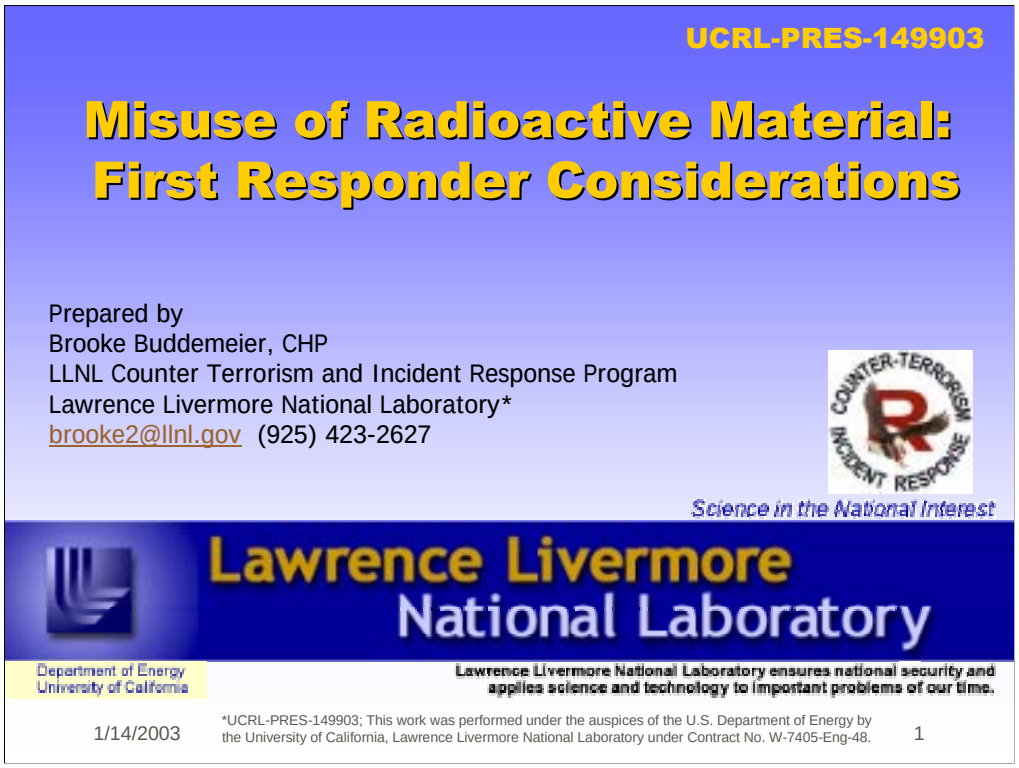
esponder Considerations



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First Responder Considerations

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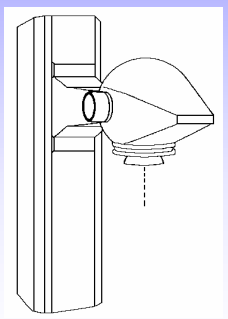
A Case Study: Goiania, Brazil 1987

- When a hospital changed locations, a radiation therapy unit was temporarily left behind.
- Scrap metal hunters found the unit and dismantled it for scrap metal (~ Sept 18th).
- The 1.4 kiloCi (1,400 Ci) Cs-137 source containment was breached during the process.
- Pieces of source distributed to family and friends.
- Everyone was impressed by "the glowing blue stones." Children & adults played with them.
- Serious radiological accident recognized on Sept 29th when Acute Radiation Syndrome symptoms where recognized by hospital staff.



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Narrative:

In 1985, the Goiania Institute of Radiotherapy moved to a new location taking a Cobalt-60 teletherapy and discharging an obsolete Cesium-137 teletherapy unit in a partially demolished session of the old building in downtown Goiania

Two young men without permanent jobs looking for a way to make some money learned that there was a heavy equipment at an abandoned and partially demolished hospital building in downtown Goiania

Possibly on September 13, they forced the entrance of the building and decided to remove the shielding head of the teletherapy unit and sell it to a junk yard.

The two men, the owner of the junk yard and his two employees initiated attempts to dismantle the equipment

The rotating assembly and a capsule containing about 1400 Curies of Cesium-137 were dismantled presumably on September 18

The capsule was ruptured and the cesium released

Pieces of the source were distributed among the junk yard owner's relatives, neighbors and most close friends

Everyone was impressed with the "power of the stone" as it glowed blue in the dark.

Some of them scrubbed the material on the skin in order to appreciate its brightness

Residences about 100 miles from Goiania were found with cesium contamination

The owner's wife observed the occurrence of the first symptoms of acute radiation syndrome among her relatives and decided to look for medical assistance at the Hospital for Tropical Diseases

Pieces of the source were put in a bag that she took along with her by bus to the hospital

On September 29, the Brazilian Nuclear Energy Commission was notified by a goianian physicist about the occurrence of a serious radiological accident

Initial Response

112,000 people (10 % of Goiania's population) were surveyed at an Olympic Stadium.

- **250 were identified as contaminated**
- **50 contaminated people were isolated in a camping area inside the Olympic Stadium for more detailed screening**
- **20 people were hospitalized or transferred to special housing with medical and nursing assistance**
- **8 patients transferred to the Navy Hospital in Rio de Janeiro**
- **Residential contamination survey was initiated**

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Narrative: Read Slide

---------- notes ----------

Note: One the primary reasons I introduce this accident is so I can Use the Source in my dispersion modeling.

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Early Consequences

- Widespread contamination of downtown Goiania
- 85 residences found to have significant contamination (41 of these were evacuated and a few were completely or partially demolished)
- People cross-contaminated houses 100 miles away
- Hot Spots at 3 scrap metal yards and one house

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Radiation Injuries and Uptakes

- **4 fatalities (2 men, 1 woman and 1 child)**
- **28 patients had radiation induced skin injuries (they held / played with the source for extended periods)**
- **50 people had internal deposition (ingestion)**

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Critical phase of the ARS (acute radiation syndrome) characterized by hematological injury

14 patients developed bone marrow depression

8 had classical signs and symptoms of ARS

4 died due to bleeding diathesis and infection (sepsis) caused by Klebsiella

External Doses:

Estimated by chromosome aberration analysis

129 subjects evaluated

5 exceeded 3 Gy

16 exceeded 1Gy

24 exceeded 0.5 Gy

Internal Contamination/Exposure:

•In vitro bioassay (excreta samples were collected in Goiania and sent to IRD in Rio de Janeiro)

• In vivo measurements (a whole body counter was set up in Goiania in November at the General Hospital)

• 4 out of 8 patients transferred to the Navy Hospital in Rio de Janeiro were monitored in IRD before they were transferred back to Goiania in November

• In March 1988 a Bioassay Laboratory was set up in Goiania to perform in vivo and in vitro measurements during the follow up phase

•Ingestion was considered to be the main pathway

• 50 people isolated and hospitalized with internal and external contamination

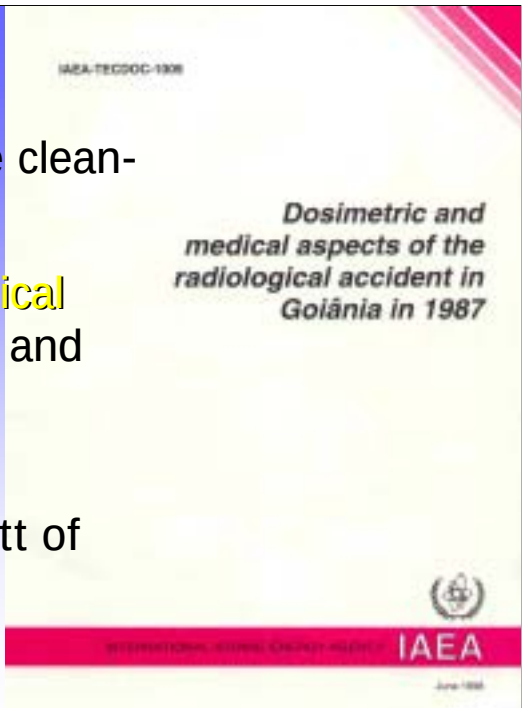
• Prussian blue (ferric ferrocyanide) was administered to some individuals to enhance elimination

• 21 treated with Prussian blue (recommended dosage = 3 g/d)

esponder Considerations

Conclusions

- Long and expensive clean-up effort.
- Profound psychological effects such as fear and depression on large populations
- Isolation and boycott of goods by neighbors



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•Intense psychological consequences amongst the population such as fear and depression.

• Discrimination against the victims and important products of local economy

• Large amounts of money spent during and after the recovering phases

• Need for the construction of a large deposit to store the radioactive waste

• Complete revision of Brazilian regulations related to the storage and use of radiation sources

Pictures obtained from "Radiation Emergency Assistance Services (SAER) from the Institute for Radiation Protection & Dosimetry (IRD), BRAZIL", or shortly SAER/IRD/Brazil.

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Response to a Radiological Incident ~ Contamination ~

- Monitor and isolate contaminated area
- Evacuate and “gross decon” victims (removal of outer clothing is an effective gross decontamination method)
- Avoid breathing in radioactive material
  - Shelter in place (close windows, turn off heating and A/C)
  - Evacuate, when safe to do so
  - Wear respiratory protection

- Radioactive material will not be uniformly distributed. Radiation “Hot Spots” near the source of the event will be a hazard.

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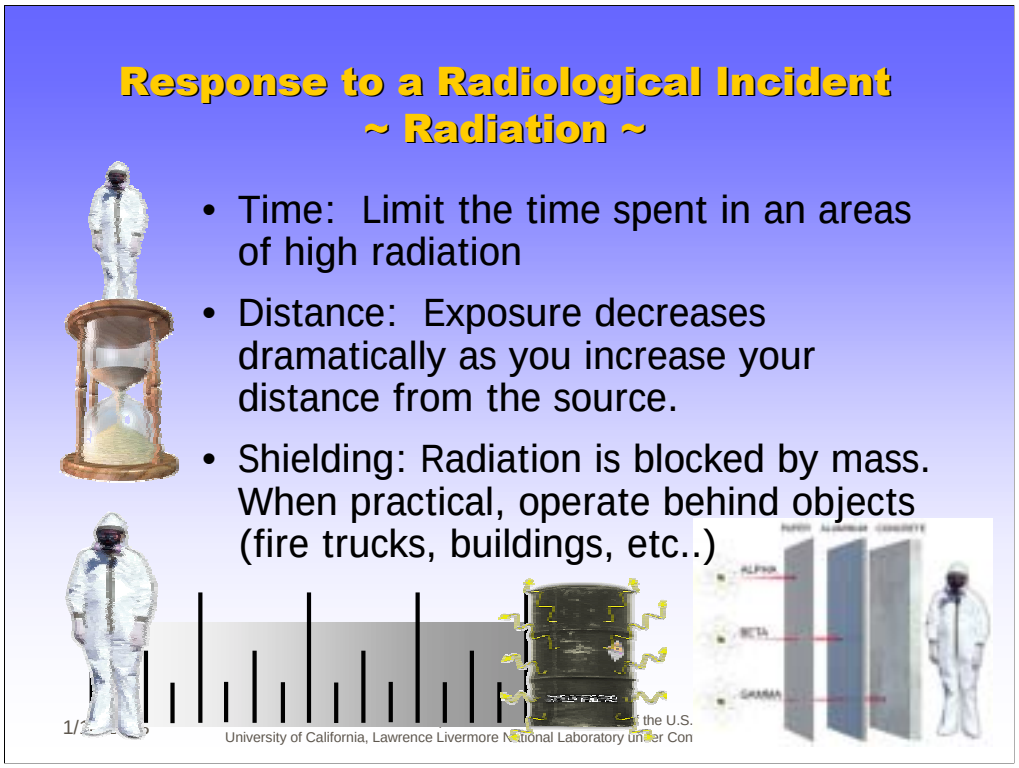
Not all exploded sources will disintegrate. Responders should be careful to check that the intended RDD didn’t simply bury a hot source in the ground or pavement.

These sources can actually be more dangerous as their external dose rates could over exposure responders that stay in the area.



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Radiological Considerations for Public Protective Actions

- The EPA has developed Protective Action Guides (PAG) that help responders determine when evacuation is necessary:
  - Shelter & Evacuation PAGs are based on 1 & 5 rem exposures to the public.
  - Emergency phase PAGs are based on a 4 day exposure to “re-suspended” material and is dependent on weather.
  - Developed for acute exposures (such as at a power plant accident), these guidelines are **conservative** for chronic internal exposures.

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Example: Brazil's 1.37 kCi (1,370 Ci) Cs-137 Source Made Into a "Dirty Bomb"

- Despite the accident in Brazil, sources of this strength are very difficult to obtain.
- This model assumes "worse case" in that:
  - The source was 100% aerosolized
  - Lots of explosive (~ 10 sticks of dynamite)
  - Presumes exposed populations "stood outside" during the exposure period.
  - Effects dependent on weather

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Very unrealistic scenario…. But it's just to provide you with a frame of reference.

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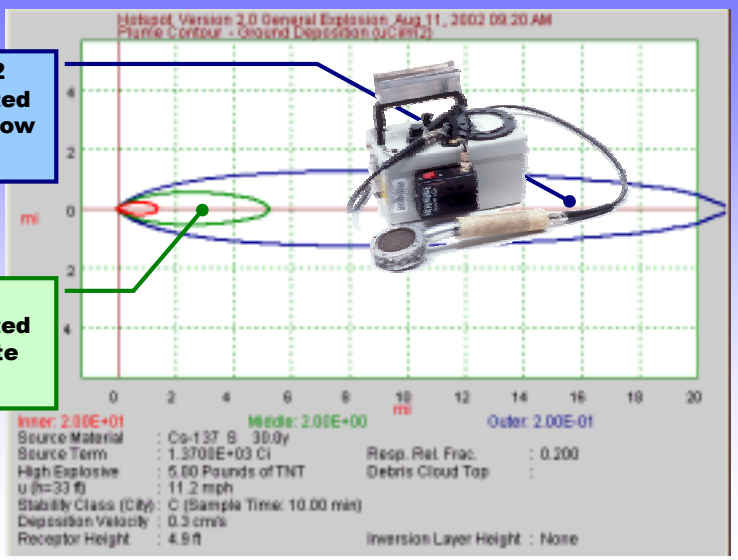
Detectable Ground Contamination Can be Found Miles Downwind

≥ 0.2 uCi/m2 Can be detected with thin window G-M meter

≥ 2 uCi/m2 Can be detected with dose rate meter



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San Francisco Example: Ground Contamination Can be Detected East of Berkeley Hills

HYPOTHETICAL

Release: 1.3 KCi CS-137 RDD with 5 lbs HE
Deposited Contamination

Color	Level (uCi/m^2)	Area (km^2)	Description
	20	5.4	Take measures to prevent cross contamination.
	2	59.04	Detectable with "hot dog" GM
	0.2	409.34	Detectable with "Pancake" GM

Release location: San Francisco Police Department, 850 Bryant
37° 46' 31" N 122° 24' 15" W

100% Aerosolized release fraction

Strong afternoon west winds 18-25 mph.

Map size: 25 x 25 km

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Change this plot for the venue in which the presentation will be given. I can help arrange site specific plots: Brooke Buddemeier (925) 423-2627

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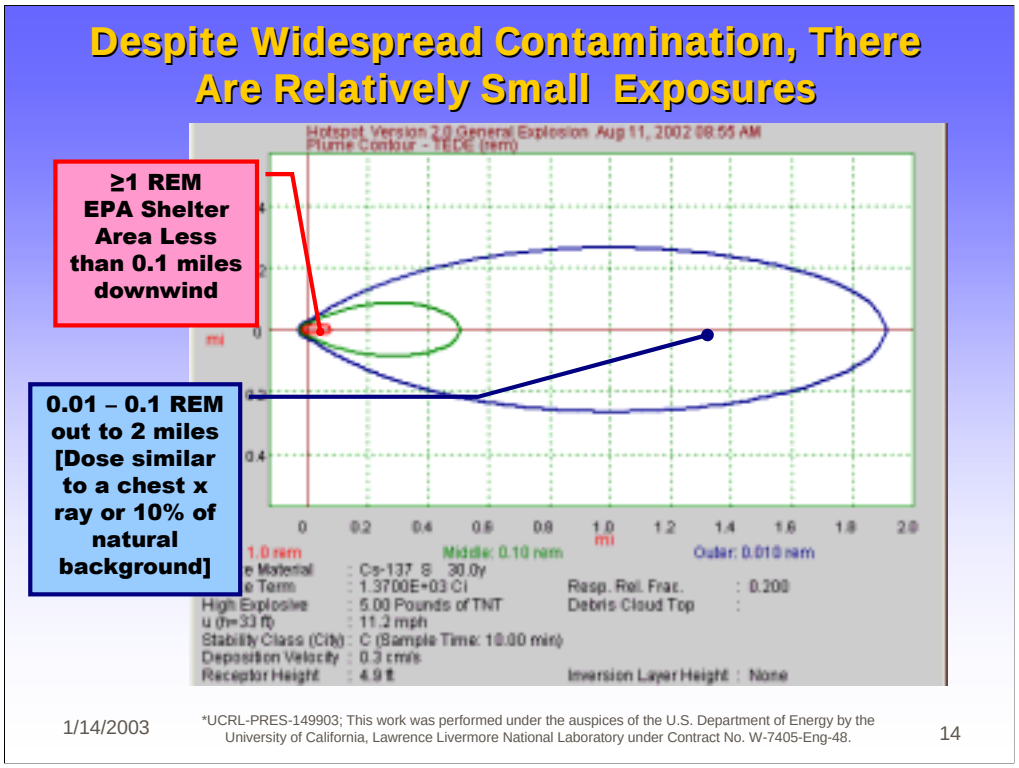


Be sure to note the change of scale to 0 – 2 miles.

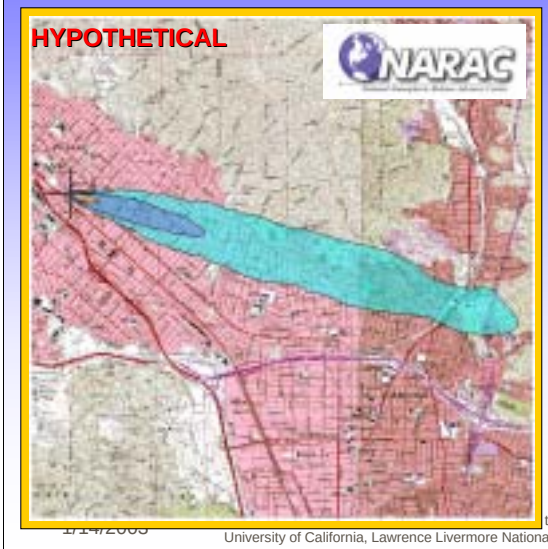
People standing outside for 4 days would get > 1 rem only on the small red area (~ 0.1 miles or a few blocks)

This is the area that the EPA would recommend sheltering in place.

Out up to two miles, people are still getting an exposure, but it is on the order od a chest X ray or 10% of everyone natural background dose.

esponder Considerations

Los Angeles Example: EPA PAG Would Recommend Shelter/Evacuation of a Few Residential Blocks



Release: 1.3 KCi CS-137 RDD with 5 lbs HE
4-Day Dose (Internal + External)
Evacuation/Relocation PAG

Color	Level (Rem)	Area (km^2)	Description
	1	0.026	Consider evacuation. Shelter in place if no evacuation.
	0.1	.42	
	0.01	3.84	

Release location: Burbank Police Department
34 10' 60"N, 118 18' 31"W

100% Aerosolized release fraction

Normal summertime west-northwest winds, 10-12 mph.

Map size: 6 x 6 km

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Conclusion:
First Responder Considerations

- Acute health effects from radiation dose are unlikely without prolonged, high-concentration exposure.
- Contamination readily detectable at long distances.
- Medical emergencies take precedent over radiological monitoring.
- Wear respiratory protection, isolate area.
- Use decontamination techniques (removing outer clothing most effective)
- **Call for assistance**

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Dr. Henry B. Spitz, Professor of Nuclear and Radiological Engineering, Department of Mechanical, Industrial & Nuclear Engineering, University of Cincinnati

Dr. Jose Julio Rozental

Bernardo Dantas, Instituto de Radioprotecao Dosimetria, Brasil

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