

**Risk Assessment and Public Health Implications of WTC Dust
Contamination of the Deutsche Bank 130 Liberty Street Property**

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Risk Assessment and Public Health Implications of WTC Dust Contamination of the Deutsche Bank 130 Liberty Street Property

Executive Summary

Introduction

The WTC Event created unprecedented environmental contamination directly impacting the building located at 130 Liberty Street, New York, NY (the “Building”). The collapse of the WTC towers created massive quantities of dust that combined with emissions from the longest-burning commercial fire in US history to create a complex mixture of chemical contaminants that were dispersed directly into the severely damaged Building. From the very beginning there have been many uncertainties and concerns regarding the human health implications of this environmental contamination. Since the WTC Event, there have been growing numbers of reports of the toxicity of WTC Dust to humans and experimental animals. The nature and extent of contamination of the Building was initially unknown. Emerging data regarding the unique composition and morphology of WTC Dust precluded any reliable prediction of risks to the health of individuals potentially reoccupying the Building in the absence of further study of conditions in the Building. Furthermore, there were no directly applicable EPA, OSHA, ATSDR or other agency criteria with which to evaluate the health significance of the pervasive surface contamination of an office building by such a complex mixture of hazardous substances. In September of 2002, a year after the WTC Event, analysis of residences impacted by WTC Dust led to the drafting of preliminary health-based screening levels and benchmarks for a select number of WTC Hazardous Substances¹ by the WTC Contaminants of Potential Concern (COPC) Committee (COPC Committee, 2002). The COPC Committee outlined an approach to establishing these criteria that targeted levels “below which the risk is negligible or consistent with New York City background level.” Since these background levels were not available for a Class A office facility such as the Building, the Health Group² was asked by the Bank to assist in

¹ In this report and in attached appendices, “WTC Hazardous Substances” includes any known toxic substance that has been identified in WTC Dust.

² The Health Group is comprised of scientists from several organizations, all of whom are experienced in the evaluation of risk and public health issues associated with environmental contamination. A summary of the education, training, and experience of each Health Group member can be found in Appendix 1. Curriculum Vitae for each member are presented in Appendix 2.

evaluating potential concentrations of WTC Hazardous Substances present in the Building prior to the WTC Event. The result of this evaluation was the development of “Appropriate Levels” for a number of WTC Hazardous Substances that were intended to represent an upper-bound of potential pre-WTC Event concentrations in the Building (CTEH, 2003). In May of 2003, or approaching two years after the WTC Event, the final report of the COPC Committee proposed health-based screening levels for an expanded number of WTC Hazardous Substances for residential properties and health-based benchmarks for a select group of these COPC (COPC Committee, 2003a). The health-based benchmarks were utilized by the EPA in determining the effectiveness of cleanup efforts in residential locations impacted by the WTC Event (EPA, 2004). These screening and benchmark values were used by the Health Group as a starting point for a health-based evaluation of the Building. However, for reasons discussed in this report, these values were not directly applicable to the Building. It is our opinion that it was incumbent upon the Bank to:

- 1) Initiate assessment of the Building following the WTC Event, and continue to assess the nature, extent, and toxicity of contamination in the Building.**
- 2) Develop health-based screening levels that were directly applicable to the Building.**
- 3) Determine whether the resulting environment in the Building as a result of remediation and abatement programs employed by either the Insurer’s or the Bank’s contractors could effectively protect the health of future occupants of the Building.**
- 4) Determine whether the resulting post-remediation/abatement environment would raise the human health risk profile of the Building from that existing before the WTC Event.**

The Health Group provided assistance on these issues. The following opinions were developed by the Health Risk Group after analysis of data and reports relating to the contamination and attempted test remediation of the Building by the Insurer’s and Bank’s contractors. The opinions stated herein are based on the Health Group’s members’ education, training, and experience and the references and data sources discussed below. A listing of scientific/technical literature and RJ Lee Group reports considered by the Health Group can be found in Appendix 12.

Opinions

- 1. Numerous WTC Hazardous Substances are present in the Building at levels in excess of health-based benchmarks or screening levels³ established by the Contaminants of Potential Concern (COPC) Committee of the World Trade Center Indoor Air Task Force Working Group (COPC Committee).**

These WTC Hazardous Substances and their presently-identified health problems include the following:

Table 1 – Health Problems Potentially Caused by WTC Hazardous Substances Exceeding COPC Committee Health-Based Screening Levels or Benchmarks¹ in the Building

Health Problems	WTC Hazardous Substance
Cancer	Asbestos, cadmium, dioxins, PCBs
Fertility/Birth Defects	Dioxins, lead, mercury, PCBs
Brain and Nerve Disease	Lead, mercury ² , manganese
Liver Disease	Chromium, copper, dioxin, PCBs
Kidney Disease	Cadmium, chromium, copper, lead, mercury
Lung and Respiratory Disease	Asbestos, barium, cadmium, chromium, copper, mercury, mold and bacteria ³
Blood and Bone Disorders	Cadmium, lead, zinc
Heart Disease	Barium
Immune System Disease	Chromium, dioxins, mercury, nickel

1 – COPC Committee (2002); COPC Committee (2003a)

2 – The ATSDR Minimal Risk Level for mercury was used as a screening level for indoor air mercury levels obtained in the Building.

3 – While mold and bacteria are not specific WTC Hazardous Substances, they are secondary contaminants occurring due to post-WTC Event conditions.

- 2. Absent effective remediation, future occupants of the Building will be exposed to WTC Dust and WTC Hazardous Substances.**

- The Building has been pervasively impacted by WTC Dust and WTC Hazardous Substances.

³ The COPC Committee established “health-based screening levels” for numerous chemicals. Based on a number of criteria, such as frequency of detection in environmental samples, and the presence of sample concentrations above the health-based screening levels, the COPC Committee selected a specific group of chemicals, and identified them as “contaminants of potential concern” (COPC) (COPC Committee, 2003a). For this select group of chemicals (i.e., the COPC), the COPC Committee developed “health-based benchmarks.” In some instances, the health-based screening level and health-based benchmark were the same value, in others they were different.

- The architectural characteristics and normal operations of the Building cause WTC Hazardous Substances to move throughout the Building.
- The physical characteristics of WTC Dust increase the likelihood for exposure.
- Unless prevented by remediation, future occupants of the Building will be exposed to the WTC Hazardous Substances by the following routes of exposure:

Table 2 – Principle Routes of Exposure for WTC Hazardous Substances

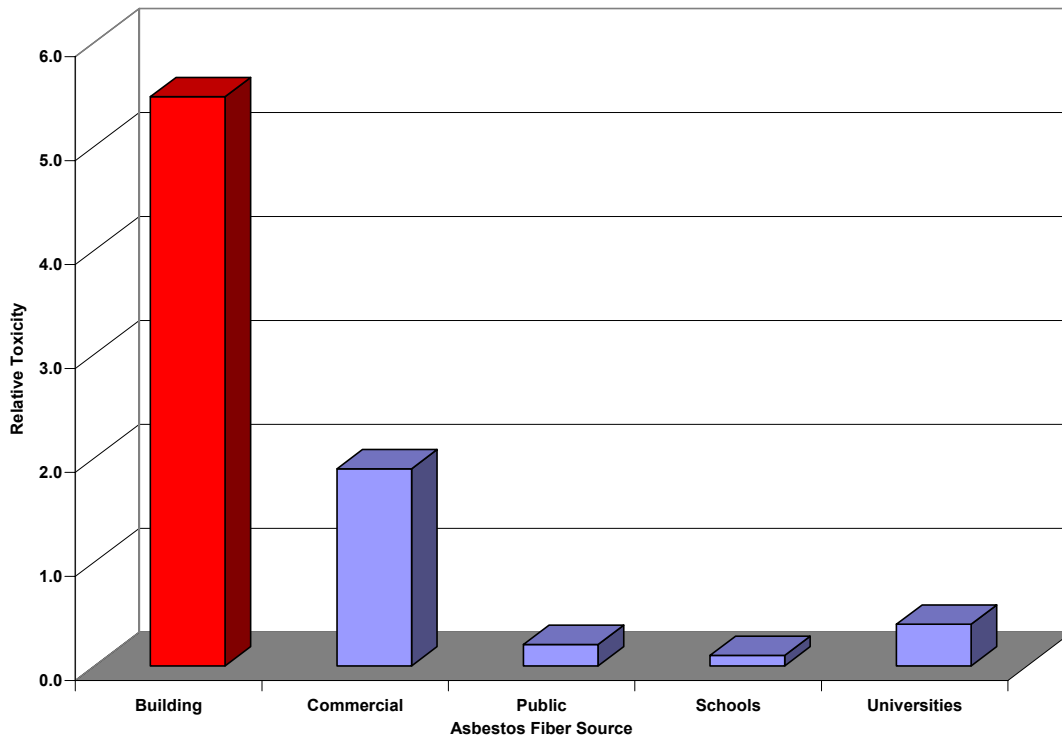
WTC Hazardous Substances	Principle Routes of Exposure		
	Inhalation	Ingestion	Skin uptake
*Asbestos	X		
Barium	X	X	
Cadmium	X	X	
Chromium	X	X	
Copper	X	X	
*Dioxins	X	X	X
*Lead	X	X	
Manganese	X	X	
*Mercury	X		
Nickel	X	X	
PCBs	X	X	X
Zinc	X	X	

*WTC Hazardous Substances selected for Building-specific analysis.

3. *The physical and chemical characteristics of WTC Dust increase the likelihood for toxic effects in humans.*

- Studies of lead in WTC Dust have shown that it will be more easily absorbed into the human body than lead from other environmental sources, increasing the likelihood of toxicity to exposed humans.
- Experimental and field studies have demonstrated that asbestos fibers contained in the WTC Dust are readily resuspended into the air, becoming available for inhalation by humans.
- WTC Dust contains a higher percentage of long, respirable asbestos fibers than is found in other asbestos-contaminated buildings not impacted by the WTC Event. Risk assessment models indicate that longer asbestos fibers produce greater toxicity. This is illustrated in the following figure:

Figure 1 – Relative Toxicity (Carcinogenicity) of a Standard Air Concentration of Total Asbestos Fibers from the Building as Compared to Other Sources



- Additive and synergistic effects on toxicity are possible from interactions of WTC Hazardous Substances in WTC Dust, and would have to be considered in future risk assessments of the Building.

4a. Given the lack of directly applicable benchmarks or screening levels and the uncertainties created by the unique nature of the WTC Dust, it was necessary to establish as a threshold step, building-specific health-based screening levels for a select number of the WTC Hazardous Substances. These substances were selected because they are prevalent throughout the Building and would be critical to any future health risk assessment for the Building.

4b. The Health Group would not recommend reoccupancy of the Building unless a complete risk assessment accounting for concurrent exposure to all WTC Hazardous Substances remaining in the Building following remediation demonstrates acceptable risk to future occupants. The protocols for making this determination have not yet been developed.

Since the screening levels developed by the COPC Committee (COPC Committee, 2003a) were not directly applicable to the Building⁴, Building-specific screening levels were developed based on public health guidelines (ATSDR, EPA, New York State Department of Environmental Conservation, OSHA, NIOSH, HUD), long-established risk assessment methodology, contamination reports of the RJ Lee Group, RJ Lee Group studies of the chemical characteristics of mercury in the Building, and WTC Dust characterization studies (RJ Lee Group), Remediation Reports of the RJ Lee Group and Morse Zentner Associates, and other reports produced with respect to the Building and delivered to the Insurers. These Building-specific screening levels are as follows:

Table 3 – Building-Specific Health Based Screening Levels for Selected WTC Hazardous Substances

WTC Hazardous Substance	Health-Based Screening Levels	
	Surface Screening Level	Air Screening Level
Asbestos	500 s/cm ²	0.00004 f/cm ³
Lead	25 µg/ft ²	0.7 µg/m ³
Dioxins	0.2 TEQ pg/100 cm ²	NA
Mercury	NA	200 ng/m ³

NA-Not Applicable. No air sampling for dioxins was performed in the Building. All mercury evaluations were based on air sampling.

It is important to note that these are screening levels only, and do not represent absolute health-based “cleanup standards” for the Building. In keeping with the conventional purpose of screening levels, they are intended to be used to evaluate whether existing contamination or residual contamination following remediation are present at levels that pose a potential health concern. Measured concentrations in excess of these screening values indicate that further evaluation and, perhaps, remediation may be warranted. If testing for a specific WTC Hazardous Substance indicates that concentrations in the Building are below its screening level, then no further action may be warranted for that substance. However, given the fact that the WTC Dust contains numerous WTC Hazardous Substances, a final decision regarding reoccupancy of the Building could only be made by performing a complete risk assessment that accounts for concurrent exposures to multiple contaminants. Such an assessment was beyond the scope of the Health Group’s analysis. Furthermore, the Health Group

⁴ See Section 4.2 below and Appendix 9.

ceased development of protocols for evaluating post-remediation risks due to the decision of the LMDC to take over and raze the Building.

5. Preliminary pilot remediation projects in the Building conducted by the Bank's and Insurers' contractors failed to reduce all of the above targeted WTC Hazardous Substances to levels below the Health-Based Screening Levels established by the Health Group.

- Preliminary studies have demonstrated that elevated levels of WTC Hazardous Substances remain in the remediated components of the Building following test remediation efforts.
- Contaminated areas of the Building that are difficult to access are more difficult to remediate and, therefore, could serve as reservoirs of WTC Hazardous Substances. These areas include, but may not be limited to, interior wall spaces, cell systems, fireproofing, curtain wall cavities, and ductwork.
- Preliminary studies have indicated that normal commercial building operations will expose humans to WTC Hazardous Substances remaining in these contaminant reservoirs.

6. Absent effective remediation, the continued presence of WTC Hazardous Substances and WTC Dust in the Building may have regulatory implications.

- Lead exposure may require employers to implement two sections of the OSHA General Industry Lead Standard (29 CFR 1910.1025). First is 29 CFR 1910.1025(l) "*Employee Information and Training*" subparagraphs (1) and (2). Second is 29 CFR 1910.1025(d)(2) "*Initial Monitoring*."
- Asbestos exposure may require employers to implement the initial awareness training provision of the OSHA asbestos standard (29 CFR §1910.1001). Annual refresher training is required thereafter.
- The employers in the Building may have to inform employees about regulated toxic substances pursuant to the New York State Toxic Substances Laws.

- 7. Microorganisms and WTC Hazardous Substances for which Building-specific health-based screening levels have not been developed may pose additional human health risks. The Health Group would need to develop screening criteria for these contaminants after further study.***

Risk Assessment and Public Health Implications of WTC Dust Contamination of the Deutsche Bank 130 Liberty Street Property

Introduction

The collapse of the WTC towers precipitated an environmental catastrophe that was unique in scope and content, and produced immense quantities of a novel mixture of toxic constituents, now referred to as WTC Dust. In addition to the massive initial collapse and fires, the event is said to have resulted in the longest-burning commercial building fire in history (Ilgren, 2001). The uncontrolled implosion and fires produced a vast amount of dust and fume derived from WTC components, jet fuel and combustion sources. WTC Dust analysis as reported by numerous agencies and researchers, and as performed on WTC Dust from the Building, indicates the presence of high levels of numerous toxic substances.

The unprecedented environmental nature of the disaster and accompanying uncertainty regarding community and residual health impacts from WTC Dust exposure were recognized early on by environmental professionals (Claudio, 2001; Manuel, 2001; Landrigan, 2001). The concerns and uncertainties regarding health effects from WTC Dust exposure were apparent in the post-WTC Event comments of experts and agencies in environmental health:

“The high temperatures of the fires, the complexity of the materials – these are things we’ve never encountered before.” (P. Landrigan, M.D., Environmental Health Perspectives, November 2001)

“The state of the science cannot possibly predict all of the possible long-term environmental health effects of this unprecedented disaster.” (L. Claudio, Ph.D., Environmental Health Perspectives, November 2001.)

“Little is known about the health effects from complex exposures such as occurred as a result of the WTC collapse and subsequent ongoing fires.” (National Institute for Occupational Safety and Health, 2002.)

In the weeks following the disaster, initial analyses of ambient WTC Dust were conducted by multiple governmental agencies and researchers. The results indicated the need for expanded WTC Dust testing for contaminants and acquisition of background contaminant data for comparison of ambient and indoor contaminant levels (IT Corporation, October 2001; Clark et al, 2001).

Dust analysis also highlighted unique characteristics of the WTC Dust, e.g., it demonstrated levels of toxic contaminants and very fine, easily-resuspended particulates which exceeded any prior environmental experience (Herzfeld, 2002; U.C. Davis News Service, 2002; Herzfeld, 2003; Swartz et al. 2002, 2003). The highest levels of certain contaminants were present in sites closest to the post-collapse fires at Ground Zero. These unique dust characteristics were of concern to contaminated indoor environments and in particular to the Building.

Due to concerns regarding indoor accumulations of WTC-derived dust and the need to characterize indoor environments for health purposes, indoor residential dust sampling surveys were undertaken by governmental agencies as well as private organizations in the weeks after the WTC Event (Chatfield and Kominsky, 2001; ATSDR, 2002; ATSDR/NYC DOHMH, 2002; CDC, 2003). Sampling results for a range of substances indicated differences between exposed and non-exposed indoor locations, confirming the presence of WTC-derived contaminants. In addition, results of indoor sampling performed post-abatement demonstrated persistent contaminants (ATSDR, 2002). Experiences with attempted building abatement in the area adjacent to the WTC indicated significant complexities related to extensive indoor contamination (Dunlap, 2002). The extent of indoor contamination indicated that building reconstruction might be required in some instances (Herzfeld, 2002).

The lack of existing background data for the broad range of WTC Dust constituents was an early and significant impediment to risk assessment efforts, particularly for indoor environments impacted by the WTC Event. Findings of unique WTC Dust characteristics, persistent contamination post-abatement in WTC-impacted structures (ATSDR, 2002), and absence of applicable indoor standards were significant factors in the approach to assessment of the Building.

In addition to containing numerous known toxic substances (WTC Hazardous Substances), the WTC Dust is a complex mixture which has shown unique and significant toxicities. The issue of potential additive and unique effects from multiple toxic constituents is particularly important for the WTC Dust and for evaluation of contaminated structures. Evaluation of initial and future health impacts from WTC Dust exposure, including community exposure to residual WTC Dust, has consistently been seen as an important component of the governmental and private responses to the WTC Event. The high level of ongoing uncertainties surrounding long-term effects of WTC

Dust exposure emphasizes the need for a cautious approach to assessment of contamination and potential abatement.

In the weeks and months following the disaster, information on persons with post-WTC Event exposure, including persons with contact with residual dust during and after abatement indicated an association with health concerns. Initial research indicated elevations of health complaints for persons in reoccupied structures in the vicinity of the WTC (NIOSH, 2002). Initial results of medical screenings of persons involved in building abatement post-disaster indicated the presence of new-onset or worsening of pre-existing symptoms, including persistent respiratory conditions, in the majority of evaluated persons. Various exposed populations were similarly affected by the WTC Dust, and the observed health effects were more persistent compared with previous environmental experience (CDC, 2002; Prezant et al., 2002; Malievskaya et al., 2002; Haughney, 2003; Herbert and Levin, 2003; Banauch et al., 2003; Forelle, 2002). Reported health findings related to post-WTC Event building occupancy were qualitatively similar to other categories of persons exposed to WTC Dust (e.g., persons exposed to the dust cloud immediately following the WTC collapse).

The specific WTC Dust-related exposure factors or contaminants associated with the observed unique effects seen in exposed persons, and also reported in office and residential occupants in the months following the WTC Event, have yet to be identified (Scanlon, 2002; Trout et al., 2002). The health problems encountered in reoccupied buildings could not be explained on the basis of available data. Respiratory effects of WTC Dust, e.g., new or worsening asthma, have been associated with exposures to the acute dust cloud environment during the WTC Event, as well as with less intense community exposure, e.g., indoor, in the weeks and months that followed. The early reports of health problems related to building exposures, the unique patterns of effects, and the unknown nature of the responsible contaminants underscored the need for a cautious and comprehensive approach in risk assessment for the Building. Highlighting the need for caution, research performed by the EPA concluded that smaller particle components of the WTC Dust could have preferentially entered buildings, resulting in a greater inhalation hazard in indoor environments (McGee et al., 2003). The full toxicity potential of these dust components remains to be evaluated.

Animal research has so far confirmed toxic effects of the WTC Dust mixture by demonstrating significant effects on the respiratory tract corresponding with effects seen in exposed persons (EPA, 2002; Gavett et al., 2002; Gavett et al., 2003). Information on

additional, unanticipated health effects of the WTC Dust mixture has begun to accrue. Preliminary reproductive research has shown an increased risk of slowed fetal growth in exposed pregnant women (Berkowitz et al., 2003; Landigran et al., 2004). Extensive research on the toxicity of the complex mixture represented by WTC Dust remains ongoing; it is important to note that only a small fraction of these research findings have been completed to date. A year following the disaster, more than 100 WTC-related health studies were either underway or planned. The extent of ongoing uncertainties regarding toxic effects of the WTC Dust mixture and safety of current environments including reoccupied areas, and the importance of ongoing research to evaluate exposure and toxicity is apparent in the statements of public health agencies and experts:

“The cumulative risk from so many different exposures at high concentrations may well have produced effects that cannot be fully discerned by examination of exposure to individual substances.” (EPA, 2002.)

“The full extent of public exposure to indoor contaminants resulting from the WTC collapse is unknown.” (EPA, 2003.)

“Only epidemiologic follow-up studies of possible health effects among particularly susceptible individuals may provide a fuller determination of the issue of possible health effects from the various pollutants in the WTC plume.” - *George Thurston, ScD* (as cited in Stephenson, 2002)

As noted previously, many factors about the destruction of the WTC were unprecedented or were not applicable to past assessments of human chemical exposure. Therefore, numerous sources of uncertainty were present and prompted a necessarily conservative approach to the protection of the health of future inhabitants of the Building. These sources of uncertainty included:

- Uncertainty of the potential for human exposure to residual WTC Dust or WTC Hazardous Substances that could not be remediated
- Uncertainty about the unknown health risks of combinations of WTC Hazardous Substances dispersed throughout the Building
- Uncertainty about the pattern of contamination throughout the Building:
- Uncertainty about potential exposure pathways of employees, maintenance workers, and cleaning crew entering the Building
- Uncertainty derived from relying on multiple exposure assumptions to predict exposure to WTC Hazardous Substances in settled dust
- Uncertainty regarding the applicability of health-based screening levels and benchmarks established by the COPC Committee

These uncertainties are discussed in detail in Appendix 3.

In keeping with the fundamental premise behind public health risk assessments that increased exposure equals increased risk, the Health Group's first task was to evaluate the potential concentrations of WTC Hazardous Substances in the Building prior to the WTC Event. This was consistent with the COPC Committee's initial approach in establishing health-based benchmarks and screening levels "below which the risk is negligible or consistent with New York City background level." This was particularly relevant for a Class A facility such as the Building where no obvious sources of contamination were anticipated. The result of this evaluation was the development of "Appropriate Levels" for a number of WTC Hazardous Substances that were intended to represent an upper-bound of potential pre-WTC Event concentrations in the Building (CTEH, 2003). Accordingly, contamination of the Building with WTC Hazardous Substances at concentrations in excess of the Appropriate Levels would indicate that the Building after the WTC Event had a higher health risk profile than before the WTC Event. In fact, extensive investigations by the RJ Lee Group demonstrated that this was the case.

Following development of the Appropriate Levels, the Health Group turned its attention to the evaluation of pre- and post-remediation environmental sampling results using traditional risk assessment methods. The following sections of this report outline in greater detail the Health Group's⁵ evaluation of these issues. The opinions stated herein are based on the Health Group's members' education, training, and experience and the references and data sources discussed below.

After completing the extensive investigations discussed herein, the Health Group has concluded that it was appropriate and necessary for the Bank to:

- 1) Initiate assessment of the Building following the WTC Event, and continue to assess the nature, extent, and toxicity of contamination in the Building.**
- 2) Develop health-based screening levels that were directly applicable to the Building.**
- 3) Determine whether the resulting environment in the Building as a result of remediation and abatement programs employed by either the Insurer's or the Bank's contractors could effectively protect the health of future occupants of the Building.**

⁵ The Health Group is comprised of scientists from several organizations, all of whom are experienced in the evaluation of risk and public health issues associated with environmental contamination.

- 4) **Determine whether the resulting post-remediation/abatement environment would raise the human health risk profile of the Building from that existing before the WTC Event**

Opinions

1.0. Numerous WTC Hazardous Substances are present in the Building at levels in excess of health-based screening levels or benchmarks established by the Contaminants of Potential Concern (COPC) Committee of the World Trade Center Indoor Air Task Force Working Group (COPC Committee).

The presence, distribution, concentration, and physical and chemical characteristics of WTC Dust has been extensively characterized and discussed in the expert reports of Dr. Richard Lee. As reported by Dr. Lee, the identity, concentration, and characteristics of the particles as well as the chemical composition of WTC Dust constitute a complex, recognizable pattern or “WTC Dust Signature” (WTC Dust Signature Report: Asbestos, RJ Lee, 2003; WTC Dust Signature Report: Metals and Organics, RJ Lee, 2003).

Shortly following the WTC Event, the Contaminants of Potential Concern (COPC) Committee of the World Trade Center Indoor Air Task Force Working Group (COPC Committee, 2002, 2003a) was formed.⁶ The COPC Committee was tasked to select COPC and set health-based benchmarks for these contaminants. These benchmarks were established to determine whether facilities were, in fact, contaminated with WTC Hazardous Substances, and whether efforts to decontaminate impacted structures were successful. As part of the COPC selection process, the COPC Committee also established health-based screening levels for numerous chemicals. (See Appendix 4 for further discussion of health-based benchmarks and comparisons of Building data against these benchmarks.) Although these health-based screening levels and benchmarks were established for residential properties not as significantly impacted by the WTC Event, the Health Group did use these values as a starting point for initial evaluation of the potential health significance of existing contamination in the Building. .

Table 2 in Appendix 4 presents the sampling data obtained from interior spaces of the Building (RJ Lee, TP-01 Contamination Report, 2003) as compared with the health-based screening levels or benchmarks established by the COPC. These

⁶ The COPC Committee is comprised of representatives of the EPA, New York City Department of Health and Mental Hygiene, Agency for Toxic Substances and Disease Registry (ATSDR), New York State Department of Health, and the US Occupational Safety and Health Administration (OSHA).

comparisons reveal that the mean, maximum and/or 95% upper tolerance limit (95%UTL)⁷ values from interior space samples from the Building were in excess of the final COPC Committee health-based benchmarks or screening levels for the following constituents:

- Barium
- Cadmium
- Chromium
- Copper
- Dioxins
- Lead
- Manganese
- Mercury
- Nickel
- PCBs
- Zinc

Furthermore, although in their final publication of health-based screening levels, the COPC Committee did not present a surface screening level or benchmark for asbestos, environmental testing in the Building revealed that it was pervasively contaminated with asbestos in concentrations in excess of the draft Tier I level⁸ initially established by the Committee (COPC Committee, 2002).

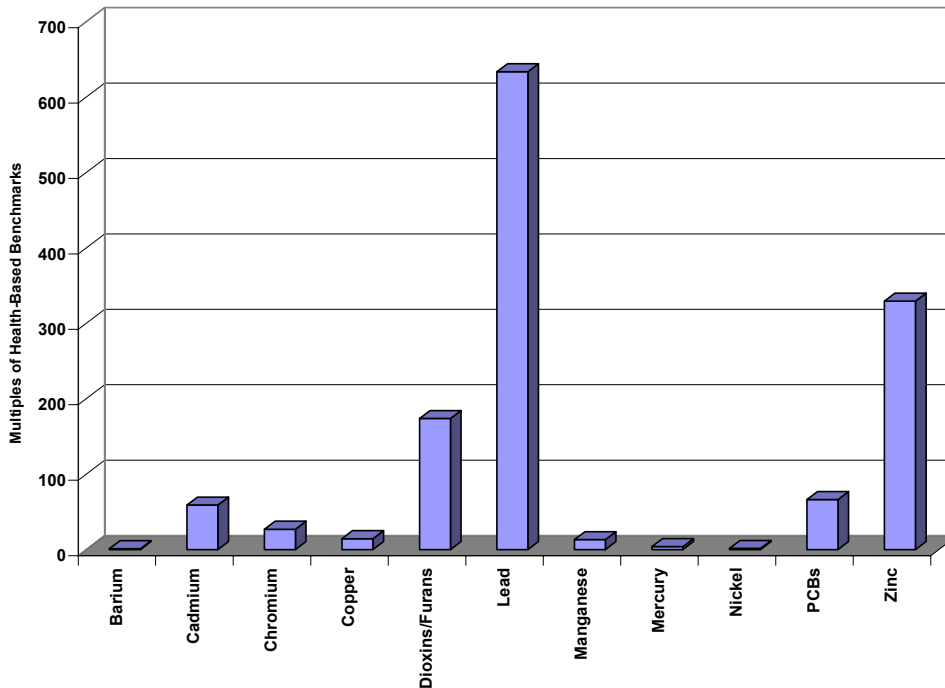
In addition, the environmental investigation of the Building performed by the Bank's contractors revealed that numerous building components were contaminated with WTC Hazardous Substances at concentrations in excess of the COPC Committee health-based benchmarks. These contaminated components included interior wall cavities (RJ Lee Group, TP-06 Contamination Report, 2003), curtain wall cavities (RJ Lee Group, TP-07 Contamination Report, 2003), cell systems and risers (RJ Lee Group, TP-09 Contamination Report, 2003), perimeter induction units (RJ Lee Group, TP-11 Contamination Report, 2003), elevators and elevator shafts (RJ Lee Group, TP-12 Contamination Report, 2003), IT equipment (RJ Lee Group, TP-01 Contamination Report, 2003), structural steel (RJ Lee Group, TP-25 Contamination Report, 2003), and furniture (RJ Lee Group, TP-01 Contamination Report, 2003). For the TP-01 data, maximum detected values for the various WTC Hazardous Substances exceeded their

⁷ A 95%UTL is a statistically derived number that represents with 95% confidence a level below which 95% of all TP-01 samples from the Building would fall.

⁸ The Tier I level for asbestos (30,000 s/cm²) was defined as the "level above which, after elimination of potential indoor sources...aggressive clean-up action should be taken expeditiously along with follow-up sampling to confirm attainment of the Tier III level."

respective health-based benchmarks by anywhere from 1.2 to 634 times (see Figure 2 below).

Figure 2. Comparison of Maximum TP-01 Surface Concentrations to COPC Committee Health-Based Benchmarks



In addition to data confirming that high levels of WTC Hazardous Substances were present on surfaces in the Building, air testing data revealed the presence of elevated levels of mercury (RJ Lee Group, H2 Report, 2004). Mercury is a toxic and persistent metal. Mercury is present in the Building in the form of metallic mercury, mercury salts (i.e., mercuric chloride), and organic mercury (i.e., methyl mercury). Although each type of mercury has unique properties that affect its toxicity, metallic mercury forms vapors at room temperatures and is therefore of particular concern in indoor air since metallic mercury vapors are efficiently absorbed from the lung into the bloodstream. Like a gas, metallic mercury vapors can move through seams in building materials, ventilation systems, and other Building structures (RJ Lee Group, R12 Report, 2004).

Sampling performed by RJ Lee indicates:

- The **average** mercury vapor from the Building during the period from November 13, 2003 to January 5, 2004 was 90 nanograms per cubic meter of

air (ng/m^3), well above the ambient range detected in background sampling conducted by RJ Lee in background buildings (5 to 20 ng/m^3) and the 4.25 ng/m^3 average reported by Carpi and Chen (2001) for a “postwar high-rise office building in mid-town Manhattan.” Maximum values of up to 191,000 ng/m^3 were observed in Building air during certain activities.

- Unpredictable spikes in mercury vapor concentrations occurred throughout the Building, often lasting for hours.
- In some instances airborne mercury concentrations in excess of OSHA workplace standards, and EPA and ATSDR long-term exposure guidelines were observed in the Building. It is important to note that the OSHA chemical exposure standards are designed for workplaces where engineering controls, protective equipment, labeling, medical monitoring, employee training and other requirements would be instituted as indicated. Such provisions are not anticipated in a Class A office building.

Based on these findings (i.e., exceedance of health-based screening levels or benchmarks for numerous WTC Hazardous Substances), an extensive program was launched to more completely characterize the full nature and extent of contamination within the Building and of potential methods for decontaminating the various components in the Building. Individual profiles detailing the toxicity and potential health effects from over-exposure to WTC Hazardous Substances identified in interior surface sampling (i.e., TP-01) in excess of the health-based benchmarks are presented in Appendix 5. As discussed in Appendix 5, the WTC Hazardous Substances and the health problems they can cause include the following:

Table 4 - Health Problems Potentially Caused by WTC Hazardous Substances Exceeding COPC Committee Health-Based Screening Levels or Benchmarks¹ in the Building

Health Problems	WTC Hazardous Substance
Cancer	Asbestos, cadmium, dioxins, PCBs
Fertility/Birth Defects	Dioxins, lead, mercury, PCBs
Brain and Nerve Disease	Lead, mercury, manganese
Liver Disease	Chromium, copper, dioxin, PCBs
Kidney Disease	Cadmium, chromium, copper, lead, mercury ²
Lung and Respiratory Disease	Asbestos, barium, cadmium, chromium, copper, mercury, mold and bacteria ³
Blood and Bone Disorders	Cadmium, lead, zinc
Heart Disease	Barium
Immune System Disease	Chromium, dioxins, mercury, nickel

1 – COPC Committee (2002); COPC Committee (2003a)

2 – The ATSDR Minimal Risk Level for mercury was used as a screening level for indoor air mercury levels obtained in the Building.

3 –While mold and bacteria are not specific WTC Hazardous Substances, they are secondary contaminants occurring due to post-WTC Event conditions.

2.0. Absent effective remediation, future occupants of the Building will be exposed to WTC Dust and WTC Hazardous Substances.

2.1. The Building has been pervasively contaminated by WTC Dust and WTC Hazardous Substances

Based on thousands of samples of dust and debris collected throughout the Building, it was definitively established that the WTC Event resulted in extensive and pervasive contamination. No Building component or area of the Building was left untouched. Testing results obtained by and reported by RJ Lee documented the presence of WTC Hazardous Substances in the following Building components:

- Interior surfaces
- Spaces between interior walls
- Fire proofing
- Furniture
- Curtain wall
- Curtain wall insulation
- Structural steel
- Perimeter induction units
- Concrete
- Risers and raceways
- Elevators and elevator shafts
- IT equipment
- Roof
- Mechanical equipment

Detailed descriptions of impacted building components are included in Appendix 6. A listing of RJ Lee contamination reports can be found in Appendix 12.

2.2. *The Structural Characteristics and Normal Operations of the Building cause WTC Hazardous Substances to move throughout the Building.*

Many of the components of the Building referenced above can act as reservoirs of WTC Dust and WTC Hazardous Substances. Extensive analysis by the RJ Lee group (e.g., R2, R4, and R5 Reports, 2004) has demonstrated that if only accessible and occupied areas of the Building were remediated, inaccessible reservoirs of WTC Hazardous Substances would be released by non-aggressive movements typically associated with normal business operations such as a bump against the wall, walking down a hallway or movement of office furniture. In addition, workmen in areas not normally disturbed by office occupants will cause movement of WTC Hazardous Substances from contaminated reservoirs in those areas into previously cleaned interior spaces. This will likely occur on a regular basis in the Building since maintenance workers and IT staff will access these spaces to maintain common Building functions (electrical and phone service, computer networks, etc). To exacerbate this problem, the Building has a number of vertical shafts (elevators, curtain wall cavities, escalators, HVAC) that act as conduits of WTC Dust and WTC Hazardous Substances resulting in problematic unpredictable redistribution of contaminants throughout the Building. In addition, the HVAC system operations will likely act as both reservoirs and distributors of WTC Hazardous Substances. Airflow studies using visible smoke have clearly demonstrated movement of air between various components of the Building (RJ Lee Group, R12 Report, 2004). Given the characteristics of the WTC Dust as discussed below, the movement of air between Building components will carry with it contaminants present in the components. Furthermore, airflow modeling of the Building by Dr. James Milke corroborates the RJ Lee Group findings (Milke, 2004). These data suggest the Building contains numerous flow paths that permit air to flow horizontally and vertically between spaces. Therefore, if contaminant reservoirs such as interior wall spaces, ductwork, fireproofing, and cell systems are not remediated, they will ultimately recontaminate previously cleaned areas. The time course and extent of this contamination is presently unknown, but preliminary studies conducted to date have demonstrated that recontamination does occur. The concerns about indoor recontamination from residual contaminants on non- or inadequately-remediated building components was specifically noted in the EPA Inspector General's report of August 2003 (EPA, 2003). Furthermore, the Health Group is familiar with data from another WTC

Event-impacted Building owned by the Bank; the office facility at 4 Albany Street. This building was previously cleaned and partially reoccupied for a short period of time. It was subsequently discovered that elevated levels of WTC Hazardous Substances are still present throughout the building.

2.3. The Physical Characteristics of the Dust Increase the Likelihood for Exposure.

Numerous studies have been performed by the RJ Lee Group that have characterized the physical characteristics of the WTC Dust. Many of the findings are particularly relevant to any assessment of exposure to future Building inhabitants that could occur if reservoirs of contamination remained following remediation. The following table summarizes the results of these studies and their potential risk assessment implications.

Table 5 – Summary of Key Studies Regarding the Physical Characteristics of WTC Dusts

Study	Findings	Risk Assessment Implications	Reference
S1: Aerosolization of Ultra Fine Fibers and Particles from WTC Dust	<ul style="list-style-type: none"> • Indoor air concentrations of 0.224 S/cm³ observed during activities • Considerable concentrations of fibers <0.25 µm in diameter observed. 	<ul style="list-style-type: none"> • WTC Dust is readily aerosolized. • Asbestos fibers in aerosolized WTC Dust are respirable. • Indoor activities result in elevated airborne asbestos concentrations. 	RJ Lee Group, S1 Report,, 2004
S2: The Relationship Between Surface And Airborne Concentrations of WTC Dust Under Known Conditions	<ul style="list-style-type: none"> • Airborne asbestos and lead levels proportional to surface concentrations. • Baseline air concentrations in the Building exceed EPA NY background level. • One-fourth of personal samples contained asbestos fibers >5 µm in length. 	<ul style="list-style-type: none"> • Surface contamination with WTC Dust increases likelihood of inhalation exposure to asbestos and other contaminants. • Fibers considered of concern in EPA and OSHA risk assessments are suspended in the air from contaminated surfaces. 	RJ Lee Group, S2 Report, 2004
S5: Airborne Fiber Dimensions: A Comparison of Asbestos Resuspended from WTC Dust to Airborne Asbestos in Other Buildings	<ul style="list-style-type: none"> • Average asbestos fiber length in indoor air samples from the Building are longer than from non-WTC event buildings. • Average asbestos aspect ratio (length/width) in indoor air samples from the Building are longer than from other sources. • >16% of fibers from the Building are longer than 5 µm in length and less than 0.5 µm wide. The same percentage from other sources is 0.4 – 3%. 	<ul style="list-style-type: none"> • Airborne asbestos fibers from WTC Dust in the Building have a higher carcinogenic potency than fibers from other asbestos-containing buildings not impacted by the WTC Event. 	RJ Lee Group, S5 Report 2004
S3: Resuspension Characteristics of WTC Dust Under Controlled Conditions	<ul style="list-style-type: none"> • Respirable dust and asbestos fibers are suspended into air following surface disturbance. • Resuspension efficiencies were similar to those obtained in other buildings contaminated with WTC Dust. • Air and surface levels are correlated. 	<ul style="list-style-type: none"> • WTC Dust is readily resuspended. • Resuspension efficiencies can be used in risk assessment. • Surface contamination with WTC Dust increases likelihood of inhalation exposure to asbestos and other contaminants. 	RJ Lee Group, S3 Report 2004
S4: Resuspension and Settling of WTC Dust Over a Three-Day Period	<ul style="list-style-type: none"> • WTC Dust from contaminated surfaces remains suspended in air for several hours following minimal disturbance. • Elevated asbestos concentrations observed following minimal disturbance. • Fibers > 5 µm in length observed in all areas tested. 	<ul style="list-style-type: none"> • Exposure to airborne WTC Dusts and asbestos fibers can occur several hours following minimal disturbance of contaminated surfaces. 	RJ Lee Group, S4 Report 2004

These studies have demonstrated that WTC Dust is readily resuspended from contaminated surfaces, remains suspended for considerable periods of time, and contains WTC Hazardous Substances with known health effects in humans.

2.4. Future Building Occupants Could Be Exposed to WTC Dust, WTC Hazardous Substances, and Mold in Numerous Ways.

2.4.1. Potentially Exposed Populations

If it were to be re-occupied, people of all ages and health conditions would be expected to enter the Building, either as workers or visitors. Some of these workers and visitors would be at particular risk to contamination in the Building. For example, some individuals may have behavior that would lead to greater exposures to the WTC Hazardous Substances, or be more sensitive to the exposure and thus more likely to experience adverse health effects. Such “sensitive individuals” may include workers or visitors with inherited disorders (e.g., inhibited detoxification or clearance of toxic substances), immune system deficiencies, or nutritional deficiencies. Potentially sensitive populations that may routinely enter the Building include asthmatics, diabetics, and those with cardiovascular disease (EPA 2000), as well as pregnant women, the elderly, and children.

For example, asthmatics can react more severely to respirable irritants (ALA, 2003). This was suggested by a recent study that found that children with asthma who lived within five miles of the World Trade Center visited a doctor more frequently, and took more medication, the year after the WTC Event than the year before the WTC Event (Szema et. al., 2004). According to the Centers for Disease Control and Prevention (CDC), the self-reported lifetime asthma prevalence rate in the state of New York is 11.5% (CDC 2002). Thus, a substantial number of both workers and visitors in the Building would be expected to have asthma and as a result be potentially more sensitive to airborne WTC Hazardous Substances.

Pregnant women are also expected to represent a portion of both office worker and visitor populations in the Building. According to pregnancy rate information from the CDC (2003), over 1/3 of the women between the ages of 25 and 44 were pregnant in 1998/1999. Thus, at any given time, a number of workers and visitors within the Building would be expected to be pregnant at any given time. The fetus of such a pregnant woman may be sensitive to contamination, particularly for WTC Hazardous Substances that can cause birth defects, such as mercury and lead (ATSDR 1999b,c). According to the ATSDR, mercury’s harmful effects that may be passed from mother to the fetus include brain damage, mental retardation, incoordination, blindness, seizures, and inability to speak (ATSDR 1999c). Unborn children exposed to lead through their

mothers could experience smaller body weight, premature births, decreased mental ability, learning difficulties, and reduced growth (ATSDR 1999b). As previously noted, preliminary studies have shown that pregnant women who were in or near the WTC during the collapse exhibited a two-fold increase in the risk of bearing an infant who is considered small for gestational age (Berkowitz et al., 2003).

More detailed information about people who may be potentially exposed to WTC Hazardous Substances is available in Appendix 6.

2.4.2. Routes of Exposure

People working in or visiting the Building could be exposed to WTC Hazardous Substances in many different ways, including the following:

Ingestion

Oral exposure to the WTC Hazardous Substances may occur during incidental ingestion of WTC Hazardous Substances on dust as a result of hand-to-mouth contact, and during ingestion of foods that have come into contact with dust or vapors.

Inhalation

WTC Hazardous Substances may be inhaled as vapors or in particulate form on WTC Dust. For example, mercury may be inhaled as a vapor while asbestos would be inhaled as a particulate.

Dermal Absorption

Direct skin contact with WTC Dusts or re-deposited volatilized WTC Hazardous Substances on building component surfaces may occur, resulting in contaminant transfer across the skin and into the blood.

The importance of these routes of exposure is increased by the potential for WTC Hazardous Substances to move from one location to another within the Building. For example, the unique physical characteristics of WTC Dust increase its likelihood of re-entrainment from contaminated surfaces. Chatfield and Kominsky (2001) demonstrated that under "passive" conditions, (i.e., when no ventilation or air condition systems were in operation, and no human activity ongoing during the monitoring), relatively high levels of airborne asbestos were detected in apartments contaminated

with WTC Dust⁹. As discussed in Section 2.3 above, similar findings have been documented in RJ Lee studies of WTC Dusts in the Building.

Maintenance/construction activities could also increase the extent to which WTC Hazardous Substances become re-entrained and transported from interior wall cavities and other less-accessible locations of the Building into public or office spaces. Because of the potential for WTC Hazardous Substances to move in the Building, visitors and typical office workers could be exposed to contamination detected not only in the interior spaces (such as lobbies, cafeterias, and individual offices), but also to contamination originally present in interior wall cavities, fireproofing, structural steel, and curtain wall cavities.

Pilot studies conducted by RJ Lee demonstrated that cleaned surfaces can be recontaminated by reservoirs of WTC Dust left behind in interior wall spaces, duct work and fireproofing. For example, surface asbestos concentrations in excess of the Building-specific health-based screening criteria developed by the Health Group (see Section 4 below) were generated by movement of air from interior wall spaces, demolition of walls, conduit demolition, dry sweeping of floors, demolition of duct work, and removal of fireproofing. Lead exceedances were observed following conduit demolition and dry sweeping of floors (RJ Lee Group, R2 Report, 2004). Similarly, pilot studies designed to simulate moderate vibrations of floors and walls during such activities as persons walking, moving furniture and operation of building equipment demonstrated recontamination of cleaned areas in excess of the Building-specific health-based screening criterion for asbestos (RJ Lee Group, R5 Report, 2004).

The principle routes of exposure for WTC Hazardous Substances are summarized in Table 6.

⁹ The final COPC Committee report (COPC Committee, 2003a) provides an airborne benchmark for asbestos, without a corresponding benchmark for settled dust. In a previous draft of the report, however, a benchmark for asbestos in settled dust was proposed, and was defined as the, "level above which, after elimination of potential indoor sources... aggressive clean-up action should be taken expeditiously..." (COPC Committee, 2002). A peer-review panel questioned the use of the COPC Committee methodology because it was, "inadequate for predicting inhalation exposure from asbestos surface loading measurement" (COPC Committee, 2003b). However, the lack of a settled dust benchmark in the COPC Committee report should not be interpreted as suggesting that settled asbestos does not pose a risk; instead, it highlights the difficulty of *quantifying* such risks.

Table 6 - Principle Routes of Exposure for WTC Hazardous Substances

WTC Hazardous Substances	Principle Routes of Exposure		
	Inhalation	Ingestion	Skin uptake
*Asbestos	X		
Barium	X	X	
Cadmium	X	X	
Chromium	X	X	
Copper	X	X	
*Dioxins	X	X	X
*Lead	X	X	
Manganese	X	X	
*Mercury	X		
Nickel	X	X	
PCBs	X	X	X
Zinc	X	X	

*WTC Hazardous Substances selected for Building-specific analysis

More detailed information regarding potential routes of exposure is located in Appendix 6

3.0. The physical and chemical characteristics of WTC Dust increase the likelihood for toxic effects.

3.1. Studies have shown that lead from WTC Dust is more easily absorbed by the body.

The chemical and physical forms of environmental lead influence the amount of lead that can be absorbed into the body, or the “bioavailability” of lead. The greater the bioavailability of a particular substance, the more readily it is absorbed into the body following exposure, in this case, ingestion. It is generally recognized that lead-contaminated dusts can be ingested via incidental “mouthing” behavior such as placing a finger, toy or other item (e.g., pencil, cigarette) into the mouth, wiping the mouth with the hand, or ingestion of food materials that have contacted the dusts. This is an important source of exposure to children and adults who live or work in areas with lead-containing dusts. In order to determine the bioavailability of lead from WTC Dust contaminating the Building, *in vitro*¹⁰ testing of samples obtained from the Building was conducted by Dr. Andy Davis of Geomega. Dr. Davis’ report is discussed in greater detail in Appendix 7. The results and conclusions are summarized below.

- Using this *in vitro* laboratory test, the bioavailability of lead was analyzed in three samples of WTC Dust from the 3rd floor of the Building. These tests predicted a bioavailability of 89%, 86%, and 97%, respectively, in the three samples. The average bioavailability of the three tests was 91%.
- By way of comparison, the EPA considers the relative bioavailability for lead in soil and dust to be 60%. Therefore, these results indicate that the lead in WTC Dust from the Building is at least 50% more bioavailable than is assumed by the EPA regarding human exposure to lead in soil and dust.
- The lead present in the WTC Dust from the Building may be much more readily absorbed into the human body than expected. If standard EPA methods for assessing lead exposure by ingestion are used for WTC Dust (such as performed by the COPC Committee in establishing their lead health-

¹⁰ *In vitro* studies are conducted in the laboratory in a manner designed to simulate what may occur in a living organism.

based benchmark), the results will underestimate the amount of lead absorbed into the body.

3.2 *Experimental and field studies have demonstrated that asbestos fibers contained in the WTC Dust are readily resuspended into the air, becoming available for inhalation by humans*

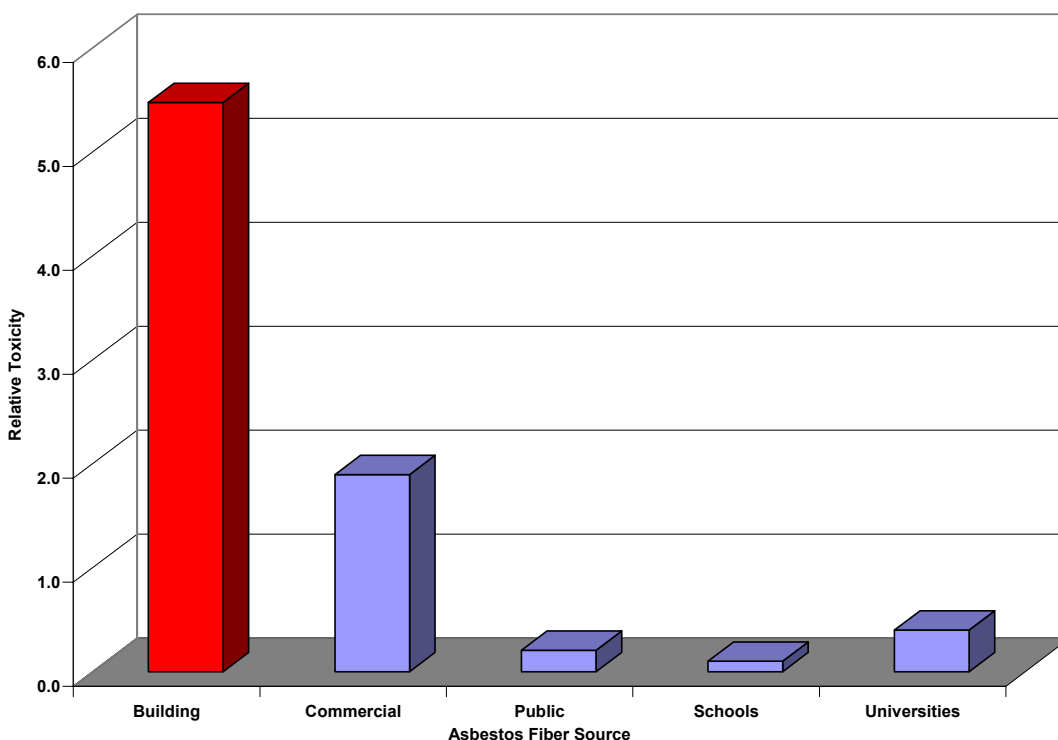
Shortly following the WTC Event two investigators, Mr. John Kominsky and Dr. Eric Chatfield, performed air sampling in two apartments impacted with WTC Dusts (Chatfield and Kominsky, 2001). These investigators reported elevated levels of asbestos under “passive” conditions, i.e., there was no activity in the areas tested and the air handling systems in the apartments were not operating. Experimental field testing within the Building demonstrated remarkably similar findings (see Section 2.3 above). Similarly, RJ Lee testing revealed that under baseline or “passive” conditions, and under conditions simulating routine building maintenance activities (e.g., changing light bulbs, moving furniture, removing ceiling tile, etc.) elevated airborne asbestos concentrations were observed. Importantly, one-fourth of all of the personal samples obtained during work activities contained asbestos fibers of a length considered toxic under EPA and OSHA criteria (RJ Lee Group, S2 Report, 2004).

3.3 *WTC Dust contains a higher percentage of long asbestos fibers than is found in other asbestos-contaminated buildings. Longer asbestos fibers have been shown to produce greater toxicity.*

Dust characterization studies revealed that a higher percentage of the asbestos fibers from WTC Dust in the Building were longer and thinner than fibers isolated from other buildings not contaminated with WTC Dust (RJ Lee Group, S5 Report, 2004). These physical characteristics are known to increase the toxicity of inhaled asbestos fibers since the lungs are unable to effectively clear them by normal physiological mechanisms (Berman et al., 1995). That is, the longer and thinner asbestos fibers play a more significant role in asbestos-induced lung cancer (ATSDR, 2003; Berman and Crump, 1999). The relative toxicity (i.e., ability to produce cancer) of asbestos fibers found in WTC Dusts from the Building and asbestos fibers found in dusts from asbestos-containing buildings (commercial, public, schools, and universities) that were not

affected by the WTC Event was calculated using proposed risk methodology for asbestos (Berman et al., 1995; Berman and Crump, 1999). These calculations are plotted in Figure 3 below. As can be seen in this figure, asbestos fibers from the Building are about three to 50 times more toxic than the asbestos fibers from other asbestos-containing buildings.

Figure 3. Relative toxicity (carcinogenicity) of a standard air concentration¹¹ of total asbestos fibers from the building as compared to other sources.



3.4. Additive and synergistic effects on toxicity are possible from the interactions of WTC Hazardous Substances in WTC Dust.

Mixtures of chemicals present some difficulty to the risk and toxicity assessment processes due to the potential effect of one WTC Hazardous Substance to alter or add to the toxicological properties of another. From a toxicological standpoint, chemicals are said to exert **additive** effects if toxicity increases when exposure to both agents occurs at the same time. Chemicals are said to act **synergistically** when their combined effect

¹¹ These calculations were performed comparing toxicity of hypothetical “standard” air samples, each containing the same **total** fiber concentration, but comprised of asbestos fibers originating from the indicated source.

is greater than the sum of the chemicals acting alone. The issue of chemical additivity and synergism is particularly important in regard to the unique toxic mixture created by the unprecedented circumstances of the WTC Event. This toxic mixture has important implications for human and environmental health. Given the potential for intermingling of any or all of these chemicals, the potential for synergistic or additive effects of two or more of the COPC are of concern and would ultimately have to be addressed in any risk assessment relating to future reoccupancy of the Building. For example, relevant studies reported in the scientific literature indicate that synergistic and additive effects can occur with the following WTC Hazardous Substances:

- Asbestos, PAHs, and PCBs
- Particulate matter and PAHs
- Lead and Mercury
- Dioxin and PCBs

It is noted that the EPA Inspector General's report (EPA, 2003) highlighted the need to consider additive effects of WTC Hazardous Substances in setting appropriate health-based benchmarks and the lack of consideration of these effects in the current COPC benchmarks. More information regarding these studies can be found in Appendix 8.

- 4a. Given the lack of directly applicable benchmarks or screening levels and the uncertainties created by the unique nature of the WTC Dust, it was necessary to establish as a threshold step, building-specific health-based screening levels for a select number of the WTC Hazardous Substances. These substances were selected because they are prevalent throughout the Building and would be critical to any future health risk assessment for the Building.**
- 4b. The Health Group would not recommend reoccupancy of the Building unless a complete risk assessment accounting for concurrent exposure to all WTC Hazardous Substances remaining in the Building following remediation demonstrates acceptable risk to future occupants. The protocols for making this determination have not yet been developed.**

4.1. The use of screening levels and risk assessment for risk and public health evaluation

Screening levels, such as those developed by the COPC Committee and the Health Group are designed to determine whether individual contaminants are present at a site in concentrations that are likely to pose an unacceptable risk. They are developed using conservative (i.e., health protective) assumptions so that testing results that fall below these levels will generally indicate that no further evaluation is warranted. It is important to note, however, that screening levels are generally developed for individual contaminants, assuming that exposure to only that contaminant is occurring. If multiple contaminants are present at a site, screening levels may have to be adjusted downward to account for multiple exposures. For example, if several contaminants are present at a given site, all of which affect the same target organ (e.g., kidney), it is entirely possible that even though each individual contaminant is present at the site at a concentration below its respective screening level, the risk associated with concurrent exposure to all of the contaminants could still exceed an acceptable risk range.

Ultimately, a decision regarding risks posed by exposure to contaminants present at a site is based on a full risk assessment that accounts for concurrent exposure of specific target populations (e.g., workers, children) to all contaminants present. Risk assessment is an interpretive process whereby relevant toxicological information (particularly dose-response relationships) is assembled and evaluated in an attempt to predict the response in humans after chemical exposure. The dose-response

relationship provides a way to determine either experimentally or mathematically a “safe” dose at which no adverse effect are likely to occur, and, through conservative (erring on the side of overestimating the risks) mathematical modeling methods, to estimate the probability or “risk of occurrence” of an adverse health effect. Various federal agencies perform risk assessments to protect the general public from possible adverse health effects after exposure to toxic agents. Most federal safety guidelines for exposure to chemicals (regulatory standards) found in foods, soil, water, the workplace, or other environments are derived at least in part by using some risk assessment methodology.

The Health Group did not (and could not at this point) perform a formal risk assessment for the Building. Instead, we developed Building-specific screening levels for a select group of individual WTC Hazardous Substances. These screening levels allowed us to evaluate the significance of existing contamination in the Building and the effectiveness of preliminary remediation testing. Any future decisions regarding reoccupancy of the Building would have to be based on a formal risk assessment that evaluates, among other things, potential concurrent exposures to residual contamination by all contaminants remaining in the Building after it is remediated. A more detailed discussion on the use of screening levels and risk assessments in public health evaluations is included in Appendix 9.

4.2. The COPC Committee Health-Based Benchmarks are not directly applicable to the Building.

The COPC Committee reports discussed above were written in response to concerns regarding chemical contamination inside residences in Lower Manhattan. The goals were to determine the COPC based on sampling of WTC Dust and ambient air and to set health-based benchmarks for exposure to those COPC in residential environments. The draft version of this report (COPC Committee, 2002) was available in the early stages of the Building exposure assessment, and the screening levels and benchmarks established in it and in the final report issue later (COPC Committee, 2003a) were used by the Health Group for a preliminary evaluation of the data from the RJ Lee Group’s sampling studies. However, for several reasons, the Health Group determined that these values were not directly applicable to the Building. These reasons include the following:

- The COPC Committee used a target cancer risk in their calculations that is less stringent than typically applied by relevant state and federal regulatory agencies in establishing screening levels.
- The COPC Committee discounted potential additive or synergistic effects of the multiple WTC Hazardous Substances present in the WTC Dusts.
- The health-based benchmarks were established for residential exposures, whereas the Building will be used as a commercial facility

The COPC Committee's selection of the less-protective target cancer risk and its failure to consider additivity were specifically noted in the EPA Inspector General's report of August 2003 (EPA, 2003). These limitations and inadequacies are discussed in greater detail in Appendix 9.

4.3 Derivation of Health-Based Screening Levels for the Building.

As noted above, the draft and final COPC Committee health-based screening levels and benchmarks served as a starting point for evaluation of sampling data from the Building. However, it was the Health Group's opinion that alternative values should be established for the purposes of assessing pre- and post-remediation sampling for the Building. Accordingly, we utilized generally accepted and/or published methodology to establish Building-specific health-based screening levels for four WTC Hazardous Substances; asbestos, lead, dioxins, and mercury. Consistent with the conventional use of screening levels, it is our opinion that sampling data from dusts obtained from the building that demonstrate existing contamination above these values determined herein would clearly signal a concern for this Building from a risk assessment and/or public health perspective. In addition, we believe that preliminary or pilot remediation testing in the Building that fails to reduce WTC Hazardous Substances levels below these health-based levels would likely be considered ineffective, unless demonstrated otherwise by a detailed risk assessment. In addition, if the same or similar methods were utilized throughout the Building, and resulted in similar results, any reoccupation determination would require a detailed risk assessment.

The derivation of alternative health-based screening levels for the Building is described in Appendix 9. In deriving these values, we have applied generally accepted methodology, correcting for the deficiencies and inadequacies of the COPC Committee

described previously. The calculated Health-Based Evaluation Criteria are shown below in Table 7.

Table 7 - Building-Specific Health Based Screening Levels for Selected WTC Hazardous Substances

WTC Hazardous Substance	Health-Based Screening Levels	
	Surface Screening Level	Air Screening Level
Asbestos	500 s/cm ²	0.00004 f/cm ³
Lead	25 µg/ft ²	0.7 µg/m ³
Dioxins	0.2 TEQ pg/100 cm ²	NA
Mercury	NA	200 ng/m ³

NA-Not Applicable. No air sampling for dioxins was performed in the Building. All mercury evaluations were based on air sampling.

An air screening level was not developed for dioxins, since the environmental assessment data for the Building were for surface samples. In addition, as noted above, the primary concern regarding mercury was the measurement of unpredictable and elevated airborne levels of this metal. Therefore, a surface screening level was not developed by the Health Group for this WTC Hazardous Substance.

5.0 Preliminary pilot remediation projects in the Building conducted by the Bank's and Insurers' contractors failed to reduce all of the above targeted WTC Hazardous Substances to levels below the Health-Based Screening Levels established by the Health Group.

5.1 The EPA Cleaning Study is Not Applicable to the Building

In May of 2003, the EPA published its Interim Final WTC Residential Confirmation Cleaning Study (WTC RCCS; EPA, 2003). This document described in detail the approach, cleaning procedures tested, and analytical results for COPC in a five-story building at 110 Liberty Street that was directly impacted by the WTC collapse. The WTC RCCS was not applicable to the cleaning of the Building for the following reasons:

- There are locations in the Building that require cleaning for which no cleaning approaches were provided in the WTC RCCS report
- The variety of locations within the Building for which cleaning must be considered is not matched by the 110 Liberty property, and is beyond the scope of the WTC RCCS.
- The 110 Liberty property was not as heavily impacted by WTC Hazardous Substances as the Building.
- The WTC RCCS contains numerous uncertainties that bring to question whether the 110 Liberty building was successfully cleaned.

In March, 2004, the EPA issued a draft report titled, "World Trade Center Residential Dust Cleanup Program – Draft Final Report." Given the timing of this document, its findings and conclusions did not impact the assessment and evaluation of data for the Building. We would note, however, that the limitations presented for the May 2003 cleaning study are generally applicable to the March 2004 report. Regarding effectiveness of cleaning for lead contamination, the EPA noted, "Approximately 14% of the pre-cleanup samples exceeded the U.S. Housing and Urban Development (HUD) screening level of 25 $\mu\text{g}/\text{ft}^2$ for lead, while only about 3% of the post-cleanup samples exceeded the screening level. This showed that the cleanup methods were effective in reducing lead." (EPA, 2004; page 2) Thus, although the EPA doesn't address this directly, these data indicate that approximately 20% of the apartments with initial lead

surface dust concentrations in excess of the COPC Committee health-based benchmark were not successfully cleaned.

Detailed discussion of these limitations and additional critique of the WTC RCCS are included in Appendix 10.

5.2 Bank Contractors' Data

5.2.1 Bank Contractor Cleaning Studies

Post-cleaning samples were obtained following attempts to remediate headers, raceways, cell systems, and high- and low-pressure ductwork in designated test-cleaning areas throughout the building. These cleaning studies are described elsewhere (RJ Lee Reports R3, R4, H3, 2004). For the sake of evaluating the cleaning methods applied in the Building to reduce levels of WTC Hazardous Substances, a comparison of pre- and post-cleaning contaminant levels on interior surfaces versus the health-based screening level discussed above for asbestos, dioxins, and lead are presented below.

Table 8 - Comparison of Post-Remediation Sampling with Building-Specific Health-Based Screening Level for Asbestos*

Asbestos (s/cm²)				
Sampling Event	Count	Average	Max	Screening Level
Post-Clean 1	15	898,200	12,390,000	500
Post-Clean 2	16	155,200	1,473,000	500
Post-Clean 3	8	187,500	1,133,000	500
Post-Clean 4	9	239,300	1,829,000	500
Post-Clean 5	6	249,000	845,700	500
Post-Clean 6	3	62,640	114,800	500

*Averages and maximum readings in **bold** are above the Building-specific screening level

Table 8 demonstrates that even after six cleaning events, the average and maximum asbestos concentration in the test areas remained markedly above the Building-Specific health-based screening level.

Table 9 - Comparison of Post-Remediation Sampling with Building-Specific Health-Based Screening Level for Dioxin*

Dioxin (TEQ pg/100 cm²)				
Sampling Event	Count	Average	Max	Screening Level
Post-Clean 1	7	0.242	1.263	0.2
Post-Clean 2	8	0.159	1.152	0.2
Post-Clean 3	7	0.049	0.220	0.2
Post-Clean 4	9	0.092	0.427	0.2
Post-Clean 5	5	0.000	0.000	0.2
Post-Clean 6	5	0.000	0.000	0.2

*Averages and maximum readings in **bold** are above the Building-specific screening level

Table 9 demonstrates the efficacy of multiple cleaning methods for the removal of dioxins from contaminated surfaces within test cleaning areas in the Building. These data suggest that at least five cleaning events would be required to reduce maximum dioxin levels below the Building-Specific health-based screening level..

Table 10 - Comparison of Post-Remediation Sampling with Building-Specific Health-Based Screening Level for Lead*

Lead (µg/ft²)				
Sampling Event	Count	Average	Max	Screening Level
Post-Clean 1	23	102	481	25
Post-Clean 2	26	814	19,800	25
Post-Clean 3	17	34.4	148	25
Post-Clean 4	19	1,900	27,100	25
Post-Clean 5	6	93.9	176	25
Post-Clean 6	6	53.1	120	25

*Averages and maximum readings in **bold** are above the Building-specific screening level

Table 10 demonstrates that the average and maximum levels of lead in test areas could not be reduced below the Building-Specific health-based screening level, even after six cleanings.

5.2.2 Bank Analysis of Samples from Insurer's Cleaning Studies

Samples were taken on behalf of the Bank in a side-by-side fashion from test abatement cells prepared and sampled by Young Laboratories on behalf of the Insurers (see Insurer's Testing Program: Abatement Cells, RJ Lee, 2003). The abatement cells were constructed in office spaces that allowed for floors, walls and other vertical structures, lights, furniture, wall cavities, and areas above ceilings to be sampled, cleaned, and then re-sampled to test the efficacy of cleaning. The following are tables comparing pre-cleaning and post-cleaning data from the Young Cells.

Table 11 - Asbestos Testing in Insurer's Abatement Cells

Asbestos (s/cm²)				
Sampling Event	Count	Average	Max	Screening Level
Pre-Clean	22	1,535,000	7,681,000	500
Post-Clean	65	146,900	2,410,000	500

Table 12 - Dioxin Testing in Insurer's Abatement Cells

Dioxin (TEQ pg/100 cm²)				
Sampling Event	Count	Average	Max	Screening Level
Pre-Clean	38	9.7	90.8	0.2
Post-Clean	82	2.4	159.2	0.2

Table 13 - Lead Testing in Insurer's Abatement Cells

Lead (µg/ft²)				
Sampling Event	Count	Average	Max	Screening Level
Pre-Clean	24	136	548	25
Post-Clean	45	47.7	483	25

5.3 Conclusions Regarding Cleaning Studies

These findings demonstrate that five or more cleanings were required to reduce the concentrations of asbestos, dioxin, and lead below the health-based screening levels developed for the Building. Furthermore, the variability of contaminant levels from one cleaning event to another suggests the potential for recontamination of cleaned spaces and/or reveals the inherent uncertainty of the cleaning process. Finally, these data represent cleaning activities in a limited set of controlled test areas within the Building. Since WTC Hazardous Substances could not be cleaned to acceptable levels in test areas, even after multiple cleanings, it has not been demonstrated that the entire Building could be cleaned of all WTC Hazardous Substances to levels that are protective of human health.

6.0. Absent Effective Remediation, the Continued Presence of WTC Hazardous Substances and WTC Dust in the Building will have Regulatory Implications.

During the ordinary course of our work as specialists in health and environmental impacts of chemicals we are often asked to provide consultation regarding compliance with workplace regulations. Based on our experience in this area we are of the opinion that the following OSHA regulations may be applicable for future employers utilizing the Building.

6.1. Lead exposure may require employers to implement provisions of the OSHA lead standard (29 CFR §1910.1025(l)(1)(i)).

Due to the lead contamination in the Building, employers may be required to notify workers of the potential for lead exposure and provide worker training that covers all adverse health effects resulting from lead exposure.

Lead exposure may require employers to implement two sections of the OSHA General Industry Lead Standard (29 CFR 1910.1025). First is 29 CFR 1910.1025(l) "Employee Information and Training" subparagraphs (1) and (2). Second is 29 CFR 1910.1025(d)(2) "Initial Monitoring."

6.2. Asbestos exposure may require employers to implement provisions of the OSHA asbestos standard (29 CFR §1910.1001).

Due to the asbestos contamination in the Building, employers may be required to notify workers of the potential for asbestos exposure and provide initial worker awareness training that covers all adverse health effects resulting from asbestos exposure. Annual refresher training is required thereafter.

6.3 *The employers in the Building may have to inform employees about regulated toxic substances pursuant to the New York State Toxic Substances Laws.*

The New York State "Right to Know" laws, located in state Labor Law Article 28, Section 875 and state Public Health Law, Article 48, Section 4800, (enacted together as the Toxic Substances Laws), require employers to provide notice to employees regarding toxic substances that are either listed in the NIOSH Health Registry of Toxic Effects of Chemical Substances or have yielded positive evidence of acute or chronic health hazards in human, animal or other biological testing — and are “found in the workplace.” Employer responsibility under the rules is triggered by the presence of the toxic substance without reference to a specified concentration.

7.0 *Microorganisms and WTC Hazardous Substances for which Building-specific health-based screening levels have not been developed may pose additional human health risks. The Health Group would need to develop screening criteria for these contaminants after further study*

7.1 *Background*

Although microorganisms were not considered a contaminant of potential concern by the COPC committee, the Bank cannot ignore potential risks to public health from microorganisms. By 2002, extensive visible mold growth characterized many floors of the Building. In response, indoor bioaerosol studies were conducted by the Bank in 2002 with more than 2,300 total samples collected from all floors of the Building. Multiple samples documented reservoirs of fungi in the Building. In response, the Bank removed visible mold from the Building using New York City Guidelines on Assessment and Remediation of Fungi in Indoor Environments. However, because window breakage, gash damage, and HVAC contamination and damage could not be resolved in 2002, indoor humidity and dampness in the Building could not be adequately controlled throughout 2003, necessitating further study of bioaerosols. Water systems in the building have been inoperable since the WTC Event, and many are now contaminated with high counts of *Legionella pneumophila* bacteria (for instance, the upper secondary system has been estimated to have 4000 organisms per ml water, while as few as 40 organisms per ml water can serve as an inoculating dose, according to B. Shelton of

Pathcon Laboratory, personal communication). Observations made throughout the Building during the final calendar quarter of 2003 indicated that mold growth is again evident in some areas of the Building where visible mold was removed during 2002.

7.2 Potential Health Effects of Microorganisms

Microorganisms, including bacteria and fungi, are normally present on surfaces of finishing and construction materials. However, chronic dampness and moisture incursion into a building will result in colonization of interior surfaces and in an increase in microbial concentration above background levels (Flannigan and Miller, 1994; Strom et al., 1990). Dampness and mold growth in residential buildings are associated with the occurrence of allergic and non-allergic respiratory disease (Pope et al., 1993; Fischer et al., 1998; Spengler et al., 1994; Ronmark et al., 1998; Peat and Dickerson, 1998; Reijula, 1998; Norback et al., 1999). Poorly maintained building water systems (air conditioning cooling towers, evaporative condensers, humidifiers, fountains) may exhibit higher than expected counts of *L. pneumophila*, an organism which can cause pneumonia if aerosolized and inhaled (Chin, 2000). Consensus scientific opinion concerning the health effects of indoor exposure to microbial particles and their derivatives in general agree that two categories of health problems can occur: 1) building associated symptoms (BAS), and 2) allergic disease (ACOEM, 2002; NYCDHMH, 2002).

7.3 Additional WTC Hazardous Substances

As discussed previously, Building-specific health-based screening levels were developed for only a select group of WTC Hazardous Substances; asbestos, lead, dioxins, and mercury. However, many other WTC Hazardous Substances have been identified in the Building at concentrations in excess of the COPC Committee health-based benchmarks. If the Building were to be reoccupied, these WTC Hazardous Substances would also have to be addressed.