSCA), in addition to other important new provisions. Described as "the most comprehensive and significant lead poisoning prevention legislation in more than two decades" (AECLP, 1993), the Act aims to provide attainable goals for reducing lead hazards in residential settings by targeting specific housing in the greatest need of abatement (AECLP, 1993).

Federally-owned and assisted housing. Title X allows for more targeted lead hazard evaluation and reduction activities in federally-owned and assisted housing (AECLP, 1993). Whereas provisions under the 1987 amendments to LBPPPA indicated that any and all houses built before 1978 that contain lead-based paint constitute hazards that may be acted upon, Title X provides a more strategic approach to reducing the hazards from lead-based paint. This approach involves requirements for risk assessments, inspections, and interim controls for pre-1978 housing (targeted housing) and also requires deadlines for action. Title X also extends federal lead-based paint requirements to all housing that receives more than $5,000 in project-based assistance under any federal housing or community development program (in addition to the federally assisted and insured houses covered under previous Acts) (Section 1012); inclusion of these houses significantly expands the universe of federally-insured and assisted housing subject to lead-based paint related requirements (AECLP, 1993).

Additional provisions apply to federally-owned housing being sold (AECLP, 1993). Properties built prior to 1978 must be inspected and their condition disclosed to the prospective buyer. Units built before 1960 that have lead-based paint (defined as priority housing) must be abated (Section 1013).

Private housing. Private housing has received greater focus under Title X than under LBPPPA. Although states, local governments or common law still determine whether landlords provide safe housing, Title X includes several features to encourage evaluation and reduction of lead-based paint hazards in private housing. One feature included formalizing into law a grant program run by the Department of Housing and Urban Development for reducing lead-based paint hazards in low-income privately owned housing. Under Section 1014, State and local governments are required to develop a Comprehensive Housing Affordability Strategy (CHAS) before receiving Federal housing or community development grants. The CHAS must include an accurate estimate of the number of housing units that contain lead based paint that are occupied by low-income families (HUD, 1997).

Other Title X provisions also affect targeted private housing (AECLP, 1993). These mandates include integration of lead hazard evaluation and reduction into local housing programs, and certain disclosure and warning requirements to be met at the time of sale or rental of any pre-1978 housing unit (Sections 1014 and 1018). Under Section 1018, a rule has been passed that requires purchasers or lessees to receive an EPA pamphlet on hazards of lead in the home, and purchasers are allowed a 10 day period for inspection for lead-based paint hazards. The Act also requires establishment of a national task force on lead-based paint hazard reduction and financing; this group is to be made up of an array of groups involved in housing, real estate, insurance, lending, abatement, and other groups (Section 1015). This Task Force has published a report called *Putting the Pieces Together: Controlling Lead Hazards in the Nation's Housing*, which recommends methods for controlling lead hazards in housing.

Safety of residents and workers. This law requires promulgation of a number of regulations addressing the safety of workers undertaking interventions and the safety of families who live or will live in treated housing. Section 1021 amends TSCA by adding a new Title IV, which primarily addresses EPA requirements for contractor training and certification. The economic analysis presented in this document supports the development of the regulation that responds to TSCA §403 (in §1021); this regulation requires EPA to define a "lead-based paint hazard" and dangerous levels of lead in dust and soil.

EPA also must set standards of minimum performance for lead-based paint activities and ensure that individuals engaged in activities are trained, that training programs are accredited, and that contractors are certified (TSCA §402). On August 29, 1996, EPA promulgated final regulations under §402 of TSCA to apply to target housing and child-occupied facilities. The Agency is also developing additional §402 regulations, which will apply to training, certification and work practice standards for public buildings constructed before 1978, commercial buildings, and steel structures such as bridges and water tanks. These rules are under development and the promulgated regulations will deal with activities that are intended to abate, delead or remove lead-based paint. In addition, the Agency is developing §402 regulations to apply to renovation and remodeling projects. While renovation and remodeling projects are not specifically intended to remove lead-based paint hazards, they may create a risk of exposure to dangerous levels of lead.

HUD and EPA are to assist in funding state certification and training programs and issue standards for a model state program (TSCA §404). As of February 1997, $36.2 million dollars in grant money had been awarded to 46 States, the District of Columbia, and 27 Native American tribes for the purpose of certification and training programs (HUD, 1997). In addition, at the same time that rules were passed under Section 402, the Agency published final rules under TSCA §404 "that will allow States and Indian Tribes to seek authorization to administer and enforce the regulations developed under section 402."

OSHA published interim final regulations requiring that contractors protect their workers from excessive exposure to blood lead in May 1993. In addition, the regulations require employers to determine lead exposure levels so that appropriate protective measures can be taken (HUD, 1997).

EPA must assure that a program is in place to certify environmental sampling laboratories and must provide for development of products and devices for testing and abatement (TSCA §405). Organizations that have authority to accredit laboratories as well as a list of accredited laboratories have been established (NCSL, 1996b). On the product side, EPA and HUD evaluated 13 different protocols for testing lead based encapsulants. This research led to the establishment by the American Society for Testing Materials (ASTM) of two standard specifications for testing lead encapsulant products. (HUD, 1997).

Education regarding lead paint hazards. Title X also mandates a variety of public educational efforts. A hotline designed to inform the public about lead hazards was set up soon after passage of the 1992 Act. The National Clearinghouse on Childhood Lead Poisoning was then established in April, 1993. The Consumer Product Safety Commission, in coordination with EPA, published 'Reducing Lead Hazards When Remodeling Your Home" which has been distributed widely including placement in hardware stores such as Home Depot that sell paint removal products (HUD, 1997). Under TSCA Section 406, regulations are currently being developed which require renovators and remodelers to inform residents of the hazards of renovation (NCSL, 1996b). HUD published the "Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing" in August 1995 in fulfillment of Section 1017 of Title X. This document is a comprehensive guide on how to identify and reduce lead-based paint hazards (HUD, 1997).

Research and development. A variety of research is also required under Title X. EPA is required to conduct a study on the hazard potential of renovation and remodeling (Section 1021: TSCA 402).

Section 405(a) mandates EPA and other appropriate agencies to develop a program to promote safe, effective and affordable monitoring and abatement measures. A wide variety of analyses and field studies have been done to support Section 405(a) (HUD, 1997). Under Section 405(b) EPA has also developed studies to establish minimum performance standards for laboratory analysis of lead in paint films, soil and dust.

Section 405(c) requires the Centers For Disease Control and Prevention (CDC) to identify sources of lead exposure for children. The CDC has numerous ongoing studies to evaluate the sources of lead exposure. One such study is the NHANES III project which collected data regarding health indicators and environmental exposure on 30,000 persons over a six year period (HUD, 1997). Section 405(c)(2) mandates the National Institute for Occupation Health and Safety (NIOSH) develop studies on methods of reducing occupation lead exposure.

A comprehensive listing of all EPA, CDC, and NIOSH studies completed as of February 1997 can be found in "Moving Toward a Lead-Safe America" (HUD, 1997).

2.3.3 Federal Guidelines and Other Activities Related to Lead in Soil and Dust Guidelines for Levels of Lead in Soil and Dust

As mentioned above, under §403 EPA is required to determine dangerous levels of lead in dust and soil under Title X. While developing these definitions, interim guidelines specifying levels down to which lead-based paint should be abated have been recommended by EPA. These levels are 100 µg/ft^2 for uncarpeted floors, 500 µg/ft^2 for window sills and 800 µg/ft^2 for window wells (Goldman, 1994). A level of 400 ppm has been set as the hazard level for soils; lead abated to this level is expected to result in no more than a 5% probability of a child having a blood lead level exceeding 10 µg/dL (Goldman, 1994).

Other Activities

Under authority of Title III of the 1986 Superfund amendments, EPA has funded projects in Boston, Baltimore, and Cincinnati to test the health effects of abating soil with high lead content in residential areas. This research has been considered in developing the final guidance on soil clearance levels.

2.3.4 State and Local Programs to Reduce Exposure to Lead-Based Paint, Dust and Soil

Activity to address lead-based paint hazards has recently increased at the state and local levels. The following discussion is broken into two sections. The first examines the lead poisoning prevention activities undertaken by states and the key issues they address. The second discusses distinguishing features of local programs, and then takes a closer look at what has been done in San Francisco, California.

State Activities

Forty-one states and the District of Columbia have laws pertaining to lead poisoning prevention activities (NCSL, 1999a). State policies tend to focus on several issues: establishing standards, blood-lead testing for children, training and/or certification requirements for inspectors, assessors, and/or R&R workers, and penalties.

The two states with the most extensive programs are California and Massachusetts. About 56 percent of states with lead poisoning prevention policies have programs and standards that are either partially or entirely linked to federal standards. The remaining 39 percent of states with programs have standards that are not explicitly linked to federal standards (NCSL, 1999a; Lexis-Nexis, 2000).

About 70 percent of all lead poisoning prevention policies address blood-lead levels of children. A majority of these states, 62 percent, provide funding for blood-lead testing for children (generally under the age of six). The remaining states require that doctors and/or schools report any cases of elevated blood-lead levels to the proper authorities as established by the legislation (NCSL, 1999a; Lexis-Nexis, 2000).

Roughly 74 percent of states with lead poisoning prevention policies have enacted, and are implementing, training and/or certification requirements for inspectors, assessors and/or R&R workers. (This includes Kansas, which is the only state with training and/or certification requirements that does not have lead poisoning prevention laws). Many of these requirements are in response to EPA §402/404 regulations, which define the elements of a model state program for lead inspection, risk assessment and abatement professionals. States have implemented policies with requirements ranging from approving training providers to comprehensive accreditation programs (NCSL, 1999b).

About 54 percent of states with lead poisoning prevention laws explicitly address penalties for those who violate the law. Penalties are an important factor in determining the effectiveness of a state's policy. Penalties can force actions which might not otherwise occur, especially among landlords (NCSL, 1999a; Lexis-Nexis, 2000).

Local Programs

Many local lead-poisoning programs have had limited resources with which to carry out their programs (HUD, 1990). Differences between typical state schemes and selected city programs lie more in the extent than in the substance of the activities (HUD, 1990). In general, city programs are more focused and seem to receive higher priority, which may be due to the urgency of the lead-paint problem in larger cities.

In the *Comprehensive and Workable Plan for the Abatement of Lead-Based Paint in Privately Owned Housing* (HUD, 1990), the Department of Housing and Urban Development outlined several distinguishing features of local programs as determined by investigation of ten selected cities:

- A city that is governed both by local ordinances and state regulations for lead-poisoning prevention and detection activities usually has local laws that are more stringent than state laws and may supersede the state requirements.

- In addition to providing intervention after cases of lead poisoning have been detected, local programs may require intervention as a result of targeted inspection or tenant complaints. Several cities, including Baltimore, Chicago, Louisville, New York, and Philadelphia, are authorized to take such preventive measures.

- In general, the city programs show more cooperation and coordination between agencies.

- City programs usually screen for high blood lead levels more systematically and target high-risk areas for screening.

In the City and County of San Francisco, Article 26 (Comprehensive Lead Poisoning Investigation, Management and Enforcement Programs) was passed in 1998. Inspections of exterior R&R projects are conducted when either a citizen files a complaint, or the City calls for an inspection of a site. Once a complaint is filed, the Department of Building Inspection (DBI) is responsible for inspecting the premise. Complaints filed by citizens led to the majority of lead inspections conducted in San Francisco in 1998 and 1999. In 1998, 284 complaints were filed with 202 resulting in violations. In 1999, 405 complaints were filed with 280 resulting in violations (DBI, 2000). A small percentage of the total complaints filed each year were for interior violations (Kimbell, 2000). Because Article 26 does not address interior lead-paint, no inspections were conducted in these cases.

Through blood-lead level screening programs, San Francisco's Department of Public Health is made aware of interior lead-based paint problems. Under Article 26, children younger than the age of six are recommended to have their blood-lead level checked annually. However, doctors and families are under no obligations to abide by this recommendation. If a child has a blood-lead test and he or she tests greater than 20µg/dL, or has two tests of 15-20µg/dL within about a 3-month period, then the landlord or homeowner has 30 days to remediate the main lead poisoning hazard, as determined by a lead inspector.

The Department of Public Health is the primary administering and enforcing agency under Article 26. Any person who fails to comply with an order from the Director is civilly liable to the City for a penalty not to exceed $500 per day, and each day the violation continues constitutes a separate violation. Any person who fails to comply with an order from the Director is also guilty of a misdemeanor. Each day a violation continues is considered a separate violation punishable by a fine not to exceed $1,000 and/or imprisonment not to exceed six months in the County jail. In 1998, the first year Article 26 was in place, the City did not fine a majority of the violators. Instead, the City in conjunction with the Citizens Advisory Committee decided to give violators the option of completing a comprehensive lead training course. The goal was to educate contractors of the health hazards associated with lead paint removal. In 1999, this option was no longer available, and violators were fined accordingly (Harrington, 1999). As of January 2000 the number of fines had not yet been totaled.

The City is not only concerned with enforcement; incentive programs are also included in Article 26. The Mayor's Office was to develop programs for grants, loan guarantees and no or low-interest loans for owners of property contaminated with lead by the end of 1999.

2.4 Non-Regulatory Initiatives to Reduce Lead-Based Paint, Dust and Soil Exposure

In addition to programs, policies and rules developed in response to Congressional mandates, several governmental agencies have undertaken programs to reduce lead exposure that go beyond the Title X and TSCA requirements.

2.4.1. Joint Initiatives

The EPA has developed two initiatives in conjunction with several other federal, state and local agencies to reduce lead exposure in high-risk, low-income communities. The Environmental Justice Initiative was constructed to: (a) demonstrate that an effectively designed program can reduce poor children's blood lead levels, (b) demonstrate the benefits of public, private and community organization cooperation in the fight against lead poisoning, (c) conduct lead screenings, hazard reduction and education efforts, (d) document the projects' successes and shortcomings and (e) foster self-sufficiency through job creation and empowerment. To these ends the EPA formed an inter-agency work group which has committed $3.7 million for pilot programs to test community-based approaches to lead poisoning reduction (HUD, 1997).

The EPA has also designed the Whole House Initiative to establish and evaluate programs which reduce multimedia exposure to lead hazard in the home. Again the EPA helped establish an inter-agency task force whose primary activities were developing a multimedia Geographic Information System (GIS) database and creating a multimedia environmental training procedures (HUD, 1997).

2.4.2 Blood Screening Programs

The CDC State and Community-Based Childhood Lead Poisoning Prevention Program provides grant monies to state and local agencies for the formulation and execution of blood lead testing programs. These programs not only screen young children for lead poisoning but also identify potential sources of lead, monitor the medical and environmental management of children who have been diagnosed with elevated blood lead, and provide information to the public on methods to reduce lead hazards (HUD, 1997).

In addition, the CDC is working with the State of Massachusetts to develop a model blood-lead database. The database provides information on the health, housing, medical and environmental management of children diagnosed as having elevated blood lead levels (HUD, 1997).

The Health Care Finance Administration of the U.S. Health and Human Services Department also supports the Early and Periodic Screening, Diagnostic and Treatment (EPSDT) Program. The EPSDT provides comprehensive and preventative health care benefits to lower income children through the State Medicare programs. All Medicaid-eligible children between the ages of six months and 72 months are required to have their blood lead tested under this program.

2.5 Benefits of Increasing Lead Awareness and Lead Poisoning Prevention Programs

Although several states and localities have taken action on lead-based paint, many have no standards for paint, dust, or soil abatement. In addition, among the states and local areas that do have standards, the levels of paint, dust, and soil considered unacceptable differ. By providing definitions at the federal level for lead paint hazards and dangerous levels of lead in dust and soil, those states that do not have standards may be prompted to adopt standards more quickly. In addition, the federal guidelines will provide consistency between the states.

In addition to federal regulation on lead hazards, there is clearly room for non-regulatory initiatives to reduce exposure to lead in paint, soil and dust. The early evidence from non-regulatory measures to reduce lead hazards indicates that community-based, joint government-private programs can help fill the gaps left by statutory regulation alone.

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3. Problem Definition and Regulatory Options

This chapter begins by characterizing the lead contamination problem to be addressed under §403. The various sources of exposure, along with related blood lead levels and health effects, are presented. Section 3.2 discusses the sources of market failure, both on a theoretical basis and specifically how incomplete information has resulted in too few lead interventions taking place. Section 3.3 also presents regulation as a reasonable solution for such a market failure, and discusses why regulation should take place at the federal level. Alternative regulatory options are presented in Section 3.4.

3.1 Lead Contamination Problem

Despite recent reductions in air, water, and food contamination, important sources of lead exposure for children remain, largely due to the widespread presence of lead-based paint in home environments. Exposure to lead results in elevated blood lead levels associated with a suite of health effects, most notably loss of IQ and other adverse cognitive effects. Recent data suggest that the blood lead level in more than one in 200 children exceeds the threshold for lead poisoning as defined by the CDC, 20 µg/dL.

3.1.1 Exposure Sources

Although lead may cause adverse health effects in any individual, exposed at any stage of life (*in utero* through adulthood), the focus of §403 and this analysis is on children exposed from birth through the sixth birthday. Young children are particularly susceptible to lead hazards because they are at a stage of rapid development of the central nervous system, and because their normal behavior is likely to result in greater exposure than older groups experience.

Currently the most significant high-dose source of lead exposure in children under school age is lead-based paint. Through the 1940's, paint manufacturers used lead as a primary ingredient in many oil-based interior and exterior house paints. During the 1950's and 1960's, the usage gradually decreased as new paints were developed, and in 1978 the Consumer Product Safety Commission (CPSC) ruled that paint used for residences, toys, furniture, and public areas must not contain more than 0.06% lead by weight. Nevertheless, an estimated 64 million (or 83%) of privately-owned, occupied housing units and 86% of public housing units built prior to 1980 contain some components covered with lead-based paint (USEPA 1995). Children's exposure to lead from lead-based paint is likely to be high when the paint is in a deteriorated state or is found on accessible, chewable, impact, or friction surfaces, making the lead paint available to children who ingest paint chips (USEPA 1986; CDC 1991). This "pica" behavior appears to be rare, but likely causes most of the highest blood lead levels observed in children.

In addition to being a source of direct exposure, deteriorated lead-based paint or the improper removal of lead-based paint from a housing unit may contaminate soil and dust. Children are exposed to lead from soil or dust in their homes as a result of typical hand-to-mouth activities. Lead-contaminated dust and soil are thought to be the major pathway through which most young children are exposed to lead from lead-based paint hazards (USEPA 1986).

Young children are also exposed to a variety of other lead sources, which appear less important on a national scale. Airborne lead is present in emissions from lead smelters, battery manufacturing plants, and solid waste incinerators. The phase-out of leaded gasoline has contributed to the reduction of airborne lead

(CDC 1991). Drinking water may become contaminated with lead after it leaves the treatment plant (CDC 1991). Although lead levels in drinking water generally do not have a statistically significant effect on blood-lead concentrations as a result of the 1986 Safe Drinking Water Act, water is still considered an important localized exposure source where lead solder and/or brass plumbing fixtures are present, because of the high absorption rate of lead in water. Lead exposure through food ingestion has declined greatly in importance due to the phase-out of lead-soldered food cans and public education (CDC 1991). Despite these improvements in exposure from air, water, and food, however, many children still experience blood lead levels exceeding CDC health guidelines.

3.1.2 National Blood Lead Levels and Health Effects

Most studies of the health effects of lead use body-lead burden as a biomarker of lead exposure. Measures of body-lead burden include lead in bones, teeth, and hair. Each of these options, however, has a variety of disadvantages, including poor sensitivity and external surface contamination problems. The most common measure used is blood-lead concentration. Although blood lead level reflects a mixture of recent and past exposure, it has the advantage of being easily and inexpensively measured.

The widest recent survey of children's blood lead levels is the Third National Health and Nutrition Examination Survey (NHANES III), Phase 2. It was conducted from 1991 to 1994 and included information from 987 children aged one to two years, the most appropriate age group for estimating the health effects studied in this analysis. The national geometric mean and standard deviation blood lead levels for this group can be calculated as 3.14 μg/dL and 2.09 μg/dL, respectively (Battelle 1997).

Elevated blood lead levels are associated with an assortment of deleterious health effects, including IQ point loss, other cognitive effects, neurological disorders, anemia and impaired heme synthesis, and impaired hearing.

IQ point loss can be used to measure neurological loss that a child experiences due to any level of lead exposure. Children's average IQ loss from lead exposure can be calculated from NHANES III data as described in the Risk Assessment. Based on the one to two year olds surveyed, the national average decrement is 1.06 points (Battelle 1997).

The number of children with IQ less than 70 and the number of children with blood lead levels above 20 μg/dL can be used to measure cognitive effects seen mostly in children with high levels of lead exposure. An IQ score of 70 is two standard deviations below the population mean; it is used as an indicator of mental retardation and as the cut-off for special education requirements. Blood lead levels above 20 μg/dL are the level at which CDC recommends a complete medical evaluation, an environmental assessment, and necessary environmental remediation for the child and his/her environment. Battelle (1997) has calculated the fraction of one to two-year olds falling within these categories, based on NHANES III data and certain assumptions. The results are that 0.115 percent of children have IQ's under 70, and 0.588 percent have blood lead levels above 20 μg/dL.

3.2 Market Failure

From an economic perspective, one necessary condition for regulations is the existence of an inefficiency in the allocation of resources. This inefficiency is commonly labeled a market failure since the market is the mechanism assumed to make efficient resource allocations possible. A market failure can come from one or more of several sources. These include poorly defined property rights (such as negative externalities, common property resources, and public goods); imperfect markets for trading property rights (because of a lack of perfect information or of contingent markets; monopoly power; distortionary taxes and subsidies and other inappropriate government regulations); and the divergence of private and social discount rates.[1]

The occurrence of any of these conditions justifies further inquiry into the need for government regulation to reduce inefficiencies in the allocation of society's resources. This section considers whether any of these conditions are linked to excess exposures from lead contamination in residential soil, dust, and paint. If so, a better understanding of the nature of the inefficiencies involved may facilitate the design of effective regulations. The specific regulation considered here is the promulgation of hazard standards as mandated by §403.

The strongest case for the existence of a market failure can be built on the apparent lack of perfect information. Correct information is an important prerequisite to the demand for intervention and other forms of lead-based paint hazard controls.[2] The property owner making the intervention decision has to know the levels of lead in soil, dust, or paint; know what risks are implied by these levels; know the significances of these risks; and know what can be accomplished through various forms of intervention. Clearly, without knowing there is a lead problem, the owner will have too low a demand for intervention. Misinformation on the other attributes of the intervention decision can also distort the demand for intervention. Research into public views of risk indicate that misperceptions about latent risks, like those associated with lead contamination, are common. These misperceptions can be biased upward or downward, resulting respectively in excess and insufficient demand for intervention. Finally, reliable information on the relative and absolute effectiveness of different intervention alternatives could be a significant obstacle.

These relationships are illustrated in Exhibit 3.1, where the line labeled D represents the demand for intervention under the condition of complete and perfect information. With this information, consumers are able to accurately compare the value of intervention activities with their costs. In this case, the number of interventions performed would be Q. There are several circumstances, however,

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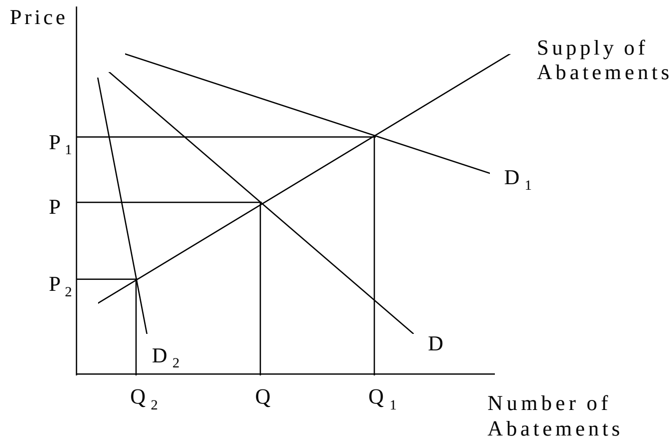
1 This taxonomy was developed from (Axelrad, 1993), and (Boadway, 1979).

2 Throughout this section, the term intervention is used to refer to the entire range of lead-based paint hazard control activities.

Exhibit 3.1. The Demand for Abatements under Alternative Information Scenarios



Where:

D = Demand for Interventions where consumers have complete information.

D_1 = Demand for Interventions where risks from lead are overestimated and/or effectiveness of interventions are overestimated and/or cost of substitutes is overestimated.

D_2 = Demand for Interventions where risks from lead are underestimated and/or effectiveness of interventions are underestimated and/or cost of substitutes is underestimated.

that would increase the demand for interventions above this optimal amount. If consumers overestimate the amount of risk they and their families are currently subject to due to their housing conditions, and/or overestimate the effectiveness of interventions, and/or overestimate the costs of alternative solutions (such as moving), then the demand for interventions would exceed that under complete/perfect information, as represented by line D_1. This situation would result in too many interventions occurring, at too high a price. Likewise, if consumers underestimate the amount of risk they and their families are currently subject to due to their housing conditions, and/or underestimate the effectiveness of interventions, and/or underestimate the costs of alternative solutions (such as moving), then the demand for interventions would be less than that under complete/perfect information, as represented by line D_2. This would result in too few interventions occurring.

The market itself has not provided a means for correcting this situation. Although businesses that offer testing or intervention services should find it in their vested interest to provide the kinds of information cited above, this possibility has not closed the information gaps for the public. One impediment may be public uncertainty about the reliability of the information that such businesses would provide. Their information may be unreliable because they are not fully competent to assess the lead contamination and what needs to be done, because the businesses are subject to moral hazard (which occurs, for example, when a firm tells a homeowner that there is a lead problem that warrants a certain intervention it can perform when the intervention is not necessary or suitable), or both. Since many property owners may lack easy access to independent sources of information to motivate their intervention decisions, doing nothing may be the likely response.

While lamentable, this lack of action is understandable given limits on the time and money that an owner can actually spend on obtaining information needed for many different decisions. For example, even though homeowners, as parents, may be deeply concerned about the welfare of their children — a key target of exposure from lead contamination — there are a host of other issues besides lead that affect their children's welfare and for which parents need information to make important decisions. These other information needs compete with the information needs of the lead intervention decision for scarce household resources. Given how little intervention has been initiated by homeowners relative to the prevalence of the problem, the likelihood that there is insufficient demand for intervention and that information gaps contribute to this circumstance appears to be high. In conclusion, it appears that at least one condition associated with market failures holds and, consequently, that inefficiencies may characterize the market for lead testing and intervention.

Before a final determination can be made about the inefficiencies associated with the lack of information, the costs of spanning the information gaps must be considered. One of the more important unknown variables in setting hazard standards under §403 is what constitutes an effective means of disseminating this information; what approaches to making information available will actually get owners to test, to consider the intervention alternatives, and to undertake intervention where appropriate. Simply setting standards, without effective dissemination of the information, is likely to have little effect.

In attempting to answer the question of whether government regulation will make the market for reductions in lead-based paint hazards more efficient, it is helpful to consider the public good aspect of promulgating hazard standards. To the extent that the public finds these hazard standards credible and takes steps to measure and reduce lead contamination, the standards are an independent benchmark for action, providing at least part of the information needed to make an appropriate intervention decision. As such, hazard standards can qualify as a public intermediate good since they can be used simultaneously by many households in making their intervention decisions.[3] Whether the hazard standards are a public good or not depends ultimately on whether the interventions induced by the standards result in benefits exceeding the costs. If so, the hazard standards are a public good. If not, they are a public bad. The analysis in this report attempts to address this issue by discriminating among various forms and magnitudes of hazard standards based on the magnitudes of their net benefits.

Other potential causes of market failure are the result of the persistence of lead intervention in residences. By undertaking intervention, the owner creates positive externalities for any occupants outside of his or her immediate family (such as renters if the owner is a landlord) and subsequent owners who are occupants of the home. If these renters and subsequent owners are fully informed about the implications of lead contamination, the market may adequately compensate the original owner for undertaking lead intervention and no externalities impede the intervention decision. If they are not fully informed, then the original owner will not be sufficiently compensated for services provided to the renters and subsequent owners. Under these circumstances, too few interventions will be undertaken. It is difficult to measure how large this

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3 The term "public intermediate good" and its definition are adapted from Boadway, 1979.

problem is since it requires information on the stock of knowledge about lead problems held by tenants and purchasers today and in the future.[4] Nevertheless, the development and wide dissemination of credible lead hazards will increase the likelihood that renters and subsequent owners will compensate the owners who undertook the interventions.

Compounding the problem of undercompensation is a divergence between social and private discount rates. Discount rates are particularly important, since this analysis anticipates that occupants as much as fifty years in the future could potentially benefit from the intervention of a given housing unit. Even if each renter or subsequent owner is willing to pay the full market value of the externality provided by the original owner's lead intervention, it is likely that the private estimate of the present value of these future payments to the original owner will be smaller than the present value based on the social rate of discount. Consequently, by relying on private decisions, fewer interventions may be undertaken. If credible lead hazard standards are widely disseminated, then the owner is likely to adopt these as his/her decision criteria, as opposed to spending the time and money to develop personal definitions of lead hazard standards. By basing the §403 lead-hazard standards on the social discount rate, EPA will encourage a level of intervention consistent with maximizing net social benefits.

This review suggests that there is one or more market failures affecting decisions regarding the intervention of residential lead contamination. The lack of perfect information is a primary culprit. The ultimate determination of a market failure, however, depends on whether gains in efficiency can be accomplished by some form of regulation. An allocation of resources is deemed inefficient if someone can be made better off without making someone else worse off. That is a core question of this analysis. The examination of risks from lead contamination does indicate a substantial potential for making individuals better off by reducing residential exposures from soil, dust, and paint. The benefit-cost analysis presented in this report examines the questions of whether these actions would result in an increase in net benefits. If the benefits of reducing lead exposures exceed costs, it is theoretically possible to increase efficiency without making anyone worse off. The costs that have to be considered include the costs of getting the right people to decide to act, to choose the right intervention, and to perform and maintain the intervention in the specified manner as well as the direct costs of testing and intervention.

3.3 Need for Federal Regulation

In the Residential Lead-Based Hazard Reduction Act of 1992 ("the Act"), the United States Congress stated that the elimination of lead-based paint hazards was a national goal. Congress found that the Federal Government must take a leadership role in building the required infrastructure, including an informed public, State and local delivery systems, certified inspectors, contractors, and laboratories, and trained workers (§1002(8)). By identifying what constitutes a lead-based paint hazard (defined as paint, dust or soil conditions that would result in adverse human health effects), §403 creates a crucial link in the integrated federal regulatory approach necessary to adequately inform the public of the dangers of lead-based paint, and to implement other portions of the Act that require either mandatory action, or in some cases recommend voluntary action, if a lead-based paint hazard exists.

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[4] Gathering such information would require a survey of homeowners and landlords as to their knowledge about lead contamination and its adverse health effects.

Justifying the need for a federal regulation requires two findings. First, there must be a market failure that can be corrected through regulation. Second, it must be shown that this regulation should be carried out at the federal level. The prior section argued that imperfect information may result in an inefficient number of interventions. One of the objectives of the benefit-cost analysis presented in this report is to demonstrate that net benefits to society can be increased. In the case of lead-based paint hazards, the necessary information has two parts: identification of situations which present a hazard and selection of the appropriate response to address the principle source of the problem. A regulation in the nature of §403 promotes the efficient identification of lead-based paint hazards by providing a metric to use as an indicator of risk. This increases the amount of information available to the consumer at a very low cost to the consumer. In this analysis, maximizing net benefits is the principal criterion used to determine a range of possible candidate standards. In this way, actions under the rule can be targeted to address both the source(s) of lead (e.g., soil, paint, dust on floors, dust on window sills) that are generating the greatest risk within the housing unit and the households that will receive the greatest benefits (e.g. households with new born children).

As written by Congress, various sections of Title X address different parts of the imperfect information problem. By setting hazard standards, §403 helps consumers identify situations that subject them to risk. Without this information, consumers may be more likely to either underestimate or overestimate the value of an intervention. Hazard standards would provide necessary, although not sufficient, information for making an informed choice. In addition, the consumer needs information on the cost and effectiveness of the various lead hazard control options available (e.g. removal of lead-based paint or lead contaminated soil, encapsulation of lead-based paint, dust clean-up). This information need is addressed by §402, which assures a supply of trained and certified personnel to identify and control lead-based paint hazards, and §406 and §1018 which provide information about lead-based hazards to the population in general and in particular at the time of property transactions. In addition, §402 reduces transaction costs, by assuring consumers that the information provided to them about their particular situation will be accurate and complete.

Lead hazards are found in residences in all parts of the nation. Federal regulations can promote cost savings by encouraging coordination among jurisdictions with resulting economies of scale. For example, training and certification costs are reduced where states share the same requirements and provide for certification reciprocity. They also promote partnerships in developing the most cost-effective ways to address lead-paint hazards. In §404, the Act encourages the individual States to adopt the federal §403 regulations, as well as federal regulations from other sections of the Act, adapting them to the specific conditions that exist in the States. By establishing a benchmark, §403 sets a standard for action which holds throughout the nation, independent of state and local circumstances. States have the option of imposing requirements that are more stringent than the federal procedures. States and localities are in a better position to determine how the hazard standards are used and how to adapt their implementation to local circumstances.

In addition, the Act authorizes certain federal expenditures to partially achieve the national goal of eliminating lead-based paint hazards. Authorized federal expenditures include federal grants for evaluating and reducing lead-based paint hazards in non-publicly owned or assisted housing, risk assessments and interim controls in federally assisted housing, and inspections and intervention of lead-based paint hazards in all federally owned housing constructed prior to 1960. The §403 identification of lead-based paint hazards is necessary to implement those federal expenditures in a manner that develops the most cost effective methods.

3.4 Regulatory Options

Options for government regulation fall into four general classes of instruments: (1) information provision and labeling, (2) performance or technical standards, (3) bans or restrictions on use, and (4) economic incentives. The first of these is most closely linked to the primary condition contributing to a market failure, as described in Section 3.2. Consequently, directly addressing the lack of adequate information will be the focus of this section and the analysis presented in this report. Examples of how the other three classes of instruments might be applied are presented to illustrate their potential. To some extent, these other instruments are used in other parts of Title X to provide an integrated approach. For example, §402 of TSCA Title IV provides performance and technical standards in the form of training and certification requirements and standards for performing lead-based paint hazard identification and control activities. Prior laws have banned the use of lead-based paint, and §402 restricts the use of certain hazard control techniques.

3.4.1 Information Provision

A draft regulator's guide on economic incentives under TSCA identifies three circumstances that are particularly favorable to making the provision of information an appropriate instrument for regulation (Eyraud, 1993). The first circumstance — that there is a significant lack of information that generates exposure problems — has already been identified as a strong likelihood. To rectify this circumstance, a corollary condition has to be met. The new information has to be able to induce exposure-reducing behavior. While additional information will alter the behavior of some portions of the population, it should not be assumed to completely bridge the gap between socially-desirable and observed exposure-reducing activites. Information programs are appealing as a means of regulation in part because they do not impose direct burdens on the economy. One of the dangers, though, is that the absence of a direct burden will come at the expense of being ineffective. This does not have to be the case. Collectively, environmental and other public health programs have amassed substantial experience in learning about what does work and what does not work in risk communication. This expertise should be tapped to render any information approach effective.

The second circumstance favorable to effective information provision is situations where the exposure is not created by an externality beyond the exposed individuals' control. In other words, the affected population has to be able to put the information to good use. While externalities between current intervention and future beneficiaries were identified as a possible cause of market failure, these do not prevent information from being effective. For example, if a house is not abated over the next 30 years, the occupants at that future time can decide to undertake intervention if they have the right information to motivate their decision. This circumstance appears to apply to the exposures from lead in residential soil, dust, and paint. There is, however, at least one major exception. Financial constraints can prevent even the best informed household from taking effective steps to reduce exposure. As homeowners, households may not be able to afford intervention or other hazard controls. As renters and buyers, they may not be able to afford housing free of lead-based paint hazards. It is important to note, however, that this impediment is not unique to an information approach.

The third circumstance favorable to the use of an information approach is where other regulations would lead to greater adverse economic impacts. Although its effects are indirect (working through changes in behavior rather than by direct enforcement), an information approach does create economic impacts. Whether these economic impacts are greater or less than those of other regulations is unknown at this time because other regulations have not been studied in as much depth.

The analysis presented in this report focuses on defining a particular type of information — hazard standards — by comparing the costs and benefits under assumed levels of activity by property owners. Promulgating such hazard standards is one means of implementing §403 of TSCA, which calls for EPA to identify lead-based paint standards, lead-contaminated dust, and lead-contaminated soil. One objective in promulgating such hazard standards is to fill part of the information gap that has been linked to sluggish rates of intervention of lead-contaminated homes. Specifically, these hazard standards are intended to indicate thresholds at which EPA recommends that certain forms of hazard controls take place. As such, they can lower the information costs for homeowners making a decision about whether to act and thus increase the demand for intervention and other control measures. It is important to note that by providing such hazard standards, EPA will not be eliminating the information costs altogether. For example, the costs of testing for levels of lead in soil, dust, and paint are still substantial. These costs are considered in this analysis. Also, any public information campaign to motivate households to be concerned about and test for lead contamination (analogous possibly to the public campaign currently being waged for radon) will impose costs. These have not been explicitly considered here.

3.4.2 Other Regulatory Options

Other regulatory instruments may also be effective for addressing the market failures that have led to the exposure of children to lead-based paint hazards. While some of these alternative instruments are utilized in other parts of Title X, they have not been examined in the context of §403 to the same extent as the primary instrument considered — information provision. Suggestions for alternatives that might be investigated further are provided in Exhibit 3.2. The list is meant to be illustrative rather than exhaustive, particularly where economic incentives are concerned. The feasibility and advisability of these alternatives could vary widely.

Exhibit 3-2
Other Regulatory Alternatives

Type of Instrument	Possible Application
Labeling	Section 1018 of the Residential Lead-Based Paint Hazard Reduction Act of 1992 requires the disclosure of lead-based paint or any known paint hazards in the sale of target housing (any housing constructed prior to 1978). This provision could be extended to provide information on soil and dust hazards, not just paint, at the time of sale of *any* housing, not just target housing.
Technical and Performance Standards	Hazard levels could be enforced through performance or technical requirements. Owners of homes where children are present would, for example, have to keep paint in good condition, and reduce and keep soil and dust contamination below the hazard levels. Technical standards could specify exactly what control actions are necessary if hazard levels are exceeded. While §402 establishes training and certification requirements, and work standards, it does not target housing with young children.
Bans and Restrictions of Use	Restrictions could be placed on the access of young children to homes where lead contamination is of concern. These restrictions could include exclusion from occupying such homes or from spending extensive amounts of time in them, or prohibitions from accessing particular areas, such as rooms with paint in deteriorated condition or bare play areas outdoors where soil contamination is high.
Economic Incentives	A quota could be established for the numbers of homes allowed to have excess lead contamination. The quota could be allocated by a system of marketable allowances. Homes without allowances would have to undertake intervention or accept restrictions on their accessibility to young children.

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4. Overview of Analytic Approach

This section summarizes key aspects of the risk assessment and its linkages with the economic analysis, and provides an overview of the methodologies used to estimate the costs and benefits of the§403 lead hazard levels. The impetus for assessing the costs and benefits of lead hazard control is to provide EPA with an estimate of society's potential return from the regulation. The cost estimates represent costs incurred by individuals, both testing and control costs to reduce lead exposure. The benefit figures are estimates of the amount society will gain if the adverse health effects caused by exposure to lead hazards are avoided. The evaluation based on a comparison of benefits and costs is straightforward. If benefits exceed costs then the lead hazard levels are expected to result in a net gain to society. Conversely, if costs exceed benefits then the lead hazard levels are expected to result in a net loss to society.

The analysis of costs and benefits of alternative standards is designed to provide an estimate of the number of interventions that would be optimal under alternative approved standards (i.e., interventions are assumed to be limited to those housing units with children present, and thus benefits will be realized). This approach is based on a model that calculates the number of lead-related interventions based on the age of the housing stock, representative lead conditions, and the number of children born over a 50-year period.

4.1 Summary of Risk Assessment

The only category of benefits considered in the analysis is that of benefits to children under the age of six. This section describes how risk assessment is used to estimate these benefits to children.

4.1.1 Scope of Analysis

This analysis considers children, from birth through the sixth birthday, living in homes that were built in 1997 or earlier. Because the potential for lead exposure in the set of currently contaminated homes may remain for some time, the analysis considers children born during the next 50 years, from 1997 to 2046. Exposure, health effects, and benefits are calculated separately for the cohorts born in each of the 50 model years.

4.1.2 Characterization of Exposure

The effects of children's exposure to dust and soil contaminated by lead-based paint are the focus of this study. Pica, the direct ingestion of paint chips, is also analyzed as a source of childhood lead exposure. Air, water and food sources of lead are not analyzed because of prior national reductions in their contamination.

The data source used for estimating exposure in children is the HUD National Survey of Lead-Based Paint in Housing (USEPA 1995), referred to as the "HUD data" in this report. Conducted in 1989-1990, this survey measured lead levels in paint, dust, and soil within 284 representative, privately-owned and occupied housing units built before 1980. Each surveyed home was assigned a national sampling weight (USEPA, 1995). Units built in 1980 or later were not included in the survey since they were assumed to be free of lead-based paint. Because this analysis considers homes built through 1997, the 28 HUD survey units built between 1960 and 1979 and containing no lead-based paint were used as templates for describing homes built 1980-1997. The total number of homes built during this latter period was simply divided by 28 to give an equal weight to each home type.

The unmodified characteristics of these total 312 “HUD home types” are used to represent the baseline lead levels found in US housing stock throughout the modeling period, 1997-2046. To represent the “post-intervention” lead levels caused by the introduction of national lead hazard standards, the values for different HUD homes are reduced based on the candidate standards in question, the hazard control interventions that consequently take place, and the effectiveness of interventions as specified in the Risk Assessment (Battelle 1997).

4.1.3 Determinations of Blood Lead Distributions: NHANES III and IEUBK and Empirical Models

To characterize the baseline national distribution of blood-lead concentrations in each cohort of children, this analysis uses data for one to two year-olds from the Third National Health and Nutrition Examination Survey (NHANES III), Phase 2. These data yield a blood-lead geometric mean (GM) value of 3.14 µg/dL, and a geometric standard deviation (GSD) of 2.09 µg/dL. It is assumed that these figures describe a lognormal distribution, and that without interventions, this baseline distribution would remain constant for all cohorts born during the 50-year model period. The latter assumption is a basic premise of the risk assessment.

The NHANES-derived blood lead GM and GSD are assumed to stem from exposure to the baseline ambient lead levels reported in the HUD data. So while NHANES data can be used to characterize the baseline blood lead level distribution, they cannot be used for post-intervention distributions, when environmental lead levels are reduced. Instead, the EPA has two independent models for predicting the blood-lead GM and GSD from ambient lead conditions in a given population. One model attempts to model the physical and biological processes underlying the relationship while the other uses a statistical/epidemiological approach.

Each model is used within separate analyses to calculate blood lead distributions for both baseline and post-intervention ambient lead levels. Model inputs for the baseline come from the baseline HUD data for all 312 home types, while post-intervention inputs are based on reduced lead contamination levels in the same homes. Predicted blood lead GM’s and assumed GSD’s for each HUD home type are weighted and aggregated using statistical formulas to derive a national predicted blood-lead distribution for both baseline and post-intervention scenarios.

Modeled post-intervention blood lead distributions cannot be directly compared to the baseline NHANES distribution in a meaningful way. Therefore, the ratio of the predicted post-intervention blood lead GM to the predicted baseline GM is multiplied by the baseline NHANES GM to derive the final modeled post-intervention GM for each cohort. The same procedure is repeated for GSD’s in order to define a distribution, which is then compared to the baseline distribution and used to measure health effects resulting from the standards.

The first of the two models used to predict blood-lead distributions from ambient lead conditions is EPA’s Integrated Exposure, Uptake, and Biokinetic (IEUBK) Model. As its name implies, this model utilizes exposure, uptake and biokinetic information to predict a distribution of blood-lead levels in children corresponding to a specific combination of environmental levels. Various parameters are fixed, including daily intake of dust and soil, and the intake of lead from other sources such as air, water, and diet. The variable inputs for this analysis are floor dust lead concentration and soil lead concentration. The effect of lead-based paint on children who exhibit pica is estimated after the IEUBK model is run, following a procedure described in Battelle (1997).

The second model used to predict blood-lead distributions is an empirical model. This model was developed using data from the Rochester Lead-in-Dust Study to estimate the relationship between blood-lead levels in young children and the observed level of lead in environmental media (paint, dust and soil) from their primary residence. The empirical model as originally developed is log-linear in form, expressing the natural-log transformed blood-lead concentration as a linear combination of natural-log transformed exposure variables. The model was adapted slightly by Battelle to accommodate the HUD data. The final variable inputs are floor dust lead load, window sill dust lead load, soil lead concentration, and an indicator for the presence of deteriorated lead-based paint *and* incidence of pica.

4.1.4 Health Effect Endpoints

This analysis considers the following health endpoints: reduction in IQ, cases of IQ less than 70, cases of blood lead levels greater than 20 µg/dL, and cases of blood lead levels falling into seven categories defined by the CDC. Avoidance of adverse health effects is then translated into monetary benefits. Reduction in IQ may stem from any level of exposure to lead hazards. The next two effects are used to represent cognitive effects more likely seen in children with unusually high levels of exposure. The seven blood lead categories correspond to different sets of general symptoms, each with a different screening and medical treatment protocol recommended by the CDC (CDC 1991).[1]

The IQ point loss for each cohort is determined by calculating the arithmetic mean total population blood lead level from the GM and GSD. The arithmetic mean is then multiplied by the size of the cohort and converted to the total number of IQ points lost using the factor 0.257 from Schwartz (1994). The difference between the IQ points lost for the baseline and post-intervention scenarios yields the IQ point loss avoided, which is the basis for benefits calculation.

The fraction of a cohort with IQ less than 70 is determined by a methodology based on Wallsten and Whitfield (1986), using the cohort blood-lead GM and GSD. The same two parameters and the same statistical procedure are used to calculate the fraction of each cohort with blood lead levels above 20 µg/dL, and the fraction falling within the seven categories defined by the CDC. The GM and GSD are log-transformed to the mean and standard deviation of a normal distribution; then the areas under the normal curve corresponding to the blood lead level ranges of interest are computed as percentages of the total area under the curve.

Cohort fractions are multiplied by cohort size to yield the number of children falling within a given health effect category. From the baseline to the post-intervention scenario, the difference in the population within each category -- IQ under 70, blood lead level over 20 µg/dL, or blood lead level within a CDC category -- is the basis for benefits calculation.

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1 The categories cover all possible blood lead levels; children with blood lead under 20 µg/dL are not expected to show significant symptoms or require medical intervention. Screening is still recommended.

4.2 Linkages Between Risk and Economic Analysis

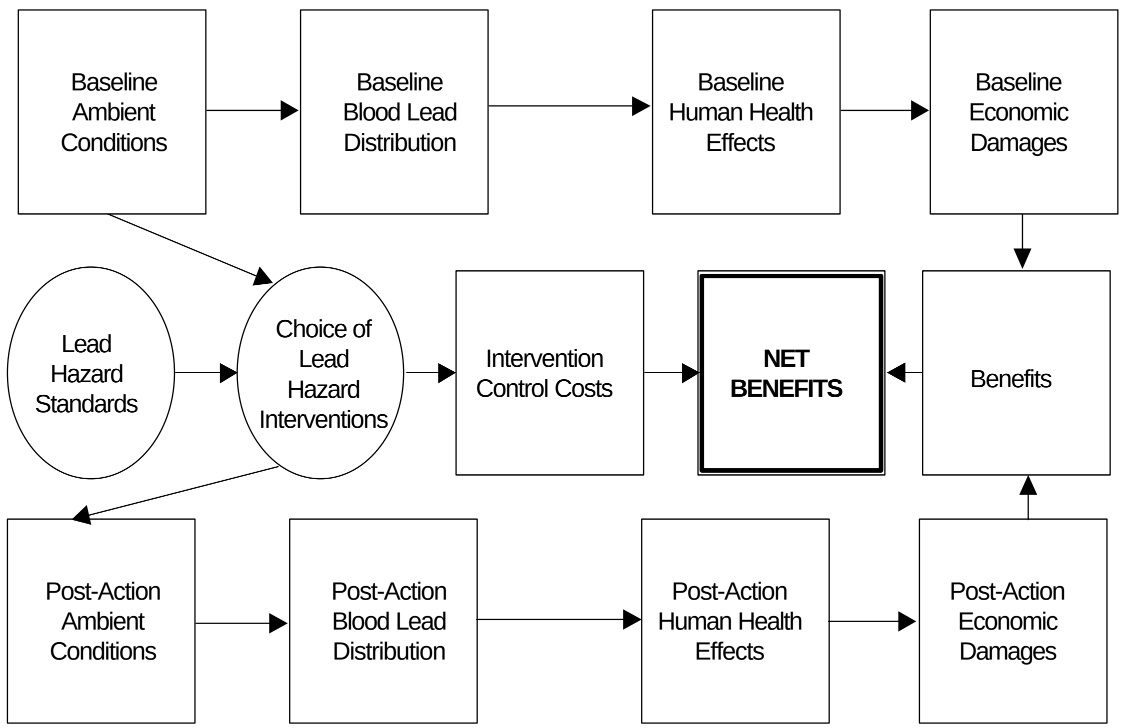
The methodology used to evaluate the economic return from the §403 hazard standards has several linkages with the risk assessment methodology, which in turn relates paint condition and the amount of lead in dust and soil to blood lead levels and health effects. Exhibit 4.1 illustrates the basic linkages between the risk assessment and economic modeling, and the scheme of the overall analysis. The links that are most relevant to this overview are those that connect alternative hazard levels and the presence of lead in each housing unit with hazard control choices and costs, and those that connect the presence of lead to blood-lead levels and thus to health effects and economic damages and benefits. The first set of linkages outlines the cost estimation process, while the latter describes the benefit estimation process.

Costs of controlling lead hazards are calculated using the unit costs of individual intervention activities, in combination with the timing and number of interventions. The occurrence of interventions depends on a variety of factors linked with the risk assessment. The primary intervention "trigger" is the birth of a child in a home. When a child is born into a housing unit whose ambient lead levels exceed the standards, the appropriate intervention is assumed to occur. This initial intervention is repeated as necessary until the child turns six years of age, at which time additional interventions will cease unless an additional child has been born during this time period. Interventions in the home will recommence if another child is born after this period, and will follow the same repeat routine.

Benefits of lead hazard control are calculated using estimates of "avoided" economic damages corresponding to avoided adverse health effects. As described above, these avoided economic damages include foregone income due to reductions in IQ, as well as increased educational and medical costs connected with unusually high levels of exposure. The model defines"avoided" as the difference between the baseline scenario (no interventions) and the ex post scenarios. In the analysis, benefits are calculated for children whose exposure to lead is reduced for the period from birth to age six. All interventions will have some level of benefit because it is assumed that there are no interventions if children are not present.

In Exhibit 4.1, the boxes along the top represent the analysis of baseline conditions, yielding an estimate of the economic damages resulting from the baseline conditions. The boxes along the bottom of the exhibit represent the analysis of ex post conditions; each alternative standard is analyzed separately. A comparison of the baseline economic damages and the ex post economic damages yields an estimate of the benefits of actions performed under the scenario. This is represented by the far-right box in the middle row of Exhibit 4.1. From these benefits, the analysis subtracts the corresponding costs to get net benefits. The evaluation candidate standards consist of calculating net benefits for a wide range of standards and then comparing them in terms of net benefits. The candidate hazard standard yielding the largest net benefits provides the greatest benefit to society.

Exhibit 4.1
Linkages Between the Risk Assessment and Economic Methodologies



4.3 Summary of Integrated Analysis

This section is divided into five parts; the first four correspond to the linkages delineated above. The first part discusses the connection between lead hazard standards and intervention choices. The second briefly discusses the link between intervention choices, ex post ambient conditions, and new blood lead levels. The third part focuses on the costs of interventions, while the fourth discusses the benefits of reducing lead hazards. The final part discusses the choice of discount rate.

4.3.1 Lead Hazard Standards and Lead Hazard Reduction Interventions

In §403 of TSCA Title IV, Congress instructs EPA to define hazard levels, or standards, for lead in soil, interior and exterior paint, and window sill and floor dust. The primary analysis used to estimate the net benefits of alternative standards assumes that hazard standards induce specific intervention activities in homes where the standards are exceeded[2]. In other words, if there is a problem in a home with children under the age of six, then there is a response action, and there is a one-to-one relationship between the

[2] This is a strong assumption (assuming hazard control occurs automatically) and overlooks factors such as informational problems, differences in income, and variation in individual preferences and behavior.

problem and the lead hazard control response.[3] For example, if lead levels in the soil exceed the hazard levels, there will be an appropriate soil intervention, but there will not be an interior paint intervention in response to elevated levels of lead in soil. Section 9 presents an alternative analysis that maintains the one-to-one relationship between the nature of the lead problem and the nature of the intervention, but makes different assumptions about the rate of intervention and the presence of children.

Six intervention or hazard control activities are considered. These include high and low intensity interventions for interior paint and exterior paint, and a single intervention each for soil and dust. High intensity hazard controls of interior and exterior paint hazards occur when deteriorated lead-based paint (LBP) is extensive. Low intensity hazard controls of paint hazards occur when deteriorated LBP is present but not extensive. Soil intervention activities occur when the soil-lead concentration exceeds the soil standard. Dust hazard control occurs when the floor dust loading exceeds the floor dust standard, the window sill loading exceeds the window sill dust standard, or when it is required to accompany another intervention type, either high intensity interior paint control or soil removal.

To determine whether or not levels are exceeded and thus when interventions will occur, baseline ambient conditions for all homes represented in the HUD data are compared to the hazard standard. Hundreds of alternative sets of hazard standards were specified to permit the comparison of results and to examine the relative efficiency of different specifications. The hazard standard is not varied for paint, however, and the level used in this model was determined by the US EPA. Baseline ambient conditions are estimated using the US Department of Housing and Urban Development (HUD) National Survey Data. See Battelle (1997) for a full description of the methodology used to characterize ambient dust, paint, and soil conditions within the US housing stock.

4.3.2 Risk Assessment: Moving from Ambient Conditions to Blood Lead Distributions to Health Effects

The baseline scenario assumes that no interventions will occur. For each alternative standard evaluated, the model calculates ex post ambient conditions in each HUD home type. Using the approach portrayed in Exhibit 4.1, these ex post ambient conditions are used to estimate a single ex post blood lead distribution for the entire cohort born each year of the model run, 1997-2046. In other words, the "post-intervention" blood lead distribution reflects ambient conditions after induced intervention activities. In addition, population blood lead distributions over time reflect changes in the housing stock that are expected to alter the distribution of lead exposure within homes. This is because homes built before 1980, which may have lead-based paint, are older and are lost to demolition at a faster rate than homes built from 1980-1997, which do not have lead-based paint. As lead-free homes comprise a greater percentage of the modeled national housing stock over time, exposure to lead hazards will drop regardless of regulations aimed at controlling health hazards.

The incidence of four health effects are estimated as a function of attributes of the blood lead distribution. These calculations are made for the baseline and "post-hazard control" blood lead distributions on an annual basis. "Avoided" health effects represent the difference between the baseline and "post-hazard

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[3] A small portion of the homes will have no intervention even though the ambient lead levels are above the standards because no children will be born in them during the 50-year period analyzed.

control" incidence estimates for each model year cohort, and serve as the basis for monetized benefits calculations.

4.3.3 Cost Estimates[4]

Drawing on a variety of sources described in Chapter 5, unit cost estimates are derived for each of the hazard control activities, in terms of cost per intervention activity per home. Hazard control activities include a combination of testing for lead content and specific interventions to reduce lead exposure. Interventions include maintaining, removing or encapsulating deteriorated lead-based paint, removing dust, and removing soil. Representing average costs, unit costs are calculated for each of the testing and intervention activities. Separate cost estimates are developed for single and multi-family housing units; multi-family unit costs are developed by adjusting the single family cost estimates to reflect the smaller size of multi-family units and the smaller yards of multi-family units.

For each hazard standard scenario, the choice of intervention activity in a home depends on its baseline ambient conditions and the alternative standard being evaluated. The lead hazard standards work in conjunction with unit costs, the birth trigger, and repeat rules to determine the home's total cost of intervention during the model run period. The repeat rules include the assumption that non-permanent interventions are repeated when their duration is exceeded if a child under six is present, with attendant costs. Exhibit 4.2 presents the assumed duration for each intervention. Thus, costs incurred by a particular housing unit accrue over time depending on the assumed hazard control choices. For example, high intensity paint interventions are assumed to have a duration of 20 years. Therefore, if a child under six is present 20 years after the initial high intensity interior paint intervention in a home, the intervention will be repeated at that time. If no child is present, an intervention will not be performed until such future time as a new child is born into the home.[5]

Because the model reflects costs over time, costs incurred after the first year are discounted to the first year using an annual discount rate of 3 percent.[6] The total model cost estimate is the sum of the cost of hazard controls in all homes for each year and represents the present value of the assumed stream of intervention costs.

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4 A more detailed presentation of the estimation of costs appears in Chapter 5.

5 In some cases, repeat interventions will be performed after the last year of the modeling period, 2046, to protect children born in 2046 or earlier (*during* the modeling period). For instance, if a high intensity interior paint intervention is performed in a home in 2028, it will be repeated in 2048 if a child under six is present who was born before 2047.

6 The sensitivity analysis presents costs, benefits and net benefits calculated with a discount rate of 7 percent as well.

Exhibit 4.2
Duration for Each Intervention

Intervention	Duration in Years
High Intensity Interior Paint	Paint: 20
Low Intensity Interior Paint	Paint: 4
High Intensity Exterior Paint	Paint: 20
Low Intensity Exterior Paint	Paint: 4
Dust	Dust: 4
Soil Removal	Soil: Permanent

4.3.4 Benefit Estimates[7]

Benefits are based on "avoided" health effects, meaning that a lead hazard standard is modeled as resulting in a lower level of exposure to lead, and thus avoiding health impacts that would have occurred under the baseline. In order to estimate the incidence of health effects under alternative standards, each intervention is associated with a specific *ex post* ambient lead condition; these *ex post* conditions are presented in Exhibit 4.3. The magnitude of avoided health effects (both changes in blood-lead concentrations and specific health endpoints) is calculated as the difference between the incidence of health effects in the baseline and under the specific standard being analyzed. Monetary values are then estimated for the avoided health effects based on the costs of medical screening and treatment for a wide range of blood-lead level categories, as well as for three specific health endpoints: lost IQ points, IQ less than 70 points, and blood lead levels greater than 20 µg/dL. In each case, the economic value is a proxy for society's willingness to pay to avoid the health effect.

Since lead hazards have been linked with a variety of health hazards for children and adults in addition to those analyzed here, the benefits estimates are likely to understate the societal return from the §403 hazard levels. Furthermore, secondary benefits such as improved energy efficiency due to new windows and increased aesthetic appeal due to repainting are not included.

The economic value of avoiding cases of IQ less than 70 is approximated by using avoided special education costs. As defined, these education costs are incurred from age 7 though age 18. Similarly, the economic value of avoiding cases of blood lead levels above 20 µg/dL is proxied by using avoided compensatory education costs. In this case, the education costs are assumed to be incurred from age 7 through age 9. With increases in blood-lead, there are increases in monitoring and medical intervention costs as recommended by CDC. The economic value of reducing the population-wide blood-lead levels is proxied by the reductions in these monitoring and medical costs. (CDC 1991)

[7] A more detailed presentation of the estimation of benefits appears in Chapter 6.

Exhibit 4.3
Post-Intervention Ambient Conditions

Intervention	Assumed Post-Intervention Condition
High Intensity Interior Paint	• *Paint*: Deteriorated interior LBP made inaccessible • *Dust*: Floor dust lead loading level reduced to 40 µg/ft^2. Window sill dust lead loading level reduced to 100 µg/ft^2. Lead concentration level reduced by 80%
Low Intensity Interior Paint	• *Paint*: Deteriorated interior LBP made inaccessible • *Dust*: Lead concentration level reduced by 80%
High Intensity Exterior Paint	• *Paint*: Deteriorated exterior LBP made inaccessible • *Dust*: Lead concentration level reduced by 80%
Low Intensity Exterior Paint	• *Paint*: Deteriorated exterior LBP made inaccessible • *Dust*: Lead concentration level reduced by 80%
Dust	• *Dust*: Floor dust lead loading level reduced to 40 ug/ft^2. Window sill dust lead loading reduced to 100 ug/ft^2. Effect on dust lead concentration depends on other interventions implemented (see Battelle 1996)
High Intensity Soil	• *Soil*: Soil lead concentration reduced to 150 ppm. • *Dust:* Floor dust lead loading level reduced to 40 µg/ft^2. Window sill dust lead loading level reduced to 100 µg/ft^2. Effect on dust lead concentration depends on other interventions implemented (see Battelle 1996)

Note: Lead levels remain constant in any case where starting levels are lower than assumed post-intervention ones.

Benefits accrue over time and are discounted to the present using an annual rate of 3 percent. Total benefits are the sum of benefits calculated for each year or cohort of children protected, and represent the present value of the stream of benefits from the interventions taken under the standard. Net benefits are simply the difference between the total benefits estimate and the total cost estimate. As such, they are an indicator of the societal gains from alternative lead hazard standards.

4.3.5 Discount Rate

The analysis of the §403 standards uses discounting to provide estimates of costs and benefits (which will be realized at different points in time in the future) in present value terms. Several characteristics of the actions affected by §403 require the use of discounting. First, actions under this rule will occur over an extended period of time (the analysis considers 50 years). Second, for any particular action, the costs and benefits might occur in different years. Third, unit benefits from reduced exposure are estimated based on future medical and education costs avoided and higher future income streams experienced. For accurate measures, future income and avoided future costs must be discounted to yield present values.

In estimating the total net benefits of alternative definitions of lead hazard levels, the model used in this analysis "assigns" intervention costs to the year in which an activity occurs, and "assigns" children's benefits to the year in which a child is born. Due to the repetition of intervention activities, and births into homes where interventions have already occurred, the costs and benefits may be assigned to different years. In the case of adult benefits, adults living in the housing unit in future years will benefit from the intervention taken in any given year. Thus discounting is used to:

- **Estimate the unit benefit value for each type of benefit.**[8] These are:
  - the present value of the future increase in income for one newborn based on a one-point IQ increase;
  - the future foregone special education costs for one newborn who crosses the threshold from IQ under 70 to IQ over 70;
  - the future foregone compensatory education costs for one newborn who crosses the threshold from blood lead over 20 µg/dL to blood lead under this level;
  - the future foregone medical costs for one newborn who moves from a higher blood lead category to a lower one;[9] and
  - the future avoided medical costs and avoided lost wages based on reduced probability of certain adverse health effect.

- **Estimate the present value of the stream of costs and benefits resulting from §403 activities in the future.** Since the model considers actions taken over the next 50 years, the benefits and costs from these future actions must be discounted so that they can be summed with actions taken in the first year. In some cases, children are born into housing units where interventions have occurred in earlier years and are still effective. Thus there would be benefits but no costs that year. In other cases, a repeat activity might occur to support benefits counted in earlier years, resulting in costs but no new benefits assigned that year.

While several factors affect discount rate estimates in general, the selection of the appropriate discount rate is considered in the context of each of these situations.

General Considerations in Selecting the Discount Rate. Selection of the appropriate discount rate to use in benefit-cost analyses is a long running controversy and is the subject of a large amount of economic literature and government policies. The choice of discount rates can make a profound difference in the results of a benefit-cost analysis, especially for programs like this one where costs and benefits may accrue at different points over an extended period of time. Most economists currently believe that no single rate is fully appropriate to use in all situations, even though that might be desirable for pragmatic reasons. The debate on selecting a discount rate involves two distinct issues: what type of discount rate is appropriate in a particular situation, and what is the magnitude of the appropriate discount rate that is selected.

Some agencies specify a single rate to be used in all situations in order to promote consistency among different analyses. For example, the Congressional Budget Office (CBO) uses the real (i.e., inflation-free) rate on long-term government bonds to discount costs and benefits of proposed legislation and in preparing

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8 Estimating the unit cost of an intervention activity does not involve discounting, since it is assumed that the costs will all be incurred at the time of the activity. Therefore no separate entry is listed for estimating unit cost values.

9 There are many unit benefits of this type depending on which two categories the newborn passes between; categories and their associated costs are described in chapter 5.

the annual budget of the United States. The CBO identified two percent as the appropriate (and non-changing) discount rate (Hartman, 1990). The Government Accounting Office recommends using the real rate of return on government bonds over one year in length. Currently this rate ranges between 2.7 and 3.0 percent (US OMB 1996b). The Office of Management and Budget (US OMB, 1996a) also recommends using a single constant discount rate that reflects the real marginal pre-tax rate of return on average private investments. The recent OMB guidance refers the reader to its 1992 guidance, in which OMB identified seven percent as the appropriate discount rate to use for Regulatory Impact Analyses (and indicated that this may change in the future).

The recent OMB guidance also says that there are circumstances where different discount rates are appropriate, and encourages RIAs to include alternative calculations using other discount rates in an appendix when justified. In the extended guidance on discounting procedures (US OMB, 1988), the OMB identified situations where the costs of the regulation are almost entirely borne by consumers as a situation where a different discount rate is more appropriate. Such is the case for §403, where much of the costs and quantified benefits are the result of lead hazard reduction activities due to voluntary consumer action and paid for by the consumers.

The debate between using a rate of return on investment capital and the consumption rate of return focuses on whether investment is being displaced. Some discounting theory emphasizes that one dollar diverted from productive investment reduces the stream of future production, while a dollar diverted from consumption would only substitute one type of consumption for another. This diverted capital argument is the basis of the "shadow price of capital" approach to discounting, which treats displaced investment as "costing" more than displaced consumption. The practical difficulty in implementing this approach is to identify which costs are diverted investments, and which are diverted consumption. Various pragmatic approaches to this have been proposed and used by the EPA and other government agencies for regulatory analysis, including the "two-staged" discounting approach (Kolb and Scheraga, 1990), or a single "blended rate" somewhere between the rate of investment return and the rate of consumption return.

Recent developments in the economic literature have raised serious questions about the extent to which capital is actually "displaced" today. The displaced capital approach holds that because regulation diverts funds from alternative investments, some investment opportunities are not undertaken. In other words, the pool of available capital is assumed to be fixed, forcing some investment to be foregone when capital is diverted away from investment. While the pool of available capital is relatively fixed (at least in the short run) in a closed economy, in an open economy capital can flow in from other countries. The increased demand for investment capital in the United States (created in part to finance the federal deficit) has attracted large amounts of capital into the country, and most economists feel this has significantly reduced the pressure that federal borrowing has had on real interest rates. While the supply of capital is not perfectly elastic, neither is it perfectly inelastic. An elastic supply of capital reduces the difference between investment rates of return and consumer rates of return.

In addition, estimates of real financial rates of return are lower than many people believe. The real rate of return on United States government bonds has been near zero percent for most of this century, while the annual return on a broad portfolio of stocks has averaged near four percent. In general, stocks have done better since 1980 (averaging 4.26 percent) than in the other periods this century, but the rate of return may return to historic norms in the future (Freeman, 1993). Thus the range of real rates of return on investment opportunities range from near zero to four percent.

The issues involving the appropriate discount rates and procedures are very complex, and are not likely to be resolved soon. Much of the recent economic literature summarizing the discount rate debate concludes that discount rates reflecting either the social rate of time preference or the rate of return on investments are the appropriate discount rates to use, and there is not that great a difference between the rates. For example Moore and Viscusi (1990) find no evidence that the rate of time preference for environmental-related health effects differs from financial rates of return, and cite evidence that two percent rate is appropriate. Lind (1990) recommends a range of one to three percent, and Freeman (1993) recommends two to three percent.

Applying these Findings to the Selection of a Discount Rate for the §403 Analysis. In this analysis, best practice suggests that both benefits and costs should be measured as consumption foregone and thus the social rate of time preference has been used for discounting, although what the rate is called is a moot point if Moore and Viscusi's findings are correct. The reasoning for basing the discount rate on foregone consumption is that the benefits of the rule (e.g., avoidance of an IQ decrement) will provide the beneficiary with a higher income and therefore greater consumption potential. In the case of costs, the reasoning for using foregone consumption as the discount rate is based on the manner in which the funds spent for rule compliance would otherwise be used. This is particularly true for homeowners, who are likely to view expenditures on improving their home as a consumption expenditure and would not divert funds from investments for lead hazard reduction activities. On the other hand, the argument could be made that landlords would reduce investments to finance lead hazard reduction activities. There are two responses to this argument. First, since the action is voluntary under §403, it can be assumed that the rate of return (say in terms of increased property value) is at least as great as the landlord would realize on the alternative investment and thus there is no decline in the future stream of production. Second, even if the landlord were to divert his own investment funds to these activities, owner-occupied housing units constitute the majority of properties affected by this rule, and thus the discount rate relevant to homeowners would dominate.

Based on the information presented above, a 3 percent discount rate has been adopted as the most appropriate rate for use in this analysis. It is used in Chapters 5, 6, and 7 for the estimation of the present value of costs, benefits and net benefits. Since a 7 percent rate is often used for government regulations, results using 7 percent are presented as a sensitivity analysis in Chapter 8 to facilitate comparison among rules.

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5. Cost Analysis

5.1 Introduction

As described in Chapter 4, candidate hazard standards are ranked in terms of their net benefits (i.e., benefits minus costs) to determine which standards yield the maximum net benefits. This chapter describes the methodology used to calculate the costs associated with each candidate hazard standard.

Two conditions are necessary for an initial intervention to occur in a housing unit. Interventions are assumed to occur in housing units where ambient lead levels exceed the lead hazard standards and a newborn child is expected in the ensuing year. Interventions are repeated as necessary to provide six years of protection for the newborn child, plus protection for any children born in subsequent years. Separate intervention activities are defined for interior and exterior paint, dust, and soil. The overall intervention strategy for a housing unit is composed of a combination of the medium-specific interventions. The appropriate combination of intervention activities is determined by comparing the lead levels in the housing unit's soil and dust, and the condition of its paint, to the lead hazard standard under consideration. For each of the housing units covered in the HUD survey, the unit costs are applied to the specific intervention strategy appropriate to that housing type. Summing across all 312 home types, weighted to represent the nation's housing supply, provides an estimate of the aggregate cost of the lead hazard standard. All cost estimates in the subsequent sections are presented in 1995 dollars.[1]

5.2 Estimating Aggregate Costs

As described in the prior chapter, the analysis compares alternative futures over a 50-year time horizon: a baseline or "no-action" alternative, for which it is assumed that no changes are made to current ambient lead exposure conditions, and a "post-action" alternative for which it is assumed that the ambient lead exposure conditions are reduced in specific ways in response to the §403 standards. In other words, this is a marginal analysis with a baseline of no intervention, and the marginal costs are the costs of inspecting and testing housing units for lead, and performing the various intervention activities.

The model used to estimate the aggregate costs of lead hazard standard analyzes each of the 312 home unit types in the HUD dataset separately (HUD 1993). These 312 home types include housing constructed after 1978. According to Title X, the regulations will apply to housing constructed before 1978. However, the analysis assumes that once EPA promulgates these standards, they will be generally applied to all housing regardless of year constructed.[2] While the use of lead-based paint was banned in 1978, dust and soil continue to be contaminated with lead from a variety of sources. Since some homes built after 1978 may have lead levels that exceed the candidate hazard standards, it is likely that the legal system and lending institutions will adopt these standards for all housing. For example, the §403 standards may be adopted by

1 The Gross Domestic Product (GDP) implicit price deflator was used to convert estimates to 1995 dollars (Office of the President, 1996). The GDP implicit price deflator is estimated by the Department of Commerce's Bureau of Economic Analysis and incorporates real income and price inflation changes over time.

2 Of the almost 23 million homes that exceed the final standards, only about 890,000 (or 3.9 percent) were built after 1978.

courts in determining when a property owner's decision to not intervene is considered an act of negligence for which the owner can be held financially liable. Likewise, mortgage lenders are likely to be more hesitant to finance property acquisitions if the properties exceed the §403 standards. This was the reaction of lending institutions to the asbestos regulations.

By tracing intervention activities in a single housing unit over a 50-year period, the model estimates the total present value of costs for that unit. This calculation of total per-housing-unit costs is performed for each of the 312 housing unit types under each of the lead hazard standards. Using the weights assigned to each of the 312 housing unit types and the timing of initial interventions during the 50-year period, the results are extrapolated to a national estimate. In other words, the present values for each housing unit type are appropriately weighted and summed to provide an estimate of the aggregate national costs for the candidate standard.

The model is illustrated in Exhibit 5-1.A. For each of the 312 housing unit types, the first stage is to compare the unit's baseline or current ambient lead condition to the lead hazard standards under consideration. If the baseline conditions meet all the standards (presence and condition of lead-based paint, the amount or loading of lead in household dust, and the concentration of lead in soil), no interventions will occur in any housing units of that type and they will incur no intervention costs. In other words, these housing units drop out of the cost calculations for this lead hazard standard.[3] If the unit exceeds any of the hazard standards (e.g., has lead levels in its soil that are greater than the standard), then the housing unit type moves to stage 2 of the analysis.

Since the model assumes that testing and interventions begin only when a child is born into the home, the housing units are divided into two groups: 1) those where a birth is expected that year, and 2) all the rest. The housing units in the second group are subjected to this same bifurcation process in the next year, after their number has been reduced due to demolition. This cycle continues through the 50-year period, with some housing units receiving their initial intervention each year and units without an initial intervention that year moving on to be considered in the following year. The current national birth rate, adjusted in future years to reflect expected changes in the national birth rate, is applied to each of the 312 housing types used in this analysis. (Battelle, 1997)

Each year, the housing units in group one (those experiencing their first birth) move to stage 3. Initial intervention activities that will bring the unit into compliance with the lead hazard standard are identified. In addition, all activities that will need to be repeated for that housing unit are identified and their timing determined based on the assumptions that the newborn will live in the unit for at least six years, and assumptions about future birth and demolition rates (Battelle, 1997). Using the unit costs specific to each intervention activity, developed later in this chapter, and a 3 percent discount rate, the discounted present value of costs to be incurred due to this stream of activities is calculated (see Exhibit 5-1.B).

[3] All units will need to be inspected at the time the birth of the initial child occurs in the unit, and inspection costs are incurred at that time.

Exhibit 5-1.A
Determining Total Costs

Each of the 312 housing unit types in the HUD dataset is analyzed year-by-year over a 50-year period, as follows:

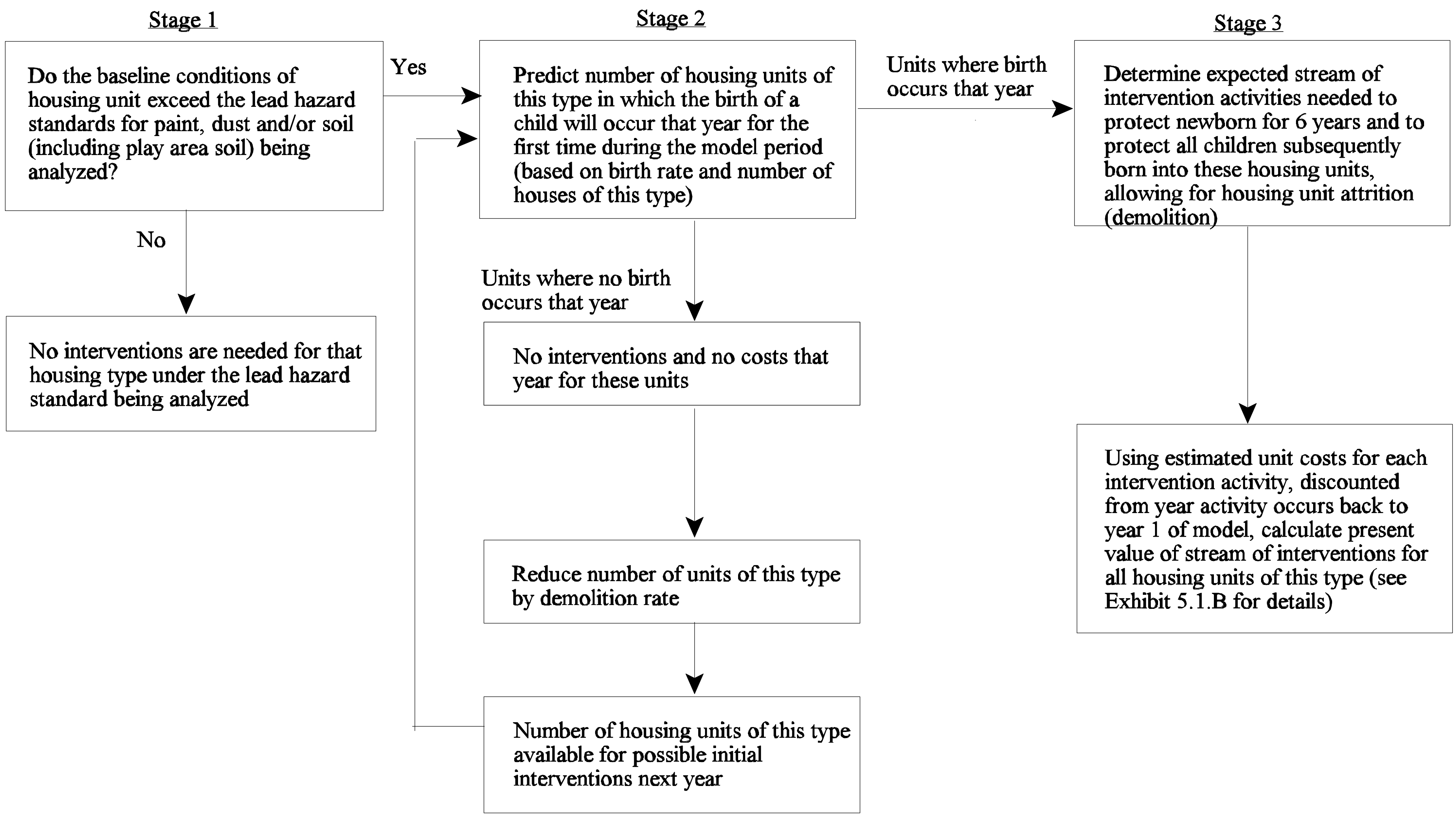
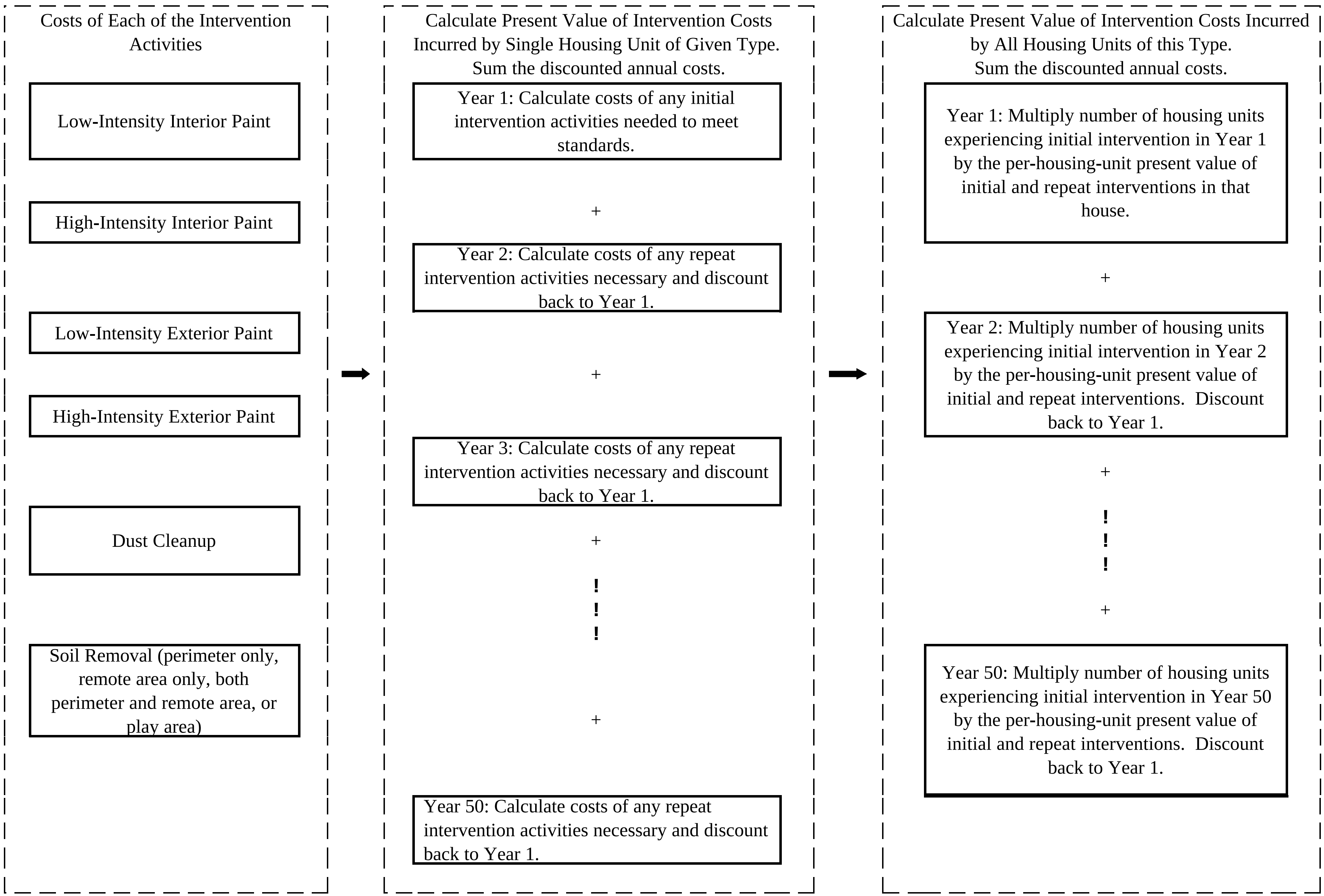


Exhibit 5-1.B
Determining Total Costs — Estimating Present Value of Aggregate Costs



Since the present value of all costs to be incurred by a single housing unit over the life of the model is calculated at the time the initial intervention action is taken, this group of housing units drops out of any further cost calculations under the lead hazard standard. Each year, another group of housing units of this type experiences their initial interventions and the present value of all the costs to be incurred by those units is calculated.[4] The total costs for all units experiencing initial interventions in a given year are calculated. The present value of the aggregate costs for all units over all years, is calculated by discounting the present value of intervention costs from the year the initial intervention takes place back to the first year of the model and summing discounted costs across all years.

The next sections of this chapter describe the development of the intervention-specific costs, including the matching of intervention activities to baseline conditions of housing units, and estimates of the number of homes exceeding the candidate hazard standards. Section 5.3 summarizes the differences between EPA's approach to estimating costs (as presented in this document) and the approach employed by the U.S. Department of Housing and Urban Development (HUD) in its *Regulatory Impact Analysis of the Proposed Rule on Lead-Based Paint* (HUD, 1996). Section 5.4 describes the data used in the cost analysis. Section 5.5 presents cost estimates for each of the lead hazard evaluation activities, while Section 5.6 offers cost, duration, and effectiveness estimates for each of the intervention activities. Section 5.7 presents the impact of alternative candidate hazard standards in terms of number of homes that exceed the candidate standards. The final section compares the rate of intervention activities assumed in this normative analysis with likely rates of activity, and discusses the likely costs of interventions.

5.3 EPA and HUD Approaches to Estimating Costs

While this analysis draws on the cost estimates developed by HUD for its *Regulatory Impact Analysis of the Proposed Rule on Lead-Based Paint* (HUD, 1996), for reasons described below the analysis uses somewhat different estimates of unit- or activity-specific costs.

5.3.1 EPA Approach

The §403 regulations will designate separate lead hazard standards for soil, dust, and paint that protect the public from adverse health effects. Given that hazard standards are set independently for each medium, costs were estimated on a medium-specific basis, and housing owners are assumed to respond to the hazard levels on a medium-by-medium basis.

It is difficult to predict the exact mix of actions the public will take in response to the lead hazard standards because the §403 regulations are voluntary and there are a variety of possible intervention approaches. Therefore, for purposes of this analysis, a set of reasonable intervention choices was defined for each medium. The types of intervention actions to be undertaken were designated as a function of the level and characteristics of the lead hazard (e.g., concentration of lead in the soil, condition of lead-based paint) in a housing unit. This analysis estimated costs for two levels of paint intervention (high and low-intensity), and one each for dust and soil.

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[4] Since all the units of a given housing unit type have the same baseline characteristics, the discounted present value of the costs to be incurred by one of these units is the same for all units of this type experiencing their initial intervention in the same year. The discounted present value of costs for this housing unit type will differ among different years of initial intervention, hazard standards, and across different housing unit types.

This approach represents a compromise between estimating a single cost for each medium (dust, soil, and paint) and establishing cost estimates for a range of detailed lead hazard reduction activities. Data limitations greatly complicated the cost estimation process. Few data were available on the public responsiveness to lead hazards. Secondly, variation in housing units confounded the derivation of unit costs. Furthermore, the limited environmental data collected in the HUD National Survey of Lead-Based Paint in Housing imposed constraints on the level of detail at which costs could be calculated.

5.3.2 HUD Approach

In its *Regulatory Impact Analysis of the Proposed Rule on Lead-Based Paint*, HUD presented a cost-benefit analysis of requirements for evaluation and hazard reduction activities in federally-owned and federally-assisted housing (HUD, 1996). To do this, HUD estimated costs for various intervention activities based on information from abatement experts and the Task Force Report (*Lead-Based Paint Hazard Reduction and Financing Task Force*, 1995). Costs were assigned to activities covered by the HUD requirements. This process was simplified by the fact that specific intervention activities (e.g., visual evaluation, interior paint repair, exterior paint repair, and area cleanup) were designated for each type of federally-owned and federally-assisted housing in the requirements.

5.3.3 Differences Between the Approaches

There are two significant differences between the EPA and HUD approaches to estimating costs. First, HUD estimated evaluation and intervention costs at a more disaggregated level than that used in this analysis. For example, cleanup activities, clearance testing, and window work were separate interventions in the HUD analysis, while they were combined and included within the medium-specific interventions of this analysis. The distinction arises because the HUD requirements specifically dictate which interventions occur and what activities comprise interventions. Because the §403 regulations are voluntary, they do not specify any particular actions that must be taken. These voluntary responses may not include all the activities specified under the HUD regulations. Alternatively, some people may choose to do more than HUD would require. This analysis, therefore, provides estimates of the costs associated with average or reasonable levels of hazard reduction work done voluntarily by housing owners.

A second notable difference is that HUD distinguished between the incremental costs associated with lead hazard reduction activities and the costs incurred in painting or other rehabilitation activities that would have been performed in the absence of the requirements. For example, the costs of scraping and repainting a room containing lead-based paint were compared with those of repainting a room without taking precautions for lead to derive the incremental cost of such an intervention. HUD assumed that paint and rehabilitation costs not associated with lead abatement were offset by the market value of benefits associated with improved housing conditions. Subsequently, their analysis only included the incremental costs in designating the net benefits of the rule. The analysis presented here does not separate costs in this fashion largely because the housing units covered under the §403 regulations are privately owned. In contrast to private housing, public and federally assisted housing benefit from federally assisted painting and rehabilitation programs. This analysis assumes that private units are already maintained to the level at which additional expenditures do not return equal or greater offsetting financial benefits. Intervention costs include the full costs of lead hazard reduction. Benefits in the form of increased market value were not considered.[5]

Where appropriate, this analysis combined the cost estimates developed by HUD for their RIA with other data to calculate intervention cost estimates. Sources in addition to the HUD data were used because in some cases it was not clear what activities were included in the HUD estimates and because of the wide scope of the §403 regulations. The HUD RIA (HUD, 1996) provided limited information on the sources of the cost data employed. Alternative sources of data were located when the HUD RIA sources could not be identified or when the HUD RIA did not provide cost estimates for an activity (e.g., lead hazard screen, soil removal) included in this analysis.

5.4 Data Sources

Costs were estimated for specific evaluation and intervention activities. Cost estimates were derived for three types of evaluation activities, two levels of intervention for interior and exterior paint, and one level of intervention for dust hazard reduction and one soil hazard intervention. Separate cost estimates were generated to apply to alternative amounts of soil removed. Primary sources of data used by this analysis included:

- the *Comprehensive and Workable Plan for the Abatement of Lead-Based Paint in Privately Owned Housing: Report to Congress* (HUD, 1990);
- the National Center for Lead-Safe Housing's SpecMaster Database of intervention costs (NCLSH, 1995) and a NCLSH report on lead hazard control for non-profit housing organizations (NCLSH, undated);
- the *Lead-Based Paint Hazard Reduction and Financing Task Force* report (Task Force, 1995)
- the 1996 HUD RIA on lead paint hazards in federally-owned and federally-assisted housing (HUD, 1996);
- *Hometech's Remodeling and Renovation Cost Estimator* (1996);
- *R.S. Means' Repair and Remodeling Cost Data* (1996);
- *American Housing Survey* (HUD, 1995);
- interviews with HUD research grantees (state and local governments) working on lead interventions; and
- selected interviews with lead testing and abatement firms, as well as landscapers, commercial cleaning services, and hazardous waste disposal firms.

Cost estimates are presented for the evaluation and intervention activities in Sections 5.5 and 5.6, respectively. Where appropriate, estimates from various sources were combined to assure reasonable unit cost estimations. Descriptions of lead hazard characteristics by housing units were based on the HUD National Survey data, and the extent of these lead hazard characteristics dictated the intervention activities that occurred in each unit.

[5] Likewise, the analysis did not include any potential decline in market value for housing units that do not receive hazard reduction activities even though they exceed the §403 standards.

Housing conditions were compared with candidate hazard standards to determine the types of intervention activities conducted. For interior and exterior paint hazards, alternative standards are not analyzed. EPA has specified that high-intensity interventions for interior and exterior paint hazards will occur when damaged lead paint equals or exceeds 50 square feet and 100 square feet, respectively. Low--intensity interventions for interior paint hazards will occur when damage is more than 22 square feet but less than 50 square feet, and for exterior paint hazards when damage is more than 10 square feet but less than 100 square feet. Alternative lead hazard standards are analyzed for soil and dust interventions. While dust interventions are always conducted as part of high-intensity interior paint and soil interventions, dust interventions were also conducted independently in homes with dust loading levels above the specified hazard level.

5.4.1 Uncertainty

The uncertainty associated with the cost estimates was largely due to data limitations. Point estimates of intervention costs were the most common data, and frequently the exact services and/or methods included in a single intervention estimate were not described in the data. This lack of complete information occurred often for paint interventions, for which the information on the area and types of surfaces stabilized or abated and the post-intervention testing were not clearly specified.

Intervention methods will change over time, as information on effectiveness becomes available and technology changes. This analysis applied unit cost estimates from the available data to the period from 1997 to 2046. Future prices are unknown and it remains unclear whether the use of current prices will overstate or understate the real costs of testing and abating. For example, with more competition in the intervention market, prices may decrease in the future. Conversely, future prices may rise as standards are introduced, because of training costs and performance requirements. In addition to the limitations imposed by the data and lack of knowledge about future costs of intervention methods, variation in the housing stock and regional prices introduced uncertainty into the costs of testing and conducting interventions to address lead hazards.

Additional uncertainty arose from the modeling of hazard reductions. The impact of interventions was modeled using effectiveness and duration estimates provided by Battelle (1997). In some cases, limited information was available on effectiveness or duration of intervention activities for lead hazards; some data on effectiveness with respect to changes in blood lead levels and dust lead loadings were available. The assumptions about effectiveness and duration may have significant, but unknown, effects on the model results. Effectiveness and duration estimates are presented for each intervention activity in Section 5.6.

5.4.2 Multifamily Housing Considerations

Single-family housing unit cost estimates served as the basis for multifamily housing unit cost estimates. Buildings with greater than four units were considered multifamily buildings by the HUD National Survey (Westat, 1995). The same definition was adopted by this analysis. Based on this definition, multifamily units composed 17.5 percent of the U.S. housing stock in 1993 (DOC and HUD, 1993). Typical multifamily housing intervention costs differ from single-family housing intervention costs for several reasons, including smaller average unit sizes, shared costs for soil interventions, and the possibilities for economies of scale in testing multiple units in a single building. In conformance with HUD regulations and §402 training guidance, this analysis assumed that lead inspections in multifamily buildings use a random sampling approach, eliminating the need to test all units. By doing so, the average per-unit costs for testing were reduced in multifamily housing.[6] It was assumed that multifamily housing is predominantly rental housing and that testing will be done by landlords on entire buildings. This appeared to be a reasonable assumption because the American Housing Survey (AHS) indicated that 89 percent of multifamily units are rental units (DOC and HUD, 1993).

Adjustments for unit size, economies of scale in evaluation, and shared soil areas were made to derive multifamily cost estimates. Cost estimates for hazard evaluation, paint inspection, interior lead paint intervention, and dust intervention were reduced to reflect the smaller average unit sizes. On average, multifamily units were estimated to be 33 percent smaller than single-family units, so a factor of 0.67 was used to adjust costs.[7] Additional reductions were made in hazard evaluation and paint inspection cost estimates to account for the fewer tests required. A factor of 0.77 was used to scale costs for lead hazard screens, risk assessments, and paint inspections in multifamily housing. This factor was based on an EPA (1995a) suggestion that 23 units out of 30 (the average number of units in multifamily buildings from DOC and HUD, 1993) be tested for a statistically valid sample. If testing of multifamily units is done by individual renters or by landlords as units turn over, testing costs may have been underestimated. Economies of scale for intervening in multiple units in a single building (e.g., simultaneous paint abatements in several units of a building) were not addressed as data were not available for this adjustment. Cost estimates for exterior paint intervention were based on costs of window replacement as multifamily units do not contain much exterior LBP. Likewise, cost estimates for soil interventions were based on estimated dimensions of areas in which soil work would be done.

5.5 Hazard Evaluation Costs

Exhibit 5-2 presents the costs estimated for two types of evaluations: lead hazard screen, and risk assessment. Activities included and data sources are also displayed. A lead hazard screen is a limited assessment used to determine the absence of lead hazards in a dwelling unit. A risk assessment is a full inspection for lead hazards in a home and includes dust testing, soil testing, visual assessment of paint condition, and limited XRF or laboratory testing of paint in bad condition. Testing scenarios were based upon the HUD guidelines (HUD, 1995), EPA's risk assessment training materials (U.S. EPA, 1995b), and EPA's regulations under Section 402 of Title IV of TSCA (Abt Associates, 1995a).

In estimating costs of each lead hazard standard, the model assumes that either a lead hazard screen (for single family units without deteriorated lead-based paint) or a risk assessment (all other units) is performed. Testing is done at the time a childbirth is expected and testing is not repeated for a unit.

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6 Costs for testing multifamily buildings may be reduced even further by using a targeted sampling approach in which units most likely to contain lead hazards are sampled, but the information needed by risk assessors to do this targeting is difficult to obtain.

7 American Housing Survey (AHS) data indicated that the median size of multifamily units was 1255 square feet, the median size of single family units was 1775 square feet (DOC and HUD, 1993 as cited by HUD, 1996), and the mean size of multifamily units was 940 square feet as compared to 1,800 square feet for single family units (DOC and HUD, 1993, calculated by Abt Associates directly). Because older units are likely to be smaller than new units and single family average sizes may be skewed by very large units, such as those built in recent decades, this analysis followed HUD (1996) in estimating multifamily units affected by lead hazard regulations to be 1,000 square feet and single family units to be 1,500 square feet.

Exhibit 5-2
Summary of Lead Hazard Evaluation Costs

Type of Testing	Activities Included	Cost per Single-Family Housing Unit in 1995 Dollars	Cost per Multi-Family Housing Unit in 1995 Dollars	Source of Information
Lead Hazard Screen	inspection of paint condition, collection and analysis of two composite soil samples, collection and analysis of two composite dust samples	212		Mean of NCLSH, undated and Task Force, 1995
Risk Assessment	collection and analysis of ten individual dust samples, collection and analysis of two composite soil samples, visual inspection of paint condition, XRF and/or laboratory testing of deteriorated paint	456	235	Mean of NCLSH, 1995 and Task Force, 1995

5.5.1 Lead Hazard Screen

Single-Family Unit Cost. A lead hazard screen requires an inspection of paint condition, collection and analysis of two composite soil samples, and collection and analysis of a minimum of two composite dust samples. Two sets of estimates were identified for the cost of conducting a lead hazard screen. The first was from the NCLSH handbook (NCLSH, undated) which reported a cost of $199 for examination of paint condition, housekeeping standards, six lead dust wipe samples, and soil lead testing. The second was from the Task Force Report (Task Force, 1995), which estimates a cost for a lead hazard screen ranging from $150 to $300. The mid-point of this range was used ($225). The cost of a lead hazard screen was calculated as the average of the NCLSH (undated) and Task Force (1995) estimates: $212. The analysis assumes that all single-family housing units that do not contain deteriorated paint will perform a lead hazard screen rather than a risk assessment or paint inspection.

Multifamily Housing Cost. This analysis assumes that multifamily housing units only conduct risk assessments, rather than lead hazard screens, due to the prevalence of children in multifamily buildings as well as the risk of liability faced by landlords.

5.5.2 Risk Assessment

Single-Family Unit Cost. A risk assessment is a full inspection of lead hazards in a home, including: dust testing, soil testing, visual assessment of paint condition, and limited XRF or laboratory testing of paint in bad condition.[8] NCLSH (1995) provided a figure of $537 per dwelling unit but did not indicate the

[8] A typical testing plan requires a visual inspection of paint condition and determination of the lead content of painted surfaces by either in situ analysis using a portable x-ray fluorescence (XRF) analyzer or by off-site laboratory analysis of paint chip samples. X-ray fluorescence analysis has the advantage of being faster, cheaper, and non-destructive when compared with laboratory paint chip analysis. However, XRF readings are not as accurate as laboratory analysis (HUD, 1990). Chemical spot testing is cheaper than XRF testing but is not accurate enough for quantitative analysis (HUD, 1995).

activities included in the assessment. The Task Force (1995) indicated a range of risk assessment costs of $200 to $500, with an average of $375 for single-family units and $260 for multifamily units (assuming that composite dust sampling is used). The risk assessment cost estimate for a single-family unit was calculated as the average of the NCLSH (1995) and Task Force (1995) single-family estimates: $456. This analysis assumes that all single-family housing units containing deteriorated lead-based paint will perform a risk assessment rather than a lead hazard screen or paint inspection.

Multifamily Housing Unit Cost. The cost of a risk assessment in a multifamily unit was estimated by multiplying the single-family cost of $456 by a factor of 0.67 to reflect the smaller size of multifamily units. See Section 5.4.2 for a complete discussion of this factor.

$$\$306 = 0.67 \times \$456$$

The analysis calculates the total cost of evaluating a multifamily *building* based on the assumption that 23 units out of 30 (the average number of units in a multifamily building from DOC and HUD, 1993) require a risk assessment. This ratio was based on an EPA (1995a) suggestion that 23 units out of 30 be tested for a statistically valid sample. If testing of multifamily units is done by individual renters or by landlords as units turn over, testing costs may be higher. Economies of scale in testing and intervening in multiple units in a single building were not addressed as data were not available for this adjustment. In addition, given assumed birth rates, the normative analysis assumes that at least one child is born into every multifamily building in year one; thereby triggering a risk assessment in all multifamily buildings and soil removal where required in year one. In contrast, interior actions taken to abate the lead hazards identified by the risk assessment occur on a unit-by-unit basis as children are born into the multifamily unit.

5.6 Intervention Costs

Exhibit 5-3 summarizes the intervention cost estimates for lead in dust, paint, and soil. In addition to the cost estimates, Exhibit 5-3 lists the activities included and the data sources. The approach used to estimate costs for the different intervention elements is discussed below. High and low-intensity intervention methods are discussed where appropriate. Duration and effectiveness assumptions are also addressed. These assumptions were based on Battelle (1997).

Exhibit 5-3
Summary of Intervention Costs for Lead in Dust, Paint, and Soil

Intervention	Activities Included	Cost per Single-family Housing Unit in 1995 Dollars	Cost per Multi-family Housing Unit in 1995 Dollars	Source of Information
Dust	HEPA vacuuming of all floors, woodwork, window wells, and furniture. Wet wipe-down of unit with lead-specific detergent. No replacement of contaminated furniture or carpets included.	391	262	Mean of NCLSH, 1995 and NCLSH, undated
High-intensity interior paint	Complete encapsulation, enclosure, or removal of LBP, including replacement of windows. Includes post-intervention dust cleanup with HEPA vacuum and clearance testing.* Multifamily cost includes disposal of hazardous waste.	6,587 (4,744 in repeat years)	4,687 (3,450 in repeat years)	Mean of Lim, 1996; HUD, 1996; and lower bound of range in NCLSH, undated
Low-intensity interior paint	Paint stabilization in one room: repair of damaged LBP, repainting, covering and sealing window wells and sills, post-intervention dust cleanup in room where work was done, and clearance testing.*	437	437	Mean of HUD, 1996 and NCLSH, undated
High-intensity exterior paint	Single-family: Complete encapsulation, enclosure, or removal of LBP. No dust intervention afterwards in interior of unit. Multifamily: Replacement of seven windows.	5,706	2,275	Mean of HUD, 1996 and NCLSH, undated for single-family; cost of window replacement from Santucci (pers. comm.) for multifamily
Low-intensity exterior paint	Single-family: Repair of damaged LBP. Multifamily: Stabilization of seven windows.	807	182	Mean of HUD, 1996 and NCLSH, undated for single-family; cost of window stabilization from NCLSH (1995) for multifamily
Soil removal	Soil removed up to a depth of six inches and disposal in a landfill. Removal may be from area away from home and/or three feet around the perimeter. Includes interior dust clean-up*.			Unit costs from *Hometech Remodeling and Renovation Cost Estimator* (1996) and R.S. Means' *Repair and Remodeling Cost Data* (1996) plus area estimates from HUD's America Housing Survey (1995) and Santucci (personal communication) .
	Removal and replacement of perimeter soil.	2,046	399	
	Removal and replacement of remote area soil.	7,878	777	
	Removal and replacement of both perimeter and remote area soil.	9,008	901	
	Removal and replacement of soil in play area	1,460	314	

* The dust cleanings performed in conjunction with the high-intensity interior paint and the soil interventions are essentially the same as the full-house "stand-alone" dust intervention listed first on this table. The dust cleaning performed in conjunction with the low-intensity interior paint intervention involves only the room where the paint intervention occurred.

5.6.1 Dust Intervention Costs

In practice, the cost of a dust intervention depends on the size of the dwelling unit and the thoroughness of the cleaning. For purposes of this analysis, dust intervention for controlling lead hazards from dust includes cleaning of the unit with a HEPA vacuum and wet mopping.

Single-family Dust Cleaning Cost. In addition to thoroughness and size of area cleaned, the cost of dust intervention depends on whether carpeting and upholstered furniture are replaced. For this analysis, the dust intervention was defined as the vacuuming of all rooms in the unit, including floors, woodwork, window wells, and furniture, with a high-efficiency particle accumulator (HEPA) vacuum, followed by a wet wipe-down of the unit with a lead-specific detergent. No replacement of furniture or carpeting was included, although this may be necessary for full cleaning of a highly-contaminated unit. NCLSH (undated) estimated a cost of $484 for cleaning a three bedroom, one-and-a-half bathroom house of moderate size after a “medium-intensity abatement.” A second NCLSH (1995) source provided an estimate of $48 per room for HEPA vacuuming followed by a wash with TSP (a lead-specific detergent) and a second HEPA vacuuming. At an average of 6.2 rooms per single-family house (DOC and HUD,1993), this yielded an estimate of $298 per house. The final cost estimate for dust intervention in a single-family home is $391, the average of the two values.

$$\$391 = \frac{\$484 + (\$48 \times 6.2)}{2}$$

Multifamily Housing. The single-family cost for dust intervention was multiplied by a factor of 0.67 to reflect the smaller size of multifamily units. The resulting cost estimate is $262, as shown below. See Section 5.4.2 for a complete discussion of this factor.

$$\$262 = 0.67 \times \$391$$

Effectiveness. The effectiveness of dust cleaning depends on the circumstances in which it is used and whether post-intervention lead levels are measured in terms of loadings or concentrations. Battelle (1997) estimated that a single cleaning would bring floor dust lead loading levels to 40 $\mu g/ft^2$ or the pre-intervention levels, whichever is less. Window sill dust lead loadings would be brought to either 100 $\mu g/ft^2$ or the pre-intervention levels. Based on Battelle (1997), post-intervention dust-lead concentrations will vary depending on:

- whether or not a soil intervention also occurs;
- whether or not a paint intervention has occurred, and, if not, whether any deteriorated lead-based paint exists in the housing unit;
- whether or not a dust cleaning has occurred in a situation where no soil or paint intervention occurred and no deteriorated lead-based paint exists in the housing unit.

See Battelle (1997) for details on calculating post-intervention concentration levels.

Duration. The duration of dust abatement also depends on the circumstances in which it is used. The dust intervention was assumed to be effective for four years based on a report by Battelle (1997). In situations where a dust cleaning is performed immediately preceding the birth of a child, and no soil nor paint intervention occur, then the dust cleaning is repeated in four years to continue the protection of that child.

5.6.2 Paint Intervention Costs

Estimated costs of interior lead paint intervention vary widely, in part due to differences in the extent of intervention. For example, replacing windows is less expensive than removing all the molding, doors and wall paint. Additional variation is due to the size of the homes abated and regional price variations. Several general cost estimates for lead paint intervention existed, but few could be used here because the work included in the interventions was not specified. Instead, estimated costs from sources that provided information on the specific activities involved and the size of the unit abated were employed. Two degrees of paint intervention are considered: high-intensity, where paint damage is extensive, and low-intensity, where paint damage is limited to a relatively small area.

Interior Paint Intervention

Single-Family High-Intensity Cost. A high-intensity paint intervention involves encapsulation, enclosure or removal of LBP in the housing unit, including removal of windows with LBP, and post-intervention cleaning using a HEPA vacuum. Several estimates from the literature were used to construct the high-intensity paint cost estimate. Lim (1996) provided a cost estimate of $6,809 for window replacement, floor smoothing, wall/door/trim treatment including encapsulation and enclosure, and unit cleanup for a small unit of up to 1,200 square feet. A second estimate was developed by combining HUD's (1996) cost estimates for interior abatement, unit cleanup, and clearance testing, plus an independent estimate of $242 for replacement of each wooden window (NCLSH, 1995) and an assumption of 12 windows, yielding a total cost of $6,504.

$$\$6,504 = \$3,000 + \$450 + \$150 + (12 \times \$242)$$

NCLSH (undated) estimated a range of $6,449 to $16,122 for work on a three bedroom house of moderate size. Their estimated cost included window replacement, enclosure of walls with gypsum, occupant relocation, and unit cleanup as well as numerous other activities. The lower bound of this range ($6,449) was used in this analysis because some of the intervention activities included in deriving the higher cost estimates (e.g., $8,383 for the abatement of a 2-story townhouse) were not included as part of the defined high-intensity paint intervention. Averaging the Lim estimate ($6,809), the HUD estimate ($6,504), and the lower bound of the NCLSH estimate ($6,449) provided a cost estimate of $6,587 for a high-intensity paint intervention in a single-family home. While this estimate may be low for removal of LBP from all surfaces of all rooms in a large unit, it is reasonable for units with a mixture of LBP and non-LBP and for encapsulation methods.

The analysis estimates costs over a 50-year time frame; therefore, high intensity interior abatements (assumed to have a duration of 20 years) may occur up to three times in one home. However, the estimated cost of a high intensity interior abatement includes some permanent measures that are not recurring, such as the replacement of windows. The cost estimates for repeat high-intensity paint interventions, therefore, exclude window replacement costs. Deducting window replacement costs used in each estimate from Lim

(1996) and HUD (1996) results in an estimated cost of $5,646 and $3,842, respectively. The final cost estimate for a repeat high intensity paint intervention is $4,744, the average of the two values.

Single-Family Low-Intensity Cost. Low-intensity paint intervention includes stabilization of the deteriorated interior LBP in a room, including repair of the LBP, covering and sealing the window sills and wells to ensure cleanability, and cleanup in the room. Using cost estimates from NCLSH (undated) for paint repair, work on two windows, and dust cleanup in the room, a cost of $311 was estimated for a single-family unit.

$$\$311 = \$215 + (2 \times \$27) + \$43$$

Combining cost estimates from HUD (1996) for interior paint repair ($500), window work on two windows ($50), and area cleanup ($13 based on $0.05 per square foot for non-HEPA vacuuming from Task Force (1995)), a second cost estimate of $563 was developed. The analysis assumes an average room size of 250 ft^2 for a single-family home.

$$\$563 = \$500 + (2 \times \$25) + \left(\frac{\$0.05}{ft^2} \times 250\ ft^2 \right)$$

The average of these two values was $437, and this was employed as the estimate of the cost of low-intensity paint intervention in a single-family home. As indicated, the cost estimate for low-intensity paint intervention included dust cleanup only in the area where work was completed.

Multifamily High-Intensity Cost. The estimate of intervention costs for high-intensity paint intervention for multifamily housing was based on the single-family cost adjusted by a factor of 0.67 to reflect the smaller size of multifamily units. This scaling resulted in an estimate of $4,413 for high-intensity intervention in multifamily housing units.

$$\$4,413 = 0.67 \times \$6,587$$

Again, the analysis estimates costs over a 50 year time frame; therefore, an estimate was required that excluded any permanent measures undertaken the first time the house was abated. This was accomplished by scaling the single-family repeat intervention costs (i.e., $4,744) by a factor of 0.67, generating a value of $3,178. In cases where exterior interventions are triggered at the same time interior paint interventions are occurring, the scaled cost of $3,178 is used in order to avoid the double counting of window replacement costs incurred as a result of the exterior abatement.

Portions of the waste generated from abatements on multifamily housing units may be subject to Resource Conservation and Recovery Act (RCRA) hazardous waste requirements. Under current regulations, only those portions of the waste that fail the Toxicity Characteristic Leaching Procedure (TCLP) for lead are considered hazardous waste. Disposal costs depend on the quantity being discarded. In the HUD abatement demonstration project, which involved extensive abatement, 217 pounds of hazardous waste, not including architectural debris, were generated per housing unit, and cost $274 to discard (U.S. EPA, 1992). All high-intensity, interior multifamily abatements are assumed to incur this incremental waste disposal cost. The cost estimates assume that architectural debris is not handled as hazardous waste (Abt Associates, 1995b).

Multifamily Low-Intensity Cost. Since low-intensity paint intervention was limited to work in one room, costs were not assumed to vary between single-family and multifamily housing. Therefore, the single-family estimate of $437 was used for multifamily units.

This analysis assumes that all interior hazard control work (high and low-intensity) in multifamily homes will be conducted on a unit-by-unit basis as children are born into the home.

Effectiveness. High-intensity interior paint interventions were assumed to have an effectiveness equivalent to that of the dust intervention described earlier in terms of dust lead load. All paint interventions reduce dust lead concentration as specified by Battelle (1997), and eliminate the source lead that would otherwise be available to children exhibiting pica.

Duration. The high-intensity paint intervention was assumed to have a duration of 20 years. Low-intensity paint interventions and the accompanying dust cleanup of the room where the work occurred were assumed to last for four years. In other words, to provide continued protection from exposure, low-intensity paint interventions will need to become repeated once during the first six years of a child's life.

Exterior Paint Intervention

Single-Family High-Intensity Cost. High-intensity exterior paint intervention involves full encapsulation or removal of all exterior LBP from a housing unit. Cost estimates reported in the literature varied according to the activities undertaken and the size of the area abated. HUD (1996) estimated the cost of encapsulation or removal of exterior LBP and interior cleanup from a single-family home of about 1,500 square feet and interior cleanup as $5,500. The NCLSH handbook (undated) provided an estimate of $5,911 to $16,122 as the cost of a complete exterior paint job designed to fully enclose LBP on the exterior of a three bedroom house of moderate size. The associated duration of interventions was reported to range from 20 to 60 years (NCLSH, undated). The lower bound of the NCLSH estimates was used since this analysis is interested in a 20 year duration. The average of the HUD (1996) estimate ($5,500) and the lower bound of the NCLSH estimate ($5,911) was $5,706, which was used for the single-family unit cost of high-intensity exterior paint intervention.

Single-Family Low-Intensity Cost. The low-intensity paint intervention cost was derived by averaging two cost estimates. Low-intensity exterior paint intervention involved repair of all damaged exterior LBP. The first estimate of $613 was reported in the NCLSH handbook for exterior paint repair plus complete paint work up to a height of five feet (NCLSH, undated). The second cost of $1,000 was estimated in HUD (1996) and included exterior paint repair for one side of a single-family house of 1,500 square feet. The average of these estimates ($807) was the cost estimate used by this analysis for low-intensity paint intervention in single-family homes. While this estimate may be low for homes needing extensive paint repair, it was likely to be reasonable for homes needing a moderate level of work.

Multifamily Housing. Multifamily buildings are not likely to have extensive amounts of exterior LBP, based on data from the HUD survey and the American Housing Survey (AHS). HUD (1990) indicated that multifamily units account for 5.5 percent of the total amount of exterior LBP, even though these units (greater than four units per structure) represented 17.3 percent of the total housing units in the 1993 AHS. The cost consultant for the National Center for Lead-Safe Housing indicated that most exterior LBP on multifamily buildings would be present on windows and fire escapes, since most multifamily buildings, and particularly the larger ones, are masonry structures (Santucci, pers. comm.). For this analysis, exterior paint intervention was considered to be repair or replacement of the windows in the multifamily unit; information about the prevalence of fire escapes in multifamily buildings was not available. Using an estimate of seven windows per unit,[9] and using the cost of stabilizing a window of $26 (NCLSH, 1995), the cost for low-intensity exterior paint intervention for multifamily units was $182. For high-intensity exterior paint abatement, the cost was estimated as the cost of replacing seven windows. Santucci (pers. comm.) estimated a cost of $250 to $400 for replacement of a window opening in a multifamily building. Using the midpoint of this range, the cost for the whole unit was $2,275. For those units that need encapsulation or enclosure of exterior walls or work on fire escapes, this estimate may be low. For other units, this cost may be high as not all windows may need replacement. For example, NCLSH (1995) estimated the cost of encapsulation of both interior and exterior window components at a cost of $43 per window, which was much cheaper than replacement. All multi-family *buildings* are assumed to conduct exterior paint interventions in year one if required by lead-hazard levels.

Effectiveness. All exterior paint interventions reduce dust lead concentrations as specified by Battelle (1997) and eliminate the source of lead that would otherwise be available to children exhibiting pica.

Duration. Low-intensity exterior paint intervention measures are assumed to have a duration of four years based on a report by Battelle (1997). A high-intensity exterior paint intervention is assumed to have a duration of 20 years, again, based on Battelle (1997).

5.6.3 Soil Removal Costs

The costs of soil intervention vary with the size of the area treated, the method used, and whether or not the waste is considered hazardous under RCRA. Residential soil intervention is a relatively new industry and no standards have been established on what constitutes an effective intervention other than removal.

Single-Family Soil Removal Cost. This analysis defines a soil intervention as the removal of topsoil to a depth of six inches, replacement with uncontaminated soil, raking and seeding, and disposal of lead contaminated soil. Three areas of the yard are potentially subject to a soil removal: around the perimeter of the unit, which is the area likely to be affected by the chipping of exterior LBP, remote areas away from the foundation, and the play area (if any). Unit costs for soil removal and replacement are based on the

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[9] This estimate of seven windows was based on personal communication with Gopaul Ahluwalia at the National Association of Home Builders, 1993. Mr. Ahluwalia estimated the average number of windows in a new single-family home (17) and the average number per unit in a new multifamily apartment building (9) based on a recent construction-material-usage data base. There were two trends in home building that needed to be considered before using these estimates as the number of windows present in homes built prior to 1980 (our population of interest for lead abatement). The first is that new homes are larger now than in the past and second, homes are currently built with more windows to increase light in the house. No quantitative information was available about the latter trend, but the former trend, was compensated for by multiplying the 1993 average number of windows by the ratio of the average square feet per single-family home in 1980 to the footage estimated for 1993 (1600 ft^2/2100 ft^2). This resulted in an estimate of 13 windows per average single-family home and 7 windows per unit for a multifamily dwelling built in 1980.

Hometech Remodeling and Renovation Cost Estimator (1996). Removal and replacement activities include: soil removal using a small backhoe, backfilling using a small backhoe, replacement soil costs, and raking and seeding of the yard. The Hometech Cost Estimator recommends an opportunity cost of $525 for use of a backhoe. In addition, costs are included for the transport and disposal of lead contaminated soil. Landfill disposal costs are based on Perket (1994) and are specific to non-hazardous waste. U.S. EPA provides an estimate of $0.22 per ton-mile for the transport of bulk solids. Unit costs are presented in Exhibit 5-4.

Exhibit 5-4
Unit Cost Estimates for Soil Removal - Single-Family

Abatement Activity	Unit Cost
Soil removal using a small backhoe*	$6.08/yd^3 (+$525)
Backfill using a small backhoe*	$0.20/ft^2
Replacement soil cost	$40.00/yd^3
Raking and seeding (by hand)	$0.30/ft^2
Landfill (non-hazardous)	$35/ton
Soil Transportation	$0.22/ton-mile

* A small backhoe is defined to have a 1/2 cubic yard bucket.

In order to calculate the total cost of conducting a soil abatement, the unit cost estimates were combined with estimates of the size of the area likely to treated. As described above, three areas of the yard are potentially subject to a soil removal -- perimeter areas and two types of yard areas away from the foundation (i.e., remote areas). The HUD data do not provide any information on the size of the yard or perimeter area; therefore, data from the American Housing Survey (AHS) were used to estimate these values for an average single-family home based on lot size, square feet within the house, and the number of floors in the house. To summarize the methodology: 1) the house's footprint (i.e., the amount of land covered by the building) was estimated by dividing the square footage of the house by the number of floors in the home; 2) from the footprint of the house, a perimeter was extrapolated (assuming a uniform shape for all homes); 3) from the perimeter of the home, an estimate of the perimeter area extending three feet from the foundation of the home was calculated; and 4) the remote area was based on yard size (calculated by subtracting the perimeter and footprint areas from the total size of the lot). The average area addressed in the removal of soil from the perimeter of a single-family home is 417 ft^{2,} and the average remote area is 2,571 ft^2. For a detailed description of the methodology, refer to Appendix 5.A. In addition, EPA assumed that the average single-family home play area is 200 ft^2.

Exhibit 5-5 provides a summary of the total soil removal costs for abating the perimeter area, remote area, perimeter and remote areas together, and play area alone. Added to each of these costs is the cost of a single-family interior dust cleanup ($391) described in Section 5.6.1. Soil transportation costs are calculated assuming a distance of 100 miles to the landfill. Economies of scale are achieved if soil is removed from both the perimeter and remote area due to the opportunity cost of using a backhoe as well as the cost of an interior dust cleanup.

Single-Family Hazardous Waste Disposal of Soil. In cases of highly-contaminated soil, the cost of disposal of soil as hazardous waste is added to the soil intervention cost. Soil is considered hazardous if it fails the Toxicity Characteristic Leaching Procedure (TCLP) for lead. Many factors affect the leaching characteristics of lead in soil, including the soil type and pH. While there is great variability in response to the TCLP test, soil is unlikely to fail the test if concentrations of lead are less than 2000 ppm (Spittler, pers. comm.). The analysis conservatively assumes that houses with a soil lead level greater than 2000 ppm will fail the test, and these houses will incur the additional soil disposal costs. The incremental costs triggered by the handling of soil as hazardous waste are calculated based upon: 1) the average quantity of soil likely to be removed during a soil intervention; and 2) the per ton price for bulk treatment and disposal of waste at a RCRA Subtitle C facility. As discussed above, the analysis assumes an area of 417 ft^2, 2,571 ft^2, and 200 ft^2 for soil removal from the perimeter, total remote, and play area, respectively. Assuming that six inches of topsoil are removed, a volume of 8 yd^3 is removed from the foundation and/or 48 yd^3 from areas away from the foundation, or 3.7 yd^3 if only the play areaa is being addressed.

Perket (1994) estimated a cost of $174 per ton for bulk waste disposal, including treatment costs, in a RCRA Subtitle C facility based on a survey of hazardous waste landfill prices. A portion of this cost is deducted to calculate the incremental cost of handling and disposing of the soil as a hazardous waste. The data used to estimate the cost of a soil abatement already include the cost of disposing of the soil as a non-hazardous waste. To avoid double counting, the disposal cost of $174 per ton for hazardous waste was reduced by $35 (i.e., the per ton cost for landfilling as non-hazardous waste), resulting in a cost of $139 per ton.

Assuming 1.3 tons per cubic yard, results in the disposal of 10 tons of contaminated soil from the perimeter of the home and/or 62 tons from the remote area of the yard or 4.8 tons from the play area alone. Multiplying these quantities by the incremental cost of disposal ($139), resulted in a total incremental cost of hazardous soil disposal of $1,397 (perimeter only), $8,608 (remote area only), $10,005 (both perimeter and remote area) and $669 (play area). If soil is removed from both perimeter and remote areas, but only one of the two areas exceeds the lead concentration of 2000 ppm, hazardous waste disposal costs may or may not be incurred. They will not be incurred if the average lead concentration of all soil removed is under 2,000 ppm, following soil mixing. If mixing could not reduce soil lead concentration beneath this threshold, then it will not be performed, and hazardous waste disposal costs will be incurred only for the soil fraction exceeding 2000 ppm.

Exhibit 5-5
Soil Abatement Costs - Single-Family Home

Abatement Activity	Unit Cost ($)	Perimeter (area or soil quantity)	Remote (area or soil quantity)	Play Area (area or soil quantity)	Total Perimeter Cost ($)	Total Remote Area Cost ($)	Total Perimeter and Remote Area Cost ($)*	Total Play Area Cost ($)
Soil removal using small backhoe	6.08/yd^3 (+$525)	8 yd^3	48 yd^3	3.7 yd^3	572	814	861	547
Backfill using small backhoe	0.20/ft^2	417 ft^2	2,571 ft^2	200 ft^2	81	501	583	40
Replacement soil cost	40.00/yd^3	8 yd^3	48 yd^3	3.7 yd^3	309	1,904	2,213	148
Raking and seeding (by hand)	0.30/ft^2	417 ft^2	2,571 ft^2	200 ft^2	125	771	896	60
Landfill (non-hazardous)	35/ton	10 tons	62 tons	4.81 tons	352	2,166	2,518	168
Soil transportation costs	22/ton (100 miles to landfill)	10 tons	62 tons	4.81 tons	216	1,330	1,546	106
Interior dust cleanup	391/home	NA	NA	NA	391	391	391	391
Total (non-hazardous)					2,046	7,878	9,008	1,460

* Represents certain economies of scale if soil is removed from both perimeter and remote area.

Multifamily Soil Removal Cost. Estimating soil removal costs for multifamily units required knowledge of the average number of units in a multifamily building, the size of the area being abated, and the unit costs for each of the soil removal activities (e.g., raking and seeding). Again, three areas of the yard are potentially subject to soil removal: perimeter areas and yard areas away from the foundation (either the entire remote area or the play area only). A different approach was used to estimate these areas for multifamily homes because the AHS does not report lot size for homes with two or more units. Santucci (pers. comm.) estimated a perimeter of 400 to 450 feet (or 1,275 ft^2 assuming an area extending three feet from the foundation of the unit) for a multifamily building of 40 units, or about 11 feet of perimeter per unit. Flaherty (pers. comm.) estimated that yards for urban multifamily buildings in the Minneapolis area were likely to be up to twice as large as single-family yards, suggesting a maximum remote area for the building of 5,142 ft^2, or 171 ft^2 per unit, based on an average of 30 units per multifamily dwelling, as estimated from the 1993 AHS. EPA assumed that the average mutli-family play area is bout 400 ft^2.

Total soil removal costs were calculated by combining these area estimates with unit costs from R.S. Means' *Repair and Remodeling Cost Data* (1996) book. The R.S. Means Cost Data book is recommended for residential, commercial, and industrial repair and remodeling projects costing between $10,000 and $1 million, and was therefore used in estimating multifamily costs. As with single family homes, removal and replacement activities include: soil removal using a small backhoe, backfilling using a small backhoe, replacement soil costs, and raking and seeding of the yard. The R.S. Means Cost Data book recommends an opportunity cost of $390 for use of a backhoe.[10] In addition, costs are included for the transport and disposal of lead contaminated soil. Landfill disposal costs are based on Perket (1994) and are specific to non-hazardous waste. U.S. EPA provides an estimate of $0.22 per ton-mile for the transport for bulk solids. Unit costs are presented in Exhibit 5-6.

Exhibit 5-6
Unit Cost Estimates for Soil Removal - Multifamily

Abatement Activity	Unit Cost
Soil removal using a small backhoe*	$7.00/yd^3 (+$390)
Backfill using a small backhoe*	$0.46/ft^2
Replacement soil cost	$40.00/yd^3
Raking and seeding (by hand)	$0.24/ft^2
Landfill (non-hazardous)	$35/ton
Soil Transportation	$0.22/ton-mile

* A small backhoe is defined to have a 1/2 cubic yard bucket.

Exhibit 5-7 provides a summary of the total soil removal costs for abating the perimeter area, remote area, perimeter and remote areas together, and play area. Added to each of these costs is the cost of a

[10] The fixed cost portion of a soil removal is greater for single family jobs than for multifamily jobs. Presumably, this reflects the fact that larger jobs provide a greater return on equipment use and thus the opportunity cost of the backhoe is less.

mutlifamily interior dust cleanup ($262 per unit) described in Section 5.6.1. Soil transportation costs are calculated assuming a distance of 100 miles to the landfill. Economies of scale are achieved if soil is removed from both the perimeter and remote area due to the opportunity cost of using a backhoe as well as the cost of an interior dust cleanup. All multifamily *buildings* are assumed to conduct soil abatements in year one if required by lead-hazard levels.

Multifamily Hazardous Waste Disposal of Soil. As discussed above, in certain cases, the cost of disposal of soil as hazardous waste is added to the soil intervention cost. Soil is considered hazardous if it fails the Toxicity Characteristic Leaching Procedure (TCLP) for lead. It is assumed that multifamily buildings with a soil lead level greater than 2000 ppm will fail the test, and will, therefore, incur the additional soil disposal costs. Soil disposal costs are calculated based upon the average quantity of soil removed and the per ton disposal cost estimated in the "Single-Family Hazardous Waste Disposal of Soil" section above. Assuming that six inches of topsoil are removed, a volume of 24 yd^3 is removed from the foundation and/or 95 yd^3 from areas away from the foundation or 7.4 yd^3 from play areas. The incremental cost of disposing of soil as hazardous waste is estimated to be $4,269 (perimeter only), $17,217 (remote area only), $21,486 (both perimeter and remote area) and $1,337 (play area) for an average 30-unit building. The same mixing principles apply as apply to single-family hazardous waste disposal of soil.

Effectiveness. Soil removal was assumed to reduce the soil lead level to 150 ppm in areas where soil was removed, based on the average of the lead levels in the replacement soil in the Urban Soil Lead Abatement Demonstration Project (Elias, 1993). Soil removal was also assumed to affect dust. The reduction of dust lead concentration was variable, depending on other interventions performed (see Battelle 1997). The dust cleaning that accompanies soil removal was assumed to reduce dust loads to 40 $\mu g/ft^2$.

Duration. Soil removal was assumed to be permanent since the topsoil containing lead was removed based on Battelle (1997). The dust effects were also assumed to be permanent as the presumed source of lead had been removed.

5.6.4 Overall Intervention Strategies

Assumptions regarding evaluation activities and intervention work determined which unit costs were associated with different housing populations. As stressed in the introduction, this analysis followed the language of the §403 regulations and assumed that individual housing owners respond to hazards on a medium-specific basis. In cases where multiple hazard levels were exceeded, adjustments were made to avoid multiple counting of costs. For example, the costs for high-intensity interior and exterior paint intervention in multifamily homes both include costs for window replacement, so adjustments were necessary in units performing both interventions.

Exhibit 5-7
Soil Abatement Costs - Multifamily Building of 30 Units

Abatement Activity	Unit Cost ($)	Perimeter (area or soil quantity)	Remote (area or soil quantity)	Play Area (area or soil quantity)	Total Perimeter Cost ($)	Total Remote Area Cost ($)	Total Perimeter and Remote Area Cost ($)*	Total Play Area Cost ($)
Soil removal using small backhoe	7.00/yd^3 (+$390)	24 yd^3	95 yd^3	7.4 yd^3	555	1,057	1,222	442
Backfill using small backhoe	0.46/ft^2	1,275 ft^2	5,142 ft^2	400 ft^2	587	2,365	2,952	184
Replacement soil cost	40.00/yd^3	24 yd^3	95 yd^3	7.4 yd^3	944	3,809	4,753	296
Raking and seeding (by hand)	0.24/ft^2	1,275 ft^2	5,142 ft^2	400 ft^2	305	1,228	1,533	96
Landfill (non-hazardous)	35/ton	31 tons	124 tons	9.62 tons	1,074	4,333	5,407	337
Soil transportation costs	22/ton (100 miles to landfill)	31 tons	124 tons	9.62 tons	660	2,661	3,321	212
Interior dust cleanup	7,852/Building (30 units per building)	NA	NA	NA	7,852	7,852	7,852	7,852
Total (non-hazardous)					11,977	23,304	27,039	9,418

* Represents certain economies of scale if soil is removed from both perimeter and remote area.

5.6.5. Enforcement Costs

There are no enforcement costs associated with §403 since it requires that the Agency set hazard standards for lead in paint, soil and dust that will be used in other sections of Title X to trigger interventions. The enforcement costs of these actions, however, are not attributable to §403 but to the section of the rule requiring the intervention. All intervention activity under §403 is voluntary and thus incurs no enforcement cost.

5.6.6 Implementation Costs

The implementation costs associated with §403 are of two types. The first is the cost of setting and promulgating the §403 hazard levels themselves; a negligible cost compared to the funding appropriated in Title X for intervention ($250 million in 1994). The second implementation cost is incurred by states or localities that voluntarily use the lead hazard standards set by the Agency as action levels in their own lead management programs. The size of these costs depends on the current level of activity at the state and local level, whether the hazard standards that the Agency sets are above or below those of the programs in place, and the number of programs that implement the hazard standards. If the Agency standards are more stringent than current practice, implementation costs could be significant. However, if the Agency standards are higher (i.e., less stringent) than those in practice, implementation costs will be negligible. If implementation costs are proportional to the number of homes affected, which could be the case if state or local authorities decided to track homes to assure intervention, then the inclusion of implementation costs in the benefit-cost analysis would favor higher hazard standards over lower ones, all other things being equal, since the number of homes to be tracked would be lower under higher hazard levels.

5.7 Number of Interventions and the Number of Housing Units that Exceed the Lead Hazard Standards

Using the normative model, the cost of any particular lead hazard standard is a function of the number of intervention actions of each type that occur and the unit cost for each of these actions. The number of intervention actions, in turn, is a function of the number of housing units that exceed the hazard standard under consideration. This section estimates the number of interventions; chapter 7 presents the resulting estimated costs and compares them to the monetary value of the benefits for various hazard standards.

As described in chapter 4, the model estimates net benefits of every combination of lead hazard standards and compares these estimates to determine which combination of standards maximizes net benefits. Due to the interactions among particular intervention actions, and the assumption that households will address all media which exceed the standards at the time of the arrival of a child, net benefits are estimated in the context of responding to each of the individual standards (paint, floor dust, windowsill dust and soil). Net benefits are not estimated for a single medium alone. For example, all soil interventions include a dust clean-up following the removal and replacement of soil. Where a soil intervention is performed, therefore, a separate dust cleaning is not required regardless of the pre-intervention level of lead in the dust. If dust standards were evaluated independent of soil interventions, the number of dust interventions would be overestimated, since it would include homes that are actually receiving their dust cleaning as part of their soil interventions. Likewise, homes that exceed both the floor and the windowsill dust standards would receive one dust cleaning not two. To avoid this potential double counting, and to properly assign costs and benefits to specific combinations of standards, the analysis estimates costs, benefits and net benefits for combinations of hazard standards.

The following subsections explore how the number and mix of interventions varies under alternative combinations of lead hazard standards. Since we are interested in illustrating the relationship between changes in a specific standard and the number of homes that exceed that standard as well as a reasonable combination of standards, each medium is investigated under the assumption that the standards for the other media are set at the option which EPA has chosen. The final option, and the number of interventions for that combination of lead hazard standards, are:

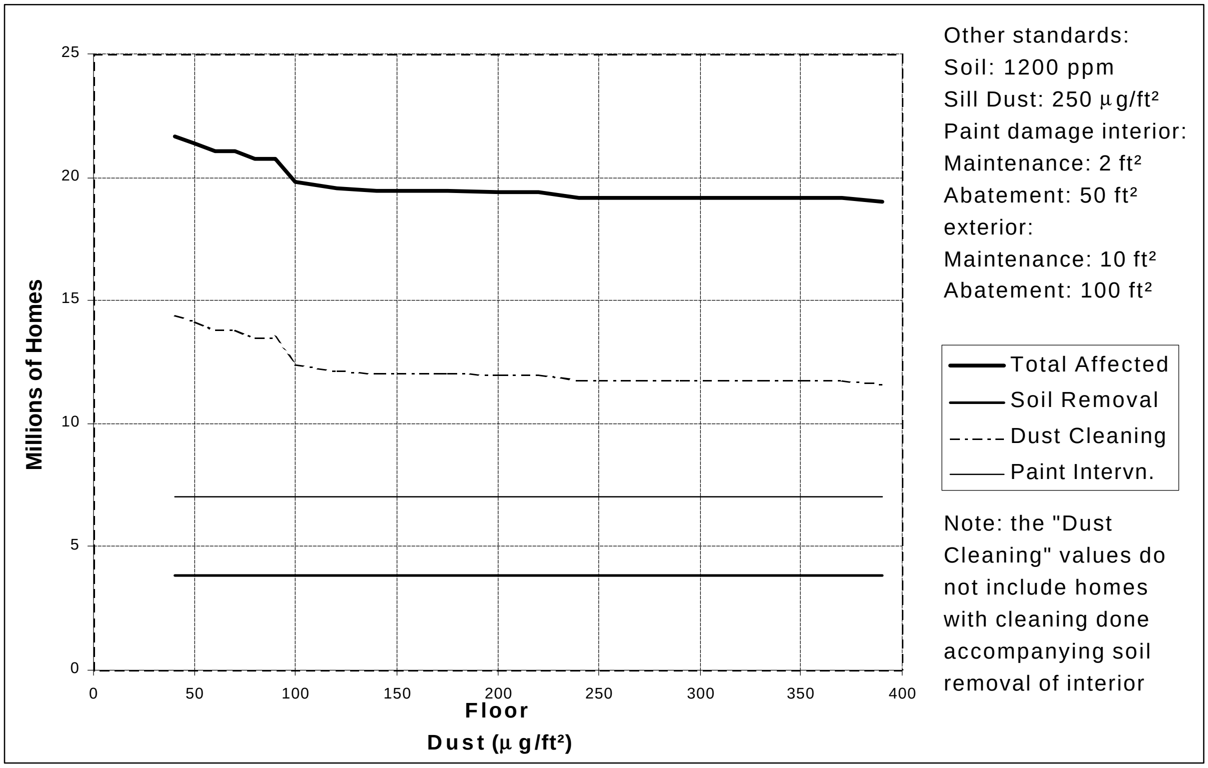
Intervention Activity	Final Standard	Number of Homes with Interventions during the Model Duration
Paint Repair/Maintenance	**Interior**: 2 sq ft or more, but less than 50 sq ft, of damaged paint **Exterior**: 10 sq ft or more, but less than 100 sq ft, of damaged paint	7.0 million homes with paint interventions
Paint Abatement	**Interior**: 50 sq ft or more of damaged paint **Exterior**: 100 sq ft or more of damaged paint	
Dust Cleaning	floor dust loading = 40 µg/ft^2, or windowsill dust loading = 250 µg/ft^2, or both	19.0 million homes with dust interventions
Soil Removal and Replacement	lead in soil = 1200 ppm	3.8 million homes with soil interventions

5.7.1 Number of Homes Performing Interventions for Alternative Floor Dust Standards

As shown in Exhibit 5-8, the number of homes performing dust interventions (not including dust cleaning associated with either paint or soil abatements), and the total number of homes performing any intervention varies only slightly with variations in the floor dust standard. The standards (shown on the horizontal axis) become less stringent as we move from left to right. The horizontal axis gives the loading of lead in the floor dust at which interventions are called for, the higher this number, the more homes that "pass" the test (i.e. the fewer homes that exceed the standard). The number of homes performing soil abatements (about 3.8 million homes at the soil standard given above -- 1200 ppm) and the number performing any form of paint intervention (about 7 million homes at the paint standard given above) do not change with changes in the floor dust standard. The total number of homes performing some form of intervention is less than the sum of homes performing soil, dust or paint interventions because some homes will perform multiple types of intervention activities.

In this exhibit, the floor dust standard varies between 40 µg/ft^2 (the assumed post-intervention dust lead loading) and 380 µg/ft^2 (the highest pre-intervention loading in the data set). The number of homes performing dust interventions is relatively insensitive to the stringency of the floor dust standards. The number of homes that perform a dust cleaning, over the model period, declines slowly for standards between 40 and 90 µg/ft^2, dipping at a standard of 100 µg/ft^2 , and declining slowly after that, approaching but staying above the number of homes that perform some form of paint interventions.

Exhibit 5-8
Number of Homes Performing Interventions (Over Model Period)



The line which represents the total number of homes performing an intervention over the model period traces a very similar path, but overall declines slightly less, indicating that some of the homes that no longer do dust interventions, as the floor dust standards become less stringent, continue to do soil and/or paint interventions. Because both paint and soil interventions are much more expensive than dust cleaning, the costs will not decline as rapidly as the total number of homes performing an intervention. At highly stringent floor dust standards (the left-hand end of the horizontal axis), homes with dust cleaning comprise a much larger percentage of total homes with any intervention than is true at the other end of the spectrum.

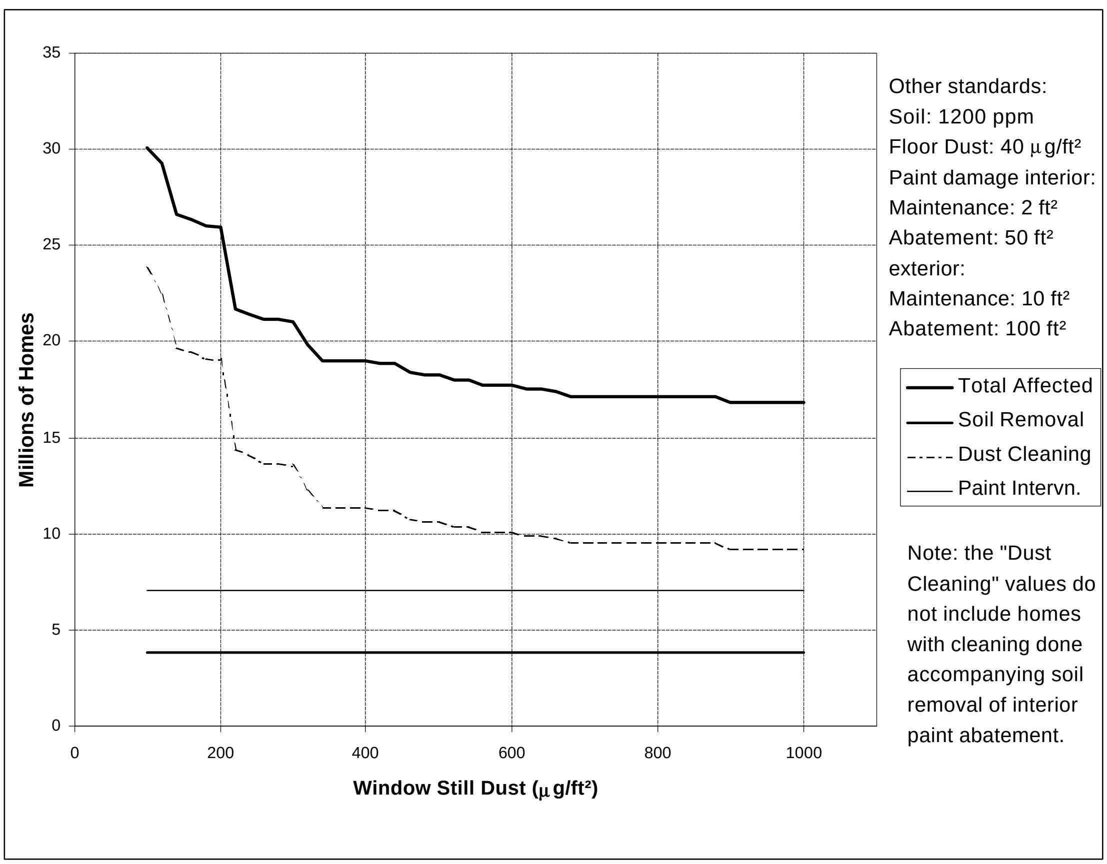
5.7.2 Number of Homes Performing Interventions for Alternative Windowsill Dust Standards

The next exhibit (Exhibit 5-9) presents the same type of information for variations in the windowsill dust standard. The windowsill dust standards vary over a much broader range than the floor dust standards. The minimum value (100 µg/ft^2) equals the assumed post-intervention lead loading. The maximum pre-intervention loadings in the data set are substantially higher than the 1,000 µg/ft^2 shown on the exhibit, but the number of homes performing dust cleaning is nearly constant above the 1,000 µg/ft^2 standard. Again, the number of homes performing soil interventions and the number performing paint interventions do not change with changes in the windowsill dust standards.

The number of homes performing dust cleaning is very sensitive to the windowsill dust standards. It declines rapidly at the most stringent standards, levels out slightly, and then declines even more at the 200-210 µg/ft^2 level. After that steep drop, the number of homes declines more gradually with decreasing stringency of the windowsill dust standards.

As with the floor dust standards, the line representing the total number of homes performing an intervention over the model period traces a very similar path, but overall declines slightly less than the number of homes performing dust cleanings. This indicates that some of the homes that no longer do dust interventions, as the windowsill dust standards become less stringent, continue to do soil and/or paint interventions. Again, costs should not decline as rapidly as number of homes, because the mix of interventions shifts towards the more expensive ones as the stringency of the windowsill standards decreases.

Exhibit 5-9
Number of Homes Performing Interventions (Over Model Period)

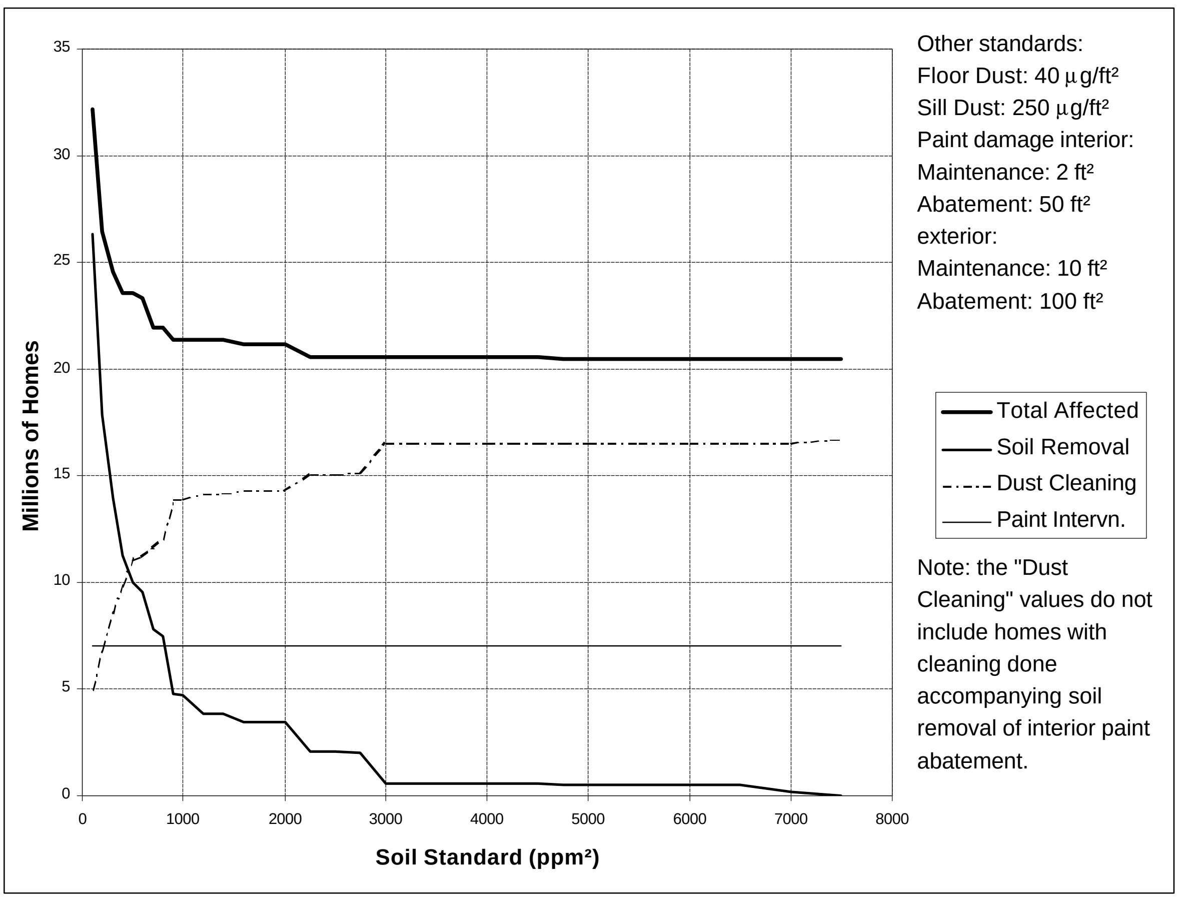


5.7.3 Number of Homes Performing Interventions for Alternative Soil Standards

The story for variations in soil standards is a little more complicated. As above, the number of paint interventions that occur remains constant over the variations in soil standards. There are, however, apparent tradeoffs between soil and dust interventions. As explained at the beginning of this section, soil abatements include a dust cleaning. Some homes that would perform a soil abatement under a stringent standard, may not perform the soil intervention but would perform a dust cleaning alone under a less stringent soil standard. Thus, homes might switch from the soil intervention to the dust intervention category.

In Exhibit 5-10, soil standards range from 150 ppm (the assumed post-intervention soil lead concentration) to slightly over 7000 ppm (the highest pre-intervention soil lead level in the data set). Homes are highly concentrated at low soil lead levels, with the number of homes performing soil interventions dropping by about one-half as soil standards decrease from 150 ppm to about 500 ppm. The decline in the number of homes continues only slightly less rapidly to about 900 ppm; it declines more gently to about 3000 ppm.

Exhibit 5-10
Number of Homes Performing Interventions (Over Model Period)



While the number of homes performing soil abatements is declining rapidly as the soil standard becomes less stringent, the number of homes performing dust cleaning is increasing at a substantial rate. The result is that the total number of homes performing some form of intervention falls as soil standards become less stringent in the 150 - 1000 ppm range. Then the total number of homes performing interventions levels off, as the majority of homes that no longer warrant a soil intervention now require a dust cleaning under the floor dust standards of 40 $\mu g/ft^2$ and windowsill dust standards of 250 $\mu g/ft^2$. In this case, costs should fall more rapidly than the number of homes performing an intervention because the relatively expensive soil interventions are being replaced with less expensive dust cleaning.

5.8 Likely Rates of Intervention and Their Impact on the Cost Estimates

As described in Chapter 4, alternative hazard standard candidates are evaluated in terms of the net benefits they would generate under a set of specific assumptions about the behavior of residential property owners and managers. The results of this analysis are intended to inform decision-makers about the relative merits of the alternative standards by providing a set of comparable estimates. The analysis, however, does not provide estimates of the likely rates of intervention, and thus the likely costs of interventions, under these standards.

The main objective of this section is to provide estimates of the likely costs that would result from the establishment of the hazard standards. Data limitations preclude defining a baseline that accurately reflects future intervention activity levels in the absence of §403 hazard standards. Likewise, data are not available on which to base an estimate of the effectiveness of the hazard standards in changing behavior, especially since the behavior changes will largely depend on the effectiveness of the information programs that will accompany the standards. Therefore, the costs estimated in this section represent an estimate of total post-regulation costs, not the incremental costs due to the §403 standards.

The most complete data currently available on intervention rates are data from the state of Massachusetts. For nearly ten years, Massachusetts has required that all residential lead inspections and interventions be reported to the state. This is the only state with data on all such activities for an extended period of time. In many ways, the Massachusetts regulations are very similar to the§403 hazard standards. In addition, Massachusetts vigorously enforces state regulations that require that landlords abate lead-based paint. State programs that provide long-term, interest-free loans to low-income households to pay for lead abatements, a tax on real estate transfers that supports the state Childhood Lead-Based Paint Protection Program, mandatory testing of children's blood for lead, and active local public health programs further promote the removal of lead-based paint. Given all this support, it is unlikely that national intervention rates will exceed those seen in Massachusetts.

Thus, the costs of interventions were estimated assuming that the §403 standards were in effect, but using an intervention rate consistent with that found in Massachusetts, as opposed to the birth rate. Since the Massachusetts program contains several factors that promote interventions that may not be present in the federal program, a second intervention rate was also used to estimate costs. This second rate was set at one-half of the Massachusetts rate. Exhibit 5.11 presents the total costs (over 50 years discounted at 3 percent) and the total number of homes with interventions for the three alternative rates of intervention activity: the rate in the analysis model, a rate equivalent to the Massachusetts rate, and one-half the Massachusetts rate. If the rate of interventions were equivalent to the average rate in Massachusetts, and the mix of interventions were consistent with the §403 standards, the total costs would be approximately 42 percent of the costs estimated by the "birth-trigger" model. It is likely that the actual rate, and thus the actual total costs, will fall below the Massachusetts rate. As shown in Exhibit 5.11, if the actual rate were to fall between the Massachusetts rate and one-half of the Massachusetts rate, between 6.4 and 12.8 million homes would experience an intervention during the 50-year period, or an average of 128,000 to 254,000 homes a year. The present value of the 50-year costs would range from $15.3 to $29.0 billion.

Exhibit 5.11
Costs Under Alternative Assumptions About Intervention Rates: Final Standards*

Intervention Rate	Present Value of Total Costs over 50 Years, Discounted at 3 Percent ($billion)	Number of Homes With Interventions (million)
Model used in Chapter 6	$68.9	21.6
Equivalent to Massachusetts Rate	$29.0	12.8
Equivalent to One-Half of Massachusetts Rate	$15.3	6.4

* Final Standards:
Interior paint: 2 sq ft or more — repair, 50 sq ft or more — abate
Exterior paint: 10 sq ft or more — repair, 100 sq ft or more — abate
Window sill dust: 250 sq ft^2
Floor dust: 40 $\mu g/ft^2$
Soil: 1,200 ppm

Appendix 5.A: Estimating Soil Removal Costs

The following discussion describes the methodology used to estimate soil intervention costs for single-family homes. As described in the risk assessment, soil removal occurs when the average of the foundation (near) and remote soil-lead concentrations or the play area alone exceeds the lead hazard standard. When the lead hazard standard is exceeded, the intervention strategies are determined by: 1) the average of the pre-intervention soil-lead concentration in samples taken at the dripline and entryway sampling areas (i.e., the foundation); and 2) the pre-intervention soil-lead concentration in samples taken at the remote areas. If the average pre-intervention soil concentrations exceed the lead hazard standard, one of the following three scenarios will result:

- The pre-intervention soil lead concentration at the foundation of the house is greater than the hazard standard, thereby triggering a soil removal intervention at the foundation of the house;
- The pre-intervention soil lead concentration in yard areas away from the foundation of the house is greater than the hazard standard, thereby triggering a soil removal intervention in yard areas away from the foundation; or
- Both the pre-intervention soil lead concentrations at the foundation of the house and yard areas away from the foundation exceed the hazard standard, thereby triggering a soil removal in both areas.

If the average pre-intervention soil-lead concentration does not exceed the lead hazard standard, then the remote sample is compared to the standard. If it exceeds the standard, then removal of soil from the play area is triggered.

To account for each of these possible scenarios, a unit cost methodology was developed to estimate the total cost of abating the foundation and remote areas of the yard both together and individually, as well as the play area. The following discussion describes the methodology used to estimate the unit costs and the size of the areas likely to be treated, respectively.

Unit Cost Estimates

Unit costs for soil abatement were estimated based on standard reference manuals used in construction cost estimation: 1) *Hometech Remodeling and Renovation Cost Estimator* (1996); and 2) R.S. Means' *Repair and Remodeling Cost Data* (1996). The R.S. Means' *Repair and Remodeling Cost Data* book is recommended for residential, commercial, and industrial repair and remodeling projects costing between $10,000 and $1 million, and was therefore used in estimating multi-family costs. The *Hometech Remodeling and Renovation Cost Estimator* was used to generate costs for a single-family home, as suggested by Robert Santucci, cost consultant to the National Center for Lead-Safe Housing (NCLSH). Exhibit 5-A-1 presents the unit cost values used in this analysis.

Exhibit 5-A-1
Unit Cost Estimates for Soil Abatements

Abatement Activity	Single-family Home Unit Costs	Multi-family Building Unit Costs
Soil removal using small backhoe*	$6.08/yd^3 (+$525)	$7.00/yd^3 (+$390)
Backfill using small backhoe*	$0.20/ft^2	$0.46/ft^2
Replacement soil cost	$40.00/yd^3	$40.00/yd^3
Raking and seeding (by hand)	$0.30/ft^2	$0.24/ft^2
Soil transportation costs	$22/ton	$22/ton
Landfill (non-hazardous)	$35/ton	$35/ton
Interior dust cleanup	$391	$7,852
Landfill (hazardous)	$139/ton	$139/ton

* A small backhoe is defined to have a ½ cubic yard bucket.

The fixed cost portion of a soil removal, shown in parentheses in the first row of Exhibit 5-A-1, is greater for single-family jobs than for multi-family jobs. Presumably, this reflects the fact that larger jobs provide a greater return on equipment use and thus the opportunity cost of the backhoe is less. Alternatively, the larger per cubic yard cost for multi-family jobs may compensate for the lower fixed cost. Also, note that the cost of the one-time dust clean-up constitutes a larger percent of total costs for multi-family jobs than for single-family jobs. This is reasonable given that the amount of soil removed from a multi-family site is proportionally much less than the number of units at the same site.

Area Calculations

In order to calculate the total cost of conducting a soil abatement, the unit cost estimates described above were combined with estimates of the size of the area likely to treated. The following sections describe the methodology used to estimate these areas for single-family homes.

Area Calculations — Single Family Homes

As described above, soil lead concentrations are measured for two areas of the yard -- perimeter areas and yard areas away from the foundation (i.e., remote areas) -- and are therefore potentially subject to a soil removal. Because the HUD data used in the analysis does not include data on the size of either the home nor yard, average areas and average costs must be calculated for use in the analysis. Data were not available to directly generate national level estimates of the average perimeter area and remote area for single-family homes in the United States; however, data were available from the American Housing Survey (AHS) to estimate these values based on lot size, square feet within the house or apartment, and the number of floors in the house or apartment.[11] To briefly summarize the methodology: 1) the house's footprint (i.e., the amount of land covered by the building) was estimated by dividing the square footage of the house by the number of floors in the home; 2) from the footprint of the house, a perimeter was extrapolated (assuming a uniform shape for all homes); 3) from the perimeter of the home, an estimate of the *perimeter area* extending three feet from the foundation of the home was calculated; and 4) the *remote area* was

[11] The AHS, conducted by the Census Bureau, collects detailed data on the Nation's housing stock using a sample of roughly 55,000 homes. Weights are assigned to each record in order to extrapolate values to the Nation.

calculated by subtracting the foundation and footprint areas from the total size of the lot. Single-family home play areas were assumed to average 200 square feet in size. The following sections describe each of these steps in greater detail, with each section building upon the values calculated in the previous section.

Median Lot Size Calculation

Median lot sizes were calculated for both single-family attached and single-family detached homes and three geographical categories (to be used later in the analysis) using data from the 1995 American Housing Survey (AHS). Buildings with 2-4 units were also included in this analysis to maintain consistency with other parts of the analysis and HUD's definition of a single-family home: a residence with 1 to 4 units. The AHS does not report lot sizes for 2-4 unit buildings; therefore, the mid-point of the single-family attached and single-family detached lot size range was used in the absence of any alternative data. According to the AHS, units in buildings with 2-4 units make up only thirteen percent of all units in buildings with 1-4 units. Median lot sizes are summarized in Exhibit 5-A-2 with response rates indicated in parentheses. Response rates are not applicable to buildings containing 2-4 units because these data were not available from the AHS.

Exhibit 5-A-2
Median Lot Sizes (sq. ft.) from the American Housing Survey

Central City			Suburb			Non-Metro		
S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building
8,400 (63 percent)	3,000 (21 percent)	5,700 (not applicable)	15,000 (76 percent)	5,500 (22 percent)	10,250 (not applicable)	40,000 (70 percent)	11,000 (25 percent)	25,500 (not applicable)

Geographic categories are defined as follows based on the categorization used in the American Housing Survey -- *Central City*: Central City; *Suburb*: Urbanized Suburb, Other Urban Suburb, Rural Suburb; *Non-metro*: Urbanized Non-Metro, Other Urban Non-Metro, Rural Non-Metro.

Median Footprint Calculation

Median footprint values were calculated for both single-family attached and single-family detached homes using data from the 1995 and 1985 AHS. Median footprint values were then subtracted from the median lot size calculations (described above) to generate estimates of yard size.[12] As previously discussed, buildings with 2-4 units were also included in this analysis. However, a different methodology was used to estimate the median footprint of a building with 2-4 units.

The AHS does not report the footprint of a home; therefore, the value was derived for single-family attached and single-family detached homes by dividing square footage values (extracted from the 1995 AHS) by the number of floors in the home (extracted from the 1985 or 1995 AHS). This methodology requires the assumption that the square footage of a multi-story, single-family home is uniformly distributed across all stories. Fifty percent of the single-family homes reporting floors data contain only one story and are therefore unlikely to be affected by this assumption.

[12] This methodology does not account for the presence of garages, porches, and paved areas that would not be subject to a lead abatement.

Data on the number of floors were extracted from both the 1985 and 1995 surveys because the Census Bureau returns to the same housing units each year the survey is conducted and since 1985 has not collected floors data when units had been visited during a previous survey year. Therefore limited floor data were available from the 1995 survey alone, and the 1985 floor values were merged with the 1995 records using a unique ID number assigned to each housing unit sampled by the AHS. All usable records -- records with square footage and number of floors -- were combined to form one data set.

A different methodology was used to calculate the footprint of a 2-4 unit building because the AHS reports square footage values on a unit basis and does not report the square footage of an entire multi-family building. The analysis assumes that all 2-4 unit buildings are configured vertically with equal sized units one above the other (similar to a Boston triple-decker).[13] By making this assumption, the square footage of an individual unit could be used to represent the entire footprint of the building. No data were available from the AHS to test the strength of this assumption. Median square footage values were used to estimate the footprint for 2-4 unit buildings in each of the geographic areas considered in this analysis (central city, suburb, and non-metro). Median footprint values are presented in Exhibit 5.A-3.

Exhibit 5-A-3
Median Footprint Sizes (sq. ft.) Derived from the American Housing Survey

Central City			Suburb			Non-Metro		
S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building
1,135 (83 percent)	667 (46 percent)	900 (46 percent)	1,150 (81 percent)	700 (60 percent)	946 (57 percent)	1,090 (86 percent)	671 (65 percent)	840 (59 percent)

Geographic categories are defined as follows based on the categorization used in the American Housing Survey -- *Central City*: Central City; *Suburb*: Urbanized Suburb, Other Urban Suburb, Rural Suburb; *Non-metro*: Urbanized Non-Metro, Other Urban Non-Metro, Rural Non-Metro.

Perimeter Area Calculation

Calculating the perimeter area required three pieces of information: 1) the perimeter of the home, 2) the configuration or shape of the home, and 3) the distance from the foundation that would likely be subject to a soil removal. Santucci estimated that an abatement action would likely involve an area extending three feet from the foundation of the home. This value, coupled with the median footprint sizes estimated above, allowed us to extrapolate a measure of the home's perimeter, assuming a rectangular home with a front to side ratio of 2:3. For example, to calculate the perimeter of a central city, single-family detached home with a footprint of 1,135 square feet, the following formula was used to calculate the length of the home's front and side :

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[13] This is equivalent to assuming that the number of floors in the building equaled the number of units, and that each floor of a unit was the same size. Examples are side-by-side, two-story duplexes.

$$FRONT = \sqrt{\frac{FOOTPRINT}{1.5}} \quad where\ FOOTPRINT = 1{,}135\ sq.\ ft.;$$

$$SIDE = \sqrt{\frac{FOOTPRINT}{0.666}} \quad where\ FOOTPRINT = 1{,}135\ sq.\ ft.$$

The perimeter areas calculated for single-family detached, single-family attached, and 2-4 unit buildings are presented in Exhibit 5-A-4. Based on Santucci, single-family attached homes are assumed to only have soil present in the front or back of the home; therefore, perimeter areas were calculated based upon the FRONT length only. Perimeter areas for 2-4 unit buildings were converted to per unit values assuming three units per building.

Exhibit 5-A-4
Perimeter Area Sizes (sq. ft.) Derived from the American Housing Survey

Central City			Suburb			Non-Metro		
S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building
496	63	147	499	65	151	486	63	142

Geographic categories are defined as follows based on the categorization used in the American Housing Survey -- *Central City*: Central City; *Suburb*: Urbanized Suburb, Other Urban Suburb, Rural Suburb; *Non-metro*: Urbanized Non-Metro, Other Urban Non-Metro, Rural Non-Metro.

Remote Area Calculation

The remote area is defined by this analysis as the yard area away from the foundation of the home. Estimates of remote areas for single-family attached, single-family detached, and 2-4 unit homes were calculated by subtracting the median footprint values and perimeter areas from the median lot size values for each of the geographic categories (central city, suburb, and non-metro). Calculations of perimeter areas, footprint areas, and lot sizes are described above. Remote areas for 2-4 unit buildings were converted to per unit values assuming three units per building. Remote area values for all single-family building types are presented in Exhibit 5.A-5.

Exhibit 5-A-5
Remote Area Sizes (sq. ft.) Derived from the American Housing Survey

Central City			Suburb			Non-Metro		
S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building	S.F. Detached	S.F. Attached	2-4 unit building
6,769	2,270	1,551	13,351	4,735	3,051	38,424	10,265	8,173

Geographic categories are defined as follows based on the categorization used in the American Housing Survey -- *Central City*: Central City; *Suburb*: Urbanized Suburb, Other Urban Suburb, Rural Suburb; *Non-Metro*: Urbanized Non-Metro, Other Urban Non-Metro, Rural Non-Metro.

Bottom Line Remote Area and Perimeter Area Calculation - Single Family Home

A weighted average of the perimeter area and remote area was calculated for each of the three geographic categories based on the prevalence of single-family attached and single-family detached homes as well as the prevalence of units in 2-4 unit buildings. Average perimeter areas and remote areas are summarized in Exhibit 5-A-6. As the perimeter areas varied little across the three geographic locations, a straight average of the three values was used in the final cost calculation: 417 square feet. Remote area values varied significantly across the three geographic categories; therefore, the central city value was used assuming a higher incidence of lead contaminated soil in central city areas. One-half the central city value (i.e., 2,571 square feet) was used in the final cost calculation because, where lots are very large, it is likely that soil would be removed from only a portion of the entire yard. In addition, paved areas, which were not accounted for in the area estimates, would not be subject to soil removal.

Exhibit 5-A-6
Weighted Average Perimeter Areas and Remote Areas By Geographic Location

Abatement Area	Weighted Average Area (sq. ft.)		
	Central City	Suburb	Non-Metro
Perimeter	373	432	447
Remote	5,142	11,700	35,220

Geographic categories are defined as follows based on the categorization used in the American Housing Survey -- *Central City*: Central City; *Suburb*: Urbanized Suburb, Other Urban Suburb, Rural Suburb; *Non-Metro*: Urbanized Non-Metro, Other Urban Non-Metro, Rural Non-Metro.

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6. Benefits

6.1 Introduction

Chapter 4 provided a description of the analytic approach used to conduct this benefit-cost analysis, and in particular the linkage between the economic analysis and the risk assessment performed in support of the §403 standards (Battelle, 1997). For a thorough discussion of the health hazards associated with lead focusing on those effects that are addressed in the benefits estimates provided here, the reader is referred to Chapter 2 of the Battelle risk assessment document. The reader is also referred to Chapters 3 and 4 of the risk assessment document for further details on the exposure modeling and dose-response modeling incorporated into the estimation of the benefits of §403 standards discussed both in this Chapter and subsequently in Chapter 7.

As described in Chapter 4, the benefit-cost analysis essentially compares alternative futures over a 50 year time horizon: a baseline or "no-action" alternative for which it is assumed that no changes are made to current ambient lead exposure conditions, and a "post-action" alternative for which it is assumed that the ambient lead exposure conditions are reduced in specific ways in response to the promulgation of §403 standards.

The benefits of implementing the §403 standards can be expressed in several ways. These include estimates of:

- The reduction in environmental lead levels (i.e., in paint, soil and dust) to which children are exposed;
- The number of children who experience lower exposure levels than they would have in the baseline;
- The reduction in blood lead levels in children resulting from lowered exposure levels;
- The reduction in the incidence of specific adverse effects or consequences associated with elevated blood lead levels in children (including IQ changes, medical interventions, remedial or compensatory education); and
- The monetary value associated with the reduction of the incidence of those adverse effects.

The remainder of this chapter presents these §403 benefits in two sections. Section 6.2 addresses the benefits as noted in the first four bullets above, which deal with reductions in environmental lead levels and changes in the incidence of adverse health consequences associated with the exposure reductions. Section 6.3 addresses the valuation or monetization of these benefits to allow for a comparison with the costs of the §403 standards.

Note that within this chapter, the benefits are presented only for the final §403 standards, namely:

> Floor dust: 40 µg/ft^2
> Windowsill dust: 250 µg/ft^2
> Soil: 1200 ppm (does not include benefits for play area standard of 400 ppm)
> Paint: Interior lead paint >2 ft^2 of damage; Exterior lead paint >10 ft^2 of damage

In Chapter 7, where benefits are compared directly with costs, the monetized value of the benefits are presented for a range of §403 alternatives.

6.2 Benefits as Reduced Exposure and Adverse Health Consequences

As noted above, this section provides estimates of the benefits of the final §403 standards in terms of reduced exposure to children and the associated reduction in adverse health consequences. In all cases, these are reductions measured against a baseline of no changes in the ambient lead exposure conditions. In other words, this is a marginal analysis with a baseline of no intervention.

As described in Chapter 4, the choice of the intervention strategy (i.e. the specific actions to be taken in a housing unit to reduce lead levels) is a function of the particular lead hazard standard under analysis and the lead conditions of that housing unit. Also, the timing of interventions in the analysis is a function of the timing of childbirths. In homes where hazard standards are exceeded, it is assumed that the interventions will be carried out just prior to the arrival of a newborn child. Furthermore, they are repeated when necessary as long as any child under age 6 is still present in the home.

Six intervention actions are considered in this analysis. These include two interior paint interventions (high-intensity and low-intensity interior paint interventions); two exterior paint interventions (high-intensity and low-intensity paint interventions); one soil intervention; and one dust intervention. Depending on the conditions of the housing unit, various intervention elements were combined to form an intervention strategy. The effectiveness and duration levels associated with interventions determine the post-intervention conditions. These levels were discussed in Chapter 4 and at greater length in Battelle (1997). The assumed post-intervention conditions for each alternative are summarized in Exhibit 6-1.

Chapter 5 provides estimates of the number of homes over the course of 50 years where these interventions would take place in response to both the anticipated presence of a new child and the existence of environmental lead levels exceeding alternative standards.

In the benefit-cost model it is estimated that over the course of the 50 year period, approximately 173 million children will be born and occupy the approximately 98 million homes estimated to comprise the current US housing stock. Of these, it is estimated that 131 million children will occupy target housing stock built prior to 1979. Assuming interventions are performed as set forth in the model, approximately 46.0 million children, 34.7% of the 131 million children occupying target housing stock, will experience a reduction in exposure to environmental lead levels from paint, soil, and/or dust as a result of the §403 standards. Also, it is estimated that in the baseline, approximately 2.36 million children will experience elevated blood lead levels due to direct ingestion of paint chips over the 50 year period; with the final §403 standards it is estimated that only 1.09 million children will experience elevated blood lead due to direct ingestion of paint chips.

Exhibit 6-1
Summary of Post-Intervention Conditions for Various Intervention Alternatives
(LBP refers to lead-based paint)

Abatement Alternative	Assumed Post-Intervention Conditions
High-Intensity Interior Paint	• Paint: Deteriorated interior LBP made inaccessible for 20 years • Dust: Floor dust lead loading level reduced to 40 µg/ft^2. Window sill dust lead loading level reduced to 100 µg/ft^2. Lead concentration level reduced to 20% of pre-intervention level for 20 years
Low-Intensity Interior Paint	• Paint: Deteriorated interior LBP made inaccessible for 4 years • Dust: Lead concentration level reduced to 20% of pre-intervention level for 4 years
High-Intensity Exterior Paint	• Paint: Deteriorated exterior LBP made inaccessible for 20 years • Dust: Lead concentration level reduced to 20% of pre-intervention level for 20 years
Low-Intensity Exterior Paint	• Paint: Deteriorated exterior LBP made inaccessible for 4 years • Dust: Lead concentration level reduced to 20% of pre-intervention level for 4 years
Dust	• Dust: Floor dust lead loading level reduced to 40 µg/ft^2. Window sill dust lead loading level reduced to 100 µg/ft^2. Duration is 4 years in both cases. Effect on dust lead concentration depends on other interventions implemented (see Battelle 1996)
Soil Removal	• Soil: Soil lead concentration permanently reduced to 150 ppm areas where soil is removed • Dust: Floor dust lead loading level reduced to 40 µg/ft^2. Window sill dust lead loading level reduced to 100 µg/ft^2. Duration is permanent in both cases. Effect on dust lead concentration depends on other interventions implemented (see Battelle 1996)

Note: Lead levels remain constant in any case where starting levels are lower than assumed post-intervention ones.

In the baseline analysis, it is assumed that the blood lead levels of children would continue to reflect levels observed in the NHANES III, Phase 2 analysis characterized as a lognormal distribution with a geometric mean (GM) of 3.14 µg/dl, a geometric standard deviation (GSD) of 2.09, and a resulting expected value (arithmetic mean) of 4.12 µg/dl. As discussed previously, EPA has employed two blood lead models (the IEUBK and the Empirical models) in the risk assessment to predict the effects of the reduction in environmental exposure levels. Using the IEUBK model, it is estimated that the blood lead GM will be 2.66 µg/dl with a GSD of 1.84 (arithmetic mean of 3.20 µg/dl). Using the Empirical model, it is estimated that the blood lead GM will be 3.02 µg/dl with a GSD of 2.04 (arithmetic mean of 3.89 µg/dl).

For the overall population of 173 million children for which these blood lead distributions apply, this is an average reduction of 0.92 µg/dl with the IEUBK model and 0.23 µg/dl for the empirical model. However, when it is recognized that these blood lead reductions are expected to occur only in the 46.0 million children noted above as being in target housing affected by these standards, it is estimated that the average blood lead reductions among those children affected are 3.49 µg/dl from the IEUBK model and 0.86 µg/dl from the Empirical model.

As noted in Chapter 2, the selected health end-points used in the assessment of the benefits of these standards include several specific blood lead levels identified by the CDC (1991) as critical values above which various levels of follow-up monitoring and/or specific medical interventions should be undertaken. Key among these are blood lead levels of 10 µg/dl and 20 µg/dl. It is estimated that for the baseline analysis approximately 10 million (of the 173 million children) born into current housing stock will have blood lead levels above 10 µg/dl, and 1 million will have blood lead levels above 20 µg/dl. With the §403 standards, these numbers are reduced to 2.6 and 8.1 million exceeding 10 µg/dl (for the IEUBK and Empirical models, respectively) and 0.08 and 0.7 million exceeding 20 µg/dl (again for the IEUBK and Empirical models, respectively).

Critical components of the estimated benefits of reduced blood lead levels in children are the potential improvement in IQ scores in general and the associated reduction in the incidence of low IQ scores (<70) in particular. As a result of the estimated reduction in average blood lead levels (coupled with the relationship between blood lead and IQ scores discussed in Chapters 2 and 4), it is estimated that the average improvement in IQ score among the 46.0 million children affected by the standards over the 50 year period would be 0.87 points based on the IEUBK model and 0.22 points based on the Empirical model.

It is also estimated that over the 50 year modeling period, the number of children avoiding IQ scores below 70 resulting from the §403 standards ranges from approximately 30,000 children (from the IEUBK model) to 8,000 children (from the Empirical model).

It is important to note that these are not the only benefits anticipated to result from the §403 standards, but rather are those considered the key benefits that are most directly measurable in this analysis.[1] These are the benefits addressed in the §403 risk assessment. The reader is referred to the Hazard Identification discussion in Chapter 2 of the risk assessment document (Battelle, 1997) for a more thorough discussion of the potential benefits of reducing environmental lead levels.

The following section of this chapter describes the approach to placing a monetary value on the benefits of reduced blood lead levels in children, including those associated with medical interventions, education, and IQ point changes.

6.3 Valuation of Benefits

The benefits are assigned monetary values to facilitate comparison with the costs of conducting interventions. The approach used by this analysis defines benefits as avoided health damages and avoided elevated blood lead levels. The main health effects considered are reductions in IQ and cognitive effects

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[1] Adult benefits are estimated in Chapter 9 of this RIA.

from lead exposure. Available economic research provides little empirical data for society's willingness to pay to avoid decreases in IQ or adverse cognitive effects. To represent some portion of society's full willingness to pay, alternative measures were calculated that considered three consequences of lead exposure for children: decreased expected lifetime earnings, increased educational resources expended, and costs of increased medical intervention. Foregone earnings are examined in Section 6.4.1. Increased educational expenditures are addressed in Section 6.4.2. Costs due to increased medical intervention are presented in Section 6.4.3. All estimates are presented in 1995 dollars. Exhibit 6-2 summarizes the components used to provide values for the health effects considered by the benefits analysis.

6.3.1 Valuing Changes in IQ Points

The valuation of changes in IQ was completed in two steps. First, an estimate of the present value of the earnings stream of an average newborn was calculated. Second, available economic literature was used to estimate the percentage increase in lifetime earnings one would expect from a one point increase in IQ.

Average Earnings. To calculate the present value of the earnings stream of an average newborn, it was assumed that at any given age the child will receive annual earnings in real terms equal to average earnings "currently" received by persons of the same age. Data from the 1992 Current Population Survey (CPS) were inflation adjusted to 1995 dollars. The projected annual earnings stream was adjusted to take three factors into account. First, some real increases in earnings were assumed to occur through general increases in productivity. Second, projected earnings were lowered to take into account probabilities of survival. Finally, the lifetime earnings stream was discounted to express the stream in present value terms.

Average earnings calculations were performed for ages ranging from 18 to 64 using 1992 CPS data on the average annual earnings, total persons, and the number of persons with earnings by gender, age, and education group (US Department of Commerce, 1993). Average earnings were calculated for those in a particular age group as a weighted average of average earnings in each gender and education sub-group. The weights used were the fractions of the age group represented by each gender and education group. Average annual earnings for those with earnings, total number of persons with earnings, and total number of persons were typically reported by gender for various age groups (e.g., 18-24; 25-34; 35-44; 45-54; 55-64; and 18-24; 25-29; 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64) and education groups (less than 9th grade, 9-12 grade with no diploma, high school graduate, some college, associate degree, bachelor's degree, master's degree, professional degree, and doctorate). Employment rates were estimated based on estimates of total persons and of total persons with earnings. Estimates of zero earnings for the unemployed were incorporated into the calculation of average earnings.

Several assumptions had to be made to calculate the average earnings stream because of limited data:

- First, the CPS data only includes some information for those with professional degrees and doctorates. In instances where numbers were not reported, earnings and employment rates were inferred by comparing information on those with at least a BA to information on those with a BA alone and those with an MA alone.

- Second, the CPS data reported total counts of persons in 10-year age groups, but earnings for those with earnings and counts of those with earnings in 5-year age groups. For the purposes of this analysis, it was assumed that employment rates within the 5-year age groups were equal to those of the 10-year age groups. The CPS data, however, did not include an estimate of the total persons, and thus employment rates, in each education group for individuals in the 18-24 age group. Since employment rates for both men and women, age 18-24, are available, this analysis assumes that the employment rate within each education group of the 18-24 age group was equal to the overall employment rate for that age group.

- Third, the analysis assumes that the 1992 distributions of earnings and educational attainment will hold constant over several decades (with some minor exceptions concerning educational attainment) and are representative of those faced by children born in 1997. It was assumed that the educational distribution remains the same as the current distribution until those born in 1997 are older than age 49. After that age, the assumed educational distribution is fixed at the distribution of those aged 45-49 in the CPS data. The data beyond age 49 reveal significant declines in educational attainment and it is for this reason that this age was selected as the cutoff. Because average years of schooling have tended to rise over this century, older people often have fewer years of schooling than younger people. If this assumption were not made, the model would have individuals losing years of education over time. With these assumptions, it was possible to calculate the average earnings for persons in the 18-24 age group and in the five year age groups ranging from 25-29 through 60-64.

Present Value of Lifetime Earnings. The estimated average earnings were used to predict the present value of future annual earnings over the lifetimes of those born in 1997, by using appropriate survival rates, productivity increases, and discount rates. Survival rates (P) are the probability that a newborn person will survive to a given age N. Survival rates are the multiplication of two probabilities: the probability that a newborn survives to age N-1 and the probability that the individual will survive from age N-1 to age N. The US Department of Commerce (1992b) provided the probability that a person of a particular age dies some time in that age year. This is sufficient information to calculate survival rates for all ages as described above. Because the model is evaluating future populations, there were some uncertainties associated with these probabilities. The model assumed that real earnings will increase by one percent per year to reflect the fact that some portion of productivity increases (X) are reflected in real earnings increases. The nation's productivity or output per capita tends to rise over time as the capital stock rises. As explained in Chapter 3, the discount rate (r) used in this analysis is 3 percent.

Exhibit 6-2
Summary of Benefits Analysis Estimate

Type of Effect	Description	Estimate	Source
Effect of a Single Point Reduction in IQ	Sum of the direct and indirect effects on the percent of earnings lost (2.379 percent) and express the effect in terms of the present value of average lifetime earnings	$9,360 in 1995 dollars	Product of the estimate of the present value of average lifetime earnings based on US Department of Commerce ($366,021 (1992 $)) and the assumed percentage loss of earnings from a single point reduction in IQ of 2.379 percent (Salkever 1995)
Cost of Additional Education	Sum of the direct costs ($316) and opportunity costs ($627) of additional education	$1,014 in 1995 dollars	Sum of the estimate of the direct and opportunity costs of additional education based on US Department of Education (1993) data
Total Effect of a Single Point Reduction in IQ	Subtract the costs of additional education from the effects on earnings lost	$8,346 in 1995 dollars	Accounting for the cost of additional education was based on Salkever (1995)
Special Education (IQ less than 70 points)	Cost of special education beginning at age 7 and ending at age 18	$53,836 in 1995 dollars	Kakalik et al. (1981) estimate annual incremental regular classroom costs of $6,458 in 1995 dollars for special education. This estimate is the discounted value of such costs for age 7 through 18.
Compensatory Education (Blood-lead greater than 20)	Cost of compensatory education beginning at age 7 and ending at age 9	$15,298 in 1995 dollars	Kakalik et al. (1981) estimate annual incremental regular classroom costs of $6,458 in 1995 dollars for compensatory education. This estimate is the discounted value of such costs for age 7 through 9.
Medical Intervention(for several blood lead ranges)	Cost of blood lead screening and medical intervention for children less than six years old (by blood lead risk group)	(All in $1995) Risk Group I:$58 R.G. IIA: $70 R.G. IIB: $227 R.G. IIIA: $417 R.G. IIIB: $678 R.G. IV: $9843 R.G. V: $9843	Recommendations and actual practice based on information from CDC (1991), AAP (1995), and medical practitioners. These estimates are the discounted costs per newborn associated with each blood lead Risk Group.

The following formula estimates the present value of average earnings at age A, for a male or female born in 1997. It is important to note that female and male earnings were calculated separately.

$$PV_A = \sum_{N=A}^{64} Y_N P_N (1+X)^{N-A+0.5} / ((1+r)^{N-A+1})$$

where:

PV = present value of the total sum of earnings of a male or female received between ages A and 64;
A = current age of male or female;
N = successive ages of male or female in the future (A+1, ..., 64);
Y = average annual earnings of male or female for a particular age (N);
P = survival rate of male or female for a particular age (N);
X = productivity rate of male or female assumed at the midpoint of age N; and
r = discount rate for the beginning of age N.

The present value average earnings are based on the 1992 CPS data, survival rates, an assumed discount rate of 3 percent, and an assumed increase in productivity of 1 percent per year. The average earnings for males was $485,946 and $250,797 for women. The average earnings for the entire population was $366,021. This is a participation-weighted average obtained using the following equation:

Ave. Earnings for Pop. = % pop. male x male earnings + % pop. female × female earnings

There are several uncertainties associated with this approach to calculating the present value of the average earnings stream:

- First, uncertainties arise concerning the earnings distribution mainly because it is a projection of lifetime earnings. Children born in 1997 and after will not enter the labor market for several decades. The type of labor market that will exist and the distribution of skills and education of this future labor force are both unknown. In addition, labor force participation rates, a real wage growth rate of one percent, and year-to-year survival probabilities are all assumed to stay the same until the year 2110. This includes the 64 year full working life for children born in year 2046, the last year of the model run. Labor force participation rates of women, the elderly, and other groups will most likely continue to change over the next decades. Real earnings of women will probably continue to rise relative to real earnings of men. Unpredictable fluctuations in the economy's growth rate will probably affect labor force participation rates and real wage growth of all groups. Medical advances will probably raise survival probabilities. Presently, the model uses information on the 1992 distribution of education and earnings by age groups to characterize the future labor market. This involves making the assumption that present trends will continue in the future and it is unclear how this might bias results.

- Second, this approach assumes that what individuals are paid in the market truly reflects their marginal product as laborers. Earnings is used in place of marginal product in this model because the latter value is a much more involved calculation. However, there is concern that certain groups of people are discriminated against (e.g., women and minorities) in the labor market such that they do not receive their true marginal product. For this reason, the average earnings calculated here may be an underestimate of the true marginal product.

- Third, the use of earnings is an incomplete measure of an individual's value to society. This is particularly true for individuals who choose to not participate in the labor force for all of their working years. If the opportunity cost of non-wage compensated work is assumed to be the average wage earned by persons of the same sex, age, and education, the average lifetime earnings estimates for these people would be significantly higher.

- Fourth, the current model uses the earnings of all persons to determine average earnings. If the exposed population are significantly different then the national population (i.e., minority populations) then the current model may be misrepresenting their future earnings streams. For example, if the exposed population earn lower earnings relative to the national population for reasons other than their lead exposure, then the average used by this analysis may be an over estimate. Yet, as emphasized in the previous comment on discrimination, it might be more appropriate to use the sample of the national population that best reflects the marginal product of labor to assess the benefits of preventing IQ reductions.

Effects on Earnings from Changes in IQ. The second part of the benefits estimation for IQ changes relies on the Salkever (1995) study. The value of avoiding a single IQ point loss was modeled as a loss in expected lifetime earnings. Direct and indirect effects on earnings were considered in valuing lost IQ points. The direct effect is the sum of the effects of IQ test scores on employment and earnings for employed persons, with the years of schooling held constant. The indirect attributes are the effect of IQ test scores on years of schooling attained, and the subsequent effect of years of schooling on the probability of employment, and on earnings for employed people.

Salkever (1995) provides updated estimates of all the necessary parameters using the most recent available data set, the National Longitudinal Survey of Youth (NLSY). Three regression equations provide these parameters. The years of schooling regression shows the association between IQ scores and the highest grade achieved, holding background variables constant. The employment regression shows the association between IQ test scores, highest grade, and background variables on the probability of receiving earned income. This regression provides an estimate of the effect of IQ score on employment when schooling is held constant, and the effect of years of schooling on employment, when IQ is held constant. The earnings regression shows the association between IQ test scores, highest grade achieved, and background variables on earnings, for people with earned income.

These three regressions provide the parameters needed to estimate the total effect of a loss of an IQ point on earnings. The direct effects of IQ on employment and earnings for employed persons, holding schooling constant, come from the employment and earnings regressions. The indirect effect of IQ on employment through schooling is the product of the effect of IQ on years of schooling, from the years of schooling regression, and the effect of highest grade on employment, from the employment regression. The indirect effects of IQ on earnings for employed persons through schooling is the product of the effect of IQ on years of schooling, from the years of schooling regression, and the effect of highest grade achieved on earnings for employed persons, from the earnings regression.

Based on the Salkever (1995) study, the most recent estimate of the effect of an IQ point loss is a reduction in earnings of 1.93 percent for men and 3.22 percent for women, which is a participation-weighted average of 2.379 percent.

There are numerous uncertainties associated with implementing this approach. Several assumptions were necessary to estimate the foregone earnings associated with IQ reductions. First, it was assumed that IQ decrements incurred through lead exposure persist throughout the exposed child's lifetime. Second, it was assumed that population changes in IQ have effects analogous to individual changes in IQ. This assumption suggests that every unit decrease in IQ has an equal effect regardless of where an individual is in the IQ distribution and what the total magnitude of the person's IQ change is. Additional uncertainties associated with specific components are discussed in the following sections.

Value of Foregone Earnings. The next step for determining the value of an IQ point involves combining the percent earnings loss estimate with an estimate of the present value of expected lifetime earnings. The present value average earnings of $366,021 is multiplied by the 2.379 percent earnings loss to yield an average value of $8,708 per IQ point.

This IQ point value of $8,708, however, does not account for the costs associated with additional years of education. The increase in lifetime earnings from additional education is the gross return to education. The cost of the marginal education must be subtracted from the gross return in order to obtain the net benefit per IQ point. There are two components of the cost of marginal education; the direct cost of the education, and the opportunity cost of lost income during education. An estimate of the educational cost component is obtained from the U.S. Department of Education (1993). The marginal cost of education used in this analysis is assumed to be $5,500 per year. This figure is derived from the Department of Education's reported ($5,532) average per-student annual expenditure (current plus capital expenditures) in public primary and secondary schools in 1989-90. For comparison, the reported annual cost of college education (tuition, room and board) in 4 year public institutions is $4,975, and $12,284 for private institutions.

Salkever estimated 0.1007 reduced years of schooling per IQ point lost. Therefore, the estimated cost of an additional 0.1007 years of education per IQ point where one year costs $5,500 is $554. Because this marginal cost occurs at the end of formal education, it must be discounted to the time the exposure and damage is modeled to occur (age zero). The average level of educational attainment in the population over age 25 is 12.9 years (U.S. Department of Education, 1993). Therefore, the marginal educational cost is assumed to occur at age 19, resulting in a discounted present value cost of $316.

The other component of the marginal cost of education is the opportunity cost of lost income while in school. Income loss is frequently cited as a major factor considered in the decision to terminate education, and must be subtracted from the gross returns to education. An estimate of the loss of income is derived assuming that people in school are employed part time, but people out of school are employed full-time. The opportunity cost of lost income is the difference between median annual full-time income of $16,501, and $5,576 for part-time employment (U.S. Department of Commerce, 1993a). The lost income associated with being in school an additional 0.1007 years is $1,100, which has a present discounted value at age zero of $627.

The net benefit per IQ point in 1992 dollars is the gross value of an IQ point minus the costs of education. This relationship is shown in the equation:

$$\$8,708 - \$316 - \$627 = \$7,765.$$

The GDP price inflator was used to adjust the 1992 dollars to 1995 dollars. This results in an IQ point value of $8,346.

6.3.2 Valuing Increased Educational Resources

Two categories of increased educational resources needed as a result of lead exposure are considered as additional effects from lead exposure. First, lead exposure results in an increase in the number of children with IQs less than 70, an indicator of mental handicap (Battelle 1997). During all their school years, these children are likely to require special education tailored to the mentally handicapped. In addition, some children whose blood lead is greater than 20 µg/dL may be less impaired but will still be affected enough to need several years of compensatory education in addition to regular schooling. The following sections describe the approaches used to obtain estimates of increased educational resources needed. Exhibit 6-2 summarizes the data used to derive educational resource expenditure estimates.

Special Education for Children with IQs less than 70. To assign a value to the reduction in the number of infants with IQs less than 70, an estimate of the reduction in education costs was calculated using available data on educational expenditures. This approach is a clear underestimate of the total benefits associated with avoiding cases of IQ less than 70.[2] Kakalik et al. (1981) used data from a study prepared for the Department of Education's Office of Special Education Programs. They estimated that part-time special education costs for children who remained in regular classrooms were $3,064 on an annual basis in 1978 (in addition to regular class costs). Adjusting for changes in the GDP implicit price deflator yields an estimate of $6,458 per child in 1995 dollars. This incremental estimate of the cost of part-time special education was used to estimate the annual cost per child needing special education as a result of impacts of lead on mental development. Costs were assumed to be incurred from ages 7 through 18. Discounting future expenses at a rate of 3 percent yields an expected present value cost of approximately $53,836 per child. This is the benefit assigned for each case of IQ under 70 avoided. It is an underestimate of the benefit since Kakalik et al. (1981) measured the increased cost to educate children attending regular school. The costs of attending a special education program were not considered and are most likely considerably higher than those associated with regular schooling.

The total cost of special education is simply the reduction in the probability a child will have an IQ less than 70 multiplied by the number of children born in a specified year and then multiplied by the cost of special education. For example, if the baseline probability of an IQ less than 70 is 0.5% and the post-intervention probability falls to 0.3% and there were a total of 1,000 children born, then the benefit society accrues from reduced special education costs is $107,672 ([0.005-0.003] × 1,000 × $53,836 = $107,672).

Compensating Education for Children with Blood Lead Levels Greater Than 20 µg/dL. When calculating the cost of compensatory education, three relatively conservative assumptions were made. First,

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[2] The largest part of this benefit is not captured in this analysis — the parents' willingness to pay to avoid having their child become mentally handicapped, above and beyond the increased educational costs.

it was assumed that no children with blood lead levels below 20 µg/dL would require compensatory education later in life. This is conservative since many studies show cognitive effects at 15 µg/dL. Second, it was assumed that only 20 percent of the children above 20 µg/dL would be severely affected enough to require and receive some compensatory education. Third, it was assumed that each child who needed compensatory education would require it for three years (age 7 through 9). Studies of the persistence of cognitive effects indicate this is a conservative estimate and that effects often last longer than three years.

Benefits were calculated by assuming that 20 percent of the children with blood lead levels greater than 20 µg/dL received compensatory education for three years. After this time, no further blood lead related educational expenditures were incurred by those children.[3] The Kakalik et al. (1981) estimate of part-time special education costs for children who remained in regular classrooms was also used to estimate the cost of compensatory education for children suffering low-level cognitive damage. As indicated above, adjusting for changes in the GDP implicit price deflator yields an estimate of $6,458 per child per year in 1995 dollars. Discounting future costs at a rate of 3 percent annually to account for the age at which costs are incurred yields a present value estimate of $15,298 in 1995 dollars.

The total value to society from a reduction in the probability of blood-lead concentrations greater than 20 µg/dl is the difference in the probability of having a blood-lead concentration greater than 20 µg/dl, times 20% of the number of children born in a specified year, times the present value per child. For example, if the probability is reduced by .05% and there are 1,000 children born then the total value is $1,530 ($0.0005 \times 0.20 \times 1,000 \times \$15,298 = \$1,530$).

6.3.3 Valuing Increased Blood Lead Screening and Medical Treatment

Blood lead screening programs have been established in many public health programs because children may remain asymptomatic even though blood lead levels are elevated. Screening programs attempt to identify children who are at risk of developing lead exposure related illnesses. Once elevated blood lead levels are detected, treatment costs are incurred to reduce blood lead to less serious levels, thereby avoiding or mitigating adverse health effects. Follow-up blood lead tests are used to ensure that intervention has accomplished the intended risk reduction.

The model calculates benefits as the reduction in these screening and medical intervention costs caused by lead interventions.

The Centers for Disease Control (CDC), in their 1991 statement *Preventing Lead Poisoning in Young Children*, has recommended protocols for blood lead screening and medical treatment for several categories of blood lead levels, called risk groups (CDC, 1991; see Exhibit 6-3 for risk grouping). The costs and assumptions used to determine the total cost per child are based primarily on treatment protocols recommended in the 1991 CDC statement and the American Academy of Pediatrics (AAP, 1995). Recommended treatments may differ from typical treatments. However, the recommended protocols are expected to serve as a reasonable approximation of typical treatment profiles. In cases where information was lacking in the 1991 CDC recommendations, assumptions about the percent of children treated in a given risk group were made based on actual practice.

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[3] See U.S. EPA (1986) for more detail on the data sources and the nature of the assumptions made to quantify this benefit category.

Exhibit 6-3
Risk Groups and Associated Screening and Medical Costs Per Child

Risk Group	Blood-Lead Concentration	Screening Costs	Medical Costs
I	0-9 μg/dL	$58	$0
IIA	10-14 μg/dL	$70	$0
IIB	15-19 μg/dL	$169	$58
IIIA	20-24 μg/dL	$169	$248
IIIB	25-44 μg/dL	$325	$353
IV	45-69 μg/dL	$1,450	$8,393
V	$\geq$70 μg/dL	$1,450	$8,393

In addition, although CDC does recommend all children younger than six should be screened, actual practice suggests screening rates that are much lower. Therefore, this analysis assumes that the percent of children screened is based on actual practice. Information from blood lead screening programs indicates the level of screening in recent years (1994, 1995) is about 15 percent (MDDE, 1996; ILDPH, 1995). This level of screening represents the percent of children six years and younger who are screened in a given year, whether they are being screened for the first time or are given repeat screening. This value compares with an average screening rate of 17 percent from nine programs in 1983 (U.S. EPA, 1987). For the current analysis, a screening rate of 15 percent was assumed for both initial as well as repeat screenings for risk groups I to IIIB.

Children are grouped into different risk groups based on their blood lead levels. The unit costs determined for each risk group assume that each child is initially screened at age one, that elevated blood lead levels are identified at the initial screening, and that children who are not medically treated remain in the same risk group through age five. It was assumed that the total percent of children initially screened were rescreened once a year from ages two through five, resulting in a total of five screenings per child. Specific treatment elements include blood lead screening and other tests, medical treatment, and health education. Where there were uncertainties regarding the percentage of children treated or the exact treatment protocol used, conservatively low estimates for treatments and costs were made.

The medical costs listed in Exhibit 6-2 are based on costs of individual treatments presented in U.S. EPA (1987), incorporate the probability that a child will be treated, and are updated from 1985 to 1995 dollars using the average medical care cost index reported by the Bureau of Labor Statistics.[4] A cost of $42 for screening was taken from U.S. EPA (1987), updated to $81 in 1995 dollars. The cost of $42 includes the full annual clinic fee of $20 per child presented in Table 4-2 of U.S. EPA (1987).[5] The screening costs

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4 The average medical care cost index increased from 113.5 in 1985 to 220.4 in 1990 (1982=100) (CEA, 1996). As 220.4/113.5 = 1.94, a medical cost (1995$) = 1.94 × medical cost (1985$).

5 The analysis presented in U.S. EPA (1987) assumed that this annual fee was divided among four children. However, because the current analysis assumes abatement decisions are based on blood lead levels of children newly born into a household (rather than existing children in a household), it was assumed that the full clinic fee may apply to one child only.

encountered after the first year were discounted to 1995 dollars, using a 3% discount rate. Additional information on the percent of children treated in different groups has been obtained from health care practitioners and public health departments. The procedure used to determine these costs is presented in Appendix 6.A.

The total benefit to society resulting from a reduction in the probability of being in a particular risk group is simply the decrease in probability multiplied by the number of children born multiplied by the reduction in screening costs. For example, if the reduction in the probability of being in risk group IIB is 0.2% and a total of 1,000 children are born, then the benefit to society from reduced screening and medical costs is $454 ($0.002 \times 1,000 \times (169 + 58) = \$454$).

6.4 Aggregation of Benefits

The values provide in Section 6.3 are the per-child benefits resulting from the reduction in household lead levels. However, in order to calculate the net benefits of §403 it is necessary to aggregate the benefits accruing to all children born during the years 1997 to 2047.

In order to calculate the total present value of benefits one first calculates the value of benefits for each cohort of children separately. A cohort of children is defined as all children born in a given year. Benefits for each cohort are determined using information on the number of children born as well as information on the per-child benefits from household lead reduction discussed in the previous section. More specifically, the present value of total benefits for each cohort is calculated as the number of children born in that cohort multiplied by the sum of the following benefit values: the value of foregone earnings, the value of the decrease in the probability of an IQ less than 70, the value of the decrease in probability of a blood-lead level greater than 20 µg/dl, and the value of a decrease in the probability of falling into the high risk groups[6]. The value of benefits for each cohort is then discounted back to 1997 dollars. Finally the present value of total benefits for each individual cohort are summed together to generate the total present value of benefits from the §403 rule.

The aggregate monetary benefit of the final §403 standards are estimated to be $191 billion based on the blood lead changes predicted using the IEUBK model. Of this amount, nearly $188 billion is associated with the overall IQ point benefits related to future earnings.

Using the Empirical model, the estimated aggregate benefits of the final §403 standards are $49 billion, of which $47 billion is associated with the overall IQ point benefits related to future earnings.

[6] A more detailed series of aggregation equations can be found in Appendix 6.B of this chapter.

Appendix 6.A Screening and Medical Costs for Risk Groups

This Appendix presents the screening costs and other medical costs, such as treatment for anemia, neuropsychological evaluation, and chelation therapy for each of the blood lead level risk groups described in Chapter 6. Where applicable, any assumptions that were made in calculating these costs are discussed. Please note that the procedures for estimating the incidence of blood lead levels falling in various ranges used in the process of estimating screening and medical intervention costs were provided in the risk assessment document (Battelle, 1997).

Risk Group I (PbB 0 - 9 µg/dL). CDC recommends all children younger than six years old be screened for elevated blood lead levels. In addition, CDC recommends yearly repeat testing for children in this risk group. In actual practice, universal screening is not being achieved. Therefore, the proportion of children screened was multiplied by the screening cost and discounted to 1995 dollars. The resulting cost per child for Risk Group I is $58.

Risk Group IIA (PbB 10 - 14 µg/dL). As with Risk Group I, Risk Group IIA also requires repeated blood lead screening. The CDC recommends that children in this risk group be screened more frequently during the first year than children in Risk Group I . Specifically, children should be tested every 3 to 4 months. After three consecutive tests indicate that blood lead levels remain below 15 µg/dL, the child should be tested again a year later (CDC, 1991). This analysis assumes that children are tested once every four months during the first year, that blood lead levels remain below 15 µg/dL, and that children are then tested once in each of the four subsequent years (at ages two through five.) Multiplying the proportion of children expected to be screened, the cost of one test, and discounting to 1995 dollars results in a cost per child for Risk Group IIA of $70.

Risk Group IIB (PbB 15 - 19 µg/dL). Based on the CDC recommendation that children in this risk group need repeat screenings every three or four months, this analysis assumes the frequency of screening for Risk Group IIB is three times per year (for ages one through five).

An additional cost not estimated for Risk Group I and IIA includes the cost of health education. CDC notes that it is prudent for parents to use simple interventions to decrease hazardous levels of lead in the home. Education about the types of intervention that can be done may be achieved through a face-to-face interview with the family (CDC, 1991). U.S. EPA (1987) presents the cost of a one-time personal evaluation by a professional as $200. Updating this cost to $1995 results in health education costs of $388.

The total cost for this risk group (incorporating the probability that a child will be screened and treated) is $227 per child.

Risk Group IIIA (PbB 20 - 24 µg/dL). CDC recommends that children in this risk group be rescreened every three to four months; the current analysis assumes that children are screened once every four months. Health education costs are assumed to be the same as Risk Group IIB.

In addition to the screening and education costs, CDC recommends that children with blood lead levels greater than or equal to 20 µg/dL be tested for iron deficiency. A cost for this test of $20 (1985 dollars) from U.S. EPA (1987) was updated to a value of $38 (1995 dollars). Based on results of the iron deficiency test, children in this group may need treatment for anemia. Medical practice indicates that about half of children who are screened for elevated blood lead levels are treated for anemia (Shannon, 1996; McCord, 1996). This information does not specify whether a greater proportion (than 50 percent) of children in higher blood lead level ranges require treatment for anemia; therefore, the current analysis assumes that half of the children with blood lead levels of 20-24 µg/dL are anemic and would require treatment for anemia. A cost of $63 for anemia treatment was presented in U.S. EPA (1987). Updating this cost to 1995 dollars results in a cost of $122.

In addition to these costs, CDC recommends that children with blood lead levels ≥ 20 µg/dL should have a pediatric evaluation, with special attention given to neurologic examination and psychosocial and language development (CDC, 1991). In this analysis, it is assumed that all children in this risk group receive this neuropsychological evaluation. For children given chelation therapy, this examination may be important both at the time of diagnosis and when the child approaches school age; however, this analysis assumes only one neurological evaluation is performed. U.S. EPA (1987) provides a cost of $600 ($1164 in 1995 dollars) for this evaluation.

Because only minimal data exist about chelating children with blood lead levels less than 20 µg/dL, CDC recommends that these children should not be chelated (CDC, 1991). In addition, AAP (1995) notes that chelation treatment is not indicated in patients with blood lead levels less than 25 µg/dL. Therefore, it is assumed that all children in this risk group (and lower risk groups) are not chelated.

Incorporating probabilities of screening and anemia treatment, the total cost per child for this risk group is $417.

Risk Group IIIB (PbB 25 - 44 µg/dL). CDC recommends that children in this risk group be rescreened every three to four months; health education costs, tests for iron deficiency for this risk group, and a neuropsychological evaluation are also recommended. However, costs for this risk group differ depending on whether or not a child is chelated. Depending on results of blood lead and further testing, some children in this group may require chelation therapy to lower their blood lead levels to acceptable levels. The costs and assumptions for blood lead screening, education, anemia treatment, and neuropsychological evaluation are the same for nonchelated children in this group as for children in Risk Group IIIA. Frequency of screening differs for chelated children compared with non-chelated children (as described below). In addition, treatment for anemia is assumed to be included as part of the chelation therapy, and is therefore not included as a separate cost for chelated children.

Children in this risk group must undergo an edetate disodium calcium (CaNa2 EDTA) provocation test to determine whether they will respond to chelation therapy. The cost of performing this test on an outpatient basis was presented as $150 in U.S. EPA (1987). This cost is used in the current analysis and updated to 1995 dollars for a resulting value of $291.

There are varying recommendations about whether children in this risk group should be chelated. CDC recommends that children in this risk group who have positive CaNa2 EDTA provocation test results should undergo a 5-day course of chelation (CDC, 1991). Information suggests that about seventy-six percent of children with blood lead levels 35-44 µg/dL and 35 percent of children with blood lead levels 25 - 34 µg/dL had positive provocation test results as noted in one source (CDC, 1991 as cited in Markowitz and Rosen, 1991). Additional information indicates varying protocols of chelation requirements for this risk group. At Children's Hospital in Boston, Massachusetts all children in this risk group are chelated (Shannon, 1996). At Children's Health Care of St. Paul, Minnesota where most children in Minnesota with elevated blood lead levels are treated, chelation is not recommended for blood lead levels lower than 40 µg/dL (McCord, 1996). Based on the information above, this analysis assumes that fifty percent of children in this risk group require chelation.

Information suggests that an oral method of chelation performed on an outpatient basis can be used for children in this Risk Group. Although CDC (1991) does not give a strong recommendation about whether to chelate these children on an inpatient or outpatient basis or the type of chelating agent that should be used, they do note that some practitioners use an oral chelating agent. The American Academy of Pediatrics suggests that children in this risk group may benefit from oral therapy, which can be done on an outpatient basis (AAP, 1995). Other information also suggests that chelation for blood lead levels in this range may be performed on an outpatient basis (U.S. EPA, 1987; McCord, 1996) if the child can be kept away from the source of exposure (U.S. EPA, 1987). Based on these recommendations, this analysis uses an outpatient chelation cost from U.S. EPA (1987); the cost is $582 in 1995 dollars (updated from $300 in 1985 dollars).

Children chelated once may need additional chelation treatment to bring blood lead down to acceptable levels on a long-term basis (CDC, 1991). This analysis assumes that fifty percent of children who receive a first chelation will require a second treatment based on information from U.S. EPA (1987).

Children who receive chelation therapy should be followed closely for at least a year or more to recheck blood lead levels. CDC (1991) recommends retesting every other week for 6-8 weeks, and then once a month for 4-6 months (or more often depending on the type of chelation performed.) Based on this information, the current analysis assumes that seven repeat tests will be performed within the year following chelation. Chelation is expected to decrease blood lead levels to below 25 µg/dL (CDC, 1991). For this analysis, it was assumed that lead levels are decreased to below 25 µg/dL but remain at levels above 15 µg/dL. Therefore, in addition to the seven repeat screenings in the year following chelation, chelated children require screenings once every four months (after the first year) through age five as suggested by CDC for children with blood lead levels greater than 15 µg/dL (CDC, 1991). Follow up testing costs are the same as initial screening costs, at $81 in 1995 dollars.

The total cost per child for this risk group, incorporating probabilities of screening and treatment, is $678.

Risk Group IV (PbB 45 - 69 µg/dL). Only fifteen percent of children in lower risk groups are expected to be screened. However, children in this group may present symptoms of lead poisoning, such as lethargy, anorexia, vomiting, abdominal pain (CDC, 1991). For this analysis, it is assumed that all children in this risk group will exhibit symptoms and will require follow up blood lead level testing.

CDC (1991) recommends that children in this group should not be given a provocation test, but should be referred for appropriate chelation therapy immediately upon identification of this blood lead level. Several sources suggest that chelation may be done on an inpatient or an outpatient basis for children in this risk group. Although AAP (1995) suggests that children in this group may be orally chelated and McCord (1996) notes that most chelations done in St. Paul are done on an outpatient basis, CDC (1991) discusses a treatment regimen limited to CaNa2EDTA for this group of children because experience using other treatments is limited. AAP (1995) recommends against performing CaNa2EDTA on an outpatient basis, and in addition, suggests that children in this group may need to be hospitalized for the initiation of therapy. Based on this information, the current analysis assumes that chelation for this risk group is performed using CaNa2EDTA on an inpatient basis. U.S. EPA (1987) lists a cost for inpatient CaNa2EDTA therapy at $1,500. Based on CDC recommendations, increased frequency of follow up blood lead testing after chelation is assumed to be the same as for Risk Group IIIB.

As with Risk Group IIIB, there may also be a need for repeat chelations. CDC (1991) indicates that a second chelation may be needed, and perhaps a third chelation may be required if blood lead levels return to levels greater than 45 µg/dL. For children with elevated blood lead levels, U.S. EPA (1987) assumes that fifty percent of children who have one chelation will require a second chelation, and that fifty percent of those who receive a second chelation will require a third. The same assumptions are used in this analysis.

As noted under Risk Group IIIB, chelation is assumed to decrease blood lead levels below 25 µg/dL. Therefore, after the first year of increased testing following chelation, testing is assumed to occur once every four months for the subsequent years through age five (recommended for children with blood lead levels greater than 15 µg/dL).

Costs of health education, tests for iron deficiency, and neuropsychological evaluation are the same as for Risk Group IIIB. As noted under Risk Group IIIB, the cost of anemia treatment is assumed to be covered in the cost of chelation.

The total cost for a child in this risk group, incorporating probabilities of medical treatment, is $9,843.

Risk Group V (PbB $\geq$ 70 µg/dL). The lead poisoning symptoms listed for Risk Group IV are most commonly associated with blood lead levels of 70 µg/dL and greater. In addition, encephalopathy may be associated with blood lead levels as low as 70 µg/dL (CDC, 1991). It is assumed that for this analysis, children in this category would exhibit symptoms, and therefore all children in this risk group would be screened.

Children in this risk group represent a medical emergency and should be hospitalized and chelated immediately (CDC, 1991). Therefore, children in this group would require inpatient chelation. A cost of $2,000 for inpatient chelation was listed in U.S. EPA (1987); the equivalent cost updated to 1995 dollars is $3880 and is used in the current analysis. The same assumptions about the need for repeated chelations and follow up screenings after chelation are used for this group as for Risk Group IV.

Children in this risk group also require an iron deficiency test, health education and neuropsychological evaluations, as indicated for Risk Groups IIIB and IV (CDC, 1991). Also, as with the previous two risk groups, costs for anemia treatments are not included because the protocol of chelation treatment is expected to alleviate iron deficiency (U.S. EPA, 1987).

The total cost for a child in this risk group, incorporating probabilities of medical treatment, is $9,843.

Use of Costs per Child in Benefits Analysis. The above monetary values determined for each risk group are used to estimate benefits associated with the change in the number of children in each risk group resulting from a change in geometric mean blood lead level. The monetary values of the avoided health effects used in the benefits estimation are summarized in Exhibit 6-2. The results of this benefits analysis are presented in Chapter 7.

Appendix 6.B Aggregating Benefits from Environmental Lead Reduction

As stated previously, this study assumes that after §403 is implemented, all children born into homes exceeding the standard will have their homes appropriately treated to insure the children's protection during the first six years of life. Accordingly, all children born post-§403 will be protected at least up to the level mandated by the standard. (Not all childbirths will trigger interventions, however, because many children will be born into homes that already meet the standard.)

The benefits analysis is based on calculating benefits for all children born in the same year, referred to as a cohort of children. Aggregating the benefits of all children born between 1997 and 2046 involves summing the total present value of benefits for all cohorts. The expected blood lead distribution must be calculated separately for each cohort (based on either the IEUBK or empirical model), because in each year different home types are demolished at different rates. As a result, a changing mix of homes causes the post-§403 blood-lead distributions to vary slightly from one year to the next. Basically, the measurement of health benefits is repeated 50 times -- once for each cohort of children. The expected benefits from §403 will consequently differ by a small amount for each group of children born between 1997 and 2046, even before discounting is taken into account.

To illustrate how benefits are determined for each cohort, equations are shown for children born in 1997, 1998, and 2046 (years 1, 2, and 50, respectively). The following variables are used in each equation:

let TB(Cohort t) = total benefits for the cohort born in year t (Cohort t)
N = total number of households in 1997
P_t = probability that a child is born into a household in year t
ϵ_t = number of homes demolished from 1997 to year t
ΔIQ_t = predicted increase in average IQ (post-§403 IQ minus pre-§403 IQ) for Cohort t
$\Delta 70_t$ = predicted decrease in the probability of IQ less than 70 for Cohort t
$\Delta 20_t$ = predicted decrease in the probability of blood-lead greater than 20 µg/dl for Cohort t
$\Delta T1_t$, ..., and $\Delta T7_t$ = the predicted change in the probability of belonging to risk group I, ..., and V, respectively for Cohort t.
PV_{IQ} = present value of an increase in IQ of one point per child in 1995 dollars
PV_{70} = present value of part-time special education costs for years 7-18 per child in 1995 dollars
PV_{20} = present value of part-time special education costs for years 7-9 per child in 1995 dollars
PV_{T1}, ..., and PV_{T7} = the present value of screening and medical treatment in risk group I, ..., and V, respectively (per child in 1995 dollars)
r = discount rate (3%)

Note that the variable for housing demolition was based on information provided in Battelle (1996) and that the variables for changes in IQ and blood lead were based on information provided in Battelle (1996) and Battelle (1997).

The first example shows the calculation for benefits to children born in 1997 (Cohort 1). These benefits are represented in Equation 1:

Equation 1:

TB(Cohort 1)=

$$P_1\times(N-\epsilon_1)\times((\Delta IQ_1)\times(PV_{IQ}) + (\Delta 70_1)\times(PV_{70}) + 0.20\times(\Delta 20_1)\times(PV_{20}) + (\Delta T1_t)\times(PV_{T1}) + ... + (\Delta T7_t)\times(PV_{T7}))$$

This equation simply takes the number of children born in 1997 ($P_1\times(N-\epsilon_1)$) and assigns to them values from four benefit categories. A reduction in number of homes from attrition (ϵ_1) is included even in 1997 because the analysis assumes that attrition takes place at the beginning of each year. The four benefit categories are the following:

1. Foregone earnings regained because of reduced loss of IQ points;
2. Decrease in the probability of an IQ score less than 70;
3. Decrease in the probability of a blood-lead level greater than 20 µg/dL; and
4. Decreases in the probabilities of falling into CDC's high blood lead risk groups.

Again, these four benefit calculations are based on the blood lead distribution changes calculated using the IEUBK or empirical model analysis associated with Cohort 1.

Total benefits to subsequent cohorts are slightly more involved because the benefits must be discounted back to 1997. The total benefits for Cohort 2 (children born in 1998) are shown in equation 2:

Equation 2:

TB(Cohort 2)=

$$\frac{P_2\times(N-\epsilon_2)\times((\Delta IQ_2)\times(PV_{IQ}) + (\Delta 70_2)\times(PV_{70}) + 0.20\times(\Delta 20_2)\times(PV_{20}) + (\Delta T1_t)\times(PV_{T1}) + ... + (\Delta T7_t)\times(PV_{T7}))}{(1+r)}$$

Again, this equation states that the number of children born into pre-1997 housing ($P\times(N-\epsilon_2)$) are assigned benefits from an increase in IQ, a reduction in the probability of an IQ less than 70, a reduction in the probability of a blood-lead concentration greater than 20 µg/dl, and the reduced probability of belonging to a high risk group. These benefits accrue when the children are born in 1998 so they are discounted back 1 year to 1997.

The total benefits for Cohort 50 (children born in 2046) are shown in equation 3:

Equation 3:

TB(Cohort 50) =

$$\frac{P_{50}\times(N-\epsilon_{50})\times((\Delta IQ_{50})\times(PV_{IQ}) + (\Delta 70_{50})\times(PV_{70}) + 0.20\times(\Delta 20_{50})\times(PV_{20}) + (\Delta T1_{t})\times(PV_{T1}) + \ldots + (\Delta T7_{t})\times(PV_{T7}))}{(1+r)^{49}}$$

The number of children born into pre-1997 housing ($P\times(N-\epsilon_{50})$) are assigned benefits. The benefits occur when the children are born in the year 2046 so they are discounted back 49 years to 1997.

The final step involves summing the present value of total benefits for all 50 cohorts:

Total Benefits = TB(Cohort 1)+ TB(Cohort 2)+ . . . +TB(Cohort 50).

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7. Net Benefits

The normative model described in Chapters 4, 5, and 6 was developed to provide estimates of the costs, benefits, and net benefits, under a set of specific assumptions about the behavior of residential property owners and managers, for alternative definitions of lead hazard standards addressing paint, floor dust, window sill dust, and soil. The estimates obtained from the model are intended to inform the decision-makers about the relative merits of the alternative standards from a benefit-cost perspective. Since both the costs and the benefits of compliance increase as hazard standards become more stringent (i.e. more protective), neither costs nor benefits by themselves provide a sufficient means for evaluating the relative merits of alternative standards. Net benefits, however, which are calculated as the difference between the benefits to society and the corresponding costs to society of compliance with a particular standard, can serve as a measure of the degree to which society is better or worse off due to compliance with alternative hazard standards, and thus better inform the decision.

By estimating net benefits for a broad range of alternative hazard standards, the analysis can identify one (or more) combinations of paint, dust and soil standards that maximizes net benefits (i.e. is the most efficient standard in economic terms). The net benefits analysis can also measure the relative degree to which society is made worse off from a standard that is less costly, but also less protective, than the one generating maximum net benefits. Conversely, it can also indicate when a set of standards that is more protective than the one that maximizes net benefit yields that greater degree of protection at a cost that exceeds the value of the additional benefits.

Because the objective of Title X is to protect children, and the objective of §403 is to provide guidance to parents and property owners to that end, the benefit-cost model focuses on how to maximize net benefits to children. In other words, the intent of §403 is to inform people about what they should do -- and when -- in the arena of protecting their children from the adverse affects of lead exposure. The consideration of when actions are taken is important in the calculation of net benefits. The model assumes that intervention actions are timed to happen just before a newborn child is introduced into the home. If interventions were to occur later, the child would experience some exposure to lead levels that exceed the standards. This would reduce the benefits that the child would otherwise receive. If interventions were to occur well before the appearance of the infant, money would be spent with no immediate benefits to the child, thus increasing the costs relative to the benefits. For these reasons, the model assumes that hazard testing and intervention will occur just before the appearance of the newborn. Although it is recognized that this is not necessarily how individuals will behave with respect to these standards, structuring the analysis in this way provides a systematic approach to estimating what the net benefits of these standards might be if affected parties do behave in a manner that both maximizes the potential benefits and minimizes the potential costs of acting to reduce lead exposure to children. Therefore, all of the net benefits estimates presented in this chapter must be viewed in the context of the above fixed assumptions concerning the timing of actions taken.

The remainder of this chapter addresses how the costs and benefits vary across alternative candidate hazard standards, identifies the candidate standards that maximize net benefits, and compares the maximum net benefits to the values estimated for the particular set of final standards established by EPA, presented in the table below.

Media	Final Standards
Paint Condition Interior Paint Standard	• More than 2 sq ft of deteriorated lead-based paint in an interior room • Any visible deteriorated or abraded lead-based paint on friction of impact surfaces • Any visible deteriorated lead-based paint on interior window sills up to five feet off the floor
Exterior Paint Standard	• More than 10 sq ft of deteriorated lead-based paint on the exterior of a property
Floor Dust	40 µg/ft^2
Window Sill Dust	250 µg/ft^2
Soil	1200 ppm
* For the analysis the following values were used: Damaged Paint: Interior: 2 sq.ft. or more -- Repair 50 sq.ft. or more -- Abatement Damaged Paint : Exterior: 10 sq.ft. or more -- Repair 100 sq.ft. or more -- Abatement	

Sections 7.1 through 7.3 examine the trends in costs, benefits, and net benefits when the numerical standards for floor dust, window sill dust, and soil are varied individually, with the remaining standards being fixed at their respective final values. As explained in Chapter 4, the analysis assumes that homes that receive any lead intervention will receive interventions for all media (floor dust, window sill dust, paint and soil) that exceed the standards. This, combined with the fact that there are interactions among the interventions for both the costs and the benefits, means that standards can not be accurately evaluated one at a time. Instead, the standards for a single medium must be evaluated in the context of specified standards for all other media. To allow for this, the analysis calculated costs, benefits and net benefits for all possible combinations of standards.[1] For simplicity of presentation, however, this chapter presents the results of the analysis varying the standard for one medium at a time, while holding the standards for the other media constant at the level of their final standard. The purpose of these sections is to provide the reader with some insights regarding the relationship between reducing exposure from these media and the resulting net benefits.

It is also important to note that the net benefit results are presented separately here for the two different blood lead models used by EPA in the risk assessment, and the differences in the results obtained from these two models are explored. In general, the analysis using the IEUBK model generates higher estimates of blood-lead changes, suggests larger net benefits at any particular set of standards, and points toward more stringent standards as maximizing net benefits, than suggested by the Empirical model.

[1] For each medium, the alternative standards were defined in terms of incremental changes in the levels of lead. For example, floor dust standards varied by increments of 10 µg/ft^2 (e.g., 40 µg/ft^2, 50 µg/ft^2, 60 µg/ft^2, 70 µg/ft^2, etc.). Likewise, soil standards were analyzed in increments of 50 ppm (150 ppm. 200 ppm. 250 ppm, 300 ppm, etc.). All combinations of standards were analyzed.

The differences in the estimates resulting from the two models are due to several factors including the incorporation of different variables and very different functional forms to relate environmental lead levels to children's blood lead levels. Notably, the functional form of the IEUBK Model is such that it is much more sensitive to changes in environmental lead than the Empirical Model. Also, the IEUBK Model uses lead dust concentrations and the Empirical Model uses dust lead loadings as input variables. Since dust lead concentrations and loadings are not well correlated in the actual housing unit data collected by HUD and used for this analysis, these differences in input variables result in differences in estimated blood-lead changes and thus benefits. Loading and concentration are not necessarily correlated: loading means the mass of lead in dust per unit area, and concentration means the mass of lead per mass of dust. In a home with a very low *dust* load, dust *lead* loading must also be small; but it is quite possible for the concentration of lead in the dust present to be high.

A third major cause of the difference between IEUBK and Empirical Model-based results are the changes in dust contamination that result from paint interventions. Based on the risk assessment, dramatic reductions in dust lead concentration accompany all paint interventions, while reductions in dust lead loadings accompany only the interior paint abatements. These interior paint abatements are relatively rare occurrences. Consequently, paint interventions lead to very large benefits under the IEUBK Model, whereas they lead to negligible benefits under the Empirical Model.

The reader is referred to Chapters 4 and 6 and to the Risk Assessment document prepared for this rule (Battelle 1997) for further discussion of these two blood lead models.

7.1 Costs, Benefits and Net Benefits for Various Candidate Floor Dust Hazard Standards

The §403 standards will define lead-based paint hazards, as well as levels of lead in floor dust, window sill dust, and soil considered to be hazards. As described in Chapters 4 and 5, when floor and/or window sill dust lead levels exceed their standards, the assumed intervention is a lead-specific dust cleaning. In addition, the same type of dust cleaning is assumed to be performed in conjunction with soil interventions and interior paint abatements (but not paint repair nor exterior paint abatements). These soil and paint related dust cleanings are performed regardless of the pre-intervention lead levels in the dust. Therefore, interventions in response to the floor and window sill dust standards occur only in cases where there is no interior paint abatement nor soil abatements. Under most of the candidate hazard standards analyzed, there will be a relatively large number of these "stand-alone" dust cleanings.

As shown in Exhibit 5.8 of Chapter 5, the number of homes performing a dust cleaning intervention is not only relatively large, but also relatively insensitive to the floor dust hazard standards. The number of homes predicted by the model to perform a dust cleaning declines slowly for floor dust standards between 40 $\mu g/ft^2$ and 90 $\mu g/ft^2$, dipping at a standard of 100 $\mu g/ft^2$, and declining very slowly after that.

While the number of homes receiving "stand-alone" dust cleanings is far larger than either the number of homes receiving paint interventions or soil interventions, dust cleanings are much less costly than either paint or soil interventions. Thus costs change very little as floor dust standards vary. The table labeled Exhibit 7-1 presents the costs for a representative selection of floor dust standards, assuming that the paint, window sill dust and soil standards are set at the final standards. The two graphs (Exhibits 7.2 and 7.3) present these same costs for a wider range of floor dust standards. As shown in the table, the costs for all interventions range from about $67.2 billion, when floor dust standards are set at their least stringent levels, up to about $68.9 billion for the most stringent (40 µg/ft^2). The most stringent level is set at the assumed post-intervention lead level, the level of lead assumed to be present in floor dust after the dust intervention occurs. The least stringent standard shown in the table is at the level where costs have leveled off, they do not drop below this level within the data set (see Exhibits 7.2 and 7.3). Note that the highest cost is only about 2.5 percent greater than the lowest cost. Thus there is little basis for choosing among floor dust standards on the basis of cost alone.

Exhibit 7-1
Costs, Benefits and Net Benefits for Alternative Floor Dust Standards, With Other Media Set at Final Standards*

Floor Dust Standards (µg/ft^2)	Total Cost of All Interventions ($ Billion)	IEUBK Model		Empirical Model	
		Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)	Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)
40	68.9	192.2	123.3	48.5	-20.3
50	68.7	190.8	122.1	48.5	-20.3
60	68.5	188.9	120.4	48.3	-20.2
70	68.5	188.9	120.4	48.3	-20.2
80	68.2	185.3	117.0	48.0	-20.2
100	67.5	178.7	111.3	46.6	-20.8
120	67.3	160.6	93.3	46.3	-21.0
140	67.2	160.2	93.0	46.2	-21.1
160	67.2	160.2	93.0	46.2	-21.1
180	67.2	160.2	93.0	46.2	-21.1
200	67.2	158.1	90.9	46.1	-21.1
220	67.2	158.1	90.9	46.1	-21.1

* Final Standards:
Interior paint: 2 sq ft or more — repair, 50 sq ft or more — abate
Exterior paint: 10 sq ft or more — repair, 100 sq ft or more — abate
Window sill dust: 250 µg/ft^2
Soil: 1,200 ppm

Exhibits 7.1, 7.2 and 7.3 also present the estimated benefits and net benefits for alternative floor dust standards. Total benefits, as estimated using the IEUBK Model, range from about $158.1 billion to $192.2 billion with increasing stringency in floor dust standards. The highest level of benefits is about 22 percent larger than the lowest benefits, with benefit levels about constant up to a standard of 120 µg/ft^2 and increasing with increasing stringency after that. Under this risk model, the benefits are still increasing much more rapidly than the costs at the most stringent levels. Therefore, net benefits are maximized at the most stringent floor dust standard of 40 µg/ft^2. Net benefits at this set of standards are estimated to be $123.3 billion.

The Empirical Model generates lower estimates of benefits, and the benefit estimates change less with changes in the floor dust standards. Using the Empirical Model, total benefits range from about $46.1 billion to $48.5 billion with changes in the floor dust standards. The highest level benefits are only about 5 percent higher than the lowest benefit level. The Empirical Model provides lower estimates of benefits, and the net benefits corresponding with each floor standard are negative (i.e. costs exceed benefits). Nevertheless, these results can be used to identify the floor dust standard that generates the maximum net benefits (i.e. the least negative net benefits). Under this risk model, net benefit levels are about constant up to 120 µg/ft^2, and increase as the floor dust standard becomes more stringent up to the standards of 80 and 60 µg/ft^2. Net benefits are nearly identical for these two standards. Net benefits are slightly worse for the 40 µg/ft^2 level.

Comparing the results of the two blood-lead models, the floor dust standard that maximizes net benefits (when the other standards are set at their final levels) appears to be in the range of 40 - 80 µg/ft^2, with about a 1.0 percent difference in costs over this range.

7.2 Costs, Benefits and Net Benefits for Various Candidate Window Sill Dust Hazard Standards

Dust cleaning interventions occur when either the floor dust or the window sill dust standard is exceeded. Unlike the floor dust standards, however, the number of homes performing a dust cleaning in response to the window sill dust standards is quite sensitive to the window sill standards. As shown in Exhibit 5.9, the number of interventions falls rapidly as window sill dust standards are reduced in stringency from 100 to 220 µg/ft^2 and then falls less rapidly until about 450 µg/ft^2, after which the number remains about constant.

Because of the relatively low cost of a dust cleaning, the percentage change in total costs of all interventions is much smaller than the percentage change in the total number of homes receiving a dust intervention. The table presented in Exhibit 7-4, and the graphs presented in Exhibits 7.5 and 7.6, give the total costs of all interventions for a range of window sill dust standards, with the other media set at the final standards. As shown in Exhibit 7-4, the costs for all interventions range from about $65.9 billion for the least stringent window sill dust standards up to about $75.4 billion for the most stringent (100 µg/ft^2). The most stringent level is set at the assumed post-intervention lead level, the level of lead assumed to be present in window sill dust after the dust intervention occurs. The least stringent standard shown in the table is at the level where costs have leveled off (see Exhibits 7.5 and 7.6). Note that the highest cost is almost 14 percent larger than the lowest cost. This range in costs is larger than the range associated with floor dust standards in part because the range of window sill dust lead levels in the data is much wider than the range of floor dust lead levels in the data. In addition, a much larger proportion of homes in the data have window sill dust lead levels above the minimum standards than have floor dust levels above the minimum floor dust standard.

Exhibit 7.2: IEUBK-based Model Costs, Benefits, and Net Benefits

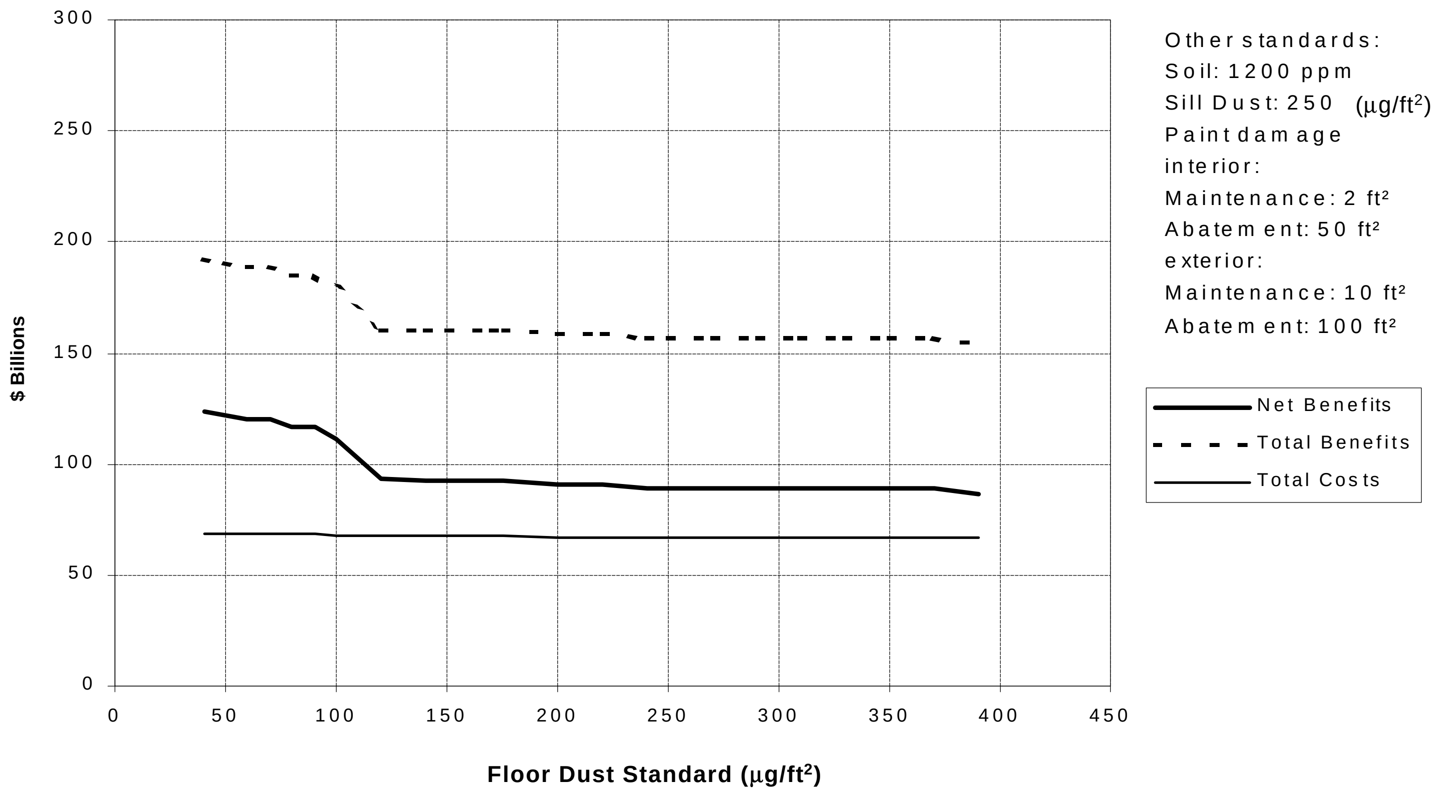


Exhibit 7.3: Empirical-based Model Costs, Benefits, and Net Benefts

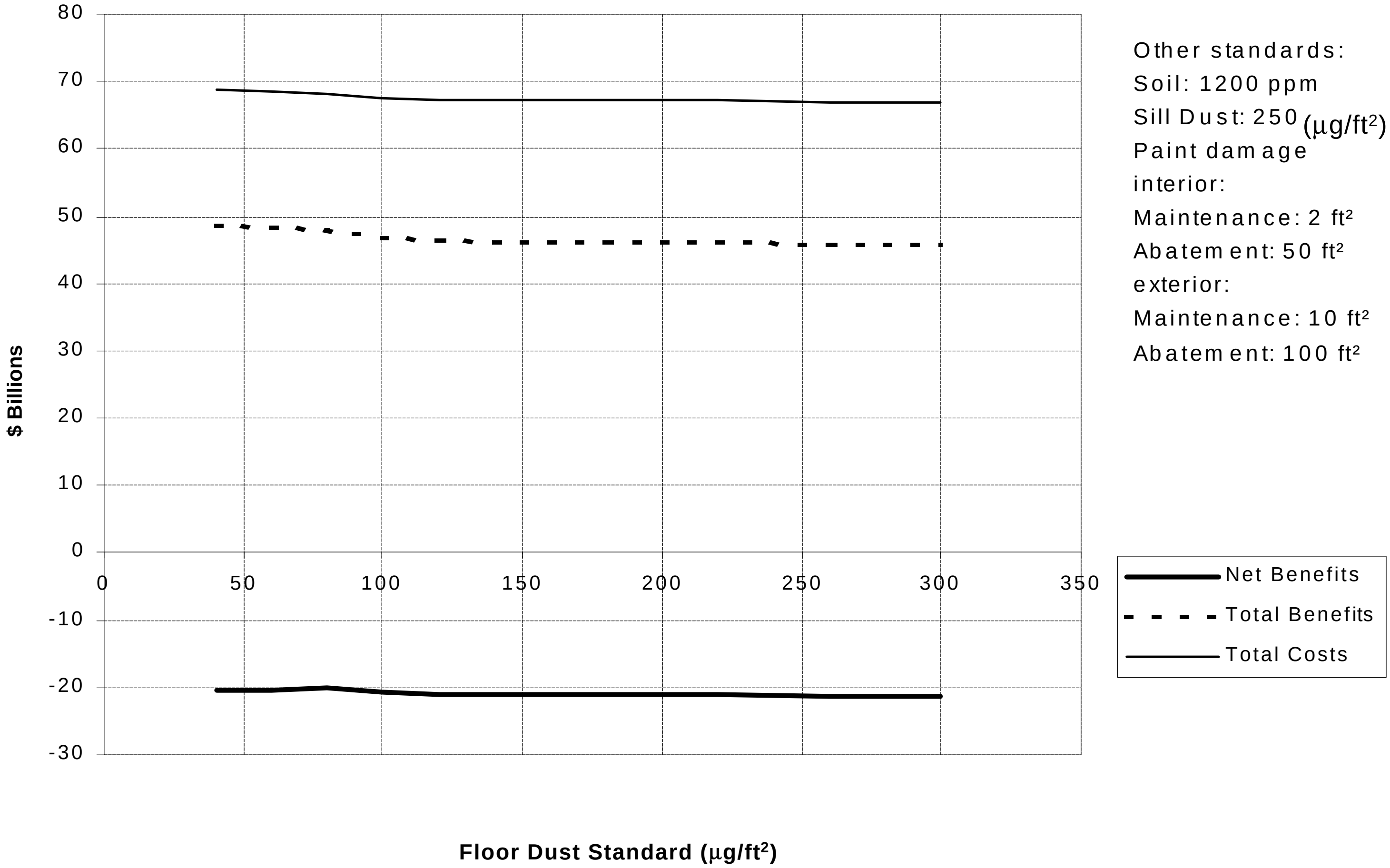


Exhibit 7-4
Costs, Benefits and Net Benefits for Alternative Window Sill Dust Standards, With Other Media Set at Final Standards*

Window Sill Dust Standards (µg/ft²)	Total Cost of All Interventions ($ Billion)	IEUBK Model		Empirical Model	
		Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)	Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)
100	75.4	210.0	134.6	52.0	-23.4
150	72.5	201.5	129.0	50.7	-21.8
200	72.2	200.5	128.3	50.6	-21.7
250	68.9	192.2	123.3	48.5	-20.3
300	68.4	191.9	123.4	48.1	-20.3
310	67.6	190.2	122.6	47.4	-20.2
350	66.9	188.6	121.6	46.7	-20.3
400	66.9	188.6	121.6	46.7	-20.3
450	66.6	186.6	120.0	46.1	-20.5
500	66.5	186.5	120.0	46.0	-20.5
550	66.1	185.8	119.7	45.6	-20.6
600	66.1	185.8	119.7	45.6	-20.6
650	65.9	185.6	119.7	45.1	-20.8
700	65.9	185.6	119.7	45.1	-20.8
750	65.9	185.6	119.7	45.1	-20.8

* Final Standards:

Interior paint: 2 sq ft or more — repair, 50 sq ft or more — abate
Exterior paint: 10 sq ft or more — repair, 100 sq ft or more — abate
Floor dust: 40 µg/ft²
Soil: 1200 ppm

Exhibits 7.4, 7.5 and 7.6 also present the estimated benefits and net benefits corresponding with alternative window sill dust standards. Total benefits, as estimated using the IEUBK Model, range from about $185.6 billion to $210 billion with changes in window sill dust standards. Benefit levels increase steadily with increasing stringency, with a jump at the most stringent window sill dust standard. The highest level of benefits is about 13 percent larger than the lowest benefits. Under this risk model, net benefits are maximized at the most stringent window sill dust standard of 100 µg/ft^2 . Net benefits at this set of standards are estimated to be $134.6 billion.

The Empirical Model generates lower estimates of benefits than the IEUBK Model. Using the Empirical Model, total benefits range from about $45.1 billion to $52 billion with changes in the window sill dust standards. As with the IEUBK results, benefits increase fairly steadily with increases in stringency. The highest level benefits are about 15 percent higher than the lowest benefit level. The Empirical Model provides lower estimates of benefits, and the net benefits corresponding with each window sill standard are negative (i.e. costs exceed benefits). Nevertheless, these results can be used to identify the window sill dust standard that generates the maximum net benefits (i.e. the least negative net benefits). Under this risk model, net benefits increase as the window sill dust standard becomes more stringent up to the standard of 310 µg/ft^2 and then decline as window sill dust standards become increasingly stringent.

The two blood-lead models generate more divergent estimates of the window sill dust standard that maximizes net benefits (when the other standards are set at their final levels) than was true for the floor dust standards. Nevertheless, the two estimates of 100 µg/ft^2 and 310 µg/ft^2 are both toward the lower end of the entire range of window sill dust lead levels present in the HUD sample of homes. The majority of homes with window sill dust lead levels above 100 µg/ft^2 , however, are within this range. Thus, the selection of a standard within this range can affect a great many homes. This is shown in Exhibit 5.9 and by the range of costs represented. The cost for a window sill dust standard of 100 µg/ft^2 is 12 percent higher than the cost at 310 µg/ft^2.

Exhibit 7.5: IEUBK-based Model Costs, Benefits, and Net Benefts for Alternative Window Sill Dust Standards

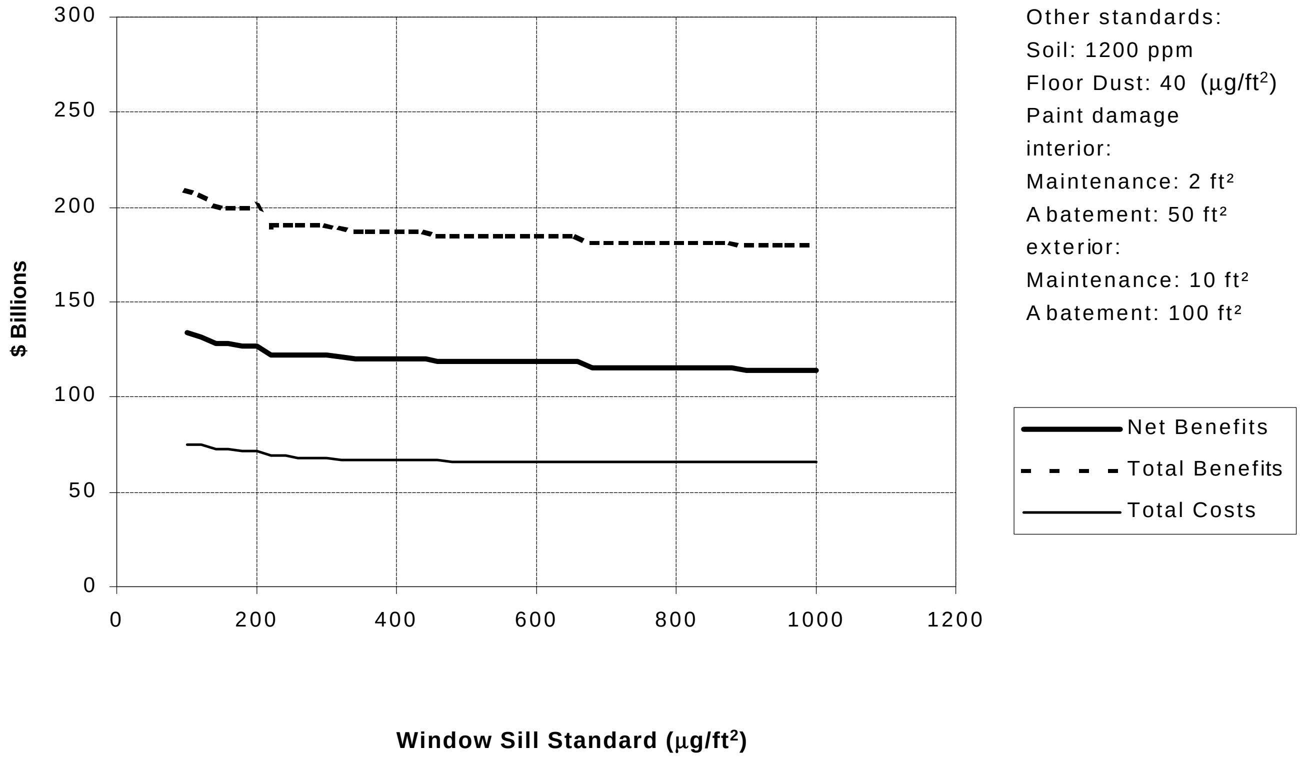
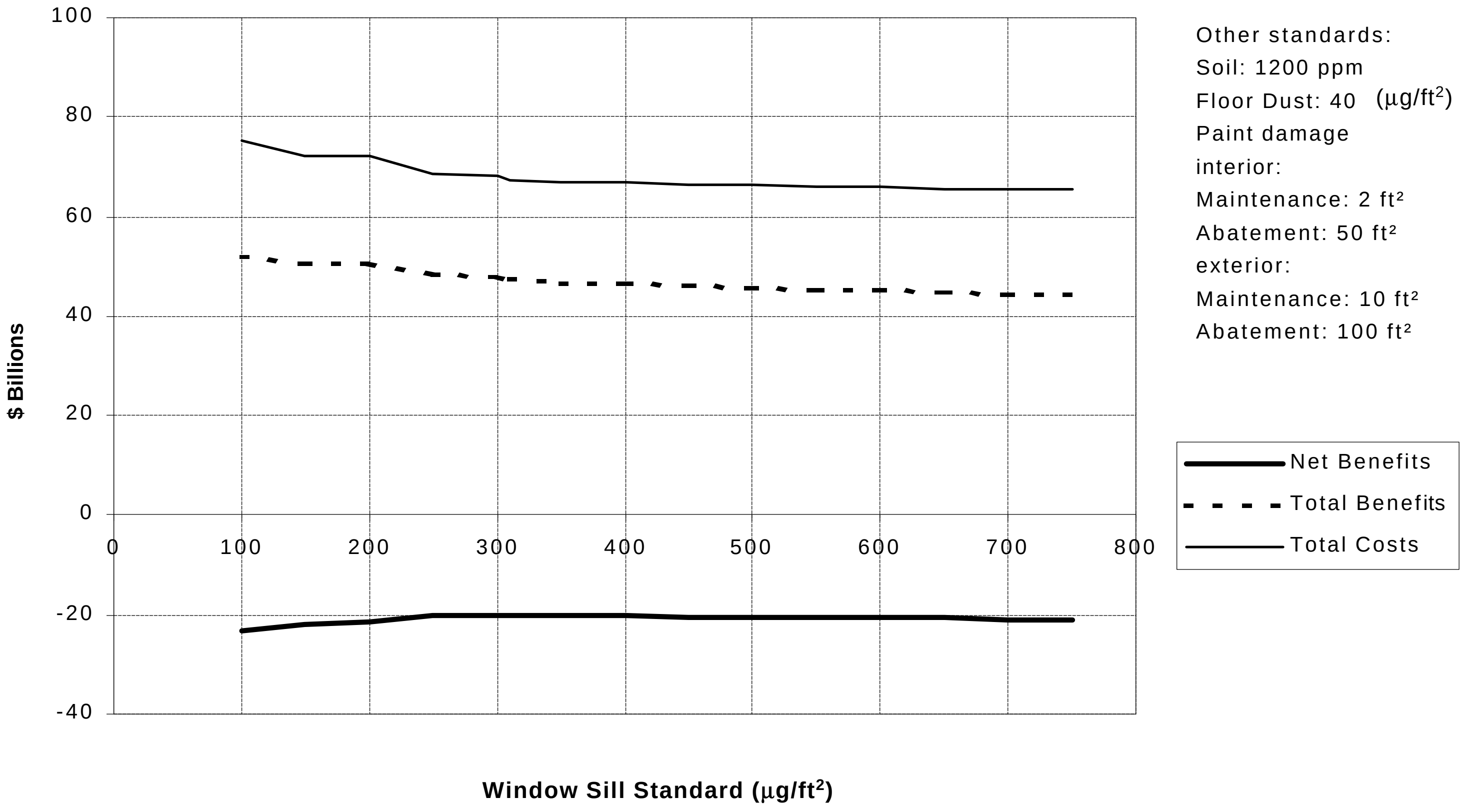


Exhibit 7.6: Empirical-based Model Costs, Benefits, and Net Benefts for Alternative Window Sill Dust Standards



7.3 Costs, Benefits and Net benefits for Various Candidate Soil Hazard Standards

While floor dust and window sill dust standards are related to each other by the fact that the same intervention action is taken in response to either one, changes in the floor or window sill dust standards do not induce changes in the number of paint or soil interventions performed. Soil dust standards, however, do affect the number of dust interventions performed. As explained in chapter 5, when soil standards become less stringent, the number of homes performing a soil abatement declines. Some of those homes, however, will have floor and/or window sill dust lead levels that exceed the dust standards and so will continue to do a dust cleaning. In other words, with the decline in the soil standards, some homes will switch from the soil intervention (with dust cleaning) category to the dust only intervention category. As shown in Exhibit 5.10, when the stringency of the soil standard declines from 150 ppm to about 900 ppm, the number of homes performing soil interventions declines very rapidly. From there, the number performing soil interventions declines less rapidly until the standard reaches about 3000 ppm, at which point the number levels off. Over the entire range, the number of homes performing soil abatements falls from greater than 25 million to nearly zero. At the same time, assuming the other media are set at their final standards, the total number of homes performing any kind of intervention falls only until the soil standard reaches about 700 ppm, after which it changes very little. The total number of homes performing any type of intervention falls from about 32 million to 20 million with changes in the stringency of the soil standards. These differences between soil interventions and total interventions are due to the homes that switch from soil to dust only interventions.

Because soil interventions are much more expensive than dust only interventions, costs also fall fairly rapidly as soil standards become less stringent. The table presented in Exhibit 7-7, and the graphs presented in Exhibits 7.8 and 7.9, give the total costs of all interventions for a range of soil standards, with the other media set at the final standards. As shown in Exhibit 7-7, the costs for all interventions range from about $46.1 billion, when soil standards are set at their least stringent level, up to about $94.6 billion for the most stringent (250 ppm). The most stringent level is set just above the assumed post-intervention soil lead level of 150 ppm, the level of lead assumed to be in the replacement soil used in the soil intervention. The least stringent standard shown in the table is at the level where costs have leveled off (see Exhibits 7.8 and 7.9). Note that the highest cost is over twice the lowest cost. This range is so large both because soil abatements are relatively expensive and because the number of homes that exceed the standards increases very rapidly as standards become more stringent than the 1500 ppm level. Note, in particular, that the number of homes that exceed the soil standard increases by 62 percent as the soil standards increase in stringency from 500 ppm to 250 ppm.

Exhibits 7.7, 7.8 and 7.9 also present the estimated benefits and net benefits for alternative soil standards. Total benefits, as estimated using the IEUBK Model, range from about $138.8 billion to $257.9 billion with changes in soil standards. The highest level of benefits is almost twice the lowest level. Benefits increase slowly with increasing stringency in the soil standards up to about 3,000 ppm. After that point, benefits increase more rapidly, with a sizeable jump between 1,000 and 500 ppm. Under this risk model, net benefits are maximized at a very stringent standard; in this case a soil standard of 250 ppm. Net benefits at this set of standards are estimated to be $163.2 billion.

Exhibit 7-7
Costs, Benefits and Net Benefits for Alternative Soil Standards,
With Other Media Set at Final Standards*

Soil Standards (ppm)	Number of Soil Removals	Total Cost of All Interventions ($ Billion)	IEUBK Model: Total Benefits of All Interventions ($ Billion)	IEUBK Model: Net Benefits of All Interventions ($ Billion)	Empirical Model: Total Benefits of All Interventions ($ Billion)	Empirical Model: Net Benefits of All Interventions ($ Billion)
250	16.2	94.6	257.9	163.2	63.6	-31.0
500	10.0	84.1	239.5	155.4	58.9	-25.2
1000	4.7	71.3	197.6	126.3	50.6	-20.7
1200	3.8	68.9	192.2	123.3	48.5	-20.3
1500	3.5	60.0	189.9	129.9	48.1	-11.9
2000	3.5	53.4	189.0	135.6	47.8	-5.7
2500	2.1	50.6	167.9	117.3	42.8	-7.8
3000	0.6	49.6	140.3	90.7	38.3	-11.3
3500	0.6	49.6	140.3	90.7	38.3	-11.3
4000	0.6	49.6	140.3	90.7	38.3	-11.3
4350	0.6	46.3	140.3	93.9	38.3	-8.1
4500	0.6	46.3	140.3	93.9	38.3	-8.1
5000	0.5	46.1	138.8	92.7	38.0	-8.1

* Final Standards:

Interior paint: 2 sq ft or more — repair, 50 sq ft or more — abate
Exterior paint: 10 sq ft or more — repair, 100 sq ft or more — abate
Window sill dust: 250 sq ft^2
Floor dust: 40 $\mu g/ft^2$

As was the case with the other media, the Empirical Model generates lower estimates of benefits. Using the Empirical Model, total benefits range from about $38 billion to $63.6 billion with changes in the soil standards. The highest level benefits are about 67 percent higher than the lowest benefit level. Similar to the IEUBK Model results, benefits increase steadily with increases in soil standard stringency, with an additional jump between 1,000 ppm and 500 ppm. Because the Empirical Model provides lower estimates of benefits, the net benefits corresponding with each soil standard are negative (i.e. costs exceed benefits). Nevertheless, these results can be used to identify the soil standard that generates the maximum net benefits (i.e. the smallest in absolute value terms). Under this risk model, net benefits are maximized at a soil standard of 2000 ppm. As the soil standards increase in stringency from that point, net benefits decline. As the soil standards decrease in stringency from 2000 ppm, net benefit decline somewhat, then increase to a secondary net benefit maximum at a soil standard of 4350-4500 ppm.

Some of the apparent kinks in the costs and benefits shown in Exhibits 7.8 and 7.9 are due to the relative thinness of data in certain ranges (i.e., there are few observations for certain soil lead levels), and some are due to the role of play area abatements. Under the final §403 standards, three areas of a yard potentially receive attention: the perimeter of the building, the remote yard in general, and the play area in particular.

If the average soil lead concentration does not exceed the standard, but the play area alone does, then the play area is assumed to be abated. A play area abatement yields benefits equivalent to abating the remote yard, but at a much lower cost. Thus, as the soil standards become less stringent, some homes will shift from a remote and/or perimeter abatement to a play area abatement. This is particularly true in the 1200 to 2000 ppm range, where there is a significant shift of homes from remote area to play area only abatements. In this range, costs decline while benefits are nearly unchanged, resulting in an increase in net benefits. In addition, there is a plateau in the 1700 to 2000 ppm range because there are no observations with soil lead levels between 1617 ppm and 2000 ppm.

The two blood-lead models generate very divergent estimates of the soil standard that maximizes net benefits (when the other standards are set at their final levels). The two estimates are either a very stringent soil standard of 250 ppm (using the IEUBK Model) or a less stringent soil standard of 2000 ppm (using the Empirical Model).

Exhibit 7.8: IEUBK-based Model Costs, Benefits, and Net Benefts for Alternative Soil Standards

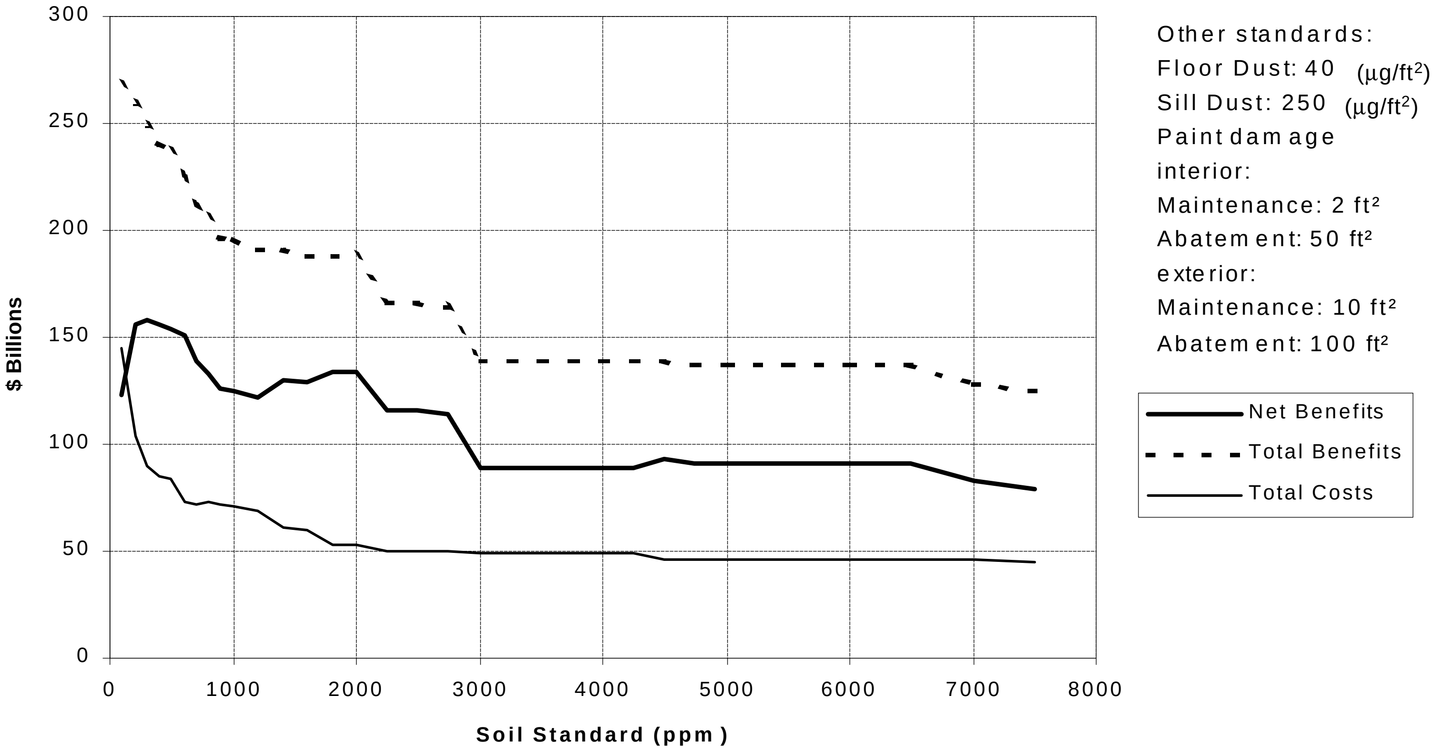
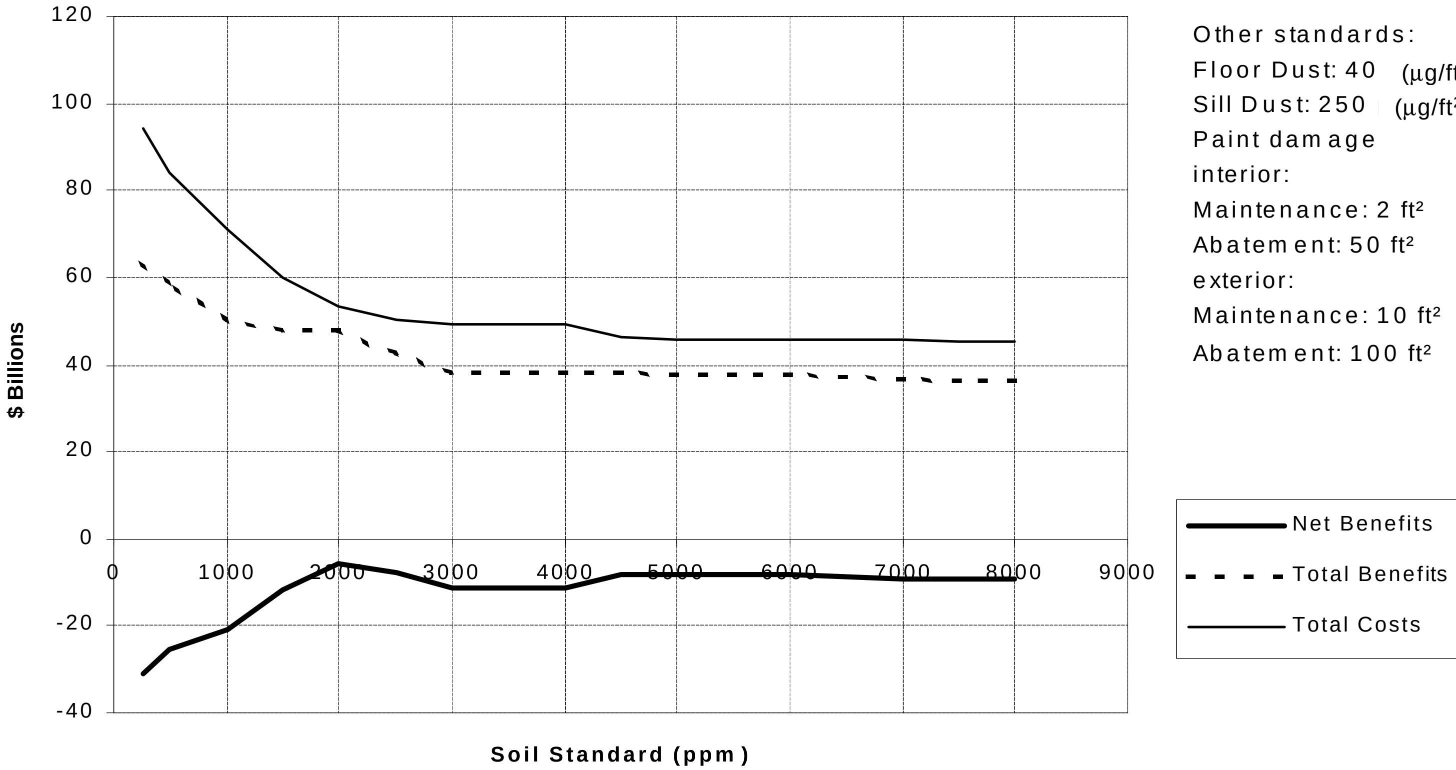


Exhibit 7.9: Empirical-based Model Costs, Benefits, and Net Benefits for Alternative Soil Standards



Other standards:
Floor Dust: 40 (µg/ft²)
Sill Dust: 250 (µg/ft²)
Paint damage
interior:
Maintenance: 2 ft²
Abatement: 50 ft²
exterior:
Maintenance: 10 ft²
Abatement: 100 ft²

7.4 Hazard Standards that Maximize Net Benefits

The prior sections of this chapter have discussed standards for each of three media, in each case assuming that the other media would be held constant at the final standards. In addition to floor and window sill dust and soil, these final standards include paint standards of:

Medium	Final Standard	Intervention Activity
Deteriorated Interior Lead- Based Paint	2 sq.ft. or more 50 sq.ft. or more	Repair Abate
Deteriorated Exterior Lead- Based Paint:	10 sq.ft. or more 100 sq.ft. or more	Repair Abate

The economic analysis did not consider costs and benefits of alternative paint standards in terms of the amount of deteriorated interior or exterior paint. Data limitations prevented EPA from quantifying the health risks (and therefore the benefits associated with risk reduction) as an explicit function of the extent of interior and exterior lead paint deterioration. The deterioration amounts used in the paint standard values shown in the above table were provided by EPA to approximate the actual final standards.

This final section of Chapter 7 presents the standards that maximize net benefits overall (i.e., lets the floor dust, window sill dust and soil standards vary independently). These standards are compared to the final standards.

As described in the earlier sections of this chapter, and shown in Exhibit 7-10, the two blood-lead models generate different benefit estimates for any given combination of standards. In addition, the benefit estimates change at different rates under the two models and thus the set of standards that maximize net benefits is different under the two models. The final standards fall in between the standards that maximize net benefits under the two models, except the final floor dust standard, which is the same as the standard under the IEUBK model that maximizes net benefits.. The three standards presented are:

	Floor Dust Standard	Window Sill Dust Standard	Soil Standard
Standards that Maximize Net Benefits under IEUBK Model	40 µg/ft^2	100 µg/ft^2	250 ppm
Final Standards	40 µg/ft^2	250 µg/ft^2	1200 ppm
Standards that Maximize Net Benefits under Empirical Model	80 µg/ft^2	310 µg/ft^2	1650 ppm

For each of the two blood-lead models, Exhibit 7-10 presents the set of standards that maximize net benefits, along with the costs, benefits and net benefits for that standard. In addition, the exhibit presents the final standard with its cost, benefit and net benefits. The final standard is shown twice, once with benefits calculated using the IEUBK Model and once using the Empirical Model. The top half of the table presents results using the IEUBK Model. The IEUBK net benefit maximizing standards are more stringent than the final standards, except for the floor dust standard, which is the same. Because of the large number of homes in the lower range of environmental lead levels, the IEUBK standards would cost about 46 percent more than the final standard and the benefits would be nearly 43 percent greater than those of the final standard. In addition, the net benefits, at $173.5 billion, would be substantially higher than the net benefits of the final standard, at $123.3 billion.

The Empirical Model net benefit maximizing standards, on the other hand, are less stringent than the final standard. There are many fewer homes in these ranges of environmental lead. The Empirical Model net benefits maximizing set of standards would cost less ($51.7 billion as compared to $68.9 billion) and would produce smaller benefits ($46.5 billion as compared to $48.5 billion) than the final standard. However, its net benefits are larger than those of the final standard, while still negative.

Appendix A to this chapter presents the costs, benefits, and net benefits for alternative candidate hazard standards, when the costs and benefits of paint interventions and testing costs are excluded from the estimates.

Exhibit 7-10
Comparison of Standards Under Alternative Risk Assessment Models

	IEUBK Model Results	
	Standards that Maximize Net Benefits	**Final Standards**
Floor Dust Standard	40 µg/ft^2	40 µg/ft^2
Window Sill Dust Standard	100 µg/ft^2	250 µg/ft^2
Soil Standard	250 ppm	1,200 ppm
Total Cost	$100.6 billion	$68.9 billion
Total Benefit	$274 billion	$192.2 billion
Net Benefit	$173.5 billion	$123.3 billion
	Empirical Model Results	
	Standards that Maximize Net Benefits	**Final Standards**
Floor Dust Standard	80 µg/ft^2	40 µg/ft^2
Window Sill Dust Standard	310 µg/ft^2	250 µg/ft^2
Soil Standard	1,650 ppm	1,200 ppm
Total Cost	$51.7 billion	$68.9 billion
Total Benefit	$46.5 billion	$48.5 billion
Net Benefit	-$5.2 billion	-$20.3 billion

Appendix 7A. Analysis of Net Benefits Considering One Medium at a Time (Single Media Standards)

As explained in the beginning of Chapter 7, standards for all of the media (dust, paint, and soil) must be analyzed jointly due to the presence of various interaction effects. Therefore hazard standard candidates have not been evaluated one medium at a time up to this point in the report. Nevertheless, some readers may be interested in the contribution to total costs and benefits that are made by each medium separately. While there are significant limitations to estimating benefits and costs for a single medium, it is possible to develop approximate values. This Appendix presents estimates for such a single media analysis.

Two types of single media interventions are considered in this Appendix: dust interventions and soil interventions. A similar analysis for paint interventions has not been undertaken since only a single candidate standard was considered for paint interventions. The single media analysis is run assuming that the standard for the media under consideration is set at one of the candidate levels and that standards for all other media are non-existent. For example, the single media analysis for soil interventions analyzes the range of soil standards under consideration, while assuming the absence of any standards for dust and paint intervention. Thus any intervention activities occurring under such a scenario are due to homes exceeding the soil standard under consideration. However, if the yard (other than just the play area) exceeds the soil standard, a dust intervention is assumed to occur and the costs and benefits of that intervention are included. This analysis omits any testing and risk assessment costs in order to permit a clearer presentation of the incremental changes in costs and benefits that are associated with changes in candidate standards for the media under consideration.

Calculations for the range of dust hazard standards considered for floor and window sill dust are presented in Exhibit 7-A.1 and Exhibit 7-A.2 for the IEUBK and the Empirical model respectively. In summary, under the IEUBK model total benefits increase in step manner as options become increasing stringent, ranging from \$44.2 billion to \$89.4 billion. Benefits increase at an increasing rate because, as dust levels decline, the number of homes at given environmental lead levels increases more quickly. For example, with the floor dust standard set at 40 $\mu g/ft^2$, moving from a sill standard of 1000 $\mu g/ft^2$ to 500 $\mu g/ft^2$ increases the number of homes exceeding the standard from about 14.4 million to about 16.7 million (an increase of about 2.3 million housing units), while moving from 250 $\mu g/ft^2$ to 100 $\mu g/ft^2$ increases the number of homes exceeding the standard from about 21.7 million to 34.4 million (an increase of about 12.7 housing units). Since total benefits increase at a faster rate than total costs, net benefits also increase as the dust standards becomes increasingly stringent, ranging from \$38.2 billion to \$70.1 billion.

Exhibit 7-A.1: Estimated Costs, Benefits, and Net Benefits for Dust-Lead Hazard Standard Alone - Using the IEUBK Model
(Soil and Paint Interventions are assumed not to occur.)

Floor Dust	Sill Dust	Number of Homes Exceeding Sill Dust Option (Millions)	IEUBK Model Results (50-years; $Billion)		
			Costs	Benefit	Net Benefit
40	100	34.4	19.3	89.4	70.1
40	250	21.7	12.1	70.6	58.5
40	500	16.7	9.2	64.5	55.3
40	1000	14.4	7.9	62.0	54.1
50	100	34.1	19.2	87.9	68.7
50	250	21.4	11.9	69.0	57.1
50	500	16.3	9.0	62.9	53.9
50	1000	13.8	7.6	57.7	50.1
100	100	33.1	18.6	81.7	63.2
100	250	19.0	10.5	55.6	45.1
100	500	13.8	7.5	49.5	42.0
100	1000	11.1	6.0	44.2	38.2

Note: Rows may not add due to rounding.
This table does not include estimated costs or benefits of paint and soil interventions, or any testing or risk assessment costs.

Under the Empirical model, total benefits increase in step manner as the dust standards increase in stringency, ranging from $23.5 billion to $36.4 billion. As is the case in the IEUBK model-based analysis, the rate at which benefits increase rises as the stringency of the standard considered increases, because the number of homes exceeding the standard increases more quickly and thus more children are protected. The rate at which benefits increase, however, is tempered somewhat because the relationship between dust-lead and blood-lead under the Empirical model remains relatively constant across the range of dust standards considered. The increasing number of children protected by more stringent standards is counterbalanced by decreasing risk reduction predicted for children living in homes with low dust levels. Thus there are smaller changes in blood lead because there are smaller changes in environmental lead between baseline dust and post-intervention levels. Net benefits range from $17.1 billion to $20.5 billion.

Exhibit 7-A.2: Estimated Costs, Benefits, and Net Benefits for Dust-Lead Hazard Standard Alone - Using the Empirical Model
(Soil and Paint Interventions are assumed not to occur.)

Floor Dust	Sill Dust	Number of Homes Exceeding Sill Dust Option (Millions)	Empirical Model Results (50-years; $Billion)		
			Costs	Benefit	Net Benefit
40	100	34.4	19.3	36.4	17.1
40	250	21.7	12.1	32.5	20.4
40	500	16.7	9.2	29.2	20.0
40	1000	14.4	7.9	26.7	18.8
50	100	34.1	19.2	36.3	17.2
50	250	21.4	11.9	32.4	20.5
50	500	16.3	9.0	29.1	20.0
50	1000	13.8	7.6	26.1	18.5
100	100	33.1	18.6	35.8	17.2
100	250	19.0	10.5	30.3	19.8
100	500	13.8	7.5	26.6	19.1
100	1000	11.1	6.0	23.5	17.4

Note: Rows may not add due to rounding.
This table does not include estimated costs or benefits of paint and soil interventions, or any testing or risk assessment costs.

Calculations for the range of soil hazard standards considered are presented in Exhibit 7-A.3 and Exhibit 7-A.4 for the IEUBK and the Empirical model respectively. Under the IEUBK model, benefits and net benefits increase as the soil standard becomes increasingly stringent, ranging from $15.9 billion to $145.0 billion. In addition, benefits appear to increase at an increasing rate as the standard becomes more stringent. Net benefits also reveal both these trends, increasing from $15.1 billion to $103.0 billion.

Exhibit 7-A.3: Estimated Costs, Benefits, and Net Benefits for Soil-Lead Hazard Standard Alone - Using the IEUBK Model
(Independent dust and paint interventions are assumed not to occur.)

Soil Option (ppm)	Number of Homes Exceeding Soil Option (Millions)	IEUBK Model Results (50-years; $Billion)		
		Costs	Benefit	Net Benefit
500	12.0	41.9	145.0	103.0
1000	5.8	27.8	87.6	59.7
1200	4.7	25.3	78.0	52.7
1500	4.3	16.3	75.4	59.1
2000	4.3	9.7	73.3	63.5
2500	2.6	6.3	48.5	42.2
3000	0.7	4.2	17.5	13.3
3500	0.7	4.2	17.5	13.3
4000	0.7	4.2	17.5	13.3
4500	0.7	1.0	17.5	16.5
5000	0.6	0.8	15.9	15.1

Note: Rows may not add due to rounding.
This table does not include estimated costs or benefits of paint and dust interventions (other than some dust interventions that occur as a result of soil abatement, as described in the text), or any testing or risk assessment costs.

Results for the soil hazard standard analysis under the Empirical model follow a pattern similar to that of the IEUBK model. Total benefits increase as the soil standard increases in stringency, ranging from $2.3 billion to $34.7 billion. The rate at which benefits increase, however, is again tempered somewhat because the relationship between soil-lead and blood-lead under the Empirical model remains relatively constant across the range of dust standards considered, with the increasing number of children being protected by more stringent standards being counterbalanced by decreasing risk reduction predicted for children living in homes with low soil-lead levels. Net benefits range from negative $7.6 billion to positive $6.8 billion, approaching the maximum level near 2000 ppm. Below 2000 ppm, net benefits decrease in a marked manner because total benefits increase at a slower rate than total costs. The increased number of children protected at more stringent standards is offset by a smaller predicted reduction in risk at lower environmental lead levels.

Exhibit 7-A.4: Estimated Costs, Benefits, and Net Benefits for Soil-Lead Hazard Standard Alone - Using the Empirical Model
(Independent dust and Paint Interventions are assumed not to occur.)

Soil Option (ppm)	Number of Homes Exceeding Soil Option (Millions)	Empirical Model Results (50-years; $Billion)		
		Costs	Benefit	Net Benefit
500	12.0	41.9	34.7	-7.3
1000	5.8	27.8	20.3	-7.6
1200	4.7	25.3	17.7	-7.6
1500	4.3	16.3	17.0	0.6
2000	4.3	9.7	16.6	6.8
2500	2.6	6.3	9.9	3.6
3000	0.7	4.2	2.5	-1.7
3500	0.7	4.2	2.5	-1.7
4000	0.7	4.2	2.5	-1.7
4500	0.7	1.0	2.5	1.5
5000	0.6	0.8	2.3	1.5

Note: Rows may not add due to rounding.
This table does not include estimated costs or benefits of paint and dust interventions (other than some dust interventions that occur as a result of soil abatement, as described in the text), or any testing or risk assessment costs.

It is important to note that the above analyses assumed that lead levels in all other media were held constant at baseline levels from HUD National Survey data. Controlling for other contributors to the blood lead levels presents a different picture of the net benefits that result from moving to a more stringent standard than does the approach used in Chapter 7.

Appendix 7B: Alternative Play Area Analysis

In addition to the play area analysis presented in the main body of this report (referred to as the main play area analysis from here on), an alternative analysis for play area soil abatement was undertaken. This alternative analysis reflects the assumption that children receive a disproportionate amount of exposure from the play area since they are likely to spend a disproportionate amount of outdoor time in the play area, as opposed to time spent in the rest of the yard. Specifically, this analysis uses a different averaging algorithm for soil lead levels in estimating exposure levels of children from lead-contaminated soil. This change results in differing estimates of the geometric mean blood-lead levels, differing estimates of benefits and net benefits, and differing estimates of the number of children with blood-lead levels that exceed 10 µg/dL. To fully develop this model the alternative analysis considers standards for the play area that are separate and independent of the standards for the rest of the yard. This appendix describes the alternative play area analysis and its results.

Decision Rule for Soil Interventions

The main play area analysis assumed the play area standard would equal the standard set for the rest of the yard. It also assumed that under certain circumstances, only the play area and none of the rest of the yard would receive any soil intervention. This section describes the circumstances under which a play area intervention is to be undertaken. The "decision rule" for the main play area analysis and the alternative analysis presented in this appendix are the same. Exhibit 7-B.1 provides a clearer understanding of what parts of the yard will be addressed under the regulations.

Both the main analysis and this alternative analysis calculate the rest of the yard soil lead average in the same manner. Data on lead levels in soil were measured at three points in the yard. Two samples were taken near the home: one at the entry and one to reflect lead levels in the soil under the roof's drip line. The third sample was taken out in the middle of the yard and is referred to as the remote sample. The rest of the yard average soil lead level is the simple average of the perimeter soil lead level (itself an average of the dripline and entry lead levels) and the remote soil lead level. This analysis used the lead levels as measured for the remote soil area as a proxy for lead levels in the play area. This assumption was made since no separate play area lead measures are available in the HUD national survey.

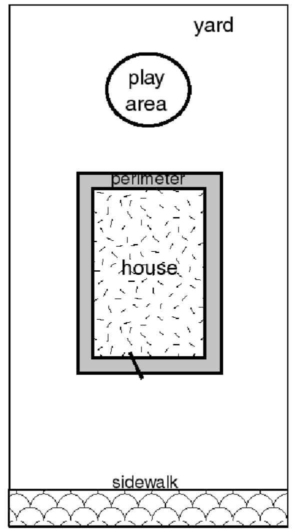
The first step is to examine the overall lead level for the home's soil as measured by the rest of the yard lead level. If the home's rest of the yard soil lead level does not exceed the soil standard, then the model assumes that no soil abatement would occur in the rest of the yard. If on the other hand the rest of the yard soil concentration does exceed the soil standard then the next step involves a comparison of the perimeter and the remote soil lead levels to the soil standard to determine which type of soil intervention would occur. This decision depends on whether the soil lead levels for the perimeter area only, remote area only, or for both areas exceeded the soil standard, and they would respectively lead to soil abatements that were restricted to the perimeter area only, remote area only, or to both the perimeter and the remote areas.

Exhibit 7-B.1: Parts of the Yard Addressed Under the Regulations

Explanation of drawings of house and yard.

1. Perimeter area of house shown in gray.
2. Remote area (everything but house and 3-foot perimeter), shown in gray.
3. Play area shown in gray.
4. Rest of yard (everything but house and play area) shown in gray.

1



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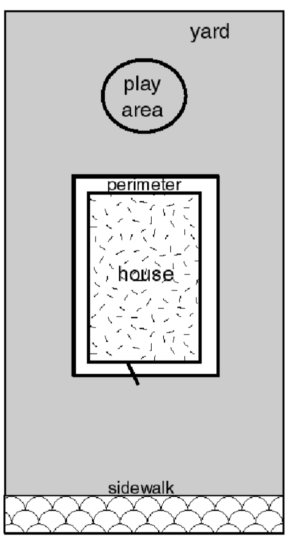

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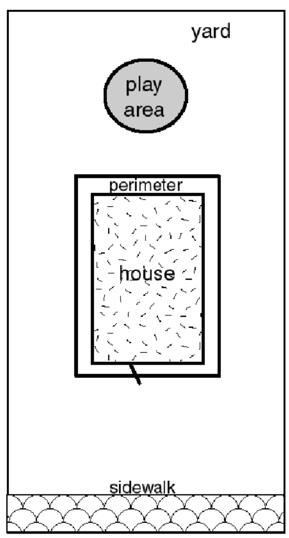

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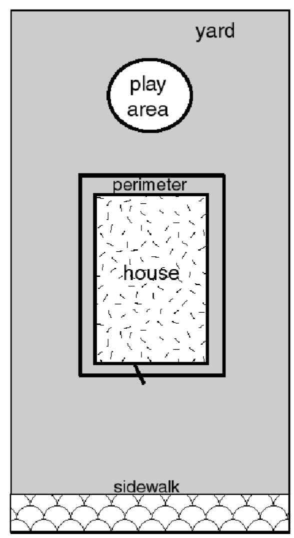

If the rest of the yard soil concentration is below the soil standard for the rest of the yard, then the play area soil concentration is compared to the play area standard. If this exceeds the play area standard, then the model assumes that the play area soil would be removed and replaced. In addition, if the perimeter area received a soil abatement but the remote area did not under the rest of the yard standard, then the play area soil concentration is compared to the play area standard. If the play area exceeds its standard then a play area abatement is also performed.

Changes in the Exposure Models

The difference between the two play area analyses arises in the manner in which the average soil lead level is calculated for input into the IEUBK and the Empirical models. These models form the basis for estimating differences in blood-lead levels and thus the benefits. The rest of the yard soil lead average is calculated for both pre-abatement and the post-abatement lead levels, and is used by the two models to determine shifts in the geometric mean (GM) and geometric standard deviation (GSD) of the NHANES blood lead levels to provide estimates of benefits from soil abatement and the number of children with blood-lead levels over 10 µg/dL.

In the main play area analysis, the average rest of the yard soil lead level is estimated as the simple average of the lead levels in the perimeter and the remote areas of the yard:

[(dripline lead level + entry lead level)/2 + remote area lead level]/2

In addition, the play area is treated as a smaller version of the remote area, and exposure changes due to a play area abatement are considered equivalent to the exposure changes due to a remote area abatement. Thus for homes that receive a play area abatement, the post-abatement play area lead level (150 ppm) replaces the remote area lead level in the above equation when estimating the post-abatement average rest of the yard soil lead level. As a result, in the main play area analysis, play area abatement is assumed to yield the same benefits as a remote area abatement, but at much lower costs.

In the alternative play area analysis, the above equation is changed to reflect the assumption that children spend a disproportionate amount of time in the play area, as opposed to the rest of the yard. Thus lead levels in the play area are given disproportionate weight in the estimation of average soil lead levels used in the IEUBK and the Empirical models. An alternative soil averaging equation is used:

0.5 × [(dripline lead level + entry lead level)/2 + remote area lead level]
+ 0.5 × (play area lead level)

The above equation assumes that 50 percent of a child's exposure occurs from the play area and the other 50 percent from the rest of the yard. The greater weight given in the above equation to the play area soil lead level is clearly evident since the play area comprises only 10 percent of the yard.

In developing the alternative play area analysis, various alternative assumptions for the size of the play area and the amount of exposure occurring from the play area and the rest of the yard were considered. These assumptions included play areas comprising 50 percent and 90 percent of the yard, exposure from the play area causing 66.6 percent of the exposure (33.3 percent from the rest of the yard) and exposure being proportional to the size of the play area. Due to a lack of evidence to support a particular choice of play area size and play area contribution to exposure, however, the analysis is based only on a single play area size (10 percent of the yard) and contribution to exposure (50 percent exposure from play area).

Cost, Benefits, and Net Benefits for Alternative Play Area Analysis

Both versions of the play area analysis use the same size for the play area: 200 square feet for single-family homes and 400 square feet for multifamily buildings. For both housing types this play area size represents 10 percent of the yard. Since the size of the play areas for single-family and multifamily housing units do not differ between the two play area analyses, the unit cost for play area soil removal do not change from those estimated in Chapter 5. Play area intervention costs are estimated to be: $1,460 for a single family house ($2,129 if the soil is hazardous), and $9,418 for a multifamily building or $314 per multifamily housing unit ($10,755 per building or $359 per unit if the soil is hazardous). In addition, since the two analyses use the same decision rule for soil intervention, total costs of all interventions are also equal under both analyses.

Due to differences in the way the average soil lead levels are calculated for use in the IEUBK and the Empirical models under the two play area analyses, both the baseline (blood-lead levels and children affected) and the effect of a given set of standards differs between the two analyses. Thus the benefits and net benefits for the alternative play area analysis are not comparable to those presented in the report with the main play area analysis.

Exhibit 7-B.2 presents the estimated number of soil abatements, costs, benefits, and net benefits for alternative play area standards and rest of the yard standards. Three alternative standards have been considered for the play area (400 ppm, 1200 ppm, and 2000 ppm). The primary interest here was to assess the benefits and costs of a play area standard that was stricter than the rest of the yard standard. A stricter play area standard reinforces the underlying assumption behind the alternative play area analysis that the play area is responsible for a disproportionate amount of exposure and therefore should be abated at a stricter hazard level.

Exhibit 7-B.2 shows that while holding the play area standard constant at 400 ppm, the total number of soil abatements is expected to decrease from 10.3 million to 6.6 million as the stringency of the rest of the yard standard decreases from 500 ppm to 5000 ppm. This decrease is much smaller than is the case when the play area and the rest of the yard standards are varied together over a similar range. The results of such a scenario are presented in Exhibit 7-7, and the number of soil abatements decrease from 10 million to just 0.5 million. Clearly, a play area standard of 400 ppm is associated with a significant number of soil interventions no matter what the rest of the yard standard.

This also explains why, as the rest of the yard standard is made more stringent, the overall number of soil abatements occurring increases at a slower rate than in the main play area analysis. Increasing the stringency of the rest of the yard standard, at least up to 2500 ppm, results in many homes switching from a play area only intervention to an intervention which covers a much larger section of the yard. The addition of homes not already undertaking a play area intervention is very limited. As the stringency of the rest of the yard standard exceeds 2500 ppm and moves towards 500 ppm it is evident that additional homes start undertaking soil interventions. As expected the less stringent play area standards of 1200 ppm and 2000 ppm, with the rest of the yard standard also set at the same level, result in a much smaller number of soil abatements, 3.8 million and 3.5 million respectively. The apparent lack of variation seen in the number of soil abatements expected between the two less stringent play area standards is likely caused by the relative thinness of data in this soil lead range.

Exhibit 7-B.2: Costs, Benefits and Net Benefits for Alternative Soil Standards, With Other Media Set at Final Standards*

Soil Standards (ppm)				IEUBK Model		Empirical Model	
Play Area	Rest of Yard	Number of Soil Removals (Million)	Total Cost of All Interventions ($ Billion)	Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)	Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)
400	500	10.3	84.4	186.0	101.7	46.8	-37.6
400	1000	8.8	72.8	177.4	104.6	46.0	-26.9
400	1200	8.2	70.5	175.6	105.1	44.8	-25.7
400	1500	8.0	61.7	174.9	113.1	44.7	-17.0
400	2000	8.0	55.2	175.6	120.4	44.8	-10.4
400	2500	7.3	52.9	170.7	117.8	42.8	-10.1
400	3000	6.7	51.9	166.4	114.5	41.8	-10.1
400	3500	6.7	51.9	166.4	114.5	41.8	-10.1
400	4000	6.7	51.9	166.4	114.5	41.8	-10.1
400	4350	6.7	48.7	167.0	118.3	41.9	-6.8
400	4500	6.7	48.7	167.0	118.3	41.9	-6.8
400	5000	6.6	48.5	166.0	117.5	41.8	-6.7
1200	1200	3.8	68.9	159.3	90.4	41.9	-27.0
2000	2000	3.5	53.6	159.3	105.7	41.9	-11.5

* Final Standards:
Interior paint: 2 sq ft or more — repair, 50 sq ft or more — abate
Exterior paint: 10 sq ft or more — repair, 100 sq ft or more — abate
Window sill dust: 250 sq ft^2
Floor dust: 40 $\mu g/ft^2$

The most interesting cost comparisons are among scenarios where the play area standard is varied. The analysis found that with the rest of the yard standard set at 1200 ppm, moving from the 1200 ppm to the 400 ppm play area standard only increased costs from $68.9 billion to $70.5 billion. Similarly, with the rest of the yard standard set at 2000 ppm, moving from the 2000 play area standard to the 400 ppm play area standard only increased costs from $53.6 billion to $55.2 billion. Under each of these cases, moving to the 400 ppm play area standard results in a small increase in costs while more than doubling the number of homes protected as a result of soil abatements.

The above conclusion is also highlighted in the estimated benefits and net benefits from the two exposure models. Under the IEUBK model total benefits increase from around $159.3 billion to $175.6 billion when the play area standard is changed from 1200 ppm to 400 ppm. Similarly, under the Empirical model total benefits increase from around $41.9 billion to $44.8 billion when the play area standard is changed from 1200 ppm to 400 ppm. Net benefits under the IEUBK model increase from $90.4 billion to $105.1 billion when the play area standard changes from 1200 ppm to 400 ppm, and from $105.7 billion to $120.4 billion when the play area standard changes from 2000 ppm to 400 ppm. Similarly, under the Empirical model net benefits increase from negative $27.0 billion to negative $25.7 billion when the play area standard changes from 1200 ppm to 400 ppm, and from negative $11.5 billion to negative $10.4 billion when the play area standard changes from 2000 ppm to 400 ppm. The findings of the alternative play area analysis indicate that a play area standard that is stricter than the rest of the yard standard will result in both a substantial increase in the number of homes protected through soil interventions and higher net benefits according to both exposure models.

Cost, Benefits, and Net Benefits for Various Candidate Floor Dust Hazard Standards

In this section the costs, benefits, and net benefits for alternative floor dust standards are assessed under the alternative play area assumptions. This analysis assumes a play area standard of 400 ppm and a rest of the yard standard of 1200 ppm. In addition, the window sill dust hazard standard and the paint standards are set at their final standards. Section 7.1 and Exhibit 7-1 present the results of a similar analysis which was undertaken based on assumptions used in the main play area analysis.

Exhibit 7-B.3 presents the results of varying the floor dust standard under the alternative analysis. At each standard level, the analysis found only a marginal ($1-2 billion) increase in the total costs of all interventions compared to costs in the main analysis. This cost increase results from the increased number of soil interventions occurring due to the stricter play area standard, as was highlighted in the previous section. As the floor dust standard increases in stringency from 220 $\mu g/ft^2$ to 40 $\mu g/ft^2$, costs increase from $69.0 billion to $70.5 billion under the alternative analysis. Thus, costs under the most stringent standard only exceeds costs under the least stringent standard by $1.5 billion (2 percent).

Exhibit 7-B.3
Costs, Benefits and Net Benefits for Alternative Floor Dust Standards*

Floor Dust	Total Costs of All Interventions ($ Billion)	IEUBK Model		Empirical Model	
		Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)	Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)
40	$70.5	$175.6	$105.1	$44.8	$(25.7)
50	$70.3	$174.2	$103.8	$44.7	$(25.6)
60	$70.2	$172.2	$102.0	$44.6	$(25.6)
70	$70.2	$172.2	$102.0	$44.6	$(25.6)
80	$70.0	$169.5	$99.5	$44.5	$(25.6)
100	$69.3	$162.1	$92.9	$43.1	$(26.2)
120	$69.2	$144.0	$74.8	$42.8	$(26.3)
140	$69.1	$143.6	$74.5	$42.7	$(26.4)
160	$69.1	$143.6	$74.5	$42.7	$(26.4)
180	$69.1	$143.6	$74.5	$42.7	$(26.4)
200	$69.0	$141.3	$72.2	$42.6	$(26.4)
220	$69.0	$141.3	$72.2	$42.6	$(26.4)

* Final Standards:
Interior paint: 2 sq ft or more — repair, 50 sq ft or more — abate
Exterior paint: 10 sq ft or more — repair, 100 sq ft or more — abate
Window sill dust: 250 sq ft^2
Soil: Play area 400 ppm, rest of yard 1200 ppm
Play area is 10% of yard, i.e., SF 200 sq ft, MF 400 sq ft and Post Soil = .50 (Post Ply) + .50 (Post Soil)

Under the IEUBK model, total benefits and net benefits increase throughout the range as the floor dust standard increases in stringency. This is the same pattern shown by benefits and net benefits under the main analysis. Total benefits increase from $141.3 billion to $175.6 billion and net benefits from $72.2 billion to $105.1 billion, as the floor dust standard is varied from 220 µg/ft^2 to 40 µg/ft^2. Net benefits are maximized at the most stringent floor dust standard (40 µg/ft^2) and equal $105.1 billion.

Under the Empirical Model, total benefits also increase throughout the range as the floor dust standard is made increasing more stringent. Total benefits increase from $42.6 billion (220 µg/ft^2) to $44.8 billion (40 µg/ft^2). The lower estimates of total benefits and smaller changes in benefits as the floor dust standard is varied, compared to the IEUBK model, are consistent with results for the Empirical model found in this report. Net benefits under the Empirical model are negative throughout the range of floor dust standards considered, however, they can still be used to identify the floor dust standard that generates the maximum net benefits (i.e., the least negative benefits). Net benefits are relatively constant for standards between 220 µg/ft^2 to 100 µg/ft^2, are maximized at standards between 80 µg/ft^2 and 50 µg/ft^2, and decrease thereafter.

While total benefits and net benefits for both exposure models appear to be lower in this analysis than in the main analysis, these estimates are not comparable for reasons cited earlier in this Appendix. Comparing the results for the two exposure models in this analysis, the floor dust standard that maximizes net benefits (when the other standards are set at their final standards) appears to lie in the range 40 µg/ft^2 to 80 µg/ft^2. This is the same range in which net benefits are maximized in the main analysis.

Cost, Benefits, and Net Benefits for Various Candidate Window Sill Dust Hazard Standards

In this section the costs, benefits, and net benefits for alternative window sill dust standards are assessed under the alternative play area assumptions. Similar to the analysis in the preceding section, this analysis assumes a play area standard of 400 ppm and a rest of the yard standard of 1200 ppm. In addition, the floor dust hazard standard and the paint standards are set at their final standards. Section 7.2 and Exhibit 7-4 present the results of a similar analysis which was undertaken based on assumptions used in the main play area analysis.

Exhibit 7-B.4 presents the results of varying the window sill dust standard under the alternative analysis. Similar to the results in the previous section, at each standard level, the analysis found only a marginal ($1-2 billion) increase in the total costs of all interventions compared to costs in the main analysis. As the window sill dust standard increases in stringency from 750 µg/ft^2 to 100 µg/ft^2, costs increase from $67.6 billion to $76.8 billion under the alternative analysis. Thus in the alternative analysis, costs under the most stringent standard exceeds costs under the least stringent standard by $9.2 billion (13.5 percent).

Under the IEUBK model, total benefits and net benefits increase throughout the range as the window sill dust standard increases in stringency. This is the same pattern shown by benefits and net benefits under the main analysis. Total benefits increase from $168.6 billion to $194.5 billion and net benefits from $101.0 billion to $117.6 billion, as the window sill dust standard is varied from 750 µg/ft^2 to 100 µg/ft^2. Net benefits are maximized at the most stringent window sill dust standard (100 µg/ft^2) and equal $117.6 billion.

Exhibit 7-B.4
Costs, Benefits and Net Benefits for Alternative Window Sill Dust Standards*

Sill Dust	Total Costs of All Interventions ($ Billion)	IEUBK Model		Empirical Model	
		Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)	Total Benefits of All Interventions ($ Billion)	Net Benefits of All Interventions ($ Billion)
100	$76.8	$194.5	$117.6	$48.0	$(28.8)
150	$74.0	$185.4	$111.4	$46.8	$(27.2)
200	$73.7	$184.4	$110.7	$46.6	$(27.1)
250	$70.5	$175.6	$105.1	$44.8	$(25.7)
300	$70.1	$175.3	$105.2	$44.4	$(25.7)
310	$69.2	$173.6	$104.3	$43.7	$(25.5)
350	$68.6	$171.9	$103.3	$43.0	$(25.6)
400	$68.6	$171.9	$103.3	$43.0	$(25.6)
450	$68.3	$169.8	$101.5	$42.5	$(25.8)
500	$68.2	$169.6	$101.4	$42.4	$(25.8)
550	$67.8	$168.9	$101.1	$41.9	$(25.9)
600	$67.8	$168.9	$101.1	$41.9	$(25.9)
650	$67.6	$168.6	$101.0	$41.4	$(26.2)
700	$67.6	$168.6	$101.0	$41.4	$(26.2)
750	$67.6	$168.6	$101.0	$41.4	$(26.2)

* Final Standards:
Interior paint: 2 sq ft or more — repair, 50 sq ft or more — abate
Exterior paint: 10 sq ft or more — repair, 100 sq ft or more — abate
Floor dust: 40 µg/ft^2
Soil: play area 400 ppm, rest of yard 1200 ppm
Play area is 10% of yard, i.e., SF 200 sq ft, MF 400 sq ft and Post Soil = .50 (Post Ply) + .50 (Post Soil)

Under the Empirical Model, total benefits increase throughout the range as the window sill dust standard is made increasing more stringent. Total benefits increase from $41.4 billion (750 µg/ft^2) to $48.0 billion (100 µg/ft^2). Similar to the results for the floor dust standards under the Empirical model, net benefits are negative throughout the range of window sill dust standards that were considered. However, the standard at which the least negative net benefits is generated can be identified. This occurs when the window sill dust standard is set at 310 µg/ft^2 and net benefits are maximized at negative $25.5 billion.

The benefit and net benefit estimates in this analysis are once again not comparable to the estimates in the main analysis. Comparing the results for the two exposure models in this analysis, the window sill dust standard that maximizes net benefits (when the other standards are set at their final standards) appears to lie in the range 100 µg/ft^2 to 310 µg/ft^2. This is the same range in which net benefits are maximized in the main analysis.

Reference

Battelle. 1997. Risk Assessment to Support Standards for Lead in Paint, Dust, and Soil. Prepared by Battelle, for National Program Chemicals Division, Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency. EPA 747-R-97-006, December.

8. Sensitivity Analysis

8.1 Introduction

The estimation of the impacts of the §403 standards presented in the preceding chapters of this report includes a large number of inputs and assumptions concerning various aspects of both the potential costs and benefits of these standards. Most of these inputs and assumptions carry with them some degree of uncertainty. In some cases, the alternative values or approaches to modeling the impacts of these rules could conceivably lead to results that are different from those presented in Chapters 5 through 7. In some cases it is possible to perform alternative calculations of the impacts using different assumptions to quantify the magnitude of the difference in outcome. In other cases, it is only possible to address the uncertainties in a qualitative manner and provide some indication based on judgment of the likely effect of those uncertainties on the impact estimates.

This chapter focuses primarily on the results of several specific sensitivity analyses that were conducted to measure the effect of particular aspects of the model on model results.[1] "Sensitivity" is an uncertainty measure that reflects the rate or degree to which the results of the analysis change relative to changes made in a particular input variable or assumption. Sensitivity analyses are not necessarily intended to provide a measure of the uncertainty in the input variable itself (that is, how well that value is known) but rather to assess how important that variable is with respect to the outcome obtained and by extension how important it is to have a particular degree of confidence in the value used for that variable in the main analysis.

As is evident from the description of the benefit-cost model presented previously (as well as the risk assessment model incorporated into it), there are numerous model elements that could have been selected for sensitivity analyses. The particular elements of the model chosen to be included in the sensitivity analysis presented here reflect those identified by EPA as likely to have a significant effect on the results or for which there was a particular interest in determining what the potential effects might be. Six particular elements were chosen for these sensitivity analyses[2]:

- Discount rate
- Monetary value of an IQ point loss/gain
- Inclusion of hazardous waste disposal costs for some soil removal
- Exclusion of small IQ point changes
- Real estate transactions rather than pending birth as the intervention trigger
- Considering dust and soil impacts independent of each other and paint impacts

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[1] It should be noted that the use of both the IEUBK and the Empirical models for predicting children's blood lead levels incorporated into the main part of the benefit-cost analysis is in effect a form of uncertainty analysis as well.

[2] Several sensitivity analyses, mostly relating to the characterization of population blood lead levels, are included in the §403 risk assessment document prepared by Battelle (1997).

The first three elements for which sensitivity analyses were conducted are parametric inputs for which alternative values are used. The second three elements involve changes in the modeling procedures used in the main benefit-cost analysis.

The sensitivity analyses consider the effect of changes in these elements on two outcomes of the benefit-cost modeling. The first is consideration of the effect of alternative specifications on the costs and benefits of the final §403 standards. The second is consideration of the effect of these alternative specifications on the determination of the set of §403 standards that produce maximum net benefits. In both cases, the analyses are conducted separately using the IEUBK and the Empirical blood lead models.

In addition to these six specific sensitivity analyses, this chapter also provides a more qualitative summary assessment of the uncertainty in various components of the benefit-cost model and the potential impact those uncertainties might have in the outcomes of the analysis.

8.2 Analyses Involving Parameter Changes

This section of the sensitivity analysis focuses on three parameters: value of the discount rate, value of each IQ point, and the cost of disposing of soil removed during soil interventions. Each of these parameters is of interest for a different reason, but in each case the question is what is the appropriate value of the parameter, not how is it used in the analysis. Because the model estimates costs and benefits over a 50-year period, and the resulting benefit streams stretch even further into the future, the results may be very sensitive to the discount rate used in the analysis. The second parameter, value of each IQ point, is likely to have a substantial impact on the benefits estimation because changes in population IQ levels account for the great majority of monetary benefits (over 98 percent at the option selected). While the third parameter is not likely to have as large an impact on results, EPA may be making a change in the hazardous waste disposal regulations that would affect the costs of soil interventions. The third parameter sensitivity analysis looks at the potential impact of such a change. In each case, the costs, benefits and net benefits for the standards are used to demonstrate the impact of the alternative parameter values. Furthermore, net benefit-maximizing standards are shown for each alternative.

8.2.1 Discount rate

A 3 percent discount rate has been adopted as the most appropriate rate for use in this analysis, based on a rationale presented in section 4.5.3 of this report. However, OMB recommends the use of a 7 percent discount rate in benefit-cost analyses for government regulations. This section presents results using 7 percent and compares them against costs, benefits, and net benefits in the baseline (3 percent) analysis. Exhibit 8-1a gives these results for the final standards.

Using a 7 percent discount rate reduces the present value of both total costs and total benefits, with the reduction in benefits relatively greater than the reduction in costs. This relative difference in declines is due to the differences in the timing of costs and benefits -- the benefits occur further in the future than their related costs, thus the higher discount rate has a bigger impact on benefits. The difference is greatest for soil removals, where the interventions are permanent (i.e. costs incurred today generate benefits for all future cohorts), and lowest for dust interventions and paint repairs, where the interventions last only four years (costs incurred today generate benefits for children present over the next four years).

Exhibit 8-1a
Effects on Costs and Benefits of Final Standards due to Changing Discount Rate Assumption

	Base (3% Discount Rate)		Alternative (7% Discount Rate)		Alternative as % of Base	
	Empirical	IEUBK	Empirical	IEUBK	Empirical	IEUBK
Costs ($ billion)	$68.9	$68.9	$45.3	$45.3	66%	66%
Benefits ($ billion)	$48.5	$192.2	$5.9	$23.0	12%	12%
Net Benefits ($ billion)	-$20.3	$123.3	-$39.3	-$22.2	n/a	n/a

Figures may not add due to rounding error.

The reductions in net benefits under both the IEUBK and Empirical models is a function of the reductions in costs and benefits under each model. While the relative changes in costs and in benefits are the same across models, the relative changes in net benefits are different, because of the different magnitudes of costs and benefits for each model. The negative net benefits under the Empirical Model nearly double in absolute value, while the net benefits under the IEUBK Model shift from strongly positive to negative.

Exhibit 8-1b compares the net benefit-maximizing standards assuming a 7 percent discount rate, versus the same for a 3 percent discount rate. Since the analysis identifies standards for each of three media, using two different risk assessment models, there are six cases to be considered in this comparison. In five out of six, standards are less stringent under a 7 percent regime; in the other case, standards are the same between scenarios. This is the expected trend given that when standards are fixed at a constant level (e.g. the option selected), the cost-to-benefit ratio for interventions is higher with a 7 percent rate than a 3 percent rate. Interventions will lead to positive net benefits only in homes with very high levels of contamination, where large improvements in conditions and in expected occupant IQ take place following intervention. The one standard that does not change between discount rates -- floor dust under the IEUBK model -- is associated with very high positive net benefits to begin with.

Exhibit 8-1b
Effects on Net Benefit-Maximizing Standards due to Changing Discount Rate Assumption

		Standards			Values ($ billion)		
Scenario	Model	Floor Dust (µg/ft²)	Sill Dust (µg/ft²)	Soil (ppm)	Costs	Benefits	Net Benefits
Base (3% Discount Rate)	Empirical	80	310	1650	51.7	46.5	-5.2
	IEUBK	40	100	250	100.6	274	173.4
Alternative (7% Discount Rate)	Empirical	none*	none*	none*	23.4	1.5	-21.9
	IEUBK	40	none*	2050	29.9	19.7	-10.2

*Net benefits are maximized when no interventions are triggered through the standard in question.
Figures may not add due to rounding error.

8.2.2 Value of an IQ Point

The economic analysis presented in chapters 4, 5, 6 and 7, uses the most recent data and approach for assessing the value of an IQ point. This value, in 1995 dollars, is $8,346 (assuming a 3 percent discount rate -- see chapter 6). However, earlier EPA analyses have used an alternative, and lower, value of $6,847, in 1995 dollars. (USEPA 1985, 1986) Exhibit 8-2a compares costs and benefits of the analysis for these two different IQ point values.

Exhibit 8-2a
Effects on Costs and Benefits of Final Standards due to Changing IQ Valuation Assumption

	Base (IQ Value = $8,346)		Alternative (IQ Value= $6,847)		Alternative as % of Base	
	Empirical	IEUBK	Empirical	IEUBK	Empirical	IEUBK
Costs ($ billion)	$68.9	$68.9	$68.9	$68.9	100%	100%
Benefits ($ billion)	$48.5	$192.2	$40.0	$158.2	82%	82%
Net Benefits ($ billion)	-$20.3	$123.3	-$28.9	$89.3	n/a	72%

Figures may not add due to rounding error.

Costs are not affected by a change in IQ point value, because unit costs are not affected nor are the number or timing of interventions. In turn, the number of children protected and post-intervention blood lead levels remain unchanged. Benefits, however, are reduced by essentially the same percentage as the reduction in IQ value ($6,847 is 82 percent of $8,346). While there are several categories of monetized benefits in this analysis which are not directly linked to changes in IQ, these categories combined make up under two percent of benefits for the option selected, under both the IEUBK and empirical models. Thus, the relative reduction in benefits is nearly the same as the relative reduction in IQ point value, for both models. Net benefits reduce as a function of the change in benefits.

Exhibit 8-2b compares the net benefit-maximizing standards under both IQ point value assumptions. Standards that maximize net benefits are set at the margin. In other words, given one standard, the standard which is one unit more stringent is preferable if the additional homes affected by that standard yield greater marginal benefits than costs.[3] In this sensitivity analysis of IQ point value, all marginal benefits are reduced by a nearly uniform factor, 18 percent, while marginal costs are not affected. As a result, when the lower IQ point value is used, the net benefit-maximizing standards should be equal to or less stringent than they are in the base analysis. The results in Exhibit 8-2b match this prediction. Two out of three standards become slightly less stringent under the Empirical model, and no standards change under the IEUBK model. The latter result may appear surprising, but is a reflection of the fact that marginal homes with relatively low dust lead loads and soil lead concentrations generally experience strongly positive net benefits when the IEUBK model is used.

Exhibit 8-2b
Effects on Net Benefit-Maximizing Standards due to Changing IQ Valuation Assumption

		Standards			Values ($ billion)		
Scenario	Model	Floor Dust (µg/ft²)	Sill Dust (µg/ft²)	Soil (ppm)	Costs	Benefits	Net Benefits
Base (IQ Value = $8,346)	Empirical	80	310	1650	51.7	46.5	-5.2
	IEUBK	40	100	250	100.6	274	173.4
Alternative (IQ Value= $6,847)	Empirical	80	340	2050	48.4	35.1	-13.3
	IEUBK	40	100	250	100.6	225.4	124.8

Figures may not add due to rounding error.

8.2.3 Hazardous Waste Disposal of Soil

This sensitivity analysis assumes that there is no cost premium for the disposal of soil with very high levels of lead. The base analysis assumes that soil with a lead concentration greater than 2000 ppm

[3] Given the structure of the economic analysis, benefits cannot be directly calculated for any specific home or group of homes smaller than the entire set. Total benefits are calculated based on the blood lead distribution as aggregated across all homes in the analysis. However, the concept of marginal benefits is very useful for understanding numerous model results. It can be construed in the following way. The marginal benefit generated by a new intervention X in a home Y is the total benefits under this scenario, minus the total benefits under a scenario identical in every way except that intervention X does not take place in home Y.

must be disposed of as hazardous waste, at a great supplement to the standard cost of soil disposal (see chapter 5 for itemization of costs). Exhibit 8-3a gives a comparison of results under each scenario.

Exhibit 8-3a
Effects on Costs and Benefits of Final Standards due to Changing Assumptions Regarding Whether Removed Soil Must Ever Be Treated as Hazardous Waste

	Base (Soil with >2000 ppm Lead is Disposed of as Hazardous Waste)		Alternative (No Soil Disposed of as Hazardous Waste, thus Reducing Costs of Disposal)		Alternative as % of Base	
	Empirical	IEUBK	Empirical	IEUBK	Empirical	IEUBK
Costs ($ billion)	$68.9	$68.9	$56.3	$56.3	82%	82%
Benefits ($ billion)	$48.5	$192.2	$48.5	$192.2	100%	100%
Net Benefits ($ billion)	-$20.3	$123.3	-$7.8	$135.9	39%	110%

Since this change in assumption does not affect the number of homes getting interventions nor the effectiveness of those interventions, benefits remain constant. Total costs decrease, however, because costs for soil removal decrease. For the option selected, with a standard of 1200 ppm for soil removal, about two million homes performing soil interventions are affected by the relaxed soil disposal requirements of the sensitivity analysis and costs decline by $12.6 million nationally.

Exhibit 8-3b compares the net benefit-maximizing standards assuming no hazardous waste disposal of soil, versus the base analysis. Since, relative to the base case, some unit soil costs decrease, and benefits are unaffected at each standard, the expected consequence of this exercise is that soil standards should become more stringent if they change at all. Analysis with the Empirical model yields this result; however, the IEUBK model produces the opposite pattern.

Exhibit 8-3b
Effects on Net Benefit-Maximizing Standards due to Changing Assumptions Regarding Whether Removed Soil Must Ever Be Treated as Hazardous Waste

		Standards			Values ($ billion)		
Scenario	Model	Floor Dust (µg/ft²)	Sill Dust (µg/ft²)	Soil (ppm)	Costs	Benefits	Net Benefits
Base (as 8-3a)	Empirical	80	310	1650	51.7	46.5	-5.2
	IEUBK	40	100	250	100.6	274	173.4
Alternative (as 8-3a)	Empirical	80	310	1650	47.6	46.5	-1.1
	IEUBK	40	100	300	88.1	266.3	178.2

Figures may not add due to rounding error.

The IEUBK result suggests that when no soil is treated as hazardous waste, soil removal at homes where the yard average concentration is between 250 ppm and 300 ppm produces negative net benefits on the whole. Similarly, when soil above 2000 ppm is treated as hazardous waste, it would appear that this collection of homes produces positive net benefits from soil removal. However, these two statements cannot both be true, because no home in the HUD survey with a yard average soil lead concentration in the 250-300 ppm range contains any soil above 2000 ppm. Thus neither costs nor benefits stemming from this group of homes should be affected by the changed assumption in this analysis. This case is a special exception to the rule that net benefit-maximizing standards are set at the margin.

The reason for the paradoxical finding under the IEUBK model has to do with the possibility of mixing soil to avoid hazardous waste disposal costs (in the case that there is a definition for soil as hazardous waste). As described in chapter 5 (section 5.6.3), special disposal of soil removed from a yard is not required in two cases. These are either none of the soil removed exceeds the hazardous waste definition, or the following conditions are met:

- Soil is removed from both the home perimeter and remote areas;
- Soil from one of the two areas exceeds the hazardous waste definition; and
- Mixed together, the soil removed from both areas does not exceed the hazardous waste definition.

Based on the HUD survey, there are 1.1 million homes where one area of the yard exceeds 2000 ppm, but the other falls between 250 and 300 ppm. They all exceed the basic soil standards in question. Of these, 931 thousand perform interventions during the course of the 50-year analysis. This means that if the hazardous waste definition of soil is 2000 ppm, these homes must incur the major expense of hazardous waste disposal when the soil standard is 300 ppm. However, when the standard is 250 ppm, soil is removed from both yard areas and may be mixed to avoid this extra cost. The supplemental cost of removing a greater volume of soil is small in comparison; overall savings for this set of homes is $2.6 billion.

Thus it appears that in the base analysis, the net benefit connected with removing soil from homes with soil lead concentrations between 250 and 300 ppm is somewhat negative. There are 2.3 million homes in this category, of which 2.0 million would perform soil interventions at a cost of $7.7 billion. The benefit associated with these interventions is, in fact, slightly less -- $7.2 billion (as calculated by the technique described in footnote 3). However, this deficit is more than offset by the $2.6 billion reduction in the cost of soil removal in 931 thousand homes, precipitated by changing the soil standard from 300 ppm to 250 ppm. These interrelations explain why net benefits are maximized at a standard of 250 ppm in the base analysis, but at 300 ppm when there is no definition for hazardous waste disposal of soil.

8.3 Analyses Involving Changes in Modeling Procedure

In addition to alternative assumptions about certain parameter values, three sets of sensitivity analyses were performed to investigate the impact of making certain structural changes in the model. Each of these changes addresses an important assumption in the analysis. The first question is how much of the benefits are the result of very small changes in IQ levels. While the value assigned to a given change in IQ can be altered simply by changing a single parameter, as in 8.2.2, eliminating small IQ changes from the estimation of benefits requires a basic restructuring in methodology. The second structural sensitivity analysis proposes an alternative "trigger" for intervention events. The model used in the analysis presented up to this point assumes that any and all interventions needed to bring the housing unit into compliance with the standards occurs just before the arrival of a newborn child in that unit. There is evidence, however, that interventions do not necessarily occur then, and do occur at other times. In particular, another type of event that frequently triggers interventions is property transaction. A "transaction trigger" model was constructed, therefore, to compare to the "birth trigger" model used in the baseline analysis. The third set of structural sensitivity analyses attempt to investigate each medium one by one, completely independent of the standards for the other media.

8.3.1 Benefits from Small IQ Changes

The core analysis assumes that a difference in average blood lead levels between two populations, no matter how small that difference is and regardless of the magnitude of blood lead levels involved, is associated with a corresponding difference in average IQ scores. The cost-benefit analysis performed for these standards is essentially a comparison of the blood-lead distributions that would occur between two populations: one with the 403 standards versus one without the 403 standards. Furthermore, the analysis relies on the empirical finding that a difference in average IQ scores between two populations, again no matter how small, is associated with a difference in average lifetime earnings. Note that it is not possible to say that for any pair of individuals, a difference in blood lead will necessarily reflect a difference in IQ scores or lifetime earnings. The available research, however, does demonstrate that such differences do occur on the average for groups of individuals.

Notwithstanding the fact that the risk assessment and benefit-cost analysis were constrained to address population average changes, it was recognized that there might be an interest in considering the contribution to those population average changes made by subgroups in the population whose particular blood lead and IQ point improvements might be considered small.

This analysis poses special problems for procedure. In the normal calculation of benefits, a blood lead distribution for each entire cohort born is calculated under baseline and post-intervention scenarios. Most children are born into homes that meet standards and thus experience no interventions. These children have the same blood lead levels between scenarios. Since this group is included in the calculation of aggregate blood lead distributions, the difference between baseline and post-intervention mean blood lead levels for each cohort tends to be quite small. It is always much smaller than the average blood lead change for children in homes where interventions do take place. Therefore, the blood lead-difference "screen" cannot be applied to the population average difference.

One way around this would be to break up the population distribution into one hundred percentiles, and then take the difference between matching percentiles for baseline and post-intervention scenarios. These differences could then be compared against the screen. The problem with this approach is that children do not remain in the same percentile groups between scenarios, so the differences are not meaningful. Children in lead-contaminated home types will be in the upper percentiles of the baseline scenario, but in the post-intervention scenario, due to the effectiveness of interventions, they may exhibit lower blood lead levels than children in home types that never exceeded any standards and performed no interventions.

The approach adopted was to consider each home type individually, and split its baseline and post-intervention blood lead distribution into one hundred percentiles.[4] It is more reasonable to assume these percentile groups stay in order. The blood lead changes in each percentile group were "scaled" so that in the aggregate (that is, across all percentiles and all housing groups) the overall average blood lead change matched the average changed obtained in the baseline analysis for the aggregate population. Then, a "screen" was applied to these scaled blood changes observed in each percentile group so that only those percentile groups where a blood lead change of 3.89 µg/dL were used to estimate the IQ point improvement benefits.

The final results of this sensitivity analysis are presented in Exhibit 8-4, alongside the core analysis results. Costs are not affected by the IQ point difference screen, because unit costs are not affected, and neither are the number or timing of interventions. Benefits are reduced, as a natural consequence of the fact that the screen excludes benefits from many children with small changes in IQ point reduction, who contribute to the core analysis benefits total.

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4 In homes with damaged lead-based paint, children are divided into separate groups according to the presence and extent of pica behavior exhibited. These pica groups are then each split into one hundred percentiles. Otherwise, children would not plausibly remain in the same percentile group from baseline to post-intervention: children exhibiting pica would move from the highest blood lead percentiles to the middle of the range, after paint ingestion exposures were eliminated.

Exhibit 8-4
Effects on Costs and Benefits of Not Counting Benefits from Individual IQ Point Changes of Less than One

	Base (No IQ Screen)		IQ Difference Screen		% of Base	
	Empirical	IEUBK	Empirical	IEUBK	Empirical	IEUBK
Costs ($ billion)	$68.9	$68.9	$68.9	$68.9	100%	100%
Benefits ($ billion)	$48.5	$192.2	$7.4	$187.4	15%	98%
Net Benefits ($ billion)	-$20.3	$123.3	-$61.5	$118.5	n/a	96%

Figures may not add due to rounding error.

A striking feature of the results is that a substantially greater portion of benefits is lost when the empirical model is used, as opposed to the IEUBK model. This is because given the same interventions, the changes in blood lead distributions for each home type are much greater under the IEUBK than the empirical model (see chapter 7 and Battelle (1997)). Thus, the Empirical model generates a much higher proportion of cases of small blood lead or IQ point changes that do not exceed the screen, and are not counted.

To clarify why this difference between models exists, it is helpful to take the example of an actual home type from the HUD dataset -- for example, home ID number 411207, which performs a dust intervention only. Using the IEUBK model, the baseline blood lead geometric mean for children living in this home type is 15.83 µg/dL, and the geometric standard deviation is 1.6. The post-intervention figures are 10.03 µg/dL and 1.6. The analysis assumes that these distributions can each be approximately scaled to become compatible with NHANES data, and divided into one hundred percentiles. These percentiles represent small groups of children with identical blood lead levels, and the percentile groups are assumed to stay in the same rank order from the baseline to the post-intervention scenario. Values for a small number of the percentile groups are shown in Exhibit 8-5. Thus, the baseline/post-intervention difference for the first percentile is 1.05 µg/dL, and for the 100th percentile is 12.89 µg/dL. Children represented by the first percentile through the 56th percentile are excluded from IQ-related benefits, because their blood lead change falls under the screen of 3.89 µg/dL.

Using the empirical model, the blood lead figures are much smaller. In the baseline, the geometric mean is 4.47 µg/dL and the geometric standard deviation is 1.6. The geometric mean reduces to 4.06 µg/dL in the post-intervention scenario. Percentile breakdowns are given in Exhibit 8-5. Children represented by all percentiles are excluded from IQ-related benefits -- a much greater portion than was the case under the IEUBK model.

Exhibit 8-5
Baseline/Post-Intervention Blood Lead Difference by Percentile Group for HUD Home 411207

	Difference Between Baseline and Post-Intervention Blood Lead Levels (µg/dL)	
Percentile	IEUBK Model	Empirical Model
1	1.05	0.15
25	2.63	0.37
50	3.62	0.51
56	3.886	0.55
57	3.93	0.55
75	4.96	0.70
100	12.89	1.81

New net benefit-maximizing standards were not determined in this analysis due to its high degree of complexity and computational intensiveness. However, based on results at the option selected, qualitative predictions are possible. Under the Empirical model, eliminating small IQ changes reduces benefits as sharply as changing the discount rate to 7 percent (by 88 percent). The discount rate change also reduces costs, but the small IQ adjustments do not. It is reasonable to expect, therefore, that when small IQ benefits are not counted, the net benefit-maximizing standards under the Empirical model should be less stringent than they are in the 7 percent discount rate analysis.

Under the IEUBK model, the reduction in benefits is not nearly so great when small IQ changes are screened out (by 2 percent). In addition, it is moderately smaller than the benefits reduction when a smaller IQ value is used (section 8.2.2 -- by 16 percent). Neither sensitivity analysis affects costs. Thus it is reasonable to expect that when small IQ benefits are not counted, the net benefit-maximizing standards under the IEUBK model should be somewhat less stringent than they are in the low IQ value analysis, where they do not change at all. In other words, there should be little or no change from the optimal standards in the baseline analysis.

8.3.2 Transaction Trigger for Interventions

The base analysis assumes that the birth of a child triggers interventions in homes that exceed §403 standards. This assumption results in maximum efficiency: each intervention performed is matched with a child to benefit from it, and is implemented at the last possible moment for maximum overlap with the child's development, and for least present value of cost (due to discounting). Furthermore, all children born into homes exceeding standards are protected. If a child under six is still present when the effectiveness of an intervention lapses, the intervention is repeated.

An alternative way to imagine response to §403 standards is that interventions will be performed at times of real estate transaction. These may be particularly convenient times to intervene because homes are likely to be unoccupied, and other renovations may be taking place as well. Additionally, Section 1018 of Title X, "Disclosure of Information Concerning Lead upon Transfer of Residential

Property," provides a new incentive for lead abatement during real estate transaction. Section 1018 requires that home sellers or lessors must tell home buyers or renters everything already known about the presence of lead in the home. The future occupant must also be granted ten days to conduct a risk assessment or inspection. Thus, it is reasonable to imagine that all parties will be aware of possible lead risks at the time of transaction, and may be likely to perform interventions to increase home saleability or safety.

Like the birth trigger model, the transaction trigger model operates on the assumption that if a child under six is present when the effectiveness of an intervention lapses, the intervention is repeated.

Exhibit 8-6a compares results between the birth trigger model (the base analysis) and the transaction trigger model (the sensitivity analysis). Costs are greater in the transaction trigger model, and benefits are lower, using either the IEUBK or empirical model for predicting blood lead levels.

Exhibit 8-6a
Effects on Costs and Benefits due to Changing Assumption about Intervention Trigger

	Base (Birth Trigger)		Transaction Trigger		% of Base	
	Empirical	IEUBK	Empirical	IEUBK	Empirical	IEUBK
Costs ($bil)	$68.9	$68.9	$96.9	$96.9	141%	141%
Benefits ($bil)	$48.5	$192.2	$24.6	$104.7	51%	54%
Net Benefits	-$20.3	$123.3	-$72.3	$7.8	n/a	6%

Figures may not add due to rounding error.

Costs increase because interventions occur at a faster rate in the transaction trigger model than in the birth trigger model. Under the transaction trigger, they occur whenever a property changes hands or the tenant moves out: 8.15 percent a year for single-family homes and 28.45 percent a year for multi-family housing units (USDOC and HUD 1989). By contrast, the birth rate is projected to be less than four percent per household every year of the model run (Battelle 1996). As a result, more total interventions take place in the transaction trigger model (by 19 percent), and they are more crowded toward the early years. They therefore receive little discounting compared to the more spread-out costs of the birth trigger model.

At the same time, benefits are lower under the transaction trigger model than the birth trigger model. This is because, with the former, many children are born into homes which exceed section 403 standards, but which have not had a recent transaction. These children receive no benefits, whereas they would be protected in the birth trigger model, in which all children born into homes exceeding standards receive protection.

Exhibit 8-6b compares the net benefit-maximizing standards assuming a transaction trigger, versus the same for the birth trigger. For the Empirical model, standards are considerably less stringent across the board with the transaction trigger. This is the expected pattern, since for any set of interventions at any set of homes, costs are higher and benefits lower assuming a transaction trigger. For the IEUBK model, the window sill dust standard is less stringent, while the floor dust and soil standards remain constant. Marginal net benefits in the latter two standards are strongly positive under the birth trigger, large enough to remain positive despite the switch to a transaction trigger.

Exhibit 8-6b
Effects on Net Benefit-Maximizing Standards due to Changing Assumption about Intervention Trigger

		Standards			Values ($ billion)		
Scenario	Model	Floor Dust (µg/ft²)	Sill Dust (µg/ft²)	Soil (ppm)	Costs	Benefits	Net Benefits
Base (Birth Trigger)	Empirical	80	310	1650	51.7	46.5	-5.2
	IEUBK	40	100	250	100.6	274	173.4
Alternative (Transaction Trigger)	Empirical	130	none*	4650	51.3	7.8	-43.5
	IEUBK	40	none*	250	125	162.2	37.1

*Net benefits are maximized when no interventions are triggered through the standard in question.
Figures may not add due to rounding error.

8.3.3 Single Medium Analysis

This section presents an alternative method of determining which standards among many may maximize net benefits -- a method that is different than the technique used in chapter 7. In both chapter 7 and this analysis, the standards for paint remain fixed, but standards for lead content in floor dust, window sill dust, and soil may vary.

In Chapter 7, alternative standards for each medium are explored independently. However, while one medium's standard is varied, the other media also have standards in effect, which go into model calculations. This sensitivity analysis explores what happens when the standard for one medium is varied, but no other standards are in effect. In other words, no interventions take place except for those triggered by the single medium standard being considered. Exhibit 8-7 summarizes the results.

Exhibit 8-7
Net Benefit-Maximizing Standards in a Single Medium Analysis

Model	Medium	Net Benefit-Maximizing Standard: Base Analysis*	Net Benefit-Maximizing Standard: Single Medium Analysis
IEUBK	Floor Dust	40 µg/ft²	40 µg/ft²
	Window Sill Dust	100 µg/ft²	100 µg/ft²
	Soil	250 ppm	250 ppm
Empirical	Floor Dust	80 µg/ft²	40 µg/ft²
	Window Sill Dust	310 µg/ft²	310 µg/ft²
	Soil	4350 ppm	1650 ppm

Figures may not add due to rounding error.

As a general rule, net benefit-maximizing standards for the single medium analysis are expected to be equally or more stringent than standards in the base analysis. This is because of partial redundancy between different standards or intervention types. When there is no window sill dust standard, for instance, under the Empirical model, the optimal floor dust standard may become more stringent if moderately contaminated floors are associated with highly contaminated window sills in some homes.

Empirical model results
This is, in fact, the case. The optimal floor dust standard drops from 80 to 40 µg/ft² between the base and single medium analyses under the empirical model. Based on the HUD dataset, 3.8 million homes have floor dust lead loads between 40 and 80 µg/ft². Of these, 2.5 million (65.2 percent) have window sill dust lead loads over 250 µg/ft². This set (set A) receives dust cleanings under both scenarios, the base analysis (where the floor dust standard is 80 µg/ft² and the sill dust standard is 250 µg/ft²), and the single medium analysis (where the floor dust standard is 40 µg/ft²). For set A, the marginal benefits of cleaning outweigh the marginal costs. However, for the other homes with floor dust lead levels between 40 and 80 µg/ft², that have low sill dust lead levels (the remaining 34.8 percent -- set B), the marginal costs of cleaning outweigh the benefits. This is why the net benefit-maximizing floor dust standard in the base analysis is 80 µg/ft². The optimal standard in the single medium analysis is 40 µg/ft² because the positive marginal net benefits from set A outweigh the negative marginal net benefits from set B. In other words, window sill dust contamination drives the choice between floor dust standards in the two scenarios described. There is no interaction with soil contamination, and little with damaged lead-based paint, in the homes considered here.

Finally, the difference between net benefit-maximizing soil standards under the Empirical model stems from the fact that 80.1 percent of the 2.1 million homes with soil lead concentrations between 1650 ppm and 4350 ppm have highly contaminated window sill dust, with lead loads well above 250 µg/ft². Soil removals are accompanied by dust cleanings, which result in reduced dust lead loads and concentrations. The soil-related benefits for homes in the 1650-4350 ppm range do not match the costs of soil removal, but when dust-related benefits are added in, marginal net benefits are positive for the group. Dust benefits are added at the margin in the single medium analysis, and that is why the optimum soil standard is 1650 ppm in that analysis. In the base analysis, however, the window sill standard is 250 µg/ft², so dust cleaning takes place in the group of homes characterized by 1650-4350 ppm soil lead and high window sill lead, even in the absence of removing soil. Since dust cleaning is less expensive than soil removal, it is more efficient in a multimedia scenario for the soil standard to remain high, at 4350 ppm, and for the dust standards to trigger dust cleaning in the homes that need it.

IEUBK model results

In contrast to the Empirical model results, all net benefit-maximizing standards remain the same under the IEUBK model, whether they are calculated using the base methodology or the single medium analysis. The reason the single medium approach does not make either dust standard more stringent is elementary: each is already at its most stringent possible value based on the baseline methodology. 40 µg/ft² is the minimum allowed standard for floor dust because it is the assumed post-intervention floor dust lead load in the risk assessment. Similarly, 100 µg/ft² is the assumed post-intervention window sill dust lead load (Battelle 1997).

The soil standard, 250 ppm, is also very close to its minimum value, 150 ppm, the assumed lead concentration in replacement soil (Battelle 1997). However, some further explanation can be offered as to why it does not drop further in the single medium analysis.

In homes with soil lead concentrations in the vicinity of 250 ppm, very little benefit can be realized directly from soil removal. However, substantial benefits may accrue following the associated dust cleaning, from reductions in dust lead concentrations. The average dust lead concentration for HUD survey homes with soil lead concentrations between 250 and 300 ppm is 562 ppm. This high value helps to explain why the net benefit-maximizing soil standard is so low in the baseline analysis. However, for homes with soil between 200 and 250 ppm, the dust average is only 213 ppm, and it is just slightly greater for homes with soil between 150 and 200 ppm. Therefore, it is not surprising that the single medium analysis does not generate a lower soil standard than 250 ppm.

Finally, lowering the soil standard may be beneficial because it can lead to soil mixing and the elimination of soil hazardous waste disposal costs. This kind of cost reduction is substantial when the soil standard changes from 300 ppm to 250 ppm (see section 7.2.3); however, no further such advantages accrue when the soil standard drops further, as far as 150 ppm. Additionally, any advantages which might have existed, would have been equal between the single medium and baseline analysis. In sum, there is no reason why the soil standard should drop any lower than 250 ppm in the single medium analysis.

Combining single medium analyses

This section has focused on the effect that a single medium analysis has on net benefit-maximizing standards chosen. Costs and benefits have not been presented because they may be misleading. They cannot be combined across media in most cases. For instance, many homes which incur costs for repeated dust interventions in a single medium analysis of floor dust, may not incur these costs in a multimedia situation because a soil removal takes place. Also, benefits cannot be added among different analyses, because they are generated based on population-wide blood lead distributions calculated from conditions in all homes. Even if there were no overlap in which home types receive interventions in different single medium analyses, it would not be appropriate to add benefits across analyses because benefits cannot be directly assigned to specific homes.

8.4 Additional Elements of Uncertainty

This section presents a qualitative assessment of additional elements of uncertainty associated with inputs to the economic analysis of §403. In many cases, the analysis is limited to a qualitative assessment because data are not available on which to base a quantitative sensitivity analysis. In other cases, the complexity of the analysis precludes it being undertaken at this time. The inputs investigated in this qualitative assessment include the unit costs of interventions, the valuation of different types of benefits, and the design of the overall analysis. These were selected because they are unique to the benefit-cost analysis, whereas other uncertainties stem from the risk assessment. In this section, first the sources of uncertainty are presented, and then an assessment of their likely impact on the estimations of costs, benefits, net benefits, and net benefit-maximizing standards are discussed.

8.4.1 Unit Costs of Interventions

Sources of Uncertainty

There are three basic sources of uncertainty with regards to the unit costs of interventions. First, inaccurate estimation of any of the inputs used to develop unit costs, as described in chapter 5, would lead to the underestimation or overestimation of those costs. There is one special case where the bias is known. The unit costs for paint abatement used in the analysis do not reflect the possibility that home occupants may need to move out temporarily during intervention. This would result in increased costs. Based on the HUD survey data, however, very few homes require paint abatements. Therefore, this source of uncertainty may not have a significant effect on total rule costs even if temporary relocation of families proves to be common during paint abatement.

Second, it is not known how future economic forces will affect unit costs. Section 403 standards are likely to result in an increased demand for intervention services: will this drive their prices up, or lead to innovation and cost reduction?

Third, it may not be appropriate to assign average unit costs to all single family, or multi-family homes. The unit costs for soil removal were calculated to reflect the fact that soil contamination is systematically and positively associated with smaller yards. However, no such adjustments were made with regards to paint or dust interventions. For instance, if dust contamination is associated primarily with the oldest homes, and if very old homes are typically larger than newer pre-78 ones, then the dust intervention unit cost should reflect the need to clean a larger home than the national average size, or different unit costs should be assigned to homes in different age classes. A similar situation may arise if the geographic regions where homes are most likely to exceed the standards are also the regions with the highest intervention costs.

Effect of Uncertainty on Benefits Estimates

For any given set of standards -- for example, the option selected -- changes in unit costs of intervention will have no effect on benefits estimates.

Effect of Uncertainty on Cost Estimates

For any given set of standards, changes in unit costs of intervention will have simple, predictable effects on total cost estimates. For example, if the estimated unit cost of exterior paint maintenance were to be raised by 30 percent, then the portion of the total estimated rule cost associated with exterior paint maintenance would increase by 30 percent. The relative increase of total costs would depend on the portion of total costs made up by exterior paint maintenance costs.

Effect of Uncertainty on Net Benefits and Net Benefit-Maximizing Standards

For any given set of standards, the effect of unit cost uncertainty on net benefits will be a direct function of its effect on cost estimates. Net benefits will decline by the amount that costs increase.

The effect on net benefit-maximizing standards is more difficult to predict. To the extent that the unit cost for an intervention type increases, however, the net benefit-maximizing standard for that intervention type will tend to become more lenient; to the extent that the unit cost for an intervention type declines, the related standard will tend to become more stringent. This is because net benefit maximizing standards are set at the margin, with the cost of each marginal intervention compared against the associated benefit, which is unaffected by any uncertainty in the costs. Uncertainty in unit costs of paint intervention will have no effect on standards that maximize net benefits in this analysis because alternative paint standards are not considered.

8.4.2 Valuation of Benefits

Sources of Uncertainty

There are two basic sources of uncertainty in the monetary values associated with reduced incidence of adverse health effects considered in this analysis. First, inaccurate estimation of any of the inputs used to develop these values, as described in chapter 6, would lead to their incorrect estimation. Second, it is impossible to know how future economic forces will affect the inputs. For instance, will expected lifetime earnings change in the future? This would affect the valuation of an IQ point.

In addition, the benefits are underestimated because certain benefits categories are not included in this analysis, such as benefits to children age six and older, to other children spending time at homes with interventions, to adults, and to ecosystem health. The size of these excluded benefits, however, is not known so the degree of underestimation is uncertain.

Effect of Uncertainty on Benefits Estimates

The potential effects of changes in the valuation of IQ have already been discussed in depth earlier in this chapter. Anything less than a major change in the other values used to calculate benefits -- the expenses assigned to special or remedial education, or to medical treatment -- should have a very small effect on benefits estimates. This is because only a small fraction of the population receives special education or medical intervention, and therefore benefits from reduction in the associated expenses, between scenarios, are low. At the option selected, these benefits account for under two percent of total monetized benefits.

The addition of benefits not previously counted in the analysis would clearly have the effect of increasing total benefits estimates, potentially by a significant amount, because the population age six and older is much larger than the population under six. This is shown in Chapter 9. However, per-individual damage from lead exposure is believed to be the greatest in young children, whose nervous system is still developing. (Battelle 1997)

Effect of Uncertainty on Cost Estimates

For any given set of standards, changes in the valuation of benefits will have no effect on cost estimates.

Effect of Uncertainty on Net Benefits and Net Benefit-Maximizing Standards

For any given set of standards, the effect of uncertainty in benefits valuation on net benefits will be a direct function of its effect on total benefits estimates. Thus, net benefits are not likely to change significantly due to changes in the cost of special education or medical intervention; however, they can increase substantially when new benefits categories are added.

Likewise, the effect of uncertainty on net benefit-maximizing standards is likely to be negligible with regards to education and medical costs, but could be significant with regards to new benefits categories. In the latter case, increased benefits may lead to more stringent standards for dust and soil.

8.4.3 Other Modeling Issues

Several analytic components in addition to cost and benefit inputs contain important elements of uncertainty. These uncertainties include the appropriate time frame of analysis, the probability of future interventions taking place even in the absence of national standards for household lead hazards, and the likely rate of interventions after standards are issued. Each area of uncertainty is addressed briefly in turn.

Appropriate Time Frame of Analysis

The economic analysis considers costs and benefits relating to cohorts of children born over the fifty year period, 1997 to 2046. This choice of time frame has effects on total costs, benefits, and net benefits, and possibly also on the standards that maximize net benefits. A shorter time frame would result in smaller absolute magnitudes of costs, benefits, and net benefits, because fewer interventions would take place, and fewer cohorts of children would benefit from them. Similarly, a longer time frame would lead to greater magnitudes.

The effect of time frame changes on net benefit-maximizing standards is less clear. When the analysis period changes, even though cost and benefit totals move in the same direction, their ratio changes. The longer the frame of analysis, the greater the ratio of benefits to the total cost of interventions. This is in large part because soil removals are assumed to have permanent effectiveness. Thus, one intervention paid for and performed in 1997 conveys benefits to a child born at the same home in 2040. Under such circumstances, the longer the period considered, the better the investment in soil removal appears.

Longer time frames, then, will tend to favor more stringent soil standards as the standards that maximize net benefits; and shorter time frames will lead to less stringent soil standards. Dust standards may move in the opposite direction, because dust interventions have short durations, and soil interventions include dust cleanings (thus preempting dust interventions that would have been triggered by dust standards). For example, if soil standards become less stringent, then homes that no longer perform soil interventions no longer receive the benefits from associated dust cleaning. This may result in an increase in the stringency of dust standards to capture dust-related benefits from these same homes.

Using a long time frame for the economic analysis has the advantage of favoring an appropriate balance between short-term and permanent interventions. However, it also carries the increased general uncertainty which comes with projections made far into the future.

Interventions without Section 403

The baseline assumes that no interventions will take place in the absence of national standards. This assumption makes possible its corollary, that the NHANES III Phase 2 national blood lead distribution will remain constant over the entire analysis duration in the baseline scenario of "no action."[5] In turn, this corollary is critical to the methodology used for projecting future national blood lead distributions in scenarios *with* interventions, and thus, for calculating benefits.

However, interventions to remove lead hazards are already taking place in the pre-standards world. How would model results change if some interventions were included as part of the baseline scenario? Because fewer interventions would be occurring as a result of 403, the costs, benefits, and net benefits would decrease.

The effect that baseline interventions might have on net benefit-maximizing standards is not as clear, especially considering the limited information available on where interventions currently do take place. However, there is reason to believe that the effect should be small or none. Standards that maximize net benefits are set at the margin. Thus, unless baseline interventions are disproportionately concentrated among homes with contamination levels near the current net benefit-maximizing standards, these standards should not be perturbed.

Intervention Rates

Two different triggers for interventions in homes that exceed standards have been presented -- births or real estate transactions. As the model is constructed, however, each trigger *always* leads to intervention in a home exceeding standards at the time of the trigger event. This results in modeled national intervention rates which are substantially greater than current known regional rates, a discrepancy which does not appear realistic even in the aftermath of the issuance of national standards. It is useful to consider briefly how the net benefit-maximizing standards would be affected by an assumed lower rate of intervention.

Clearly, costs, benefits, and net benefits would all decrease in rough proportion to the decrease in interventions, since interventions are what engender both costs and benefits. The effect on net benefit-maximizing standards, however, is more difficult to assess. Especially if the decrease in intervention rates were applied uniformly across different home types, there is no clear reason to suspect that these standards should indeed change from the current analysis results.

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5 The distribution will remain constant within the housing stock considered in the analysis: homes built before 1997.

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9. Supplemental Analyses

While cost-benefit analyses provide a way to estimate society's net gain as a result of a regulation, they do not examine the distributional effects of the rule. In other words, the cost-benefit analysis looks at the total costs imposed by the standards and the total benefits generated; it does not look at who pays these costs nor who are the direct beneficiaries. Thus a series of separate analyses were performed to estimate the impact of the standards on groups who are of particular interest. These include the rule's financial impact on small entities (governmental and business), its potential for imposing unfunded mandates on state and local governments, the paperwork burden imposed by the standards, and finally, the distribution of costs and benefits by race and income as a measure of the "environmental justice" of the standards, as well as the impacts on children. This chapter presents the results of these supplementary analyses.

Another area of interest is the potential impact of these standards on the level and composition of abatement activity. While not examined in detail, some factors are fairly well established. Based on the limited data available, the current annual number of abatements is relatively small. While this number is likely to increase after the promulgation of the §403 standards, the number will continue to be far less than that assumed in the cost-benefit analysis. In addition, while lead-based paint abatements are more likely to occur where there are small children, and this is likely to increase with the promulgation of the 403 standards, not all abatements occur under such circumstances. Thus, both the costs and the benefits to children of these standards are likely to be less than the estimated costs and benefits presented in chapter 7, with the benefits to children probably declining more than the decline in costs. In addition to the neurological benefits to children estimated by the cost-benefit analysis, however, there will be benefits to teenagers and adults from the reduced incidence of lead in residential environments. These benefits to teenagers and adults will help offset the costs of abatements even where there are no children in the housing unit.

9.1 The Regulatory Flexibility Act (RFA) and Small Business Regulatory Enforcement Fairness Act (SBREFA)

As described in the Preamble and earlier chapters of this report, the §403 standards do not require or mandate any actions by homeowners, landlords, or personnel performing lead-based paint identifications and interventions. Instead, §403 standards inform decision-makers about what conditions constitute a hazard and recommend potential actions. As a result, EPA is not required to conduct a Regulatory Flexibility Analysis under the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA).

When an economic impact on the small entities is necessitated by the RFA, it requires that the analysis identify the types, and estimate the numbers, of small entities "to which the proposed [or final] rule will apply," and describe the rule "requirements" to which small entities "will be subject" and any regulatory alternatives, including exemptions and deferrals, which would lessen the rule's burden on small entities. (Sections 603 and 604 of the RFA.) Rules that do not establish requirements applicable to small entities (e.g., rules establishing or revising national ambient air quality standards under the CAA or water quality standards under the Clean Water Act) are thus not susceptible to RFA analysis and may be certified as not having a significant economic impact on a substantial number of small entities. This is particularly true when the national standards do not themselves require any particular action, as is the case with §403.

Nevertheless, EPA has conducted a more limited analysis of the potential impact on small entities of these standards as they work within the market. Two groups of entities are considered: lead-based paint inspection and abatement firms, and landlords. The small entity impacts of §403 on the lead testing and abatement sector are presented in Section 9.1.1 and the small entity impacts on the real estate sector are presented in Section 9.1.2.

9.1.1 Impact of §403 on the Lead Testing and Abatement Industry

The impact of §403 on small lead testing and abatement firms is likely to be positive (i.e., to improve their markets). In general, it is expected that the information dissemination facilitated by §403 will result in additional household lead interventions[1]. Even if it were possible to estimate how many additional interventions will occur, it is not known whether these additional interventions would result in relatively more business for small testing and abatement firms. Data on the size distribution of firms in this industry can allow for some informed speculation regarding the likely impact of §403 on small businesses.

There is no North American Industry Classification System (NAICS) code that uniquely corresponds to the lead testing and intervention industry. Based on the types of activities performed, however, most of the firms affected by this regulation are likely to be part of two NAICS groups:

- NAICS 54138: Professional, Scientific, and Technical Services: Testing Laboratories, or

- NAICS 56291: Administrative and Support, Waste Management and Remediation Services: Remediation Services.

Inferences about the potential impact of §403 on the lead testing and intervention industry can be made based on data available from the Census on these two NAICS codes.

The Small Business Administration (SBA) defines the small business threshold for the testing industry (NAICS 54138) as firms earning less than $5 million per year, while the small business threshold for the remediation services industry (NAICS 56291) is defined as firms earning less than $11.5 million . Exhibit 9-1 provides data from the Economic Census (1997) on the size distribution of firms in these two industries.

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[1] It is possible, although unlikely, that §403 will result in fewer household lead interventions. This would occur if households are currently intervening at lead levels below those outlined in the §403 standards and if those interventions stopped occurring once the §403 standards were distributed. Given the current low rate of interventions and the persistence of lead levels in excess of those warranting intervention under the standards, it is expected that interventions will not decrease after promulgation.

Notice that 95.67% of the firms in the testing industry (NAICS 54138) are small businesses and at least 95.48% of the firms in the remediation services industry (NAICS 56291) are small businesses.[2] To the degree that §403 will increase demand for lead testing and abatement services, the fact that almost all firms in these two industries are small businesses implies that the impact on small businesses will be positive and potentially substantial. In other words, the §403 rule may potentially expand the markets available to these small firms.

Exhibit 9-1
Characteristics of Establishments — Lead Testing and Abatement Firms

	Number of Establishments	Percent of Total Establishments	Average Sales ($)	Average Number Employees
NAICS 54138: Small Businesses				
Less than $100k	534	10.85%	59,588	1.7
$100 to $249k	1,005	20.42%	169,623	3.1
$250 to $499k	975	19.81%	363,574	6.0
$500 to $999k	920	18.69%	709,592	10.6
$1 to $2.49 mil	888	18.04%	1,576,164	20.8
$2.5 to $4.9 mil	387	7.86%	3,422,282	42.1
Total - Small	4,709	95.67%	835,349	11.5
NAICS 54138: Large Businesses				
$5 to $9.99 mil	150	3.05%	6,887,873	78.2
$10+ mil	63	1.28%	20,773,143	218.1
Total - Large	213	4.33%	10,994,784	119.6
NAICS 56291: Small Businesses				
Less than $100k	102	7.09%	53,402	2.3
$100 to $249k	186	12.93%	167,849	3.4
$250 to $499k	187	13.00%	364,930	5.8
$500 to 999k	217	15.08%	699,816	10.2
$1 to $2.49 mil	354	24.60%	1,644,969	19.3
$2.5 to $4.99 mil	198	13.76%	3,528,722	35.2
$5 to $9.99 mil	130	9.03%	7,134,769	63.1
Total - Small	1,374	95.48%	1,794,247	19.1
NAICS 56291: Large Businesses				
$10+ mil	65	4.52%	47,832,446	217.4
Total - Large	65	4.52%	47,832,446	217.4

1. The Economic Census for the remediation services industry groups all establishments with receipts of $10 million or more within a single category; therefore, an accurate assessment of the number of small establishments could not be made. The reported figure of 95.48% is thus a lower-bound estimate of the proportion of small businesses in the remediation services industry (NAICS 56291).

[2] The Economic Census for the remediation services industry groups all establishments with receipts of $10 million or more within a single category; therefore, an accurate assessment of the number of small establishments could not be made. The reported figure of 95.48% is thus a lower-bound estimate of the proportion of small businesses in the remediation services industry (NAICS 56291).

9.1.2 Impact of §403 on the Rental Real Estate Sector

The analysis of the impact of the §403 rule on the real estate sector is restricted to owners of multi-family residential properties. Even though §403 does not mandate any intervention activity and, as a result, carries no direct legal mechanism to ensure that homes exceeding the standard are abated, these standards will become part of Federal mortgage programs administered by the U.S. Department of Housing and Urban Development. In addition, it is likely that an indirect legal enforcement mechanism will develop through the threat of tort law liability suits. While §403 was developed to provide guidance for homeowners to determine when a lead intervention is warranted, it can also serve as guidance for the courts in determining when a property owner's decision to not intervene is an act of negligence for which the owner can be held financially liable.

Furthermore, mortgage lenders are likely to be more hesitant to fund property acquisitions if those properties exceed the §403 standards. This reluctance stems from the mortgage lenders desire to ensure that they are not held liable for any adverse health impacts that lead levels in excess of the standard may induce[3]. The combination of tort liability suits and mortgage lending requirements indicates that landlords are the group most likely to follow §403 to the letter, intervening whenever the standard is exceeded and not intervening when lead levels are deemed "acceptable" by §403.

Definition of Small Entity

The focus in this section is on the cost to multi-family residential property owners of complying with §403 and any potential difference in the cost burden likely to fall on owners of smaller rental businesses. To do this it is necessary to define what constitutes a small rental business. The Small Business Administration defines the small business threshold for "Lessors of Residential Buildings and Dwellings" at $5 million in rental revenue.

Data from the Property Owners and Managers Survey (POMS) is used to determine if property meets the small business criteria and whether owners are able to absorb intervention costs associated with §403 out of their rent streams. POMS is a national survey of rental units conducted from November 1995 to June 1996 by the U.S. Census Bureau. The sample consists of 16,300 rental units in 5,754 properties which were stratified and assigned weights to reflect the national stock of rental units. Publicly owned, military, owner-occupied and vacation units were excluded from the study.[4]

Total rental revenue per owner was determined by multiplying the rent of the unit surveyed by the number of units in all properties owned by the landlord. Using the SBA definition of a small rental business, nearly all of the properties (99.6%) surveyed by POMS were owned by small businesses.

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3 The presumption the mortgage lenders may be hesitant to lend for purchases of property with lead standards in excess of §403 standards stems from the experience with the asbestos regulations. After promulgation of the asbestos regulations, mortgage lenders made asbestos abatement a condition of lending. While this conditional lending has declined over time, it is anticipated that a similar initial response will result from the potential liability issues implied by the §403 standards.

4 A separate survey, asking a different set of questions, was performed for single-family rental units. Since the number of single family rental units is very small, the analysis here relies solely on multi-family rental units.

Expected Impacts

The ratio of annual compliance costs to annual rent streams gives an indication of the ability of a rental business to comply with the §403 standards. In order to calculate this ratio one needs data on the lead levels in the property (this determines what interventions, if any, must be performed), the number of units in the building, the rate at which interventions occur, and the total rent from all units in this property. Unfortunately no single data source contains all of this information. The HUD data set described in Chapter 4 provides data on household lead levels for 63 multi-family properties. The POMS data set provides data on the rent for each rental unit sampled, as well as the number of units in the property. Using these data, the analysis calculates the annual costs each landlord would incur for testing and intervention, and compares this to the landlord's annual rent. The ratio of costs to rents is then compared against standard benchmarks to evaluate whether or not the impact would be characterized as significant.

In order to make combined use of the HUD and POMS data, the analysis exploited the fact that each sample was representative of multi-family housing nationwide. Hence, the frequency of interventions predicted based on the HUD data set reflect nationwide frequency, and these frequencies could then be applied to the properties found in the POMS data set. Exhibit 9-2 below gives the percentage of multi-family properties that require various lead interventions according to the HUD data, the frequency with which those interventions need to be repeated to insure that a child is protected for six years, and the cost of each intervention.

As with the cost and benefit estimation in Chapters 5 and 6, the cost of compliance calculated here assumes that units are tested and interventions are performed whenever a child is about to be born into a unit. The birth rate of 3.8% determines the frequency of testing and the birth rate combined with the probability of requiring different lead interventions given in Exhibit 9-2 determine the frequency of lead interventions within a property.

Exhibit 9-2
Frequency of Lead Interventions in Multi-Family Housing

	Probability of occurrence in multi-family housing	Frequency of intervention required to protect child for 6 years	Cost of each intervention
Low-intensity Interior Paint	0.4%	2	$437
High-Intensity Interior Paint	0.0%	1	$4,687
Low-Intensity Exterior Paint	2.1%	2	$182
High-Intensity Exterior Paint	0.0%	1	$2,275
Dust	29.6%	2	$262
Removal & Replacement of Perimeter Soil	1.8%	1	$399
Removal & Replacement of Remote Area	0.0%	1	$777
Removal & Replacement of Both Perimeter	0.0%	1	$901
Removal & Replacement of Soil in Play	0.0%	1	$314

Testing	100.0%	1	$235

For example, a dust intervention must be repeated every four years, and hence, two dust interventions are required per child born (on average).[5] Using a birth rate of 3.8% and a probability of occurrence of 29.6%, the annual number of dust interventions in a 100 unit building is 2.25 units (100*.296*.038*2=2.25) at a cost of $590 (2.25*$262=$590). Similar calculations are performed for low-intensity interior and exterior paint interventions and testing. The annual costs for each type of intervention are summed together with the testing costs to determine the total annual compliance cost. This calculation is performed for each property in the POMS data set based on the number of units in the property.

The annual rent stream for each property is calculated as the rental revenue from the single unit surveyed in the POMS study multiplied by the number of units in the building. This calculation assumes that the unit surveyed in the POMS study is representative of the other units in the building. There is no means of determining whether this assumptions leads to an over or underestimation of the rent stream.

The ratio of annual compliance costs to annual rent payments is equivalent to the commonly used ratio of compliance cost to sales, and it determines the degree to which the property owner will be capable of complying with the §403 standards. For the purposes of determining small business impacts it is assumed that business can accept a compliance cost to rent ratio of less than 3%. Exhibit 9-3 provides the number of property owners experiencing a compliance cost to rent ratio greater than 3%, between 3% and 1%, and less than 1%.

Notice that no property owners experience a cost to rent ratio larger than 3%. No large businesses experience a compliance cost to rent ratio greater than 1%. Just over 22,000 small rental businesses are expected to have an annual compliance cost to rent ratio greater than 1% but less than 3%. While 22,000 may appear to be a large number of businesses, there are over 2.2 million small rental businesses in existence. Thus, only 1% of all the small rental businesses experience a cost to rent ratio greater than 1%. Given the relatively small impact on the rental real estate sector in general, and small rental businesses in particular, the §403 rule will not have significant economic impact on a substantial number of small entities.

[5] An exception to this occurs if any given unit has more than one child under 6. For example if a couple has 2 children 2 years apart then only 2 interventions will be performed and both children will be protected for 6 years. However, for the small business analysis, we assume that 2 interventions are performed for each child born. This leads to an overestimation of compliance costs for property owners.

Exhibit 9-3
Ratio of Annual Compliance Costs to Annual Rent Payments, by size of business

	Comparative Ratios		Large Businesses	Small Businesses
	Annual Compliance Cost / Annual Rent Payments	< 1%	15,060	2,192,394
1%	Annual Compliance Cost / Annual Rent Payments	< 3%	0	22,191
	Annual Compliance Cost / Annual Rent Payments	≥3%	0	0
	Total Number of Businesses		15,060	2,214,585

9.2 Unfunded Mandates Reform Act (UMRA)

Under Title II of the Unfunded Mandates Reform Act, the cost to state, local and tribal government or the private sector of compliance with federal regulations must be calculated and considered during the regulatory process. Because §403 is a regulation which provides information to consumers about household lead safety and does not require households or public entities to take any action with respect to that information, this action is not subject to the requirements of sections 202 and 205 of UMRA. It does not contain any "federal mandates." Similarly this regulation contains no regulatory requirements that might significantly or uniquely affect small governments, so no action is needed under Section 203 of UMRA.

9.3 Paperwork Reduction Act (PRA)

The Paperwork Reduction Act (PRA) requires EPA to prepare an Information Collection Request (ICR), which estimates the reporting and recordkeeping burden imposed by their regulations. Under the PRA, "burden" means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

Section 403 contains no reporting or recordkeeping requirements, and thus no ICR is necessary for this rule. However, an ICR was prepared and filed for the promulgation of regulations for TSCA §402(a) and 404, and these burden estimates were based on estimates of the number of lead-based paint identification and intervention activities anticipated. EPA re-examined the §402(a) and 404 ICR and determined that these estimates would not change due to the §403 standards. The §402(a)/404 RIA and ICR estimated lead-based paint identification and intervention rates based on activity levels in Massachusetts. Massachusetts standards are similar to EPA's final standards, and Massachusetts has a very aggressive enforcement program coupled with state loan programs to encourage abatements in units occupied by low-income families. Therefore, national rates under §403 are unlikely to be higher than these. In addition to number of events, the reporting and recordkeeping burden is affected by the number of people trained and filing for certification, and the number of firms offering training. Again, the §402(a)/404 RIA and ICR based these numbers on Massachusetts estimates. The analysis determined, and state officials confirmed, that there was significant overcapacity in the state. Both because the number of events and the number of persons and firms were overestimates for §402(a)/404, and because the §403 standards are similar to the Massachusetts standards, EPA determined that the §402(a)/404 ICR did not need to be revised to reflect the §403 standards.

9.4 Executive Order 12898 Federal Actions to Address Environmental Justice

Increasingly questions of equity are playing a role in crafting environmental regulations. Two questions are of particular interest. First, what is the relationship between who receives the benefits of regulation and who bears the costs? Second, do these net benefits help the poor and otherwise disadvantaged populations? Initially one might assert that the voluntary nature of this rule ensures that those who bear the costs of §403 also receive the benefits and, hence, the distribution of costs and benefits across any demographic or socioeconomic group would mirror the distribution of the lead problem these regulations are seeking to solve. However, two households performing the same intervention with the same costs may receive different benefit levels. For example, a reduction of soil lead from 5000 ppm to 150 ppm will yield greater benefits than a reduction from 2100 ppm to 150 ppm despite the fact that the cost of the soil interventions are the same. This section seeks to determine how the costs and benefits of §403 are distributed across race and income groups.

Two sources of data are available that might help answer these questions: the HUD national survey of lead in homes and the NHANES III (Part 2) survey. Data on race and income were collected during the HUD survey along with information on lead levels in interior and exterior paint, dust, and soil. The HUD sample was stratified and weights were assigned so that the sample represents the housing characteristics of the nationwide housing stock. Data on race were also collected which permit assigning home types to four major categories: non-Hispanic white, African-American, Hispanic, plus an Other category. Data on income from the HUD survey can be used to form two income categories: households with an annual income of more or less than $30,000.

The HUD survey, however, was not designed to be used for an environmental equity analysis. Given the relatively small size of the HUD sample, it cannot be assumed that the data are representative of the demographic characteristics of the nation's households. The results of the NHANES III (Phase 2) survey, on the other hand, provide a more accurate representation of blood-lead levels for various racial and income groups. Since the remaining major sources of lead exposure for children are residential in nature (condition of lead-based paint, amount of lead in dust and soil), there is a close correlation between current blood-lead levels and environmental lead levels. Thus, the HUD data can be compared to the NHANES data to determine if the HUD data present an accurate picture of the conditions faced by various racial and income groups. If it does, then the HUD data can be used to perform a detailed analysis of who gains and who loses under the §403 standards. The relevant comparisons are discussed below.

- **Is the HUD sample demographically representative of the national population?** Because demographic analysis was not the purpose for which the data were originally collected, the sample was not stratified to represent the demographic make-up of the nationwide population but rather to reflect the characteristics of the national housing stock. Thus, the first assumption required to use the HUD data for the equity analysis is that the HUD sample is a reasonable representation of the population living in the housing units. This would be a strong assumption because the HUD survey substantially under represents the number of African Americans living in the United States. Based on the HUD survey weights, there are approximately 7.2 million African-American households while in actuality the figure is closer to 10.2 million. This discrepancy could be overcome somewhat by focusing strictly on percentage of households and per-household measures of equity.

- **Does the HUD sample accurately reflect the housing conditions and environmental lead levels experienced by each demographic and socio-economic group?** While this comparison is somewhat more difficult to make, the HUD data appear to be a poor representation of environmental lead levels experienced by the various racial and income groups. Blood-lead levels for each demographic group are estimated by applying the IEUBK and Empirical Models to the home types in which members of the demographic group reside. If the HUD data were representative of demographic group-specific housing conditions, then the predicted blood-lead levels and benefits would mirror those in the NHANES data. However, even at the national level, the geometric mean of the blood-lead distributions estimated by the IEUBK and Empirical Models using the HUD data do not match the NHANES geometric mean. Even so, it would be expected that the ranking of groups would agree between the two data sources. Based on the NHANES data of actual blood-lead levels, the African American population has higher blood-lead levels than the white population. However, predicted blood-lead levels based on the HUD data appear to indicate the opposite, that African Americans have lower blood-lead levels than non-Hispanic whites. Likewise, the blood-lead levels by income groups are reversed. According to NHANES, blood-lead levels are inversely related to income. Based on the HUD data, however, higher income households have slightly higher blood-lead levels than lower-income households. See Exhibit 9-4.

  Extending this comparison to homes that exceed the standards, the ranking of income groups, based on HUD data, appears to be inconsistent with the ranking based on NHANES data. For race, the results are mixed. The HUD data indicate that the largest percentage of homes that exceed the standards are among African-Americans, which is consistent with their having the highest blood-lead levels. The results for Whites and Hispanics are not consistent between the two data sources, however.

Exhibit 9-4: Comparison of the Third National Health and Nutrition Examination Survey (NHANES) Phase 2, and the HUD Survey Data

	NHANES Blood-lead Levels	Blood-lead Levels Estimated, Based on HUD Data	Percent of Homes Exceeding the Standards, Based on HUD Data
		Race	
Highest value	Non-Hispanic Blacks	Non-Hispanic Whites	African-Americans
Middle value	Mexican Americans	African-Americans	Non-Hispanic Whites
Lowest value	Non-Hispanic Whites	Hispanic	Hispanic
		Income	
Highest value	Low Income	High Income	Low Income
Middle value	Middle Income	N/A	N/A
Lowest value	High Income	Low Income	High Income

- **Do birth rates vary across racial and income groups?** The advantage of using the HUD data would be that costs and benefits for each home type (and the various racial and income groups) could be estimated. Consistent with the rest of the analysis presented in this report, these calculations would be based on the "birth-trigger" model, which assumes that interventions occur when a child is born into a housing unit with lead levels that exceed the §403 standards. No differentiation in birth rates across race or income is incorporated in the models. If birth rates differ by race or income, then costs and more particularly benefits would be underestimated for groups with higher birth rates.

Given the response to these questions, the analysis has chosen to reduce its emphasis on the HUD data in evaluating the equity impacts of these rules. Since the HUD survey provides the only compilation of data on both lead characteristics of homes and demographic composition of the members of the household, this analytic decision limits the degree to which the impacts on specific racial and income groups can be quantified.

9.4.1 The Distribution of Benefits and Costs by Race and Income

In the national analysis, the percentage change in the national blood-lead distribution (calculated using the IEUBK and the Empirical Models) is applied to the NHANES blood-lead distribution to estimate the actual expected change in blood-lead levels due to interventions undertaken. This estimated change in the NHANES blood-lead distribution measures the benefits of the standards.

The NHANES data report blood-lead levels by race and income, as well as for the nation as a whole. As shown in Exhibit 9-5, a higher percentage of non-Hispanic Black children have blood-lead levels over 10µg/dL than is true for other racial groups. Likewise, they tend to have higher blood-lead levels (as measured by the geometric mean). The same is also true for low-income children, as compared to children from households with moderate or high incomes.

Because the §403 lead hazard standards apply to all housing units, a disproportionate number of Black and low-income children will benefit from these regulations. White and high-income children already have the lowest blood-lead levels, implying that they already tend to live in homes with relatively low lead levels. Thus, they will not receive as great a benefit from these regulations. Hispanic or Mexican American children tend to fall in the middle. This may reflect the fact that many Hispanics live in parts of the country with relatively new housing (e.g., Florida, Texas, and California).

The benefit cost analysis for §403 assumes that a home which exceeds any of the four environmental lead standards (levels of lead in floor dust, window sill dust, or soil, and condition of lead-based paint) established by the §403 standard will perform the appropriate interventions at the birth of a child. Thus the cost of compliance with §403 is a function of the condition of the housing stock--older homes with paint in deteriorating condition or homes with high soil lead levels will have higher costs of compliance than newer homes or homes with low soil lead levels.

The distribution of the costs can be evaluated by using the percentage of any given race or income group that lives in housing that exceeds the §403 standards. As described above, the available data do not allow for a reliable analysis of the distribution of costs by race or income. Under these circumstances, inferences about the cost distribution are drawn from the NHANES data. Based on the blood-lead numbers presented in Exhibit 9-5, Blacks are most likely to be living in units with elevated levels of lead, followed by Hispanics. Non-Hispanic Whites are least likely to be living in units that expose their children to lead. In other words, owners of properties where African American or Hispanic families live are more likely to bear the costs of the rule. Also, low income households are more likely than middle or high income households to bear the costs of the rule. These cost impacts will be lessened, however, by Federal and state/local programs (e.g. HUD grantee programs) that use the §403 lead hazard standards in distributing grants and low-cost loans to subsidize the costs of lead abatements

Exhibit 9-5. Percentage of Children Aged 1-5 with Blood-Lead Levels (BLLs) ≥10 µg/dL, and Weighted Geometric Mean (GM) BLLs. — United States, Third National Health and Nutrition Examination Survey — Phase 2: 1991-94

Characteristics	Percent with BLLs ≥10 µg/dL	GM BLLs (µg/dL)
Race/Ethnicity*		
Black, non-Hispanic	11.2%	4.3
Mexican American	4.0%	3.1
White, non-Hispanic	2.3%	2.3
Income**		
Low	8.0%	3.8
Middle	1.9%	2.3
High	1.0%	1.9

* Data for other racial/ethnic groups were too small for reliable estimates.

** Income categories were defined using the poverty-income ratio (PIR), where: low income was defined as PIR 1.300, middle income as PIR=1.301-3.500, high income as PIR ≥3.501.

Source: Table 2, Morbidity and Mortality Report, CDC, February 21, 1997, Vol. 46 No. 7.

9.5 Executive Order 13045--Protection of Children from Environmental Health Risk and Safety Risks

Executive Order 13045 requires that regulations undergo review by the Office of Management and Budget (OMB) if the regulatory action is economically significant and concerns an environmental health risk or safety risk that an agency has reason to believe may disproportionately affect children. The focus of the §403 regulation is on the protection of children's health and the household lead standards were chosen based on an analysis of the health risks to children only. The benefits from §403 outlined in Chapter 6 are a reflection of benefits to children under 6 years old only.

Of the estimated 173 million children born between 1997 and 2046, approximately 131 million children will be born into housing built prior to 1979. It is estimated that §403 will result in reductions in exposure to household lead in soil, dust, and paint for 46.0 million children over the next 50 years. This reduction in exposure, in turn, will reduce the incidence of elevated blood-lead levels and increase average IQ. Exhibit 9-6 presents blood-lead and IQ statistics for both the baseline and post-compliance scenarios.

Notice that the health impacts of §403 are often substantial. The reduction in the number of children suffering from elevated blood-lead levels due to pica (direct ingestion of paint chips) is on the order of 1.3 million. The reduction in the number of children with elevated blood-lead levels (greater than 10 µg/dL) from all sources is estimated at 2.0 to 7.5 million. The increase in average IQ depends greatly on which benefits model is used but is estimated to be between 0.23 and 0.90 points for the 46.0

million children estimated to be affected by interventions. The number of children who will avoid an IQ less than 70 points is between 8,000 and 30,000 depending on the benefits model employed.

Exhibit 9-6
Beneficial Health Impacts on Children Resulting from §403

	Mean blood-lead level (µg/dL)	Number with elevated blood-lead due to pica (millions)	Number with blood-lead greater than 10 µg/dL (millions)	Number with blood-lead greater than 20 µg/dL (millions)	Average IQ point gain	Number avoiding IQ less than 70
Baseline	4.12	2.4	10.0	1.0	NA	NA
Post-§403 IEUBK	3.18	1.1	2.5	0.1	0.90	30,000
Post-§403 Empirical	3.88	1.1	8.0	0.7	0.23	8,000

9.6. Impact on Other Federal Agencies

The lead hazard standards established under §403 will apply to other federal agencies. Primary among these are the Department of Housing and Urban Development (HUD), the Department of Defense (DoD), and potentially the Department of Energy (DoE). This section of the Economic Impact Analysis addresses the likely impact of the final §403 regulations on DoD. The Department of Housing and Urban Development has already performed their own analysis of the impact of §403 on their operations (HUD 1999). Discussions with the Department of Energy indicate that they have few if any residential properties that will be affected by the §403 standards.

In December, 1999, DoD and Environmental Protection Agency jointly issued a guidance document (known as the "Field Guide"[6]) for use by DoD and EPA personnel in the evaluation and control of lead-based paint at DoD residential real property scheduled for disposition under the base realignment and closure (BRAC) program[7]. EPA and DoD have agreed that Title X would govern for residential property. The Field Guide states that "Although EPA concluded that the release of lead to soil from lead-based paint from structures falls within the CERCLA definition of a hazardous substance release, EPA and DoD agree that for the majority of situations involving target housing, Title X is sufficiently protective to address the hazards posed by lead-based paint." Based on the Guide, DoD is currently following the lead level in the Proposed Title X rule. When the rule is finalized, the Field Guide will reflect the level stated in the final rule.

At this time, there is no agreement between EPA and DoD as to lead standards for non-residential property. DoD has no guidance on lead-based paint for non-residential property, and the Department

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[6] Department of Defense and U. S. Environmental Protection Agency "Lead-Based Paint Guidelines for Disposal of Department of Defense Residential Real Property - A Field Guide" Interim Final, December 1999.

[7] BRAC facilities are transfers and closures, excluding Superfund and National Priorities List (NPL) sites.

feels they do not have specific limits to meet with regard to such property. DoD interprets §403 as applying only to residential property. EPA would like to see deed restrictions requiring property to remain non-residential if it is transferred without being remediated. DoD does not want any deed restrictions.

There are only limited data available on which to base an estimate of the potential costs of the final §403 standards. Data have been collected by EPA Region IX for four DoD sites, measuring lead concentration in soil for a number of locations at each site. This study looked at non-residential property, such as water towers, buildings, etc.[8] It is being assumed by DoD and EPA that the concentrations are representative of lead levels at DoD facilities nationwide.[9]

The Region IX sampling did not follow TSCA standards. The data were collected in areas that would be expected to have the highest lead concentrations (i.e., at roof driplines, on the soil surface, and/or close to the structure), and no averaging was done. Thus the data represents the "worst cases". The results of the study show that lead concentrations ranged widely, from background to 10,000 ppm (see Exhibit 9-7). No correlations were found between type of building, age of building, maintenance or any other factors and lead concentration. In short, no patterns were found in the data. Also, an exposure pathway could not be established by EPA.

Because the data taken at the four DoD non-residential sites are being treated as representative of what may be found at residential sites, the analysis compared these results to the final standards. In all four cases, the average soil lead level for the building locations sampled are above 1200 ppm. In two cases, Mare Island and Moffett NAS, these averages are inflated due to one very contaminated location at each site. Never the less, of the 64 building locations where samples were taken, 27 of them (42%) have average lead levels over 1200 ppm. While these data do not provide a basis for estimating specific costs to DoD, they clearly indicate that a soil standard of 1200 ppm could involve substantial costs for base conversion.

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8 Data on lead levels collected by DoD from the inside of buildings has either not been collected, or is spotty and informal (depending on who you ask). Each service does it separately.

9 The EPA FFRR Office had begun a pilot study on DoD Brownfield and Superfund facilities (all non-residential) to assess the risk of exposure to lead from lead-based paint. This pilot study has been canceled because EPA is considering the levels found in the Region IX study to be representative.

Exhibit 9-7
Lead Soil Levels at Four Department of Defense Sites*

Presidio Lead Based Paint Survey Other than Residential

Building	Date Constructed	XRF Dripline/ Near Bldg Avg (mg/kg)	Number Samples
2	1864	4,928	31
38	1940	188	36
40	1941	2,446	13
45	1863	399	9
47	1940	309	9
116	1885	4,466	9
563	1903	1,870	17
567	1903	1,530	16
569	1903	2,245	14
682	1902	3,223	20
1040	1900	1,097	10
1182	1919	1,625	8
1216	1912	598	18
1218	1912	423	16
1224	1912	802	11
1243	1941	555	12
1340	1917	366	15
1802	1928	97	2
1807	unknown[c]	387	12
1903	unknown[c]	792	12
Average		**1,417.3**	

Mare Island Lead Based Paint Survey Other than Residential

Building	Date Constructed	XRF Dripline/ Near Bldg Avg (mg/kg)	Number Samples
H-1	1889	10,427	23
H-71	1927	1,399	26
H-72	1926	1,318	24
H-80	1939	486	4
H-83	1943	1,853	22
H-84	1943	1,978	17
Tank 188	1915	5,056	8
396	1941	900	24
571	1942	797	31
617	1942	445	6
621	1942	419	42
650	1985	59	8
653	1943	365	6
658	1936	338	8
755	1945	237	6
892	1935	2,478	20
926	1939	1,250	40
928	1941	567	8
1294	1970	90	44
Average		**1,603.3**	

Mather AFB Lead Based Paint Survey Other than Residential

Building	Date Constructed	XRF Dripline/ Near Bldg Avg (mg/kg)	Number Samples
2389	1942	2,910	6
2400	1958	713	6
2460	1953	572	33
2470	1942	1,357	8
2474	1942	3,307	6
2480	1963	78	4
3306	1942	2,436	16
3335	1942	584	14
3374	1942	2,691	9
3430	1942	510	23
3455	1942	428	10
3494	1942	1,310	20
3550	1942	2,008	11
3686	1942	1,087	26
3790	1942	3,351	14
7005	1963	268	17
7024	1962	259	30
Average:		**1,404.1**	

Moffett NAS Lead Based Paint Survey Other than Residential

Building	Date Constructed	XRF Dripline/ Near Bldg Avg (mg/kg)	Number Samples
2	1933	1,898	6
50	1958	320	8
64/85	1940/1944	744	7
82	1944	1,857	3
107	1948	102	4
126	1944	8,252	21
151	1953	97	14
934	1940	127	6
Average		**1,674.6**	

*DoD data are reported in mg/kg, which is the equivalent of ppm..

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