FACT SHEET

EPA
Region 7

Mine Waste February 2003

Introduction

The U S Environmental Protection Agency (EPA) Region 7 is providing this fact sheet as a public guidance on mine waste usage in the states of Missouri and Kansas Some residual wastes from mining are a commercial commodity and have been used for many years Proper use of the wastes can reduce some threats to the environment and to human health that currently exist Removing chat piles and covering tailings can also bring non productive land back to beneficial and safe use However improper uses of mine wastes may increase the threat to human health and the environment The ultimate use of the material should not allow people and in particular young children to come into contact with the material easily

Site Background

Historic lead and zinc mining in the Midwest was centered in two major areas the Tri State area covering more than 2 500 square miles in southwestern Missouri southeastern Kansas and northeastern Oklahoma and the Old Lead Belt covering about 110 square miles in southeastern Missouri The first recorded mining occurred in the Old Lead Belt in about 1742 The production increased significantly in both the Tri state area and the Old Lead Belt during the mid 1800s and lasted up to 1972 Currently production still occurs in a third area the Viburnum Trend in southeastern Missouri Mining and milling of ore produced more than 500 million tons of wastes in the Tri State area and about 250 million tons of wastes in the Old Lead Belt More than 75 percent of the waste has been removed and used for many purposes over the years Today approximately 100 million tons of waste remain in the Tri State area and 60 million tons in the Old Lead Belt EPA Region 7 the states of Kansas and Missouri local communities and private companies are working together to seek solutions to the potential adverse impacts of these mine wastes which are contaminated with lead zinc cadmium and other metals

Chat and Tailings

Ore production consisted of crushing and grinding the rock to standard sizes and separating the ore Ore processing was accomplished in either a dry gravity separation or through a wet flotation separation Dry processes produced a fine gravel waste commonly called chat The flotation process resulted in the creation of tailings ponds used to settle out material from solution The wastes from flotation are typically sand and silt size and are called tailings Milling resulted in large chat waste piles and in flat areas with tailings deposited some depth below the ground surface Tailings are generally held in a dammed impoundment and contain higher concentrations of heavy metals and therefore present a higher risk to human health and the environment through ingestion

Another lesser source of mine waste is called development rock Development rock is the waste rock generated in drilling shafts to the deep mines and therefore did not come from the major ore producing rocks Typically development rock consists of large boulders and is locally known as bullrock Smelters also operated historically in Kansas Missouri and Oklahoma but this fact sheet does not address smelter related wastes

Legal Considerations

If waste material is used in a way that creates a threat to human health or the environment the owner of the property and the party responsible for creating the hazardous situation could be liable for a cleanup under the Superfund law Because these mine wastes often contain lead cadmium zinc or other metal contaminants at levels that present a risk to both human health and the environment using them in situations that would allow people or species to regularly come into contact with the material could result in unacceptable situations which could be considered a Superfund problem The property owners haulers operators and individuals or businesses that sell buy or use mine waste materials need to ensure they are using the materials in a manner that prevents direct contact by human and ecological receptors and is not detrimental to the environment

Typical uses

EPA and the states of Kansas and Missouri are willing to provide assistance in reviewing specific uses of mine wastes but have no formal approval procedures The following is a list of typical uses of mine wastes with a general assessment of whether or not the use may result in significant human health or environmental threats The list represents EPA Region 7 s views on acceptable and unacceptable uses of mine wastes

Mine waste uses that are not likely to present a threat to human health or the environment

- Applications that bind material into a durable product These would include its use as an aggregate in batch plants preparing asphalt and concrete (note other engineering and chemical properties of the chat may not be compatible with its use in concrete)

- Applied below paving on asphalt or concrete roads and parking lots

- Applications that cover the material with clean material particularly in areas that are not likely to ever be used for residential or public area development Examples would include spreading chat around utility pipe in excavated trenches or placing chat as deep fill on commercial sites

- Applications that use the material as raw product for manufacturing a safe product such as in glass or manufacturing

Mine waste uses that may present a threat to human health or the environment

- Playground sand or surface material in play areas

- Driveways parking lots and roadways including roadway shoulders that are not paved

- Residential usages in general The placement in a residential setting could cause a problem in the future if an unknowing person excavated the material and allowed it to be re exposed Also construction of residential homes or siting public use areas such as parks or playgrounds on or very near mine waste piles may result in unacceptable exposures

- Public areas in which children play such as parks and school grounds

- Placement of fill material which comes in contact with free standing water in an excavation or with surface water

- Sandblasting

- Use as an agricultural soil amendment to adjust soil alkalinity

Additional Information

If you would like additional information about this fact sheet or Superfund mining sites in Kansas or Missouri please contact EPA Region 7 s Office of External Programs 901 N 5th Street Kansas City Kansas 66101 1 913 551 7003 or toll free in Kansas and Missouri 1 800 223 0425

A STUDY ON THE POSSIBLE USE OF CHAT AND TAILINGS FROM THE OLD LEAD BELT OF MISSOURI FOR AGRICULTURAL LIMESTONE

by

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Nord L Gale
and
Brian E Davies

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A STUDY ON THE POSSIBLE USE OF CHAT AND TAILINGS FROM THE OLD LEAD BELT OF MISSOURI FOR AGRICULTURAL LIMESTONE

By
Bobby Wixson, Nord Gale and Brian Davies

I INTRODUCTION

Lead and zinc mining and milling procedures have historically produced large quantities of gange or waste rock from which most but not all of the ore minerals have been removed From 1850 to 1960 three major lead and zinc mining districts were developed in Missouri's Lead Belt which contributed to the state becoming the primary producer of lead for the United States in 1902 Initially most of this production came from the Old Lead Belt in Madison and St Francis Counties with St Joseph Lead Company being the main producer However these resources became worked out and the mines in the Old Lead Belt were closed by 1965 This closure was also due to the discovery of the Viburnum Trend or New Lead Belt developed during 1968 which presently produces some 92% of the total U S lead production (1)

During the productive life of the Old Lead Belt two different methods of mineral beneficiation were employed The first method used density separation or jigging which produced a coarse waste rock material called chat This material was commonly disposed of in large piles or heaps often resembling small mountains From 1915 to 1922, the froth flotation method of separating lead zinc and copper from the parent rock by the use of chemical collectors was developed resulting in a finer particle waste rock material (tailings) and a more effective removal of sulphide minerals Therefore three general types of chat heaps or tailings piles exist in the "Old Lead Belt' area of Missouri These are 1) chat, 2) tailings, 3) a mixture of chat and tailings representing historical changes in ore separation and mineral collection technology

These rather dominant waste hills or deposits of chat or tailings, unless specially treated will remain sterile of vegetation because of unfavorable physical properties (e g surface instability or moisture retention characteristics), lack of essential plant nutrients, and residual concentrations of heavy metals The tailings or chat heaps may be unsightly and environmentally damaging if the rock waste material is blown or washed from the hills into neighboring fields or waterways (2) The most common ameliorative practice to date has been by landscaping and revegetation However, the chat or tailings heaps also offer the possibility of being used as an economically valuable material such as in building foundations highway construction and use of the calcareous material as agricultural limestone However, questions were raised concerning residual heavy metal content which might restrict the use of tailings or chat for use as agricultural limestone purposes

According to Davies and Roberts (3) and other studies (4) similar reuse of limestone tailings in north Wales (Great Britain) was believed to have contributed to the formation of a major contamination area (171 km^2 contaminated by Pb) resulting in significant problems of heavy metal uptake by vegetables Also, the residual organic content following froth flotation had limited reuse in Derbyshire, England (5)

The Missouri Department of Natural Resources (DNR) has been constantly asked by the public and the mining industries if the tailings, or chat materials in the Old Lead Belt area might be used as agricultural limestone thereby presenting a potential for resource reuse and contributing to removal of a possible pollution source However, additional research information was needed on the chemical characterization and metals possibly available to soil and plants if the tailings or chat materials were to be used for agricultural lime purposes

Based on the needs of the Missouri DNR a research study was designed and performed to answer these important research questions

II OBJECTIVES

Based on the needs noted and a request from the Missouri DNR the objectives of this study were to

1 Characterize physical and chemical composition of selected chat and tailings piles in the Old Lead Belt and New Lead Belt

2 Collect and analyze soil and vegetation samples from fields where tailings or chat had been previously used as agricultural lime

3 Collect and analyze soil and vegetation samples from control areas where commercial limestone has been applied for at least five years

4 Perform bioassays for plant uptake of metals in radish and lettuce plants grown on uncontaminated soil agricultural limestone (controls) and soils treated with tailings or chat with the pH adjusted to 7 or neutral

5 Summarize and evaluate analytical results to determine if selective tailings or chat materials might be used for agricultural purposes without the bioconcentration of heavy metals from the soil to the plant system at levels which might be of concern to public health

III RESEARCH METHODOLOGY

A research program was proposed which involved both survey, experimental and analytical work with the objectives of characterizing the Old Lead Belt chat and tailings chemically and establishing, if these materials were applied to the land as agricultural limestone, whether they might release heavy metals to the soil-plant system at levels of concern for public health Since the Old Lead Belt initially utilized older, less efficient extractive technologies, it was proposed to also survey some selected tailings from newer mining operations in the Viburnum Trend where more effective ore concentration techniques are presently employed

In St Francois County there are six major chat or tailings areas at Leadwood down the Big River to the Desloge pile in a meander loop of the river at Bonne Terre the Elvins tailings pile the Federal tailings pile and the National tailings pile at Flat River Missouri All except the Federal tailings were studied in the Old Lead Belt Two further tailings piles were investigated in the New Lead Belt at the St Joe Viburnum operation and the Cominco American Magmont Mine

Meetings were held with the Missouri DNR project director Mr John C Ford, and a statistical package was developed for the necessary number of samples needed for each chat or tailings pile to attain the level of confidence needed by the Missouri DNR The number of samples collected followed the population standard deviation suggested for the 95% confidence level

A Tailings and Chat

Tailings and chat samples were taken along a number of transects which were determined to be most representative of the tailings or chat pile At each sample location, samples were collected from approximately the 20 - 40 cm depth below the surface This was intended to distinguish between weathered and leached surface material and the less altered interior material Samples were bagged in polyethylene and labelled as to location in the respective pile The material was returned to the laboratory air dried and sieved with the less than 40-mesh fine fraction being dissolved in nitric acid and analyzed for lead, cadmium and zinc by atomic absorption (AAS) or the inductively coupled argon plasma (ICAP) method

B Soils

Two fields were located where tailings had been applied for lime supplementation for at least the past five years The pedological nature of the soil were established at each site with the assistance of Mr Burton L Brown of the Soil Conversation Service and at each site a random survey of the topsoil was made using the standard staggered W method Samples were comprised of auger cores to a depth of 10 cm which were then bulked in a polyethlene bag

Soils were then returned to the laboratory where they were dried at room temperature gently ground and passed through a 2 mm nylon sieve Metal analysis was performed by the Environmental Trace Substances Research Center in Columbia Missouri using the AAS (flame or graphite furnace or ICAP method

C Vegetation

The plant material was cropped with stainless steel implements and placed in a polyethylene bag and then, in turn, in a second bag with the sample label Label and sample record sheet contained the same information as used for soil samples As soon as practicable, the samples were placed in an ice chest

In the laboratory the plant material was carefully washed by accepted methods and dried at 100°C followed by milling Analysis (wet or dry ashing) was made by AAS or ICAP as previously described

D Bioassays

Radish and lettuce were the two experimental plants used for controlled growth experiments

Pots used in the study were 20 cm/8 in commercial plastic Soils were brought in to the laboratory, spread thin on plastic sheeting and large debris removed The soils were sampled for analysis and then potted and mixed with 25% volume of inert (e g chert) grit After the soils were analyzed each pot was emptied on to the plastic and the appropriate amount of lime and fertilizer mixed in The soils were then returned to the pot, watered with deionised water and allowed to stand for 48 hours to equilibrate Each pot was then sown with 25 seeds of the respective plant and the seeds allowed to germinate and grow They were then thinned to 5 plants per pot and allowed to grow to maturity After plant harvest the pot soils were reanalysed

Soils were derived from localities identified during the earlier survey work with a sufficient amount excavated to fill the pots Soils were returned to the laboratory in plastic sacks contained within plastic trash cans

All pot treatments were triplicated and received a basal treatment of NPK compounded from laboratory pure chemicals The soils used comprised an uncontaminated control soil, the same with sufficient agricultural limestone to adjust the pH to approximately 7, a soil known to have been treated with dolomitic tailings, the control soil plus metal-rich tailings from the Old Lead Belt sufficient to raise pH to approximately 7 the control plus tailings from the New Lead Belt sufficient to raise pH to approximately 7

When the plants were harvested the yield from each plot was weighed immediately after the soil was washed from the roots with deionised water Lettuce was divided into leaves and roots the leaves weighed and root length measured Radish was divided into leaves bulb and roots leaves and bulbs weighed and analyzed for Pb or Cd

E Commercial Limestone

Thirteen samples of commercial agricultural limestone were obtained and submitted to the Environmental Trace Substances Research Center in Columbia, Missouri for ICAP analyses These samples represented four out-of-state samples and nine samples representative of the different locations within the State of Missouri that are presently producing agricultural limestone

F Quality Control

Since this study needed to determine if selected chat or tailings may be used for agricultural lime purposes, an efficient quality control method was necessary In order to maintain this sixteen (16%) of the study samples were analyzed by the Environmental Trace Substances Research Center (ETSRC) in Columbia Missouri Also selected sample duplicates and spikes were incorporated into the analytical program at the University of Missouri-Rolla (UMR) and the ETSRC to validate analytical results

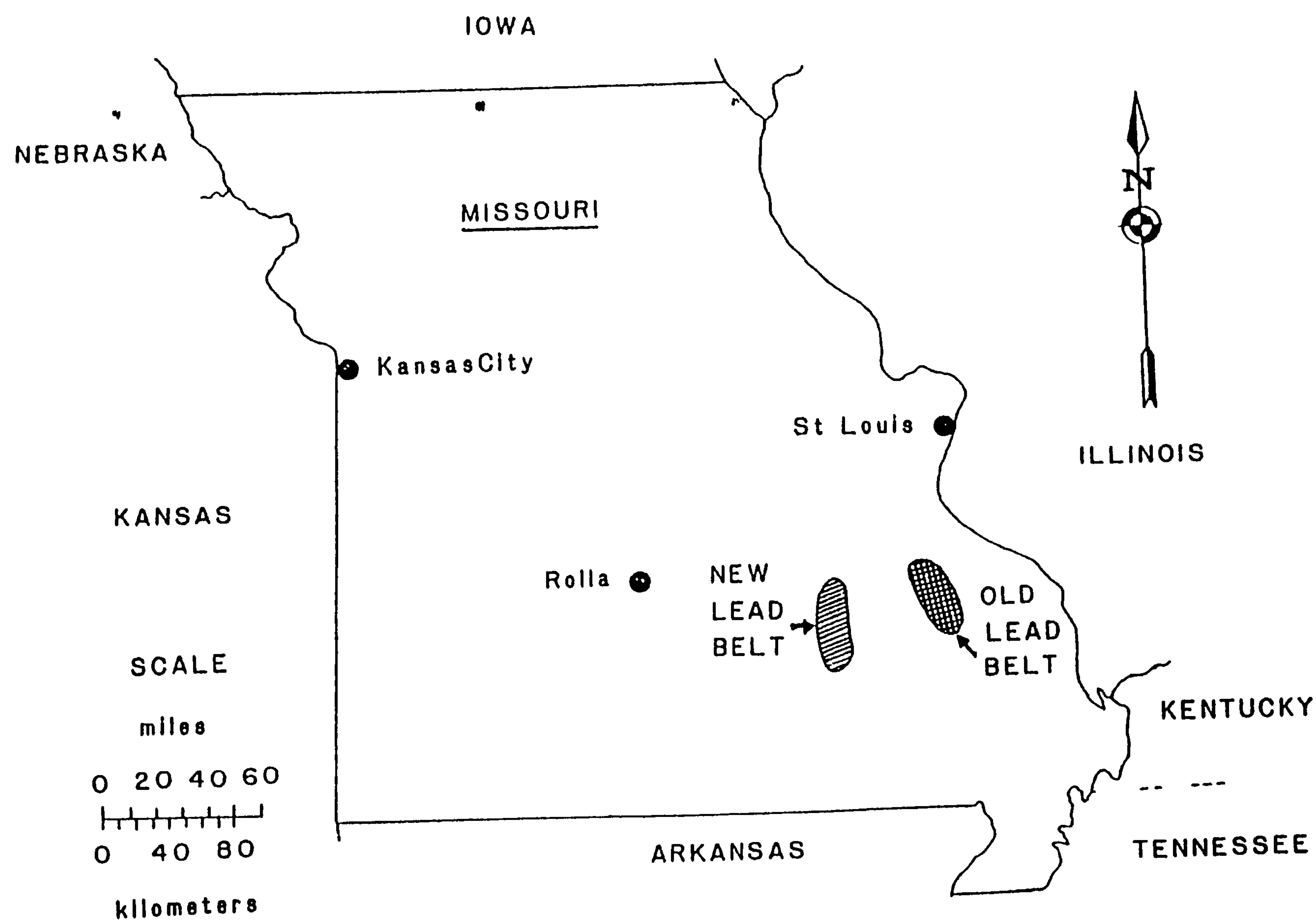
IV STUDY AREA

The study area selected for this investigation is comprised of the Leadwood, Big River, Desloge, Elvins, National and Bonne Terre tailings piles within the confines of the Old Lead Belt in St Francois County, Missouri The Old Lead Belt is located about 113 km (70 mi) south of St Louis, Missouri and contains the cities of Bonneterre, Leadwood, Elvins Desloge, and Flat River This old mining region covers an area of approximately 285 sq km (110 sq mi) and is bordered by latitudes 38°00' and 37°49'5 and by longitudes 90°37'30' and 90°28 45'

According to a report submitted by Heyward M Wharton to the St Joe Minerals Corporation on 28 October 1983 (6) the acreage affected by inactive lead-zinc mining in the Old Lead Belt represented 3085 acres as contrasted with the 1822 presently impacted by active or development mining operations in the Viburnum Trend " Figure 1 provides a visual perspective of the area including its location with respect to major cities in Missouri

The topography consists of gently rolling hills with narrow table-lands areas and alluvial plains comprise most of the topography in the Old Lead Belt with the exception of the extreme southwestern portions of St Francois County, which is mountainous (7) Hickory, elm and sycamore trees compliment the lowland stream areas, while red white and black oaks are abundant in the upland areas (8)

The climate of this region usually consists of warm humid summers, and mild winters Extremes of -30°F (-34°C) and 115°F (46°C) have been



LOCATION OF OLD AND NEW LEAD BELTS OF MISSOURI

FIGURE 1

recorded, but are not common to the area Annual rainfall averages generally total about 40 inches (9)

Galena, the most important mineral ore of lead, was the principle ore mined within the Old Lead Belt of Missouri (10,11) Normal thickness of this mineralization varied from a few inches to about 6 1 m (20 ft) These ore deposits were horizontal concentrated along flat shale bands or other easily permeated plains, and found in the Bonne Terre dolemite with thicknesses of nearly 131 m (400 ft) The La Motte sandstone, with thicknesses up to 400 feet underlies this dolemite while shale and siliceous dolemite, in thicknesses up to 152 m (500 ft) is found above it

V CHARACTERIZATION OF TAILINGS AND CHAT PILES

Five different tailings or chat piles within the Old Lead Belt area were selected for sampling These were the Leadwood, Big River-Desloge, National, Elvins and Bonne Terre (two areas) tailings piles illustrated in Figure 2

These tailings and chat piles in the Big River area of the 'Old Lead Belt" were subjected to metal sampling to determine the amounts of lead, cadmium and zinc present Since some of the chat piles which were generated before the introduction of the froth flotation extraction technology, around 1917 contain larger gangue particles and more metals, it was necessary to categorize these tailings or chat disposal areas which are a contributing source for tailings material (and metals) introduced into the sediments of Big River through storm water runoff

Concentrations of lead in sediments and water of the Big River are shown in Figures 3 and 4 These sediment data indicate that the highest concentrations of lead were found near the confluence of Eaton Creek with the Big River at Leadwood Lead concentrations of the sediments derived from the Desloge tailings pile are uniformly in the range of 1,000-3 000 ppm and the sediment data reflect the composition of this tailings pile (12) Concentrations of lead in river water are quite low throughout the region including water from over river sediments shown to have anomalously high lead concentrations (5 ppb lead in water at Leadwood) In most instances the lead concentrations remain below the recommended limits for drinking water standards This is consistent with the known limited solubility of lead compounds in hard alkaline

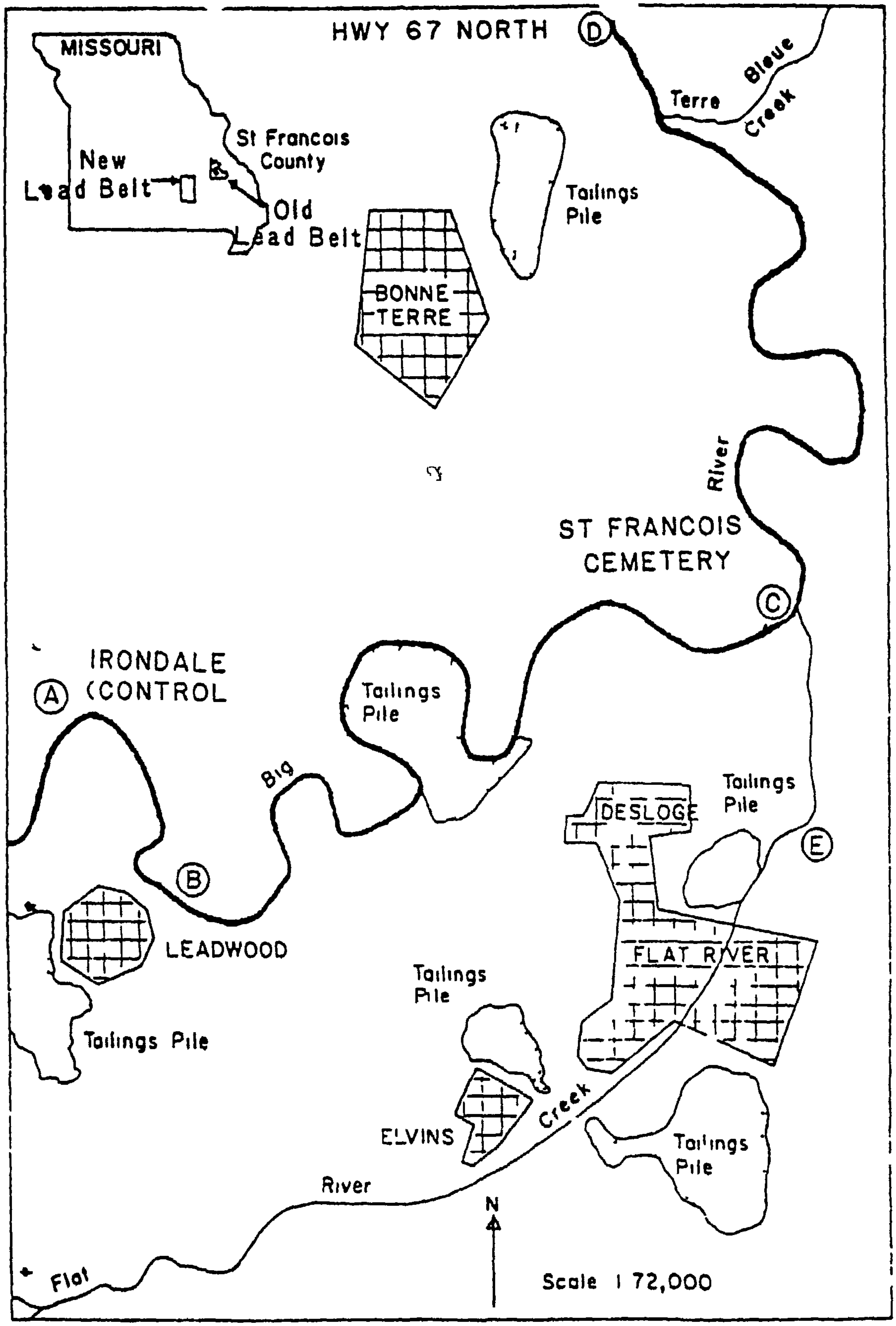


FIGURE 2 LOCATION OF TAILINGS PILES STUDIED IN THE OLD LEAD BELT

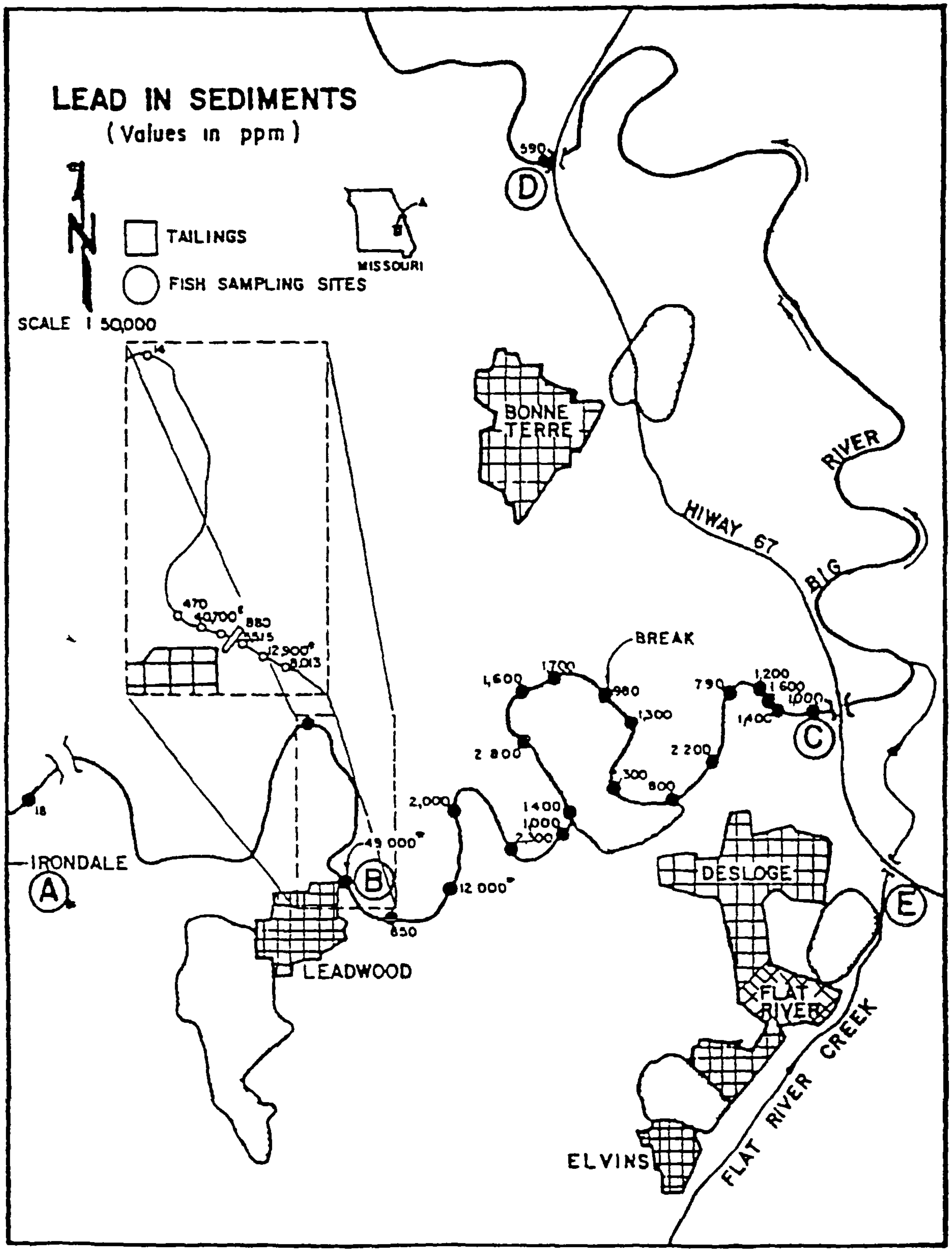


FIGURE 3 DISTRIBUTION OF LEAD IN SEDIMENTS OF BIG RIVER ASSOCIATED WITH TAILINGS PILES

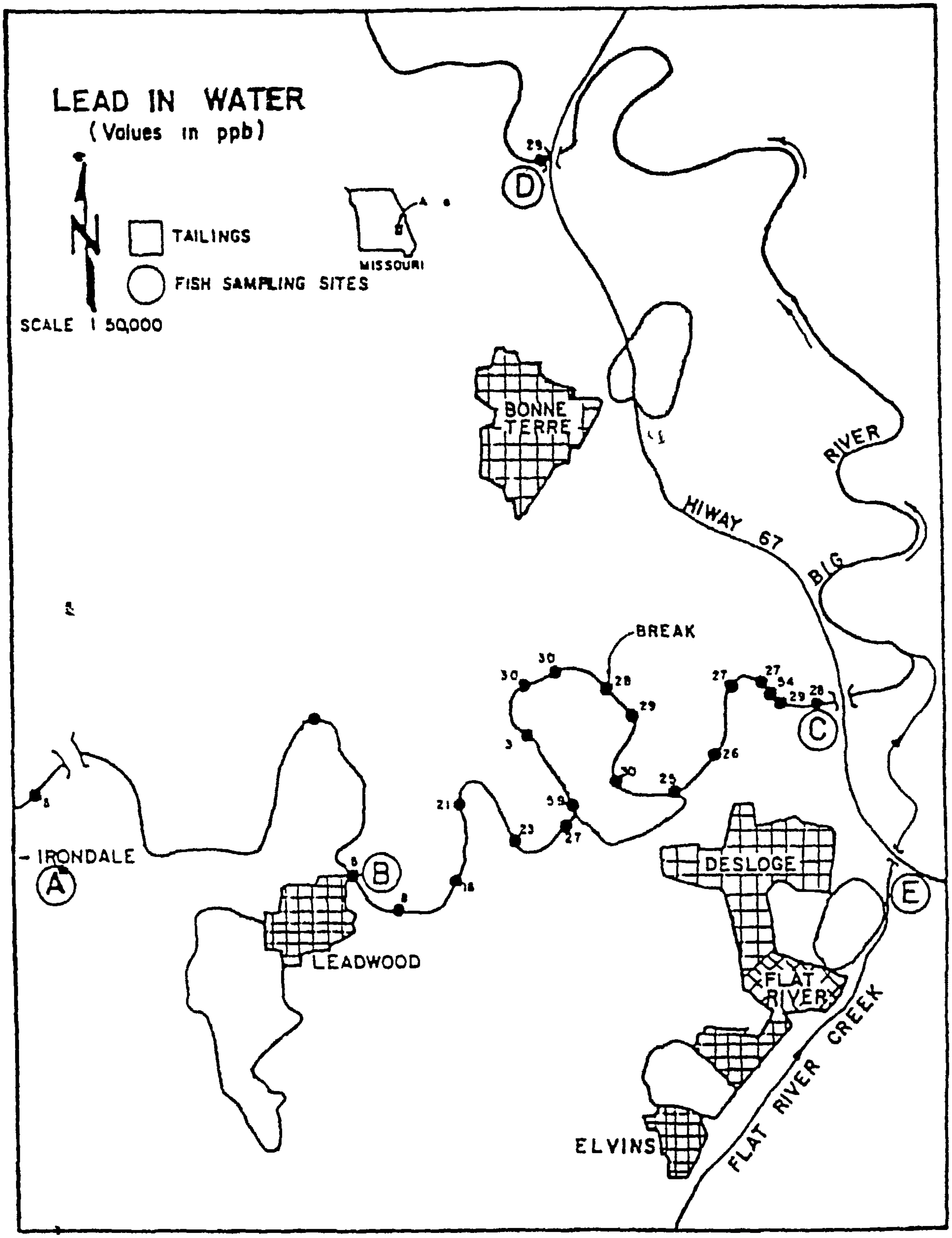


FIGURE 4 LEAD IN WATER OF BIG RIVER IN THE OLD LEAD BELT REGION OF MISS URI

waters The two notable exceptions were 1) a sample of water taken directly from a pipe from an old drill hole (59 ppb) some distance upstream of the eroded break in the Desloge tailings pile, and b) a sample taken from the Big River at the junction with sewage effluent from the Desloge-Flat River city sewage treatment plant (54 ppb)

Sampling transects were designed to take the most representative samples of tailings (or chat) material from the unweathered portion (depth of 20 cm) of the piles in sufficient numbers to meet the Missouri DNR statistical program discussed in the methods section of the report and included in the Appendix Sampling locations were noted by number on the appropriate tailings figures and followed by tables giving the metal values for Pb Cd and Zn

The National tailings pile was the subject of a M S thesis by Elliott (15) and only the pertinent findings are discussed in this report However a copy of Elliott s thesis (15) will accompany the report as a part of the research evaluation

Individual tailings or chat piles are discussed according to characterization by sampling data A statistical analysis and evaluation of the different tailings piles is included at the end of this section of the report

A <u>Leadwood</u>

A series of transects were established for the Leadwood tailings and chat pile located along the eastern border of the town of Leadwood, Missouri and extending slightly to the south of town Figure 5 illustrates the samples numbering for the 98 samples taken at near-surface unweathered

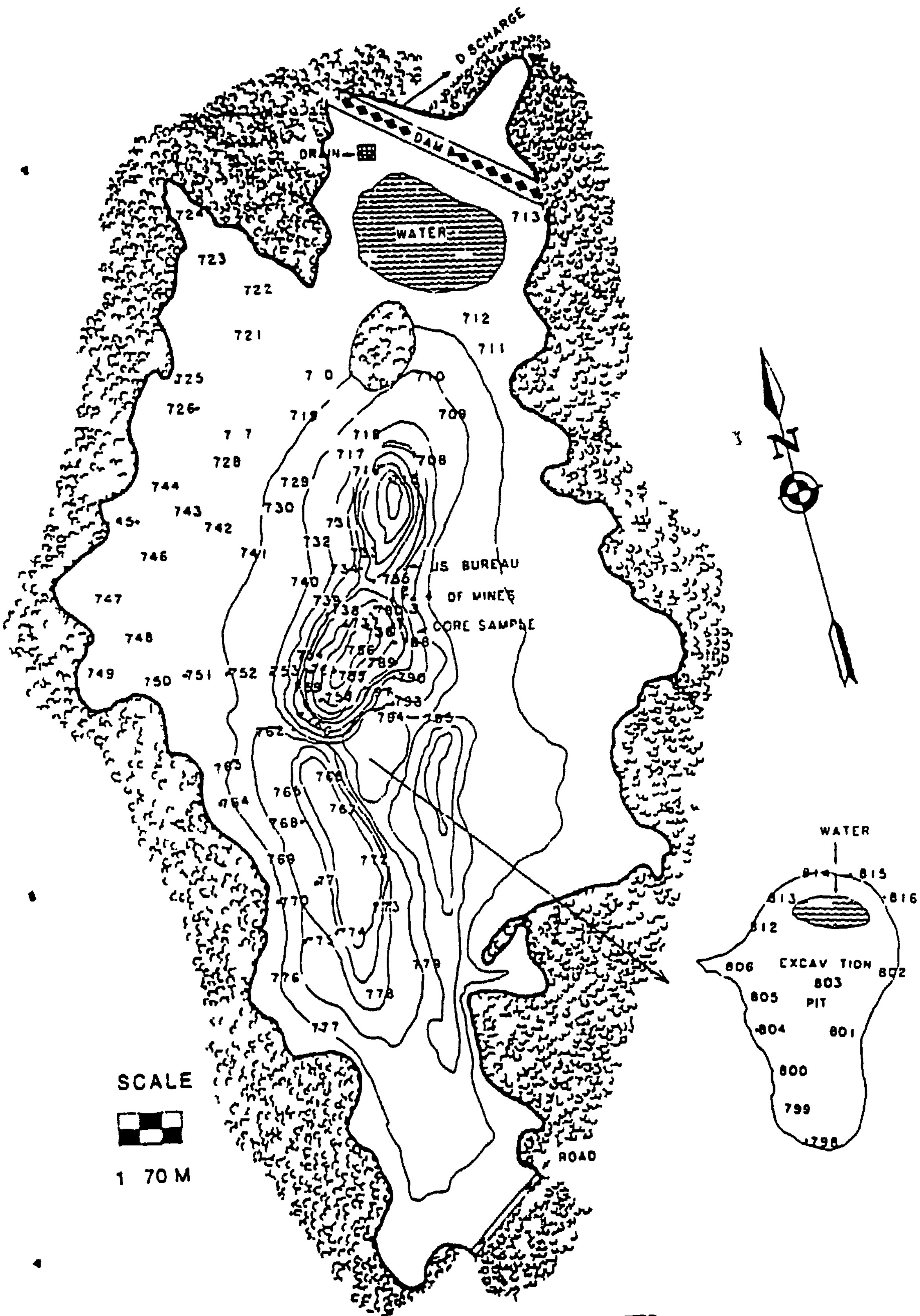


FIGURE 5 LOCATION OF SAMPLING SITES ON LEADWOOD TAILINGS PILE

materials Table I indicates the metal concentrations for Pb, Cd, and Zn in micrograms per gram (parts per million) by sample number

Since the U S Department of the Interior Bureau of Mines was performing a research study associated with tailings deposits in the Old Lead Belt , a cooperative effort was worked out with their research people whereby the near surface sampling results would be shared with them in return for the Bureau of Mines coring down to the bottom of the Leadwood and National tailings piles Mr Larry George Glynn Horter and Scot Lay assisted with the coring procedure and Figure 6 illustrates the location of the hand augered samples (two-to-four foot depth) and the drill hole locations which extended to twelve feet at one location and twenty four feet at a second location to reach bedrock under the Leadwood tailings pile Table 2 gives the Pb Cd, and Zn concentrations associated with the hand augered samples and the two coring drill holes (Courtesy of the Bureau of Mines) Table 3 gives the inductive coupled argon plasma (ICAP) analysis for the core samples at site R-1 down to 24 ft and Table 4 gives the ICAP data for the core samples at site R-2 down to 12 ft or bedrock

The highest lead values found for the Leadwood tailings pile were 17 000 micrograms per gram which came from a site close to the earthen dam at the north-eastern portion of the area The next highest sample of 13 800 ppm came from the center of the excavated pit on the south side of the main pile Shallow hand augered samples did not show a significant change in composition down to a depth of four feet

TABLE - 1
LEADWOOD TAILINGS PILE

Sample No	Metal Conc, ug/g Pb	Cd	Zn
L708	1320	66 9	3490
L709	1880	89 7	4750
L710	1630	63 6	3550
L711	1110	40 0	2290
L712	2420	67 4	3570
L713	17000	158	8630
L714	9500	243	15200
L715	1620	88 8	4150
L716	1800		4940
L717	2310	105	5150
L718	1900	87 5	4370
L719	1780	66 0	3100
L720	2580	74 5	3630
L721	1830	49 5	1710
L722	1680	47 5	2180
L723	1510	39 6	1980
L724	2280	41 6	1880
L725	1620	37 6	1600
L726	1020	42 3	1830
L727	2580	70 6	3250
L728	1620	57 2	2860
L729	3310	115	6040
L730	1070	64 0	3200
L731	1990	111	6150
L732	1860	101	5620
L733	1630	101	5340
L734	1260	171	9720
L736	2530	98 9	4650
L737	1600	96 7	4830
L738	1630	94 2	4510
L739	1720	78 3	3720
L740	919	44 0	1600
L741	886	28 3	1040
L742	761	30 4	1050
L743	823	34 5	1340
L744	986	33 5	1300
L745	2170	83 7	7980
L746	832	75 3	3760
L747	1430	763	3820
L748	1070	596	2840
L749	890	763	3560
L750	880	547	2930
L751	2520	1610	8530
L752	2300	1870	10100
L754	2260	1720	8320

(CONTINUED)
TABLE - 1
LEADWOOD TAILINGS PILE

Sample No	Metal Conc ug/g Pb	Cd	Zn
L755	1170	1230	6060
L756	1900	1350	7060
L758	1950	995	5460
L759	4740	1120	5890
L760	920	45 9	2480
L761	1050	625	3520
L762	1680	858	4390
L763	1430	1200	6730
L764	1670	856	4480
L765	736	1010	5570
L766	3420	20 4	1710
L767	597	308	1250
L768	3290	20 3	1430
L769	1330	372	1660
L770	1400	721	3420
L771	1300	15 9	987
L772	2260	77 2	4050
L773	788	31 1	1280
L774	1120	44 3	2210
L775	916	46 7	2240
L776	2600	37 9	1710
L777	909	85 0	4250
L778	1140	56 3	3010
L779	1130	55 6	2780
L780	3640	155	8610
L781	2550	249	14600
L782	7470	220	13600
L783	4320	162	9180
L784	3490	151	8460
L786	1120	37 3	1960
L787	1250	67 2	3660
L788	934	46 9	2530
L789	615	9 3	633
L790	1640	77 3	4050
L791	3770	78 4	4220
L792	5560	78 7	5214
L793	1270	70 2	3980
L794	1100	84 6	4720
L795	10100	456	25800
L798	1380	47 2	2460
L799	1360	46 7	2630
L800	1710	80 5	4790
L801	1970	76 4	3910
L802	8230	278	15800
L803	13800	524	
L804	1440	69 2	3930

(Continued)

TABLE 1

LEADWOOD TAILINGS PILE

Sample No	Metal Conc ug/g Pb	Cd	Zn
L805	1740	69 6	3970
L806	2830	87 8	5380
L812	6200	177	9900
L813	4180	325	19600
L814	3521	147	8320
L815	4340	158	9570
L816	2490	137	8850

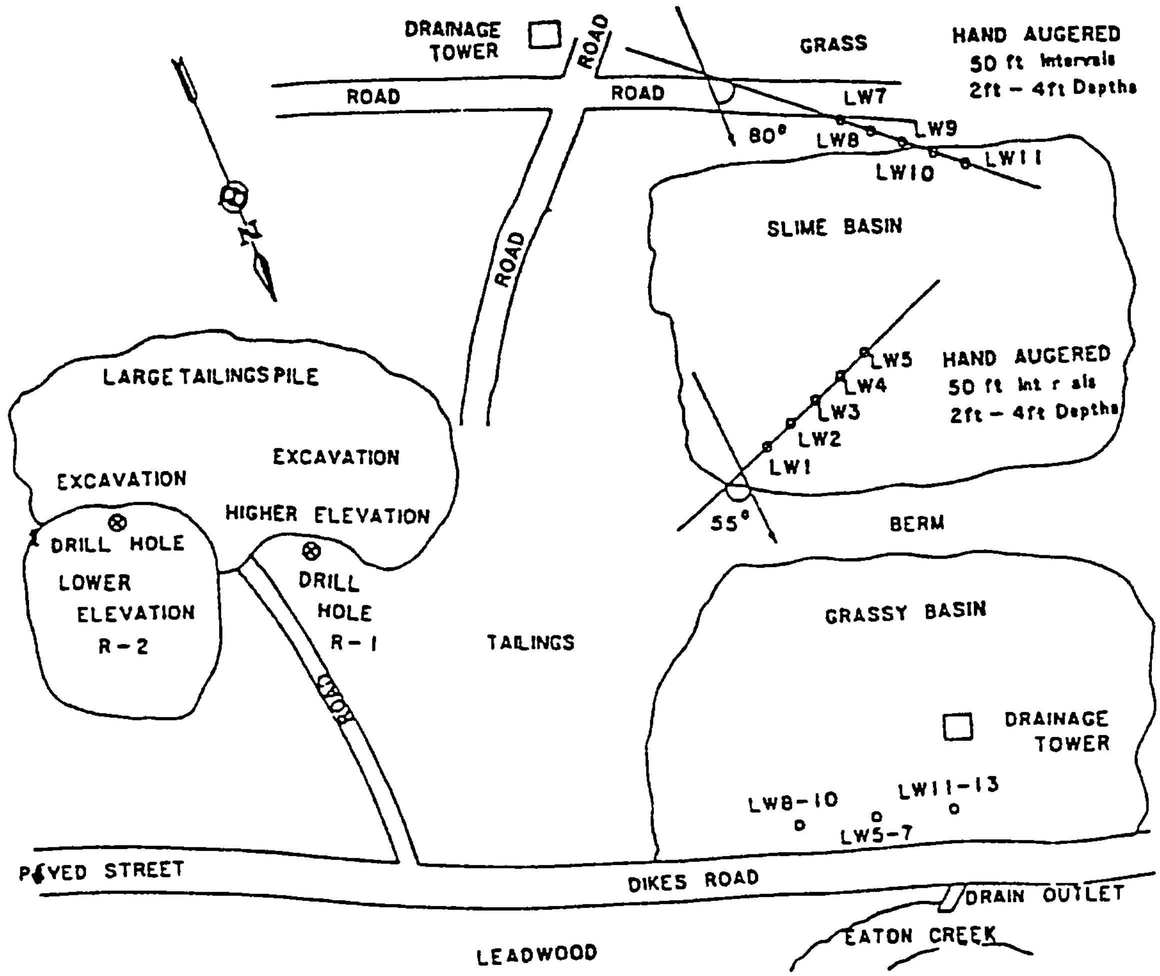


FIGURE 6 LOCATION OF U S BUREAU OF MINES AUGER AND CORE SAMPLING SITES ON LEADWOOD TAILINGS PILE

TABLE 2
AUGER AND CORE SAMPLING OF
LEADWOOD TAILINGS PILE (Courtesy Bureau of Mines)

Sample No	Metal Conc ug/g Pb	Cd	Zn
<u>Surface</u>			
LW 5-7	2200	40	833
LW 8-10	2167	37	800
LW 11-13	2850	35	500
<u>Augered</u> - Surface - two - four foot depth			
LW 1-Surface	1300	40	1000
LW 1-2 ft	600	40	400
LW 1-4 ft	700	30	300
LW 2-Surface	1600	40	1200
LW 2-2 ft	2000	40	1100
LW 2-4 ft	2500	40	1300
LW 3-Surface	600	30	400
LW 3-2 ft	1200	40	1000
LW 3-4 ft	700	30	800
LW 4-Surface	1600	80	1300
LW 4-2 ft	3200	80	1300
LW 4-4 ft	4000	100	1800
LW 5-Surface	2000	130	1800
LW 5-2 ft	2400	100	1700
LW 5-4 ft	2800	110	1400
LW 7-Surface	1400	110	1000
LW 7-2 ft	1200	90	1300
LW 7-4 ft	1500	70	1400
LW 8-Surface	1400	50	1000
LW 8-2 ft	1500	80	1100
LW 8-4 ft	1600	80	1200
LW 9-Surface	1500	90	1200
LW 9-2 ft	1500	100	1000
LW 9-4 ft	1500	120	1300
LW 10-Surface	1300	40	1000
LW 10-2 ft	1000	40	1000
LW 10-4 ft	1900	60	1600
LW 11-Surface	2600	50	1200
LW 11-2 ft	1100	60	1700
LW 11-4 ft	1000	60	1400

TABLE 2 (Cont)
AUGER AND CORE SAMPLING OF
LEADWOOD TAILINGS PILE (Courtesy Bureau of Mines)

Sample No	Metal Conc ug/g		
	Pb	Cd	Zn
Rotary Cored	Pb	Depth	
R-1	5000	3 ft	
	5100	6	
	5500	9	
	5200	12	
	4900	15	
	4500	18	
	4300	21	
	4600	24 - Bottom on tailings	
R-2	16600	3 ft	
	12100	6	
	10400	9	
	10500	12 - Bottom of tailings	

TABLE 3

ROTARY CORE SAMPLING OF LEADWOOD TAILINGS DEPOSIT

INDUCTIVE COUPLED ARGON PLASMA ANALYSIS (ICAP) FOR SITE R-1 BY DEPTH

(UNITS ARE MICROGRAMS/GRAM)

Element	3 ft	6 ft	9 rt	[illegible]	15 f	18 ft	21 ft	24 ft
Ag	20	20	17	21	15	8	9	10
Al	830	820	1200	720	520	490	760	740
As	9	9	9	7	5	5	6	6
B	5	6	10	6	6	5	5	3
Ba	11	3 4	7 0	6 7	4 9	3 6	4 0	3 4
Be	0 89	1 0	1 1	0 96	0 83	0 83	1 0	0 9
Ca	190 000	190 000	180 000	180 000	190 000	190 000	190 000	190 000
Cd	250	270	180	170	160	130	120	120
Co	27	32	37	37	35	32	33	30
Cr	6 8	4 3	10	18	20	22	25	41
Cu	15	12	12	14	15	11	13	10
Fe	19 000	19 000	20 000	20 000	20 000	21 000	21 000	20 000
Li	2	1	2	1	1	1	1	2
Mg	100 000	100 000	99 000	100 000	100 000	100 000	100 000	100 000
Mn	3400	3400	3400	3500	3500	3600	3600	3500
Mo	20	20	20	30	30	30	30	20
Ni	16	18	18	23	18	18	23	16
P	190	200	210	210	210	200	190	190
Sb	9	8	9	9	10	10	9	9
Se	10	10	20	40	30	30	30	20
Si	180	340	160	250	210	140	100	110
Sn	<2	<2	<2	<2	<2	<2	<2	<2
Sr	50	52	50	50	50	51	50	51
Ti	<0 3	<0 3	<0 3	<0 3	<0 3	<0 3	<0 3	<0 3
V	4	4	4	[illegible]	4	4	4	3
Zn	13 000	14 000	9800	9800	8400	7300	6600	6300

TABLE 4
ROTARY CORE SAMPLING OF LEADWOOD TAILINGS DEPOSIT
INDUCTIVE COUPLED ARGON PLASMA (ICAP) ANALYSIS FOR SITE R-2 BY DEPTH
(UNITS ARE MICROGRAMS/GRAM)

Element	3 ft	6 ft	9 ft	12 ft
Ag	23	30	27	24
Al	1800	1000	1100	760
As	10	10	10	10
[illegible]	10	8	3	<2
Ba	7 3	6 0	7 3	8 1
Be	1 1	1 0	1 0	0 66
Ca	160 000	170 000	170 000	150 000
Cd	350	450	430	420
Co	53	74	86	130
Cr	6 8	11	16	54
Cu	15	15	17	22
Fe	20 000	20 000	21 000	21 000
Li	3	2	2	1
Mg	90 000	90 000	90 000	82 000
Mn	3200	3200	3300	3000
Mo	20	30	30	30
Ni	25	37	50	67
P	240	230	240	270
Sb	9	7	4	<3
Se	10	20	10	10
Si	96	470	130	220
Sn	<2	<2	<2	<2
Sr	46	45	45	41
Ti	<0 3	<0 3	<0 3	<0 3
V	6	5	5	4
Zn	19 000	23 000	23 000	23 000

The rotary core samples were taken in the area where prior sampling had indicated that the chat contained elevated levels of metals and probably represented the oldest part of the deposit The R-1 site was cored to the bedrock at the bottom of the pile which represented a depth of 24 feet Samples were taken every three feet and analyzed for a complete host of elements by the ICAP method Lead at this location did not show an increase toward the bottom of the hole but remained in the 4600 to 5000 ppm range The water brought up in the coring samples was fresh and without any anaerobic smell which leads one to postulate that the rainwater leachate is moving away from the tailings pile to the drain at the northern edge of the tailings area ICAP data also indicates that the concentration of other elements tends to remain fairly constant again indicating a more rapid flow through of rainwater with no appreciable concentrations at the bottom of the chat deposits

The rotary core samples at site R-2 were started in a depression some 12 feet lower than the R-1 site and approximately 100 yards to the south of the R-1 site Lead concentrations at the surface ran 16,600 ppm and decreased to 10,500 ppm at the 12 foot depth or bottom of the hole at dolomite bedrock Again the water brought up with the samples did not contain any anaerobic odor and was of a quality that could be attributed to rainfall The ICAP data for the R-2 site did not exhibit any unusual increases or decreases in the elements surveyed which seemed to further confirm the rapid penetration and subsurface flow of storm runoff water through the tailings pile and into the drain for Eaton Creek branch

B Big River-Desloge

The Big River-Desloge tailings pile is located on a turn of the Big River approximately two miles downstream from Leadwood, Missouri and east of the town of Desloge, Missouri During the past four years, this tailings pile received much attention from the regulatory agencies researchers and the press due to a break in the elevated pile allowing for the discharge of tailings into the Big River along the eastern slope

The Kansas City Times headline article of March 28 1981 carried a banner headline saying Old Mines Leave a Legacy of Danger (13) which expressed concern about repairs to halt the runoff of lead

The break has since been repaired but the unstability of the tailings pile along the eastern slope and bordering the Big River remains to be a problem

Figure 7 illustrates the sampling pattern employed in characterizing the Big River-Desloge tailings pile Table 5 gives a listing for Pb, Cd and Zn concentrations found for the various sample sites A total of 74 samples were taken to meet the statistical requirements suggested by the Missouri Department of Natural Resources (14)

C National

The National tailings pile is situated in the northern portion of Flat River Missouri and is shaped like a large dome covering approximately 1 3 square km (0 5 square miles) in area Storm water runoff from the tailings area is discharged into Flat River creek which flows some three miles before it discharges into the Big River

FIGURE 7 LOCATION OF SAMPLING SITES (BIG RIVER-DESLOGE TAILINGS PILE)

TABLE 5

BIG RIVER-DESLOGE TAILINGS PILE

Sample	Metal Conc, ug/g		
No	Pb	Cd	Zn
D900	1670	37 8	1670
D901	1540	38 9	1700
D902	1420	27 4	1150
D903	1190	11 7	330
D904	1420	54 8	2380
D905	2590	30 2	1320
D906	3840	34 9	1750
D907	3560	26 5	1380
D908	970	6 8	875
D909	1250	15 6	950
D910	1800	15 7	1040
D911	1360	25	1080
D912	2310	40 0	1890
D913	4470	18 3	821
D915	1530	13 8	680
D916	826	15 7	531
D917	3140	31 7	1440
D918	1020	17 4	637
D919	958	21 4	798
D920	2710	29 9	1380
D921	1570	8 0	511
D922	997	7 0	406
D923	835	8 0	373
D924	896	7 5	437
D925	1310	9 8	373
D926	1080	13	297
D927	983	11 8	354
D928	877	16 5	518
D929	964	13 8	373
D930	1380	15 0	582
D931	1010	18 5	698
D932	1150	21 5	816
D933	951	11 6	233
D934	1620	20 5	840
D935	5530	46 9	404
D936	1570	24 2	933
D937	1400	8 7	525
D938	1330	19 8	733
D939	1140	21 5	783
D940	2380	19 2	1380
D941	1120	9 2	558
D942	1410	15 4	715
D943	4320	68 2	3580
D944	1800	15 8	1210
D945	1710	21 1	1090

TABLE 5 (Cont)
BIG RIVER-DESLOGE TAILINGS PILE

Sample No	Metal Conc ug/g Pb	Cd	Zn
D946	3190	17 5	1350
D947	933	12 0	344
D948	1440	13 5	439
D949	2380	18 1	644
D950	1730	15 9	693
D951	1540	55 9	519
D952	1490	7 7	560
D953	1070	24 5	1030
D954	4710	31 4	1510
D955	2780	30 7	1570
D956	5360	28 8	1330
D957	6200	37 3	1720
D958	2910	37 1	1680
D960	1880	35 8	3990
D961	1830	39 4	3080
D962	1950	38 9	2910
D963	1410	32 9	1970
D964	2180	45 6	2500
D965	2130	43 8	1780
D967	1980	37 8	1720
D968	2310	37 9	1870
D969	1810	25 6	1100
D970	3610	38 2	1850
D971	5822	46 2	2250
D972	2240	22 9	994
D973	4070	44 5	2090
D974	2110	33 6	1560
D975	3130	51 6	2410
D976	2690	78 6	3970

An extensive study was carried out on the National tailings pile for this project and resulted in a thesis entitled "Impact of Tailings from Abandoned Lead Mines on the Water Quality and Sediments of Flat River Creek and Big River in Southeastern Missouri' by Mr Larry E Elliott (15)

Figure 8 indicates the location of the sampling sites on the National tailings pile used for this study A total of ninety three samples of tailings material were collected and analyzed for lead, zinc cadmium and copper seventy eight from the main pile eight and seven from the erosion areas on the north and east sides respectively as shown in Table 6 Table 7 provides a statistical analysis of the metal concentrations in each of the three areas

Samples from the main pile were found to contain lead concentrations ranging from a low of 1640 ppm to a high of 9283 ppm with values well distributed between these two extremes Although samples taken in close proximity to one another often reflected similar concentrations with respect to the wide range of values encountered no definite pattern seemed evident The concentrations of lead appeared to be randomly dispersed from both the top to the bottom as well as around the perimeter of the pile This random behavior was displayed by all four of the metals studied

Zinc was found in concentrations generally ranging from 87 ppm to 978 ppm with the exception of three samples which were found to be much higher Two of these were just under 2000 ppm while the third collected from the northwest side of the pile contained 5055 ppm of zinc

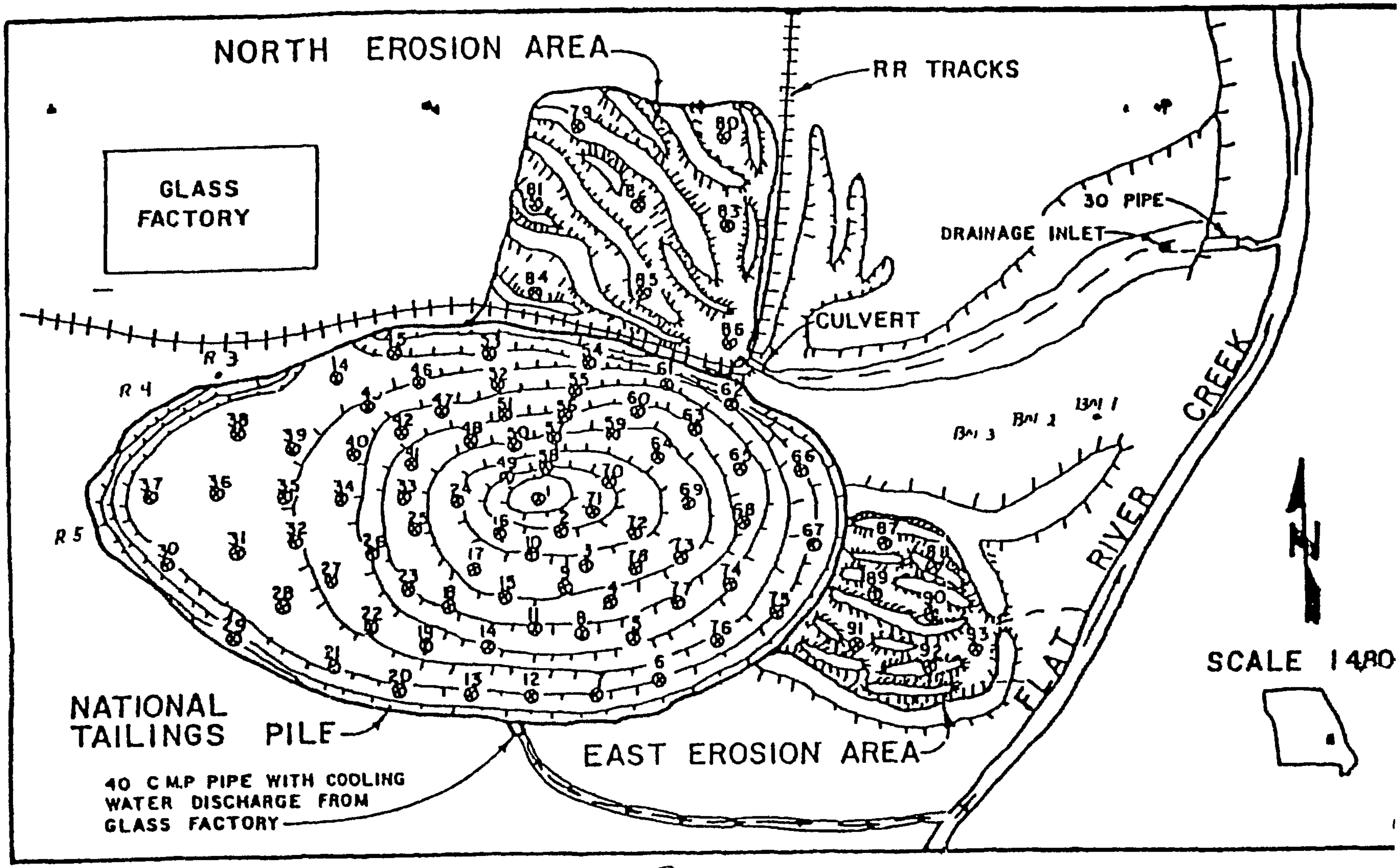


FIGURE 8 LOCATION OF SAMPLING SITES AT THE NATIONAL TAILINGS PILE (15)

TABLE 6
NATIONAL TAILINGS PILE (15)

Sample Number	Metals, ppm			
	Pb	Zn	Cd	Cu
1	5261	518	7	133
2	4225	305	6	122
3	1815	240	5	65
4	19[illegible]9	108	4	95
5	2377	95	3	92
6	4780	238	3	190
7	4822	289	3	145
8	1822	87	3	[illegible]
9	2585	90	3	133
10	2348	258	5	[illegible]
11	4044	496	8	244
12	2581	432	7	264
13	4566	628	8	183
14	3881	703	9	176
15	[illegible]376	665	12	95
16	2579	156	4	64
17	3880	471	6	67
18	2396	174	5	165
19	3166	312	6	358
20	4327	9[illegible]	13	197
21	3242	469	7	502
22	4762	621	9	354
23	2570	188	4	227

TABLE 6 (Cont)
NATIONAL TAILINGS PILE (15)

Sample Number	Metals ppm			
	Pb	Zn	Cd	Cu
24	2318	207	3	106
25	2413	722	11	63
26	2205	47[illegible]	7	99
27	1678	4[illegible]4	7	154
28	4461	510	6	[illegible]57
29	3504	436	[illegible]	22[illegible]
30	4558	[illegible]33	[illegible]	52
31	5341	547	6	4[illegible]
32	2292	391	6	603
33	2189	245	4	91
34	1984	11[illegible]	2	628
35	3007	314	4	215
36	3254	3[illegible]6	6	3[illegible]7
37	7101	1[illegible]7[illegible]	29	308
38	3519	403	6	339
39	[illegible]7[illegible]4	254	3	196
40	28[illegible]4	2[illegible]7	[illegible]	109
41	2619	302	4	162
42	6[illegible]46	19[illegible]	30	380
[illegible]	7766	[illegible]	87	81
44	9[illegible]83	626	10	182
45	2951	313	5	282

TABLE 6 (Cont)
NATIONAL TAILINGS PILE (15)

Sample Number	Metals ppm Pb	Zn	Cd	Cd
46	5141	439	[illegible]	305
47	3512	363	[illegible]	130
48	4853	183	4	287
49	2283	95	3	67
50	4998	460	6	110
51	2635	280	5	114
52	3186	449	6	[illegible]1
53	2203	267	6	[illegible]41
54	2157	253	5	181
55	5333	397	6	90
56	2063	112	3	81
57	5060	408	6	135
58	5519	587	7	136
59	2380	176	4	131
60	2268	978	12	142
61	2093	232	4	101
62	4119	271	5	95
63	7[illegible]4	379	5	107
64	3369	385	6	110
65	2240	329	6	101
66	2004	22	[illegible]	99
67	2962	302	5	137
68	1826	98	3	105

TABLE 6 (Cont.)
NATIONAL TAILINGS PILE (15)

Sample Number	Metals, ppm Pb	Zn	Cd	Cu
69	4732	493	7	129
70	6759	609	7	131
71	3274	321	[illegible]	113
72	3465	211	[illegible]	121
73	[illegible]	387	6	115
74	[illegible]	277	4	101
75	[illegible]	234	5	111
76	1640	127	3	139
77	3317	156	4	126
78	694	115	[illegible]	[illegible]
79	2477	39		44
80	[illegible]	102	11	32
81	5494	398	9	98
82	1553	107	4	88
83	1177	34	3	53
84	3229	70	3	39
85	2774	39	4	36
86	1183	107	4	99
87	4641	127		122
88	5204	129	4	286
89	7991	245	7	64
90	9245	135	4	183
91	7047	192	5	79

TABLE 6 (Cont)
NATIONAL TAILINGS PILE (15)

Sample Number	Metals ppm			
	Pb	Zn	Cd	Cu
92	8818	1170	19	459
93	6315	72	3	181

TABLE 7
STATISTICAL ANALYSIS OF HEAVY METALS
IN THE NATIONAL TAILINGS PILE (14)
Note All Values in ppm

	Lead	Zinc	Cadmium	Copper
MAIN TAILINGS PILE				
Mean	3508	457	7 2	183
Standard Deviation	1516	613	10 1	124
95% Confidence Interval	317[illegible]<μ<3844	94<μ<567	2 5<μ<10 3	102<μ<290
NORTH EROSION AREA				
Mean	2510	112	4 9	61
Standard Deviation	13[illegible]	112	2 8	[illegible]7
95% Confidence Interval	159[illegible] μ 3428	29 μ<190	3 0 μ<6 8	42 μ 80
EAST EROSION AREA				
Mean	6894	295	6 4	196
Standard Deviation	1464	361	5 1	127
95% Confidence Interval	5809<μ 7979	94<μ<562	2 5 μ<10 3	102<μ<290

Cadmium was generally low in concentrations compared to the other three metals With the exception of sample number fourty-three, containing eighty-seven ppm, all the samples contained concentrations of three to thirty ppm inclusive Sample number fourty-three exhibited the highest value of zinc, and contained nearly 8000 ppm of lead This sample was also adjacent to the tailings sample showing the highest lead concentration

Copper concentrations ranged from 51 ppm to a high of 628 ppm with the samples being well distributed throughout these limits Of the four metals, copper seemed to be the most random in distribution with samples in close proximity even differing greatly from one another

Although no definite pattern was observed for the distribution of the metals throughout the pile a sample abundant in one metal tended to have high concentrations of the others with the exception of copper For example tailings materials rich in lead would likely be rich in zinc and cadmium

The north erosion area displayed lower average concentrations for all four metals when compared with the main pile and the east erosion area A lead pattern of dispersion not apparent for the main pile were evidenced in this area Samples on the west and southwest edge of this area were highest in lead, followed by steadily decreasing concentrations as the sample sites progressed eastward

Even though the highest value for zinc (398 ppm) and lead was shared by the same sample the pattern of dispersion found for lead did not occur with zinc cadmium or copper Zinc was found almost exclusively to fall within the interval of 34 ppm low to 107 ppm high

The values for cadmium ranged from 2 to 11 ppm, while copper ranged from 32 ppm to 99 ppm

Unlike material from the main pile, samples in the north erosion area that were rich in one metal did not generally correspond to high concentrations in any of the other three metals

The east erosion area contained the highest average concentrations for lead and copper and demonstrated a pattern of dispersion for lead while zinc, cadmium, and copper failed to exhibit a recognizable pattern

Lead, up to a high value of 8818 ppm on the southern portion of the erosion area and a low of 4641 ppm on the northern portion, tended to increase in concentration as the sample points progressed southward The sample points going from east to west, however, differed only slightly in their respective concentrations of lead

Hand augered samples to a depth of 8 feet were made by the U S Bureau of Mines team for the north and east erosion area Samples number BM-1, BM-2 and BM-4 were made in the tailings runoff area affected by storm water that ultimately drain into Flat River Creek to the east of the deposit Augered samples were also taken in the vicinity of samples number 82, 89 and 90 in the erosion areas

Rotary core samples were taken to the bottom of the tailings piles at locations R-3, R-4 and R-5 All of these locations are noted in Figure 8 Table 8 indicates the augar and core samples by depth with concentraions of Pb, Cd and Zn Table 9 gives the ICAP data for elements found at different depths for the R-3 and R-4 coring sites Table 10 gives the rotary core ICAP analysis for site R-5 down to the clay layer underlying the pile at a depth of approximately eleven feet

TABLE 8
AUGER AND CORE SAMPLES ON NATIONAL
TAILINGS PILE (Courtesy of Bureau of Mines)

Sample No		Metal Conc ug/g		
		Pb	Cd	Zn
Hand Augered				
BM-1	Surface	1100	40	700
BM-1	2 ft	4100	20	300
BM-1	4 ft	4600	30	400
BM-2	Surface	4700	30	400
BM-2	2 ft	3800	30	300
BM-2	4 ft	2000	40	300
BM-3	Surface	2700	40	300
BM-3	2 ft	1900	40	200
BM-3	4 ft	1500	40	200
89	2 ft	2800	01.0	76
89	4 ft	3400	01 4	74
90	Surface	1800	2	78
82	2 ft	2100	1	28
82	4 ft	1100	5	270
82	6 ft	1200	3	150
82	8 ft	1200	1	40
82	Gully Side	760	1	42
Rotary Cored				
R-3	3 ft	7400	45	2700
R-3	5 ft	1400	15	1200
R-4	2-5 ft clay	6400	26	1200
R-4	3 ft chat	10200	72	3400
R-5	3 ft	9700	76	3700
R-5	6 ft	7100	120	6300
R-5	9 ft	8600	80	4100
R-5	10 ft	8300	88	5000
R-5	11 ft bottom clay	820	220	330

TABLE 9
ROTARY CORE SAMPLING OF NATIONAL TAILINGS
DEPOSIT INDUCTIVE COUPLED ARGON PLASMA ANALYSIS
(ICAP) FOR SITES R-3 AND R-4 BY DEPTH
(UNITS ARE MICROGRAMS/GRAM)

	R-3		R-4	
Element	3 ft	5 ft	2 5 ft	3 ft
Ag	9	4	8	7
Al	3500	16,000	1300	8000
As	<2	<8	8	<2
B	6	<8	3	7
Ba	29	104	8 1	66
Be	1 2	0 73	1 5	0 92
Ca	140 000	31 000	170 000	130 000
Cd	45	15	72	26
Co	150	30	180	61
Cr	9 5	26	3 9	10
Cu	58	45	96	29
Fe	34 000	30 000	41 000	29 000
Li	4	8	2	7
Mg	69 000	16 000	84 000	70 000
Mn	3800	2300	4600	3400
Mo	40	<8	50	40
Ni	97	31	150	56
P	260	320	270	280
Sb	<3	<17	<3	<3
Se	50	<17	30	30
Si	180	410	86	450
Sn	<2	<8	<2	<2
Sr	32	12	37	35
Ti	20	180	<0 3	54
V	10	39	5	18
Zn	2700	1200	3-00	1200

TABLE 10
ROTARY CORE SAMPLING OF NATIONAL TAILINGS DEPOSIT
INDUCTIVE COUPLED ARGON PLASMA (ICAP) ANALYSIS FOR
SITE R-5 BY DEPTH
(UNITS ARE MICROGRAMS/GRAM)

Element	3 ft	6 ft	9 ft	10 ft	BOTTOM CLAY 11 ft
Ag	10	10	8	8	0 7
Al	1100	1100	1500	1800	4200
As	6	6	9	20	20
B	20	<2	10	7	3
Ba	4 5	5 9	7 2	13	19
Be	1 5	1 4	1 5	1 2	0 2
Ca	180 000	170 000	170 000	160 000	98 000
Cd	76	120	80	88	220
Co	78	76	93	100	4 8
Cr	3 2	7 0	14	22	6
Cu	130	72	99	83	6 8
Fe	39 000	31 000	35 000	34 000	6400
Li	2	2	3	2	3
Mg	90 000	86 000	85 000	81 000	57 000
Mn	4700	4300	4400	4200	550
Mo	50	40	50	40	<2
Ni	67	49	72	77	6 0
P	280	360	340	370	90
Sb	<3	<3	<3	<3	<3
Se	30	30	40	30	<3
Si	130	220	130	130	170
Sn	<2	<2	<2	<2	<2
Sr	40	40	<0 03	38	30
Ti	<0 3	<0 3	<0 3	2	32
V	4	4	5	7	11
Zn	3700	6300	4100	5000	330

The samples BM-1, BM-2 and BM-4 in the drainage pattern reflect the tailings transport from the north erosion area and part of the main dome-like structure of the main pile The lower lead values shown for the two erosion areas reflect the slime pool discharges that had more of the lead removed during processing

The rotary core samples were made along the edge of the older chat material at the western side of the main tailings pile It was known that the chat material in this area averaged around 8000 to 10,000 ppm lead and we wanted to determine what the depth of the chat materials was in this area The deposit turned out to be thinner than thought in most areas (3-5 feet deep) where people had been hauling the chat away for road material or use as agricultural limestone The clay layer underlying the deposit had low lead and zinc values but increased cadmium levels (up to 220 ppm) which were significantly higher than concentrations normally found in the tailings chat or slime line materials

Water brought up with the core samples did not exhibit an anaerobic or methane odor again suggesting that rainwater percolates through the chat and tailings materials and then moves horizontally along the top of the clay materials and drains into Flat River Creek

D Elvins

The Elvins tailings pile borders northern Elvins, Missouri and covers a land area of approxiamtely 0 6 square km (0 25 square miles) Two shallow lakes are found on the southwestern edge of the tailings pile and seepage from the base of the deposit passes through these shallow lakes and then flows into Flat River Creek These waters contain high levels of dissolved calcium, magnesium, zinc and lead which have an impact on the sediments and biota of Flat River Creek

The Elvins tailings pile was studied in 1976 by Kramer (16) and the growth of algae in the zinc rich wastes and seepage water has been reported by Whitton, et al (17) Presently a small asphalt paving plant operates on the southern perimeter of the tailings pile with the tailings being used as a finer sized aggregate source

Figure 9 illustrates the location of 91 sampling sites on the Elvins tailing pile Table 11 gives the metal concentrations of Pb, Cd and Zn found at the sampling locations

E Bonne Terre

The Bonne Terre tailing deposits consist of two different areas and configurations A large chat and tailings dome is situated on the east side of Bonne Terre Missouri and covers an area of approximately 50 acres of land The second area is located about 1/2 mile to the west of the chat hill just across Missouri Highway 67 and is a mostly dried-up tailings pond covering about 272 acres

Figure 10 gives the location of sampling sites on the Bonne Terre tailings pile which is shaped like a small hill overlooking a golf course Table 12 lists the metal concentrations found for Pb, Cd and Zinc at the tailings pile

Figure 11 shows the location of sampling sites on the flat tailings deposits of the Bonne Terre east deposit which still has water confined at one end Table 13 gives the metal concentrations found for Pb Cd and Zn at the recorded sampling locations

F Statistical Analysis of Different Tailings Piles

Heavy metal data from the characterization of the different tailings and chat piles studied were statistically evaluated for

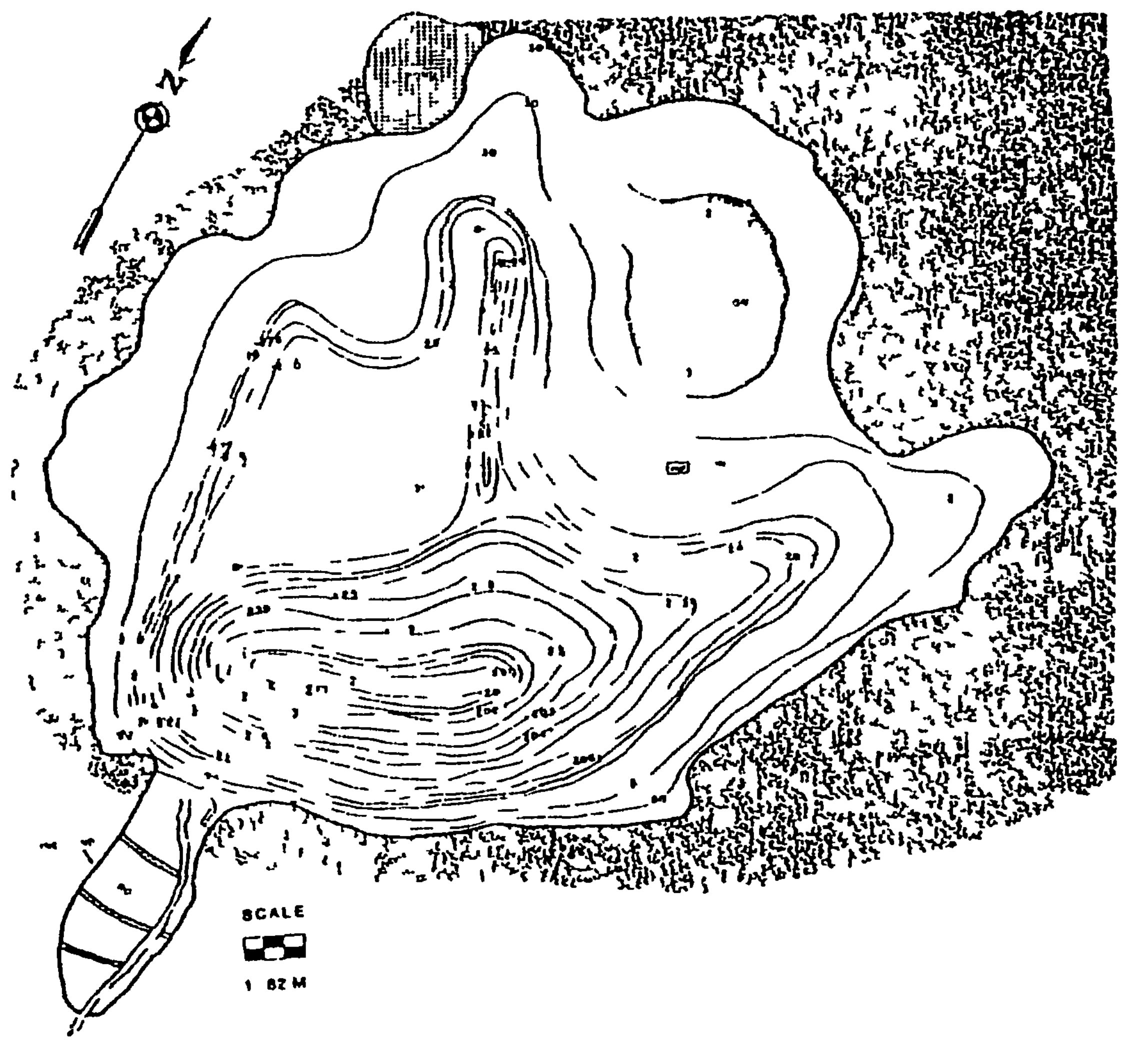


FIGURE 9 LOCATION OF SAMPLING SITES ON ELVINS TAILINGS PILE

TABLE - 11
ELVINS TAILINGS PILE

Sample No	Metal Conc ug/g Pb	Cd	Zn
E200	5990	190	6100
E201	6420	180	11200
E202	7950	202	11200
E203	5130	199	10600
E204	4460	165	9210
E205	4200	156	8620
E206	4400	168	9510
E207	3570	140	8210
E208	3650	152	8180
E210	5180	171	11800
E211	4190	179	11400
E212	6000	153	9600
E213	4630	160	9630
E214	5450	155	8610
E215	6780	156	8080
E216	6960	172	9260
E217	5240	120	6870
E218	4980	114	6000
E219	7500	106	5600
E220	4760	168	10500
E221	6820	163	11400
E222	5500	110	6400
E223	5990	114	6100
E224	4470	70 8	4350
E225	5270		8590
E226	4010	92 9	5320
E227	1880	51 5	1290
E228	3680	84 6	5150
E229	5180	132	6480
E230	4550	76 3	6540
E231	4300	189	11900
E232	3880	138	8820
E233	3170	151	2040
E234	2780	126	6510
E235	3630	112	6090
E236	3180	92 5	4560
E237	1300	79 6	4470
E238	8140	106	1760
E239	8360	135	9280
E240	6200	84 0	4290
E241B	8000	95 0	1300
E242	9600	157	10900
E245	11100	91 8	4950
E246	5640	161	9680
E247	7080	159	8360
E248	3780	144	7870
E249	4600	129	6990

TABLE - 11 (Cont)
ELVINS TAILINGS PILE

Sample No	Metal Conc, ug/g Pb	Cd	Zn
E250	6410	138	2040
E251	6190	114	6290
E252	4850	127	7020
E253	4050	118	6340
E254	4440	115	5360
E255	1700	51 3	2480
E256	2750	52 8	2210
E257	1350	48 3	2290
E258	1170	45 0	2190
E259	2180	54 4	2440
E260	2750	69 8	3300
E261	1060	61 4	2170
E262	1400	110	5500
E263	1270	74 8	3570
E264	1120	72 2	3230
E265	1620	75 5	3770
E266	4230	119	1440
E267	1060	74 7	3620
E268	1050	74 8	3660
E269	991	58 2	2140
E270	851	57 9	2600
E271	1100	74 7	2650
E272	4190	82 3	4240
E273	8890	85 0	4250
E274	4890	63 9	3290
E275	7160	100	4810
E276	9310	19 8	792
E277	9260	31 5	1950
E278	10000	134	8510
E279	11600	163	10900
E280	7200	94 4	5960
E290	4020	62 9	3510
E291	2750	56 1	3000
E292	2890	50 2	2330
E293	1080	41 7	2450
E294	2940	67 6	3380
E295	2190	75 8	3980
E296	2230	99 1	5820
E297		59 3	3600
E298	1890	48 4	2610
E299	3160	61 7	3210
E300	2270	47 3	2360
E301	2080	54 4	2230
E302	1780	42 2	1990
E303	1650	44 9	2120
E304	1900	42 6	108

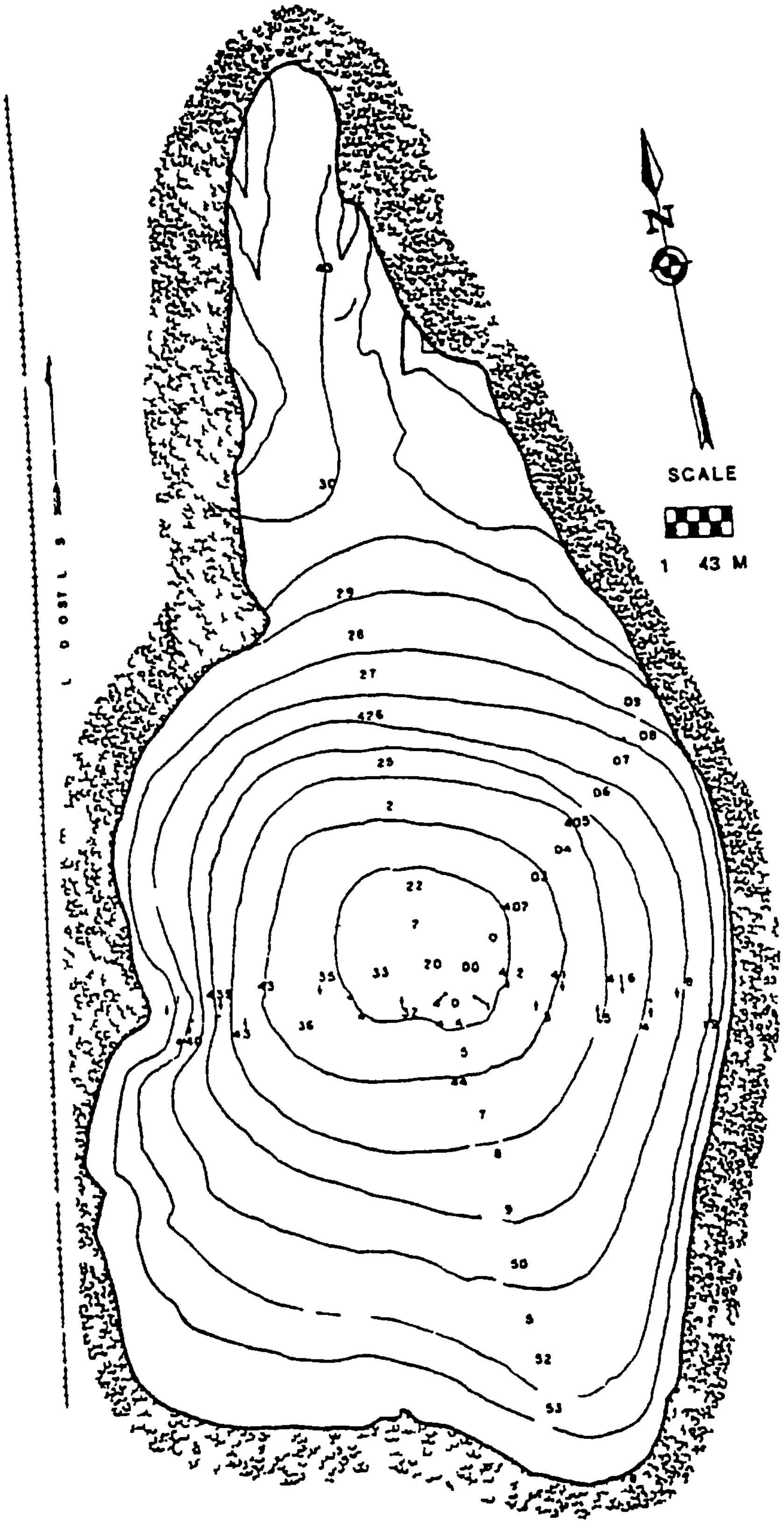


FIGURE 10 LOCATION OF SAMPLING SITES ON BONNE TERRE TAILINGS PILE

TABLE - 12

BONNE TERRE TAILINGS PILE

Sample No	Metal Conc ug/g Pb	Cd	Zn
BT400	5330	9 7	469
BT401	5020	5 4	273
BT402	1300	10 2	309
BT403	2020	9 9	430
BT404	2280	11 7	451
BT405	3540	11 9	689
BT406	3070	12 1	718
BT407	1890	17 6	650
BT408	1540	12 3	587
BT409	3230	14 9	501
BT410	3590	13 9	51 3
BT411	4120	13 4	671
BT412	4450	17 7	757
BT413	3140	14 4	722
BT414	4350	12 0	309
BT415	2540	16 1	757
BT416	3040	16 4	648
BT417	1630	9 6	486
BT418	1840	13 7	597
BT419	1760	10 0	641
BT420	1480	3 0	150
BT421	3080	5 5	194
BT422	2050	13 3	434
BT423	1940	13 0	479
BT424	2190	13 5	458
BT425	2380	15 1	573
BT426	2390	17 2	622
BT427	1580	15 1	553
BT428	1860	14 2	686
BT429	1340	13 9	661
BT430	4720	29 5	786
BT431	2650	7 0	150
BT432	3200	15 2	705
BT433	3200	15 8	650
BT434	7010	8 2	426
BT435	6670	15 3	477
BT436	5820	10 9	361
BT437	5210	18 1	559
BT438	4290	11 5	573
BT439	6730	13 6	755
BT440	6840	12 8	618
BT441	5800	16 0	180

TABLE - 12
BONNE TERRE TAILINGS PILE

Sample No	Metal Conc ug/g Pb	Cd	Zn
BT444	3280	15 1	511
BT445	4530	13 6	444
BT446	4220	17 4	697
BT447	5030	19 2	746
BT448	5980	22 5	967
BT449	5190	28 8	623
BT450	3390	22 4	922
BT451	3540	22 0	878
BT452	2791	15 7	563
BT453	6230	10 4	539

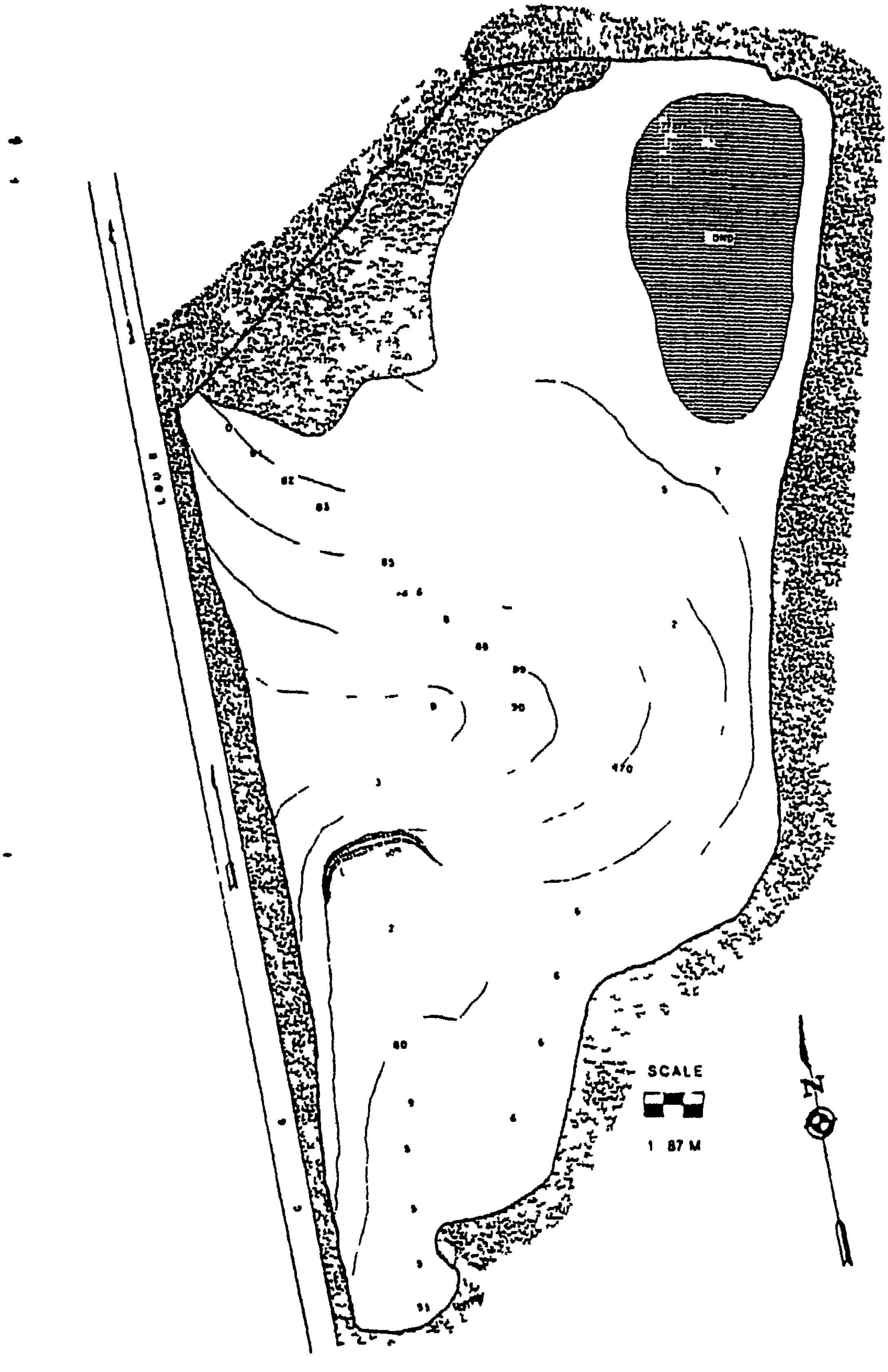


FIGURE 11 LOCATION OF SAMPLING SITES ON BONNE TERRE TAILINGS FLAT

TABLE 13
BONNE TERRF TAILINGS FLAT

Sample No	Metal Conc ug/g		
	Pb	Cd	Zn
BT455	1232	5 9	173
BT456	3020	10 2	361
BT457	6650	10 5	312
BT458	1810	5 9	385
BT459	1600	9 0	354
BT460	1920	12 3	491
BT461	1170	9 3	312
BT462	1610	10 0	234
BT463	989	8 4	185
BT464	1560	7 3	205
BT465	1550	11 2	244
BT466	2310	12 0	380
BT467	1540	10 8	366
BT468	3450	10 4	243
BT469	1620	9 5	255
BT470	1860	6 0	157
BT471	1520	4 5	87 2
BT472	2710	6 3	222
BT473	1170	3 6	99 5
BT474	660	7 9	151
BT475	1440	4 7	156
BT476	2610	4 9	330
BT477	1320	6 0	165
BT478	1900	13 2	337
BT479	1760	9 8	273
BT480	1290	13 8	524
BT481	1480	15 1	543
BT482	1780	13 3	321
BT483	1820	5 6	618
BT484	1400	6 7	171
BT485	2840	10 0	1470
BT486	7610	20 9	698
BT487	1590	6 7	152
BT488	1020	6 4	115
BT489	1950	8 1	321
BT490	1120	5 2	170

TABLE 14
STATISTICAL ANALYSIS OF HEAVY METALS
IN THE DIFFERENT TAILINGS PILES

	LEAD	CADMIUM	ZINC
LEADWOOD			
Mean	2444	267	5009
Standard Deviation	4072	394	4894
95% Confidence Interval	2455<u<3231	223<u<299	4957<u<5894
Maximum	17000	1870	25800
Minimum	597	9 3	633
BIG RIVER DESLOGE			
Mean	2077	26	1226
Standard Deviation	1294	15 2	860
95% Confidence Interval	1931<u<2224	24<u<28	1129<u<1323
Maximum	6200	78 6	3990
Minimum	826	6 8	233
NATIONAL			
Mean	3508	7 2	457
Standard Deviation	1516	10 1	613
95% Confidence Level	3172<u<3844	2 [illegible]<u<10 3	94<u<562
1) **NORTH EROSION AREA**			
Mean	2510	4 9	112
Standard Deviation	1325	2 8	112
95% Confidence Interval	1592< u<3428	3 0<u<6 8	29<u<190
2) **EAST EROSION AREA**			
Mean	6894	6 4	295
Standard Deviation	1464	5 3	361
95% Confidence Interval	5809<u<7979	2 5<u<10 3	94<u<562
ELVINS			
Mean	4392	103	5482
Standard Deviation	2581	47 1	3179
95% Confidence Interval	4130<u<4654	98<u<108	516[illegible]<u<5803
Maximum	11600	202	11900
Minimum	851	19 8	108
BONNE TERRE			
Mean	3515	13 9	541
Standard Deviation	1705	5 3	211
95% Confidence Interval	3285<u<3744	18 2<u<14 6	512<u<569
Maximum	7010	29 5	967
Minimum	1300	3 0	51 3

Elliott (15) and Wixson et al (12) have noted that the tailings materials tend to move downriver during storm events with the heavier metal rich fraction tending to settle out first as the storm water event decreases This accounts for pulses of metals that may be found at different locations following periods of elevated rainfall and rapid runoff into and down the Big River

Considering the amount of sediments found in the intestines of bottom feeding suckers, the bioavailability of lead and other metals in the sediments is rather small However continued monitoring is needed to make sure that lead levels in edible fish tissues do not approach levels of concern to human health

VI FIELD STUDIES OF TAILINGS USED FOR AGRICULTURAL LIMESTONE PURPOSES

One of the objectives of this research project was to sample, analyze and evaluate soil and vegetation in a natural field environment where tailings material had been used for agricultural limestone over a period of years With the assistance of Mr John Carter, Environmental Engineer, St Joe Minerals Corporation and the permission of Mr T Ferguson, a series of such samples were taken on the Ferguson farm near Farmington, Missouri

At this site a random survey was made of the soil using the standard 'staggered W" method Each sample was comprised of 20 auger cores to a depth of 10 cm and bulked into a polyethylene bag Soil samples were then dried at air temperature in the laboratory, ground and passed through a nylon sieve of 2 mm aperature

Vegetation samples of grass and clover were collected with stainless steel implements at appropriate soil sampling sites and placed in polyethylene bags with the root system intact in the soil sample In the laboratory, the plant material was separated from the soil and carefully washed by standard methods and dried at 100^{o}C followed by milling and analysis

Analysis for the soil samples was by AAS (flame or graphite furnace) or ICAP performed by the Environmental Trace Substances Research Center at the University of Missouri in Columbia Missouri Appropriate preparation, extraction and control techniques were employed in the analysis of the soil and plant material

Figure 12 illustrates the staggered W sampling scheme and sample site locations within the confines of the Ferguson farm Table 15 gives the ICAP analysis for soils, grass, leaves stems and roots, and clover flowers, leaves and roots These data are important to determine how much metal (such as lead) might be removed from the tailings amended soil and translocated into the roots stems leaves or flowers of grass and clover grown in the field for animal consumption Additional elements determined by the ICAP method are also listed for the soil and vegetation sampled Units reported are micrograms/gram (dry weight for plant materials)

Table 16 indicates the soil analysis (AAS) for sample sites on the Ferguson farm where grass or clover samples were not collected

The Ferguson farm pasture studied was last limed with tailings from the Big River-Desloge tailings pile in 1978 according to information received from Mr Ferguson Tailings from other locations had also been used on this seventeen acre field for a number of years preceeding the 1978 application

The highest lead soil value found was 200 µg/g and the grass growing in this material gave an analysis of 40 for the roots 4 for the stems and 13 in the blade portion of the grass At sample site number 420 the soil contained 100 µg/g Pb and the grass roots reflected 100 µg/g with 2 in the stem and 5 found in the blades or leaves

The clover plants had even less accumulation of lead or other metals in the roots, stems leaves or flowers of the plant growing on the tested soil

TABLE 15

SOIL AND VEGETATION ANALYSIS (ICAP) FOR
SAMPLE SITES ON FERGUSON FARM
(UNITS IN MICROGRAMS/GRAM)

Element	419 Soil	420 Soil	420 Grass Leaves	420 Grass Stems	420 Grass Roots
Ag	<0 3	<0 3	0 4	< 0 3	<0 2
Al	5300	8500	130	190	4100
As	10	10			
B			5 2	4	4
Ba	63	66	9 8	7 0	45
Be	0 49	0 46	<0 03	<0 03	0 44
Ca	6400	12000	4500	1700	27000
Cd	0 7	0 9	0 3	<0 3	1 4
Co	8 0	9 3	0 3	0 5	7 2
Cr	13	13	0 88	0 7	17
Cu	34	28	5 8	4	27
Fe	12000	12000	150	210	17000
K	290	530	14000	9800	2400
Li	3 4	6 6	<0 3	<0 3	2 4
Mg	3400	6600	3500	2100	13000
Mn	720	740	81	77	1100
Na	23	42	230	160	600
Ni	5 6	9 5	0 8	0 8	5 5
P	270	540	3300	2500	1100
Pb	78	100	4 9	2	100
Si	48	54	220	170	43
Sr	4 8	9 1	6 6	3 4	12
Ti	19	66	1 5	3 1	93
V	23	24	0 3	0 5	27
Zn	32	58	14	23	70

TABLE 15 (Cont)

Element	421 Soil	421 Clover Roots	421 Clover Stems	421 Clover Flowers	421 Clover Leaves
Ag	<0 3	<0 6	<0 2	0 3	<0 4
Al	6000	1600	<2	53	40
As	10				
B		9	19	29	16
Ba	67	32	23	11	18
Be	0 46	0 07	<0 02	<0 02	<0 04
Ca	14000	5400	7500	12000	19000
Cd	1 0	<1	<0 2	0 6	~0 4
Co	8 2	3 0	0 3	1 1	0 8
Cr	13	3 9	<0 2	2 5	0 4
Cu	18	34	5 3	28	16
Fe	11000	2900	41	94	150
K	420	4400	6600	13000	7400
Li	4 5	1 2	<0 2	<0 2	<0 4
Mg	7300	6600	6500	3800	3900
Mn	780	260	19	81	150
Na	40	800	54	120	110
Ni	7 1	1 5	0 95	3 8	9 3
P	690	2900	1300	2900	1800
Pb	100	12	<1	3	8 8
Si	360	230	<0 5	<0 8	r 8
Sr	11	17	20	14	20
Ti	35	24	<0 2	<0 2	0 4
V	21	8 0	<0 2	<0 2	<0 4
Zn	70	45	13	780	53

TABLE 15 (Cont)

Element	425 Soil	425 Grass Roots	425 Grass Stems	425 Grass Leaves	425 Clover Roots
Ag	<0 3	0 3	1	<0 4	0 5
Al	8100	2500	80	350	330
As	10				
B		6	<4	6	16
Ba	76	42	12	15	15
Be	0 54	0 3	<0 07	<0 04	<0 05
Ca	16000	24000	2100	3500	2800
Cd	2 8	7 0	<0 7	0 6	0 5
Co	8 6	6 2	<0 7	0 9	0 7
Cr	12	10	1	1 6	1
Cu	15	24	4 6	8 4	23
Fe	10000	8300	120	390	400
K	660	2500	22000	27000	5600
Li	6 3	1 5	<0 7	<0 4	<0 5
Mg	8800	12000	3400	3700	5900
Mn	980	1000	60	74	60
Na	45	540	190	270	1100
Ni	10	6 0	1	2 3	1
P	450	1100	4200	4400	3400
Pb	200	40	<4	13	5
Si	44	410	<1	310	30
Sr	9 9	11	3 6	5 2	10
Ti	78	33	2 6	16	3 3
V	22	16	0 8	1	2 3
Zn	120	410	45	27	22

TABLE 15 (Cont)

Element	425 Clover Stems	425 Clover Flowers	425 Clover Leaves	425 Soil
Ag	0 3	<2	<0 2	<0 3
Al	9	<20	40	8100
As				10
B	22	10	28	
Ba	20	7 3	12	76
Be	<0 02	<0 2	<0 02	0 54
Ca	6400	12000	18000	16000
Cd	0 3	<2	0 3	2 8
Co	<0 2	<2	0 4	8 6
Cr	0 4	<2	0 4	12
Cu	6 1	14	14	15
Fe	48	91	120	10000
K	9400	21000	13000	660
Li	<0 2	<2	<0 2	6 3
Mg	3700	3200	3600	8800
Mn	16	66	92	980
Na	55	150	91	45
Ni	0 5	2	1 3	10
P	1700	4400	2500	450
Pb	<1	<8	2	200
Si	<0 5	<3	0 6	44
Sr	17	8 5	14	9 9
Ti	<0 2	<2	<0 2	78
V	<0 2	<2	<0 2	22
Zn	14	49	43	120

TABLE 15 (Cont)

Element	429 Soil	429 Grass Roots	429 Grass Stems	429 Grass Leaves
Ag	<0 3	<0 3	<0 3	0 4
Al	4400	2300	110	180
As	10			
B		<2	<1	6
Ba	71	33	19	14
Be	0 62	0 30	<0 03	<0 04
Ca	22000	18000	2400	3800
Cd	2 2	1 3	0 88	<0 4
Co	13	6 1	0 6	0 4
Cr	9 6	6 6	2 2	1
Cu	33	25	7 9	7 0
Fe	13000	6800	160	200
K	410	4900	25000	39000
Li	3 1	1 6	<0 3	<0 4
Mg	11000	9200	2700	4100
Mn	1200	690	54	57
Na	42	490	170	230
Ni	7 8	4 2	2 3	1 5
P	620	1200	3100	5200
Pb	160	68	2	6 6
Si	230	58	170	300
Sr	9 5	9 9	5 0	6 9
Ti	30	50	2 9	3 0
V	20	14	0 5	0 5
Zn	93	120	36	23

TABLE 15 (Cont)

Element	430 Soil	430 Grass Roots	430 Grass Leaves	430 Grass Stems
Ag	<0 3	<0 3	<0 3	<0 3
Al	6500	2600	130	150
As	26			
B		4	<2	4 5
Ba	76	40	13	14
Be	0 66	0 15	<0 03	<0 03
Ca	17000	9000	3400	1900
Cd	2 0	0 8	<0 3	0 4
Co	14	6 8	0 4	0 5
Cr	12	5 0	0 4	0 6
Cu	22	40	7 5	5 6
Fe	13000	4900	180	180
K	580	4700	32000	17000
Li	5 1	1 6	<0 3	<0 3
Mg	9000	4200	3600	1900
Mn	1100	620	59	53
[illegible]	39	380	250	120
Ni	8 9	3 8	0 4	0 7
P	550	1100	4500	2500
Pb	120	27	3	2
Si	27	42	260	210
Sr	8 8	7 5	6 2	3 8
Ti	30	52	2 7	3 7
V	23	12	0 3	0 6
Zn	110	130	21	32

TABLE 15 (Cont)

Element	430 Soil	430 Clover Leaves	430 Clover Roots	430 Clover Stems
Ag	<0 3	<0 3	<0 2	<0 2
Al	6500	190	420	80
As	26			
B		32	14	23
Ba	76	13	15	29
Be	0 66	<0 03	0 02	<0 02
Ca	17000	18000	3500	7900
Cd	2 0	<0 3	0 3	<0 2
Co	14	0 8	0 95	0 4
Cr	12	0 97	0 93	0 5
Cu	22	15	11	7 2
Fe	13000	300	630	91
K	580	16000	11000	29000
Li	5 1	0 3	0 3	<0 2
Mg	9000	4600	3100	4000
Mn	1100	91	76	20
[illegible]	39	77	240	92
Ni	8 9	0 8	0 7	0 5
P	550	1900	2000	1300
Pb	120	5 0	11	2
Si	27	90	52	59
Sr	8 8	18	9 7	24
Ti	30	5 3	9 2	3 1
V	23	0 6	1 2	0 3
Zn	110	34	14	15

TABLE 15 (Cont)

Element	435 Soil	435 Grass Leaves	435 Grass Stems	435 Grass Roots
Ag	<0 3	<0 4	<0 4	<0 2
Al	8600	120	170	6600
As	10			
B		6	<2	11
Ba	61	6 1	7 0	88
Be	0 57	<0 04	<0 04	0 73
Ca	20000	3700	2300	24000
Cd	0 8	0 4	0 6	1 9
Co	9 2	<0 4	<0 4	13
Cr	13	0 9	1 9	17
Cu	22	6 2	5 7	25
Fe	14000	160	210	22000
K	800	25000	16000	3700
Li	7 2	<0 4	<0 4	5 0
Mg	10000	3800	2500	12000
Mn	1000	70	72	1900
Na	62	<50	120	390
Ni	8 4	1 6	2 6	6 6
P	780	4300	3000	1300
Pb	120	5	2	73
Si	100	340	7	420
Sr	11	4 4	3 6	16
Ti	83	2 5	6 6	87
V	28	<0 4	0 5	36
Zn	65	25	43	110

TABLE 15 (Cont)

Element	436 Soil	436 Clover Roots	436 Clover Stems	436 Clover Leaves
Ag	<0 3	<0 5	<0 3	<0 3
Al	6200	470	20	67
As	10			
B		18	18	31
Ba	58	12	12	7 2
Be	0 61	<0 05	<0 02	<0 03
Ca	18000	3500	6600	17000
Cd	1 1	<0 5	<0 3	<0 3
Co	8 8	1	<0 3	0 6
Cr	11	1	<0 3	1
Cu	21	19	7 2	11
Fe	13000	720	42	130
K	570	13000	20000	22000
Li	5 0	<0 5	<0 2	<0 3
Mg	9400	4700	3200	3100
Mn	1100	110	15	87
Na	46	380	90	180
Ni	7 0	5 5	<0 3	0 6
P	760	3600	2300	2500
Pb	160	<3	<2	4
Si	62	39	35	82
Sr	9 4	10	13	10
Ti	34	12	0 3	1
V	24	2	<0 2	<0 3
Zn	75	17	89	37

TABLE 15 (Cont)

Element	441 Soil	441 Grass Roots	441 Grass Leaves	441 Grass Stems
Ag	<0 3	<0 3	<0 2	<0 3
Al	9300	3400	180	140
As	17			
B		5	6 3	<2
Ba	79	220	9 7	5 5
Be	0 65	0 68	<0 02	<0 02
Ca	10000	11000	5200	1700
Cd	1 0	0 7	0 4	0 7
Co	11	48	0 3	0 4
Cr	15	12	1 0	2 6
Cu	30	140	5 9	5 0
Fe	13000	16000	170	260
K	720	4700	29000	24000
Li	7 2	2 1	<0 2	<0 3
Mg	5600	5500	4800	2700
Mn	990	3100	92	140
Na	47	600	220	430
Ni	816	30	1 1	0 9
P	690	1400	3400	3900
Pb	170	77	7 1	<2
Si	370	410	230	4
Sr	9 8	9 5	8 1	3 4
Ti	81	49	0 79	5 8
V	29	30	0 6	3 4
Zn	65	120	19	50

TABLE 15 (Cont)

Element	442 Soil	442 Grass Roots	442 Grass Leaves	442 Grass Stems
Ag	<0 3	<0 4	<0 3	<0 3
Al	12000	2100	56	100
As	18			
B		6	5	<1
Ba	92	30	8 7	9 4
Be	0 62	0 16	<0 03	<0 03
Ca	10000	7500	4100	1500
Cd	1 3	1 2	0 5	<0 3
Co	11	4 3	<0 3	0 7
Cr	17	4 8	0 7	0 4
Cu	16	29	5 3	5 1
Fe	16000	4300	120	190
K	1000	4800	28000	17000
Li	8 4	1 2	<0 3	<0 3
Mg	5700	3400	4400	2100
Mn	1000	510	73	94
Na	54	610	260	170
Ni	9 6	3 6	0 8	0 7
P	750	1200	3100	2800
Pb	84	27	6 4	<1
Si	74	500	250	29
Sr	11	7 0	7 7	3 4
Ti	130	32	1	1 9
V	33	10	<0 3	0 5
Zn	72	120	18	29

TABLE 15 (Cont)

Element	442 Soil	442 Clover Roots	442 Clover Stems	442 Clover Leaves	442 Clover Flowers
Ag	<0 3	<0 6	<0 3	<0 3	<0 3
Al	12000	820	120	30	18
As	18				
B		17	18	18	25
Ba	92	20	24	11	14
Be	0 62	0 06	<0 03	<0 03	<0 03
Ca	10000	5600	7800	16000	12000
Cd	1 3	<0 6	<0 3	<0 3	<0 3
Co	11	2 0	0 5	0 8	0 8
Cr	17	2	0 4	0 5	0 4
Cu	16	22	6 3	16	13
Fe	16000	1900	170	110	78
K	1000	10000	24000	22000	19000
Li	8 4	<0 6	<0 3	<0 3	<0 3
Mg	5700	4100	2400	3500	3700
Mn	1000	200	34	89	58
Na	54	620	120	250	110
Ni	9 6	1 8	0 4	1 2	0 8
P	750	2300	1400	1600	3100
Pb	84	6 9	2	10	4 2
Si	74	250	3	89	83
Sr	11	12	19	14	17
Ti	130	12	2 5	<0 3	<0 3
V	33	3 9	0 3	<0 3	<0 3
Zn	72	18	16	40	30

TABLE 16

SOIL ANALYSIS (AAS) FOR SAMPLE SITES ON FERGUSON FARM

Sample No	Metal Conc, ug/g			
	Pb	Cd	Zn	Co
422	20	< 3	38	8
423	20	< 3	31	8 2
424	20	< 3	21	6 1
427	130	< 3	22	4 3
428	40	< 3	24	6 1
429	20	< 3	25	7 0
432	20	< 3	21	5 1
433	200	< 3	72	32
434	200	< 3	25	38
438	82	< 3	64	59
439	80	< 3	34	17
440	110	< 3	37	16
443	30	< 3	31	11
444	30	< 3	24	10
445	30	< 3	22	9
446	41	< 3	26	-
447	220	< 3	94	-
448	200	< 3	69	-

A second location where tailings material had been used for agricultural limestone purposes was suggested by Mr Burton L Brown of the U S Soil Conservation Service in Farmington, Missouri This pasture was approximately one mile south of Farmington, Missouri and named "Young Farmers" after the cooperative association that owned the land Soil and grass samples were taken from this area and the analytical findings (ICAP) are presented in Table 17 The soil samples indicated 180 µg/g Pb while the grass roots from the same soil contained 6 µg/g Pb and the leaves contained 9 µg/g Pb

A normal Crider soil was suggested by Mr Burton using his soil report (19) to locate a typical control soil and the ICAP analysis for this soil taken from an undeveloped field one mile north of Farmington Missouri is shown in Table 18 Interestingly enough the undisturbed control soil was found to contain 140 µg/g Pb and the grass growing in this material contained 9 µg/g Pb in the roots and 6 µg/g Pb in the blades again indicating that the Pb is not bioconcentrated in the plant from the soil material Leaf litter at the control soil area was analyzed to determine if atmospheric fallout might influence the metal levels and the levels were found not to be of concern (Table 18)

The Crider soil selected for the natural control soil was also used in the experimental plant growth experiments conducted in the laboratory

TABLE 17

SOIL AND VEGETATION ANALYSIS (ICAP) FOR THE YOUNG FARMERS FIELD WHERE TAILINGS WERE USED FOR AGRICULTURAL LIMESTONE (UNITS IN MICROGRAMS/GRAM)

Element	YF-1 Soil	YF-1 Grass	YF-1 Roots
Ag	< 1	5 7	2 4
Al	6100	260	530
B	20	4	10
Ba	140	29	14
Be	0 51	< 0 1	< 0 1
Ca	3700	3600	1500
Cd	0 5	< 0 6	< 0 5
Co	8 4	< 0 6	< 0 5
Cr	15	< 0 6	< 0 5
Cu	13	8 7	11
Fe	10000	260	410
K	680	16000	6300
Li	4 0	< 0 6	< 0 5
Mg	1800	2200	700
Mn	1300	83	63
Na	25	130	180
Ni	9 4	4 8	0 8
P	540	2900	1700
Pb	180	9	6
Si	120	380	210
Sr	6 5	6 0	2 5
Ti	56	8 4	23
V	20	0 8	1 7
Zn	65	42	47

TABLE 18

SOIL AND VEGETATION ANALYSIS (ICAP) FOR
CRIDER SOIL (CONTROL) NEAR FARMINGTON MISSOURI
(UNITS ARE IN MICROGRAMS/GRAM)

Element	C-11 Soil	C-11 Roots	C-11 Stems	C-11 Leaves
Ag	< 0 3	< 0 6	< 0 5	< 0 6
Al	11000	3100	590	350
B	6	16	3	3
Ba	230	89	73	42
Be	0 70	< 0 1	< 0 1	< 0 1
Ca	1600	3100	3400	1900
Cd	< 0 3	< 0 6	< 0 5	< 0 6
Co	12	3 2	1	< 0 6
Cr	22	2 0	< 0 5	< 0 6
Cu	9 5	15	6 4	9 7
Fe	13000	2200	480	310
K	1400	19000	9700	43000
Li	7 7	1 9	< 0 5	< 0 6
Mg	1200	1800	1700	1900
Mn	1700	520	430	220
Na	27	330	700	47
Ni	14	4 1	0 6	3 0
P	300	1200	590	2500
Pb	140	7	9	< 6
Si	200	1900	150	77
Sr	11	17	16	8 7
Ti	170	150	22	12
V	30	7 7	1 6	0 9
Zn	37	50	31	26

VII COMMERCIAL LIMESTONE STUDY

It was necessary to determine the elements present in commercial agricultural limestone which were used as a control during the experimental growth studies Mr Paul R Rexroad and Ms Mary A Pagett at the Agriculture Experiment Station Chemistry Lab of the University of Missouri-Columbia were kind enough to furnish information on the list of lime quarries and stockpiles by counties After further consultation, thirteen samples were selected for ICAP analysis at the ETSRC in Columbia to determine baseline elemental composition

Four samples were selected from neighboring states (Illinois, Iowa, Arkansas and Kansas) and the remainder of the samples were from within the State of Missouri Three of the samples selected for comparison in the State of Missouri were from old lead belt mining operations

Table 19 indicates the identification number, name and location of the limestone quarry followed by the identification number used by the ETSRC for the ICAP analysis Table 20 presents the ICAP data for the various commercial agricultural limestone used in this study

TABLE 19

LOCATION OF COMMERCIAL AGRICULTURAL LIMESTONE USED IN STUDY AND LEAD CONTENTS (ug/g)

Customer I D	Quarry	Location	Sample #	Pb (ug/g)
2039	Calcium Carbonate Co	Quincy Illinois	83010076	9
2011	Ampel	Des Moines, Iowa	77	8
1976	Twin Lakes	Midway Arkansas	78	12
2006	Cullor L S Co	Ft Scott Kansas	79	11
2088	Conco Quarries	Springfield Mo	80	11
1918 (2)	St Joe Minerals Corp	Viburnum, Mo **	81	350
2019	Rolla Materials, Inc	Rolla, Mo	82	8
2025	Jeff-Cole Co	Jefferson City Mo	83	8
1919 (1)	Agric Limestone Co	Bonne Terre, Mo *	84	1800
1921 (1)	James D Allen Materials	Farmington, Mo *	85	1700
1922 (1)	Lead Belt Materials Co Inc	Flat River, Mo *	86	1100
1949	Mississippi Lime Co	Ste Genevieve Mo	88	13
1993	Harris Lime	Patterson Mo	89	7

* Denotes Old Lead Belt Area
** Denotes New Lead Belt Area

TABLE 20

ICAP ANALYSIS (ug/g) FOR COMMERCIAL LIMESTONE

	2039 83010076	2011 83010077	1976 83010078	2006 83010079
Ag	< 7	< 7	< 7	< 7
Al	< 50	400	920	1800
As	< 70	< 70	< 70	< 70
B	< 30	< 30	< 30	< 30
Ba	2	8 0	2	16
Be	< 1	< 1	< 1	< 1
Ca	367000	251000	171000	334000
Cd	< 7	< 7	< 7	< 7
Co	< 7	< 7	< 7	< 7
Cr	< 7	21	15	< 7
Cu	< 7	< 7	29	16
Fe	390	1900	3300	5400
K	< 500	< 500	< 500	< 500
Li	< 7	< 7	< 7	< 7
Mg	3300	70000	98000	4400
Mn	220	210	120	420
Na	200	330	150	92
Ni	< 7	14	10	13
P	< 70	3400	350	360
Pb	< 30	< 30	< 30	< 30
Se	< 70	< 70	< 70	< 70
Si	100	430	340	260
Sn	< 70	< 70	< 70	< 70
Sr	96	180	72	970
Ti	< 10	< 10	< 10	< 10
V	< 7	< 7	< 7	8
Zn	110	36	340	81

TABLE 20 (Cont)

ICAP ANALYSIS (ug/g) FOR COMMERCIAL LIMESTONE

As	2088 83010080	1918(2) 83010081	2019(1) 83010082	2025 83010083
Al				
As	< 7	< 7	< 7	< 7
B	300	60	750	1200
Ba	< 70	< 70	< 70	< 70
Be	< 30	< 30	< 30	< 30
Ca	2	3 6	7 0	4 5
Cd	< 1	< 1	< 1	< 1
Co	365000	191000	163000	155000
Cr	< 7	10	< 7	< 7
Cu	< 7	19	< 7	< 7
Fe	< 7	< 7	10	11
K	12	290	15	19
Li	490	12000	4400	2900
Mg	< 500	< 500	< 500	< 500
Mn	< 7	< 7	< 7	< 7
Na	1400	110000	94000	91000
Ni	200	1700	180	180
P	180	170	180	160
Pb	< 7	33	10	11
Se	100	300	1100	620
Si	< 30	340	< 30	< 30
Sn	< 70	< 70	< 70	< 70
Sr	160	280	240	230
Ti	< 70	< 70	< 70	< 70
V	150	54	59	59
Zn	< 10	< 10	< 10	< 10
	< 7	< 7	7	< 7
	16	750	7	< 7

TABLE 20 (Cont)

ICAP ANALYSIS (ug/g) FOR COMMERCIAL LIMESTONE

	1919(1) 83010084	1921(1) 83010085	1922(1) 83010086	1949 83010088	1993 83010089
Ag	< 7	< 7	< 7	< 7	< 7
Al	140	150	300	80	880
As	< 70	< 70	< 70	< 70	< 70
B	60	40	< 30	< 30	< 30
a	11	3 9	3	8 7	8 0
Be	< 1	< 1	< 1	< 1	< 1
Ca	192000	184000	189000	371000	196000
Cd	< 7	24	42	< 7	< 7
Co	27	15	20	< 7	< 7
Cr	7	8	11	14	< 7
Cu	170	93	40	8	20
Fe	44000	31000	22000	360	2900
K	< 500	< 500	< 500	< 500	< 500
Li	< 7	< 7	< 7	< 7	< 7
Mg	91000	92000	102000	1800	115000
Mn	5300	4500	3500	16	140
Na	230	260	230	110	260
Ni	28	17	24	< 7	< 7
P	310	430	320	80	300
Pb	1700	1600	1100	< 30	< 30
Se	< 70	< 70	< 70	< 70	< 70
Si	270	280	310	120	260
Sn	< 70	< 70	< 70	< 70	< 70
Sr	36	44	47	140	53
Ti	< 10	< 10	< 10	< 10	< 10
V	10	7	7	< 7	8
Zn	350	860	2100	32	22

VIII PLANT METAL UPTAKE STUDIES

Using the survey of metal contents in tailings and chat piles from the Old Lead Belt of Missouri with high lead values, bulk samples were then collected from areas with the highest known lead content for use as limestone in laboratory plant growth experiments Quantities of tailings material from the New Lead Belt mill operations were also collected for comparison The tailings were analyzed for cadmium and lead prior to experimental soil preparation

The experimental design involved the mixing of tailings with an uncontaminated acid soil derived from the Old Lead Belt area The typical soil chosen belongs to the Crider series This is a dark brown silt loam formed in loess or clay residuum with pH in the top 20 cm being approximately 5 0 unless limed The soil is classified as a mesic Typic Paleudalf (19)

In a control study the same acid soil was amended with equivalent amounts of a commercial agricultural limestone known to contain only background levels of heavy metals For further comparison soil was collected from a farm where Old Lead Belt tailings had been spread on the land over a number of years

Soil samples were laid out on polyethylene sheeting to dry in the laboratory Large particles and stones were removed by hand Dried soils were ground with a large mortar and pestle and passed through a stainless steel sieve of 2 mm aperature The sieved material was then mixed with coarse gravel (inert) at a ratio of 3 1 to improve drainage The experimental soil mixtures used for plant growth were prepared by mixing the appropriate soil sample with commercial agricultural limestone or tailings on a volume basis

The various types of soils and amended soils utilized for laboratory plant growth experiments were as follow

1 Uncontaminated control soil (Crider)

2 Control soil commercial agricultural limestone (3 1)

3 Control soil commercial agricultural limestone (7 1)

4 Control soil New Lead Belt tailings (3 1)

5 Control soil New Lead Belt tailings (7 1)

6 Control soil Old Lead Belt tailings (3 1)

7 Control soil Old Lead Belt tailings (7 1)

8 Ferguson Farm soil (previously treated with Old Lead Belt tailings as agricultural limestone)

Each of these soil mixtures was used to prepare six experimental pots Each pot received a bottom layer of glass fiber, 2 5 cm thick over which the soil mixture was placed Prior to planting each pot received a surface application of liquid fertilizer and was allowed to equilibrate for 48 hours

Radish (French Breakfast) and lettuce (Paris White) seeds were sown at a rate of 25 per pot and covered with a 1 cm layer of the appropriately treated soil All pots were placed in a commercial greenhouse in a randomised block, and watered thoroughly from below with local tapwater

Initial growth was rapid and the plants were thinned to 10 per pot for radish and 5 per pot for lettuce Plants were harvested after 6 weeks

At Harvest, plants were divided into leaves and roots and tubers in the case of radish Each plant part was weighed, washed thoroughly with distilled water to remove soil particles, and dried in paper bags for 24 hours in an oven with a forced draught and set at 90 C After drying plants were reweighed ground and sent to the Environmental Trace Substances Laboratory at Columbia Missouri for analysis Soil samples from each pot were also collected and analysed Analysis was by the inductively coupled argon plasma emission method or flameless atomic absorption for lead

RESULTS AND DISCUSSION

The analytical values for the soils and limestones are illustrated in Table 21

For each treatment, the mean and standard error of the three replications of each plant was calculated on a dry weight basis These are presented graphically for Pb and Cd in radish bulbs in Figures 13 and 14 Figures 15 and 16 illustrate the Pb and Cd in lettuce leaves For each diagram the treatments have been ranked in order of increasing metal contents of the treatments left to right along the X axis

The diagrams for lead indicate a distinct upward trend in metal content of plants from left to right i e as soil metal levels increase The trend for Cd is not as marked

The highest levels of Pb in the soils were noted in the 3 1 mixtures of Old Lead Belt tailings and these soils yielded radish with the highest Pb contents in the range 5 - 7 μg/g dry matter One way of interpreting these values is to use the maximum permissible limit for lead in food in Great Britain In Britain it is an offense to sell food containing >1μg Pb/g on a fresh weight basis Although the

TABLE 21

LEAD, CADMIUM AND ZINC IN SOIL, TAILINGS AND AGRICULTURAL LIME USED IN EXPERIMENTAL SOILS

(MICROGRAMS/GRAM DRY WEIGHT)

	CRIDER (SOIL CONTROL)	AG LIME (STE GENEVIEVE)	FERGUSON FARM	NEW LEAD BELT TAILINGS	OLD LEAD BELT TAILINGS
PB	29	7 3	41	320	9100
CD	< 0 3	< 0 3	< 0 3	7 5	64
ZN	35	21	26	500	3100

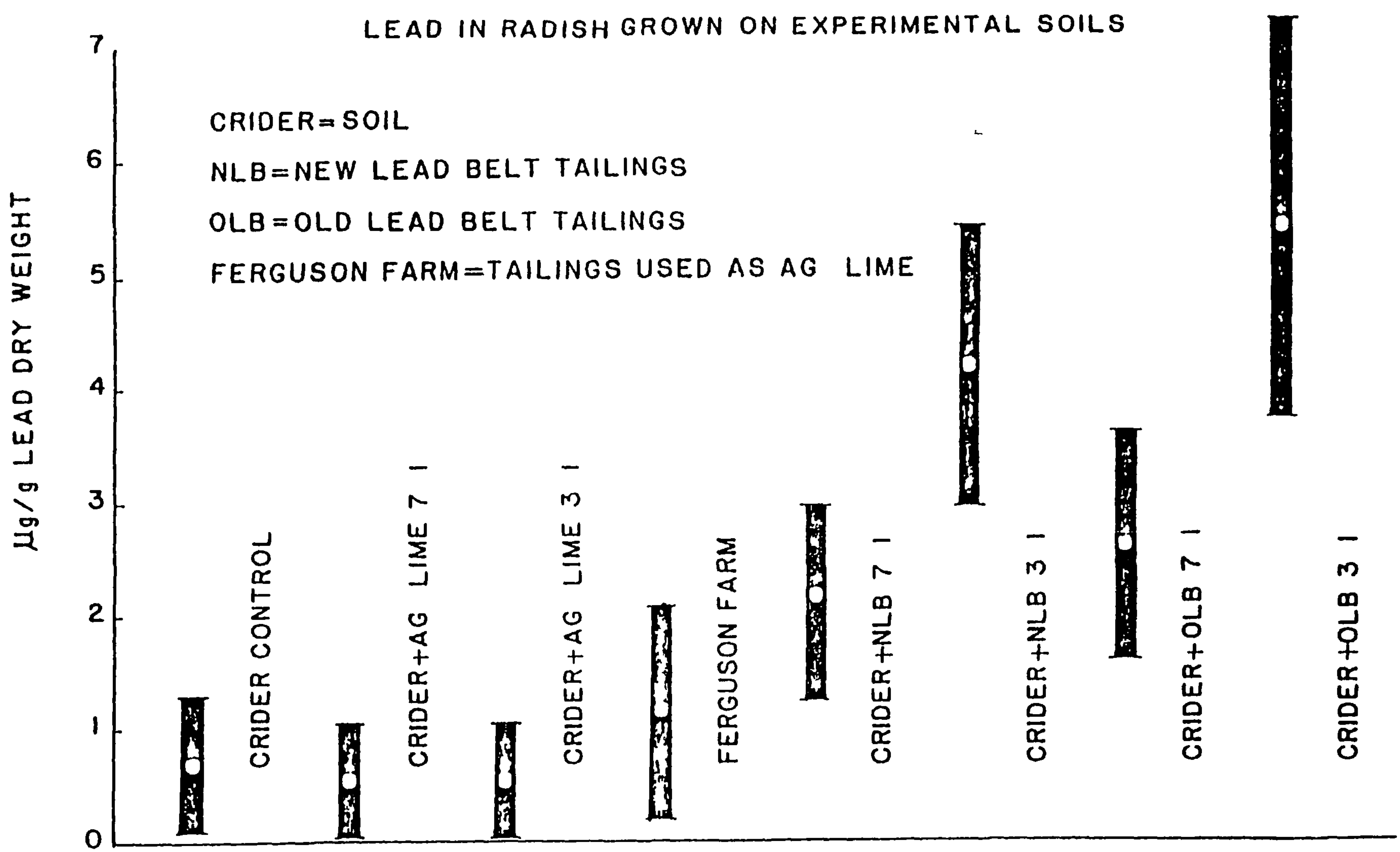

LEAD IN RADISH GROWN ON EXPERIMENTAL SOILS
CRIDER= SOIL
NLB=NEW LEAD BELT TAILINGS
OLB=OLD LEAD BELT TAILINGS
FERGUSON FARM=TAILINGS USED AS AG LIME
μg/g LEAD DRY WEIGHT
0
1
2
3
4
5
6
7
CRIDER CONTROL
CRIDER+AG LIME 7 I
CRIDER+AG LIME 3 I
FERGUSON FARM
CRIDER+NLB 7 I
CRIDER+NLB 3 I
CRIDER+OLB 7 I
CRIDER+OLB 3 I

FIGURE 13

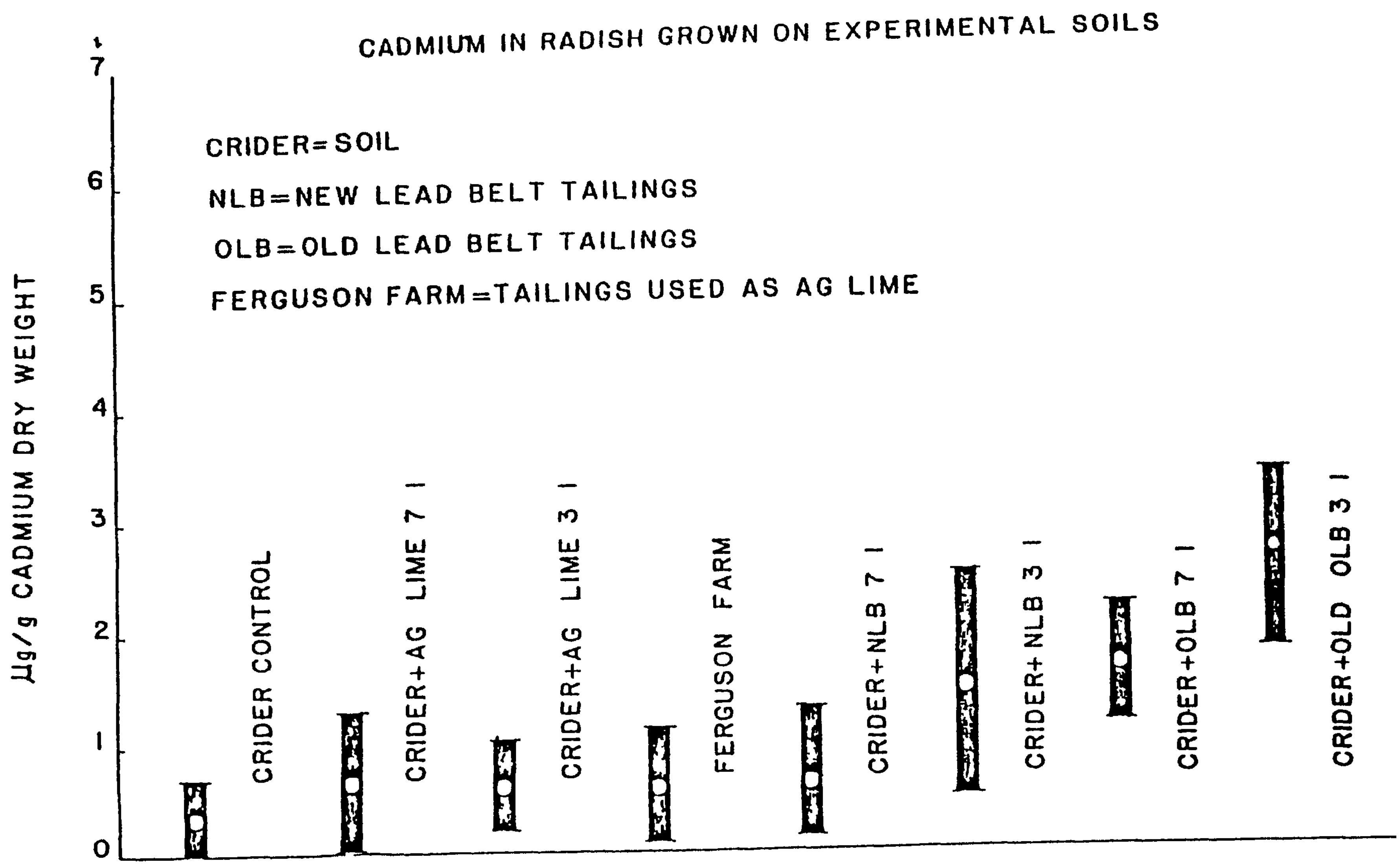

CADMIUM IN RADISH GROWN ON EXPERIMENTAL SOILS
CRIDER=SOIL
NLB=NEW LEAD BELT TAILINGS
OLB=OLD LEAD BELT TAILINGS
FERGUSON FARM=TAILINGS USED AS AG LIME
μg/g CADMIUM DRY WEIGHT
0
1
2
3
4
5
6
7
CRIDER CONTROL
CRIDER+AG LIME 7 I
CRIDER+AG LIME 3 I
FERGUSON FARM
CRIDER+NLB 7 I
CRIDER+ NLB 3 I
CRIDER+OLB 7 I
CRIDER+OLD OLB 3 I

FIGURE 14

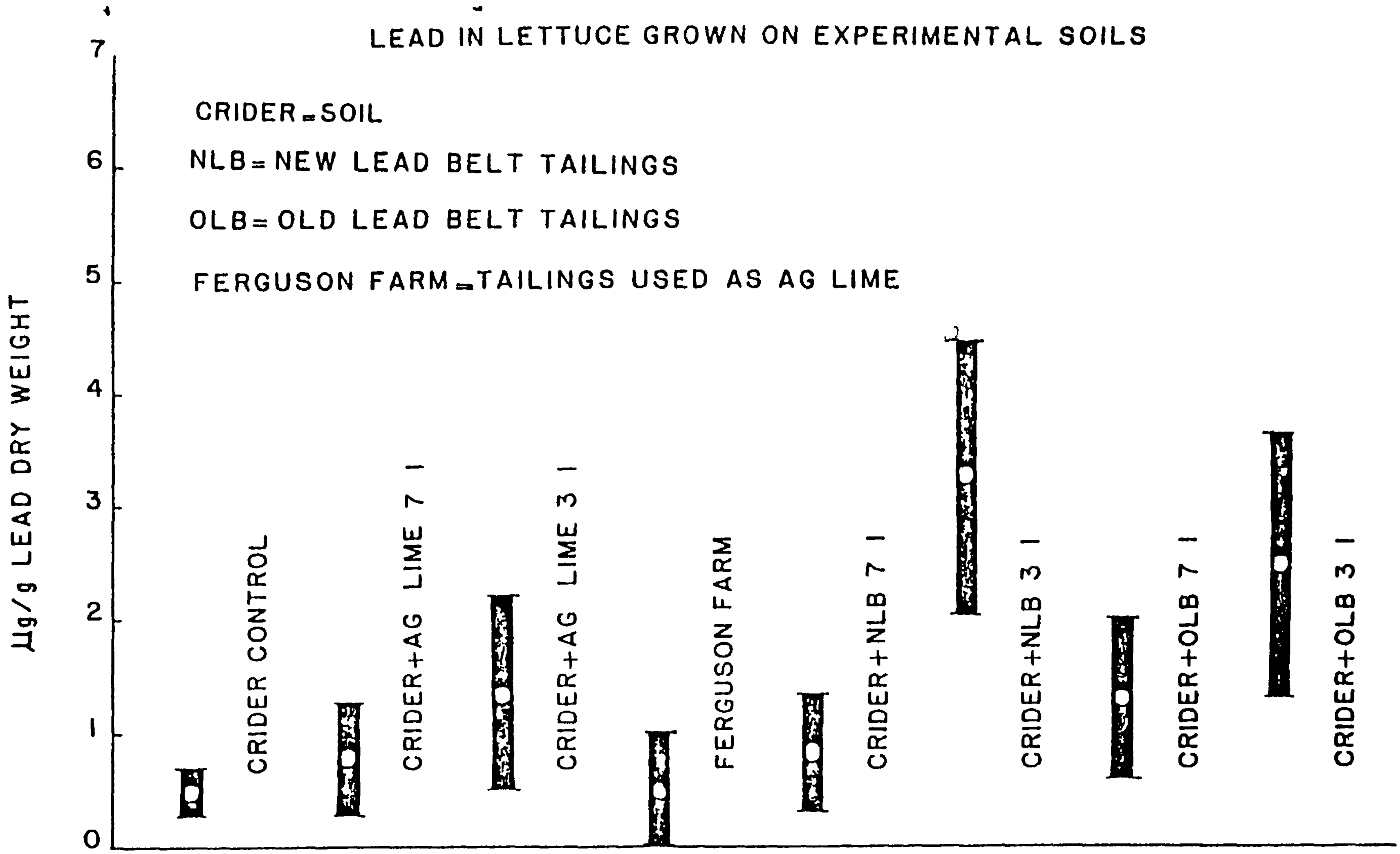

LEAD IN LETTUCE GROWN ON EXPERIMENTAL SOILS
CRIDER = SOIL
NLB = NEW LEAD BELT TAILINGS
OLB = OLD LEAD BELT TAILINGS
FERGUSON FARM = TAILINGS USED AS AG LIME
µg/g LEAD DRY WEIGHT
0
1
2
3
4
5
6
7
CRIDER CONTROL
CRIDER+AG LIME 7 I
CRIDER+AG LIME 3 I
FERGUSON FARM
CRIDER+NLB 7 I
CRIDER+NLB 3 I
CRIDER+OLB 7 I
CRIDER+OLB 3 I

Figure 15

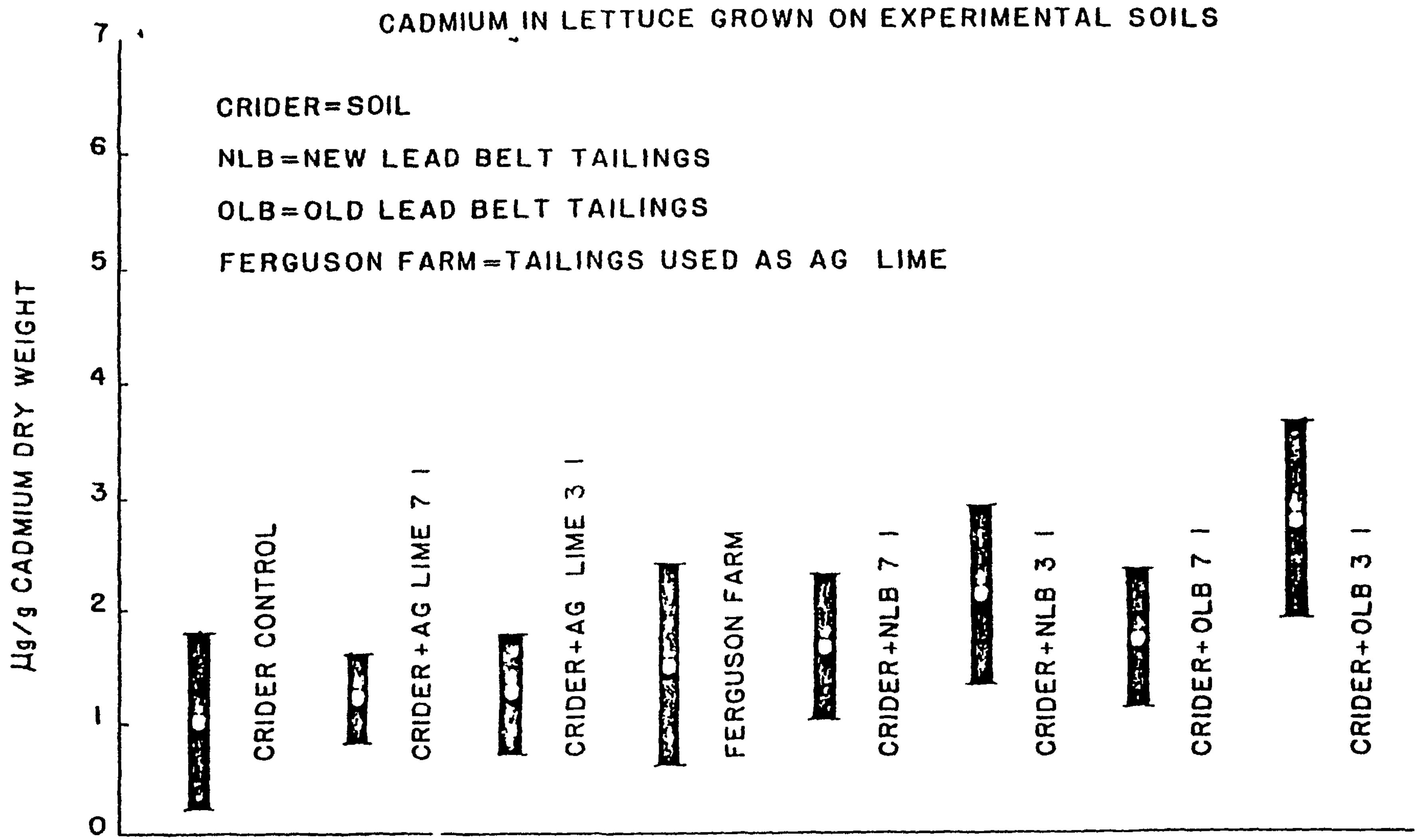

CADMIUM IN LETTUCE GROWN ON EXPERIMENTAL SOILS
CRIDER=SOIL
NLB=NEW LEAD BELT TAILINGS
OLB=OLD LEAD BELT TAILINGS
FERGUSON FARM=TAILINGS USED AS AG LIME
μg/g CADMIUM DRY WEIGHT
0
1
2
3
4
5
6
7
CRIDER CONTROL
CRIDER+AG LIME 7 I
CRIDER+AG LIME 3 I
FERGUSON FARM
CRIDER+NLB 7 I
CRIDER+NLB 3 I
CRIDER+OLB 7 I
CRIDER+OLB 3 I

FIGURE 16

dry matter content of vegetables is variable it is a useful approximation to suppose most contain about 10% dry matter and the permissible limit therefore converts to 10 μg/g dry weight The highest lead contents of the radish are lower than this limit Levels in the lettuce are even lower and lettuce dry matter contents are more usually nearer 5% than 10% It is interesting to note that in both lettuce and radish, slightly elevated levels occurred in the New Lead Belt 3 1 tailings This suggests that even though the New Lead Belt tailings contain less Pb than the Old Lead Belt ones when added at a rate of 3 1 (soil tailings), soil Pb levels could become higher than those observed when Old Lead Belt tailings are added at a rate of 7 1 (soil tailings) In the case of lettuce New Lead Belt tailings at 3 1 produced higher plant levels than Old Lead Belt tailings at 3 1

The Cd contents of radish and lettuce showed a similar trend to that of Pb i e increasing with the content of the underlying soil Levels in the highest Cd treatment were 6 times those in the control for radish and 3 times those for lettuce and in both cases this was about 3 μg/g dry weight On a fresh weight basis this would correspond to 0 3 μg/g for radish and 0 15 μg/g for lettuce In neither Great Britain nor the USA is the food content of cadmium controlled by law Davies and White (20) argued that using the same premises that were used to derive a lead limit a limit of 0 2 μg Cd/g wet weight is applicable The highest radish value is above the limit of 0 2 mg/kg for Cd suggested by Davies and White (20)

The liming regimes used in this experiment were far in excess of those which would be considered normal agricultural practice In normal liming practices, two tons of lime are applied to one acre of soil (top 6 inches) Using calculations for Crider soil, this represents two tons of agricultural lime per 1089 tons of soil or a ratio of 544 1 (soil-to-lime) Hence with normal rates of application, metal levels accumulated by crops would be expected to be far lower This was in fact observed where the plants were grown on the Ferguson farm soil which has received mill tailings as agricultural limestone over a number of years However the low uptake observed could also be a function of the high pH maintained by the added lime In practice therefore, uptake may increase if high metal levels are allowed to accumulate in soils, and are subsequently made more available by a lowering of pH e g by discontinuation of the liming regime

IX CONCLUSIONS

Five of the major chat or tailings piles and areas in the "Old Lead Belt" of Missouri have been sampled, analyzed and evaluated for the concentrations and distributions of pertinent metals Near surface and core samples were collected in sufficient numbers and patterns to statistically characterize the studied deposits resulting from different separation techniques employing jigging or froth flotation technology

The National and Elvins tailings piles were found to contain the highest mean Pb values (4000-6800 ppm) while the Leadwood deposit contained the highest mean Cd values (267 ppm) coupled with elevated zinc concentrations (5482 ppm) Each tailings or chat pile and area displayed specific characteristics that may be utilized in planning for stabilization revegetation control or runoff discharges into streams or rivers determining impacts on biota or utilization of these waste rock materials for construction agricultural limestone or other constructive uses

Field studies carried out in pastures where tailings from the Old Lead Belt had been used for a number of years as agricultural limestone did not indicate any significant movement of Pb Cd or Zn from the tailings enriched soil into the roots, stems or leaves of the grass or clover analyzed Control soil and vegetation growing in the same samples indicated a similar trend of no bioconcentration of elements from the soil

A number of commercial limestone samples from Missouri and from neighboring states were analyzed for comparison with tailings and local limestone used in laboratory plant growth and bioassay experiments to ascertain whether the Old and/or New Lead Belt tailings could be used as agricultural limestone without elevating heavy metal contents of farm crops to unacceptable levels

Plant metal uptake studies indicated that both lettuce and radish tended to accumulate some of the Pb and Cd added when lead-zinc mill tailings were mixed with soil as agricultural limestone Radish bulbs accumulated Pb to a higher degree than lettuce, but both accumulate Cd to the same level However neither was considered a health hazard according to accepted or proposed standards for Cd and Pb in food with the possible exception of radish grown at the highest rate of appliction of Old Lead Belt tailings, which is significantly higher than normal liming practices

This research evaluation of the data suggests that dolomitic limestone tailings in Southeast Missouri from both the Old and New Lead Belts could be used as a cheap and convenient substitute for agricultural limestone with resultant environmental benefits (21) Utilization of tailings on a broader scale would also enable much of the chat or tailings piles to be removed as a resource material and thereby eliminate some of the stability and erosion problems while improving the appearance of the landscape However, since the different milling waste piles contain varying amounts of cadmium and lead, the materials selected for such use should not contain elevated metal levels found in some of the older chat or tailings locations characterized in this study

ACKNOWLEDGEMENTS

Many different people, agencies or industries have participated or helped with this study and the authors would like to acknowledge their efforts

The research work was supported by the Missouri Department of Natural Resources and the suggestions, support, leadership and patience of John Ford, John Howland and Robert Schrieber is most appreciated

This project was also funded in part, under a continuing 208 grant from the U S EPA and this support is also gratefully acknowledged

John Carter, St Joe Minerals Corporation was most helpful in assisting with field work and admission to St Joe property and data Special thanks must go to Theodore Ferguson and his family for allowing us to sample his farm pasture Burton Brown from the soil conservation service in Farmington, Missouri gave of his time, shared data and suggested area soils for the study

Mr Lee Cash of the Lead Belt Materials Company and Gayle Blackwell and George Carroul of the St Francis County Environmental Corporation allowed our team to sample on their properties

Larry George, Glynn Horter and Scot Lay from the Bureau of Mines in Rolla, Missouri assisted with auger and coring work on the tailings piles The permission to include the Bureau data and assistance of Don Paulson is also appreciated

Paul Rexroad and Mary Pagett at the University of Missouri-Columbia helped with the selection of commercial limestone for analysis The analytical preparation and analysis carried out by Ed Hindergerger, Millie Kaiser and Tom Clevenger at the Environmental Trace Substances Research Center in Columbia, Missouri gave the quality control needed for the study

Heyward Wharton from the Missouri DNR Division of Geology and Land Survey furnished maps suggestions and data that were most helpful Dr Brian Davies was a visiting professor at the University of Missouri-Rolla during this research and thanks to UMR and the University College of Wales-Aberystwyth, Wales for their support

Larry Elliott completed his M S Thesis on the National Tailings pile with support from the Missouri DNR

Special thanks must go to the students and staff associates who sweated long hours in the sun or lab to collect the necessary samples and data They are Bill Ray, Tanzeer Ahmed, Nicola Houghton David Schlotzhauer, Ross Hazelhorst and Sue Hills

To all these fine people and others who helped on this study our sincere thanks

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October 28, 1983

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Professor of Environmental Health
University of Missouri - Rolla
321 Engineering Research Lab
Rolla, Mo 65401

OCT 31

Dear Dr Wixson

Thank you for your recent letter acknowledging the cooperation provided by Bureau of Mines employees at the Rolla Research Center We are pleased that their assistance was beneficial, especially the supplemental data that you wish to include in your final report on the characterization of the lead tailings piles in southeast Missouri

The analytical results and other technical assistance that was provided by the Bureau may be incorporated in your final report

If we can be of further assistance in the future, please let us know

Sincerely yours,

D L Paulson
Research Director
Rolla Research Center

October 6 1981

Dr Bobby Wixson
University of Missouri Rolla
Rolla Missouri 65401

Dear Dr Wixson

Thank you for forwarding copies of the preliminary data from the sampling and analysis of heavy metals in selected chat piles and tailings ponds There were several interesting points including

1 The great variability in zinc concentration between chat piles

2 The apparent enrichment of material at the outflow from the Flat River pile which suggests some selective process

I have put together some comments on the variances of the samples you have taken and how they relate to adequate sample size (no of samples) It appears that with the number of samples taken the sample means for metals levels in chat piles are within 30% of the true mean and in the Desloge tailings within 15% of the true mean These figures assume a 95% confidence level

I would welcome your comments on the attached materials which document my estimation of appropriate sample sizes

Sincerely

John C Ford
Environmental Specialist
Water Pollution Control Program

JCF jc

MISSOURI DEPARTMENT OF NATURAL RESOURCES
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I believe there are ypes of conclusions concerning eavy metals concentrations in tailings that require some degree of statistical corroboration

1 The mean or average concentration of a given metal in a particular chat pile or tailings pond and
2 The mean concentration of a given metal in one chat pile or tailings pond relative to the mean concentration of that metal in a second chat pile or tailings pond

The following procedure is my attempt to calculate the minimum sample size necessary to provide that statistical cooroboration

In order to make estimates of a certain precision that are representative of a population at a given level of confidence the following formula is used

$$n = \frac{t^2 s^2}{d^2}$$

Where n = no of samples
t = Student's t (confidence level desired)
s^2 = population variance estimate
d = desired precision

Student's t

I wish to use a 95% confidence level Assuming cost restraints will put the sample size in the range of $3 \leq r \leq 15$ then $2\ 35 < t < 1\ 75$ For the purposes of estimating sample size (which must be rounded off to a whole number anyway) I will use t = 2

Population Variance Estimate, s^2

I made four separate estima es of population variance for Pb Zn and Cd In choosing samples I was careful not to include samples sites that may have been of different origin Thus at the Elvins chat pile the coarse material (sample 87) was not included nor were tailings moved by water (samples 76-80) At the Flat River pile the material in the lower pile (samples 55-57) were not included

Results are as follows based upon metals concentration in parts per million

		Approx Sample Variance (s^2)		
Location	Sample Numbers	Pb	Zn	Cd
Elvins Chat Pile	73-75 81-84	623 000	2 400,000	687
Flat R '	49-54 58 59 63 64	3 250,000	13 800	7 6
Leadwood '	36-38 42-47	3 000 000	9 000,000	3 086
Deslodge Tailings Pond	24-30	160 000	54 000	35 3

The high variance for Zn at Leadwood is caused by 2 of the nine values If we consider them outliers and ignore them for the moment then the maximum variance we are experiencing at the 3 chat piles is about 3 million and for the tailings pond 160 000

Desired Precision d

Precision here is the maximum allowable difference between the sample estimate and the true population valve which can be detected with a given level of confidence In this case I have chosen one-tenth of the sample mean Asking for considerably more precision than this like 01 of the sample mean may be exceeding the capability of the analytical procedures

For simplicity an average value of d for chat piles of 300 was used for Pb and 400 for Zn (a value of 25 7 will be used for the Flat River pile since it is considerably different in [Zn]

	Value of d		
Location	Pb	Zn	Cd
Elvins Chat Pile	260	377	7 3
Flat R	408	25 7	5 4
Leadwood	295	463	9 1
Desloge Tailings Pond	176	126	2 7

Calculation of Sample Size n

		t^2	s^2	d^2	n
Chat Piles	Pb	4	3 10^6	90 000	133
	Zn	4	3 10^6	160 000	75
Flat R Zinc	Zn	4	13 800	660	84
	Cd	4	3 000	50	240
Tailings Ponds	Pb	4	160 000	31 000	21
	Zn	4	54 000	16 000	14
	Cd	4	35 3	7	20

The high variances in Pb Zn and Cd concentrations in chat result in the large number of samples required to obtain a sample estimate within 10% of the true mean 95% of the time By looking at the log of the metals concentrations sample variances can often be reduced

Transformation of Data

All metals concentrations were transformed as follows ($\log_{10}$ concentration) +1

This leads to the following set of sample variances

	s^2		
Location	Pb	Zn	cd
Elvins Chat Pile	019	037	025
Flat R Chat Pile	030	056	052
Leadwood Chat Pile	050	059	054
Desloge Tailings Pond	011	007	009

'd transformed becomes $\left[(\log_{10}\text{ sample mean}) + 1\right] - \left[\log_{10}\ 9\text{ sample mean}) + 1\right]$

	d		
Location	Pb	Zn	cd
Elvins/Leadwood Chat	0 05	0 04	0 05
Flat R Chat Pile	0 05	0 05	0 05
Desloge Tailings	0 05	0 05	0 05

Location		t^2	s^2	d^2	n
Elvins/Leadwood Chat	Pb	4	050	0025	80
	Zn	4	059	0016	148
	Cd	4	054	0025	86
Flat R Chat	Zn	4	056	0025	90
Desloge Tailings	Pb	4	011	0025	18
	Zn	4	007	0025	11
	Cd	4	009	0025	14

By reducing the amount of precision smaller sample numbers are obtained They are summarized as follows

			Sample mean and true mean within		
Location	Material	Metal	10% for log	15% transformed data	20%
Elvins/Leadwood	Chat	Pb	80	41	20
		Zn	148	48	29
		Cd	86	44	22
Flat R	Chat	Pb	80	41	20
		Zn	90	46	22
		Cd	86	44	22
Desloge	Tailings	Pb	18	9	4
		Zn	11	6	3
		Cd	14	7	4

2 Choosing sample size to determine relative concentrations in 2 or more piles requires hypothesis testing Tables are available to give number of samples needed once the following variables are estimated or defined

δ - the difference between means which will be detected —— percent of the time when a true difference exists

σ - an estimate of population standard deviation

α - the probability of saying a true difference exists when the samples are really from the same population

$(1-\beta)$ - the probability that the test detects a true difference when a true difference actually exists

δ

We will use the same values for δ that we did for d for the transformed data

σ

We will use the standard deviations of the samples $\alpha, (1-\beta)$ We will define α = .05 and $(1-\beta)$ - .80

Using the attached table the appropriate sample sizes are

		Sample size n (for each of 2 samples)		
		δ = .05	δ = .07	δ = .10
Elvins/Leadwood Chat Piles	Pb	> 100	> 100	83
	Zn	> 100	> 100	>100
	Cd	>100	>100	90
Flat R Chat Pile	Pb	>100	> 100	83
	Zn	>100	> 100	95
	Cd	>100	>100	90
Desloge Tailings Pond	Pb	75	37	19
	Zn	45	24	12
	Cd	60	32	16

Conclusions

The high variability of metals concentrations in chat mean that large numbers of samples will be needed to make conclusions with a [illegible] level of confidence [illegible] will take between 20-25 samples to come within 20 of the true mean metals co[illegible]t of a chat pile 40-50 samples to come within 15% and 80-100 samples to come w[illegible] n 10% of the true mean metal content Log transformation has been used and has resulted in a slight decrease in necessary samples size

Tailings which are typically more homogeneous do not require as many samples Only 10-20 samples are required to achieve a sample mean within 10% of the true mean and only 4 samples to have a sample mean within 20% of the true mean

Hypothesis testing which would determine which of two sets of materials contained more metals require considerably more sampling as the table on page 4 shows

Obviously, sample variance is of great importance in determining sample size Should future sampling indicate sample variances different from those used here the sampling data should all be combined and new variances calculated This may result in a lower estimate of adequate sample size and a cost saving

APPENDIX 10[1]

NUMBER OF OBSERVATIONS FOR t-TEST OF DIFFERENCE BETWEEN TWO MEANS[1]

[illegible] *The Design and Analysis of* [illegible] Oliver and Boyd [illegible] [illegible]

	Level of t-Test																				
	0.01					0.02					0.05					0.1					
Single-Sided Test / Double-Sided Test	α = 0.005 / α = 0.01					α = 0.01 / α = 0.02					α = 0.025 / α = 0.05					α = 0.05 / α = 0.1					
β	0.01	0.05	0.1	0.2	0.5	0.01	0.05	0.1	0.2	0.5	0.01	0.05	0.1	0.2	0.5	0.01	0.05	0.1	0.2	0.5	
0.05																					0.05
0.10																					0.10
0.15																					0.15
0.20																				137	0.20
0.25															124					88	0.25
0.30										123					87					61	0.30
0.35					110					90					64				102	45	0.35
0.40					85					70				100	50			108	78	35	0.40
0.45				118	68				101	55			105	79	39		108	86	62	28	0.45
0.50				96	55			106	82	45		106	86	64	32		88	70	51	23	0.50
0.55			101	79	46		106	88	68	38		87	71	53	27	112	73	58	42	19	0.55
0.60		101	85	67	39		90	74	58	32	101	74	60	45	23	89	61	49	36	16	0.60
0.65		87	73	57	34	101	77	64	49	27	88	63	51	39	20	76	52	42	30	14	0.65
0.70	100	75	63	50	29	90	66	55	43	24	76	55	44	34	17	66	45	36	26	12	0.70
0.75	88	66	55	44	26	79	58	48	38	21	67	48	39	29	15	57	40	32	23	11	0.75
0.80	77	58	49	39	23	70	51	43	33	19	59	42	34	26	14	50	35	28	21	10	0.80
0.85	69	51	43	35	21	62	46	38	30	17	52	37	31	23	12	45	31	25	18	9	0.85
Value of 0.90	62	46	39	31	19	55	41	34	27	15	47	34	27	21	11	40	28	22	16	8	0.90
0.95	55	42	35	28	17	50	37	31	24	14	42	30	25	19	10	36	25	20	15	7	0.95
$D = \frac{\delta}{\sigma}$ 1.00	50	38	32	26	15	45	33	28	22	13	38	27	23	17	9	33	23	18	14	7	1.00
1.1	42	32	27	22	13	38	28	23	19	11	32	23	19	14	8	27	19	15	12	6	1.1
1.2	36	27	23	18	11	32	24	20	16	9	27	20	16	12	7	23	16	13	10	5	1.2
1.3	31	23		16	10	28	21	17	14	8	23	17	14	11	6	20	14	11	9	5	1.3
1.4	27	20	17	14	9	24	18	15	12		20	15	12	10	6	17	12	10	8	4	1.4
1.5	24	18	15	13	8	21	16	14	11	7	18	13	11	9	5	15	11	9	7	4	1.5
1.6	21	16	14	11	7	19	14	12	10	6	16	12	10	8	5	14	10	8	6	4	1.6
1.7	19	15	13	10	7	17	13	11	9	6	14	11	9	7	4	12	9	7	6	3	1.7
1.8	17	13	11	10	6	15	12	10	8	5	13	10	8	6	4	11	8	7	5		1.8
1.9	16	12	11	9	6	14	11	9	8	5	12	9	7	6	4	10	7	6	5		1.9
2.0	14	11	10	8	6	13	10	9	7	5	11	8	7	6	4	9	7	6	4		2.0
2.1	13	10	9	8	5	12	9	8	7	5	10	8	6	5	3	8	6	5	4		2.1
2.2	12	10	8	7	5	11	9	7	6	4	9	7	6	5		8	6	5	4		2.2
2.3	11	9	8	7	5	10	8	7	6	4	9	7	6	5		7	5	5	4		2.3
2.4	11	9	8	6	5	10	8	7	6	4	8	6	5	4		7	5	4	4		2.4
2.5	10	8	7	6	4	9	7	6	5	4	8	6	5	4		6	5	4	3		2.5
3.0	8	6	6	5	4	7	6	6	4	3	6	5	4	4		5	4	3			3.0
3.5	6	5	5	4	3	6	5	4	4		5	4	4	3		4	3				3.5
4.0	6	5	4	4		5	4	4	3		4	4	3			4					4.0

Agency for Toxic Substances and Disease Registry

Division of Health Studies

Big River Mine Tailings Superfund Site Lead Exposure Study

St Francois County, Missouri

August 1998

U S DEPARTMENT OF HEALTH & HUMAN SERVICES
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ATLANTA, GEORGIA

BIG RIVER MINE TAILINGS SUPERFUND SITE
LEAD EXPOSURE STUDY

SUBMITTED BY

MISSOURI DEPARTMENT OF HEALTH
BUREAU OF ENVIRONMENTAL EPIDEMIOLOGY
JEFFERSON CITY, MISSOURI

June 1998

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ABSTRACT

The purpose of this study was to determine if living close to the Big River Mine Tailings Superfund Site increased blood lead levels of resident children and what contribution mining waste had to any increase The average blood lead level of the 226 children in the study group was 6 52 µg/dl compared to 3 43 µg/dl in the 69 control children The proportion of children with blood lead levels greater than or equal to 10 µg/dl in the study and control groups was 17% and 3% respectively Soil and dust lead levels were up to 10 times higher in the study group compared to the control group Source characterization of lead levels in soil in the study area indicated that approximately 50% of the lead could be determined to originate from mine waste Approximately 26% of the vacuum dust could be attributed to waste pile source and 37% to soil of which a proportion probably originated from mine waste

The results of this study indicated that blood lead levels were a product of exposure to lead mining waste lead based paint and other sources Because the only substantial difference between the study and control areas in terms of exposure to lead was the presence of lead mining mining waste is the most reasonable explanation for the differences between the blood lead levels in the two communities

BIG RIVER MINE TAILINGS SUPERFUND SITE
LEAD EXPOSURE STUDY

INTRODUCTION

RATIONALE FOR STUDY

A Preliminary Public Health Assessment for the Big River Mine Tailings Superfund Site (considered the Site in the text) (Agency for Toxic Substances and Disease Registry 1994) was reviewed by the Health Activities Recommendation Panel (HARP) at the Agency for Toxic Substances and Disease Registry (ATSDR) It was determined that individuals living on or near this Site were exposed to contaminants at levels of concern Considering the widespread lead contamination at the Site the potential for social and personal costs of lead poisoning in children, and the HARP review the Missouri Department of Health (DOH) proposed to ATSDR to conduct a study of children exposed to lead

This Site provided an opportunity to evaluate the impact of mine waste without appreciable waste from smelting operations on blood lead levels of children living in the area Two smelting operations located in Bonne Terre operated for less than 10 years around the turn of the century

In 1995 a report from DOH to ATSDR documented that children living in a Superfund site in Jasper County Missouri contaminated with lead had significantly higher blood lead levels than children living in a comparison community (ATSDR, 1995) The Jasper County Site was contaminated with waste from lead mining milling and smelting operations The smelting operations consisted of primitive lead smelting operations in hundreds of backyard smelters

RATIONALE FOR LIMITING STUDY TO CHILDREN

Children are at highest risk for lead exposure therefore only children six to 90 months of age were selected for this study This is the age range for considerable hand to mouth behavior In the Jasper County Study, adults youths and children were evaluated Although blood lead values for all age groups were significantly higher than for a comparison group, only one person in the adult group and one in the youth group had levels greater than 10 micrograms of lead per deciliter of blood (µg/dl) compared to fourteen percent of the children

Study Objectives

The first overall objective of this study was to determine if living in a former lead mining area increases blood lead levels of resident children Secondly, if this increase does occur what contribution did mining waste have to that increase

BACKGROUND

PROBLEM STATEMENT

Prominent reminders of mining history remain today at the Site with six major tailings piles or ponds several smaller tailings areas and numerous closed mines scattered throughout the 110 square mile Old Lead Belt area (USGS 1988) In 1990 an assessment of the Big River Mine Tailings site was completed by The Ecology and Environment Field Investigation Team (E&E/FIT) under an EPA contract Sampled media included air soil sediment and surface and ground water on the Site as well as off the Site Surface water and sediment were collected from the Big River and tributaries in contact with the mining waste piles Laboratory results indicated that lead levels found in the pile samples ranged from 910 parts per million (ppm) to 13 000 ppm with a mean concentration of 2 215 ppm These values represented high concentrations compared with background concentrations (background samples were collected for all media) as low as 64 ppm These were similar to those reported in a study carried out by the University of Missouri Rolla (Wixson, 1983) Two residential samples and one near a day care center showed very high lead concentrations similar to those reported from the tailings[1]

E&E/FIT concluded that the Site was affecting the area located to the south In addition, areas located approximately 1 500 feet from the Site to the east and southeast seemed to be the most significantly affected From this information it follows that blood lead levels particularly in children living in the area, should be investigated

RELATIONSHIP BETWEEN LEAD EXPOSURE, BLOOD LEAD LEVELS, AND HEALTH PROBLEMS

The Centers for Disease Control and Prevention (CDC) considers lead poisoning the number one preventable pediatric health problem facing children today (CDC 1991) At low levels of exposure comparable to those found near the Site several signs of lead toxicity have been described They include decreased attention span, hyperactivity and lower IQ scores (Ernhardt et al 1981) Lead levels as low as 10 µg/dl have been shown to affect child development (Bellinger et al 1987 Bellinger et al 1991 Dietrich et al 1987 Needleman et al 1990 Ernhart et al 1986 Lyngbye et al 1990) Needleman and Gatsonis (1990) report that children s IQ scores are related inversely to low levels of lead burden Several studies provide sufficient evidence that children s cognition was adversely affected by lead (Bergomi et al 1989 Ferguson et al 1988 Fulton et al 1987 Hansen et al 1989 Hawk et al 1986 Hatzakis et al 1989 Lansdown et al 1986 Schroeder et al 1985 Silva et al 1988 Winneke et al 1990 Yule et al 1981)

---

[1]*Mining and milling waste can also be referred to as chat or tailings These terms are used interchangeably throughout the text*

Adverse effects of lead on intelligence are persistent across socioeconomic strata, as well as different ethnic and racial groups (Baghurst et al 1992 Dietrich et al 1993a, Bellinger et al 1991 Dietrich et al 1993b) The ATSDR has estimated that among all American children, 17% have blood lead levels above 15 ug/dl (ATSDR, 1988) Among white children, 7% of those with good socioeconomic conditions have elevated lead levels in contrast to 25% in poor whites (ATSDR, 1988) The estimates for black children are 25% among those in good socioeconomic conditions compared with 55% among poor blacks (ATSDR, 1988)

Relevant exposure pathways (i e ingestion inhalation) and sources for children include lead-based paint materials ambient air indoor dust and soil Lead based paint is a major contributor to lead poisoning in older homes Since dust is airborne before it settles lead particulates in dust are likely to be inhaled Lead exposure is greatest in indoor dust where the contaminants are dispersed trapped, and settled over a confined area (Lepow et al 1974 Vostal et al 1974) Few studies are available that indicate how much lead in dust and soil may result in increased blood lead levels when lead is ingested or inhaled (Lepow et al 1974 Vostal et al 1974)

People who work in certain hobbies or industries such as the production of storage batteries chemical substances such as paint and gasoline additives metal products such as sheet lead solder and pipe and ammunition, may also be at risk because of exposure at the work place as well as at home Potential for contamination of the home environment exists from particulates transferred from work to the household environment (Prior et al 1994 Klemmer et al 1975 Knishkowy and Baker 1986)

EXPOSURE SOURCES RELATED TO THE BIG RIVER MINE TAILINGS SITE

Chat and tailings have been used as fill material or mixed with asphalt as gravel for road surfacing, and for many other house and garden uses The material has been spread through the area by man and by erosion Erosion significantly contributes to down gradient deposition of the contaminated material (Wixson, 1993)

Lead has been detected in private wells at a maximum of 32 9 ppb Recent monitoring indicates that the level of lead in public water was below the current EPA Action Level of 15 ppb Lead is naturally occurring in the area, but the deposition of mine tailings at ground surface has made lead more accessible to people Lead is also a problem in older homes where lead paint has been used People living near the Site and tailings throughout the area, have been exposed to lead through incidental ingestion of soils and dust contaminated with lead

Lead exposure is probably greatest in indoor dust where the contaminants are trapped dispersed and settled over a confined area In the study area, lead has previously been detected at a concentration of 27 460 ppm in the vacuum dust of a home where work with lead products was a hobby (MDOH 1986) In the same study lead was found in other homes (with no lead-related hobbies) at a maximum of 5 230 ppm (MDOH, 1986) These concentrations are an indication of the amount of lead in dust that was distributed throughout the households and accessible to the occupants

Description of Exposure Area

The Big River Mine Tailings Site is located approximately 70 miles south of St Louis in an area of southeast Missouri known as the Old Lead Belt Although lead was discovered in the area in the 1700s mining was done by individuals as a dispersed and mostly superficial operation until 1860 At that point large scale mining was established in the region Between 1907 and 1953 this area was the major producer of lead in the nation Mining operations ceased in October 1972 when the last mine was officially closed (USGS 1988)

Prominent reminders of the mining history remain today with six major tailings piles or ponds several smaller tailings areas and numerous closed mines scattered throughout the 110 square mile Old Lead Belt area (USGS 1988) These piles are the result of the stockpiling of tailings One of these piles is currently listed as a Superfund site The Site consists of approximately 600 acres of mine tailings in a pile that ranges in height from ground level to more than 100 feet with an average height of approximately 50 feet The majority of the Site is situated within a horseshoe shaped bend of the Big River which flows on the east north and west sides Residential areas and the city of Desloge are adjacent to the Site on the south and southeast

In addition to the city of Desloge the city of Park Hills is also south of the Site and contains three additional tailings piles A fifth tailings pile (the Bonne Terre pile) is approximately two miles north of the Site in Bonne Terre A sixth tailings pile the Leadwood pile is approximately two miles west of the Site The piles are shown on a map in Figure 1

Most of these large piles are located adjacent to residential areas In some cases tailings are slumping into existing backyards of adjacent homes In addition to this deposition in nearby yards lead contaminated dust is blown from the piles and redeposited throughout the study area

A total of approximately 250 million tons of tailings were produced in the Old Lead Belt with the majority stored in the six major tailings piles (E&E 1991) The material encountered in the piles and scattered throughout the area consists of small particles ranging from powder to silt and sand This variety is the result of two methods of separation used for mineral extraction from limestone Density separation resulted in larger size particulate called chat (approximately the size of fine gravel) and chemical separation resulted in much smaller and fine particulate called tailings (silt/sand type material) which is the predominant form contained in the piles (Wixson et al 1983)

The piles have been found to have high concentrations of lead Other metals found in the material include cadmium, arsenic and zinc Mine tailings dust containing these metals has been spread into the environment and the surrounding community by wind and rain Varying concentrations of the heavy metals can be found in environmental media throughout the area including off site soil groundwater and surface water household dust and in the water sediment plants and animals of the Big River

In late spring 1977 the area received heavy rainfall which caused a large portion of the tailings from the Site to become supersaturated and collapse into the Big River An estimated

50 000 cubic yards of tailings washed into the river at that time (UMC 1977) An investigation was initiated by the Environmental Protection Agency (EPA) in response to a concern of the Missouri Department of Natural Resources (MDNR) over pollution of the Big River as a result of the collapse (UMC 1977) The EPA concluded that the Big River had been degraded as a consequence of physical disturbances in its benthic zone Chemical toxicity was not reported at that time The conclusion was based upon aquatic population density and diversity data (EPA, 1991)

Since then elevated levels of lead cadmium, arsenic and zinc have been found in plants crayfish, mussels and fish in the river As early as 1980 elevated levels of lead detected in fish downstream of the Site were reported by the Missouri Department of Conservation (MDOC) Lead levels in edible fillets ranged from 0 4 ppm to 0 7 ppm (MDOC 1980) This prompted a news release issued by the MDOC and the DOH, warning people not to eat fish in the affected area The DOH issued an advisory against eating bottom feeding fish taken from the 50 mile section of the river between Desloge and the Mammoth Access The fish advisory is still in effect for bottom feeding fish The advisory now extends to the Big River s confluence with the Meramec River and sunfish have been added

The United States Fish and Wildlife Service released the results of their study on the effects of the chat and tailings material on the Big River in 1982 The findings reported elevated heavy metal residues mainly lead, cadmium, and zinc in all biologicals examined Algae rooted plants crayfish, mussels and fish were examined in the study (Schmitt and Finger 1982)

In 1985 St Joe Minerals Corporation organized a task force that included representatives of the corporation, MDNR, local officials and other interested parties The Desloge Tailings Task Force was in charge of supervision as well as oversight of short and long term stabilization activities on the Site These activities included seeding and planting black locust trees and settlement of snow fences and have only partially controlled erosion of the piles

During the same year the DOH conducted a study of lung cancer in the area As part of the study dust was sampled in 46 homes The average metals concentrations found resembled the concentrations found in the piles The report concluded that the piles were the major source of lead-contaminated household dust in the area (MDOH, 1986)

METHODS

STUDY DESIGN

In order to ensure that study participants had the greatest likelihood of being exposed to lead contaminants in soil, air and water media, a study was carried out at the end of summer and early fall when children were most likely to have spent time outside Children were located by canvassing the study area to locate eligible participants Details of this activity are discussed in Section III D Children qualified for participation if the following applied

- They were six to 90 months in age and
- They had been living in the defined study area for at least 60 days prior to the beginning of the study

A random sample of all homes with eligible children was generated from the study and control areas If more than one eligible child was available in a home one child was selected at random from that home In addition after exhausting all homes on the initial list without enrolling the required number of children, another random list of remaining eligible homes was drawn As it happened we needed to draw several consecutive lists of eligible homes to get enough participants and this resulted in most all eligible homes in the study and control areas being selected

Two nurses and an environmental specialist were sent to each participant s home that had been included in the sample and whose parents consented to have their child participate in the study After informed consent the investigators completed a questionnaire that included information on the child and on the household A copy of the questionnaire is included in Appendix 1

A venous blood sample was taken from the child and processed according to the approved protocol (see section III F) Environmental samples were collected from the home and yard according to the environmental sampling protocol (see section III G)

All participant s parents were required to sign a consent to answer the questionnaire and have a venous blood sample taken from their children Copies of consent forms are included in Appendix 2

The purpose of the questionnaire was to document demographic behavioral occupational and educational information Parents were asked to provide questionnaire information for their participant child Behavior that increases risk of exposure to contaminated environmental media and other possible factors related to lead exposure were documented Interviewers were trained by DOH staff and by Saint Louis University School of Public Health (SLUSPH) A copy of the questionnaire is included in Appendix 1

STUDY AREA SELECTION

The study area consisted of Bonne Terre and the area east of Bonne Terre Desloge Leadington, Park Hills Leadwood Frankclay Wortham, Mitchell and adjacent areas Demographic data on these areas from the 1990 U S Census are presented in Table 1 These cities are adjacent to the largest mine tailings in the study area (Figure 1)

These towns were chosen for the study because

I they presented comparable demographic composition
II had high lead levels reported in prior environmental analysis
III are located around the largest lead waste piles in the region and
IV their proximity to each other

CONTROL AREA SELECTION

The control group was chosen from Salem, Missouri an area outside the Old Lead Belt Salem is 72 miles from the study area Census data was used to select this area based upon similarities with the study group Variables from the census data used to make the determination for selection of the control area included total population, percent of managers or professionals percent with a high school diploma, percent of families with a child under the age of six, percent of black population under age of six, percent of housing units built before 1960 percent of families with an income below the poverty level median family income and median value of owner occupied housing groups

The selection criteria was to include those zip code areas within the state with a population between 10 000 and 20 000 persons the zip code areas extend beyond the city limits and therefore do not correspond to the data presented in Table 1 This eliminated all but 75 Missouri zip codes Percentage of values for the above variables were calculated The weighted average of these variables was then calculated based on the populations of the zip codes in the study area This average was used to determine how other zip codes compared with these zip codes by producing an index for each variable Indices were calculated for each of the above variables The indexes for each variable were then averaged for each zip code area to obtain an overall index The overall index was ranked and those zip codes with an overall index value of between 0 95 and 1 05 were kept All but 18 zip codes were eliminated

The standard deviation of these variables was also calculated to determine the degree of variation between the variables for each zip code A zip code could have an extremely low value for one variable and a high value for another that could possibly cause it to have an index of near 1 000 If the standard deviation was less than 0 200 that zip code was included as part of a final list Six zip codes met these criteria After examining the location of these zip codes the city of Salem was chosen because it was the closest to the study area

Although this area is located outside the mining area, soil and drinking water samples were taken from 10 randomly selected homes prior to the study initiation to ensure that lead levels were not elevated Levels were considered elevated if the average soil lead levels were greater than background (75 90 ppm) or the average water lead levels were greater than the EPA action level for drinking water (15 ppb) No elevations in lead levels were determined

Performance of Canvassing Activities

The purpose of the canvass was to identify (from both the study and control areas) all children eligible for participation in the study Groundwork was laid for the canvass by raising area residents awareness that it would soon be taking place This increased awareness was accomplished through media interviews and information releases arranged and provided by the St Francois County Health Department (Appendix 3) Local law enforcement authorities in both the study and control areas were notified of the canvass activities enabling these agencies to address residents concerns about the legitimacy of canvassers calling or visiting the homes

Preceding the canvass training was conducted for interviewers who would be contacting residents and performing the canvass The initial training session for canvassers was conducted at the St Francois County Health Department on March 1 1995 and included five participants from Mineral Area College four from SLUSPH and four from the St Francois County Health Department Two additional training sessions were conducted within approximately one month of the first session to expand the size of the canvass workforce The total number trained included thirty one students from Mineral Area College (MAC) seven from SLUSPH, and seven from the DOH All training was conducted by the same individual using the same lecture outline and handouts (Appendix 4) The training sessions included discussion of the following topics

a) Background information on the study and the purpose of the canvass General information about the health effects of lead
b) Description of the study methodology
c) General description of the canvass and
d) Detailed description of the canvass form item by item

The canvass began on March 1 1995 and was completed on July 30 1995 A two part approach was used for this canvass including telephone and door to door contacts The information acquired for each home included name address phone number and number of residents age six or younger Additional information was acquired if there were eligible children in the home The canvass form used is included as Appendix 5

The canvass was initiated by phone After at least four attempts were made to contact a resident by phone follow up actions were conducted door to door Phone calls and home visits were made on different days and at different times of the day A minimum of five attempts combining telephone and door to door visits were made for each home in the study and control areas

To aid with the telephone process a criss cross directory was utilized A criss cross directory provides lists of residents by street with phone numbers providing an effective canvass management tool facilitating the transition from telephone to door to door efforts The criss cross directory used was produced two years earlier by a local phone company and only covered the study area Unfortunately a newer directory was not available and residents of the area are somewhat mobile Although the dated directory did pose several problems requiring some effort to update the data, it still provided an excellent starting point for the telephone portion of the census

The problems encountered when accomplishing the canvass of the study area were compounded due to the recent consolidation of the towns of Rivermines Flat River Esther and Elvins into the new township of Park Hills This resulted in 53 recent street name changes in Park Hills The adjacent town of Desloge had also recently changed the names of 26 streets in response to the realignment of the surrounding community This made many homes difficult to locate and some properties difficult to define The problems introduced by these changes were minimized by the efforts of the St Francois County Health Department They updated much of the directory by hand divided it into manageable sections and distributed it to the canvassers

The control area was separated by approximately a one and one half hour travel time from the study area Three phone lines were installed at the St Francois County Health Department with toll free numbers to Salem, MO to facilitate the phone canvass After several attempts were made by phone to each home in Salem, a team of canvassers traveled to Salem for five days to complete the door-to door follow up

POPULATION SAMPLING STRATEGIES

Study Group Recruitment

All recruitment in the study area was accomplished by telephone contact from the St Francois County Health Department The telephone recruitment was preceded by a letter from the local health department explaining the hazards associated with lead and the benefits of participating in the study (Appendix 6) When it became apparent that the population would be exhausted a newspaper advertisement was placed in the local paper (Appendix 7) to identify interested residents missed during the canvass and those who might have initially declined

Homes with phones were called at least five times Those that could not be reached by phone were recruited door-to door

Control Group Recruitment

Prior to the initiation of recruitment efforts in the control area, the local law enforcement authorities were notified of the upcoming recruitment This enabled them to resolve residents concerns that may have been generated by a study recruiter inquiring about their children The Dent County Health Department was also notified and provided background information on the study to enable them to thoroughly address questions from concerned callers

The control area recruitment was initially attempted via telephone by a male representative from SLUSPH. After approximately 20 calls it was believed that local residents were suspicious of a stranger calling their home and inquiring about their children The approach was then changed to door to-door It was hoped that a personal visit from a recruiter wearing an appropriate identification card would alleviate the suspicions of the residents This approach did not appear to be substantially more effective Approximately 30 eligible homes were visited and consent was acquired from 7 (23%) However because of the number of homes with eligible children in the comparison area, a consent rate of greater than 50% was needed to gain the desired number of participants

A factor in this low response rate was thought to be the use of a single male recruiter visiting homes during the day when many mothers were home alone with their children Although every effort was made to show the legitimacy of the recruiter with professional apparel and the wearing of visible identification the reception was still suspicious and often negative In an effort to resolve this uneasiness a team was formed of one male and one female representative Although this did resolve much of the apparent nervousness of the individuals approached, the consent rate was still inadequate with approximately 30% of contacted homes agreeing to participate in the study

The feedback obtained from those who refused seemed to indicate a fundamental lack of awareness concerning lead hazards In an effort to increase their awareness and willingness to participate a letter was drafted placed on Dent County Health Department letterhead and signed by the local health department director The letter was sent to homes not yet contacted and to homes that had been contacted but had not yet agreed or refused to participate It was anticipated that this would not only increase awareness but also reduce the perception that this was an activity being accomplished solely by agencies and organizations outside the community The letter was somewhat effective however the response rate was still not adequate

In a final attempt to increase the consent rate of those remaining a secretary from the Dent County Health Department agreed to contact the remaining homes by phone It was believed that having a local resident make the contact would bring greater legitimacy to the effort thereby resulting in a more successful recruitment Since it was apparent that the available control population would be exhausted an advertisement was placed in the local paper (Appendix 8) soliciting the involvement of any eligible homes in the area It was hoped that this would identify any homes missed during the census and provide an opportunity for residents who initially declined to reconsider involvement in the study

Homes were visited at least four times during different days of the week and different times of the day Also those with phone numbers were attempted numerous times

1 Sampling Team Development

a Team Composition

There were a total of three primary sampling teams In addition, there was one back up sampling team to act as individual substitutes or whole team substitution as the need arose Each sampling team was comprised of three individuals an environmental sanitarian, a nurse and a nurse phlebotomist Although all team members were cross trained to obtain environmental samples and perform household interviews only the environmental sanitarian was trained to use the X ray Fluorescence Spectrometer (XRF) for direct determination of lead paint concentrations In addition, only the nurse phlebotomist collected the blood samples Appendix 9 contains information on team members and responsibilities

b Team Training

The first two primary sampling teams and the back up team attended a two day in house seminar (July 19 20 1995) The training was provided by SLUSPH and DOH staff Training was provided on overall study protocol and questionnaire administration, environmental sampling protocol for obtaining field samples (soil water dust wipes XRF measurements floor vacuum and vacuum bags) storage and chain of custody methods and requirements A one day (August 4 1995) mock field sampling exercise at two homes was performed using the finalized sampling protocols The third primary sampling team entered the study at a later date and was trained in a similar manner over a two day period (September 20 21 1995) by the same personnel and two of the primary sampling team members

c Team Supervision

During the first two days of field sampling (August 8 - 9 1995) the primary teams were closely supervised for proper performance of the sampling protocols for blood environmental measurements and samples and interview methods by SLUSPH and DOH staff In addition, the field sampling teams were supervised through periodic visits and observations of sampling practice throughout the sampling period

BLOOD COLLECTION AND ANALYSIS TECHNIQUES

Venous blood samples were collected from children in the study and comparison groups The CDC protocol for blood collection and shipment was followed Samples were analyzed for blood lead levels The analysis was conducted by the Missouri Department of Health State Public Health Laboratory and the Division of Environmental Health Laboratory Sciences (DEHLS) Centers for Disease Control and Prevention (CDC) Atlanta, Georgia These laboratories are certified by the National Lead Laboratory Accreditation Program Protocols for blood collection are included in Appendix 10

Environmental Sampling and Analysis

Outdoor soil, household soil/dust, drinking water and selected paint samples were collected at the residence of each study and control participant Painted surfaces inside and outside of each residence that may have been a source of lead exposure to the study population were evaluated for lead content with the use of a portable XRF monitor a NITON™ XL Quality control measures practiced during all procedures included split samples with secondary laboratory analysis side by side sample collection, and submittal of National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) as a blind reference sample All samples were collected and stored in pre labeled and numbered zip lock 4 mil (0 004 inch thickness) re sealable plastic bags All sampling methods record keeping requirements forms used and additional information recorded is described in detail in the Environmental Sampling Protocol Standard Operation Procedures in Appendix 11

1 Sampling Methods Location and Rationale

a Soil

Outdoor soil sampling included up to five with a minimum of four composite soil samples collected from each of three locations (1) the non play yard area surrounding the house (yard) (2) the area surrounding the foundation of the house (dripline areas within three feet of structure walls) and (3) indicated/designated play areas within the yard Each sample of a composite consisted of the first one half inch of normal top soil without vegetation obtained with a slotted 7/8 inch soil recovery probe (HUD 1993 E 8) Soil samples were taken from up to five (with a minimum of four) sites for each composite At the time of sampling the soil condition as to compaction, moistness and extent of vegetation was assessed and recorded

Yard area composite soil samples were used to assess environmental sources other than exterior paint that may contain lead Dripline sampling assessed contributions from exterior lead paint In addition, it assessed ambient airborne particulate sources that may impact the house structure and wash off with precipitation Yard play area samples were used to assess primary outdoor play area exposure sources

The four main sides of the residence delineated the drip line composite sample area Where there was a distinct difference in the house exterior structure a fifth side/sample was added Each sample was collected from approximately the center of each designated side at least three feet from any visible water run off area, such as a rain spout between six and thirty inches from the wall and when possible from a non vegetated location

The yard area composite sample areas were also determined by using the natural outlines of the residence to segregate the yard into four main boundary areas by drawing an imaginary line from each corner of the residence to the closest corner boundary of the yard A fifth area was added when the house and yard configuration warranted Within each boundary area, a sample was obtained as close to the center of each boundary area as feasible from non vegetated areas that were not considered play areas and were at least three feet from a water run off source

The yard play area composite samples were obtained from those areas indicated as such by the parent/guardian Composite samples were collected from as close to the center of each area as feasible and in a non vegetated location when available Sand boxes and other non soil areas were not included

In addition to environmental sampling at residences community play grounds that were indicated by the participants parents to be main play areas were sampled Composite soil samples were obtained from five locations within the observed play regions From visual observation, the observed play areas within each community play ground were divided up to five regions of approximate equal size as possible A soil sample was obtained as close to the center of each region as feasible from non-vegetated areas when available XRF measurements were performed on playground equipment These sampling protocols are included in Appendix 11

b House Dust

Indoor house dust samples were obtained from three sources (1) collection of the bag filter within the household vacuum cleaner when available (2) a composite vacuum sample taken from up to five one square foot locations of the household (child s bedroom, main entry area and up to three play areas) using a modified University of Cincinnati method (HUD 1992 pp L10 14) and (3) a composite wipe sample using Wash n Dri wipes (Millson, et al 1994 Ashley 1994) from a measured area of up to five operable window sills randomly selected in the child s bedroom and main play areas (HUD 1992 pp L15-17) These sampling protocols are included in Appendix 11

c Paint

Painted surfaces that had the potential for being a current source of lead exposure were evaluated for lead content with the XRF monitor Indoors this included up to a total of four rooms three rooms indicated as primary play areas and the child s sleeping area For indoor outdoor and detached painted surfaces that were found to contain greater than 0 7 milligrams of lead per square centimeter of area (mg/cm^2) the surface type physical condition, damage type potential source of damage and total and damaged square footage of each painted surface was determined Paint chip samples for subsequent analysis were only obtained if a valid XRF reading could not be made or if XRF readings were $\geq$ 0 7 mg/cm^2 and a representative paint chip was available from a damaged area (no paint surfaces were to be damaged to obtain a paint chip sample) These paint chip samples were only used to help in determining the source of the lead found in selected dust samples These sampling protocols are included in Appendix 11

d Water

First draw (defined as no water usage within the past 8 hours) kitchen tap water samples were collected A sample was collected from the kitchen cold water tap into a 250 ml polyethylene bottle (containing nitric acid preservative) These sampling protocols are included in Appendix 11

2 Samplıng Protocol

Envıronmental samples were obtaıned at each study sıte through use of field XRF samplıng dust wıpe of wındow sılls filter vacuum of floors collectıon of household vacuum cleaner bag or contents paınt chıp samples drınkıng water and soıl samples Fıeld samplıng teams also completed forms assessıng the characterıstıcs of envıronmental samples (ıncludıng condıtıon of lead paınt and sample matrıces) and an exposure assessment evaluatıon (See Appendıx 11 for field samplıng protocols and data collectıon forms)

The daıly field samplıng protocol consısted of

a) Preparatıon for field work (assurıng all needed supplıes are present obtaınıng addresses loadıng vehıcles etc)
b) Completıon of consent forms prıor to samplıng
c) Home schematıc drawıng and determınatıon of ındoor sample locatıons whıch ıncluded the study chıld s bedroom up to three prımary play areas and the maın occupant entry An outdoor schematıc ındıcatıng the outdoor soıl sample areas and a Global Posıtıonıng System (GPS) readıng for the study sıte locatıon
d) XRF analysıs of all paınted and varnıshed surfaces wıthın sample locatıons outsıde wall areas and detached structures
e) Collectıon of paınt chıps ıf no valıd XRF result could be obtaıned or ıf XRF readıngs were $\geq$ 0 7 mg/cm^2 and ıf the sample could be obtaıned wıthout damage to the surface
f) Wındow sıll wıpes of up to five operatıonal wındows from the ındoor sample sıtes
g) Floor filter vacuum of one square foot ın each of the ındoor sample locatıons
h) Separate Composıte soıl samples from up to five sıtes each of the house drıp lıne non play area yard play area yard and communıty play areas
ı) Chaın of custody forms for all collected samples and
j) Pre and post calıbratıon of XRF and vacuum pump used to obtaın floor cassette vacuum sample

SAMPLE ANALYSIS METHODS

The prımary laboratory used was TC Analytıcs located ın Norfolk, VA The laboratory ıs accredıted by the Amerıcan Industrıal Hygıene Assocıatıon (AIHA) for metals analysıs and partıcıpates satısfactorıly ın the EPA Lead Profıcıency Analytıcal Testıng (ELPAT) Program for paınt chıps soıl and dust wıpes Through the Commonwealth of Vırgınıa, Department of General Servıces Dıvısıon of Consolıdated Laboratory Servıces the laboratory ıs certıfied to perform drınkıng water analysıs for lead The secondary lab used for the preparatıon of Standard Reference Materıals (SRM s) and analysıs of duplıcate and splıt samples was Mıdwest Research Instıtute (MRI) ın Kansas Cıty MO MRI ıs certıfied by the Amerıcan Assocıatıon for Laboratory Accredıtatıon (AALA) under the ELPAT Program for lead ın soıl paınt chıps dust aır and drınkıng water Laboratory certıficatıons are lısted ın Appendıx 12 Lead analysıs was performed usıng the methodologıes ın Appendıx 13

Laboratory analysis specifications on instrument method detection limits and instrument practical quantification limits for milligrams of analyte per liter of solution (mg/L) along with the digestion volume were used to determine the practical quantification limits (PQL) and method detection limits (MDL) for the primary lab reported in Appendix 14 The limits for the secondary laboratory met or exceeded these limits The MDL s were determined using the procedure outlined in CFR 40 Part 136 Appendix B The PQL s were considered to be the lowest standard used in the calibration of the instrument The reported limits take into account the digestion volumes for the samples

1 Identification of Source Contributions

Source apportionment of lead in house dust soil and airborne particles from potentially contributing sources is a difficult task Determination of source contributions may be affected by many factors such as similarity of chemical make up of the lead analyte from different sources and environmental chemical processes that occur due to solubility and changes in pH leading to chemical degradation and transformations to other lead species during transport and over time

An automated individual particle analysis (IPA) based on scanning electron microscopy (SEM) and X-ray energy spectroscopy (EDX) was used to assess the potential originating sources of the lead found These techniques have been shown to be able to discriminate between lead particles at the individual level when bulk sample analysis indicate compositionally similar products (Hunt et al 1992) Chemical/elemental morphology and composition is determined through SEM and EDX analysis Particles with morphologies and elemental associations characteristic of different particulate lead source types can be identified and enumerated If a classification scheme for IPA results can be developed that provides distinctive signatures for the different source type materials it can be applied to ambient dust samples analyzed under identical conditions providing a descriptive source apportionment Based on knowledge of product composition and potential degradation products groups of particles that most likely are derived from the same source can be probabilistically identified on the basis of morphology and composition

This method has been used in the United Kingdom as part of a comprehensive study of lead contamination in environmental dusts and as part of a lead contamination study in Australia (Johnson and Hunt 1994) as well as in studies to determine lead sources near a lead smelter in Missouri (Vander Wood and Brown, 1992) At present this method generates essentially semi-quantitative results but should be sufficient for discriminating between lead derived from paint alone or other environmental sources such as mining waste piles (Johnson and Hunt 1994) Assessment of the samples for source contribution was performed at the State University of New York, College of Environmental Science and Forestry Department of Chemistry

QUALITY CONTROL MEASURES

To assure quality control in the environmental sampling and analytical protocols employed the following methods were used

1 Use of laboratories with good laboratory practice as evidenced by their accreditation through the AIHA Laboratory Accreditation Program for metal analysis or the AALA (Appendix 12)

2 Use of laboratories participating in the ELPAT program with satisfactory proficiency (Appendix 12)

3 Inter and intra laboratory QA/QC results were reported as required under their accreditation programs The minimum procedures frequency and criteria for these quality control practices are shown in Appendix 15

4 Submission of blind NIST SRM samples mixed with the field samples (Appendices 16 and 17) SRM was prepared by the secondary laboratory MRI using NIST standards and spiked onto vacuum filter cassettes dust wipes water and soil samples and submitted to the primary laboratory blindly along with collected field samples The sample results obtained from the primary laboratory were submitted to MRI for a QC evaluation and a reporting of the absolute and percent difference The NIST SRM s used for the spikes are listed in Appendix 16

5 Submission of field sampling blanks (Appendix 17) Media blanks for vacuum cassette filters dust wipe media, sample storage containers and gloves worn during field sampling were submitted and analyzed to assess possible contamination inherent in the sampling protocol from the presence in the field or from transport

6 Preparation and submission of split soil and water samples to a second laboratory for inter-laboratory comparison Composite soil and water samples were split and one sample submitted to MRI for sample preparation and analysis concentration verification (Appendix 17)

7 To assess variability of the analytes within the soil sample media, a second side by side sample was taken for the soil samples within six inches of the first sample (Appendix 17) and

8 All blood lead samples were analyzed by Missouri Department of Health State Public Health Laboratory Duplicates from 74% of these samples were also analyzed by the DEHLS The results from the two labs were correlated at r = 97 and an alpha coefficient of reliability of 98 This value indicates a very close agreement between laboratories

Quality Control for Data Entry

Data was entered into a Microsoft Access Data Base system from the original data collection forms Quality control was performed through the use of data range delimiters which would indicate data fields containing improper values such as letters instead of numbers or values outside of allowable ranges and a random re check of data entry for 10% of all household files

Not including the questionnaires a total of 31 case files (11%) were re checked for entry error rate from the data collection forms Each case file contained from 17 to 21 separate forms with approximately 50 entries per form, for an approximate total of 950 entries per case file A total of 65 entry errors were found and corrected for an error rate of 0 2% per case file or 0 01% per form An initial re check of 20% of the questionnaires (60) was performed for data entry Each questionnaire contained approximately 150 entries and demonstrated an error rate of 2 4% per questionnaire This was found to have resulted from a format error in the data base entry form After the format error was corrected, an additional 9% (28) questionnaires were rechecked for data entry A final error rate of 0 1% was found per questionnaire

Quality Control for Environmental Samples

Entry of environmental sample analysis results were cross referenced with sample numbers on the chain of custody forms as the results were received and double checked on entry Data-base delimiter parameters were used to immediately indicate any values outside of expected value ranges to be re checked A 10% quality control check of environmental analysis data entries showed no entry errors Two soil samples were lost due to inaccurate labeling of sample containers and chain of custody forms in the field Given the number of total environmental samples (over 2 500 excluding blanks splits and blind reference samples) this resulted in a sample loss rate of less than 0 08%

In general the quality control results indicated good accuracy precision, and no interferences Analysis of field blanks indicated no contamination or interference from the field sampling collection media during field use shipment, and handling The analysis of blind reference materials showed good recovery and accuracy by the primary laboratory with possibly low recovery or loss of sample possible with filter cassettes The split sample analysis showed good agreement between the primary and secondary laboratory The side by side samples indicated good precision within the primary laboratory as well as consistency within the soil matrix and compositing procedure

Appendix 17 shows the frequency of quality control submittals which were achieved Almost all quality control submission rates were as intended or exceeded the intended rate The situations where the achieved rate was less than intended (which were only for field blanks for the gloves and collection bags) were due to chance The field study sampling was ended prior to the time the field sampling teams would have obtained the last field blank of these items

Standard Reference Material (Blind Reference)

These samples were inserted into the sampling chain of custody protocol in the same manner as field samples to monitor the performance of the laboratory analysis These samples also provide laboratory analysis analyte recovery information for assessing the accuracy and precision of field sample data through sample preparation and analysis activities It should be noted however that the accuracy and precision achieved for field samples is partially dependent on the matrix matching between the QC sample and field sample since analytical results are generally matrix sensitive It is not possible to completely match the matrix of the field sample This is particularly difficult for soil samples but the use of split samples as a QC tool helps to compensate for this loss

A summary of the SRM or Blind Reference sample results are shown in Table 2 Actual concentration values obtained are not shown Instead the ratio of the reported lab result to the SRM known concentrations are reported Descriptive statistics presented include the total number of samples number of samples reported between the practical quantification limit (PQL) and method detection limit (MDL) number of samples reported below the MDL minimum, maximum geometric mean (GM) natural log standard deviation (LNsd) and lower and upper 95% Confidence Limits (CL) for these ratios

Except for the cassette filter all ratios of the laboratory value to the reference value for all media were close to one indicating good recoveries and accuracy in the analysis In all cases except for one maximum drinking water and one minimum vacuum cassette sample the minimum and maximum ratios were within the CL For drinking water one value exceeded the upper CL by just over 2% The stability of the drinking water SRM solutions over time was proven through testing of aliquots of stored solution over the sample submittal period (September 1995 through February 1996) The average concentration was found to be 24 26 ug/L with a standard deviation of 0 46 ug/L

The recovery on the cassette filters had a GM of around 50% and two of the vacuum cassette samples were well below the lower 95% CL and could be considered outliers Censoring of these two values as anomalies showed an improved sample recovery response with a GM of around 60% The poor recovery of sample with the filter cassettes was most likely due to loss of media onto the cassette through static charge and material movement In addition, the reference material used (Urban particulate) was of a much different consistency than the material collected in the field It was finer of more uniform size and did not contain the organic materials that were collected in field samples This material was placed on the filter rather than vacuumed which resulted in a lower adherence There was no embedding into the surface material that would happen with the field samples During the transfer of the filter it was much easier to lose the reference type material than the field material It was expected that the recovery of field samples is greater than for the reference material A typical accepted tolerance for SRM samples is within 80% to 120% of the true value (percent error of 20%) All SRM summary results excluding the vacuum cassettes fell within acceptable ranges

Field Side-By-Side Samples

Side by sides soil samples were included to determine variability due to the sample collection process and the natural variability due to environmental conditions Ratios of the paired samples greater/lessor values were determined for analysis Table 2 reports descriptive statistics that include the number of samples number of total samples between PQL and MDL number of samples below MDL minimum and maximum ratio GM ratio LNsd and 95% upper CL

The inherent variability between field samples was evident in these results Despite being collected side-by side (within six inches of each other) a number of pairs were measured to have very different lead contents as reflected in the higher ratios GM difference of 64% and relatively large estimated upper 95% CL The removal of one outlier from the lead sample showed an improved maximum ratio difference of 6 8 and a GM difference of only 39% with an R squared of 0 81 These values indicated a relatively good homogeneity within the soil samples obtained and a consistent sampling procedure

Split (Duplicate) Samples

Split or duplicate samples are expected to be relatively similar in analyte content because they are representative samples from a composite field sample collection mixture One of each of the two samples were sent to the primary and secondary laboratories The descriptive statistics were the same as generated for the field side by side analysis and are summarized in Table 2 Due to variations in compositing and media, a normal tolerance for split sample analysis is 40% Although the lead analysis for vacuum filter samples was close to the extreme of the range all GM ratios were within this range The soil split samples agreed very well, and when three of the soil lead outliers were taken into account the soil GM ratios of differences were below 30% The R squared value for soil lead was 0 89 and for vacuum bag lead was 0 44

The water split sample ratios were almost 1 with very little range between the minimum and maximum ratios Almost all water samples were below the PQL so a meaningful R squared value could not be determined Results for soil and water split samples indicated very good agreement between the two labs and were indicative of good accuracy and precision in the sample results

Field Blanks

Field blanks are identical to regular field samples except that no sample is actually collected Field blanks provide information on the extent of contamination experienced through field samples resulting from a combination of laboratory processing and field handling The field blank samples were analyzed for lead A summary of the field blank results are presented in Table 2 The descriptive statistics were the same as generated for the SRM The upper CL was only reported since the reported concentration limits could not go below the MDL All of the cassette filter and dust wipe results for lead were below the PQL The largest lead concentration reported for a field blank dust wipe was 13 8 µg The GM for lead was 4 9 µg All of the GM for the field blanks were very close to their respective PQL s Data suggest that no contamination of field samples occurred during the sampling handling, and field transport activities

DATA ANALYSIS

Statistical data analysis was performed by SLUSPH The Statistical Package for Social Sciences (SPSS) was used The variety of statistical analyses included

- Comparison of mean blood lead and environmental lead data between the study and control populations by t test and analysis of covariance

- Comparison of proportion of children with blood lead levels above 10 μg/dl between the two groups using chi square analysis

- Comparison of mean blood lead levels between various risk factor groups by t test and analysis of variance and
- Correlation analysis was used to assess the relationship between blood lead levels and a number of environmental variables (soil, dust paint water lead condition of house etc) behavioral variables demographic variables socio economic variables and household characteristics

RESULTS

CANVASS INFORMATION

The Study and Control areas were somewhat different in dimensions however findings indicate they were demographically very similar A comparison of the study and control area canvass can be seen in Table 3 At least 95% of the homes in each area were contacted by either telephone or home visit The canvass required a total of 5 937 phone calls with a mean of 1 62 calls needed for those homes successfully contacted by phone and 6 553 home visits with a mean of 1 25 visits needed for those homes successfully contacted by door to door visits This combined approach proved to be effective in meeting the objectives of the canvass Of the homes successfully contacted by phone 65% were reached on the first call and 86% by the second Comparing this to the home visits 82% of homes successfully contacted by a visit were reached on the first visit and 94% were contacted by the second

Recruitment Information

The canvass of the study area identified 779 homes eligible for participation in the project From the 779 30% participated in the study 39% refused to participate 8% canceled their appointments after initially consenting 11% moved or refused to participate due to an anticipated move and 2% could not participate for other reasons Others excluded had children that were not yet six months old or had children who were older than 90 months In summary those refusing canceling moving or excluded for other reasons totaled 60% of the homes There were also 10% of the homes that could not be contacted (Table 3)

The canvass of the control area (Salem Missouri) identified 249 homes eligible for participation in the project From the 249 29% participated in the study 29% refused to participate 14% canceled their appointments after initially consenting 10% moved or refused to participate due to an anticipated move 10% could not participate for other reasons In summary those refusing canceling moving or excluded for other reasons totaled 63% of the homes Another 8% of the homes could not be contacted (Table 3)

Descriptive Statistics of Study and Control Areas

This study evaluated 235 children from an area of Missouri where lead mining had taken place over the past century (study) and 72 children from an area where lead mining had never taken place (control) The children were between the ages of six and 90 months at the time of sampling except for one child who was 92 months This child was included because an incorrect date of birth was obtained during the canvass Since a blood sample had been obtained and the child was only two months over the cutoff date the child was retained Statistical analysis was repeated without this child without any effect on mean values

Figure 2 presents the frequency distribution of blood lead results for the study and control groups Blood samples could not be obtained from nine children in the study area and three children in the control area Seventeen percent of the children in the study group had blood lead levels greater than or equal to 10 µg/dl the level of concern established by the Centers for Disease Control and Prevention (CDC) and 3 5% had levels greater than or equal to 15 µg/dl Only two children in the study group had levels greater than 20 µg/dl In the control group two children had blood lead levels of 10 µg/dl Remaining blood lead levels were less than 10 µg/dl

Table 4 presents the responses to the questionnaire administered to a parent or legal guardian of each child The information was obtained from the mother in approximately 86% of the interviews Both the study and control groups were of similar age with an overall average age of 3 72 years Approximately 50% of both groups were female and all except three children in the study group were white The distribution of household income was similar between the two groups The distribution of years of education was also similar except that slightly fewer mothers in the control group finished high school In the study area, 48% of the homes were built prior to 1960 compared to 32% of the homes in the control area Significantly more homes in the study area were owner occupied than in the control area, 62 3% versus 45 8% Plastic pipes were predominant in the study area homes while copper piping was most frequently used in the control area The source of water for both the study and control groups was almost always from a public water system, however significantly more children in the study area drank bottled water Numbers in the tables will not always be the same as the number of children recruited because some measurements could not be made on every child

Almost half the homes in both areas have had some form of renovation within the past year particularly in the child s bedroom Over 20% of the homes in the study area used mining material in the yard compared to 4% in the control area More often a household member in the study area repaired automobile radiators and worked in auto maintenance Although a number of household members in both groups worked in occupations or had hobbies that might result in contact with lead, there were no other differences between the two groups that might result in bringing lead contamination into the home Few people in either community currently work in a lead mining activity

Slightly more households in the control community used foreign made clay pottery or ceramic dishes to prepare serve or store food or drinks There were no differences in the use of copper or pewter between groups Few differences in housecleaning methods or frequency were evident between the two groups except the study group is more likely to dry dust

Approximately 50% of the households in both areas had at least one person that used tobacco products in the home Of those families with children less than two years of age more children breast feed in the control area Children spent similar amounts of time playing on the floor in both groups approximately 5 5 hours per day Children seemed to play outdoors a little more often in the control area than in the study area and when playing outdoors they spent more time there Over 40% of children in both groups had a favorite blanket or toy but study children were less likely to put that item in their mouth More households in the study area had a vegetable garden in which children were more likely to eat from while control children were more likely to eat vegetables grown elsewhere in local area

Comparison of Blood Lead and Environmental Factors

Table 5 presents a comparison of mean blood lead levels and environmental data between the study and control groups The average blood lead values were almost twice as high in the study compared to the control group 6 52 and 3 43 µg/dl respectively There was also significantly more variation in the study group The concentration of lead found in the vacuum bag was seven times higher in the study area compared to control area The lead concentration found in the soil of the designated play areas of the study group was over 10 times that for the control area In both areas the soil lead at drip line was higher than the average of the yard soil It is interesting to note that the soil lead levels in the play area were higher than the average for the rest of the yard All values for lead collected from the floor using the vacuum cassette sampling method were significantly higher in the study area This was also true of the dust wipe samples taken from the window sill Indoor XRF reported readings tended to be higher in the study area Outdoor XRF readings were similar in the two groups In the study area, 72% of the homes had indoor XRF values greater than zero mg/cm^2 and 55% had values greater than or equal to 7 mg/cm^2 Outdoor areas greater than zero mg/cm^2 occurred in 80% of the homes and 64% of the homes had XRF readings greater than or equal to 7 mg/cm^2 on outdoor surfaces Water lead levels were slightly higher in the control group however this was not statistically significant Although measures of dustiness of rooms were slightly lower in the study area the differences were not statistically significant

Mean blood lead comparisons were repeated correcting for total indoor XRF and total outdoor XRF values because of the differences in XRF values for the study and control homes This also adjusts for age of house which differed between the two groups Age of house correlates with the objective measure of lead paint XRF These XRF measures were chosen as covariates because they had the highest correlation with blood lead levels The mean values for the study and control groups before correcting for covariates were 6 52 and 3 43 µg/dl and after correction were 6 44 and 3 70 µg/dl respectively No other factors were determined to be confounding variables

BLOOD LEAD COMPARISON ON CATEGORIES FROM QUESTIONNAIRE

Table 6 displays blood lead level comparisons between various categories on the questionnaire A t test was used for two category comparisons and analysis of variance was used for multi category comparisons Care should be taken when interpreting the data in categories that contain less than five children because the significance level might not be meaningful It is possible to collapse groupings with multi-category variables that contain few children, however it was decided to show all categories for the readers information A one way analysis of variance was chosen because the purpose of this analysis was to investigate potential confounding variables not to compare study and control groups

Blood lead levels for males and females were not significantly different from each other Within both groups average blood lead levels decreased with an increase in income but the differences were only statistically significant for the study group Blood lead levels tended to decrease with increasing levels of education A comparison between homes built before 1960 and after 1960 showed a significant difference in both the study and control groups however the difference was only on average approximately 1 µg/dl Children who came from homes that were rented tended to have slightly higher blood lead levels than children coming from resident owned homes however this difference was only significant for the control group

In the study group blood lead levels were similar for children using public water and those using bottled water The blood lead levels however were significantly lower in children using well water for both drinking water and water for cooking (note the number of children using well water was quite small) When a family member worked in auto bodies or auto maintenance children in that household had higher blood lead levels than for children with family members not involved in these occupations Six family members in the study group indicated that they casted or smelted lead The children in these families had significantly higher blood lead levels The few children who were in families with members who recently worked in mining had significantly higher blood lead levels than children from non mining families Although there was a significant difference between the categories of dry sweeping the pattern of differences was not consistent Children living in homes that always dry sweep have the highest blood lead levels however the next highest level is in families who never dry sweep

Household cigarette smoking is associated with significant higher blood lead levels There is a very consistent pattern associated with a child playing in dirt The more frequently that this occurs the higher the blood lead levels The more often that a child takes food snacks or candy outside the higher their blood lead levels

Correlational Analysis

Table 7 presents correlation coefficients and significance levels for various environmental factors and questionnaire data correlated with blood lead levels in children in the study area Table 8 displays this data for the control group A level of 0 10 was chosen as borderline significance and of potential interest in interpreting the results

Most environmental measures reported in Table 7 for the study area were significantly correlated with blood lead levels A number of correlation coefficients were statistically significant for the questionnaire data

Higher blood lead levels in children were associated with the following

- Homes using a dry sweep method more often
- Children who play in dirt more often
- Children who take food outside more often
- Children who wash more often before sleeping
- Children who carry a favorite toy around more often
- Children who swallow things more often

Lower blood lead levels were associated with the following

- Children who wash more often after playing in dirt
- Children who chew fingernails more often
- Mothers who have higher education levels
- Families who spend more on food and
- Families who have a higher household income

The only environmental factor for the control group (Table 8) that was significantly correlated to blood lead levels was the lead level of the yard soil The only significant correlations with questionnaire data were how often the child plays in grassy areas how often the child plays in dirt how often a child uses a pacifier the mother s education level and the household income

Table 9 shows correlations between dust and soil lead measures in the study group The only significant relationship was between soil lead at the drip line and wipe samples of the window sills Total XRF values were significantly correlated with lead concentrations in vacuum bag lead concentration in soil at drip line and dust wipe samples of window sills (Table 10)

In all cases the correlation coefficients are low and have only limited predictive value They do suggest relationships between a number of environmental and sociobehavioral factors and blood lead levels that can be utilized in designing an intervention project

IDENTIFICATION OF SOURCE CONTRIBUTIONS

Individual Particle Analysis (IPA) technique with the use of automated scanning electron microscopy (SEM) coupled with image analysis and X ray energy spectroscopy was used to

1 Determine whether particulate lead forms in the mining waste materials in the study area could be distinguished from those of lead bearing paint origin

2 Determine a classification scheme to discriminate mining waste particulate from paint and

3 To estimate the source contributions to the lead present in household dusts

The results from analysis of samples from five different composites of mining waste piles and twelve paint chip samples were used to develop an algorithm for assessing source contribution A composite of six study area soil samples which did not contain paint chip samples indicated that a classification scheme was possible to separate the results of IPA measured characteristics into source descriptive categories This classification scheme was used to identify and proportion the relative percent contribution for source of lead found in vacuum bag dust samples for eight selected study area homes The homes from the study area were selected randomly from homes that were found to contain lead based paint as well as lead within yard soil vacuum bag dust and window sill wipe samples

Table 11 indicates the range and median percentages attributed to the source categories of waste pile paint, soil or common (could not differentiate with IPA between the possible sources) The common category was based on the presence of lead oxide and lead carbonate that were oxides of lead from which the originating source could not be determined The formation of the oxides could be from weathering or fine abrasion The most conservative classification schemes are presented In addition to the final results for the source contribution to the dust in the home vacuum bags the application of the developed classification scheme on the waste pile paint chip and soil composite samples are also shown The first level of the classification scheme developed weights the percent attributed to a source category based on the volume sum of the particles analyzed and are identified as Waste Volume (WV) Paint Volume (PV) Soil Volume (SV) and Common Volume (CV) The second level additionally weights by the fraction of lead determined in each particle as shown by WVL PVL SVL and CVL respectively For example a comparison of WV and WVL for Waste Piles showed that the total volume of particles that were a source of lead and that could be identified as derived from the waste piles was 79 1% of the total particle volume Inclusion of the fraction of the lead present in the total volume indicated that only 69 4% of the lead measured could be said to have been derived from the waste piles In other words for this example even though the total volume was greatest from the waste piles (79 1%) for particles containing lead only 69 4% of the total lead measured could be said to have been derived from the waste piles

Using both the developed classification schemes on known waste pile samples (i e samples obtained from the waste piles) a high identification as to the actual source (69 4 79 1%) was

(1993) and Bjerre et al (1993) that found no relationships between environmental lead from mining operations and blood lead levels These conclusions have been questioned by Mushak (1991) and Gulson (1994) who argue that many of the reports suggesting the absence of relationships between blood lead and mining waste contaminated soil were based upon historic data of questionable epidemiological quality Lead in the mine waste from this study was also in the form of lead sulfate and yet the blood lead levels from children exposed to this waste were considerably higher than the control group

Gulson et al (1994) reported a positive relationship between lead mine waste and blood lead levels Soil and dust samples from a lead mining community in Australia showed a high degree of bioavailability Blood lead levels in 899 children (1 to 4 years of age) from a mining community showed that approximately 20% had blood lead levels greater than 25 µg/dl and over 85% had greater than 10 µg/dl They concluded that ingestion of soil and dust was the main pathway and source for the elevated blood lead levels reported for children living in this community In another lead mining and smelting area, an association between soil lead and blood lead levels in children age six 71 months was demonstrated (Cook, 1993) Additional evidence of a relationship between lead mining activities and blood lead was provided by Dutkiewicz et al (1993) who determined that blood lead values in a mining area were significantly higher than a comparison population Also a study of a mining area in Missouri with lead mining and smelting activities demonstrated that blood lead levels were approximately twice as high in the mining area compared to a control area and that 14% of the children had blood lead levels greater than 10 µg/dl compared to none in the control group (Murgueytio et al 1996)

The implications of elevated blood lead levels of children living in the study area goes beyond the children sampled for this study The 1990 census recorded 1702 children between the ages of 0 and 72 months living in the Big River mine area If 17% of these children were expected to have had elevated blood lead levels as determined in this study 289 children in 1990 would have been expected to have blood lead levels greater than or equal to 10 µg/dl and therefore were at risk for toxicological effects such as decreased attention span hyperactivity lower IQ scores (Ernhardt et al 1981 Needleman and Gatsonis 1990) child developmental problems (Bellinger et al 1987 Bellinger et al 1991 Dietrich et al 1987 Needleman et al 1990 Ernhart et al 1986 Lyngbye et al 1990) and decreased general measures of cognition (Bergomi et al 1989 Ferguson et al 1988 Fulton et al 1987 Hansen et al 1989 Hawk et al 1986 Hatzakis et al 1989 Lansdown et al 1986 Schroeder et al 1985 Silva et al 1988 Winneke et al 1990 Yule et al 1981) Estimating from 1990 census data, over 200 children are born each year into this area and become at risk for elevated blood leads resulting in approximately 34 new children becoming lead poisoned annually

To further evaluate the contribution of mine waste to the excess elevated blood lead levels a discussion of the relationship between lead in soil dust and paint should be considered It was assumed that sources of soil and dust lead were similar in the study and control areas except for the presence of mining waste in the study area This would be consistent with the environmental data and the results of the source characterization

All environmental measures of soil and dust lead were many times higher in the study group compared to the control group For example the soil lead levels in the children s play areas were 10 times higher in the lead mining area averaging 1282 µg/g (ppm) A composite of six soil samples from the study area were analyzed for source characterization Less than one percent derived from a paint source between 50% and 60% derived from mining waste and between 40% and 50% could not be determined as either waste or paint Since the soil samples were from the yard distant from the drip line they were not expected to have a large percentage of lead based paint It was expected that the source for a large percentage of the yard samples would not be identifiable due to chemical transformations that would alter the samples original physiochemical form The percentage of soil that was identified as derived from mining waste probably resulted from the transport of mining waste as fill or from being recently wind blown into the area

Source analysis of the household vacuum bag dust within the study area, based on particle volume indicated the proportion derived from the mining waste was 26% the proportion derived from a paint source was 16% and the proportion from soil was 37% In 15% of the lead identified a specific originating source could not be determined These results suggested that the waste piles were at least as important a contribution source as paint but it is reasonable to assume that a large percent of the source derived from yard soil originated from the waste piles The overall contribution, therefore of the waste piles may be two to three times the contribution from paint by both total particle volume and lead concentration

Further evidence that soil and dust lead in the study area related to blood lead levels were the significant correlations in the study area but not in the control area There was somewhat better correlation between dust lead and blood lead than soil lead and blood lead This might be related to a child spending more time inside the home than playing in soil outside the home or it might be an artifact related to the greater variation in soil lead levels The strongest correlation with blood lead levels in the study area was lead in dust on the floor followed by indoor XRF values followed by loading of lead on the window sill

Total XRF values were significantly correlated with lead concentrations in vacuum bag lead concentrations in soil at drip line and dust wipe samples of window sills but were not correlated with soil lead in play areas or with the lead concentration on the floor of the homes in the study area This indicated that both indoor and outdoor lead based paint contributes to dust lead and to drip line soil lead but not to soil lead distant from the house

This correlational analysis suggests that blood lead levels can be reduced by interventions that address all of these sources Interventions might include remediation of mine waste material that children are exposed to through soil or dust and remediation or abatement of lead based paint in the homes Educational interventions might include limiting exposure children have to soil by covering lead contaminated soil with non contaminated soil and by planting yard vegetation Children s exposure to dust can be reduced by better housecleaning techniques by keeping children s hands and toys clean, and by controlling what a child puts in their mouths

XRF values were slightly higher for indoor paint in the study area To determine if this difference might confound the blood lead levels an analysis of covariance adjusting for both indoor and outdoor XRF values was performed The mean blood lead values were minimally affected by this adjustment The adjusted mean values were still approximately twice as high in the study area There was little or no difference in other potential confounders between the study and control groups and therefore no additional adjustments to the comparisons between study and control groups were necessary

The results of this study were remarkably similar to those reported for Jasper County Missouri a mining area on the western side of the state (Murgueytio 1996) In that area both mining waste and past local smelting contributed to the lead levels Fourteen percent of the children living in that mining area had blood lead levels greater than 10 µg/dl In the study reported here 17% had elevated blood lead levels The average blood lead level in the Jasper County study was 6 25 µg/dl in the study group and 3 59 µg/dl in the control group This is very similar to the average in the present study 6 52 µg/dl and 3 44 µg/dl in the study and control groups respectively

It was originally suspected that blood lead levels might be higher in the Jasper County study compared to this study because of the presence of diverse smelting operations in Jasper County resulting in a lead form that might be more bioavailable This proved not to be the case Results of the Big River study were very similar to the Jasper County study resulting in the conclusion that mine waste with or without smelting waste is related to elevated blood lead levels The results of the Jasper County and Big River studies combined strengthens the premise that exposure to lead mining waste elsewhere in the state or in the nation might result in elevated blood lead levels and therefore steps should be taken to reduce exposure to this lead source

CONCLUSIONS

The results of this study indicated that blood lead levels were a product of exposure to lead mining waste lead based paint and other sources Because the only substantial difference between the study and control area in terms of exposure to lead is the presence of lead mining mining waste was the most reasonable explanation for the dramatic differences between the blood lead levels in the two communities

RECOMMENDATIONS

1 Although mining waste accounts for the difference between the study and control area, both lead paint and soil/dust lead were related to blood lead levels Blood lead levels can be reduced by efforts to both reduce exposure to mining waste and to reduce exposure to lead based paint

2 An educational and environmental intervention program that addresses both of these sources should be initiated

3 Future studies should focus on effective interventions to reduce exposure and on adverse neurobehavioral outcomes such as school achievement and IQ XRF technology could be used to estimate long term exposure to lead by measuring accumulation of lead in bone These measures of exposure could then be evaluated against markers of cognitive development

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Table 1 — Area Population by Age and Gender from 1990 U S Census Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997 Study Area

Bonne Terre

Age Group (years)	Male	Female	Total
<1	9	26	35
1 2	63	44	107
3 4	58	65	123
5 6	60	72	132
Subtotal	190	207	397
≥ 7	1 628	1 846	3 474
TOTAL	1 818	2 053	3 871

Desloge

Age Group (years)	Male	Female	Total
<1	22	22	44
1 2	61	52	113
3-4	59	61	120
5 6	58	62	120
Subtotal	200	197	297
≥ 7	1 743	2 010	2 753
TOTAL	1 943	2 207	4 150

Table 1 — (cont) Area Population by Age and Gender from 1990 U S Census Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

Park Hills

Age Group (years)	Male	Female	Total
<1	57	63	120
1 2	119	122	241
3 4	129	143	272
5 6	129	113	242
Subtotal	434	441	875
≥ 7	3 239	3 821	7 055
TOTAL	3 673	4 262	7 935

Leadwood

Age Group (years)	Male	Female	Total
<1	10	5	15
1 2	18	16	34
3 4	24	10	34
5 6	22	28	50
Subtotal	75	59	133
≥ 7	532	582	1 114
TOTAL	606	641	1 247

Table 1 — (cont) Area Population by Age and Gender from 1990 U S Census Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997 Control Area

Salem

Age Group (years)	Male	Female	Total
<1	26	67	93
1 2	91	37	128
3 4	47	50	97
5 6	78	35	113
Subtotal	242	189	431
>7	1753	2302	4055
TOTAL	1995	2491	4486

Table 2 — Quality Control Summary Results Big River Mine Tailings Superfund Site Lead Exposure Study Missouri 1997

Type	Analyte	Unit	No. of Samples	No. < PQL/MDL	No. < MDL	Min	Max	Mean (GM)	Std	95% Confidence LCI	UCI
Field blanks Media ed V l											
Cassette Filters	l d	g	71	2	71	2.50	2.50	2.50	0.00		2.50
Dust wipe	l t	g	118	35	81	2.50	13.75	4.95	1.0(		40.08
Glove Wipes	l d	g	7	2	1	2.50	25	11.60	1.31		797.48
Bag Wipes	l d	g	4	0	4	2.50	2.50	2.50	0.00		2.50
Bl nd R f (SRM) Ratio f Pri ry Lab V l e/R ference											
Soil	lead	g/g	29	0	0	0.65	0.97	0.84	0.10	0.69	1.03
Cassett	lead	g	60	0	0	0.01	0.93	0.49	0.78	0.10	2.30
	l d	g	58	0	0	0.15	0.93	0.55	0.18	0.2(	1.17
Dust	l d	g	8	0	0	0.76	0.93	0.85	0.06	0.73	1.00
W t	lead	g/l	7	0	0	0.80	1.24	1.06	0.07	0.88	1.26
Spl t S mples R t f Greate V l e/Lessor V l											
S l	lead	g/g	62	0	0	1.00	11.38	1.43	0.50		3.90
	lead	g/g	59	0	0	1.00	3.01	1.30	0.27		2.22
V cu h gs	lead	g/L	14	0	0	1.02	3.75	1.52	0.46		4.06
W t	lead	g/l	28	2(	0	1.00	1.(7	1.05	0.12		1.36
S l D S d R t of G t r V l e/l r V l											
S l	lead	ug/L	35	1	0	1	63.91	1.64	0.77		7.87
	lead[7]	g/g	34	1	0	1	6.7(	1.47	0.44		3.62

1 IQL l ct 1Q nt l t L t 2. MDL M u Detect or l L 3 l sd = l g N Ist d d d t L 4 LCI l e C f der L L
5 UCL = Upper Confidence l L 6 g = er gram 7 R sult tl vnl f der t f d tl rs

Table 3 —Overvıew of Study and Control Area Canvass and Recruıtment Effort Bıg Rıver Mıne Taılıngs Superfund Sıte Lead Exposure Study, Mıssourı 1997

	Study Area		Control Area	
Area (square mıles)		20		2
Populatıon		17 270		4 484
Total number of homes		5 702		2 264
Total number of elıgıble homes for study		778		249
Recruıtment Summary	**Percent**	**(n)**	**Percent**	**(n)**
Refused	39%	(307)	29%	(72)
Canceled	8%	(60)	14%	(34)
Moved	11%	(83)	10%	(25)
Inelıgıble	2%	(16)	10%	(25)
Unable to contact	10%	(78)	8%	(21)
Consented	30%	(235)	29%	(72)
Total	100%	(779)	100%	(249)

Table 4 —Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study Missouri 1997

FACTOR[1]	STUDY (n = 235)	CONTROL (n = 72)	p-VALUE[2]
Person answering question			
Mother	85 1%	87 5%	
Father	8 9%	6 9%	
Grandparent	4 7%	4 2%	
Other person	1 3%	1 4%	954
Age (years)	3 70 ± 1 77[3]	3 80 ± 1 72	655
Gender			
Male	49 8%	47 2%	
Female	50 2%	52 8%	403
Race			
Black	1 3%	0%	
White	98 7%	100%	NA[4]
Total gross household income before taxes			
≤ $4 999	8 1%	20 8%	
$5 000 $9 999	8 1%	8 3%	
$10 000 $14 999	9 8%	11 1%	
$15 000 $19 999	9 8%	6 9%	
$20 000 $24 999	11 1%	4 2%	
$25 000 $29 999	11 1%	9 7%	
$30 000 $34 999	10 6%	8 3%	
$35 000 $39,999	8 1%	8 3%	
≥ $40 000	16 2%	20 8%	
Refused	0 9%	0%	
Don t Know	6 4%	1 4%	149
Highest year of education completed by the mother of the child			
No schooling	0%	0%	
Elementary School	12 8%	20 8%	
High School	49 8%	52 8%	
Technical or Trade School	9 8%	2 8%	
Junior/Community College	18 3%	15 3%	
Four year College/University	7 2%	6 9%	
Attended Graduate school	2 1%	1 4%	.277
Year house was built[5]			
<1900 1909	8 8%	0%	
1910 1919	3 6%	2 4%	
1920 1929	6 6%	2 4%	
1930 1939	8 8%	9 8%	
1940 1949	10 2%	12 2%	
1950 1959	10.2%	19 5%	
1960 1969	2 9%	24 4%	
1970 1979	16 8%	12 2%	
1980 1989	16 1%	4 9%	
1990 present	16 1%	12 2%	001

Table 4 —(cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 2ɔɔ)	CONTROL (n = 72)	p- VALUE
House rented or owned?			
Rented	34 9/	ɔ4 2/	
Owned	62 6/	45 8/	
Other	2 6/	0/	008
Type of water pipes			
Lead	1 7/	2 9/	
Plastic	45 7/	17 6/	
Galvanized Steel	10 4/	11 8/	
Copper	13 3/	50 0/	
Iron	0 6/	0/	
Mixed	27 7/	17 6/	
Other	0 6/	0/	<001
Source of house water for drinking			
Public water	91 9/	98 6/	
Well	2 6/	1 4/	
Other	5 5/	0/	NA
Source of house water for cooking			
Public water	96 2/	98 6/	
Well	2 1/	1 4/	
Other	1 7/	0/	NA
Source of child s water for drinking			
Public water	78 6/	97 2/	
Well	3 8/	1 4/	
Bottled	17 5/	1 4/	NA
Source of child s water for cooking			
Public water	91 9/	98 6/	
Well	2 1/	1 4/	
Bottled	6 0/	0/	NA
Water in kitchen faucet filtered or treated			
Yes	16 2/	14 5/	
No	83 8/	85 5/	450
Any part of house repainted sanded or stripped chemically or by heat within last year?			
Yes	48 7/	47 8/	
No	51 3/	52 2/	504

Table 4 —(cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p- VALUE
What part of house was work done in?			
Bedroom	45 3%	44 0%	
Living Room	22 1%	20 0%	
Bathroom	7 4%	16 0%	
Kitchen	8 4%	8 0%	
Outside walls	11 6%	12 0%	
Porch	5 3%	0%	
Deck	0%	0%	703
How often air conditioning is used during summer			
Never	7 2%	11 3%	
Rarely	1 3%	2 8%	
Sometimes	13 2%	5 6%	
Frequently	32 8%	19 7%	
Always	45 5%	60 6%	037
Where air conditioning is used			
Central	48 9%	50 0%	
Living/family room	33 8%	37 5%	
Child s bedroom	3 7%	1 6%	
Other bedroom	5 5%	0%	
Kitchen	1 8%	9 4%	
Other	6 4%	1 6%	012
Mine smelter or lead industry materials used in or around house or yard			
Yes	20 4%	3 8%	
No	79 6%	96.2%	002
Pets go in and out of house			
Yes	38 2%	38 0%	
No	61 8%	62 0%	548
In the last 90 days any member of household			
Painted pictures with artists paints?			
Yes	6 9%	9 7%	
No	93 1%	90 3%	283
Painted stained or refinished furniture?			
Yes	17 5%	19 4%	
No	82 5%	80 6%	415
Painted the inside or outside of a home or building?			
Yes	37 3%	29 6%	
No	62 7%	70 4%	146
Worked with stained glass?			
Yes	0 4%	0%	
No	99 6%	100%	NA
Cast lead into fishing sinkers bullets or anything else?			
Yes	4 7%	5 6%	
No	95 3%	95 4%	474

Table 4 —(cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p- VALUE
In the last 90 days any member of household			
Worked with soldering sheets of metal?			
Yes	7 9/	2 9/	
No	92 1/	97 1/	110
Worked with soldering pipes?			
Yes	9 5/	4 2/	
No	90 5/	95 8/	113
Repaired auto radiators?			
Yes	9 0/	1 4/	
No	91 0/	98 6/	022
Worked on auto bodies or auto maintenance? (includes mechanics)			
Yes	38 9/	21 4/	
No	61 1/	78 6/	005
Worked at a sewage treatment plant?			
Yes	0 4/	0/	
No	99 6/	100/	NA
Made pottery?			
Yes	0 9/	0/	
No	99 1/	100/	NA
Ridden a dirt bike mountain bike or ATV in the local area?			
Yes	15 7/	19 4/	
No	84 3/	80 6/	.284
Welded?			
Yes	13 7/	8 6/	
No	86 3/	91 4/	178
Cleaned or repaired firearms?			
Yes	19 8/	12 7/	
No	80 2/	87 3/	115
Visited indoor firearm target ranges?			
Yes	1 7/	1 4/	
No	98 3/	98 6/	NA
Done wire/cable cutting or splicing?			
Yes	23 2/	15 7/	
No	76 8/	84 3/	120
Casted or smelted lead?			
Yes	2 6/	1 4/	
No	97 4/	98 6/	NA
Worked in plastics manufacture?			
Yes	2 6/	0/	
No	97 4/	100/	NA
Worked in battery manufacture?			
Yes	0/	1 4/	
No	100/	98 6/	NA
Worked in pipe machining?			
Yes	1 7/	0/	
No	98 3/	100/	NA

Table 4 —(cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p VALUE
In the last 90 days any member of household			
Done electroplating with lead solutions?	0%	0%	
Yes			
No	100%	100%	NA
Worked in refining gasoline?			
Yes	0%	0%	
No	100%	100%	NA
Worked in paint, glaze and ink manufacture?			
Yes	1 7%	0%	
No	98 3%	100%	NA
Worked in rubber manufacture?			
Yes	1 3%	0%	
No	98 7%	100%	NA
Worked in scrap metal recovery?			
Yes	7 7%	5 6%	
No	92 3%	94 4%	NA
Had any other lead related job of activity?			
Yes	1 3%	8 3%	
No	98 7%	91 7%	NA
People living in house worked in mining or a mining related job in last 90 days?			
Yes	3 0%	6 9%	
No	97 0%	93 1%	123
For those answering yes how often does the person wear their clothes home after working?			
Never	71 4%	40 0%	
Rarely	0%	0%	
Sometimes	0%	0%	
Frequently	0%	0%	
Always	28 6%	60 0%	NA
For those answering yes how often does the person come home from work without showering?			
Never	57 1%	40 0%	
Rarey	0%	0%	
Sometimes	0%	20 0%	
Frequently	0%	0%	
Always	42 9%	40 0%	NA
When food or drinks are prepared served stored how often are they placed in clay pottery or ceramic dishes which were homemade or made in another country?			
Never	95 7%	86 1%	
Rarely	3 0%	11 1%	
Sometimes	0 4%	2 8%	
Frequently	0 9%	0%	
Always	0%	0%	NA

Table 4 —(cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p- VALUE
When food or drinks are prepared served stored how often are they placed in copper or pewter dishes or containers?			
Never	97 4/	98 6/	
Rarely	2 1/	1 4/	
Sometimes	0 4/	0/	
Frequently	0/	0/	
Always	0/	0/	NA
When food or drinks are stored or put away how often are they stored in the original can after being opened?			
Never	87 2/	83 3/	
Rarely	7 7/	11 1/	
Sometimes	3 8/	2 8/	
Frequently	1 3/	2 8/	
Always	0/	0/	614
How often do you vacuum?			
Never	3 4/	1 4/	
Rarely	2 1/	1 4/	
Sometimes	13 2/	13 9/	
Frequently	56 0/	69 4/	
Always	25 2/	13 9/	.218
How often do you dry sweep?			
Never	7 7/	11 1/	
Rarely	5 1/	6 9/	
Sometimes	10 7/	11 1/	
Frequently	37 6/	45 8/	
Always	38 9/	25 0/	285
How often do you mop?			
Never	17 0/	22 2/	
Rarely	4 7/	9 7/	
Sometimes	28 9/	36 1/	
Frequently	37 9/	26 4/	
Always	11 5/	5 6/	087
How often do you wet wipe?			
Never	3 8/	1 4/	
Rarely	5 5/	5 6/	
Sometimes	22 6/	23 6/	
Frequently	47 7/	61 1/	
Always	20 4/	8 3/	108

Table 4 —(cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p- VALUE
How often do you dry dust?			
Never	17 1/	20 8/	
Rarely	17 5/	20 8/	
Sometimes	28 6/	41 7/	
Frequently	29 9/	12 5/	
Always	6 8/	4 2/	029
How often do you use other house cleaning methods?			
Never	65 2/	47 9/	
Rarely	7 3/	14 1/	
Sometimes	14 2/	15 5/	
Frequently	10 3/	22 5/	
Always	3 0/	0/	008
How many times per month are the following rooms cleaned			
Kitchen	22 4 ± 16 5	28 1 ± 16 7	011
Child s bedroom	12 4 ±11 5	12 0 ±11 0	783
Living/family room	19 0 ± 12 9	20 7 ± 16 0	354
How long do you spend cleaning the following rooms each time you clean them? (minutes)			
Kitchen	36 6 ±35 4	39 9 ± 18 0	294
Child s bedroom	34 4 ± 33 5	32 5 ± 20 9	568
Living/family room	29 2 ±23 5	28 7 ± 13 7	824
Do you have a vacuum cleaner?			
Yes	94 5/	94 4/	
No	5 5/	5 6/	595
If yes how long ago was the vacuum cleaner last used? (days)	2 3 ± 3 2	2 7 ± 4 9	372
If yes how long ago was the vacuum cleaner bag emptied or last changed? (days)	23 6 ± 38 2	24 4 ± 39 6	887
Does anyone smoke tobacco products in your home?			
Yes	58 7/	50 0/	
No	41 3/	50 0/	121
If yes how many people smoke in this house?	1 4 ± 2 0	2 1 ±4.2	193
How long has the child been living in this home? (months)	28 4 ± 21 7	19 8 ± 17 4	001
Does child breast feed? (Only for participants ≤2yrs old)			
Yes	38 8/	64 3/	
No	61 2/	35 7/	073
Does child currently take a bottle?	45 8/	40 9/	
Yes			
No	54 2/	59 1/	438

Table 4 —(cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p- VALUE
Hours per day the child usually spends playing on the floor in this house	5 5 ± 3 0	5 4 ± 3 4	837
How often does the child play outdoors?			
Never	1 3/	5 6/	
Rarely	9 4/	12 5/	
Sometimes	26 8/	19 4/	
Frequently	49 8/	41 7/	
Always	12 8/	20 8/	053
If the child plays outdoors hours per day on the average the child plays outdoors	2 6 ±1 9	3 2 ±2 8	073
Where does child usually play when outside this house?			
Back yard	51 1/	36 6/	
Front yard	25 8/	35 2/	
Side yard	12 4/	12 7/	
Street and side walk	1 7/	2 8/	
Other	9 0/	12 7/	267
When the child is not playing around the house where does he/she usually play?			
Neighbor s yard	24 2/	27 8/	
Playground	5 2/	5 6/	
Near or around creek or ditch	0/	2 8/	
On or near sidewalks or streets	1 7/	0/	
Park	5 2/	6 9/	
Only plays around the home	30 7/	6 9/	
Other	32 9/	50 0/	798
How often does the child play on a grassy area?			
Never	5 2/	6 9/	
Rarely	10 3/	5 6/	
Sometimes	19 3/	18 1/	
Frequently	45 5/	48 6/	
Always	19 7/	20 8/	761
How often does the child play on concrete/asphalt?			
Never	12 9/	8 5/	
Rarely	30 2/	25 4/	
Sometimes	29 3/	35 2/	
Frequently	24 6/	26 8/	
Always	3 0/	4 2/	678
How often does the child play in dirt?			
Never	9 9/	11 1/	
Rarely	25 3/	19 4/	
Sometimes	28 3/	29 2/	
Frequently	27 5/	27 8/	
Always	8 6/	12 5/	837

Table 4 — (cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p- VALUE
Is there any park or common play areas where the child plays?			
Yes	50 6/	56 9/	
No	49 4/	43 1/	212
Does child			
Crawl	5 5/	4 3/	
Walk	76 6/	52 2/	
Both	17 9/	43 5/	NA
How often does child take food snacks or candy outside to eat?			
Never	22 7/	23 6/	
Rarely	38 2/	31 9/	
Sometimes	24 9/	26 4/	
Frequently	9 4/	12 5/	
Always	4 7%	5 6/	872
How often does the child take a bottle or pacifier outside with them?			
Never	85 5/	88 7/	
Rarely	4 7%	5 6/	
Sometimes	5 1/	1 4/	
Frequently	1 7/	4 2/	
Always	3 0/	0/	NA
How often does the child wash hands or face before eating?			
Never	0 4/	2 8/	
Rarely	4 3/	5 6/	
Sometimes	15 0/	28 2/	
Frequently	28 2%	26 8/	
Always	52 1/	36 6/	022
How often does the child wash hands or face before going to sleep?			
Never	2 1%	0/	
Rarely	4 3/	0/	
Sometimes	12 3/	15 3/	
Frequently	23 8/	25 0/	
Always	57 4/	59 7/	283
How often does the child wash hands or face after playing with dirt or sand?			
Never	3 5/	2 8/	
Rarely	2 6%/	0/	
Sometimes	9 7%	15 3%	
Frequently	20 7/	20 8/	
Always	63 4/	61 1/	465

Table 4 — (cont) Questionnaire Responses by Factors and GroupBig River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n=72)	p- VALUE
Number of times the child is bathed or given a shower per week	6 4 ± 2 1	6 2 ± 2 0	546
How often has the child used a pacifier in the last 6 months?			
Never	88 5 /	88 7 /	
Rarely	3 0 /	1 4 /	
Sometimes	1 7 /	1 4 /	
Frequently	2 1 /	2 8 /	
Always	4 7 /	5 6 /	NA
How often does the child suck their thumb or fingers?			
Never	71 1 /	65 3 /	
Rarely	8 9 /	6 9 /	
Sometimes	10 6 /	13 9 /	
Frequently	4 7 /	11 1 /	
Always	4 7 /	2 8 /	269
How often does the child chew on their fingernails?			
Never	58 3 /	65 3 /	
Rarely	16 2 /	13 9 /	
Sometimes	12 3 /	11 1 /	
Frequently	8 9 /	2 8 /	
Always	4 3 /	6 9 /	366
Does the child have a favorite blanket or toy?			
Yes	44 3 /	51 4 /	
No	55 7 /	48 6 /	177
For those answering yes how often does the child carry this around during the day?			
Never	21 9 /	13.2 /	
Rarely	19 0 /	15 8 /	
Sometimes	21 9 /	28 9 /	
Frequently	25 7 /	34 2 /	
Always	11 4 /	7 9 /	577
For those answering yes how often does the child put this blanket or toy in their mouth?			
Never	51 9 /	31 6 /	
Rarely	16 3 /	26 3 /	
Sometimes	15 4 /	7 9 /	
Frequently	7 7 /	23 7 /	
Always	8 7 /	10 5 /	025
How often does the child put things other than food into their mouth?			
Never	15 9 /	17 4 /	
Rarely	27 9 /	26 1 /	
Sometimes	27 0 /	26 1 /	
Frequently	15 9 /	20 3 /	
Always	13 3 /	10 1 /	879

Table 4 — (cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p- VALUE
How often does the child put their mouth on furniture or on the window sill?			
Never	44 4%	37 5%	
Rarely	20 9%	25 0%	
Sometimes	21 4%	23 6%	
Frequently	9 4%	11 1%	
Always	3 8%	2 8%	827
How often does the child swallow things other than food?			
Never	74 9%	66 7%	
Rarely	17 0%	25 0%	
Sometimes	6 0%	6 9%	
Frequently	1 7%	1 4%	
Always	0 4%	0%	593
How often does the child put paint chips in their mouth?			
Never	96 6%	97 1%	
Rarely	1 7%	2 9%	
Sometimes	1 7%	0%	
Frequently	0%	0%	
Always	0%	0%	NA
Does your household have a vegetable garden?			
Yes	29 5%	16 7%	
No	70 5%	83 3%	020
For those answering yes how often does the child eat vegetables grown in your garden?			
Never	21 9%	42 9%	
Rarely	20 5%	7 1%	
Sometimes	27 4%	14 3%	
Frequently	24 7%	14 3%	
Always	5 5%	21 4%	083
How often does the child eat vegetables grown elsewhere in the local area?			
Never	44 6%	22.2%	
Rarely	18 2%	27 8%	
Sometimes	23 8%	30 6%	
Frequently	10 8%	13 9%	
Always	2 6%	5 6%	015
Has the child ever been treated with traditional folk, or herbal medications?			
Yes	6 4%	7 0%	
No	93 6%	93 0%	520
Number of people living in house	4 4 ± 1 4	4 0 ± 1 2	024

Table 4 — (cont) Questionnaire Responses by Factors and Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY (n = 235)	CONTROL (n = 72)	p-VALUE
Amount of money spent on food per week in household			
≤ $25	1 7/	2 8/	
$25 $50	16 7/	26 4/	
$50 $75	38 0/	36 1/	
$75 $100	30 3/	23 6/	
> $100	13 2/	11 1/	382

1 Some factors had more responses offered than are displayed in this table If no participants answered a particular response the response was not included in the table
2 P-values are for proportions from chi square analysis and for interval data from t-test
3 Mean plus or minus standard deviation
4 NA not calculated because more than 25% of cells had less than five subjects expected per cell
5 Results do not include responses of don t know or refused There were 98 such responses in the study group and 31 such responses in the control group

Table 5 —Mean Blood Lead and Environmental Lead Results Compared between Study and Control Groups Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR[1]	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)	p VALUE
Blood lead (all values included) (µg/dl)	6 52 ± 3 92 (226)	3 43 ± 1 98 (69)	000
Lead concentration in tap water (µg/l)	2 38 ± 7 23 (235)	3 55± 3 02 (72)	181
Lead concentration in drip line soil(µg/g)	1794 62 ± 2030 58 (231)	625 62 ± 2224 31(71)	000
Lead concentration in play area soil (µg/g)	1282 28 ± 1447 11 (222)	127 15± 211 89 (60)	000
Lead concentration in yard soil (µg/g)	1078 76 ± 120 88 (233)	87 57 ± 180 16 (72)	000
Lead concentration in vacuum bag (µg/g)	1214 49 ± 440 76 (201)	173 02 ± 238 90 (61)	001
Lead loading of floor cassette vacuum (µg/ft²)	18 04 ± 56 01 (226)	4 10± 18 59 (65)	002
Lead concentration of floor cassette vacuum (µg/g)	763 23 ± 2122.28 (234)	283 69 ± 690 95 (67)	070
Visible dust during floor cassette vacuum (lower the value the less visible the dust)	82 ± 21 (227)	84 ± 21 (72)	560
Lead loading in window sill dust wipe (µg/ft²)	1641 52 ± 5534 92 (221)	196 95 ± 319 34 (66)	000
Visible loose dust during window sill dust wipe (lower the value the less the loose dust)	93 ± 15 (221)	91± 17 (66)	480
Visible dust when blown during window sill dust wipe (lower the value the less visible the dust)	92 ± 15 (221)	90 ± 18 (66)	344
Observed visible soiling of dust wipe sampling material (lower the value the less visible the soiling)	89 ± 21 (219)	93 ± 14 (66)	085
XRF for all indoor surfaces (mg/cm²)	28 ± 51 (235)	14 ± 22 (72)	001
XRF for indoor surfaces by room (mg/cm²)	28 ± 51 (235)	14 ± 22 (72)	001
XRF for indoor surfaces by room and friction (mg/cm²)	.34 ± 58 (235)	22 ± 36 (72)	031
XRF for indoor friction surfaces only (mg/cm²)	36 ± 61 (235)	.22 ± 36 (72)	013
XRF >0 for indoor surfaces (mg/cm²)	1 32 ± 1 21 (192)	1 17 ± 1 22 (51)	405
XRF ≥ 0 7 for indoor surfaces (mg/cm²)	3 14 ± 1 32 (130)	2 75 ± 1 38 (33)	141
XRF for indoor surfaces weighted[2] by d/t (mg/cm²)	3 18 ± 1 40 (101)	2 93 ± 1 57 (18)	488
XRF for indoor surfaces weighted by d/t by room (mg/cm)	2 20 ± 1.28 (101)	1 52 ± 1 04 (18)	036
XRF for indoor surfaces weighted by d/t by room and friction (mg/cm²)	1 05 ± 83 (101)	57 ± 43 (18)	001
XRF for indoor friction surfaces only weighted by d/t (mg/cm²)	1 66 ± 1 15 (101)	1 01 ± 72 (18)	003
XRF for all outdoor surfaces (mg/cm²)	.29 ± 36 (235)	34 ± 41 (72)	346
XRF >0 for outdoor surfaces (mg/cm²)	1 93 ± 1 55 (188)	2.26 ± 1 93 (57)	.244
XRF ≥ 0 7 for outdoor surfaces (mg/cm²)	3 46 ± 1 62 (150)	3 98 ± 2 50 (44)	189
Observed general condition of rooms (scale of 1=poor to 5=good)	3 22 ± 89 (235)	3 52 ± 99 (72)	014

1 Bolded factors showed a significant difference ($p < 05$) between the study and control groups

2 d/t = damaged area/total wall area Contains only XRF values ≥ 0 7 mg/cm²

Table 6 —Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
Gender		
Male	6 76 ± 4 63 (112)	3 44 ± 1 98 (32)
Female	6 28 ± 3 07 (114)	3 43 ± 2 01 (37)
p-value[1]	360	992
Race		
Black	6 33 ± 4 16 (3)	
White	6 52 ± 3 93 (223)	3 43 ± 1 98 (69)
p-value	935	
Total gross household income before taxes		
≤ $4,999	8 11 ± 4 33 (19)	4 00 ± 2 45 (15)
$5 000 $9 999	9 26 ± 6 40 (19)	4 83 ± 2 79 (6)
$10 000 $14 999	7 09 ± 3 83 (22)	4 00 ± 1 93 (8)
$15 000 $19 999	6 00 ± 2 02 (22)	2 00 ± (3)
$20 000 $24 999	7 08 ± 5 11 (26)	4 33 ± 1 15 (3)
$25 000 $29 999	6 52 ± 3 29 (25)	2 86 ± 1 57 (7)
$30 000 $34 999	6 09 ± 3 25 (22)	2 83 ± 1 17 (6)
$35 000 $39 999	4 78 ± 1 70 (18)	3 00 ± 1 55 (6)
≥ $40 000	5 18 ± 2 68 (38)	2 93 ± 1 73 (14)
p-value	010	280
Highest year of education completed by the mother of the child		
Elementary School	7 41 ± 2 88 (29)	4 13 ± 2 33 (15)
High School	6 76 ± 4 65 (112)	3 53 ± 1 99 (36)
Technical or Trade School	7 17 ± 3 01 (23)	5 00 ± 1 41 (2)
Junior/Community College	6 10 ± 3 10 (41)	2 31 ± 1 25 (10)
Four year College/University	4 06 ± 2 05 (16)	2 60 ± 1 14 (5)
Attended Graduate school	4 20 ± 1 30 (5)	2 00 ± (1)
p-value	048	159
Year house was built[2]		
<1900 1909	6 50 ± 3 03 (10)	
1910 1919	11 6 ± 12 9 (5)	3 00 ± (1)
1920 1929	6 67 ±3 61 (9)	5 00 ± (1)
1930 1939	6 18 ± 3 19 (11)	3 00 ± 1 83 (4)
1940-1949	6 29 ± 2 95 (14)	4 20 ± 1 30 (5)
1950 1959	6 29 ± 3 34 (14)	2 88 ± 1 13 (8)
1960 1969	4 75 ± 2 22 (4)	2 80 ± 1 81 (10)
1970 1979	5 41 ± 2 52 (22)	2 20 ± 1 10 (5)
1980 1989	6 24 ± 3 00 (21)	1 00 ± (2)
1990 present	4 32 ± 2 34 (22)	2 67 ± 58 (3)
p-value	045	232

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
House built prior to 1960	6 78 ± 4 65 (63)	3 37 ± 1 38 (19)
House built after 1959	5 28 ± 2 67 (69)	2 45 ± 1 47 (20)
p-value	023	052
House rented of owned?		
Rented	7 07 ± 3 35 (81)	4 05 ± 2 28 (38)
Owned	6 20 ± 4 14 (139)	2 68 ± 1 19 (31)
p value	180	002
Type of water pipes		
Lead	5 67 ± 1 53 (3)	3 00 ± (1)
Plastic	6 21 ± 2 96 (76)	4 60 ± 1 14 (5)
Galvanized Steel	10 18 ± 8 38 (17)	3 67 ± 3 06 (3)
Copper	5 35 ± 2 81 (23)	3 19 ± 1 80 (16)
Iron	4 00 ± (1)	
Mixed	6 84 ± 3 70 (45)	3 50 ± 1 52 (6)
Other	7 00 ± (1)	
p-value	011	655
Source of house water for drinking		
Public water	6 71 ± 3 95 (208)	3 47 ± 1 97 (68)
Well	2 33 ± 1 03 (6)	1 00 ± (1)
p value	007	
Source of house water for cooking		
Public water	6 68 ± 3 91 (217)	3 47 ± 1 97 (68)
Well	2 60 ± 89 (5)	1 00 ± (1)
p-value	021	
Source of child s water for drinking		
Public water	6 79 ± 4 09 (176)	3 45 ± 1 98 (67)
Well	3 11 ± 2 09 (9)	1 00 ± (1)
Bottled	6 15 ± 3 05 (40)	5 00 ± (1)
p-value	018	
Source of child s water for cooking		
Public water	6 68 ± 3 96 (207)	3 47 ± 1 97 (68)
Well	2 60 ± 89 (5)	1 00 ± (1)
Bottled	5 62 ± 3.23 (13)	
p value	049	
Any part of house repainted sanded or stripped chemically or by heat within last year?		
Yes	6 71 ± 3 87 (108)	3 12 ± 1 52 (33)
No	6 34 ± 3 99 (115)	3 30 ± 1 88 (33)
p-value	479	667

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
Mine smelter or lead industry materials used in or around house or yard		
Yes	6 35 ± 4 48 (40)	3 50 ± 2 12 (2)
No	6 54 ± 3 96 (157)	3 31 ± 1 91 (48)
p-value	798	893
Pets go in and out of house		
Yes	6 97 ± 4 79 (87)	3 85 ± 2 25 (27)
No	6 26 ± 3 26 (137)	3 20 ± 1 78 (41)
p-value	193	185
In the last 90 days any member of household		
Worked on auto bodies or auto maintenance? (includes mechanics)		
Yes	7 37 ± 3 78 (87)	3 80 ± 2 40 (15)
No	6 01 ± 3 93 (138)	3 29 ± 1 88 (52)
p-value	001	387
Made pottery?		
Yes	9 00 ± 1 41 (2)	
No	6 50 ± 3 93 (224)	3 43 ± 1 98 (69)
p-value	370	
Ridden a dirt bike mountain bike or ATV in the local area?		
Yes	6 47 ± 3 16 (34)	3 43 ± 2 31 (14)
No	6 53 ± 4 05 (192)	3 44 ± ± 1 91 (55)
p-value	940	990
Welding?		
Yes	6 94 ± 3 54 (31)	3 67 ± 1 63 (6)
No	6 47 ± 3 98 (194)	3 36 ± 2 00 (61)
p-value	548	718
Cleaned or repaired firearms?		
Yes	7 56 ± 5 45 (45)	4 00 ± 2 74 (9)
No	6 25 ± 3 41 (178)	3 36 ± 1 87 (59)
p-value	131	3710
Casting or smelting lead?		
Yes	10 67 ± 3 72 (6)	2 00 ± (1)
No	6 38 ± 3 87 (219)	3 36 ± 1 83 (67)
p-value	008	
Other lead related job of activity?		
Yes	8 33 ± 7 51 (3)	4 83 ± 2 99 (6)
No	6 46 ± 3 90 (218)	3 30 ± 1 84 (63)
p-value	708	070

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
People living in house worked in mining or a mining related job in last 90 days?		
Yes	9 71 ± 4 99 (7)	5 20 ± 3 11 (5)
No	6 42 ± 3 85 (219)	3 30 ± 1 83 (64)
p-value	028	038
When food or drinks are prepared served stored how often are they placed in clay pottery or ceramic dishes which were homemade or made in another country?		
Never	6 61 ± 3 98 (215)	3 42 ± 2 07 (60)
Rarely	4 57 ± 1 90 (7)	3 57 ± 1 51 (7)
Sometimes		3 50 ± 71 (2)
Frequently	4 50 ± 71 (2)	
p value	307	981
When food or drinks are prepared served stored how often are they placed in copper or pewter dishes or containers?		
Never	6 51 ± 3 93 (221)	3 34 ± 1 93 (67)
Rarely	6 00 ± 3 56 (4)	6 00 ± (1)
Sometimes	11 00 ± (1)	
p-value	504	178
When food or drinks are stored or put away how often are they stored in the original can after being opened?		
Never	6 66 ± 4 07 (197)	3 48 ± 2 05 (58)
Rarely	5 28 ± 2 47 (18)	3 57 ± 98 (7)
Sometimes	5 50 ± 2 98 (8)	3 50 ± 3 54 (2)
Frequently	7 33 ± 2 08 (3)	1 50 ± 71 (2)
p value	438	587
How often do you vacuum?		
Never	8 25 ± 4 13 (8)	10 00 ± (1)
Rarely	5 80 ± 1 30 (5)	2 00 ± (1)
Sometimes	6 90 ± 4 75 (30)	2 40 ± 1 08 (10)
Frequently	6 02 ± 3 95 (127)	3 57 ± 2 01 (47)
Always	7 25 ± 3 35 (56)	3 30 ± 1.25 (10)
p-value	200	004
How often do you dry sweep?		
Never	6 28 ± 2 93 (18)	3 71 ± 2 93 (7)
Rarely	5 82 ± 2 52 (11)	3 80 ± 84 (5)
Sometimes	5 44 ± 2 79 (25)	3 38 ± 2 26 (8)
Frequently	5 71 ± 3 01 (86)	3 59 ± 2 06 (32)
Always	7 78 ± 4 93 (86)	2 94 ± 1 56 (17)
p-value	004	822

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
How often do you mop?		
Never	6 00 ± 2 86 (39)	3 40 ± 1 99 (15)
Rarely	5 70 ± 1 77 (10)	3 14 ± 1 46 (7)
Sometimes	6 38 ± 3 81 (65)	3 08 ± 1 69 (24)
Frequently	6 68 ± 4 62 (85)	4 00 ± 2 43 (19)
Always	7 37 ± 3 71 (27)	3 50 ± 2 38 (4)
p value	627	663
How often do you wet wipe?		
Never	6 12 ± 2 64 (8)	
Rarely	6 23 ± 3 00 (13)	2 75 ± 50 (4)
Sometimes	6 68 ± 3 28 (53)	4 76 ± 2 59 (17)
Frequently	6 04 ± 4 17 (106)	2 98 ± 1 55 (42)
Always	7 59 ± 4 30 (46)	3 33 ± 1 97 (6)
p-value	263	012
How often do you dry dust?		
Never	6 56 ± 3 09 (39)	3 57 ± 1 55 (14)
Rarely	6 44 ± 5 13 (41)	3 87 ± 2 56 (15)
Sometimes	6 97 ± 4 56 (63)	3 47 ± 1 96 (30)
Frequently	6 23 ± 3 00 (66)	3 00 ± 1 53 (7)
Always	6 31 ± 2 91 (16)	1 33 ± 58 (3)
p-value	871	349
How often do you use other house cleaning methods?		
Never	6 73 ± 4 31 (144)	3 58 ± 2 03 (31)
Rarely	7 06 ± 3 54 (17)	3 50 ± 1 72 (10)
Sometimes	6 15 ± 3 25 (33)	3 45 ± 2 62 (11)
Frequently	5 67 ± 2 76 (24)	3 25 ± 1 65 (16)
Always	6 50 ± 2 59 (6)	
p-value	713	962
Does anyone smoke tobacco products in your home?		
Yes	7 07 ± 4 14 (133)	3 82 ± 2 39 (34)
No	5 73 ± 3 46 (93)	3 06 ± 35 (35)
p-value	011	112
Does child breast feed? (Only for participants ≤2yrs old)		
Yes	5 33 ± 1 15 (3)	
No	6 69 ± 3 39 (65)	3 50 ± 2 22 (16)
p-value	494	

Table 6 —(cont) Mean Blood Lead Values Compared to Questıonnaıre Factors by Group
Bıg Rıver Mıne Taılıngs Superfund Sıte Lead Exposure Study, Mıssourı 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
Does chıld currently take a bottle?		
Yes	6 66 ± 3 91 (29)	3 62 ± 2 92 (8)
No	6 46 ± 2 91 (39)	3 58 ± 1 88 (12)
p-value	816	969
How often does the chıld play outdoors?		
Never	2 00 ± (1)	2 00 ± (3)
Rarely	6 71 ± 4 23 (21)	4 00 ± 2 93 (8)
Sometımes	6 35 ± 4 04 (62)	3 23 ± 2 65 (13)
Frequently	6 13 ± 2 93 (112)	3 23 ± 1 43 (30)
Always	8 33 ± 5 92 (30)	4 00 ± 1 85 (15)
p-value	058	429
Where does chıld usually play when outsıde thıs house?		
Back yard	6 09 ± 3 15 (115)	2 96 ± 1 57 (25)
Front yard	6 93 ± 3 44 (60)	4 00 ± 1 91 (24)
Sıde yard	7 11 ± 6 02 (27)	4 44 ± 2 79 (9)
Street and sıde walk	3 75 ± 1.26 (4)	3 00 ± 1 41 (2)
Other	7 79 ± 5 57 (19)	2 38 ± 1 92 (8)
p-value	153	085
When the chıld ıs not playıng around the house where does he/she usually play?		
Neıghbor s yard	7 00 ± 4 61 (55)	2 95 ± 1 32 (20)
Playground	7 92 ± 3 68 (12)	4 33 ± 1 15 (3)
On or near sıdewalks or streets	6 00 ± 2 16 (4)	5 00 ± 4 24 (2)
Park	6 45 ± 7 17 (11)	5 20 ± 3 49 (5)
Only plays around the home	6 39 ± 3 69 (70)	3 40 ± 2 41 (5)
Other	6 18 ± 2 98 (71)	3 29 ± 1 85 (34)
p-value	705	205
How often does the chıld play on a grassy area?		
Never	6 36 ± 3 88 (11)	1 75 ± 50 (4)
Rarely	5 96 ± 2 84 (24)	1 67 ± 58 (3)
Sometımes	5 93 ± 3 65 (45)	3 54 ± 2 37 (13)
Frequently	6 64 ± 3 61 (102)	3 23 ± 1 57 (35)
Always	7 30 ± 5 24 (43)	4 71 ± 2 30 (14)
p-value	509	017
How often does the chıld play on concrete/asphalt?		
Never	7 11 ± 4 00 (28)	2 40 ± 1 14 (5)
Rarely	6 74 ± 3 56 (69)	4 50 ± 2 85 (18)
Sometımes	5 65 ± 3 17 (66)	3 12 ± 1 13 (25)
Frequently	6 17 ± 3 04 (54)	3 18 ± 1 74 (17)
Always	12 14 ± 10 14 (7)	3 67 ± 2 08 (3)
p-value	001	105

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
How often does the child play in dirt?		
Never	5 52 ± 3 03 (21)	3 29 ± 3 25 (7)
Rarely	5 88 ± 3 69 (57)	2 64 ± 2 27 (14)
Sometimes	6 23 ± 3 38 (64)	3 20 ± 1 20 (20)
Frequently	6 73 ± 3 15 (62)	4 05 ± 1 85 (20)
Always	9 70 ± 6 89 (20)	4 00 ± 1 85 (8)
p-value	003	277
Is there any park or common play areas where the child plays?		
Yes	6 48 ± 3 81 (114)	3 74 ± 2 02 (39)
No	6 53 ± 4 05 (109)	3 03 ± 1 88 (30)
p-value	925	141
How often does child take food snacks or candy outside to eat?		
Never	6 50 ± 3 20 (48)	3 29 ± 2 46 (14)
Rarely	5 97 ± 3 62 (87)	3 48 ± 1 93 (23)
Sometimes	6 44 ± 3 08 (57)	3 37 ± 1 89 (19)
Frequently	7 64 ± 3 44 (22)	3 00 ± 1 66 (9)
Always	9 55 ± 9 46 (11)	5 00 ± 1 63 (4)
p-value	037	562
How often does the child take a bottle or pacifier outside with them?		
Never	6 51 ± 3 68 (196)	3 17 ± 1 61 (60)
Rarely	5 10 ± 2 08 (10)	7 50 ± 3 00 (4)
Sometimes	7 36 ± 4 82 (11)	2 00 ± (1)
Frequently	13 33 ± 13 05 (3)	2 67 ± 58 (3)
Always	4 33 ± 1 03 (6)	
p-value	012	< 001
How often does the child wash hands or face before eating?		
Never	10 00 ± (1)	1 00 ± (1)
Rarely	3 90 ± 1.29 (10)	3 75 ± 2 06 (4)
Sometimes	6 54 ± 3 26 (35)	3 79 ± 1 81 (19)
Frequently	6 52 ± 5 38 (62)	2 78 ± 1 11 (18)
Always	6 73 ± 3 25 (117)	3 73 ± 2 47 (26)
p-value	235	320

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
How often does the child wash hands or face before going to sleep?		
Never	3 40 ± 1 67 (5)	
Rarely	5 50 ± 3 14 (10)	
Sometimes	6 59 ± 6.27 (29)	3 09 ± 1 92 (11)
Frequently	5 96 ± 2 86 (54)	3 41 ± 1 54 (17)
Always	6 94 ± 4 02 (128)	3 54 ± 2 18 (41)
p-value	171	806
How often does the child wash hands or face after playing with dirt or sand?		
Never	11 17 ± 11 70 (6)	1 00 ± (1)
Rarely	6 00 ± 1 79 (6)	
Sometimes	6 68 ± 2 761 (22)	3 27 ± 2 45 (11)
Frequently	6 29 ± 4 25 (45)	3 71 ± 2 40 (14)
Always	6 43 ± 3 36 (140)	3 44 ± 1 72 (43)
p-value	065	611
How often has the child used a pacifier in the last 6 months?		
Never	6 60 ± 4 03 (201)	3.26 ± 1 82 (61)
Rarely	4 40 ± 1 67 (5)	2 00 ± (1)
Sometimes	6 74 ± 1 89 (4)	
Frequently	5 00 ± 2 35 (5)	5 00 ± 1 41 (2)
Always	5 55 ± 3 62 (11)	4 75 ± 3 59 (4)
p value	681	255
How often does the child suck their thumb or fingers?		
Never	6 53 ± 3 86 (162)	3 43 ± 2 08 (47)
Rarely	7 10 ± 2 84 (21)	2 50 ± 58 (4)
Sometimes	5 30 ± 2 72 (23)	3 80 ± 1 62 (10)
Frequently	7 27 ± 7 17 (11)	3 57 ± 2 51 (7)
Always	7 11 ± 4 57 (9)	3 00 ± (1)
p-value	516	867
How often does the child chew on their fingernails?		
Never	6 90 ± 4 46 (131)	3 61 ± 2 06 (44)
Rarely	6 22 ± 3 36 (37)	3 20 ± 1 87 (10)
Sometimes	6 00 ± 2 64 (28)	3 13 ± 1 55 (8)
Frequently	6 05 ± 3 12 (21)	1 50 ± 0 71 (2)
Always	4 89 ± 1 62 (9)	3 60 ± 2 51 (5)
p-value	435	632
Does the child have a favorite blanket or toy?		
Yes	5 98 ± 3 09 (100)	3 44 ± 1 81 (34)
No	6 94 ± 4 44 (126)	3 43 ± 2 16 (35)
p-value	066	979

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
For those answering yes how often does the child carry this around during the day?		
Never	5 43 ± 2 33 (23)	2 75 ± 1 26 (4)
Rarely	5 42 ± 2 97 (19)	3 00 ± 1 58 (5)
Sometimes	6 09 ± 3 75 (22)	3 90 ± 2 33 (10)
Frequently	5 88 ± 2 70 (25)	3 54 ± 1 81 (13)
Always	7 67 ± 3 80 (12)	2 33 ± 1 16 (3)
p-value	294	657
For those answering yes how often does the child put this blanket or toy in their mouth?		
Never	5 90 ± 3 16 (52)	3 20 ± 1 48 (10)
Rarely	4 94 ± 2 56 (17)	3 40 ± 1 84 (10)
Sometimes	7 69 ± 3 59 (16)	2 67 ± 1 53 (3)
Frequently	6 14 ± 2 85 (7)	3 50 ± 2 67 (8)
Always	5 13 ± 1 64 (8)	4 00 ± 1 41 (4)
p-value	111	915
How often does the child put things other than food into their mouth?		
Never	5 97 ± 2 91 (34)	3 09 ± 1 64 (11)
Rarely	6 14 ± 3 09 (64)	3 17 ± 1 42 (18)
Sometimes	6 83 ± 4 59 (63)	3 71 ± 2 31 (17)
Frequently	7 91 ± 4 87 (35)	3 46 ± 2 76 (13)
Always	5 68 ± 3 60 (28)	3 43 ± 1 27 (7)
p-value	119	924
How often does the child put their mouth on furniture or on the window sill?		
Never	6 59 ± 4 13 (100)	3 08 ± 1 98 (25)
Rarely	6 22 ± 2 97 (49)	4 00 ± 2 32 (17)
Sometimes	6 60 ± 3 96 (48)	3 00 ± 1 41 (17)
Frequently	7 05 ± 5 36 (20)	4 00 ± 2 33 (8)
Always	6 00 ± 2 51 (8)	4 50 ± 0 71 (2)
p-value	935	383
How often does the child swallow things other than food?		
Never	6 29 ± 4 00 (170)	3 29 ± 2 11 (45)
Rarely	6 84 ± 3 20 (57)	3 50 ± 1 72 (18)
Sometimes	8 00 ± 4 85 (14)	4 20 ± 1 92 (5)
Frequently	7 75 ± 3 40 (4)	5 00 ± (1)
Always	7 00 ± (1)	
p-value	526	661

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
How often does the child put paint chips in their mouth?		
Never	6 47 ± 3 97 (216)	3 45 ± 1 99 (65)
Rarely	6 25 ± 3 30 (4)	4 50 ± 2 12 (2)
Sometimes	7 50 ± 1 91 (4)	
p-value	868	464
Does your household have a vegetable garden?		
Yes	6 64 ± 4 72 (66)	3 08 ± 1 83 (12)
No	6 44 ± 3 55 (159)	3 51 ± 2 02 (57)
p-value	733	503
For those with a vegetable garden how often does the child eat vegetables grown in your garden?		
Never	4 79 ± 2 91 (14)	3 50 ± 2 17 (6)
Rarely	5 07 ± 1 77 (14)	3 00 ± (1)
Sometimes	6 80 ± 3 47 (20)	4 00 ± 2 83 (2)
Frequently	8 41 ± 7 66 (17)	3 00 ± (2)
Always	7 25 ± 3 50 (4)	2 33 ± 1 53 (3)
p-value	184	896
How often does the child eat vegetables grown elsewhere in the local area?		
Never	6 07 ± 3 11 (99)	4 00 ± 2 94 (13)
Rarely	6 35 ± 3 17 (40)	2 65 ± 1 04 (20)
Sometimes	6 48 ± 4 14 (54)	3 41 ± 1 99 (22)
Frequently	7 40 ± 3 87 (25)	4 00 ± 1 76 (10)
Always	10 80 ± 13 03 (5)	4 25 ± 1 71 (4)
p-value	072	224
Has the child ever been treated with traditional folk, or herbal medications?		
Yes	6 73 ± 3 75 (15)	3 20 ± 2 05 (5)
No	6 43 ± 3 87 (209)	3 46 ± 2 01 (63)
p-value	766	781

Table 6 —(cont) Mean Blood Lead Values Compared to Questionnaire Factors by Group Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997

FACTOR	STUDY Mean ± SD (n)	CONTROL Mean ± SD (n)
Amount of money spent on food per week in household		
≤ $25	5 25 ± 2 99 (4)	1 00 ± (1)
$25 $50	6 18 ± 2 87 (39)	3 00 ± 1 22 (17)
$50 $75	5 92 ± 3 53 (85)	3 65 ± 2 21 (26)
$75 $100	7 39 ± 4 61 (67)	4 00 ± 2 29 (17)
> $100	7 07 ± 4 31 (30)	3 00 ± 1 53 (7)
p-value	157	209

1 P values for factors with two categories are from t test factors with more than two categories are from Analysis of Variance All are two tailed significance

2 Results do not include responses of don t know' or refused There were 98 such responses in the study group and 31 such responses in the control group

Table 7 —Correlation Coefficients and Level of Significance for Questionnaire and Environmental Data with Blood Lead Levels in Study Group Big River Mine Tailings Superfund Site Lead Exposure Study MO 1997

Variable [1]	Correlation Coefficient	p-value [2]	Number of Children
Questionnaire			
Age	011	866	2 6
How often[3] do you dry sweep	1>7	018	? 6
How oft n do ou mop	099	1 8	—6
How often do ou wet wipe	068	>10	6
How oft n do you dry dust	0?	716	>
How often child plays outdoors	094	158	6
How often child plays on grassy area	101	1	>
How often child plays on concrete asphalt	011	868	4
Ho v often child plays in dirt	1?8	0>6	2_5
How often child takes food outside	1>	0	
How often child takes pacifier outside	018	788	? 6
Ho often child asnes hands betor ating	081	_66	
How often child washes before sleeping	1 5	04?	—6
Ho v often child ashes after pla ing in d rt	11o	088	19
How often child us d pacifie last six month	0 5	60	6
Hov often child s cks thumb	00	.968	6
How often child chews fingernails	1	066	6
How often child carries ta onte to around	1 6	078	101
How often child puts blanket tov in mouth	0	46	100
How often child puts other things in mouth	0>9	_8	2_4
Ho often child puts mouth on furnitu or nd il	006	.9 4	5
How often child swallow things other than food	111	098	6
Mother s highest le l of education	191	004	6
Money spent on food per eek	1 _	048	—>
Gross household income before taxes	2	000	6
Environmental Samples			
Lead concentration in tap ater	069	>00	6
Lead concentration in vacuum bag	0 4	6	19
Lead concentration in ard soil	1	046	4
Lead concentration in play area soil	10	1	16
L ad concentrat on found n the drip line soil	_17	00	—
Lead loading in floor cassette vacuum	> 7	000	0
Lead conc ntration n floo assett m	194	004	—>
Lead loading in indo sill dust ipe	>19	000	1>
Observed visible soiling of dust wipe sampling material	181	008	18
XRF for all ndoor surfaces	>57	000	6
XRF >0 for indoor surfaces	_17	00	18>
XRF ≥0 7 for indoor surfaces	074	410	1 6
XRF for indoor friction surf es onl	>	000	6
XRF for indoor surfaces by room	>>/	000	—6
XRF for indoor surfaces by room and frict on	>4>	000	6
XRF for indoor fri tion surfaces onl weight d b d t	—>6	01	98
XRF for indoor surfaces weighted b d/t b room	—4>	016	98
XRF for indoor surfaces weighted by d t by room and friction	>66	000	98
XRF for all outdoor surfaces	2>?	000	6
XRF >0 for outdoor surfaces	068	>68	1 9
XRF ≥0 7 for outdoor surfaces	016	850	144

1 Bolded variables have a significant correlation at the 0 10 level
2 Two-tailed significance level
3 All How often questions utilized Likert scale of 1 (never) through 5 (always)
4 d/t = damaged area/total wall area Contains only XRF values ≥0 7 mg/cm

Table 8 —Correlation Coefficients and Level of Significance for Questionnaire and Environmental Data with Blood Lead Levels in Control Group Big River Mine Tailings Superfund Site Lead Exposure Study MO 1997

Variable[1]	Correlation Coefficient	p-value	Number of Children
Questionnaire			
Age	091	460	69
How often do you dry sweep	106	386	69
How often do you mop	088	474	69
How often do you wet wipe	187	1 4	69
How often do you dry dust	181	1 6	69
How often child plays outdoors	10	400	69
How often child plays on grassy area	345	004	69
How often child plays on concrete/asphalt	088	4 4	68
How often child plays in dirt	19	0 0	69
How often child takes food outside	077	528	69
How often child takes toys outside	081	51	68
How often child washes hands before eating	04	7 8	68
How often child washes before sleeping	0 8	5 4	69
How often child washes after playing in dirt	081	510	69
How often child used pacifier last 6 months	19	0 4	68
How often child sucks thumb	0 1	80	69
How often child chews fingernails	095	4 6	69
How often child carries food to around	0 9	8 6	5
How often child puts blanket to in mouth	104	55	5
How often child puts other things in mouth	0 5	550	66
How often child puts mouth on furniture or window sill	110	5 0	69
How often child swallows things other than food	144	58	69
Mother s highest level of education	84	018	69
Money spent on food per week		10	69
Gross household income before taxes		0	9
Environmental Samples			
Lead concentration tap water	1	8	69
Lead concentration in vacuum bag	119	5 4	58
Lead concentration in yard soil	9	048	69
Lead concentration in play area soil	15	40	58
Lead concentration found in the drip line soil	1 1	84	69
Lead loading in floor cassette vacuum	1 1	500	64
Lead concentration in floor cassette vacuum	154	9	64
Lead loading in window sill dust wipe	104	41	65
Observed visible soiling of dust wipe sampling material	1 4	06	69
XRF for all indoor surfaces	11	360	69
XRF >0 for indoor surfaces	0	754	55
XRF ≥0 7 for indoor surfaces	1 9	5 8	
XRF for indoor friction surfaces only	1	1 6	69
XRF for indoor surfaces by room	116	34	69
XRF for indoor surfaces by room and friction	1 4	1 4	69
XRF for indoor friction surfaces only weighted by d/t	9	6	18
XRF for indoor surfaces weighted by d/t by room	0	4 0	18
XRF for indoor surfaces weighted by d/t by room and friction	00	8	18
XRF for all outdoor surfaces	101	406	69
XRF >0 for outdoor surfaces	04	754	55
XRF ≥0 7 for outdoor surfaces	0 0	846	44

1 Bolded variables have a significant correlation at the 0 10 or less level
Two-tailed significance level
All How often questions utilized Likert scale of 1 (never) through 5 (always)
4 d/t = damaged area/total wall area. Contains only XRF values ≥0 7

Table 9 —Correlations Between Dust and Soil Lead Measures in the Study Area Big River Mine Tailings Superfund Site Lead Exposure Study Missouri 1997

		Lead Concentration in Floor Vacuum Cassette	Lead Loading in Window Sill Dust Wipe	Lead Concentration in Vacuum Bag
Lead Concentration in Drip Line Soil	Pearson Correlation Coefficient =	048	315	130
	Two tailed significance level =	469	000	068
	Number of samples =	230	218	197
Lead Concentration in Play Area Soil	Pearson Correlation Coefficient =	020	026	010
	Two-tailed significance level =	764	705	888
	Number of samples =	221	209	192
Lead Concentration in Yard Soil	Pearson Correlation Coefficient =	028	019	008
	Two tailed significance level =	667	779	912
	Number of samples =	232	219	199

Table 10.—Correlations Between XRF Dust and Soil Lead Measures in the Study Area, Big River Mine Tailings Superfund Sites Lead Exposure Study, Missouri 1997

		Lead Concentration in Vacuum Bag	Lead Concentration in [illegible] Vacuum [illegible]	Lead Loading in Window Sill Dust Wipe	Lead Concentration in Drip Line Soil	Lead Concentration in Play Area Soil	Lead Concentration in Yard Soil
[illegible]	Pearson Correlation Coefficient	[illegible]	070	405	388	041	111
	Two-tailed significance level	007	285	000	000	544	091
	Number of pairs	201	231	221	231	222	233
[illegible]	Pearson Correlation Coefficient	[illegible]	001	337	[illegible]	007	014
	Two-tailed significance level	000	98	000	000	920	827
	Number of pairs	201	231	221	231	222	233

1 Bolded correlations are significant at the 0.05 or less level

Table 11 —Range and Median of Percent Contribution of Lead from Selected Sources[1] in the Study Area as Predicted from Modeled Classification Scheme Big River Mine Tailings Superfund Site Lead Exposure Study Missouri 1997

	Waste Pile Source		Paint Source		Soil		Common	
	WV	WVL	PV	PVL	SV	SVL	CV	CVL
Waste Piles	47 8 – 95 6 (72 1)	22 – 86 2 (69 45)	0 2 – 4 6 (3 4)	0 2 – 6 8 (4 7)	--	--	3 9 – 18 3 (16.3)	13 6 – 72 2 (26 8)
Paint Chips	0 – 5 1 (0 35)	0 5 1 (0 3)	27 – 93 1 (82 25)	12 8 – 98 2 (85 65)		--	0 8 – 88 7 (15 85)	1 – 85 5 (13 85)
Soils	58 5	51 5	0	05	--		41 5	49 5
Vacuum Bags	8 1 – 57 3 (26.35)	5 8 – 60 1 (21 05)	1 6 – 80 3 (16 05)	1 2 – 88 5 (23 15)	0 1 – 57 1 (36 84)	2.5 – 18 2 (8 1)	2 7 – 37 6 (11 7)	4 1 – 73 5 (29 1)

1 Lead sources are waste pile paint soil or common (cannot differentiate between the possible sources The first level of the classification scheme developed weights the percent attributed to a source category based on the volume sum of the particles analyzed These are identified as WV (Waste Volume) PV (Paint Volume) SV (Soil Volume) and CV (Common Volume) The second level additionally weights by the fraction of lead determined in each particle as shown by WVL (Waste Volume Lead) PVL (Paint Volume Lead) SVL (Soil Volume Lead) and CVL (Common Volume Lead)

2 Soil determination was only used for characterization of the study and control area samples

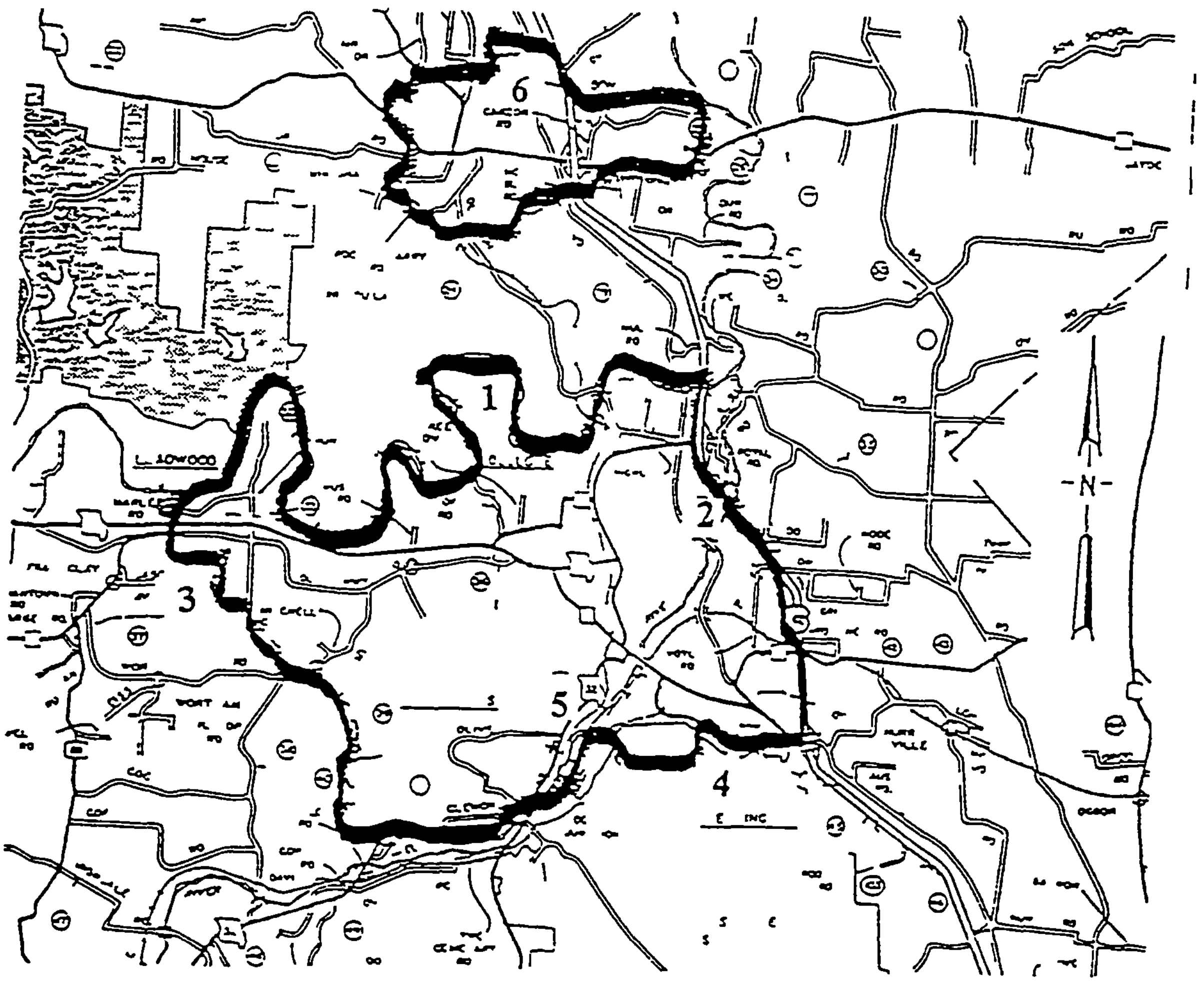
3 Values in parenthesis represent median percentages

4 The prediction model developed for the classification scheme uses a least squares apportionment method Due to the nature of a model negative entries are bound to occur but they are all less than 10% This suggests a reasonable prediction of potential sources

Figure 1

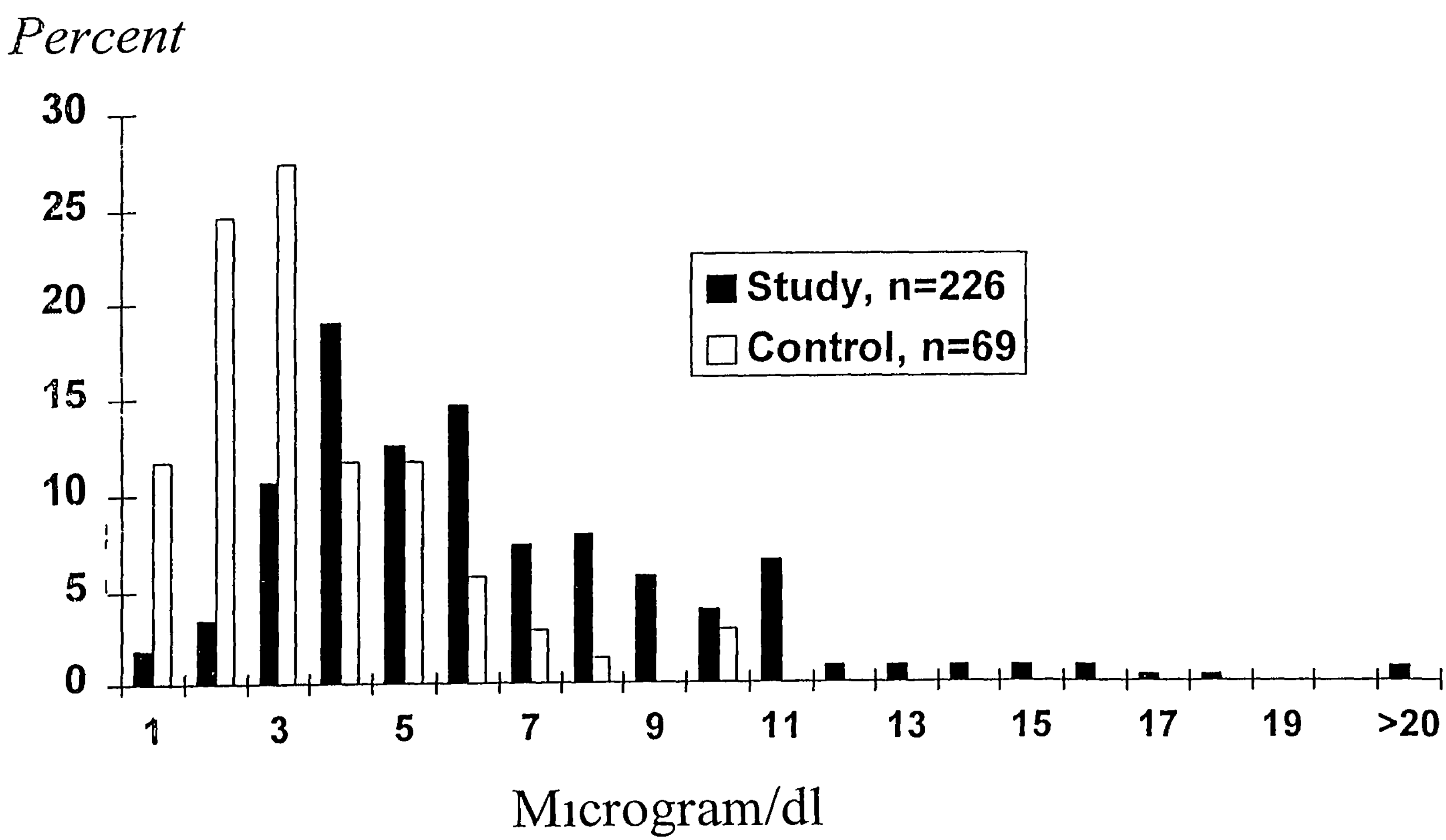
Study Area

Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri 1997



1 Big River Tailings Pile 2 National Tailings Pile 3 Leadwood Tailings Pile 4 Federal Tailings Pile 5 Elvins Tailings Pile 6 Bonne Terre Tailings Pile

Figure 2 Blood Lead Levels for Study and Control Groups
Big River Mine Tailings Superfund Site Lead Exposure Study, Missouri, 1997



95-50 #0?7-
BIG R[illegible]ER (MO)
LEAD STUDY

DATE __/__/__

BIG RIVER MINE TAILINGS SUPERFUND SITE
LEAD STUDY

QUESTIONNAIRE

DATE Month ______ Day ________ Year ________
INTERVIEWER ______________________________

NAME OF RESPONDENT ______________________
CHILD S NAME ______________________________

SECTION I HOUSEHOLD CHARACTERISTICS

The following questions must be answered by the parent or legal guardian of the child **Circle applicable answer**

1 Who is answering these questions?

1=child s mother
2=child s father
3=child s grandparent
4=child s other relative
5=other ____________
8=refused

First I would like to ask you some questions about the home *child s name* lives in
Where child has lived most of the time in the last 90 days

2 What year was this house built? *Oldest part*

00=<1900 1909	06=1960 1969
01=1910 1919	07=1970 1979
02=1920 1929	08=1980 1989
03=1930 1939	09=1990 present
04=1940 1949	88=refused
05=1950 1959	99=don t know

3 Is the home *child s name* lives in rented or owned?

1=rented
2=owned
3=other___________
8=refused
9=don t know

4 What type of water pipes does your home contain?

1=lead	6=mixed, specify_______________
2=plastic	7=other specify_______________
3=galvanized steel	8=refused
4=copper	9=don t know
5=iron	

5 What is the source of water to your house?
Circle one per column

	Drinking	Cooking
Public water	1	1
Well	2	2
Other ________________	3	3
Refused	8	8
Don t know	9	9

6 What type of water does *child s name* normally use for

	Drinking	Cooking
Public water	1	1
Well	2	2
Bottled	3	3
Refused	8	8
Don t know	9	9

7 Is the water in your kitchen faucet filtered or treated?

1=Yes
2=No
8=Refused
9=Don t Know

8 Has any part of your house been repainted sanded or stripped chemically or by heat within the last year? *If NO go to question 9*

1=Yes
2=No
8=Refused
9=Don t Know

8a *If YES* approximately when was this most recently done?

___ ____ / ____ ______
Month Year (Enter 99 if respondent doesn t know months)
8=Refused

8b And in what part of the house was the work done?
(Circle all that apply)

1=bedroom?
2=living room?
3=bathroom?
4=kitchen
5=outside walls?
6=porch?
7=deck?
8=refused
9=other ________________

9 How often do you use air conditioning the summer?
If NEVER go to question 10

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

9a And where is your air conditioning used? (circle all that apply)

central?	1
living/family room	2
child s bedroom	3
other bedroom	4
kitchen	5
refused	8
other ________________	

10 Has anyone ever used any matenals from mines or smelters such as chat or slag or lead industry matenal in or around your house or yard?

1=Yes
2=No
8=Refused
9=Don t know

11 Do you have any pets that go in and out of the house?

1=Yes
2=No
8=Refused
9=Don t know

SECTION II ENVIRONMENTAL SOURCES

Next I have some questions about a number of activities you or other household members may do or may have done in the last three months These include things you may have done for work hobbies or chores at home or at another place

12 In the last 90 days have any members of your your household (Circle all that apply)					12a IF YES Was this done at home work or elsewhere?					12b IF WORK/OTHER Were those clothes worn home?				Did he/she shower before coming home?			
	Yes	No	Refused	Don t know	HOME	Work/ OTHER	BOTH	Refused	Don t know	Yes	No	Refused	Don t know	Yes	No	Refused	Don t know
a Painted pictures with artists paints? (not children s paints)	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
b Painted stained or refinished furniture?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
c Painted the inside or outside of a home or building?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
d Work with stained glass?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
e Cast lead into fishing sinkers bullets or anything else?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
f Worked with soldering sheets of metal?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9

12 In the last 90 days have any members of your your household (Circle all that apply)					12a IF YES Was this done at home work or elsewhere?					12b IF WORK/OTHER Were those clothes worn home?				Did he/she shower before coming home?			
	Yes	No	Refused	Don t know	HOME	Work/ OTHER	BOTH	Refused	Don t know	Yes	No	Refused	Don t know	Yes	No	Refused	Don t know
g Soldering pipes or sheets of metal?	1	2	8	9	3	4	5	8	)	1	2	8	9	1	2	8	9
h Repaired auto radiators?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
i Worked on auto bodies or auto maintenance? (includes mechanics)	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
j Worked at a sewage treatment plant?	1	2	8	9	3	4	5	8	9	1	?	8	9	1	2	8	9
k Made pottery?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
l Ridden a dirt bike mountain bike or ATV in the local area?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
m Welding?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
n Cleaned or repaired firearms?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
o Visited indoor firearm target ranges?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9

12 In the last 90 days have any members of your your household (Circle all that apply)					12a IF YES Was this done at home work or elsewhere?					12b IF WORK/OTHER Were those clothes worn home?				Did he/she shower before coming home?			
	Yes	No	Refused	Don t know	HOME	Work/ OTHER	BOTH	Refused	Don t know	Yes	No	Refused	Don t know	Yes	No	Refused	Don t know
p Wire/cable cutting or splicing?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
q Casting or smelting lead?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
r Plastics manufacture?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
s Battery manufacture?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
t Pipe machining?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
u Electroplating with lead solutions?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
v Refining gasoline?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
w Paint glaze and ink? manufacture?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
x Rubber manufacture?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
y Scrap metal recovery?	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9
z Other lead related job or activity? SPECIFY ______________	1	2	8	9	3	4	5	8	9	1	2	8	9	1	2	8	9

1

Now I d lıke to ask you some questıons about the mıne related persons lıvıng ın thıs home

13 Have any people lıvıng ın thıs house worked ın mınıng or a mınıng related job such as materıal handlıng or transportatıon ın the last 90 days?

1=Yes
2=No (If no skip to questıon 18)
8=Refused
9=Don t know

14 What type of mınıng or mıne related work was done?

	YES	NO	Refused	Don t know
a Underground	1	2	8	9
b Surface	1	2	8	9
c Mıllıng	1	2	8	9
d Transportatıon/ handlıng	1	2	8	9
e Clerıcal/Admın	1	2	8	9
f Smelter	1	2	8	9
g Other	1	2	8	9

*If Other specıfy*______________________

15 What type of mıne materıals were worked wıth? *Cırcle all that apply*

	YES	NO	Refused	Don t know
a Lead	1	2	8	9
b Zınc	1	2	8	9
c Sılver	1	2	8	9
d Molybdenum	1	2	8	9
e Coal	1	2	8	9
f Lımes one	1	2	8	9
g Clav	1	2	8	9
h Other	1	2	8	9

*If Other spec fy*______________________

16 Does this person wear *his/her* clothes home after working?

never	1
rarelv	2
sometimes	3
frequently	4
alwavs	5
refused	8
don t know	9

17 Does this person come home from work without showering?

never	1
rarelv	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

SECTION III BEHAVIORAL FACTORS

Now I d like to ask you some questions about your **diet and food preparation**

18 When food or drinks are prepared served or stored how often are they placed in clay pottery or ceramic dishes which were homemade or made in another country?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

19 When food or drinks are prepared served or stored how often are they placed in copper or pewter dishes or containers?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

20 When food or drinks are stored or put away how often are they stored in the original can after being opened?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

21 How often do you **vacuum**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

21a How often do you **dry sweep**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

21b How often do you **mop**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

21c How often do you **wet wipe**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

21d How often do you **dry dust**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

21e How often do you use **other house cleaning methods**? *Specify* ____ ______

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

22 How often do you clean the following rooms?

	times per month	how long each time *(in minutes)*
kitchen	___________	___________
child s bedroom	___________	___________
living/family room	___________	___________

23 Do you have a vacuum cleaner? *If No go to 24*

1=yes
2=no
8=refused
9=don t know

23a How long ago was the vacuum cleaner last used? _______________*(days)*

23b How long ago was the vacuum cleaner bag emptied or last changed?_______*(days)*

Now I have a few other questions about **smoking** in your household

24 Does anyone smoke tobacco products in *your* home?
Circle responses (1 pack = 20 cigarettes)

1=Yes
2=No (If no skip to question 26)
8=Refused
9=Don t know

25 How many people smoke in this house? Include regular visitors/baby sitters

________ number of people
8=refused
99=don t know

Participant Child Questionnaire

Now I need to ask a number of questions about *child s name*

26 How long has *child s name* been living in this home?

Years ____ _____
Months ____ _____

If less than 90 days obtain previous address

____

____

27 What is *child s name* date of birth?

(MO/DA/YR) ____/____/_____

88=refused
99=don t know

28 Is *child s name* a boy or girl?

1=boy 2=girl

29 Which of the following best describes *child s name* racial background?

1=Black
2=White
3=Asian or Pacific Islander
4=American Indian/Alaska native
8=Refused
9=Don t know

30 *If response to question 29 is Black or White* is *child s name* Hispanic?

1=Yes
2=No
8=Refused
9=Don t know

If child is two years old or younger ask questions 31 32 and 33

31 Does *child s name* currently breast feed?

1=Yes (If yes skip to 33)
2=No
8=Refused
9=Don t know

32 *If response to above question is NO* was *child s name* breast fed?

1=Yes ______ *If YES* for how long?______
2=No ______
8=Refused
9=Don t know______

33 Does the *child s name* currently take a bottle?

1=Yes
2=No
8=Refused
9=Don t know

34 How many hours during the day does *child s name* usually spend playing **on the floor** when he or she is **in this house**?

________Hours (88=refused) (99=don t know)

35 How often does *child s name* **play outdoors**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

36 *If YES* then how many hours a dav on the average does *child s name* play outdoors?

__________Hours (88=refused) (99=don t know)

37 Where does *child s name* usually play when outside this house? *Circle one*

1=Back yard
2=Front yard
3=Side yard
4=Street or side walk
7=Other (specify) ____________
8=Refused
9=Don t know

38 When *child s name* is not playing around the house? where does *he/she* usually play? *Circle one*

1=Neighbor s yard
2=Playground
3=Near or around creek or ditch
4=On or near sidewalks or streets
5=Park
6=Only plays around the home
7=Other (Specify) ____________________
8=Refused
9=Don t know

39 How often does *child s name* play on a **grassy** area?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

40 How often does *child s name* play on **concrete/asphalt**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

41 How often does *child s name* play in **dirt**?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

42 Is there any park or common play areas where the *child s name* plays?

1=Yes
2=No
8=Refused
If yes indicate where the area is located ______________________________

43 Does *child s name* crawl?=1 or walk?=2 or both?=3

44 How often does *child s name* take food snacks or candy outside to eat?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

45 How often does *child s name* take a bottle or pacifie outside with *him/her*?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

46 How often does *child s name* wash hands or face before eating?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

47 How often does *child s name* wash hands or face before going to sleep?

never	1
rarelv	2
sometimes	3
frequently	4
alwavs	5
refused	8
don t know	9

48 How often does *child s name* wash hands or face after playing with dirt or sand?

never	1
rarely	2
sometimes	3
frequently	4
alwavs	5
refused	8
don t know	9

49 How many times is *child s name* bathed or given a shower per week?

____________ per week (88=refused) (99=don t know)

50 How often has *child s name* used a pacifier in the last 6 months?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

51 How often does *child s name* suck *his/her* thumb or fingers?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

52 How often does *child s name* chew on *his/her* fingernails?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

53 Does *child s name* have a favorite blanket or toy? *If NO go to question* 56

1=yes
2=no
8=refused
9=don t know

54 How often does *child s name* carry this around during the day?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

55 How often does *child s name* put this blanket or toy in his/her mouth?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

56 How often does *child s name* put things **other than food** into *his/her* mouth?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

57 How often does *child s name* put *his/her* mouth on furniture or on the window sill?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

58 How often does *child s name* **swallow** things other than food?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

*Specify items swallowed*______________________

59 How often does *child s name* put paint chips in his/her mouth?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

60 Does your household have a vegetable garden?
If NO go to question 62

1=Yes
2=No
8=Refused
9=Don t know

61 How often does *child s name* eat vegetables grown in your garden?

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

62 How often does *child s name* eat vegetables grown elsewhere in the local area?
(*neighbor s garden or local farmer s market*)

never	1
rarely	2
sometimes	3
frequently	4
always	5
refused	8
don t know	9

63 Has *child s name* ever been treated with traditional folk or herbal medications?

1=Yes
2=No
8=Refused
9=Don t know

If yes what was the medicine called?______________________________

SECTION IV DEMOGRAPHIC AND SOCIOECONOMIC FACTORS

64 How many people live in this house? No __________

64a Could you tell me their **names** and **ages** and their **relationship** to *child s name*?

NAME	AGE	RELATIONSHIP	*(relationship categories)*
			Mother
			Father
			Siblings
			Grandparents
			Other
			Refused
			Don t know

65 What is the highest year of education that was completed by the **mother** of this child? *Circle one*

No schooling	1
Elementary School	2
High School(Ged=o12)	3
Technical or Trade School	4
Junior/Community College	5
Four Yr College/University	6
Attended Graduate School(higher)	7
Refused to answer	8
Don t know	9

66 What is the number that corresponds to the amount of money spent on food per week in this houshold?

01=$25 or less
02=$25 to $50
03=$50 to $75
04=$75 to $100
05=more than $100
08=Refused
09=Don t know

67 What number corresponds to the total gross household ıncome before taxes?

01=$4 999 or less	07=$30 000 to 34 999
02=$5 000 to $9 999	08=$35 000 to $39 999
03=$10 000 to $14 999	09=$40 000 to more
04=$15 000 to $19 999	88=Refused to answer
05=$20 000 to $24 999	99=Don t know
06=$25 000 to $29 999	

End This completes the questionnaire Do you have any questions or comments about it?

____

____

____

Thank you very much for your time

MISSOURI DEPARTMENT OF HEALTH

Mel Carnahan
Governor

Coleen Kivlahan M D M S P H
Director

P O Box 570 Jefferson City MO 65102-0570 314 751 6400 FAX 314 751-6010

RELEASE OF MEDICAL INFORMATION TO PARTICIPANT'S PHYSICIAN

BIG RIVER MINE TAILINGS SUPERFUND SITE AND SURROUNDING AREA BLOOD LEAD & ENVIRONMENTAL EXPOSURE STUDY

I understand that medical information about me has been and/or will be collected during the lead exposure study I request that this information be released to my physician to assist him/her in providing any necessary medical advice and care

Participant	Physician
Name (Please print)	Name (Please print)
Signature	Street
Date	City State Zip

MISSOURI DEPARTMENT OF HEALTH

Mel Carnahan
Governor

Coleen Kivlahan M D M S P H
Di -- o

P O ox 570 Jefe or City MO 65102-0570 314 751 6400 FAX 3 4 751 6010

REQUEST FOR PARTICIPANT REIMBURSEMENT

BIG RIVER MINE TAILINGS SUPERFUND SITE AND SURROUNDING AREA BLOOD LEAD & ENVIRONMENTAL EXPOSURE STUDY

I understand that I will be paid $15 00 by mailed check for agreeing to participate in the lead exposure study and that this will be the only monetary reimbursement I will receive My name and mailing address are

Printed Name ______________________ Street ______________________

Signature ______________________ City ______________ State ______ Zip ______

Date ______________________

MISSOURI DEPARTMENT OF
HEALTH

Mel Carnahan
Governor

Coleen Kivlahan M D M S P H
Director

P O Box 570 Jefferson City MO 65102 0570 314 751 6400 FAX 314 751 6010

Participant Consent to Environmental Sampling In and Around Home

I understand that the health department's lead exposure study will include some environmental sampling in and around the homes of the participants The sampling will include drinking water, vacuum bags, household dust, interior and exterior paint, and yard soil The samples will be taken by St Francois County Health Department and they will carry and show identification

If my home is selected for sampling, I will allow reasonable access to properly identified representatives/contractors I understand there will be no cost to me for this sampling and that I will be notified of the results Prior to any sampling I will be contacted by phone for the arrangement of a convenient date and time

Printed name ______________________ Signature ______________________

Today s Date ______________________ Address ______________________

Daytime Phone ______________________ ______________________

Nighttime Phone ______________________ Directions to home ______________________

____

MISSOURI DEPARTMENT OF HEALTH

Mel Carnahan
Gove nor

Coleen Kivlahan M D M S P H
Di ec or

P O Box 570 Jefferson City MO 65102-0570 314 751-6400 FAX 314 751-6010

RELEASE OF MEDICAL INFORMATION TO DENT COUNTY HEALTH DEPARTMENT

BIG RIVER MINE TAILINGS SUPERFUND SITE AND SURROUNDING AREA BLOOD LEAD & ENVIRONMENTAL EXPOSURE STUDY

I understand that medical information about me has been and/or will be collected during the lead exposure study I request that this information be released to the Dent County Health Department to assist in providing any necessary follow up

Participant

____
Name (Please print)

____
Signature

____
Date

MISSOURI DEPARTMENT OF HEALTH

CONSENT FOR PARTICIPATION IN RESEARCH ACTIVITIES DESLOGE/BIG RIVER MINE TAILINGS SUPERFUND SITE BLOOD LEAD STUDY

This study is intended to determine if children living near the Desloge/Big River Superfund Site have higher blood lead levels than children not living in the area The research study is being conducted by St Louis University School of Public Health in cooperation with the Missouri Department of Health St Francois County Department of Health U S Environmental Protection Agency and Agency for Toxic Substances and Disease Registry

Investigators on this study and their telephone numbers are

Ana Maria Murgueytio MD MPH, Assistant Professor	314 977 8134
Gregory Evans Ph D Associate Professor	314 977 8133
David Sterling Ph D Assistant Professor	314 977 8123

Drs Murgueytio Evans and Sterling have requested my participation in this research study Desloge/Big River Mine Tailings Superfund Site Blood Lead Study I understand that the purpose of this research is to investigate childhood lead poisoning in the communities near the Big River Mine Tailings Superfund Site as well as various environmental behavioral demographic sociocultural and economic factors as they relate to blood lead levels of children in communities near the Superfund site compared to blood lead levels of children living in an area distant to the Superfund site My participation will involve answering a questionnaire allowing my child to provide blood for laboratory analysis and to allow the investigators to take samples of the soil and dust in my home for laboratory analysis My participation will also include allowing the investigators to take samples of soil from my yard around my home The participation is an one time event and should involve approximately 2 1/2 hours of my time I understand that the risks for my child if I agree on his/her participation in the study are minor discomfort for the blood drawing and probably bruising in the area of the needle stick I understand that if discomforts do occur the investigators will try to minimize them as appropriate

I understand that the information collected will be evaluated by the investigators and in cooperation with the other state and federal agencies I understand that the results of the research study will be published but that my and my child s identity will not be revealed and that the records will remain confidential In order to maintain confidentiality Drs Murgueytio Evans and Sterling will not use my name my child s name or our personal identifying information and that other forms used for this study will be kept along with the results in a locked file cabinet

I understand that the possible benefits of my child s participation in the research is that, if elevated blood lead levels are determined my child will be referred for further follow up and environmental assessment by an appropriate public health agency The results might also be important to the design of future studies to develop appropriate interventions to help my child or other children with elevated blood lead levels

I understand that my child s participation is voluntary and that refusal to participate will involve no penalty to me or my child or loss of any benefits to which my child is otherwise entitled I understand that I may withdraw my child s participation in the research study at any time without penalty or prejudice Specifically I understand that I need not answer any questions asked by the Investigators if I do not wish to and that I can stop my child s participation at any point without needing to give a reason Since participation is voluntary I understand that I or my child will not be charged for any part of this research project or for the services provided and that an alternative to this study is not to participate To the best of my knowledge my child is not participating in any other medical research study

Any questions that I may have concerning my child s participation in this research study will be answered by Dr Ana Maria Murgueytio Dr Gregory Evans or Dr David Sterling whose telephone numbers are listed above for my contact I understand I will be compensated with a small amount of money by the University for my child s participation If I have any questions about my child s rights as research participants or in the event I believe my child has suffered an injury as a result of participation in the research project, I may contact the Chairperson of the St Louis University Institutional Review Board at 314 577 8108 who will review the matter with me identify other resources that may be available to me and provide further information as to how to proceed

I have read the above statement and have been able to ask questions and express concerns which have been satisfactorily answered bv the investigators I believe I understand the purpose of the study as well as the potential risks and benefits that are involved I hereby give my informed and free consent for my and my child s participation in this study

Date ____________________
M th/D /Yea

Parent/Guardian Signature ______________________________

Parent/Guardian Name (Printed) ______________________________

Witness Signature ______________________________

Witness Name (Printed) ______________________________

I certify that I have explained to the above individual(s) the nature and purpose of this research study the potential benefits and possible risks associated with participation have answered any questions that have been raised and have witnessed the above signature

These elements of informed consent conform to the assurance given by St Louis University to the Department of Health and Human Services to protect the rights of persons who participate in research studies I have provided the participant with a copy of this signed corsent document

Date ____________________
M th/D y Year

Investigator Signature ______________________________

ealth officials start blood study
ith phone calls to area residents

By Renee Jean
aily Journal Staff Writer

ne calls from the St Francois y Health department to about households in Park Hills vood Bonne Terre East Terre and surrounding areas art Thursday according to of with the health department.

ry Bertram Environmental rian with the health depart said the phone calls will es h an accurate census of holds for an upcoming blood tudy to be conducted in areas wind of mine tailings piles in ancois County

e study conducted under the ces of the Missouri Depart of Health will gather informa about elevated blood lead s found in some St Francois ity children

cording to statistics between nd 30 percent of children par ating in the well baby clinic and programs have had higher than al levels of lead in their d stream over the past two years Both programs serve lower income families

The source of the elevated levels is currently unknown according to Bertram who said that contributing factors range from old pipes to how often a family dusts County wide statistics on blood lead levels are not currently available

Census workers who are from Mineral Area College or the St. Francois County Health Department will clearly identify themselves on the phone Bertram said

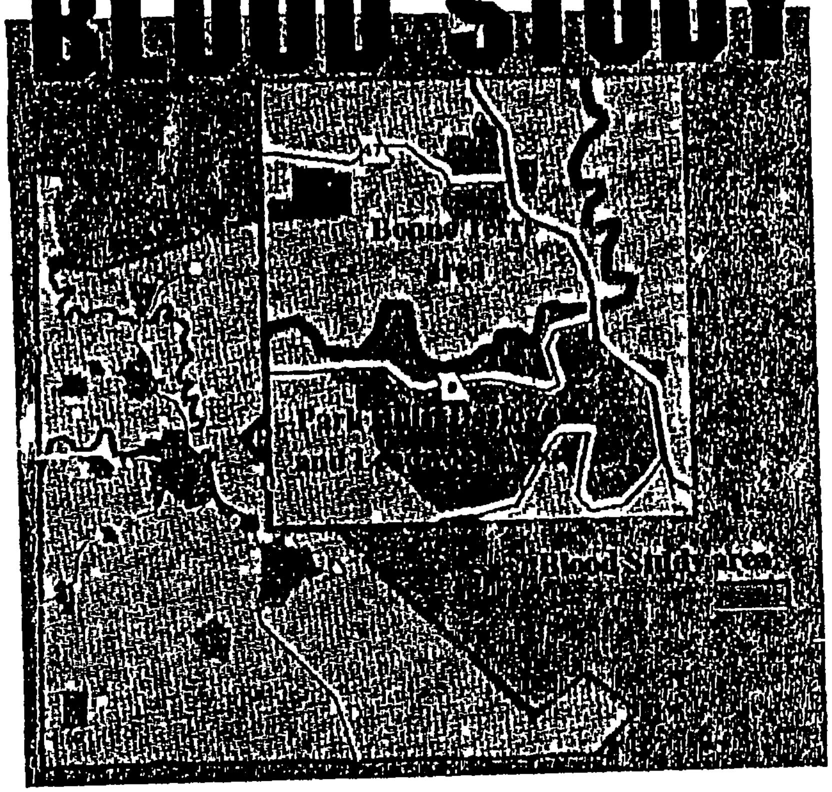
The census takers will gather information about the number of residents living in the households the number of children under six the address of the resident and the age of the house

Those households with children under six will be contacted to participate in the voluntary blood lead study Bertram said.

Results of the study will be used to make recommendations to the Department of Natural Resources and to help residents reduce the

(See BLOOD, page 3)

BLOOD STUDY



Blood

(Continued from page 1

likelihood of exposure to le cording to Brian Quinn a man for the Missouri Depart Health

Childhood exposure to le cause decreased intelligen paired neural develo decreased growth hearing and ability to maintain a ste ture Bertram said

For more information lead study contact the Department of Health B Environmental Epidemiol Box 570 Jefferson City M or call toll free at 800/392

Lead-exposure census takers to open study

By Renee' Jean
Daily Journal Staff Writer

Census takers gathering background information for an upcoming lead-exposure study in St. Francois County will begin door-to-door surveys Saturday in Bonne Terre and Desloge health department officials reported today.

Response to the census has not been as smooth as officials would like with some residents refusing to provide information, but officials say they are confident they will reach optimum participation levels in both study and control areas.

The lead-exposure study will gather information on blood-lead levels of St. Francois County children in Bonne Terre, Terre Du Lac, Desloge, Leadington, Park Hills, Leadwood and Mitchell. That study will not begin until census information is completed.

Officials want to have at least 250 children aged six months to six years participate in the upcoming study in St. Francois County.

"We hope people will realize that this part of the study is just intended to gather accurate population data and to identify potential study participants. Answering census questions doesn't obligate anyone to be in the upcoming blood-lead study," said Gary Bertram, environmental sanitarian with the St. Francois County Health Department.

Questions from census takers are mainly designed to determine potential study participants, whose parents will be contacted at a later time about the study.

Questions include name, age, sex and number of children living in the home, as well as the length of residency.

A mirror-image census is currently under way in Salem, an area chosen because of similarities to the study area in St. Francois County.

Salem has no mining history but other factors are similar including socio-economic make up, population and houses of similar age and type according to officials with the Missouri Department of Health.

Calls to Salem residents started today and health officials said they want to have a group of at least 150 children participate. Blood and environmental samples will eventually be taken in that area, with about the same time-frame as that in St. Francois County.

The control group is crucial to the outcome of the study because data

(See STUDY page 2)

gained there will be used as a baseline of comparison for blood lead data gathered in St. Francois County.

The purpose of the lead-exposure study is to evaluate environmental and other factors that have led to elevated blood lead levels in some St. Francois County children.

According to statistics between 25 and 30 percent of children participating in the well baby clinic and WIC programs have had higher than normal levels of lead in their blood stream over the past two years. Both programs serve lower income families.

The source of elevated lead levels is currently unknown, according to officials. In previous interviews Bertram said contributing factors range from old pipes to how often a family dusts.

Environmental factors that could contribute to elevated lead levels will also be considered in the study which will make recommendations about lowering the levels to the Department of Natural Resources.

Childhood exposure to lead may cause decreased intelligence, impaired neural development, decreased growth and hearing acuity and inability to maintain a steady posture.

For more information about the study contact the Missouri Department of Health, Bureau of Environmental Epidemiology at 1 800 392 72-5

Missouri Department of Health
Big River Area Lead Study
Residential Census Guidance

Background Information

The Missouri Department of Health (DOH) will conduct a study to determine whether the lead tailing piles in the Park Hills and Bonne Terre areas may be affecting the health of local residents The study will focus on children between six months and six years of age since they are at higher risk for lead exposure

Prior to the study, a census of residents in the study area and a comparison area will be conducted Salem, Missouri will serve as the comparison area since it is demographically similar to the study area

Census Description

Information Using the "Household Census Forms"

- How many people live at the residence
- For those six years old and younger, what are their names, birthdates (or age), sex, race and time at the residence
- Age of the home
- Address and phone numbers

Method

- Call if you have the phone number
- Visit the homes that you don't have phone numbers for
- If you get no answer, or if nobody is home, call or return to the home on a different day of the week at a different time of day
- If you cannot get a response from a home, ask a neighbor
- Document every attempt you make on the census form

Safety

- Wear a visible picture I D
- Do not visit or call after 8 30 p m
- Stay on sidewalks and avoid walking through the yards
- Respectfully decline an invitation to go inside the home

- If a person is hostile do not argue with them

Other Important Tips

- If a resident refuses politely try to find out why
- If a resident questions who you are what you are doing or wants more information on lead exposure, refer them to

Gary Bertram
St Francois County Health Department
(314)431-1947

Always be pleasant and smile

Sample Introduction

Hello, I am (your name) from Mineral Area College We are working with the Missouri Department of Health conducting a census of your neighborhood for a future study May I ask you a few questions? It will only take a moment

Missouri Department of Health

Household Census Form

Big River Blood Lead Exposure Study Missouri

Interviewer # ________

Telephone Call Number 1 2 3 4 5 6 7 8 9 ≥10 (Mark an X on each number that applies)

Date/Time 1 ________ Date/Time 2 ________ Date/Time 3 ________

Date/Time 4 ________ Date/Time 5 ________ Date/Time 6 ________

Date/Time 7 ________ Date/Time 8 ________ Date/Time 9 ________

Date/Time 10 ________

Visit Number 1 2 3 4 5 6 7 8 9 ≥10 (Mark an X on each number that applies)

Date/Time 1 ________ Date/Time ________ Date/Time 3 ________

Date/Time 4 ________ Date/Time 5 ________ Date/Time 6 ________

Date/Time 7 ________ Date/Time 8 ________ Date/Time 9 ________

Date/Time 10 ________

Name of Responder ____________________

1 How many members in this household? (Circle number)
0 1 2 3 4 5 6 7 8 9 ≥10

2 What is your relationship in this household?______ (1 Parent, 2 Child 3 Other family member 4 Other)

3 What are the names dates of birth ages sexes race and length of residence of persons in the household between ages 0 and 72 months of age? (List below)

First and Last Name (0 72 Months)	Date of Birth	Age (opt)	Sex	Race	Time at Residence

If no date of birth is available

PRINT

Residential Address ____________________ (Street, R R Box #) City ________

Telephone (Home) ____________ (Work) ____________ (Respondent) Zip code ________

Mailing Address (if different) ____________________ (Street, R R Box #)

City ____________ Zip code ____________

What is the age of this house (years)? ________

St. Francois County Health Center

1025 West Main
P O Box Q
Park Hills Missouri 63601

(573) 431 1947
FAX 431 7326

Jane C Hartrup R N B S
Administrator

Jon L Peacock
Environmental Sanitarian III

Counties Served
Iron
Madison
St Francois
& Ste Genevieve

To St Francois County Parents August 28 1995

Lead may be found in the soil in your yard It also may be in the paint on your home Sometimes lead may be found in the dust in your home or even in the water you drink

Lead is most dangerous to children It can hurt them without you knowing it Even tiny amounts of lead are bad It can harm their brain and change the way they think and act Large amounts of lead can cause serious injury or death

We are trying to find out how much your child has been exposed to lead Only 250 homes will be tested in St Francois County Your home has been chosen to be tested for lead You will be contacted by a health department worker They will either call or stop by your home When you are contacted please let them know if you would like to have your home tested

If you are interested someone will contact you at a later date and set up a time that is good for you to have your home tested The testing will include

* the soil from your yard
* the dust in your home
* the paint on your house and
* the water in your home

We will also test one of your children under the age of 6 for lead A nurse will take a small blood sample from your child

These tests will all be done at your home and will take about 2 hours This will tell you if your child is being poisoned by lead in your home

Thank you

Jane Hartrup R N

Administrator

* *Attention Salem Parents* *

Free Testing for Lead in Salem Homes

With Children 6 Months to 6 Years Old

The Missouri Department of Health and Saint Louis University are conducting lead testing in Salem Lead may be found in the dirt in your yard paint on your home or in the water you drink It is especially dange ous to children Low levels effect the way they think and act High levels of lead exposure can cause serious injury or death

Testing of 150 homes in Salem Missouri has already begun You are eligible to have your home tested for lead if

1. You live in the city limits of Salem (Any dwelling including mobile homes and apartments)
2. You have lived in your home for at least 90 days
3. You have a child in the home between 6 months and 6 years of age

The testing takes about two hours and is done for free It includes soil from your yard dust in your home paint on your house and water in your home It also includes a blood test for your child under the age of 6 A nurse will take a small sample from your child There is a questionnaire that will be conducted with the parent or guardian of the child These tests will tell you if your child is being poisoned by lead in or around your home In addition to the free test, you will be paid fifteen dollars ($15 00) for your time

If you me t the three requirements listed above and want to have your home tested please contact the Dent County Health Department at (314) 729 3106

SAMPLING TEAMS

Sampling Team/Initial Date	Members/Responsibilities
1 Primary July 19 1995	Gary Bertram XRF Environmental Samples Jane Hartrup R N Blood Interview Environmental Samples Sharon Bach R N Blood Interview Environmental Samples
2 Primary July 19 1995	Jon Peacock XRF Environmental Samples Diane Eaton R N Blood Interview Environmental Samples Jane Howard R N Blood Interview Environmental Samples
3 Primary September 20 1995	Brad Wilson XRF Environmental Samples Dorothy Wilson L P N Blood Interview Environmental Samples Sharon Johnson L P N Blood Interview Environmental Samples
4 Back up July 19 1995	Robert Royal XRF Environmental Samples Barbara Huff R N Blood Interview Environmental Samples Judy McCarty Interview Environmental Samples

BIG RIVER MINE TAILINGS LEAD STUDY

CASE 95 0059

SPECIMEN COLLECTION AND SHIPPING PROTOCOL

Division of Environmental Health Laboratory Sciences
National Center for Environmental Health
Centers for Disease Control and Prevention
Atlanta Georgia 30333

evised 07 06/95

INTRODUCTION

The proper collection processing storage and shipment of physiologic specimens from participants in this study is critical to the success of the study The following sections describe the procedures which must be followed for all specimen collections These procedures must be strictly adhered to in order to avoid contamination loss or degradation of the specimens Please familiarize yourself with the study protocol and insure that you understand the concept of the study the role of all the personnel involved and your own role

Please note that if participants are required to report to the collection site in a fasting state blood collection should be accomplished early in the visit to avoid discomfort to the subject and an adverse impact on compliance Blood collection must be completed and processed under carefully controlled conditions of good laboratory practice Blood processing must be accomplished promptly to avoid degradation of the specimen

It is extremely important that all records associated with each participant be maintained in an organized and complete manner to ensure that all information is properly collected and accurate Specimens should be labeled promptly and processed as a unit or run and precautions must be taken to avoid patient specimen label record mix ups This type of error is usually the most common error in the laboratory setting but careful planning and a well organized work area will keep such errors at a minimum Some of the information required for the specimen label and shipping list will be collected at the time of specimen collection Problems in blood collection should be noted in the sample log and in the comments section of the shipping list

II WHOLE BLOOD COLLECTION

UNIVERSAL PRECAUTIONS SHOULD ALWAYS BE FOLLOWED IN THE COLLECTION AND HANDLING OF HUMAN BLOOD)

A Collection procedure

1 Materials needed per participant

Disposable gloves
Gauze sponges
Alcohol wipes (2)
Bandaid
3 mL purple top vacutainer tube (1)
23g 3/4 butterfly needle with 12 tubing with multiple sample luer adapter
22g Vacutainer needle
5 mL Syringes (to be used with butterfly or syringe needle for hard to get venipunctures)
Sharps disposal container for used needles
Pre printed labels
Tourniquet
Vacutainer needle holder (pediatric size for 3 mL tubes)
Vacutainer needle holder with pediatric tube adapter
Refrigerator or container with ice packs

NOTE USE ONLY THE SUPPLIES PROVIDED BY CDC WHICH HAVE BEEN SCREENED FOR LEAD

2 Venipuncture procedure

Locate a suitable table and chair for blood collection and lay out blood collection supplies

Locate the puncture site Hold with 2 fingers on one side of the alcohol wipe so that only the other side touches the puncture site Wipe the area in a circular motion beginning with a narrow radius and moving outward so as not to cross over the area already cleaned Repeat with a second alcohol wipe

Locate vein and cleanse in manner previously described then apply the tourniquet If it is necessary to feel the vein again do so but after you feel it, cleanse with alcohol prep again and dry with a sterile gauze square

Fix the vein by pressing down on the vein about 1 inch below the proposed point of entry into the skin and pull the skin taut Approach the vein in the same direction the vein is running holding the needle so that a 15 ° angle with the examinee s arm

Push the needle with bevel facing up firmly and deliberately into the vein Activate the vacuum collection tube If the needle is in the vein blood will flow freely into the tube If no blood enters the tube probe for the vein until entry is indicated by blood flowing into the tube

After blood flow is established loosen the tourniquet. Collect ONE 3ml purple top tube per participant and after collection invert the tubes gently to mix the blood with the contained anticoagulant Release the tourniquet entirely after the last tube has filled Withdraw the needle with a swift motion

When the needle is out of the arm press gauze firmly over the puncture site Heavy pressure as the needle is being withdrawn should be avoided to prevent the sharp point of the needle from cutting the vein

If blood cannot be collected using the vacutainer system pre screened syringes have been provided for sample collection USE ONLY THE SYRINGES WHICH HAVE BEEN PROVIDED After collecting the blood (3 mL) in the syringe transfer the blood as soon as possible to the purple top tube This may be accomplished by pushing the needle used to collect the blood from the subject into the stopper of the purple top tube and allowing the vacuum in the tube to transfer the blood from the syringe If the stopper has to be removed in order to transfer the blood extreme care must be taken to avoid contamination of the top of the tube and the stopper Invert the tubes immediately to mix

Have the examinee raise his arm (not bend it) and continue to hold the gauze in place for several minutes This will help prevent hematomas

Report to the physician any reaction experienced by the participant during the venipuncture procedure

Place a bandaid on the subject s arm

B Processing procedure

Assign an id number to each participant and the tube with the preprinted labels provided

Extra labels are provided for paperwork or any other document to cross reference the number assigned with the participant to whom it was assigned

Record each collection on the inventory/shipping list provided

Place tubes in the storage boxes provided Refrigerate (DO NOT FREEZE) these tubes until they can be sent back to CDC

Place each box in a zip lock back before shipping

II SHIPMENT OF SPECIMENS TO CDC ATLANTA GA

A BEGINNING OF STUDY AND GENERAL INSTRUCTIONS

1 Determine the times FEDERAL EXPRESS packages are picked up in order to connect with the best flights to Atlanta Georgia Shipments to Atlanta may be scheduled weekly and scheduled on Monday through Thursday mornings IMPORTANT Since the materials packed in accordance with the instructions below will remain cool (over cold packs) only about 2 days shipments should not arrive in Atlanta on weekends or on Federal holidays If another carrier is used inquire about their requirements when shipping blood specimens

2 Inquire about regulations in your area concerning shipment of human blood Whole blood shipments will require the use of cold packs to keep the materials cool during shipment (NOT FROZEN) Also make sure the specimens will be received at CDC within 24 hours For all shipments do not pack shippers with the specimens and coolant until just before shipment

3 Telephone or fax the laboratory at CDC the day the shipment is mailed Tel (404) 488 4305 Fax (404) 488 4192 Speak with Charles Dodson

B SPECIMEN SHIPPING LIST

1 For each shipment fill out a Specimen Shipping List provided by CDC Please give the following information on the shipping lists

a Page number e g 1 of 4
b Shipment Number number shipments sequentially starting with 1
c Total number of refrigerated shippers containing whole blood specimens which are being mailed in this shipment
d Type of Specimens whole blood serum or urine
e Number of Specimens number of each type of specimen shipped
f Name Title Signature and Phone Number of person sending shipment or initials as indicated on the continuation sheets
g Date shipped
h Specimen ID for each participant e g 95 0039 0001 For each participant, check (X) each individual specimen type/aliquot included in this shipment
i Date Collected e g MM DD YY
j Comments Specify any deviations from collection storage and shipment protocols and date of occurrence

Make a copy of the completed shipping list. The original to be shipped with the specimens and the copy retained for your records

SPECIMEN TEST NAME	ABBREVIATION
LEAD	PB

THE ABOVE TEST IS PERFORMED UTILIZING WHOLE BLOOD COLLECTED IN 3 mL PURPLE TOP TUBES CONTAINING 4 5 MG OF EDTA(K3) AND 0 012 MG OF POTASSIUM SORBATE IN 0 06 mL OF 7 5% EDTA(K3) SOLUTION (PURIFIED WATER TO VOLUME)

A TOTAL OF 3 mL OF BLOOD IS ALL THAT IS REQUIRED FROM EACH PARTICIPANT

--

BIG RIVER MINE TAILINGS LEAD STUDY

CASE 95 0059

WHOLE BLOOD COLLECTION AND PROCESSING PROTOCOL

BLOOD (3 mL FASTING)

(1) 3 mL purple top tube
B1
<u>BLOOD LEAD</u>

Refrigerate and store
at 4 C

Ship to CDC on ice packs
using FEDERAL EXPRESS
label

NOTE ALL ITEMS IN QUOTES AND UNDERLINED ARE <u>LABELS</u>

WHOLE BLOOD COLLECTION/SHIPPING LOG

BIG RIVER MINE TAILINGS LEAD STUDY

CDC STUDY NO 95 0059

B1 = BLOOD LEAD

For each specimen collected indicate below the participant id number mark the spaces with an (X) to indicate that blood was collected or (O) if unable to collect

PARTICIPANT ID NO	B1	COLLECTION DATE	COMMENTS (SPECIFY DEVIATIONS IN COLLECTION, STORAGE, OR SHIPMENT)

SPECIMEN SHIPPING SUMMARY
BIG RIVER MINE TAILINGS LEAD STUDY
CDC STUDY NUMBER 95 0059

Shipment Number	______________
Shipment Date	______________
Shipped By (PRINT)	______________
Signature	______________
Number of Shippers (Boxes)	______________
Received By	______________
Signature	______________
Date Received	______________

Appendix 11 Environmental Sampling Protocols and Forms

SOP 100

Environmental Sampling Protocol
Indoor Environmental Assessment Form
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of information for the ' Indoor Environmental Assessment Form

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines An Indoor Environmental Assessment Form and Home Schematic Form will be completed for each residence and will include the study child s bedroom the main entry area room and up to two other indicated play areas This form will contain information by room assessed concerning room type, surface and substrate type, damage type and source if present total and damaged area XRF measurements obtained and general comments A different form is used for each room

Selection of Sample Locations

1 The Home Schematic Form (FRM 100) will be completed and include a floor plan diagram of all living and play areas within the residence
2 The study child bedroom the main entrance area and up to two additional play areas, will be determined from the parent/guardian and indicated on the home schematic Each of these areas will have a separate Indoor Environmental Assessment Form (FRM 110) completed
3 The numbering sequence will be the study child s bedroom as #1 the play areas as #2 through #4 and the main entry area as #5
4 Closets will only be included if there are no doors on the closet or is large enough to be considered as a walk in closet and will be included as part of the area being assessed
5 An enclosed porch area will be considered as a separate indoor room Otherwise it will be considered as an outdoor area

6 On form indicate surfaces with similar paint histories Identify all friction surfaces all surfaces less then three feet from floor and all surfaces greater than three feet from floor and greater than one square foot in area

Sampling Equipment Sampling equipment will consist of a minimum of

- Tape measures large and small
- "Indoor Environmental Assessment Forms and Home Schematic Form"
- Pen
- Portable XRF unit (this can be used following completion of all assessment forms)
- Step ladder
- Random number generator

Method of Sampling

1 On the 'Home Schematic Form (FRM 100)' indicate all living areas by floor indicate family dwelling type, number of floors, total number of rooms and floors, and draw a rough schematic on the backside of the form for each floor Circle the designated child bedroom, occupant main entry area, and up to two additional child play areas Using the Global Positioning System (GPS) determine latitude and longitude from a secured position in the backyard or porch area and indicate on form The GPS will need to stabilize for up to fifteen minutes prior to recording reading

2 For each area/room being assessed a separate assessment form (FRM 110) is to be completed

3 Complete the general information part of the form identifying and describing the room area Circle or write in the information as indicated

4 A diagram of the room should be sketched on the reverse side of the form, or use the Home Schematic" diagram if feasible (if so indicate use on back of form) Each common history painted surface within the room should be indicated (surface number) and assessed as to surface type and substrate type If the surface is determined to contain (0 7 mg/cm or greater), then additional information of damage and source if any height from floor to the lowest part and total and damaged area measurement should be completed

- For surface type use the numbered selections given, and for substrate type the underlined bold letters Only one response for each should be entered If the correct response is not given, indicate other and write in the correct response
- For damage type and source enter up to three responses from the underlined bold letters
- Total square feet should be estimated/measured to the nearest foot and be inclusive of all surfaces with similar painting history
- Height from floor should be estimated to the nearest foot
- Damaged square feet, if present, should be estimated/measured to the nearest foot and be inclusive of all surfaces with similar painting history If there is no damage a 0 ' should be entered
- The numbering system should start from the main entry into the room/area, as viewed when in the room, and go in a clockwise manner For example, if all doors or windows appear to have a common painting history, only one of the doors or windows need be indicated with the total area, damage and source inclusive of all doors or windows The surface indicated should be the surface in which XRF measurements are performed

5 XRF measurements are to be determined for representative similar paint history areas on the following painted surfaces
- All surfaces less than three feet from the floor which are greater than one square foot in combined homogenous (similar paint history) area or are indicated as damaged
- All friction surfaces including,
  - Representative window stools
  - Representative window sashes, stops, troughs and casings from only operable windows
  - Representative doors, jams and casings,
- Surfaces over three feet from the floor which are indicated as damaged or greater than ten square feet in combined homogenous (similar paint history) area
- Any surface which shows indication of chewing This information should be marked in the comments area

6 XRF Measurements (Recorded on to FRM 110)
- At start and end of the sampling day the XRF Use and Custody (FRM 130) form must be completed

- Prior to each XRF measurement the clear button should be pressed
- The XRF measurement recorded should be the indicated 'L' shell reading after the error has reached a plus or minus 0 1 mg/cm^2 Mark '>' if indicated by the spectrum reading (note this should never be greater then >5) If the spectrum reading indicates a result cannot be accurately obtained, or a reading cannot be obtained for other reasons, mark 99 as the response
- If more than one reading is made, record all readings in same space keeping in line with XRF sample number recorded
- If surface is visibly soiled/dusty, place a piece of plastic or paper between the instrument and surface and/or wipe surface with a non alcohol wipe as necessary
- The XRF calibration check (FRMs 120) should be performed prior to use at each new location/residence, the instrument is knocked, dropped or other impact, turned off for more than one hour, and at the completion of each sampling day (See 'Calibration Check Form)
- Mark yes (Y) or no (N) for spectrum indication if lead is buried below top layer of paint or material
- Indicate XRF sample number given on the instrument
- Enter any comments relevant to interpretation of XRF measurements or other potential exposure observations

7 At the end of each sample day after the final XRF calibration check the XRF data should be down loaded into a prepared data file (SOP 920) After checking that data was properly downloaded, the instrument data file can be erased for the next use

SOP 150

Environmental Sampling Protocol
Paint Sample Collection
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of paint samples from study residences

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines Paint samples will be collected from potential primary lead paint sources on the interior and exterior of the residence as determined from the 'Indoor and Outdoor Environmental Assessment" form and XRF results These samples will be stored and analyzed as needed for either confirmatory results of lead content or source characterization determinations Disposable gloves will be worn for the collection of each sample

Selection of Sample Locations Interior paint chip samples will only be obtained from each surface with different painting histories in the study child s bedroom and main play area(s) **indicated as having damage** which may result in release of paint **and** which are indicated as having lead content equal or greater than 0 7 mg/cm^2 by XRF analysis **Or** for which a valid XRF reading cannot be obtained **and** where the square foot area is greater than 10 **and** the material is indicated as damaged

One exterior paint chip sample will be collected from each painted surface which appears to have a different painting history which are **indicated as having damage** which may result in release of paint **and** which are indicated as having lead content equal or greater than 0 7 mg/cm^2 by XRF analysis **Or** for which a valid XRF reading cannot be obtained **and** where the square foot area is greater than 100 **and** the material is indicated as damaged

In all cases paint chip samples will only be removed from previously damaged areas which are as representative as can reasonably be achieved

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- Razor or utility knife
- Chiseled edge scraper
- Wet wipes for decontamination
- 4-mil re-sealable bag for sample storage
- Step ladder

Method of Sampling Samples will be collected as a sample of convenience No damage to painted surfaces will be made Since paint samples will only be obtained from damaged surfaces, the sample will be collected at a site of damage which is representable of the paint If no damaged sites are available no samples will be obtained and this will be recorded

1 Label sample container with residence ID sticker and sample number (sample number will increase sequentially starting with **P-1**)
2 Place on new pair of disposable gloves
3 Obtain an approximate 2 inch square sample from a representable damaged area
4 Complete sample location information on "Paint Chip Sample Collection (FRM 150)" form
   - Indicate if sample came from (I) indoor, (O) outdoor, or (D) detached surface
   - If indoor give room number If outdoor indicate wall letter
   - Indicate surface number assigned on "Indoor or Outdoor Environmental Assessment form
   - Describe sample location if not clearly indicated on schematic Environmental Assessment form drawing Include any relevant comments to interpretation of data
   - If no damaged areas exist, indicate on the proper Environmental Assessment form in the Comments section that paint chip sample could not be obtained
5 Place all collected samples into a large zip lock storage freezer bag and label with residence ID number

SOP 200

Environmental Sampling Protocol
Dust Floor Vacuum Collection
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of dust floor vacuum samples from residences

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines Up to five indoor composite dust vacuum samples will be collected from the study child's bedroom and play area(s) on to a 0 8 um poly cellulose acetate filter using a personal sampling pump with a nozzle attachment Disposable gloves will be worn for the collection of each sample All sample pumps should be charged daily and fully discharged and recharged once per week

Selection of Sample Locations

1 The bedroom and main play area(s) of the study child, and main entry way location (this will be the entrance most used by the occupants) will be determined from the parent/guardian being interviewed See Home Schematic' FRM 100
2 The bedroom, up to three additional play areas and the main entry area will be sampled
3 If there are greater than three play areas, then carpeted play areas will first be sampled followed by a random selection of non-carpeted areas, up to a total of three play areas If all areas are carpeted then a random selection of three play areas will be sampled
4 If the area is carpeted a vacuum sample will be taken from the center area
5 If the area is not carpeted, a vacuum sample will be taken from the wall corner to the right of the main entry into the room (as viewed when in the room facing the entry)

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- Calibrated sampling pump
- Pre-weighed or matched weight 0 8 um MCE filter in 37 mm sampling cassette
- Vacuum nozzle attachment
- tygon tubing
- 4 mil resealable plastic bags
- Small tape measure or template
- Wet-wipe for decontamination
- Random number generator

Method of Sampling

1 Label sample cassette and storage container with sample number (should be **V-1** for each residence)
2 Calibrate sampling pump to 2 5 L/m air flow or check with rotometer (may be calibrated at the beginning of the day and checked at the end of the day with a primary calibration standard SOP 210 and FRM 210) Indicate that a rotometer air flow check was performed each use on the sample form If the rotometer is off by more than one half of a division correct the air flow and indicate **N** under calibration check, otherwise **Y** If the air flow needed to be corrected, recalibrate pump as soon as reasonably possible with a primary calibration standard
3 Place on new pair of disposable gloves
4 Measure one square foot (25 cm^2) area or use decontaminated template
5 Hold nozzle at 45° angle from the floor and sweep in the same direction at a rate of 2 seconds per stroke, overlapping each stroke only slightly, until the entire area has been covered Repeat the process at 90° from the initial direction
6 Complete "Floor Dust Vacuum Collection (FRM 200) form
    - Dimensions of wiped area (possibilities exist where a square foot area may not be available)
    - Calibration check of pump was performed and satisfactory (Y) or needed to be corrected (N)
    - Visible soil or dust on general inspection from one foot distance
    - Surface very smooth (1) means no irregularities during vacuum (such as very smooth hard surface floor), to very rough (5) means many irregularities (such as thick shag carpet)

7 Continue the process at each sample site until all samples have been collected on to the same filter cassette

8 Place filter cassette into storage container

9 Decontaminate or dispose of sampling nozzle Decontaminate template if used with wet-wipe

SOP 210

Environmental Sampling Protocol
Sampling Pump Calibration
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the calibration and calibration checks of sampling pumps used for dust vacuum samples

Application The procedure outlined in this SOP are applicable to all environmental sampling for the Big River Study

General Guidelines At the beginning of each sampling day the sampling pumps to be used for dust floor vacuum collection samples will be calibrated with a primary standard to 2 5 L/minute The rotometer setting will be recorded and checked during the sample day as a qualitative measure At the end of each sampling day the sampling pump is then checked against the primary standard to determine the end of day flow rate Also, between each sampling day all pumps are to be charged Once per week the pump batteries are to be depleted and recharged to avoid creation of a battery memory

Equipment

- Sampling pumps
- Filter and cassette same as to be used in field collection
- Tygon tubing
- Primary calibration standard (Dry calc calibrator)

Methodology

1 Attach sampling pump to primary calibration standard with filter and cassette in line between the two
2 Start sampling pump and adjust flow to 2 5 L plus or minus 0 1 L
3 After sampling pump has been adjusted perform a minimum of three and preferably ten flow rate checks and record the average and number

of tests perfomed Also record the pump rotometer setting to the nearest half reading

4 Complete enter date, name of individual perfoming calibration, sampling pump SN and time on the Calibration Form (FRM 210)

5 At the end of the calibration day check the calibration
   - Connecting the sampling pump to the primary standard with a filter and cassette between the two
   - Perform a minimum of three, and preferably ten flow rate checks and record the average and number of tests perfomed
   - Record the results, time and name of individual performing the calibration on the same form (FRM 210)

6 Connect the sampling pump to the charger at the end of each sampling day

7 Once per week set the charger on drain and trickle charge

SOP 250

Environmental Sampling Protocol
Window Stool Dust Wipe Sampling
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of interior dust wipe samples from residences

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines Wipe sample site selection and collection will be performed after the 'Indoor Environmental Assessment (FRM 110)" form has been completed Up to five wipe samples will be obtained from selected operable window stools to form one composite sample for analysis The areas to be sampled will be the study child s bedroom and main play area(s) All surface areas sampled will be measured Disposable gloves will be worn for the collection of each sample

Selection of Sample Locations

1 The study child bedroom and main play area(s) will be determined from the parent/guardian being interviewed See Home Schematic form (FRM 100)
2 The number of operable windows in each room will be determined by trial or information from the parent/guardian being interviewed
3 If the number of operable windows is five or less, all windows are selected for sampling
4 If the number of operable windows is greater than five then random sampling for one window stool in each room of the operable windows will be performed If there are fewer than five rooms the remaining operable windows will be randomly sampled until a total of five windows are sampled

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- Wash n Dry Wipes or similar approved product

- Measuring tape
- 4-mil re sealable plastic containers
- Random number generator

Method of Sampling

1 Complete "Wipe Sampling (FRM 250)' form header information (Residence ID sticker Composite sample number Date, Inspector initials and general description of composite samples)
2 Label sample collection bag with composite sample number (this should be **W-1** for each residence)
3 Prior to the collection of each sample for the composite complete the following information on the sample form
    - the room number and surface number of the sample site from the "Indoor Environmental Assessment" form
    - Dimensions of the area to be wiped to the closest inch This should be a rectangular area adjacent to the window sash, and not to include edges along the side of the vertical window casing
    - Soiling Index questions
        - If visible loose soil/dust is visible on a general inspection within one foot of the window stool, then yes, otherwise no
        - If visible movement is observed when a light puff of air is blown on the window stool within one foot, then yes, otherwise no
        - After each of the three wipes look at the wipe sample for visible soil/dust collection
    - Smoothness of surface This recorded after sampling A very smooth (1) surface would have no grooves felt or catching edges during the wipe sample A very rough (5) surface would contain numerous ridges and/or catching edges during the wipe sample
    - General comments concerning conditions or sampling procedure which may affect interpretation of results
4 Place on new pair of disposable gloves
5 If the wipe sample media used comes from a continuous roll, such as Wash'n Dry, then the first towelet should be removed and disposed of If this is the first wipe removed during the day, the first two towelets should be disposed
6 Remove a new towelet and place flat at one end of the window sill and wipe in an 'S' pattern over the entire surface making sure that each

stroke only slightly overlaps the previous stroke Fold the wipe in half with the dirt side inside and the re-wipe the sill at 90° from the first wipe Fold the wipe again in the same manner and re-wipe the stool similar to the first wipe Again fold the dirt side inside and place into the pre-labeled sample container

SOP 300

Environmental Sampling Protocol

Vacuum Bag Collection

Standard Operating Procedure

for

Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of vacuum bag samples from residences

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines Contents of the vacuum cleaner will be collected by placing disposable vacuum cleaner bags, or emptying non-disposable bags into the collection container Disposable gloves will be worn for the collection of each sample

Selection of Sample Locations

1 The resident will be requested to identify and open (or give permission to open) the household vacuum cleaner If there is more than one vacuum cleaner the one indicated as being used primarily for the bedroom and play area(s) of the study child will be used
2 If resident will not allow disposable bag to be removed, and contents cannot be emptied, then no samples will be obtained and so indicated on the collection form

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- 4-mil plastic re-sealable bags (12" x 15") Small garbage bags of at least 0 6 mil with twist ties may be used for disposable bag samples

Method of Sampling

1 Label sample container with sample residence ID sticker and number Sample number should be **B-1** for each residence
2 Place on new pair of disposable gloves
3 If vacuum bag is disposable type, place entire bag into sample collection container

4 If vacuum bag is non-disposable empty contents of vacuum cleaner into sample collection container
5 Seal sample collection container
6 Complete Vacuum Cleaner Bag Collection (FRM 300) form

SOP 350

Environmental Sampling Protocol

Drinking Water Sample Collection

Standard Operating Procedure

for

Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of drinking water samples from residences

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines First draw kitchen cold tap drinking water samples will be collected into sample containers with nitric acid preservative supplied by the laboratory performing the analysis Disposable gloves will be worn for the collection of each sample

Selection of Sample Locations The drinking water sample will be collected from the cold tap of the kitchen faucet

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- 250 or 1000 ml polyethylene bottles containing nitric acid stabilizer supplied by the laboratory performing the analysis

Method of Sampling

1 When the site visit is being arranged the resident will be requested not to use the kitchen water tap for eight hours prior to site visit
2 Label sample collection container with sample number (should be **W-1** for each location)
3 Place on new pair of disposable gloves
4 Place collection container under cold water kitchen faucet
5 Fill container
6 Seal sample collection container
7 Complete "Drinking Water Collection (FRM 350)' form
    - Sample location and date identifiers (number date and [illegible]

SOP 400

Environmental Sampling Protocol
Outdoor Environmental Assessment Form
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of information for the Outdoor Environmental Assessment Form'

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines An Outdoor Environmental Assessment Form (FRM 400" will be completed for each residence and will include all exterior painted areas This form will contain information by exterior wall or detached areas, assessing surface and substrate type, damage type and source if present total and damaged area, XRF measurements obtained and general comments A different form is used for each wall with a reasonably assumed similar painting history All detached areas are put onto one form

Selection of Sample Locations

1 All outdoor representative homogenous (surfaces with similar painting histories) surfaces whether attached or detached from the residence and which are greater than ten square-feet in surface area any damaged surface bordering a non vegetated soil or hard surface play area and representable window sashes casings, stops and wells doors, jams and casings will be included on the Outdoor Environmental Assessment Form' If any painted play equipment, fences our structures within the yard are present they should be identified on the detached form
2 The Wall numbering sequence which identifies the distinct side of the residence will start at the street address main entrance side to the residence as A and will increase alphabetically in a clockwise direction

S mpling Equipment Sampling equipment will consist of a minimum of

- Tape measures large and small

- Outdoor Environmental Assessment Forms (FRM 400)"
- Clip board
- Pen
- Portable XRF unit (this can be used following completion of all assessment forms)
- Step ladder
- Random number generator

Method of Sampling

1 A separate form will be completed for each distinct Wall area which is reasonably assumed to have a similar painting history (typically side of residence) and for detached surface areas (play area equipment, fences and other detached painted surfaces) being assessed Draw an aerial schematic of the yard on the first form used, indicating the designated Wall letter **and insure that all detached surfaces are indicated** (the "Away From House Soil Collection" form can be used if feasible, but indicate such use on the back of the form) Each form used should have a side view schematic numbering the surfaces as is reasonable in the diagram

2 Complete the general information part of the form identifying and describing the area

3 Each painted surface should be indicated (surface number) and assessed as to surface type and substrate type If, after XRF analysis the surface is found to contain lead at 0 7 mg/cm^2 or greater, then information on damage and source if any, and total and damaged area measurement should be completed

   - For surface type use the numbered selections given, and for substrate type the underlined bold letters Only one response for each should be entered Of the correct response is not given, indicate 'other' and write in the correct response
   - For damage type and source enter up to three responses from the underlined bold letters
   - Total square feet should be estimated/measured to the nearest foot and be inclusive of all surfaces with similar painting history
   - Damaged square feet, if present, should be estimated/measured to the nearest foot, and be inclusive of all surfaces with similar painting history If there is no damage a "0" should be entered

4 XRF measurements will be determined on all painted surfaces greater than ten square feet in surface area and any damaged surface bordering a non vegetated soil or hard surface play area Only the ground level floor and items which can be reached with a small step ladder will be tested

- At start and end of the sampling day the XRF Use and Custody (FRM 130) form must be completed
- Prior to each XRF measurement the clear button should be pressed
- The XRF measurement record should be the indicated L shell reading after the error has reached a plus or minus 0 1 mg/cm^2 Mark > if indicated by the spectrum reading (note this should never be greater then >5) If the spectrum reading indicates a result cannot be accurately obtained or a reading cannot be obtained for other reasons mark 99 as the response
- If more than one reading is made, record all readings in same space keeping in line with XRF sample number recorded
  - If surface is visibly soiled/dusty, place a piece of plastic or paper between the instrument and surface Wipe surface with a non alcohol wipe as necessary
  - The XRF calibration check should be performed prior to use at each new location the instrument is knocked dropped or other impact or turned off for more than one hour (See Calibration Check' Form FRM 120)
  - At the end of each sample day the XRF data should be down loaded into a prepared data file After checking that data was properly downloaded the instrument data file can be erased for the next use (SOP 920)
- Mark yes (Y) or no (N) for spectrum indication if lead is buried below top layer of paint or material
- Indicate XRF sample number given on the instrument
- Enter any comments relevant to interpretation of XRF measurements or other potential exposure observations

5 For play area equipment and other detached painted surfaces in the comments section indicate the Wall letter which is opposite the surfa type Draw separate schematics as may be needed

4 If a designated region does not contain any soil within the designated region of the structure then no sample will be taken from this region If fewer than four regions have soil areas for sampling then additional soil samples will be taken from the largest existing region in a random selection site as described above If four samples have still not been collected, then the next largest region will be selected, and so on

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- Slotted 7/8 inch soil recovery probe
- Wet wipes and paper towels for decontamination
- Bucket of water and brush for decontamination
- 4-mil resealable plastic bags (8 x 8')
- Large zip-lock freezer bags
- Large tape measure
- Knife

Method of Sampling

1 Label sample storage container with composite sample number

2 Complete ' Soil Collection (FRM 450)" form for composite sample to be obtained This will entail determining the percent of bare ground to covered ground in sectioned area Covered ground is considered vegetation (as described below) and hard surfaces (concrete asphalt, etc), and, testing the soil consistency in a location adjacent to where the sample is to be collected

   - Soil compaction is determined by pressing on the intact soil If the soil will not compress or give to the pressure it is compact (1) If the soil easily compresses and if spaces by seen between soil particles it is loose (5)
   - If soil breaks-up or crumples easily with finger pressure into small particles it is easily broken (1) If soil must be pried apart or impact force used to break up is is difficult (5)
   - Soil which is wet enough to thickly pour out of the hand is considered wet (1) to soil with no obvious moisture as dry (5)
   - A soil surface area which is totally covered with grass or other live organic material with a root system is vegetated (1) A totall bare soil surface area is non vegetated (5)

3 The direction of the sectioned area facing away from the residence and that wall letter designation should be recorded for each sample in the composite
4 Place on new pair of disposable gloves
5 Remove any visible paint chips and other non soil debri prior to taking sample and indicate presence of paint chips on sample site form in description section for sample area
6 Insert soil probe at least two inches into soil and remove with sample
7 Remove any vegetation from top of soil sample
8 Cut out top half inch of sample and slide into collection container
9 Dispose of any remaining soil and wipe residual soil from sample probe
10 Continue the process at each sample site placing each new composite into sample container until at least four samples have been collected
11 De contaminate sample probe (and knife if not disposable) by wiping off all visible soil with gloved hand and paper towels/wipes Place soil probe into bucket and brush inside and outside of probe Change water as appropriate

SOP 500

Environmental Sampling Protocol

Away From House Soil Collection

Standard Operating Procedure

for

Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of away from house soil samples from study residences

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Studv Within the study area a side by-side soil sample of six inch depth will be obtained in a similar fashion

General Guidelines Away from house composite yard soil samples of up to five one half inch each of normal top soil without vegetation will be collected Disposable gloves will be worn for the collection of each sample

Selection of Sample Locations

1 An aerial view diagram of the residence and property will be sketched, on the reverse side of the ' Soil Collection (FRM 450) Form", and divided visually into four approximate equivalent yard areas extending from the corner of the residence to the nearest corner of the property boundary Wherever possible the natural outlines of the residence and yard will be used to segregate the areas, and the exterior wall letter designations will be indicated on the sketch A fifth area will be used depending on the property and residence configuration
2 The sample areas will be identified with the main street entrance area as '1' and increasing count in a clockwise direction This should correspond with the exterior wall letter designations as much as possible
3 Within each of the selected areas non-vegetated regions which are not child play areas will be indicated which are greater than three and one half feet from the house wall If there is more than one non-vegetated non-play area, one will be randomly selected for sampling Samples will be collected from the center of each sample area and at least three feet from anv water run off source

4 If there are no non vegetated non plav areas a sample site will be selected at the approximate mid point of the region The vegetated material will be removed from the sample prior to addition to the composite sample collection container

5 If a designated region does not contain anv soil outside of three and one half feet of the structure then no sample will be taken from this region If fewer than four regions have soil areas for sampling then additional soil samples will be taken from the largest existing region in a random selection site as described above If four samples have still not been collected then the next largest region will be selected and so on

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- Slotted 7/8 inch soil recovery probe
- Wet wipes and paper towels for decontamination
- Bucket of water and brush for decontamination
- 4 mil resealable plastic bags (8 x 8 for 1/2 cores 12 x 15 for 6 cores)
- Extra large (for six-inch cores) and large (for one half-inch cores) zip-lock freezer bags
- Large and small tape measure
- Knife
- Random number generator

Method of Sampling

1 Label sample storage container with residence ID sticker and composite sample number Sample number should be a sequential number for all soil samples starting with S ?

2 Complete Soil Collection (FRM 450) form for composite sample to be obtained This will entail checking sample type at top of form and determining the percent of bare ground to covered ground in sectioned area Covered ground is considered vegetation (as described below) and hard surfaces (concrete asphalt etc) and testing the soil consistency in a location adjacent to where the sample is to be collected

    - Soil compaction is determined by pressing on the intact soil If the soil will not compress or give to the pressure it is compact (1) If the soil easily compresses and if spaces by seen between soil particles it is loose (?)

- If soil breaks up or crumples easily with finger pressure into small particles it is easily broken (1) If soil must be pried apart or impact force used to break up is difficult (5)
- Soil which is wet enough to thickly pour out of the hand is considered wet (1) to soil with no obvious moisture as dry (5)
- A soil surface area which is totally covered with grass or other live organic material with a root system is vegetated (1) A totally bare soil surface area is non-vegetated (5)

3 The direction of the sectioned area facing away from the residence, the distance to the closest perpendicular wall, and that walls letter designation should be recorded for each sample in the composite

4 Place on new pair of disposable gloves

5 Insert soil probe at least two inches for one half inch samples, and eight inches for six inch soil samples, into soil and remove with sample

- When samples are collected within the 'study area' (not the control area), wherever a half inch sample is collected for a soil composite a six-inch sample will also be obtained within six-inches of the half-inch core site A separate composite sample will be collected for the six inch cores

6 Remove any vegetation from top of soil sample

7 Cut out top half inch, or six inches of sample, as appropriate, and slide or place into collection container

8 Dispose of any remaining soil and wipe residual soil from sample probe

9 Continue the process at each sample site placing each new composite into sample container until at all samples have been collected

10 Place sample collection container into extra large zip lock freezer storage bag for six-inch samples and a large zip-lock freezer bag for half-inch samples

11 De-contaminate sample probe (and knife if not disposable) by wiping off all visible soil with gloved hand and paper towels/wipes Place soil probe into bucket and brush inside and outside of probe Change water as appropriate

SOP 550

Environmental Sampling Protocol
Home Play Area Soil Collection
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of soil samples within child play areas of each residence

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines A composite of soil samples one-half inch each of normal top soil without vegetation will be collected from the indicated child play areas of the house Disposable gloves will be worn for the collection of each sample

Selection of Sample Locations

1 The aerial view diagram of the residence sketched and areas indicated for the Away From House Soil Collection (FRM 450) Form may be used or a new sketch made The study child play areas will be marked as indicated by the parent/guardian being interviewed Sand boxes and other non soil areas will not be included
2 Each of the non-vegetated play areas indicated (up to five) will be sampled If there are more than five play area sites that are non-vegetated up to a total of five will be randomly selected If there are less than four, a random sample among all sites will be performed until there are a minimum of four samples collected
3 Samples will be collected from the center of each sample area

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- Slotted 7/8 inch soil recovery probe
- Wet wipes and paper towels for decontamination
- Bucket of water and brush for decontamination
- 4 mil resealable plastic bags (8 x 8 for 1/2 cores 12 x 15 for 6 cores)

- Extra large zip-lock freezer bags
- Large tape measure
- Knife

Method of Sampling

1 Label sample storage container with composite sample number

2 Complete ' Soil Collection (FRM 450) form for composite sample to be obtained This will entail determining determining the percent of bare ground to covered ground in sectioned area Covered ground is considered vegetation (as described below) and hard surfaces (concrete, asphalt, etc), and, testing the soil consistency in a location adjacent to where the sample is to be collected
    - Soil compaction is determined by pressing on the intact soil If the soil will not compress or give to the pressure it is compact (1) If the soil easily compresses and if spaces by seen between soil particles it is loose (5)
    - If soil breaks-up or crumples easily with finger pressure into small particles it is easily broken (1) If soil must be pried apart or impact force used to break-up is difficult (5)
    - Soil which is wet enough to thickly 'pour' out of the hand is considered wet (1) to soil with no obvious moisture as dry (5)
    - A soil surface area which is totally covered with grass or other live organic material with a root system is vegetated (1) A totally bare soil surface area is non vegetated (5)

3 The direction of the sectioned area facing away from the residence, the distance to the closest perpendicular wall, and that walls letter designation should be recorded for each sample in the composite

4 Place on new pair of disposable gloves

5 Insert soil probe at least two inches into soil and remove with sample

6 Remove any vegetation from top of soil sample

7 Cut out top half-inch of sample and slide into collection container

8 Dispose of any remaining soil and wipe residual soil from sample probe

9 Continue the process at each sample site placing each new composite into sample container until at least four samples have been collected

10 Place sample collection container into large zip-lock freezer storage bag

11 De contaminate sample probe (and knife if not disposable) by wiping off all visible soil with gloved hand and paper towels/wipes Place soil probe

SOP 600

Environmental Sampling Protocol
Community Play Area Soil Collection
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection of soil samples from community/neighborhood child play areas

Application The procedure outlined in this SOP are applicable to all personnel collecting environmental samples for the Big River Study

General Guidelines A composite of up to five soil samples one half inch each of normal top soil without vegetation will be collected from each indicated community/neighborhood child play area Disposable gloves will be worn for the collection of each sample

Selection of Sample Locations

1 Study children common community play areas will be determined from the parent/guardian interview information
2 For each community play area an aerial view diagram of the play area will be sketched All non-vegetated play areas greater than ten square feet will be indicated Sand boxes and other non-soil areas will not be included If there are fewer than four non-vegetated play areas, then the vegetated play areas will be indicated
3 Up to five non-vegetated areas will be randomly selected If there are fewer than five areas then a random selection among the vegetated areas will be made until there are five sample areas The sample areas will be identified with the north most area as '1' and increasing count in a clockwise direction
4 Samples will be collected from the center of each selected sample area

Sampling Equipment Sampling equipment will consist of a minimum of

- Disposable gloves
- Slotted 7/8 inch soil recovery probe
- Wet wipes and paper towels for decontamination

- Bucket of water and brush for decontamination
- 4-mil resealable plastic bags (8 x 8 for 1/2 cores 12 x 15 for 6 cores)
- Large zip lock freezer bags
- Large tape measure
- Knife
- Random number generator

Method of Sampling

1 Label sample storage container with composite sample number
2 Complete Soil Collection (FRM 450) form for composite sample to be obtained This will entail determining the percent of bare ground to covered ground in sectioned area Covered ground is considered vegetation (as described below) and hard surfaces (concrete, asphalt etc), and testing the soil consistency in a location adjacent to where the sample is to be collected
   - Soil compaction is determined by pressing on the intact soil If the soil will not compress, or give, to the pressure it is compact (1) If the soil easily compresses and if spaces by seen between soil particles it is loose (5)
   - If soil breaks up or crumples easily with finger pressure into small particles it is easily broken (1) If soil must be pried apart or impact force used to break up is difficult (5)
   - Soil which is wet enough to thickly 'pour out of the hand is considered wet (1) to soil with no obvious moisture as dry (5)
   - A soil surface area which is totally covered with grass or other live organic material with a root system is vegetated (1) A totally bare soil surface area is non-vegetated (5)
3 Place on new pair of disposable gloves
4 Insert soil probe at least two inches into soil and remove with sample
5 Remove any vegetation from top of soil sample
6 Cut out top half inch of sample and slide into collection container
7 Dispose of any remaining soil and wipe residual so l from sample probe
8 Continue the process at each sample site placing each new composite into sample container until at all samples have been collected
9 Place sample collection container into a large zip lock freezer sto age bag

10 De contaminate sample probe (and knife if not disposable) by wiping off all visible soil with gloved hand and paper towels/wipes Place soil probe into bucket and brush inside and outside of probe Change water as appropriate

SOP 900

Environmental Sampling Protocol
Field QA/QC Samples
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for the collection and submittal of laboratory spike samples as an assessment of laboratory quality control, laboratory blanks to assess media component contamination field blank samples to assess field methodology contamination and field second collection samples to assess variability in the media sampled

Application The procedure outlined in this SOP are applicable to all environmental sampling for the Big River Study

General Guidelines All laboratories involved in the sample analysis will be accredited through the American Industrial Hygiene Association Laboratory Accreditation Program for metal analysis, and, be a participant in the Lead Proficiency and Analytical Testing (LPAT) program with satisfactory proficiency ratings, and, be accredited for drinking water analysis within a State

As one of the components to assess laboratory analysis quality control the following will be performed

- Spiked vacuum filter (20%) wipe (2%), soil (2 5%) and water (2 5%) samples prepared by a third party laboratory using NIST standards will be submitted with normal field samples
- Split soil (5%) and water (5%) samples will be submitted to a second laboratory for sample preparation and analysis concentration verification
- Media blanks for each lot used of filters, sample storage containers, and gloves, for laboratory use will be maintained and analyzed for interference by the laboratory

To assess possible contamination from presence in the field the following will be performed

- One field blank per sampling day per sampling team will be submitted for laboratory analysis of vacuum filters and wipes
- One field blank per every 40th residence per sampling team will be submitted for laboratory analysis of wipe media and wipe samples of latex gloves

To assess variability of the analytes within the soil sample media a second sample will be taken for 5% of the soil samples within six inches of the first sample

Spiked Laboratory Samples Dust spiked samples shall be submitted as part of the regular sample submittals by the Field Project Manager in a manner so that the laboratory cannot distinguish the spiked samples from the field samples Spiked wipe samples will be submitted for every 50 field wipe samples Spiked vacuum filters will be submitted for every 5 field vacuum samples Spiked soil samples will be submitted for every 40 field soil samples Spiked water samples will be submitted for every 40 field collected water samples

The spiked samples will be given the sample number and ID of the location of the last home performed on the sample day each spike is submitted On the appropriate sample form the word "Spike" will be entered

The following NIST Standard Reference Materials (SRM's) will be used for the spikes

- Wipe samples - NIST Lead Paint Dust Standard Powdered Lead Based Paint SRM 1579a
- Filter samples - NIST Standard Urban Particulate Standard SRM 1648
- Water samples - NIST traceable solutions for lead by graphite furnace absorption
- Soil samples - NIST Standard Montana II Soil SRM 2711

Split Samples Split samples of soil will be obtained for 5% of the samples and submitted to a second laboratory for analysis verification

Water samples will be split in the field by taking a 500 ml sample and using this sample to fill two 250 ml containers supplied by the laboratory One of these samples will be sent to the secondary laboratory

From each set of 20 sequential soil prepared by the laboratory a random sample will be selected and sent to the second laboratory

Split samples will be given a separate sample number to distinguish between the two with the word Split Sample entered in the comments section of the appropriate form

Laboratory Media Blanks Laboratory media blanks for filters, wipes gloves and sample storage containers will be maintained or sent to the laboratory for each lot number

- Filters will be supplied by the laboratory
- Water containers will be supplied by the laboratory
- Gloves will be supplied by the contractor
- Other sample storage containers will be supplied by the contractor (4 mil and 8-mil zip-lock bags)

Field Blanks Field sampling media blanks for filters and wipes will be supplied to the laboratory at a rate of one per sampling day per sampling team Field blanks for gloves and sample bag containers will be submitted at a rate of 1 per 40 sampling sites per sampling team These will be submitted with the field samples collected each week The field sample blanks will be collected during the sampling at the final sample site of the day

Filter field blanks will be obtained by removing the end-plugs on a filter cassette, then re-inserting the end-plugs and placing into a similar labeled sample container as the field samples A sample collection form (FRM 200) is completed with the words ' Field Blank" written in the comments section

Wipe field blanks will be obtained by first removing and disposing of the top wipe, and then removing three wipes and placing into a similar labeled sample container as the field samples A sample collection form (FRM 250) is completed with the words ' Field Blank' written in the comments section

Glove field blanks will be obtained by removing two gloves as would normally be performed and placing on the hands Three successive wipes, after throwing away the first wipe, will be made of the gloves and the wipes submitted as field blanks for the gloves in a sample container The words "Glove Field Blank" and the ID number are written on the sample container and the chain of custody form

Sample bag field blanks will be obtained by removing a sample bag, one of each size as would normally be performed and placing into a sample container The words "Sample Bag (bag type) Field Blank and the ID number are written on the sample container and the chain of custody form

If two field sample blank results in a row are greater than detectable but below the quantitative limit, the field sampling methodology will be reviewed and observed to determine contaminant sources or mechanisms If and field sample blank result is greater than the quantitative limit, the field sampling methodology will be reviewed and observed to determine contaminant sources or mechanisms

Second Samples A second one and one-half inch soil sample will be collected within six inches of each soil sample for every twenty samples taken to form a second composite The soil collection form (FRM 450) will be completed and the words 'Second Sample" will be written in the comments section A sequential sample number will be given (S 2)

SOP 910

Environmental Sampling Protocol
Sample Chain of Custody, Storage and Transport
Standard Operating Procedure
for
Big River Study

Purpose The purpose of this SOP is to establish uniform procedures for completion and compliance with the chain of custody requirements storage requirements and transport of samples to the laboratory or secondary storage location

Application The procedure outlined in this SOP are applicable to all environmental sampling for the Big River Study

General Guidelines At the end of each sample day Chain of Custody Record (FRM 910)' forms will be completed for each residence sampled that day The samples are stored at the designated storage location and conditions each day Once per week the samples are transported by the field project manager or designated individual to Saint Louis University or the selected laboratory

Equipment

- Refrigerator or coolers and ice packs for water samples which are not stabilized with nitric acid
- Storage containers (rigid cardboard boxes or similar container) for soils filters, wipes paint chips and vacuum bags

Methodology

1 At the end of each sampling day all collected environmental samples from each residence will be entered onto a Chain of Custody Record' form (FRM 910)
2 At the end of each sampling day all samples will be stored in secured locations The water samples will be stored in a designated refrigerator or cooler with ice packs if not stabilized with nitric acid All other samples will be stored in a solid storage container such as a rigid cardboard box with a lid or other similar container

3 Once per week all samples will be transported to Saint Louis University or the Laboratory by the Field Project Manager or designated individual

4 Whenever the samples change hands such as from environmental technicians to individual transporting samples to the laboratory accepting the samples the chain of custody record will remain with the samples and be completed (signed and dated) by all associated individuals

5 A copy of the Chain of Custody form when it is first completed each day, and a second copy with the final transfer signature from the laboratories will be made and kept on file at Saint Louis University

6 Samples are to remain in control of the individual who last signed for the samples such as within eye-sight or stored in an appropriate secured location

FRM 010

List of SOP's and Associated Forms, Expected Sample Numbers Per Residence, and Sample Type Codes

SOP No	SOP's	Associated Forms	Form No	Minimum Sample No	Maximum Sample No	Sample Indicator Code
	Soil					
500	Away From House	Soil Collection	450	1	5	S
450	Drip Line	Soil Collection	450	4	5	S
550	Home Play Areas	Soil Collection	450	4	5	S
600	Community Play Areas	Soil Collection	150	4	5	S
200	Dust Floor Vacuum	Floor Dust Vacuum Collection	200	1	5	V
		Home Schematic	100			
		Sampling Pump Calibration	210			
300	Vacuum Bag	Floor Dust Vacuum Bag Collection	300	0	1	B
150	Paint Chips	Paint Chip Collection	150	5	20	P
350	Drinking Water	Drinking Water Collection	350	0	1	W
250	Window Stool Dust Wipe	Dust Wipe Collection	250	4	5	D
		Home Schematic	100			
100	Indoor Environmental Assessment	Indoor Environmental Assessment	110	25	150	XRF
		XRF Calibration Check	120			
		XRF Use and Custody	130			
		Home Schematic	100			
400	Outdoor Environmental Assessm	Outdoor Environmental Assessment	100	20	100	XRF
		XRF Calibration Check	120			
		XRF Use and Custody	130			
910		Chain of Custody	910			
210	Sampling Pump Calibration	Sampling Pump Calibration	210			
900	Field QA/QC Sampling	Field QA/QC Samples	900			
910	Sample Chain of Custody Storage and Transport	Chain of Custody	400			
920	XRF Data Computer Download	XRF Download Logsheet	920			
			Totals	73	292	

FRM 015

Check List of Items Each Sampling Team Should Have Available At Each Sampling Location

Check	Items Each Sampling Team Should Have Immediately Accessible	No
	Residence file with all forms and ID labels (Should also always have extra forms)	1
	Writing board/clip board	1
	Pens/pencils and indelible markers	1 each
	Flashlight	1
	Calculator	1
	Paper Towels	2 rolls
	Baby wipes	2 boxes
	Utility knife	1
	Razor knife	1
	Bucket	1
	Bottle brush	1
	Alconox soap	1 container
	Distilled water and pouring container	1 container
	Framing square	1
	Measuring tapes small and large	1 each
	Gloves to wear when collecting all samples (latex or vinyl)	2 boxes
	Tweezers	1
	Sample collection bags 4 mil 8 x 8 (for cassettes wipes and 1/2 inch soils)	2 boxes
	Sample collection bags 4 mil 12 x 15 (for vacuum bags and 6 inch soils)	2 boxes
	Small freezer zip lock bags (for double bagging 1/2 inch soil samples)	2 boxes
	Large freezer zip lock bags (for doubl ba gin 6 inch soil samples and combinin all samples from residence)	2 boxes
	Soil coring tool	1
	Filter cassettes	1 box
	Drinking water collection containers (250 ml) supplied by lab	2
	500 ml container for measuring split water samples	1
	Small screwdriver for adjusting sampling pump as needed	1
	Tygon tubing cut to length with 45° on one end for vacuuming and extra as needed	As needed
	Sampling pump (Calibrated to 2 5 L/minute)	1
	XRF Unit (Also case with transport information and calibration standards)	1
	Dosimetry rings to wear when using XRF	1
	Global Positioning System (GPS)	1

FRM 100

Home Schematic

Put ID Sticker Here

On back side of form draw rough schematic floor plan of each floor which contains living space and label each room by its type **Indicate 'Study Childs Bedroom Circle up to four primary play areas of study child**

First Floor	**Second Floor**	**Basement (If living or play space only)**	**Other** ________

Is this (**Check One**)	___ Single family	___ 4 Units or less	___ 4 Units or more
Location is/has (Check One)	___ Basement	___ Slab	___Trailer
Total number of floors above ground _______			
Total Number of Rooms in Residence _______			

Suggested room type names

Study Child Bedroom (SBDR)	Bathrooms (BTR #)	Living Room (LR)	Dining Room (DR)
Other Bedrooms (BDR #)	Family Room (FR)	Play Room (PR)	Kitchen (K)
Breakfast Room (BRKR)	Nursery (NSRY)	Porch (P)	Hallways (H #)
Occupant Main Entrance (ME)			

Global Positioning System (performed at secured back yard location)

- Allow to operate for fifteen minutes prior to recording readings

Latitude _____° _____ ________ minutes

Longitude _____° _____ ________ minutes

C 0/?

XRF Calibration Check

Date (MM/DD/YY) __/__/__

XRF SN ________________

Page ___ of ___

Inspt Initial	Time	Response Verification	Source Check One (0.29 mg/cm^2)		Source Check Two (1.0 mg/cm^2)		Three (1.63 mg/cm^2)		Four Back of Two		Action/Comments
			Sample No	Result	Sample No	Result	Sample No	Result	Sample No	Result	
			Average								
			Average								
			Average								
			Average								
			Average								
			Average								
			Average								

Perform all calibration checks on top of instrument case

Perform each calibration check 20 seconds each for three trials and average

Perform calibration checks

- Prior to use at each location
- Instrument was knocked/dropped or otherwise sustained impact
- Instrument was turned off for one hour

If any value is off be more than 20% from the average then repeat test

Check if performed

FRM 150 July 29 1995

Paint Chip Collection

Put ID Sticker Here	Date (MM/DD/YY) _ _/_ _/_ _ Inspector Initials (F/M/L) _ _ _

	In/Out/ Detatched	Room No or Wall letter	Surface No	Comments/location
P 1				
P 2				
P 3				
P 4				
P 5				
P 6				
P 7				
P 8				
P 9				
P 10				
P 11				
P 12				
P 13				
P 14				
P 15				
P 16				
P 17				
P 18				
P-19				
P 20				
P 21				
P 22				
P 23				
P 24				
P 25				
P 26				
P 27				
P 28				
P 29				
P 30				
P 31				
P 32				

FRM 200 - Floor Dust Vacuum Collection

Put ID Sticker Here	Composite Sample Number V-_____ Date (MM/DD/YY) __/__/__ Inspector Initials (F/M/L) __/__/__

General Composite Description

Location and Description for each composite (See Indoor Environmental Assessment Diagram)

1 Room number __ Floor type (carpet wood tile linoleum other __________)
General Comments

Dimensions of vacuumed area (inches) _______X______ Calibration check Y N
Visible Soil/dust **(Circle One)** Y N
Surface very smooth (1) to very rough (5) **(Cirlce One)** 1 2 3 4 5

2 Room number __ Floor type (carpet wood tile linoleum other __________)
General Comments

Dimensions of vacuumed area (inches) _______X______ Calibration check Y N
Visible Soil/dust **(Circle One)** Y N
Surface very smooth (1) to very rough (5) **(Cirlce One)** 1 2 3 4 5

3 Room number __ Floor type (carpet wood tile linoleum other __________)
General Comments

Dimensions of vacuumed area (inches) _______X______ Calibration check Y N
Visible Soil/dust **(Circle One)** Y N
Surface very smooth (1) to very rough (5) **(Cirlce One)** 1 2 3 4 5

4 Room number __ Floor type (carpet wood tile linoleum other __________)
General Comments

Dimensions of vacuumed area (inches) _______X______ Calibration check Y N
Visible Soil/dust **(Circle One)** Y N
Surface very smooth (1) to very rough (5) **(Cirlce One)** 1 2 3 4 5

5 Room number __ Floor type (carpet wood tile linoleum other __________)
General Comments

Dimensions of vacuumed area (inches) _______X______ Calibration check Y N
Visible Soil/dust **(Circle One)** Y N
Surface very smooth (1) to very rough (5) **(Cirle One)** 1 2 3 4 5

FORM 210
Sampling Pump Calibration Form

Page ___ of ___

Calibration							Post Calibration check			
Date	Calibrator Name	Pump SN	Time	Flow Rate Average (L)	Averaging Number	Rotometer Setting	Time	Calibrator Name	Flow Rate Check (L)	Average Number

* Must be average of at least three measurements, preferably 10

Put ID Sticker Here	Composite Sample Number D____ Inspector Initials (F/M/L) _ / _ / _	Date (MM/DD/YY) __/__/__
General Composite Description		

Location and Description for each composite (See Environmental Assessment Diagram)

1 Room number __ Surface number___ Comments

Dimensions of wiped area (inches) _______X_______

Soiling Index (Circle Y or N)

Visible loose soil/dust	Y N	First wipe	Visible soiling	Y	N
Visible Movement when blown	Y N	Second wipe	Visible soiling	Y	N
		Third wipe	Visible soiling	Y	N

Smoothness of surface very smooth (1) to very rough (5) 1 2 3 4 5

2 Room number __ Surface number___ Comments

Dimensions of wiped area (inches) _______X_______

Soiling Index (Circle Y or N)

Visible loose soil/dust	Y N	First wipe	Visible soiling	Y	N
Visible Movement when blown	Y N	Second wipe	Visible soiling	Y	N
		Third wipe	Visible soiling	Y	N

Smoothness of surface very smooth (1) to very rough (5) 1 2 3 4 5

3 Room number __ Surface number___ Comments

Dimensions of wiped area (inches) _______X_______

Soiling Index (Circle Y or N)

Visible loose soil/dust	Y N	First wipe	Visible soiling	Y	N
Visible Movement when blown	Y N	Second wipe	Visible soiling	Y	N
		Third wipe	Visible soiling	Y	N

Smoothness of surface very smooth (1) to very rough (5) 1 2 3 4 5

4 Room number __ Surface number___ Comments

Dimensions of wiped area (inches) _______X_______

Soiling Index (Circle Y or N)

Visible loose soil/dust	Y N	First wipe	Visible soiling	Y	N
Visible Movement when blown	Y N	Second wipe	Visible soiling	Y	N
		Third wipe	Visible soiling	Y	N

Smoothness of surface very smooth (1) to very rough (5) 1 2 3 4 5

5 Room number __ Surface number___ Comments

Dimensions of wiped area (inches) _______X_______

Soiling Index (Circle Y or N)

Visible loose soil/dust	Y N	First wipe	Visible soiling	Y	N
Visible Movement when blown	Y N	Second wipe	Visible soiling	Y	N
		Third wipe	Visible soiling	Y	N

Smoothness of surface very smooth (1) to very rough (5) 1 2 3 4 5

FRM 300

Floor Dust Vacuum Bag Collection

Put ID Sticker Here	Sample Number B__	Date (MM/DD/YY) __/__/__
	Inspector Initials (F/M/L) __/__/__	

Comments

Brand ________________________________

Model ________________________________

Disposable Bag **(Circle One)** Y N

How full **(Circle One)** Full 3/4 1/2 Less than 1/2

If a sample could not be collected indicate reason below

Refused by occupant ___

No vacuum present ___

Other ____________

07/30/95

FRM 400 OUTDOOR ENVIRONMENTAL ASSESSMENT
PAINTED SURFACES ONLY

Separate Page For Each Side Of Structure   Draw Diagram On Reverse Side Of Sheet (Indicate North)

Put ID Sticker   WHERE SUPPLIED [Write Highlighted Letter in Space Provided

Here   Date (MM/DD/YY) __/__/__   Inspector Initials (F/M/L) __/__/__   XRF N0 ________   Page __ of __

Wall Letter ___ (Start with front entrance and go clockwise) OR   Check Here ___ if detatched areas

Direction facing away from residence? (Circle One N NE E SE S SW W NW)

Any visible paint chips present on the ground? (Circle One Yes No)   Total No Doors _____   Total No Windows _____

Surface No	Surface Type	Substrate Type	Damage Type	Damage Source	Total (sqft)	Damage (sqft)	XRF (mg/cm)	Buried Y or N	XRF Sample No	Comments
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										

1 Door	11 Rail	Wood	Chipping	Water	General Comments Indicate Other in space provided
2 Door Jam	12 Floor	Metal	Peeling	Gouge	
3 Door C sing	13 Und Floor	Siding	Flaking	Aging/Use	
4 Wall	14 Ea e	MAsonry	CRacking	Scrape	
5 Stair T ead	15 Pl y Equip	Brick	Loose	WEather	
6 Stair Riser	16 Furn ture	Other	None	Other	
7 Win Well	17 Structu e	Not Known	Other	None	
8 Win Cas ng					
9 Wn sash					
10 Post	20 Other				

FRM 910

CHAIN OF CUSTODY RECORD

(O Shc t for Each Res denc)

P c ___ of ___

Date __/__/__

Put ID Sticker Here	B R c St d 9 59 Sa nt Lou Un ersity School of P bl c Health 66 L ndell Bl d St Lou MO 6 108	Contact Da d Sterlin Ph D CIH (14) 9 81 3 (W) (14) 9 81 0 (F) sterlin @slu ca slu edu

	Sample Number	Laboratory Number	Date Collected	Sample Area (inches) ___ X ___ or Core Depth	Comments
1					
2					
3					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

	Signature	Company	Date/Time	Comments
Relinquished By				
Recieved By				
Relinquished By				
Recieved By	--			
Relinquished By				
Recieved By				

Prefix before sample number indicates matrix type P Paint chip W Drinking Water with nitric acid preservative (supplied by lab) V Hand vacuum with 0 8u MCE filter for dust/soil B Vacuum bag with dust/soil sample S Soil sample D Wipe sample to include dimensions of area tested

07/31/95

Appendix 12 Environmental Laboratory Certifications

Appendix 14 Laboratory Detection and Quantification Limits for Environmental Samples

Appendix 16 Nist Standard Reference Materials used for Spikes

NIST STANDARD REFERENCE MATERIALS USED FOR SPIKES

Sample Type	Standard Reference Material (SRM)
Wipe	NIST Lead Paint Dust Standard Powdered Lead Based Paint SRM 1579a
Vacuum Cassette Filter	NIST Standard Urban Particulate Standard SRM 1648
Soil	NIST Standard Montana II Soil SRM 2711
Water	NIST Trace Metals in Water Standard SRM 1643d

Appendix 17 Intended and Achieved Frequency of Environmental Sample Quality Control

INTENDED AND ACHIEVED FREQUENCY OF ENVIRONMENTAL SAMPLE QUALITY CONTROL

Quality Control Type	Dust Wipe	Vacuum Bag	Soil	Vacuum Cassette	Drinking Water	Latex Gloves	Collection bags
SRM		NA				NA	NA
• Intended	2%		2.5%	20%	2.5%		
• Achieved	1.9%		2.4%	20%	2.3%		
Field Blanks[1]		NA	NA		NA		
• Intended	1/day/field team			1/day/field team		2.5%	2.5%
• Achieved	1/day/field team			1/day/field team		1%	1.5%
Side By Side	NA	NA		NA	NA	NA	NA
• Intended			5%				
• Achieved			5.1%				
Split	NA			NA		NA	NA
• Intended		5%	5%		5%		
• Achieved		5.3%	5.3%		5.9%		

NA Not applicable This type of quality control was not performed

[1] Field blanks for dust wipes and vacuum filter cassettes were obtained on a daily basis for each field team