AD-A072 246 ARMS CONTROL AND DISARMAMENT AGENCY WASHINGTON DC F/G 15/6
THE EFFECTS OF NUCLEAR WAR. (U)
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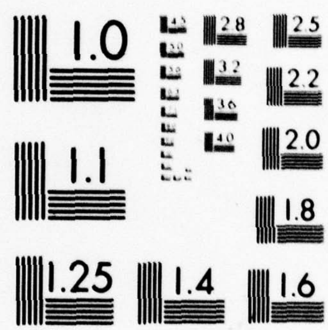

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

U.S. Arms Control and Disarmament Agency

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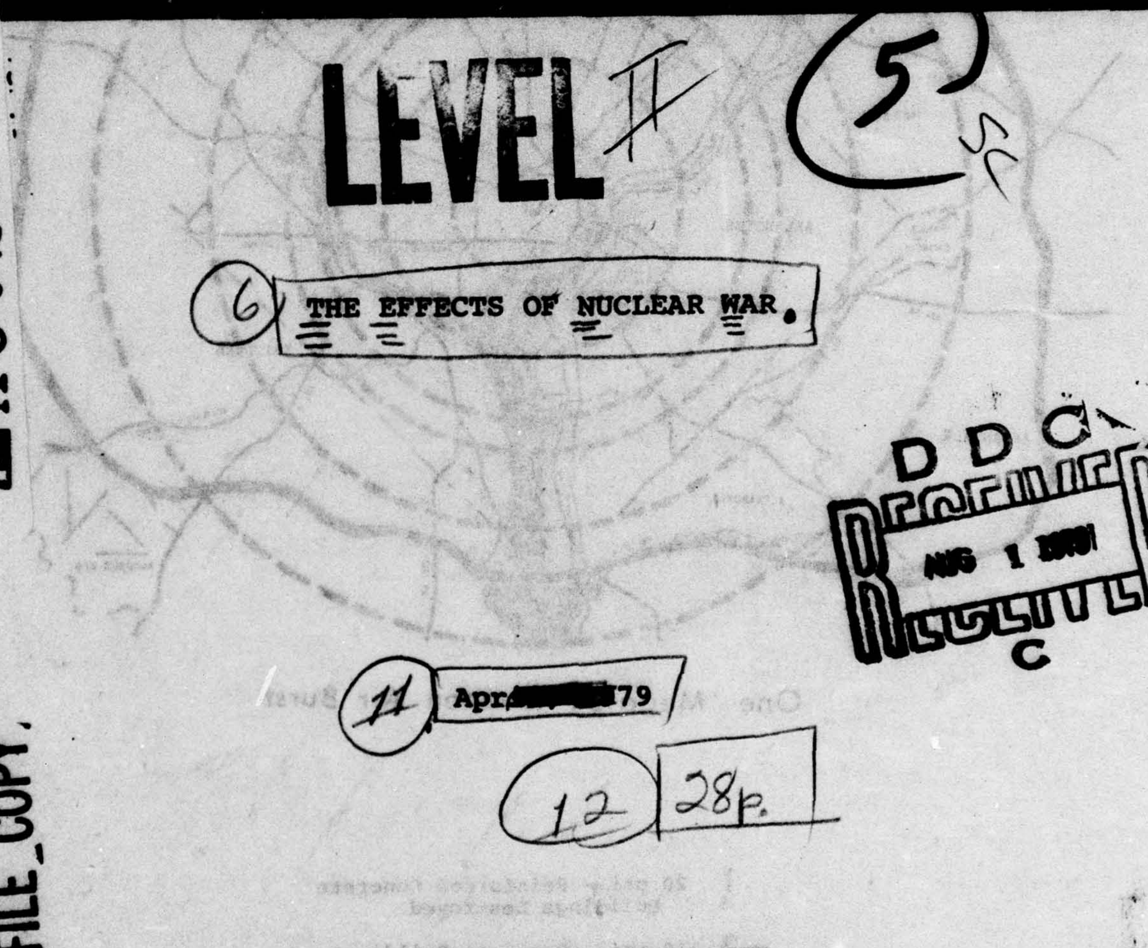

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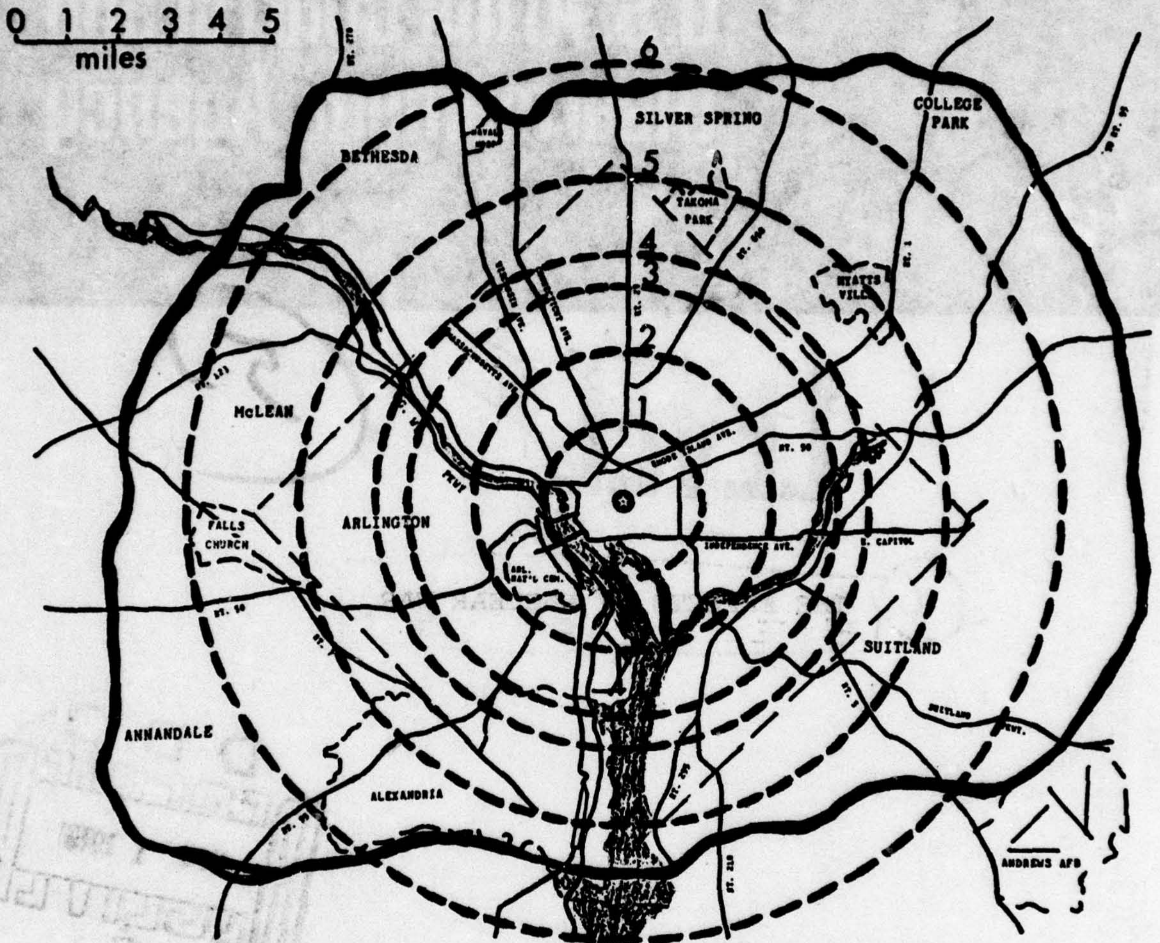
FIGURE 1

WASHINGTON, D.C.



One Megaton Weapon Air Burst

1 20 psi - Reinforced Concrete Buildings Destroyed

2 10 psi - Concrete Buildings Destroyed

3 5 psi - Brick and Wood Frame Houses Destroyed

4 25 calories/cm^2 - Spontaneous Ignition, Clothing and House hold Combustibles

5 12 calories/cm^2 - Third Degree Burns

6 1.7 psi - Moderate Damage, Bric and Wood Frame Houses

The Effects of Nuclear War

A. Introduction

This report presents a summary of the effects of nuclear war. The first part of the report will deal with the effects of a single nuclear weapon, the second part will discuss the effects of general nuclear war between the United States and the Soviet Union, and finally the paper will address some of the less known but nonetheless important effects of such a war.

B. Effects of One Nuclear Warhead

To illustrate the effects of a single nuclear weapon, a one-megaton* warhead was selected. Figure 1 shows the destruction of various parts of Washington, D.C., if such a weapon were detonated in the air over the White House. The map in Figure 1 shows various circles of destruction.

The six circles delineate the areas in which the following weapon effects are exceeded: Circle 1 - 20 psi (pounds of pressure per square inch), Circle 2 - 10 psi, Circle 3 - 5 psi, Circle 4 - 25 calories/cm^2, Circle 5 - 12 calories/cm^2, and Circle 6 - 1.7 psi. The labels on each circle correspond to the kind of damage to be expected from these weapon effects.

Each of these circles will be described and photographs from Nagasaki and the Nevada Test Site are included to give visual illustrations of the destruction effects at each circle.

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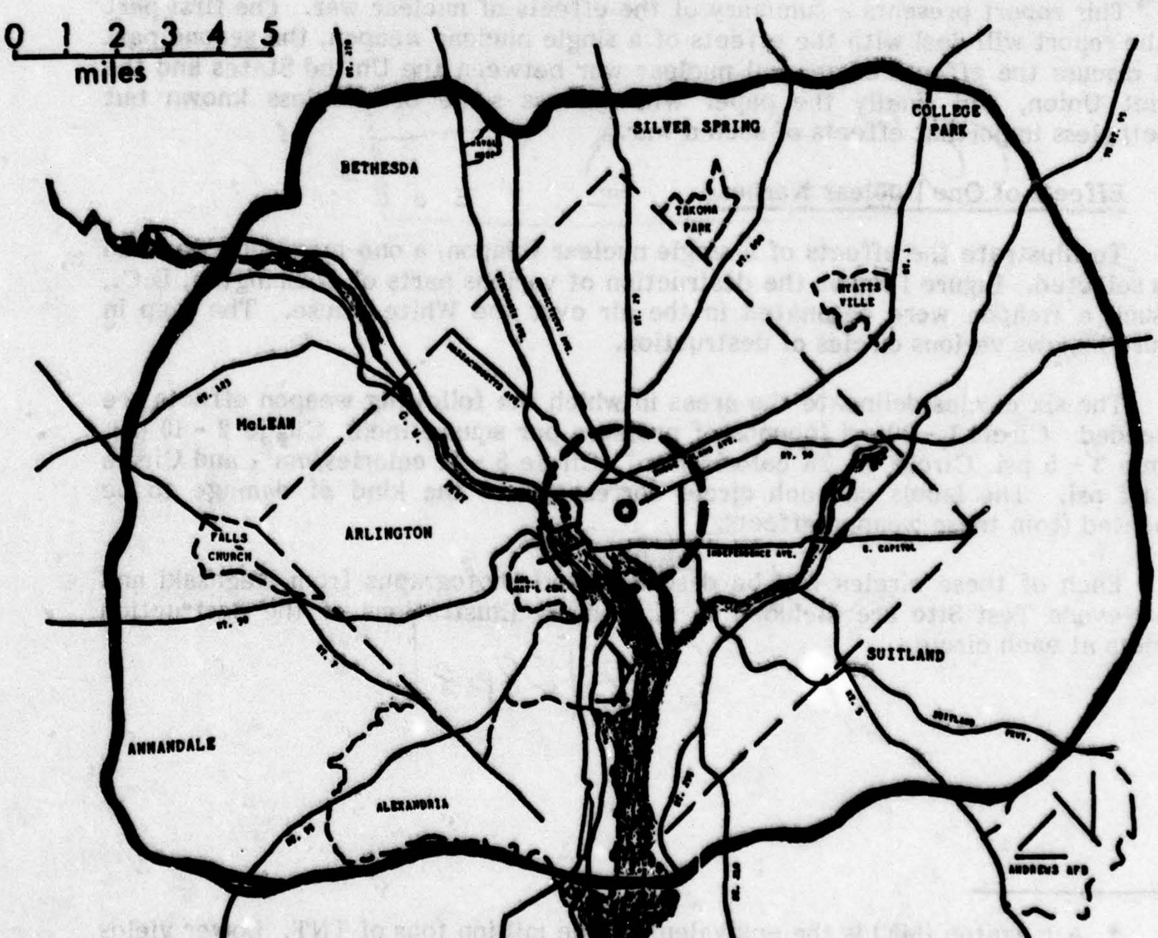
* A megaton (MT) is the equivalent of one million tons of TNT. Lower yields are sometimes expressed in kilotons (KT) which refers to the thousands of tons of TNT equivalent.

The innermost circle labeled #1, "<u>Reinforced Concrete Buildings Destroyed,</u>" is the circle in which the overpressure will be 20 psi (pounds per square inch) or more. In this circle winds would exceed 500 mph (miles per hour) and the blast would destroy office-type multi-story reinforced-concrete frame buildings. Most people in this area would be killed. For the one-megaton weapon, the radius of this circle is 1.5 statute miles (this radius would be 1.2 miles for a 500 KT (kiloton) weapon, 2.6 miles for a 5 MT (megaton) weapon and 4.1 miles for a 20 MT weapon). Figures 2 and 3 show the destruction in Nagasaki corresponding to the weapons effects within this circle.

WASHINGTON, D.C. 20 PSI



ONE MEGATON WEAPON AIR BURST

FIGURE 2

Nagasaki
(20 to 30 psi)

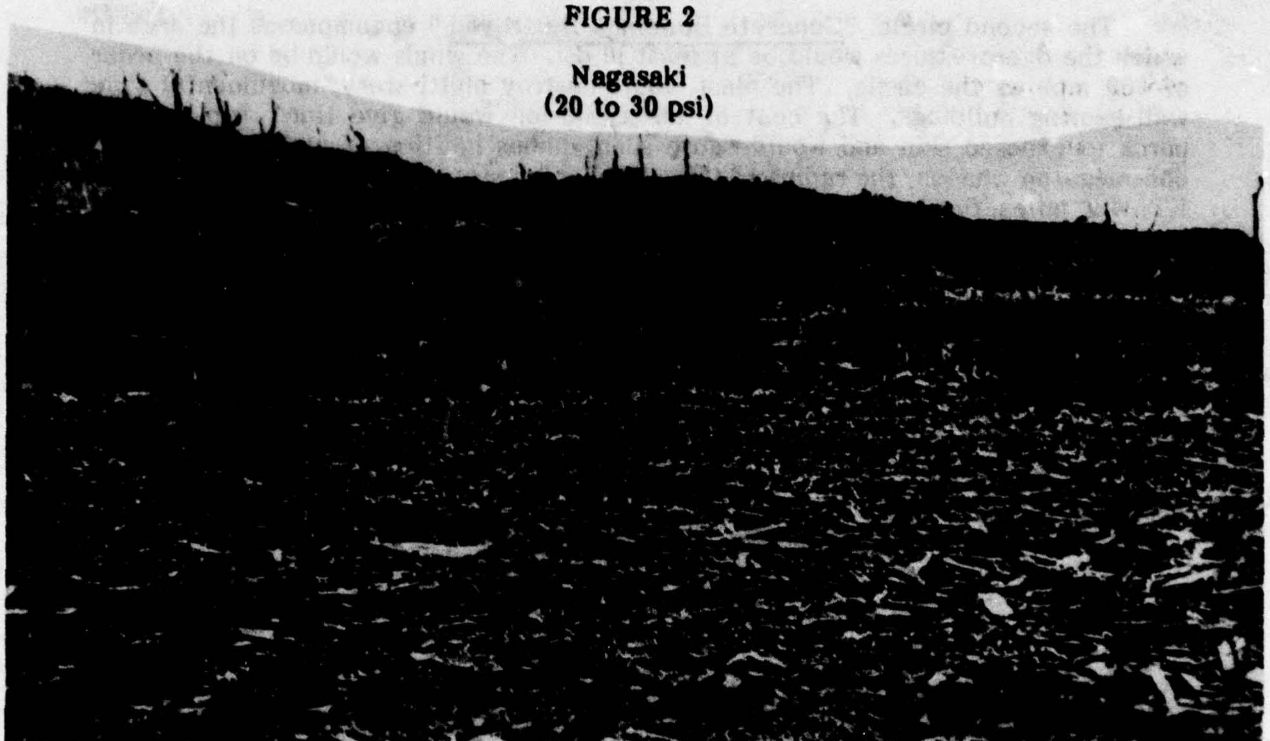
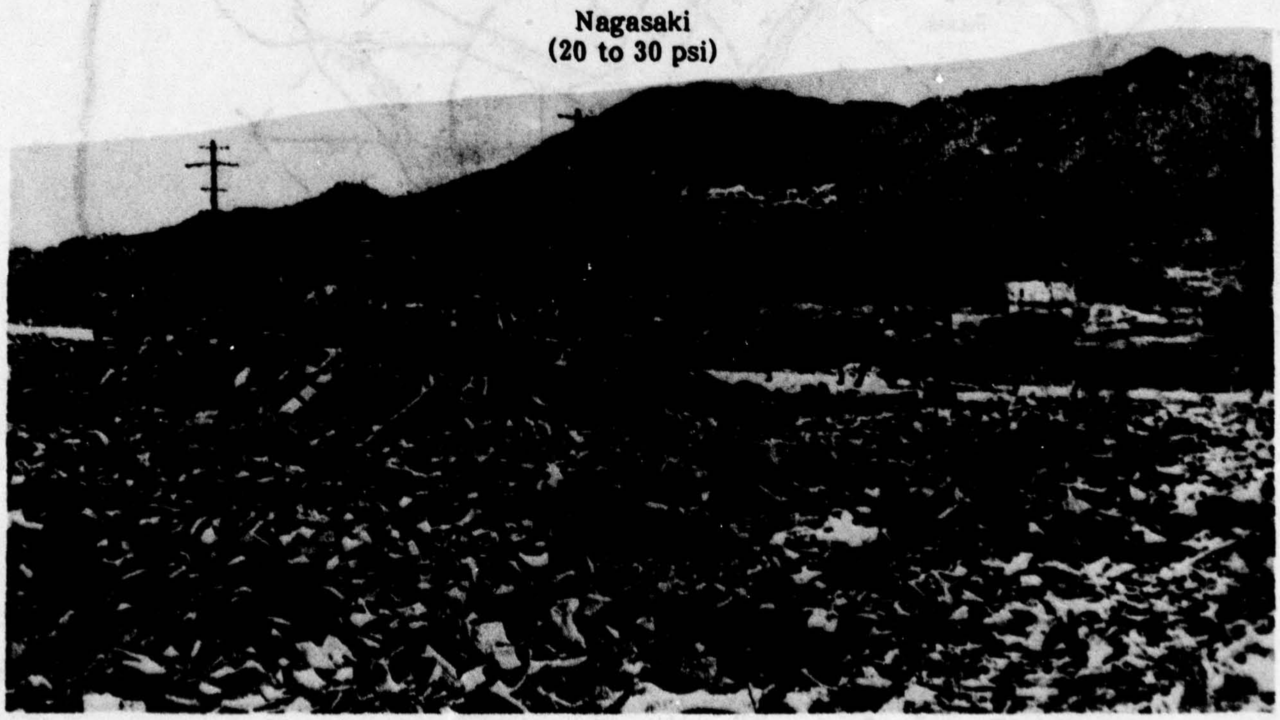


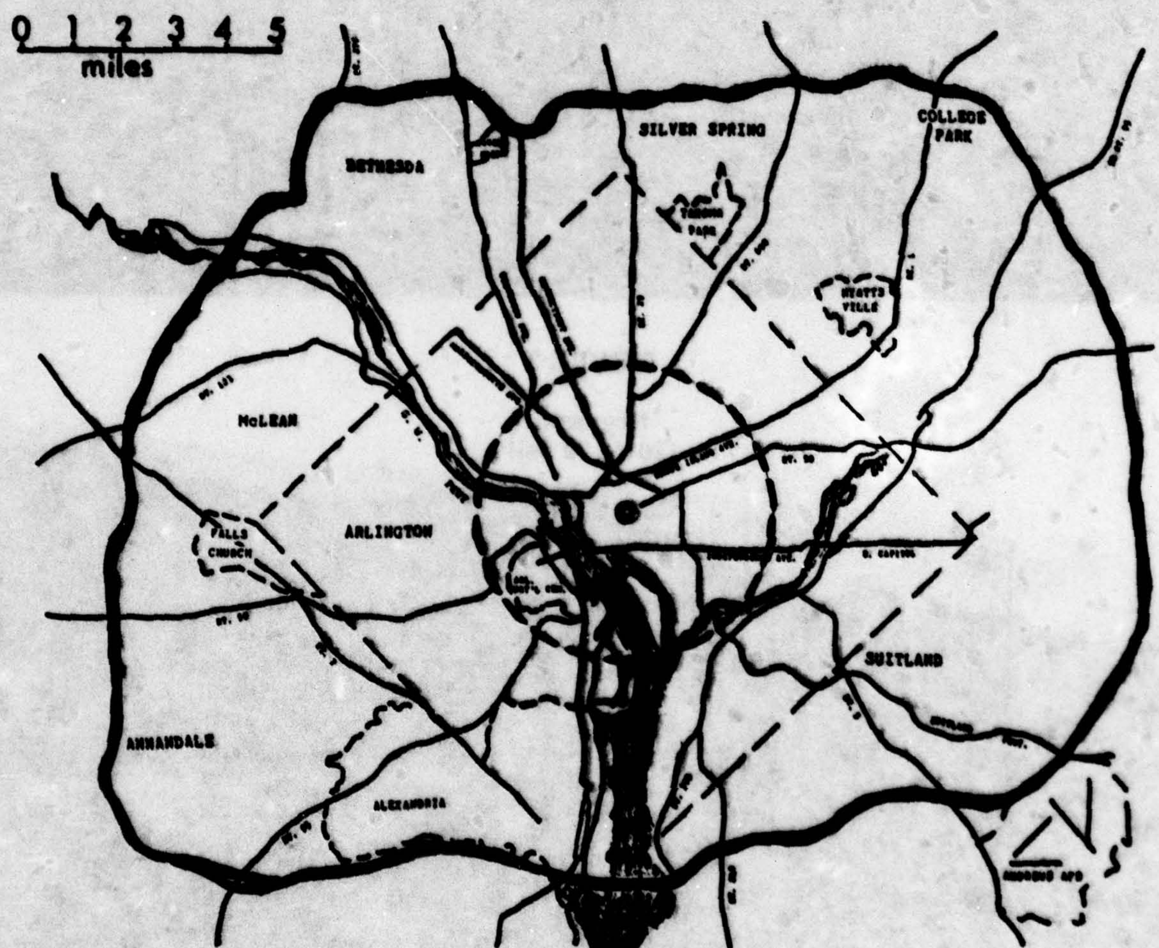
FIGURE 3

Nagasaki
(20 to 30 psi)



The second circle, "Concrete Buildings Destroyed," encompasses the area in which the overpressures would be at least 10 psi. The winds would be on the order of 300 mph at the circle. The blast would destroy multi-story, monumental type wall-bearing buildings. The heat of the explosion would give third degree flash burns to exposed skin and would cause spontaneous ignition of clothing. For the one-megaton weapon, the radius of this circle is 2.9 statute miles (2.3 miles for 500 KT, 4.9 miles for 5 MT and 7.8 miles for 20 MT). Figures 4 and 5 show the destruction in Nagasaki corresponding to these distances from the weapon explosion.

WASHINGTON, D.C. 10 PSI



ONE MEGATON WEAPON AIR BURST

FIGURE 4
Nagasaki - Natural Gas Tank
(12 psi)

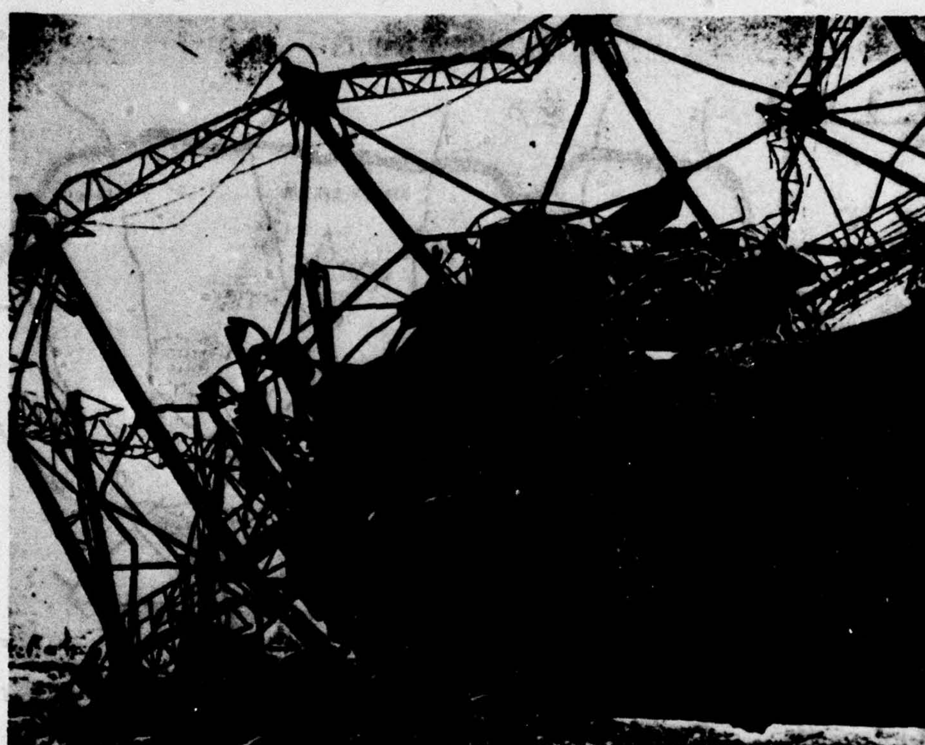
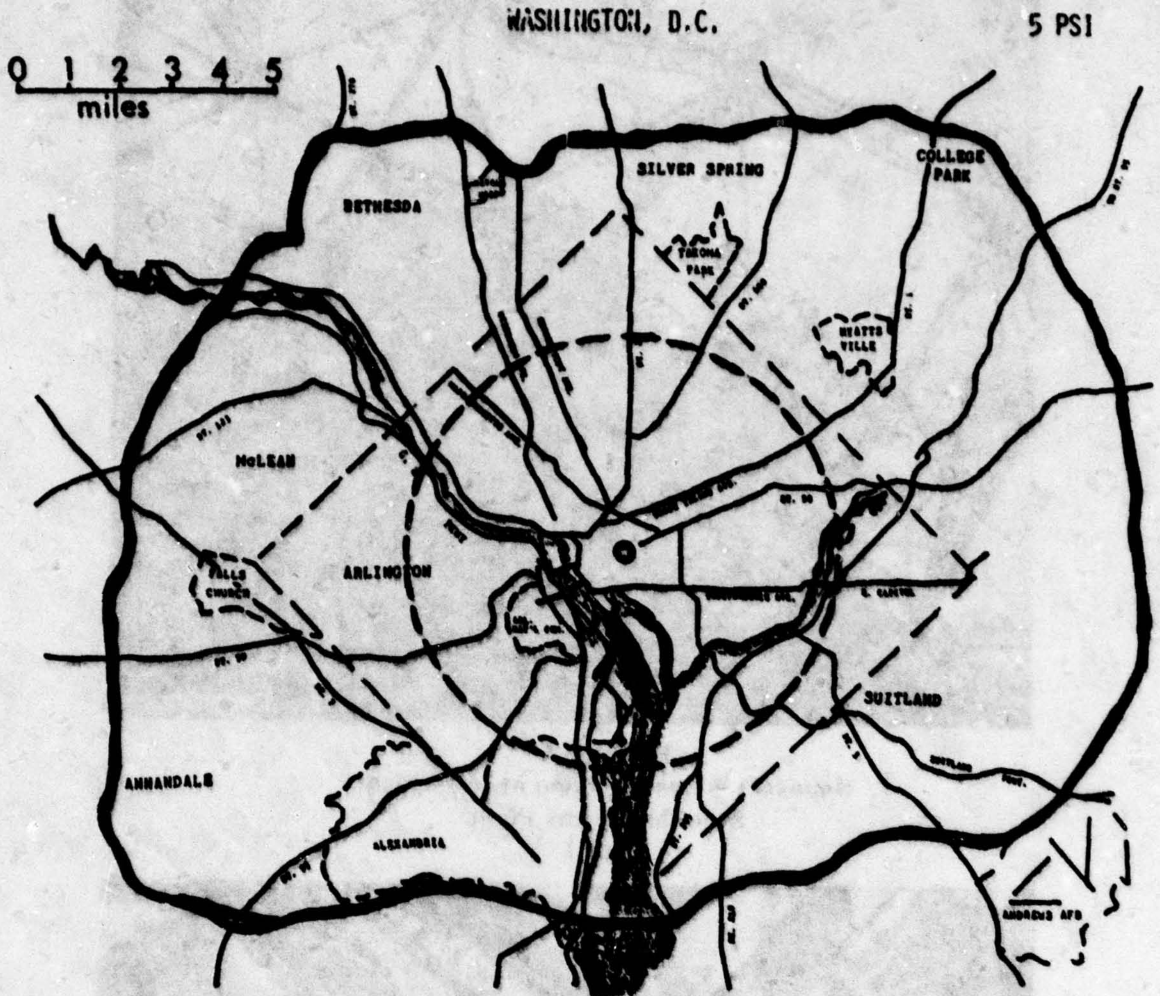


FIGURE 5
Nagasaki - Casting Shop at Mitsubishi
Steel and Arms Plant
(9 psi)



ONE MEGATON WEAPON AIR BURST

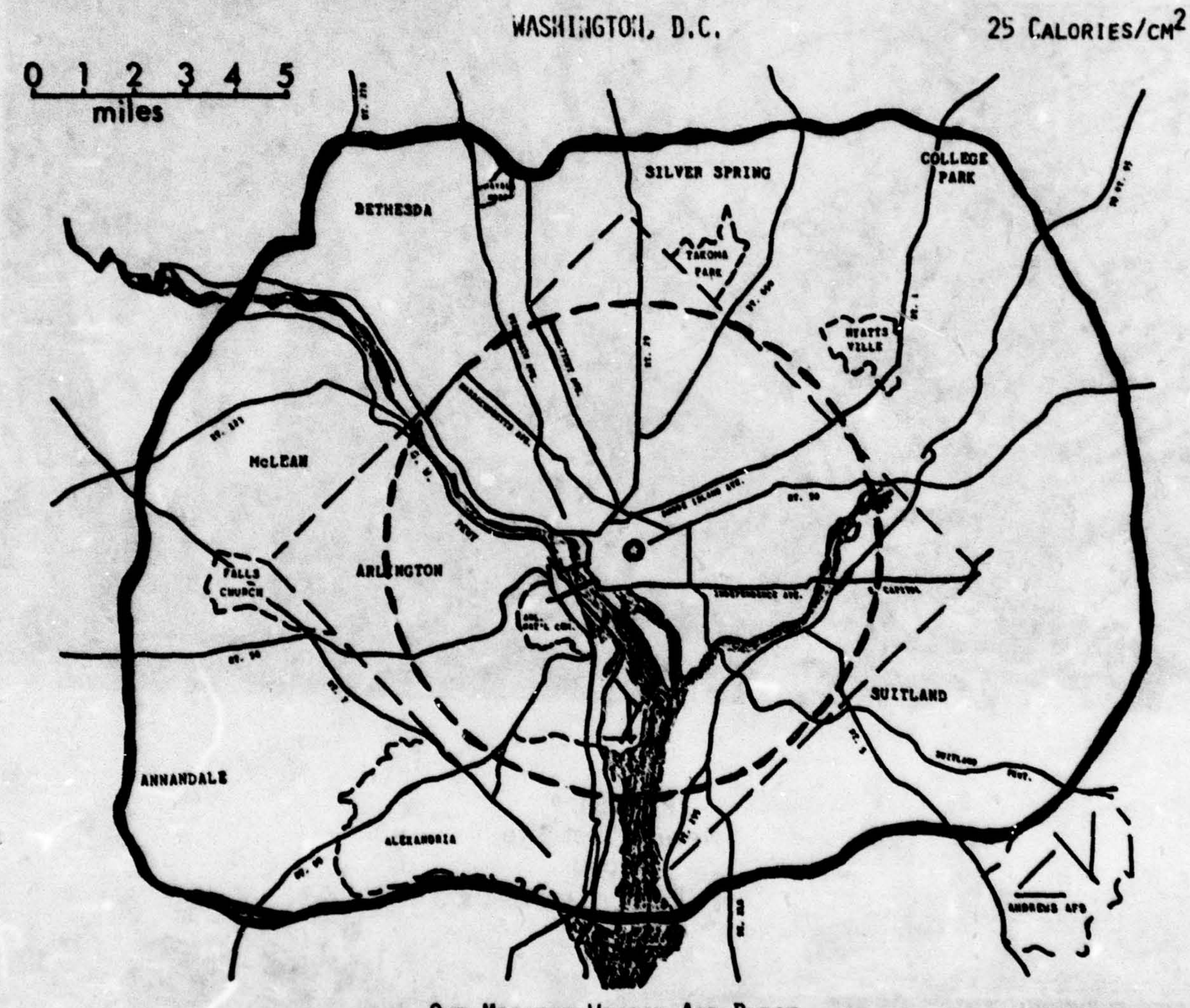
The third circle, "Brick and Wood Frame Houses Destroyed," encompasses the area in which the overpressures would be at least 5 psi and the winds would be on the order of 160 mph or more. The blast would destroy unreinforced brick and wood frame houses. The heat from the explosion would give third degree flash burns to exposed skin and produce spontaneous ignition of clothing. The one-megaton radius of this circle is 4.2 statute miles (3.3 miles for 500 KT, 7.2 miles for 5 MT and 11.4 miles for 20 MT). Figure 6 shows damage corresponding to these ranges from Nagasaki and Figure 7 shows damage at these ranges to a brick house at the Nevada Test Site.

FIGURE 6

Nagasaki
Machine Shop at Mitsubishi
Steel and Arms Plant
(6 psi)

FIGURE 7
Nevada Test Site
(5 psi)

Before   After



ONE MEGATON WEAPON AIR BURST

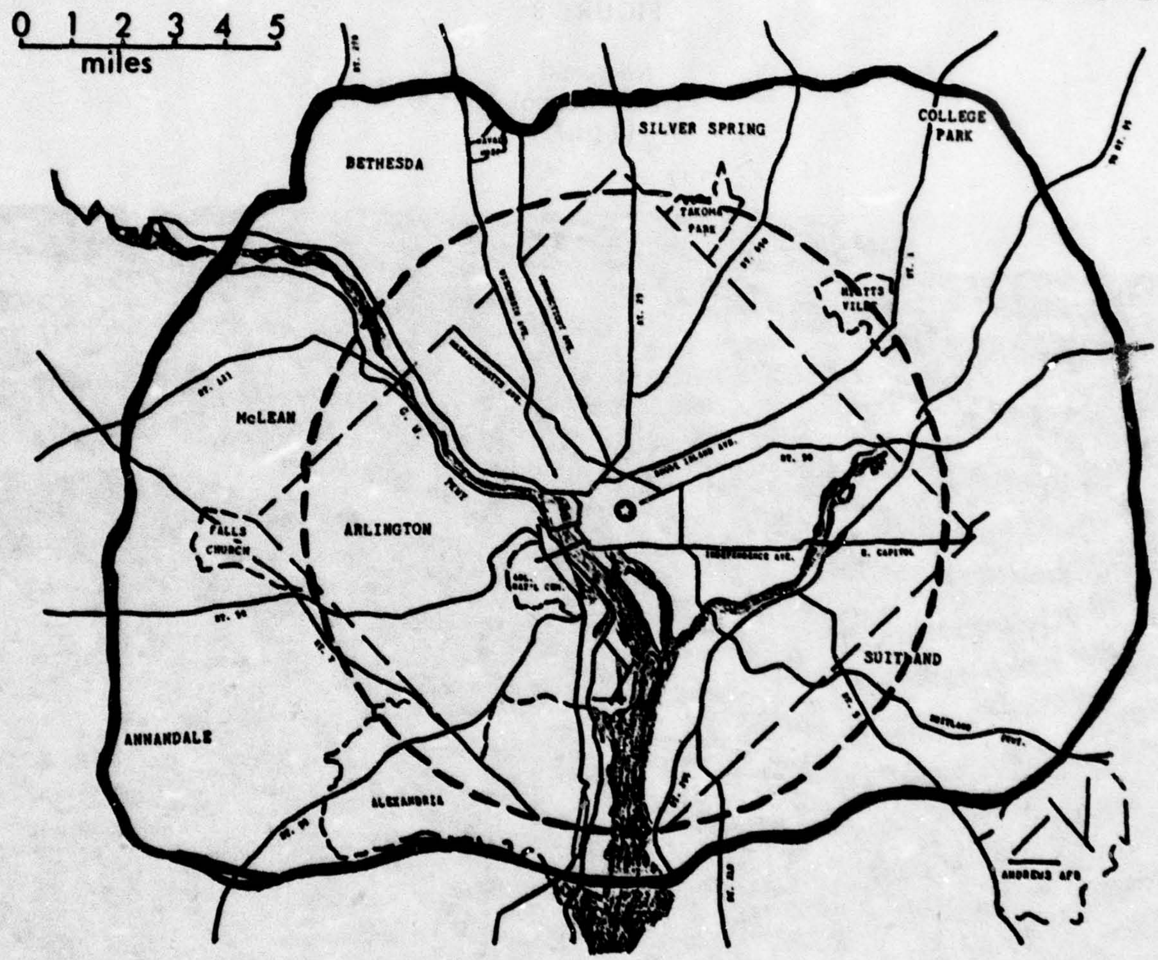
The fourth circle, "Spontaneous Ignition, Clothing and Household Combustibles," encompasses the area in which the heat will exceed 25 calories/cm^2. Fires could be expected to spread outside this circle, depending upon building density and the direction and velocity of the wind. The one-megaton radius of this circle is 4.9 statute miles (3.8 miles for 500 KT, 8.9 miles for 5 MT and 14 miles for 20 MT). Figure 8 shows the total burn-out of a school house at Nagasaki that was exposed to the effects occurring at these ranges.

FIGURE 8

Nagasaki
Grade School
(4 psi)

WASHINGTON, D.C.

12 CALORIES/CM^2

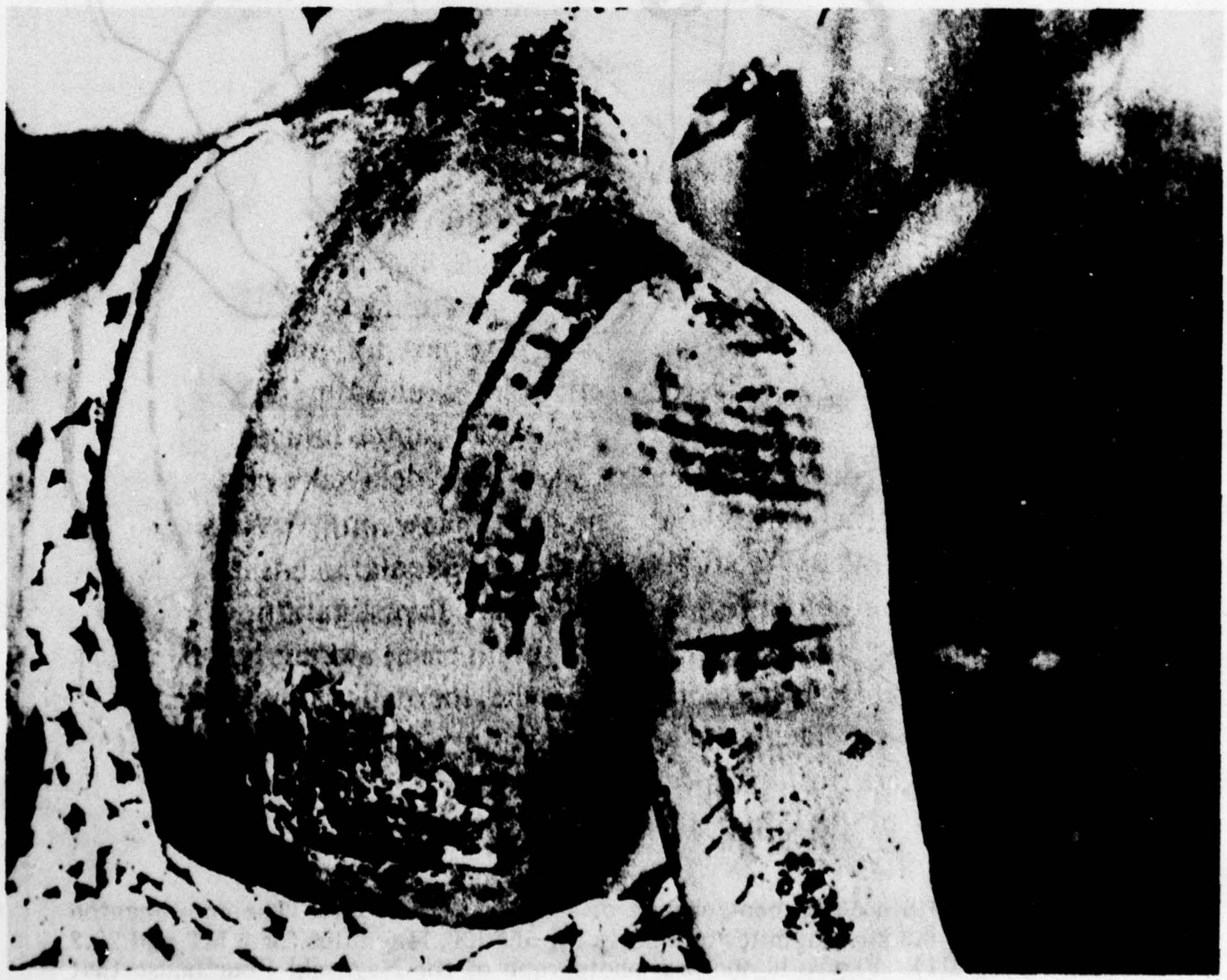


ONE MEGATON WEAPON AIR BURST

The fifth circle, "3rd Degree Burns," encompasses the area in which the heat exceeds 12 calories/cm^2. Essentially, 100 percent of exposed skin would suffer third degree burns. The one-megaton radius of this circle is 6.2 statute miles (4.9 miles for 500 KT, 11 miles for 5 MT and 16.1 miles for 20 MT). Figure 9 shows a photograph of a Japanese woman that was burned at Nagasaki when exposed to the heat occurring at these ranges.

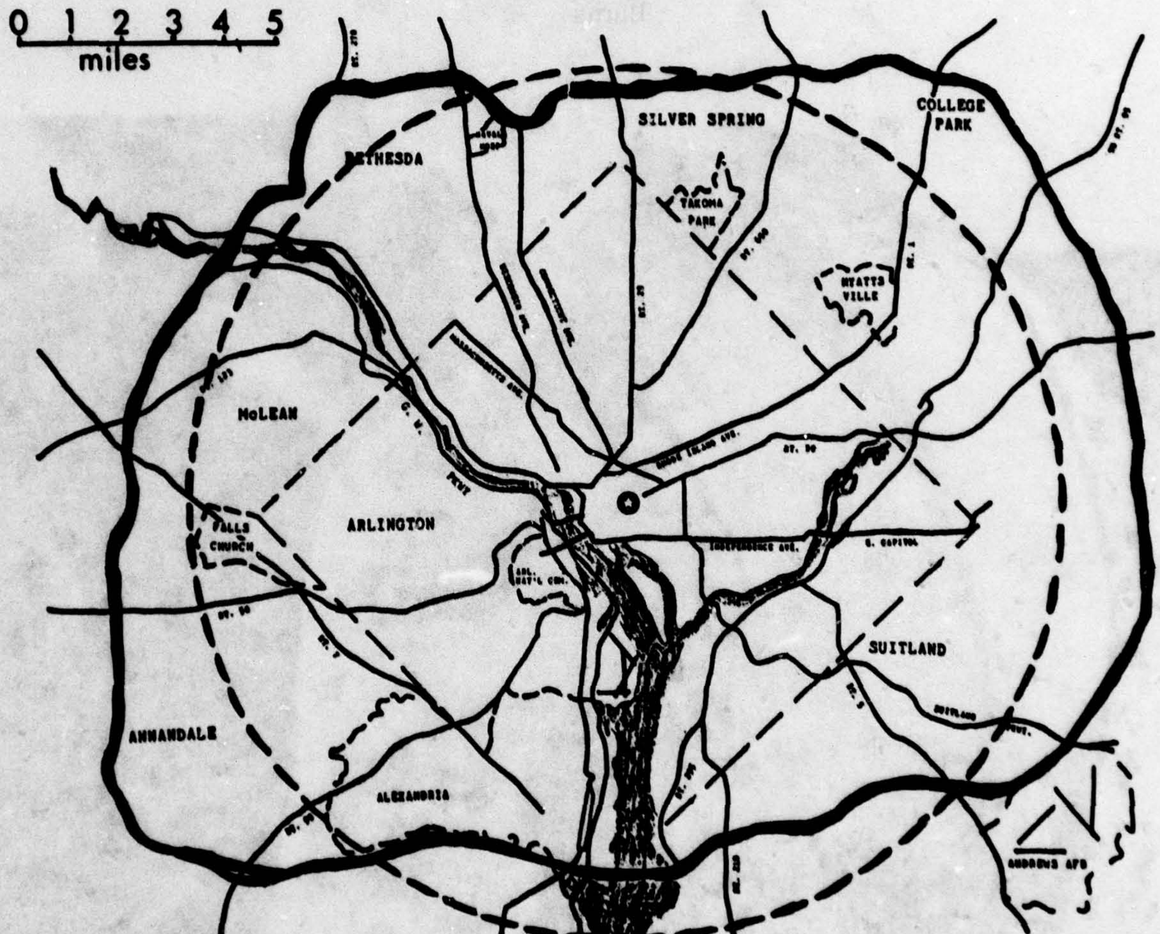
FIGURE 9

Nagasaki
Burns



The sixth circle, "Moderate Damage, Brick and Wood Frame Houses," represents the distance beyond which overpressure would finally drop below 2 psi and the typical residential type building would remain usable. However, extensive repairs would still be needed as far out as this circle. The damage would include the cracking of wall framing, severe damage to roofs, and the interior partitions would be torn down. In addition at these ranges the heat would be around 6

WASHINGTON, D.C. 2 PSI

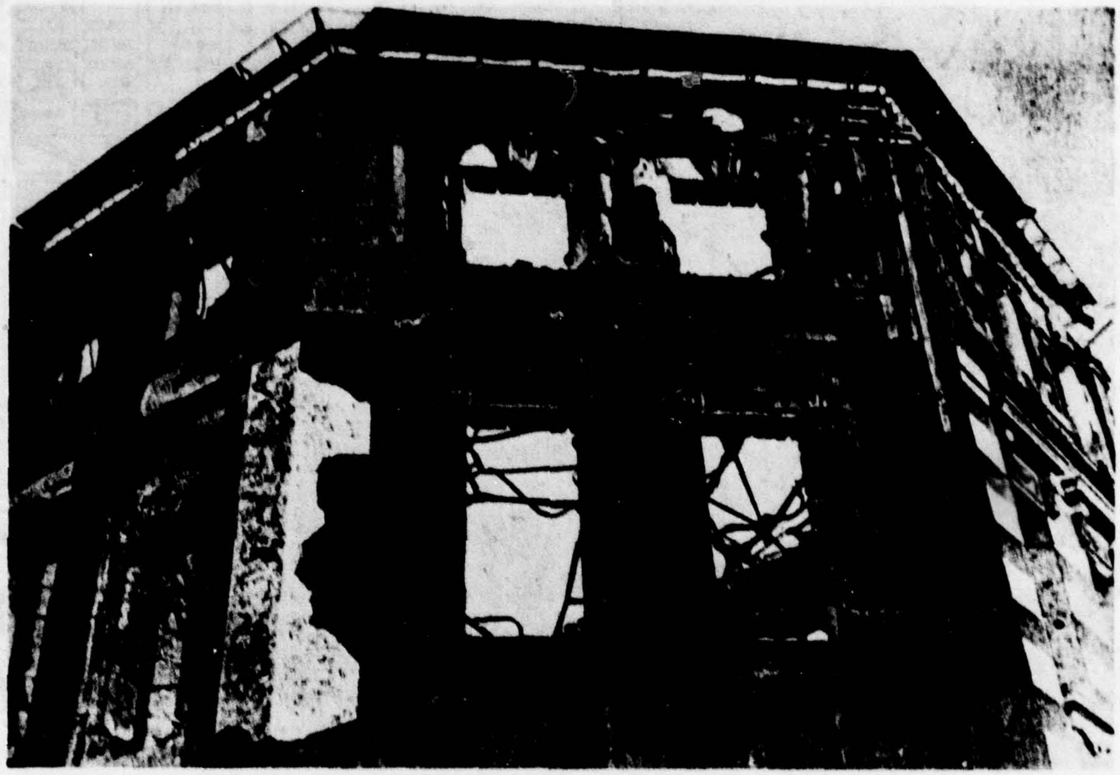


ONE MEGATON WEAPON AIR BURST

calories/cm^2 with a 50 percent chance of second degree burns. The one-megaton radius circle is 8.5 statute miles (6.8 miles for 500 KT, 14.6 miles for 5 MT and 23.2 miles for 20 MT). Figure 10 shows a photograph of the Nagasaki Courthouse that was exposed to the nuclear effects that would exist at these ranges.

FIGURE 10

Nagasaki
Courthouse
(less than 2 psi)

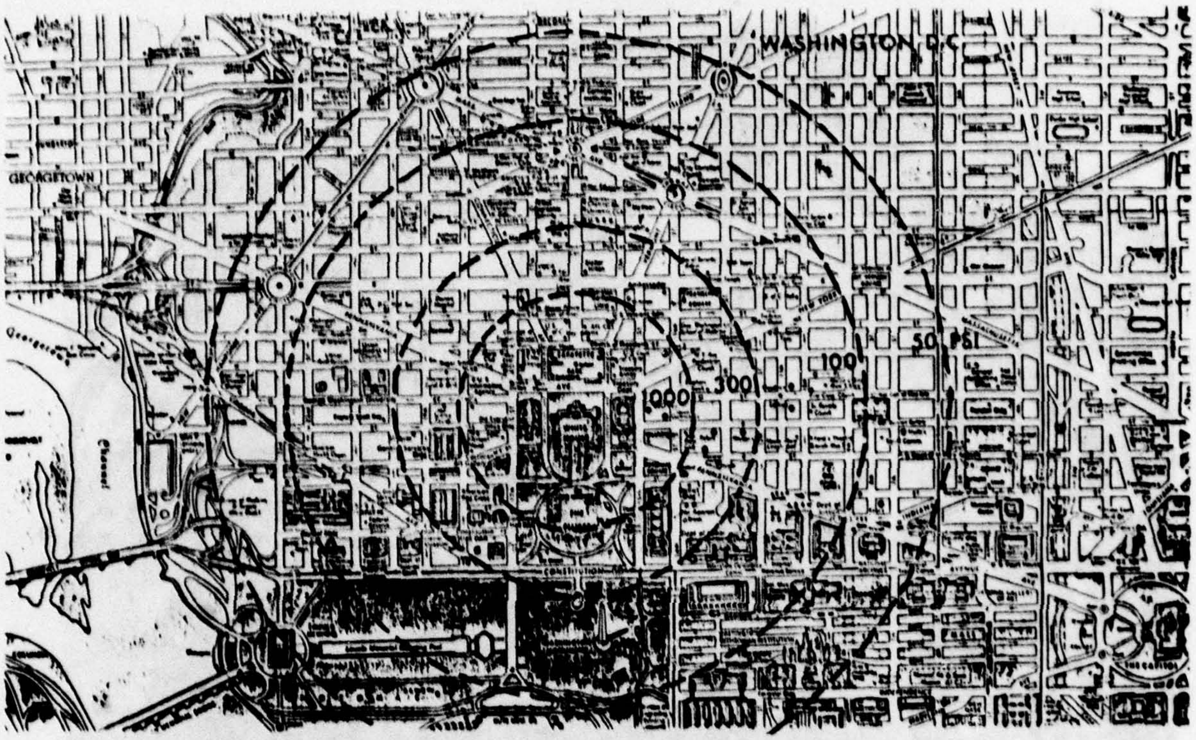


The effects discussed above result from a one megaton airburst weapon. If instead of being air burst the weapon were detonated at ground level, the extent of the blast and heat effects would be somewhat reduced but there would be a substantial increase in the amount of overpressure near the target's central area and in the amount of radioactive fallout.

Figure 11 shows the overpressure in the downtown Washington area if a one megaton warhead is ground burst on the White House. It can be seen that in this case the overpressures are very high - over 1000 psi out to 1500 feet and over 50 psi out to almost one statute mile from the burst point. Keeping in mind that at 20 psi reinforced concrete buildings are destroyed, one can readily imagine the destruction at these very high levels of overpressure.

FIGURE 11

ONE MEGATON WEAPON GROUND BURST



Figures 12 and 13 show the fallout contours from this weapon. Figure 12 shows the fallout contours over the city with the prevailing a westerly wind condition. It can be seen that some parts of the city will have doses up to 5000 roentgens and that the 1000 roentgen contour covers about 20 percent of the area inside the beltway. Figure 13 shows the 100 REM* fallout contour. This dose level is important since 100 roentgens is the maximum dose a human can absorb without serious damage. It can be noted that this contour not only covers the entire city but extends over Maryland and Delaware out to the Atlantic Ocean.

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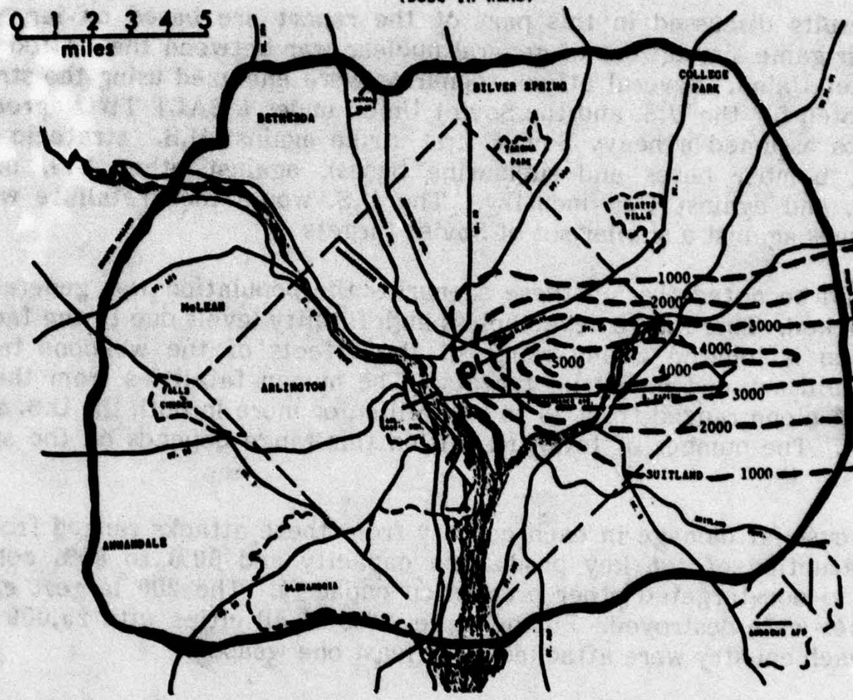
* REM is short for "roentgen equivalent man." It is a unit of nuclear radiation which equates all the various radiation products to the damage produced in man by one unit of gamma ray radiation.

FIGURE 12

FALLOUT ONE MEGATON GROUND BURST
(Dose in REMS)



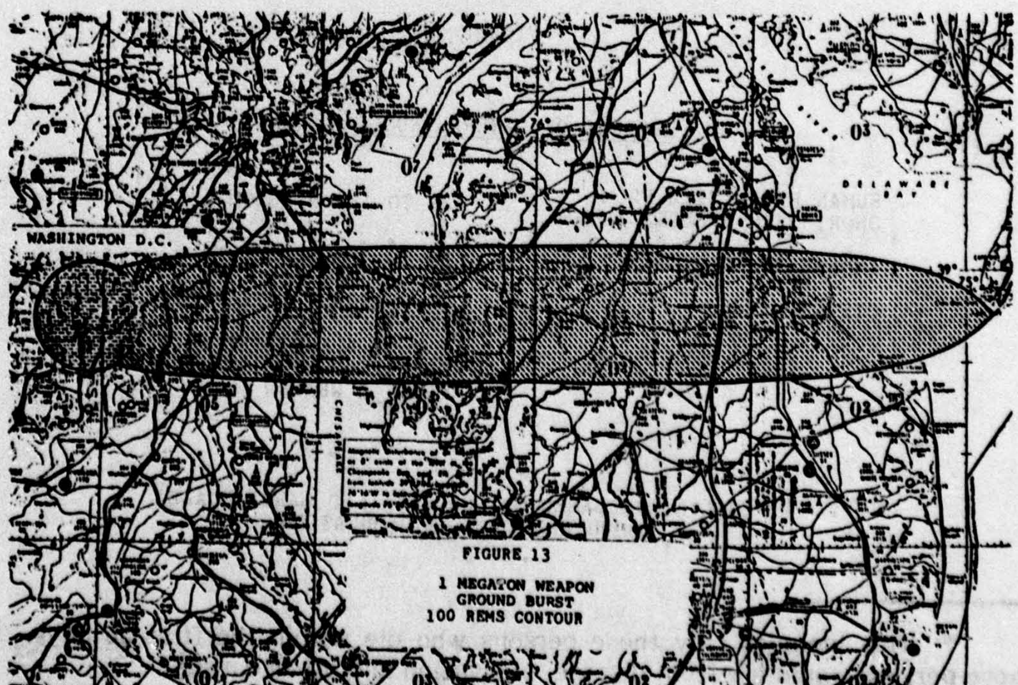


FIGURE 13

1 MEGATON WEAPON
GROUND BURST
100 REMS CONTOUR

C. Effects of General Nuclear War

The results discussed in this part of the report are based on large scale computer war game simulations of general nuclear war between the United States and the Soviet Union. Several attack scenarios were analyzed using the strategic forces projected for the U.S. and the Soviet Union under a SALT TWO agreement. The scenarios assumed a heavy Soviet first strike against U.S. strategic forces (ICBM silos, bomber bases and submarine bases), against other U.S. military installations, and against U.S. industry. The U.S. would then retaliate with its surviving forces against a similar set of Soviet targets.

It should be noted that in these scenarios the population was generally not directly attacked. There were nevertheless high fatality levels due to the fact that the population is located within range of the effects of the weapons targeted against the military and industrial targets. The human fatalities from the short term effects* alone ranged from 25 to 100 million or more in both the U.S. and the Soviet Union. The number of fatalities within this range depends on the specific scenario.

The industrial damage in each country from these attacks ranged from 65% to 90% destruction of the key production capacity and 60% to 80% collateral destruction to non-targeted other production capacity. The 200 largest cities in both countries were destroyed. Furthermore, 80% of all cities with 25,000 people or more in each country were attacked by at least one weapon.

Figure 14 summarizes the short term effects of general nuclear war that would occur in each of the two countries.

FIGURE 14

EFFECTS OF GENERAL NUCLEAR WAR

HUMAN FATALITIES FROM SHORT TERM EFFECTS ALONE	25 TO 100 MILLION
INDUSTRIAL DAMAGE	65 TO 90% DESTROYED
CITIES	200 LARGEST CITIES DESTROYED
	80% OF ALL CITIES WITH 25,000 PEOPLE OR MORE ATTACKED BY AT LEAST 1 WEAPON

RESULTS ARE BASED ON OUR DETAILED LARGE SCALE COMPUTER WAR GAME SIMULATION

* This includes only those persons who die within the first 30 days. Many more persons would die from disease, starvation and other causes.

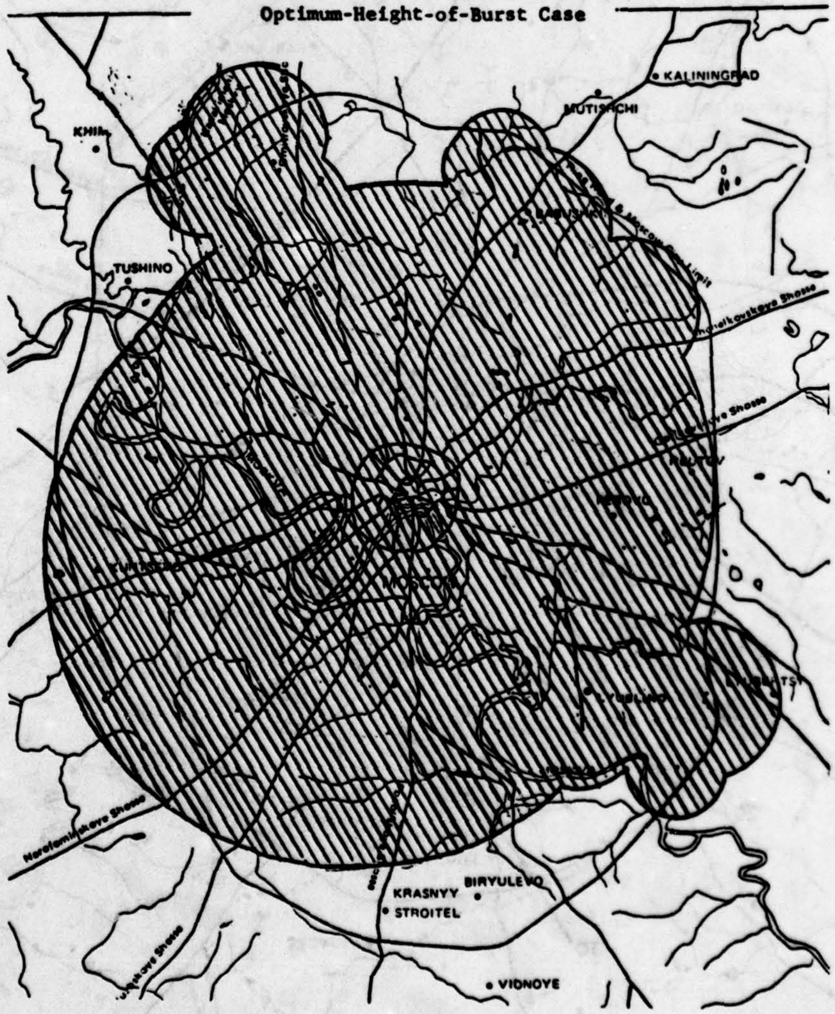
To understand the severity of general nuclear war, a detailed examination was made of the effect of the simulated retaliatory attack on Moscow. In this attack approximately 60 warheads went down within the Moscow city limits, which would be typical of a major nuclear exchange. Such an attack represents about 1400 times as much megatonnage as used against Hiroshima and Nagasaki in 1945. Peak overpressures throughout the downtown Moscow area were so severe (over 100 psi) that not a building or tree would remain standing. Clearly these attacks are orders of magnitude larger than the Hiroshima and Nagasaki bombings.

Much of the damage to cities, however, does not come from blast overpressures alone; secondary fires would also be a significant factor. Generally, it is estimated that total fire burn-out would occur within the same region exposed to blast levels of 3 to 5 psi or more. This estimated burn-out area does not assume that a "fire storm" would occur, but it is based on an estimate that fires once started could not be fought because of the intense radiation environment and the fact that the water supply would be destroyed. Figure 15 shows the 5 psi

FIGURE 15

5 PSI OVERPRESSURE CONTOURS-MOSCOW

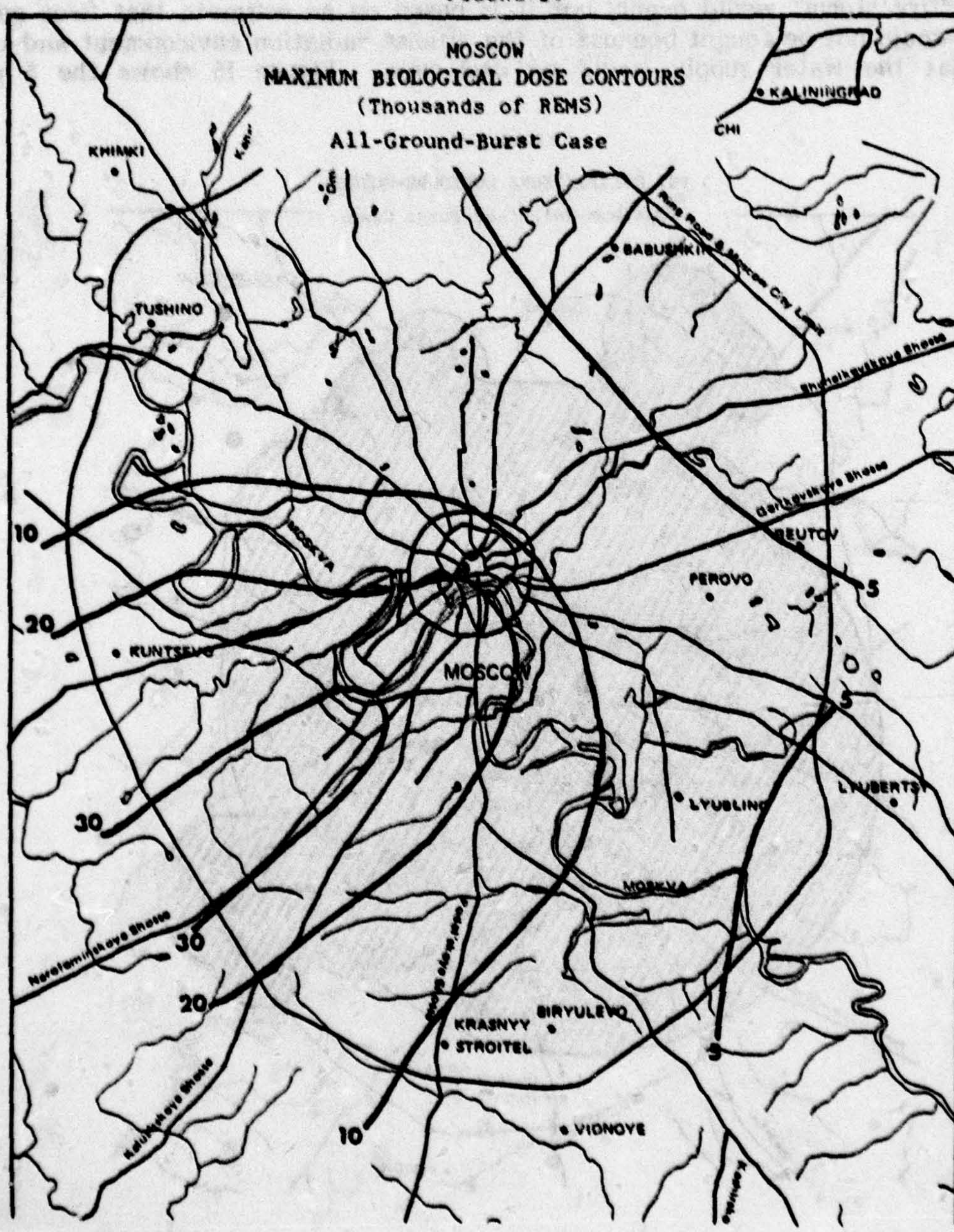
Optimum-Height-of-Burst Case



overpressure contour from the simulated attack on Moscow. This figures shows that the probable burn-out area would cover 85 to 90% of total urban housing.

Figure 16 shows radiation dose contours over the city in thousands of REMs. Almost the entire city is covered by more than 5000 REMs and, in some parts of the city, the dose is above 30,000 REMs. To understand the magnitude of this radiation, one must keep in mind that only doses of 100 REMs or less can be absorbed by human beings without serious consequences. Even that dose, although it will not create serious illness, will substantially increase the risk of cancer and other diseases. A dose of 200 REMs will cause incapacitating radiation sickness to

FIGURE 16

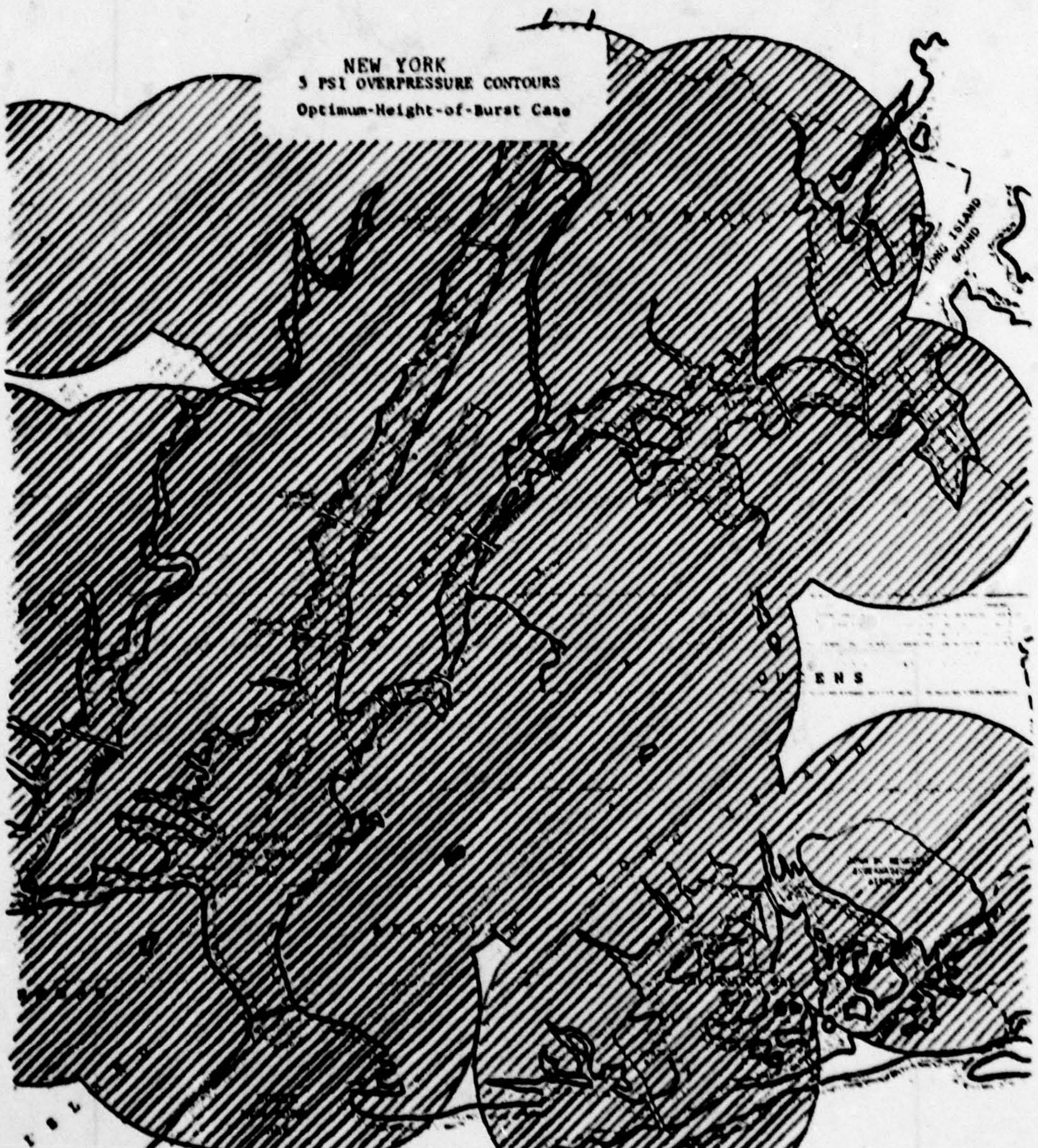


MOSCOW
MAXIMUM BIOLOGICAL DOSE CONTOURS
(Thousands of REMS)
All-Ground-Burst Case

50% of the people exposed to it, and a dose of 450 REMs will cause 50% fatalities to the people exposed to it. Clearly, no human being exposed to the kind of radiation dose that would exist in Moscow could survive. People in the area who were very well sheltered could have some chance if they stayed inside for several months.

Finally it should be understood that similar devastation would occur in the United States. Figure 17 illustrates the 5 psi (total burn-out) area that would occur in the greater New York City area. Clearly the cities of both countries would be devastated.

FIGURE 17



The short term radioactive fallout resulting from general nuclear war will vary depending on how the war is fought. The most important factor with respect to fallout is the number of weapons which are ground burst. Figures 18 to 21 illustrate typical fallout contours if half the weapons are ground burst. The shaded areas in Figures 18 (Soviet Union) and 19 (United States) represent the areas exposed to 100 REMs or more. It is only outside of these areas that people in the

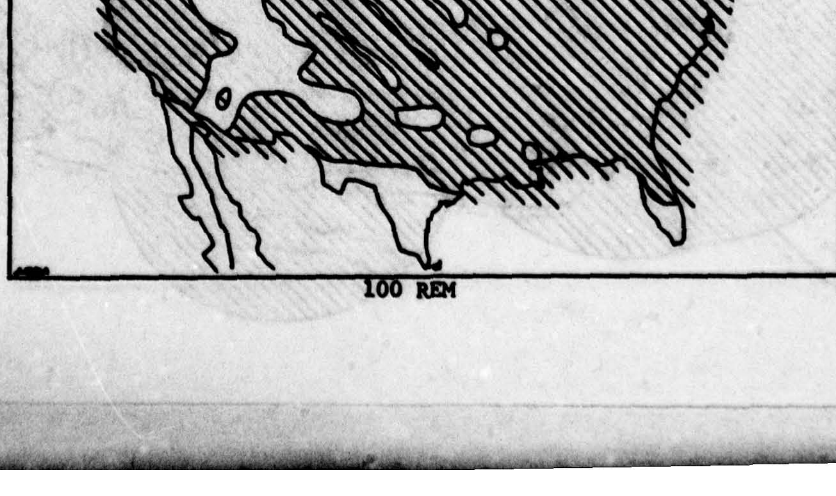
FIGURE 18

AREAS COVERED BY 100 REMS OR MORE
SOVIET UNION

FIGURE 19

AREAS COVERED BY 100 REMS OR MORE

UNITED STATES



100 REM

open will escape the short term damage effects of radiation. In the Soviet Union, 82% of the urban population and 75% of the rural population is located within areas exposed to 100 REMs or more. The figures for U.S. population are similar.

Figure 20 represents the areas of the United States covered with 1000 REMs or more. Anyone outdoors in these areas, even with clothes that cover most of the body (a protection factor of about 1.3), would still receive 700 to 800 REMs which is clearly a lethal dose. People in frame houses (a protection factor of 2 to 3), would receive doses from 300 to 500 REMs. These are dose levels which would cause incapacitating radiation illness to all and kill many. Figure 21 shows the areas covered by 4500 REMs or more. People in these areas even in basements (protection factors of about 10) would still receive 450 REMs or more. That is, more than half of the people in basements would still die from radiation exposure.

FIGURE 20

AREAS COVERED BY 1000 REMS OR MORE

1000 REM

Now consider people in the cities that are in shelters that manage to survive the blast and fire effects. Someone located in a shelter with a protection factor (PF) of 100 would, in the southeast corner of Moscow, still be exposed to doses of more than 30,000/100 = 300 REMs. Actually a much larger dose would be received

FIGURE 21

AREAS COVERED BY 4500 REMS OR MORE

4500 REM

because, to obtain the full 100 PF protection, a person would have to stay in the shelter until the radiation levels had decayed, a period that can last for several months. Figure 22 shows two shelter-use patterns that illustrate the difficulty of radiation avoidance even in excellent shelters. Note that even in a highly

FIGURE 22

EFFECT OF USE PATTERN

SHELTER EFFECTIVENESS

TO AVOID RADIATION ILLNESS (100 REM)

Shelter Use Pattern					
FIRST MONTH	SECOND MONTH	THEREAFTER	NEAR PERFECT SHELTER PF = 500	GOOD SHELTER PF = 40	BASEMENT PF = 10
100 % IN SHELTER	75% IN SHELTER 25% INDOORS	75% INDOORS 25% OUTDOORS	30% OF URBAN AREA DENIED	65% OF URBAN AREA DENIED	80% OF URBAN AREA DENIED
98% IN SHELTER 2% OUTDOORS	75% IN SHELTER 25% INDOORS	75% INDOORS 25% OUTDOORS	60% OF URBAN AREA DENIED	70% OF URBAN AREA DENIED	85% OF URBAN AREA DENIED

protective shelter with a PF of 500, if an occupant stayed 100% of the time in the shelter the first month after the attack, and 75% of the time in the shelter during the second month of the attack, 30% of the urban area would be too "hot" for this kind of activity - that is, they would have to stay in the shelter for an even longer period. In the second pattern illustrated occupants leave the shelters for 2% of the time during the first month; in this case 60% of the urban area is too "hot" for this regime. Any lesser shelter stay time would of course make this situation even worse.

Another factor to be considered is reentry to the urban areas by people who have not been exposed to any radiation. The first problem would be to find such people, since 80% of the population (including the evacuated population) is located in areas that are exposed to 100 or more REMs. Even people who have received no dose at all would have to wait one month to reenter half the urban areas, two months to reenter three quarters of the urban areas, and up to six months to reenter the entire urban area.

In addition to the fatalities presented earlier in this report, it is estimated that there would be 30 to 50 million injured. The care of these injured people would be an immense problem and many would die. Hospital and medical facilities would be very scarce, for example, 80% of the urban hospitals in the Soviet Union were destroyed (93% of the Moscow hospitals were destroyed). Hospitals, of course, were not attacked; they are, however, located near many of the military and industrial facilities that were targeted.

In addition to the large number of injured people, there would be a large increase in disease due to poor sanitation, crowded living conditions (½ to 1 square meters per person in shelters), shortage of food and medical supplies, and reduced resistance to disease due to radiation exposure.

In summary, the number of injured and sick people would be at least an order of magnitude larger than in any previous war.

D. Other Effects of Nuclear War

This part of the report addresses effects of nuclear war that are often neglected. While some work has been done on most of these effects, great uncertainty exists in predicting the consequences of many of these effects. Some of these effects are discussed below.

1. Housing. Over 90% of the urban housing would be destroyed in a general nuclear war. In addition a substantial portion of the rural housing would also be damaged. Since it is estimated that more of the housing than people would be destroyed, massive housing shortages would exist for years after the war.

2. Food and Water Supplies. Stock requirements of food and water would vary from one week to several months depending on the fallout pattern. Furthermore, destruction of the transportation nodes would delay redistribution of supplies by two months or more. Stocking two months of supplies is a major problem. Undoubtedly many survivors would have to leave shelters prematurely to search for food and water, and would be exposed to radiation.

3. Agriculture. An estimate was made of the effect of these nuclear attacks on agricultural crops. The results are sensitive to the time of the year the attack occurs. If the attack takes place during the growing season, then up to 30% of the crops could be lost. On the other hand, if the attack is in the winter the effect on crops would be minor. A considerable amount of uncertainty surrounds these estimates. It seems that crops would not be too seriously affected, yet we find that on Bikini Island 25 years after the completion of our nuclear tests, crop contamination problems still exist.

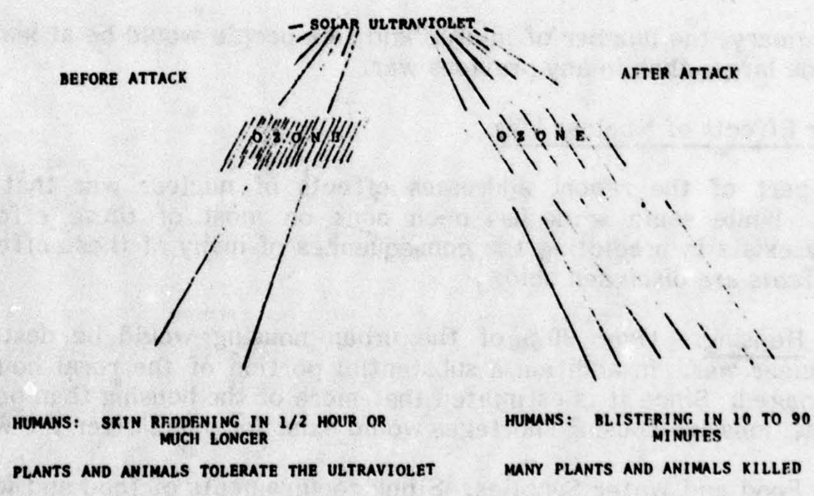
The situation with livestock is much more serious. Over half of the grazing animals would die and over one quarter of large farm animals fed on stored food would die.

This estimate of damage to agriculture and livestock is based only on the effects of blast and fallout; it does not take into account the potential additional effects of "ozone" depletion and other potential climatic changes.

4. The Ozone Problem. A considerable amount of uncertainty is associated with estimating the effects of nuclear war on the ozone layer. Even greater uncertainties exist when considering long term climatic and genetic changes. Many of these effects were studied by the National Academy of Sciences*. In this analysis the estimates produced by the National Academy of Sciences were translated to the attacks conducted in this simulation.

Figure 23 is a sketch which illustrates the effect of depletion of the ozone layer. Before the attack, exposure to the ultraviolet rays of the sun can produce a

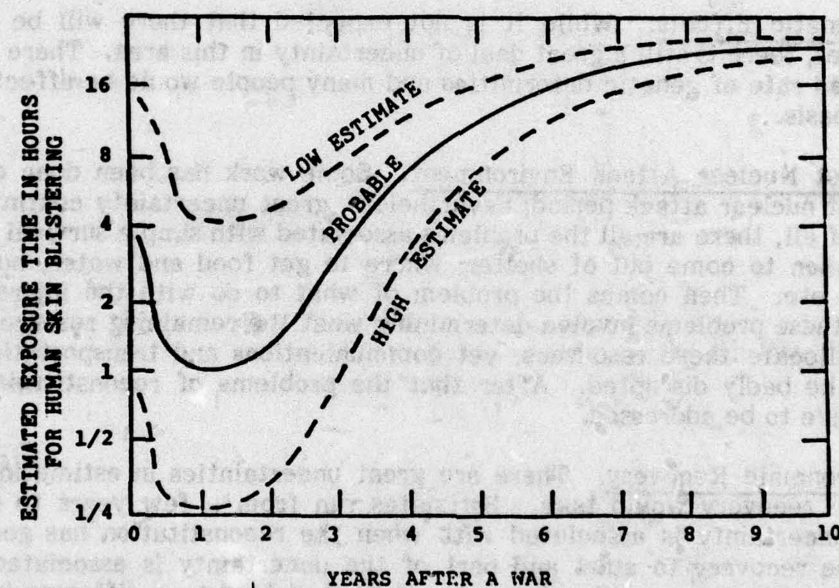
FIGURE 23



* "Long-Term Worldwide Effects of Multiple Nuclear-Weapons Detonation," National Academy of Sciences, Washington, D.C., 1975.

sunburn after exposure of ½ to 1 hour; after the attack such an exposure would produce blistering burns on the body. Plants and animals of course would be subject to similar increases in ultraviolet rays and many would be destroyed. The most serious aspect of the depletion of the ozone layer is illustrated in Figure 24. This figure shows that the worst depletion occurs six months after the attack and that the ozone layer does not return to its normal stage for a period of several years. Considering that this effect would cover the entire northern hemisphere of the earth, it represents a very serious factor. Reduction of the ozone layer in the southern hemisphere would be a less severe, but not an inconsequential, problem.

FIGURE 24



5. Disease. The first disease problem to be faced after the attack is the disposal of tens of millions of cadavers from the humans and animals that were killed in the attack. In this respect it should be noted that most of the blast and fire victims will die during or soon after the attack, the victims of radiation fallout, however, will die over a longer period of time (a few days to several weeks). The surviving population in the first 10 years after the attack will have a substantially increased disease rate due to lowered resistance because of radiation, general hardship and poor sanitation. In the longer run there would be an increase in the cancer rate due to radioactivity and ultra-violet burning.

6. Radiation Hot Spots. Since radioactive material drifts, "hot spots" with much higher activity than the average are expected. The significance of these "hot spots" is that when the survivors determine that the radioactivity has subsided to an acceptable level, many areas will still be too hot for exposure. Therefore it will

be necessary to make extensive radiation measurements and post exclusion areas before people can venture out of shelters or enter a new area.

7. Climatic Changes. The long term effects of general nuclear war on the climate are very uncertain. It should be noted, however, that even small changes in the average temperature could radically alter the agricultural patterns. The joint effect of temperature changes, ultra-violet burning due to ozone depletion and radioactive fallout is very difficult to estimate, but it could seriously alter vegetation patterns and climate.

8. Aquatic Environment. Another effect that has great uncertainty. Radioactive contamination would be a problem in some localities. Ozone burning of surface living organisms could alter fish populations.

9. Genetic Effects. While it is not expected that there will be major genetic changes, there is still a great deal of uncertainty in this area. There would be an increased rate of genetic deformities and many people would be affected on a world wide basis.

10. Post Nuclear Attack Environment. Some work has been done on the near term post nuclear attack period; nevertheless, great uncertainty continues to exist. First of all, there are all the problems associated with simple survival - i.e., what to do; when to come out of shelter; where to get food and water, housing, medical help; etc. Then comes the problem of what to do with the injured and dead. All of these problems involve determining what the remaining resources are and how to allocate these resources, yet communications and transportation for doing so will be badly disrupted. After that the problems of reconstituting the society will have to be addressed.

11. Economic Recovery. There are great uncertainties in estimating how long economic recovery would take. Estimates run from a few years to never. Part of the uncertainty is associated with when the reconstitution has gone far enough for the recovery to start and part of the uncertainty is associated with what is meant by recovery. The recovery might well lead to a different kind of society. The massive destruction of the urban areas would undoubtedly lead to a much more rural society. In addition there would probably be increased regimentation as government control resumes. Strong government control would be required to aid survivors in the short term. Anarchy could exist in some places. The long term effects on the governmental structure are much less certain. Great difficulty will be experienced in establishing a financial system. In addition the reconstruction of pre-attack property and financial rights may be almost impossible.