

Overview
Asbestos Exposures & Risks

WTC-STAC Meeting
February 15-16, 2012

WTC Dust Cloud



WTC and Post 9/11 Exposures

- Initial dust cloud estimated to be in excess 100,000 $\mu\text{g}/\text{m}^3$
- Initial cloud affected all of southern Manhattan with dispersal of dusts and gases east and southeast of WTC
- Liroy et al. described 5 specific post 9/11 environmental/occupational exposure categories.

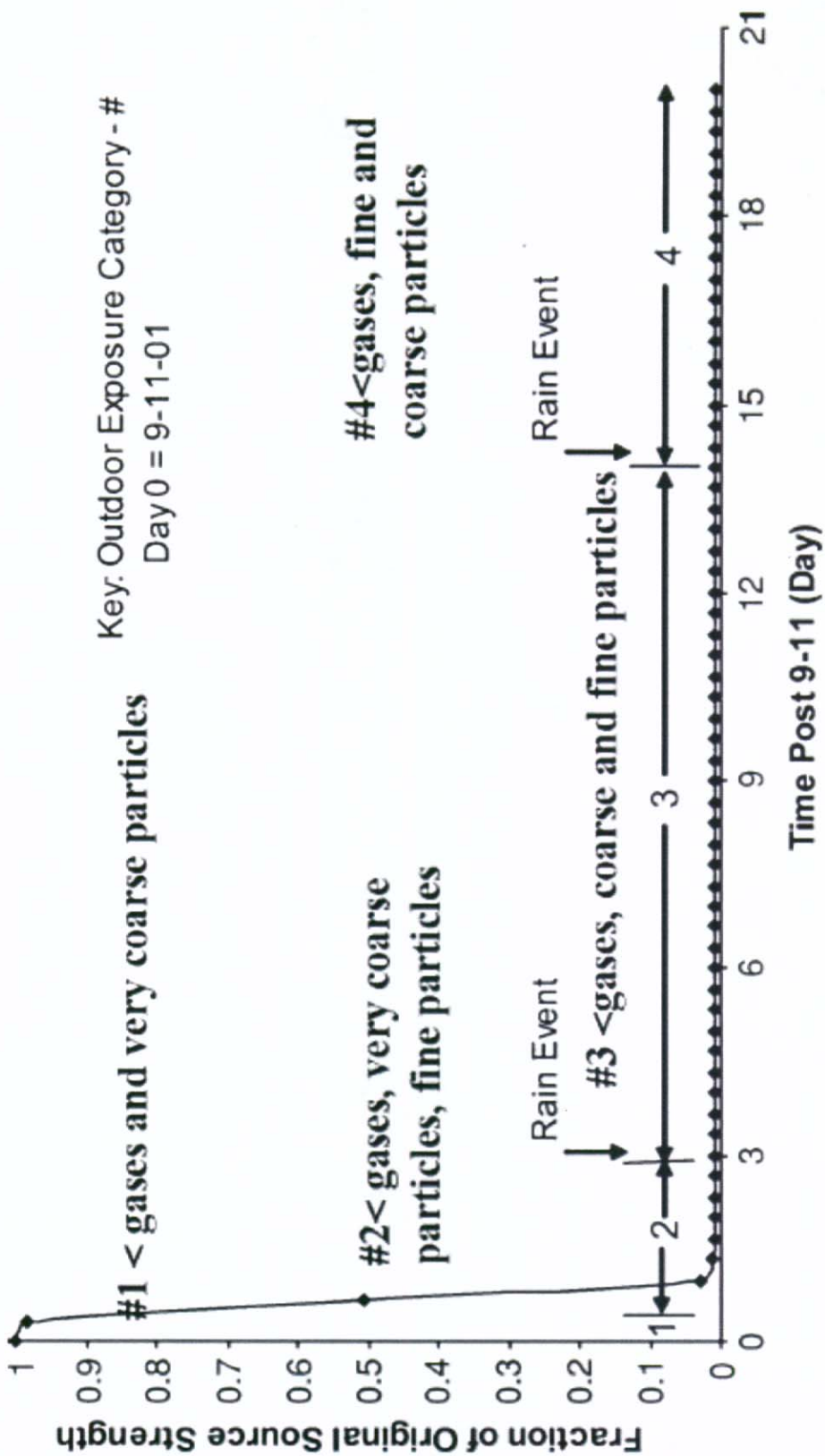
Exposed Populations by Category

[Lioy, 2006]

Sequence of environmental and occupational exposures				
Category	Time period for categories of exposure	Predominant sources of pollution	Pollutants and pollutant classes	Primary exposure groups
1	First 12 h post-collapse (9/11)	Collapse of Twin Towers Burning jet fuel Building fires Resuspended dust and smoke	Combustion products Evaporating gases Gaseous, fine, and supercoarse particles	WTC workers Local employees Local residents Commuters Rescue workers Fire and police Federal law enforcement Press
2	Days 1.5-2	Burning jet fuel Building fires Resuspended dust and smoke	Combustion products Evaporating gases Gaseous, fine, coarse, and supercoarse particles	Rescue workers Fire and police Federal law enforcement Local residents Press
3	Days 3-13	Smoldering fires Resuspended dust and smoke	Combustion products Gaseous, fine, and coarse particles	Recovery workers Construction workers Local residents Fire and police
4	Day 14 through Dec 29, 2001	Smoldering fires Debris removal by trucks and equipment	Combustion products Gaseous, fine, and coarse particles	Recovery workers Construction workers Local residents Fire and police
5	Indoors: 9/11 through ?	Resuspended dust and smoke	Supercoarse particles Some fine and coarse particles	Recovery workers Local residents Fire and police Cleanup workers Local residents Employees Building visitors

Conceptual WTC Outdoor Plume Impacts

[Lioy et al. 2005]



Dust/Fiber Measurement Methods

Parameter	Midget Impinger	Phase Contrast Microscopy	Scanning Electron Microscopy		Transmission Electron Microscopy
Range of Magnification	100	400	2,000–10,000	5,000–20,000	
Particles Counted	All	Fibrous Structures ^b	Fibrous Structures ^b	Fibrous Structures ^{b,c}	
Minimum Diameter (size) Visible	1 μm	0.3 μm	0.1 μm	< 0.01 μm	
Resolve Internal Structure	No	No	Maybe	Yes	
Distinguish Mineralogy ^d	No	No	Yes	Yes	

Chrysotile Asbestos in WTC Dusts

- Chrysotile asbestos constituted 0.8 - 3.0% of mass in settled dusts with most fibers $<5 \mu\text{m}$ in length.
- No measurements were made of chrysotile airborne dust concentrations until 9/14, long after the extraordinarily high initial dust cloud.
- 9400 TEM samples with 22 exceeding the AHERA standard of 70 structures $>0.5 \mu\text{m}$ long per mm^2
- 19,000 air samples by PCM, and 4 exceeded the OSHA permissible exposure limit (PEL) of 0.1 f/cm^3
- 804 breathing zone or general area PCM air samples by NIOSH or contractors detected countable fibers (aspect ratio ≥ 3 and length $>5 \mu\text{m}$) in 45% of the samples. 25 samples had $>0.10 \text{ f/cm}^3$ by PCM but $<0.1 \text{ f/cm}^3$ by TEM.

Types of Regulated Asbestos

- Serpentine
 - Chrysotile
- Amphiboles
 - Amosite
 - Crocidolite
 - Tremolite
 - Anthophyllite

Asbestos Carcinogenicity

IARC 2009: Concluded that exposure to all forms of asbestos (chrysotile, crocidolite, amosite, tremolite, actinolite, and anthophyllite) was associated with an increased risk of lung cancer and mesothelioma.

- **Sufficient evidence** from epidemiological studies that asbestos also caused cancer of the larynx and ovary.
- **Limited evidence** that it caused cancer of the colorectum, pharynx, and stomach.

NTP 2011: “Asbestos and all commercial forms of asbestos are *known to be human carcinogens* based on sufficient evidence of carcinogenicity from studies in humans.”

Asbestos Quantitative Risk Assessments

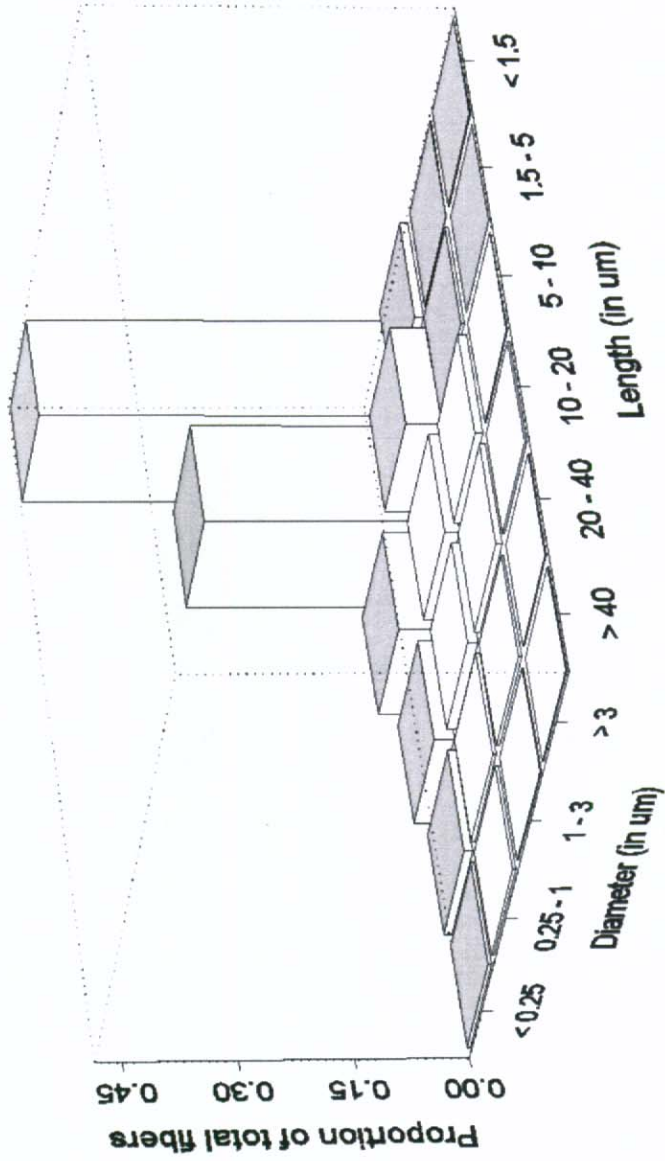
- Human Populations: Retrospective occupational cohorts
- Measurement Method: PCM measurements of fibers >5 μm in length.
- Risk Metric: Cumulative exposures based on the product of PCM concentration and exposure duration (fiber-years).
- Risk Models: Nearly all assessments use a no-threshold model.
- No Effect Levels: No scientifically justified threshold for asbestos-related cancers has been established.

Limitations of Risk Assessments

- Limited historical exposure measurement data, resulting in exposure misclassification and likely dampening of the exposure-response.
- PCM methods measure only a fraction (typically <10%) of the total chrysotile fiber exposure.
 - Fibers < 0.25 μm in diameter are not detected
 - Only fibers > 5 μm are counted.
- Mesotheliomas are not well captured in mortality studies as there was no specific code for mesothelioma until ICD-10 (1999).

TEM Airborne Size Distribution Chrysotile in Textiles

Only Small Fraction $>5 \mu\text{m}$ in Length



Mesothelioma Case-Control Studies

- Iwatsubo et al., 1998: France, 405 cases and 387 controls
 - Odds-ratios increased strongly with cumulative exposure.
 - Odds-ratio = 4.2 (95% CI=2.0-8.8) for cumulative exposures of 0.5 to 0.99 fiber-years.
- Rodelsperger et al., 2001: Germany, 125 cases and 125 controls
 - Odds-ratios increased strongly with cumulative exposure
 - Odds-ratio = 7.9 (95% CI=2.1-30.0) for cumulative exposures <0.15 fiber-years

OSHA PEL is Not Zero Risk

- **OSHA PEL:** 0.1 fibers > 5 μm in length per cm^3 as a 8-hour time-weighted-average exposure.
- **OSHA's risk assessment:** Exposures to 0.1 f/cc over a working lifetime is associated with an excess risk of 3.4 cancers per 1,000 workers.
- **OSHA Standard Preamble:** "The 0.1 f/cc level leaves a remaining significant risk."