

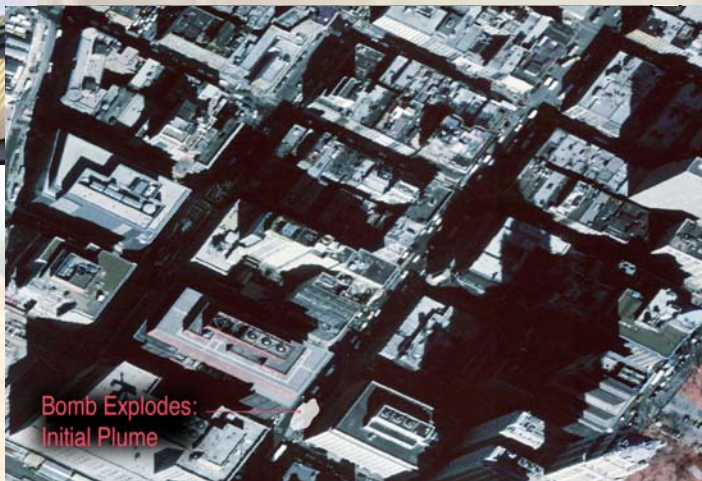


HVAC – Exhaust

HVAC – Air Supply



Lobby



Bomb Explodes:  
Initial Plume

# *Radiation Dispersal Devices (RDDs)*

## *Rapid and Realistic Response*

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**WM**  
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## RDDs or Dirty Bombs:

- use conventional bombs or methods to disperse radiological materials
- are **Weapons of Mass Disruption** causing panic disproportionate to the real danger
- contaminate vital infrastructure and trigger large economic consequences
- While most radiological source materials are small, with little *real radiological consequence*, **large RDDs over 50,000 Curie** are feasible and can have major consequences.
- logistically similar to 9-11 attacks
- It is imperative to reduce these vulnerabilities, lessen the impact, and mitigate the aftermath effects.
- The first RDD attack will most likely be against a U.S. military base overseas



### The Threat is Real

- Several credible designs and plans for a dirty bomb attack against the USA have been found in Al Qaeda records
- Two actual dirty bombs were deployed by Chechen separatists (foiled and failed)
- 38 Alazan missiles outfitted with dirty bomb warheads for sale in Moldova

## **Social - risks facing Americans over the past 5 years**

**alcohol consumption**

**automobile driving**

**coal industry**

**construction**

**contraception**

**hunting**

**iatrogenic**

**nuclear industry**

**police work**

**smoking tobacco**

In numerous polls over the last ten years, when asked to rank this list of activities from most dangerous to least dangerous, the average citizen ranked the nuclear power industry as the first or second most dangerous activity in America.

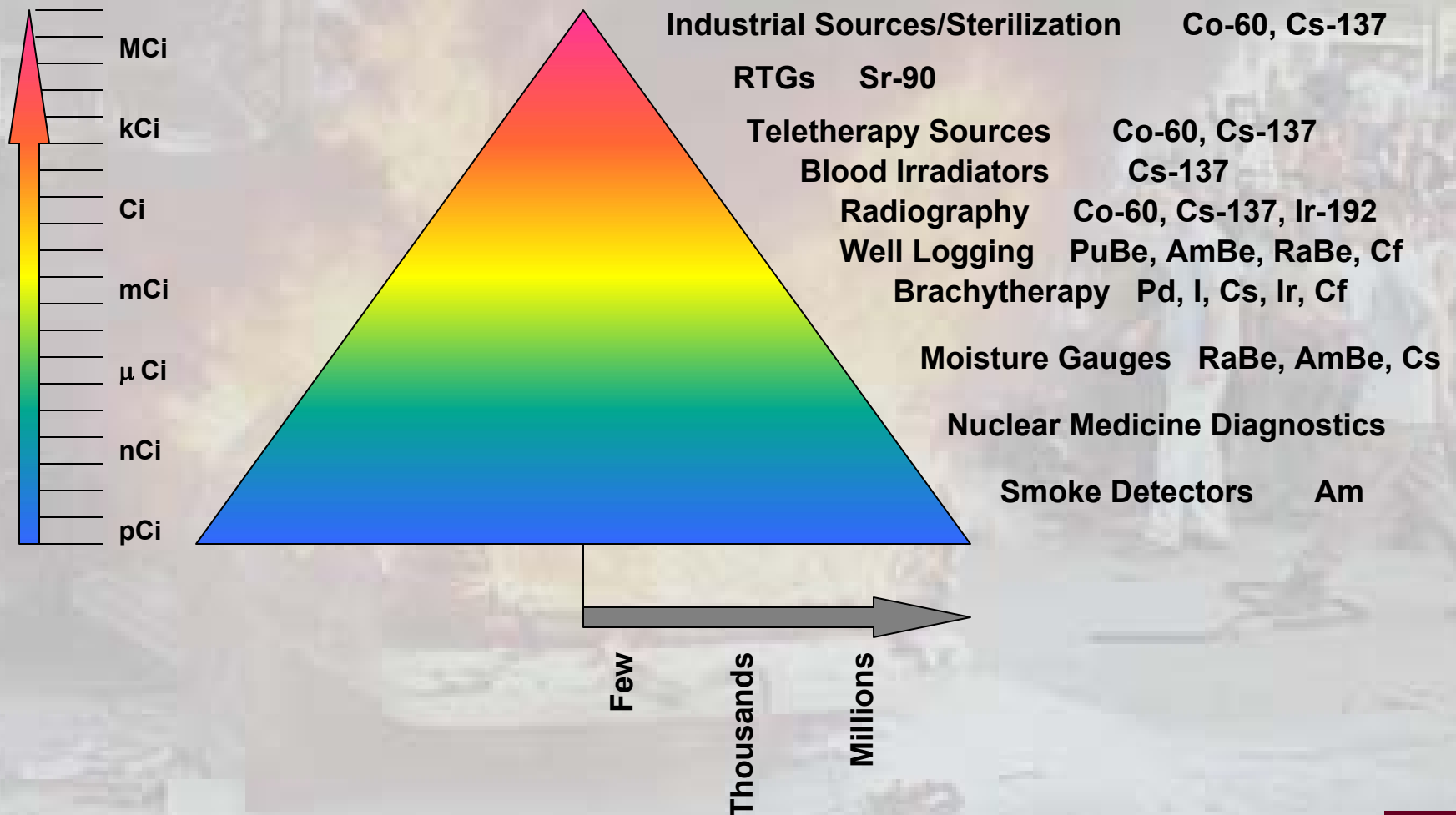
## **Activity**

## **Number of Deaths in the past 5 years**

iatrogenic	950,000
smoking	760,000
alcohol	500,000
automobile accidents	250,000
coal use (~50% of U.S. power)	90,000
construction	5,000
hunting	4,100
police work	800
contraception	750
nuclear industry (~20% of U.S. power)	0

**Misperceptions about radiation suggest extreme panic will follow an RDD attack, hampering response and reoccupancy. The public trusts first responders more than all other officials and will take their queues from them.**

# Small & Insignificant Sources Greatly Out-Number Large & Hazardous Sources



## Candidate RDD Materials

- **Industrial sterilization units**
  - $^{60}\text{Co}$  - 100,000 to 8,000,000 Ci (190 worldwide)
  - $^{137}\text{Cs}$  - 10,000 to 250,000 Ci (unknown; ~ 100 worldwide)
- **Research irradiators**
  - $^{137}\text{Cs}$ ,  $^{60}\text{Co}$  - 2,000 to 24,000 Ci [100,000 Ci] (>100 worldwide)
- **Seed irradiators**
  - $^{137}\text{Cs}$ ,  $^{60}\text{Co}$  - 800 to 20,000 Ci (>100 former Soviet Union states)
- **Teletherapy units**
  - $^{137}\text{Cs}$ ,  $^{60}\text{Co}$  - 3,000 to 15,000 Ci (5,300; Co-western, non-U.S.; Cs-eastern)
- **Blood irradiators**
  - $^{137}\text{Cs}$  - 600 to 5,000 Ci (>300 U.S.; 2,000 worldwide)
- **Radioisotope Thermal-Electric Generators (RTGs)**
  - $^{90}\text{Sr}$  - 1000 to 400,000 Ci (~1,000 former Soviet Union states)
- **Radiography and well-logging units**
  - [ $^{192}\text{Ir}$ ,  $^{238}\text{Pu}$ ,  $^{241}\text{Am}$ ,  $^{252}\text{Cf}$ ,  $^{75}\text{Se}$ ,  $^{226}\text{Ra}$ ,  $^{169}\text{Yb}$ ] < 100 Ci (>10,000 worldwide)

## Necessary Simplifications Concerning RDDs

- Only two scenarios are likely to be effective
  - $^{137}\text{CsCl}$  car bomb (RDD)
  - $^{60}\text{Co}$ -gamma death mobile (RED) [possibly a large  $^{90}\text{Sr}$ ]
    - there may be a technological fix for each of these scenarios



# The Two Primary Non-Nuclear Radiological Threats

RDD

$^{137}\text{Cs}$  Gamma  
Car Bomb



casualties < 500  
 $\text{LD}_{50}$  depends upon dispersion  
Major infrastructure  
contamination  
> \$500 billion



Terrorist's choice

RED

$^{60}\text{Co}$  Gamma  
Death-Mobile



casualties > 100,000  
 $\text{LD}_{50}$  in 20 sec @ 2 yards  
No infrastructure  
contamination  
<< \$1 billion



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  - initial clean-up must be fast - must not require a permitting process
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- **Fire and Police will be the primary first responders**
  - must have basic RDD training and a small alarming dosimeter
  - first responders need to secure the site until the NG CST, DOE RAP, or other specialized teams arrive, but they should still be the ICs
  - tertiary response should include rapid wash down of area; 48 - 72 hrs

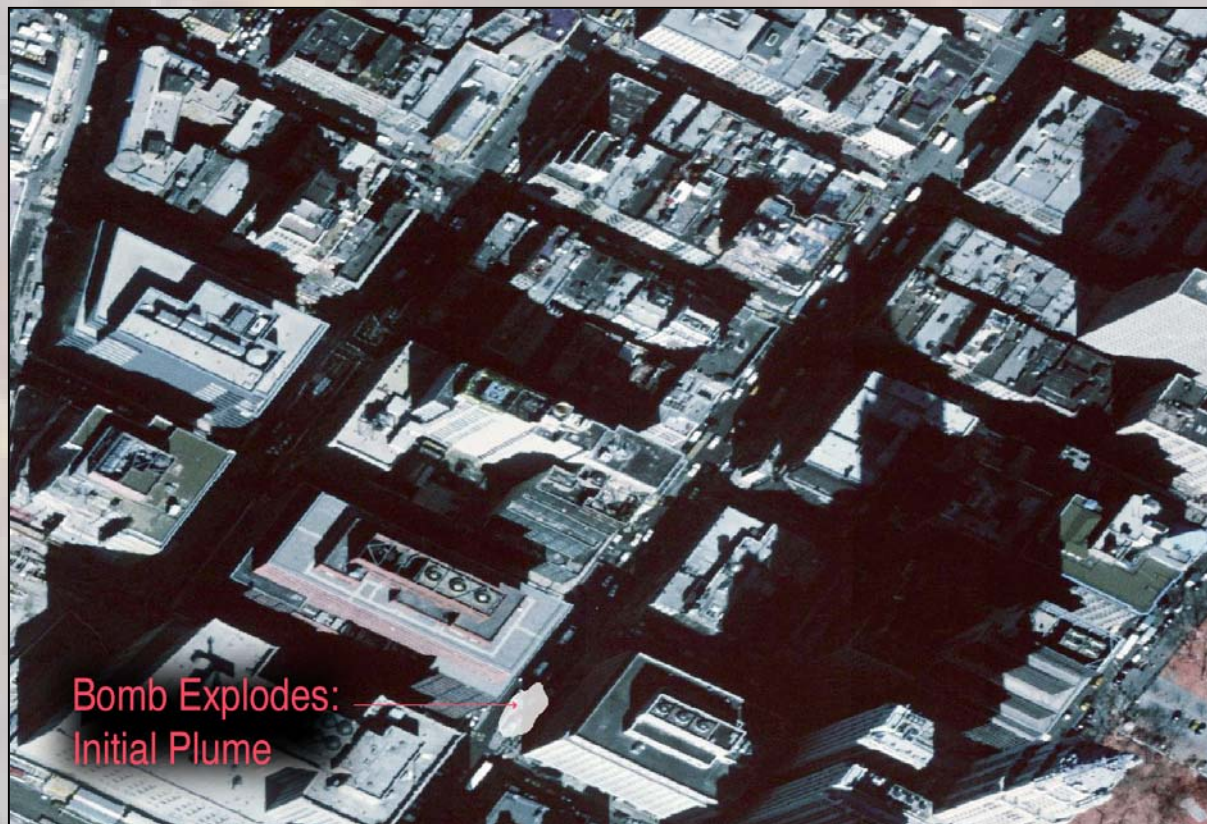
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- **Reoccupying requires correcting the assumptions of the linear no-threshold dose theory/misperceptions of radiation**
  - no demonstrable health effects from acute doses  $< 10$  rem



9:30 AM

## Bomb Explodes



wind  
direction



9:32 AM

Smoke/Cs Plume Develops - 1 rem/hr inner hot zone



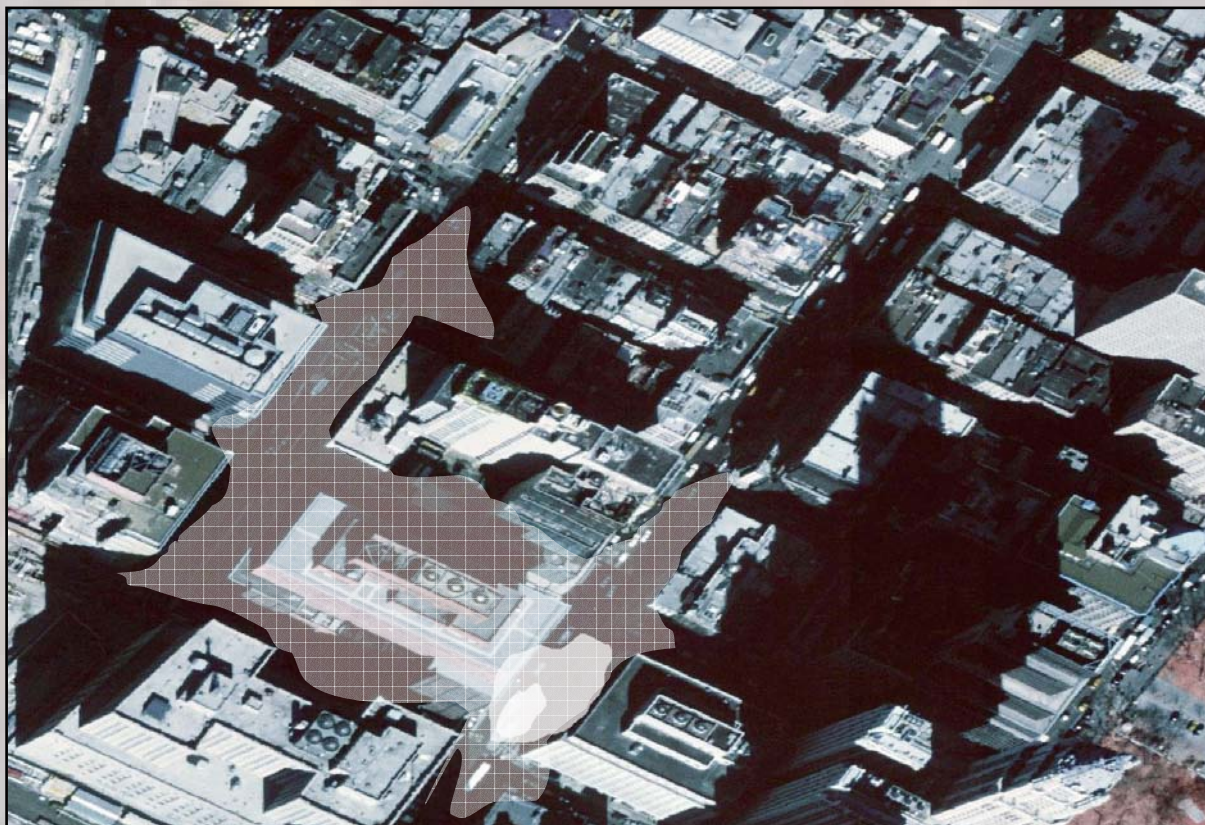
↖ wind  
direction





9:40 AM

Larger Particulates Settle - 0.1 rem/hr warm zone

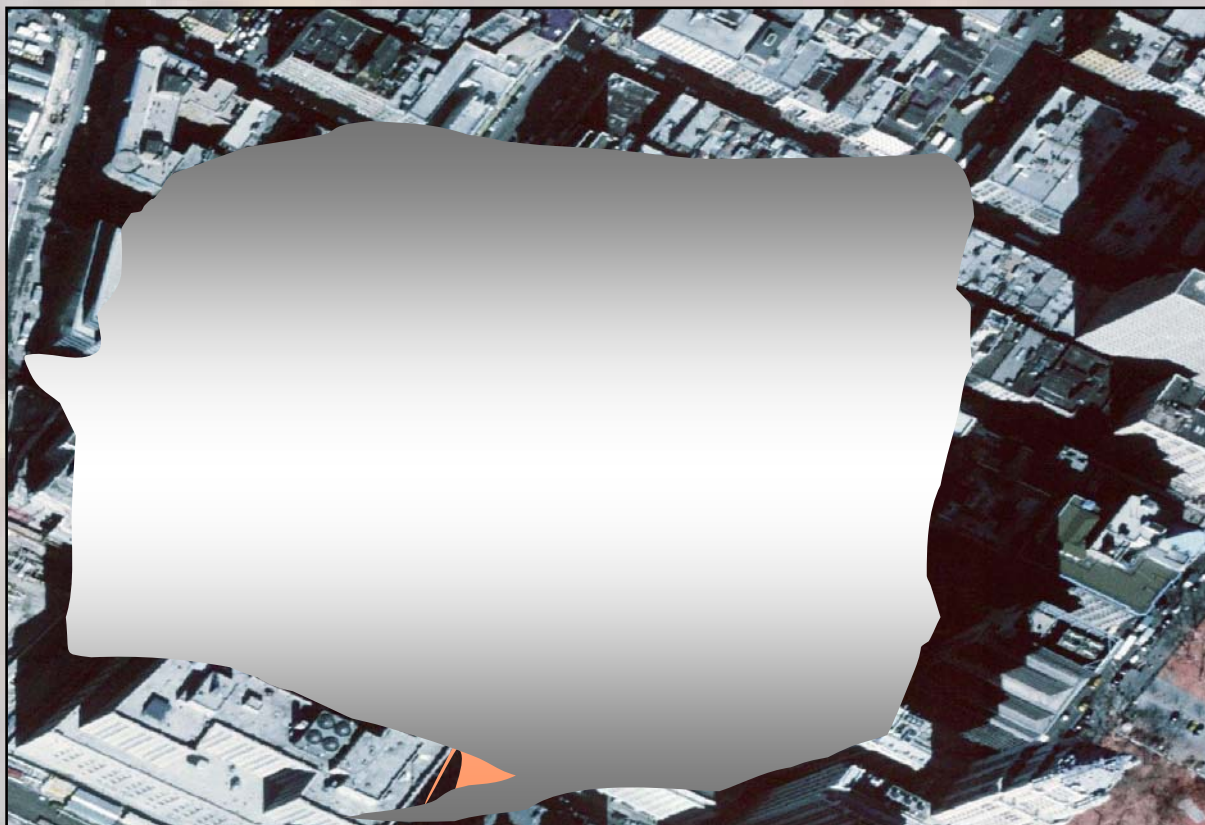


↖ wind  
direction



9:50 AM

Fine Particulates Settle - 2 mrem/hr affected area



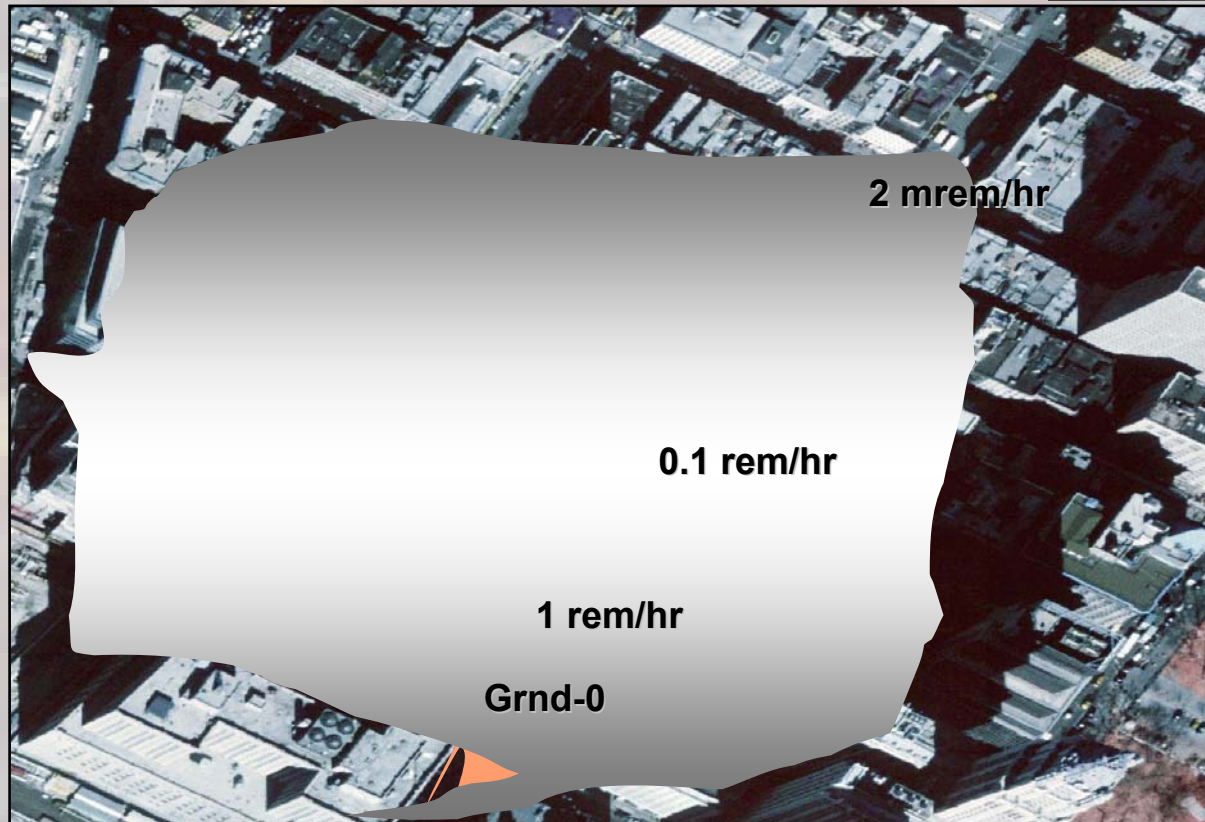
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direction







## First Responders - Delineate Zones



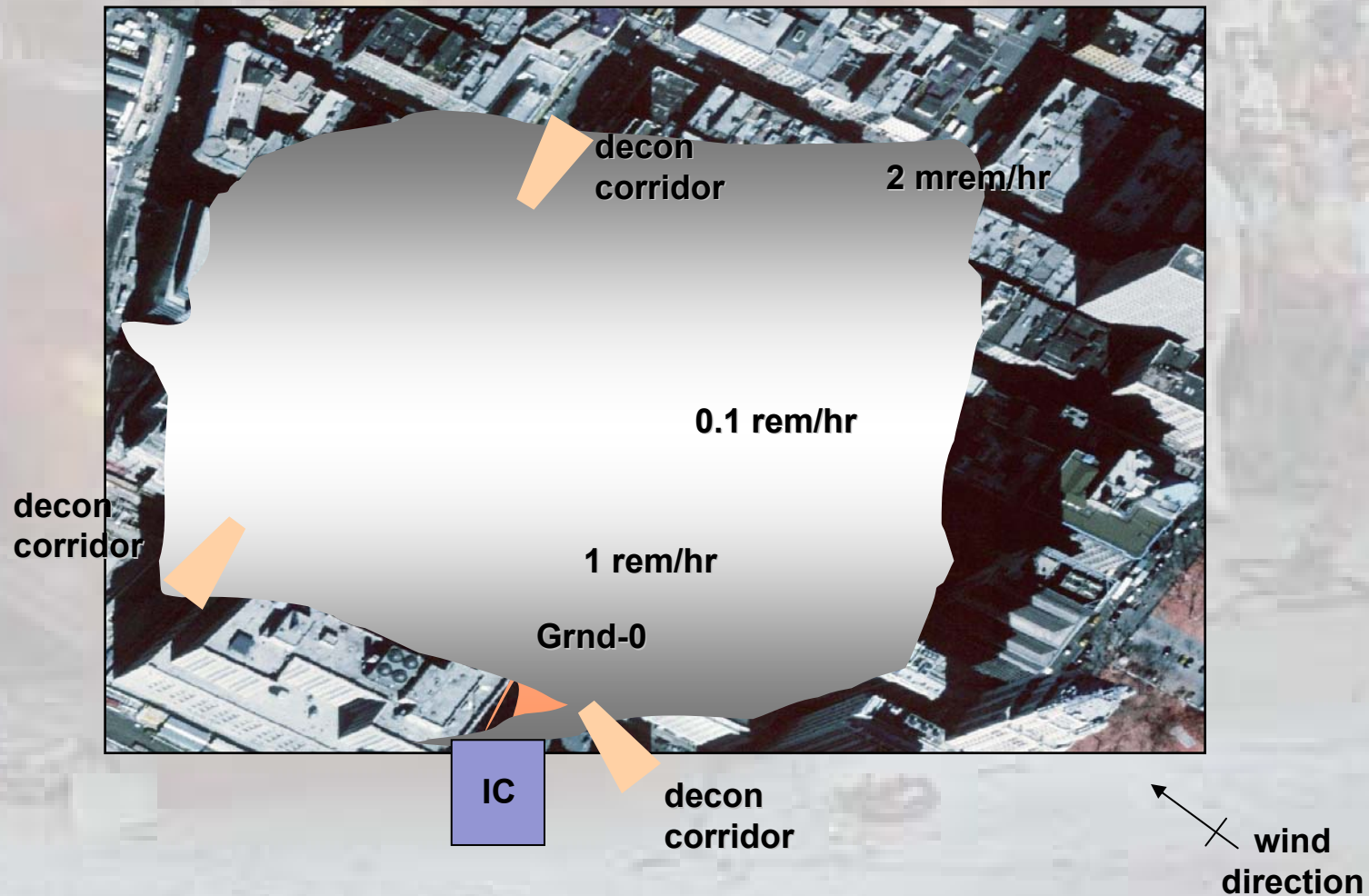
↖ wind  
direction

# Place IC and decon corridor(s)

Cognizant of geometric and logistical issues

Use building interiors and underground if possible

Commence mapping and evacuation



## **What are the risks to responders working in the affected area?**

### **Relative risks to first responders:**

- **10 rem acute dose**
  - In the working hot zone for a day - no measureable health effects ever reported for 10 rem
    - Fighting a dumpster fire
    - Hand-cuffing an inebriated nuisance
- **25 rem acute dose**
  - In the working hot zone for a few days
    - Fighting a three-alarm fire from the street
    - Disarming a perpetrator who has no weapon
- **50 rem acute dose** (DHS responders' suggested upper limit for saving life in large numbers)
  - In the working hot zone for a week
    - Running into a burning building not at risk of collapse
    - Disarming a perpetrator who has a knife
- **100 rem acute dose**
  - In the working hot zone (0.1 to 1 rem/hr) for a month/~10 min priority rescue at Grnd 0
    - Running into a burning building at risk of collapse
    - Disarming a perpetrator who has a gun



## **Rapid Washdown of Affected Area**

- **systematic washdown  
of building exteriors,  
streets and other  
surfaces into storm  
water drainage system  
can occur if the plume  
is kept outside, if it is  
already delineated and  
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- Various types of solutions to be tested in the next few years, but surface area in 10 x 10 city blocks  $\geq 1,000,000,000$  sq ft
  - 100 fire hydrants operating for 24 hrs = 100,000,000 gallons

## Rapid Washdown of Affected Area

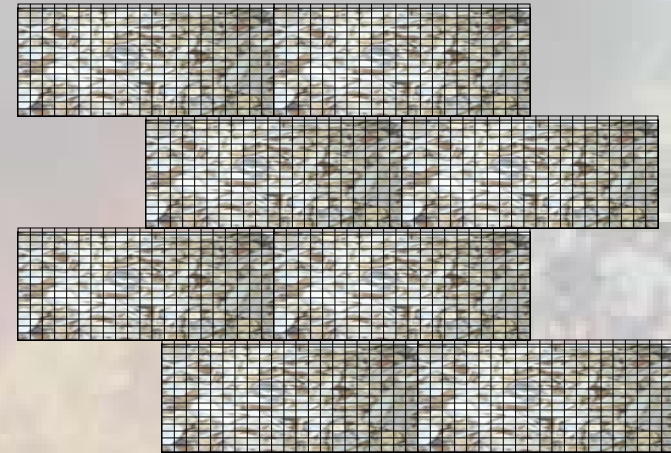
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  - 100 fire hydrants operating for 24 hrs = 100,000,000 gallons
- Zeolitic gravel plugs or special filter plugs at storm water outflow pts (very specific for Cs and other nuclides; only kgs of  $^{137}\text{CsCl}$  in largest RDDs)



# Sewage and Stormwater Outlets



**Gabions of zeolitic tuff gravel inserted into drainages and outflow points; \$80/ton**



**Washwater exiting sewer or storm drainage pipes can be treated by inexpensive zeolite tuff gravel that is highly specific for Cs, and that can be easily disposed of to a low-level waste facility @\$1000/gabion**

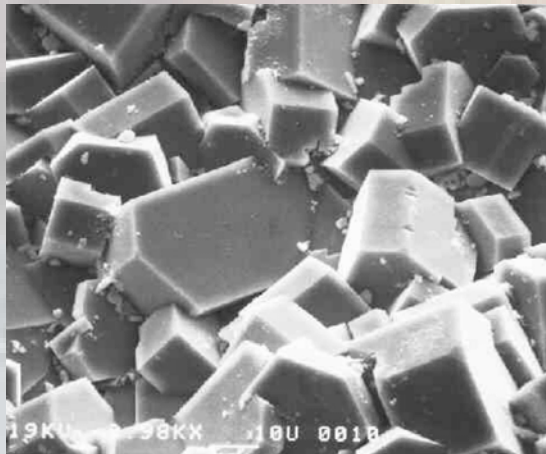




**Gabions of zeolitic tuff gravel can be stockpiled near target cities easily.**

**A large shipping container filled with zeolite gabions costs about \$10K**

**It is rock so needs no special storage conditions**



**Clinoptilolite**



**exchangeable with Cs, Li, Sr, Ba**

**Erionite**



**exchangeable with Rb, Cs, Ba, Sr**





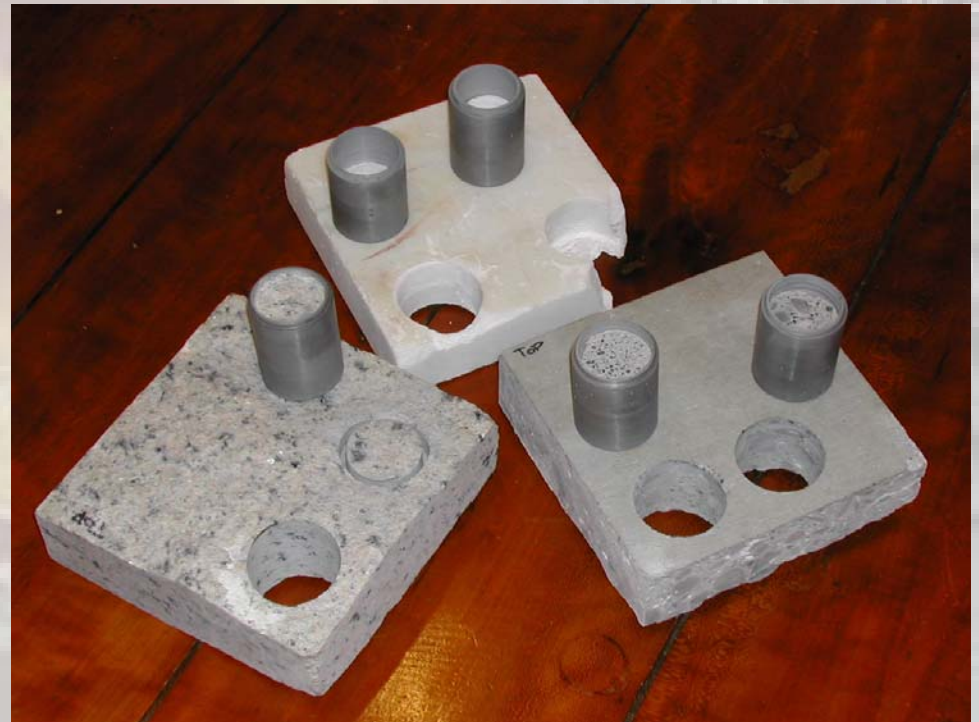
# Cs removal efficiencies from building and paving materials

## Materials

- concrete/grout, granite, limestone/marble, asphalt, SS/Al metal, glass, wood, rubber/plastics
  - 99% of surfaces in target areas
  - asphalt and concrete are most problematic

## Applications

- aerosol deposition ( $<1\text{lb/ft}^2$ )
- effects of soot on Cs sorption chemistry
- resuspension and mobility
- foot and traffic effects ( $200\text{--}1,000\text{ lb/ft}^2$ )
- bomb pressure insertion ( $>10,000\text{ lb/ft}^2$ )

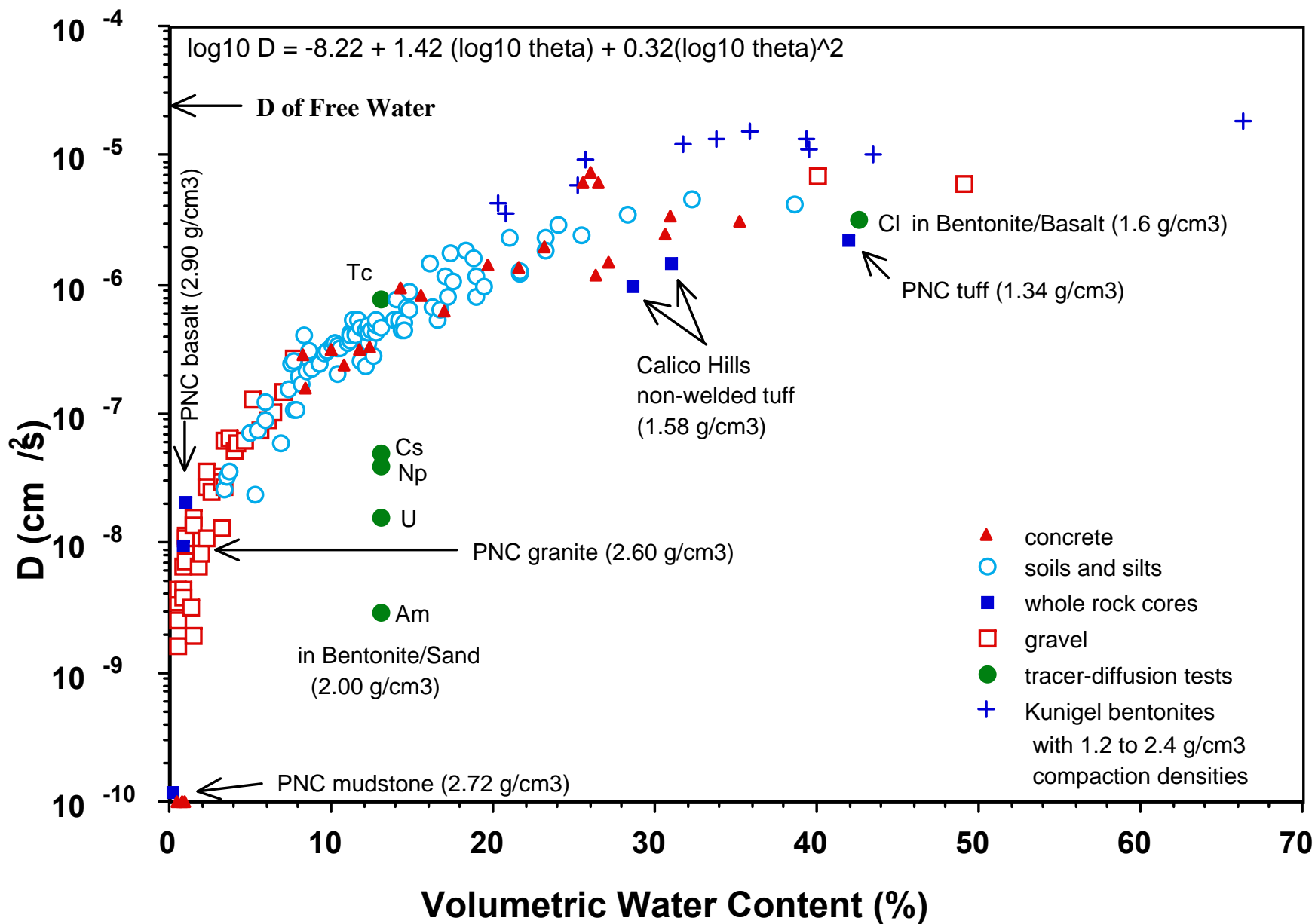


# Cs removal efficiencies from building and paving materials

## CONCRETE

CsCl Application Pressure (dry)	CsCl Removal Efficiency with Water (fire hose @ 100 yd for 10 sec)
< 1 lb/ft <sup>2</sup> (aerosol)	100%
200 lb/ft <sup>2</sup> (foot traffic)	100%
1000 lb/ft <sup>2</sup> (vehicular traffic)	100%
10,000 lb/ft <sup>2</sup> (bomb pressure)	--- (crumbling occurred)





## Radionuclide diffusion coefficients (D) in building and paving materials

(directly proportional to moisture content,  $\theta$ )

$$x = (Dt)^{1/2}$$

$$\log_{10} D = -8.22 + 1.42(\log_{10} \theta) + 0.32(\log_{10} \theta)^2$$

Material	dry (<50% RH)	damp (100% RH)	heavy fog	drizzle rain
Granite	$10^{-15} \text{ cm}^2/\text{s}$	$10^{-13} \text{ cm}^2/\text{s}$	$10^{-11} \text{ cm}^2/\text{s}$	$10^{-10} \text{ cm}^2/\text{s}$
Cement	$10^{-15} \text{ cm}^2/\text{s}$	$10^{-10} \text{ cm}^2/\text{s}$	$10^{-8} \text{ cm}^2/\text{s}$	$10^{-6} \text{ cm}^2/\text{s}$

Therefore, if  $^{137}\text{Cs}$  is left on a wet building surface for a month it will diffuse into granite less than a 1/100 of an inch, but will diffuse into uncoated concrete over 2 inches, making clean-up difficult to impossible and triggering complete defacing or demolition of the building exterior, unless innovative decontamination methods are developed.

**How to convince the public to  
reoccupy the affected area?**

**Issue cheap alarming dosimeters  
to *every civilian***



~ \$70 each