Baltimore Integrated Environmental Management Project

Phase II Report

Reducing the Hazards from Abatement of Lead Paint

Regulatory Integration Division
Office of Policy Analysis
Office of Policy, Planning, and Evaluation
U.S. Environmental Protection Agency

1987

BALTIMORE
INTEGRATED ENVIRONMENTAL MANAGEMENT PROJECT

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Preface

This report was prepared under the auspices of the Baltimore Integrated Environmental Management Project (IEMP). The Baltimore IEMP is a collaborative effort of the State of Maryland, Anne Arundel and Baltimore Counties, the City of Baltimore, and the Environmental Protection Agency. EPA initiated the project as part of its pursuit of new approaches to environmental management and policy. The purpose of the IEMP is to use an integrated approach to identify and assess environmental issues that concern managers, to set priorities for action among these issues, and to analyze effective approaches to managing them.

The Baltimore IEMP represents the second of four geoxgraphic projects that EPA initiated across the country. The Baltimore area was chosen, not because it has a significant toxics problem, but because EPA and local officials wanted to explore better ways to identify, assess, and manage the human health risks of environmental pollutants in the area. Other IEMPs include Philadelphia, Santa Clara County, and Denver.

The decision-making structure of the Baltimore IEMP consisted of two committees, which also served as the means for State and local participation: the Management Committee (MC) and the Technical Advisory Committee (TAC). The MC, with members representing Baltimore City, Baltimore County, Anne Arundel County, and the State, managed the IEMP and set its overall policy directions. The TAC, composed of technical managers from the City of Baltimore, the two counties, the State, as well as representatives from the Maryland Regional Planning Council and the academic community, recommended issues to study, advised the MC on the technical and scientific aspects of the project, and oversaw and commented on all EPA and consultant work. EPA provided administrative, technical, and analytical support.

The Baltimore IEMP examined five environmental issues: air toxics, Baltimore Harbor, indoor air pollution, lead-paint abatement, and potential contamination of groundwater from underground tanks. For further information on these reports or other IEMP studies, contact the Regulatory Integration Division, the Office of Policy Analysis (PM-220) in the Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, Washington, D.C. 20460.

ACKNOWLEDGMENTS

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NILFISK of America, Inc., and Clayton Associates: provided the HEPA vacuums

Mrs. Virginia Grant of the Kennedy Institute Trace Metals Labortory: analyzed the dust samples

St. Ambrose Housing Aid Center: made their properties available to the project

Neil Briggs, Executive Director of the Building Congress and Exchange: convened the planning panel

Sheryl James of the Maryland Department of Health and Mental Hygiene: helped collect household dust samples

Baltimore City Health Department and Terry Staudenmaier of the St. Ambrose Housing Aid Center: performed the XRF testing of paint

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EXECUTIVE SUMMARY

Children who live in older, deteriorated houses, painted when the use of lead-based paints was widespread, are particularly susceptible to lead poisoning. Traditional techniques of lead-paint removal (principally, propane torching, sanding and scraping, no repainting, and minimal cleanup) actually increase the levels of lead-dust in the environment. These techniques often increase children's exposure to and absorption of the hazardous lead-bearing particulates in household dust.

To counteract this problem, we initiated a project in which we demonstrated and evaluated alternatives to traditional techniques used in Baltimore City. These alternatives include using caustic chemicals; off-site dipping; high-effeciency, particle-accumulator vacuums; repainting; and sealing off floors and walls. Our data on household surface dust-lead levels suggest that these methods are more effective than both traditional methods and methods used by Baltimore City crews in 1984 (partial abatement by electrical heat gun, repainting, and cleanup with standard vacuums and wet scrubbing). (See Table ES-1.)

A significant conclusion of our work is that better abatements are not simply a matter of different tools and chemicals. Training of workers in the new practices and careful on-the-job supervision of workers by well-informed managers are equally important. Consequently, we strongly recommend efforts to inform contractors and workers in particular about the new abatement methods and the safety and health issues involved in lead-paint abatements. We feel that awareness of the reasons for new abatement practices is critical to effectively applying the new techniques. We encourage the development of trades-based clearing house of information on evolving abatement methods.

Also, while using alternative abatement methods can significantly reduce dust-lead levels, additional improvements, especially in the effectiveness of post abatement cleanup procedures, are necessary to reach our assumed target levels for a "lead-free" house.

Finally, research is still needed. In Part 1 of this document we make a number of recommendations concerning data and methods. We believe it is particularly important to establish a "scientifically defensible" basis for a "safe" level of household lead-dust. Such a level, coupled with an easy field method of measurement, would quicken testing of abatement practices.

We also estimated the following health benefits and avoided medical and other costs from using improved abatement techniques:

- Better abatements could reduce the hospitalizations of children for chelation therapy[1] by an estimated 55 cases in Baltimore. This represents a 43 percent decrease in our baseline estimate of 128 annual hospitalizations.

- Use of better techniques in the projected 350 annual abatements could reduce nonhospitalized treatment for lead poisoning for up to 572 children currently living in those houses and for a range of 700-2,100 children who may be living in those houses in the future.

- Better abatement techniques could avoid the need for an estimated three years of special education for 50 current child residents and 105-315 future child residents in 350 annually abated houses.

- Better abatements could result in 84 fewer cases of elevated erythrocyte protoporphyrin (EP),[2] 70 fewer cases of anemia, 93 fewer cases of kidney dysfunction, and 35 fewer cases of decreased hearing ability among children currently living in abated houses. These are recurring benefits for these children.

- Better abatements should reduce damage to children's mental and physical development and should reduce prenatal impacts.

- For adult men, 350 better abatements result in 7 fewer cases of hypertension, 11 fewer cases of reproductive effects, 17 fewer cases of neurological problems, and 28 fewer cases of elevated EP. These are recurring benefits.

- For adult women, these better abatements result in 17 fewer cases of neurological problems and 46 fewer cases of elevated EP. These also are recurring benefits.

- Overall, for those health benefits where we were able to provide a dollar value (avoided medical, educational, and other costs), we estimate a range of total present and future benefits of \$3.6-\$6.5 million from 350 better abatements.[3] Net benefits (benefits

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1 Chelation therapy is a treatment to remove lead from blood.

2 Elevated EP signifies the disruption of normal synthesis of hemoglobin. See Part 2, page 5.

3 Present value analysis assumes a 20-year time period and a 3 percent discount rate. Values given are in 1987 dollars.

less the higher cost of better abatements) range from $2.2 million to $5.1 million. Our calculation of the dollar benefits assumed better abatements cost an average of $5,000 ($4,000 more than a traditional abatement). Given the range of total benefits, our sensitivity analysis indicates that the average cost of better abatements could range from $10,000 to $18,000 (two to three times higher than we assumed) and still provide positive benefits. (See Part 2, Chapter 10 for sensitivity analysis).

Tables ES-2 and ES-3 summarize those health benefits and avoided costs for which we are able to provide quantitative estimates.

Our estimates do not include all health effects. For example, the National Health and Nutrition Examination Survey (1976-80) provided data showing significant relationships between blood-lead levels and children's development in speaking, walking, height, weight, and chest circumference. Other studies have suggested positive relationships between maternal and fetal blood-lead levels and adverse aspects of fetal development. We are unable to provide any quantified estimate of the number of these avoidable adverse health effects, or to estimate other physical and mental effects, such as the pain associated with chelation therapy or family concern. Also, our estimates for adults most likely are greatly underestimated due to a general lack of data for them. For example, it is only for adult males aged 45-59 that we can find data on high blood pressure health effects. Thus, our estimates do not include all adult males.

Our estimates of dollar benefits are likely underestimates. Medical costs are considered to be the lower bound of the true costs of an illness, since they do not reflect the cost of lost wages or other opportunity costs that are not easily monetized. Studies indicate that individuals are often willing to pay two (or more) times the actual cost of medical treatment in order to avoid adverse health effects. To the extent that this rule of thumb applies, our estimate of $1.6-$2.2 million in avoided medical costs may be projected to $3.2 million or more. In addition, we of course have not calculated any avoided costs for health effects, we are unable to quantify (e.g. delays in development, paint and suffering.

Who really pays for the cost when only traditional abatements are done? The physical health costs are borne by the patient and family, who typically are in a low-income group. As a result, neither they nor an insurer pays the cost of medical treatment. The public, in the Maryland Medical Assistance Program, bears the financial cost of care for the vast majority of children treated for lead poisoning in Baltimore. Similarly, the public school system bears the cost of compensatory education for such children. Thus the critical economic finding of this study emerges from consideration of the distribution of the costs of the problem. The public pays the costs of increased lead exposure from traditional abatements.

While better abatement techniques can result in net benefits to society, it does not necessarily follow that the all segments of the population will share these benefits. In the case of landlord-owned housing, the costs and benefits fall to different individuals or groups of individuals. The benefits of better abatements fall to the children, their families, and the taxpayers, while the cost are borne by the landlords. In this case--a common situation in Baltimore City--the landlord has no preexisting economic incentive to perform better abatements. Some public enforcement mechanisms, such as regulations, will be required to motivate the landlord to incur the costs of better abatements if society chooses to reap the benefits.

On July 1, 1987, the City of Baltimore promulgated lead-abatement regulations that incorporate many of the features of our better abatements. The findings of this project provide additional justification for those regulatory changes. While the regulations proscribe the use of traditional methods of abatement, they require abatement only after identification of a lead-poisoned child. Thus, they may reduce the incidence caused by the previously permitted traditional abatements, but will not eliminate cases of lead-poisoned children.

[NOTE. This report is in two parts: Part 1 presents the results of pilot demonstration of alternative methods for abatement a lead paint. Part 2 presents the benefit-cost analysis of these aternative methods.]

TABLE ES-1

Mean Household Dust-Lead Levels After Abatement and Final Cleanup by Traditional Methods, by Alternative Methods by City Crews in 1984, and by our Experimental Methods

(micrograms per square foot)

Surface	Traditional Abatement*	Alternative Abatement	Our Experimental Abatements range **
Floors	4,750	895	37 - 558
Window Sills	11,410	730	107 - 3,649
Window Wells	31,550	27,360	100 - 8,368

* Values are mean post-abatement and post-cleanup PbD levels across 53 homes abated by traditional methods (propane torch and/or sanding, minimal cleanup, no repainting) and 18 homes abated by city crews in 1984 using alternative methods (heat gun, cleanup by standard vacuums and wet scrubbing, and repainting).

** Values are the ranges of arithmetic mean PbD values found in each of our 4 experimental abatement homes after final cleanup.

Table ES-2

Estimated Health Benefits Resulting from 350 Homes Abated with Better Techniques

Estimated Health Benefits*
(case avoided)

Health Effects		Current Children	Future Children
Hospitalizations		55	(a)
Nonhospitalizations		572	700-2100
Compensatory Education		50	105-315
Elevated EP	(b)	84	(a)
Anemia	(b)	70	(a)
Renal effects	(b)	91	(a)
Hearing loss	(b)	35	(a)

Health Effects		Current Adults	Future Adults
Blood pressure	(b)	7	(a)
Reproductive effects	(b)	11	(a)
Neurological effects	(b)	34	(a)
Elevated EP	(b)	74	(a)

* Note: Not all benefits could be quantified. See Part 2, Chapters 5-6 for discussion.

(a) We assumed none. Under alternate assumption, we would estimate same values as for "current." See Part 2, Chapter 9.

(b) These are annually recurring benefits for the affected individual.

Table ES-3

Estimated Avoided Medical and Other Costs Resulting from
350 Homes Abated with Better Techniques*
(1987 dollars)

Types of Costs	Immediate	Future	Total
Hospitalizations	$833,000	(a)	$833,000
Nonhospitalizations	$384,000	$360,000-$1,080,000	$744,000-$1,469,000
Compenatory Education	(b)	$1,813,000-$4,021,000	$1,831,000-$4,021,000
Hypertension	2,000		$ 33,000
Energy-Efficient Windows	12,000		$ 189,000

Estimated Benefits

Benefit/Cost Ratio: Approximately 2.6-4.7:1

Net Benefits: $2.2 - $5.1 million
(assumes 350 abatements at marginal cost of $4,000 per abatement.

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* Note. For those health effects we are able to quantify. Not all effects could be estimated nor could dollar values be assigned to all. These figures probably underestimate avoided costs.

(a) As before, all benefits of hospitalizations avoided are assumed to accure only to current child residents for whom they are one "one-time" benefits. See Part 2, Chapter 9, p. 4 for discussion.

(b) Although both current and future children avoid costs of compensatory education, we define these as future (in time) benefits (see Part 2, pp. 24 and 42).

INTRODUCTION

Integrated Environmental Management Projects

This study was conducted as part of the Baltimore Integrated Environmental Management Project (IEMP). The Environmental Protection Agency (EPA) initiated the project as part of its pursuit of new approaches to environmental management and policy. The purpose of the IEMP is to use an integrated approach to identify and assess environmental issues that concern managers, to set priorities for action among these issues, and to analyze effective approaches to managing them.

EPA adopted the concept of integrated environmental management as a potential solution to the shortcomings of traditional approaches to pollution control. The traditional approach of focusing on one pollutant or class of pollutants within each medium (e.g., air, water) at a time may result in environmental programs and regulations that do not use resources as efficiently as possible. Grounded in the concepts of risk assessment and risk management, the IEMP uses estimates of risk--that is, the probability of adverse effects--as common measures for comparing and setting priorities among environmental issues that involve different pollutants, sources of pollutants, and pathways of exposure to those pollutants that may affect human health, ecosystems, and resources. The need for setting priorities is prompted by the realization in the past ten years that hundreds of chemicals present in our environment pose some risk of causing cancer or other adverse health effects. Comparing the risks allows environmental managers to set priorities and focus limited resources in a manner that will achieve the greatest public benefit--the greatest reduction in risk for a given cost of control. The projects are also intended to involve all local responsible parties and agencies in managing and coordinating the projects, ensuring the issues of greatest local concern are adequately addressed.

The IEMPs are divided into two phases. In the first phase, project managers establish the decision-making structure of the projects, identify key environmental issues, and set priorities among them. Risk is just one of the criteria used in ranking issues; the others include analytical feasibility, relevance to EPA, State and local program objectives, and the potential for effective response. In the second phase, the IEMP studies the priority issues in greater detail and analyzes strategies for their control or resolution.

The Baltimore IEMP

The Baltimore IEMP is a cooperative effort involving the governments of the State of Maryland, the City of Baltimore, Baltimore and Anne Arundel Counties, and EPA. The Baltimore area was chosen because EPA and local officials wanted to explore better ways to identify, assess, and manage the human health risks of environmental pollutants in the area. It represents the second of four full-scale geographic projects that EPA has initiated to date across the country.

The Baltimore IEMP study area covers Baltimore City and Anne Arundel and Baltimore Counties. It extends from the Pennsylvania border on the north, to south of Washington, D.C., and borders on the Chesapeake Bay on the southeast. (See the map on the following page.)

The decision-making structure of the IEMP consisted of two committees, which also represented the vehicles for State and local participation: the Management Committee (MC) and the Technical Advisory Committee (TAC). The Management Committee, with members representing Baltimore City, Baltimore County, Anne Arundel County, and the State, managed the IEMP and set its overall policy directions. The Technical Advisory Committee, composed of technical managers from the City of Baltimore, the two counties, and the State, as well as representatives from the Maryland Regional Planning Council and the academic community, recommended issues to study, advised the MC on the technical and scientific aspects of the project, and oversaw and commented on all EPA and consultant work. EPA provided administrative, technical, and analytical support. In Phase II, work groups with members from both the TAC and MC and representatives from industry, public interest groups, government, and academia were organized around each priority issue. They provided specialized expertise in examining the issues.

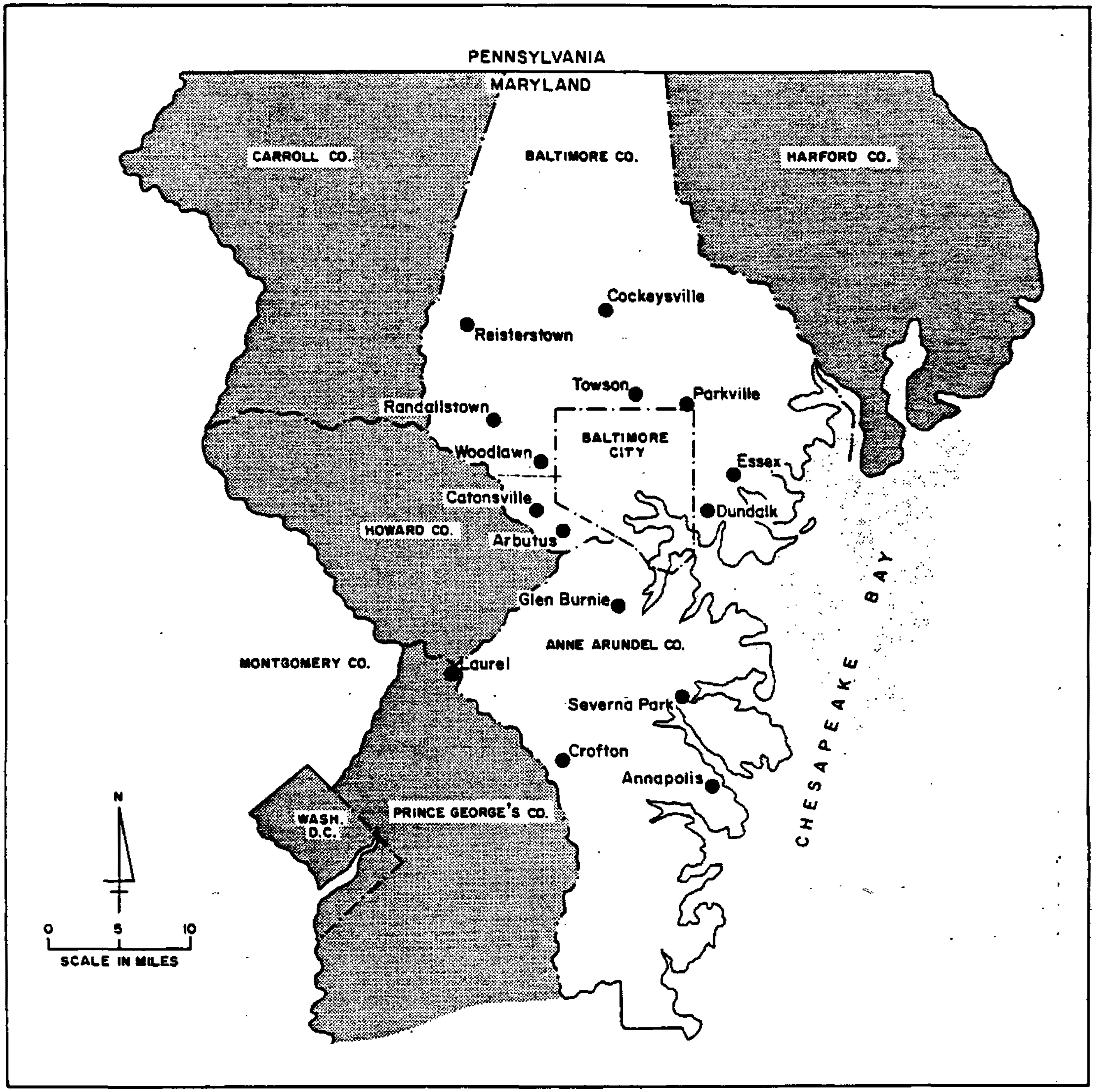
<u>Phase I: Setting Priorities</u>

The major task in Phase I was to identify environmental issues of concern in the study area and to set priorities among them for further study. The Baltimore IEMP set priorities on the basis of available information, supplemented by data from a brief ambient monitoring effort conducted by EPA. Chapter IV of the <u>Baltimore Integrated Environmental Management Project: Phase I Report</u> (May 1987) contains a detailed account of the priority-setting process.

First, the TAC members defined the geographic boundaries of the study. Second, they identified thirty-two potentially important environmental issues, drawing heavily upon their experience and knowledge. Third, they agreed on the use of three separate measures of environmental degradation to evaluate the severity or significance of the thirty-two issues. These measures--human health risk, ecological impact, and groundwater resource impact--also would define a set of three categories into which each of the thirty-two issues would be placed.

Five topics were chosen for further examination in Phase II of the Baltimore IEMP. (See the Phase I report for a description of the selection process.) They are:

BALTIMORE I.E.M.P. STUDY AREA



1. Multimedia metals. The goal was to develop cost-effective techniques for lead-paint removal and dust abatement in Baltimore homes.

2. Air toxics. The goal was to estimate ambient air concentrations of selected air toxics, analyze associated risks, and develop strategies for reducing these risks.

3. Baltimore Harbor. The goal was to define current and future uses of the harbor's waters and to identify actions, additional research, and institutional arrangements necessary to help environmental decision makers manage the harbor.

4. Underground storage tanks. The goal was to develop a strategy for identifying which groundwater resources are at greatest risk of being contaminated by leaks from underground tanks.

5. Indoor air pollution. The goal was to develop information necessary to support discussion of possible programs to reduce exposures to indoor air pollution and to support the expansion of local government capability to respond to inquiries concerning indoor air pollution.

In addition, a risk analysis conducted in Phase I on trihalomethanes, which result from the disinfection of drinking water through chlorination, was to provide a reference point for risks identified in the air toxics study.

Baltimore
Integrated Environmental Management Project

Phase II Report:

Reducing the Hazards from Abatement of Lead Paint

Part 1 -- Pilot Demonstration and Evaluation of Alternative Abatement Practices

Prepared by
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LEAD POISIONING: ITS EFFECTS AND ITS ABATEMENT

Lead Can Seriously Damage Children's Health

Lead poisoning of children is one of the most prevalent and insidious child health problems in the United States. The second National Health and Nutrition Examination Survey (1976-1980) estimated that 1 in 25 American children (approximately 680,000 children) and nearly 1 in 5 poor black urban children had toxic levels of lead in their bloodstreams (Annest et al., 1983). In 1985, the Centers for Disease Control changed the definition of the toxic level as a blood-lead concentration (PbB) greater than 30 micrograms per deciliter (mcg/dl) to a level of greater than 24 mcg/dl. Since then, a growing body of evidence suggests that the level of concern is a PbB between 10 and 15 mcg/d [2, 7, 17].

Since the mid-1970s, State and local health agencies have conducted mass screening programs to detect affected children before they develop severe lead poisoning. Currently, the vast majority of cases show no symptoms and have PbBs lower than 49 mcg/dl at the time of detection. (In Baltimore, children with levels greater than 49 mcg/dl generally receive chelation therapy.)[1]

Children are the segment of the population most susceptible to lead poisoning. They have more opportunities to ingest lead via the normal and repetitive hand-to-mouth activity of toddlers and preschoolers. Furthermore, children absorb ingested lead more efficiently than adults. Rapid neurological development places the fetus and the young infant at greatest risk of neurobehavioral effects [17].

All of lead's known effects are adverse. In children, lead produces a continuum of toxic effects over a range of exposures. Lead affects a number of bodily systems and the kidneys (EPA, 1986). Neurobehavioral effects in children cause the greatest concern, particularly since the effects can be severe (e.g., mental retardation) and irreversible.

In children, a blood-lead concentration of approximately 30 mcg/dl is the lowest observed level for IQ and learning deficits and for negative classroom behavior, such as shortened attention span and hyperactivity. At PbBs lower then 20 mcg/dl, lead is also associated with adverse effects on birth weight, gestational

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[1] Chelating agents are metal-binding agents. Chelation therapy increases the excretion of lead and thereby reduces to a certain extent the body's lead burden. At present, there is no agent that will remove all the lead from the body safely.

age, growth, and hearing acuity [17]. Findings from recent studies indicate that prenatal exposure to lead is associated with developmental deficits during the first two years of life (Bellinger et al., 1987; Dietrich et al., in press). Infants with an umbilical cord PbB equal to or higher than 10 mcg/dl scored lower on Bayley Scales of Infant Development than infants with PbBs lower than 4 mcg/dl.

The serious nature of the health effects of exposure to lead in paint, together with the data on its wide incidence, have led to the recognition of the tremendous annual social costs associated with lead toxicity in children. Provenzano (1980) estimated that the social costs of lead-induced health and intellectual deficits in this country were as high as one billion dollars (1978 dollars). His estimates of special education costs due to learning difficulties and mild mental retardation exceeded direct medical costs. Our benefit/cost analysis, described in volume 2 of a companion report to this study, reached a similar conclusion.

Most Child Exposure to Lead Occurs in Residences

The United States has made great progress in reducing some important sources of lead exposure (EPA, 1985). In the near future, lead is scheduled to be phased out entirely as a gasoline additive. The lead content of food has been reduced, particularly infant foods and formulas, by altering food packaging materials and containers. Water with a high lead content is now a localized and sporadic problem.

Currently, residential paint, household dust, and soil constitute the major sources of lead exposure in children. Residential paints are the most concentrated form of household-lead exposure. They can contain up to 40 to 60 percent lead by weight. Conservative estimates are that lead paint was used in 65 percent of the housing built before 1940, 32 percent of the housing built in the 1940s and 1950s, and 20 percent of the housing built between 1960 and 1975 (EPA, 1977). One study in Baltimore found that 98 percent of pre-1940 dwellings contained lead-based paint (Schucker, GW; Edward, H; Veil; EH; Kelly; EB; Kaplan, E; 1965 Public Health Reports vol. 80).

Traditional Lead Abatement Techniques Are Ineffective

Two recent studies have shown that traditional methods of abating lead paint hazards have not been effective in reducing children's blood-lead concentrations to acceptable levels. Indeed, they have often increased the absorption of lead. Chisolm et al. (1985) examined children who received chelation therapy between 1978 and 1982 and then returned to houses partly abated of lead hazards by traditional open-flame torching and sanding methods with minimal cleanup. They found that 40 percent of the cases (75 out of 184) had at least one recurrence of PbB in excess of 49 mcg/dl--well above the Centers for Disease Control's current acceptable level of 24 mcg/dl. First recurrences of PbB in excess of 49 mcg/dl occurred within three months of the children's discharge from the hospital. The study also indicated that the blood - lead concentrations of affected children commonly remained elevated for years unless they moved to completely "lead-free" housing.

A second study also in Baltimore (Farfel, 1987), compared the effectiveness of traditional abatement (propane torch and/or sanding to a height four feet above the floor, minimal cleanup, no repainting) to the alternative approach (electrical heat guns on surfaces up to four feet above floor level, repainting, thorough cleanup) used by Baltimore City work crews in 1984. The results (see Table 1) indicated that:

1. Traditional methods increase exposure to lead in household dust (typically 10- to 100-fold).

2. Alternative methods used by city crews represent modest improvement over traditional methods, although they do not adequately reduce blood-lead concentrations or the hazards associated with domestic exposure to lead particles.

3. More effective methods for removing residual particulates are necessary to reduce dust-lead to acceptable levels.

4. More extensive treatment of windows and floors is necessary.

Table 1: Mean Household Dust-Lead Levels After Abatement and Final Cleanup by Traditional Methods and by Alternative Methods by City Crews in 1984.

(micrograms per square foot)

Surface	Traditional Abatement*	Alternative Abatement*
Floors	4750	895
Window Sills	11,410	730
Windows	31,550	27,360

* Values are mean post-abatement and post cleanup PbD levels across 53 homes abated by traditional methods (propane torch and/or sanding, minimal cleanup, no repainting) and 18 homes abated by city crews in 1984 using alternative methods (heat gun, cleanup by standard vacuums and wet scrubbing, and repainting).

Source: Farfel 1987

At the request of the Kennedy Institute, the Building Congress and Exchange of Baltimore convened (Sept. 1986) a panel of experts in home building, building supplies, and renovation to assist in defining specific methods for abating the hazards of residential lead-paint. Dr. Farfel provided the panel with the following objectives based on an editorial in the American Journal of Public Health (Chisolm, 1986). A new approach to lead-paint abatement should:

- reduce both lead-paint and lead-dust hazards,
- not create or leave behind lead-bearing particulates,
- attain long-term human health protection from exposure,
- not be toxic, or use a flammable solvent,
- not involve heat or open flame, and
- be cost-realistic and cost-effective.

Although the panel did not identify techniques not already known to Dr. Farfel, it concluded that "... the technology and materials are available for the abatement of lead-paint and dust hazards by removal, by covering, and by enclosing." The panel also noted a lack of durable encapsulation products for lead-paint on wood trim surfaces.

In addition to the abatement objectives mentioned above, our pilot project emphasized:

- containment of lead debris created during abatement;
- use of high-efficiency particle accumulator (HEPA) vacuums as part of cleanup;
- proper disposal of lead debris;
- treatment of wood floors by sealing or covering;
- abatement of all components of windows;
- repainting of abated surfaces; and
- worker protection, training, and safety.

STUDY METHODOLOGY

This Project Demonstrated and Evaluated New Abatement Methods

As the initial step in the project, we demonstrated and evaluated experimental methods for abating lead-paint in four houses. Then to demonstrate the importance of cleanup procedures to reducing dust-lead levels, we evaluated better cleanups (decontaminations) of three houses that had already been abated by traditional open-flame burning and/or sanding methods. We collected dust and blood samples as measures.

Although there are federal standards for lead in drinking water, air, gasoline, and new residential paints, there are none for lead in dust or soil. (EPA is considering setting such standards (EPA Soil-Lead Abatement Demonstration Workshop, Research Triangle Park, NC, April 6-7, 1987).) Thus, to evaluate abatement methods, we selected a target range of lead in dust of less than 150 micrograms per square foot (mcg/dl ft). This range is approximately the range of dust-lead levels reported (1) in a small sample of 11 modern and renovated homes in Baltimore (Farfel, 1987) and (2) in homes of children with blood-lead concentrations below the suspected range of concern (mean 10 mcg/dl). Clark et al. (1985) reported a mean household dust-lead level of 19 mcg/sq ft. We recognize that the choice of the target range is critical to evaluation of our methods; moreover, we acknowledge that more research needs to be conducted to determine what "acceptable" dust-lead levels are.

Trained inspection personnel from the Baltimore City Health Department and the St. Ambrose Housing Aid Center tested the lead content of paint in candidate study homes using portable x-ray fluorescence equipment. We measured the levels of lead in the household dust of the demonstration homes at the following intervals: immediately before and after abatement, after the cleanup, and one month and three months after abatement. We also periodically monitored levels of lead in the household dust of the comparison homes throughout the study period (10/86 through 9/87). We performed the one-month and three-month post-abatement monitoring to determine the rate of reaccumulation of dust-lead and whether the new occupants could maintain household dust-lead at low levels. We measured blood-lead levels of the workers as a check on their safety while using our experimental procedures. The Maryland Occupational Safety and Health Administration monitored airborne lead to determine the rate at which our experimental methods produced airborne lead particulates and the need for respirator protection (see Appendices C & D). One month after they returned to their decontaminated homes, we also monitored the blood-lead levels of the children who received chelation therapy.

The Baltimore County Department of Public Works and the Kennedy Institute's Trace Metals Laboratory (TML) analyzed the lead content of waste water, and the laboratory developed a treatment for waste water to reduce its lead content (see Appendix E). The TML also analyzed workers' blood-lead levels before and during the project.

We First Demonstrated Experimental Methods of Abatement in Four Houses

During the fall of 1986, we obtained the assistance of the St. Ambrose Housing Aid Center, a nonprofit organization, in selecting potential study dwellings. We selected three vacant dwellings and one occupied dwelling, all with identified lead-dust hazards. St. Ambrose had already scheduled the three vacant dwellings for renovation followed by reoccupation. St. Ambrose agreed to permit us to try our experimental methods of lead-paint abatement before the renovation work itself. The renovation included lead hazard removal and encapsulation measures that were of interest, including:

- new drywall coverings,
- new tile floor coverings in kitchens and bathrooms,
- repainting of all abated surfaces,
- coating of wooden floors with polyurethane or deck enamel, and
- replacement of some windows with vinyl units.

The typical dwelling was a two-story six-room row house in substandard condition. We define "substandard" housing as poorly maintained, structurally sound housing with some code violations, and maintainable without major renovation. We excluded grossly substandard dwellings (i.e., structurally unsound) for safety reasons and because they are unabatable without major renovation.

We chose substandard row housing for the following reasons: (1) much of the housing stock in Baltimore City consists of substandard row houses, and (2) one recent study in Baltimore (Farfel, 1987) suggests that children identified with lead poisoning often live in substandard housing. Furthermore, for abatements we selected vacant dwellings that had lead-based paint on multiple surfaces. To determine if abatement was feasible in a furnished home, we abated one occupied dwelling while the family was temporarily relocated. We removed all lead-based paint on surfaces that gave positive X-ray fluorescence (XRF) readings (greater than 0.6 milligrams per square centimeter).

For comparison purposes we measured dust-lead levels in two substandard older housing units (i.e., conditions similar to our demonstration dwellings) and two older dwellings that had already been renovated in the same neighborhood as our four experimental abatements.

After explaining the study procedures, we obtained written permission for dust sampling from families in comparison (nonabated) dwellings and decontaminated dwellings, and from families that moved into experimentally abated dwellings after deleading and renovation. Our consent forms were approved by a review committee at the Johns Hopkins Hospital.

The Baltimore Jobs in Energy Project (BJIEP) performed most of the lead abatement work for St. Ambrose. We provided BJIEP workers with a half-day training session on Maryland's regulation regarding lead exposure in construction (MOSH, 1984), the health effects of lead, and worker protection. BJIEP provided workers with protective equipment, including properly fitting respirators, goggles, face shields, protective suits, gloves, and boots.

Recognizing that a single abatement method may not be adequate or effective for all housing conditions and types of surfaces in this project, we used a mix of the following methods for abatements:

- PEEL AWAY(R) - This is a caustic paste that is covered with a synthetic blanket and left to act overnight. The paste and blanket are removed and discarded, and the surfaces are washed. This paint removal system can be used on wood, metal (except aluminum), stone, brick, and flat and irregular surfaces.
- Off-site dipping - Wood trim, woodwork, and doors are removed from the house and transported to dipping plants. There they are stripped of paint in enclosed chemical tanks containing methylene chloride.
- HEPA sander - This is a power disk sander that attaches to a HEPA vacuum. The HEPA vacuum traps debris and is useful on flat surfaces only.
- Replacement - Wood trim and old windows are replaced with new materials.

Table 2 summarizes the abatement methods used in each study dwelling and the dates of work. (See Appendix A for a detailed description of work in each dwelling.) Table 3 lists the experimental treatments by surface type. In all cases, post-abatement cleanup consisted of vacuuming with a HEPA vacuum. In most cases, we combined HEPA vacuuming with wet washing with high-phosphate detergents.

Table 2: Abatement Methods by Dwelling

STUDY DWELLING	METHOD TESTED	DATES OF WORK	STATUS
1	Home-made caustic mix removed with high-pressure spray; off-site dipping of doors and mantle.	1/87 to 1/21/87	vacant
2	PEEL AWAY on wood trim interior and exterior; off-site dipping of doors and some sashes.	2/2/87 to 3/1/87	vacant
3	Off-site dipping of all easily removable trim; PEEL AWAY on openings - door and window jambs.	2/27/87 to 3/13/87	vacant
4	Off-site dipping of easily removable trim; PEEL AWAY on rest of woodwork; HEPA sander tested on door jambs.	5/24/87 to 6/12/87	furnished, family relocated

Table 3: Experimental Abatement Method by Type of Surface

Surface Type	Abatement Methods
Floors	Polyurethane paint Deck enamel Tile covering (vinyl)
Woodwork/trim	Off-site chemical dipping PEEL AWAY HEPA sander Replacement
Walls	Drywall after tearing out old party walls* (vinyl covering and fiberglass matting)
Window Components	Off-site dipping (trim and sashes) PEEL AWAY (trim, sashes, jambs) HEPA sander on jambs vinyl replacement units

* The Mayor's Task Force on Lead Poisoning (Baltimore) sponsored these treatments in August 1986 as part of a demonstration project.

We Decontaminated Three Residences Previously Abated by Traditional Methods

Using the following procedures, we decontaminated three traditionally abated homes of lead-poisoned children admitted for chelation therapy (PbB > 49 mcg/dl). We identified those children through the inpatient service of the Lead Poisoning Division of the Kennedy Institute. The following decontamination procedures were carried out by BJEIP and by a private contractor (Renovation Services, Inc.).

- vacuuming with a HEPA vacuum, followed by wet scrubbing;
- repainting all surfaces that had been burned or sanded as part of the prior abatement;
- coating wooden floor surfaces with polyurethane; and
- vacuuming all surfaces a second time with a HEPA vacuum, followed by wet scrubbing.

DATA COLLECTION AND MEASUREMENT

We Collected Dust and Blood Samples

No standard method for dust collection exists. The principal investigator and an industrial hygienist, employed by the Maryland Department of the Environment and supervised by the investigator, collected all samples.

Dust samples were collected from floors, window sills, and window wells by wiping the surfaces with an alcohol towelette. Window sill refers to the interior portion of the sill. Window well refers to the metal "trough" or wood surface between the window sill and the exterior ledge that receives the window sash when it is closed (See Figure 1).

We chose the wipe sampling technique for the following reasons:

- o The goal of abatement is to reduce the amount of lead available to a child on a given household surface. For purposes of evaluating abatement methods, measures of the amount of lead for each unit of surface area are preferred to measures of the concentration of lead in dust.

- o It is a practical means of collecting large numbers of samples at multiple sites. The alternative, a vacuum system, is cumbersome to set up and relocate.

- o The cost of analysis of wipe samples is low compared to the cost of analysis of vacuum filters.

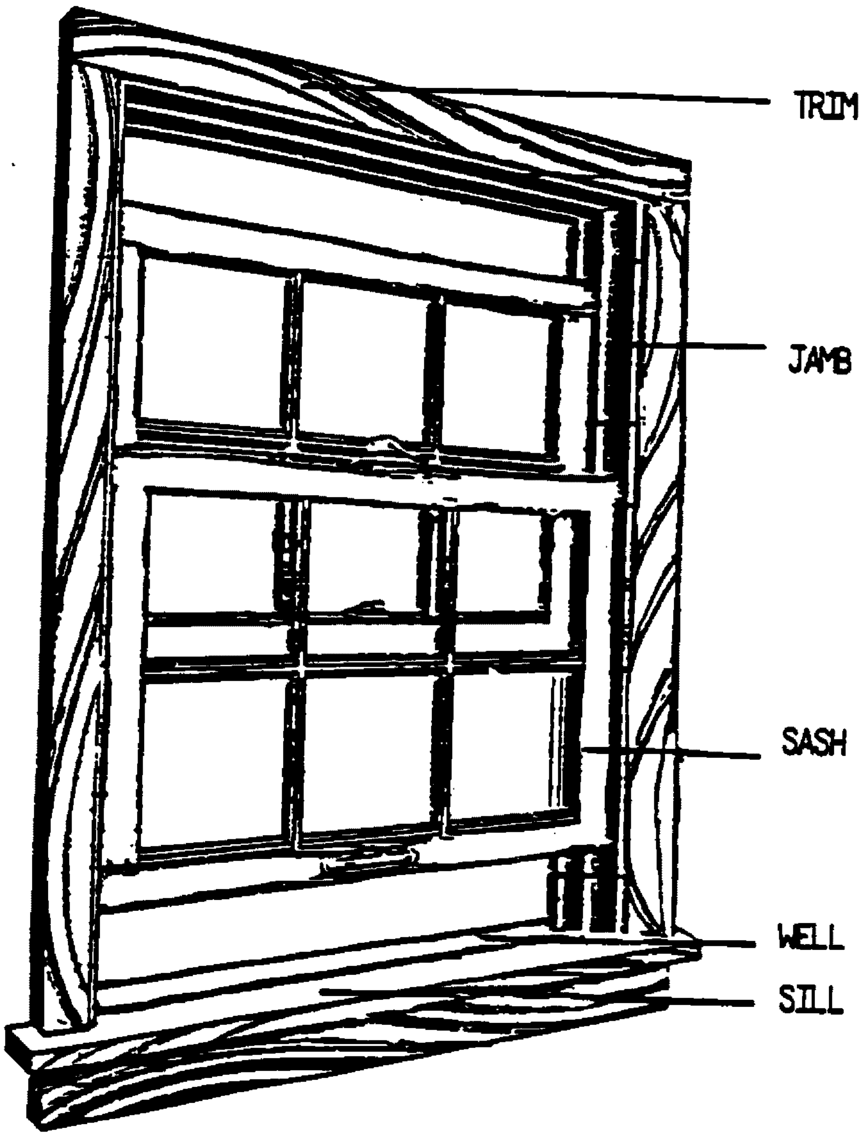
- o Vacuum samples are more efficient in collecting dust on uneven surfaces.

At each sampling period, we collected approximately 30 dust samples from each experimentally abated dwelling and approximately 15 samples from each comparison and decontaminated dwelling. For each dust sample, we noted the location, type of surface, surface material, surface area, and the abatement status of the site. We used a template to wipe one square foot of floor surface. Often, we collected visible particulate matter and loose chips of paint in samples from untreated window sills and window wells. We placed all samples in capped plastic tubes, and stored them in a cold room before analyzing them.

Lead clinic staff at the Kennedy Institute collected worker blood samples before, during, and after abatement and children's blood samples before and after decontamination. They collected the blood as macro samples (2 ml. of venous blood), using Abbott butterflies, polypropylene syringes, and stainless steel needles. They collected the blood in low-lead Vacutainer^{R} tubes.

FIGURE I:

ANATOMY OF A DOUBLE-HUNG WINDOW



As a Final Step We Measured Lead in Dust and Blood Samples

There is no standard method for analyzing lead in dust. The approach we used provided an estimate of the bioavailable lead in the sample (Vostal et al., 1974). (Bioavailable lead is lead in the gastrointestinal system that may be absorbed by action of gastric juices.) Used in previous studies (Farfel, 1987; Charney et al., 1983; Sayre et al., 1974), the method is less labor intensive and better suited for mass testing than the alternative approach. The alternative is to determine the total amount of lead in the sample by extraction with a concentrated acid (nitric, perchloric, and hydrochloric acids) at high temperature (Que Hee et al., 1985). Not all of the lead measured by the latter method of analysis would be considered bioavailable.

Briefly, we placed the wipe towelettes in tubes rinsed in acid, to which we added 30 ml of 0.1 N hydrochloric (HCl) for lead extraction at room temperature for at least 16 hours. We analyzed samples by flame atomic absorption spectrophotometry at the Kennedy Institute's Trace Metals Laboratory. Extraction with 0.1 N HCl simulates the acidity of gastric acid. Due to the nature of the extraction procedure (it is a proxy for what really happens), we probably underestimated bioavailable lead in this study, particularly in samples that contained quantities of visible paint chips and particulates and gross levels of lead (most often samples from window wells).

The Kennedy Institute's Trace Metals Laboratory (TML) measured blood-lead concentrations in duplicate by anodic stripping voltametry (Morrell and Gridhar, 1976).[2] We used the average of the two measurements in all calculations. The TML is a reference laboratory for the Centers of Disease Control, and it regularly participates in the Centers' proficiency testing program for blood tests.

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[2]Blood lead was measured in duplicate 100 microliter aliquotes of venous blood with an Environmental Science Associations, Inc., rapid blood-lead analyzer, ESP Model 3010A. This instrument was calibrated with spike porcine blood-lead standards prepard in the Trace Metals Laboratory and containing 3, 20, 40, 60, 80, and 97 micrograms per deciliter.

FINDINGS

Pre-Abatement Dust-Lead Levels for Houses Abated with Experimental Techniques Were Comparable to Levels Found in City Houses of Children with Elevated Blood-Lead Levels

Tables 4 through 7 display arithmetic mean household dust-lead (PbD) levels over time for experimental abatement dwellings 1 through 4 (see Appendix B for raw dust-lead data for each study dwelling). At pre-abatement, PbD levels were comparable to levels found in Baltimore City houses of children with evaluated blood-lead concentrations (Farfel, 1987). We found order-of-magnitude differences among PbD levels from floors, window sills, and window wells. Window wells had the highest PbD levels (typically greater than 10,000 mcg/sq ft). Furthermore, we found that pre-abatement PbD levels in our demonstration homes were well above levels found in: (1) two previously renovated older city homes in our comparison group (see Tables 9 and 10) and (2) a small sample of renovated homes, public housing units, and modern homes in the Baltimore area (Farfel, 1987). PbD levels in the latter types of housing were typically less than 150 mcg/sq ft.

Dust-Lead Levels Can Initially Increase During Experimental Abatements

We found that PbD levels can increase during abatement. In experimental dwellings 1, 2, and 4, dust-lead levels increased after the removal of lead paint, the plastic floor coverings, and the debris and before the painting of abated trim, the coating of floors, and the final cleanup. Mean floor levels increased by 3- to 8-fold, and mean sill levels increased by 2- to 10-fold. Window well PbD levels remained high at this point in the process. PbD levels at individual sites increased by as much as 100-fold or more.

At the same stage of abatement, PbD levels for the floors and sills in dwelling 3 remained essentially unchanged, and window well levels were reduced. This is because in that dwelling, workers did the best job of maintaining the plastic sheeting on the floors.

In This Study, Our Total Abatement Practices Generally Reduced Dust-Lead Levels Overall but Not Necessarily to the Target Range

Figure 2 is a skeleton graph for displaying changes in household PbD levels. Reference lines placed at 150 mcg/sq ft on both scales indicate our target range for dust values. Together with a line of no change (pre = post), these reference lines create the following zones for viewing pre- and post-abatement changes in house dust levels:

TABLE 4: HOUSEHOLD DUST LED LEVELS BEFORE AND AFTER ABATEMENTA BY "PEEL AWAY" AND BY OFF-SITE DIPPING AND HEPA SANDER a

Experimental Dwelling 1

ARITHMETIC MEAN

(micrograms/sq ft)

SITE (N) *	PRE ABATE	POST ABATE	POST PAINT & FLOOR TX**	POST CLEANUP***	1 MONTH POST	2 MONTHS POST
	10/31/86	1/21/87	3/30/87	4/7/87	5/22/87	8/1/87
FLOORS						
** = coated (12)	751	3,456	18	144	95	44
** = titled (3)	1,057	4,957	1,220	258	58	34
- no tx (1)	8,340	7,620	3,030	3,030	1,760	300
WINDOW SILLS (8)	6,304	-	2,100 (7)*	887	1,350	800
WINDOW WELLS						
Replaced with vinyl unit (3)	24,080	21,202	753	100	267	335
not replaced (2)	60,950	73,945 (1)	2,057	3,086	4,560	10,040 (1)

*(N) = (number of samples)
**TX = Treatment
***Cleanup: Wet cleaning with high phosphate detergent followed by HEPA vacuuming.

TABLE 5: HOUSEHOLD DUST LED LEVELS BEFORE AND AFTER ABATEMENTA BY "PEEL AWAY" AND BY OFF-SITE DIPPING AND HEPA SANDER a

Experimental Dwelling 2 a

ARITHMETIC MEAN a

(micrograms/sq ft) a

SITE (N) *	PRE ABATE	POST ABATE	POST PAINT & FLOOR TX**	POST CLEANUP***	1 MONTH POST	2 MONTHS POST
	10/31/86	2/26/87	5/7/87	5/11/87	6/12/87	8/14/87 e
FLOORS (17)						
TX = coated (14)	401	3,364	39	37	304 (12)*	62
** = titled (3)	675	3,010	425	41	36	36
WINDOW SILLS (9)	2,560	27,127	561	107	278 (7)	480 (8)
WINDOW WELLS (6)	35,675	35,077	2,352 (5)	577	3,276 (4)	6,555 (5)

*(N) = (number of samples)
**TX = treatment
*** Cleanup: Single cleaning with high phosphate detergent followed by HEPA vacuuming

TABLE 6: HOUSEHOLD DUST-LEAD LEVELS BEFORE AND AFTER ABATEMENT BY "PEEL AWAY" AND BY OFF-SITE DIPPING

Experimental Dwelling 3

(micrograms/sg ft)

SITE (N) *	PRE ABATE	POST ABATE	POST PAINT & FLOOR TX**	POST CLEANUP***	1 MONTH POST	3 MONTHS POST
	10/32/86	5/19/87	6/19/87	6/27/87		8/26/87
FLOORS						
TX = coasted (13)	522	857	31	473	-	188 (12)*
TX = tiled (2)	1,017	1,220	605	255	-	77
WINDOW SILLS (6)	4,577	-	554	616	-	298
WINDOW WELLS						
replaced with vinyl unit (3)	26,398	2,740	3,234	1,287	-	1,891
not replaced (2)	34,858	-	10,111	8,368	-	0,129

* (N) = (numnber of samples)
** TX = treatment
*** Cleanup: Single cleaning with high phosphate detergent followed by HEPA vacuuming.
**** We were unable to arrange home visit to collect dust.

TABLE 7: HOUSEHOLD DUST LEAD LEVELS BEFORE AND AFTER ABATEMENT BY "PEEL AWAY" AND BY OFF-SITE DIPPING AND HEPA SANDER

Experimental Dwelling 4

ARITHMETIC MEAN

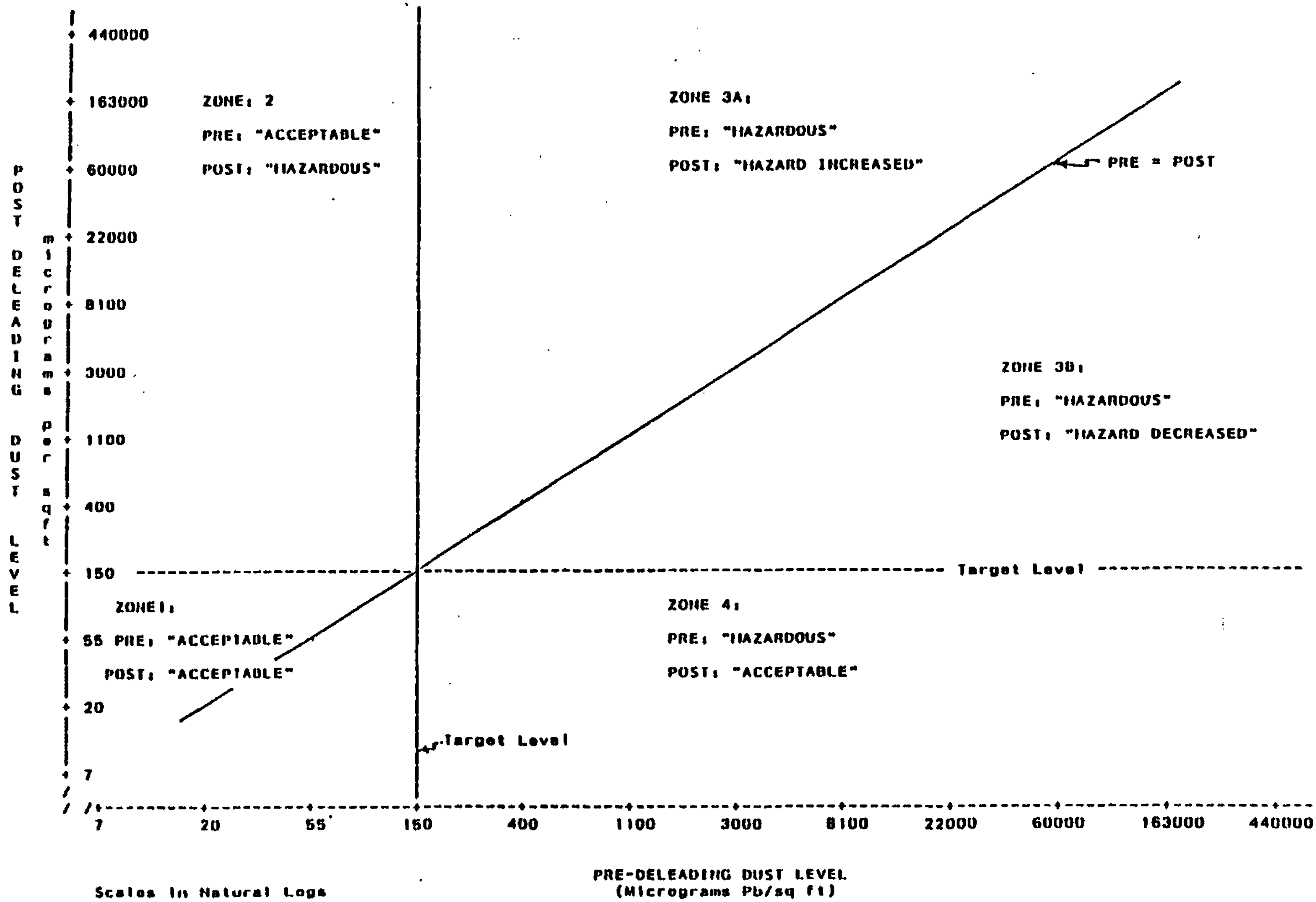
(micrograms/sq ft)

SITE (N)*	PRE ABATE	POST ABATE	POST PAINT & FLOOR TX**	POST Cleanup***	1 MONTH POST	3 MONTH POST
	5/15/87	6/12/87	6/16/87	7/6/87	8/8/87	10/4/87
FLOORS						
TX = coated (8)	938	3,319	470 (6)*	558	339	326
TX = tiles (1)	258	3,930	420	300	150	70
No TX (1)	4,320	60,700	3,457	13,800	5,730	3,690
WINDOW SILLS (7)	10,793	18,863	718 (5)	3,649	12,189 (1,396)[a]	5,185 (2,654)[c]
WINDOW WELLS						
abated and painted (7)	114,480	15,910	1,282(5)	3,593 (1,580)[b]	6,060	29,294 (6)
abated (1)	5,486	62,500	25,457	32,457	91,768	83,537[c]

*(N) = (number of samples)
**TX = treatment
***Cleanup: Single cleaning with phosphate detergent followed by HEPA vaccuming.

a. mean value after excluding 2 outliers (29,116 and 49,230)
b. mean value after excluding 1 outlier (15,672)
c. mean value after excluding 1 outlie (17,368)

FIGURE 2 SKELETON GRAPH FOR DISPLAYING CHANGES IN HOUSEHOLD DUST LEAD LEVELS



ZONE 1: PRE: Acceptable and POST: Acceptable (< 150 mcg/sq ft)

ZONE 2: PRE: Acceptable and POST: Hazardous (> 150 mcg/sq ft)

ZONE 3A: PRE: Hazardous and POST: Hazard increased

ZONE 3B: PRE: Hazardous and POST: Hazard decreased but still outside the target range

ZONE 4: PRE: Hazardous and POST: Acceptable

One important objective of an abatement is to have post-abatement, post-cleanup PbD levels in the target range (Zones 1 and 4). Figures 3 through 6 show pre-abatement to post-abatement post-cleanup changes in PbD by surface type (floor, window sill, and window well) for experimental dwellings 1 through 4.

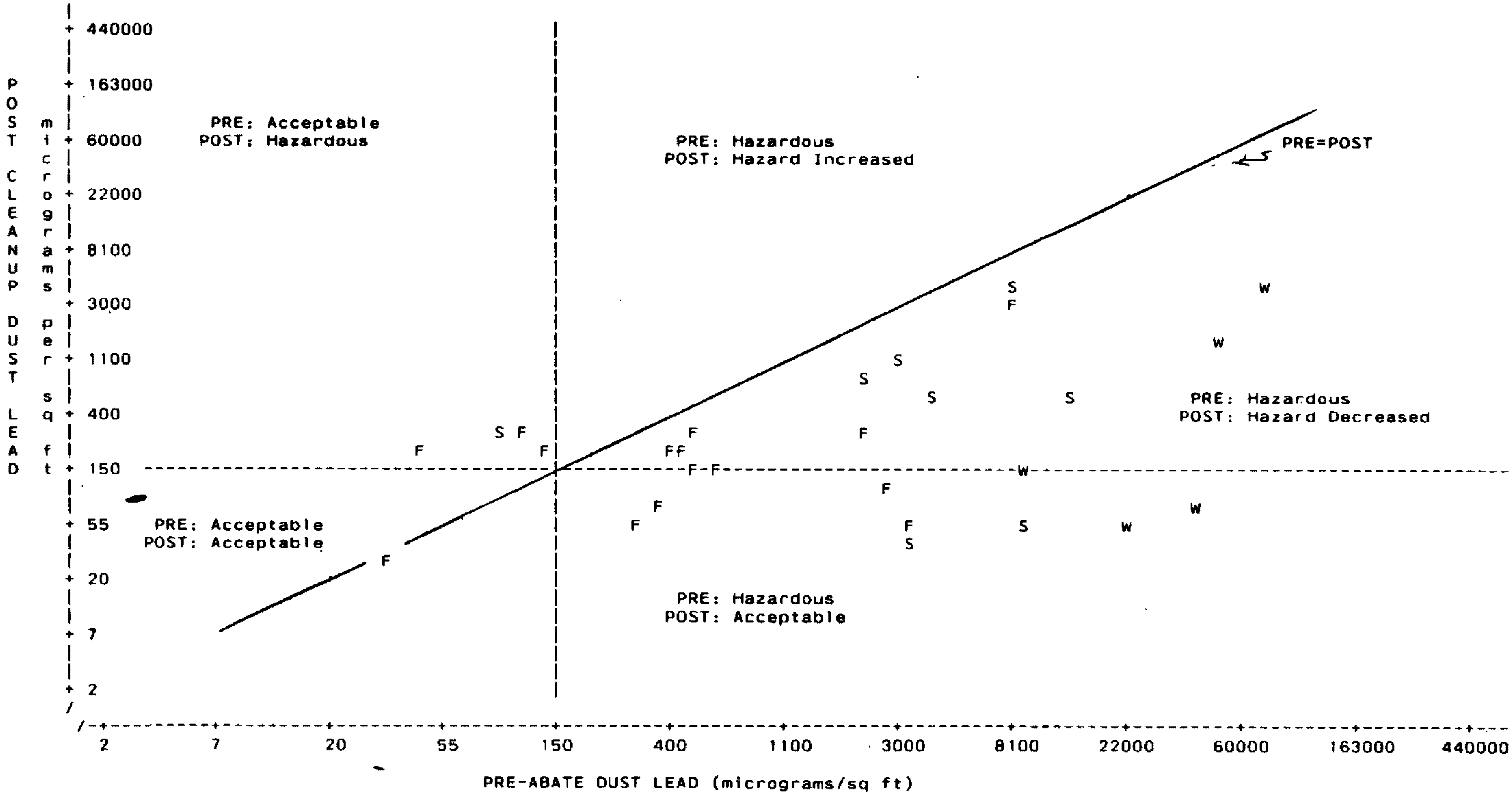
Before abatement in dwelling 1, the vast majority (24 out of 29) of sites had PbD levels outside the target range (greater than 150 mcg/sq ft). After abatement, repainting, floor treatments, and the final cleanup, nearly all sites (25 out of 29) had improved; nearly half (13 out of 29) of the sites were within the target range, and eight others (primarily floors) were just outside the target range. A single cleanup was not sufficient, however, because most of the window sills and two of the window wells did not have post-cleanup PbD levels within, or close to, the target range.

Abatement in dwelling 2 was more effective than abatement in dwelling 1. After abatement, repainting, and floor treatments, all sites had improved PbD levels, and nearly all floors were in the target range. Following the final cleanup and compared to pre-abatement levels, the number of sampling sites within the target range (less than 150 mcg/sq ft) increased from 4 to 26 (of 32 tested). Cleanup reduced PbD levels on floors, window sills, and window wells. The remaining six sites outside the target range after cleanup were primarily window wells that had large reductions in PbD. Repeated cleanup would have been necessary only on window surfaces.

Before abatement, all but one (25 out of 26) of the sampled sites in dwelling 3 had PbD levels outside the target range (greater than 150 mcg/sq ft). After abatement, repainting, and floor treatments and before the final cleanup, all coated floors (13 out of 13) were well within the target range, and all (6 out of 6) sills and wells (5 out of 5) had improved levels that remained outside the target range. Cleanup, however, was not effective. After cleanup, all floor levels increased to levels exceeding the target range, and sills and wells typically remained unchanged.

FIGURE 3: PRE TO POST ABATEMENT-POST CLEANUP CHANGE, IN HOUSEDUST LEAD LEVELS BY TYPE OF SURFACE

EPA PILOT STUDY: EXPERIMENTAL ABATEMENT DWELLING 1

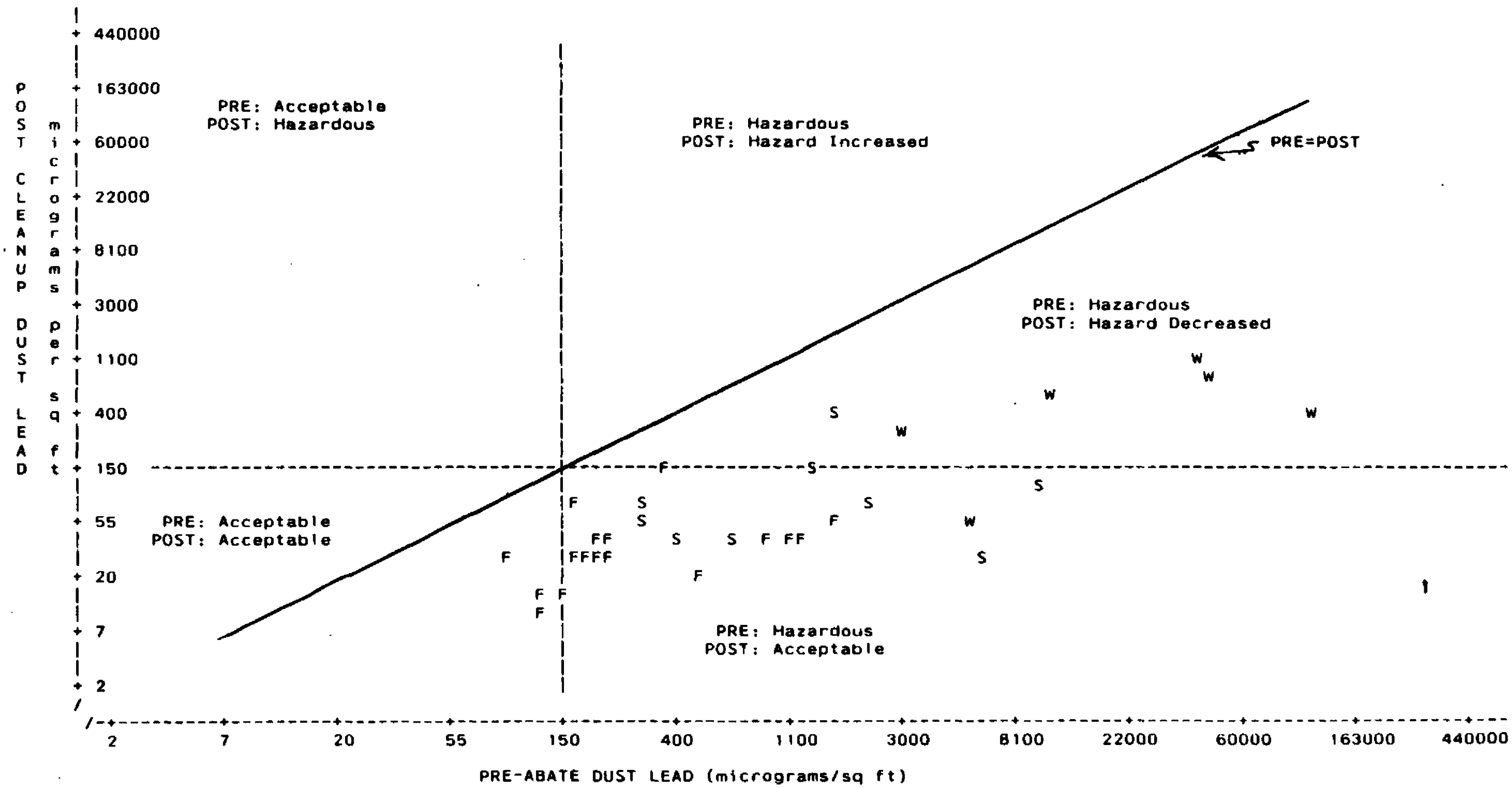


LEGEND: F=Floor S=Window sill W=Window well
Scale: natural logs
Note: 1 Obs hidden

Source: M. Farfel, Kennedy Institute 1987

FIGURE 4: PRE TO POST ABATEMENT & CLEANUP CHANGE IN HOUSEDUST LEAD LEVELS BY TYPE OF SURFACE

EPA PILOT STUDY: EXPERIMENTAL ABATEMENT DWELLING 2

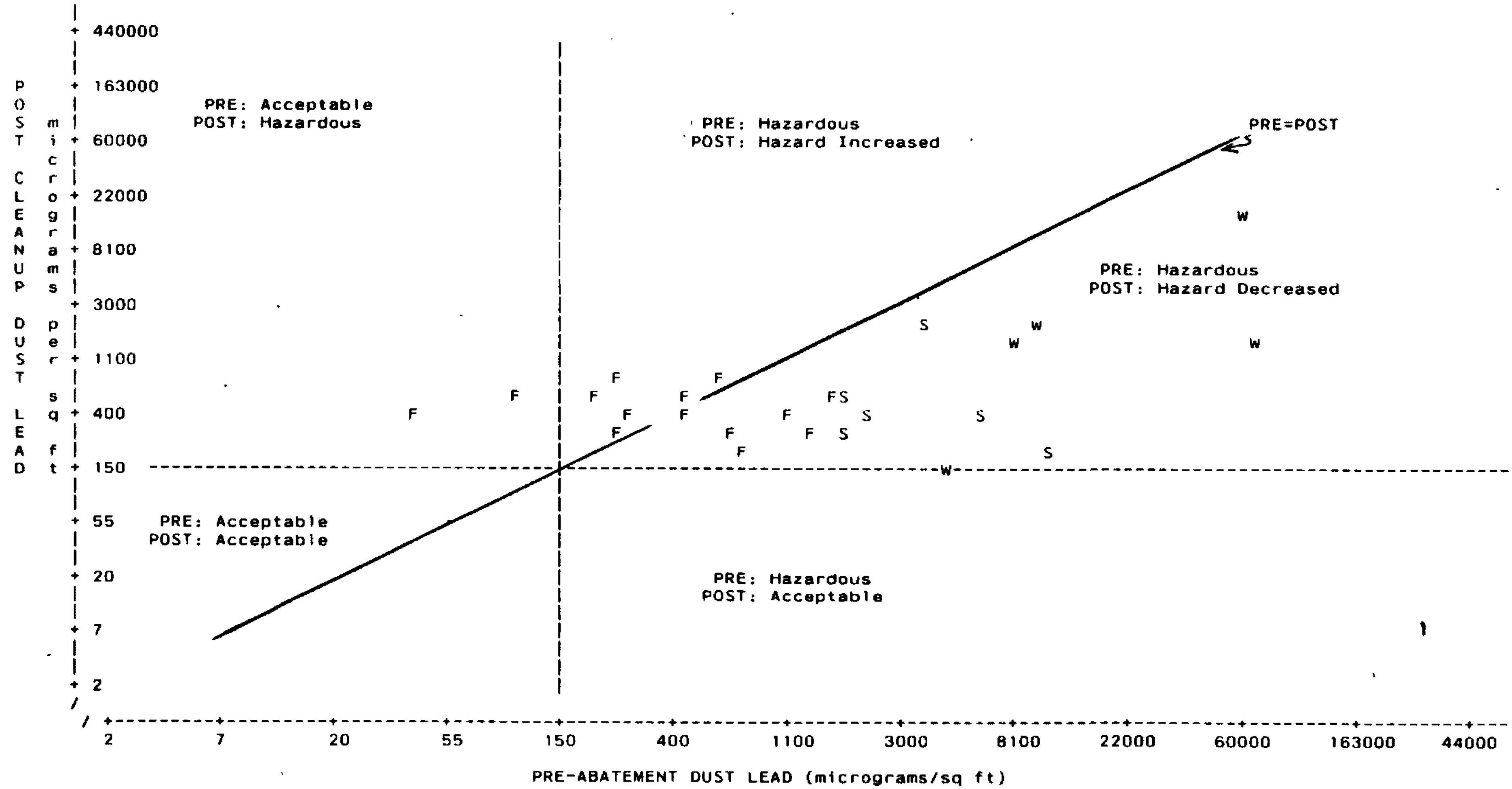


LEGEND: F=Floor S=Window sill W=Window well
Scale: Natural logs

Source: M. Farfel, Kennedy Institute, 1987

FIGURE 5: PRE TO POST ABATEMENT & CLEANUP CHANGE IN HOUSE DUST LEAD LEVELS BY TYPE OF SURFACE

EPA PILOT STUDY: EXPERIMENTAL ABATEMENT DWELLING 3

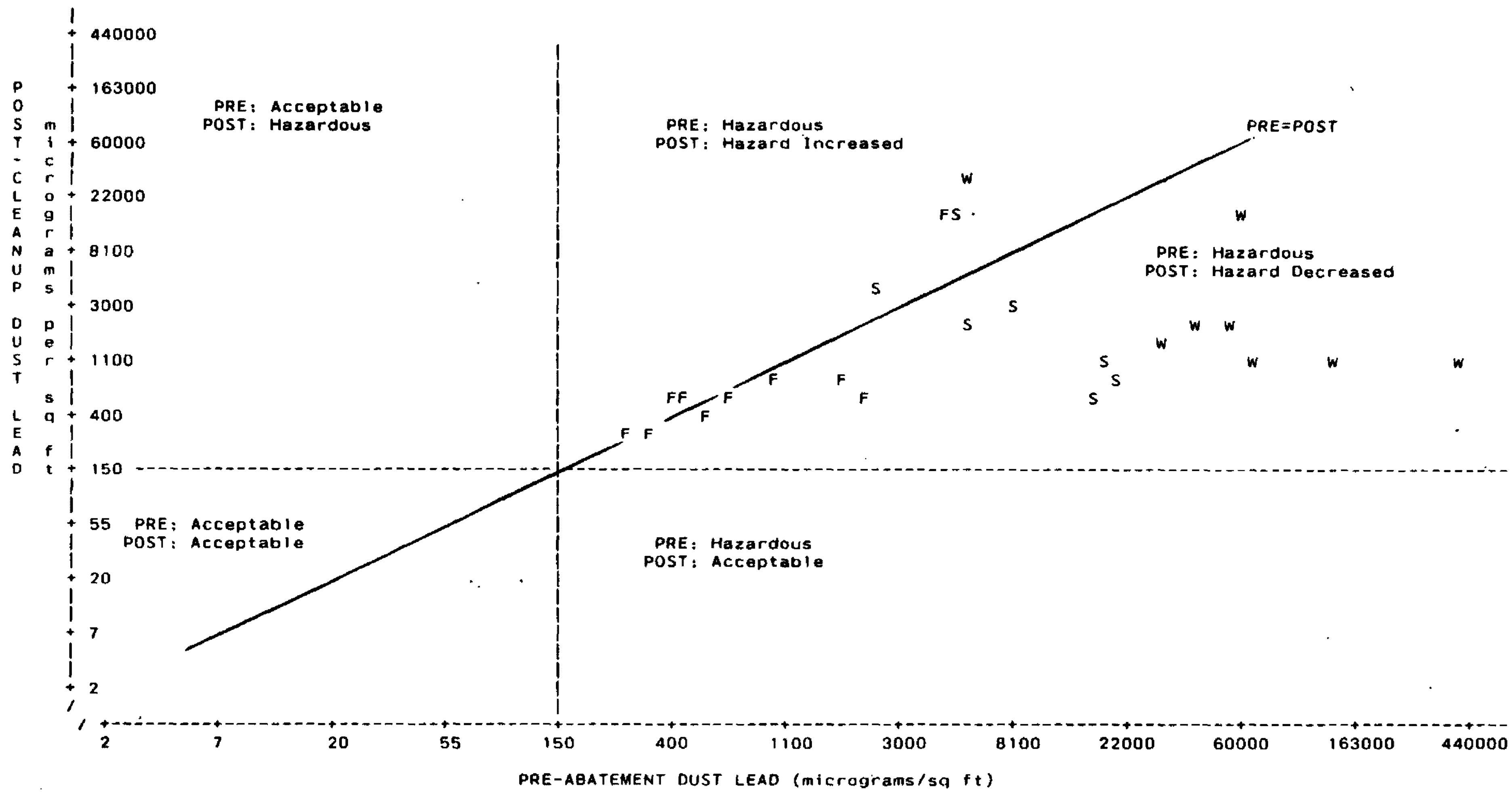


LEGEND: F=Floor S=Window sill W=Window well
Scales in Natural Logs

Source: M. Farfel, Kennedy Institute, 1987

FIGURE 6: PRE TO POST ABATEMENT & CLEANUP CHANGE IN HOUSE DUST LEAD LEVELS BY TYPE OF SURFACE

EPA PILOT STUDY: EXPERIMENTAL ABATEMENT DWELLING 4



LEGEND: F=Floor S=Window sill W=Window well
Scales in Natural Logs

Source: M. Fartel, Kennedy Institute, 1987

In dwelling 4, before abatement, all sampled sites (27 out of 27) had PbD levels outside the target range. After abatement, repainting, and floor treatments, all sites remained outside the PbD target range, despite substantial improvements in sill and well levels overall. Again, the final cleanup was not effective in reducing dust-lead levels, and some sites had increased levels.

In summary, prior to abatement nearly all household sites in our four experimental abatement dwellings had dust-lead levels outside the target range. During abatement, PbD levels tended to increase. After abatement, floor treatments, and repainting, dust-lead levels on floors, window sills, and window wells generally improved. Most floors were within the target range. The results after final cleanup, however, were inconsistent: sometimes PbD levels decreased, and sometimes they increased. A single cleanup with a HEPA vacuum and wet scrubbing was not sufficient for window sills and window wells.

Dust Levels at One and Three Months After Abatement Were Generally Lower Than Pre-Abatement Levels but Not Necessarily in the Target Range

Compared to post-cleanup levels, mean PbD levels on floors decreased or remained the same one and three months post-occupancy. Post-occupancy, treated floors (tiled or coated) in abatement homes 1 through 3 had mean PbD levels within or close to the target range. In abatement home 4, mean one- and three - month levels on treated floors were over 300 mcg/sq ft. However, we found that lead in dust tended to reaccumulate on window wells over time. On window sills, we found increasing, decreasing, and unchanging mean PbD levels over time after abatement and across the four abatement homes.

Dust-Lead Levels in Previously Renovated Comparison Group Dwellings Were Generally Within the Target Range

Tables 8 through 11 display PbD levels over time in comparison group dwellings (see Appendix B for raw data). Comparison dwellings 1 and 2 were renovated before this study. Both were occupied dwellings with new walls, vinyl replacement windows, and vinyl tile or linoleum floor coverings. We selected these houses to compare PbD levels in our demonstration houses with PbD levels in houses without lead-based paint that were in the same older housing neighborhood. Comparison dwellings 3 and 4 were occupied and fairly well maintained, but not previously renovated, older dwellings with original walls and windows and, for the most part, original wood flooring.

Unlike pre-abatement PbD levels in our substandard demonstration dwellings, mean PbD levels on floors and window sills in our two previously renovated comparison houses were within the target range (less than 150 mcg/sq ft) at the beginning of the study period. And although mean PbD levels on window wells were outside the traget range, they were an order of nagnitude less than the mean pre-abatement PbD levels on window wells in our demonstration

TABLE 8: HOUSEHOLD DUST-LEAD LEVELS OVER TIME

COMPARISON DWELLING 1

Completely Renovated Row Home
- New walls, floor coverings, windows

ARITHMETIC MEAN
(micrograms/sq ft)

SITE (N)*	WINTER Time 1	SPRING Time 2	SUMMER Time 3	FALL Time 4
	12/15/86	4/22/87	7/2/87	10/5/87
FLOORS (2) (tile)	7	13	13	3
WINDOW SILLS (4)	15	16	29	27 (3)*
WINDOW WELLS (4) vinyl replacement	1,058	927	614	517 (3)*

*(N) = (number of samples)

TABLE 9: HOUSEHOLD DUST-LEAD LEVELS OVER TIME

COMPARISON DWELLING 2

Previously Rehabilitated Row Home
- (renovated after house fire)

ARITHMETIC MEAN
(micrograms/sq ft)

SITE (N)*	WINTER Time 1	SPRING Time 2	SUMMER** Time 3	FALL Time 4
	12/5/86	4/20/87		10/5/87
FLOORS (3) (linolium & painted wood)	17	60	-	6
WINDOW SILLS (5) (new wood)	128	161	-	49
WINDOW WELLS (4) (vinyl replacement)	290	869	-	315 (n=3)

*(N) = (number of samples)
**We were unable to arrange home visit to collect dust.

TABLE 10: HOUSEHOLD DUST-LEAD LEVELS OVER TIME

COMPARISON DWELLING 3

Fairly well maintained older row home - original walls, nearly all windows and floors original wood

ARITHMETIC MEAN
(micrograms/sq ft)

SITE (N)*	WINTER Time 1	SPRING Time 2	SUMMER** Time 3	FALL Time 4
	11/19/86	4/20/87		9/24/87
FLOORS (6) (wood & linol)	126	103	-	92
WINDOW SILLS (4) (original and recently painted)	346	655	-	1,670
WINDOW WELLS				
vinyl (1)	745	528	-	345
original (2)	34,427	9,692	-	12,470

*(N) = number of samples
**We were unable to arrange home visit to collect dust.

TABLE 11: HOUSEHOLD DUST-LEAD LEVELS OVER TIME

COMPARISON DWELLING 4

Older row home
- original walls, nearly all windows and floors original wood

ARITHMETIC MEAN
(micrograms/sq ft)

SITE (N)*	WINTER Time 1	SPRING Time 2	SUMMER Time 3	FALL Time 4
	12/2/86	4/22/87	7/2/87	9/26/87
FLOORS				
linol, polyur or painted (5)	193	68	119	28
original wood (2)	2,543	927	630	153
WINDOW SILLS				
new wood (2)	466	20	192	118
original wood (5)	6,273	4,851	8,179	7,355
WINDOW WELLS				
vinyl (1)	1,146	1,422	1,015	615
new wood (2)	131	282	51	147
original wood (3)	90,925	57,850	94,137	58,529

*(N) = (number of samples)

dwellings. Furthermore, we found that mean PbD levels in these renovated houses remained constant at low levels, over a 10-month period. Mean floor, sill, and window well PbD levels in these homes had the following ranges: floors--6 to 60 mcg/sq ft; sills--15 to 161 mcg/sq ft; and wells--290 to 1,058 mcg/sq ft.

Comparison dwelling 3 is a fairly well-maintained older home with original walls, windows, and floors. Mean floor levels were in the target range across time. Mean sill PbD levels (range: #346 to 1670 mcg/sq ft) were lower than mean pre-abatement levels on sills in our demonstration dwellings (range: 2,560 to 10,793 mcg/sq ft). The original window wells had PbD levels similar to levels found in the demonstration dwellings.

We selected comparison dwelling 4 because it allowed for a comparison of PbD levels on new and original surfaces within the same dwelling. We found striking differences (typically 10- to 20-fold) in PbD values between replacement windows and original units and between original wood floors and floors that had been covered or coated. Mean PbD levels on original floor, sill, and window well surfaces over time were similar to pre-abatement PbD levels in our demonstration dwellings (i.e., similar to levels in homes of lead-poisoned children). However, mean PbD levels from covered or coated floors and replacement windows (sills and wells) were similar to levels found on corresponding surfaces in our previously renovated comparison homes.

We also have data suggesting that the construction of the window unit may influence PbD levels on window wells. We measured a 100-fold increase in PbD in going from the sills to window wells of vinyl replacement windows in renovated comparison dwellings 1 and 2. We did not find this difference with wooden replacement window units in comparison home 4. This suggests that certain types of vinyl replacement windows may trap exterior dust in the window well.

Air-Lead Levels Often Exceed Safe Levels

The State of Maryland requires monitoring of workers' blood-lead levels when their exposure to airborne lead exceeds 30 micrograms (mcg) per cubic meter per hour on average over an eight-hour day. Respirator protection is required at levels in excess of an average of 50 mcg per cubic meter per hour over an eight-hour day (MOSH, 1984).

In this project, we conducted limited air-lead monitoring to begin to establish a data base on worker exposure from various methods of abatement. We monitored the air during the removal of wood trim components for off-site dipping (see Appendix C). Some of the tests revealed levels in excess of 50 mcg per cubic meter per hour. However, these test results were unreliable because of dry sweeping that was done by one worker. (Dry sweeping should not be done before, during, or after lead paint abatement because of dry sweeping that was done by one worker. Dry sweeping should not

be done before, during, or after lead paint abatement because it can resuspend lead-bearing particulates in the air and expose workers to them unnecessarily.)

In a previous study, airborne lead levels were monitored during the application and removal of PEEL AWAY in one demonstration dwelling abated as part of the Mayor's Task Force on Lead Paint Poisoning (August 1986). The air-lead levels were found to be less than 10 mcg per cubic meter per hour. These findings suggest that respirator protection may not be necessary when abatement is performed using this caustic chemical system (see Appendix G). However, further air monitoring is warranted to confirm this finding.

We also performed air-lead monitoring during a demonstration of a disk sander that attaches to a HEPA filtering vacuum cleaner (see Appendix D). Again, some, but not all, of the tests indicated that air-lead exposure exceeded 50 mcg per cubic meter per hour.

Chemical Precipitation Greatly Reduces Lead in Waste Water

Waste water is generated during the PEEL AWAY process when abated surfaces are rinsed with water to remove lead-laden residue. We found that this waste water also had a high lead content (greater than 660 ppm) well in excess of the extraction process (EP) toxicity concentration of 5 ppm. EP toxicity is one of the criteria for determining whether a material must be handled as a hazardous waste under federal law (Resource Conservation and Recovery Act).

To reduce the lead concentrations below 5 ppm and pass the EP toxicity test, we precipitated the lead from the waste water using either sodium hydroxide or phosphoric acid (see Appendix E). After this chemical precipitation, the waste water had lead concentrations lower than 5 ppm and as low as less than 1 ppm. In order to prepare the water and precipitate for disposal, we had to carefully separate the water from the precipitate in a manner that prevents mixing.

Blood-Lead Levels in a Small Sample of Workers Did Not Exceed State Standards for Medical Removal from the Job

We obtained limited blood-lead (PbB) data from three workers performing the four abatements. Before starting this project, we tested the PbB levels of 13 Baltimore Jobs in Energy Project (BJIEP) workers employed in various construction tasks. The PbB distribution ranged from 14.5 mcg/dl to 38 mcg/dl.

BJIEP workers selected for abatement work had pre-project PbB concentrations of 15.5 to 20 mcg/dl, which were above the average U.S. adult level (less than 10 mcg/dl) [17]. None of the documented PbBs of the workers exceeded 22 mcg/dl during the project period (see Appendix F), and no worker required medical removal from the job, as specified in Maryland regulations (i.e., PbB of at least 40 or 50 mcg/dl, depending on PbB history (MOSH, 1984)).

Each Experimental Abatement Produced Valuable Information About Actual Abatement Practices

People abating the hazards of lead paint by propane torch or sanding methods can readily get clinical lead poisoning and have their blood-lead concentrations rise over 50 mcg/dl in a short period of time (personal communication, Dr. James Keogh). Previous experience with workers using electrical heat guns for abatement suggests that lead absorption can increase (Farfel, 1987). Mean blood-lead concentrations for 23 abatement workers and supervisors rose from 12.2 mcg/dl before any abatement work was performed to 21.9 mcg/dl approximately eight months later when the abatement project ended.

This section summarizes some of what we learned from each experimental abatement dwelling. Appendix A contains detailed descriptions of the processes and scope of work.

Experimental Abatement Dwelling 1

In this dwelling we tested a home-made caustic mix and high-pressure water spray as an abatement method for removing lead paint from all interior wood trim surfaces in a vacant dwelling. The method is routinely used to remove paint from exterior brick. In summary, we learned the following:

1. The method is not effective in one or two applications as a total abatement method for interior wood trim surfaces. Removal of three to six layers of paint was incomplete and spotty.

2. Caustic mix and two gallons of water from a medium-pressure spray is a successful and needed method for removing lead paint from radiators.

3. The basic principles of abatement (e.g., containment of debris, worker protection, floor coverings, and thorough cleanup) run counter to the training and work habits of construction workers. The development of an abatement team that puts the principles of abatement into practice is a process that takes time.

4. When abatement work is being done at the same time as renovation work, coordination with the other trades is important in ensuring that other workers are not exposed to lead and that abatement work can proceed unhampered.

5. On-site supervision is crucial to reinforcing the principles of abatement.

Experimental Abatement Dwelling 2

In this dwelling we tested a combination of off-site dipping and PEEL AWAY as an abatement method for removing lead paint from all interior and exterior wood trim surfaces in a vacant dwelling. We learned the following:

1. Considerable on-the-job training is required for workers and supervisors to learn to use the PEEL AWAY stripping system as a one-step abatement procedure. The procedure has multiple steps (application, removal and wash down, and pH adjustment), each of which must be performed correctly to achieve a successful abatement.

2. Off-site dipping, in addition to PEEL AWAY, was successful in removing lead paint. However, we detected residual lead-dust on the surface of dipped wood that needs to be removed by wet scrubbing. We also detected lead-laden residue surfaces abated by PEEL AWAY that need to be removed as part of the abatement process.

3. None of the glass in doors and windows broke, and few of the joints became unglued. Wood trim components can be removed, sent off site for chemical stripping in enclosed tanks, and returned with very little breakage.

Experimental Abatement Dwelling 3

In this dwelling we tried to remove lead paint more efficiently by having all easily removable trim from doors, baseboards, and windows dipped off site and by restricting PEEL AWAY to door and window jambs. We learned the following:

1. Having had some experience, the workers performed abatement more easily and with more attention to containment and floor coverings. (Post-abatement dust-lead levels were lowest among the four experimental dwellings.)

2. Cleanup was easier because plastic coverings were on the floors throughout the abatement process.

3. A single application of PEEL AWAY was successful for door and window jambs.

Experimental Abatement Dwelling 4

In this dwelling we removed lead paint from an occupied home using a combination of off-site stripping, PEEL AWAY, and a HEPA sander. The residents were temporarily relocated, and the furnishings remained in the home. Again the strategy was to maximize off-site dipping and restrict PEEL AWAY to sites where trim could not be easily removed. We learned the following:

1. Working in a furnished home hampers the abatement activities and cleanup.

2. In occupied dwellings, security concerns dictate the order in which the work is done. Window components (including sashes) and doors can be removed, stripped off site, and rehung in one day to avoid security problems in a furnished home.

3. The HEPA sander did remove lead paint from flat surfaces (e.g., door jambs). The unit requires an air compressor.

4. The ease of trim removal should be checked. Trim removal was hampered by large cut nails every six inches.

<u>Abatement Costs Decease With Experience</u>

Table 12 summarizes the labor and material costs for abatement by study dwelling. Costs in abatement dwelling 1 include the costs of using what turned out to be an unsuccessful method for interior wood trim (caustic mix and high-pressure spray) and then doing the abatement by off-site dipping. During abatement in dwelling 2, BJIEP workers learned how to use the PEEL AWAY system; labor costs reflect considerable on-the-job training. Dwelling 3 was the first to be abated with a crew that had at least some experience with the methods. Dwelling 4 was occupied and had the largest scope of work (see Appendix A).

Experimental abatements 1 through 3 were done in the context of a general renovation and upgrading of the property. Abatement 4 was not. The crew was somewhat experienced with the abatement techniques by the time they did abatement number 3. The cost of abatement 3 probably best reflects the additional costs of work required to completely remove the lead paint and dust, given all the other renovation work that was done. The owner of the dwelling was already planning to cover or coat all the floors, to replace some of the original windows, and to paint all the household surfaces. To conduct a complete abatement in the dwelling, we needed to remove all the interior and exterior lead paint on trim components and on windows that were not replaced. The total direct cost for this additional abatement work in this two-story row house was $2,759, exclusive of the cost to rehang, prime, and repaint the trim that was abated off site. The total direct cost for abatement 4, including the costs of floor treatments, rehanging trim, and priming and painting abated trim, was $5,810.

TABLE 12: ABATEMENT COST SUMMARY

	EXPERIMENTAL ABATEMENT DWELLING			
	1*	2*	3*	4**
Labor (a)	$1,889	$4,360***	$1,117	$2,100
Supplies and Protective Gear	440	1,217	659	1,100
Off-Site Dipping	732	268	788	1,800
Rental	325(b)	-	-	210(c)
PEEL AWAY	-	440	195	600
Total Direct Costs	$3386	$6285	$2759	$5810

* Totals do not include the costs of floor treatments, re-hanging trim and painting. These activities were done by the owner of the dwellings as part of a general upgrading of the dwellings.

** Totals include costs of floor treatments, re-hanging trim, and painting.

*** Labor costs are high because the abatement workers were learning how to use a new process - PEEL AWAY.

(a) labor costs averaged $9.00 per hour, including FICA and worker's compensation.

(b) rental of high pressure sprayer.

(c) rental of air compressor.

Many home renovation activities abate the hazards from lead lead paint either by replacing or by encapsulating the lead-painted areas (e.g., new replacement windows, floor coverings, and drywall). Thus, an abatement that is done as part of a renovation can be less costly than one that is not.

In Decontamination (Better Cleanup) of Three Traditionally Abated Houses, Target Levels Aren't Always Reached

Tables 13 through 15 display mean household dust-lead levels for three traditionally abated houses before and after we decontaminated them in May and June of 1987. The time period between the abatements and our decontaminations was two to three months. Figures 7 through 9 display plots of pre- to post-final cleanup changes in dust-lead levels.

Mean dust-lead levels two to three months after abatement by traditional methods and before our decontamination were similar to, or higher than, (1) levels previously found in homes of lead-poisoned children (Farfel, 1987) and (2) the mean pre-abatement levels in our demonstration dwellings. Indeed, children with blood-lead elevations and a history of chelation therapy lived in each of the three decontamination dwellings. At pre-decontamination, mean PbD levels had the following ranges: floors--380 to 4,024 mcg/sq ft; sills--4,869 to 34,138 mcg/sq ft; and window wells--6,091 to 156,065 mcg/sq ft.

Following the decontamination and painting and before the final cleanup, mean PbD levels on floors, sills, and window wells improved; however none of the mean values was in the target range. Findings from decontamination dwelling 2 indicate that the final cleanup was effective in reducing levels further; mean PbD values were within or close to the target (less than 150 mcg/sq ft). Findings from dwelling 3, however, indicate that the cleanup was not effective, and that mean PbD levels on floors, sills, and wells increased. In dwellings 1 and 3, mean post- cleanup levels were higher than the target range. In all cases, mean PbD values on treated floors were less than mean values on untreated floors. In dwelling 3, one worker reported that the wash water was not frequently changed and that wash water used on highly contaminated window wells was also used on the floors. This may account for the relatively high lead levels on floors after cleanup.

By one month after decontamination, mean PbD levels increased by less than a factor of 2 in two dwellings and decreased by more than half in the third dwelling. Mean PbD levels on window sills and window wells tended to increase during this period because only partial abatement (up to four feet from the floor) was performed in these substandard homes, and the remaining paint continued to deteriorate. Overall, however, PbD levels one month after our decontaminations were lower than levels found before decontamination.

TABLE 13: HOUSEHOLD DUST-LEAD LEVELS BEFORE AND AFTER DECONTAMINATION BY HEPA VACUUM AND WET CLEANING

In Dwelling Abated of Lead Paint by Traditional Methods

Decontamination Dwelling 1

ARITHMETIC MEAN
(micrograms/sq ft)

SITE (N)*	PRE DECON-TAMINATION	POST DECON-TAMINATION & PAINT***	POST FINAL CLEAN	ONE MONTH POST
	7/27/87		7/30/87	8/26/87
FLOORS				
TX** = coated (4)	380	-	940	199
no TX (4)	448	-	871	326
WINDOW SILLS (7)	34,138	-	486	1,359
WINDOW WELLS (2)	156,065	-	5,600	25,315

*(N) = (number of samples)
**TX = treatment
***We were unable to arrange home visit to collect dust.

TABLE 14: HOUSEHOLD DUST-LEAD LEVELS BEFORE AND AFTER DECONTAMINATION BY HEPA VACUUM AND WET CLEANING

In Dwelling Abated Of Lead Paint By Traditional Methods

Decontamination Dwelling 2

ARITHMETIC MEAN (micrograms/sq ft)

SITE (N)*		PRE DECON-TAMINATION	POST DECON-TAMINATION & PAINT	POST FINAL CLEAN	ONE MONTH POST --
		7/29/87	8/20/87	8/26/87	9/26/87
FLOORS					
TX* = coated	(5)	3,648	254	136	162
no TX	(1)	1,620	510	210	330
WINDOW SILLS (4)		4,869	332	44	641
WINDOW WELLS (5)		6,091	690	2,507 (185)[a]	2,376

*(N) = (number of samples)
**TX = treatment
a. mean value excluding 1 outlier (11,798)

TABLE 15: HOUSEDUST LEAD LEVELS BEFORE AND AFTER DECONTAMINATION BY HEPA VACUUM AND WET CLEANING

In Dwelling Abated Of Lead Paint By Traditional Methods

Decontamination Dwelling 3

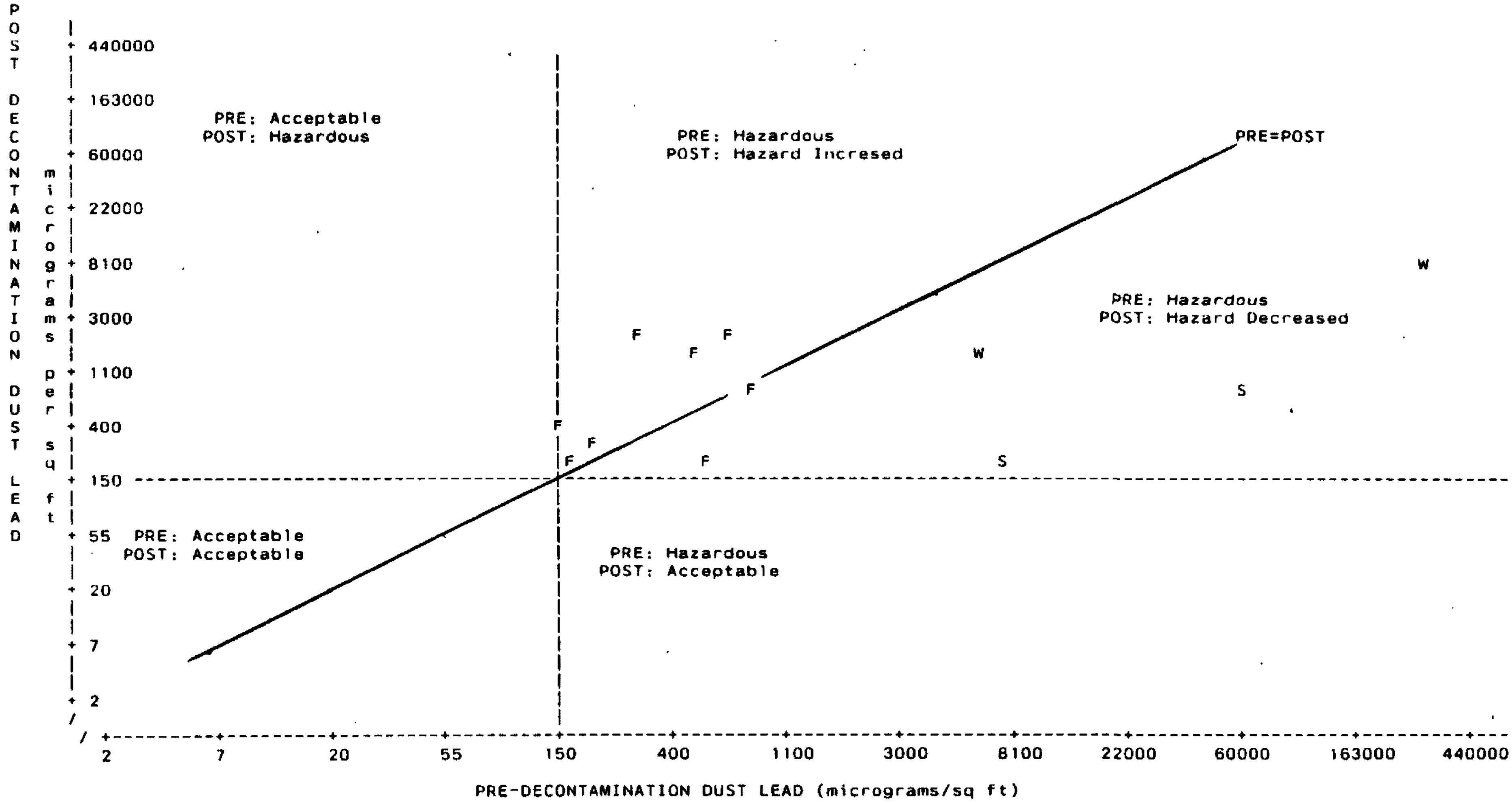
ARITHMETIC MEAN
(micrograms/sq ft)

SITE (N)*	PRE DECON-TAMINATION	POST DECON-TAMINATION & PAINT	POST FINAL CLEAN	ONE MONTH POST
7/27/87	8/20/87	8/27/87	10/4/87	
FLOORS (7)	4024	256**	513	822
WINDOW SILLS (6)	30,972	185	210	2850 (590)[a]
WINDOW WELLS (2)	72,338	4210	8079	25,032

*(N) (number of samples)
** all coated with polyurethane
a. mean value excluding 1 outlier (13,148)

FIGURE 7: PRE TO POST DECONTAMINATION & CLEANUP CHANGE IN HOUSE DUST LEAD LEVELS BY TYPE OF SURFACE

EPA PILOT STUDY: DECONTAMINATION DWELLING 1

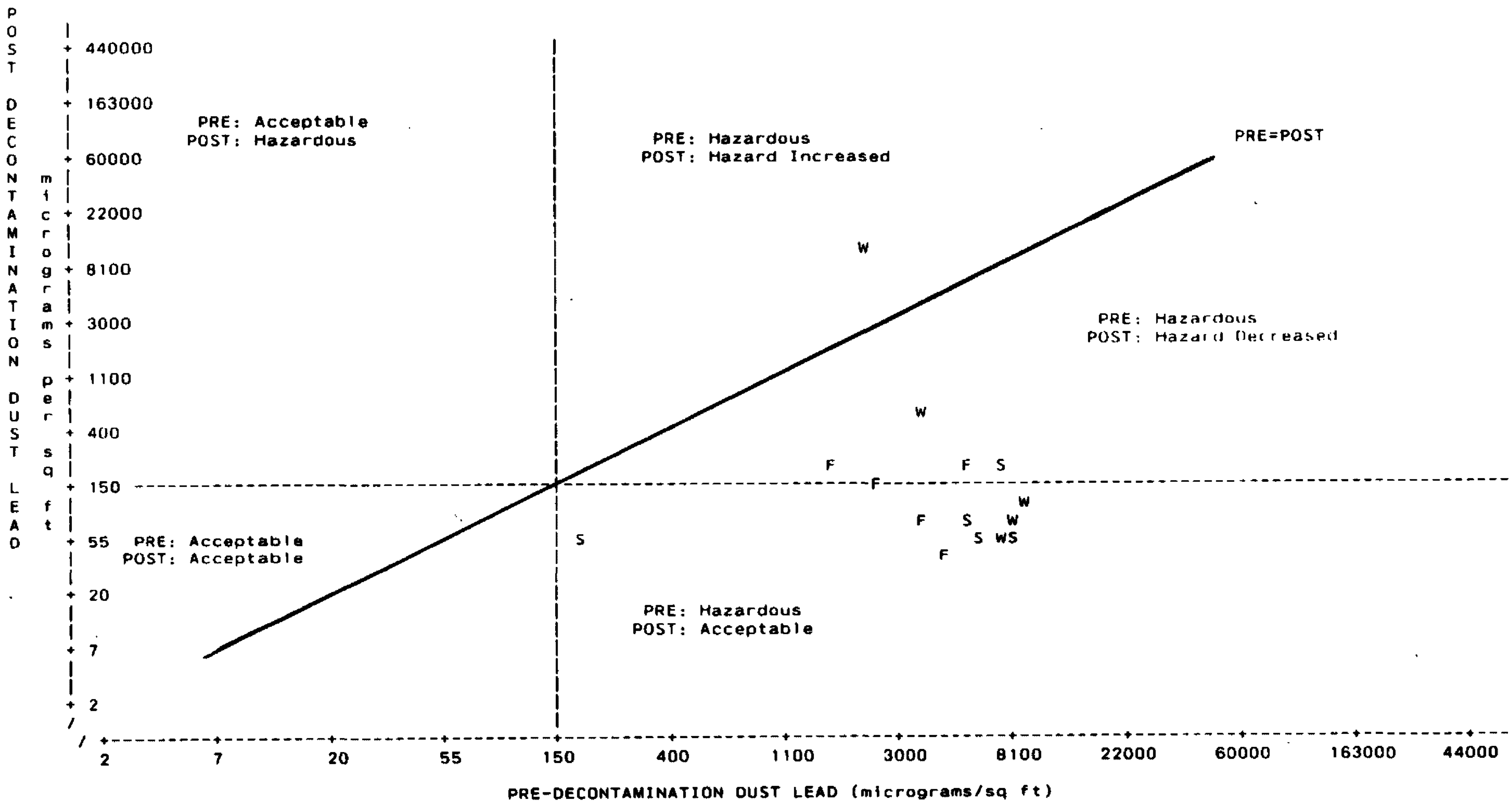


LEGEND: F=Floor S=Window sill W=Window well
Scales in Natural Logs

Source: M. Farfel, Kennedy Institute, 1987

FIGURE 8: PRE TO POST DECONTAMINATION & CLEANUP CHANGE IN HOUSE DUST LEAD BY TYPE OF SURFACE

EPA PILOT STUDY: DECONTAMINATION DWELLING 2

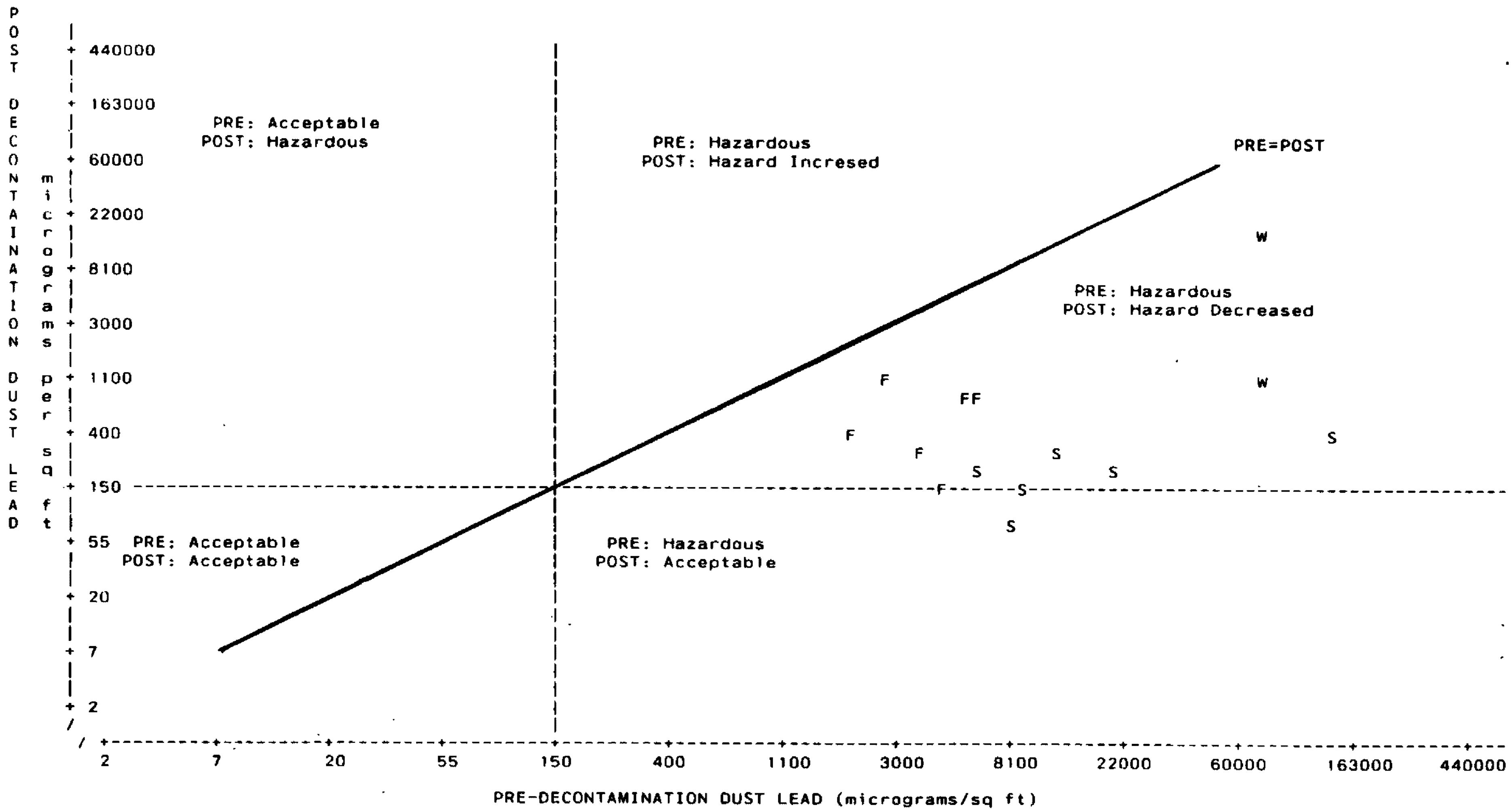


LEGEND: F=Floor S=Window sill W=Window well
Scales in Natural Logs

Source: M. Farfel, Kennedy Institute, 1987

FIGURE 9: PRE TO POST DECONTAMINATION & CLEANUP CHANGE IN HOUSE DUST LEAD LEVELS BY TYPE OF SURFACE

EPA PILOT STUDY: DECONTAMINATION DWELLING 3



LEGEND: F=Floor S=Window sill W=Window well
Scales in Natural Logs
Note: 1 Observation is hidden

Source: M. Farfel, Kennedy Institute, 1987

Children's Blood-Lead Levels Remained Stable Following Decontamination for the Small Number Sampled

Blood-lead (PbB) concentration is an indicator of recent lead absorption, and can rapidly reflect increased absorption. Previous studies (Chisolm et al., 1985; Farfel, 1987) have documented the problem of renewed excessive lead absorption (PbBs greater than 49 mcg/dl) in approximately 40 percent of children following chelation therapy and discharge to traditionally abated older homes. Most readmissions for chelation therapy occurred during the first month following discharge.

We have one-month post-discharge PbB values for children who received chelation therapy and returned to their decontaminated homes. Among one child in decontamination dwelling 1 and two children in dwelling 2, we found no evidence of renewed and excessive lead absorption at one month. Based on experience, and in the absence of a decontamination, we would have expected at least one of three children to have had renewed and excessive lead absorption. We have no data on the children in dwelling 3 because the family has repeatedly failed to keep clinic appointments. Admittedly, our sample is so small as to be inconclusive.

Decontamination Costs Vary with Dwelling Size and Vacuum Quality

Decontamination consisted of:

- vacuuming household surfaces with a HEPA vacuum and wet scrubbing,
- applying two coats of polyurethane or paint to all exposed wood floors,
- priming and painting all abated and unpainted wood trim, and
- revacuuming with a HEPA vacuum and wet scrubbing.

The costs for decontamination in study homes 1, 2, and 3 were $1,300, $760, and $1,105, respectively. Decontamination dwellings 1 and 3 were four-room apartments. Dwelling 1, however, was larger than dwelling 3. Dwelling 2 was a two-story, six-room row house.

HEPA vacuums cost $1,000 - $2,000. The cost varies with the quality, capacity, and performance of the vacuum. Replacement HEPA filters cost approximately $500; secondary filters, $15 each; and bags, $2 each. The life of the HEPA filter is difficult to predict; however, it is maximized when the bags and the secondary filters are changed regularly.

CONCLUSIONS

Our dust-lead findings suggest the following conclusions:

1. Our experimental methods are more effective at reducing exposure to lead-dust than traditional methods (e.g., propane torch and/or sanding) and alternative methods used by Baltimore City crews in 1984 (heat gun, repainting, and cleanup by standard vacuums and wet scrubbing) (see Table 16).

2. Our experimental abatement methods may achieve household dust-lead levels similar to levels found in renovated homes and modern suburban homes. However, we did not consistently achieve target dust-lead levels across study households. We did measure at least one mean household dust-lead level in the target zone after final cleanup on treated floors, window sills and window well surfaces.

3. Even our experimental abatement techniques increase dust-lead levels; they too produce residues laden with lead. Thus post-abatement cleanup is a key part of the entire abatement. It reduces (but does not eliminate) lead-bearing particulates and residues.

4. High-efficiency particle accumulator (HEPA) vacuums are a vital part of post-abatement cleanup procedures. Clark et al. (1985) indicate that much of the lead in dust is in the smallest particle size range (less than 175 microns). HEPA vacuums can trap particles down to 0.3 microns. However, a single cleanup by HEPA vacuuming and wet scrubbing is not adequate to reduce household sites to the target range (less than 150 mcg/sq ft), particularly window wells. Some sites also had increased PbD levels after cleanup, which suggests that lead may be spread from one site to another, if the cleanup is not done carefully. Furthermore, the findings suggest that cleanup may be more difficult and less effective in an occupied dwelling than in a vacant dwelling.

5. Repainting and covering are particularly effective measures for reducing dust-lead levels. Lead-bearing particulates are sealed and made inaccessible. This finding is consistent with findings from demonstration dwellings treated by the Mayor's Task Force in 1986 and other monitored homes (Farfel, 1987).

6. Better abatement and cleanup do not simply require different physical methods and equipment. Workers must be taught why better abatement and cleanups are important for their safety as well as for the safety of the future occupants of the house. Supervisors must reinforce the principles that are the basis for better abatement (e.g., minimize production of lead-bearing particulates, contain debris, clean up thoroughly, and use of personal protection gear).

Table 16: Mean House Dust-Lead Levels After Abatement and Final Cleanup by Traditional Methods, by Alternative Methods by City Crews in 1984, and by Our Experimental Methods

(micrograms per square foot)

Surface	Traditional Abatement*	Alternative Abatement*	Our Experimental Abatements**
Floors	4,750	895	37 - 558
Window Sills	11,410	730	107 - 3,649
Window Wells	31,550	27,360	100 - 8,368

* Values are mean post-abatement and post-cleanup PbD levels across 53 homes abated by traditional methods (propane torch and/or sanding, minimal cleanup, no repainting), and 18 homes abated by city crews in 1984 using alternative methods (heat gun, cleanup by standard vacuums and wet scrubbing, and repainting).

** Values are the ranges of arithmetic mean PbD values found in each of our 4 experimental abatement homes after final cleanup.

RECOMMENDATIONS

We Must Make Sure Abatements Are Performed Safely and Consistently

Our pilot project suggests that better abatement techniques and cleanups can lead to significant reductions in residual dust-lead levels in comparison with both traditional and formerly permitted city practices. This means reduced risk of exposure for child and adult occupants of abated houses, as well as workers performing the abatements.

On July 1, 1987, Baltimore City promulgated regulations concerning the conditions for and conduct of required abatements of lead paint. In general, the regulations require abatement and cleanup practices analogous to those described in this report. (See Section IV of the attached regulations.) A notable difference is that the City regulations permit the use of heat guns. Nonetheless, these regulations are a definite step in the right direction.

In our findings, we noted that better abatements and cleanups, however, are not solely a function of chemicals and machines. Equally important are an understanding of why the new practices are necessary. In recognition of the importance of these factors, we recommend the following specific actions:

1. Disseminate information about the new city regulations to landlords, contractors, and workers via associations, trade groups, and unions.

2. Establish efforts to inform contractors and workers about the new abatement methods and the health and safety issues that clarify for the need for the new regulations.

3. Encourage the development of a trades-based clearinghouse of information on evolving abatement methods.

4. Vigorously enforce the new city regulations.

We Must Conduct Research in Several Areas

To confirm the findings of this pilot project, expand our data base, and fill in gaps in abatement information, we recommend:

1. Additional surveys of lead-dust in "lead-free" houses in order to establish more firmly the target range of residual dust-lead levels that better abatements and cleanups must obtain.

2. Additional surveys of lead-dust levels over time following better abatement and cleanup to determine the contribution of ambient exposure to residual levels.

3. Development and evaluation of more effective methods for reducing lead-bearing particulates in household dust, specifically:

   - evaluation of the use of heat guns and the dust-lead levels they generate;

   - post-abatement cleanup methods that will consistently yield dust-lead levels in the target range; and

   - methods for removing lead-laden dust/residue that remains on surfaces after using PEEL AWAY and off-site dipping methods.

4. Development of field methods for:

   - mass-testing of the lead content of household dust in order to more quickly judge the efficacy of abatement and cleanup techniques and

   - easy measurement of the rate of reaccumulation once levels have been reduced to target levels after abatement and cleanup.

5. Extensive monitoring of blood-lead levels of workers to obtain data on:

   - pre-project blood-lead levels and

   - increases in blood-lead levels under different abatement practices. Concurrent monitoring of air-lead levels should occur to determine if workers are experiencing exposure via this pathway.

6. Extensive monitoring of the blood-lead levels of children residing in houses abated, cleaned, and maintained using better techniques to establish the effectiveness of abatements in reducing blood-lead levels of children.

7. Development of field methods to:

   - test the EP toxicity of lead in various forms of abatement waste in order to comply with disposal requirements; and

   - test and treat waste water on site.

8. Collection of better and more data on the labor, material, and disposal costs of better abatements.

9. Development of preventive strategies (e.g., evaluation of periodic professional decontamination to reduce children's exposure to household lead-dust during their High-risk years (ages 1-6).

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APPENDIX A: DESCRIPTIONS OF ABATEMENT WORK

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING #1

DATES OF WORK: January 1987

OBJECTIVE:

To test a home-made caustic mix and high-pressure spray as an abatement method for removing lead-based paint from all interior wood trim surfaces in a vacant dwelling. The caustic mix and the high-pressure spray method is routinely used to remove paint from exterior brick.

METHOD: Caustic Mix

A. Caustic soda flakes were mixed in varying concentrations as follows:

weakest: 2 boxes of corn starch as thickener and 2 cups of caustic flakes in 4 gallons of water

strongest: 1 box of corn starch and 4-5 cups of caustic flakes in 4 gallons of water

B. Application and Removal

Caustic mix was brushed on wood trim surfaces including door and window trim, jambs, baseboards, and a stairway railing, posts, spindles and trim that were identified with lead paint in excess of 0.1 mg Pb/sq cm using a portable XRF analyzer. These surfaces had approximately six coats of old paint. The XRF analyzer does not specify which layers of paint contained lead. The caustic mix was left on overnight and sprayed with high-pressure water (approx. 4000 psi) to see if it would remove the paint in one application.

C. Anticipated Problems and Preventive Measures

1. Worker safety:

BJEP staff experienced in application of caustic on exteriors of buildings conducted a one day training session for the crew. Goggles, face shields and rubber suites and gloves were provided to each worker. Running water and vinegar were available in case of accidential exposure. On-site supervision was provided at all times during use of pressure spray. The dwelling was also ventillated.

Experimental Abatement Dwelling #1

2. Water damage due to excessive water:

Floors were prepared with 3-5 layers of paper covered with 4 ml plastic which was stapled in place. Plastic was used to cover walls up to level of window aprons. Saw dust was used for water absorption and control on top of the plastic (especially around radiators). Two-by-fours were used to create small dams and lakes to catch and collect the waste water so that it could be removed immediately following spraying using wet vacuums.

3. Cold weather conditions and subfreezing temperatures:

We arranged for heat to be turned on and did not store any chemicals on site that might freeze (eg glacial acetic acid).

4. Contamination of environment with caustic and lead:

We planned to bag all chips, paper, saw dust and debris and send it to sanitary land fill for disposal.

UNANTICIPATED PROBLEMS and CORRECTIVE ACTIONS

1. Access to dwelling to do work: We had a limited period of 5-7 days in which to apply castic, spray and clean up. We were further hampered by other work in progress in the home: electrical, plumbing, heating, window measurement.

2. Weather Conditions: 25 inches of snow, sub-freezing temperatures during most of the operation lasting over two weeks. Heat was turned on in the dwelling, however it was disconnected after the second application of caustic. The caustic mix froze and was reactivated with water.

3. Some water, not caustic to the touch and minus the settled paint chips and solids, was allowed to go into the storm drain (approx 300 gallons).

4. After clean-up, the dwelling resembled a poorly abated "PEEL AWAY" dwelling. We decided to remove easily removable trim for off-site chemical dipping and to try a second application of the caustic/pressure spray method on the stairwell components to see if it would work as a two-step process. Remaining lead paint was finally abated by methylene chloride, and scraping.

Experimental Abatement Dwelling #1

RESULTS

WASTE COLLECTION AND DISPOSAL

The paper, plastic and saw dust successfully controlled excess water, and thereby prevented damage to wood floors and other surfaces. If a process such as this requires large volumes of water (hundreds of gallons), then one day of preparation in combination with "dams" and "lakes" can prevent water damage. Some water was absorbed into the paper and the sawdust. Excess water was collected in wet vacuums. All solid debris was disposed of at a sanitary landfill.

UNSUCCESSFUL APPLICATIONS

The caustic/high pressure spray method at any strength did not remove six layers of paint from wood trim in a single application. Removal was inconsistent, incomplete and sooty. Interspersed with flat and irregular areas where all layers of paint had been removed and the wood was exposed were other flat and irregular areas that still had 2-3 layers of paint. Unlike the PEEL AWAY method, this method did not include working the surfaces with brushes and plastic spatulas. The method was still laborious. Similar results were obtained after the second application of the caustic mix/high pressure spray method on the stairwell trim. Again, large quantities of water were generated that had to be collected and vacuumed.

SUCCESSFUL APPLICATIONS

Radiators: 4-5 cups of caustic to 1-2 boxes of corn starch mixed with 4 gallons of water makes a strong mix that if applied to radiators and allowed to sit overnight can be washed off with a light brushing (hard bristles) and a paint sprayer (psi and gallons/min) using approximately two gallons of water. The water is easily controlled with paper covered with plastic, both under the radiator and over the wall surface behind the radiator. Waste water can be collected using a dam made from 2x4's around the sides of the radiator. This water can then be vacuumed. The radiators with 2-4 coats of paint became completely clean in one application without the use of a high-pressure sprayer. Two gallons of water is no more than that produced by a leaky valve that might stain the ceiling below.

Off-Site Dipping: Since the home-made caustic mix and high pressure spray method was not successful, all easily removable wood trim (baseboards, doors, window and door trim) was removed and sent off-site for commercial stripping in enclosed chemical tanks. Trim was removed and returned with very little breakage. Paint removal was close to 100 percent after dipping.

Methylene chloride was used sucessfully as a touch-up method.

Experimental Abatement Dwelling #1

DAMAGE to SURFACES

There was minimal damage to the wood by the caustic and high pressure soray. "Fuzzing " or raising of the grain of pine and minor splintering of small areas of wood was observed.

WORKER PERCEPTIONS, ATTITUDES, ACCEPTANCE

Although the workers were protected, they were not at all happy or interested in using the method again. The cold and mess of the job made it unappealing. The workers did not perform as well during the second application of the method as during the first. They were sure that the second application would not work.

Mr. Dobie has explained to us that the basic principles of lead abatement (eg, containment of lead debris, worker protection, floor coverings, and clean-up) run counter to the training and work habits of construction workers. He feels that the development of an abatement team is a process that takes time, just as the development of abatement methods is a process that takes time.

SUMMARY and RECOMMENDATIONS

In conclusion, a caustic mix/ hign pressure soray method is not effective in one or two applications as a total abatement method for lead-based paint on all interior wood trim surfaces. The fact that all of the paint was not removed from wood trim in one application is discouraging because single application methods are desireable both from cost and worker performance perspectives.

This demonstration did, however, identify a needed and successful method for abating radiators, i.e. caustic mix and medium pressure spray from a paint sprayer. We also found that trim components can be easily removed for off-site dipping.

Experimental Abatement Dwelling #1

Recommendations:

These findings do not preclude the testing of home-made caustic mixes together with plastic coverings and medium/low pressure sprays such as paint sprayers and hand held sprayers and light brushing as a lower cost alternative to the commercial PEEL AWAY product.

Examine further the radiator abatement method in other study homes.

Continue to have easily removable trim sent off-site for chemical stripping.

Continue to use methylene chloride as touch-up or finishing method as long as precautions are followed.

Until such time as the abatement principles and concepts become automatic with the workers, the project should continue to rely on the on-site supervisor to direct the work and reinforce the concepts with the workers.

Cost-effectiveness:

The theory that after capitalization and training the use of caustic and pressure spray would be a very cost-effective total house method for removing all lead paint from wood trim was negated by the results of only partial paint removal. Materials (caustic, corn starch) were inexpensive, however, equipment (rental of high-pressure sprayer), labor (including clean-up) and training costs accounted for most of the abatement expenses.

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING #2

DATES OF WORK: 2 February 1987 - 1 March 1987

OBJECTIVE:
To test a combination of off-site dipping and Peel Away as an abatement method for removing lead-based paint from all wood trim surfaces* in a vacant dwelling.

METHOD: Off-site Dipping
Wood trim, some doors, some window sashes, and the shutters, which were identified with lead paint in excess of 0.1 mg. Pb/sq. cm. using a portable XRF analyzer, were removed and sent to Baltimore Stripping Company. These surfaces had approximately six coats of old paint. At the stripping company, the wood pieces were dipped in caustic ingredients and solvents (eg.; methylene chloride).

RESULTS: Off-site Dipping
All of the wood pieces sent in were totally stripped to a ready-for-repainting surface in one application. This method is quick and provides no exposure to toxic chemicals. In addition, two anticipated problems turned out to be unfounded: none of the glass in the doors or windows broke and almost none of the joints became unglued (or even loosened) during the process.

METHOD: Peel Away
PREPARATION: All of the floor and up the wall a foot was covered with 4 mm. plastic, stapled in place, to protect the floor from water and tracking of lead-contaminated substances.
APPLICATION: Peel Away (a caustic adhesive paste, 15.1 % sodium hydroxide) was applied to jambs, columns, the mirror, some window sashes, and one door with lead paint in excess of 0.1 mg. Pb/sq. cm.. Application was done using one of two methods. One method was to apply the Peel Away directly to the wood surface with a wall scraper, trowel, or rubber glove. Then the Peel Away was covered with strips of the specially designed paper (which keeps the Peel Away moist so that it can keep working and bonds to the Peel Away layer for easy removal). The other was to apply the Peel Away to strips of paper and then put the paper onto the wood surface. On relatively large flat surfaces, there was no difference

*-Total:	7 doors/jambs + 1 jamb	
	5 double-hung windows/jambs + 1 sash	
	3 columns, total surface area	= 39 sq. ft.
	2 shutters, " "	= 30 sq. ft.
	1 mirror, " "	= 60 sq. ft.
	trim, " "	= 712 sq. ft.

between the two methods other than personal preference. But on rounded or carved surfaces, the apply-to-strip method seemed to work better.

REMOVAL AND WASHDOWN: Peel Away and paper was left on for one or two days and removed using scrapers to loosen while pulling on the paper. The used Peel Away and paper was deposited into plastic trash bags and tied closed. Washdown consisted of spraying, using 3 gal. capacity hand-held sprayers, with varying concentrations of acetic acid in water:

weakest: 2 gal. 5 % acetic acid : 10 gal. water
strongest: 1 gal. 99 % acetic acid : 10 gal. water

Acetic acid was used to **solubulize** lead and to neutralise the strong alkalinity of the Peel Away (leaving the surfaces safe and paint-ready). While spraying, the wood surfaces were scraped with metal and plastic scrapers and brushed with soft-bristled brushes. Waste water was vacuumed using a wet/dry vacuum and deposited into a large plastic garbage can for analysis.

CLEAN UP: All abated wood surface were washed down with a weak solution of trisodium phosphate (7.3 % phosphate) (1 c. : 5 gal. water) to try to precipitate more lead out. The plastic covering the floors was taken up. The floors were mopped with trisodium phosphate solution as well.

SAFETY MEASURES FOR WORKERS:

Rubber boots and gloves, poly vinyl chloride rain suits, mist goggles, and face shields were provided (with instruction as to proper usage) to each worker. Water was available in case of accidental exposure to caustic. Dwelling was also ventilated.

PROBLEMS:

1) PREPARATION: Not all of the floors were covered as completely or as smoothly as desired. Consequently, daily clean up and the big clean up at the end was not easy.

2) APPLICATION: Some surfaces had to be re-done for the first application was too thin. Successful thicknesses were 1/8" - 1/4" of Peel Away. A few windows and one door became softened by the Peel Away, so that even a plastic spatula cut into the surface. A way to figure out which surfaces will be damaged needs to be figured out before application.

3) REMOVAL AND WASHDOWN: Removal and washdown was the most time intensive step. There was no running water nor electricity on site for most of the time. The acetic acid accidently froze and so needed to be thawed out. Meanwhile, vinegar had to be bought daily (since the amount needed was unknown). Sometimes while the job coordinator was out trying to take care of these problems, surfaces were left overnight from which the Peel Away had been removed but which had not been washed down, thus making them twice as hard to wash down the next day.

Experimental Abatement Dwelliing #2

RESULTS: Peel Away
Except as noted above, Peel Away was almost completely successful in removing lead paint in one application, with no toxic fumes and nothing flammable. What little paint that was left could easily be removed by methylene chloride. However, the removal/washdown step of abatement using Peel Away was very time intensive.

WORKERS' PERCEPTIONS, ATTITUDES, ACCEPTANCE:
Workers' attitudes had improved over their attitudes toward using the homemade caustic because all of the workers had had previous experience with Peel Away and knew that it could work and that it was not nearly as toxic as the homemade mix. However, they are still developing as an abatement team. While they are improving, they are still experiencing difficulty with automatically containing lead debris, wearing their protective gear, covering the floors, and washing down well.

SUMMARY AND RECOMMENDATIONS:
A combination of off-site dipping/Peel Away is effective in one application as a total abatement method for lead-based paint on all wood trim surfaces.
RECOMMENDATIONS: In order to effect a quick complete abatement, all lead painted trim, doors, window sashes, and anything else that can be easily removed, should be dipped off-site. The remaining wood surfaces (usually jambs) should be abated using the Peel Away method. Especially important for quick removal is to have electricity and water hooked up, to put Peel Away on thick (1/8" - 1/4") and to further develop the workers as an abatement team (eg.; to cover floors completely, washdown same day as removal, and wear protective gear).

COST EFFECTIVENESS:
The combined off-site dipping and Peel Away method is very effective in terms of removing lead-based paint safely. However, neither dipping nor Peel Away is inexpensive. Cost may be reduced by using off-site dipping as much as possible, thereby eliminating much of the time, labour, and materials in using the Peel Away method. Only further testing of alternative methods will locate a cheaper method (or combination of methods) that is as effective and safe as the off-site dipping/Peel Away method.

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING #3

DATES OF WORK: 27 February 1987 - 13 March 1987

OBJECTIVE:
To test a combination of off-site dipping and Peel Away as an expeditious abatement method for removing lead-based paint from all wood trim surfaces+ in a vacant dwelling. (To improve on the abatement at

METHOD: Off-site Dipping
Same as at EA Dwelling #2* except that all wood trim, doors, and window sashes, which were identified with lead paint in excess of 0.1 mg. Pb/sq. cm., were removed and sent out to be dipped.

RESULTS: Off-site Dipping
Same as at EA Dwelling #2*. Most importantly, since everything that could be dipped was dipped, the bulk of the wood surfaces to be abated were abated in a very quick, safe manner with very little labour, time, and materials spent by BJEP.

METHOD: Peel Away
Same as at EA Dwelling #2* except/and:
PREPARATION: Special attention was paid to covering all of the floor and up the wall a foot, as smoothly and as continuously as possible.
APPLICATION: Special attention was paid to putting on the Peel Away 1/8" - 1/4" thick.
REMOVAL AND WASHDOWN: Undiluted 5% acetic acid was used for the washdown. Very importantly, water and electricity were hooked up before the Peel Away was removed and the surfaces were washed down.
CLEAN UP: No change from the method used at 2629 Barclay.*

SAFETY MEASURES FOR WORKERS:
Same as at EA Dwelling #2* and canvas bags were provided for each worker to keep their protective gear in.

RESULTS: Peel Away
Same as at EA Dwelling #2* except that Peel Away was even more successful in removing lead paint in a timely manner. Since the preparation was done so well, CLEAN UP was very

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+-Total:	8 doors/jambs	
	6 double hung windows/jambs and 1 sash	
	1 column, total surface area =	18 sq. ft.
	stairs, " " =	77 sq. ft.
	2 bannister posts, " " =	3 sq. ft.
	trim," " =	3000 sq. ft.

*-See write-up for EA Dwling #2

quick and easy because none of the debris ever touched the floor. Except for the column (whose layer of Peel Away and paper for some unfathomable reason kept sliding down), no Peel Away had to be re-applied from having been put on too thinly.

The REMOVAL AND WASHDOWN step was much quicker EAD #3 than at EAD #2 . One reason was that there were so fewer wood surfaces to wash Peel Away off of. Also, water and electricity were hooked up before work commenced, eliminating time-consuming trips to get gas for a generator and water for washdown, clean up, and washing tools and protective gear. Removal and wash down was much more quickly done at 27th— even including the extra time taken to try to get the pH of the stripped wood surfaces down (from Peel Away's 14) to neutral (7). It is still unknown as to how low in pH it is necessary to get the surfaces to be safe and paint-ready.

The canvas bag that each worker got for her/his protective gear saved time by promoting better care of her/his protective gear and tools, thus eliminating time spent in replacing lost or mis-used gear/tools.

On the non-improvement side, there was not a full, productive abatement team available to the effort at EA Dwelling #3 Two of the four workers were fired because of their continual unproductive and irresponsible work conduct. Thus, the rest of the time, the work was done by only two workers.

SUMMARY AND RECOMMENDATIONS:
A combination of off-site dipping/Peel Away is effective in one application as a quick total abatement method for lead-based paint on all wood trim surfaces.
RECOMMENDATIONS: A quick, complete abatement can be effected by using the same proceedures used at EA Dwelling #3 with a full abatement team of four people.

ADDENDUM: FINAL CLEAN UPS AT:

Experimental Abatement Dwelling #1
Date of Work: April 3 1987

Method:

After all rehabilitation work was completed, all window wells, radiators, stairs (including handrail and rail at bottom of spindles), baseboards, and floors were HEPA vacuumed to reduce the amount of lead dust which had settled. These same surfaces were sponged/mopped with a 1 c. trisodium phosphate: 3 gal. water solution. The second floor was HEPA vacuumed and sponged/mopped twice, while the first was done only once.

Experimental Abatement Dwelling #2

Date of Work: May 10 1987

Method:

After all rehabilitation work was done, all of surfaces (as above) on the second floor and in the kitchen were sponged/mopped with a 1 c. trisodium phosphate:3 gal. water solution and then HEPA vacuumed. The surfaces on the first floor were only HEPA vacuumed.

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING #4

DATES OF WORK: 19 May 1987 - 12 June 1987

OBJECTIVE:

To see if/how a lead paint abatement could be done in an occupied house* (residents temporarily moved out but all furniture and dog still present) using a combination of sanding/HEPA vacuum, off-site dipping, Peel Away, and touch-up with methylene chloride.

METHOD AND RESULTS: OFF-SITE DIPPING

Same as at EAD #3 (see report for EAD #3).

METHOD: SANDING

Sanding was done with a Nilfisk sanding unit (an orbital sander with a shroud which connects it to a HEPA vacuum), a HEPA vacuum, and an air compressor. We tried sanding window jambs and door jambs.

RESULTS: SANDING

The assemblage was very noisy, so that we had to wear ear plugs. The air compressor also produced a lot of carbon monoxide, but the distance from which it can be moved from the worker is limited by the length of the compressor to sander hose. The sander worked the best on door jambs (taking approximately one hour to do a door or window jamb). But at the corners and all along the outside stop bead on the window jamb, Peel Away had to follow up on the sander.

METHOD: PEEL AWAY

Same as at EAD #3 except:
WASHDOWN became two steps (washdown and clean up). Washdown consisted of washing down most of the Peel Away with just water (using a bucket, brush, scraper, and a sponge). Clean up consisted of a vinegar washdown (after allowing the surface to dry slightly) to rid the surfaces of the white powdery residue (using a spray/vacuum machine spraying a 1:5 vinegar:water solution). The trim, doors, and windows which were dipped off-site were cleaned this time (following a high lead dust level test report of dipped surfaces).

RESULTS: PEEL AWAY

Same as at EAD #3
WASHDOWN: washdown and clean up were effected more quickly as separate steps. Since washdown, which is the most time intensive step, was done using only hand tools, we were not limited to one machine (sprayer/vacuum) - we could all washdown. And it was easier to do the bulk of washdown with our hand tool ensemble because of the superiority of the stiffer hand-held brushes. Finally, it was a great save on vinegar to do the bulk of the washing with water, then finish up with vinegar. The surfaces were neutralised more quickly as well.

SAFETY MEASURES FOR WORKERS:

Same as EAD #3 and:
EPA monitoring showed that trim removal and/or dry sweeping produced levels of air-prone lead dust at which respirators should be (and were) worn. Ear plugs (which provided protection to 26 decibels) were worn by everyone during the use of the sanding unit. An eye wash was purchased and used several times.

PROBLEMS:

Some unforeseen problems which swallowed up time were:

* TOTAL ABATED LEAD PAINTED SURFACES:

# Doors/jambs = 10 + 1 jamb
# Windows/jambs = 11
Trim = 1770 sq. ft.
Exterior back wall (brick) = 53 sq. ft.

Removing the TRIM was very (unexpectedly) difficult (because of large cut nails every six-twelve inches).

The abatement of the BACK WALL was very difficult as well because it was covered with many layers of paint, at least one of which containing something which Peel Away could not, even on three applications, get through — probably cementatious paint.

Another problem had to do with trying to BALANCE IDEAL WITH ACTUAL conditions. Abatement is suppo d to occur from top to bottom, back to front. So that is how we tried to apply the Peel Away. But in an actual occupied house, SECURITY is very important. So we found ourselves removing from the outer edge of the house (windo s and exterior doors) to the inside, first floor first to secure the house. This meant that when we got to the second floor, a lot of the surfaces, especially the exterior part of the window jambs, were dried, thus possibly releasing lead dust into the air, but certainly difficult to remove and washdown.

Another IDEAL VR ACTUAL problem came up with the CARPENTRY step (replacing trim, installing window sashes, stop and parting bead, and hanging doors). The plan was to have carpenters go into a room, do everything in it and go onto the next room then the clean up crew can come in (since they had to wash the trim). But for a production carpenter it made more sense not to go room by room but to do the whole floor step by step (eg.; install all the windows first, then replace all the trim). Unfortunately, since this was not known before now, it was not set up to make that happen easily. Since the clean up crew had to keep working and they were not skilled carpenters, they had to clean up where the carpenters were going to come back. Thus, the two crews got in each others way and even more importantly, lead dust was probably tracked from dirty rooms to clean rooms.

SUMMARY AND RECOMMENDATIONS:

All in all the lead painted surfaces were abated efficiently using the above methods. Recommendations would try to answer the problems encountered above.

A sampling should be made of each kind of TRIM (door, window, baseboard) REMOVAL. Then we could see it they can be dipped (i.e.; if they can be removed without destroying the surrounding surfaces) and if so, if they are difficult to remove, we can plan to have the necessary amount of workers there. And if the trim can not be removed, we can plan to have the necessary amount of Peel Away there.

BACK WALL: a test patch of all proposed Peel Away surfaces should be made as well (to see if Peel Away is in fact the method to use).

IDEAL VR ACTUAL: SECUIRTY AND CARPENTRY: the lead paint abatement should be done a floor at a time instead of a room at a time. Remove all trim that will be dipped; apply all the second floor; apply test patches in the first floor; remove, washdown, clean up second floor, then have carpenters do their work on the second floor; apply first floor (enough days before done with the second floor so that - according to the test patches - first floor will be ready for removal when done with second floor); remove, washdown, clean up first floor, then have the carpenters do their work on the first floor. Then final clean up (water and trisodium phosphate sponge/mop) the whole house second floor to first, back to front.

APPENDIX B: RAW DUST-LEAD DATA
FOR EACH STUDY DWELLING

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 1

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	PRE-ABATEMENT 10/31/86	POST-ABATE 1/21/87	POST-Paint & FLOOR Tx 3/30/87	POST CLEAN 4/7/86	1 MO POST OCCUPANCY 5/22/87	3 MO POST OCCUPANCY 8/1/87
1st Floor:	*	**	***	****		
Vestibule	P 8340	7620	3030 none	3030	1760	300
Hall -	P+ 2800	3030	45 paint	120	78	33
Frt Rm at R sill	576	P+ 1720	22 paint	171	74	30
Frt Rm at mantle	P 3310	4620	15 paint	60	13	42
Mid Rm at entrance	P+ 368	3050	6 paint	84	53	57
Mid Rm at center	P 367	1970	3 paint	90	64	15
Kitchen at center	420	P 4830	540 tile	201	41	15
Kitchen at bk dr	2300	P+ 8210	2640 tile	330	50	42
2nd Floor:						
Frt Rm at L sill	P+ 491	P 8580	40 paint	150	342	70
Frt Rm at mid rm	P+ 115	P 1740	20 paint	252	156	51
Hall at rail	P+ 303	2427	33 paint	57	48	36
Mid Rm at sill	P+ 32	585	12 paint	27	72	69
Mid Rm at center	P+ 44	P- 323	6 paint	213	45	22
Bk Rm at R sill	P 480	P+ 11800	14 paint	324	138	54
Bk Rm at center	P 128	1630	2 paint	177	52	15
Bathrm at center	450	1830	480 tile	243	42	33

* House in initial stages of demolition

** Post-Abatement samples taken after unsuccessful treatment with a home-made caustic mix and a contractor type clean -up; trim was then taken out for off-site dipping.

*** Floors painted 2 days prior and no one entered until samples were collected; trim was painted 2 weeks prior.

**** 1st Floor: HEPA Vacuuming followed by mopping with trisodium phosphate solution; 2nd Floor: same x2

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 1

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

WINDOW SILLS	PRE-ABATEMENT 10/31/86	POST-ABATE 1/21/87	POST-Paint & FLOOR Tx 3/30/87	POST CLEAN 4/7/86	1 MO POST OCCUPANCY 5/22/87	3 MO POST OCCUPANCY 8/1/87
	*	**	***	****		
1st Floor:						
Frt Rm right	2234	removed	P 4430 paint	828	P 2688	1613
Frt Rm left	2953	removed	P 5593 paint	1075	P 3511	1356
Kitchen sill	C- 4010	P 4216	P+ 1684 paint	491	P 354	P 384
2nd Floor:						
Bk Rm right	C 9874	30266	P 567 paint	43	P 269	P- 327
Bk Rm left	C 8930	removed	P 630 paint	56	P 358	260
Bath sill #1	228	C+P 16840	removed	removed	removed	removed
Bath sill #2	86	C+P 68837	463 paint	281	442	206
Frt Rm left	C- 14040	removed	1333 paint	541	P 1775	P 1083
Frt Rm right	C- 8308	removed	removed	3833	P 1408	1167
WINDOW WELLS						
1st Floor:						
Frt Rm right	NA	P+ 41946	stuck	30300	NA	P 36017
Kitchen well	C- 8616	PC 9145	P+ 1306 vinyl replacement	164	194	435
Bk Rm right	C+ 42085	PC 30440	P 500 vinyl replacement	73	400	238
Bk Rm left	C+ 21540	C 24020	P 452 vinyl replacement	64	207	333
Frt Rm left	C 51500	C- 64230	stuck	C 1577	P 4343	NA
Frt Rm right	C+ 70400	C 83660	2057	4594	P 4777	10040

Note: P-, P, P+ = varying quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.
* , ** , ***, and **** - see previous page

NA = Not Available

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 2

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	PRE-ABATEMENT 10/31/86	POST-ABATE 2/26/87	POST-Paint & FLOOR Tx 5/7/87	POST CLEAN 5/11/87	1 MO POST OCCUPANCY 6/12/87	3 MO POST OCCUPANCY 8/14/87
1st Floor:		*	**	***		
Vestibule	354	P 2280	114 paint	135	190	96
Hall -	167	P 1530	26 paint	78	87	39
Frt Rm at sill	P 501	P 2140	5 paint	21	84	96
Frt Rm at center	122	P 1380	3 paint	10	39	P 51
Mid Rm at fr dr	127	P 1710	3 paint	15	69	42
Mid Rm at center	143	P+ 1770	3 paint	13	93	P 87
Kitchen at L col	227	P+ 2560	228 tile	28	15	15
Kitchen at bk dr	P 1590	P+ 3600	651 tile	53	57	39
2nd Floor:						
Top Stair tread	P 206	P+ 2760	14 paint	35	112	15
Frt Rm at L sill	P+ 1140	P+ 11500 (on plastic)	112 paint	40	280	57
Frt Rm at center	930	1290	12 paint	38	69	40
Mid Rm at sill	P 169	750	78 paint	29	96	45
Mid Rm at center	220	P 1510	21 paint	24	60	54
Hall	178	P 7000	29 paint	33	72	33
Bathrm at center	209	P 2870	396 tile	32	27	39
Bk Rm at bk door	1270	P 8850	99 paint	34	NA	156
Bk Rm at center	87	3670	3 paint	27	NA	36

* Post-Abatement samples taken after abatement by PEEL AWAY. Visible PEEL AWAY residue was observed on these samples.

NA = Not Available

** Floors painted 1 day prior and no one entered until samples were collected; trim was painted ~1 week prior.

*** 1st Floor: HEPA Vaccuming only; 2nd Floor: wet mopping with trisodium phosphate solution followed by HEPA vacuum.

Note: Post values - PEEL AWAYED door jamb 4251 (light residue) PEEL AWAY column 427 (residue); Dipped door 8880; non-tx door 235.

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 2

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

WINDOW SILLS	PRE-ABATEMENT 10/31/86	POST-ABATE 2/26/87	POST-Paint & FLOOR Tx 5/7/87	POST CLEAN 5/11/87	1 MO POST OCCUPANCY 6/12/87	3 MO POST OCCUPANCY 8/14/87
		*	**	***		
1st Floor:						
Frt Rm sill	P 1636	P 16574	603 paint	400	297	1485
Hall Mirror	P 675	P 1057	P 950 paint	38	73	8
Kitchen sill	287	P 2580	P- 925 paint	81	252	275
2nd Floor:						
Frt Rm left	P 9956	P+ 40335	P 74 paint	102	486	179
Frt Rm right	P 6210	P+ 57143	138 paint	33	357	452
Mid Rm sill	P 2291	P+ 2875 (not abated)	P 1500 paint	81	159	125
Bath sill	292	P- 1856 (not abated)	180 paint	58	324	52
Bk Rm right	P 1298	P+ 85205 (incomplete rinse)	P- 363 paint	136	NA	1260
Bk Rm left	P 412	P 36923 (incomplete rinse)	276 paint	38	NA	NA
WINDOW WELLS						
1st Floor:						
Frt Rm well	PC- 3268	stuck	stuck	NA	NA	PC 6667
Kitchen well	P 2889	C- 39524	stuck	284	1143	P 2286
Bathrm well	P+ 5602	P+ 2286 (not abated)	137 paint	58	P 794	1587
2nd Floor:						
Frt Rm left	C+ 108260	P+ 40335	3179 paint	425	P- 9853	P 7010
Frt Rm right	C 46330	P+ 49896	1553 paint	902	P- 1315	P 1440
Bk Rm right	C 40444	P+ 38280	C-P 2710 paint	P-1236	NA	20452
Bk Rm left	C 11127	P- 45400	P 4182 paint	555	NA	NA

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

NA = Not Available

* , ** , and *** - see previous page.

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 3

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	PRE-ABATEMENT 10/31/86	POST-ABATE 5/19/87	POST-Paint & FLOOR Tx 6/19/87	POST CLEAN 6/27/87	1 MO POST OCCUPANCY -	3 MO POST OCCUPANCY 8/26/87
1st Floor:		*	**	***		
Vestibule	622	1068	84 paint	840	NA	260
Hall -	1050	1320	10 paint	390	NA	180
Frt Rm at sill	253	P 1040	10 paint	330	NA	P 330
Frt Rm at center	462	864	15 paint	420	NA	210
Mid Rm at entrance	P 462	P 1680	10 paint	510	NA	180
Mid Rm at center	278	699	10 paint	420	NA	NA
Kitchen at center	1290	1030	300 new tile	270	NA	63
Kitchen at sill	P 744	1410	910 new tile	240	NA	90
2nd Floor:						
Stair 2nd	PC- 720	P 1634	18 paint	179	NA	118
Frt Rm at L sill	PC 1670	P 564	10 paint	540	NA	130
Frt Rm at center	P 242	P- 357	15 paint	720	NA	120
Mid Rm at center	97	P- 307	15 paint	600	NA	195
Mid Rm at entr fr	204	307	15 paint	570	NA	175
Bk Rm at center	41	P- 459	15 paint	360	NA	200
Bk Rm at sill	P+C- 685	P- 842	15 paint	270	NA	160

* Post-Abatement samples taken after abatement by PEEL AWAY and Off-Site Dipping

NA = Not Available

** After floors were coated, no one entered until samples were collected: trim was painted weeks prior to sampling.

*** HEPA Vaccuming followed by wet cleaning with trisodium phosphate solution followed by HEPA vacuuming again.

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 3

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

WINDOW SILLS	PRE-ABATEMENT 10/31/86	POST-ABATE 5/19/87	POST-Paint & FLOOR Tx 6/19/87	POST CLEAN 6/27/87	1 MO POST OCCUPANCY -	3 MO POST OCCUPANCY 8/26/87
		*	**	***		
1st Floor:						
Frt Rm sill	CP 1794	1770	540	295	NA	885
Kitchen sill	P 1780	5450	274	583	NA	P- 294
2nd Floor:						
Frt Rm left	C 6805	removed	538	356	NA	89
Frt Rm right	C 11275	removed	334	222	NA	147
Bath sill	C- 3508	removed	1284	1885	NA	P 91
Bk Rm sill	C 2300	3592	354	355	NA	284
WINDOW WELLS						
1st Floor:						
Frt Rm well	NA	NA	NA	NA	NA	NA
Kitchen well	CP 10205	P 6192	3376 vinyl	2063	NA	P 2063
2nd Floor:						
Frt Rm left	C 7726	boarded	3314	1463	NA	1714
Frt Rm right	C 61990	14537	16908	15272	NA	P- 18545
Bk Rm	C 4403	P 584	498 vinyl	166	NA	P 158
Bath Rm	C 64585	P 1443	5827 vinyl	1640	NA	P+ 3453

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

NA = Not Available

*, **, and *** - see previous page.

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 4

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	PRE-ABATEMENT 5/15/87	POST-ABATE 6/12/87	POST-Paint & FLOOR Tx 6/16/87	POST CLEAN 7/6/87	1 MO POST OCCUPANCY 8/8/84	3 MO POST OCCUPANCY 10/4/87
1st Floor:		*	**	***		
Vestibule	P 4320	60700	3457	P 13800	5730	3690
Frt Rm at R sill	978	780	NA paint	P- 750	360	330
Frt Rm at door	633	4080	NA paint	P- 620	690	420
Mid Rm at sill	1870	P 9000	360 paint	P 840	540	600
Mid Rm at center	447	P 4050	330 paint	P- 540	240	130
Kitchen at center	258	3930	420 tile	300	150	70
2nd Floor:						
Hall at BR#2	318	2220	1450 paint	P- 330	150	90
Frt Rm at door	534	2280	420 paint	390	170	110
BR#2 at sill	PC 402	2490	190 paint	480	300	P 600
Bk Rm at center	2320	1650	68 paint	P 510	P 260	330

* Visible PEEL AWAY residue was observed in these samples.

** Single coat of polyurthane-based paint was applied to the floors. Furnishings were in the home during abatement.

*** HEPA vacuuming followed by wet scrubbing with trisodium phosphate solution followed by HEPA vacuuming

NA = Not Available

EPA PROJECT EXPERIMENTAL ABATEMENT DWELLING 4

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

WINDOW SILLS	PRE-ABATEMENT 5/15/87	POST-ABATE 6/12/87 *	POST-Paint & FLOOR Tx 6/16/87 **	POST CLEAN 7/6/87 ***	1 MO POST OCCUPANCY 8/8/87	3 MO POST OCCUPANCY 10/4/87
1st Floor:						
Frt Rm L sill	P 5550	1105	NA	2088	1439	P 17368
Frt Rm R sill	18502	8526	NA	1145	1263	P- 2947
Kitchen sill	P 4692	P 79302	1256	14093	29116	5721
Mid Rm sill	P 7817	19230	538	P- 2846	P 49230	4923
2nd Floor:						
Frt Rm mid sill	19440	6642	896	800	1940	1343
Mid Rm sill BR#2	2412	13489	234	P- 3939	1655	4424
Bath sill	P- 17140	3750	659	614	682	568
Bk Rm right	NA	3187	NA	934	850	1700
WINDOW WELLS						
1st Floor:						
Frt Rm L well	P+C 63062	5851	NA	P- 1265	P- 3056	CP 62112
Frt Rm R well	P+C+ 417000	43200	NA	1021	P- 9900	C-P 56400
Kitchen well	P+ 5486	P- 62500	25457	P- 32012	P 91768	CP- 83537 not paint
Mid Rm well	P+C 60900	19791	585	C- 15672	P 12806	CP- 22478
2nd Floor:						
Frt Rm mid	P+C+ 134184	P 13878	306	1021	2857	P 10068
Mid Rm (BR#2)	P+C+ 30450	P 10615	630	P- 1719	P- 4678	P+ 23268
Bath well	P+C 56084	13989	1494	P- 2430	5013	NA
Bk Rm right	PC 39660	4046	NA	P- 2057	P 4114	PC- 1440

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

NA = Not Available
*, **, and *** - see previous page

EPA PROJECT DECONTAMINATION DWELLING 1

Apartment in Older Poorly Maintained Row Home

- original walls. floor coverings. windows
- previously and partially abated by traditional methods (i.e. open-flame burning, not repainted)

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS		PRE DECONTAM 7/27/87	POST DECONTAM	POST CLEANUP 7/30/87	1 MONTH POST 8/26/87
Frt Rm at sill -wd		540	NA	190	390
Frt Rm at entrance -wd		200	NA	270	140
Entrance to apt -wd		480	NA	1350	160
Living Rm at entr -lin		300	NA	1950	105
Living Rm at R sill -lin		660	NA	1950	no tx 900
Living Rm at center -lin		150	NA	450	no tx 140
Kitchen at center -lin		170	NA	185	no tx 45
Kitchen at bk door -l	P	810	NA	900	no tx 220 P
WINDOW SILLS					
Frt Rm L sill	PC	61236	NA	731	446
Living Rm R sill	P	7040	NA	240	P 2271
WINDOW WELLS					
Frt Rm L well	C+	306370	NA	9469	P 48438
Living Rm R well	P+C	5760	NA	1731	P 2192

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

NA = Not Available

EPA PROJECT DECONTAMINATION DWELLING 2

Apartment in Older Poorly Maintained Row Home

- original walls, floor coverings, windows
- previously and partially abated by traditional methods (i.e. open-flame burning, not repainted)

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	PRE DECONTAM 7/29/87	POST DECONTAM 8/20/87	POST CLEANUP 8/26/87	1 MONTH POST 9/26/87
Frt Rm at R sill -wd	5640	220	240	210
Frt Rm at L sill -wd	P- 4290	145	42	120
Frt Rm at entr. -wd	3810	140	66	190
Hall -top of stairs -wd	2490	165	160	170
Mid Rm at R sill -wd	2010	600	170	220
Kitchen at center -wd	1620	P 510	210	330
WINDOW SILLS				
Frt Rm R sill	5374	193	66	1903
Frt Rm L sill	7989	765	57	P- 1275
Mid Rm R sill	5935	320	29	262
Bath Rm R sill	176	49	25	122
WINDOW WELLS				
Frt Rm R well	9360	600	91	366
Frt Rm L well	P-C- 8501	1882	65	P- 9547
Mid Rm R well	2025	629	C- 11798	P- 1685
Kitchen well	P- 7070	244	57	193
Bath Rm R well	3497	96	P- 526	91

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

EPA PROJECT DECONTAMINATION DWELLING 3

Older Poorly Maintained Row Home
- original walls, floor coverings, windows
- previously and partially abated by traditional methods (i.e. open-flame burning, not repainted)

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	PRE DECONTAM 7/27/87	POST DECONTAM 8/20/87	POST CLEANUP 8/27/87	1 MONTH POST 10/4/87
2nd Fl				
Bk Rm at center -wd	5820	300	690	1320
Mid Rm at center -wd	2760	51	1170	630
Frt Rm at L sill -wd	5370	225	780	1230
Stair - 3rd - wd	3500	174	269	462
1st Fl				
Frt Rm at sill	4329	278	165	P 1215
Mid Rm at entrance -wd	4410	164	160	360
Kitchen at bk door -wd	1980	P 600	360	540
WINDOW SILLS				
2nd Fl				
Bk Rm sill	11654	77	295	1192
Mid Rm sil	130510	218	350	1285
Frt Rm L sill	6250	190	178	333
1st Fl				
Frt Rm sill	PC- 20556	176	204	PC 13148
Mid Rm sill	8108	215	81	P 892
Kitchen side sill	C 8752	236	154	247
WINDOW WELLS				
Mid Rm well	C- 72025	1910	C- 1002	C- 18539
Frt Rm L well	C- 72650	P- 6511	C- 15156	C-P 31524

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

EPA PROJECT COMPARISON DWELLING 1

Completely Renovated Row Home
- New walls, floor coverings, windows

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	WINTER 12/5/86	SPRING 4/22/87	SUMMER 7/2/87	FALL 10/5/87
(carpeted except kitchen)				
Kitchen tile at sill	5	16	15	3
Kitchen tile at cntr	8	9	10	3
WINDOW SILLS				
1st Floor:				
Kitchen new wood sill	7	10 (sash open)	13	58
Frt Rm new wood R sill	9	2	35	3
2nd Floor:				
Bk Rm new wood R sill	21	26 (sash open)	38	19
Bk Rm new wood L sill	24	26 (sash open)	30	NA
WINDOW WELLS				
1st Floor:				
Kitchen - vinyl replacement	P 743	P 1113 (sash open)	P 870	P 348
Frt Rm - vinyl replacement	P 1677	P 1328	723	702
2nd Floor:				
Bk Rm -Rt vinyl replacement	P 1187	P 88 (sash open)	P 846	P 500
Bk Rm -Lt vinyl replacement	P 625	P 1177 (sash open)	15	NA

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

NA = Not Available

EPA PROJECT COMPARISON DWELLING 2

Rehabilitated Row Home - (renovated after fire)

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	WINTER 12/5/86	SPRING 4/20/87	SUMMER 7/8/87	FALL 10/5/87
(floors carpeted except-)				
Basement Kitchen				
- new linoleum at door	9	81	NA	3
- new linoeum at stairs	7	45	NA	3
Basement stair (painted wood)	P 34	53	NA	3
WINDOW SILLS				
Basement Living Room:				
- Front sill (new wood)	118	80	NA	P 180
1st Floor:				
Bk Rm sill (new wood)	C- 370	C- 394	NA	69
2nd Floor:				
Frt Rm -left (new wood)	22	85	NA	48
Bathrm siil (new wood)	32	P 104	NA	40
Bk Rm sill (new wood ?)	C- 99	PC 142	NA	34
WINDOW WELLS				
Basement living room:				
- vinyl replacement	P 290	P 863	NA	P 366
1st Floor:				
Bk Rm -vinyl replacement	PC- 280	P 1515	NA	NA
2nd Floor:				
Bathrm -vinyl replacement	457	P 1056	NA	P 481
Bk Rm -vinyl replacement	131	P 40	NA	P 98

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

NA = Not Available

EPA PROJECT COMPARISON DWELLING 3

Fairly well maintained Older Row Home -
original walls, nearly all windows and floors original wood

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS	WINTER 11/19/86	SPRING 4/20/87	SUMMER 7/17/87	FALL 9/27/87
1st Floor:	*			
Frt Rm - wood at sill	230	90	NA	72
Mid Rm - wood at sill	64	51	NA	63
Kitchen linoleum at sill	102	159	NA	210
2nd Floor:				
Frt Rm - wood at sill	118	180	NA	96
Mid Rm - wood at center	48	39	NA	39
Bk Rm - linoleum	P 199	P 96	NA	69
WINDOW SILLS				
1st Floor:				
Frt Rm sill	1190	P 560	NA	P 1385
Kitchen sill	58	P 1450	NA	1364
2nd Floor:				
Frt Rm -right	63	335	NA	PC 3062
Bk Rm sill	73	253	NA	867
WINDOW WELLS				
1st Floor:				
Frt Rm -	CP 45950	6521	NA	PC 23577
2nd Floor:				
Frt Rm -right	CP 22904	P+12863	NA	PC 1364
Bk Rm -vinyl replacement	P 745	528	NA	P 345

Note: P-, P, P+ = varing quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varing quantities of visible chips of paint were observed in the samples.

NA = Not Available

* sills appeared to be recently repainted
floors appear to have coat of wax or urethane

EPA PROJECT COMPARISON DWELLING 4

Older Row Home
- original walls, nearly all windows and floors original

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

FLOORS		WINTER 12/2/86		SPRING 4/22/87		SUMMER 7/2/87	FALL 9/26/87
1st Floor:							
Frt Rm -wd polyur at door		468		111		42	15
Frt Rm -wd polyur at kitch		42		132	P	36	33
Kitchen newer linol. L sill		342		21		180	42
Bk Rm - newer linol at sill		33		15	P	270	10
2nd Floor:							
Frt Rm - wood at R sill	CP	975	C	1400	C-	510	140
Frt Rm - painted wd at door		80	CP	63		69	42
Mid Rm - wood at R sill	PC+	4110		453	PC-	750	165

Note: P-, P, P+ = varying quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varying quantities of chips of paint were observed in the samples.

EPA PROJECT COMPARISON DWELLING 4

Older Row Home
- original walls, nearly all windows and floors original

DUST LEAD LEVELS OVER TIME (micrograms/square foot)

WINDOW SILLS	WINTER 12/2/86	SPRING 4/22/87	SUMMER 7/2/87	FALL 9/26/87
1st Floor:				
Frt Rm L sill (new wood)	879	340	P 277	80
Frt Rm side sill (old wood)	835	536	P 1398	677
Kitchen L sill (old wood)	651	PC- 10685	C+P 13808	C- 4767
Bk Rm side sill (old wood)	211	263	301	356
2nd Floor:				
Frt Rm -right (old wood)	C- 15460	C- 8545	6636	4727
Mid Rm - right (old wood)	C 14213	C 4225	C+ 18750	C 26250
Bk Rm right sill (new wood)	52	76	P 106	P 155
WINDOW WELLS				
1st Floor:				
Kitchen - left (metal)	C+P+ 166400	C+ 124545	C+P+ 131818	C 128182
Bk Rm -side (old wood)	CP 31543	CP 25370	23771 C+P+	C 15360
2nd Floor:				
Frt Rm -vinyl replacement	P 1146	P 1422	P 1015	P 615
Mid Rm -right (old wood)	C+ 74835	C 23636	C 126818	C 32045
Bk Rm -side (new wood)	97	350	39	230
Bk Rm -back (new wood)	164	215	63	32

Note: P-, P, P+ = varying quantities of visible dust/particulates were observed in the samples.

Note: C-, C, C+ = varying quantities of chips of paint were observed in the samples.

APPENDIX C: AIR-LEAD LEVELS:

REMOVAL OF TRIM AND USE OF HEPA SANDER

STATE OF MARYLAND

WILLIAM DONALD SCHAEFER
Governor

WILLIAM A. FOGLE, JR.
Secretary

HENRY KOELLEIN, JR.
Commissioner

Department of Licensing and Regulation
DIVISION OF LABOR AND INDUSTRY

501 ST. PAUL PLACE
BALTIMORE, MARYLAND 21202-2272

DIRECT DIAL 301/333-4210

August 20, 1987

Mr. Mark Farfel, Outreach Associate
John F. Kennedy Institute
707 N. Broadway
Baltimore, Maryland 21205

Dear Mr. Farfel:

As part of the Private Sector Consultation Service that you requested, a written report is sent to the employer on the working conditions examined by the consultant. Attached is the written report of occupational health consultant, Maurice Wooden, who conducted the survey of your facility on May 20, 1987.

Private Sector Consultation Service is a cooperative approach to solving safety and health problems in the workplace. It is intended to be advisory in nature and assist you in achieving voluntary compliance through the prompt correction of any observed hazards.

If you need further assistance or information, please contact me by calling (301) 333-4210.

Sincerely,

Etta Mason

Etta Mason, Project Manager
Private Sector Consultation

EM/rg

Request No. : 451271670
Survey Dates: May 20 to August 3, 1987
Consultant : Maurice Wooden

THE KENNEDY INSTITUTE

Request Summary:

Upon the request of Mark Farfel on May 15, 1987 an initial survey visit was conducted at the project site on May 20, 1987. Assistance was desired in evaluating employee airborne lead exposures. The resonsibilities under Consultation Services were discussed during the opening conference.

The employer sponsored the detoxification of a residential dwelling as part of a project in the employer's child lead paint poisoning program. The employer received Consultation Services' assistance in July, 1986 when a water based chemical was used to remove the leaded paint of a home.

Description of Worksite:

The worksite was a two story townhouse in east Baltimore where lead paint had been identified. The water based chemical was used again, but also powered portable hand tools with local exhaust ventilation systems were used. Monitoring for employee exposures while using these hand tools was the emphasis of the surveys.

Work practices consisted of manually removing door and window frame casings, doors and window sashes, and hand tool sanding of painted wood surfaces. Employees also applied and removed the water based stripping chemical on painted surfaces.

Survey Methodology:

Employees were personally monitored with portable air sampling equipment. The point of air sample collection was on the collar of the employee. The test durations were based on employee work activities so that conclusions could be drawn about specific operations along with 8 hour time weighted average (TWA) exposures.

Request No. : 451271670
Company: The Kennedy Institute
Survey Dates: May 20 to August 3, 1987

Results:

LEAD

On May 20, 1987 employees removed door and window frame casings in a 2nd floor middle room. Nails were removed from the woodwork, the area was dry swept and the debris manually removed from the room. Plastic sheets were put in the room in preparation for the water based chemical application. The results follow:

EMPLOYEE	TEST DURATION (in hours)	RESULTS (in ug/M^3)	8 hr. TWA (in ug/M^3)
A.A.	2.4	26.4	8.0
C.D.	2.0	42.7	10.8

A HEPA equipped vacuum was planned to be used in the room to prevent dry sweeping, but it had not arrived at the site by the time of the operation. The consultant believes the bulk of the above results derived from the dry sweeping practices.

On May 26, 1987 an employee used the powered hand sander with local exhaust ventilation attachments. The employee worked on the 1st floor front room window casings. Ventilation smoke tubes were used and the air suction around the sanding disc was good. The results follow:

EMPLOYEE	TEST DURATION (in hours)	RESULTS (in ug/M^3)	8 hr. TWA (in ug/M^3)
J.L.	0.9	24.7	2.8

NOTE: Very little visible dust was observed during the operation.

On May 27, 1987 the same employee used the sander with the attachments on the doorway separating the 1st floor front room from the middle room. The results follow:

EMPLOYEE	TEST DURATION (in hours)	RESULTS (in ug/M^3)	8 hr. TWA (in ug/M^3)
J.L.	1.4	84.3	14.9

Request No. : 451271670
Company: The Kennedy Institute
Survey Dates: May 20 to August 3, 1987

NOTE: Little visible dust was observed.

On the same day, the employee used the sander on the dwelling entrance door frame. This exterior wood surface had paint on it that did not appear to be in as good (tight) a condition as the previously mentioned interior surfaces. This operation generated very visible dust particles. The results follow:

EMPLOYEE	TEST DURATION (in hours)	RESULTS (in ug/M³)	8 hr. TWA (in ug/M³)
J.L.	0.8	79.9	8.0

With both tests being taken into account on Mr. L , his 8 hr. TWA exposure for lead on May 27, 1987 was 22.9 ug/M³. Mr. L, along with the other monitored employees, wore full body disposable suits and NIOSH approved half mask respirators with HEPA filters. Employees used the available water on the site for wash up purposes and had received training in respirator use and maintenance. All employees had blood monitoring performed before the work commenced. All employee blood leads were below 30 micrograms.

The test results show that the employee exposures were below the MOSH 8 hr. TWA action level for lead of 30 ug/M³ and the standard of 50 ug/M³. The results also show that if certain work activities are performed for the majority of a workshift, the MOSH threshold levels can be exceeded when using the specially equipped hand sander.

STATE OF MARYLAND
DEPARTMENT OF LICENSING AND REGULATION
DIVISION OF LABOR AND INDUSTRY

301/333-4210

ON-SITE CONSULTATION SERVICES REPORT

REPORT NO.: 451271670

DATE: August 20, 1987

ITEM # 1

Location: 2nd floor middle room of Project Dwelling

Standard Reference: 09.12.32.08B.(2)

A dry method was used to clean floors when vacuuming and wet methods were practicable choices.

Condition:

Employees performed dry sweeping of debris containing lead paint chips. Air monitoring revealed exposure of 42.7 ug/M^3 after two hours of performing the operation. The employer had provided a HEPA equipped vacuum for the job, but it was not on site when the operation was performed.

Hazard:

Dry cleaning methods create dust which can contain lead particles. This can increase the worker's exposure to airborne lead levels. Lead is known to cause nervous system, reproductive system and muscular system dysfunction.

Recommendation:

When HEPA vacuum is not available, wet down the debris and wet shovel it into containers. Follow with wet sweeping or mopping. Prohibit dry clean up on all jobs.

Classification: Other Than Serious

Agreed Upon Correction Date: N/A - job completed.

APPENDIX D: AIR LEAD LEVELS:

APPLICATION AND REMOVAL OF PEEL AWAY

HARRY HUGHES
GOVERNOR

FREDERICK L. DEWBERRY
SECRETARY

STATE OF MARYLAND

DOMINIC N. FORNARO
COMMISSIONER

NANCY B. BURKHEIMER
DEPUTY COMMISSIONER

RAYMOND E. LLOYD
ASSISTANT COMMISSIONER
MOSH

DEPARTMENT OF LICENSING AND REGULATION
DIVISION OF LABOR AND INDUSTRY
OCCUPATIONAL SAFETY AND HEALTH

501 ST. PAUL PLACE BALTIMORE, MARYLAND 21202-2272
301/659-4210

August 27, 1986

Mark Farfel, Outreach Associate
John F. Kennedy Institue Lead
Poisoning Clinic
707 N. Broadway
Baltimore, Maryland 21205

Dear Mr. Farfel:

As part of the Private Sector Consultation Service that you requested, a written report is sent to the employer on the working conditions examined by the consultant. Attached is the written report of occupational health consultant, Maurice J. Wooden, who conducted the survey of your facility on June 9, 1986.

Private Sector Consultation Service is a cooperative approach to solving safety and safety problems in the workplace. It is intended to be advisory in nature and assist you in achieving voluntary compliance through the prompt correction of any observed hazards.

If you need further assistance or information, please contact me by calling (301) 659-4210.

Sincerely,

Etta Mason

Etta Mason, Project Manager
Private Sector Consultation

EM/rg

BALTIMORE METRO AREA 659-4210
OUTSIDE BALTIMORE METRO AREA
TOLL FREE 1-800-492-6226

TTY FOR DEAF
BALTIMORE AREA 383-7555
D.C. METRO AREA 565-0451

Request No.: 451279657
Survey Date: June 9, 1986 to August 12, 1986
Consultant : Maurice J. Wooden

THE KENNEDY INSTITUTE

Request Summary:

Per Mr. Farfel's request, a consultation survey was begun on June 9, 1986. Assistance was desired in determining employee lead exposure during residential paint removing projects. At the initial meeting employer responsibilities under Consultation Services were discussed.

Description of Workplace:

The worksite involved two residential locations. They were identified as having lead paint on woodwork surfaces. The houses were part of a pilot project to demonstrate and evaluate various methods of household lead paint removal. The "Peel Away" product and method were used in the two residence.

Survey Methodology:

Personal employee air monitoring was performed on employees performing the application and removal of the product at the first location. The employees were also monitored during clean-up of removed paint. The point of workroom air collection was at the employees' shirt collar which was in their breathing zone.

At the second location area air samples were taken in the room where the "Peel Away" removal took place.

Results:

Date: July 9, 1986

Location: 2nd floor front room of Denmore Avenue dwelling

Activity: "Peel Away" application

Request No.: 451279657
Company: Kennedy Institute
Survey Date: June 9, 1986

Employee	Test Duration (in hours)	Results (Concentration) (in ug/m³)
Carpenter's helper	1.2	<2.3
Laborer	1.6	<1.7

Date: July 10, 1986

Location: Same as July 9

Activity: "Peel Away" removal and clean-up

Employee	Test Duration (in hours)	Results (Concentration) (in ug/m³)
Carpenter's helper	1.2	10.9
Laborer	1.2	2.2

Date: July 18, 1986

Location: 1st floor kitchen area of E. Madison St. dwelling

Activity: "Peel Away" removal and clean-up

Monitoring Location	Test Duration (in hours)	Results (Concentration) (in ug/m³)
near west wall @ 5 feet above floor level	1.3	2.1
near east wall @ 3 feet above floor level	1.3	<2.1

NOTE: The less than sign (<) indicates that the lead levels were below the detection limit of analysis which is essentially a zero result.

Request No.: 451279657
Company: Kennedy Institute
Survey Date: June 9, 1986

Discussion:

The results show very low exposure to airborne lead levels while using the "Peel Away" method for removing lead paint. The MOSH standard requires respirator usage and feasible engineering controls where levels equal or exceed 50 ug/m and blood lead testing of employees where levels equal or exceed 30 ug/m .

The MOSH standards are based on a full shift (8 hours) time weighted average (TWA) exposure. Because of this, the air monitoring test were begun when work began and ended. By testing in this manner, the result is a true measure of exposure only while the work is performed.

If the two employees performing the removal on July 10, 1986 worked for a full day removing the paint, one would expect their full shift exposure to be in the 2-11 ug/m range. Because there are breaks, lunch periods and slow periods during a day, their actual TWA exposure wuld be even less. Many of the sections of the Lead In Construction Work standard are not required when using the "Peel Away" method because of the low air monitoring test results.

Recommendations:

1. Clean up falling debris from removal process before it looses its moisture and dries. Cleaning up dry material can create a dust hazard.

2. Keep employees elevated so work will remain at chest height during the removal process. This minimizes the need for personal protective equipment to only forearm lenght gloves. Above the head work may require an apron and face shield along with gloves.

3. Educate the employees on the hazards of the "Peel Away" product such as causing burns to the skin. The material is 90% caustic. Even though it is diluted with water, skin irritation can develop. Use the information on the material safety date sheet (MSDS) for guidance in this area.

Request No.: 451279657
Company: Kennedy Institute
Survey Date: June 9, 1986

4. Use this report as your written record of initial determination as required by the MOSH Lead in Construction Work standard.

It is hoped that the survey and report will assist you in your work with the Lead Poisoning Clinic. Attached are employee hazards noted during the survey relating to the lead standard. Thank you for the cooperation extended to me on my visits.

APPENDIX E: WASTE-WATER LEAD LEVELS AND TREATMENT PROCEDURES

TEST RESULTS AND OUTLINE OF WASTE WATER TREATMENT PROCEDURES USED AT TRACE METALS LABORATORY KENNEDY INSTITUTE

#1 - Original wash solution from water vacuum ~.5m Acetic Acid

pH 4.5 <u>840 ppm Pb</u>

#2 - <u>Supernatant</u> from first OH^- precipitation

pH 4.5 to 10.7 <u>15 ppm Pb</u>

#2 SN split

#3 - SN from second OH^-
pptn. of #2 SN
pH 10.7 to 11.25
<u>4. ppm Pb</u>

#4 - SN from a parallel OH^-
pptn of #2 SN
pH 10.7 to 11.85
<u>7. ppm Pb</u>

Note: higher pH --> higher Pb

#5 - SN from first $PO_4^{\equiv}$ pptn
Orig. wash made just pH 5.8 with NaOH then
$PO_4^{\equiv}$ RGT added.
RGT = .5 m NaOH + .5 m KH_2PO_4
$PO_4^{\equiv}$ added = 14 X Pb^{++} in SN to pH 5.9
but certainly $Pb_3(PO_4)_2$ was not only ppt formed
<u>6 ppm Pb</u>

#6 - SN from second $PO_4^{\equiv}$ pptn of #5 SN
pH 5.9 to 6.1
$[PO_4^{\equiv}]$ = 230 X $[Pb^{++}]$ in SN5

<u>< 1ppm Pb</u>

NOTE: In neither procedure does combining of pptn steps produce same results; separation of first ppt from SN appears necessary.

RESULTS OF TWO WASTE-WATER TREATMENT PROCEDURES FOR LIQUID WASTE FROM THE "PEEL AWAY" METHOD OF ABATEMENT

(Testing done by Baltimore County Division of Pollution Control)

SAMPLE	CADMIUM milligram/liter (ppm)	CHROMIUM milligram/liter (ppm)	LEAD milligram/liter (ppm)
Original Waste Water	0.62	0.21	1005
Supernatant from Sodium Hydroxide (NaOH)Precipitation	0.48	0.23	660
Centrifugate from 1st NaOH Precipitation (pH 10.2)	0.12	0.09	14.4
Centrifugate from 2nd NaOH Precipitation (pH 10.7 to 11.9)	0.12	0.07	6.8
Centrifugate from 2nd NaOH Precipitation (pH 10.7 to 11.2)	0.11	0.07	3.3 *
Supernatant from Phosphoric Acid (PO_4) Precipitation **	0.50	0.45	750
Centrifugate from 1st PO_4 Precipitation	0.15	0.06	5.9
Centrifugate from 2nd PO_4 Precipitation	0.14	0.05	0.67 *

* Concentration is less than extraction process (EP) toxicity level of 5 ppm

** Original waste-water made pH 5.8 with NaOH then PO_4 reagent was added. See page E-2 for details.

APPENDIX F: WORKER BLOOD LEAD LEVELS

DATE	HEMATOCRIT	FREE ERYTHROCYTE PROTOPORPHYRIN	BLOOD LEVEL CONCENTRATION
	(%)	(micrograms per deciliter of red blood cells)	(micrograms per deciliter whole blood)
WORKER 1			
12/9/86	33	188	18,19
12/19/87	36	167	16,17
5/19/87	36	172	12,14
6/12/87	37	203	17,19
WORKER 2			
12/9/86	45	73	21,19
2/16/87	45	60	19,20
5/19/87	44	70	20,21
WORKER 3			
5/19/87	48	60	15,16
6/12/87	48	60	21,22

APPENDIX G: BALTIMORE CITY ABATEMENT REGULATIONS FOR LEAD PAINT

HABC

ABATEMENT REGULATIONS

FOR

LEAD PAINT

July 1, 1987

CITY OF BALTIMORE

CLARENCE "DU" BURNS, Mayor

RULES AND REGULATIONS GOVERNING HOUSING

Pursuant to the power conferred upon the Committee composed of the Commissioner of Housing and Community Development, the Chief of the Fire Department, the Commissioner of Health, and a member of the City Council by Sections 401 and 402 of Article 13 of the Baltimore City Code (1983 Replacement Volume), the following rule and regulation is deemed proper and necessary for the enforcement of Sections 101 and 104 of Article 11 of the Baltimore City Code and "The Housing Code of Baltimore City" (Baltimore City Code, 1983 Replacement Volume) and for the protection of the health of the inhabitants of the City of Baltimore, and is hereby adopted:

Regulation 5. Lead-Based Paint Abatement

I. Definitions

In this regulation, certain words, terms and phrases, and their derivatives shall be construed and given the meaning specified below:

1) abate/abatement - shall mean the appropriate reduction of, removal of, or encapsulation of lead followed by thorough clean-up and post clean-up treatment of the surfaces and sources that promote exposure resulting in the possibility of lead toxicity or poisoning.

2) child/children - shall mean a person under age six (6).

3) Commissioner - shall mean the Commissioner of the Baltimore City Health Departement or his/her designee.

4) Department - shall mean the Baltimore City Health Department.

5) elevated blood lead (EBL) - shall mean excessive absorption of lead in the blood in concentrations defined as an elevated blood lead level in children by the Centers for Disease Control (CDC) of the United States Department of Health and Human Services, as that definition may be revised in the future by the CDC.

6) environmental inspection - shall mean a survey of a property, conducted by the Commissioner or Department, to determine the presence of any or certain health hazards.

7) health hazard - shall mean a condition, as determined by the Commissioner, posing a threat to the welfare, safety and health of any individual, the general public or certain populations thereof.

8) lead-based paint - shall mean paint, varnish, shellac or similar coating containing more than 0.06% of lead in the final dried solid.

9) lead-based paint violation - shall mean (a) the violation of any state or local law regulation concerning lead-based paint, or (b) the presence of lead-based paint on the interior or exterior surfaces of any property or on any toy, appliance, item of furniture or other household item that is easily accessible to a child; or that is cracking, peeling, chipping, blistering, or flaking or is in an otherwise deteriorated condition; or that is chalking so that the lead dust generated therefrom is determined by the Commissioner to pose a health hazard; or that is present on surfaces defined as woodwork or woodtrim.

10) lead dust - shall mean dust containing lead, generated by the deterioration of lead-based paint or by environmental factors.

11) owner - shall mean any person, firm, corporation, guardian, conservator, receiver, trustee, executor, or other judicial officer, who, alone or jointly or severally with others, owns, holds, or controls the whole, or any part, of the freehold or leasehold title to any property, with or without accompanying actual possession thereof, and shall include in addition to the holder of legal title, any vendee in possession thereof, but shall not include a mortgagee or an owner of a reversionary interest under a ground rent lease. In the case of a toy, appliance, item of furniture or other household item which is the property of a tenant, the term "owner" shall mean tenant for the sole purpose of the abatement of a lead-based paint violation existing thereon.

12) secondary residence - shall mean a caretaker's home, day care center, or other dwelling, institution or property frequented by an EBL child.

13) surface that is easily accessible to a child - shall mean the interior, exterior or other surface of a dwelling or secondary residence that presents a potential biting surface (up to 4 feet in height and 4 inches in depth) to a child.

14) woodwork or woodtrim - shall mean all wooden or metal interior fittings or ornamentation, such as moldings, doors, staircases and window sashes and trim; and all such exterior surfaces easily accesible to a child.

6-3

II. Procedures related to the identification of an EBL child

A. In the event a child has been identified as having an elevated blood lead (EBL) level, the Commissioner shall request the Department to conduct an environmental inspection of the child's dwelling and/or secondary residence. If a lead-based paint violation is found, the Commissioner shall issue a notice requiring the abatement of the violation by the owner in conformance with this regulation.

III. Procedures related to the issuance of an order to abate

A. In the event the Commissioner determines the existence of a lead-based paint violation, the Commissioner shall notify the owner of the property of the existence of the lead-based paint violation and order the abatement of such violation within a specified time of the receipt of the notice, not to exceed 30 days unless otherwise ordered by the Commissioner. Such violations shall be abated in conformance with the standards set forth in Section IV below.

B. To determine the existence of a lead-based paint violation, the Commissioner shall request the Department to conduct an environmental inspection of the property, to include common areas of multi-family dwellings. A rebuttable presumption of the presence of lead-based paint shall be based on one or more of the following:

1) readings of the X-RF analyzer taken during the environmental inspection which indicate a lead content greater than 0.7 mg/cm^2;

2) analysis of paint samples taken during the environmental inspection indicating more than 0.5% lead;

3) analysis of dust samples taken during the environmental inspection which indicate the existence of a health hazard as determined by the Commissioner.

C. In the event the environmental inspection results in the determination that lead dust is present in any dwelling or secondary residence, but that a lead-based paint violation does not exist, the Commissioner may require that the dwelling or secondary residence be cleaned in conformance with Section IV, Subsection B.6. below.

IV. Standards for abatement

The minimum mandatory standards for every abatement of a lead-based paint violation, whether or not that abatement is being carried out in response to a notice issued by the Commissioner, an agency of government, a court, or voluntarily, are as follows:

A. Posting of dwelling or secondary residence under abatement

1. A person engaged in the abatement of a lead-based paint violation shall post 20 inch by 14 inch caution signs immediately inside the entrances and exits of a dwelling or secondary residence under abatement. Such signs shall be conspicuously placed and shall inform persons entering or exiting the property that an abatement of a lead-based paint violation will be or is being performed.

2. Except in emergency situations, signs shall be posted at least three days in advance of commencing the abatement project.

3. Such signs shall remain posted until the Department issues a written notice in conformance with Section V, Subsection C below to the owner.

B. Methods of Abatement

Abatement of a lead-based paint violation includes all of the following: removal of lead-based paint, encapsulation of lead-based paint, or replacement of surfaces containing lead-based paint; thorough clean-up; and post clean-up treatment of surfaces (including floors). Abatement must be carried out in conformance with the following:

1. General

a. If the surface requiring abatement is subject to a Baltimore City Code violaton or is found to be in violation of the Baltimore City Code, the violation must be corrected prior to the abatement of the lead-based paint violation, unless the Commissioner determines that the correction of the violation is more appropriate after the abatement process.

b. Work shall be done in progression through the dwelling or secondary residence beginning with the area farthest from the entrance. In a multi-story dwelling or secondary residence, work shall begin on the uppermost floor in the area farthest from the stairway.

c. Furnishings, including wall-to-wall carpeting, must be removed from each room or area as it is prepared for abatement. Those furnishings that cannot be moved (e.g., built-in furniture) must be covered with plastic at least 6 mils. thick and sealed with tape. Furnishings should be thoroughly cleaned to remove lead dust before returning them to a room that has undergone abatement.

d. Each area that is to be abated shall be sealed with plastic at least 6 mils. thick and tape prior to abatement in order to contain the lead dust and abatement residue.

e. Sanding and use of an open flame torch and chemical strippers containing methylene chloride are prohibited abatement techniques. Methylene chloride based strippers may be used, if necessary, in small quantities as a final touch-up method.

f. All cabinets, closets and drawers must be sealed with tape so as to prevent contamination by lead dust and/or lead particles.

g. In the case of a rental property, the tenant is responsible for the removal of all ingestibles from any room or area under abatement prior to the commencement of the abatement.

h. The entire floor of the work area shall be covered with plastic at least 6 mils. thick, and all seams and edges secured with tape or staples.

i. All abated surfaces must be inspected by the Department prior to the painting or coating of said surfaces. Such inspections will be completed within a reasonable timeframe.

Walls/ceilings

a. If the defective area of a wall or ceiling surface is localized, only the defective area should be scraped and repaired to create a smooth surface. The entire wall or ceiling (not simply the defective area) must then be repainted with a paint containing less than 0.06% lead in the final dried state, after (1) a Departmental inspection in conformance with Subsection 1.i. above, and (2) performing a clean-up in conformance with Subsection 6 below.

b. If the wall or ceiling condition is determined by the Department to be unsuitable for repainting, covering with fiberglass, vinyl, sheetrock and/or any type of paneling or other covering which seals the seams and edges will be satisfactory.

3. Woodwork and woodtrim

a. Approved methods are replacement, covering with new wood with sealed or caulked seams, and/or paint removal using a heatgun or chemical strippers not containing methylene chloride. Methylene chloride based strippers may be used, if necessary, in small quantities as a final touch-up method. Off-site chemical stripping of woodwork or woodtrim is also acceptable.

b. All abated surfaces must be repainted with paint containing less than 0.06% lead in the final dried state, after (1) a Departmental inspection in conformance with Subsection 1.i. above, and (2) performing a clean-up in conformance with Subsection 6 below.

4. Windows

a. Acceptable methods are replacement window units and/or removal of lead-based paint by use of heatgun or chemical strippers not containing methylene chloride. Methylene chloride based strippers may be used, if necessary, in small quantities as a final touch-up method. Replacement window slides may be used on sides of the existing frame.

b. Windows must be completely abated, including inside, outside, and sides of sashes; window frames must be abated to the outside edge of the frame, including slides, sash guides and window wells.

c. All abated surfaces must be repainted with paint containing less than 0.06% lead in the final dried state, after (1) a Departmental inspection in conformance with Subsection 1.i. above, and (2) performing a clean-up in conformance with Subsection 6 below.

5. Floors

a. Floors coated with lead-based paint must be encapsulated using vinyl tile or linoleum flooring. Upon written request from the owner, the Commissioner may consider other appropriate means of abating floor surfaces.

b. After clean-up of the entire work area in conformance with Subsection 6 below, all floors, stair treads and risers must be sealed using polyurethene, deck enamel or the equivalent. As an alternative, vinyl tile, linoleum flooring, or the equivalent may be used.

c. Floors, already covered with intact vinyl tile, linoleum flooring, or the equivalent need only be cleaned in conformance with Subsection 6 below.

6. Clean-up

a. At the end of each workday, rooms or areas in which abatement is incomplete shall be thoroughly cleaned in conformance with this subsection, or properly sealed from the remainder of the dwelling or secondary residence.

b. Before unsealing each room or area, it should be thoroughly cleaned, inspected by the Department within a reasonable timeframe, surfaces recoated, and then cleaned again. Once a room or area has received clean-up, it should not be re-entered by workmen.

c. At a minimum, the first clean-up should consist of a thorough High Efficiency Particle Accumulator (HEPA) vacuuming of all surfaces, including woodwork and woodtrim, walls, ceilings, windows and window wells, and floors, followed by a high phosphate wash and a second HEPA vacuuming. After repainting or coating walls, woodwork and woodtrim, ceilings, windows, and floors, the clean-up process should be repeated.

d. In the absence of a HEPA vacuum, two thorough wet washings with a high phosphate wash, with frequent changes of water, each followed by a wet vacuuming while surfaces are still wet followed by two additional such treatments after repainting or coating; will be considered satisfactory.

e. Use of an ordinary household vacuum for clean-up of abatement debris is prohibited. Sweeping should be limited to preliminary cleanings only.

f. All sponges, rags, mopheads and other materials used in clean-up must be properly disposed of along with other abatement debris.

C. Presence of occupants during abatement

1. The Commissioner shall exercise his/her best efforts to instruct the occupants of the dwelling or secondary residence of the health hazards associated with the abatement procedures. All occupants must be out of the work area while abatement is underway.

2. Children and pregnant women are specifically prohibited from entering and/or remaining in a dwelling or secondary residence at any time during the abatement process, including times when work is not in progress. These persons should not return to the dwelling or secondary residence until such time as the Commissioner determines that abatement has been completed in a satisfactory manner.

D. Safety of workers

1. Persons carrying out abatement activities must comply with all applicable federal, state, and local laws and/or regulations related to safety in the workplace.

E. Disposal of abatement waste

1. Disposal of waste generated in the course of the abatement process shall be in compliance with Hazardous Waste Small Quantity Generators regulations as required by COMAR 10.51.03. Lead waste subject to COMAR 10.51.03 shall be removed from the site not later than seven days after completing the abatement. Lead waste not subject to COMAR 10.51.03 shall be removed from the site not later than twenty-four hours after completing the abatement.

2. Lead abatement waste shall be transported and disposed of in a manner to prevent lead from becoming airborne.

3. If disposal of lead waste is within the State of Maryland, disposal facilities authorized for that purpose shall be used.

4. In no event shall such waste be disposed of through regular residential or commercial trash collection.

F. Exemptions

1. The Commissioner may, on a case-by-case basis, approve an alternative procedure for abatement of a lead-based paint violation, provided that the owner submits a written description of the alternative procedure to the Commissioner and demonstrates to the satisfaction of the Commissioner that compliance with this regulation is not practical or feasible, or that the proposed alternative procedure provides the equivalent control and removal. The Commissioner, following his/her review, may approve an alternative procedure if he/she determines that it will minimize the emissions of lead into the environment.

V. Procedures related to inspection of the abatement

A. The Commissioner may inspect any dwelling or secondary residence at any time during the abatement to determine compliance with abatement standards.

B. When the abatement has been completed, the Commissioner shall perform a follow-up environmental inspection to determine if the abatement has been completed in conformance with this regulation. This determination shall be made based on one or more of the following:

1) reading of the X-RF analyzer;
2) dust sample analysis;
3) analysis of paint samples.

If a visual inspection of the property by a bonafide employed inspector of the Department discloses that the abatement was not carried out in conformance with this regulation, further abatement action may be required.

C. If abatement is determined to have been in compliance with any notice to abate and in conformance with this regulation, the Commissioner shall issue a written statement to the owner that the lead-based paint violation notice has been abated. Such statement shall not preclude the Commissioner from issuing future notices of lead-based paint violations against the same dwelling or secondary residence. The owner has a continuing obligation to maintain the dwelling or secondary residence in accordance with this regulation.

D. At the conclusion of an abatement performed under proper permit from the City of Baltimore, the final sign-off of the permit by the proper authority shall indicate that, to the best of the Department's ability to determine, the abatement was performed in conformance with this regulation.

VI. Liability of the Department

A. The issuance of a statement by the Commissioner to an owner that a lead-based paint violation notice has been abated does not subject the Commissioner or the Department to any claims for liablity if the issuance of the statement was made in good faith.

VII. Penalties

A. Any violation of this regulation shall be deemed a violation of the Baltimore City Housing Code and violators shall be subject to any and all penalties set forth therein.

VIII. Severability

A. The provisions of this regulation are hereby declared severable. If any word, phrase, clause, sentence, paragraph, section or part in or of this regulation or the application thereof to any person, circumstance or thing is declared invalid for any reason whatsoever, the remaining provisions and the application of such provisions to other persons, circumstances or things shall not be affected thereby but shall remain in full force and effect, the Committee hereby declaring that it would have ordained the remaining provisions of this regulation without the word, phrase, clause, sentence, paragraph, section or part, or the application therof, so held invalid.

Approved:

Marion W. Pines
Commissioner
Neighborhood Progress Administration/
Department of Housing and Community Development

Peter J. O'Connor
Chief
Fire Department

Susan R. Guarnieri, M.D.
Commissioner
Health Department

Martin E. "Mike" Curran
Member
City Council of Baltimore

Date adopted: 24 June 1987

Date effective: 1 July 1987

Baltimore
Integrated Environmental Management Project

Phase II Report:

Reducing the Hazards from Abatement of Lead Paint

Part 2 -- Benefits and Costs of Alternative Abatement Practices

Prepared by:

Elliott Hamilton
Regulatory Integration Division
U.S. Environmental Protection Agency

1987

TABLE OF CONTENTS - Part 2

LIST OF TABLES AND FIGURES

Chapter 1

PURPOSE AND RATIONALE FOR STUDY

This study estimates the benefits and costs of using improved techiques for removing lead paint in houses. Lead poisoning remains a serious problem for children and some adults. In children, it has long-term effects on the nervous system, interferes with learning ability, damages the kidneys, and causes blood disorders. In adults, it has reproductive effects and neurological effects, and leads to higher blood pressure and hypertension. Fetuses are extremely sensitive to lead's toxic effects due to their rapidly developing nervous system (CDC, 1985).

The main source of lead poisoning in children is paint in older homes. Virtually all cases of lead poisoning occur in children who live in old, deteriorated houses that were built and painted years ago when the use of lead-based paints on housing surfaces was widespread.

The paint in most homes built during the first half of this century contains up to 40%-60% lead. It is estimated that over 191,000 dwelling units in Baltimore City have lead paint hazards. Expensive older homes are also potential sources of poisoning. Many of these homes were painted with layers of heavily leaded paint. Renovations and remodeling and simple deterioration over time cause lead poisoning through the lead fumes and lead dust produced.

Although the condition of the painted surface is of some importance in predicting risk, the paint need not be visibly peeling or chewed on by the child to be hazardous. With age, the surface of leaded paint starts to deteriorate and gives off fine dust that is incorporated with the general house dust. This inevitably becomes carried on the hands of children to their mouths through food, toys, or normal hand-to-mouth activities. The entire home, therefore, may be rendered hazardous (Maryland Department of Health and Mental Hygiene, 1984).

Baltimore City regulations require abatements when there is evidence of chipping or flaking paint containing more than 7 mg/cm^2 of lead on any surface, or where paint is deteriorating on easily accessible biting surfaces. Houses are only inspected for lead hazards once a child is identified as being lead poisoned.

Traditional abatement methods used in Baltimore are open-flame burning, scraping, and/or sanding. The abatements are limited to 4 feet high on the walls and wood work. There is usually minimal cleanup and no repainting of wood surfaces.

Evidence developed at the Kennedy Institute in Baltimore showed that traditional abatements often leave a house with greatly increased surface dust-lead levels (typically 10 - 100 fold) and increased blood-lead levels in children residing in abated homes.

For this reason, the Kennedy Institute developed new techniques to make an abated house as safe as a house without lead paint, to protect the workers doing the abatements, and to perform the abatements at a reasonable cost. These improved abatement techniques include:

- paint removal that does not create or leave behind fine lead bearing particulates;
- better cleanup measures, including the use of high-efficiency particle-accumulator vacuums;
- sealing or covering walls and floors;
- stripping wood trim and doors off-site;
- repainting abated surfaces with lead-free paint;
- containment and proper disposal of lead debris; and
- worker training and protection.

Three previous lead studies conducted in Baltimore help to derive the benefits of better abatement techniques:

Farfel (1987a) found increased house dust lead levels and increased blood lead levels of children attributable to traditional abatement techniques. Chisolm et. al. (1985) found abated houses to be significantly associated with recurrences of blood-lead levels in children greater than 49 ug/dl. Charney et. al. (1983) found that dust control measures in abated houses led to a decrease in blood lead levels of children. A more in-depth examination and significance of these studies is in Chapter 6.

This study estimates the benefits and costs of improved techniques for removing lead paint in houses. We report the health benefits for children and adults both as avoided health effects and avoided medical and other costs. We also report nonhealth benefits that result from improved abatement techniques. Since better abated houses should also not expose future occupants to the danger of lead paint, this study will estimate both the immediate and future benefits of the improved abatements.

We use Baltimore City-specific data when available. Otherwise, we use data from other cities' or national data.

We rely mainly on previous EPA studies concerning the health effects of lead. This study is not meant to present a compendium of the health effects of lead. It is only a summary of the health effects highlighted in the literature as being important and quantifiable. An interested reader should go to the following EPA studies for further information concerning lead's health effects:

- Air Quality Criteria for Lead EPA Office of Research and Development (1986)

- Costs and Benefits of Reducing Lead in Gasoline; EPA Office of Policy Analysis, Schwartz (1985)

- Reducing Lead in Drinking Water: A Benefit Analysis; EPA Office of Policy Analysis, Levin (1986)

- Review of the National Ambient Air Quality Standards for Lead: Assessment of Scientific and Technical Information, EPA Office of Air and Radiation (1986)

- Health Score Evaluation for Pollutants in the Santa Clara Valley Project: Inorganic Lead; EPA Office of Policy Analysis, Perlin (1986)

Chapter 2

BASELINE INFORMATION FOR BALTIMORE CITY

A baseline for Baltimore City serves as the level of activities and facts against which to measure the benefits and costs of better abatement techniques. Unless otherwise noted, we used historical data to establish the baseline of information in the following categories:

- Number of lead poisonings per year by class type and hospitalizations
- Number of abatements per year
- Demographics of persons living in abated houses
- Average blood lead levels of children and adults

A Significant Number of Lead Poisonings Occur in Baltimore City Every Year

The CDC defines lead poisoning in children as a blood lead level greater than 25 micrograms per deciliter (ug/dl). Baltimore City adopted this level in 1986 for its reporting purposes. Previously, lead poisoning was defined at 30 ug/dl.

Table 2-1 shows the classification of affected children for priority medical evaluation, with Class IV the most serious. Class levels are determined by both the blood lead level and by the erythrocyte protoporphyrin (EP) level in the blood. Class I children are classified as being at low risk. Class II children are classified as being at medium risk. Abatements are usually required for Class II children, and periodic screening is recommended. Class III and IV children are classified as being at high to urgent risk. Abatements and chelation therapy are usually required at these levels.

Approximately 32,000 screening tests for lead poisoning are done annually in Baltimore by various clinics, with an unknown number being repeat tests. The Baltimore City Health Department estimates that these screenings cover about 20% of Baltimore City's children "at risk" (children aged 1-6 years living in dilapidated housing) (Maryland Dept. of Health and Mental Hygiene, 1984).

Table 2-1

CDC Risk Classification Classes

Erythrocyte Protoporphyrin (EP) by Extraction

Risk Classification of Asymptomatic Children for Priority Medical Evaluation

Blood Lead #	Erythrocyte Protoporphyrin (EP) #			
	<35	35-109	110-249	>250
Not done	I	*	*	*
<24	I	Ia	Ia	EPP+
25-49	Ib	II	III	III
50-69	**	III	III	IV
>70	**	**	IV	IV

\# = Units are in μg/dl of whole blood.
* = Blood lead test needed to estimate risk.
EPP+ = Erythropoietic protoporphyria. Iron deficiency may cause elevated EP levels up to 300 μg/dl, but this is rare.
** = In practice, this combination of results is not generally observed; if it is observed, immediately retest with venous blood.

NOTE: Diagnostic evaluation is more urgent than the classification indicates for—

1. Children with any symptoms compatible with lead toxicity.
2. Children under 36 months of age.
3. Children whose blood lead and EP levels place them in the upper part of a particular class.
4. Children whose siblings are in a higher class.

These guidelines refer to the interpretation of screening results, but the final diagnosis and disposition rest on a more complete medical and laboratory examination of the child.

Source: CDC 1985

Erythrocyte protoporphyrin (EP) is the protoporphyrin found in the red blood cells. Protoporphyrin is an intermediate product in the production of heme, which is a critical component in the formation of normal hemoglobin and other hemoproteins that affect cellular respiration and energetics. Lead inhibits at least two enzymes which are necessary for the synthesis of heme, causing a buildup of intermediate products in the blood and urine. Lead may also interfere with the entry of iron into the mitochondria, where iron is joined with protoporphyrin to make heme. (Perlin, 1986)

Table 2-2 projects 600 annual cases of lead poisoned children. This projection is based on the new reporting procedures beginning with 1986 data and preliminary 1987 data. These cases are broken down by class type based on newly diagnosed cases and requirement of hospitalization, as reported by the Baltimore City Health Department. The table is broken down into new hospitalizations or readmissions. This breakdown reveals whether the child is having the first chelation or a repeat treatment.

Chelation therapy consists of the administration of two drugs, calcium disodium EDTA and penicillamine, orally and by injection. These drugs act as chelating agents -- that is, they bind with metals, in the body. The metals are then excreted in the urine. Because the chelation agents also bind with other metals, the children are given iron, zinc, and copper, together with multivitamins, to replace the essential metals lost through the therapy. The therapy normally takes three weeks, with the chelating drugs administered daily. The children are tested weekly during the therapy to monitor their progress.

Table 2-2

Baseline Information for Baltimore City

	Projected annual	1981	1982	1983	1984	1985	1986
Abatements[1]	350	235	369	466	241	362	176
Lead poisonings[2]	600[2]	180	528	242	249	290	649
- Class II[3]	537[2]	58	381	172	222	241	611
- Class III[3]	56	43	138	56	23	43	32
- Class IV[3]	7	7	9	9	4	6	6
Hospitalizations[4]	128	93	111	103	153	156	101
- New	80	NA*	NA	76	86	90	69
- Readmissions	48	NA	NA	27	67	66	32

* Not Available

Notes:

1 The number of abatements are what the city required and does not reflect any voluntary abatements. Some abatements are also done on secondary residences of the lead-poisoned child, such as relatives' houses.

No average was taken due to the unusually low number of abatements in 1986, which we believe is not an accurate reflection of future activities. Baltimore City became more hesitant to require abatements after evidence showed that abatements may increase the lead exposure. If safer abatements were available, then more abatements would be required than currently.

2 No average was taken due to changing definitions. From 1981 to 1985, lead poisoning was defined in Baltimore City at 30 ug/dl. In 1986, the lead poisoning definition was lowered to 25 ug/dl as suggested by guidelines from the CDC. Preliminary data for 1987 show that the number of lead poisonings will continue in the 600 range, including greater numbers of Class II types. It is not clear why there was such a high number of reported lead poisonings in 1982.

3 Class types are for newly diagnosed cases, and does not reflect more serious Class levels a person may reach.

4 An average was taken from 1983 to 1986 due to data not being available for new hospitalizations or readmissions in 1981 and 1982. Chapter 4 explains our estimates of "new" and "readmissions."

Very Few Traditional Abatements Are Projected for Future Years

Table 2-2 shows the number of abatements done in Baltimore City for the past six years as reported by the Baltimore City Health Department. We project 350 yearly abatements as the figure expected in the future, which is approximately the average number of abatements from 1981 to 1985. We are not using 1986 data because they do not accurately reflect future activities. The 1986 figure is unusually low due to Baltimore City's being hesitant to require abatements after evidence showed that traditional abatements may actually increase the lead exposure. If safer abatement techniques were available, the Baltimore City Health Department would be likely to require more abatements.[1]

We Assume Specific Demographics for People in Abated Houses

Virtually all of Maryland's reported lead poisonings and hospitalizations occur in Baltimore City. Data from the Baltimore City Health Department show that almost all lead poisoning cases and hospitalizations are for children between the ages of 1 and 6 years from low-income families. Screening is not done for children older than 6, because they generally have less exposure to lead. However, we cannot conclude that lead poisoning does not occur in older children.

No data are available on the number of adults or children living in abated houses. Further, there is no information on how many of the lead-poisoned children come from the same household. Anecdotal information tells of 3 families having 27 hospitalizations in 1984, and in 1986, 2 siblings having 10 hospitalizations between them. Using data from the 1980 Census of Population of Housing for the Baltimore SMSA, we assumed two adults, one male and one female, live in an abated house, two "at risk" children currently live in an abated house, and from two to six additional "at risk" children will live in an abated house over the next 20 years (the time period assumed in this study).

Data on Blood Lead Levels in Baltimore Are Lacking

No specific data are reported on the blood-lead levels of Baltimore City adults and children, except for the identified lead-poisoned children. National data on blood-lead levels are available from the second National Health and Nutrition Examination Survey 1976-1980 (NHANES II) study. The data show that the average blood-lead levels (ug/dl) for black adult males, females,

1 Communication with Jerome Troy of the Lead Program of the Baltimore City Health Department, July 1987.

preschool age children, and older children are 17.4, 11.8, 20.8, and 14.6, respectively. Later in this report we assume a range of 10-25 for adults.

Several Major Assumptions Underlie This Study's Benefits and Cost Calculations

We use the following assumptions to calculate the benefits and costs of improved abatement techniques.

- 128 annual hospitalizations for chelation therapy: 80 for the first time, and 48 for any repeated time. (See Chapter 4 for an explanation of the derivation of these key baseline data.)

- 350 annual abatements.

- two "at risk" (from 1 to 6 years old) children currently live in each abated house.

- children currently living in houses abated with improved techniques will have approximately a 10 ug/dl decrease in blood lead levels.

- from two to six "at risk" children will live in better abated houses over the next 20 years.

- children living in houses abated with improved techniques in the future will avoid an approximately 25 ug/dl increase in blood lead levels.

- 3 years of compensatory education is needed by learning-disabled children.

- 1 male and 1 female adult per household.

- adults living in houses abated with improved techniques will have a 5-8 ug/dl decrease in blood-lead levels.

- a traditional abatement costs $1,000; a better abatement, $5,000.

- a 3% discount factor and a 20-year time period for benefits.

- benefits accrue at the beginning of a year. For example, 20 years of benefits from energy-efficient windows consist of savings today (year 0) plus 19 years; for education, assuming a 3 year-old receives 3 years of special education upon entering school at age 5, the future benefits occur in years 5, 6, and 7.

Additional assumptions will be noted in the text when used. Chapter 10 provides a sensitivity analysis of the cost of better abatements and the discount rate.

Chapter 3

COSTS OF ABATEMENTS

This study assumes that better abatement techniques cost, on average, $4,000 more per abatement than traditional techniques for a six-room, two-story rowhouse. The following costs for traditional and better abatement techniques are used to derive the marginal cost.

The Range of Costs for Traditional Abatements is Broad

This study uses $1,000 as the cost of a traditional abatement, based upon cost data in the literature and from limited Baltimore City data.

Data on costs of traditional abatements done in Baltimore City are limited and of variable quality, as also noted by Farfel (1987a). Berwick and Komaroff (1982) report that the costs for correcting only peeling and chipping lead paint hazards can range from $200 to $2,000 in 1987. In 1984, Baltimore City estimated that the average cost of abatements done by the City was $800, not including repainting (Maryland Department of Health and Mental Hygiene (1984).

The wide range in cost is due to several factors. One is that there are many types of traditional abatement techniques (open-flame burning, scraping or sanding) with varying cost. Another is that houses vary widely by size and degree of abatement needed. A third factor is that property owners with many rental units may have their own maintenance crews doing the abatements.

Better Abatements Are More Expensive

This study uses $5,000 as the average cost expected for the better abatement techniques, based upon cost information provided by Farfel (1987b).[1]

Complete cost information is not available on the better abatement techniques. Partial cost information for 4 houses abated by the better techniques are $2,759, $3,386, $5,810 and $6,285. Farfel reports that the $6,285 figure is not an expected cost of an

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1 For more information on the improved abatement techniques and their costs, please see the comparison report to this study. Pilot Lead-Paint and Lead-Dust Abatement Project, Farfel (1987b).

improved abatement, because of first-time use of an experimental technique. The $5,810 includes costs of floor treatments, and rehanging the trim, and painting. None of the four estimates includes cleanup costs. Thus, actual costs may be somewhat higher, but not markedly so.

Alternatively, the cost of improved abatements may be lower than $5,000 if the abatements are done in conjunction with general renovation of the dwelling. Then the floor treatments window replacement, and cleanup procedures that are done for the improved abatements would be done anyway and, thus, not be considered as costs of the improved abatement techniques.

One must also note that the costs are for experimentally abated houses. Future costs should be lower than these. One reason is that the techniques are being revised for better efficiency and performance. Another reason is that the techniques are new to the workers doing the abatements.

We conducted alternative analysis of the improved abatement techniques, assuming they cost $1,500 and $6,000 more than traditional techniques. Results are presented in Chapter 10.

Chapter 4

REDUCTIONS IN BLOOD-LEAD LEVELS ASSUMED WITH IMPROVED ABATEMENT TECHNIQUES

Occupants of houses abated with improved techniques should have lower blood-lead levels than occupants of traditionally abated houses. We assume the efficacy of the better abatement techniques (described in Farfel's accompanying report) in reducing residual dust lead levels to those of a lead-free house. Consequently, we estimate children currently living in abated houses would experience approximately a 10 ug/dl decrease, and children living in these houses in the future would avoid approximately a 25 ug/dl increase in blood-lead levels. We estimate adults would experience approximately a 5-8 ug/dl decrease in blood-lead levels due to improved abatement techniques.

This chapter explains how we determined these estimates. Chapters 5 and 6 then use these estimates of lower blood lead levels as the basis for estimating the health problems avoided.

Children Living in Lead-Painted Houses Have High Blood-Lead Levels

This study uses previous studies of children's residences to estimate changes in blood-lead levels that may be associated with traditional and improved abatement techniques.

One technique used in the improved abatement techniques is better floor coverings to ease cleaning. Charney et. al. (1983) found that repeated dust control measures over a one-year period reduced children's lead levels by approximately 6 ug/dl in traditionally abated houses. Measures included wet washing surfaces with high phosphate detergent and standard vacuuming. Charney's study suggests that using better floor coverings, or sealing floors for easier cleaning as a part of better abatements, may help reduce dust-lead levels.

As shown in Table 4-1, Chisolm et. al (1985) found that blood-lead levels after 24-30 months for children already chelated and sent back to traditionally abated houses were approximately 38-35 ug/dl, while those for children sent back to houses free of lead paint were approximately 29-25 ug/dl.

Table 4-1

Children's Median Blood-Lead Levels (ug/dl) After Chelation Therapy by Housing Type[1]

Housing Type	Blood-lead levels after: 6 months	(N)*	24-30 months	(N)*
Incompletely abated	55	(59)	52.9[1]	(3)
Abated by City guidelines[2]	38	(93)	34.4	(70)
Homes without lead paint	29	(32)	28.2	(38)

*N = Number of children.

[1] Only three children out of 59 initial children remained in incompletely abated housing after 24-30 months.

[2] In effect prior to 7/1/87. On this date, the City enacted regulations proscribing traditional abatement practices.

Source: Chisolm et. al., 1985.

Table 4-2 shows two previous lead studies matching housing type to blood-lead levels, as reported by Chisolm (1985). There is approximately a 22-25 ug/dl difference between children growing up in houses with lead paint versus houses without lead paint. As stated previously on page 2, this study assumes that the lead exposure from living in a house abated by improved techniques is equal to that of living in a house without lead paint.

Table 4-2

Median Blood Lead-Levels (ug/dl) of Children by Presence of Lead Paint in Houses

City and Year	Deteriorated houses with lead paint	Houses without lead paint
Baltimore, 1975	38	16.5
Cincinnati, 1983	35	10

Source: Chisolm et. al., 1985.

Why do children growing up in lead-free houses have blood-lead levels lower than those who receive chelation and then live in lead-free houses? The difference is due to the increased body lead burdens of previously lead poisoned children and the slow body turnover rate in bone. (Lead has a half-life of 20 years in bone.) Consequently, lead levels in poisoned children are not expected to rapidly decrease even after they receive chelation therapy and are no longer exposed to lead. Thus, children growing up in houses free of lead paint will have blood-lead levels 12-15 ug/dl lower than children that have been lead poisoned from houses with lead paint.

Based on Chisolm's study, this study attributes approximately a 10 ug/dl decrease in blood-lead levels of children currently living in houses using better abatement techniques. Further, this study assumes children who live in the future in houses abated by better techniques will avoid approximately a 25 ug/dl increase in blood lead levels.

Adults Living in Lead-Painted Houses Are Also Affected

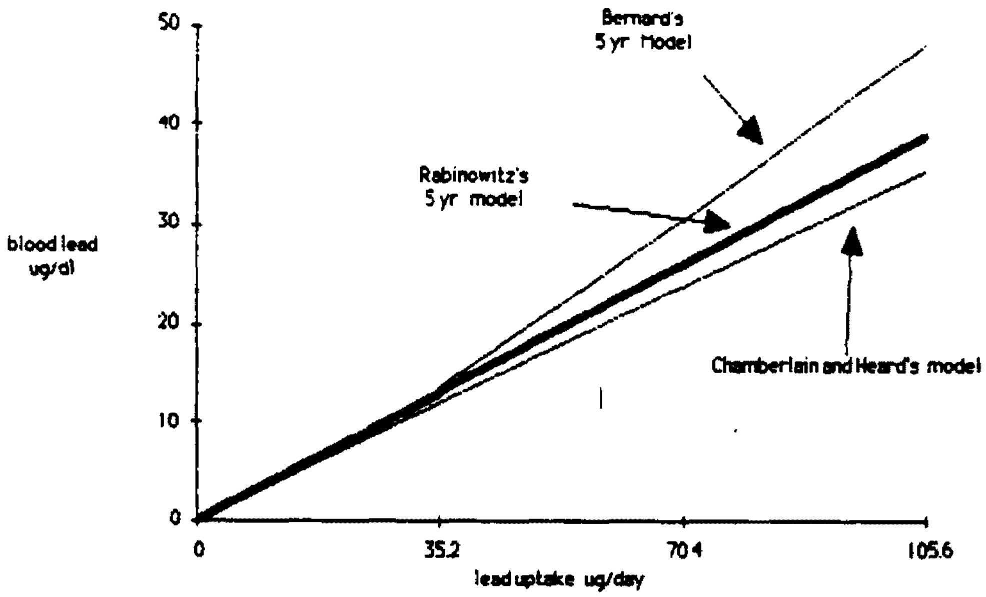
No previous studies exist that associate housing stock and adult blood lead levels. However, estimates can be made correlating the added exposure of lead dust in lead-painted houses to blood-lead levels in adult males.

EPA's Air Quality Criteria for Lead estimates that an extra 17 ug/day of lead is consumed on average by an adult male living in a lead-painted house. One approach to translate the 17 ug/day uptake of lead into blood lead to use the rate of absorption of lead dust through the gut. Using EPA's suggested coefficient of lead dust absorption of .3 gives an average of 5.1 ug/dl of added lead blood associated with adults living in houses with lead paint.

Another approach is to translate the lead uptake by using physiological modelling techniques. Figure 4-1 shows the results of three such models for adult males. Hammond et al.'s (1981, 1982) computations of Bernard (1977) and Rabinowitz et al.'s (1976) physiological models show the blood-lead levels after 5 years of lead uptake ranging from a slope of .37 to .484. Chamberlain and Heard's (1981) model is based on epidemiological data and has a constant slope of .34 (EPA, State and Air Standards Division, 1986). Based on these models, the extra 17 ug/day of lead uptake corresponds to a range of 5.1 to 8 ug/dl rise in blood-lead levels.

Figure 4-1

Adult Blood-Lead Level Associated with Lead Uptake



Source: Compiled from EPA, Office of Research and Development, 1986.

Chapter 5

ESTIMATED HEALTH BENEFITS FOR CHILDREN

Children are a high-risk group to lead's toxicity due to their high exposure and susceptibility. Children are exposed to lead more than adults are because of their increased hand-to-mouth behavior. This behavior is especially pronounced in infants and toddlers. Children below the age of 6 are also in the home more often than adults and older children, and are thus more frequently exposed to lead-bearing paint and dust. Children have a higher rate of intake of lead per body weight than adults due to their higher metabolism. In addition, children absorb lead into their blood at a faster rate than adults. A child's nutritional status is also important, as deficiencies in iron, calcium, and phosphorous may lead to a greater absorption of lead. A child is also more susceptible to lead's toxic effects due to physiological differences with their developing organs and systems (EPA, Office of Research and Development, 1986).

Table 5-1 shows the health areas and the associated methodologies used in this study to calculate benefits from better abatement techniques. We estimate that with these techniques, 55 out of our baseline of 128 hospitalizations for chelation therapy could be avoided, and 50 special education cases could be avoided. Better abatements will also reduce the incidence of blood disorders (154 cases), renal effects (91 cases), hearing loss (35 cases), and development effects. Finally, for those adverse health effects to which we are able to attribute dollar values, we estimate $1.2 million in medical costs and approximately $0.7 million in education costs are avoidable.

Table 5-1

Health Areas and Methodologies

Health Areas	Methodology Used
1. Hospitalization - first time - subsequent	This study uses a combination of Farfel's (1987) and Chisolm et al.'s (1985) studies to arrive at the number of hospitalizations that could be avoided due to better abatement techniques.
2. Medical treatment for nonhospitalized children	Massachusetts cost estimates for children requiring only follow-up treatment are applied to the number of children in abated houses.
3. Compensatory education	Berwick and Kamaroff's estimates for the probability of having learning disability or mental retardation are used with the number of children in abated houses.
4. Renal and renal effects	Perlin's dose-response curves are used in conjunction with the number of children in abated houses.
5. Hearing loss	Schwartz and Otto's (1987) dose-response curve is used with the number of children in abated houses.
6. Developmental effects	Schwartz and Otto's and Schwartz, Angle, and Pitcher's (1986) studies show that elevated blood-lead levels are negatively correlated with developmental activities.

1. HOSPITALIZATIONS

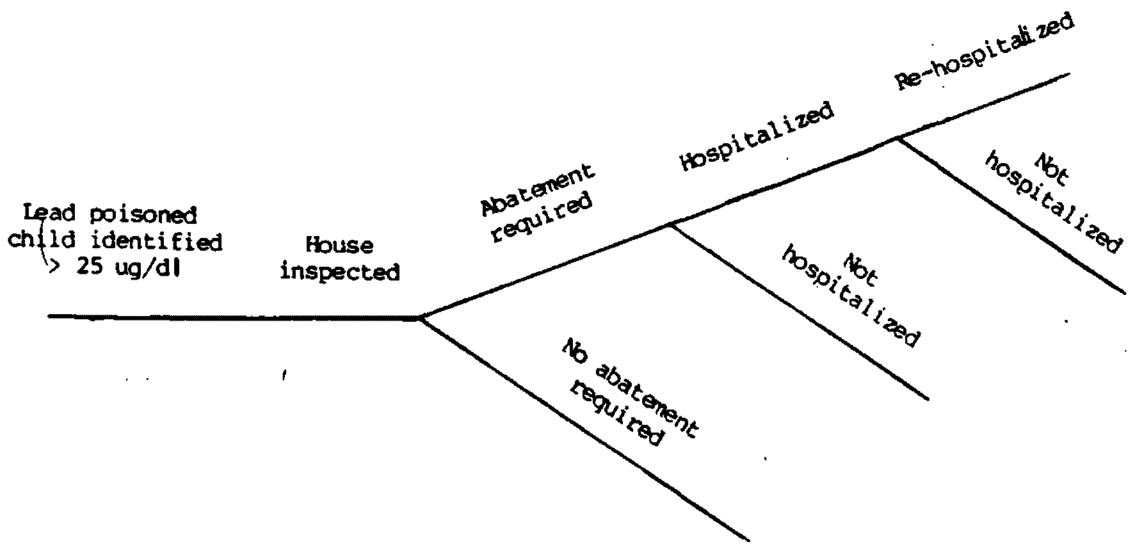
Traditional Abatements Cause Hospitalizations and Rehospitalizations

We used Chisolm et al.'s (1985) and Farfel's (1987b) studies to estimate that 26 first-time hospitalizations and 29 rehospitalizations could be avoided if improved abatement techniques were used in the abated houses in Baltimore City. These avoided hospitalizations are based on Baltimore protocols for treatment of lead-poisoned children. The following discussion explains this finding.

Figure 5-1 shows the sequence that a lead-poisoned child can undergo. Farfel's study concerns itself with the first hospitalization, while Chisolm's study looks at the rehospitalizations.

Figure 5-1

Sequence of a Lead-Poisoned Child



Children in Baltimore are hospitalized when their blood-lead levels are greater than 50 ug/dl. Chelation therapy is given to these children to reduce the lead in their blood and tissues. The baseline information (p. 8) shows that there are 128 hospitalizations per year; 80 are first-time hospitalizations, and 48 are re-hospitalizations. Dr. Chisolm, head of the Lead Poisoning Clinic at the Kennedy Institute, says that 99% or more of the hospitalizations are due to deteriorated lead paint in homes. He also states that 40% of the initially hospitalized children have to be rehospitalized because their blood lead again rose to over 50 ug/dl[1].

First-Time Hospitalizations

Baltimore City inspects the house of a lead-poisoned child for lead paint hazards. If a lead paint hazard is found, then the City requires an abatement. Farfel (1987) found that the abatements themselves are responsible for some children having higher blood-lead levels and needing to be hospitalized for the first time.

Farfel followed 27 children with high blood-lead levels who had never been hospitalized, but whose homes were traditionally abated. He found that one-third of these children had to be hospitalized for the first time within one month following the abatement. Thus, we estimate that improved abatement techniques could avoid approximately 33% of first-time hospitalizations. This equals 26 of the 80 new hospitalizations a year expected in Baltimore (from the baseline information, p. 8).

Rehospitalizations

Chisolm et al. followed 184 children who received chelation therapy and traced whether they went back to their traditionally abated homes or whether they went to houses without lead paint. Chisolm found that 123 out of 127 children who were rehospitalized lived in traditionally abated homes, as shown in Table 5-2.

Table 5-2

Incidence of Rehospitalization by Housing Type

Housing Type	Number of Children	Number of Readmissions 1	2	3 or more	Total Re-admissions
Abated housing	152	39	23	10	123
Houses without lead paint	32	2	1	0	4

Source: Chisolm et al., 1985.

1 Communication with Dr. Julian Chisolm, Jr., Kennedy Institute, Clinic for Lead Poisoning, Baltimore, May 26, 1987.

Dr. Chisolm estimates that approximately 10% of the rehospitalizations can never be prevented. This is because the lead that is stored in the bones is redistributed into the blood. Thus, 90% of the rehospitalizations in Baltimore could be avoided by better abatement techniques.

An important finding of Chisolm's study is that many abatements were not performed completely according to local requirements. This finding underscores the fact that monitoring to ensure correct abatements is equally important as having better abatement techniques.

Many Hospitalizations Could Be Avoided by Better Abatement Techniques

Combining Farfel's and Chisolm's studies provides a method to estimate the total hospitalizations in a one-year period associated with traditional abatement techniques. Since these children will not be hospitalized at all, there is no chance they will be rehospitalized. Farfel's study shows that 26 of the 80 (33%) expected new hospitalizations could be avoided with better abatement techniques. Thus, instead of 48 (from the baseline information, p. 8) expected rehospitaliations, there will only be approximately 32 rehospitalizations. This assumes a 33% reduction in rehospitalizations, comparable to the 33% reduction in new hospitalizations.

Using Chisolm's finding that 90% of the rehospitalizations could be avoided, together with Farfel's finding that 32 rehospitalizations will occur, produces approximately 29 rehospitalizations that could be avoided with better abatement techniques.

Adding Farfel's 26 new hospitalizations with Chisolm's 29 hospitalizations results in an estimate of 55 total hospitalizations that could be avoided with better abatement techniques.

Costs of Hospitalizations Could Also Be Avoided

Data from the Kennedy Institute, which handles almost all of the lead-poisoning hospitalizations in Baltimore, show that hospitalized lead-poisoned children stay an average of 26 days at $570/day, or $14,820 total for inpatient treatment per child. The inpatient costs include chelation therapy as well as a thorough developmental workup, clinical psychology, hearing and speech, and social service referral. The inpatient costs may drop 30%-50% in the future by using a hospice rather than a hospital bed to house the child until either the abatement is completed or alternative housing is found.[1] Consequently, the reported benefits of avoided hospitalizations may be too high.

[1] Communication with Dr. J. Chisolm, Jr., 1987.

Children receive outpatient care until their blood-lead levels stabilize or improve, or until 6 years of age. For children going back to abated houses, outpatient care is currently almost always given until age 6 as their blood-lead levels remain dangerously high. Kennedy Institute data show that an average of 3.2 outpatient visits are performed per patient per year, costing $104 for each visit. This study assumes that one year of outpatient care will be required. The annual outpatient cost, thus, is $333 per admission or a total of $18,315 a year for the 55 extra hospitalizations. (We did not discount these outpatient costs to present dollars due to the small amount involved.)

We estimate approximately $833,000 in avoidable costs of hospitalization. Table 5-3 presents this information in summary form. The cost of hospitalization does not include the possibility of adverse effects from the medical treatment (chelation therapy can cause renal damage).

Table 5-3

Yearly Hospitalization Costs Avoided with Better Abatement Techniques

Avoidable hospitalizations	55	
Inpatient cost per hospitalization	$14,820	
Total inpatient cost		$815,100
Outpatient cost per hospitalization	$333	
Total outpatient cost		$ 18,315
Total hospitalization costs avoided		$833,415

2. MEDICAL TREATMENT COSTS FOR NONHOSPITALIZED CHILDREN

Children who are lead poisoned but are not hospitalized also incur medical treatment costs. A recent study by the Conservation Law Foundation of New England, Inc., (1987) on lead poisoning reports that the average cost of treating a child requiring only follow-up treatment is $1,343. This cost estimate comes from actual costs charged at seven hospitals in Massachusetts.

This study assumes 572 children currently living in better abated houses who are not hospitalized could avoid one-half of the follow-up medical treatment costs (350 abated houses with two children per house = 700). Of these, 128 require hospitalization. Of the remaining 572, all are lead poisoned to some extent. Better abatements will enable them to avoid one-half of nonhospitalized treatment, since they will not get as sick as they would in a traditionally abated house. For this group we estimate approximately $384,000 in one-time avoidable medical costs.

Children who live in better abated homes in the future would avoid also such costs. Chapter 9 presents the value of these avoided costs.

Table 5-4

Nonhospitalization Costs Avoided with Better Abatements

Benefits	
Nonhospitalized number of children	572 x
Medical treatment cost avoided	$672 = (.5x $1343)
Total Non hospitalization cost avoided	$384,098

3. COGNITIVE DAMAGE - COMPENSATORY EDUCATION

Lead readily enters the brain and is retained for long periods of time, even after external exposure ends. The sensitivity of the brain in infants tends to magnify the severity of the long-term effects of lead. These effects may be irreversible (EPA, Strategies and Air Standards Division, 1986). In terms of cognitive damage, lead exposure leads to mental retardation, learning disability, behavior problems, IQ loss, and reduced attention span. To estimate the value of cognitive abilities lost, this study considers the costs of compensatory education needed by children.

Approximately 50 annual cases of compensatory education result from lead exposure in traditionally abated houses. The total education costs associated with the 50 children are almost $613,000. The following sections explain how we calculated the number of cases and the associated costs.

With Beter Abatements, Fewer Children Would Need Special Education

Children with high blood-lead levels are seven times more likely to repeat a grade or be referred for psychological counseling than children with low blood-lead levels (EPA, Schwartz, 1986). The special education that lead-poisoned children need is one method used to account for lead's cognitive effects.

No data are available on the number of children in special education programs in Maryland due to lead poisoning. This study uses Berwick and Komaroff's (1982) estimates to determine the number of children suffering from cognitive effects of lead. Table 5-5 shows the probability of learning disability and mental retardation associated with class levels.

Benefits are estimated separately for the 128 hospitalized children and the other 572 children currently living in abated houses (from baseline information, p. 8). This study assumes that one-half of the 128 hospitalized children will be brought from a Class III to a Class I risk level with better abatement techniques. Also, one-third of the 572 children in abated houses are assumed to be brought from a Class II to a Class I risk. These assumptions take into account the 10 ug/dl decrease in blood-lead levels that children experience with better abatement techniques as calculated in Chapter 4. Using the probabilities in Table 5-5 and the number of children with reduced risk, we estimate approximately 2 case of mental retardation and 48 cases of learning disability that could be prevented each year with better abatement techniques.

Table 5-5

Probability of Cognitive Effects Associated with Class Levels

Risk level	Probability of learning disability even if detected	Probability of mental retardation even if detected
Class I	.10	.02
Class II	.25	.02
Class III	.40	.05

Source: Berwick and Komaroff, 1982.

Significant Compensatory Education Costs Could Be Avoided

Schwartz's Costs and Benefits of Reducing Lead in Gasoline estimates that the additional cost of part-time special education for learning-disabled children who remain in regular classrooms is $5,000 per year per pupil, adjusted to 1987 dollars. Schwartz estimated that a minimum of three years is required for learning-disabled children. This study assumes that the "at risk" child is aged 3 years and, upon beginning school at age 5, needs 3 years of special education from that point. The present value of this education, using a 3% discount rate, is approximately $14,150. Table 5-6 shows that the total cost of three years of compensatory education for 50 children is approximately $708,000.

Table 5-6
Present Value of
Avoided Costs of Compensatory Education
with Better Abatement Techniques
for Current Children

Types of Costs	Number of cases/year	Cost for 3 years per child	Total costs
Mental retardation	2	$14,150	$ 28,300
Learning disability	48	$14,150	$679,200
Total Costs		$14,150	$707,500

The education costs are a conservative estimate. The cost for special education is based on likely and not preferred practice. The additional education costs do not include the costs of additional years of schooling due to children being held back a grade. Also, many children may need more than three years of compensatory education. Finally, absent better data, we assumed the same costs of special education for the retarded and the disabled.

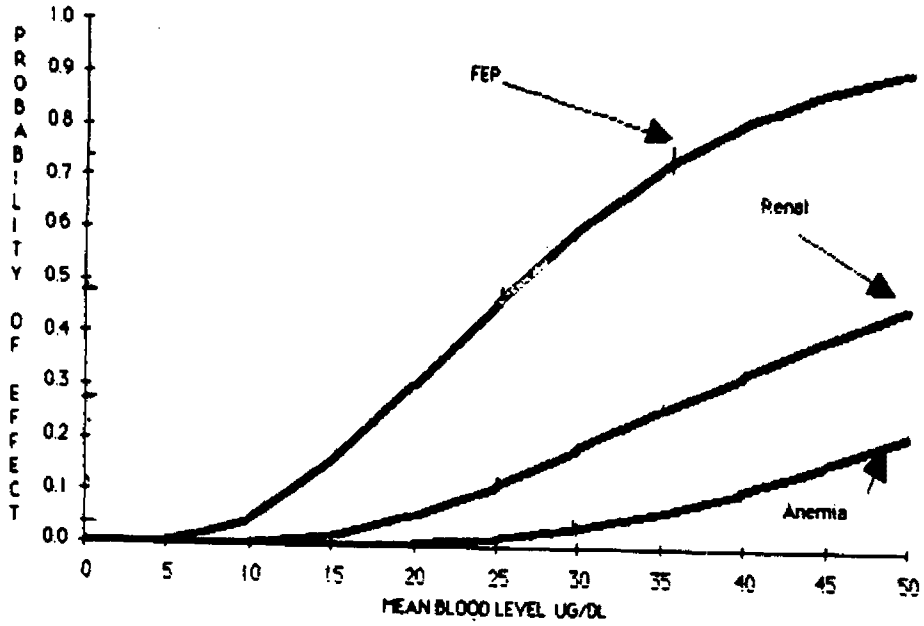
4. BLOOD AND RENAL EFFECTS

We estimate approximately 70 cases of anemia, 84 cases of elevated erythrocyte protoporphyrin (EP), and 91 cases of renal effects can be avoided in children with a 10 ug/dl reduction in blood-lead levels, as calculated in Chapter 5.

Cases of anemia, elevated EP (which is a measure of blood disorder), and renal effects are estimated using Perlin's (1986) dose-response curves, as shown in Figure 5-2. Perlin's dose-response curves are a rough estimate of the health effects.

Figure 5-2

Blood and Renal Effects Dose-Response Curves



source: EPA, Perlin, 1986

Many Cases of Blood Effects Could Be Avoided with Better Abatements

This study looks at two blood disorders: anemia and elevated EP. Anemia is often the earliest symptom of lead poisoning. Symptoms of anemia in children include pallor, sallow complexion, fatigue, irritability, and decreased play activity. Children with anemia are also more susceptible to infections. Figure 5-2 shows that a 10 ug/dl reduction in blood lead levels is associated with approximately a .10 decreased probability of anemia. Assuming 700 children currently living in the abated houses, we estimate 70 cases of anemia could be avoided with improved abatement techniques.

Elevated EP (which FEP is a measure of) in children impairs heme and hemoprotein formation for red blood cells. Besides its role in forming hemoglobin, heme is also active in liver function, vitamin D metabolism,and the nervous system. Figure 5-3 shows that a 10 ug/dl reduction in blood lead is associated with approximately a .12 decreased proability of elevated EP levels in children. Assuming 700 children living in abated houses, we estimate 84 cases of elevated EP levels that could be avoided if better abatement techniques were used.

Many Cases of Renal Effects Could Be Avoided with Better Abatement Techniques

Lead exposure in children can interfere with a variety of physiological processes that are associated with normal renal function. At low doses, lead impairs mitochondrial functions, including respiration, oxidative phosphorylation and synthesis of heme, proteins, nucleic acids, and vitamin D hormone. Epidemiological studies have suggested that lead exposure in children may be followed by later kidney damage, but this remains disputed. The total effects of low-level exposure on renal functions have not been adequately investigated for either children or adults (EPA, Perlin, 1986).

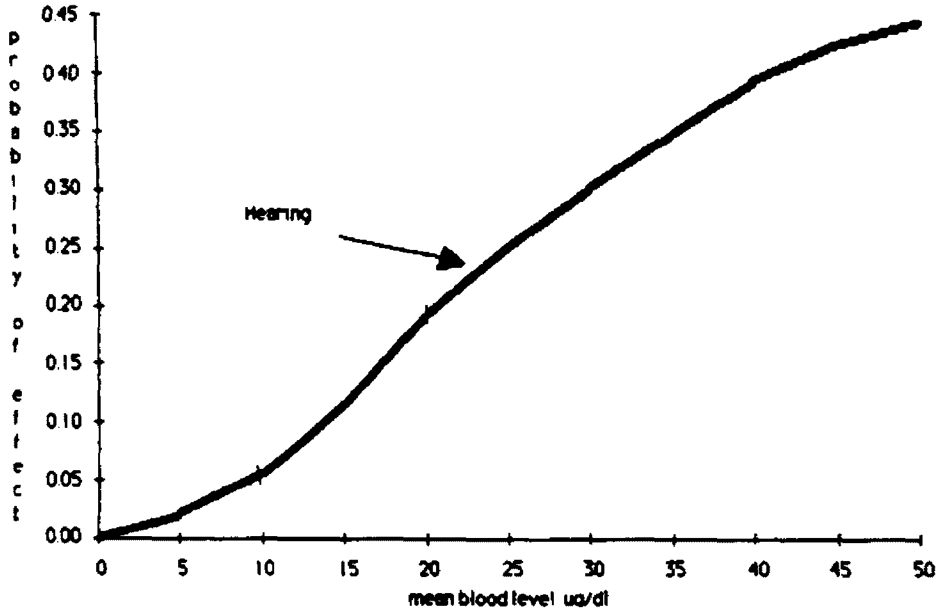
Figure 5-3 shows a dose-response curve for renal effects based on lead's interference with vitamin D metabolism, much of which is controlled by the kidney. For a 10 ug/dl blood-lead decrease, there is a corresponding .13 decreased probability of renal dysfunction. Assuming 700 children currently living in abated houses, we estimate 91 cases of impaired renal function avoided by the use of improved abatement techniques.

5. HEARING EFFECTS

Schwartz and Otto (1987) analyzed the NHANES II data for slight hearing loss associated with blood-lead levels in children. They found that lead levels across a wide range of exposure were significantly related to decreased hearing ability. Figure 5-3 shows that a 10 ug/dl reduction in blood-lead levels lowers the probability of a child's having elevated hearing threshold for 2 kHz levels by approximately 5%. Assuming 700 children, we estimate 35 cases of decreased hearing ability are avoidable due to improved abatement techniques.

Figure 5-3

Dose-Response Curve for Hearing Loss



Source: Schwartz and Otto, 1987.

6. DEVELOPMENTAL ACTIVITIES

Central nervous system damage caused by early childhood lead poisoning can adversely affect a child's development pace. Recent analysis of the NHANES II data have found a significant relationship between blood-lead levels and the following developmental areas:

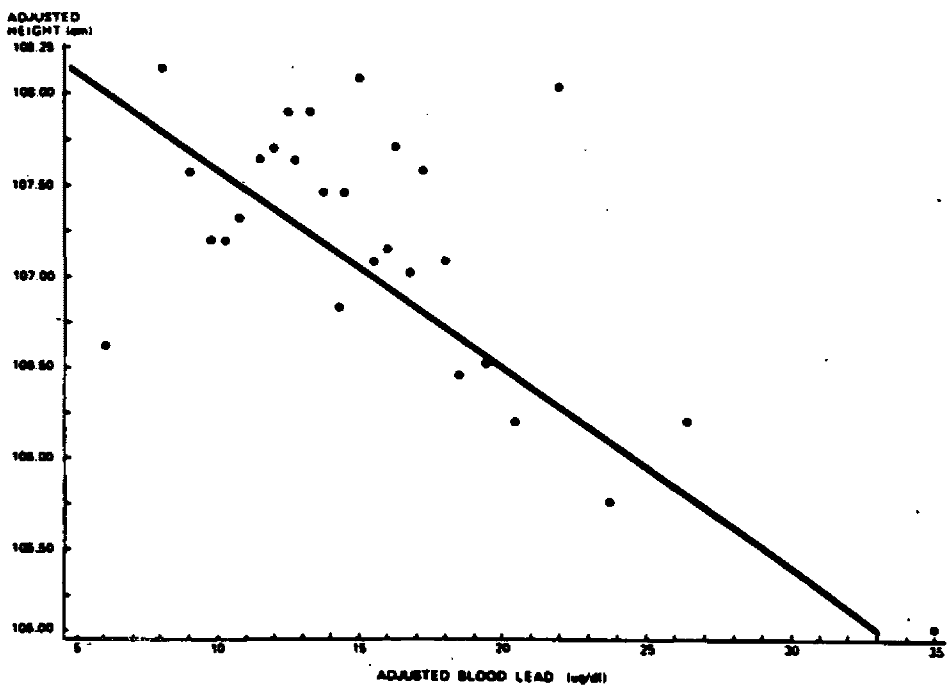
- first spoken words
- first begin walking
- first sits up
- height
- weight
- chest circumference

Schwarts and Otto (1987) found that increasing blood-lead levels are negatively correlated with when a child first speaks, walks, and sits up. On average, a child takes approximately 8.7 extra days to first speak words for a 10 ug/dl increase in lead-blood levels. Due to the young age when children first speak, walk, and sit up, children currently living in the abated houses will not receive any of these benefits. Only future children living in the abated houses will receive the benefits.

Schwartz, Angle and Pitcher (1986) found that increasing blood-lead levels are negatively correlated with height, weight and chest circumference. Figure 5-4 shows that for children aged 7 years and younger, a 10 ug/dl reduction in lead levels corresponds to approximately a 1.2 cm increase in height.

Figure 5-4

Relationship Between Blood-Lead Levels
and a Child's Height



Source: Schwartz, Angle, and Pitcher, 1986.

SUMMARY OF HEALTH EFFECTS

Table 5-7 is a summary of the quantifiable health costs for children currently in traditionally abated houses that could be avoided with better abatement techniques. Chapter 9 presents the quantifiable health costs that could be avoided for current and also future children over 20 years.

Table 5-7

Summary of Health Effects and Costs Avoided by Children Currently Living in 350 Houses Abated by Better Techniques
(rounded to 000's)

Health Area	Health Cases	Avoided Costs
Hospitalization (1)	55	$833,000
Non-hospitalization costs (1)	286	$384,000
Compensatory education (2)	50	$708,000
Anemia (3)	70	NA
Elevated EP (3)	84	NA
Renal effects (3)	91	NA
Hearing loss (3)	35	NA
Height, weight and chest circumference (3)	NA	NA
Total dollars		$1,925,000

NOTE: Estimates of health cases and avoided costs are partial estimates of benefits. Refer to text in Chapter 5 for discussion of nonquantifiable benefits.

(1) One-time benefit for current residents.

(2) Future benefit for current residents.

(3) Recurring benefit for current residents.

NA: Data not available to provide quantified estimate.

Chapter 6

ESTIMATED HEALTH BENEFITS FOR ADULTS

Better abatement techniques can result in significant health benefits to adults. The lower blood-lead levels associated with the better abatements reported in Chapter 4 are used along with Perlin's (1986) dose-response curves to produce the health benefits. Perlin's dose-response curves associate blood-lead levels with the incidence of health effects. Perlin's work has not been peer-reviewed; the dose-response curves should not be seen as definitive, but only as an attempt to estimate the incidence of health effects.

The following adverse health effects are seen at low to moderate blood-lead levels.

- Blood pressure elevation
- Reproductive effects
- Neurological effects
- Elevated erythrocyte protoporphyrin (EP)

There are few in-depth studies of the risks to adults from low-level exposure to lead. Thus, there are inadequate data to establish cause/effect relationships for adults. This is especially true for women, for workers doing the abatements, for blood pressure effects in nonwhite men, and for all adults exposed to chronic low levels of lead (EPA, Schwartz, 1985). Consequently, many of the health risks may be under-reported, and our estimates of the health problems avoided may be similarly under-reported.

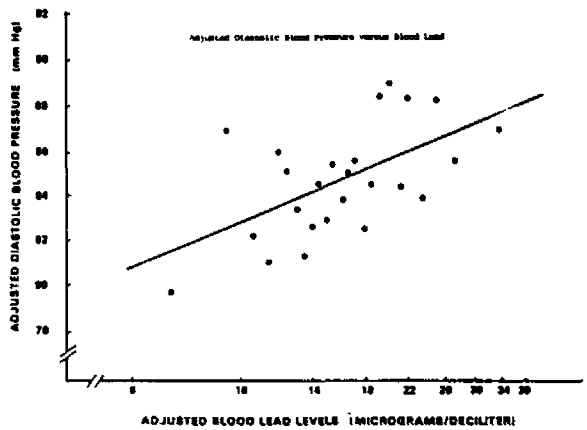
We estimate that better abatement techniques may enable adult men living in abated houses to avoid approximately 7 cases of hypertension (aged 40-59), 11 cases of reproductive effects, 17 cases of neurological effects, and 28 cases of elevated erythrocyte protoporphyrin (EP). Women living in abated houses in Baltimore City can annually avoid 17 potential cases of neurological effects and 46 potential cases of elevated EP. Finally, workers performing abatements using the improved techniques should be exposed to lower dust air-borne lead. This chapter explains how we derived these estimates.

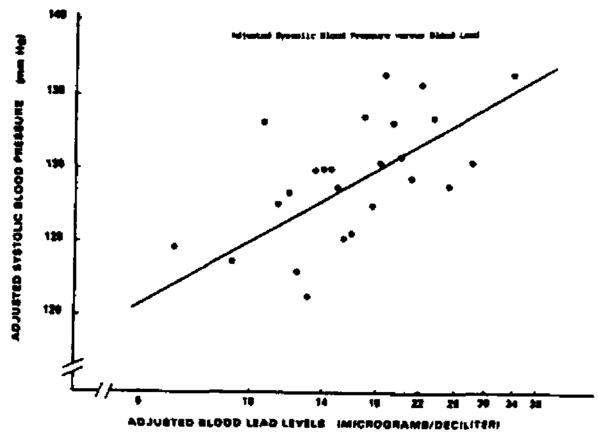
BLOOD PRESSURE ELEVATION

Blood-lead, even as low as 7 ug/dl, levels can affect blood pressure, as shown in Figures 6-1 and 6-2.

Figures 6-1 and 6-2

Blood Pressure Associated with Lead Levels
for Men Aged 40-59





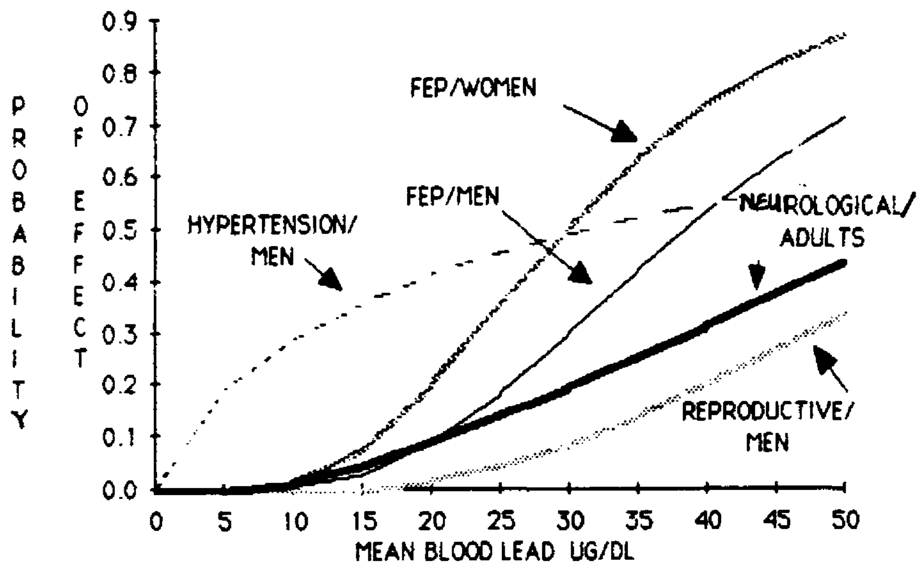
Source: EPA, Schwartz, 1985.

High blood pressure is linked to a variety of health effects, including hypertension, myocardial infarction, stroke, and death. The present data show that lead appears to affect blood pressure in men, but not in women. Past analysis has only focused on men in the age group 40 to 59 because it is very hard to differentiate the effects of aging from lead's effect on blood pressure. In addition, of all health effects asociated with blood pressure, only hypertension has been associated with nonwhites; there are inadequate data on the other blood pressure health effects among nonwhites. Consequently, the estimates of adult male benefits are likely to be understated significantly, especially for older males and nonwhite males of all ages (EPA, Schwartz, 1985).

Benefits due to a lower incidence of hypertension are calculated for all males age 40 to 59 living in abated houses. Figure 6-3 shows that an associated drop of 5.1-8 ug/dl of blood lead results in approximately a .07 decrease in the probability of hypertension across blood-lead levels of 10-25 ug/dl that are commonly found in urban males.[1] Assuming 350 abated houses per year, a 30% chance of an adult male age 40 to 59 living in an abated house,[2] and a .07 reduced probability of hypertension, we estimate a decrease of approximately 7 hypertension cases per year due to better abatement techniques.

Figure 6-3

Dose-Response Curves for Adult Health Effects.



[1] Here, and elsewhere following the values for decreaesed probability of the effect from Perlin's work (1986).

[2] Calculated from 1980 Census of Population and Housing, Baltimore SMSA, U.S. Bureau of the Census.

EPA's Costs and Benefits of Reducing Lead in Gasoline study estimated that the annual cost per hypertension case is $285, adjusted to 1987 dollars. This cost includes drugs, physician visits, hospitalization, and lost wages. Multiplying $285 times 7 fewer hypertension cases per year yields $1,995 in yearly benefits due to reduced hypertension in adult males age 40 to 59. These costs avoided by better abatement techniques are recurring benefits.

REPRODUCTIVE EFFECTS

Lead has been linked to a decrease in male fertility. Female exposure to lead has been associated with menstrual disorders, infertility, spontaneous abortions, stillbirths, and neonatal deaths. The reproductive curve in Figure 5-3 shows the incidence of damaged sperm (reduced numbers and less vigor) in males, based on a study by Lancranjan et al. (1975). No similar incidence curve has been established for female reproductive effects due to inadequate data (EPA, Perlin, 1986).

Assuming a 5-8 ug/dl decrease in blood lead, Figure 6-3 shows a .03 decrease in the probability of damaged sperm in adult males. Assuming 350 abatements and one adult male in each abated house, we estimate approximately 11 fewer cases per year of reproductive damage in males due to a reduced exposure to lead-painted houses.

NEUROLOGICAL EFFECTS

The nervous system is a critical target for the toxicity of lead exposure. Lead can effect the brain and spinal cord and the sensory nerves of the peripheral nervous system. Disturbance in oculomotor function, reaction time, visual-motor performance, hand dexterity, IQ scores, memory, learning ability, mood, and nervousness have been observed in workers with lead-blood levels of 50-80 ug/dl and, in some cases, as low as 27-52 ug/dl for weighted time averages (EPA, Perlin, 1986). The incidence curves, as shown in Figure 5-3, are based on a study by Seppaainen et al. (1979) and refer to slowed peripheral nerve condition for men and women.

Assuming a 5-8 ug/dl decrease in blood levels for men and women, Figure 6-3 shows a .05 decrease in the probability of slowed peripheral nerves. Assuming 350 abatements and one adult male and one adult female living in each abated house, we estimate approximately 35 cases of neurological damage for men and women avoided by improved abatement techniques.

ELEVATED EP (erythrocyte protoporphyrin) EFFECTS

One of the first biochemical changes associated with blood lead is an increase in FEP (which measures EP). High levels of EP impair heme and hemoprotein formation in many tissues. Heme helps in forming hemoglobin and is active in liver function, vitamin D metabolism, and the nervous system. The incidence curves for men and women shown in Figure 6-3 are based on a study by Roels et al. (1975) and measure adults' having some lead-induced disturbance in the hemoglobin synthesis due to an increase in EP. The health consequences of small increases of EP are controversial, as there are no obvious symptoms associated with the increases.

Figure 6-3 shows a .08 decrease for men and a .13 decrease for women in the probability of having elevated levels of EP, assuming an increase in lead-blood levels of 5-8 ug/dl. Assuming 350 abatements, we estimate approximately 28 fewer cases of elevated EP for men and 46 fewer cases for women due to reduced exposure to lead.

GASTROINTESTINAL AND RENAL EFFECTS

Gastrointestinal and renal effects are two other health areas associated with lead exposure. No benefits will be reported in this study for these health areas due to inadequate data on the low-level chronic exposure that would be experienced in lead-painted houses. Gastrointestinal signs and symptoms caused by lead intoxication include constipation, diarrhea, abdominal pain, nausea, and indigestion. Mild symptoms have been associated with lead levels in the 50-70 ug/dl range and as low as 30 ug/dl. Renal effects have been associated with blood-lead levels greater than 40 ug/dl. However, the effects of chronic low-level lead exposure in adults or children have not been adequately investigated (EPA, Office of Research and Development, 1986).

BENEFITS TO WORKERS DOING THE ABATEMENTS

There are virtually no data on the blood-lead levels of workers performing the traditional abatements for property owners. There is evidence that sanding and burning lead paint, as done in the traditional abatement methods, can cause dangerously high blood lead-levels for the workers (personal communication, Dr. James Keogh).

SUMMARY OF HEALTH BENEFITS

Table 6-1 shows the quantifiable health benefits to adults of a 5-8 ug/dl reduction in blood lead due to reduced exposure to lead-painted houses. As stated previously, the benefits are underestimated due to inadequate data for adults in general, as well as for older men, workers doing the abatements, and non-whites. Also, we were unable to quantify the dollar benefits associated with reproductive, neurological, and elevated EP problems.

Table 6-1

Summary of Yearly Adult Health Benefits for a 5-8 ug/dl Decrease in Blood Lead Levels for 350 Abated Houses

Health Area	Probability Decrease		Reduction in Cases	Cost/ Case	Dollar Benefits
	Male	Female			
Hypertension	.07*	NA	7	$285	$1,995
Reproductive effects	.03	NA	11	NA	NA
Neurological effects	.05	.05	35	NA	NA
Elevated EP	.08	.13	74	NA	NA

* Age 40-59.

NA: No data available.

Chapter 7

ESTIMATED HEALTH BENEFITS FOR PRENATAL AND NEWBORN CHILDREN

The effects of lead exposure on fetuses is a matter of increasing interest and concern in light of recent studies. The available evidence supports the conclusion that fetal exposure to lead at low and prevalent concentrations can have harmful effects on infant mental development, length of gestation, and possible other aspects of fetal development (EPA, Office of Research and Development, 1986).

Fetuses are the highest risk group to regard to lead's toxic effects because of their rapidly developing nervous system. In fact, the risk to fetuses from exposure to lead may be even higher than their mother's blood level would indicate. While previous studies have generally found a high correlation between maternal and umbilical cord blood-lead levels, Levin (1986) reports that in one-fourth of the cases, the cord blood-lead level was higher than the mother's.

Elevated Blood-Lead Levels Cause Neurobehavioral Damage

Several studies have examined the relationship between maternal and fetal blood-lead levels and subsequent mental development in infants. These studies show a consistent and significant inverse relationship between blood-lead levels and infant development, even at blood-lead levels of 10 ug/dl and lower. Levin (1986) reports that Bellinger et al. (1984 and 1987) and Vimpani et al. (1984) both found test scores on the Bayley Mental Development Index to be inversely related to umbilical cord blood-lead levels. Bellinger found that there was a significant difference on the test scores between low (< 3 ug/dl) blood-lead levels in umbilical cords and high (> 10 ug/dl) umbilical blood-lead levels. Follow-up tests show that the association between test scores and cord blood-lead levels continues for at least two years.

In addition to mental development, other studies show an inverse relationship between blood-lead levels and other neurobehavioral effects. Ernhart (1985 and 1986) showed that lead exposure at three months of age is correlated with jitters and hypersensitivity. Winneke et al. (1985) showed a significant relationship betwen prenatal blood-lead levels and one measure of psychomotor ability at ages 6-7 (EPA, Levin, 1986).

Elevated Blood-Lead Levels Also Inhibit Early Development

The evidence from several studies indicates that gestational age appears to be reduced as prenatal lead exposure increases, even at low blood-lead levels below 15 ug/dl. Levin (1986) reports that Moore et al. (1982) found that fetal blood-lead levels of 12 ug/dl corresponded to a significant level of premature births. McMichael et al. (1986) found that women with blood-lead levels greater than 14 ug/dl were four times more likely to deliver pre-term than women with blood-lead levels less than 8 ug/dl. Excluding cases of stillbirths, the relative risk increased to over 8.

Lead has also been implicated in complications of pregnancy, including first-trimester bleeding, early births and stillbirths, and possibly, low-level congenital anomalies (EPA, Levin, 1986).

Chapter 8

OTHER BENEFITS

In addition to the health benefits for adults and children, other potential benefits are associated with better abatement techniques. These include:

- energy savings from efficient windows,
- better health of family pets,
- better maintenance and living conditions in general,
- avoidance of income loss and inconvenience to family members,
- avoidance of anxiety to family members, and
- improved property values and reduced insurance rates for owners.

Efficient Windows Save Energy

The new abatement techniques provide for a complete refinishing of all windows with lead paint in a house. The refinishings will not only reduce the lead hazard, but also result in greater energy efficiency. Greater energy efficiency comes from general maintenance of the windows that results in tighter fitting windows.

The Baltimore City Jobs and Energy Office, which does similar window refinishings and replacements as part of its program, estimates that each tighter window saves approximately $34 in energy costs per year. The program states that to calculate a house's yearly energy savings, one divides the $34/window by two due to the airflows in a house. This study assumes that the equivalent of two windows will be upgraded, resulting in energy savings to an abated house of $34 yearly. Assuming 350 abated houses per year, the total yearly energy savings come to $11,900. These cost savings are a recurring benefit and will be assumed to last 20 years. Chapter 9 presents the total present value of these savings.

Better Living Conditions May Result

Traditional abatements often left debris in the houses and unsightly and dangerous burnt wood trim and doors. Improved abatement techniques require extensive cleanup as well as better maintenance and repairs in general. These improvements, while required for health reasons, also provide for a better quality of living and improved aesthetics for those in the houses.

Income Loss and Inconvenience to Family Members Are Avoided

A child requiring hospitalization has to spend an average of 26 days in the hospital. In addition, many children require re-hospitalization due to traditional abatements, totalling many months in the hospital. Family members may have to take off work as well as change their normal daily patterns to attend to the child.

Anxiety for Family Members Is Avoided

Families of lead-poisoned children can suffer much mental anguish as they wonder whether their children will be mentally and behaviorally impaired throughout their lives.

Property Values May Increase and Insurance Rates May Decrease

Correctly abating a dwelling can improve its property value because it removes a future liability associated with the presence of lead paint. Future buyers, thus, do not have to face the potential costs of lead poisonings, lawsuits, and abatements. Owners may also receive lower insurance rates as they no longer have the liability of lawsuits from parents of lead-poisoned children.

Family Pets Are Healthier

Lead can harm the health of family pets, just as it harms health of humans. The Committee on Lead in the Human Environment of the National Academy of Sciences concluded that animal sensitivity to lead might equal or exceed that of humans (EPA, Strategies and Air Standards Division, 1986). The exposure of household cats and dogs to lead dust would be equal to or greater than that of infants. This is due to pets' licking their dust-laden fur, pica activity and time spent inside near dusty floors. Fish are also be exposed to lead's danger, as lead dust falls into their tank. Studies have shown that fish are very sensitive to lead. Goldfish have shown neurological and behavior changes at 10-100 ug/l lead water levels. Other symptoms found in fish include black tails (indicating spinal deformity) and spinal curvature (which increases mortality and prevents successful reproduction).

Chapter 9

THE PRESENT VALUE OF FUTURE AVOIDED MEDICAL AND OTHER COSTS

In Chapter 4 we presented information on the nature of the adverse effects of elevated blood lead levels for children and adults. We attributed reductions in the level of lead in blood for children and adults to better abatement techniques. In Chapters 5 and 6 we quantified some of the costs of adverse health effects in terms of dollars of medical, educational, or other costs incurred in treating these effects. We have assumed that these costs are avoidable if better abatement techniques are employed. We define these avoidable costs as the "monetized benefits" (i.e., value in dollars) of better abatements.

Some benefits of better abatements are "one-time" benefits, such as an avoided hospitalization. Others are "recurring" (i.e., annual) benefits, such as energy savings from more efficient windows or lower blood pressure. Better abatements may create such benefits both now and in the future both for current and for future residents.

To capture more fully the complete set of possible monetized benefits resulting from better abatements, we try to estimate these future benefits, in addition to those immediately occurring. This chapter presents our estimates of the present (1987) dollar value of expected future benefits we are able to monetize.

Table 9-1 (p. 43) summarizes the present value benefits that abatements produced. We estimate a range of \$3.6 - 6.5 million in avoided costs for those benefits we were able to monetize. We have probably underestimated the value of these benefits because of our inability to quantify all of the health effects and monetize them.

Present Value of the Future Benefits Realized by Better Abatements

- Children living in better abated houses.

Hospitalization

We have assumed that a major benefit of better abatements is a reduction in the number of children requiring either first-time or repeat hospitalizations for chelation therapy (see pp. 18-22). We estimated the total "immediate" value from the avoided in-patient and out-patient care of these cases is approximately \$833,000. There are no recurring benefits for current children from this improvement (unlike the case of adult hypertension).

In addition, we have assumed there are no benefits for future child residents. Our reasoning is that the traditional abatement aggravates the environment for current residents--seriously enough to require hospitalization. We have made the conservative assumption that future residents, however, will not require hospitalization from today's traditional abatement.

Non-hospitalization

As we noted in Chapter 5 (p. 22), children not hospitalized may still incur costs for medical treatment from lead poisoning. The average cost for follow-up treatment is $1,343.

This study assumed an average of two children in the "at risk" age group (1-6 years) currently living in the 350 annually abated houses. We estimated the total "immediate" value of this avoided cost at approximately $384,000. Again, these are one-time benefits for this group.

Most abatements are done on rental units that have high turnover rates. Consequently, it is likely that other children will live in the house in the future. Lacking any data on how many of these children there might be, we assumed a range of 2 to 6 children in the "at risk" age group who might live in a house in the future (defined as the next 20 years). For 350 better abated houses, this results in an estimate of 700-2,100 future child residents in the "at risk" group.

Unable to predict exactly when in the 20-year future these children might reside in the house, we arbitrarily assumed residency at a point 10 years in the future. We again assumed they avoid one-half of the one-time, nonhospitalization costs of $1,343.

The present value of these benefits to the "at risk" children who might live in the better abated houses in the future is approximately $360,000 - $1,080,000.

Compensatory education

As previously presented (pp. 23-25), we estimated that better abatements would avoid 50 cases of cognitive damage, valued at approximately $708,000 for current child residents.

Children residing in better abated homes in the future will also avoid costs of compensatory education. We assume they will avoid a 25 ug/dl increase in blood-lead levels (as estimated on p. 17).

We have assumed that these are nonhospitalized children and are in the Class II risk level (p. 34). By virtue of their residence in the better abated houses, they will move from Class II to Class I, corresponding to a 15% decrease in the probability of a learning disability (p. 34). (Note there is no reduction in the probability of mental retardation in a move from Class II to Class I.) As before, we estimated a range of 700-2,100 (350 abatements times 2-6 children/house) possible future child residents. Using the 15% reduction in the probability of a learning disability, we estimated a range of 105-315 possible avoided cases of compensatory education for children living in the better abated homes in the future.

Again, assuming these children are living in those homes in 10 years and that the required special education (3 years duration) begins 2 years later, we estimated a present value for one case of avoided special education costs of $10,520. Over the range of 105-315 possible cases, this results in an estimate of $1,105,000 - $3,313,000 in future benefits for future child residents.

o Adults living in better abated houses

Hypertension

We estimated that better abatements might eliminate 7 cases of hypertension and produce a total "immediate" benefit of $1,995 in avoided medical costs (pp. 19-21).

We assumed a representative individual aged 49 in the 40-59 affected age group. Over 20 years, the present value of the total future benefits of the avoided medical costs is approximately $31,000.

o Energy-efficient windows

We estimated "immediate" energy savings for better windows at $11,900 per year (p. 39). We assume these savings will last for 20 years which results in a present value of $177,000.

Table 9-1

Current and Future Quantifiable Benefits That 350 Better Abatements Produce
(1987 dollars)

Benefits	Immediate	Future Savings[1]	Total Savings[1]
Hospitalization	$833,000	(2)	$833,000
Nonhospitalization	$384,000	$ 360,000 - $ 1,080,000	$ 744,000 - $1,464,000
Compensatory Education	(3)	$1,813,000 - $ 4,021,000	$1,813,000 - $4,021,000
Hypertension	$ 2,000	31,000	$ 33,000
Energy-Efficient Windows	$ 12,000	$ 177,000	$ 189,000
Total Savings			$3,612,000 - $6,540,000

Note: Data limitations preclude estimating all health effects or assigning dollar values for them. These figures probably underestimate the total avoided costs.

(1) Future and total savings reflect the following assumptions:

- from 2 to 6 "at risk" children (aged 1-6 yrs.) may reside in the house in the future, a range of 700-2,100 children, given 350 abatements;

- the time period for analysis is 20 years;

- the discount rate for present value analysis is 3%; and

- benefits occur at the beginning of a year; for example, 20 years of benefits from energy-efficient windows consist of savings today (year 0) plus 19 years; or for education, assuming a 3-year-old who receives 3 years of special education upon entering school at age 5. The future benefits occur in years 5, 6, and 7.

(2) As discussed (p. 42), we assumed no future children would require hospitalization. Thus, all benefits are "one-time" and accrue only to current children.

(3) As previously discussed (pp. 25 and 43), all costs of compensatory education occur in the future for both current and future children.

Chapter 10

SUMMARY OF FINDINGS AND SENSITIVITY ANALYSIS

Tables 10-1 and 10-2 show the quantifiable health benefits and avoidable costs associated with better abatement techniques. As can be seen, the dollar benefits range from $3.6 million to 6.5 million, depending on the number of children assumed to benefit in the future. The benefit/ cost ratio associated with better abatement techniques ranges from 2.6:1 to 4.7:1. These estimates are probably low, as many health effects could not be quantified or monetized. Also, many intangibles associated with the traditional abatement techniques could not be accounted for. These include the extreme pain associated with chelation therapy, the behavioral changes of a person, and the health effects not yet known due to inadequate data.

Another limitation on calculating the benefits is that monetizing the actual avoided costs associated with improved abatements may inherently underestimate the health benefits. This is because medical costs do not reflect the cost of lost wages or other opportunity costs that are not easily monitized. An individual is often willing to pay more than the medical costs to avoid the adverse health effect. In general, willingness-to-pay studies indicate that individuals are willing to pay two (or more) times the cost of medical treatment (e.g., U.S. Environmental Protection Agency. "Oxidants and Asthmatics in Los Angeles: A Benefits Study." Addendum. March 1986). Thus, the approximately $1.6 - $2.3 million in medical costs that we find associated with traditional abatements may mean society is actually willing to pay $3.2 or more million to avoid the medical cost.

Table 10-1

Estimated Current and Future Health Benefits Resulting from 350 Homes Abated with Better Techniques

Estimated Health Benefits*
(cases avoided)

Benefits	Current Children	Future Children
Hospitalizations	55	(1)
Non-Hospitalizations	572	700-2100
Compensatory Education	50	105-315
Elevated EP	(2) 84	(1)
Anemia	(2) 70	(1)
Renal effects	(2) 91	(1)
Hearing loss	(2) 35	(1)

Benefits	Current Adults	Future Adults
Blood pressure	(2) 7	(1)
Reproductive effects	(2) 11	(1)
Neurological effects	(2) 34	(1)
Elevated EP	(2) 74	(1)

* Note. Not all benefits could be quantified. See Chapters 5-6 for discussion.

(1) Assume none. See chapter 9. Under alternate assumption, we would estimate same values as for "current."

(2) These are annually recurring benefits for the affected individual.

Table 10-2

Estimated Current and Future Avoided Costs**
Resulting from 350 Homes Abated with Better Techniques
(1987 dollars)

	Current	Future*	Total*
Hospitalizations	$833,000	(1)	$833,000
Non-hospitalizations	$384,000	$360,000-$1,080,000	$744,000-$1,469,000
Compensatory Education	(2)	$1,813,000-$4,021,000	$1,831,000-$4,021,000
Hypertension	2,000	31,000	$ 33,000
Energy Efficient Windows	12,000	177,000	$ 189,000
Estimated Benefits			$3,612,000-$6,540,000

Benefit/Cost Ratio: Approximately 2.6-4.7:1

Net Benefits: $2.2 - $5.1 million
(assumes 350 abatements at additional cost of $4,000 per abatement.

Note. For those health effects we are able to quantify. Not all effects could be estimated nor could dollar values be assigned to all. These figures probably underestimated avoided costs.

** Future and total savings reflect the following assumptions:

- from 2-6 "at risk" children (aged 1-6 yrs.) may reside in the house in the future, a range of 700-2100 children, given 350 abatements

- time period for analysis is 20 years

- discount rate for present value analysis is 3%

- benefits occur at the beginning of a year; for example, 20 years of benefits from energy efficient windows consist of savings today (year 0) plus 19 years; or for education, assuming a 3-year old who receives 3 years of special education upon entering school at age 5. The future benefits occur in years 5, 6, and 7.

(1) As before, all benefits of hospitalizations avoided are assumed to accrue only to current child residents for whom they are one "one-time" benefits. See chapter 9, p. 42 for discussion.

(2) Although both current and future children avoid costs of compensatory education, we define these as future (in time) benefits (see pp.25 and 43).

Sensitivity Analysis of Benefits and Costs

We conducted a limited sensitivity analysis of our efforts to quantify the dollar value of the reductions in adverse health effects.

We assumed the average cost of the abatements might be as high as $7,000 per house and as low as $2500. The former adjusts upward for costs we omitted (cleanup, repainting, etc.). The latter adjusts downward for gains in efficiency.

We also assumed a discount rate of 7%. At 3%, society is saying the future benefits are pretty important; in effect, it values those benefits enough to defer present consumption for them. At 7%, the balance shifts towards the present; in effect, society says those future benefits are less important.

This is particularly important because to the extent our analysis is able to quantify benefits, a substantial part of the benefits we report occur in the future, as opposed to today. For example, the bulk of the non-hospitalization and compensatory education benefits estimated derive from the future child residents we projected.

Table 10-3 presents a summary of our analysis assuming discount rates of 3% and 7% and marginal costs for better abatements of $1,500; $4,000; and $6,000.

Table 10-3

Net Benefits
(1987 dollars)

	Marginal Cost of 350 Better Abatements at $1.5 K/house	$4.0 K house	$6.0 K/house
	$525,000	$1,400,000	$2,100,000
Estimated Benefits (From tables 9-1&10-2)			
at 3% $3,600,000	$3,100,000	$2,200,000	$1,500,000
$6,500,000	$6,100,000	$5,100,000	$4,400,000
at 7% $2,800,000	$2,300,000	$1,400,000	$ 700,000
$4,800,000	$4,300,000	$3,400,000	$2,700,000
	Benefit/Cost Ratios		
at 3%	6.9	2.6	1.7
	12.4	4.6	3.1
at 7%	5.3	2.0	1.3
	9.1	3.4	2.3

Not surprisingly, more costly abatements and higher discount rates reduce the net benefits and the benefit/cost ratios. However, two observations are important. First, net benefits remain positive, even with the more expensive abatements and the higher discount rate. Second, as we have repeatedly stated, our benefits are most likely underestimated due to a lack of knowledge of the health effects of lead on adults in general, and our inability to put dollar values on many of the health effects we estimated.

Finally, a simple break-even analysis indicates that better abatements could cost, on average, as much as $10,000 - $18,000 ($9,000-$17,000 at the margin) at a 3% discounat rate an d still be worth while. At 7% they could cost from $5,000 to $9,000 on average ($4,000 - $8,000 at the margin) and still result in positive benefits.

Distributional Effects

Who really pays for the cost when only traditional abatements are done? The physical costs is borne by the patient and family. Typically this is a low-income group. As a result neither they nor an insurer pays the cost of medical treatment. To the contrary the financial cost of care for the vast majority of children treated for lead poisoning in Baltimore is borne by the public via Maryland Medical Assistance Program. Similarly the cost of compensatory education for such children is found in the public school system. Thus the critical economic finding of this study emerges from consideration of the distribution of costs of the problem. The public pays the costs of increased lead exposure from traditional abatements.

While the reduced lead exposure of better abatement techniques can result in net benefits to sociery, it does not necessarily follow that all segments of the population will share these benefits equally. The benefits, better health quality and resultant lower costs, will be received by the children and adults living in the houses, their families and to the extent medical and compensatory education costs are covered by public funds, the tax payers. The costs of the abatements are borne by the landlord or home owner. In the case of a middle class family that owns a house, most of the costs and benefits will fall on the family, and there will be economic, if not emotional, reasons for the family to undertake the better abatements. In the case of landlord-owned housing, however, the costs and benefits fall to different individuals or groups of individuals.

In this latter case, a common situtation in Baltimore City, the landlord has no preexisting economic incentive to perform better abatements. The landlord may recover some costs, of the better abatements by increasing the rent and through lower liability insurance costs due to the decreased risk. Realistically, some public enforcement mechanism such as regulation, will be required to motiviate the landlord to incurr the costs of better abatements, if society chooses to reap the benefits. In Baltimore regulations that incorporate many of the features of our better abatements were put into effect on July 1, 1987.

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