Sampling for Exterior Lead Dust in Single Family Housing Demolition

Presented by Salvatore Cali

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[2]Center for Neighborhood Technology

[3]National Center for Healthy Housing

[4]Chicago Dept. of Public Health, Childhood Lead Poisoning Prevention Program

Project PI: David Jacobs

UIC UNIVERSITY OF ILLINOIS AT CHICAGO Environmental and Occupational Health Sciences Division SCHOOL OF PUBLIC HEALTH

Objective

Describe the study design, challenges and successes of project management, and present preliminary summary of results

Note: UIC Institutional Review Board (IRB) reviewed this research protocol and determined that it did not involve human subjects.

Background

Several previous studies of exterior lead dust fall from demolition informed this study

1) Two full studies in East Baltimore (one sampled 3 groups of row houses, other included several hundred row houses)

2) One Pilot study in Chicago on single-family (4 units or less) demolition

(See references)

Studies used passive dust fall method (APHA Method 502); One Baltimore study also collected air samples, results below lab RL of 0.001 mg/m^3

Primary Hypotheses

1. Lead dust fall from demolition can exceed federal standards for interior settled lead dust on floors (40 $\mu g/ft^2$) within a day in at least 10% of demolition sites where dust suppression is not used in Chicago.
2. Use of new dust suppression techniques in Baltimore study will keep lead dust fall levels significantly lower ($p<0.05$) than levels at comparable Chicago demo sites without dust suppression.

Study Description

- Target 100 events at free-standing, single-family (4 units or less) homes in Chicago undergoing demolition activities
- Measure total and lead dust fall (deposition rate), (APHA Method 502, analysis EPA Methods 3050b & 6020a) near events and record housing characteristics and demo activities

- Compare to total and lead dust fall at a variety of background locations
- Opportunistic sampling

Study Description (continued)

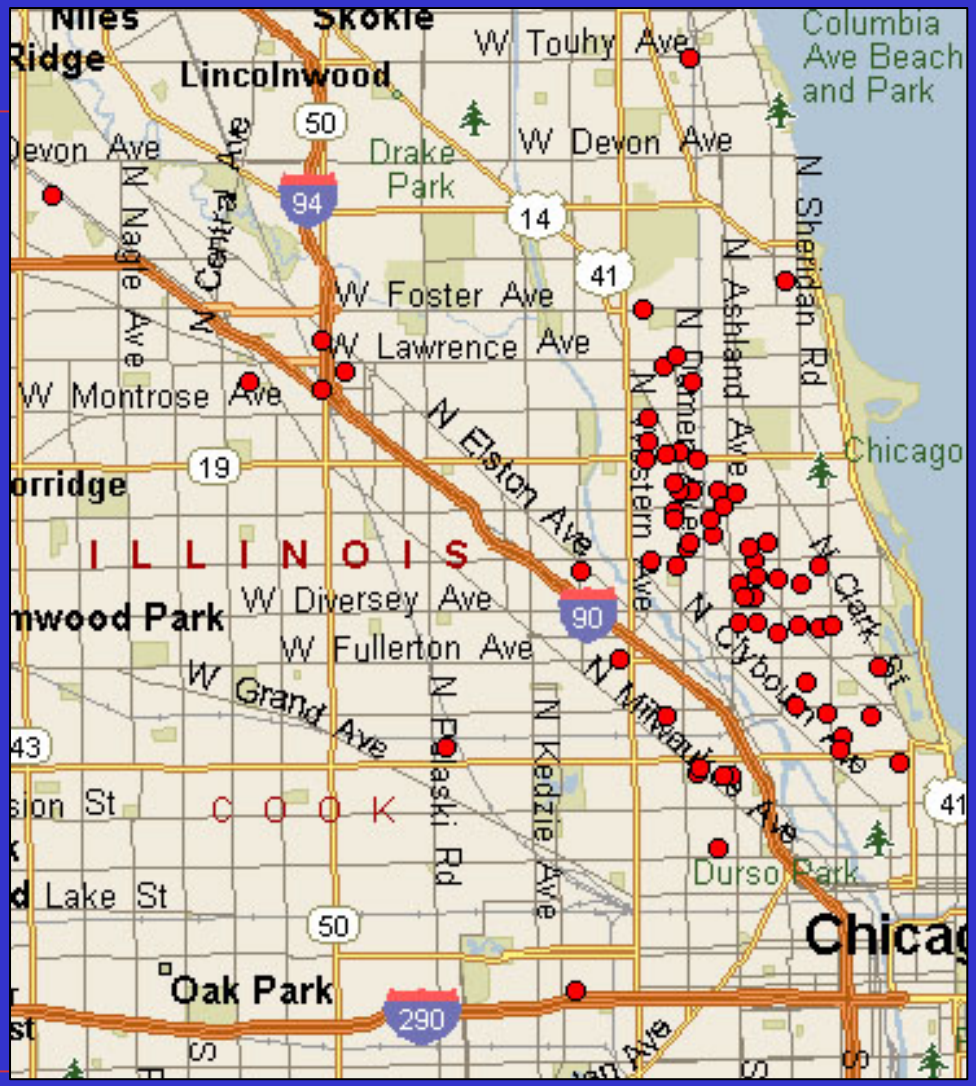
- Compile meteorological information
- Characterize dust in subset of 20 demo/ 5 BG events using a variety of size-selective samplers and analysis for silica, asbestos, and metals (ICP-MS)

Preliminary results

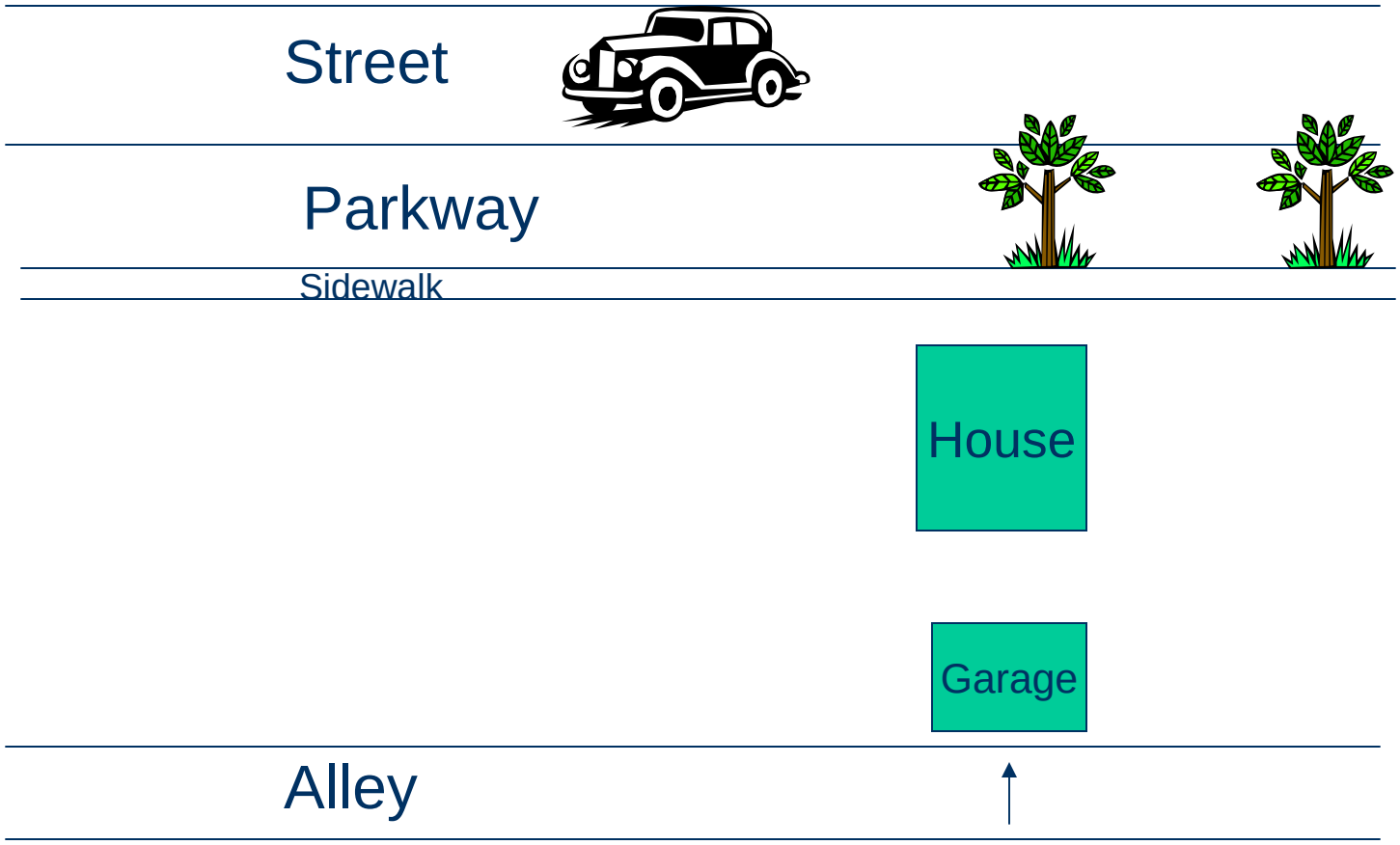
Preliminary dust fall results from 88 events & dust characterization subset are subjects of 2 posters presented at 2008 AIHCe conference:

- Alison Welch: *Ambient Lead and Dust Deposition in Chicago and at Demolition Sites*
- Bogdan Catalin: *Size-Fractioned Particulate Matter Area Exposure Assessment near demolition of Single Family Housing Units in an Urban Environment*

Site locations



Typical demo process/ activities: Approach



Typical demo process/ activities: Reaching

Photos courtesy of Bogdan Catalin

Enclosed stairwell removed

Typical demo process/ activities: Tight spaces

Typical demo process/ activities: Tight spaces

Typical demo process/ activities: Debris removal

Summary Previous Lead Dust Fall Studies

East Baltimore Study

(1999-2000)

Demolition:

N=22 (3 sets of rowhouses)

Geo Mean=410 ug/m^2/hr

Debris removal:

N=36

Geo Mean=61 ug/m^2/hr

Background:

N=38

Geo Mean=10.0 ug/m^2/hr

Chicago Pilot Study

(Mar-Oct, 2006)

Demolition:

N=47 (10 locations)

Geo Mean=48.0 ug/m^2/hr w/dust suppression, 74.5 w/o dust suppression

Background:

N=22 (6 locations)

Geo Mean=13.0 ug/m^2/hr

EBDI East Baltimore 60-day (11/10/06) N=238

Geo Mean=7.71 ug/m^2/hr

Summary of preliminary results for this study

Perimeter samples	Non-perimeter samples	All Background samples
N=249 (88 events)	N=145 (88 events)	N=98
Geo mean = 60.4 ug/m^2/hr	Geo mean = 16.5 ug/m^2/hr	Geo mean = 2.5 ug/m^2/hr
Lead content = 1870–1940 ppm	Lead content = 2250–2270 ppm	Lead content = 130–160 ppm
(65% of lead mass was found in 6 samples)		

Preliminary results relative to 1st hypothesis

"Lead dust fall from demolition can exceed federal standards for interior settled lead dust on floors (40 $\mu g/ft^2$= 40 $\mu g/ft^2$/8 hrs=56 $\mu g/m^2/hr$) within a day in at least 10% of demolition sites where dust suppression is not used in Chicago."

(40 $\mu g/ft^2$ is lead dust clearance level for interior floors).

In first 88 events, 120/249 (48%) perimeter and 37/145 (26%) non-perimeter samples exceeded 56 $\mu g/m^2/hr$, where water hose dust suppression was used at 77/88 events (In some of the 11 events, not used account rain night before).

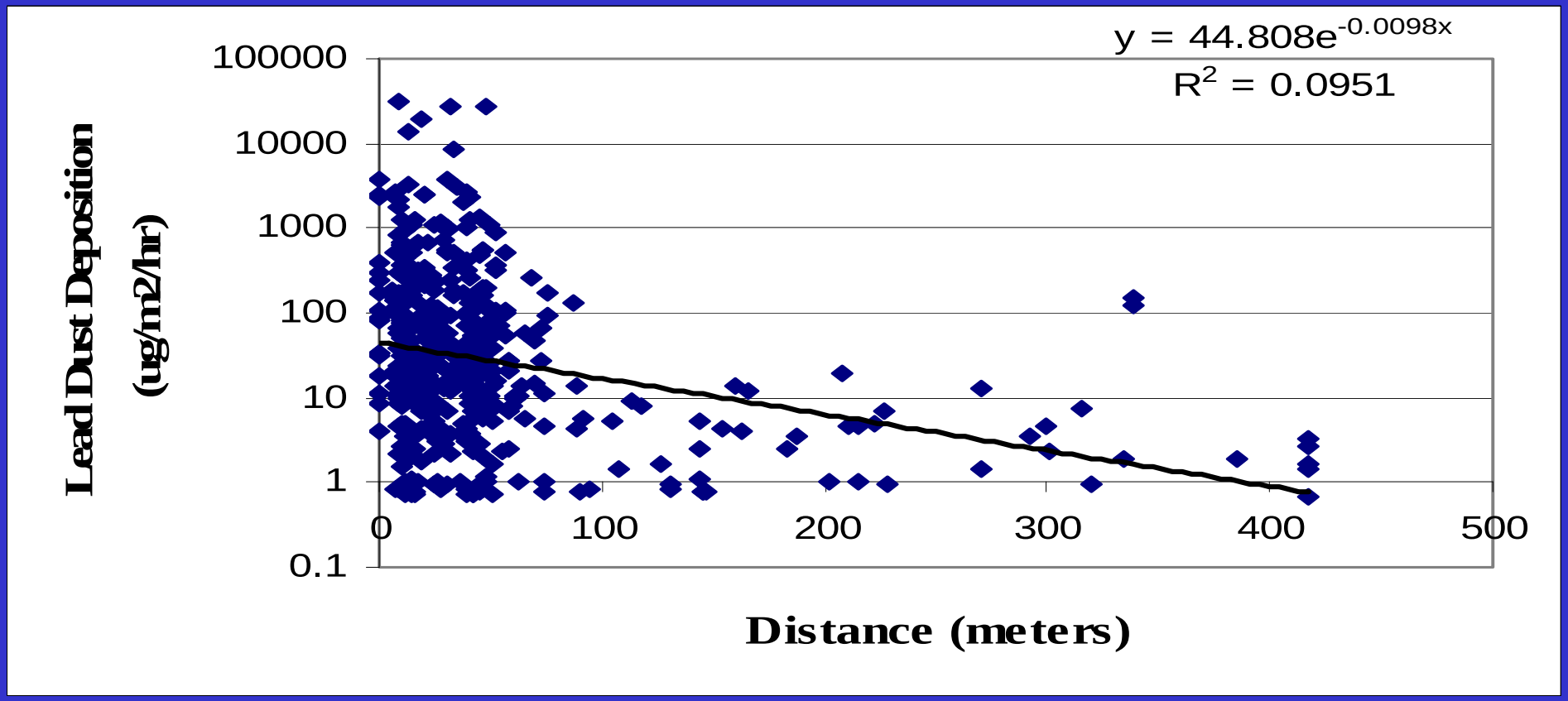
Preliminary results relative to 1st hypothesis

Another HUD guideline for exterior surfaces (HUD Guidelines) is 800 $\mu g/ft^2$ = 800 $\mu g/ft^2/8$ hrs = 1120 $\mu g/m^2/hr$).

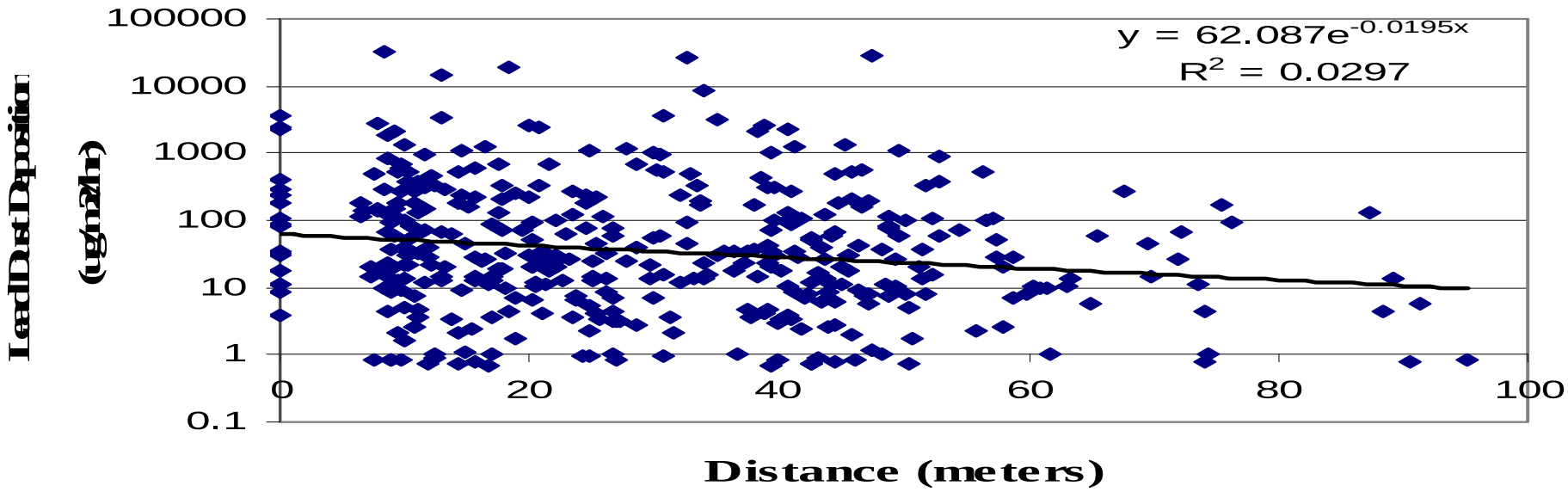
In first 88 events, 21/249 (8.4%) perimeter and 4/145 (2.8%) non-perimeter samples exceeded 1120 $\mu g/m^2/hr$.

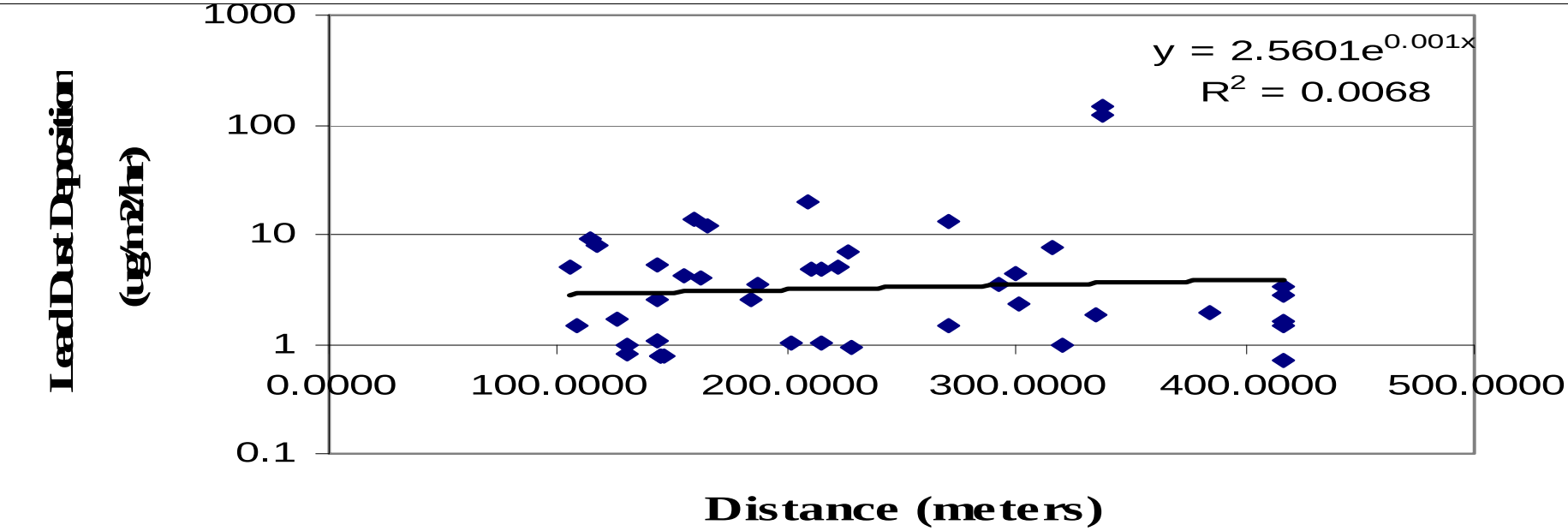
Water hose dust suppression was used at 77/88 events (In some of the 11 events, not used account rain night before).

Lead dust fall reduction by distance



Lead dust fall reduction by distance





Lead dust fall by distance issues

- Property lines
- All particles vs. lead particles
- (All) particle size and deposition rates
  - MMD = 11.5-12.3 μm aerodynamic diameter
  - ≈ 10% <2.5 μm
  - ≈ 30% 2.5-10 μm
  - ≈ 60% >10 μm
- Efforts to correlate dust fall with ambient air monitoring stations

Project Management Challenges

- Finding active demo events (opportunistically)
  - Observation and combing neighborhoods
  - Gas utility shutoff list
  - Resourceful students friendly with demo crews
- Maintaining sampling team and supply availability w/ fluid schedule
- Remaining unobtrusive at events, not affecting operations

Project accomplishments and progress

- 88 active demo events in 2007, good data
- Current housing sale slowdown appears to have affected frequency of demolitions (2 events found this year)
- Observer effect on dust suppression use?

Conclusions & General IH recommendations

- Passive dust fall sampling has a role in conjunction with traditional IH methods
- Opportunistic sampling forces simpler study design
- Significant amount of lead dust is emitted by demolition of older homes
- Research and improvement of dust suppression techniques needed

References

Lead Dustfall from Demolition of Scattered Site Family Housing: Developing a Sampling Methodology, Amy Pelka Mucha, University of Illinois at Chicago (UIC), Division of Environmental and Occupational Health Sciences; Nicole Stites, Chicago Department of Public Health; Anne Evens, Center for Neighborhood Technology; Patrick M. MacRoy, Chicago Department of Public Health; Victoria W. Persky, UIC, Division of Epidemiology and Biostatistics; David E. Jacobs, UIC, Division of Environmental and Occupational Health Sciences and National Center for Healthy Housing (Manuscript submitted to Environmental Research, in review)

Sixty Day Air and Dust Fall Monitoring of East Baltimore Development Inc., Phase I Demolition, Report prepared for East Baltimore Development, Inc., by EBA Engineering, Inc., November, 2006, Baltimore, MD

Study of Urban Housing Demolitions as Sources of Lead in Ambient Dust: Demolition Practices and Exterior Dust Fall Mark R. Farfel,[1,2] Anna O. Orlova,[2] Peter S.J. Lees,[3] Charles Rohde,[4] Peter J. Ashley,[5] and J. Julian Chisolm, Jr.[1] [1]Kennedy Krieger Research Institute, Baltimore, Maryland, USA; [2]Department of Health Policy and Management, [3]Department of Environmental Health Sciences, and [4]Department of Biostatistics, The Johns Hopkins University Bloomberg School of Public Health, Baltimore, Maryland, USA; [5]U.S. Department of Housing and Urban Development, Washington, DC, USA, ***Environmental Health Perspectives* Volume 111, Number 9, July 2003**

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BUILDING A FRAMEWORK FOR HEALTHY HOUSING

2008 National Healthy Homes Conference

A New Colorimetric Spot Test for Lead in Household Paint and Dusts based on Catalytic DNA-Nanoparticles

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Department of Chemistry
University of Illinois at Urbana-Champaign

Importance of Lead (Pb) Detection for Healthy Homes

- Many old houses contain leaded paints
- Remediation of those leaded paints may create leaded dusts
- Lead exposure affects the brain and nervous system of children and causes reproductive problems and hypertension in adults
- Knowing how much Pb in paints and dusts is important both before and after Pb paints and dusts remediation work.

Instrumental Methods for Lead Detection in Central Labs

Atomic absorption spectrometry (AA)
Inductively coupled plasma mass spectrometry
Anodic stripping voltammetry

Advantages

- Industrial standard
- Highly sensitive (down to ~ppb or less)
- Detect a number of targets simultaneously

Disadvantages

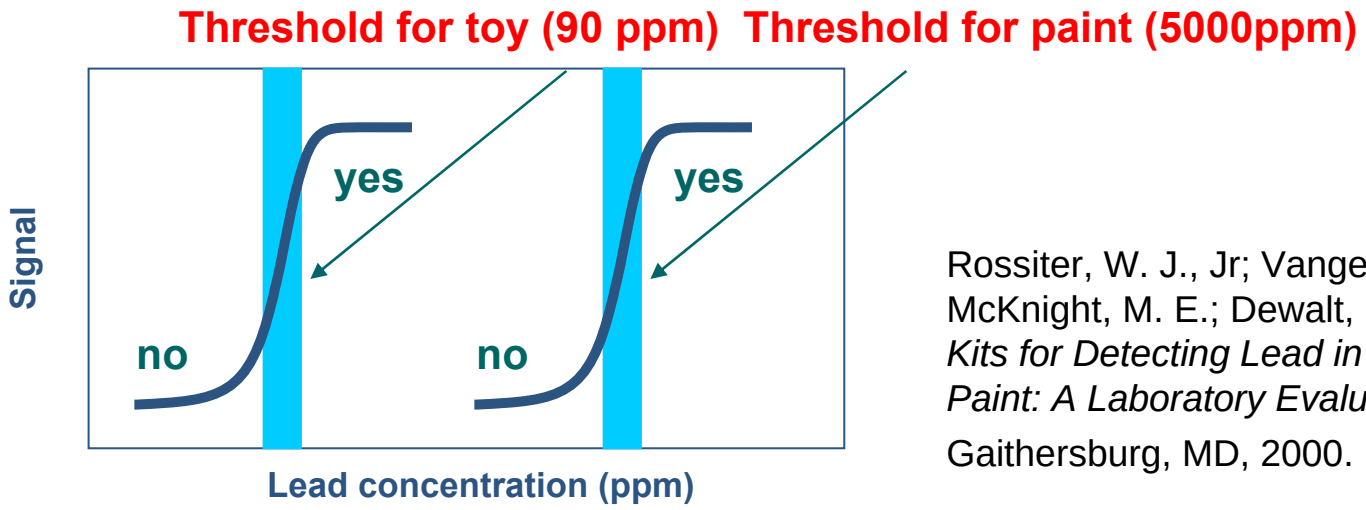
- Require sophisticated equipment, sample pretreatment, and skilled operators
- Difficult for on-site and real-time detection
- Therefore incurs extra time and costs for inspectors and government officials

Portable X-ray Fluorometers (XRF) is the state-of-the-art for on-site detection But XRF is still expensive to acquire and maintain, and difficult to detect at low concentration, e.g., 90 ppm, safe level for toy.

Our aim: Develop simple, accurate and reliable spot test for Pb

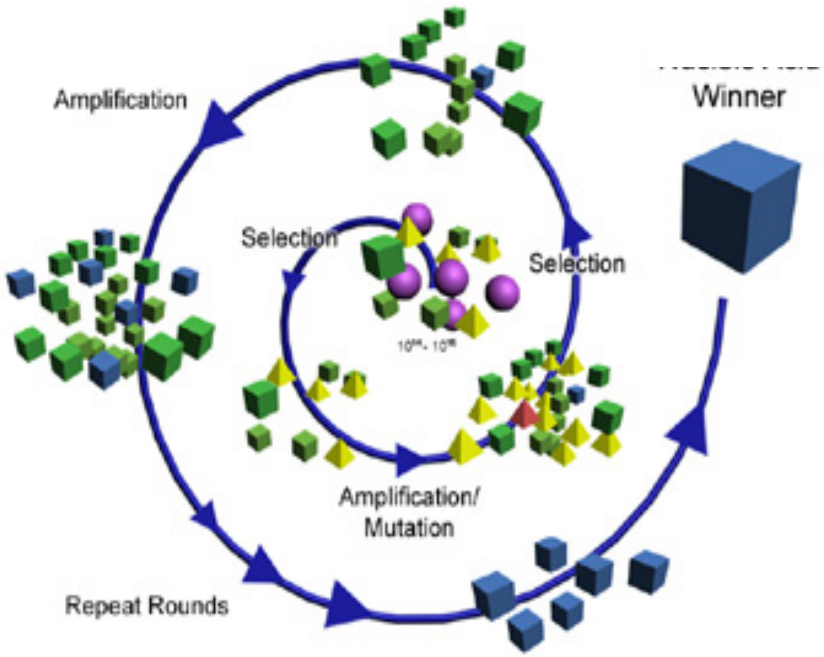
The Need for New Spot Test Method for Pb

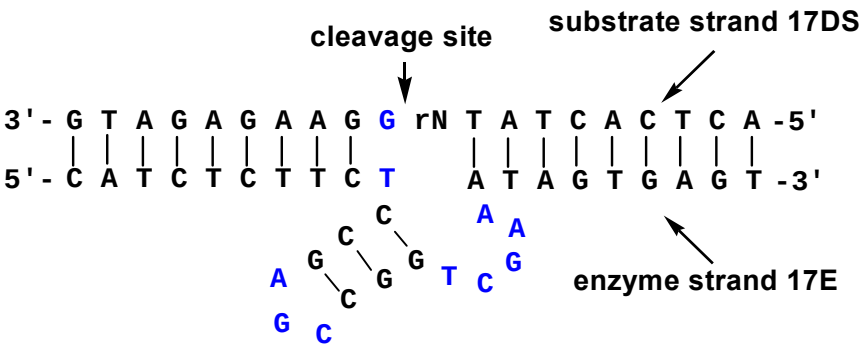
- Study of available spot test kits showed high rates of either false positive or false negative results when compared to laboratory results
- US federal "threshold" for Pb in paint is 1.0 mg/cm^2 or 0.5%
- Rossiter et al. has defined an ideal performance of a spot test kit for Pb
- No current spot test kit can meet the ideal performance standard
- No current spot test kit can move its thresholds (e.g., paint, dust, water, toy)

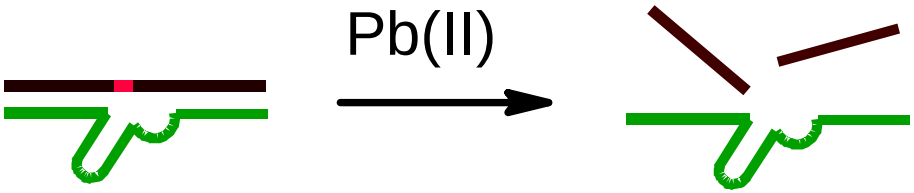


Rossiter, W. J., Jr; Vangel, M. G.; McKnight, M. E.; Dewalt, G. *Spot Test Kits for Detecting Lead in Household Paint: A Laboratory Evaluation*; Gaithersburg, MD, 2000.

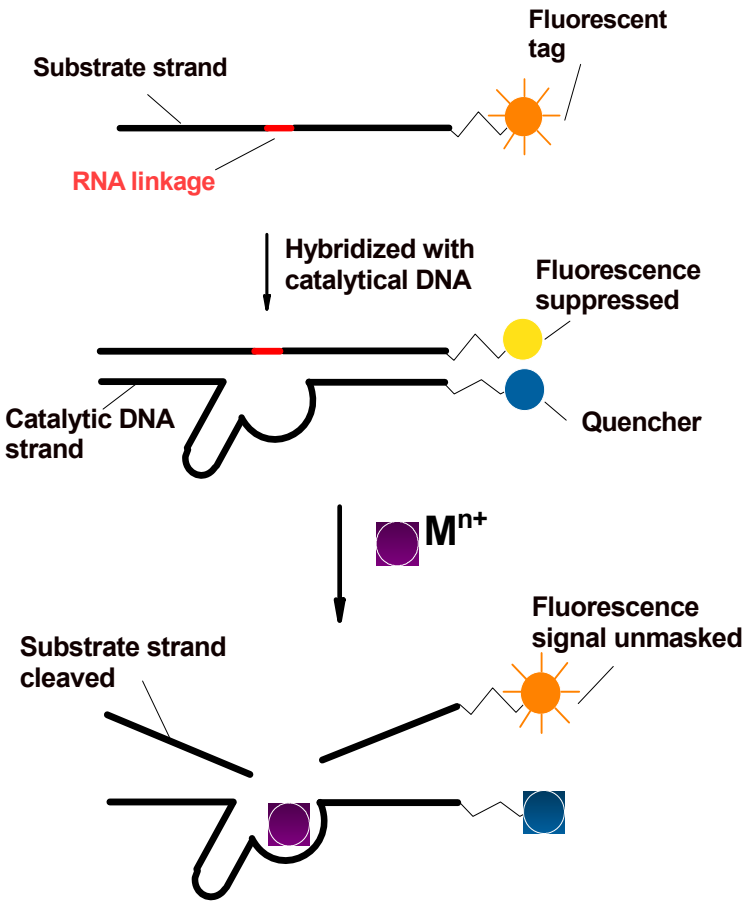
Recent development in Biology: Catalytic DNA that is specific for Pb

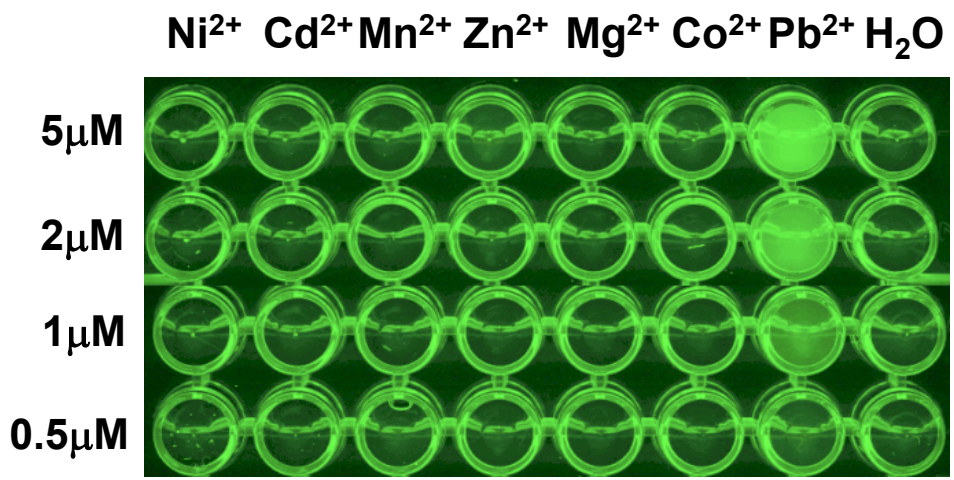






Fluorescent Pb sensor based on catalytic Beacon

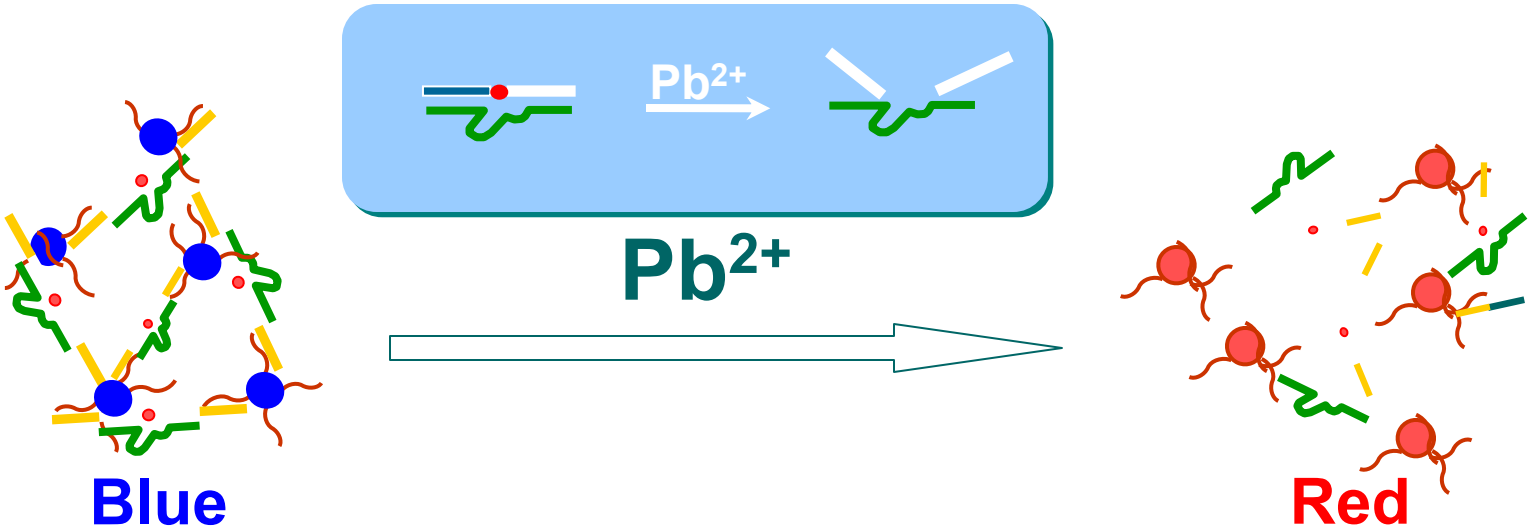


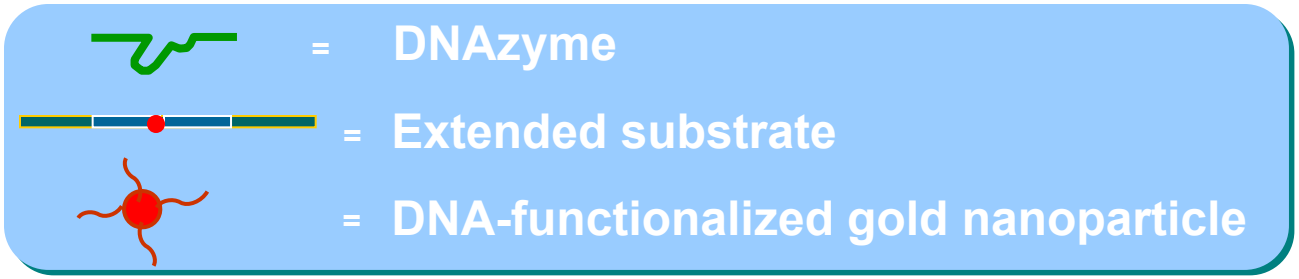


Detection limit down to 1 nm (0.2 ppb)
(EPA MCL for water: 75 nM (15 ppb))
High selectivity over other metal ions

Li, J.; Lu, Y. *J. Am. Chem. Soc. 122,* 10466-10467 (2000).
Liu, J.; Lu, Y. Anal. Chem. 75, 6666 – 6672 (2003);

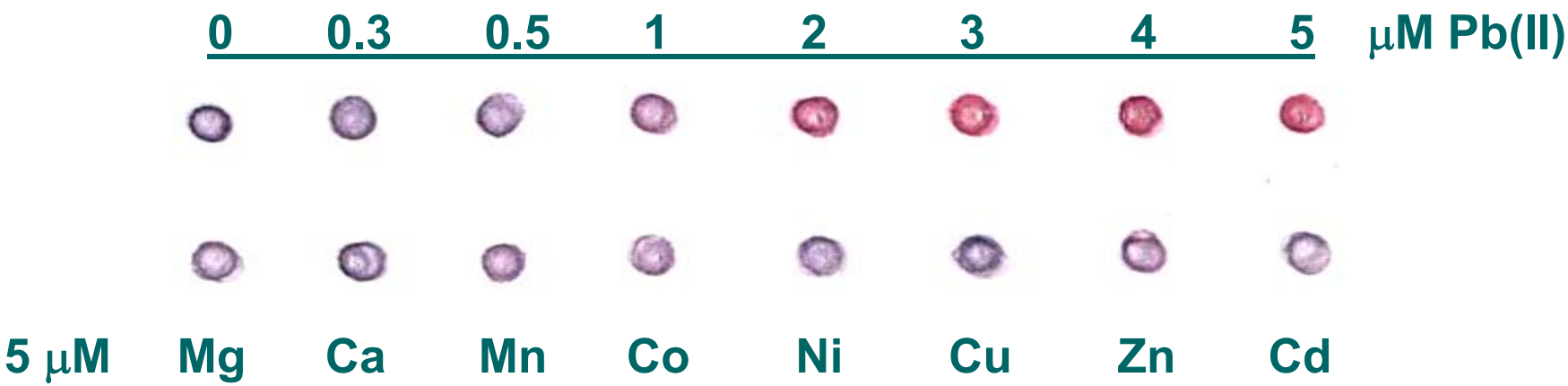
Combining Biology with Nanotechnology: a Colorimetric Pb^{2+} Sensor based on catalytic DNA-gold nanoparticles





Liu, J.; Lu, Y. *J. Am. Chem. Soc. 125*, 6642-6643 (2003).

Colorimetric Detection of Pb^{2+}



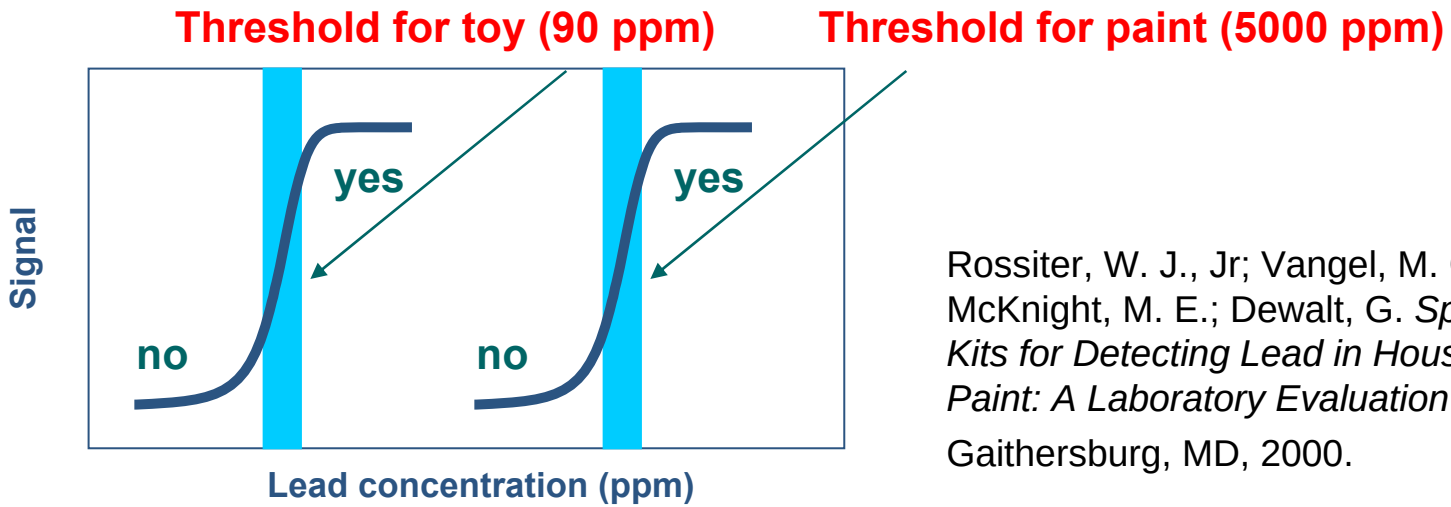
Fast: Color change (1-2 minutes)

Quantifiable: Color can be monitored by naked eyes or a portable colorimeter

Liu J.; Lu, Y. *J. Am. Chem. Soc. 125, 6642-6643* (2003);
Liu J.; Lu, Y. *J. Am. Chem. Soc. 126,* 12298 (2004);
Liu J.; Lu, Y. *J. Am. Chem. Soc. 127,* 12677 (2005).

Ideal performance curve for Pb test

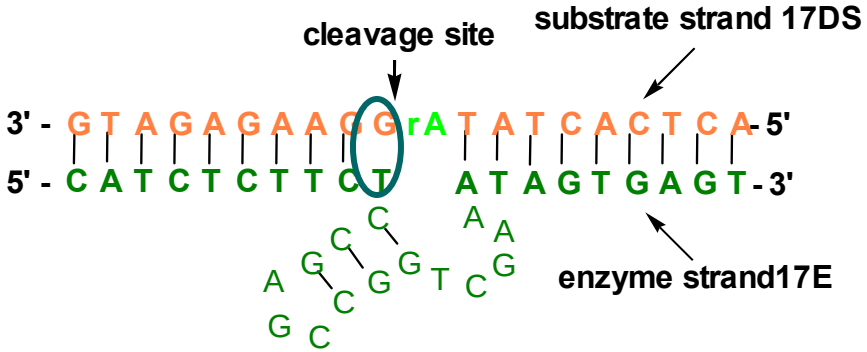
- US federal "threshold" for Pb in paint is 1.0 mg/cm^2 or 0.5%
- Rossiter et al. has defined an ideal performance curve of a spot test kit for Pb
- The key to meeting the ideal performance standard is to design Pb sensor with tunable dynamic range



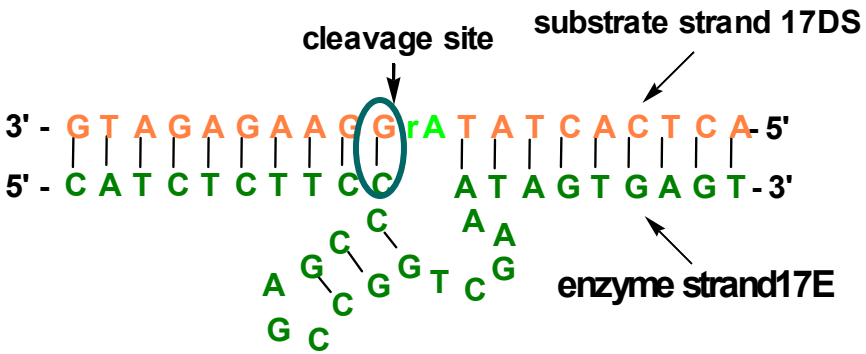
Rossiter, W. J., Jr; Vangel, M. G.; McKnight, M. E.; Dewalt, G. *Spot Test Kits for Detecting Lead in Household Paint: A Laboratory Evaluation*; Gaithersburg, MD, 2000.

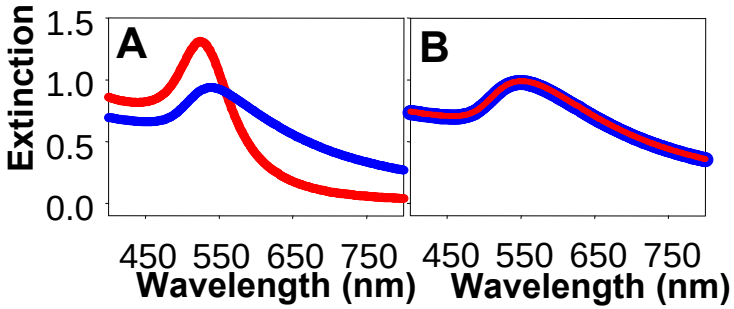
Pb Sensor with Tunable Dynamic Range

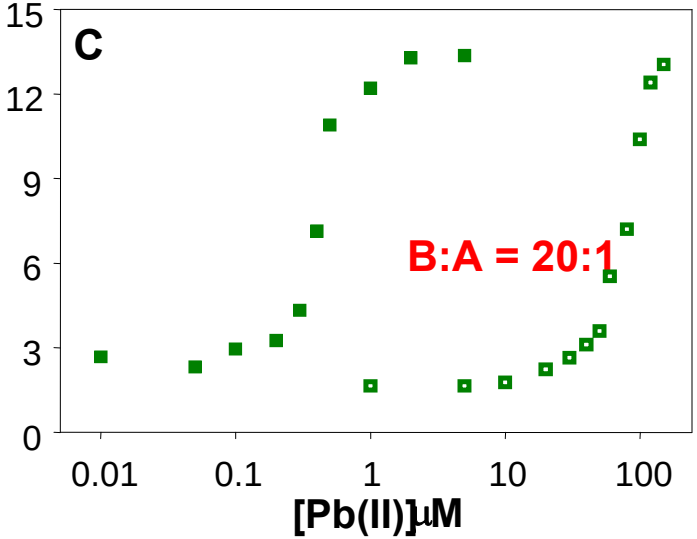
A. Active DNA



B. Inactive DNA



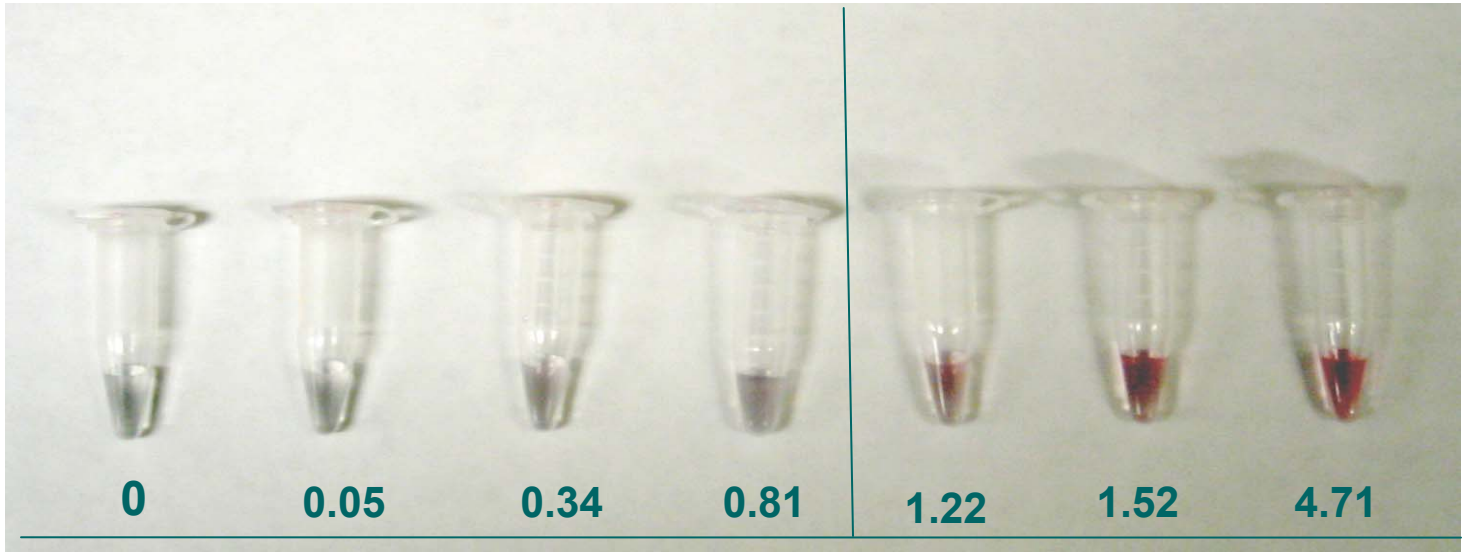




Liu, J.; Lu, Y. *J. Am. Chem. Soc. 125*, 6642-6643 (2003).

Spot test for Pb in paints: qualitative

1.0 mg/cm^2 (threshold)

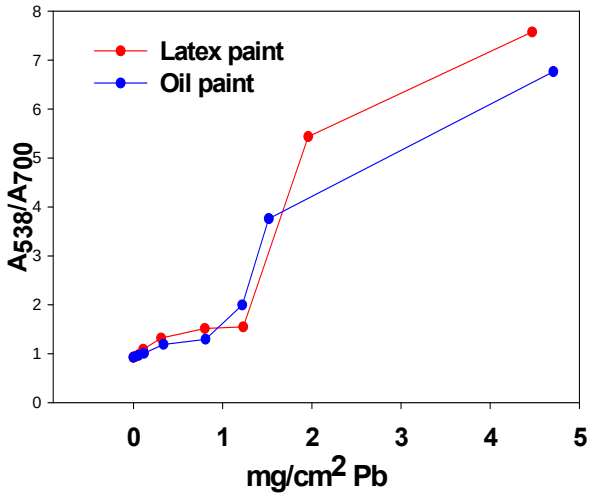


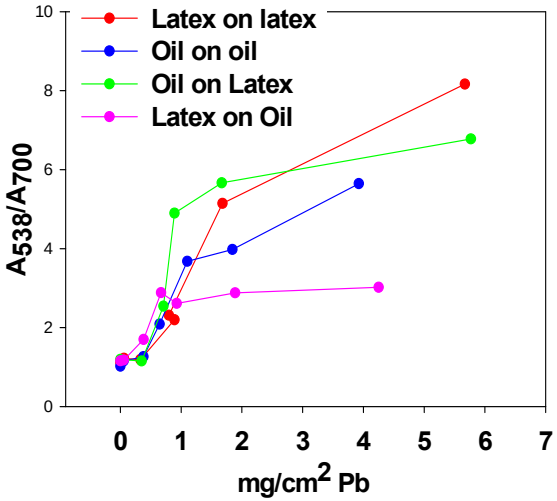
mg Pb / cm^2 paint

The color change occurs right at federal threshold.

Spot test for Pb in paints: quantitative

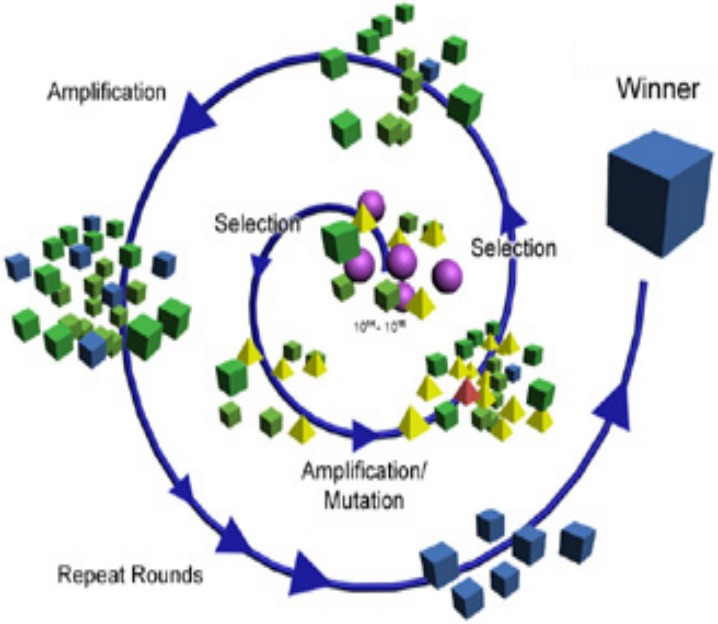
Portable colorimeter





Lead detection curves obtained with our Pb colorimetric sensor closely resemble ideal curve

Beyond Pb detection: spot test for other targets



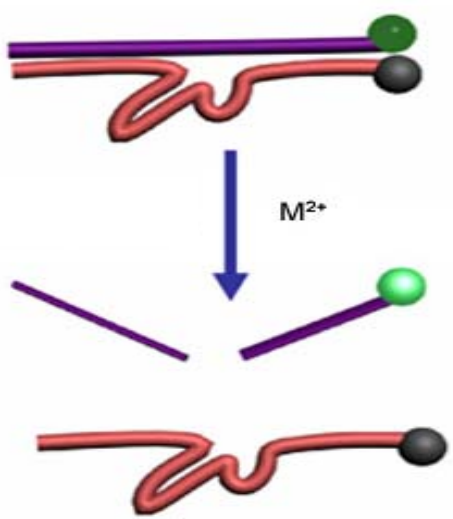
A partial list of contaminants recognized by selected DNA/RNA

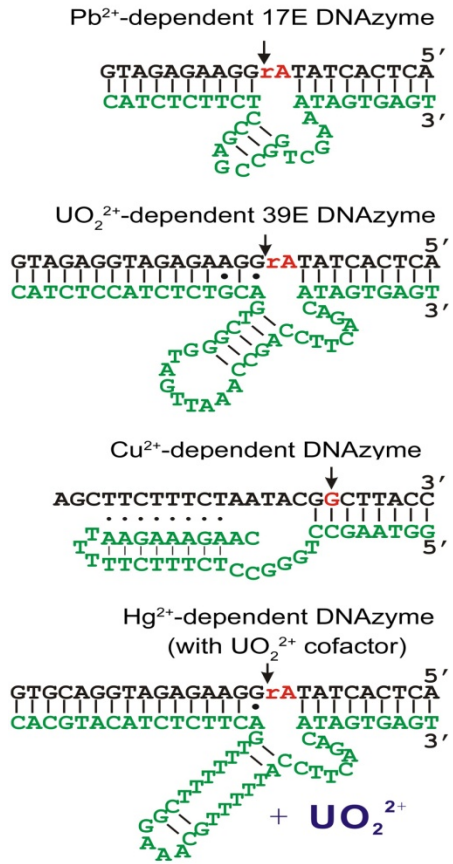
Contaminant type	Examples
Metal ions	Pb^{2+}, Cu^{2+}, UO_2^{2+}, Hg^{2+} , As^{5+}, Zn^{2+}
Radionuclides	UO_2^{2+}
Toxins	Ricin, Abrin toxin, Microcystin
Antibiotics	Vasopressin, Streptomycin, Tetracycline, Viomycin, Chloramphenicol
Endocrine disrupting compounds & hormones	17β-estradiol, Thyroxine hormone
Protein	HA1 proteins of H5N1 influenza virus
Other small organic molecules	Cocaine, Cholic acid, (R)-thalidomide, Ethanolamine
Cells and bacteria	Anthrax spores, Campylobacter jejuni

J. Liu and Y. Lu, *Curr. Opion. Biotech.* 17, 580–588 (2006).
D. Mazumdar and Y. Lu, In *Nanotechnology Applications: Solutions for Improving Water Quality* (in press).

Sensors for mercury, uranium and copper

Fluorescent sensors
Based on catalytic beacon





Pb^{2+}: Detection limit: 1 nM (0.2 ppb)
EPA MCL: 75 nM (15 ppb)

UO_2^{2+}: Detection limit: 45 pM (11 ppt)
EPA MCL: 126 nM (30 ppb)
(ICP-MS: 420 pM (100 ppt)

Cu^{2+}: Detection limit: 35 nM (2.3 ppb)
EPA MCL: 20 µM (1.3 ppm)

Hg^{2+}: Detection limit: 2.4 nM (0.5 ppb)
EPA MCL: 10 nM (2 ppb)

J. Liu, et al. *Proc. Natl. Acad. Sci* 104, 2056 (2007).
J. Liu and Y. Lu J. *Am. Chem. Soc*. 129, 9838 (2007).

Beyond Pb detection: spot test for other targets

Household application

- Drinking water (As, Pb, Hg)
- Food (milk (Ca), vegetable (Fe))
- Swimming pool, playground, etc.

Environmental monitoring

- Lake
- Soil
- Sewage

Detection and Quantification

Developmental biology or clinical toxicology

- Metal ion spatial distribution
- Real-time change or transportation

Industrial process monitoring

- Waste water treatment
- Contamination site remediation
- Ocean/deep sea M^{n+}distribution

Summary

- Innovative combination of recent breakthroughs in biology and nanotechnology has resulted in catalytic DNA-nanoparticle sensors that are highly sensitive and selective.
- A simple, accurate spot test kit for Pb in paints and dusts has been developed.
- A unique feature is tunable dynamic range that change colors right at federal threshold, and the change can be moved with threshold needs (for paint, dust or water).
- The technology can be applied to detecting Pb in other media such as Pb in water or soil, and to detecting a wide range of other contaminants in household and environment.

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"All the News That's Fit to Print"

The New York Times

Washington Edition

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A search and rescue team headed into the flooded areas of Sabine Pass, Tex., on Sunday.

NEW ORLEANS RESCUES BALTIMORE, CLEVELAND DETROIT FROM LEAD

NEWS ANALYSIS

Other Cites Next

By DOMA [illegible] and NYT, CNN

bankruptcy and setting off worries of a worldwide sell-off when markets open on Monday.

While some investors feared a precipitous decline in the markets Monday, others hoped that Bank of America's surprise announcement Sunday that it was buying Merrill Lynch might provide enough reassurance to calm investors.

"This would be seen as very good news," Liz Ann Sonders, the chief investment strategist for Charles Schwab & Company, said of Bank of America's $50 billion or $29 a share offer, a price far higher than Merrill's close on Friday but less than a third of what the stock was worth early last year before the mortgage crisis began to damage financial firms.

With major Asian markets closed for a holiday on Monday, the answer regarding investor response could wait until European markets open, and, after that, the American exchanges.

In the Lehman talks on Sunday, the government, worried to collectively take on the risk that Lehman's assets were worth far less than the firm claimed. The firms, worried about their own capital, balked at doing so, thought at the end they may take on some of the risk as Lehman's investments are unwound.

Now, the risk for the financial firms is that investors would respond by trying to do exactly what they are trying to do — minimize their risk. If enough investors do that and choose to sell stocks could plummet in markets around the world, thus increasing the risks rather than easing them.

"We don't want to be the first one in," said Thomas Atteberry, a partner at First Pacific Advisors, an investment firm in Los Angeles specializing in fixed income. "I would rather wait and see that there are other participants in the marketplace."

A bankruptcy filing could delay any immediate sell-off of some

Continued on Page A10

For 300 Million Fundred Dollars, The True Value of Children's Health

This article was reported by *Jenny Anderson, Edmund L. Andrews, Eric Dash, Michael J. de la Merced, Andrew Ross Sorkin, Louise Story* and *Ben White*. It was written by Mr. Sorkin.

In one of the most dramatic days in Wall Street's history, Merrill Lynch agreed to sell itself to Bank of America for roughly $50 billion to avert a deepening financial crisis, while another prominent securities firm, Lehman Brothers, barred toward bankruptcy after it failed to find a buyer, people briefed on the deals said.

The humbling moves, which reshape the landscape of American finance, mark the latest chapter in a tumultuous year in which once-proud financial institutions have been brought to their knees as a result of tens of billions of dollars in losses because of bad mortgage loans and real estate investments.

They culminated a weekend of frantic around-the-clock negotiations as Wall Street bankers huddled in meetings at the behest of Bush administration officials to avoid a downward spiral in the markets stemming from a crisis of confidence.

"My goodness, I've been in the business 35 years, and these are one, two, extraordinary events I've ever seen," said Peter C. Peterson, co-founder of the private equity firm the Blackstone Group, who was head of Lehman in the 1970s and a secretary of commerce in the Nixon administration.

It remains to be seen whether the sale of Merrill, which was [illegible]

Rebuilding from Below the Ground Up

By JULIE BARGHANN

HOUSTON — State officials mounted the largest rescue operation in Texas history on Sunday, taking nearly 3,000 people by boat and helicopter out of flood-ravaged towns on the coast in the aftermath of Hurricane Ike. At the same time, millions of others faced whipping aftermath and faced shortages of food, water and gasoline.

Texas workers expressed hope, however, that more bodies [illegible] in the hard-hit coastal areas swamped by the

Lead Contamination Given Innovative "TLC" Paydirt Method

By ANDREW HUNT

GALVESTON, Tex. — For thousands of people stuck on an increasingly frail Galveston Island, the aftermath of Hurricane Ike is proving to be far worse than the storm itself.

With no water or power, no working toilets, no food or phones, people faced growing public health concerns here on Sunday. More than 3,000 residents who had defied an evacuation order were taken off the island, and state officials tried to ensure that no one could return.

"The storm was easy," said Angela Ingram, 37, who [illegible] out, but I can't tell if it is from too much heat or too little food."

She said the lack of toilets had become so bad in her neighborhood that she had been avoiding eating so she would not have to use the bathroom.

Three people were found dead in Galveston on Sunday, including one person in a submerged vehicle near the airport. Officials expressed fears that more would be found as other areas of flooding were assessed, particularly on the west end of the island, where there was "horrendous" devastation, said the city man-

Lead Safe Cities a Reality

By LOUISE STORY

It's the end of an era for Merrill Lynch, the brokerage firm that brought Wall Street to Main Street.

At another venerable Wall Street firm hurtled toward bankruptcy on Sunday, Merrill, its [illegible] developing, prepared

Percent change in stock price Since Dec. 31, 2007

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The Development of a Citywide Jobs Program

Operation: PAYDIRT

SOUS TERRE

STUDY :	SAFE HOUSE AKA FUNDRED / PAYDIRT VAULT	LOCATION :	2461 NORTH VILLERE , NEW ORLEANS, LA

ARTIST :	MEL CHIN	DATE :	07. 14. 2008

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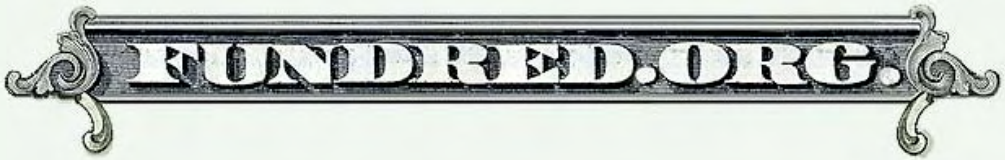

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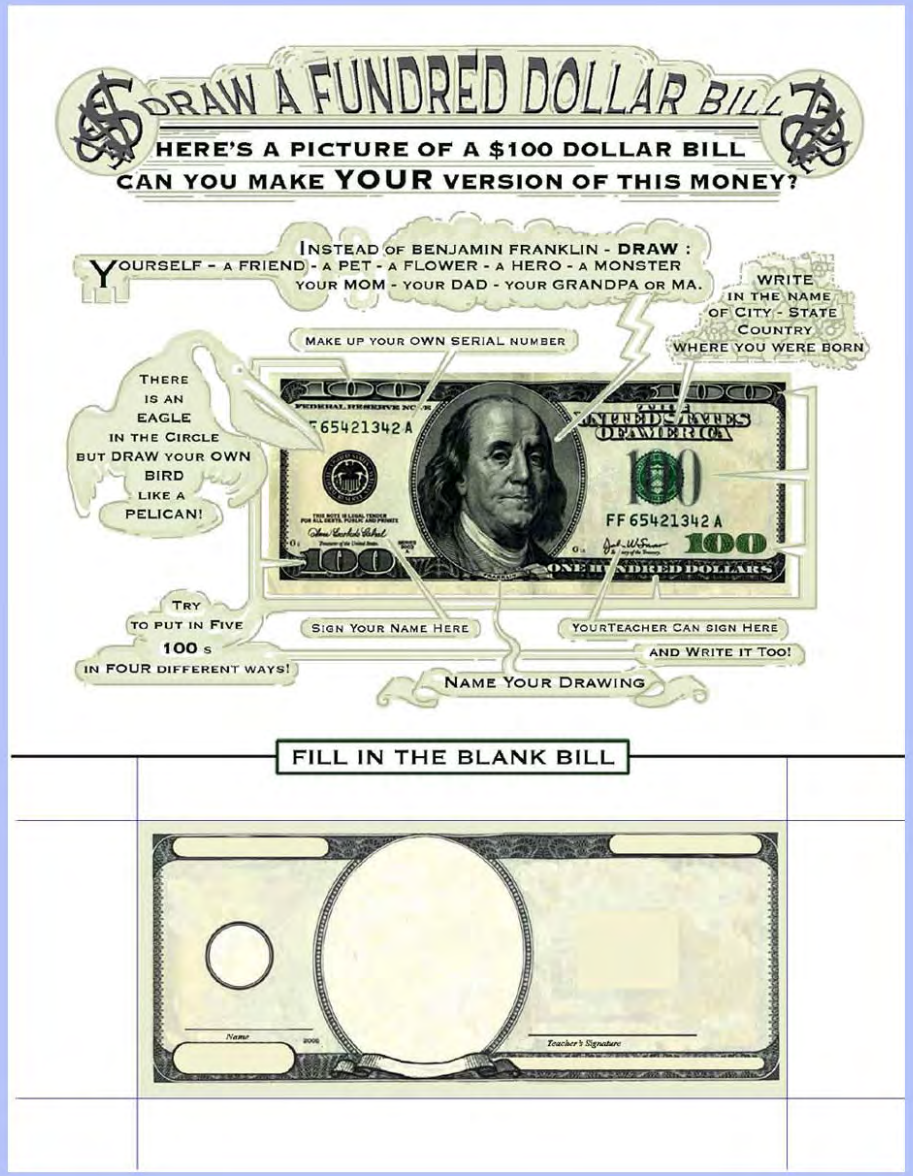

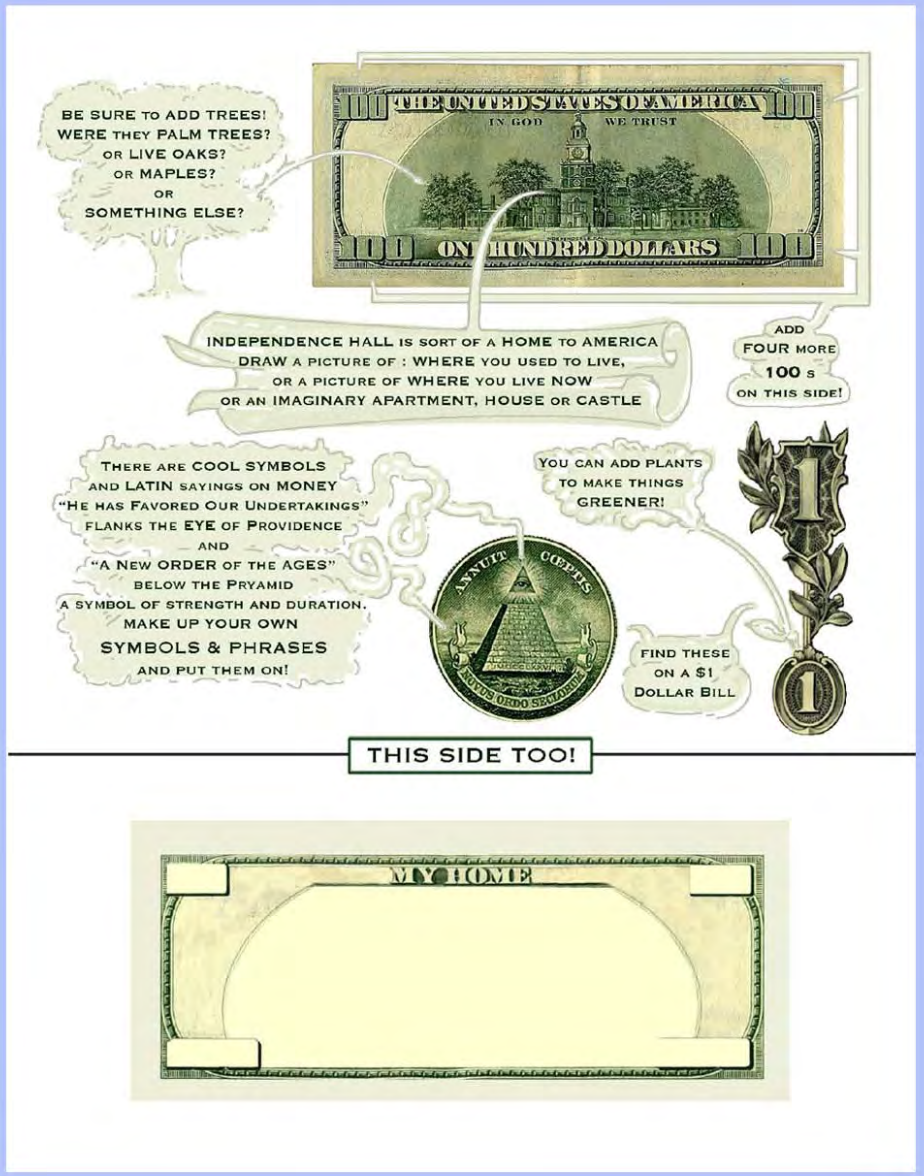

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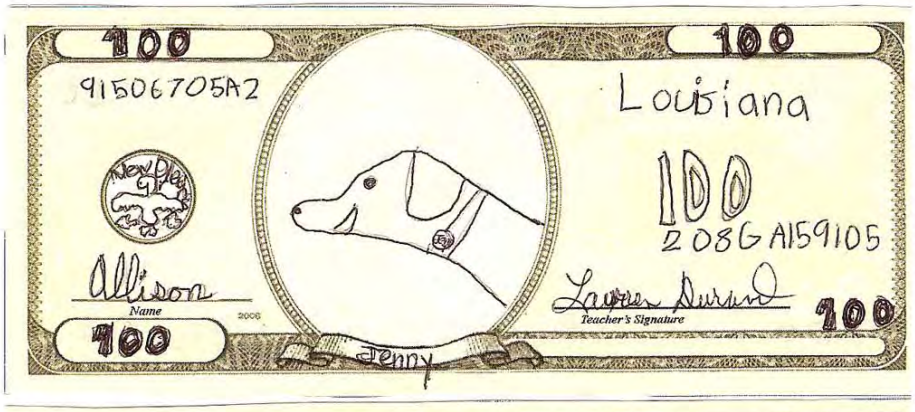
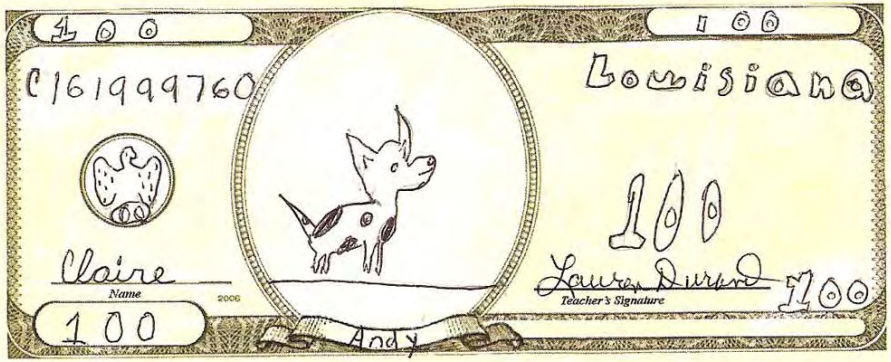
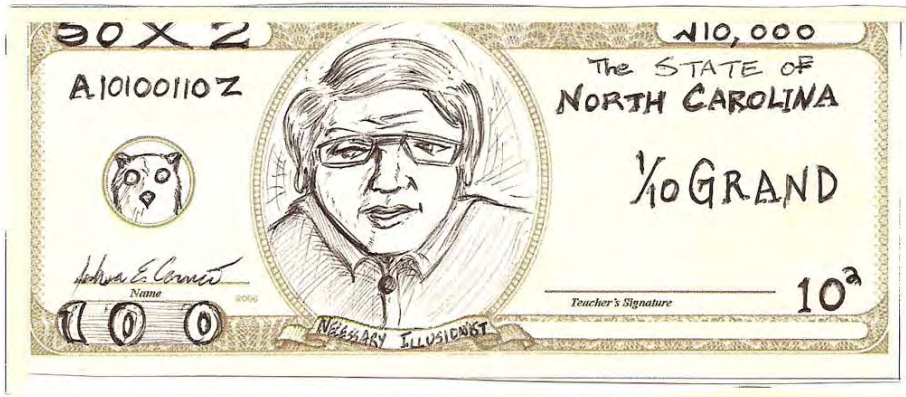
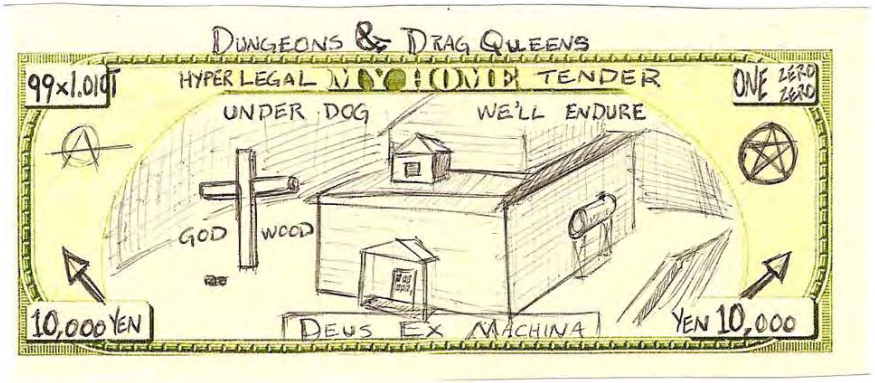


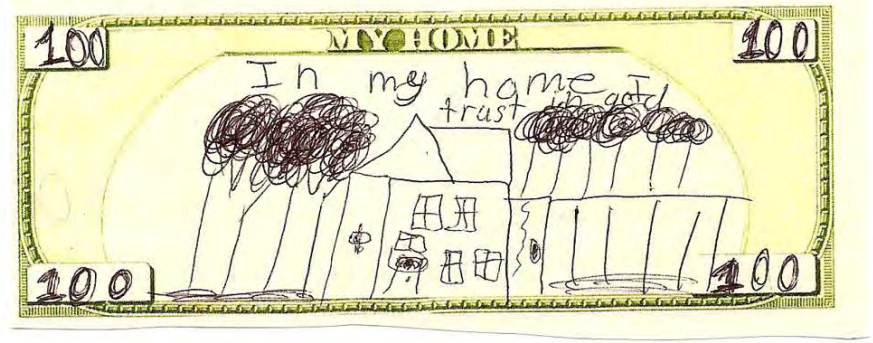


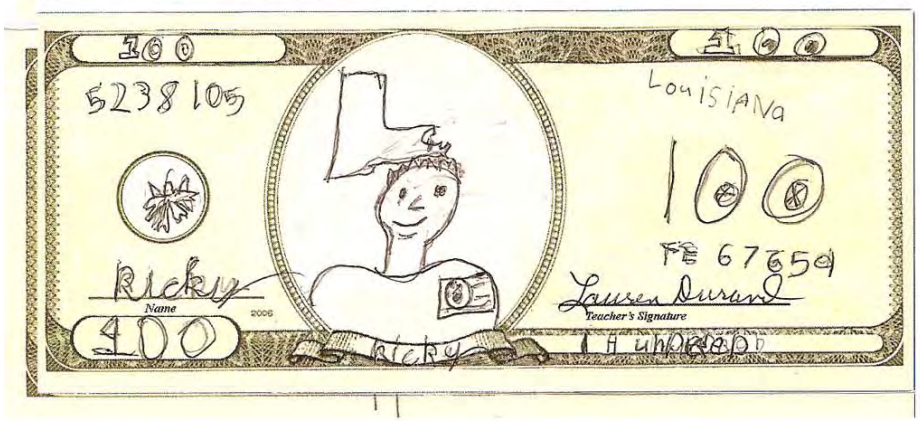
FACE **BACK**

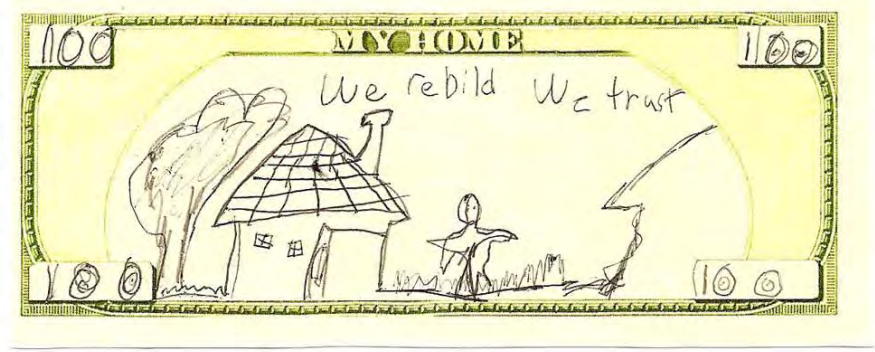
ANIMALS











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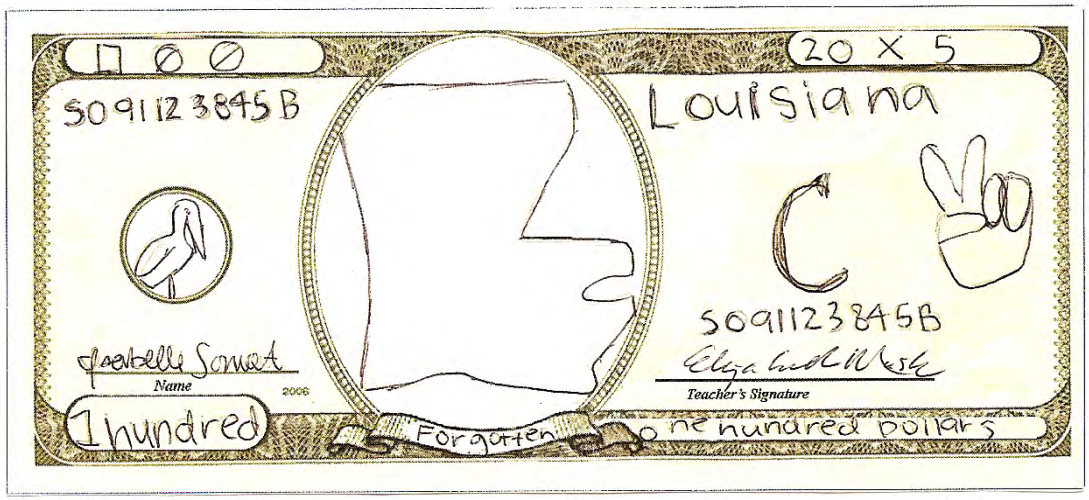
PEOPLE & PLACES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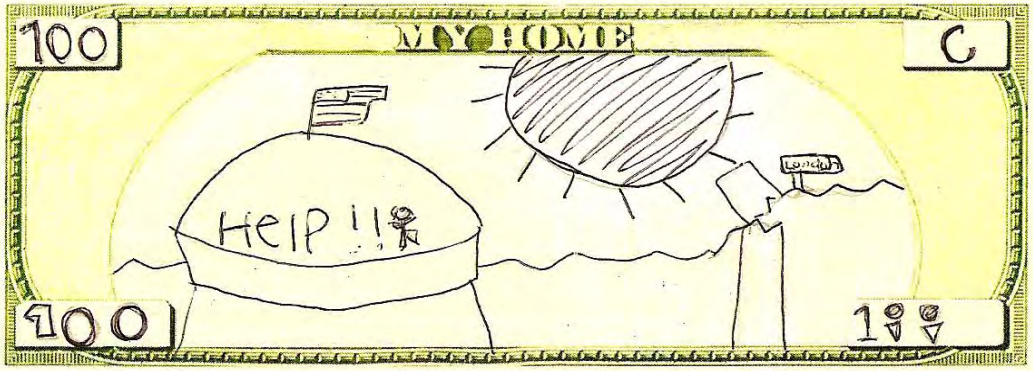
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HELP !!
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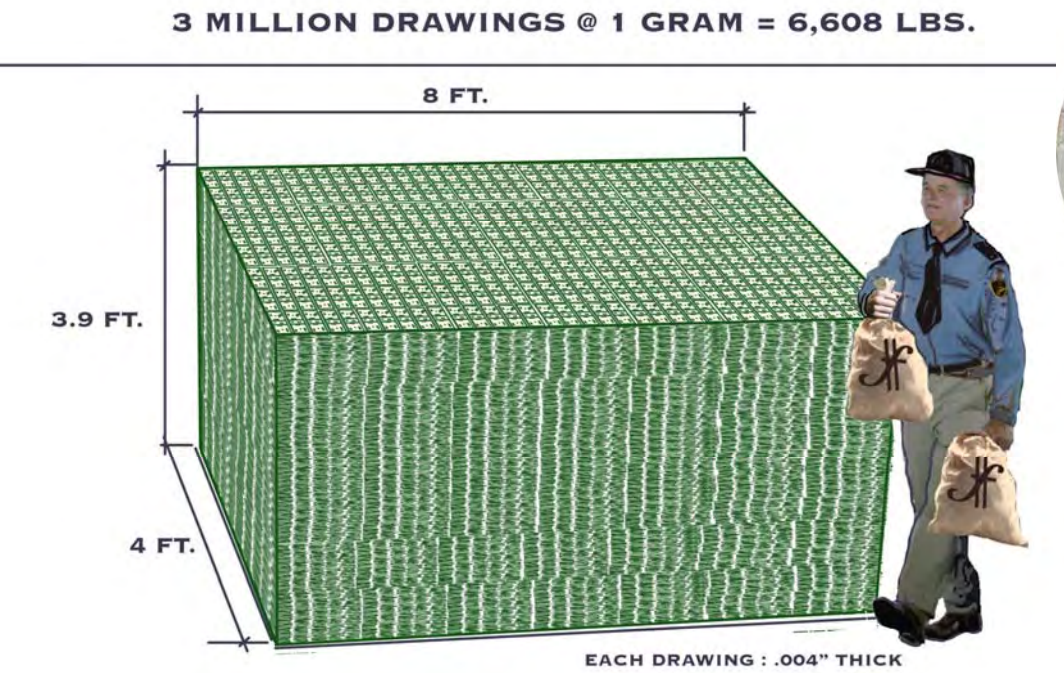
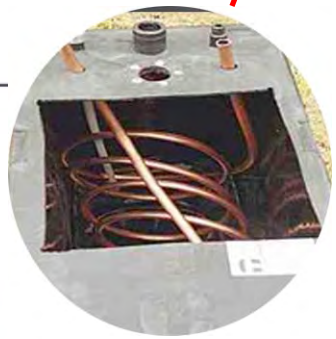


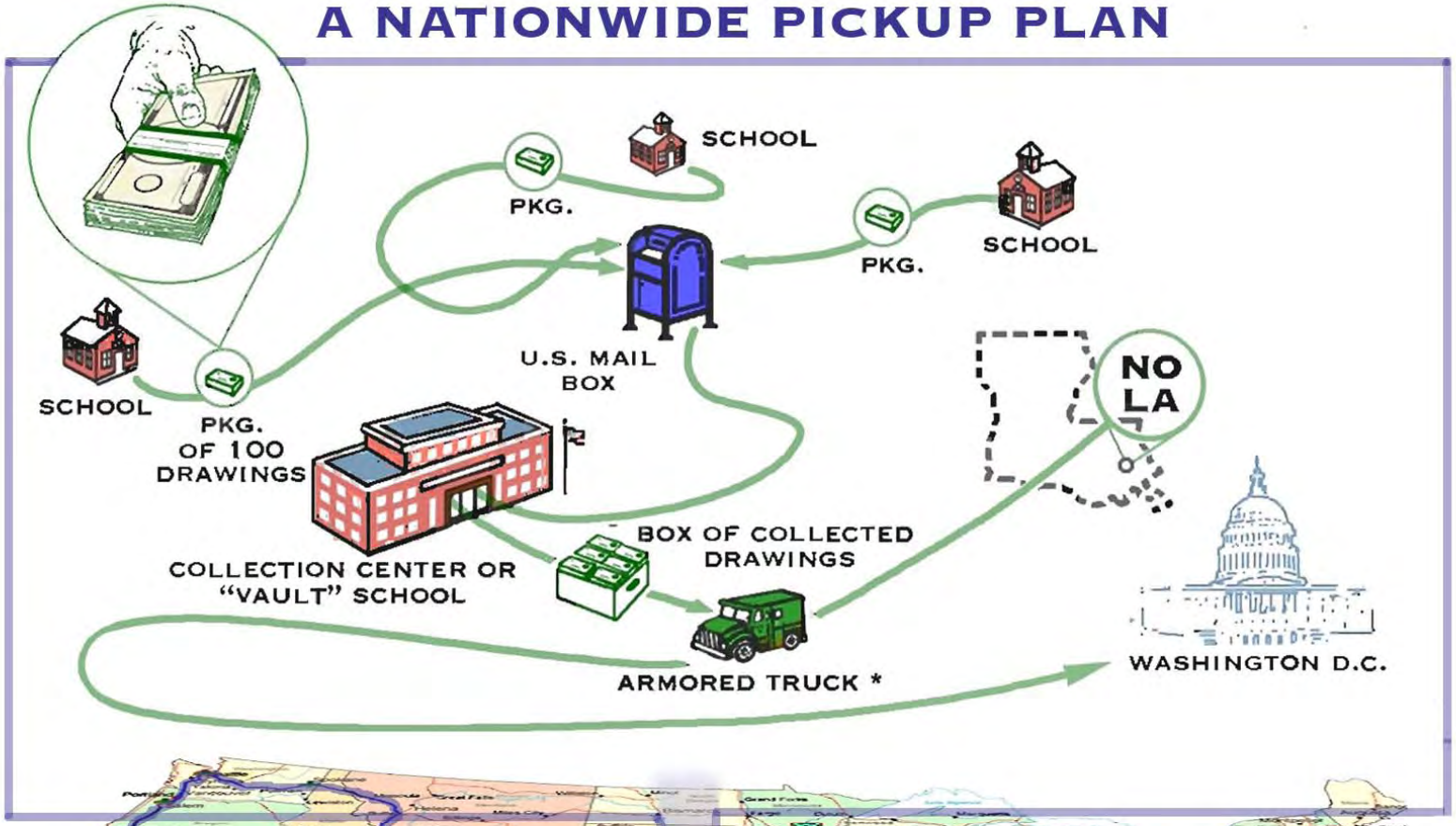


Tank conversion

Engine modification
To run on straight
Vegetable oil (SVO)

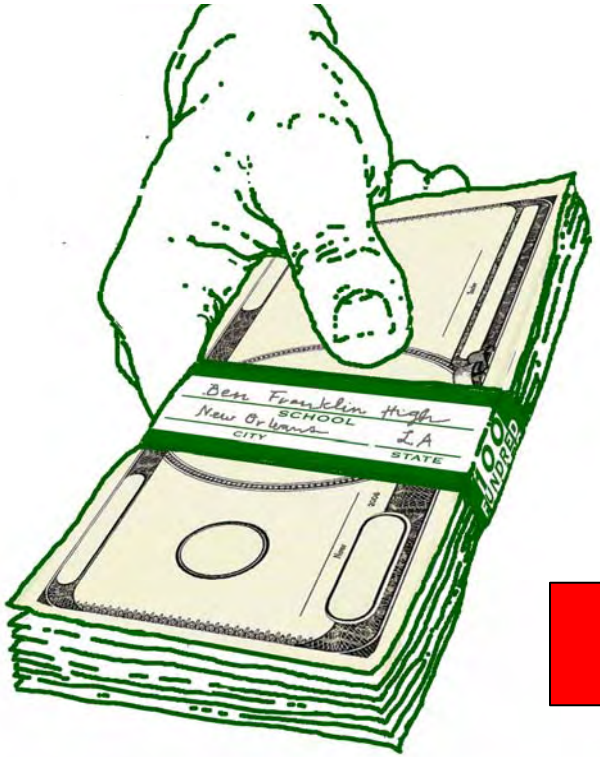
Soil to grass color scheme
W/ "company" logo and
Katrina date serial number
designation

A NATIONWIDE PICKUP PLAN



*POWERED BY USED COOKING OIL FROM SCHOOL CAFETERIA

Currently 70 Collection Center Vaults in 33 States


Ben Franklin High
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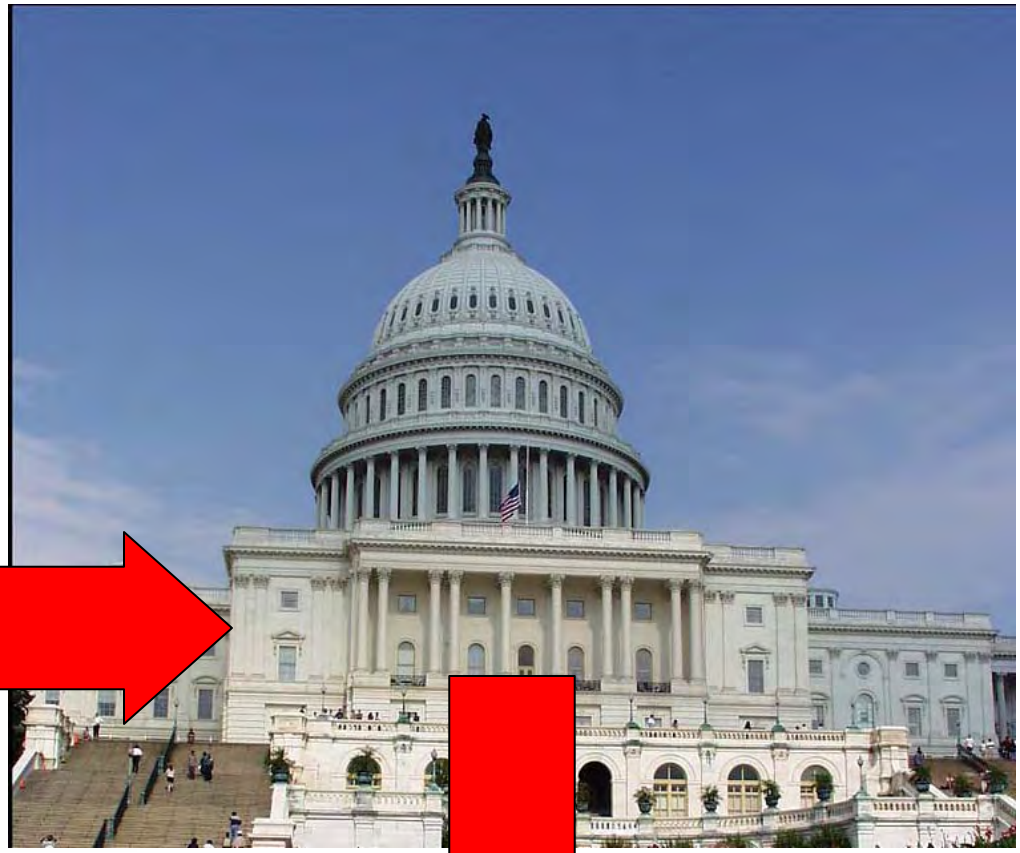

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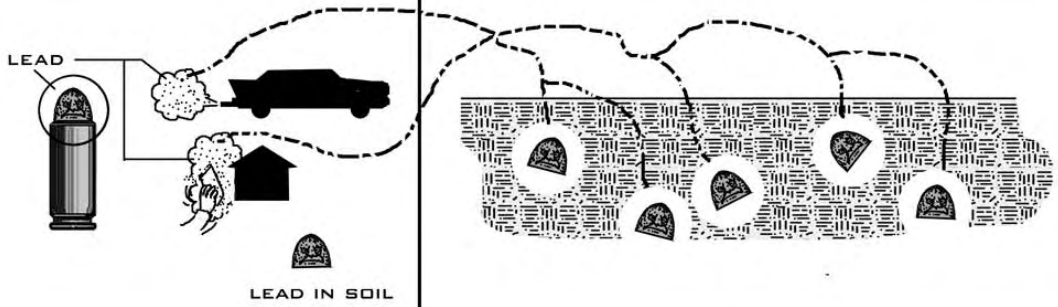
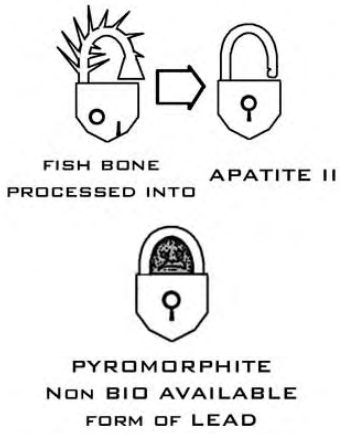
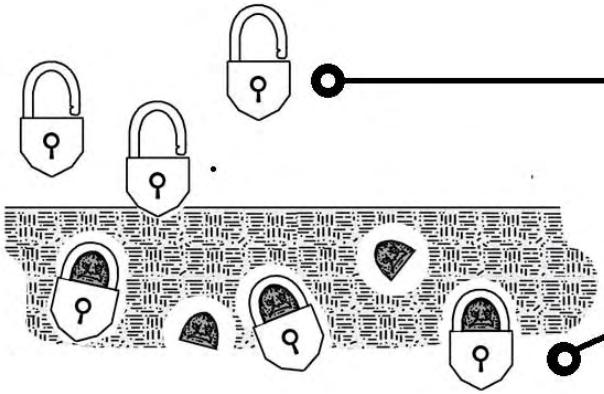


Existing conditions

lead above 400 ppm in the top 2 -4 cm in urban soil

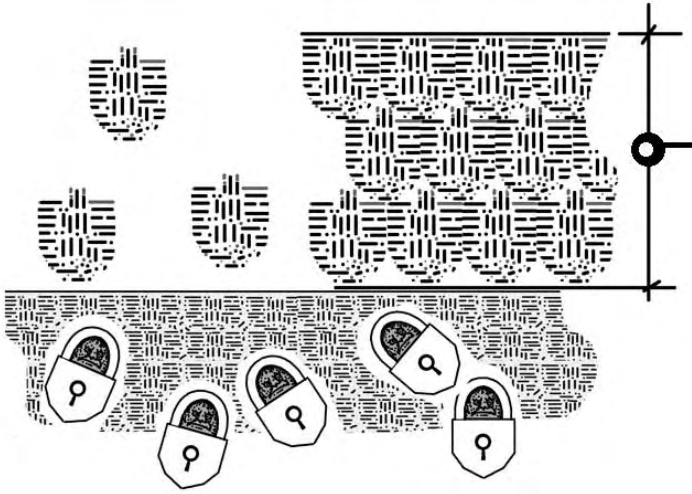




TREAT: with APATITE II

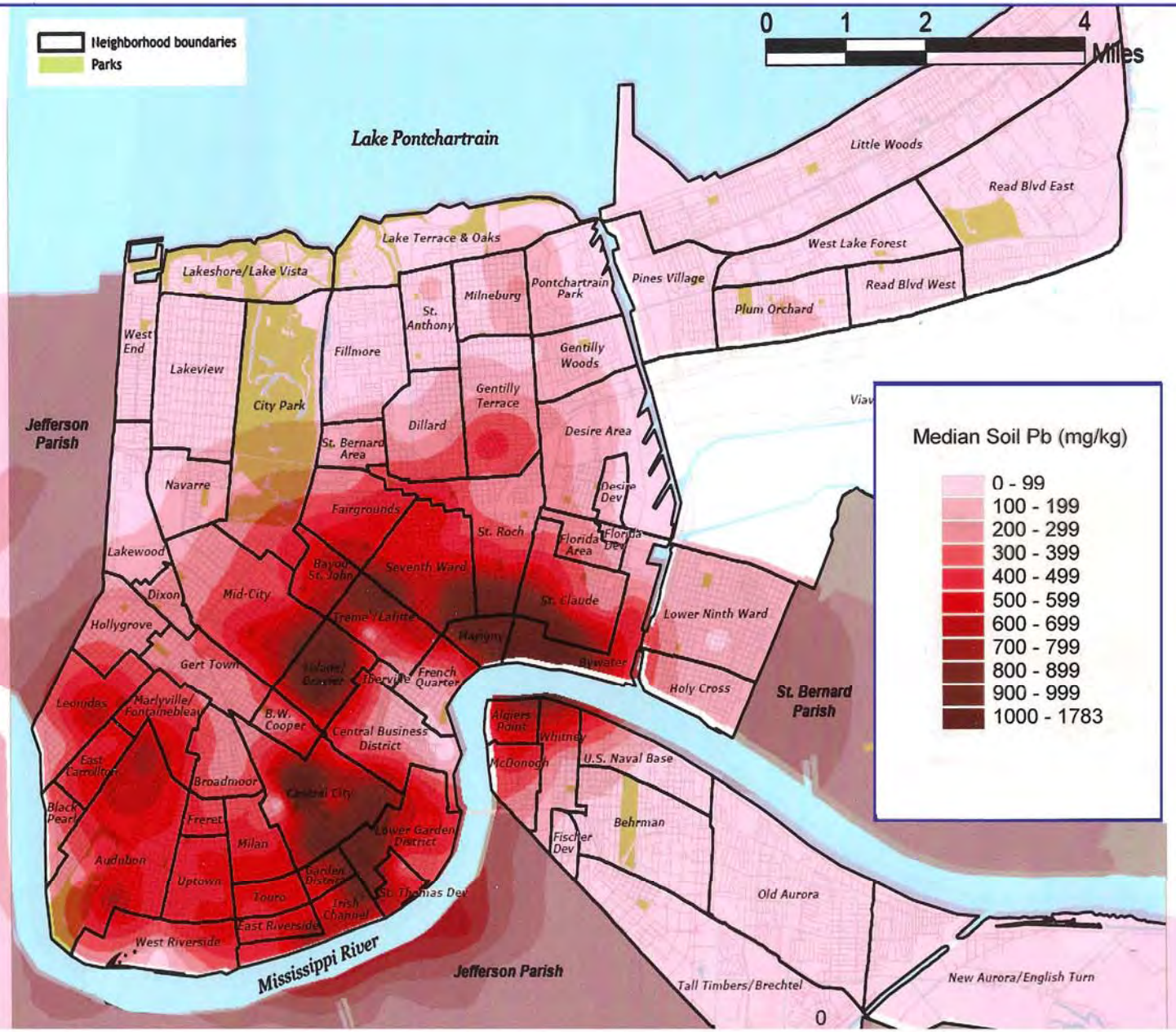
LOCK: Phosphate Induced Metal Stabilization.

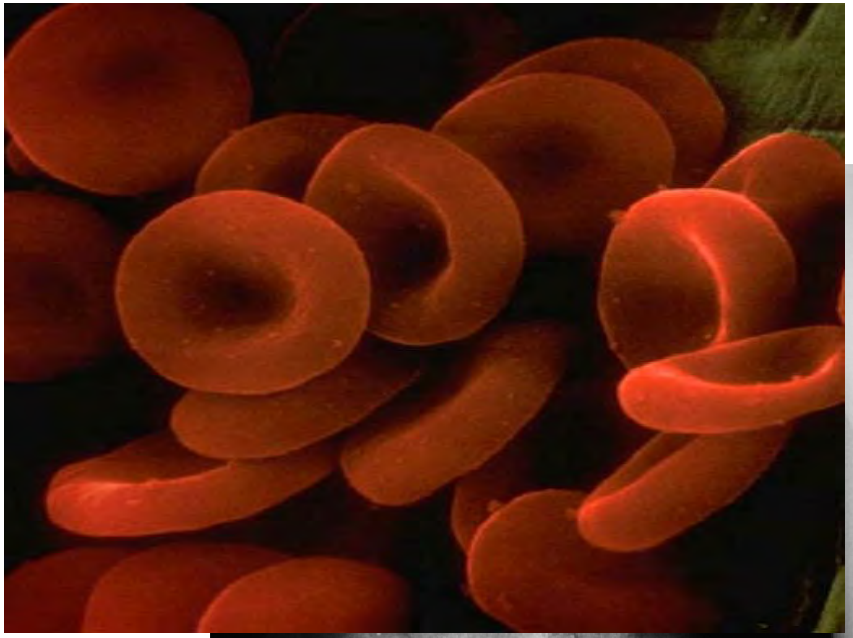
CLEAN MISSISSIPPI RIVER SEDIMENT

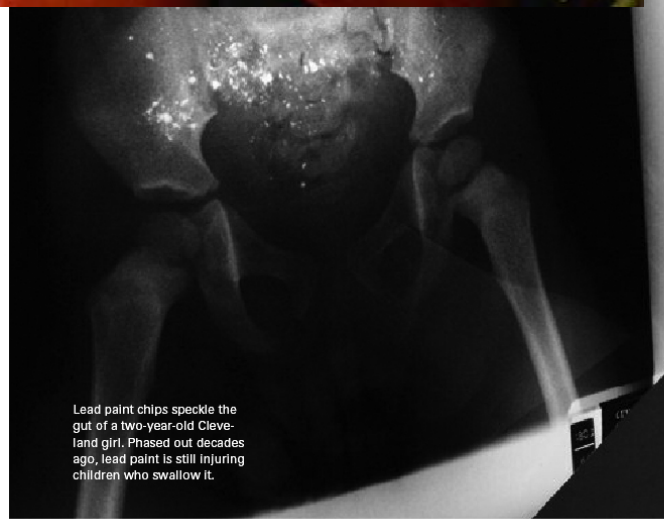


COVER: with clean mississippi sediment

LEAD CONCENTRATIONS IN NEW ORLEANS NEIGHBORHOODS







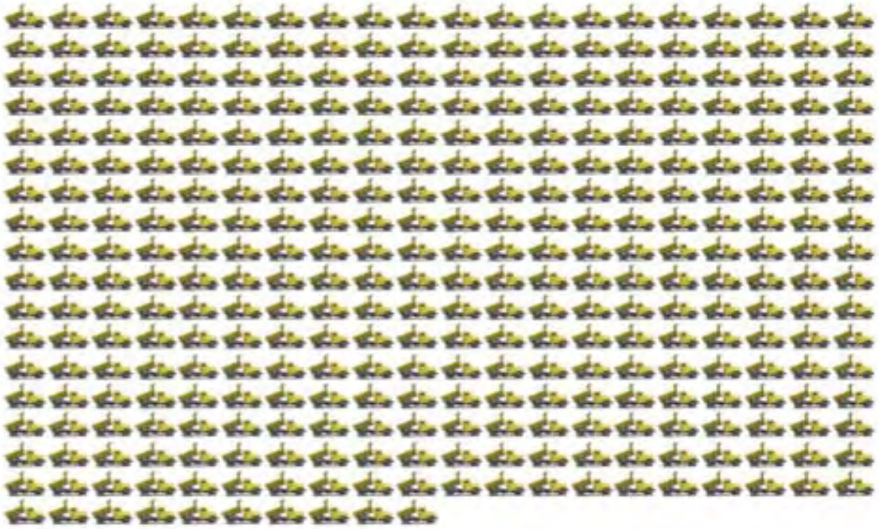
Lead paint chips speckle the gut of a two-year-old Cleveland girl. Phased out decades ago, lead paint is still injuring children who swallow it.

TWENTY TO THIRTY PERCENT OF THE CHILDREN OF INNER CITY NEW ORLEANS HAVE LEAD POISONING.

86,000 PROPERTIES HAVE LEVELS OVER 4OO PPM

For 86,000 properties add:

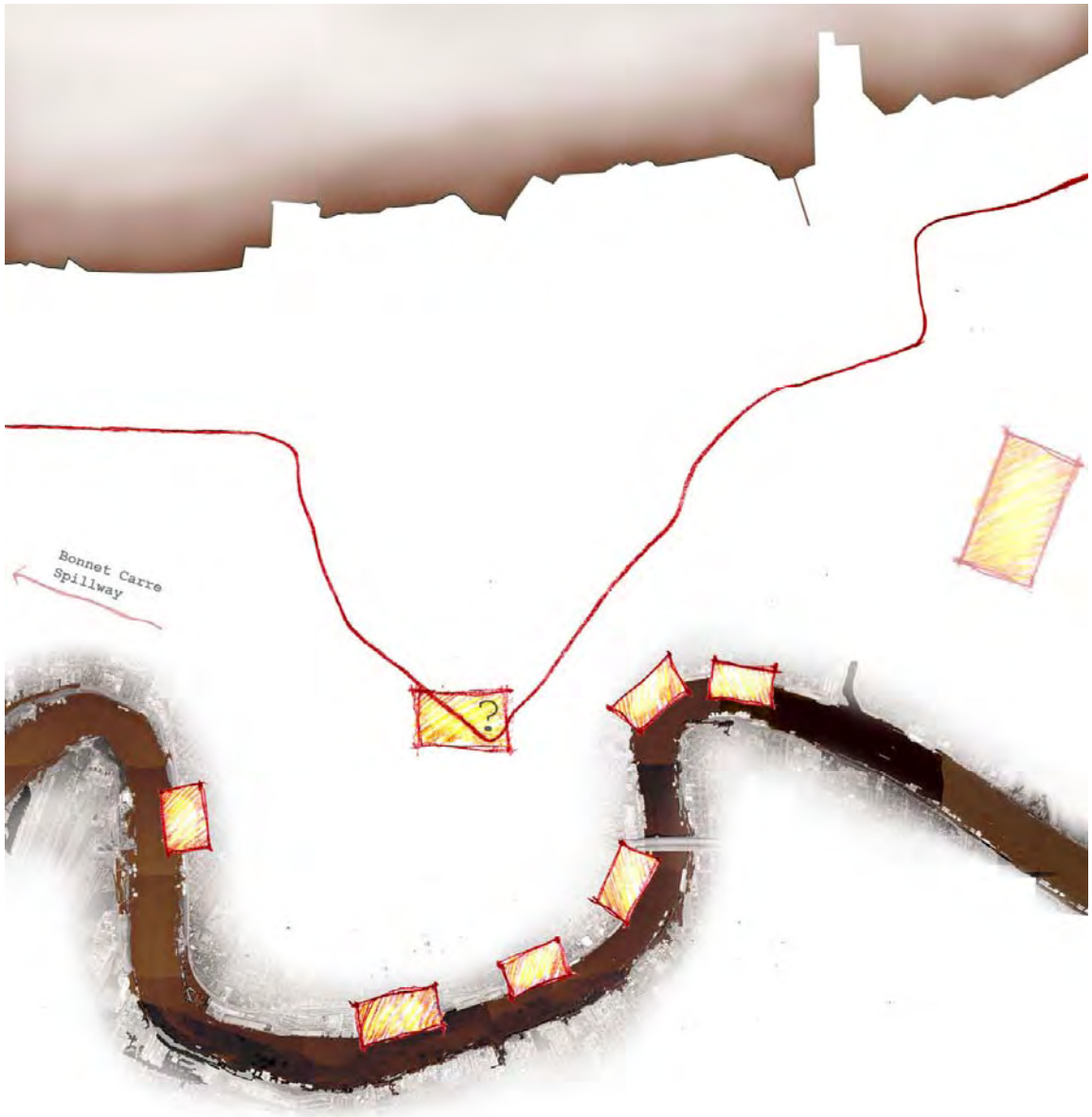
7 million cubic yards clean sediment + 3.5 million cubic yards compost



350,000 truckloads

175,000 truckloads

=1,000 trucks 20 cu.yd each



PAYDIRT DEPOTS

supply centers at the scale of the city

Stockpiling

Drying

Bagging

Growing

Delivering

CITY SUPPLY CENTERS

prepare ingredients for distribution to communities

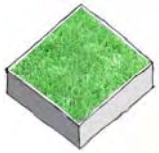
PAYDIRT SQUARES

supply centers at the scale of the neighborhood

Sediment

Compost

Sediment, Compost, Seed Sacks



Sod Mod

Meadow Mod

NEIGHBORHOOD SUPPLY CENTERS

SOUS TERRE

TRANSPORT

EST.

2006

NEW ORLEANS, LOUISIANA

BUILDING A FRAMEWORK FOR HEALTHY HOUSING

2008 National Healthy Homes Conference

Recover New Orleans with low lead Mississippi River alluvium: A method for reducing children's lead exposure

Howard W. Mielke

Center for Bioenvironmental Research at Tulane and Xavier Universities

Acknowledgements 1

- Statisticians Drs. Paul Mielke and Ken Berry
- Dr. Rufus Chaney, USDA, Beltsville, MD
- University of Maryland, Baltimore County
- Patrick Reagan, Minnesota Lead Coalition
- Macalester College & St. Paul Foundation
- Center for Urban and Regional Affairs, U of Minn.
- Many colleagues and students over 30 years

Howard Mielke

Acknowledgements 2

- ATSDR/MHPF Cooperative Agreement to Xavier University. Soil geochemistry surveys of New Orleans
- Section of Environ. Epidemiology and Toxicology & LACLPPP, Louisiana Office of Public Health
- HUD Recover New Orleans. Lead Technical Study grant to Xavier University of LA
- Tulane University Department of Chemistry and CBR

Outline: Lead from Exterior Sources

Major question: How can cities meet the 2010 Public Health Service goal of no children with lead exposure at or above 10 µg/dL?

"as few as possible"

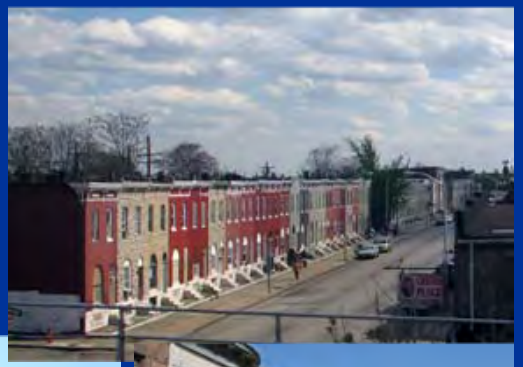
- Evidence that mediation is not in synch with children's needs for preventing exposure to exterior lead sources

- Exterior lead maps of Baltimore and Louisiana and children's exposure response to exterior lead sources

- Proposal: An innovative approach to create lead-safe communities for children

Baltimore: Inner vs. Outer City
1970's perspective on exterior lead

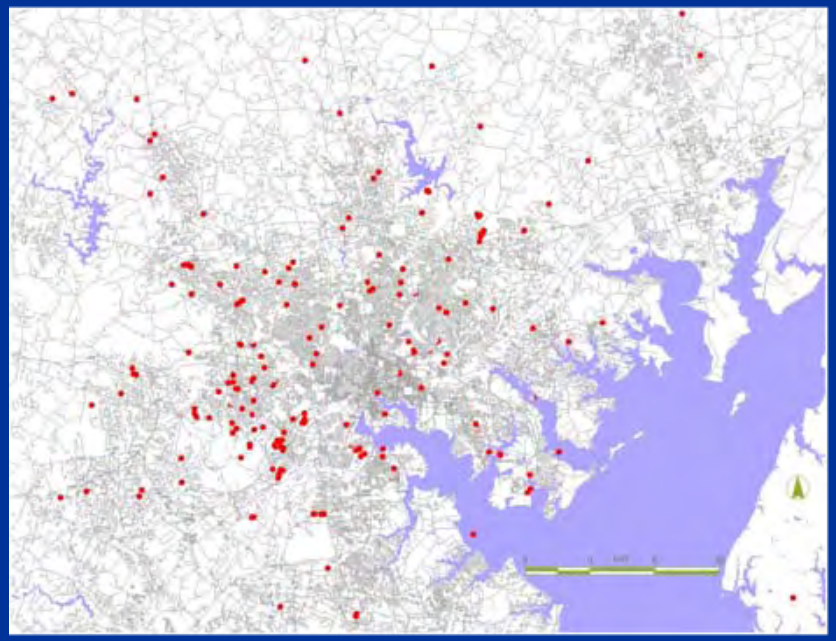
Brick



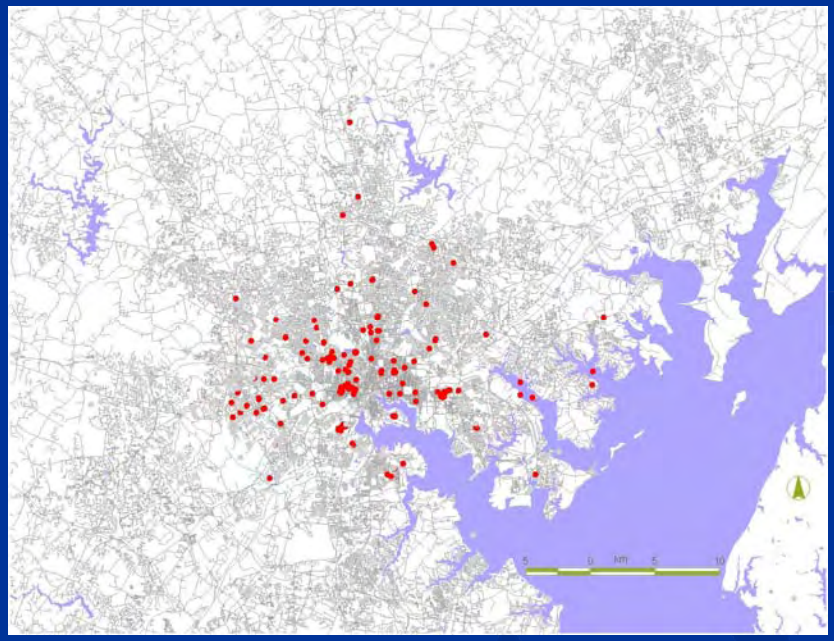
Painted

Baltimore 1977: (n = 422 garden samples)
Pb median = 100 mg/kg
P-value < 10^{-23}

≤ median



> median



~5,000 to 10,000 metric tons of lead from traffic in Baltimore City during 40-50 years

Exterior sources of lead

Lead-based house paints

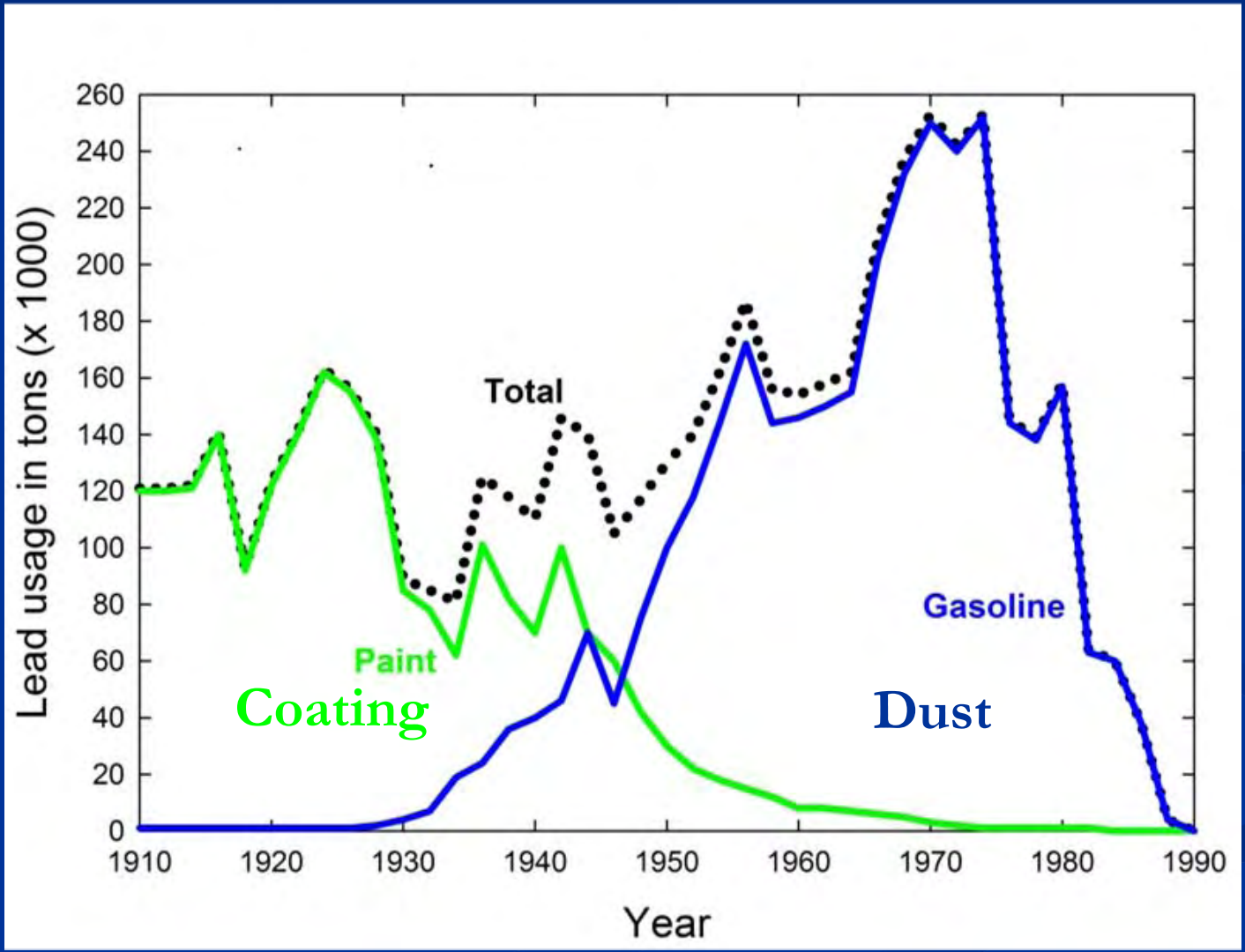
*U.S. 1880's – 1978 ban

Lead additives to fuel

*U.S. 1920's to 1986 ban

Quantity of lead over time?

Quantity of Pb from mines to products in the U.S. (12 million metric tons)



Minnesota Studies on Exterior Lead Health Impacts-1980's perspective

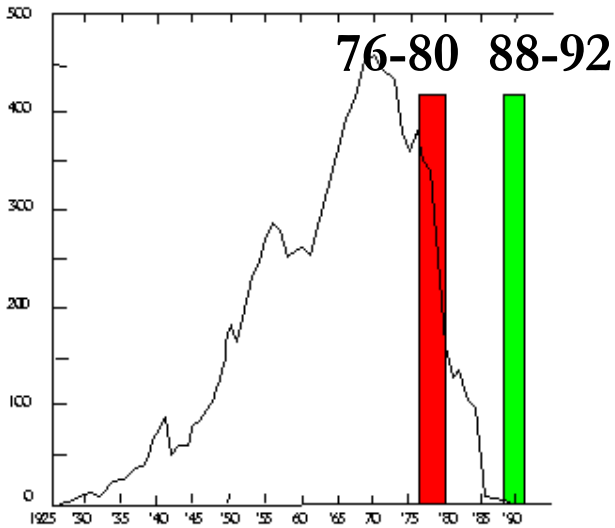
St. Paul

Minneapolis

Howard Mielke

Minnesota Legislature 1984 petition to Congress to ban TEL

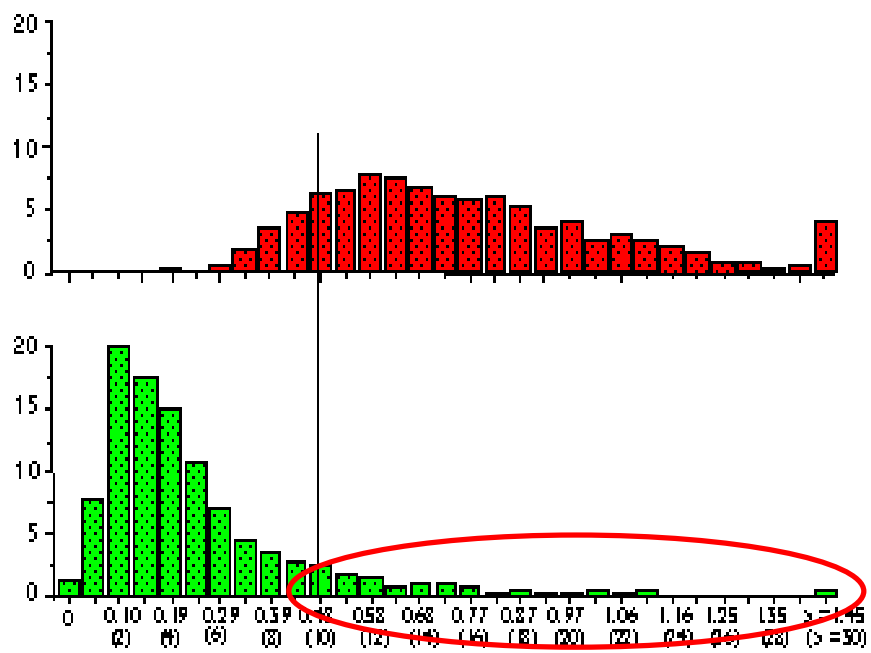
Exposure changes before and after the USA TEL ban: National Childhood Lead Surveys 1976-80 and 1988-92



10 µg/dL

% of Children 76-80

% of Children 88-92



Louisiana Exterior Pb Studies 1989-2008

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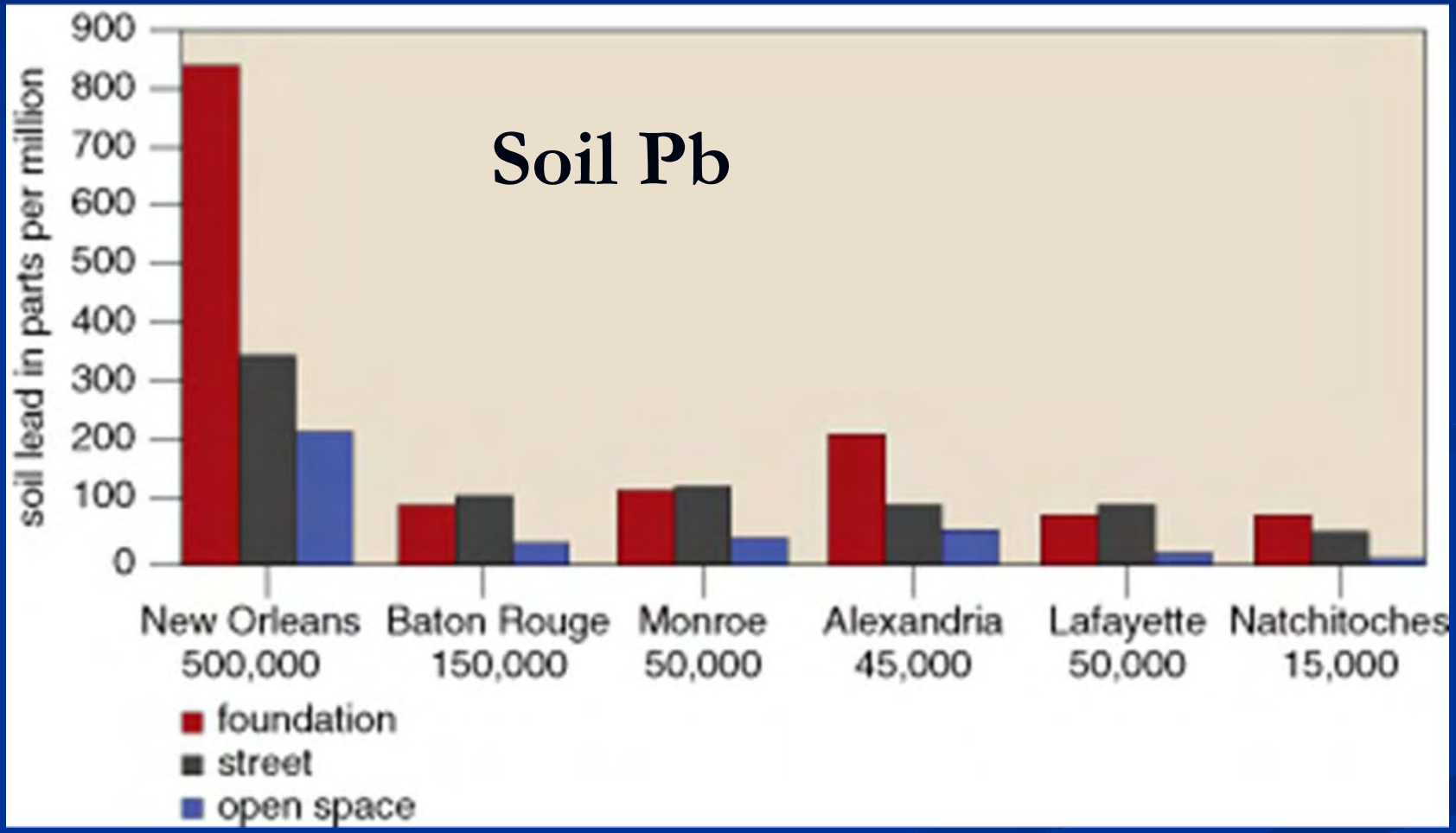
Louisiana: Exterior Pb in small vs. large cities



Input of Pb particles from gasoline
Large vs. small city mid-1960's to 1970's

Calculated *annual* metric tons of lead emitted within one km radius of major intersections: Inner-City New Orleans & Central Thibodaux

New Orleans Inner City		Thibodaux Lafourche	
ADT *1000's*	**Pb** *Metric tons*	**ADT** *1000's*	**Pb** *Metric Tons*
95 (N =8)	**5.15**	**10 (N=3)**	**0.45**
Median Soil Lead (mg/kg)			
400-1200		**50-90**	

Metric tons = (ADT/MPG x Pb/gal. x Fuel Factor x Auto Emission Factor) x 365 days.

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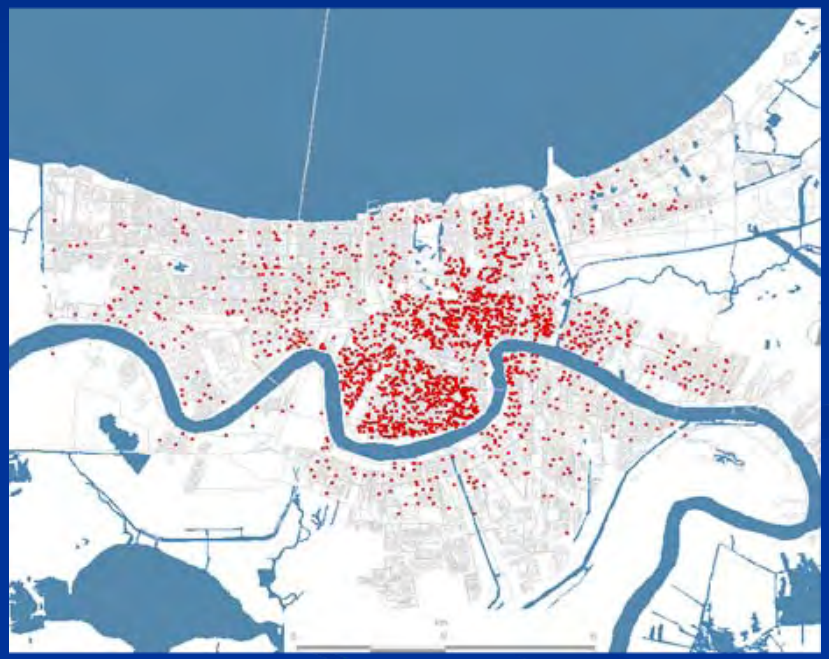
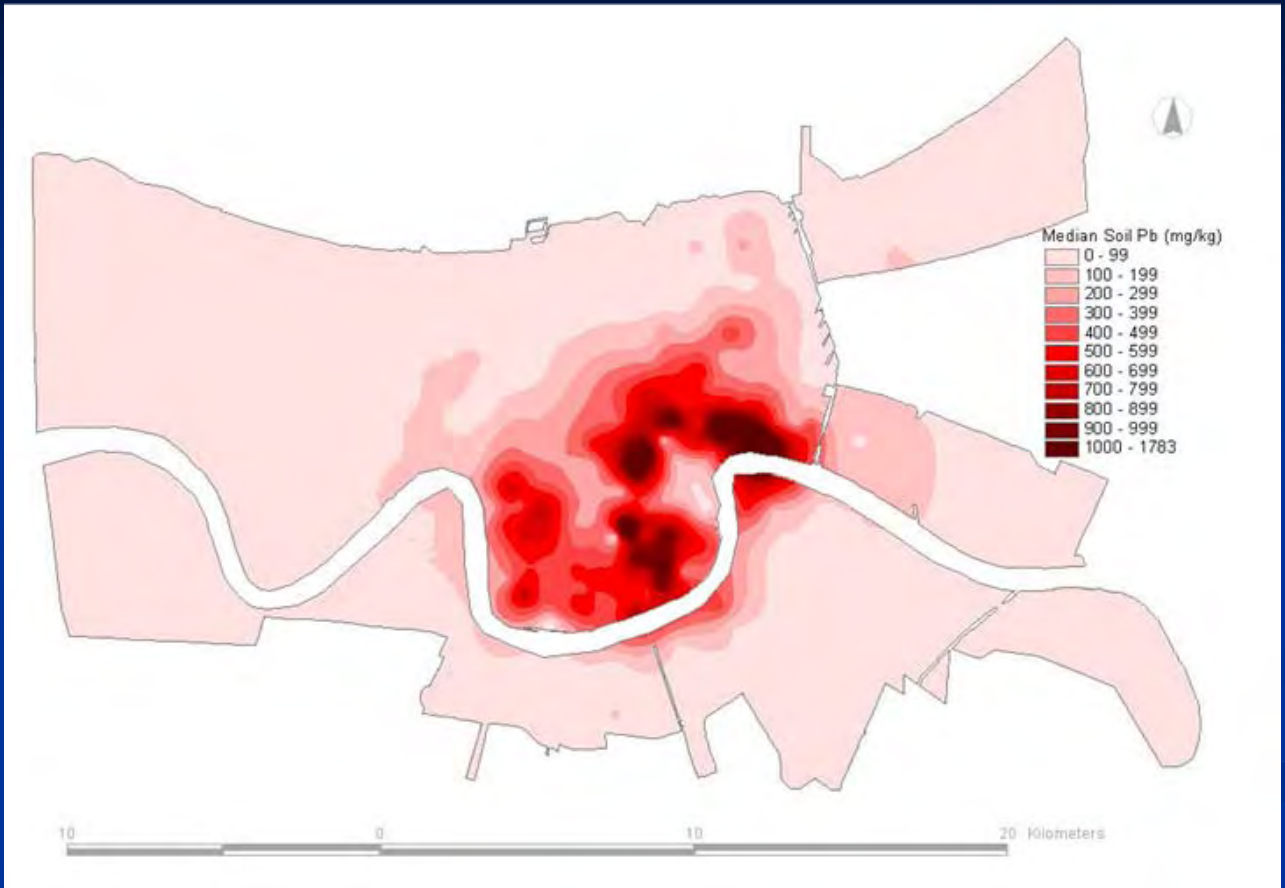
New Orleans soil Pb
(N = 5,467; median 120 mg/kg)

≤ median

> median



Exterior soil Pb Quantities



<u>Pb per m^2 x 2.5 cm (~ 3 $feet^2$ x 1 inch depth)</u>

@ 1,000 ppm soil Pb = 37.5 g Pb (37.5 million µg)

@ 500 ppm soil Pb = 18.75 g Pb (18.75 million µg)

@ 250 ppm soil Pb = 9.375 g Pb (9.375 mill. µg)

@ 25 ppm soil Pb = 0.938 g Pb (938,000 µg)

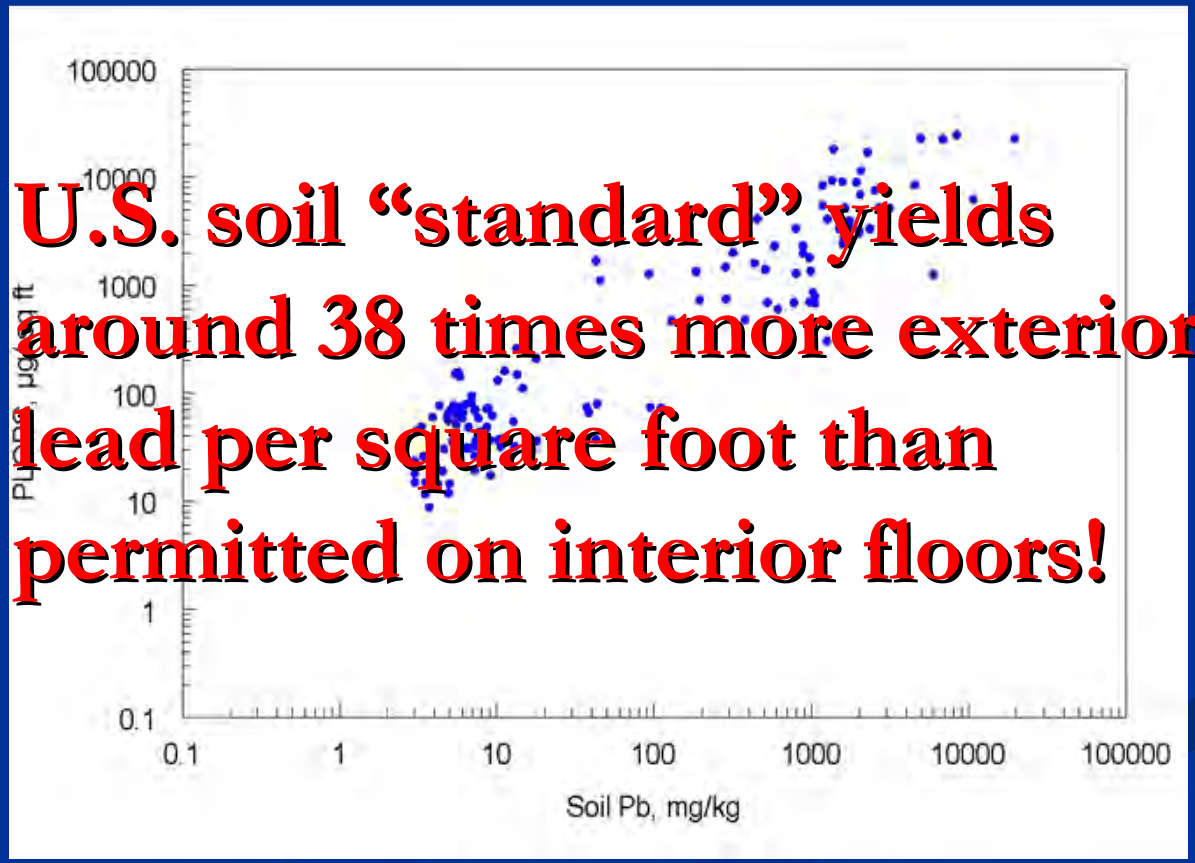
Relation of soil Pb content to surface Pb

Particulate Lead on Play Surfaces (PLOPS): $SL = -7.4 + 0.41\ PLOPS^{0.97}$

U.S. floor Pb standard is 40 $\mu g/ft^2$ (i.e. 0.431 $mgPb/m^2$)

U.S. soil Pb standard is 400 mg/kg

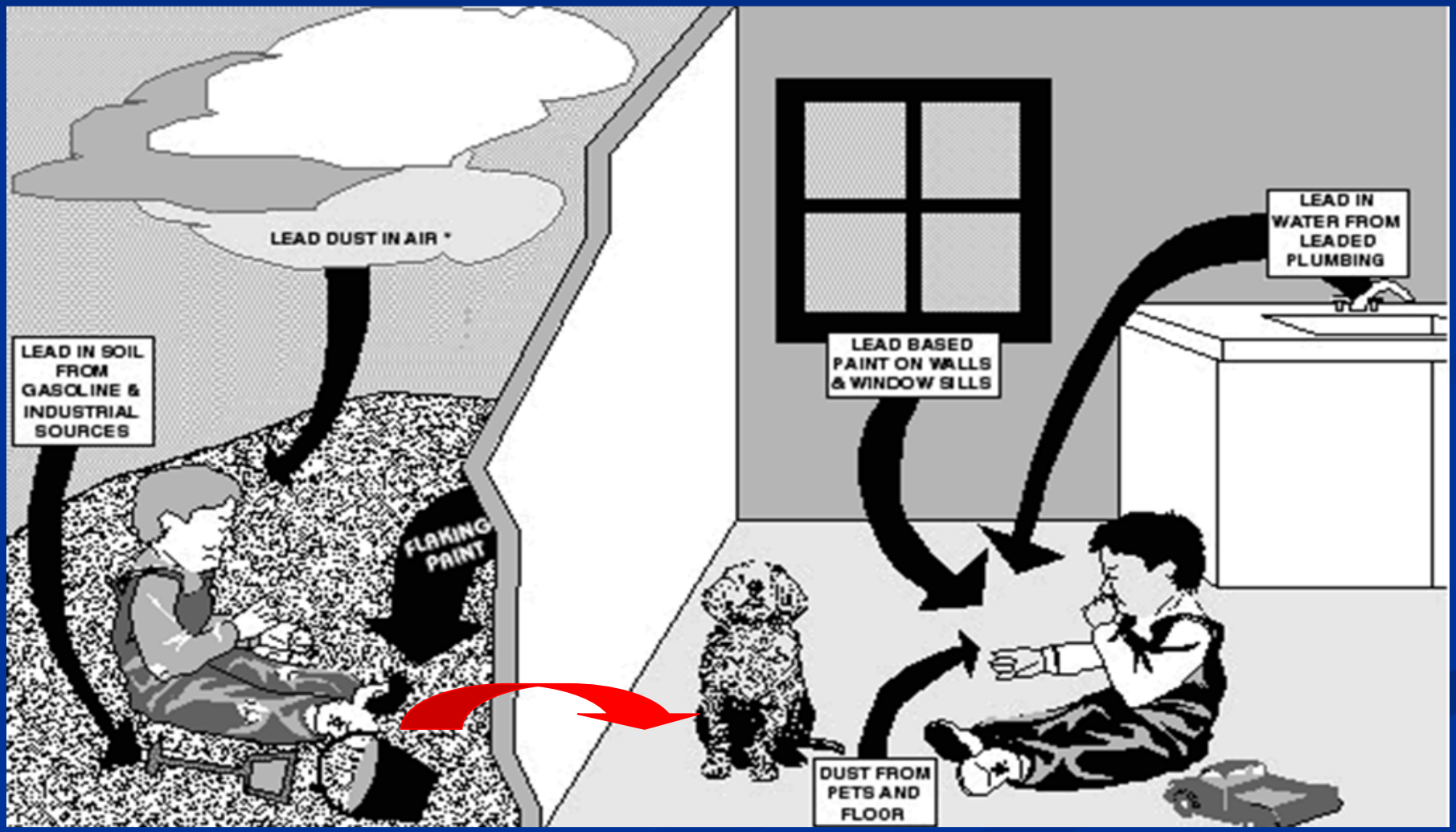
Soil Pb 400 mg/kg ~1500 $\mu gPb/ft^2$ (~16 $mgPb/m^2$)



U.S. soil "standard" yields around 38 times more exterior lead per square foot than permitted on interior floors!

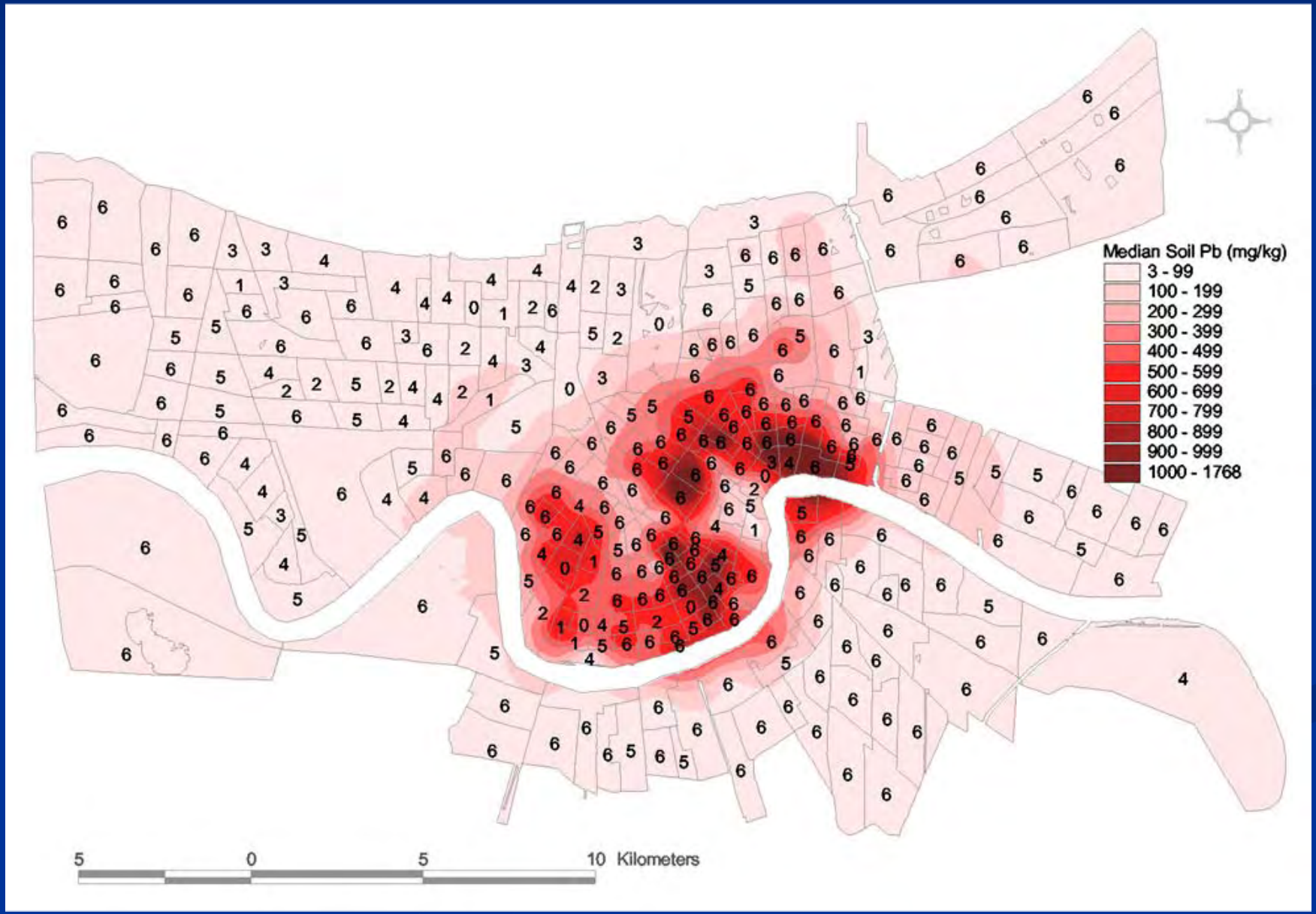
Children's hand-to-mouth playing in Pb dust contaminated environments

* TTDI for Pb = 6 µg Pb per day!



BLL response (n = 55,551) spatially matched with exterior Pb (5,467 stratified by 281 Census Tracts)

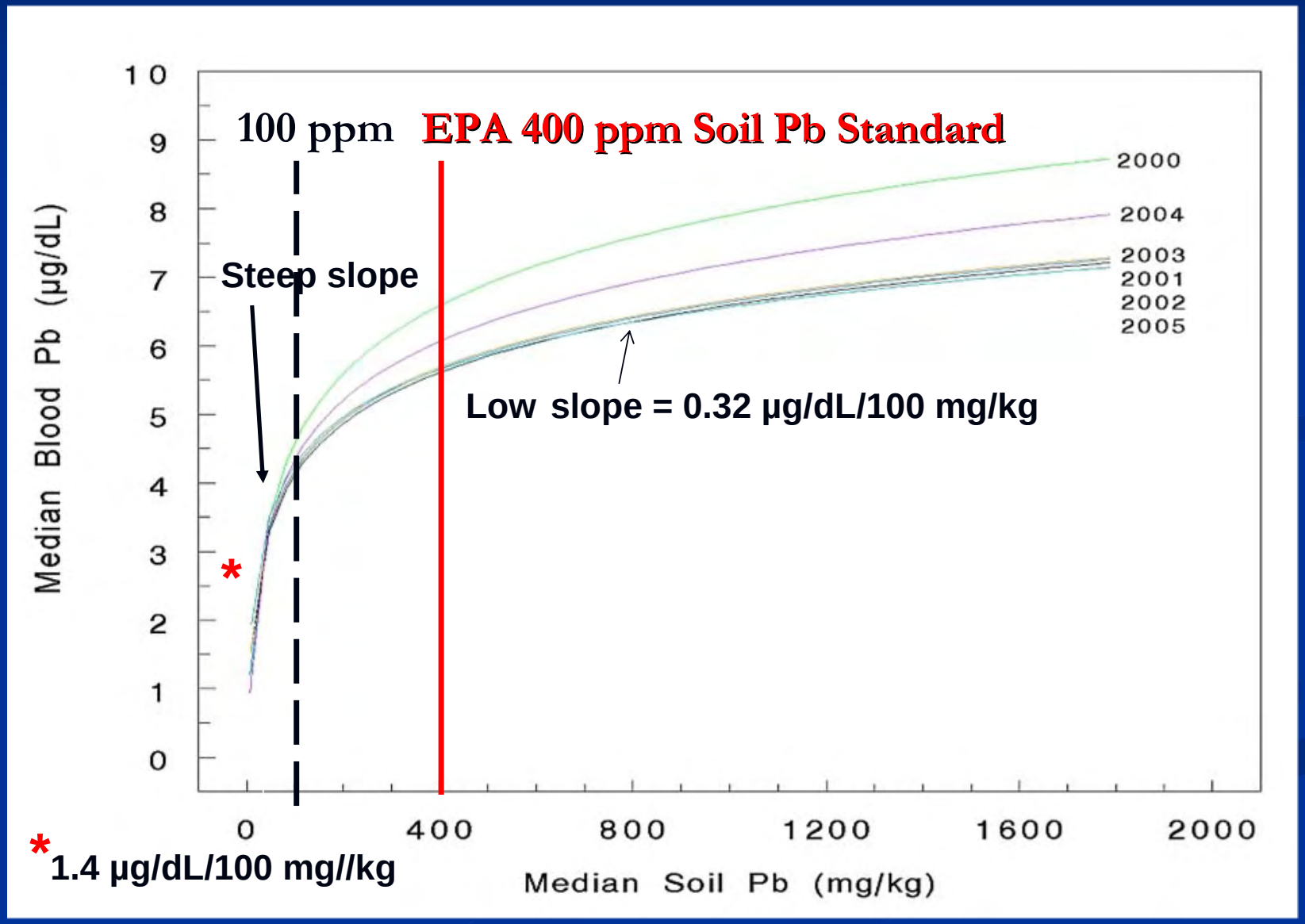
Census tract matches of BLL & SL in 6 years



BLL response to exterior Pb in 286 census tracts

Overall model: BLL=2.038+0.172×(SL)$^{0.5}$

[Agreement (ℜ) of 0.534, an r^2 of 0.528, P-value of 1.0×10^{-211}]



Exterior Lead Coupled with % Children BLL of 10 μg/dL or greater, 2000-2005 [r^2 of 0.528, P-value 1.0×10^{-211}]

Median Exterior Lead (mg/kg)

- 6.2- 44.5
- 44.6- 98.5
- 98.6- 403
- 404-1789

% BLL ≤ 10 μg/dL

- 0.00 - 2.16
- 2.07 - 5.65
- 5.66 - 20.08
- 20.09 - 54.72

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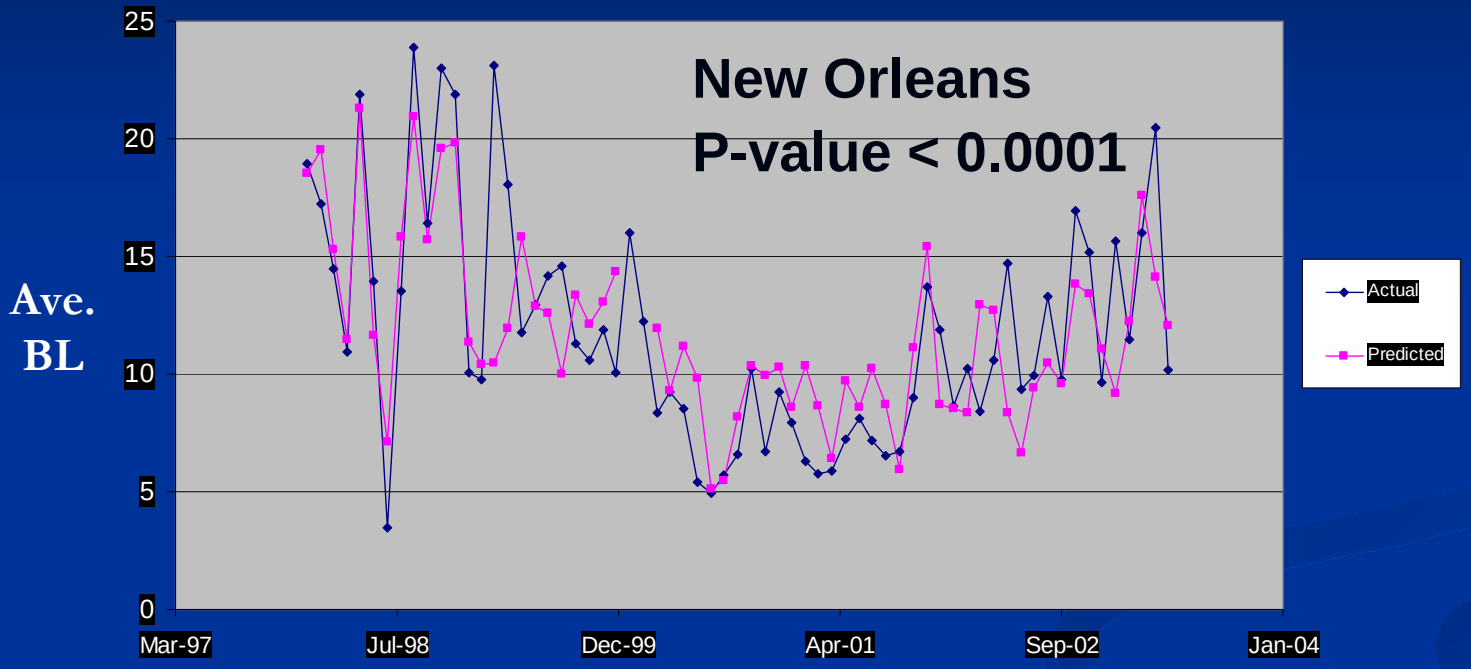
BLL Response to exterior Pb (airborne & deposition) Syracuse, Indianapolis, & New Orleans (Laidlaw *et al.* 2005 EHP 113:793-9)



M.A.S. Laidlaw, G.M. Filippelli 2008
Resuspension of urban soils as a persistent source of lead poisoning in children: Review and new directions

Applied Geochemistry 23: 2021–2039

Howard Mielke

Chronic Pb exposure is associated with many diseases including:

- Irreversible fetal brain damage
- Learning disabilities (2 μg/dL)
- Violence
- Schizophrenia in the era of leaded gas (Oakland study)
- Hypertension
- All cause and cardiovascular mortality at ≥ 2 μg/dL
- Increased cataracts
- Chronic kidney disease
- Diabetes [*Environ Health Perspect* 112:1178-82 (2004)]
- Alzheimer's disease
- Impaired bone synthesis
- Osteoporosis

Inverse association between soil lead and school performance by 4th graders in New Orleans (Red=high; Blue=low) P-value 1.7×10^{-9}

Soil Lead by School District

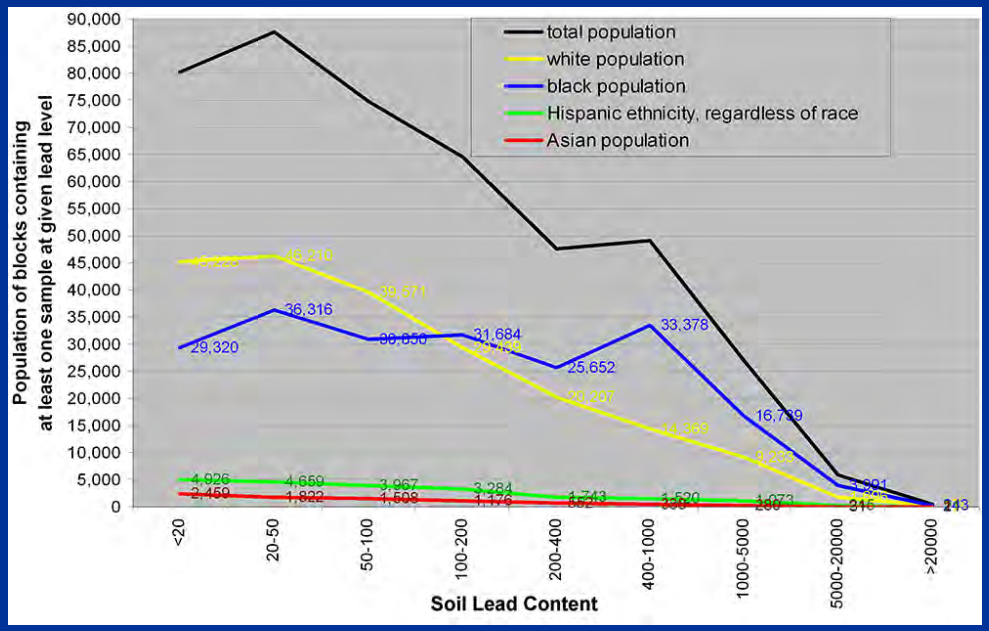
4th Grader's Science Scores by School District

Jonathan Kozol

Howard Mielke

Societal cost of lead poisoning

Human geography of exterior lead exposure



Est. New Orleans Pre-Katrina cost $76 million per year

Mediation of exterior lead?

HUD funded Recover New Orleans study
Mississippi River sediment 5 ppm Pb "Parent soil"
300 tons /minute

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Delivery and grading 84 yards^3 of Bonnet Carré soil

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Final soil preparation and hydro seeding grass

Howard Mielke

Completed hydro seeding and lawn, 6 weeks later

Measurements: Particulate lead on play surfaces “PLOPS”; soil samples; entrance wipe samples

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Impact of intervention on median soil, PLOPS and entrance wipes

BEFORE		AFTER	
Soil#	1,000+	New Soil#	13
PLOPS*	9,349	PLOPS*	32
Front*	172	Front*	45
Side*	198	Side*	83

#mgPb/kg
*($\mu gPb/ft^2$)

Child's BLL response:

Before: **BLL ~ 23 µg/dL.**

***After 6 weeks*: BLL ↓ 8 µg/dL.**

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Recover New Orleans with low lead Mississippi River alluvium

- Pb Legacy: 6 million tons in coatings + 6 million tons as fuel additive
- Huge reservoir of Pb dust 1000's of $\mu g/ft^2$ in urban soil
- Strong exposure response by children
- Pb poisoning cost ~ $76 mil./yr
- Focus on exterior Pb dust to create children's lead-safe communities:
  - Paint: Total ban on power sanding to prevent lead dust
  - Huge reservoir of exterior Pb dust ~86,000 properties with > 400 ppm or >1500 $\mu g/ft^2$. Est. mediation cost ~ $300 million
  - Payback: ~ 8 years if half of Pb exposure is from exterior sources
- Promote a more just & humane environment; benefits health, education and behavior of children and the entire communities

BUILDING A FRAMEWORK FOR HEALTHY HOUSING
2008 National Healthy Homes Conference

Recover New Orleans with low lead Mississippi River alluvium: A method for reducing children's lead exposure

Howard W. Mielke
Center for Bioenvironmental Research at Tulane and Xavier Universities

Outline: Exterior Sources of Lead

- There is a growing need for evidence-based science regarding the sustainable and healthy urban environments for children
- Major issue: What can our nation do to meet the Public Health Service goal of no children with lead exposure of 10 µg/dL?
- Lead maps of Baltimore and cities in Minnesota and Louisiana and evidence of childhood lead exposure response to exterior lead sources
- Evidence that actions are not in synch with causes of exposure
- Proposal: An integrated way to lower childhood Pb exposure

BUILDING A FRAMEWORK FOR HEALTHY HOUSING 2008 National Healthy Homes Conference

1. Baltimore: Inner vs. Outer City 1970's Ter Haar perspective

Brick

Painted

Baltimore 1977: (n = 422 garden samples) Pb median = 100 mg/kg p-value < 10^{-23}

≤ median > median

1983 Baltimore Soil Metal Results Mielke, Anderson, Berry, Mielke, Chaney

Soil Pb as an exposure factor: AJPH 1983; 73: 1366-9

TABLE 1—Probability of Being Clustered by Chance Alone and Selected Percentile Values for Each Metal (ppm) and Soil pH

Element	Lead	Cadmium	Copper	Nickel	Zinc	Soil Acidity (pH)
N*	422	417	422	419	420	421
Probability‡	10^{-23}	10^{-18}	10^{-15}	10^{-18}	10^{-19}	0.39
	in ppm	in ppm	in ppm	in ppm	in ppm	in ppm
Percentile						
Maximum	10,900.0	13.65	96.70	53.40	4,880.00	8.16
90	777.5	3.17	63.45	8.40	521.00	7.17
80	421.0	1.83	41.10	5.50	325.50	6.88
70	258.5	1.33	29.30	4.45	212.50	6.67
60	187.0	0.82	22.65	3.50	152.00	6.50
50 Median	100.0	0.56	17.25	2.80	90.00	6.36
40	55.5	0.41	13.45	2.40	55.55	6.14
30	35.0	0.29	10.15	1.75	33.45	5.83
20	24.5	0.19	7.40	1.40	18.80	5.51
10	14.5	0.12	5.35	0.85	10.65	5.06
Minimum	1.0	0.02	0.70	0.50	0.30	4.11

*Number of sites (N) varies because of missing values.
‡P-value based on the average distance between all pairs of sites with values greater than or equal to the median value.

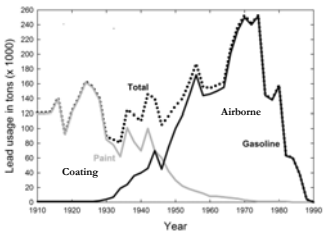
High Production Sources of Pb

Lead-based house paints
*U.S. 1880's – 1978 ban

Lead additives to fuel
*U.S. 1920's to 1986 ban

Quantity of lead over time?

Quantity of Pb from Mines to U.S. Cities (12 million metric tons)



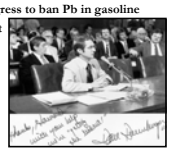
2. Minnesota Urban Pb Soil Studies Health Impacts-1980's perspective

St. Paul

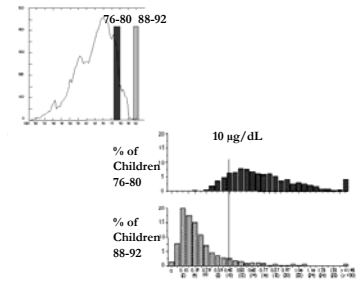
Minneapolis

Results from Minnesota Funded by St. Paul foundation & legislature

- Minneapolis and Saint Paul inner-city vs. outer-city differences were similar to Baltimore, Md.
- The amount of soil lead was directly related to the size of the city.
- Children's blood lead was directly associated with the amount of soil lead in the community.
- High school dropout rates were associated with city size and soil lead.
- Minnesota Legislature petitioned Congress to ban Pb in gasoline
- Ban by the Committee on Environment and Public Works
  [US Senate, 89th Congress, S.2609 June 22, 1984]



Exposure changes before and after the USA ban of TEL: National Childhood Lead Surveys 1976-80 and1988-92



3. Louisiana Soil Pb Research-1990's on

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Field and laboratory geochemistry experience with New Orleans urban soil Funding: AMHPS/ATSDR Coop-agreement

- Survey cities, large small
- Apply GIS to Map the results

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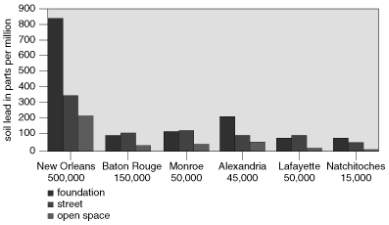
Louisiana: City Size vs. Soil Pb



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Input of Pb particles from gasoline

Large vs. small city mid-1960's to 1970's

Calculated *annual* metric tons of lead emitted within one km radius of major intersections: Inner-City New Orleans & Central Thibodaux

New Orleans Inner City		Thibodaux Lafourche	
ADT *1000's*	Pb *Metric tons*	ADT *1000's*	Pb *Metric Tons*
95 (N =8)	5.15	10 (N=3)	0.45
Median Soil Lead (mg/kg)			
400-1200		50-90	

Metric tons = (ADT/MPG x Pb/gal. x Fuel Factor x Auto Emission Factor) x 365 days.

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New Orleans soil Pb (n=5,467; median 120 mg/kg)

≤ median > median

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Soil Surface (1 in.) Quantities of Pb

Pb per m^2 x 2.5 cm (~ 3 $feet^2$ x 1 inch depth)

@ 1,000 ppm soil Pb = 37.5 g Pb (37.5 million µg)
@ 500 ppm soil Pb = 18.75 g Pb (18.75 million µg)
@ 250 ppm soil Pb = 9.375 g Pb (9.375 mill. µg)
@ 25 ppm soil Pb = 0.938 g Pb (938,000 µg)

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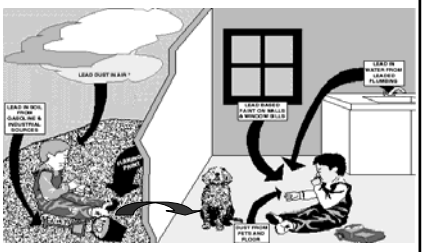
Human response: Children playing in Pb dust contaminated environments

*** TTDI for Pb = 6 µg Pb per day!**



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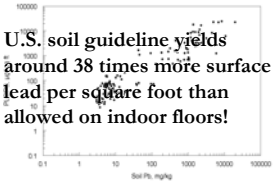
Relation of soil Pb content to surface Pb

Particle Lead on Play Surfaces (PLOPS): SL = -7.4 + 0.41 $PLOPS^{0.97}$

U.S. floor Pb standard is 40 µg/ft^2 (i.e. 0.431 mgPb/m^2)
U.S. soil Pb standard is 400 mg/kg
Soil Pb 400 mg/kg ~1500 µgPb/ft^2 (~16 mgPb/m^2)



U.S. soil guideline yields around 38 times more surface lead per square foot than allowed on indoor floors!

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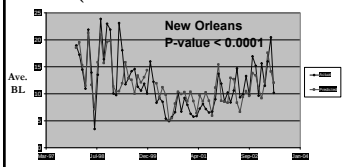
BL Response to dry soil (airborne Pb & deposition) Syracuse, Indianapolis, & New Orleans (Laidlaw *et al.* 2005 EHP 113:793-9)



M.A.S. Laidlaw, G.M. Filippelli 2008 Resuspension of urban soils as a persistent source of lead poisoning in children: Review and new directions

Applied Geochemistry 23: 2021–2039

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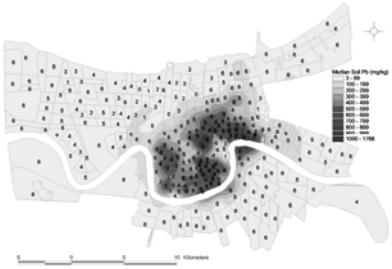
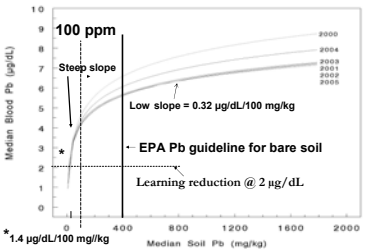
BL response (n = 55,551) spatially matched with SL (5,467 stratified by 286 Census Tracts) Census tract matches of BL & SL over 6 years



Blood Pb response to soil Pb in 286 census tracts

Overall model: $BL=2.038+0.172\times(SL)^{0.5}$

[Agreement (%) of 0.534, an r^2 of 0.528, P-value of 1.0×10^{-211}]



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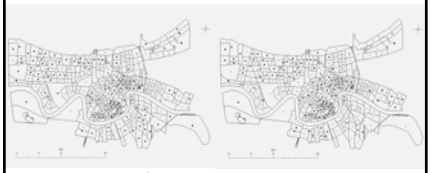
Soil Lead and Percent of Children with BLL at 10 µg/dL or greater 2000-August, 2005



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- Increased cataracts
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- Diabetes [*Environ Health Perspect* 112:1178-82 (2004)]
- Alzheimer's disease
- Impaired bone synthesis
- Osteoporosis

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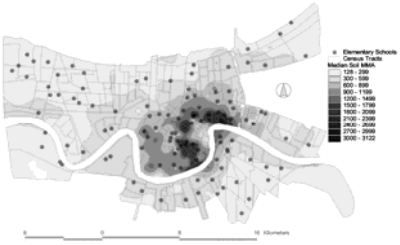
Lead and Learning: 4th grade Educational Assessment & Soil Metal Map (n = 111 schools)

[Mielke et al, Env. Res. 97 (2005) 67-75]



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Inverse association between soil lead and school performance by 4th graders in New Orleans (Red=high; Blue=low) P-value 1.7 x 10-9

Soil Lead by School District

4th Grader's Science Scores by School District

Jonathan Kozol

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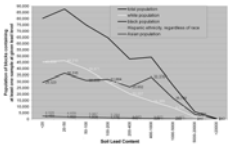
Societal cost of lead poisoning

Human geography of lead poisoning



Est. New Orleans Pre-Katrina cost $76 million per year

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4. What can be done?

Norway's National Action Plan for Soil Remediation

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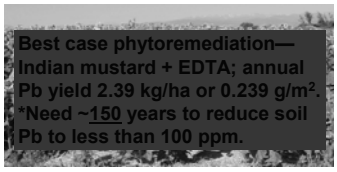
Sunflowers?
Requirement per inch (~yard^2) for safe soil



Soil Pb	Pb Removal Required
1,000 ppm	36.5 g
500 ppm	17.5 g
250 ppm	8.4 g
25 ppm	OK

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Ten census tracts with median soil Pb ≥ 1,000 ppm

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HUD funded Recover New Orleans study
Mississippi River sediment 5 mg ppm "Parent soil"
300 tons /minute

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Transporting ~655 yds ^{3} or 36 truckloads of clean soil to an inner city lot & grading

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Property with home: Dumping and Grading 84 yards^3 of Bonnet Carré soil

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Final soil preparation and hydro seeding grass

Howard Mielke

Completed hydro seeding and lawn, 6 weeks later

Howard Mielke

Measurements: Particle lead on play surfaces "PLOPS"; soil samples; entrance wipe samples

Howard Mielke

Impact of intervention on median soil, PLOPS and entrance wipes

BEFORE		AFTER	
Soil#	1,928	New Soil#	13
PLOPS*	9,349	PLOPS*	32
Front*	172	Front*	45
Side*	198	Side*	83

#mgPb/kg
*(µgPb/ft^2)

Before: child BL ~ 23 µg/dL.
After : child BL ↓ 8 µg/dL.

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Pre-Katrina soil cover on 25 properties

[Mielke et al. Env. Sci. & Tech. 40 (2006) 2784-9]

- **BEFORE:**
  Median 1,051 mg/kg (5 to 19,627)
- Recover with 15 cm (6 inches) of soil
  - 100 truck loads of soil brought into the city
  - 1,710 cubic yards weighing ~750 tons (about 2 ½ minutes of sediments carried by the Mississippi River)
  - All properties with homes were seeded
- **AFTER INTERVENTION:**
  Median 6 mg/kg (3 to 18)
  - Covered 69,153 square ft (6,424 square meters) of land with clean soil

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Results of recover New Orleans on 25 properties (soil Pb in mg/kg).

Percentile	Before	After 1 mo	After 18 mo
min	5	3	5
10%	93	4	7
25%	438	5	10
Median	**1051**	**6**	**16**
75%	1977	9	31
90%	3136	13	75
max	19627	18	1155
n	75	77	78

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Impact of Katrina and the "catastrophic structural failure" on clean soils

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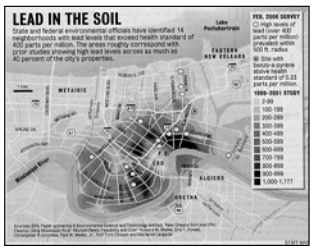
EPA, USGS & DEQ results after Hurricane Katrina: "historic soil Pb"



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Soil Pb Survey III & H_2O depth (m) 46 Census Tracts (874 soil samples) Collected during the summer of 2006

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Comparison of soil Pb collected Pre and Post Katrina n = 46 CTs (n = 874): MRPC results of Survey II versus III

Chance of difference: P-value = 1.7×10^{-7}

Survey II Pb

Survey III Pb

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Conclusions: Recover New Orleans with low lead Mississippi River alluvium

- Pb Legacy: 6 million tons in coatings & 6 million tons as fuel additive
- Huge reservoir Pb dust in urban soil–exposure response of children
- Pb poisoning cost ~ $76 mil./yr
- Focus on Pb dust to establish lead-safe communities for children:
  - Paint: Total ban on power sanding and prevent lead dust
  - Soil: Huge reservoir of Pb dust ~86,000 properties with > 400 ppm or >1500 µg/ft². Est. cleanup cost ~ $225-290 million
  - Payback: ~ 8 years if half of exposure is from soil
- New Orleans is an ideal place for a Pb-safe community pilot project
- Promote a more just & humane environment; benefits health, education and behavior of children and the entire communities

BUILDING A FRAMEWORK FOR HEALTHY HOUSING 2008 National Healthy Homes Conference

Acknowledgements 1

- Statisticians Drs. Paul Mielke and Ken Berry
- Dr. Rufus Chaney, USDA, Beltsville, MD
- University of Maryland, Baltimore County
- Patrick Reagan, Minnesota Lead Coalition
- Macalester College & St. Paul Foundation
- Center for Urban and Regional Affairs, U of Minn.
- Many colleagues and students over 30 years

Howard Mielke

Acknowledgements 2

- ATSDR/MHPF Cooperative Agreement to Xavier University. Soil geochemistry surveys of New Orleans
- Section of Environ. Epidemiology and Toxicology & LACLPPP, Louisiana Office of Public Health
- HUD Recover New Orleans. Lead Technical Study grant to Xavier University of LA
- Tulane University Department CBR

Howard Mielke

Lead Particulate Deposition from Housing Demolition (Baltimore)

David E. Jacobs,[1 2] B Catalin,[2] A Welch,[2] A Mucha,[2] N Stites,[3] S Dixon,[1] P MacRoy,[3] A Evens,[2] S Erdal,[2] J Phoenix,[4] VW Persky,[2] S Cali[2]

[1]National Center for Healthy Housing, U.S.

[2] University of Illinois at Chicago, School of Public Health

[3] Chicago Department of Public Health

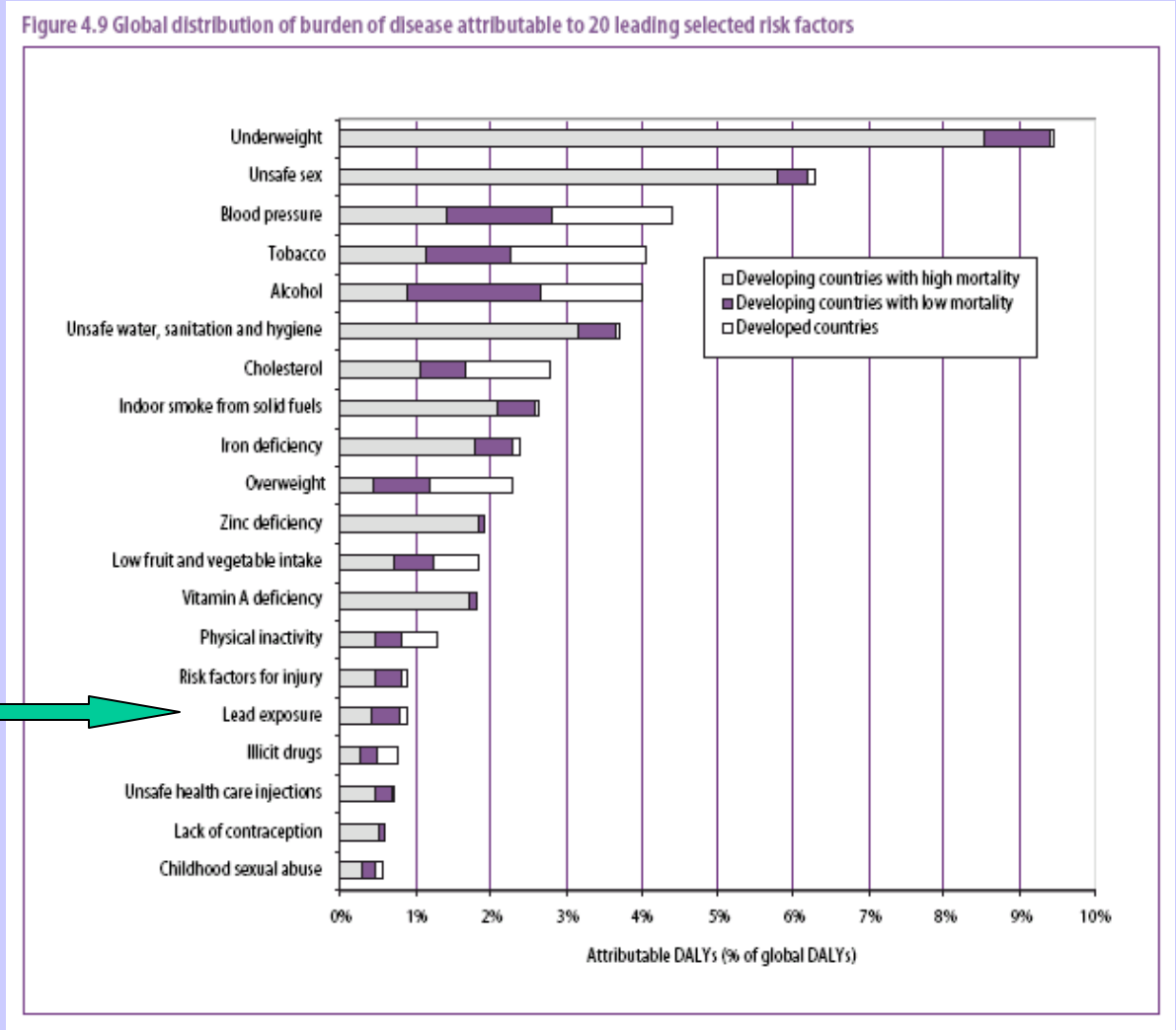
[4] Coalition for Environmentally Safe Communities, U.S.

September 2008

Introduction

- Description of studies in Baltimore (MF) and Chicago (SF) – Chicago Data Presented Separately by S. Cali
- New dust suppression methods in Baltimore
- Results of lead in air, soil, settled dust and dustfall measurements
- Implications for housing demolition work
- Evidence of new lead paint production
- Conclusions

Global Distribution of Burden of Disease
Lead = 16th in DALYs (WHO 2002)

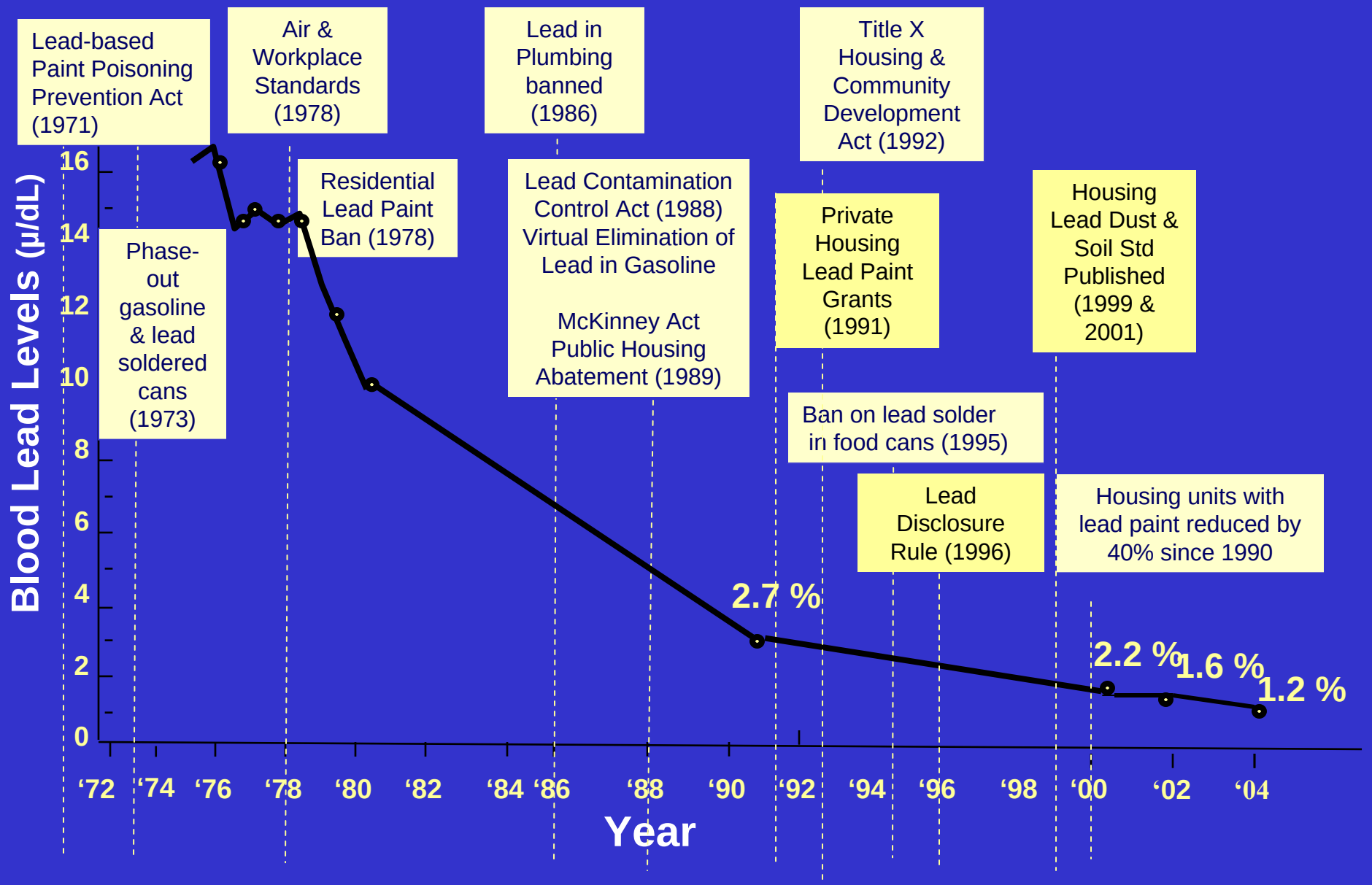


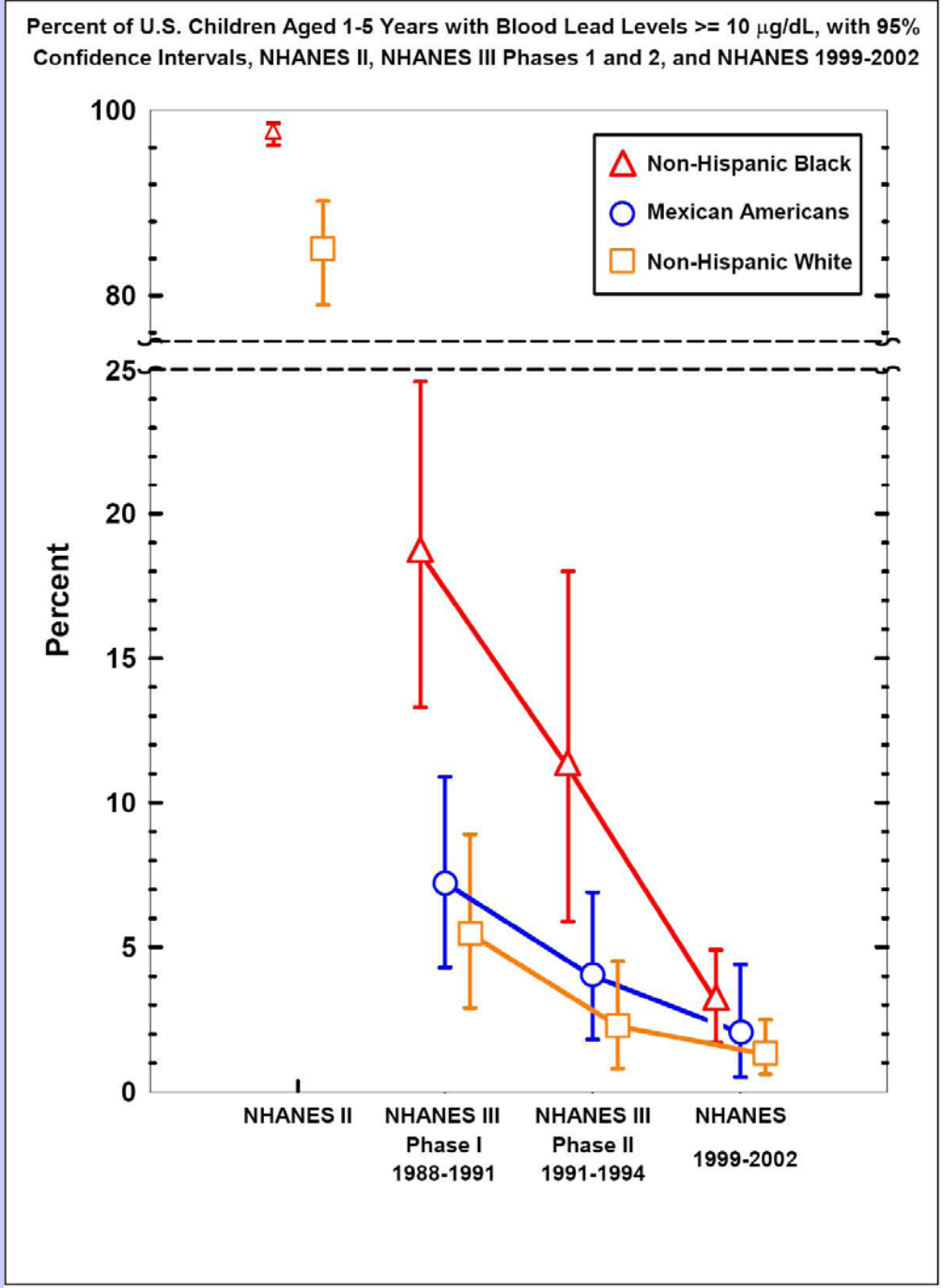
Existing Lead Standards

- Paint
- Interior Settled Dust
- Soil
- Water
- Dinnerware
- Exterior Airborne Dust

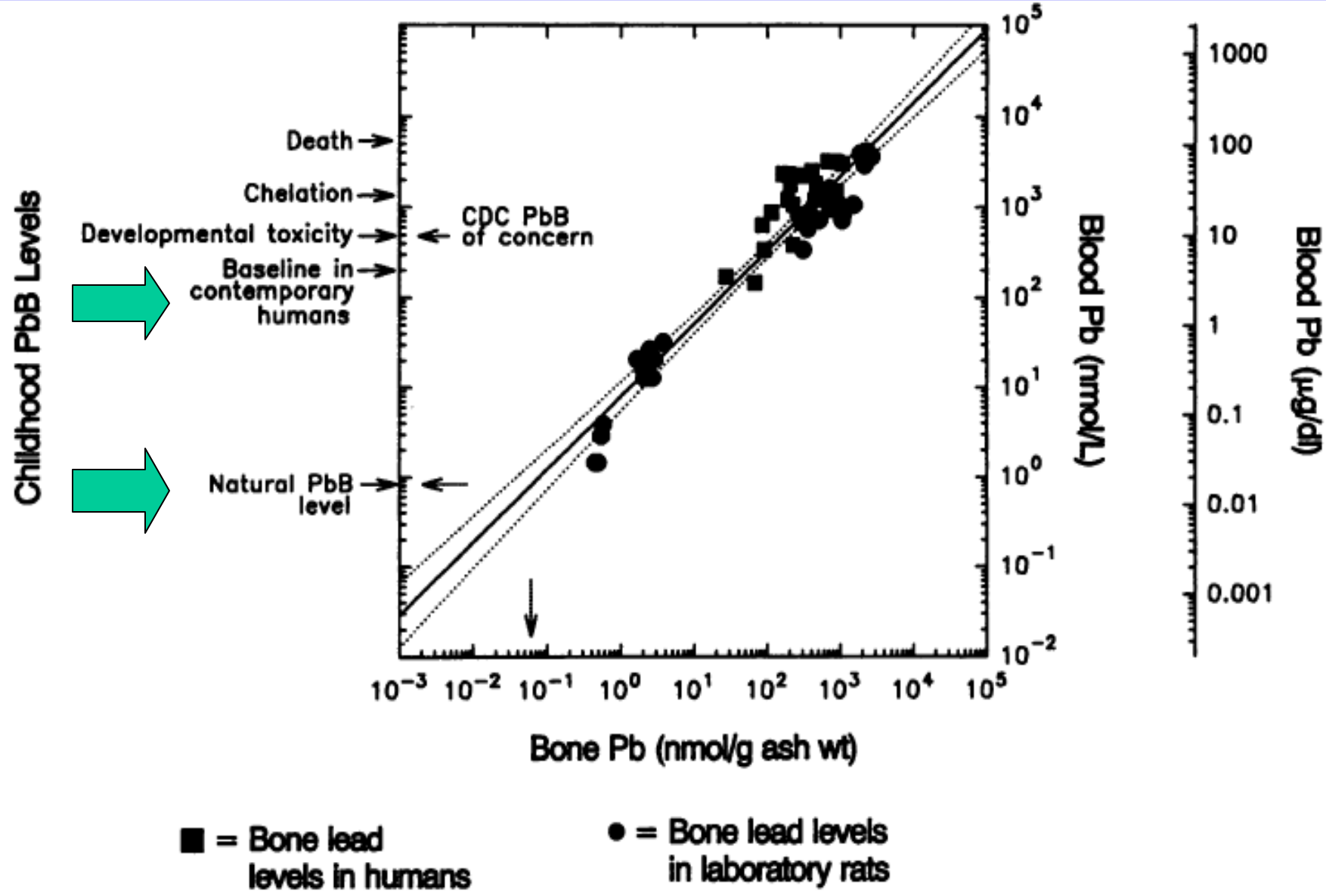
- None for Exterior Settled Dust or Demolition

US Policies & Blood Lead 1971-2004

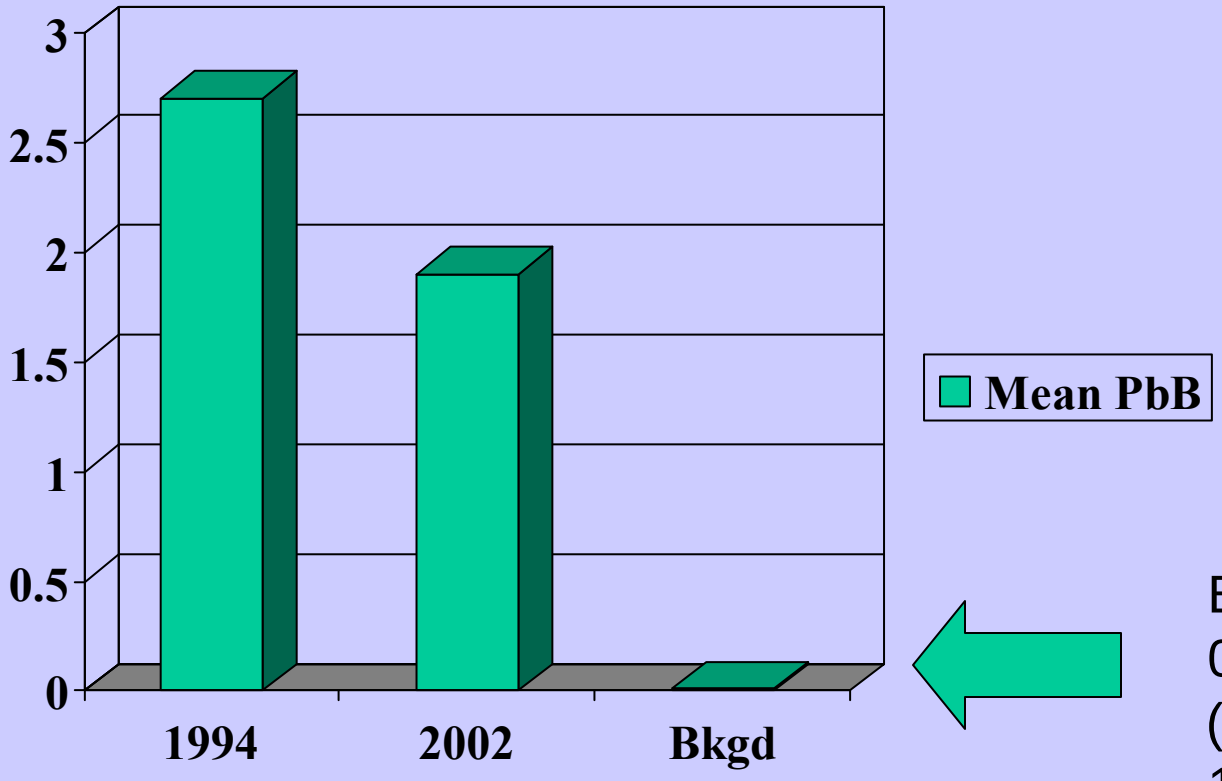



Percent of U.S. Children Aged 1-5 Years with Blood Lead Levels >= 10 μg/dL, with 95% Confidence Intervals, NHANES II, NHANES III Phases 1 and 2, and NHANES 1999-2002
Non-Hispanic Black
Mexican Americans
Non-Hispanic White
Percent
100
80
25
20
15
10
5
0
NHANES II
NHANES III Phase I 1988-1991
NHANES III Phase II 1991-1994
NHANES 1999-2002

Has the Lead Problem Already Been Solved?


Childhood PbB Levels
Death
Chelation
Developmental toxicity
Baseline in contemporary humans
Natural PbB level
CDC PbB of concern
Blood Pb (nmol/L)
Blood Pb (µg/dl)
Bone Pb (nmol/g ash wt)
■ = Bone lead levels in humans
● = Bone lead levels in laboratory rats

US Childhood PbB Compared to "Natural" Background PbB



Bkgd = 0.016 ug/dL (Flegal 1986)

The Lead Experience

- A Public Health Success Story
- A “Pyrrhic Victory”

- Future Challenges are Large
  - How Large Are They?

Settled Dust Lead & Paint Lead

- Current definition of lead paint = 1 mg/cm^2
- Sand a one square foot area into dust
- Spread the dust over a 10 ft x 10 ft room
- Resulting lead dust loading = 9,300 ug/ft^2
- Current US Government Limit = 40 ug/ft^2

How Much Lead Paint Is Left?

- 7.5 billion square feet interior
- 29.2 billion square feet exterior

- Total = **<u>36.7 billion square feet</u>**

- Implications for demolition and lead dust

Source: HUD National Survey of Lead and Allergens, 2000

Comparison of Baltimore and Chicago Sites

- **Total Structures in Baltimore Site**
  - Over 500 buildings in one area demolished
  - Typically 3 housing units/bldg
  - Avg age is pre-1910, likely to have lead paint
  - Lead in air, soil, ext. settled dust (wipe) and dustfall
- **Total Structures in Chicago Site**
  - Single family units
  - Likely to have lead paint
  - Lead in dustfall (PM_{10}, $PM_{2.5}$ silica, other metals, asbestos to be reported later)

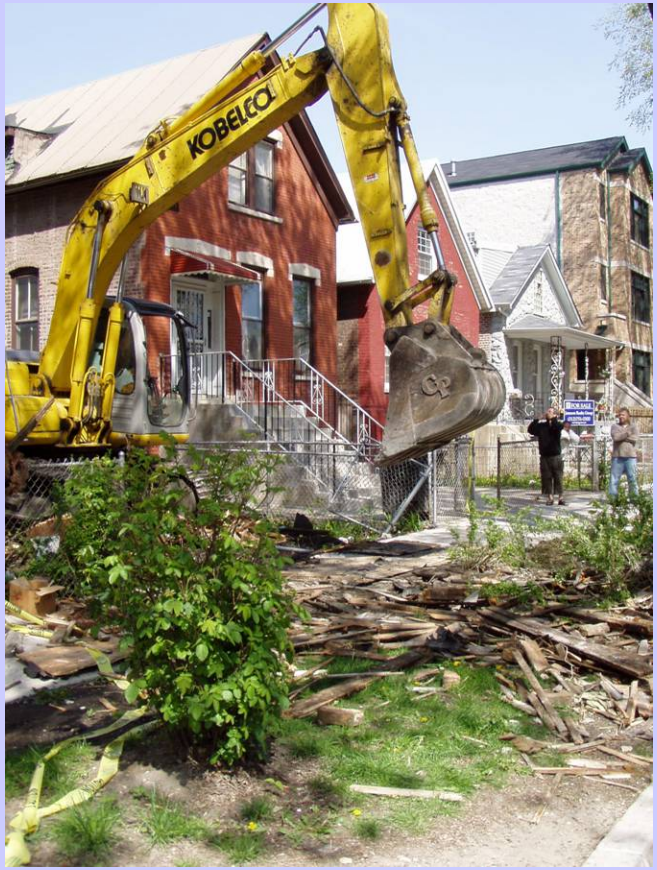
Summary of EBDI, Chicago, and 1999 Baltimore Demolition

	Housing Type	**Decon-struction**	**Water Use**	**Contain-ment**
EBDI	Multiple Row Homes	Some	2-4 fire hoses	Jersey Barrier/ Covered Fencing
Chicago	Single Family Detached	None	None or irregular – 1hose	6 foot fence
Baltimore 1999	Multiple Row Homes	None	1 hose	Unknown

Chicago 2006

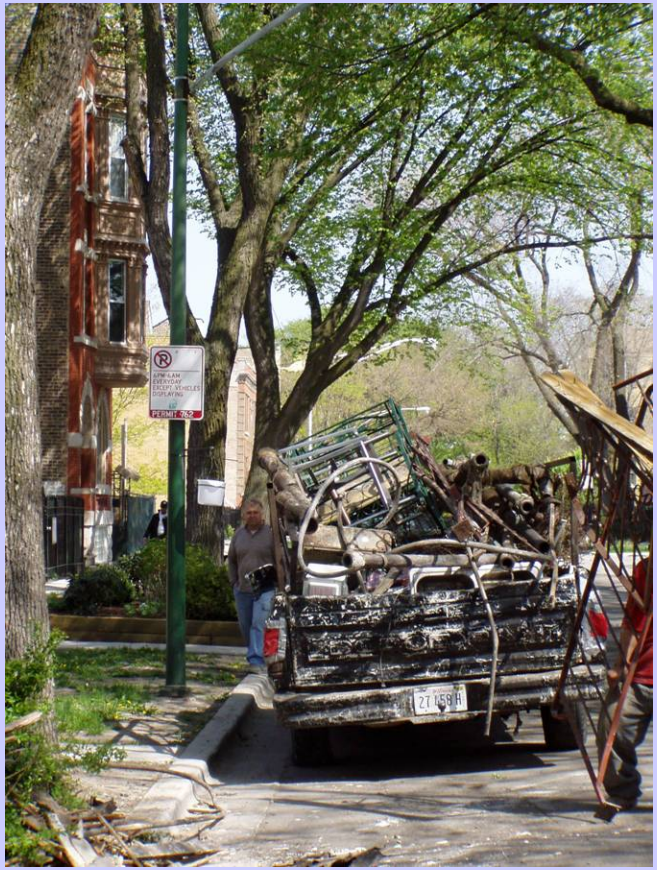
Chicago 2006

Chicago 2006
(no dust suppression or site containment)



Chicago 2006
(limited dust suppression)

Debris Removal Chicago 2006
(no dust suppression)



Chicago 2006
(no dust suppression/observer)

Baltimore 2006
EBDI Site

a partnership for progress

east baltimore development inc.

Operations Protocol

Operations Protocol for Salvage, Deconstruction, Demolition and Site Preparation Activities

Baltimore

Photo 1: Image taken at the 1800 block of Ashland Avenue and 800 block of N. Durham Street intersection. View from south to the north.

EBDI Demolition Protocols (1)

- Roles & Training in Lead Safe Work Practices
- Designation of Full Time Dust Suppression Manager
- Salvage and Deconstruction
- Community Organization Meetings & Notification
- Independent Advisory Panel
- Walk-off mats and HEPA vacuums for nearby residents
- Demolition, Debris Removal, Transport
- Landscaping, greening of lots, street and sidewalk cleaning
- Environmental Monitoring & Reporting

EBDI Demolition Protocols (2)

- Jersey Barriers
- Fencing with Poly
- Sediment control
- Fire Hoses
  - At least 2 hoses during active demolition
    - one above, one below
  - 1 hose used on debris when equipment is moving over it
  - 4 hoses on many occasions to reduce dust
- Deconstruction & salvage if feasible given structural soundness of buildings

EBDI Project Area – July 2006

Dust Fall Measurement (µg Pb/m^2/hr) (APHA Method 502)

Jersey Barriers and Fencing Baltimore

Photo 16: Image taken at the 1700 block of E. Eager Street and 1000 block of McDonough Street intersection. View from south to the north.

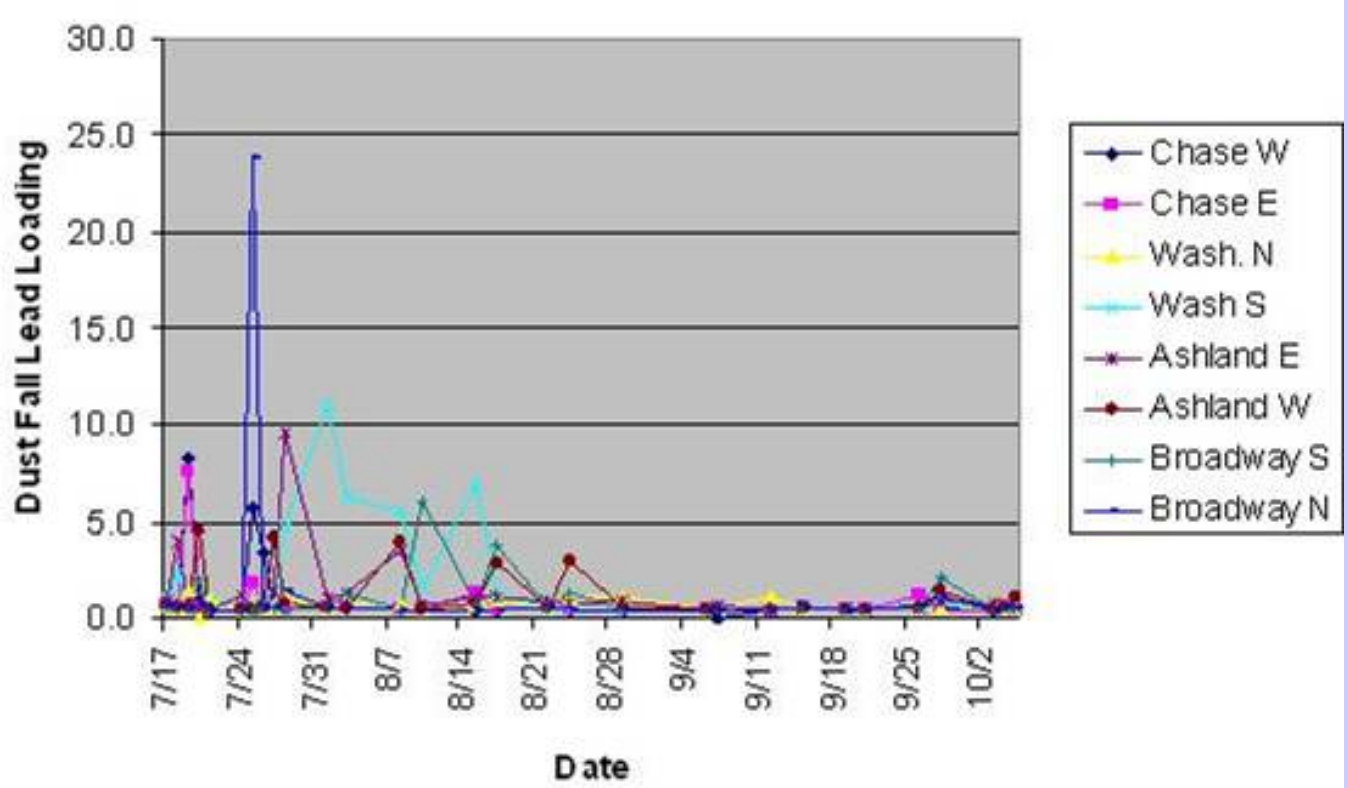
Baltimore Results - 1

Media	No. Samples	Geometric Mean	95% CI	Federal Standard
Airborne Lead During Demolition ($\mu g/m^3$)	239	<1.0 (all samples below detection)	--	1.5 (quarterly average)
Soil Lead Before Demolition ($\mu g/g$)	16 (matched)	449	(294, 686)	400 (play areas) 1200 (yard)
Soil Lead After Demolition ($\mu g/g$)	16 (matched)	166	(102, 269)	400 (play areas) 1200 (yard)

Baltimore Results - 2

Media	n	GM	95% CI	Fed Guidance
Settled PbD Before Demolition	12	74 $\mu g / ft^2$	(24, 233)	800 (troughs)
Exterior Settled PbD After Demo & Cleaning	12	44 $\mu g / ft^2$	(21, 90)	800 (troughs)
Ambient Dustfall Pb (1 mile away)	36	<5.71 $\mu g / m^2 / hr$	---	None
Demolition Dustfall Pb	238	7.64 $\mu g / m^2 / hr$	<5, 257	None

Lead in Dust Fall by Date and Sampling Site (Baltimore)



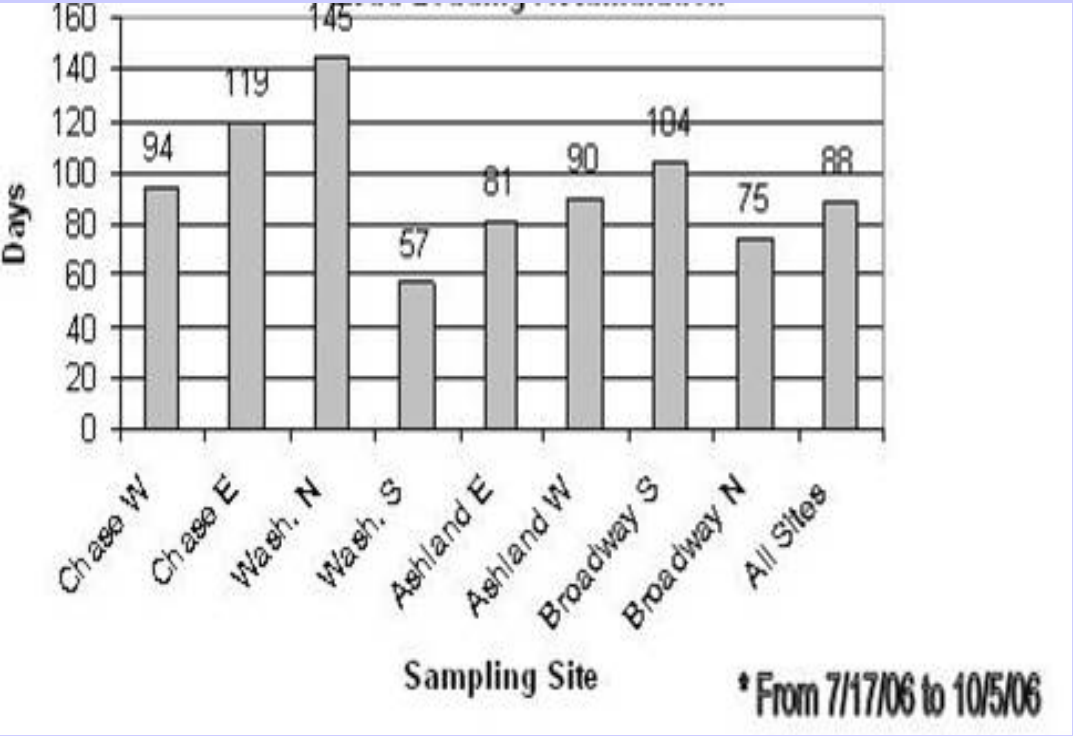
- Peak of 23.85 ug/m^2/hr observed at Broadway North during a day when several houses collapsed.

Exterior Pb Dustfall Standard?

- Currently does not exist
- Existing exterior dust lead cleanup standard from US Dept of Housing & Urban Development =

  800 ug/ft^2
- Assume 1 hour = 8,600 ug Pb/m^2/hr
- Assume no loss to wind, rain, re-entrainment
- Estimate number of days of demolition that would be required to exceed the HUD guideline

Days of Demolition for Dust Fall Lead Loading to Reach HUD Standard (Baltimore)



- For Chase West it would take 94 days of full time eight hour a day demolition to reach 800 μg/ft^2
- For Broadway North it would take 75 days of continuous demolition eight hours per day to exceed 800 μg/ft^2

Days of Demolition for Dust Fall Lead Loading to Reach HUD Standard (Chicago)

- Max dustfall lead = 32,000 ug Pb/m^2/hr
- 1 hour std = 8,600 ug Pb/m^2/hr
- Standard would be exceeded in only **<u>16 minutes</u>** of demolition activity
- Occupied houses in Chicago are within 3-5 meters of demolition
- Distance from Demolition (Next Talk S Cali)

Future Work

- Particle size distribution, metal speciation, silica, asbestos, total dust, $PM_{2.5}$ and PM_{10}
- Correlation between ambient pollutant monitoring and dustfall for lead, PM?
- Replicate samples to estimate spatial variability
- Policy implications for better control of dust emissions from housing demolition
- Need for exterior settled dust lead standard
- Need for demolition dust suppression

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The lead content of currently available new residential paint in several Asian countries ☆

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New Lead Paint Production

Table 1
Lead Concentration (ppm) in new household paints by country (analyses by atomic absorption)

Country	Number of paint samples	Median (ppm)	Maximum (ppm)	% (No.) Paints ⩾600 ppm
China	9	3280	73,400	56 (5)
India	17	16,720	187,200	100 (17)
Malaysia	32	21,300	143,000	72 (23)
China, India, and Malaysia combined	58	17,570	187,200	78 (45)
Singapore	22	9	3500	9 (2)

American Public Health Association

- **Calling for a Global Ban on Lead Use in Residential Indoor and Outdoor Paints, Children's Products, and All Nonessential Uses in Consumer Products**
- **Policy Date:** 11/5/2007
  Policy Number: LB-07-01

Future Challenges (1)

- Updated or new exposure limits needed for dustfall from housing demolition, new paint, settled interior dust, plastics, airborne particulate & consumer products
- Immigrants to US have high blood lead levels, suggesting large exposures in developing world
- No clear global regulatory system

Future Challenges (2)

- Non-essential uses of lead continue to proliferate
- Primary Prevention is essential, but reactive approach still dominates
- Recalls are ineffective
- Need to address both legacy sources and emerging exposures

Conclusion

- The Lead Experience:

- One of the Best Public Health Success Stories, but
- Primary Prevention Remains a Large Challenge
- Dust from Housing Demolition Requires Control

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