Testimony of
Dr. Henry Kelly, President
Federation of American Scientists
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Introduction

Surely there is no more unsettling task than considering how to defend our nation against individuals and groups seeking to advance their aims by killing and injuring innocent people. But recent events make it necessary to take almost inconceivably evil acts seriously. We are all grateful for the Committee's uncompromising review of these threats and its search for responses needed to protect our nation. Thank you for the opportunity to support these efforts.

My remarks today will review the dangers presented by radiological attacks, situations where nuclear materials that could be released, without using a nuclear explosive device, for the malicious purpose of killing or injuring American citizens and destroying property. Our analysis of this threat has reached three principle conclusions:

1. Radiological attacks constitute a credible threat. Radioactive materials that could be used for such attacks are stored in thousands of facilities around the US, many of which may not be adequately protected against theft by determined terrorists. Some of this material could be easily dispersed in urban areas by using conventional explosives or by other methods.

2. While radiological attacks would result in some deaths, they would not result in the hundreds of thousands of fatalities that could be caused by a crude nuclear weapon. Attacks could contaminate large urban areas with radiation levels that exceed EPA health and toxic material guidelines.

3. Materials that could easily be lost or stolen from US research institutions and commercial sites could contaminate tens of city blocks at a level that would require prompt evacuation and create terror in large communities even if radiation casualties were low. Areas as large as tens of square miles could be contaminated at levels that exceed recommended civilian exposure limits. Since there are often no effective ways to decontaminate buildings that have been exposed at these levels, demolition may be the only practical solution. If such an event were to take place in a city like New York, it would result in losses of potentially trillions of dollars.

The analysis I will summarize here was conducted by Michael Levi, Director of the Strategic Security Program at the Federation of American Scientists (FAS), and by Dr. Robert Nelson of Princeton University and FAS.

Background

Materials are radioactive if their atomic nuclei (or centers) spontaneously disintegrate (or decay) with high-energy fragments of this disintegration flying off into the environment. Several kinds of particles can so be emitted, and are collectively referred to as radiation. Some materials decay quickly, making them sources of intense radiation, but their rapid decay rate means that they do not stay radioactive for long periods of time. Other materials serve as a weaker source of radiation because they decay slowly. Slow rates of decay mean, however, that a source may remain dangerous for very long periods. Half of the atoms in a sample of cobalt-60 will, for example, disintegrate over a five year period, but it takes 430 years for half of the atoms in a sample of americium-241 to decay.

The radiation produced by radioactive materials provides a low-cost way to disinfect food sterilize medical equipment, treat certain kinds of cancer, find oil, build sensitive smoke detectors, and provide other critical services in our economy. Radioactive materials are also widely used in university, corporate, and government research laboratories. As a result, significant amounts of radioactive materials are stored in laboratories, food irradiation plants, oil drilling facilities, medical centers, and many other sites.

a. Commercial Uses

Radioactive sources that emit intense gamma-rays, such as cobalt-60 and cesium-137, are useful in killing bacteria and cancer cells. Gamma-rays, like X-rays, can penetrate clothing, skin, and other materials, but they are more energetic and destructive. When these rays reach targeted cells, they cause lethal chemical changes inside the cell.

Plutonium and americium also serve commercial and research purposes. When plutonium or americium decay, they throw off a very large particle called an alpha particle. Hence, they are referred to as alpha emitters. Plutonium, which is used in nuclear weapons, also has non-military functions. During the 1960s and 1970s the federal government encouraged the use of plutonium in university facilities studying nuclear engineering and nuclear physics. Americium is used in smoke detectors and in devices that find oil sources. These devices are lowered deep into oil wells and are used to detect fossil fuel deposits by measuring hydrogen content as they descend.

b. Present Security

With the exception of nuclear power reactors, commercial facilities do not have the types or volumes of materials usable for making nuclear weapons. Security concerns have focused on preventing thefts or accidents that could expose employees and the general public to harmful levels of radiation. A thief might, for example, take the material for its commercial value as a radioactive source, or it may be discarded as scrap by accident or as a result of neglect. This system works reasonably well when the owners have a vested interest in protecting commercially valuable material. However, once the materials are no longer needed and costs of appropriate disposal are high, security measures become lax, and the likelihood of abandonment or theft increases.

Concern about the intentional release of radioactive materials changes the situation in fundamental ways. We must wrestle with the possibility that sophisticated terrorist groups may be interested in obtaining the material and with the enormous danger to society that such thefts might present.

Significant quantities of radioactive material have been lost or stolen from US facilities during the past few years and thefts of foreign sources have led to fatalities. In the US, sources have been found abandoned in scrap yards, vehicles, and residential buildings. In September, 1987, scavengers broke into an abandoned cancer clinic in Goiania, Brazil and stole a medical device containing large amounts of radioactive cesium. An estimated 250 people were exposed to the source, eight developed radiation sickness, and four died.

In almost all cases, the loss of radioactive materials has resulted from an accident or from a thief interested only in economic gain. In 1995, however, Chechen rebels placed a shielded container holding the Cesium-137 core of a cancer treatment device in a Moscow park, and then tipped off Russian reporters of its location.

Enhanced security measures at commercial sites that use dangerous amounts of radioactive material are likely to increase the cost of using radioactive materials and may possibly stimulate development and use of alternative technologies for some applications.

c. Health Risks

Gamma rays pose two types of health risks. Intense sources of gamma rays can cause immediate tissue damage, and lead to acute radiation poisoning. Fatalities can result from very high doses. Long-term exposure to low levels of gamma rays can also be harmful because it can cause genetic mutations leading to cancer. Triggering cancer is largely a matter of chance: the more radiation you're exposed to, the more often the dice are rolled. The risk is never zero since we are all constantly being bombarded by large amounts of gamma radiation produced by cosmic rays, which reach us from distant stars. We are also exposed to trace amounts of radioactivity in the soil, in building materials, and other parts of our environment. Any increase in exposure increases the risk of cancer.

Alpha particles emitted by plutonium, americium and other elements also pose health risks. Although these particles cannot penetrate clothing or skin, they are harmful if emitted by inhaled materials. If plutonium is in the environment in particles small enough to be inhaled, contaminated particles can lodge in the lung for extended periods. Inside the lung, the alpha particles produced by plutonium can damage lung tissue and lead to long-term cancers.

Case Studies

We have chosen three specific cases to illustrate the range of impacts that could be created by malicious use of comparatively small radioactive sources: the amount of cesium that was discovered recently abandoned in North Carolina, the amount of cobalt commonly found in a single rod in a food irradiation facility, and the amount of americium typically found in oil well logging systems. The impact would be much greater if the radiological device in question released the enormous amounts of radioactive material found in a single nuclear reactor fuel rod, but it would be quite difficult and dangerous for anyone to attempt to obtain and ship such a rod without death or detection. The Committee will undoubtedly agree that the danger presented by modest radiological sources that are comparatively easy to obtain is significant as well.

Impact of the release of radioactive material in a populated area will vary depending on a number of factors, many of which are not predictable. Consequences depend on the amount of material released, the nature of the material, the details of the device that distributes the material, the direction and speed of the wind, other weather conditions, the size of the particles released (which affects their ability to be carried by the wind and to be inhaled), and the location and size of buildings near the release site. Uncertainties inherent in the complex models used in predicting the effects of a radiological weapon mean that it is only possible to make crude estimates of impacts; the estimated damage we show might be too high by a factor of ten, or underestimated by the same factor. The following examples are then fairly accurate illustrations, rather than precise predictions.

In all three cases we have assumed that the material is released on a calm day (wind speed of one mile per hour). We assume that the material is distributed by an explosion that causes a mist of fine particles to spread downwind in a cloud. The blast itself, of course, may result in direct injuries, but these have not been calculated. People will be exposed to radiation in several ways.

- First, they will be exposed to material in the dust inhaled during the initial passage of the radiation cloud, if they have not been able to escape the area before the dust cloud arrives. We assume that about 20% of the material is in particles small enough to be inhaled. If this material is plutonium or americium (or other alpha emitters), the material will stay in the body and lead to long term exposure.

- Second, anyone living in the affected area will be exposed to material deposited from the dust that settles from the cloud. If the material contains cesium (or other gamma emitters) they will be continuously exposed to radiation from this dust, since the gamma rays penetrate clothing and skin. If the material contains plutonium (or other alpha emitters), dust that is pulled off the ground and into the air by wind, automobile movement, or other actions will continue to be inhaled, adding to exposure.

- In a rural area, people would also be exposed to radiation from contaminated food and water sources.

The EPA has a series of recommendations for addressing radioactive contamination that would likely guide official response to a radiological attack. Immediately after the attack, authorities would evacuate people from areas contaminated to levels exceeding these guidelines. People who received more than twenty-five times the threshold dose for evacuation would have to be taken in for medical supervision.

In the long term, the cancer hazard from the remaining radioactive contamination would have to be addressed. Typically, if decontamination could not reduce the danger of cancer death to about one-in-ten-thousand, the EPA would recommend the contaminated area be eventually abandoned. Decontaminating an urban area presents a variety of challenges. Several materials that might be used in a radiological attack can chemically bind to concrete and asphalt, while other materials would become physically lodged in crevices on the surface of buildings, sidewalks and streets. Options for decontamination would range from sandblasting to demolition, with the latter likely being the only feasible option. Some radiological materials will also become firmly attached to soil in city parks, with the only disposal method being large scale removal of contaminated dirt. In short, there is a high risk that the area contaminated by a radiological attack would have to be deserted.

We now consider the specific attack scenarios. The first two provide examples of attacks using gamma emitters, while the last example uses an alpha emitter. In each case, we have calculated the expected size of the contaminated area, along with other zones of dangerously high contamination. The figures in the Appendix provide a guide to understanding the impact of the attacks.

Example 1- Cesium (Gamma Emitter) – Figure 1

Two weeks ago, a lost medical gauge containing cesium was discovered in North Carolina. Imagine that the cesium in this device was exploded in Washington, DC in a bomb using ten pounds of TNT. The initial passing of the radioactive cloud would be relatively harmless, and no one would have to evacuate immediately. But what area would be contaminated? Residents of an area of about five city blocks, if they remained, would have a one-in-a-thousand chance of getting cancer. A swath about one mile long covering an area of forty city blocks would exceed EPA contamination limits, with remaining residents having a one-in-ten thousand chance of getting cancer. If decontamination were not possible, these areas would have to be abandoned for decades. If the device was detonated at the National Gallery of Art, the contaminated area might include the Capitol, Supreme Court, and Library of Congress, as seen if figure one.

Example 2 – Cobalt (Gamma Emitter) – Figures 2 and 3

Now imagine if a single piece of radioactive cobalt from a food irradiation plant was dispersed by an explosion at the lower tip of Manhattan. Typically, each of these cobalt "pencils" is about one inch in diameter and one foot long, with hundreds of such pieces often being found in the same facility. Admittedly, acquisition of such material is less likely than in the previous scenario, but we still consider the results, depicted in figure two. Again, no immediate evacuation would be necessary, but in this case, an area of approximately one-thousand square kilometers, extending over three states, would be contaminated. Over an area of about three hundred typical city blocks, there would be a one-in-ten risk of death from cancer for residents living in the contaminated area for forty years. The entire borough of Manhattan would be so contaminated that anyone living there would have a one-in-a-hundred chance of dying from cancer caused by the residual radiation. It would be decades before the city was inhabitable again, and demolition might be necessary.

For comparison, consider the 1986 Chernobyl disaster, in which a Soviet nuclear power plant went through a meltdown. Radiation was spread over a vast area, and the region surrounding the plant was permanently closed. In our current example, the area contaminated to the same level of radiation as that region would cover much of Manhattan, as shown in figure three. Furthermore, near Chernobyl, a larger area has been subject to periodic controls on human use such as restrictions on food, clothing, and time spent outdoors. In the current example, the equivalent area extends fifteen miles.

To summarize the first two examples, materials like cesium, cobalt, iridium, and strontium (gamma emitters) would all produce similar results. No immediate evacuation or medical attention would be necessary, but long-term contamination would be render large urban areas useless, resulting in severe economic and personal hardship.

Example 3 – Americium (Alpha Emitter) – Figures 4 and 5

A device that spread materials like americium and plutonium would create present an entirely a different set of risks. Consider a typical americium source used in oil well surveying. If this were blown up with one pound of TNT, people in a region roughly ten times the area of the initial bomb blast would require medical supervision and monitoring, as depicted in figure four. An area 30 times the size of the first area (a swath one kilometer long and covering twenty city blocks) would have to be evacuated within half an hour. After the initial passage of the cloud, most of the radioactive materials would settle to the ground. Of these materials, some would be forced back up into the air and inhaled, thus posing a long-term health hazard, as illustrated by figure five. A ten-block area contaminated in this way would have a cancer death probability of one-in-a-thousand. A region two kilometers long and covering sixty city blocks would be contaminated in excess of EPA safety guidelines. If the buildings in this area had to be demolished and rebuilt, the cost would exceed fifty billion dollars.

Recommendations

A number of practical steps can be taken that would greatly reduce the risks presented by radiological weapons. Our recommendations fall into three categories: (1) Reduce opportunities for terrorists to obtain dangerous radioactive materials, (2) Install early warning systems to detect illicit movement of radioactive materials, and (3) Minimize casualties and panic from any attack that does occur. Since the US is not alone in its concern about radiological attack, and since we clearly benefit by limiting access to dangerous materials anywhere in the world, many of the measures recommended should be undertaken as international collaborations.

1)_Reduce access to radioactive materials

Radioactive materials facilitate valuable economic, research and health care technologies. Measures needed to improve the security of facilities holding dangerous amounts of these materials will increase costs. In some cases, it may be worthwhile to pay a higher price for increased security. In other instances, however, the development of alternative technologies may be the more economically viable option. Specific security steps include the following:

- Fully fund material recovery and storage programs. Hundreds of plutonium, americium, and other radioactive sources are stored in dangerously large quantities in university laboratories and other facilities. When these materials are actively used and considered a valuable economic asset, they are likely to be well protected. But in all too many cases they are not used frequently, resulting in the risk that attention to their security will diminish over time. At the same time, it is difficult for the custodians of these materials to dispose of them since in many cases only the DOE is authorized to recover and transport them to permanent disposal sites. The DOE Off-Site Source Recovery Project (OSRP), which is responsible for undertaking this task, has successfully secured over three-thousand sources and has moved them to a safe location. Unfortunately, the inadequate funding of this program serves as a serious impediment to further source recovery efforts. Funding for OSRP has been repeatedly cut in the FY2001 and 2002 budgets and the presidential FY2003 budget proposal, significantly delaying the recovery process. In the cases of FY01 and FY02, the 25% and 35% cuts were justified as money being transferred to higher priorities; the FY03 would cut funding by an additional 26%. This program should be given the needed attention and firm goals should be set for identifying, transporting, and safeguarding all unneeded radioactive materials.

- Review licensing and security requirements and inspection procedures for all dangerous amounts of radioactive material. HHS, DOE, NRC and other affected agencies should be provided with sufficient funding to ensure that physical protection measures are adequate and that inspections are conducted on a regular basis. A thorough reevaluation of security regulations should be conducted to ensure that protective measures apply to amounts of radioactive material that pose a homeland security threat, not just those that present a threat of accidental exposure.

- Fund research aimed at finding alternatives to radioactive materials. While radioactive sources provide an inexpensive way to serve functions such as food sterilization, smoke detection, and oil well logging, there are sometimes other, though possibly more expensive, ways to perform the same functions. A research program aimed at developing inexpensive substitutes for radioactive materials in these applications should be created and provided with adequate funding.

2) Early Detection

- Expanded use of radiation detection systems. Systems capable of detecting dangerous amounts of radiation are comparatively inexpensive and unobtrusive. Many have already been installed in critical locations around Washington, DC, at border points and throughout the US. The Office of Homeland Security should act promptly to identify all areas where such sensors should be installed, ensure that information from these sensors is continuously assessed, and ensure adequate maintenance and testing. High priority should be given to key points in the transportation system, such as airports, harbors, rail stations, tunnels, highways. Routine checks of scrap metal yards and land fill sites would also protect against illegal or accidental disposal of dangerous materials.

- Fund research to improve detectors. Low-cost networking and low-cost sensors should be able to provide wide coverage of critical urban areas at a comparatively modest cost. A program should be put in place to find ways of improving upon existing detection technologies as well as improving plans for deployment of these systems and for responding to alarms.

3) Effective Disaster response

An effective response to a radiological attack requires a system capable of quickly gauging the extent of the damage, identifying appropriate responders, developing a coherent response plan, and getting the necessary personnel and equipment to the site rapidly. The immediate goal must be to identify the victims that require prompt medical attention (likely to be a small number) and to ensure that all other unauthorized personnel leave the affected area quickly, without panic, and without spreading the radioactive material. All of this requires extensive training.

- Training for hospital personnel and first responders. First responders and hospital personnel need to understand how to protect themselves and affected citizens in the event of a radiological attack and be able to rapidly determine if individuals have been exposed to radiation.

  There is great danger that panic in the event of a radiological attack on a large city could lead to significant casualties and severely stress the medical system. Panic can also cause confusion for medical personnel. The experience of a radiological accident in Brazil suggests that a large number of people will present themselves to medical personnel with real symptoms of radiation sickness – including nausea and dizziness – even if only a small fraction of these people have actually been exposed to radiation. Medical personnel need careful training to distinguish those needing help from those with psychosomatic symptoms. While generous funding has been made available for training first responders and medical personnel, the program appears in need of a clear management strategy. Dozens of federal and state organizations are involved, and it is not clear how materials will be certified or accredited. Internet-based tools for delivering the training will almost certainly be necessary to ensure that large numbers of people throughout the US get involved. In the US, there are over 2.7 million nurses and over a million police and firefighters who will require training, not to mention the medics in the US armed services. However, there appears to be no coherent program for developing or using new tools to deliver needed services, and to ensure that training and resource materials are continuously upgraded and delivered securely.

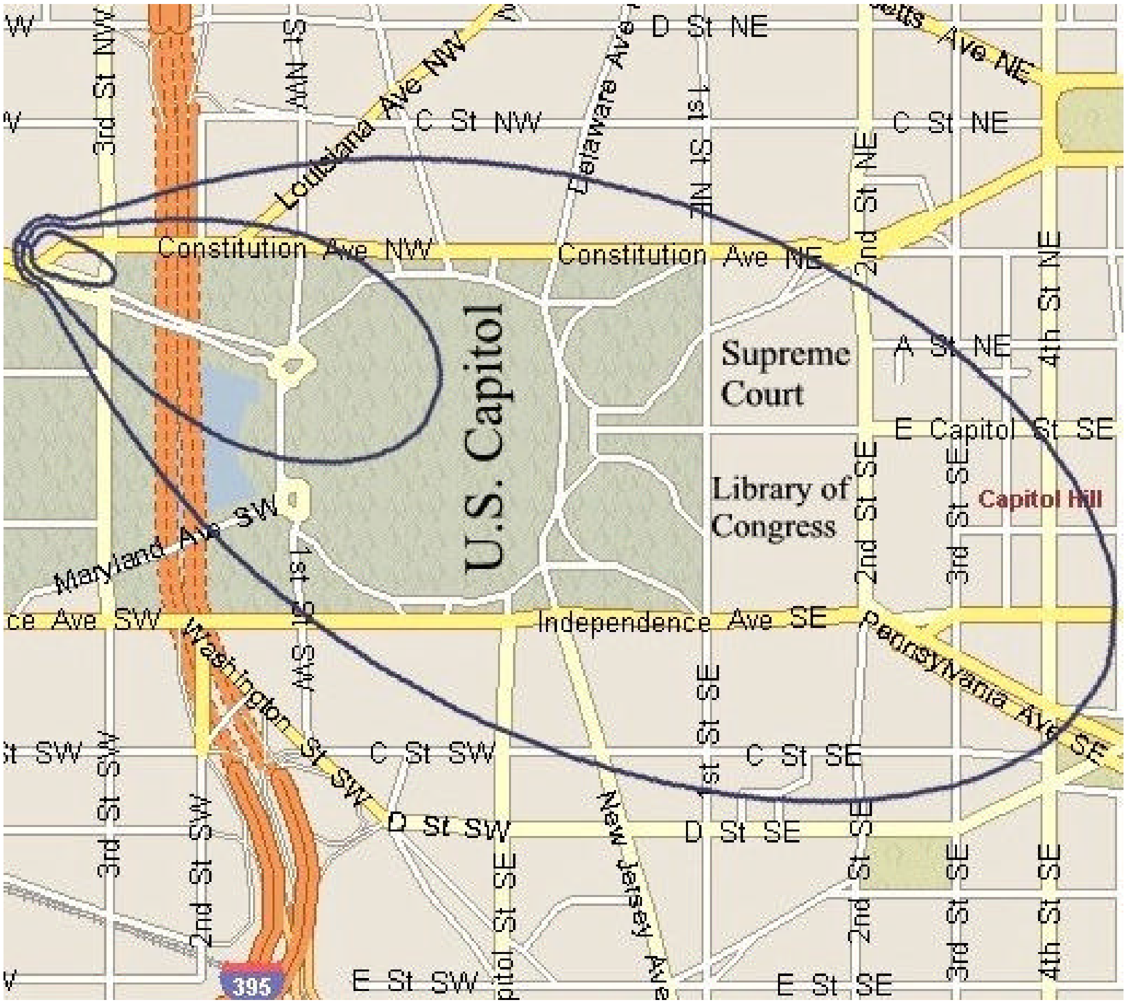
- Decontamination Technology. Significant research into cleanup of radiologically contaminated cities has been conducted in the past, primarily in addressing the possibility of nuclear war. Such programs should be revisited with an eye to the specific requirements of cleaning up after a radiological attack. As demonstrated above, the ability to decontaminate large urban areas might mean the difference from being able to continue inhabiting a city and having to abandon it.

Conclusion

The events of September 11 have created a need to very carefully assess our defense needs and ensure that the resources we spend for security are aligned with the most pressing security threats. The analysis summarized here shows that the threat of malicious radiological attack in the US is quite real, quite serious, and deserves a vigorous response. Fortunately, there are a number of comparatively inexpensive measures that can and should be taken because they can greatly reduce the likelihood of such an attack. The US has indicated its willingness to spend hundreds of billions of dollars to combat threats that are, in our view, far less likely to occur. This includes funding defensive measures that are far less likely to succeed than the measures that we propose in this testimony. The comparatively modest investments to reduce the danger of radiological attack surely deserve priority support.

In the end, however, we must face the brutal reality that no technological remedies can provide complete confidence that we are safe from radiological attack. Determined, malicious groups might still find a way to use radiological weapons or other means when their only goal is killing innocent people, and if they have no regard for their own lives. In the long run our greatest hope must lie in building a prosperous, free world where the conditions that breed such monsters have vanished from the earth.

Figure 1: Long-term Contamination Due to Cesium Bomb in Washington, DC

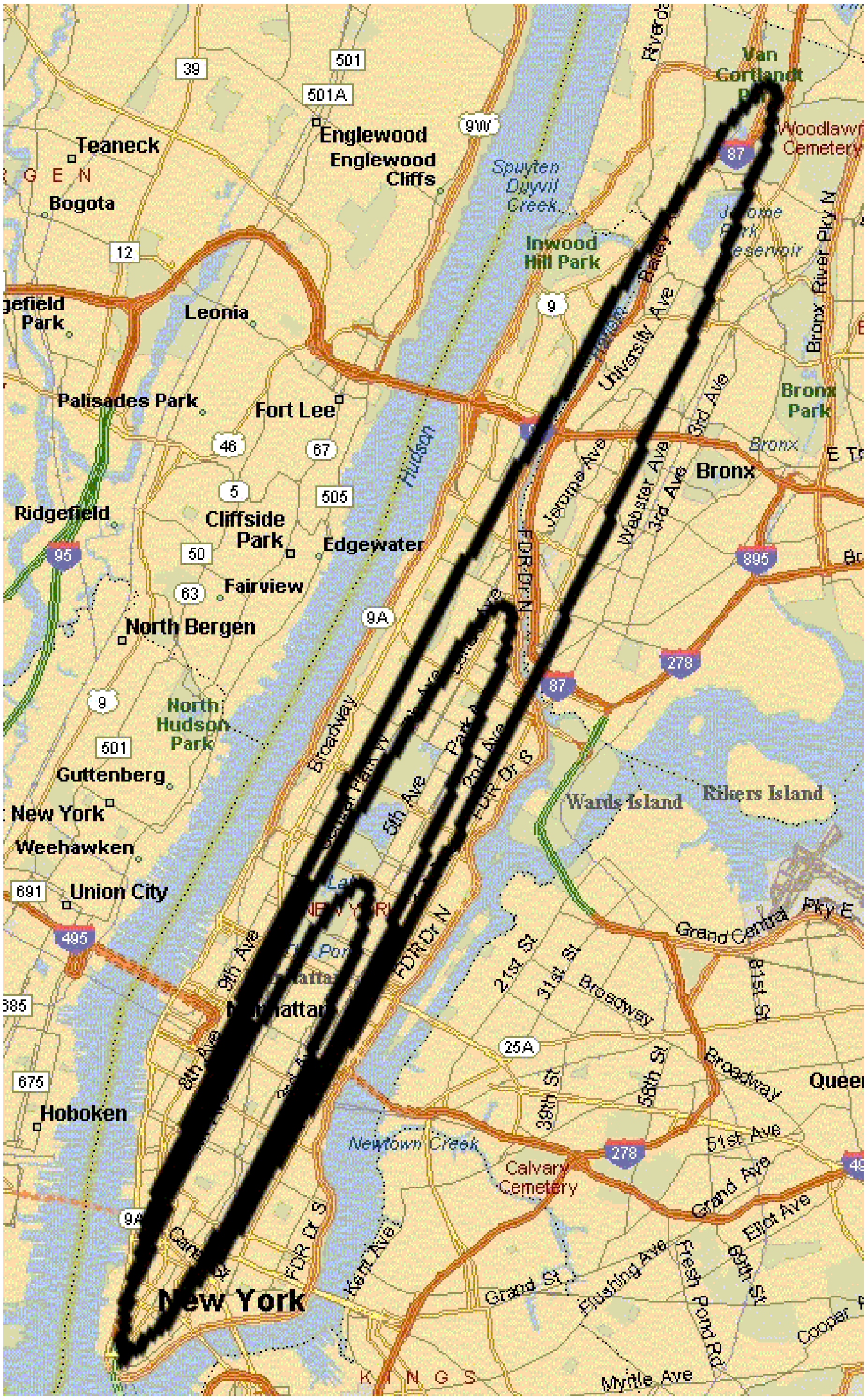


Inner Ring:	One cancer death per 100 people due to remaining radiation
Middle Ring:	One cancer death per 1,000 people due to remaining radiation
Outer Ring:	One cancer death per 10,000 people due to remaining radiation EPA recommends decontamination or destruction

Figure 2: Long-term Contamination Due to Cobalt Bomb in NYC – EPA Standards

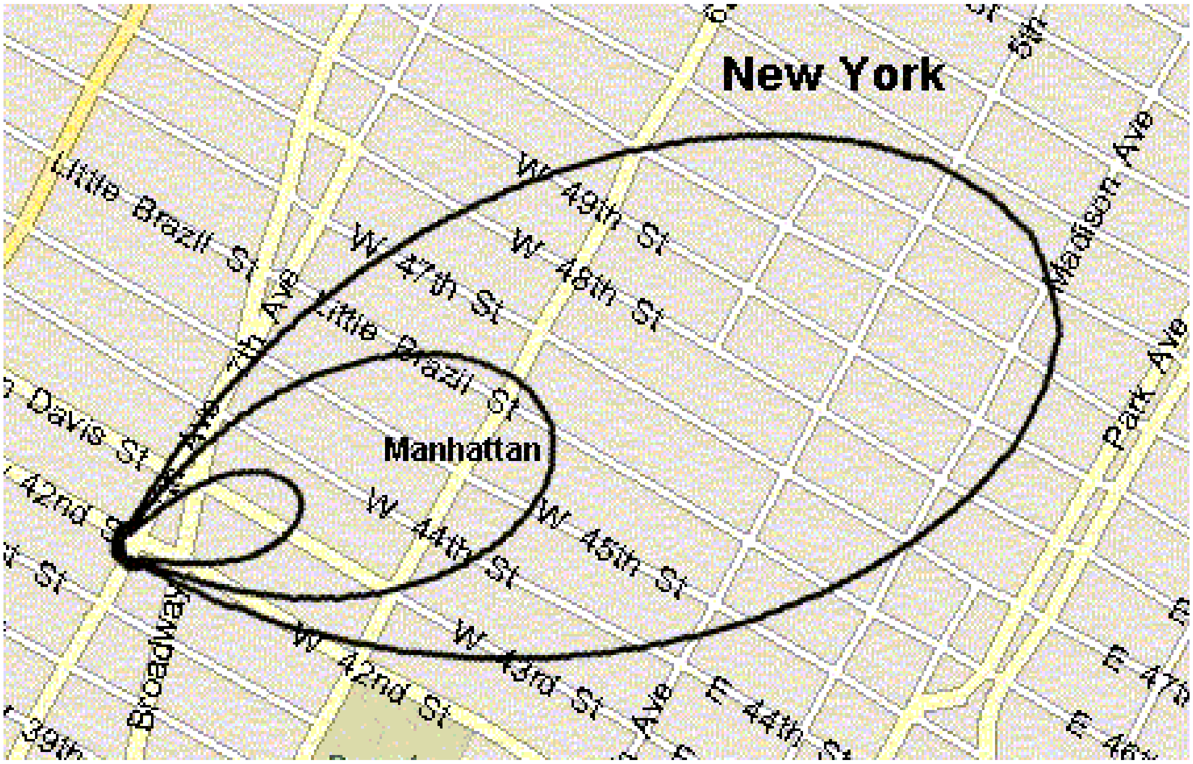
Inner Ring:	One cancer death per 100 people due to remaining radiation
Middle Ring:	One cancer death per 1,000 people due to remaining radiation
Outer Ring:	One cancer death per 10,000 people due to remaining radiation EPA recommends decontamination or destruction

Figure 3: Contamination Due to Cobalt Bomb in NYC – Chernobyl Comparison



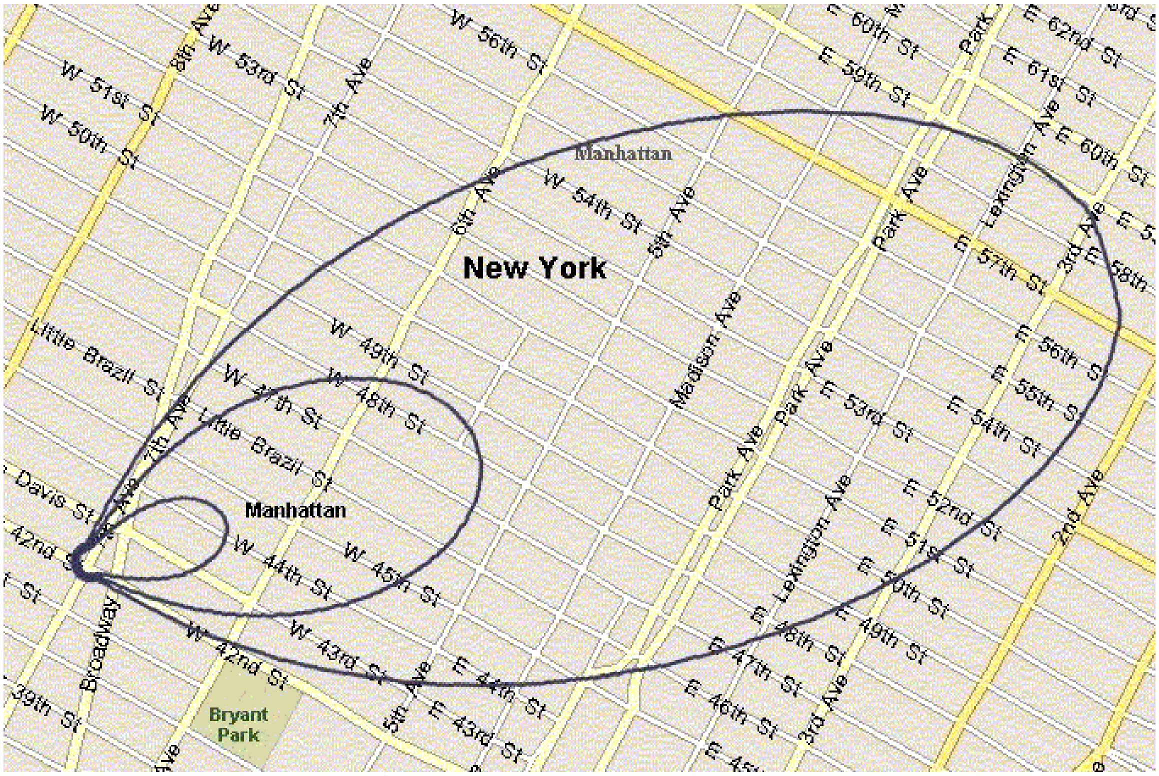
Inner Ring:	Same radiation level as *permanently closed* zone around Chernobyl
Middle Ring:	Same radiation level as *permanently controlled* zone around Chernobyl
Outer Ring:	Same radiation level as *periodically controlled* zone around Chernobyl

Figure 4: Immediate Effects Due to Americium Bomb in New York City



Inner Ring:	All people must receive medical supervision
Middle Ring:	Maximum annual dose for radiation workers exceeded
Outer Ring:	Area should be evacuated before radiation cloud passes

Figure 5: Contamination Due to Americium Bomb in New York City



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