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DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 1

INTRODUCTION TO NUCLEAR EMERGENCY OPERATIONS

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

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WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

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LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 1

This introduction to nuclear emergency operations is aimed at the reader who has no special knowledge of the subject. It does not assume knowledge of the material in subsequent chapters of the Manual. However, material in this chapter is referred to in subsequent chapters.

Information is presented in the form of "panels" each consisting of a page of text and an associated sketch, photograph, chart or other visual image. Each panel covers a topic. This preface is like a panel with the list of topics in Chapter 1 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with two introductory panels, followed by four panels on current enemy capabilities. There are six panels on direct effects, followed by two on fallout. The next six panels discuss operating contingencies, leading to the nine Basic Operating Situations. Three subsequent panels elaborate the relationship among the contingencies. Finally, two panels emphasize the need for coordination of emergency actions, leading to the concept of operations under nuclear attack. There is a list of suggested additional reading for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 1

"INTRODUCTION TO NUCLEAR EMERGENCY OPERATIONS"

CIVIL DEFENSE OPERATIONS

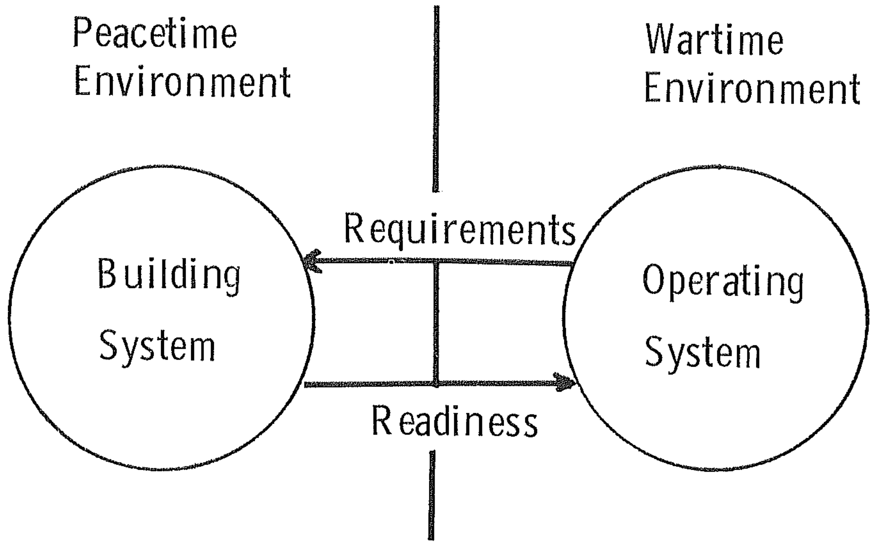
In the Federal Civil Defense Act, Congress stated, "It is the policy and intent of Congress to provide a **system** of civil defense for the protection of life and property in the United States from attack." Additionally, "The term 'civil defense' means all those **activities** and **measures** designed or undertaken (1) to minimize the effects on the civilian population caused or which would be caused by an attack upon the United States, (2) to deal with the immediate emergency conditions which would be created by any such attack, and (3) to effectuate emergency repairs to, or the emergency restoration of vital utilities and facilities destroyed or damaged by any such attack."

Civil defense operations are the **activities** and **measures** undertaken in event of attack for the purposes defined above. They will be undertaken in a **wartime environment** by the **civil defense operating system**, as indicated by the upper illustration.

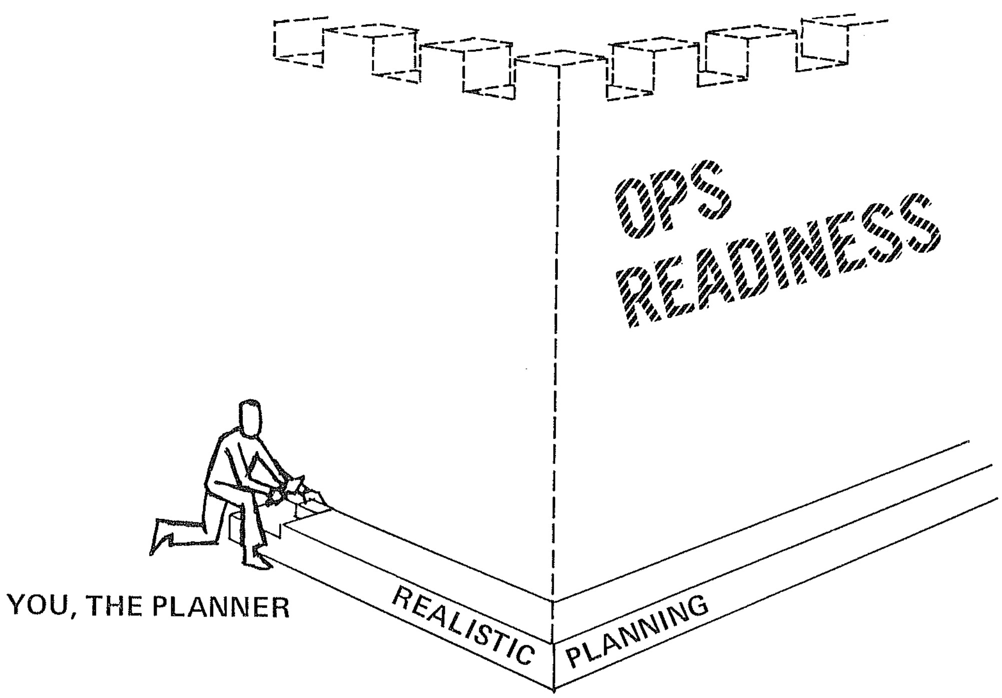
Only by a careful study of the needed civil defense operations and the attack environment that demands and constrains them can one understand the **requirements** for effective civil defense operations. This manual is intended to aid in this understanding.

To the extent that the operating requirements can be met, a locality is operationally ready. Building **local operational readiness** is the basic purpose of peacetime civil defense. Realistic **operational planning** is the foundation of operational readiness. Planning is the process by which the existing capabilities and resources of a community or area are organized in advance so that coordinated wartime operations are possible. Good planning also forms the basis for the development of additional capabilities needed to fulfill unmet requirements so as to improve local operational readiness.

Many of the civil defense operations needed to save lives and property in event of attack are also needed in peacetime emergencies. Therefore, civil defense operational readiness can serve both wartime and peacetime purposes. However, preparedness for peacetime contingencies does not automatically ensure readiness for attack contingencies. The ways in which wartime operational requirements are expected to differ from peacetime emergency experience will be emphasized in this manual where appropriate.



TWO CIVIL DEFENSE SYSTEMS



PANEL 1

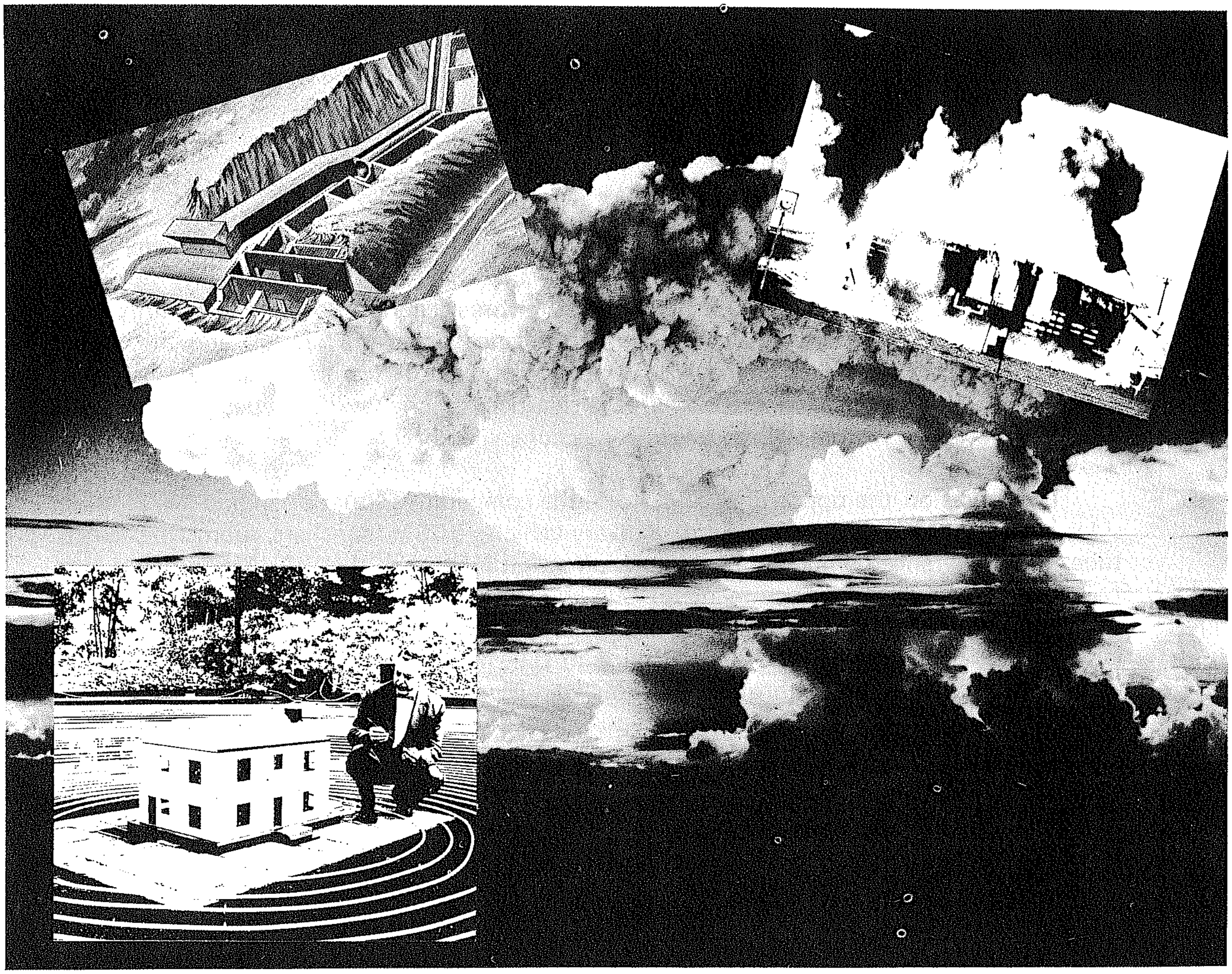
THE BASIS FOR OPERATIONAL PLANNING

Neither national defense policy nor local emergency operating plans for protecting the population against a nuclear attack can be based on experience. The expected effectiveness of any civil defense program or emergency action can be evaluated in a believable way only through simulation—hypothesizing various attack and defense combinations, and evaluating the consequences. Hopefully, by this means, meaningful insights can be developed as a substitute for the hard facts that do not exist from actual experience.

It is from such studies that the essential planning premises are developed. The extent of areas that probably would experience direct effects and severe fallout, the protection required, and probable shelter stay times are examples. The realistic planning of emergency operations under nuclear attack conditions places the most demanding requirement on the state of knowledge. Under what conditions will people survive blast and fire effects in American buildings? How fast will fires develop and spread? How much radiation exposure can an emergency team receive without serious permanent injury or degradation of performance? Questions such as these are answered only partly or not at all by analysis of the Japanese experience at Hiroshima and Nagasaki in World War II and the data from the nuclear weapons testing program of the 1950s. To fill in the most important voids in the information needed for planning and training has been the most important task of DCPA research during the past decade.

Illustrations of the experimental techniques used to provide a basis for nuclear emergency operations are those shown here. At upper left is the blast tunnel facility (see Chapter 2). At upper right is an instrumented building fire (see Chapter 3). At lower left is a fallout shielding experiment using a scale model (see Chapter 6).

The information in this manual depends heavily on the research base that has been built during the 26 years since the advent of nuclear weapons. Wherever appropriate, the basis for the facts presented will be described. But, first, in this Chapter, we present the "big picture," without which the attack environment information would not be useful.



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PANEL 2

ENEMY CAPABILITIES

The probable nature of nuclear attack and its consequences are related to enemy capabilities. The Soviet Union is the primary potential adversary with the capability to inflict major damage and loss of life in the U.S. There are three general measures customarily used in summarizing the overall strategic offensive balance between the U.S. and the Soviet Union. These are numbers of delivery vehicles, numbers of warheads, and megatons of explosive yield. No one of these measures is significant alone, and all must be considered together with other factors such as reliability, accuracy, and range.

The tables on the opposite page indicate the comparative situation in mid-1972. Both sides have about 2200 intercontinental delivery vehicles (ICBM launchers, submarine launch tubes and long-range bombers), the Soviets somewhat more than the U.S. The U.S. has over twice as many weapons, since many of our ballistic missiles have been modified to carry multiple warheads. At the same time, substituting multiple small-yield weapons for single large weapons has resulted in a sharp decline in U.S. megatonnage. Soviet ballistic missiles have considerably greater "throw weight" or warhead capacity than U.S. ballistic missiles. Therefore, the estimated 2500 Soviet weapons constitute a much greater megatonnage than that represented by the more numerous warheads of the U.S.

Note from the table that most of the Soviet delivery capability is represented by ballistic missiles, both ICBMs and submarine-launched missiles.

STRATEGIC FORCE STRENGTHS

Mid-1972*

	USSR	USA
ICBM's	1550	1054
SLBM's	580	656
Bombers	140	531
Total Delivery Vehicles	2270	2241
Total Weapons	2500	5700

*p. 40 of Sec Def Statement of Feb 15, 1972

SIZE OF WEAPONS

Most of the Soviet attack capability would be delivered by ballistic missiles. The largest of these, the SS-9, could carry a single warhead with a yield of 25 megatons. There is a possibility that the Soviet Union may be in the process of fitting multiple warheads to its missiles, just as the U.S. is doing. The SS-9 has been tested with three warheads, each capable of a yield of 5 megatons. The majority of Soviet missiles have warheads with a yield of considerably less than 5 megatons.

Civil defense planners should be aware that there has been and likely will continue to be a trend toward larger numbers of smaller-yield nuclear weapons. The implications of this trend are:

(1) The larger number of warheads suggests more localities may experience the direct effects of nuclear weapons (blast, fire, and initial nuclear radiation) than if fewer large weapons existed.

(2) Some attack effects, such as initial nuclear radiation, become more important to civil defense planning if small-yield weapons are used (see Chapter 5 for more details).

(3) The overall fallout threat decreases when multiple warheads are used on missiles. Note, for example, that the Soviet SS-9 with 3 warheads carries only 15 megatons total yield as opposed to 25 megatons in the single-warhead version. If larger numbers of warheads were placed on the SS-9, the total yield would be even smaller. Also, as weapon size is reduced, the distances to which fallout is carried by the winds are reduced (see Chapter 6 for more details).

SOVIET MISSILES*

<table>
<tr><th></th><th>SS-7</th><th>SS-8</th><th>SS-9</th><th>SS-11</th><th>SS-13</th></tr>
<tr><td>First Deployed</td><td>1961</td><td>1963</td><td>1965</td><td>1965</td><td>1967</td></tr>
<tr><td>Warhead Yield</td><td>5 MT</td><td>5 MT</td><td>20-25 MT</td><td>1-2 MT</td><td>1 MT</td></tr>
<tr><td>Estimated Number</td><td colspan="2">220</td><td>~280</td><td>over 900</td><td>60</td></tr>
</table>

Soviet submarine-launched missiles are similar to the SS-13.

*As estimated in The Military Balance, 1971-1972, The Institute for Strategic Studies, London.

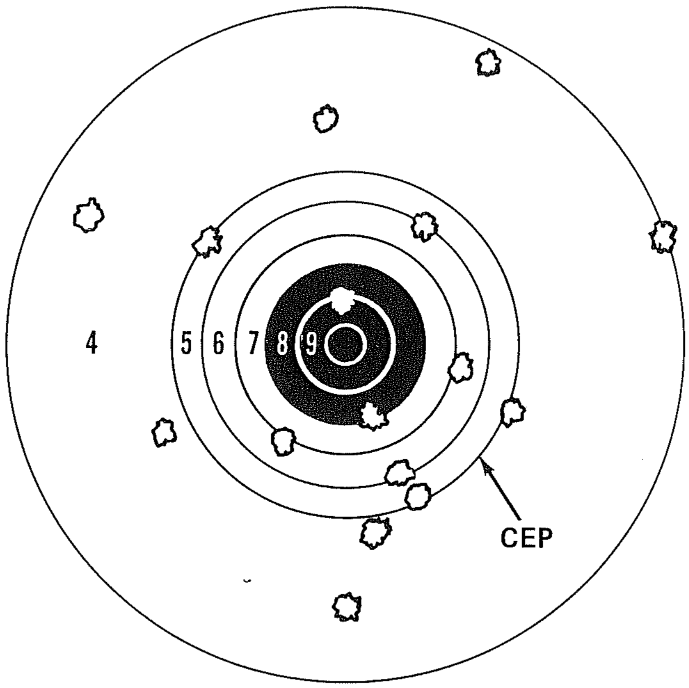
ACCURACY OF WEAPONS

How closely a missile or bomb can be delivered to an aiming point is measured by the CEP (circular error probable) of the weapon system. If a large number of weapons were to be aimed at a single aiming point, the CEP is the radius of the circle that includes half of the resulting actual "ground zeros" or hit points. In other words, half of the ground zeros would be closer than the CEP and half would be further away, as shown in the illustration. A single weapon, then, has a 50-50 chance of hitting within the CEP.

Modern strategic weapon systems have a reasonably high degree of accuracy. A CEP of one-quarter to one-half mile is a common assumption in unclassified discussions of this subject. Since cities are fairly large, weapon accuracy is not an important factor in civil defense planning, although the planner should recognize that, in a large attack, a few weapons will be widely off the mark.

25- FT. TARGET

For All Air and CO   Pellet Rifles



In this target, the ring between 4 and 5 turns out to be the CEP circle because half the shots are inside the circle and half are outside.

RELIABILITY OF WEAPONS

Most of the nuclear weapons that might be used to attack this country would be delivered by ballistic missiles, either land-based (ICBM) or sea-based (SLBM). These missiles are of recent development and have never been used in war. Since no mechanical contrivance works perfectly every time, reliability is an important factor both in planning an attack and in carrying it out. Estimates of reliability are developed in test firings and other operational checks. What the U.S. and U.S.S.R. believe to be the reliability of their own and the other's missiles is a closely-kept secret, but the general range has been described in Congressional testimony.

There are various ways that a missile may fail to achieve its programed objective. It may be in process of a technical modification or scheduled maintenance at the time of need. It may not be "ready" to be launched because of some malfunction that prevents a complete countdown. It may malfunction in the launch process. Finally, it may malfunction in flight. These various problems are multiplicative, so that even when great efforts are made to reduce the probability of failure at each stage, the combination of probabilities may result in limited overall **system** reliability. The table shows an example calculation, assuming that the probability of failure is only one in ten at each stage. Therefore, while the reliability of the missile force of the Soviet Union will never be known until they are used in an attack, that reliability could be as low as 0.5 and is unlikely to be as high as 0.9.

The implication for civil defense planning is not limited to the recognition that only part of the Soviet capability described previously can be expected to be delivered on U.S. targets. It also implies that no one can be certain that destruction of a particular target will actually take place. No part of a city can be "written off." Emergency planning should consider all reasonable contingencies. An example to illustrate this is given in the following pages.

MISSILE RELIABILITY*

Degradation Factor	Assumed Reliability
Missile Availability	0.9
Missile Readiness	x 0.9
Launch Reliability	x 0.9
In-flight Reliability	x 0.9
Overall Reliability	0.66

Under these assumptions, only 2/3 of the missile force would arrive on target. Of the missiles available and targeted, only about 3/4 would arrive.

*As estimated by Daniel J. Fink, former Deputy Director of Defense Research and Engineering in Science and Technology, October 1968.

DIRECT EFFECTS OF A 5-MT WEAPON

The energy released by a nuclear detonation alters the environment in a variety of ways. In the immediate region of the detonation, the main effects are due to the blast wave and the thermal pulse or heat flash. The blast wave can destroy or damage buildings, spread debris, and overturn trees. The thermal pulse can ignite exposed thin fuels, causing many sustained fires. These are the main **direct effects** of the detonation. The general reach of these effects for a 5-MT surface burst is shown in the illustration. The additional reach of an air burst of the same size is given at the bottom of the illustration.

Although people in the open can be burned by the thermal pulse and crushed by the pressure in the blast wave, if it is quite strong, most of the deaths and injuries in cities will result from people being thrown about or struck by missiles formed by the destruction of buildings, trees, and other objects. The overall survivability of people in ordinary structures is also shown in the illustration.

The strength of the blast wave is measured in pounds per square inch overpressure (psi) (see Chapter 2 for details). Note that damage of some significance extends to the region of 1 psi. The region where fires would be ignited as a result of the thermal pulse is well within the damaged area and mainly within the region covered by at least 2 psi overpressure. (See Chapter 3 for more information.)

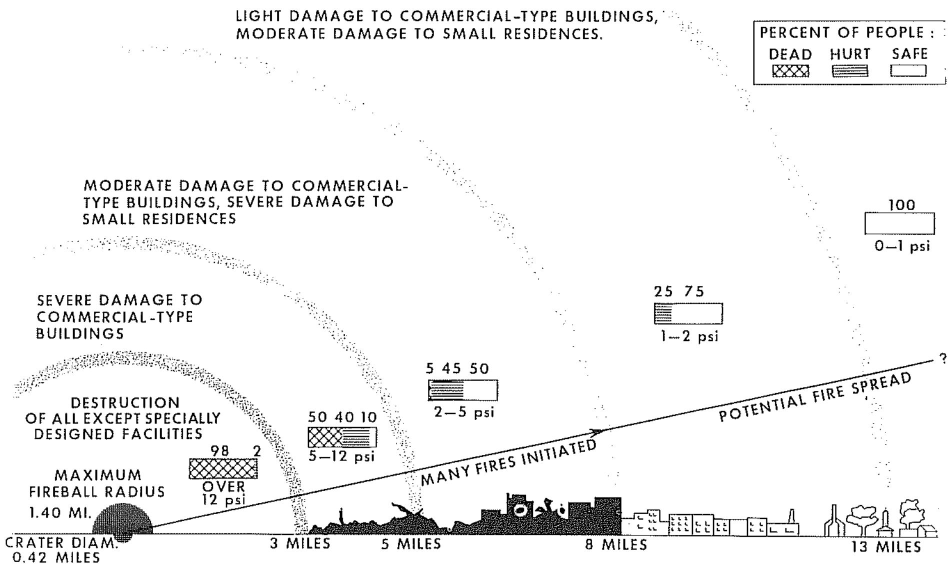
The implications for operational planning where direct effects may occur are:

(1) There will be many survivors in the damaged area, even if no special shelters are provided.

(2) The main firefighting and rescue needs are in the damaged area where debris may bar movement of wheeled vehicles and where water pressure may be lost because of broken connections.

Additional direct effects not shown are initial nuclear radiation and the electromagnetic pulse (EMP). These effects are not important in surface-burst weapons in the megaton yield range. The conditions under which they are important are discussed in Chapters 4 and 5.

DIRECT EFFECTS OF 5 MT. BLAST (SURFACE BURST)



IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 8 MILES TO 13 MILES.

PANEL 7

DIRECT EFFECTS OF OTHER YIELDS

Shown here are the blast and fire consequences of a 1-megaton and a 25-megaton detonation. This covers the yield range of current Soviet missile warheads.

Note that the range of "moderate damage and initial fires on a clear day" changes from 5 miles to 14 miles, an increase by a factor of about 3, for a yield increase of 25 times. This reflects the fact that, for practical purposes, the reach of blast and fire effects vary as the cube root of the weapon yield. (The cube root of 25 is 2.92.) In other words, for the range of direct effects to increase by a factor of 10, the yield must increase a thousand-fold. And that is what happened when "H-bombs" in the megaton-yield range replaced the "A-bombs" having an explosive power in the kiloton-yield range.

Note that an "air burst" at the appropriate altitude would expand the diameter of the damaged area by about 50 percent. These increased effects would be purchased at the price of elimination of the fallout hazard and the reduction of danger from high overpressures. Indeed, a detonation high enough in the air to maximize the reach of moderate damage (2 psi) would produce less than 15 psi at ground zero, leaving many survivors in ordinary buildings, just as there were in the attacks on Hiroshima and Nagasaki.

The areas of moderate damage and fire ignitions are large in any event, ranging from nearly 80 square miles for a 1-MT surface burst to about 625 square miles for a 25-MT surface burst. The average U.S. city of 100,000 has an area of about 25 square miles. Thus, only the very large cities would be of such size as to require multiple weapons or air bursts for widespread damage.

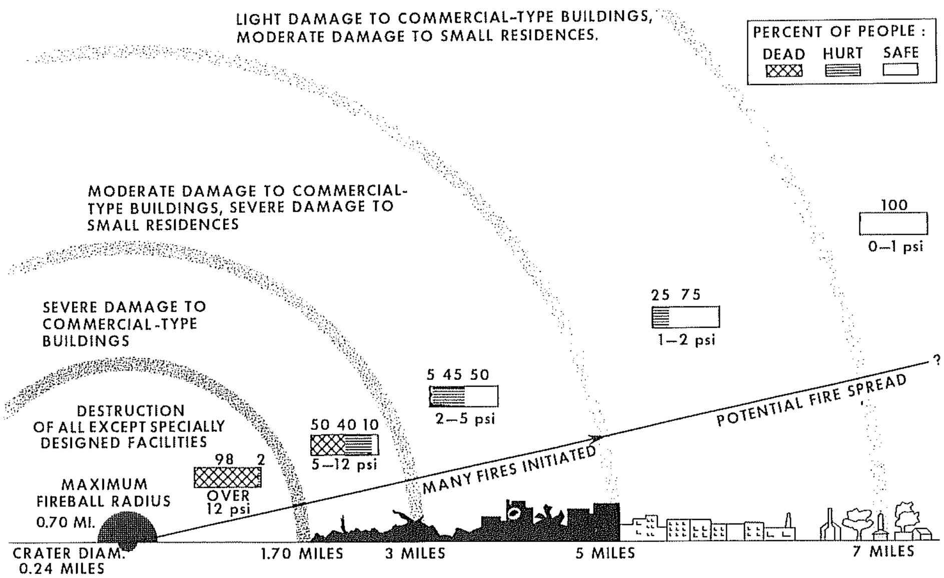
The implications for local emergency planning in metropolitan areas are:

(1) A community should be regarded as being "involved" in a situation of large extent if direct effects are experienced, rather than the reverse—an area of damage within the community's boundaries.

(2) There is a high probability that neighboring and nearby communities will experience similar damage as that in your community.

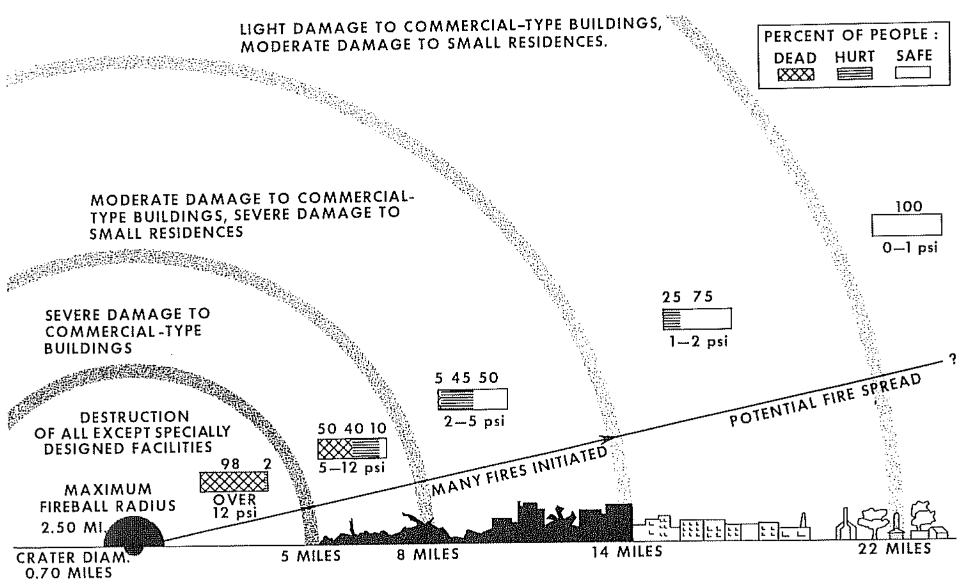
(3) A concerted effort to reduce the resulting threats to life and property by all the communities in the metropolitan area (and beyond) will be needed.

DIRECT EFFECTS OF 1 MT. BLAST
(SURFACE BURST)



IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 5 MILES TO 8 MILES.

DIRECT EFFECTS OF 25 MT. BLAST
(SURFACE BURST)



IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 14 MILES TO 22 MILES.

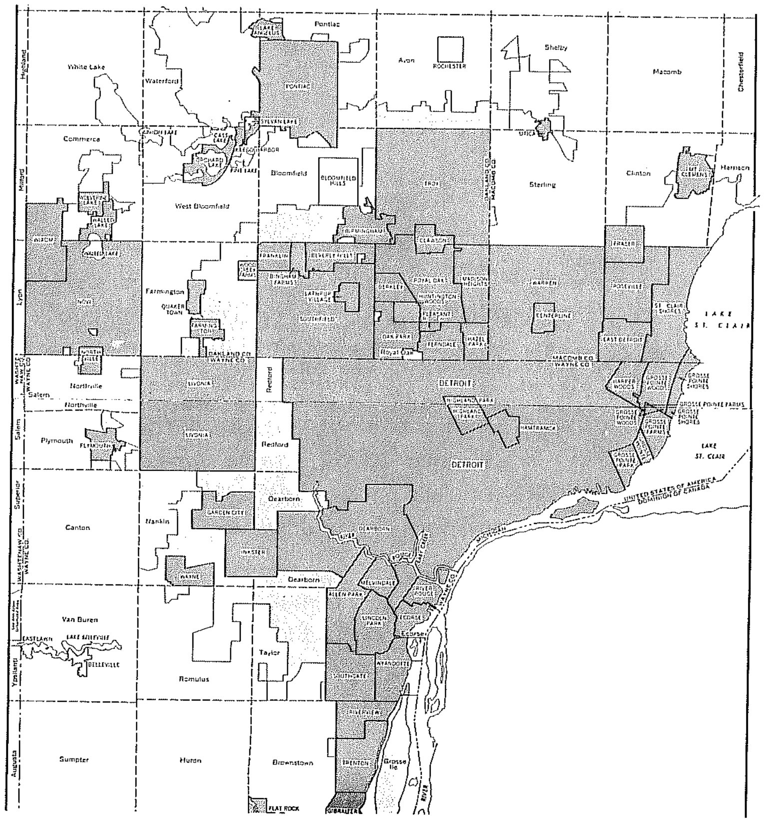
PANEL 8

AN EXAMPLE CITY ATTACK

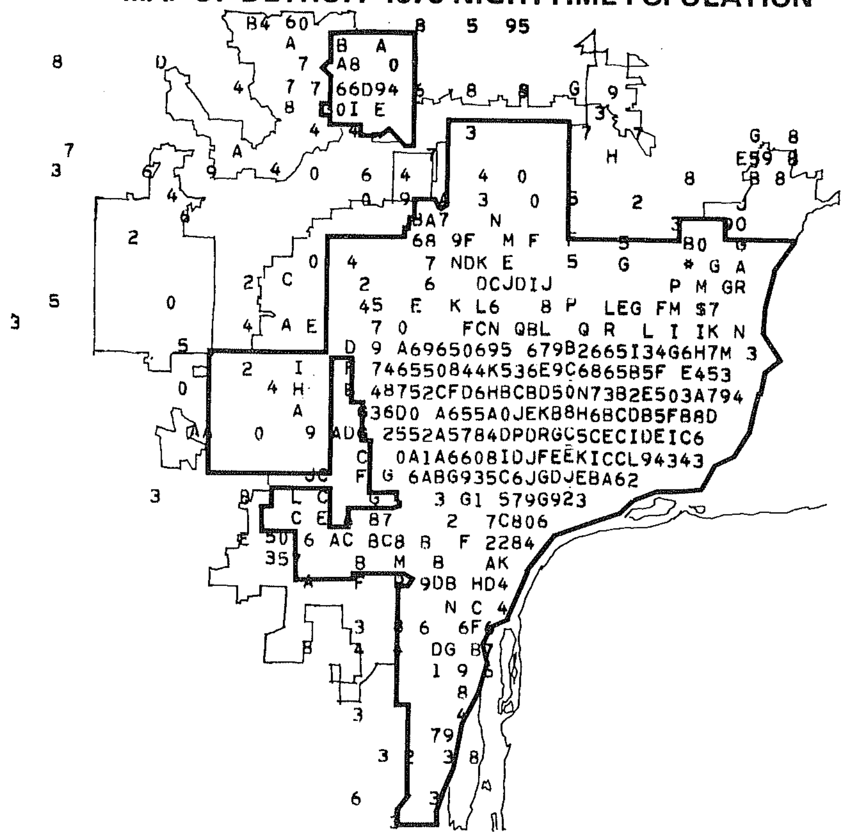
In the next few pages, we will present a picture of what might happen to the population of a city directly attacked by nuclear weapons. The example city is the Detroit metropolitan area. A census map of the Detroit area is shown in the upper figure. Below it is a computer map of the same area, showing the projected night-time population distribution in 1975.

Each number (and letter) in the computer map represents the number of people in "squares" that are 1 mile in the north-south direction and six-tenths of a mile in the east-west direction. The number 1 represents 1000 people or, more specifically, a population count between 500 and 1499 persons. The numbers 2, 3, etc., represent populations of 2000, 3000, etc., within the six-tenths of a square mile occupied by the number. The number 0 represents 10,000 people; the letter A represents 11,000; the letter B, 12,000; etc. Where a blank occurs, there are less than 500 people resident in the location.

CENSUS BUREAU MAP OF DETROIT URBANIZED AREA



MAP OF DETROIT 1975 NIGHTTIME POPULATION



PANEL 9

SURVIVORS FROM TWO 5-MT WEAPONS

Suppose 5-MT weapons were aimed to detonate where they would kill the most people. The weapon accuracy (CEP) is assumed to be one-half mile, and the missile reliability is assumed to be 0.75. All detonations are surface bursts. The population is assumed to be at home in single-family residences, townhouses, apartment houses, and the like.

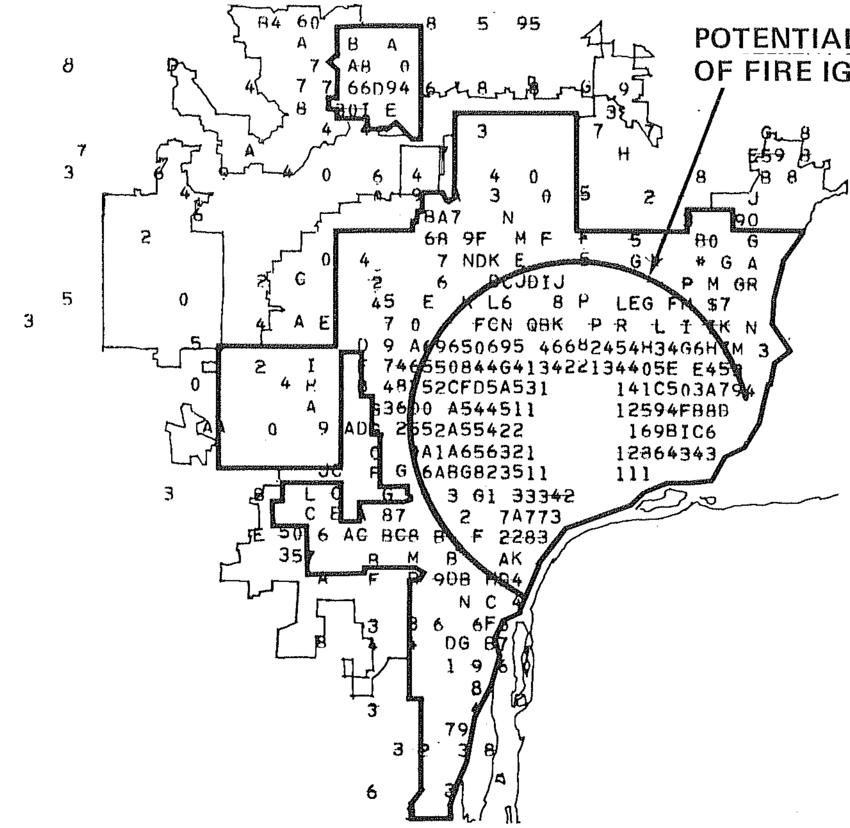
The upper map shows the survivors from a weapon aimed at the most densely populated area. A "hole" of about 3 miles radius has been created in the population map and the neighboring numbers of survivors are quite small. But overall, nearly 82 percent of the population survive the blast effects of this detonation.

The lower map shows the survivors from the detonation of two weapons. Two holes are evident and the total survivors have been reduced to less than 70 percent.

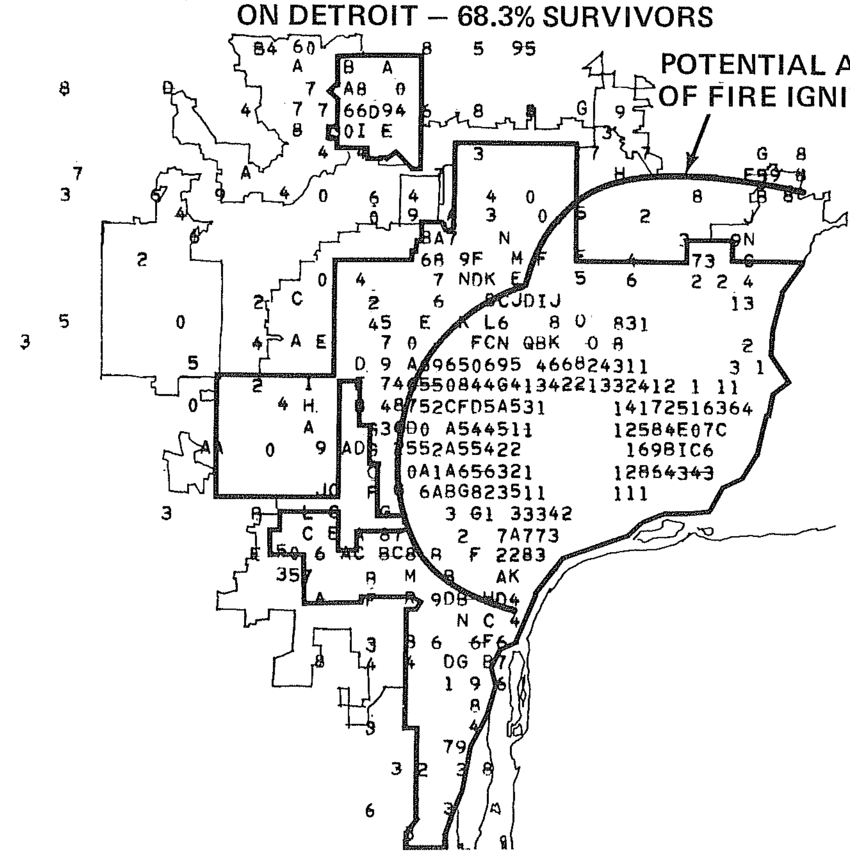
In either case, there are great numbers of survivors in the Detroit area. Civil defense emergency operations would be of great importance. Large numbers of these survivors would be injured and many trapped in wreckage. Although most of the dead are within a few miles of the detonations, fires ignited by the heat flash could be expected out to 8 miles. There would be much debris in this same area and then there would also be fallout. Civil defense operations would be important—and difficult.

Regardless, what these charts show is that, despite the destructiveness of weapons of this size, the city and its people are not obliterated. It is not a case of one bomb—one city (unless the city is quite small). Emergency operations readiness can pay off, even in target areas.

SURVIVORS FROM SAMPLE MONTE CARLO RUN FOR A SINGLE 5 MT WEAPON ON DETROIT – 81.5% SURVIVORS



SURVIVORS FROM SAMPLE MONTE CARLO RUN FOR TWO 5 MT WEAPONS ON DETROIT – 68.3% SURVIVORS



PANEL 10

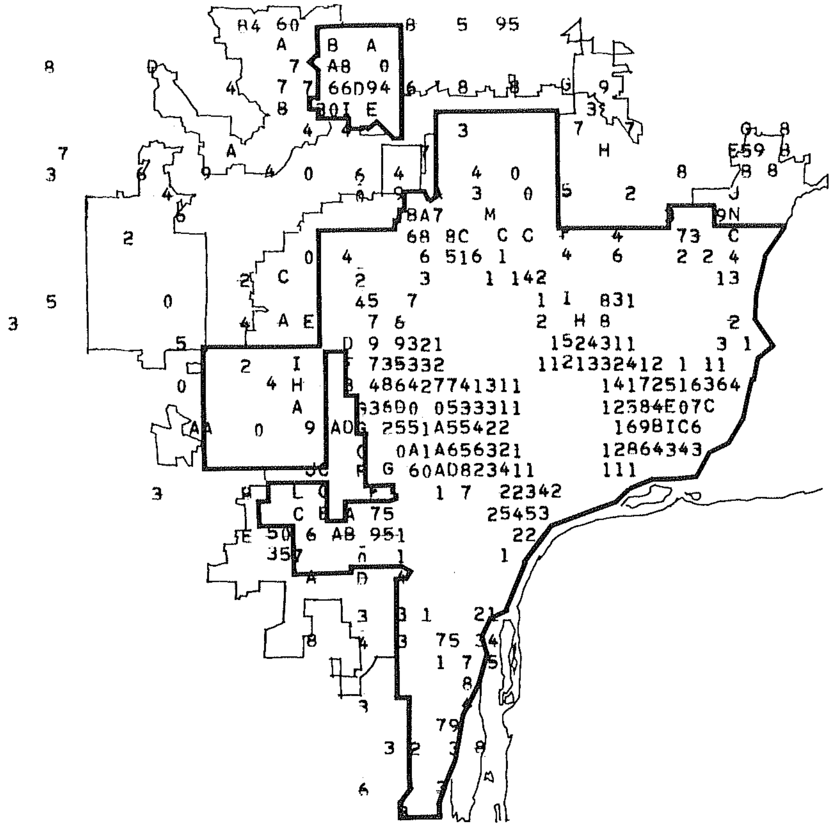
SURVIVORS FROM LARGER ATTACKS

Suppose a much larger attack were made on the Detroit urban area. The upper figure shows the result of five 5-MT weapons aimed at Detroit. Almost half of the population of the metropolitan area survive the blast effects of these weapons.

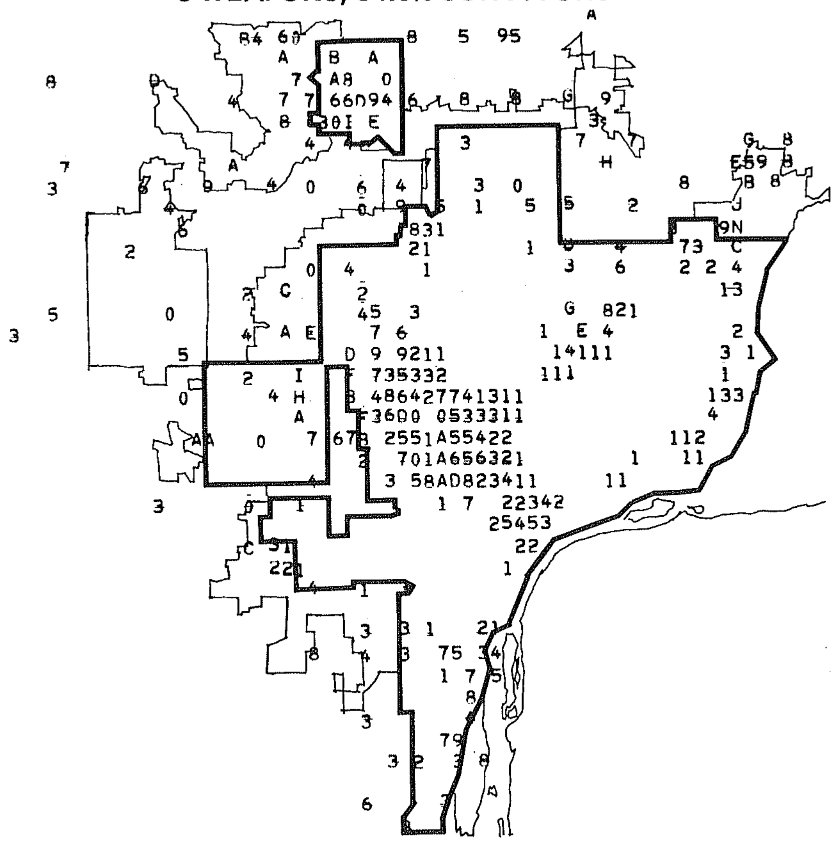
A comparison of this map with the earlier map of the night-time population will disclose only 4 "holes" in the population map. One of the weapons failed to arrive because the missiles are assumed only 75 percent reliable. In effect, the computer draws a number at random from 1 to 100. If the number drawn is 75 or less, the weapon is delivered. If greater than 75, it "malfunctions." In this particular case, weapon number 4 failed to arrive.

The lower figure shows the result for nine aimed weapons. About one-third of the population survive, partly because two weapons fail to arrive. Note the major "island" of survivors in a portion of downtown Detroit.

SURVIVORS FROM SAMPLE MONTE CARLO RUN FOR FIVE 5 MT WEAPONS ON DETROIT – 48.8 SURVIVORS



9 WEAPONS, 34.6% SURVIVORS



PANEL 11

SURVIVORS FROM A VERY LARGE ATTACK

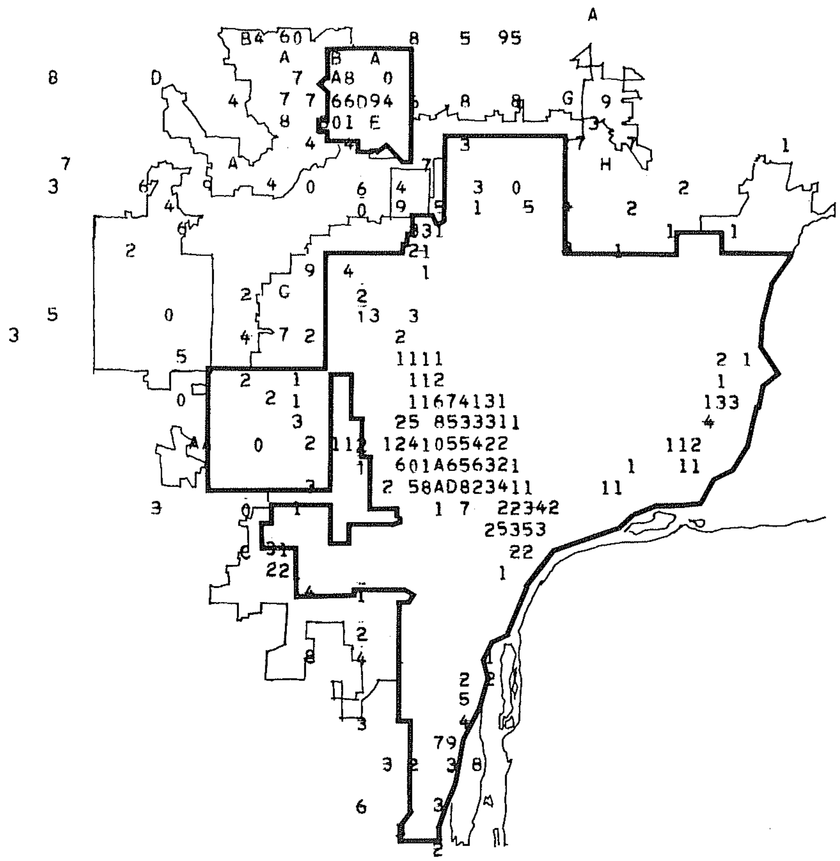
The final map shown is for 15 weapons, each a 5-MT ground burst aimed at the Detroit area. In this computer run, three of the 15 weapons fail to arrive. Nearly one-quarter of the population survive and the "islands" caused by failed weapons are quite evident. Of course, more or fewer missiles could have failed and those that failed could have been others in the group.

The important points for the planner are: (1) many targeted weapons will not arrive; (2) even fallout shelter may be useful in cities; and (3) very large attacks leave survivors in need of emergency aid. As was noted in Panel 10, many of these survivors are injured and at risk from fire and fallout.

One final point. The vulnerability of the population in these examples was assessed as if they were in the aboveground parts of buildings.

If they had been sheltered in the basements of large buildings, about 45 percent of the urban population would have survived the blast effects of a 15-weapon attack. The basis for this statement is discussed in Chapter 2.

SURVIVORS FROM SAMPLE MONTE CARLO RUN FOR FIFTEEN 5 MT ON DETROIT – 22.4% SURVIVORS



PANEL 12

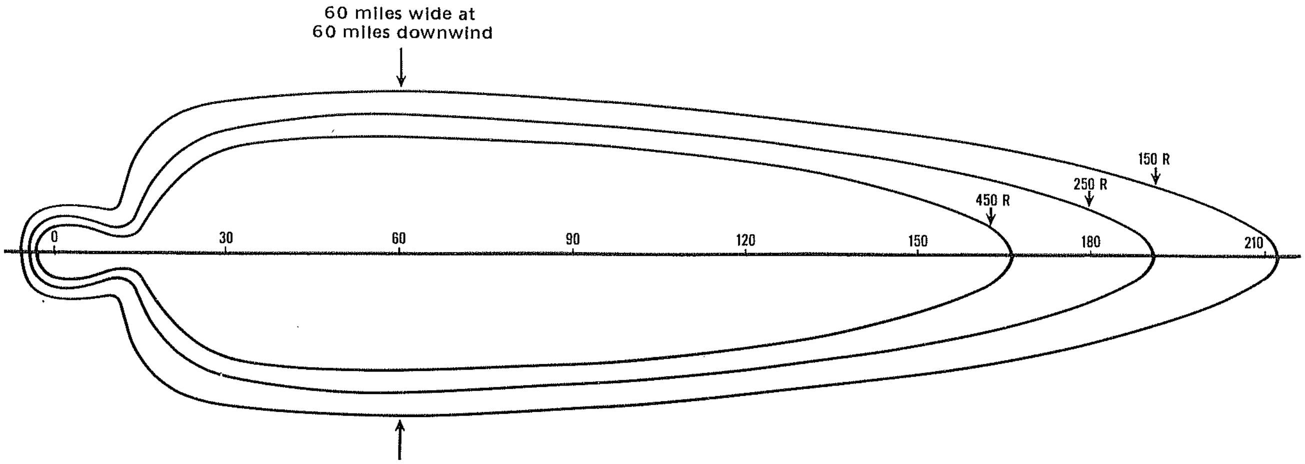
FALLOUT FROM A 5-MT SURFACE BURST

The upper figure shows the general extent of the fallout hazard generated by a single 5-MT surface burst (assuming wind speed of 15 miles per hour blowing toward the right). The contours shown represent the one-week dose to unprotected persons. See Chapter 6 for information on the effect of wind on fallout areas.

The table at the bottom shows the latest information on the consequences of radiation exposure. To illustrate the meaning of the table, people receiving no more than a total of 150 Roentgens, as measured by a dosimeter, during a period of one week or less (1 hour, 1 day, 3 days, for instance) are not expected to need medical care nor to become ineffective in work performance. Accrual of 250 Roentgens would cause some radiation sickness and reduction in work performance. A dose of 350 Roentgens over a period less than one month would have a similar outcome.

Note that one-week doses in the open above 150R may extend over 200 miles downwind of ground zero. Overlapping fallout from several weapons would extend the hazard area much farther.

UNSHIELDED ONE WEEK RADIATION DOSE CONTOURS (SCHEMATIC)



- The expected results of various radiation exposure doses, if received over various periods of time, are shown in the following table.

Acute Effects \ Total Exposure in Roentgens in Any	1 Week	1 Month	4 Months
Medical Care Not Needed	150	200	300
Some Need Medical Care Few if Any Deaths	250	350	500
Most Need Medical Care 50% + Deaths	450	600	*

*Little or no practical consideration.

SIGNIFICANCE OF THE THREAT

If the Soviet Union were to mount an all-out attack on the United States with their present strategic forces, taking into account accuracy, reliability, and other factors, almost the whole population would be located less than 100 miles of at least one nuclear detonation. About half the population would be in areas experiencing at least light damage (overpressure greater than 1 psi). An approximate picture of the probable location of people to weapons aimed against military and industrial facilities can be gained from the table opposite.

The significance for emergency operations planning is:

(1) Virtually every person is within range of potentially serious fallout radiation exposure. All localities need plans for this contingency.

(2) About half the population would be involved in direct weapons effects. Localities near important military and industrial facilities need plans for this contingency as well.

DISTANCE FROM NEAREST WEAPON

(Military-Industrial Attacks)

Distance (miles)	Fraction of Population (percent)
10	45
20	65
40	75
100	95
200	99

WHAT IS A CONTINGENCY?

It is not possible to be sure in advance that any hazardous conditions will or will not occur at any given place. It is necessary to develop civil defense readiness for the major contingencies or attack environments that could reasonably occur.

As the result of enemy attack, a community could find itself in any of the four conditions shown in the figure:

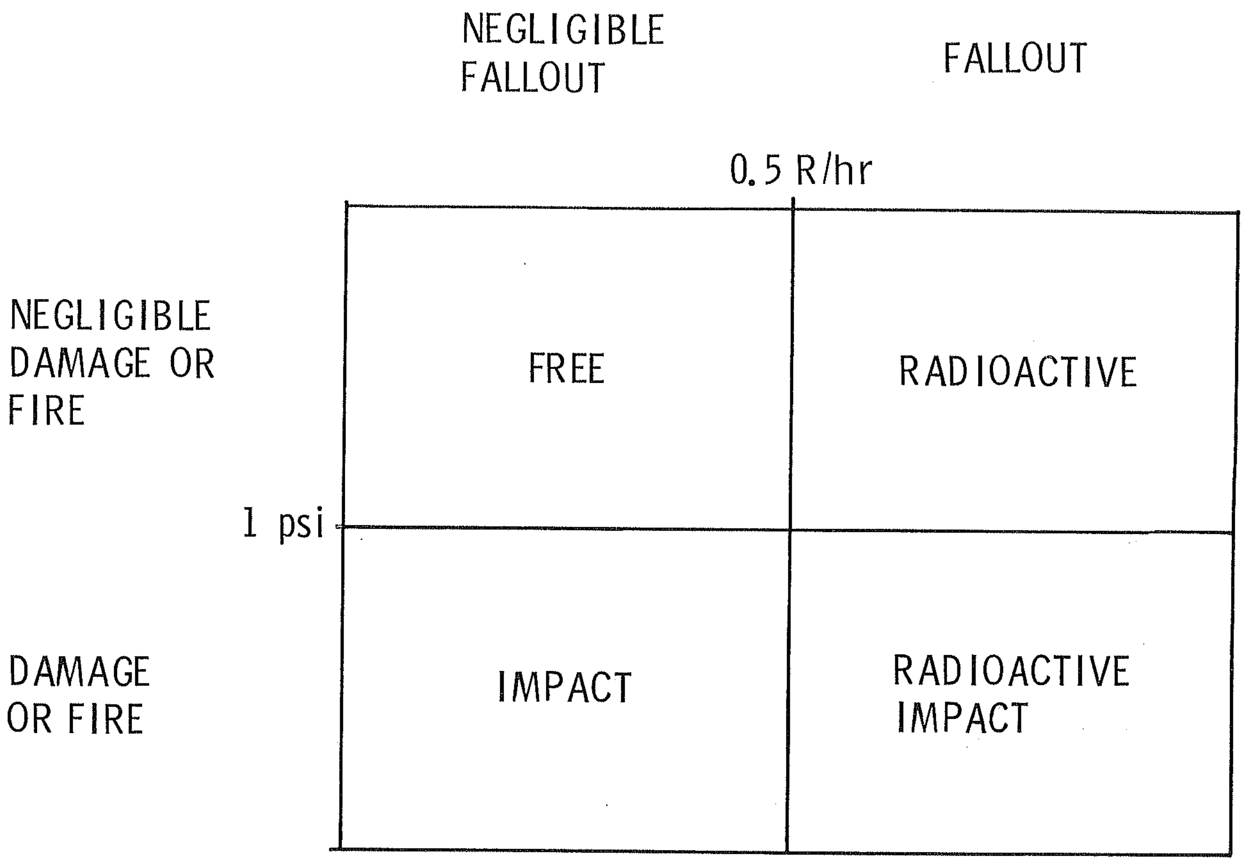
- Free or undamaged areas would be those not affected at all or affected only by fallout radiation of such limited intensity that the dose rate never exceeds 0.5 Roentgens per hour. (Exceeding this dose rate is the standard definition of fallout arrival.) Movement in free areas would not be restricted nor would protective measures be required. But, as we have seen, communities in free areas would generally be within a hundred miles or so of damaged areas and generally much closer. The effectiveness of civil defense operations in saving lives and property could well depend on the carrying out of plans for aid to stricken areas.

- "Radioactive" areas would be affected by fallout only but to such a degree that the dose rate exceeded 0.5 R/hr. Depending on the peak level of fallout radiation that occurs, the fallout radiation hazard could represent a minor impediment to emergency operations or could make any outside operations very hazardous.

- "Impact" areas are those affected by blast damage caused by overpressures in excess of 1 psi or by both damage and ignited fires, but not affected by fallout radiation exceeding a dose rate of 0.5 R/hr. This could occur as the result of air burst weapons or in crosswind and upwind parts of the area of damage from a surface burst.

- "Radioactive-impact" areas would be affected by both damage from blast and fire and fallout radiation in excess of a dose rate of 0.5 R/hr. Emergency operations in such areas would be the most complex and difficult.

These conditions, which are combinations of the presence or absence of direct weapons effects (blast, fire, and initial radiation) and fallout, are the main attack environments for which contingency plans are needed. These plans are "contingency plans" because it will not be known until an attack occurs which of the plans will be needed.


NEGLIGIBLE FALLOUT
FALLOUT
0.5 R/hr
NEGLIGIBLE DAMAGE OR FIRE
FREE
RADIOACTIVE
1 psi
DAMAGE OR FIRE
IMPACT
RADIOACTIVE IMPACT

PANEL 15

EMERGENCY OPERATIONS

Most people have a general idea of the kinds of actions likely to be needed in an emergency. A list of emergency functions is shown, together with an explanatory statement of the purpose of each.

Many of these emergency functions are needed in peacetime and most have been required in various natural disasters. This peacetime familiarity and experience can be a trap for the unwary planner who is unfamiliar with the nuclear attack environment described in this handbook. The common practice of assigning responsibility for emergency functions to local departments and agencies whose peacetime functions are similar, although entirely reasonable, often compounds the operational readiness problem because operating officials tend to assume that their usual methods and procedures will be effective.

A useful definition of an "emergency" is a situation in which the routine ways of coping with problems no longer work. If this were not true, a good deal of the need for "emergency readiness" would vanish.

As an example, consider the function of fire fighting. Accidental fires and arson are everyday threats in peacetime. Professional fire departments, both paid and volunteer, are organized, trained, and equipped to deal with the peacetime fire threat. But, as we have already seen, the wartime fire threat will exist almost entirely in areas of damage where debris may litter the streets, water pressure may be lost, and fire trucks may be trapped in the station house. Even if this were not so, the number of simultaneous building fires in an area serviced by a single fire company could number in the hundreds—far beyond the capability of the professional forces. Just as World War II fire fighters had to rely on stirrup-pump and sand-bucket, every ablebodied man must be a fireman in nuclear attack. More important, the real pay-off in fire defense lies in preventing as many ignitions as possible before the attack occurs. That is why the fire fighting mission is stated as it is. The professionals of the fire department must rise to be the builders, leaders, and controllers of this "emergency fire fighting" capability.

The information needed to develop a real operational readiness to combat fire is contained in Chapter 3. But almost none of the other functions listed can be carried out effectively without use of the information in some part of this handbook.

OPERATING SYSTEM FUNCTIONS

FUNCTION	MISSION
1. Sheltering	To shield against weapon and attack effects and to provide a viable environment for shelter occupants
2. Warning	To alert people and to inform them so that a prudent man will act so as to bring himself into the system as intended.
3. Moving	To move people to where the system can protect or support them and back home when displacement is no longer needed.
4. Rescuing	To assist people to move from a hazardous place to one of lesser hazard.
5. Maintaining Health	To minimize the spread of disease.
6. Fire Fighting	To minimize personal injury and property damage by reducing thermal flux, probability of ignition, and burning rate and by suppressing fires.
7. Maintaining Law and Order	To protect people and property against illegal acts and to improve system effectiveness by maintaining order.
8. Protecting Livestock	To minimize damage to, and denial of the product of, livestock.
9. Emergency Shutdown	To reduce damage to property caused (1) by leaving it unattended or (2) by not leaving it in its best posture to sustain attack effects.
10. Medical Care	To minimize death and disability from illness and injury and to care for those displaced because of the threat or the effects of attack.
11. Feeding	To provide food and water to those displaced by attack or threat of attack or to whom normal supply channels are closed.
12. Housing	To provide temporary lodging to people displaced in a strategic or remedial movement.
13. Restoring Facilities	To repair or replace utilities and facilities vital to the survival of the people and the functioning of the system.
14. Decontaminating	To minimize denial of access and radiation damage by removing contaminating radioactive materials.
15. Welfare Services	To provide material aid and counsel for people displaced by attack or threat of attack.

*From Devaney, J.F., **The Use of Systems Techniques in Civil Defense**, URS Research Co., May 1970.

PANEL 16

OPERATIONS IN VARIOUS CONTINGENCIES

Not all emergency functions will be needed in every contingency. Indeed, one might conclude that no emergency functions would be required at all where the community found itself free of weapon effects following an enemy attack. The table shown here indicates that such is not the case. Widespread loss of electric power because of attack effects elsewhere and the disruption of normal supply channels could precipitate health and feeding problems. The normal livelihood of many individuals would have been jeopardized. Refugees from stricken areas, many injured, may need care. And, in any event, the population must be sheltered until it becomes clear that the local area will remain free of attack effects. Thus, a plan for the free contingency is needed.

Although the table indicates the general applicability of emergency measures in the various contingencies, it leaves important issues unresolved. Sheltering and many other functions are of a different character in radioactive areas than they are in impact areas. Fire fighting in impact areas where fallout is also present presents problems not encountered in impact areas without fallout. (Accidental fires can occur outside impact areas, but these can be dealt with more or less routinely, as in peacetime.) And what if fires rage out of control, despite the best efforts of the defenders?

Questions like these suggest that what is needed for emergency operational planning is an indication of the relative priorities among the various emergency functions and the ways they should be grouped into coordinated activities.

OPERATIONS IN CONTINGENCIES

Function	Contingencies			
	Free	Impact	Radioactive	Radioactive-Impact
1. Sheltering	*	Yes	Yes	Yes
2. Warning	*	Yes	Yes	Yes
3. Moving	No	Yes	Yes	Yes
4. Rescuing	No	Yes	No	Yes
5. Maintaining Health	Yes	Yes	Yes	Yes
6. Fire Fighting	No	Yes	No	Yes
7. Maintaining Law and Order	Yes	Yes	Yes	Yes
8. Protecting Livestock	*	No	Yes	No
9. Emergency Shutting Down	*	Yes	Yes	Yes
10. Medical Care	**	Yes	Yes	Yes
11. Feeding	Yes	Yes	Yes	Yes
12. Housing	**	Yes	Yes	Yes
13. Restoring Facilities	No	Yes	No	Yes
14. Decontaminating	No	No	Yes	Yes
15. Welfare Services	**	Yes	Yes	Yes

*At least until threat of attack is over.
**At least for evacuees from affected areas.

TWO BASIC FIRE SITUATIONS

As we have seen, sheltering is the basic measure that shields the population against weapon effects, both direct effects and fallout. This is true whether special-purpose shelters are constructed, best available space in existing structures is used, or people are evacuated from cities to the hinterland where "expedient" protection is sought.

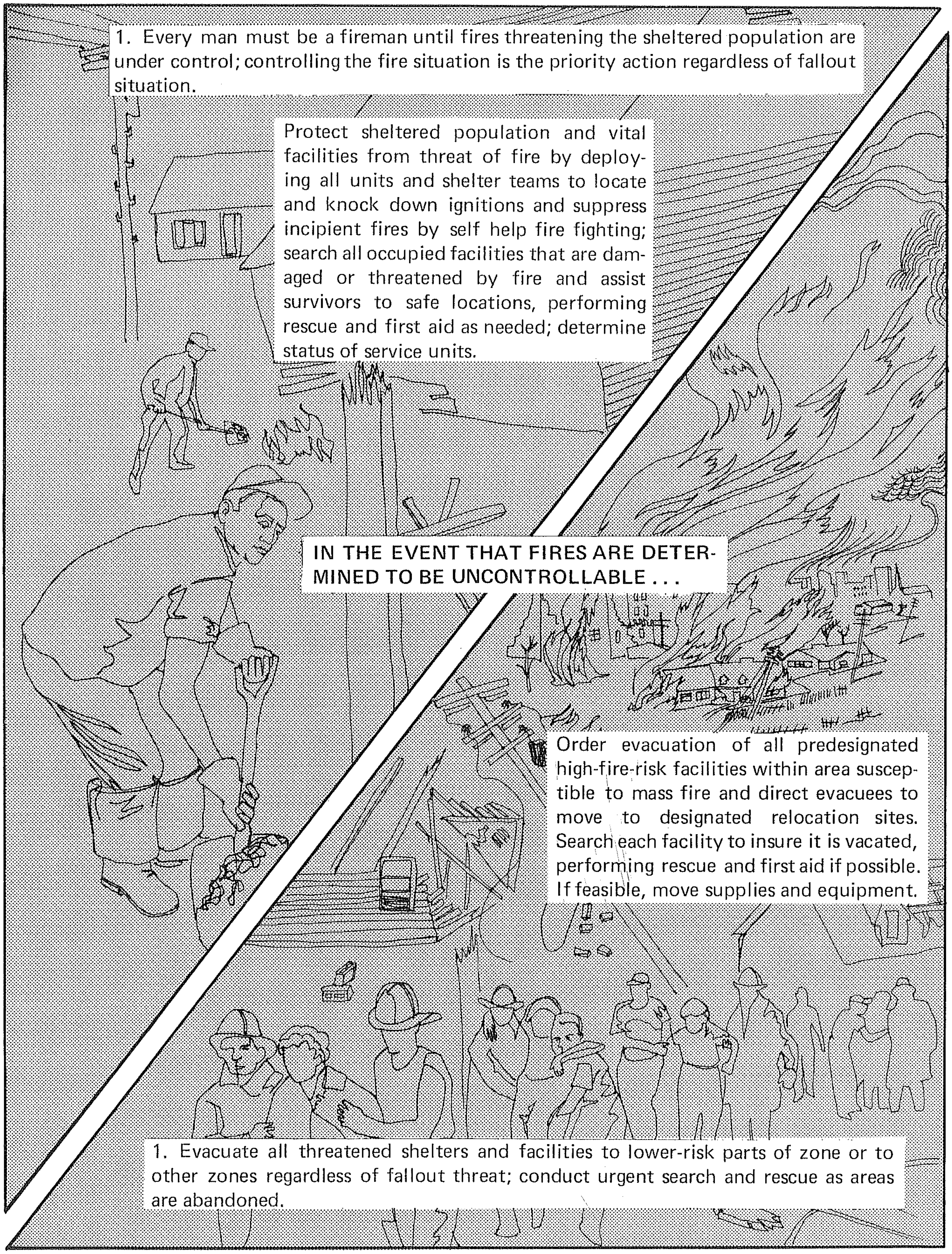
In impact areas and radioactive-impact areas, the basic goal of emergency operations must be to preserve the population in their sheltered condition. Fire developing from ignitions caused by the blast and thermal pulse will be the major continuing threat to the sheltered population. Therefore, emergency operations in these areas will necessarily focus on and be determined by the emerging fire threat.

As will be seen in Chapter 3, the ignitions develop slowly into sustained fires, partly because the blast wave tends to reduce them to a smouldering condition. Prompt action to control ignitions in their early stages can be quite effective. For a period ranging up to an hour or more, all ignitions are potentially controllable. During the "controllable fire" situation, all efforts must be directed toward fire suppression, and other emergency actions would be taken only for the purpose of contributing to the fire control effort.

If emergency fire fighting is successful, the incipient fires will be suppressed or contained, with perhaps the loss of only a few buildings. On the other hand, the fire suppression effort may be insufficient and developing fires may get out of hand. Where most survivors are injured or damage and debris prevent prompt action, it may become clear almost at the outset that the developing fires cannot be controlled. In the "uncontrollable fire" situation, the focus of actions would shift from fire suppression to the search, rescue, and movement of the survivors out of the fire area or to refuges where they can survive the ensuing burnover.

These two fire situations—controllable and uncontrollable— are really two different contingencies to be planned for. In other words, two separate plans for two separate sets of coordinated actions will be needed for impact areas.

PANEL 18


1. Every man must be a fireman until fires threatening the sheltered population are under control; controlling the fire situation is the priority action regardless of fallout situation.
Protect sheltered population and vital facilities from threat of fire by deploying all units and shelter teams to locate and knock down ignitions and suppress incipient fires by self help fire fighting; search all occupied facilities that are damaged or threatened by fire and assist survivors to safe locations, performing rescue and first aid as needed; determine status of service units.
IN THE EVENT THAT FIRES ARE DETERMINED TO BE UNCONTROLLABLE . . .
Order evacuation of all predesignated high-fire-risk facilities within area susceptible to mass fire and direct evacuees to move to designated relocation sites. Search each facility to insure it is vacated, performing rescue and first aid if possible. If feasible, move supplies and equipment.
1. Evacuate all threatened shelters and facilities to lower-risk parts of zone or to other zones regardless of fallout threat; conduct urgent search and rescue as areas are abandoned.

PANEL 18

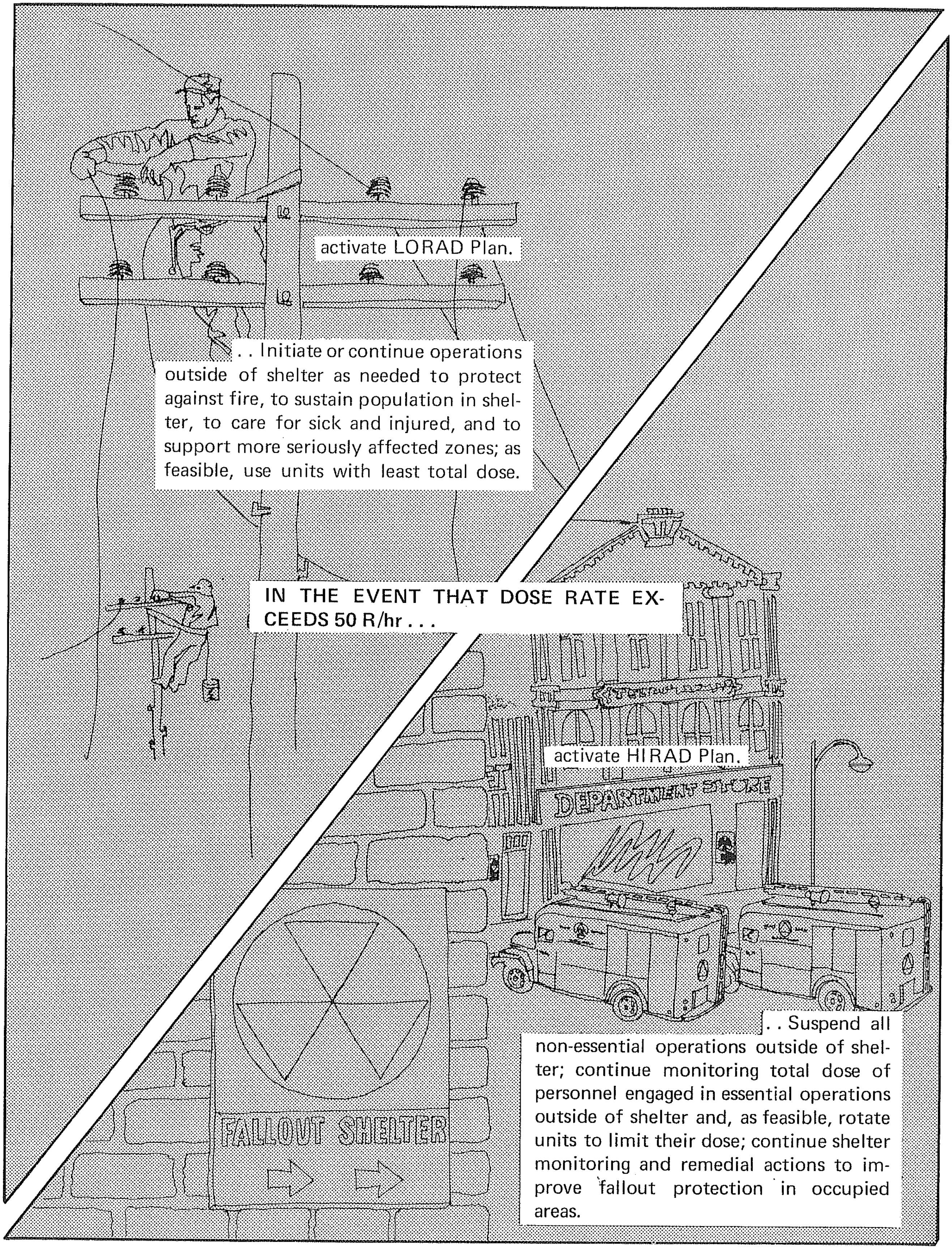
TWO BASIC FALLOUT SITUATIONS

For operational purposes, it is also important to subdivide the radioactive condition into two basic operating situations. Dose rates of a few Roentgens per hour, although above the fallout arrival criterion of 0.5 R/hr, would place only minor restrictions on outside operations. At higher dose rates, less and less time could be devoted to emergency operations without subjecting personnel to doses that could prove disabling. At 50 R/hr, three to four hours of exposure would result in some radiation sickness.

In the high radiation region above 50 R/hr, few outside operations are feasible without risking incapacitating exposure. Only desperate needs, such as protecting the population against fire, would justify emergency operations. Unless a critical need existed, the most appropriate response would be to "pin down" in the best available fallout shelter until radioactive decay results in a less hazardous fallout environment.

Below 50 R/hr, outside operations are generally feasible. Operations should be confined to essential tasks, such as search and rescue, resupply of shelters, and reconstitution of urgent utility services. Exposure of persons conducting such operations can be controlled by rotation of work crews and similar measures. Therefore, the range of appropriate emergency actions is much greater than in the high radiation situation and should be planned for as a separate contingency.

For planning purposes, the measured dose rate of 50 R/hr has been taken as the dividing line between dose-controlled operations in radioactive areas and a virtual "pin down" situation.


activate LORAD Plan.
. . Initiate or continue operations outside of shelter as needed to protect against fire, to sustain population in shelter, to care for sick and injured, and to support more seriously affected zones; as feasible, use units with least total dose.
IN THE EVENT THAT DOSE RATE EXCEEDS 50 R/hr . . .
activate HIRAD Plan.
DEPARTMENT STORE
FALLOUT SHELTER
. . Suspend all non-essential operations outside of shelter; continue monitoring total dose of personnel engaged in essential operations outside of shelter and, as feasible, rotate units to limit their dose; continue shelter monitoring and remedial actions to improve fallout protection in occupied areas.

PANEL 19

BASIC OPERATING SITUATIONS

Based on consideration of the fire and fallout problems, the four conditions of damage should be expanded to the nine Basic Operating Situations shown here. As can be seen, the "Radioactive Area" has been divided into the two fallout situations, "moderate" and "severe." The "Impact Area" has been subdivided into two fire situations, "controllable" and "uncontrollable." The Radioactive-Impact Area has become four basic situations: 5, 6, 8, and 9. The combinations of conditions of fire and fallout are shown in the boxes, where NEG- means negligible, LO means moderate or controllable, and HI means severe or uncontrollable.

In general, these Basic Operating Situations (BOS) form an adequate basis for the preparation of contingency plans for emergency operations under nuclear attack conditions. It is the purpose of this handbook to give the planner some insight into the nature of the attack environment that would be encountered in each of these situations and the implications of the attack environment for emergency operations planning.

Each BOS (pronounced "bahss") can be identified by readily observable characteristics of the attack environment. In an actual attack, rapid assessment of the BOS and automatic response through planned actions will be essential if timely operations to save lives are to be carried out.

It will be noted that the numbering of the Basic Operating Situations corresponds approximately to the severity of the situation. If more than one BOS were to exist within the community at the same time, the contingency plan appropriate to the most severe situation (highest numbered BOS) should be used. BOS numbers will also be found highly useful as a brevity code for communicating a situation report.

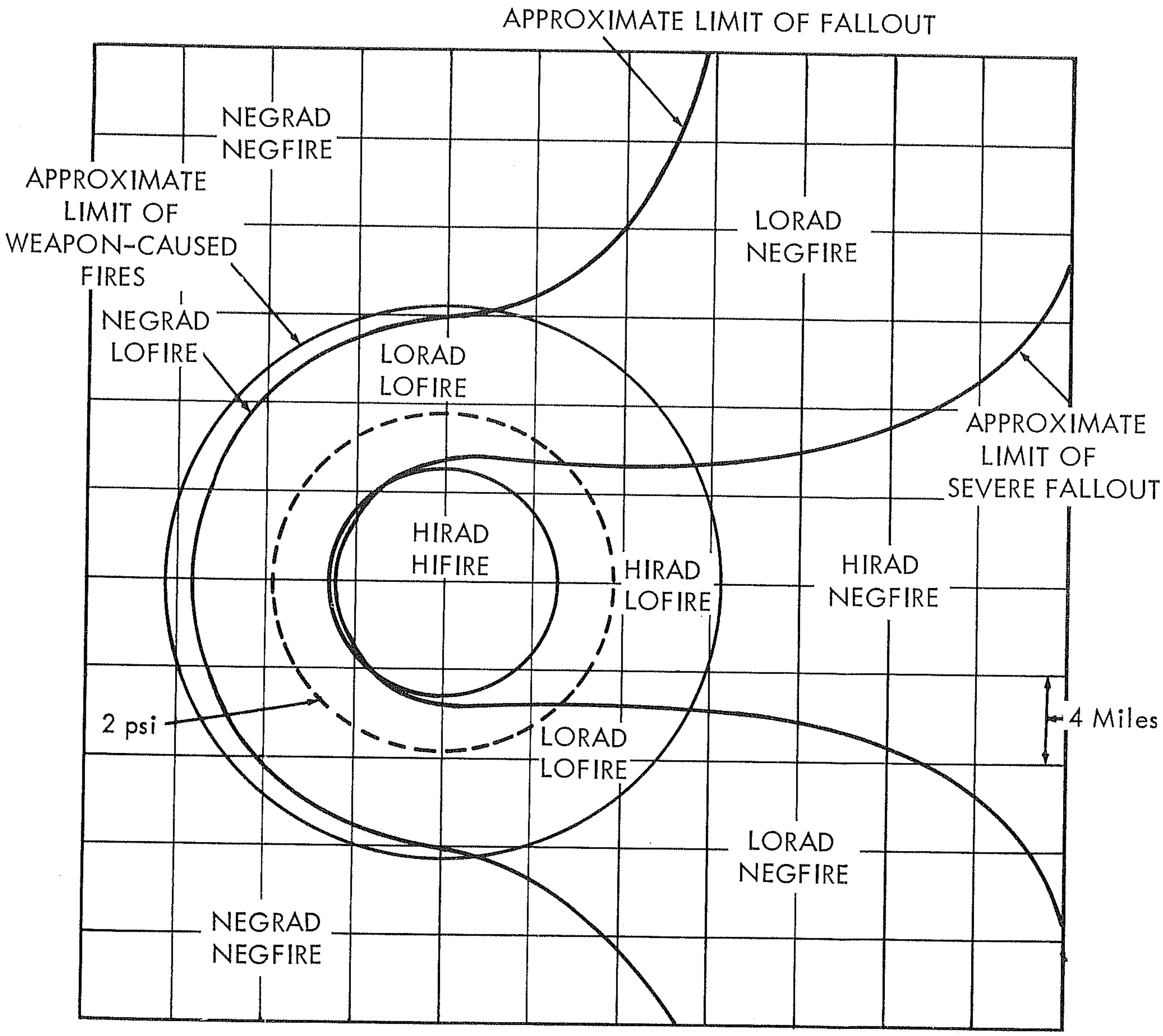
	NEGLIGIBLE FALLOUT	MODERATE FALLOUT	SEVERE FALLOUT
		0.5R/hr	50R/hr
NEGLIGIBLE DAMAGE OR FIRE	1 NEGRAD NEGFIRE	2 LORAD NEGFIRE	3 HIRAD NEGFIRE
1 psi			
DAMAGE OR CONTROLLABLE FIRE	4 NEGRAD LOFIRE	5 LORAD LOFIRE	6 HIRAD LOFIRE
UNCONTROLLABLE FIRE	7 NEGRAD HIFIRE	8 LORAD HIFIRE	9 HIRAD HIFIRE

Basic Operating Situations

APPLICATION TO A 5-MT SURFACE BURST

A first approximation of the relationships among the nine Basic Operating Situations can be seen in this illustration of the close-in area around a single 5-MT surface burst. The most severe BOS is shown in the various parts of the area and related to a grid 4 miles on a side.

The fallout pattern is representative for a wind speed of about 15 miles per hour. (See Chapter 6 for a discussion of the effect of wind speed.) The assumptions defining the fire area are more complex. The LOFIRE area is assumed to be defined by the area having a blast overpressure of at least 1 psi, which encompasses the region of significant damage to buildings, especially single-family residences. The range of initial fires on a clear day, however, is likely to be limited to about the 2-psi line, which is shown as a dotted circle. As will be discussed in Chapter 3, the region of uncontrollable fire (HIFIRE) is related more to the built-upness of the urban area and the fire defense actions taken than it is to the distance from Ground Zero. For illustrative purposes, we have assumed that the HIFIRE circle encompasses the area having an overpressure of at least 4 psi. The actual fire situation is likely to be much less uniform than that shown here. The circumstances under which uncontrollable fires may occur are described in Chapter 3.



CLOSE-IN EFFECTS OF 5-MT SURFACE BURST
(15 mph wind speed)

PANEL 21

APPLICATION TO A MILITARY-INDUSTRIAL ATTACK

A better appreciation of the significance of the nine Basic Operating Situations for planning can be gained by considering the location of blast survivors after a large attack against military and industrial targets in the U.S. The delivered megatonnage in this hypothetical attack is 4700, with weapon yields ranging from 1MT to 25 MT.

About 17 percent of the preattack population (about 35 million people) are judged to have been killed outright in the direct effects area. The percentage figures in the diagram indicate the proportion of survivors experiencing at most the BOS shown.

Note that 70 percent of the survivors are outside the direct effects area (a BOS of 3 or less). Most of these people (nearly 90 percent) are in fallout areas; the majority in a severe fallout area. The safety of more than half the survivors would depend on how well communities are prepared with community shelter plans and the emergency operations plans to make the best available fallout shelter work.

Almost all of the survivors in the direct effects area (BOS 4 and higher) will also experience fallout. Preserving the fallout shelter of these people would be of prime importance. The assumptions on fire in this case are the same as in the previous chart. Under the assumption of uncontrollable fire above 4 psi blast overpressure, most of the blast survivors would be in an uncontrollable fire situation and would need to be moved to safer areas. A major implication for emergency planning is that the continued survival of over 60 million survivors would depend on how well prepared the urban communities were to control the fires in the damaged areas.

BASIC OPERATING SITUATIONS FOR BLAST SURVIVORS OF A MILITARY-INDUSTRIAL ATTACK

	NEGLIGIBLE FALLOUT	MODERATE FALLOUT	SEVERE FALLOUT	
NEGLIGIBLE DAMAGE OR FIRE	1 8%	2 16%	3 46%	70%
DAMAGE OR CONTROLLABLE FIRE	4 (Very Small)	5 1%	6 8%	9%
UNCONTROLLABLE FIRE	7 Negligible	8 4%	9 17%	21%
	8%	21%	71%	

Fallout boundaries: 0.5 R/hr (between negligible and moderate fallout); 50 R/hr (between moderate and severe fallout). Damage boundary: 1 psi (between negligible damage or fire and damage or controllable fire).

The survivors of this 4700-MT attack against military and industrial objectives constitute 83 percent of the preattack population, 17 percent having been killed immediately by the blast effect.

PANEL 22

ANOTHER USEFUL APPROACH TO PLANNING

We have seen that, in a large attack, almost the whole population will find itself within 100 miles of at least one nuclear detonation. This suggests that emergency aid to the communities in the damaged areas could save many lives. The previous example indicated that about 70 percent of the immediate survivors would be free of direct effects. This majority of survivors constitutes a great potential for mutual aid, either immediately or as soon as the severe fallout hazard subsides.

If we define a "nearby burst" as one sufficiently near for the blast wave to break windows (about 0.1 to 0.2 psi), most of the population that was "free of direct effects" would be nearby. Communities in this situation should be prepared to render "close support" to those in the direct effects area. Communities beyond the region of glass breakage should be prepared to render "back-up support" if requested.

Planners who are familiar with the format of the Checklist Guide for Nuclear Emergency Operations Planning (also called ALFA NEOP—being published as CPG 2-2A) will recognize that the plan sections in the checklist follow this approach.

Plan B covers Back-up support to distant burst areas.

Plan C covers Close support to nearby areas.

Plan D covers Damage control in the direct effects area.

Plan E covers Evacuation of shelters at risk from uncontrollable fire.

Plan A, of course, is the preattack increased readiness plan.

With respect to mutual aid, this will be found to be a useful approach to contingency planning.

FREE OF DIRECT EFFECTS	DISTANT BURSTS	B ackup Support
	NEARBY BURSTS	C lose Support
DIRECT EFFECTS	CONTROLLABLE FIRE	D amage Control
	UNCONTROLLABLE FIRE	E vacuation of Area

PANEL 23

THE NEED FOR DIRECTION AND CONTROL

The general nature of civil defense operations under nuclear attack conditions that has been presented in this Chapter should indicate the need for effective direction and control of emergency operations. Time is of the essence in emergency operations. Measures tardily taken will probably be ineffective. The Basic Operating Situation must be assessed quickly so that coordinated actions can be carried out expeditiously. Local organization and training must reflect the reality of the probable contingencies.

Direction and control functions, which span those shown here, are best centered in an Emergency Operations Center (EOC) where the decision-makers can be provided with all of the relevant information on attack effects and the condition of emergency forces and the population. Operations in radioactive areas, for example, require information on fallout conditions that can only be obtained by special monitoring equipment, the use of which is discussed in Chapter 6. This RADEF capability is an essential part of direction and control.

Because nuclear weapons effects cover large areas and are no respector of jurisdictional boundaries, a hierarchy of EOCs is needed. No community can afford to plan to "go it alone" as if the war stopped at the city limits. In many instances, mutual aid will make the difference of life or death for large numbers of people.

Similarly, each community will need subordinate direction and control nodes for the operating services and the sheltered population. In subsequent chapters, the planner will be reminded of the usefulness of staging areas and shelter complex headquarters in the carrying out of emergency operations.

DIRECTION AND CONTROL*

CONTROL	MISSION
1. Organizing	To control the employment of available staff, facilities, equipment, and supplies so as to maximize system readiness to use its remaining capability in the real emergency environment.
2. Planning	To define the problems existing in the situation and to inform the executive as to the courses of action available to him and the probable results and risks expected for each.
3. Informing	To acquire data, process them into the required form, store and retrieve them, and communicate them to the person who needs them when he needs them.
4. Deciding	To judge the relative worth and desirability of alternative courses of action and to select the course to be taken.
5. Commanding	To require that a selected course of action be taken and to review the effects of taking it.

*From Devaney, J. F., The Use of Systems Techniques in Civil Defense, URS Research Company, May 1970.

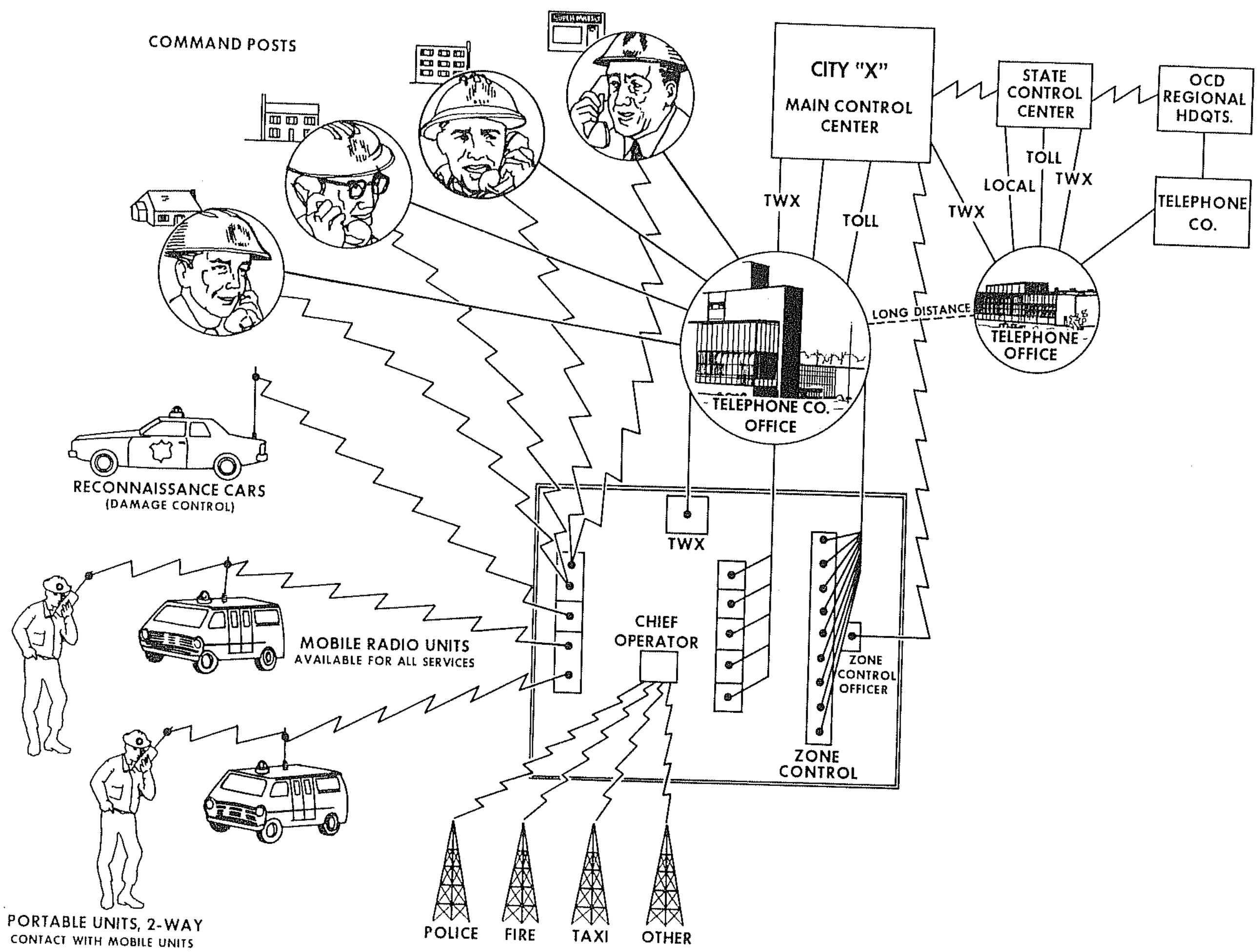
THE IMPORTANCE OF COMMUNICATIONS

Organized and coordinated emergency actions require communication of essential information throughout the civil defense operating system. Public safety in peacetime depends on police, fire, and public works communication nets. The disruptive effects of natural disasters on communications have often been a major impediment to effective emergency operations. The nuclear attack environment will place additional strains on communication capabilities. Some of the threat to continued communication, such as the electromagnetic pulse (EMP), are peculiar to nuclear attack and not well understood by most people. These problems and the practical ways to deal with them will be outlined in appropriate parts of this manual.

Some essential parts of the civil defense operating system do not have well-developed emergency communications. Notable examples are the medical services and the shelter system. Planners must pay particular attention to improving operational readiness in these areas.

Despite the best efforts of all concerned, communications outages must be expected under nuclear attack conditions. Plans must be laid to permit operations to "degrade gracefully" in the face of communications difficulties. Through training and exercises, the basic concepts of emergency operations must be instilled at all levels of operation so that direction and control can become decentralized as necessary to meet the situation. If this is not done, communications losses can lead to catastrophic failure of organized action.

COMBINED WIRE AND RADIO COMMUNICATIONS



CONCEPT OF OPERATIONS

All of the foregoing leads to the general concept of operations summarized here.

The challenge of realistic emergency operations planning is to translate these precepts into specific arrangements that will organize all local capabilities and resources to carry out the civil defense mission within the particular community and the surrounding region. The general actions needed are enumerated in planning guidance and emergency action checklists. They are further discussed in the following chapters.

Until the planner explores each necessary action to the point where specific assignments can be made, the foundation for operational readiness will not be laid. Realistic plans will define exactly who will carry out what tasks and with what resources in response to events precipitated by the attack. This will require a firm understanding of the operating conditions under which each action must be carried out.

SUGGESTED ADDITIONAL READING

The following sources provide additional background on the material in this chapter:

Effects of Nuclear Weapons, Revised Edition 1964, Glasstone, S. (editor), Superintendent of Documents, GPO.

DCPA **Local Emergency Action Check List (Field Test Edition)**, FG G-1.2/2, June 1971.

Devaney, J.F., **The Use of Systems Techniques in Civil Defense**, URS Research Co., May 1970.

National Security Strategy of Realistic Deterrence, Annual Defense Department Report for FY 1973, February 1972.

Background of Civil Defense and Current Damage Limiting Studies, OCD, TR-35, June 1966.

Schmidt, L.A., A **Sensitivity Analysis of Urban Blast Fatality Calculations**, Institute for Defense Analyses, January 1971.

Rainey, Charles T., **Nuclear Emergency Operations Planning at the Operating Zone Level**, Stanford Research Institute, October 1970.

Harker, Robert A., **Evaluation of Emergency Operations Simulation Training**, URS Research Co., November 1970.

NOW THAT WE'RE ORGANIZED
WHAT THE HECK ARE WE SUPPOSED TO DO?

CPG 2-1A2
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 2

WHAT THE PLANNER NEEDS TO KNOW
ABOUT BLAST AND SHOCK

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 2

This description of the blast and shock effects of nuclear attack is intended to provide the operational planner with the basic information needed to plan realistic actions to be taken in damaged areas. It does not assume knowledge of the material in subsequent chapters of the Manual. It does presume that the reader is familiar with the material in Chapter 1—Introduction to Nuclear Emergency Operations.

Information is presented in the form of "panels" each consisting of a page of text and an associated sketch, photograph, chart or other visual image. Each panel covers a topic. This preface is like a panel with the list of topics in Chapter 2 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with three introductory panels, followed by three panels on air blast characteristics. There are five panels on basic blast effects, followed by seven on survival in various types of buildings. Three subsequent panels summarize the best available blast shelter and how best to use it. The next nine panels discuss blast damage to equipment and facilities, including the nature of the resulting debris situation. Two panels provide answers to common questions about the effects of terrain and builtup areas on blast destruction. Finally, four panels summarize the overall blast effects in urban areas. There is a list of suggested additional reading for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 2

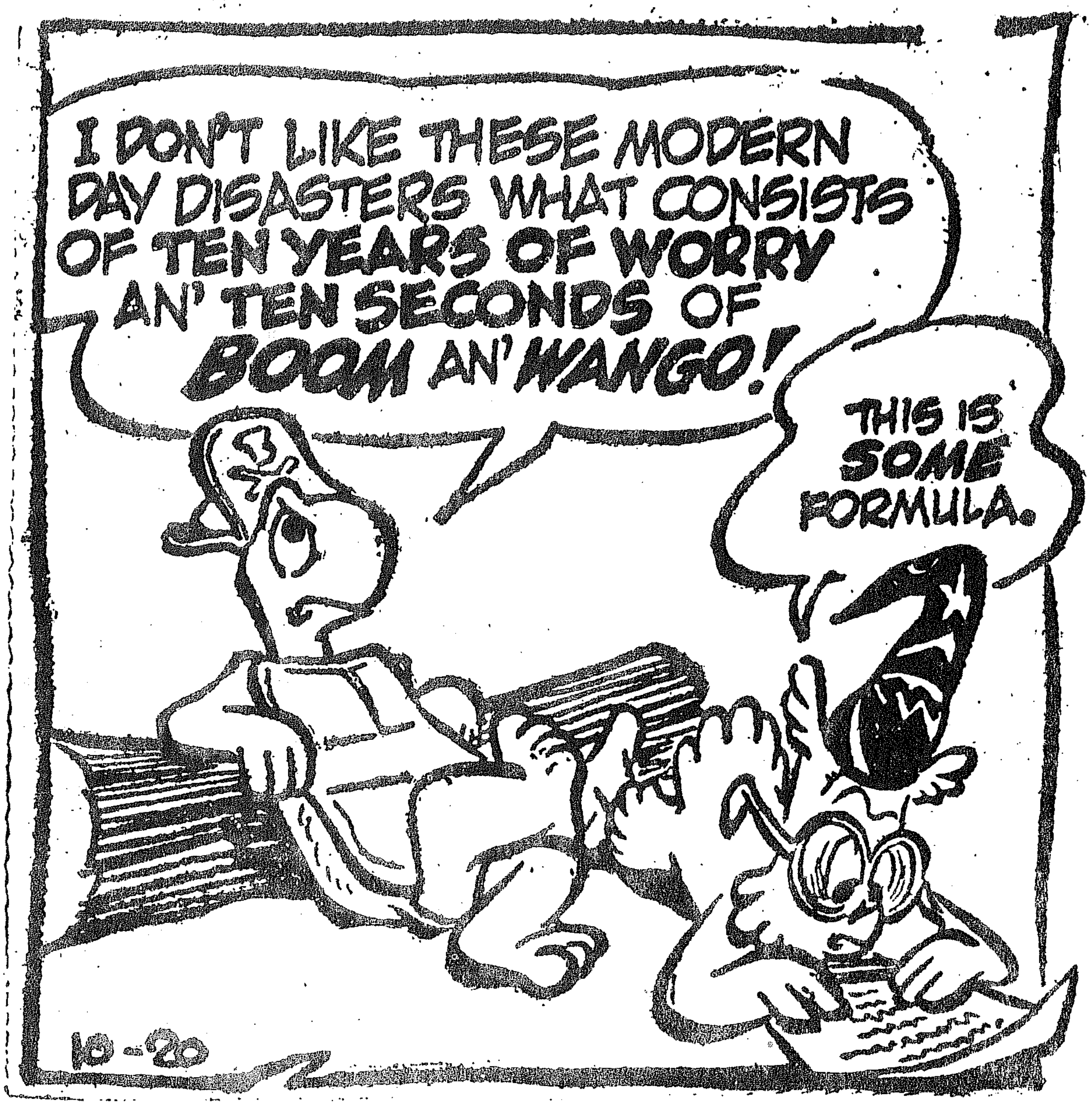
"WHAT THE PLANNER NEEDS TO KNOW ABOUT BLAST AND SHOCK"

GENERAL EFFECTS OF BLAST

The blast or shock wave created by an exploding nuclear weapon is responsible for the "boom and wango" part of nuclear attack. This Walt Kelly character, Churchy La Femme, doesn't have the timing quite right. The "worry" has lasted more than 10 years and the blast wave is capable of causing damage for more than 10 seconds after the detonation.

At one minute following the detonation of a 5-MT surface burst, the blast wave has traveled outward to about 15 miles from ground zero. Its pressure above the normal pressure of the atmosphere (overpressure) has decreased to about eight-tenths of a pound per square inch (psi) and it is now capable only of window breakage and similar minor damage. Closer in, however, it has left a region of increasing destruction toward ground zero. Buildings are damaged or destroyed, utilities disrupted, and debris hurled into the streets. People with insufficient protection have been killed or injured.

The destructive potential of the blast wave will generate most of the need for repair and rehabilitation following attack. The character of this damage will be described later in this chapter. But, first, we will concentrate on the survival of people, since the most important part of the civil defense mission is the saving of lives.


I DON'T LIKE THESE MODERN DAY DISASTERS WHAT CONSISTS OF TEN YEARS OF WORRY AN' TEN SECONDS OF BOOM AN' WANGO!
THIS IS SOME FORMULA.
10-20

PANEL 1

SURVIVAL IN ORDINARY BUILDINGS

The planner will be concerned primarily with the use of ordinary buildings, such as those identified in the National Fallout Shelter Survey (NFSS) and residences, as shelter for the population. The best available protection should be used to shelter the population in a particular community.

In areas potentially subject to direct effects, more than just fallout protection should govern the selection of "best available shelter space." A first approximation of the relative protection afforded by buildings is shown here. Note that blast survival is always better in basements (belowground) than it is aboveground. In particular, people are expected to survive closer in to the detonation (at a higher overpressure) in home basements than in the aboveground floors of NFSS buildings identified as having adequate fallout shelter. Where home basements exist, they deserve special consideration in the development of community shelter use plans.

An indication of the life-saving potential of intensive use of basements for shelter was referred to in Chapter 1. It will be recalled that a series of attacks on the Detroit urban area was described. For the heaviest attack—fifteen 5-MT ground bursts— somewhat less than 25 percent of the population survived the blast effects. The calculation was based on a median lethal overpressure (MLOP) of 6.5 psi, generally typical of aboveground locations. When the calculation was repeated using a MLOP of 12 psi, the blast survivors increased to 45 percent.

The information shown here is only approximate. Some basements offer no more blast protection than aboveground space. To see why this is so, we need to understand some key characteristics of the blast wave and how it damages buildings and people. We will be concerned with the "low overpressure" region of the blast area, where overpressures do not exceed, say, 20 psi. Closer in to a detonation, the blast characteristics are more complex than described here but they are of primary interest to the designers of blast-resistant structures and not to emergency planners.

BLAST PROTECTION IN CONVENTIONAL BUILDINGS

	Median Lethal Overpressure*	
Location	Residences	NFSS Buildings
Aboveground	5 psi	7 psi
Belowground	10 psi	12 psi

*The median lethal overpressure is that blast overpressure at which 50 percent of the occupants may be expected to be fatally injured.

THE IMPORTANCE OF "LOW" OVERPRESSURES

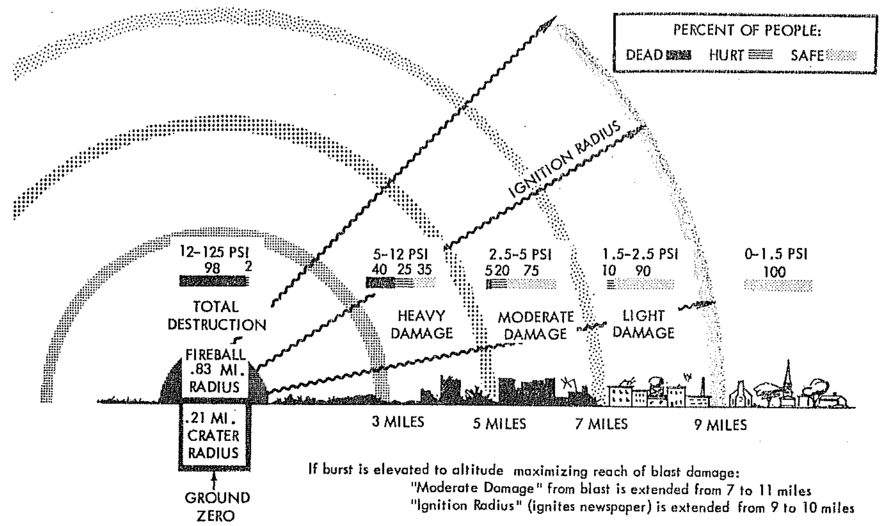
The fact that civil defense planning is largely concerned with the low overpressure region of the direct effects area should not be interpreted as concern for only a small part of the area affected by blast. Quite the contrary, most of the direct effects area is subjected to "low" overpressures. We have seen that an ability to position the population of the Detroit metropolitan area in basements with a median lethal overpressure of 12 psi would have doubled the survivors of a very heavy attack.

The importance of knowledge about the effects of low overpressure is graphically illustrated in these two sketches. The upper sketch is the picture of direct effects of a 5-MT surface burst that has been presented in OCD literature, including the Federal Civil Defense Guide, for the past 5 years. It shows the limit of light damage as extending to 9 miles from ground zero. The lower sketch is the recent revision of this effects picture. It shows light damage extending to 13 miles. This change more than doubles the direct effects area.

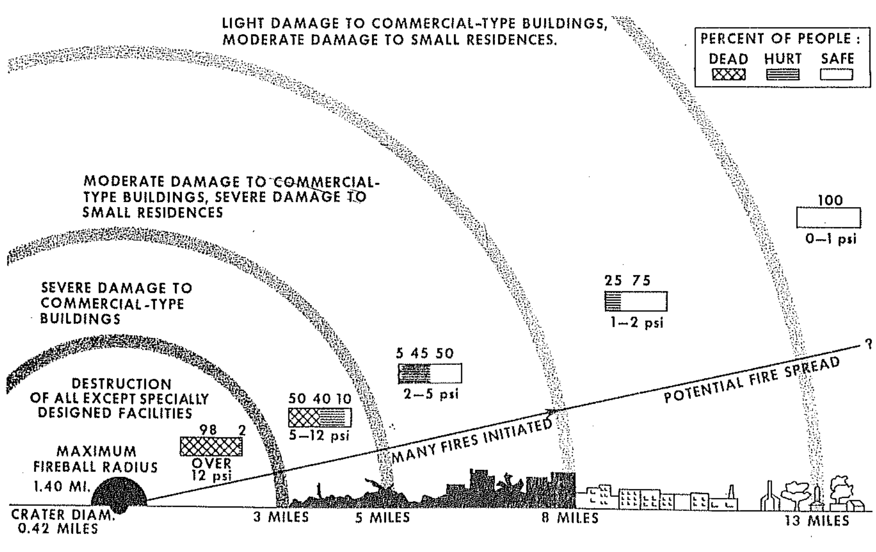
A close comparison of the two sketches reveals that the principal change was a downward shift of 1/2 psi in the overpressure needed to cause damage—from 2.5 psi to 2 psi for moderate damage and from 1.5 psi to 1 psi for light damage. The change came about as the result of experimental work, some of which will be described in this chapter. It is significant that such small changes in knowledge of blast effects can make such large changes in the area of coverage. The implication for emergency planning is that small changes in the vulnerability of people can make large changes in survival. Intelligent use of best available shelter can result in such changes.

And, remember: The area covered by overpressures less than 12 psi constitutes 95 percent of the whole area experiencing at least 1 psi blast.

EFFECTS OF A 5 MT BLAST



DIRECT EFFECTS OF 5 MT. BLAST (SURFACE BURST)



IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 8 MILES TO 13 MILES.

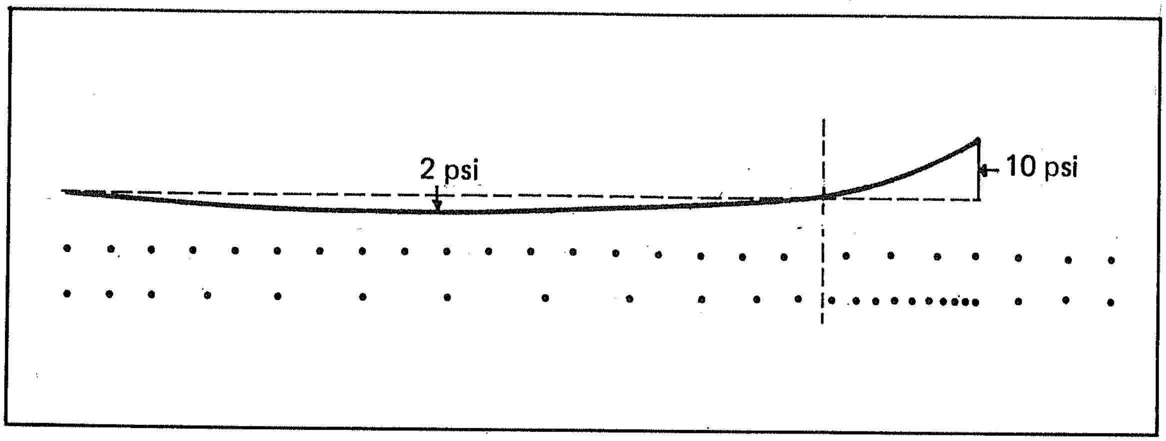
WHAT THE BLAST WAVE IS

When a nuclear weapon explodes in air, the air surrounding the detonation point is rapidly compressed and forced outward, initially at speeds much higher than the speed of sound. A blast or shock wave is created whenever air is suddenly forced to move very rapidly. Commonly observed but very weak shock waves are those created when the end of a whip is snapped to supersonic velocities or when a supersonic jet aircraft creates a "sonic boom."

As the blast wave expands, it encompasses an ever greater volume of space. The peak pressure at the leading edge of the wave (commonly called the shock front) continuously decreases as it expands outward and the speed of expansion slows down. (The amount by which this pressure exceeds normal atmospheric pressure is known as the overpressure.) At great distances from a nuclear detonation, the shock front velocity slows to the speed of sound (about 1100 feet per second or 750 miles per hour). At this point, the shock front disappears and the disturbance becomes an ordinary sound wave—a "boom."

A schematic illustration of the blast wave is shown here. The upper row of dots represents a row of undisturbed air molecules. As undisturbed air is overtaken by the shock front, the air molecules are jammed up into the leading edge of the wave and carried along for a bit, as shown by the lower row of dots. It is this compression of the air in the shock wave that produces the overpressure. The jammed-up air molecules never reach the speed with which the blast wave is expanding and gradually fall behind the shock front. Because of the violent outward movement, however, at some distance behind the wave front, the air becomes thinner than normal and the pressure is less than atmospheric, indicated by the vertical dashed line in the sketch. The overpressure behind the shock front falls off to an "underpressure" about one-fifth the overpressure at the shock front. The air behind the shock front eventually begins to flow back into the low-pressure region to restore the normal atmospheric pressure.

The overpressure part of the blast wave is called the "positive phase;" the underpressure part, the "negative phase." Since the negative phase contributes little to casualties and destruction, the planner need not be concerned with it.

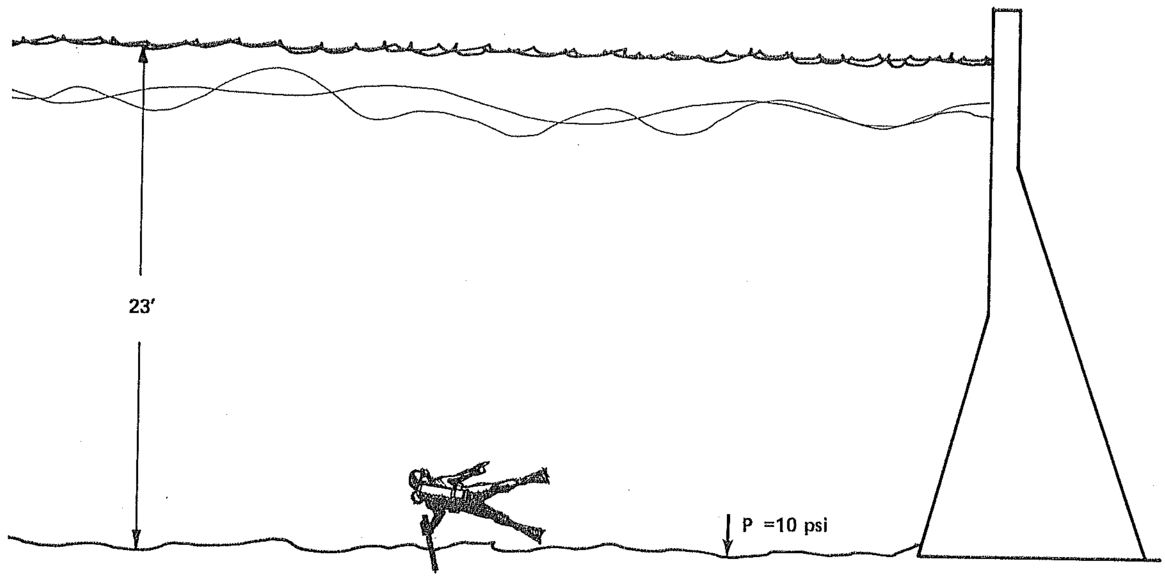


PANEL 4

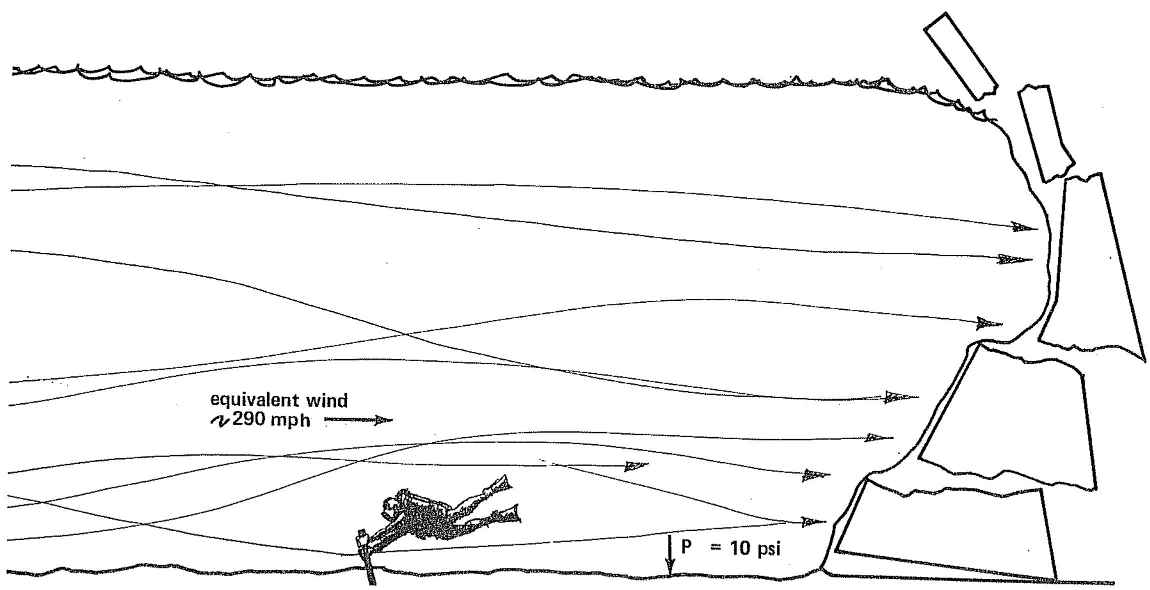
A DAM ANALOGY

People are so accustomed to the world around them that they are not aware that they are being pressed in by the weight of the atmosphere, about 15 pounds per square inch at sea level. Nevertheless, the pressure is real. In the upper picture, we see a diver holding to an anchor at the bottom of a reservoir 23 feet deep. At that depth, the weight of water above him exerts an overpressure of about 10 psi above atmospheric pressure and he would be aware of it.

If the dam were suddenly to fail, as in the lower figure, he remains under the pressure of 23 feet of water but now the water begins to move and tends to tear him from his anchor point. In an air blast wave, this "tearing force" is a wind produced by the outward movement of the air molecules. At an overpressure of 10 psi, the momentary wind velocity accompanying the shock front is about 290 miles an hour.



**HYDROSTATIC PRESSURE
BEHIND DAM**



HYDROSTATIC PRESSURE + WATER MOVEMENT

PANEL 5

A DAM ANALOGY

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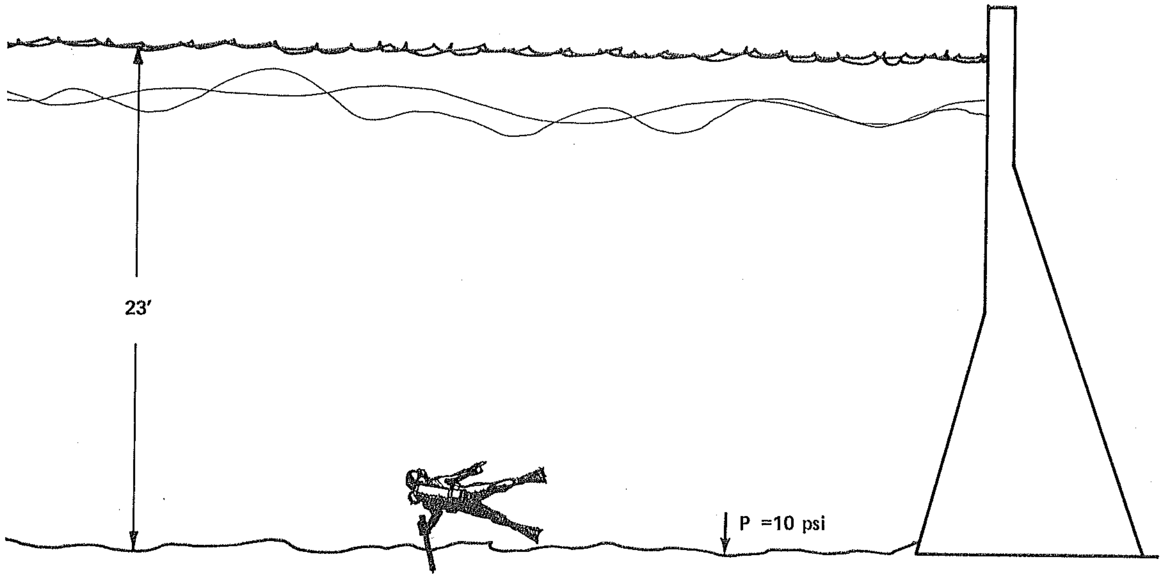
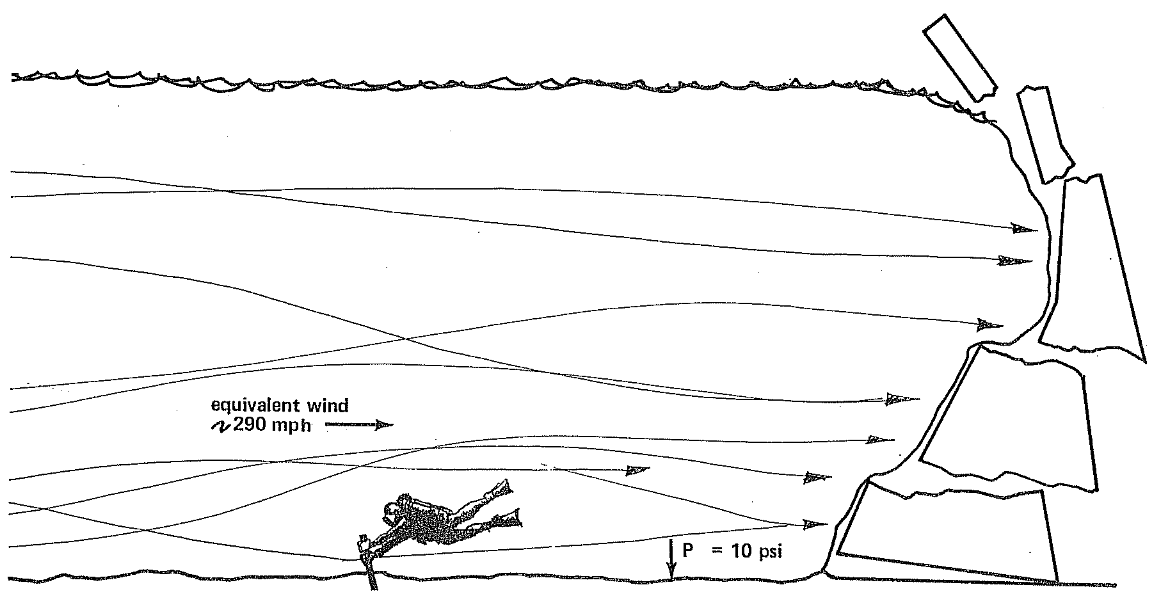


HYDROSTATIC PRESSURE BEHIND DAM



HYDROSTATIC PRESSURE + WATER MOVEMENT

PANEL 5

RELATIONSHIP OF BLAST WIND TO OVERPRESSURE

It will be seen that both the overpressure in the blast wave and the blast wind are important causes of damage and casualties. This table shows the relationship between the two. All buildings will suffer light damage at about 1 psi peak overpressure—shattered windows, doors damaged or blown off the hinges, and interior partitions cracked. The maximum blast wind velocity would be about 35 miles per hour. As the overpressure increases, so does the blast wind, exceeding hurricane velocities above about 2 psi.

The most significant difference between the blast effects of kiloton-yield weapons and megaton-yield weapons is the length of time that the overpressure and blast wind persist. For kiloton-yield detonations, such as those at Hiroshima, Nagasaki, and at the Nevada Test Site, the duration in the low overpressure region is about one second. For detonations in the megaton-yield range, the duration is 5 seconds or more. (Actually, the duration of the positive phase varies as the cube root of the yield; the blast wave for a 20-MT detonation lasts **10 times** as long as that for a 20KT explosion.)

This change in duration is most significant for the blast wind gust. To get an idea of the significance, clap your hands twice, one second apart. Then, using the 1001, 1002 procedure for counting at one second intervals, clap your hands 6 seconds apart. Imagine the sort of winds shown on this chart persisting for several seconds. Of course, as the overpressure behind the shock front falls off, the blast wind lessens accordingly.

BLAST WAVE CHARACTERISTICS
(surface burst)

Peak Overpressure (psi)	Wind Velocity (mph)	Wind Duration for 5-MT Burst (sec)
1	35	9.5
2	70	8.5
5	160	6.8
10	290	6.0
20	470	5.8
30	670	5.6
100	1400	4.3

EFFECTS ON PEOPLE IN THE OPEN

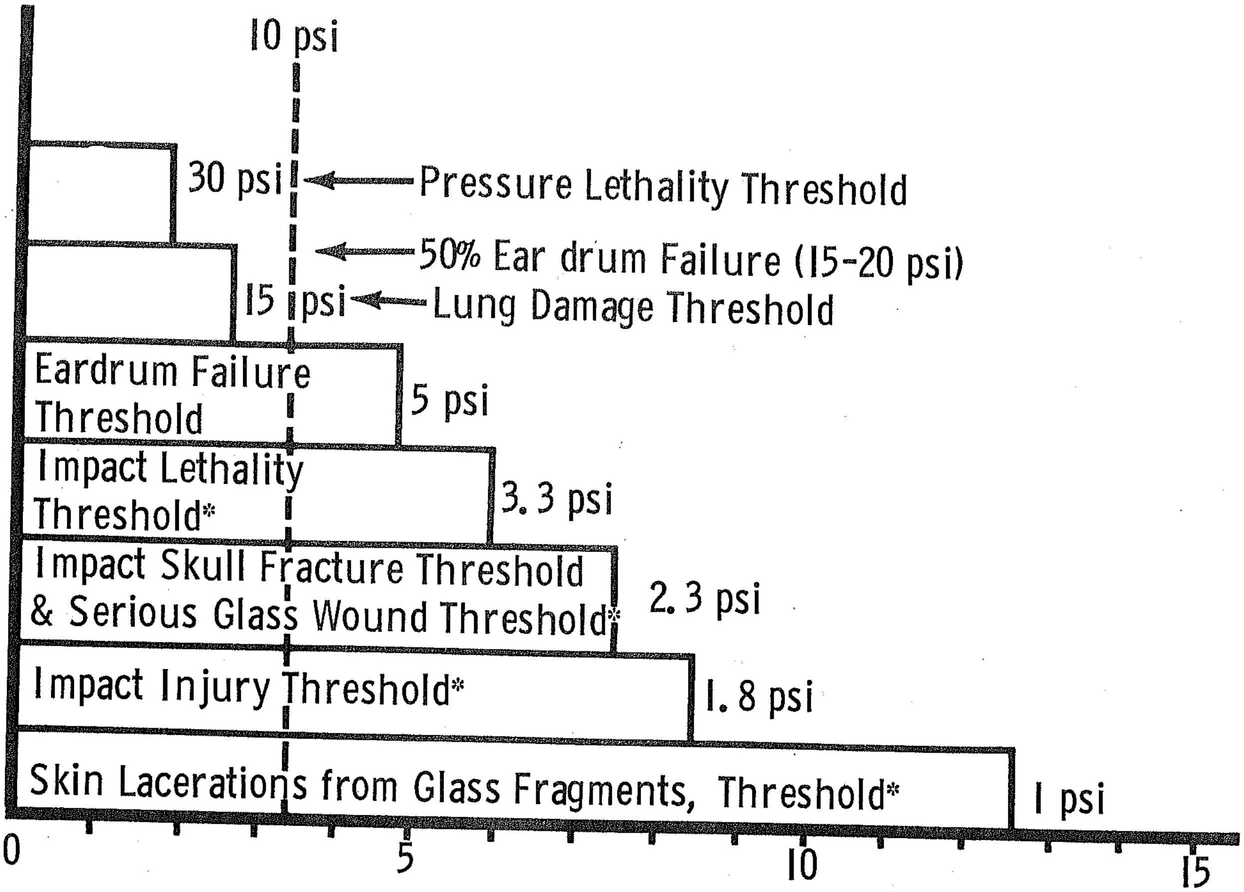
Consider a person standing in the open at a distance of three and one-third miles from the detonation of a 5-MT ground burst. The shock wave would arrive at his location about 7 seconds after the detonation. He would first feel the sharp "air slap" as the shock front strikes. He would be enveloped in less than a thousandth of a second. He would then feel a 10-psi pressure over his body. As can be seen from the chart, this pressure would be too low to cause death or lung damage. He might experience a perforated eardrum although 20 psi would be required to make this likely. Eardrum failure has been recorded, however, at overpressures as low as 5 psi.

In addition to this overpressure, however, the person would experience a blast wind of as high as 290 miles per hour for several seconds. This wind would blow him through the air for a considerable distance. When he struck the ground, he would likely sustain injury and, possibly, a fatal injury. If there were structures nearby, he might also sustain injury from flying fragments of glass or other debris.

The implication of the chart is that it is the bodily displacement and missile hazard created by the blast wind that causes most injury and death, not the overpressure itself. The overpressure, however, can break up buildings, creating the missiles that might cause injury. Very generally, a person outside in a residential area has about the same chance of surviving the blast wave as he would in a frame residence.

The information shown here comprises a small part of the great amount of data that exists from animal experiments and weapons tests for specific injuries and causes of death.

BLAST INJURY THRESHOLDS IN OPEN



Miles from GZ from 5-MT Surface Burst

*For impact injury or death to occur at stated overpressure, the body must be thrown at least 10 feet before impact. Otherwise, a higher overpressure is required to achieve necessary velocity. Glass fragments must also travel at least 10 feet.

Based on **The Nature of the Problems Involved in Estimating the Immediate Casualties from Nuclear Explosions,** White, C.S. CEX 71.1. NTIS, U.S. Department of Commerce, Springfield, Virginia 22151.

DAMAGE TO BUILDINGS

We have concluded that people are mainly affected by the winds accompanying the blast wave. People are so quickly engulfed by the shock front that there is little time for the overpressure to act on the near side before it is also acting on the far side. Being relatively non-crushable, people react mainly to the wind. There are structures, such as telephone poles, smoke stacks, and radio towers that behave the same way.

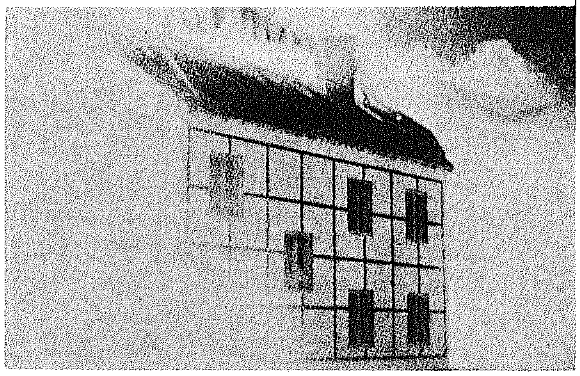
Buildings, however, are large enough that the overpressure acts on the facing side before it can act on the other sides. Buildings are therefore affected by both the overpressure and the blast wind. These views show the effects of blast from a 47-KT weapon on a brick test house, as seen from the rear. In the first picture, the blast front has just struck the far side of the house and is spilling around the structure. The overpressure in the shock front is about 3 psi, but the load on the building face at this time is about doubled because the blast wave is reflected. Damage is occurring to roof panels.

The situation 0.6 of a second later is shown in the second picture. Light roofing panels are being hurled by the blast wind, which had a maximum velocity of about 100 miles per hour. The roof framing is lifted nearly vertically by the wind force. At 1 second after blast wave arrival (third picture), the positive phase is over, the roof rafters have moved back into place and roof panels are falling to the ground.

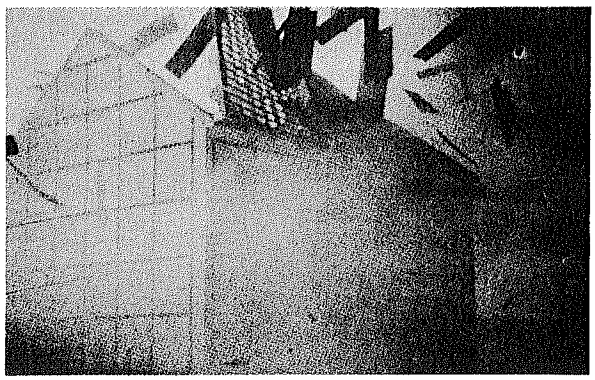
The final picture shows a front view of the house after the test. The roof has collapsed but the main brick structure appears to be in good condition. The test report estimates that this structure suffered 10 percent damage. It should be noted that this test structure represented a kind of masonry construction considerably stronger than ordinary U.S. houses.

Is this test representative of what we might expect at 3 psi from a megaton-yield weapon? The answer is NO. For a 5-MT detonation, the positive phase of the blast wave lasts 5 times longer than in this test. Not only would we expect the roof panels to be thrown much farther but the entire roof structure would have been removed.

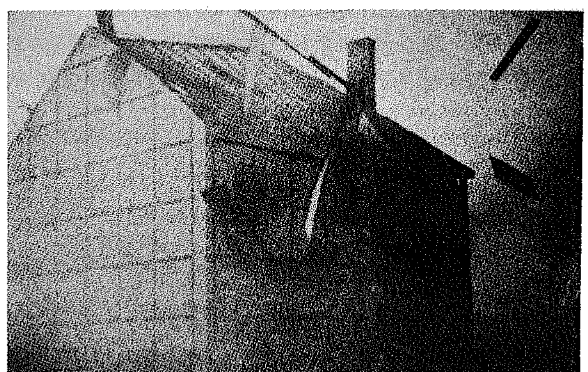
It is an unfortunate fact that past weapons test programs have yielded almost no direct data on blast damage to buildings for megaton-yield explosions. To remedy this lack of information, theoretical analyses have had to be supported by blast tests of a non-nuclear variety.



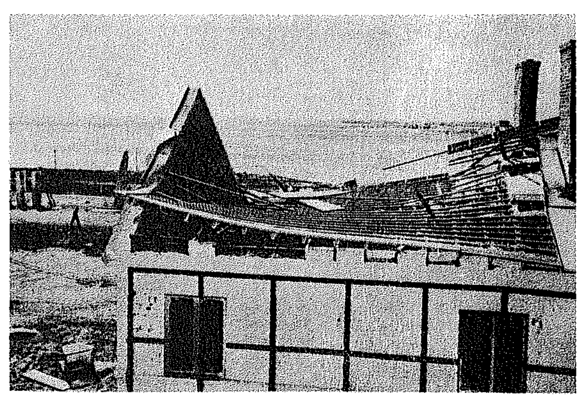
Impact



Impact + 0.6 second



Impact + 1.0 second



Afterward

PANEL 8

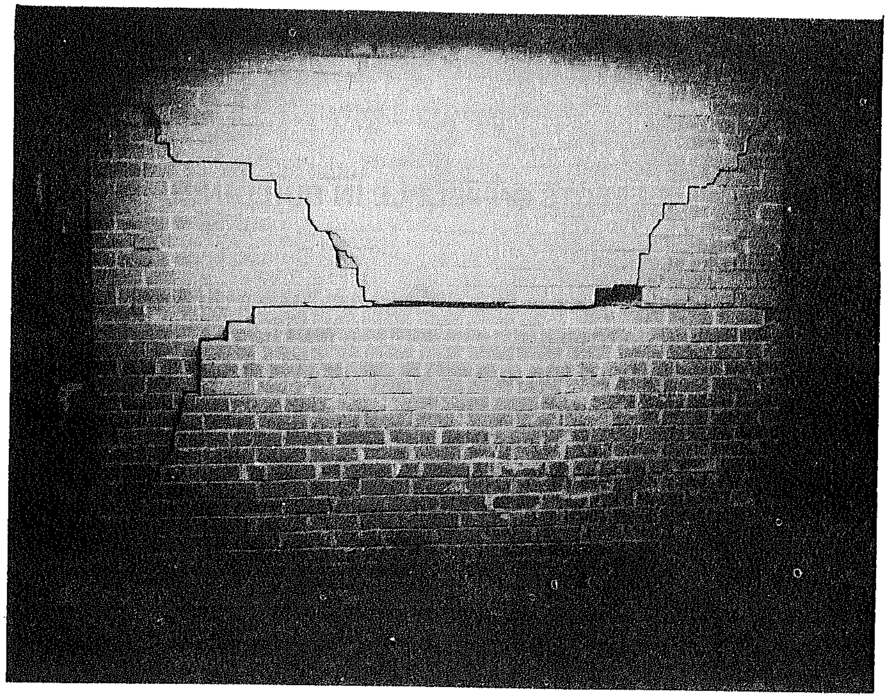
A TYPICAL BLAST EXPERIMENT

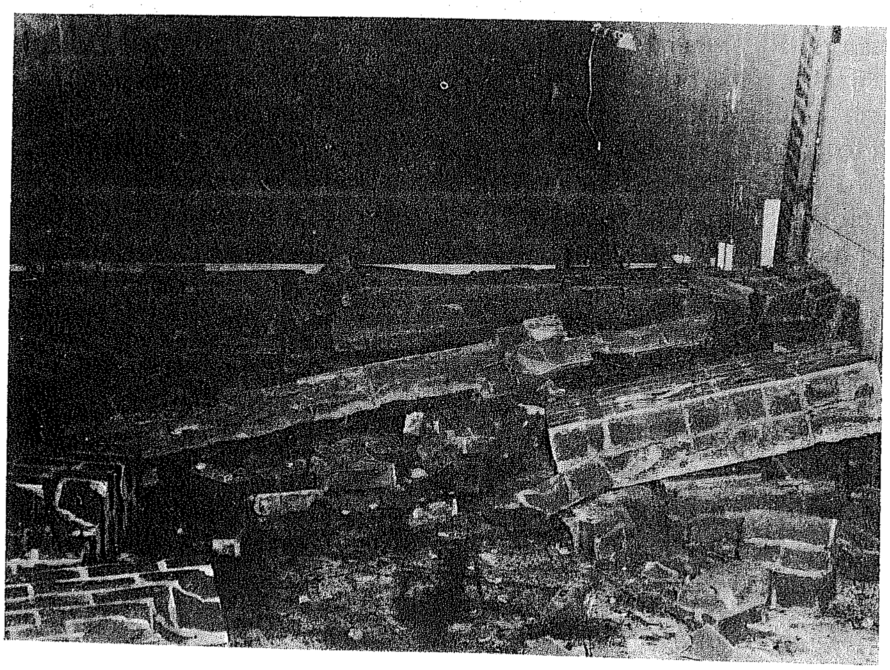
For the past several years, DCPA has been investigating the way walls fail under blast loading in a "blast tunnel" that permits us to duplicate the long-duration peak overpressure loads caused by nuclear detonations in the megaton-yield range. Two typical results are shown here.

The upper figure shows a brick wall that is on the point of "incipient collapse" after blast loading. The wall failed horizontally near the middle of the wall. The peak overpressure in this test was about 1½ psi.

The lower figure shows a similar brick wall after exposure to 3 psi overpressure. The wall has been thrown many yards down the tunnel, breaking into many small pieces in the process.

These tests have given good information on the overpressures required to cause various types of walls to fail and how the size of the pieces vary with the incident overpressure. The particular walls tested here are typical of relatively weak masonry walls, often found in single-story commercial buildings and residences. Their weakness stems from the fact that they are not locked into a stronger frame at their edges. In some kinds of buildings, the brick walls are held rigidly in a surrounding frame. Such walls, called "arching" walls, are much stronger than those shown here. Tests have shown that, in many cases, these arching walls will withstand more than 10 psi overpressure, even though they are no thicker than those shown here. It usually requires a person familiar with building construction and some special training to distinguish "weak" masonry walls from "strong" masonry walls.





PANEL 9

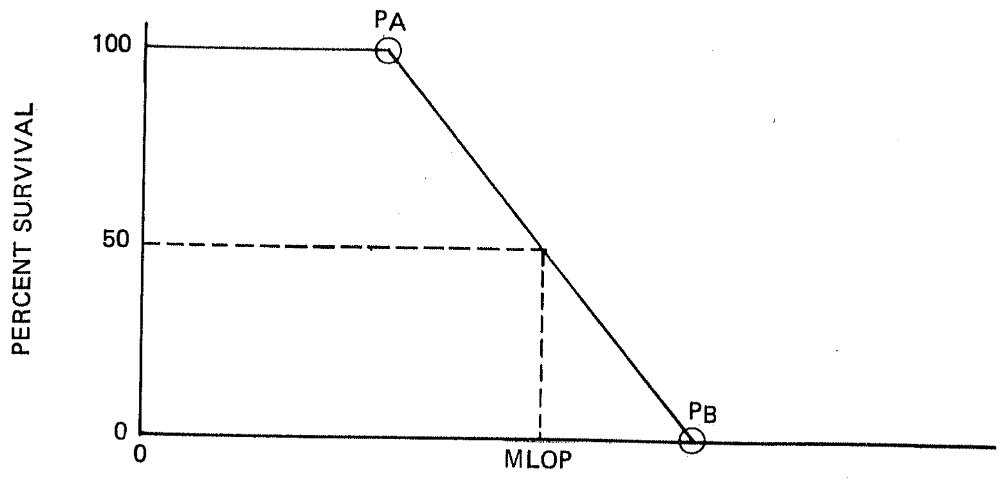
EFFECTS ON PEOPLE IN BUILDINGS

Estimating the survival of people in buildings has been a difficult problem. Blast casualties are related to building damage but to describe a building as "moderately damaged" says nothing about the survivability of the people therein. Two basic approaches to casualty estimation have been tried.

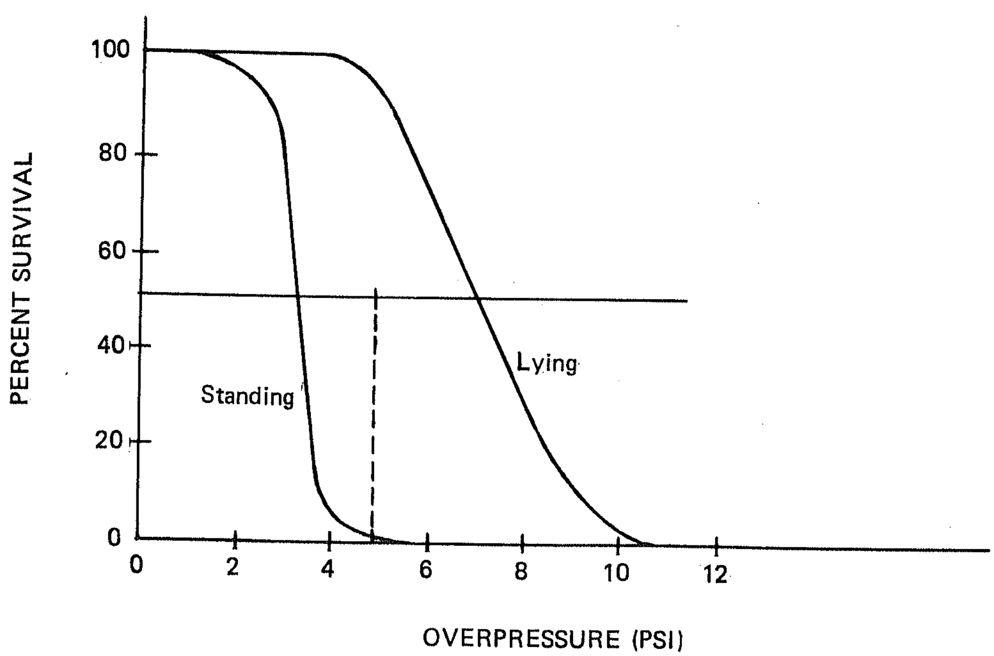
The first and oldest method has been to analyze carefully what happened to people in buildings at Hiroshima and Nagasaki in an attempt to estimate what would have happened to people in American buildings damaged by megaton-yield weapons. Thousands of detailed case histories have been studied. One difficulty has been to separate the blast casualties from casualties due to other effects, such as fire and initial radiation. A second, and more difficult problem has been to extrapolate the results to the long-duration blast wave of the megaton weapon. The first problem has proved easier than the second. The results are now suspect because they tend to give survival estimates that are inconsistent with the blast experiments just described.

The newer approach has been to break the casualty-producing mechanism into its constituent parts. The survival curve, in its simplest form, is shown here. People survive up to an overpressure, P_A, where the wall, for example, is at the point of "incipient collapse," shown in Panel 9. The overpressure, P_B, on the other hand, is well above the overpressure for complete building collapse because the blast wind must be capable of accelerating people and debris to impact velocities that would be lethal. To arrive at an estimate, careful calculations of the displacement of people and debris are made and compared with the specific injury and mortality data that has been obtained in animal experiments and at weapons tests. When we indicated in Panel 2 that the median lethal overpressure (MLOP) for people in aboveground parts of residences was 5 psi, the estimate was based on this type of calculation. Note in the lower sketch that 5 psi represents an average vulnerability. People standing are more vulnerable; people lying down are less vulnerable.

SIMPLE SURVIVAL CURVE



SURVIVAL ABOVE GROUND IN WOOD FRAME HOUSE

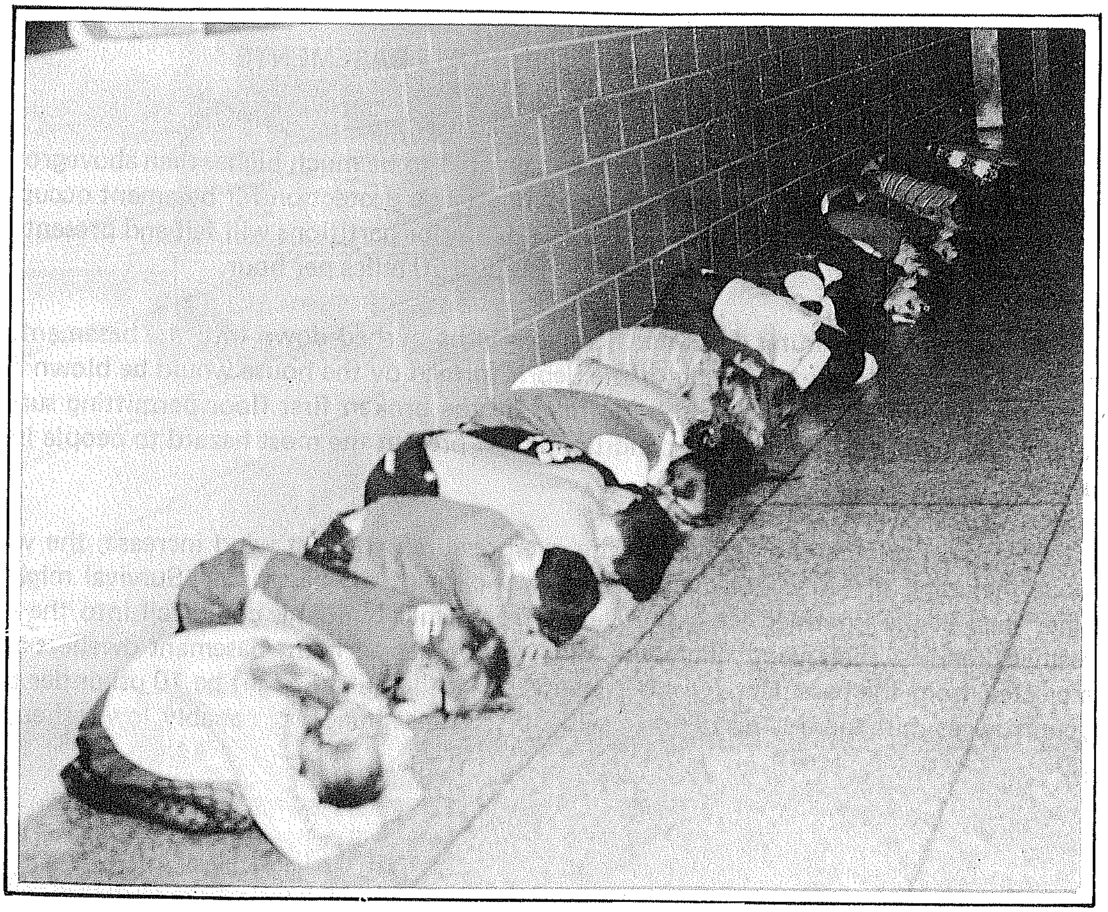


PANEL 10

PROTECTIVE ACTIONS

The newer method of casualty estimation can show the value of protective positions on the part of people. For example, it requires about 8 times the blast wind force to move a person who is lying down compared to a standing person. People crouched or lying down also offer a much poorer target to glass shards and debris missiles.

These school children are practicing a good protective posture to improve blast survival. Lying down would be even better. Calculations show that the median lethal overpressure (MLOP) in aboveground areas can be increased by 2 or more psi by these protective actions. The planner should recognize that a change in vulnerability of this magnitude can save many lives.



Photograph courtesy of The News—Virginia, Wayneboro, Virginia.

BLAST PROTECTION IN HOME BASEMENTS

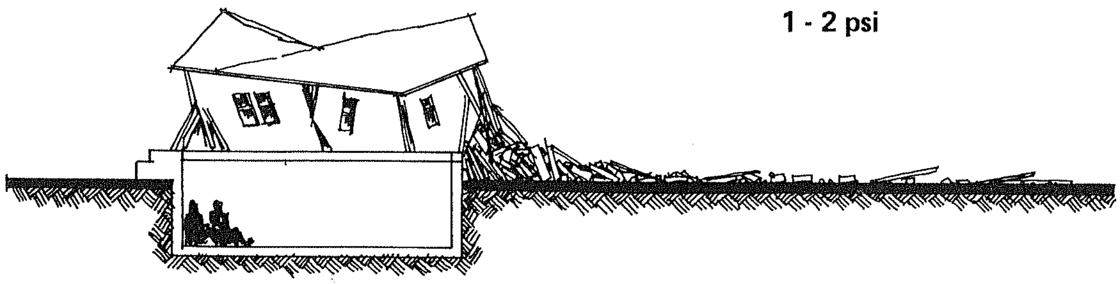
Blast survival in residential basements is estimated to be much higher than aboveground. As shown in the upper sketch, the first floor will provide protection for basement occupants at low overpressures where windows, doors, and interior partitions will fail and present missile hazards above. The blast wind would range up to 70 miles per hour.

At higher overpressures, the first floor would be pushed down into the basement. As shown in the middle sketch, much of the debris formed by the house would be blown from above the basement. Voids would be formed by the broken first floor permitting survival along the walls. This intermediate condition might present the most hazard to people in the basement.

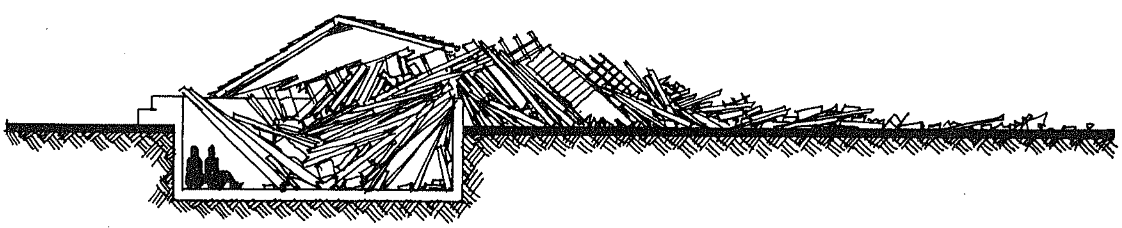
The lower sketch shows that, as the overpressure and blast wind increase, the whole house, including the first floor would be blown clear of the basement. Survival might be higher than in the intermediate case. Debris from other buildings could fall into the open basement, and, as blast winds increased above 300 miles an hour, basement dwellers could be ejected from the basement. Our best guess is that the MLOP might be 10 psi under these circumstances, but there is no definite evidence. The estimate is probably low rather than high.

HOME BASEMENT SHELTER

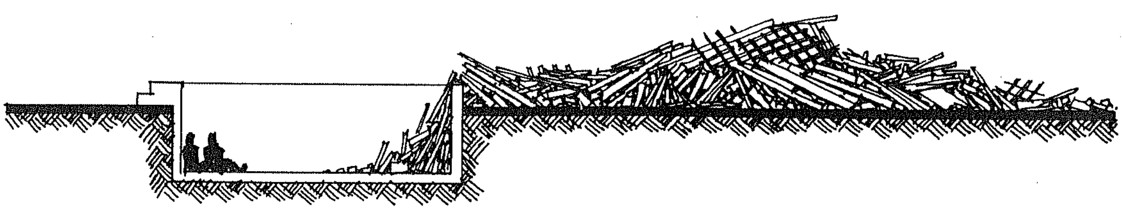
1 - 2 psi



2 - 5 psi



over 5 psi



PANEL 12

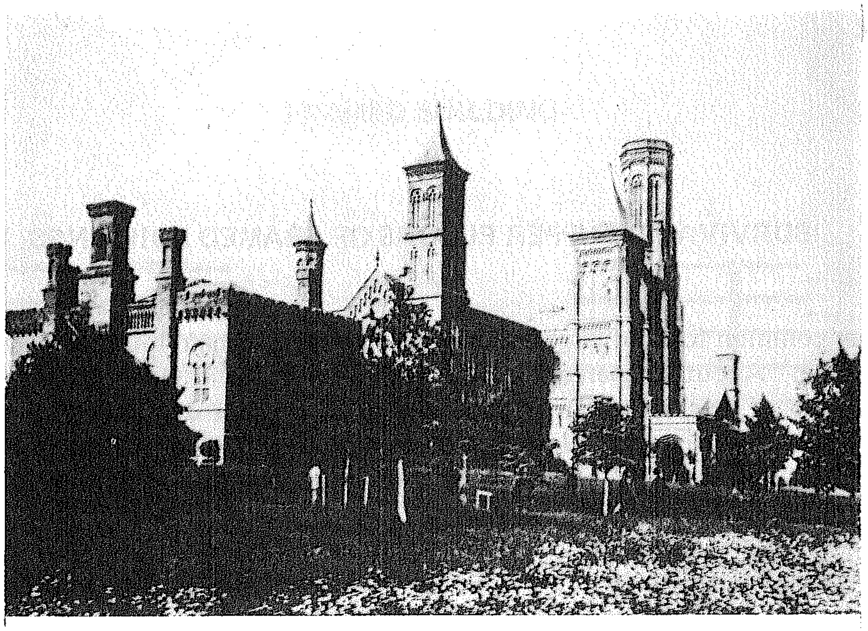
SURVIVAL IN LOAD-BEARING WALL BUILDINGS

Although the National Fallout Shelter Survey (NFSS) was not directed toward protection against direct effects, considerable information was gained on the structural characteristics of most large buildings in the United States. Additionally, a special statistical sample of NFSS buildings in five cities has been studied in great detail as part of a research program to develop an all-effects survey. The five cities—Providence, New Orleans, Detroit, Albuquerque, and San Jose (Calif.)—were chosen to exhibit a full range of regional and other urban characteristics.

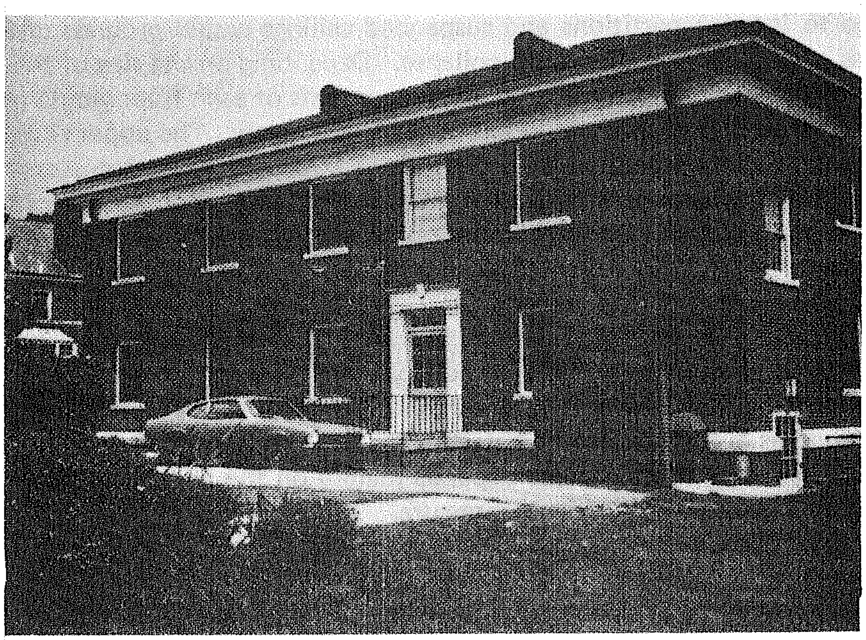
Many NFSS buildings have continuous masonry walls and partitions from the foundation to the roof. In these buildings, the floors are commonly supported by the walls. About half the large buildings in New Orleans, Detroit, and Albuquerque have load-bearing walls; about three-quarters are of this type in Providence and San Jose.

Some load-bearing wall buildings are of the monumental type, with massive walls that may resist overpressures of 10 psi or more. People lying near the exterior walls of the aboveground floors of such buildings would have better shelter than those in aboveground floors of most steel and concrete framed buildings. An example of a monumental-type structure is shown in the upper picture.

Most brick or masonry load-bearing wall buildings have little resistance to the lateral forces of overpressure and blast wind. The bearing walls tend to crack at about 4 psi, with collapse likely by 6 psi. The collapse of the exterior bearing walls results in collapse of most of the structure that is supported by them. Since the masonry debris is heavy, it is not thrown far by the blast wind gust. It is unlikely that the floor over the basement would be able to withstand the combined effects of the overpressure and the falling debris. Survival is about the same both aboveground and belowground in this type of building. Thus, except for monumental-type buildings, basements in load-bearing wall buildings are not much better than upper floors as protection against blast. A typical weak-walled brick apartment house is shown in the lower picture.



EXAMPLE OF MONUMENTAL MASONRY BUILDING



EXAMPLE OF WEAK LOAD-BEARING WALL BUILDING

SURVIVAL ON UPPER FLOORS OF FRAMED BUILDINGS

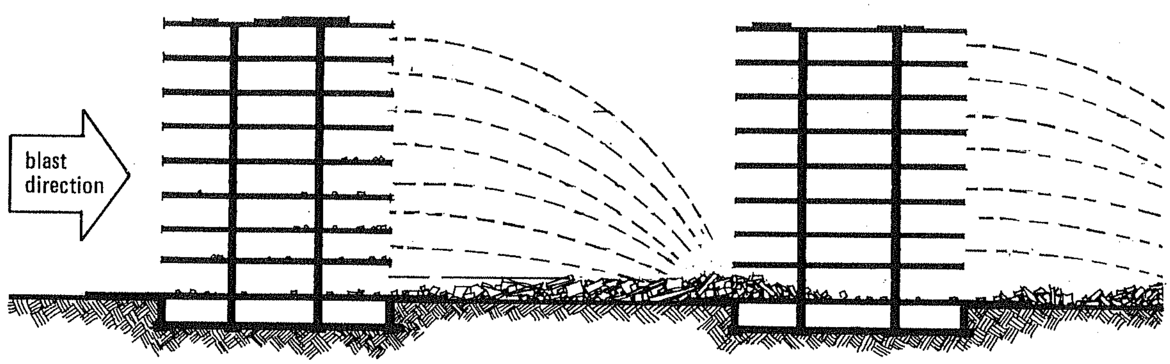
Another common form of large building construction is the reinforced-concrete or steel framed building. About 40 percent of the NFSS buildings in New Orleans, Detroit, and Albuquerque are of this type. Only about 20 to 25 percent of Providence and San Jose buildings are framed structures. Nonetheless, essentially all "high-rise" buildings in the five cities are of this type, containing large amounts of fallout shelter space on the upper floors.

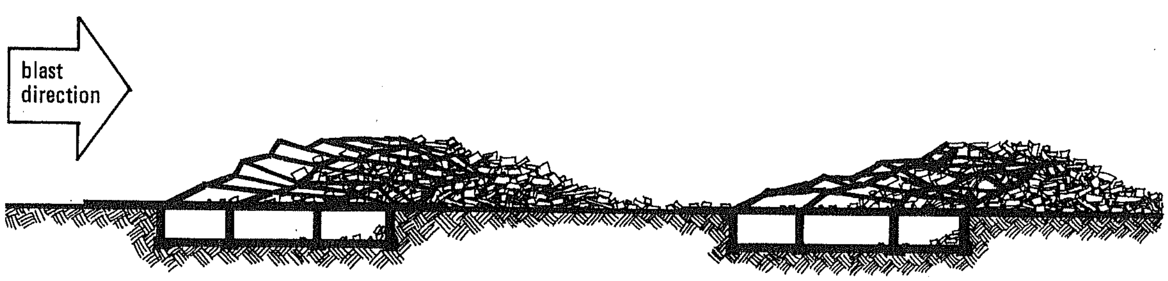
The exterior walls of framed buildings tend to be very weak (2 - 3 psi), being simply mounted on supports attached to the building frame, or fairly strong (greater than 10 psi), actually built into the building frame to create an "arching" wall. In any event, at overpressures lower than those that would fracture the walls, people lying near the exterior walls would likely escape both flying glass and the jet action of the blast wave as it pours through the windows.

Damage to interior partitions and suspended ceilings would progress until, at higher overpressures, the exterior walls would collapse. Depending on the size of the building and the strength of the blast wind, some or all of the contents of each floor would be ejected out the far side of the building and would fall to the street below. The upper sketch shows two 8-story framed buildings separated by a distance of 100 feet. At overpressures high enough to sweep out the aboveground stories (4 to 10 psi) the contents of each story would follow somewhat the paths shown. Survival would obviously depend on not being above the third floor at the least.

At overpressures in excess of 10 psi, the structural frame, which would remain as a "drag-type" object, would be subject to collapse by the wind force. Failure would be as shown in the lower sketch. Note that, in a framed building, the basement does not receive a large debris load as is the case in the catastrophic collapse of a load-bearing wall building. Whether the basement suffers damage depends mainly on the ability of the first floor over the basement to withstand the blast overpressure.

FRAMED BUILDING





PROTECTION IN BASEMENTS

As has been indicated, the basement areas of large buildings, particularly steel or reinforced-concrete framed structures, potentially offer good protection against blast. The most important consideration in this respect is the strength of the ground floor directly above the basement. Other considerations are the nature of exterior openings into the basement (apertures), whether the basement walls extend above the ground level, and the location of nearby buildings.

The structural statistics shown indicate that from 40 to 70 percent of NFSS buildings in the five city sample have no basement wall exposure. In other words, the floor above the basement is at ground level, a desirable situation. An even higher percentage, 60 to 90 percent, have no basement wall apertures. Entrances to the basement are internal to the building. This feature offers some advantages for blast protection but may complicate ventilation and access, particularly if the aboveground part of the building is damaged or demolished. About 40 to 70 percent of the buildings do not have common walls or immediately adjacent buildings. This means that these buildings are probably surrounded with streets, alleyways, or parking areas.

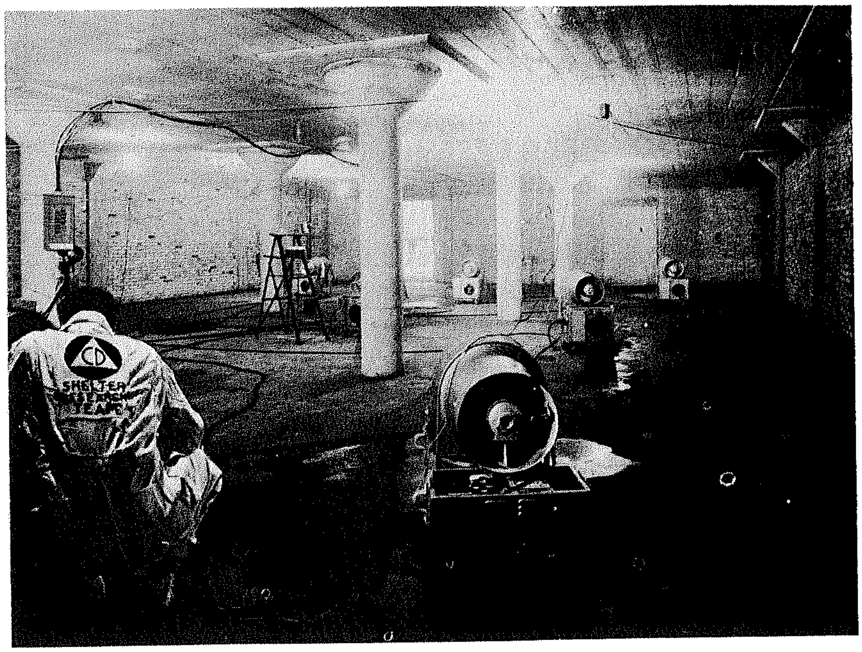
It goes without saying that a floor of wood or light steel framing above the basement offers little protection, unless the structure above is wood-frame or of other light construction. In that case, the protection is similar to that afforded by a home basement. Most ground floors are of reinforced concrete, supported by columns, pillars, or, occasionally, interior bearing walls. Typical load limits on first floors range from 100 to 150 pounds per square foot. This is equivalent to about 1 psi. Of course, large and usually unknown "factors of safety" enter into the floor design, which is intended to avoid any significant distortion. Major sagging, cracking, and distortion of the floor, on the other hand, would not necessarily result in major casualties among building occupants.

Older buildings were generally built in ways that enhance basement blast protection. Since World War II, however, building practices have emerged, generally in an effort to reduce labor costs, that meet building codes but offer much less blast resistance. It can be seen from the table that a majority of buildings in Providence, New Orleans, and Detroit were built before 1945. In the newer cities of the west, only about one-third are of pre-war construction.

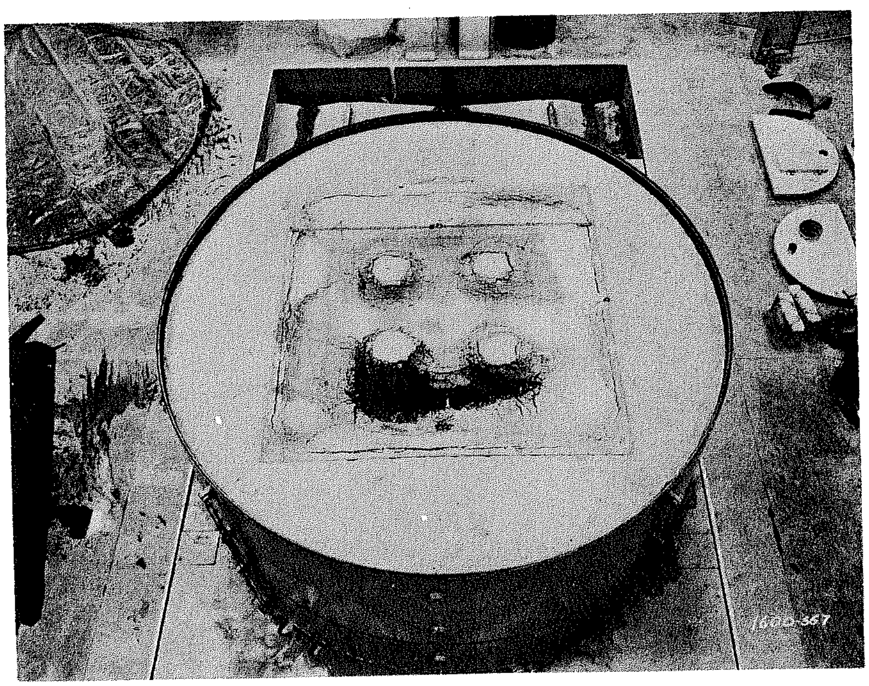
SELECTED STATISTICS

Characteristic	Percentage of Buildings with Characteristic				
	Providence	New Orleans	Detroit	Albuquerque	San Jose
Contains Basement	96	44	94	93	87
Framed Building	20	37	41	40	24
No Basement Wall Exposure	39	40	62	37	68
No Basement Wall Apertures	61	59	74	76	86
No Immediately Adjacent Buildings	72	44	37	73	47
Built Before 1945	51	73	82	27	36

FLAT SLAB FLOOR



UNDERSIDE OF FLAT SLAB



BLAST FAILURE OF FLAT SLAB

PANEL 16

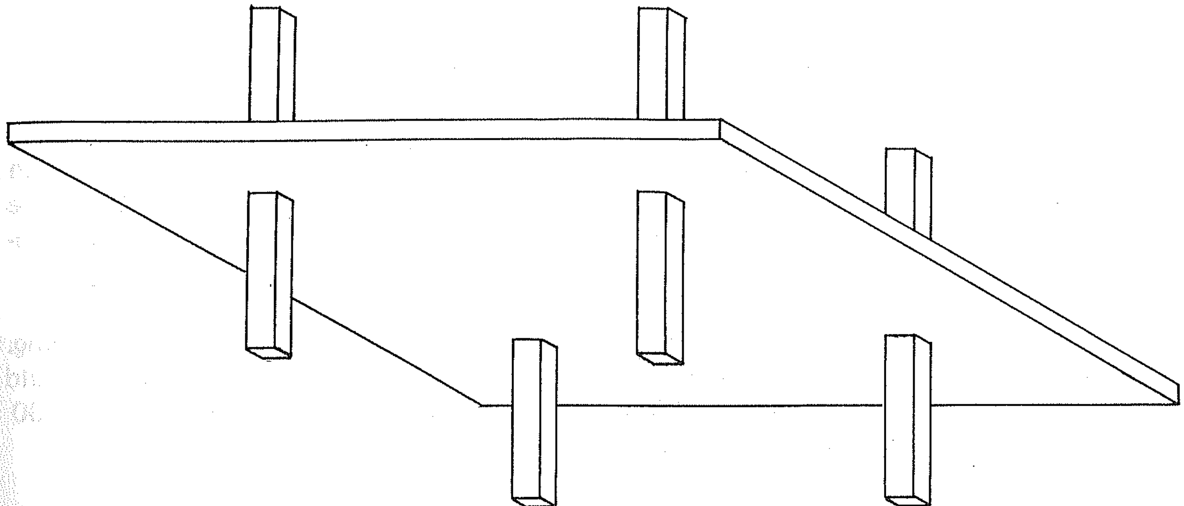
POORER BASEMENT SHELTER

Since about 1950, and at an increasing rate, a type of floor construction called "flat plate" has supplanted the flat slab and slab and beam types of construction. Flat plate construction is adequate to meet the design loads and is much more economical. As shown in the upper sketch, the floor is supported only at the columns. To compensate for this simplified construction, the floor itself is about twice as thick as in flat slab construction.

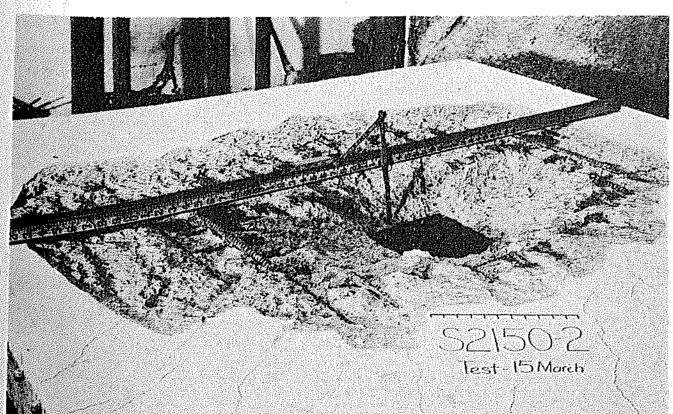
Under blast loading, stresses are set up that result in shear failure near the columns. The whole floor punches down into the basement, leaving a small portion at the top of the column. This catastrophic type of failure is shown in the two lower photographs. Failure is expected to occur at about 6 to 7 psi. While shelter in this type of basement is probably better than in the upper stories, this is one of the least blast-resistant types of basement.

Although only perhaps 10 percent of the basement space in the NFSS inventory is in buildings using flat plate construction, many of the newer buildings are built this way at the present time. Because they are new, your local building engineers probably have a good record of them.

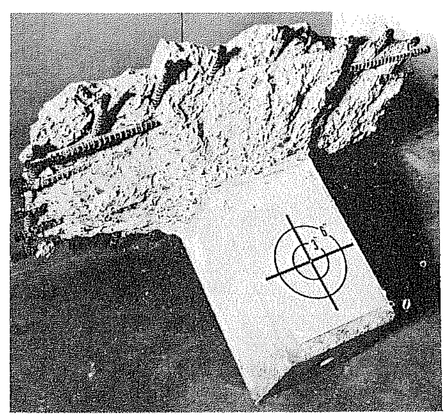
FLAT PLATE FLOOR



FLAT-PLATE SYSTEM



UPPERSIDE OF TEST FLOOR SHOWING FAILURE AREA



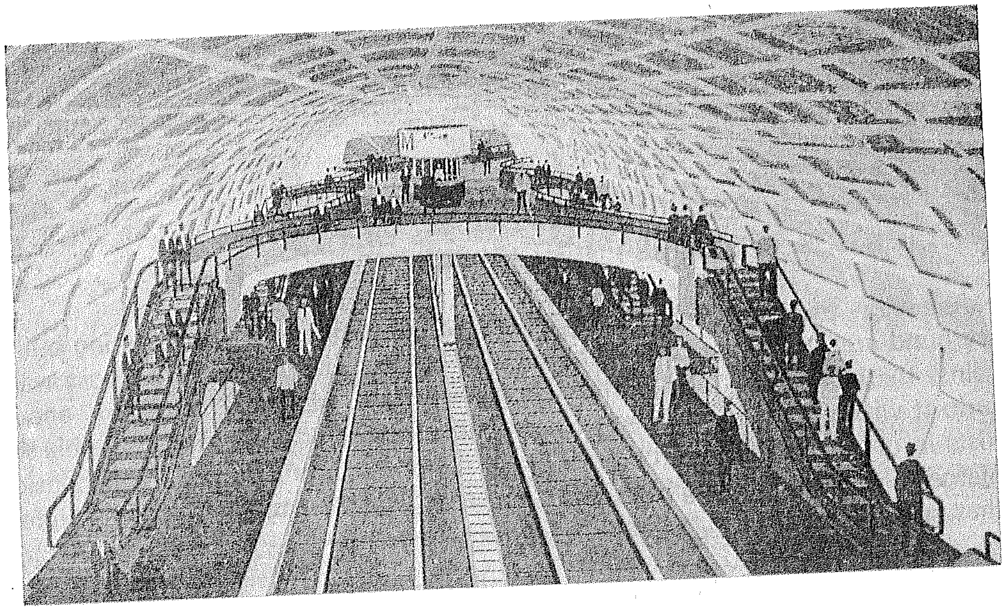
COLUMN AND FAILURE CONE

SUBWAYS, TUNNELS, MINES, AND CAVES

About 12 million fallout shelter spaces have been identified in underground areas, both man-made and natural. Nearly all of these areas offer good blast protection as well. The Soviet Union has emphasized the use of subways as blast shelters in cities. They have provided blast doors in the entrances to the subway station.

Most underground structures are stronger than building basements against blast loading. A recent analysis of a subway station being built in Washington, D.C., indicated that it could withstand an overpressure of 100 psi. Without blast doors, survival might be limited to 30 or 40 psi because of the blast wave entering through entrances and ventilation openings.

Underground subways and tunnels usually contain a large volume of air. When the blast wave enters through relatively small openings into a large-volume space, the blast wave overhead will pass by before the chamber has time to fill. This means that the pressure rise is relatively slow, which increases survival chances, and the overpressure inside may never reach the outside peak overpressure.



PANEL 18

BEST AVAILABLE BLAST SHELTER

The discussion to this point should provide some insight into how existing buildings and underground areas can best be used to increase blast survival. Identifying best available shelter against the blast hazard is a fairly technical task and, we admit, not nearly enough is known to do it with precision. In lieu of professional assistance, we offer the table shown here. It lists in order of survivability the various shelter locations that could be considered by the emergency planner. Using the space represented near the top of the list is preferable to using that near the bottom of the list.

One cautionary note should be sounded. Attempting to move people considerable distances to gain shelter is unwise in blast-prone areas. There may not be enough warning time. Increasing the population density in downtown areas is also a questionable tactic, even if the better shelter is there. The ideal movement plan is one that moves people as little as necessary and, in general, in the direction of the more sparsely populated parts of an urban area. Unfortunately, there is no easy way to compare the value of better shelter with the value of a more widely distributed population. Many studies have shown, however, that sending the daytime population home is "good" civil defense. Since even the work force is at home about 70 percent of the time, emphasis should be on locating suitable basement space close to where people live. An implication for planning is that residential basement space is of great potential value.

RELATIVE BLAST PROTECTION

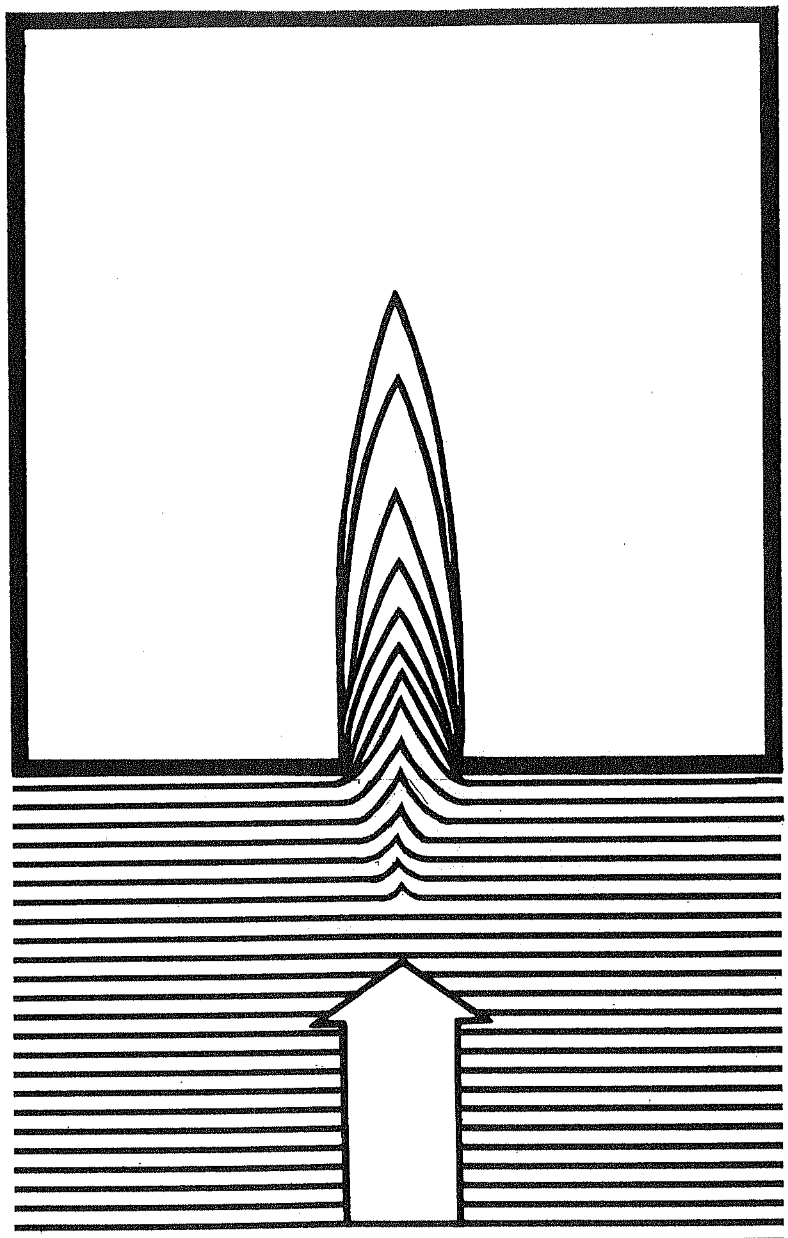
Preference	Description
A	Subway stations, tunnels mines, and caves with large volume relative to entrances.
B	Basements and sub-basements of massive (monumental) masonry buildings.
C	Basements and sub-basements of steel and reinforced-concrete framed buildings having flat slab or slab and beam ground floor construction.
D	First three floors of buildings with "strong" walls.
E	Basements of wood-frame and brick-veneer residences.
F	Fourth and higher floors of buildings with "strong" walls.
G	Basements of steel and reinforced-concrete framed buildings with flat plate ground floor.
H	First three floors of buildings with weak walls, brick buildings and residences
I	Fourth and higher floors of buildings with weak walls.

PROTECTIVE POSTURE FOR BLAST SURVIVAL

As noted previously, being thrown by the blast wind is the main source of injury and death in aboveground locations. Lying down rather than standing up is the preferred protective posture and would save many lives.

In basement areas, the hazard situation is somewhat different. People in basements will be subjected to severe wind forces only for as long as it takes the blast overpressure to fill the basement volume. The blast wave would enter through stairways, ventilation ducts, and other openings. In most basements, the filling process would be complete in several tenths of a second as compared to the several seconds of wind gust aboveground. In the vicinity of the major openings, however, the compressed air behind the shock front will rush into the shelter in the form of a high velocity air jet, as shown in the sketch.

The velocity in the jet can be sufficient to cause impact injury and death for a distance up to 10 times the width of the entranceway. In planning the use of basement areas, this hazard should be taken into account. The best location for people is near the exterior wall of the basement, out of the line of the entranceways. This location also takes advantage of the failure pattern of the ground floor over the basement. Since good basement space will usually be at a premium, people should be close-packed in a sitting position, with children sitting between the legs of adults. This protective posture can be maintained for several hours after the shelter is occupied. If people must be located in more hazardous areas, they should be encouraged to lie prone.



SHOCK WAVE

PANEL 20

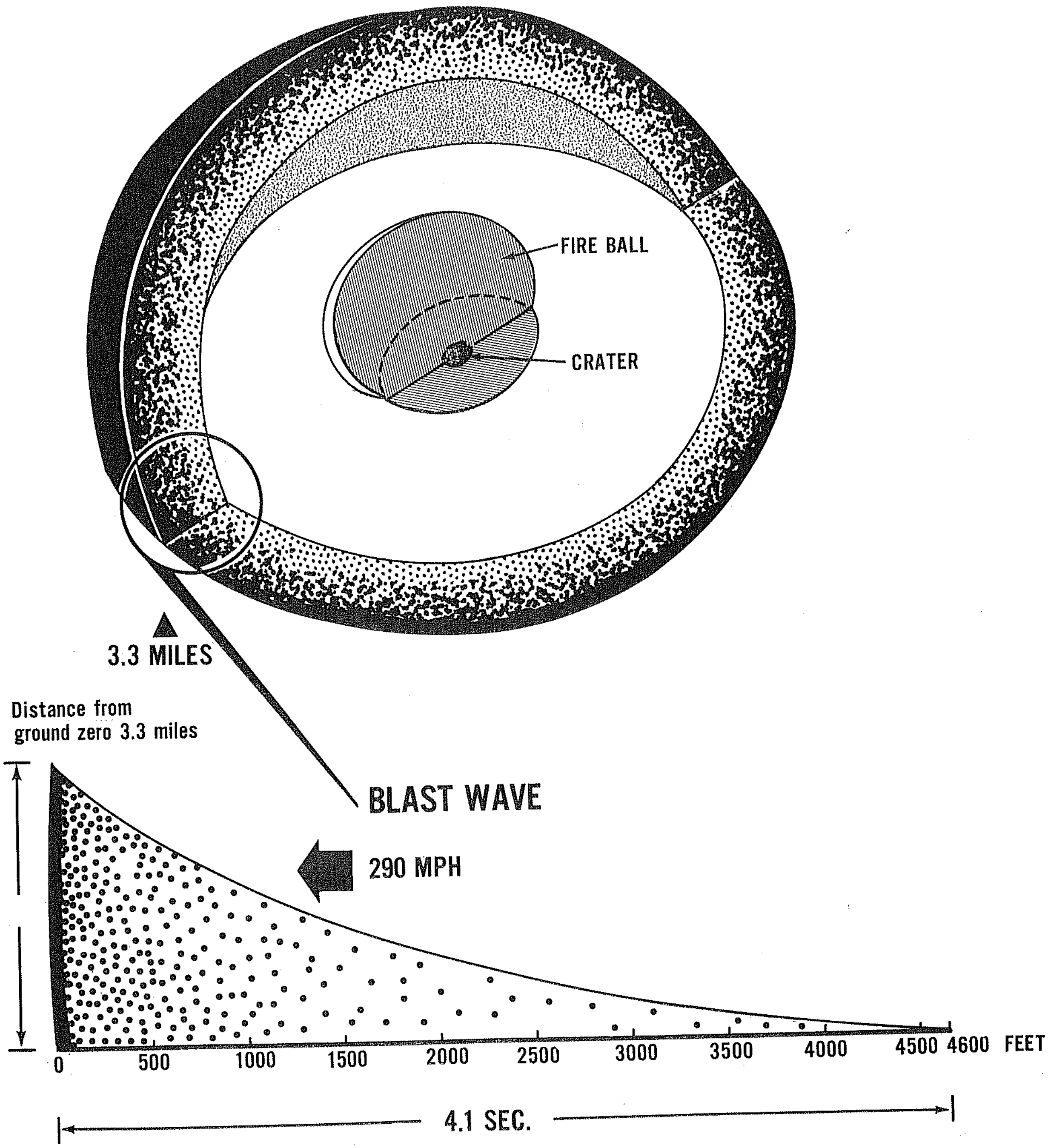
EFFECTS OF GROUND SHOCK ON PEOPLE

Up to now, we have ignored the pressure wave propagated through the earth by a nuclear detonation. The reason is that ground shock causes little damage in the "low overpressure" region with which civil defense planners are concerned. However, the ground shock should be considered in positioning people in basements.

There are two sources of ground shock. A surface burst imparts a portion of its energy directly to the ground, forming a crater and creating a "direct" shock wave. This direct shock decays rapidly as it expands outward into the ground. Additionally, the advancing air blast wave exerts intense pressures on the ground beneath it. As shown in this sketch, the blast wave is pressing down on a circular band of ground nearly one mile wide when the peak overpressure is 10 psi. It is continuously generating a wave in the ground that has a duration about the same as that of the air blast wave itself. This "air-induced" ground shock cannot affect aboveground portions of buildings as much as the air blast wave itself. But belowground portions can be moved suddenly for small distances, possibly causing injury to people if they are leaning against the basement wall. Therefore, people should be positioned near but not against the exterior wall.

A good plan for positioning people in basements is to have them sit back-to-back in a double row, with one row facing the basement wall. Injury through the soles of the feet is unlikely if the knees are bent. By using two back-to-back rows, with children between the legs of adults, people can be "packed" into the safest parts of the shelter area, leaving the central area and areas near entrances free. An on-site survey of each basement should be made to determine how many people could be accommodated in this fashion.

5 MT SURFACE BURST



DAMAGE FROM GROUND SHOCK

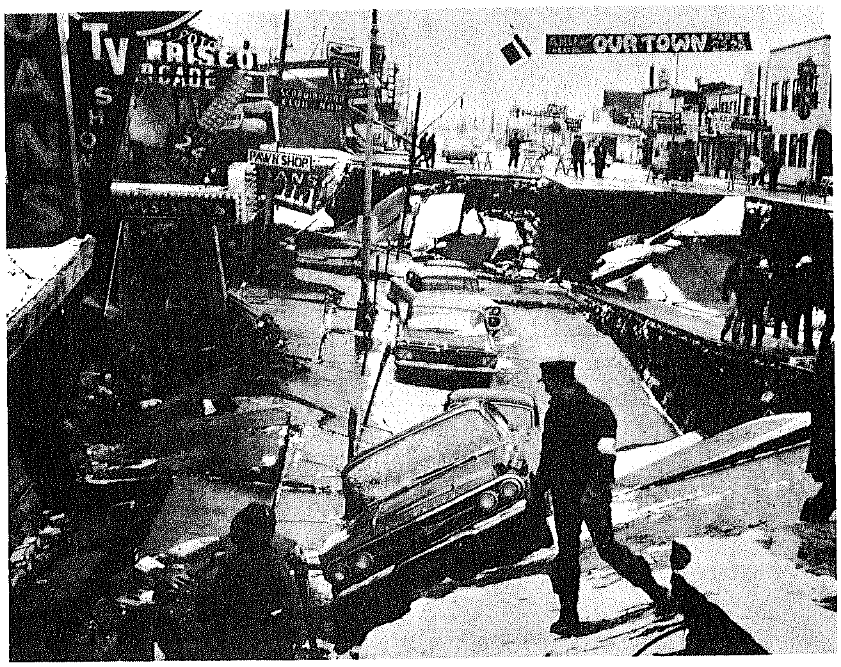
Air blast overpressure and the associated wind gust will cause most of the damage in the "low overpressure" region of interest to civil defense planners. The ground motion produced by the passage of the blast wave will, however, have some consequences. The surface overpressure generates a compressive wave that travels through the soil. The differential motion of the soil can stress underground piping at joints and connections. The ground shock wave also compacts the soil. Differential settlement and soil "liquefaction" can occur in "poor" soils. Filled land and areas with a high water table are especially vulnerable.

Generally, underground piping will not be seriously disrupted below an overpressure of 10 to 15 psi. It must be remembered, however, that failure in buried piping occurs in peacetime from traffic loads and other causes, especially in older water, gas, and sewer systems. Therefore, sporadic failures are to be expected in lower overpressure areas. Breaks in water mains under streets can result from cave-ins as shown in the upper photograph. There is some similarity between earthquake damage and the air-induced ground shock of a nuclear detonation, although the mechanisms are different.

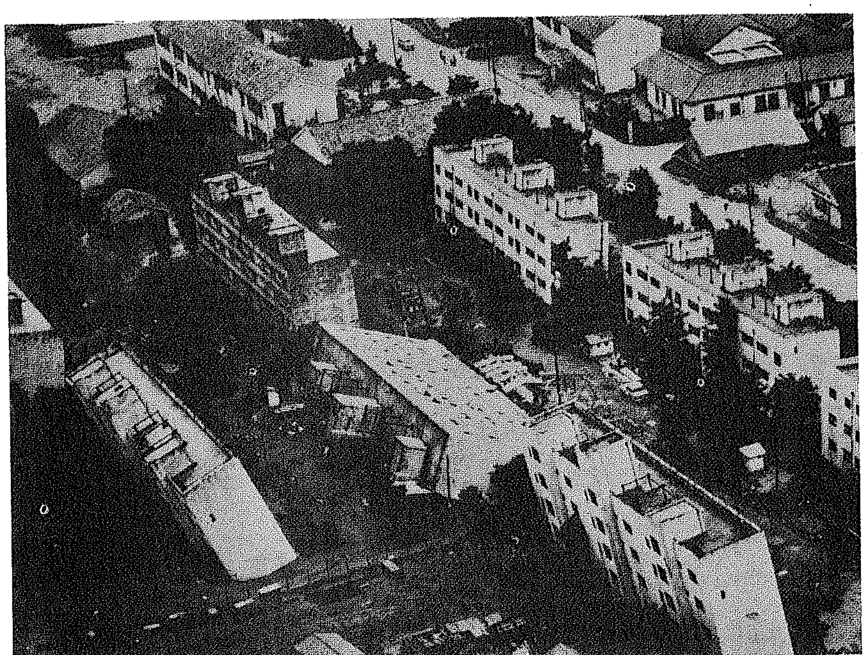
Differential settlement of the ground and liquefaction can adversely affect the foundations of large buildings. Loss of bearing support can contribute to the tendency of relatively strong-walled buildings to overturn under the pressure of the air blast wave and wind loading. An earthquake example of this type of damage is shown in the lower photograph.

There is also some evidence that long-range ground motion can cause window breakage and other minor damage beyond the area of breakage from air blast.

GROUND MOTION DAMAGE



STREET CAVE-IN, ANCHORAGE ALASKA EARTHQUAKE, 1964



TILTED APARTMENT HOUSE AFTER EARTHQUAKE IN NIIGATA, JAPAN

PANEL 22

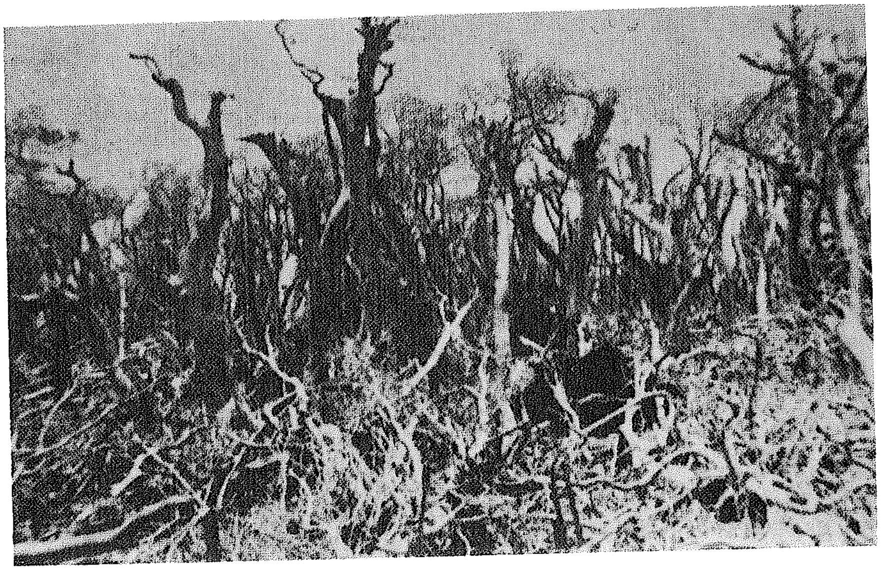
DAMAGE FROM BLAST WIND

Trees, utility poles, and radio antenna towers are "drag-type" structures, principally damaged by the blast wind. Trees are less vulnerable in winter than when in full leaf. The 70 miles per hour wind associated with 2 psi overpressure will tear off many branches. At 3 psi (100 mph wind) shallow-rooted trees and those in cities with constricted roots will be blown down. The upper photograph shows wind damage to trees resulting from a megaton weapons test. Few trees will be standing above 5 psi overpressure.

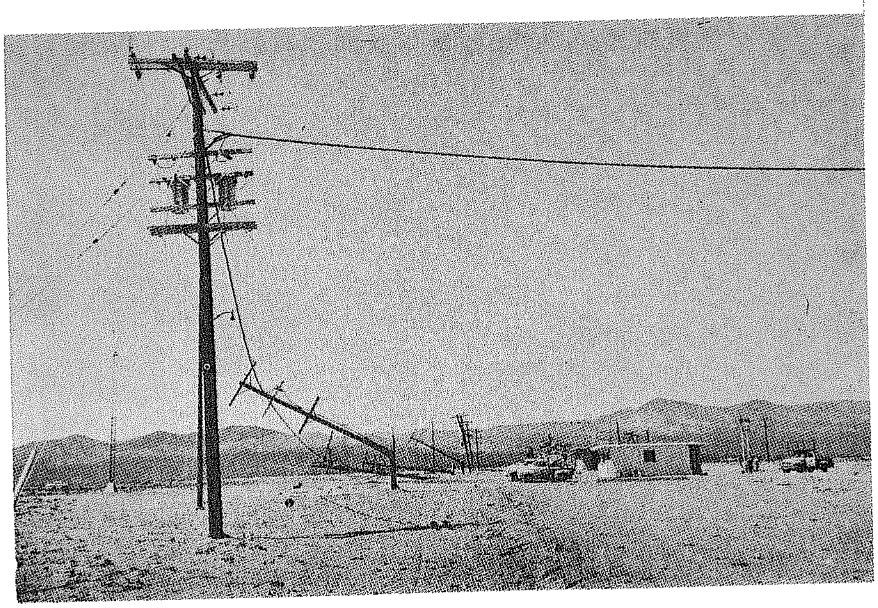
Utility poles and transmission towers with lines transverse to the blast will collapse at about 3 psi. Lines radial to the blast will be brought down above 4 to 5 psi. Well-anchored antenna towers can resist the blast wind about as well as steel building frame, failing at 4 to 6 psi.

The lower photograph shows damage to a pole-mounted transformer in Nevada at 5 psi. This sort of damage can be expected at about 3 psi for the longer-duration blast wind of megaton-yield winds. Trees, poles, and signboards can add appreciably to debris clogging access routes for emergency operations.

BLAST WIND DAMAGE



DECIDUOUS FOREST SUBJECTED TO 2.4 PSI FROM A MEGATION
–RANGE WEAPON. NOTE EXTENSIVE CROWN BREAKAGE



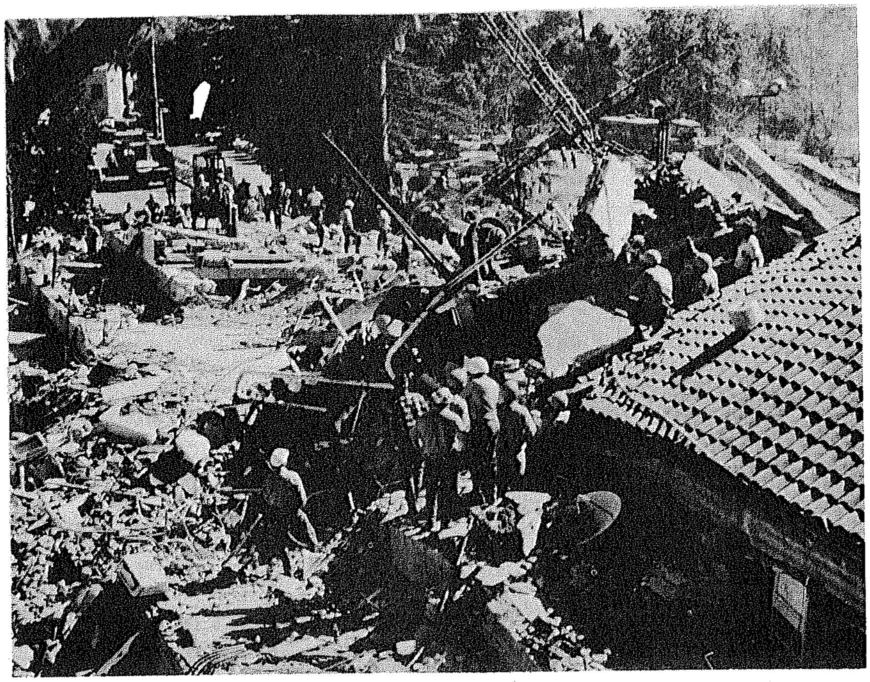
UTILITY POLE DAMAGE AT 5 PSI AT NEVADA
PROVING GROUNDS

DEBRIS FROM NUCLEAR BLAST

This chapter has emphasized the importance of the long-duration blast wave from megaton-yield nuclear detonations. In particular, the persistence of the blast wind associated with the overpressure will distribute debris to large distances from the initial site. As a result, the debris from damaged buildings can be expected to be "off-site" rather than "on-site."

The upper photograph is of debris caused by the California earthquake of February 9, 1971. Parts of the building have collapsed directly on to the building site. This is **not** the situation to be expected as the result of a nuclear detonation.

The lower photograph shows debris near the water front at Pass Christian, Mississippi, following Hurricane Camille, August 1969. The floor slab of a building near the street at lower left is nearly clear of debris. Much debris is seen behind the original site, with the building roof several hundred feet further on. This example is more nearly like the action of the blast wind.



PANEL 24

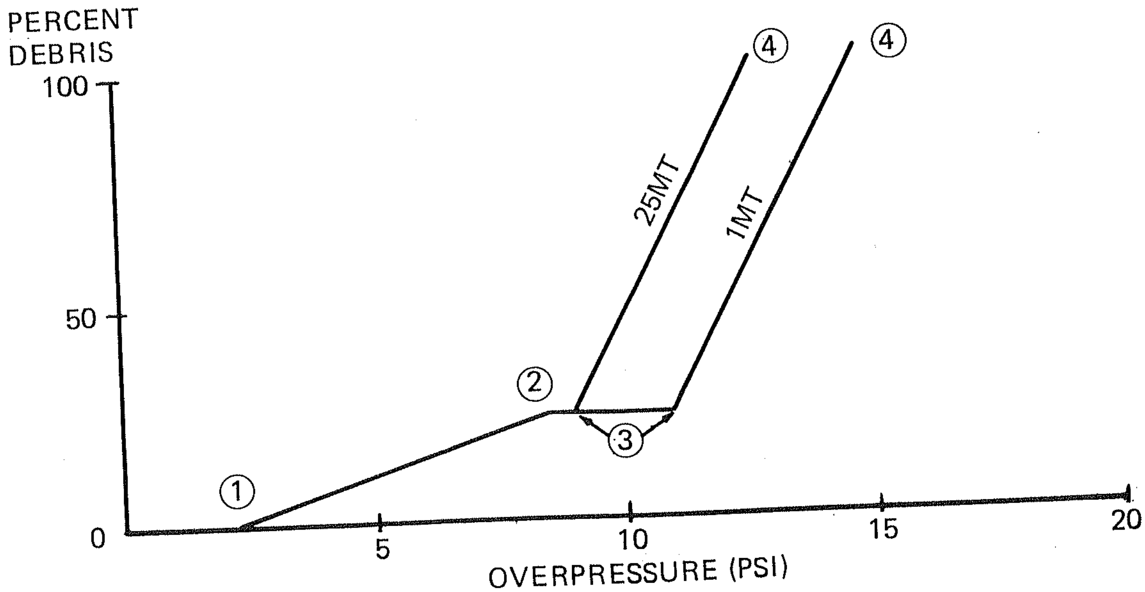
HOW DEBRIS IS RELATED TO DAMAGE

Unless a building is completely destroyed, only the parts of the structure that fail under blast loading plus the contents of the failed part of the building can become debris. Except for wood-frame and load-bearing masonry buildings, many buildings have relatively light walls and partitions that will fail at a much lower overpressure than the frame itself.

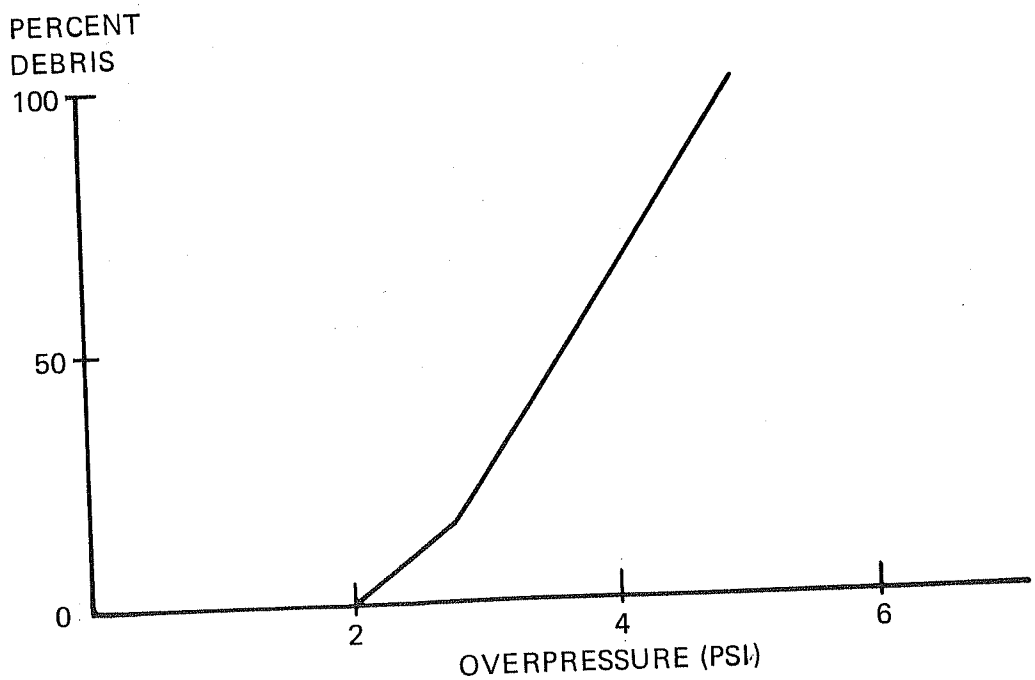
The upper sketch shows a typical "debris chart." Points 1 and 2 are the initiation and completion, respectively, of failure of the "frangible" elements of a building. The plateau between points 2 and 3 is caused by the differences in overpressure between final failure of the frangible parts (walls, etc.) and the start of failure of the "drag-sensitive" or ductile structure of the building. The location of points 3 and 4 is determined by the failure characteristics of the main structural system, which depend on the blast wind duration, and, hence, on the weapon yield. The chart shows the pattern for a multistory frame building for both 1-MT and 25-MT weapons. The height of the plateau is determined by the proportion of the total building represented by the frangible parts and the contents of the aboveground floors.

Wood-frame and masonry buildings have very little ductility and points 2 and 3 practically coincide, eliminating the plateau effect. The lower sketch is the current debris estimate for wood-frame buildings. Debris begins to form at about 2 psi and the building is completely collapsed at 5 psi. Debris is strewn off-site by 7 psi.

Masonry structures may fail at somewhat higher overpressures but the debris chart otherwise looks very much like that shown for wood-frame construction.



DEBRIS CHART FOR MULTISTORY STEEL OR
R.C. FRAMED BUILDING WITH LIGHT EXTERIOR PANELS



DEBRIS CHART FOR WOOD-FRAME BUILDING

PANEL 25

DEBRIS DEPTHS

The debris charts of Panel 25 were constructed by calculating the volume of structural material contained in the various building components and then estimating the part of these components that would become debris at a particular overpressure. The volume of structural material from buildings is relatively small compared with the volume occupied by the undamaged structure, generally less than one-tenth as much. The contents of buildings can also become debris. A rough rule of thumb is that the volume of contents as debris equals the debris volume of the structure. Additionally, the jumble of debris contains much void space, so the volume of **debris** is generally twice as much as the volume of the actual materials involved.

The structure and contents of a single-story frame residence represents 2 feet of material (and voids) over the plan area of the house. Of course, the debris would be spread over a much larger area of perhaps several hundred feet extent. Typical debris depths for the frangible parts and contents of a number of building types under these circumstances are shown in the table. It can be seen that debris depths may be quite small in many residential and industrial areas. In downtown areas of many high-rise buildings and relatively narrow streets, debris depths could be tens of feet deep. Should overpressures exceed that necessary to collapse the frames of tall buildings, they would "lay over" as in Panel 14, blocking the neighboring streets and areas away from the burst.

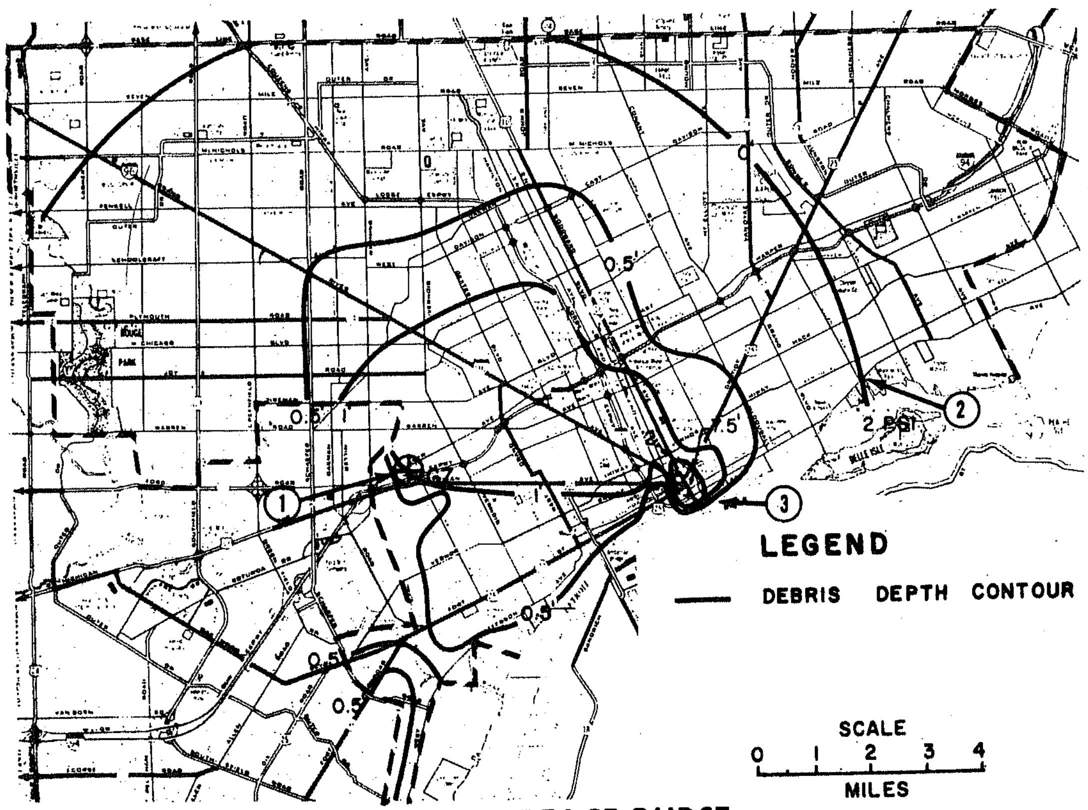
TYPICAL DEBRIS DEPTHS

Building	Average Debris Depth (feet)
One-story Industrial	0.3
Two-story Wood-frame Residence	0.5
One-story Brick Residence	0.5
Three-story Duplex or Row House	3.0
Five-story Steel-frame Apartment House	7.0
Twenty-three-story High-rise Building	33.0

BUILDING DEBRIS IN A CITY

This map shows an estimate of the blast debris resulting from a 5-MT surface detonation in Detroit. Arrow No. 1 points to the hypothetical Ground Zero. The limit of significant debris is taken to be the 2 psi line, indicated by Arrow No. 2. Most of the area has average debris depths of one foot or less, even close to Ground Zero. This reflects the type of buildings and built-upness involved. Only in the downtown area (Arrow No. 3) are streets obstructed by two or more feet of debris. The maximum estimate is about 7.5 feet. The downtown area was subjected to 4 to 5 psi in this case so the debris is mostly light walls, partitions, and contents of the many multistory buildings.

In the higher overpressure region, building debris may be distributed fairly uniformly. But, for the most part, the debris would be distributed away from Ground Zero. Therefore, wide streets, such as Michigan Avenue, Ford Road, and Livornois, that lead directly away from (or to) Ground Zero should be relatively free of debris except where overpasses are down. On the other hand, streets running across the damaged area are likely to be obstructed. Planning of emergency operations should take into account the accessibility features of freeways, parkways, and wide streets in areas of modest construction.



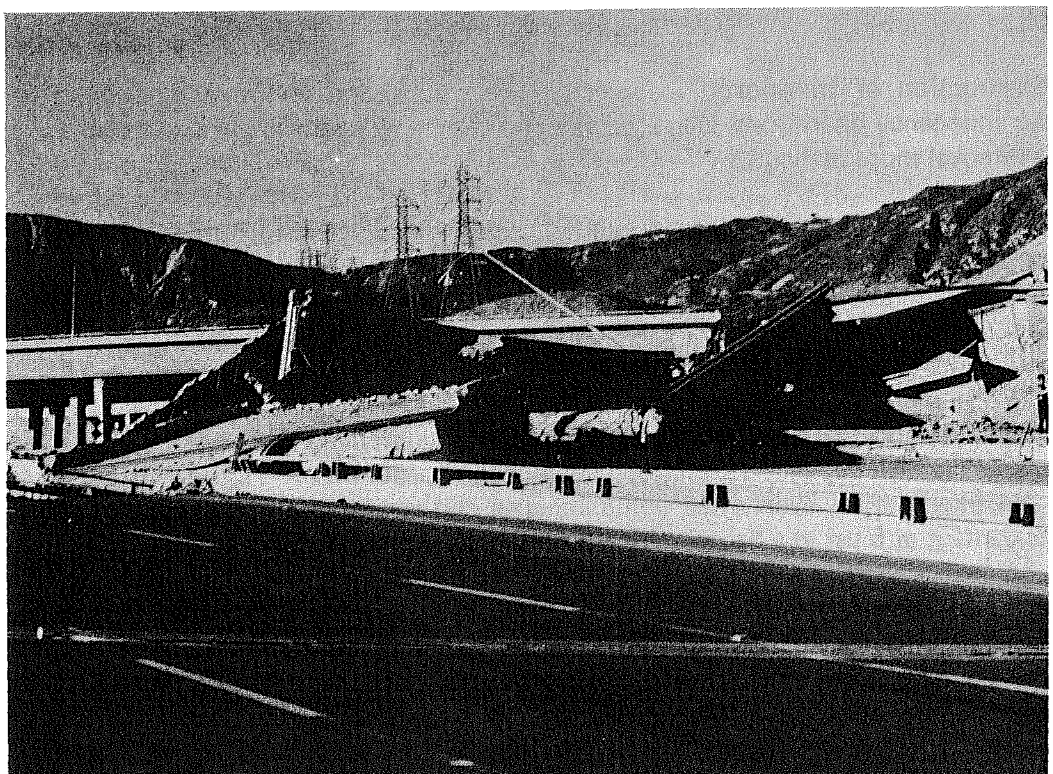
5MT SURFACE BURST

Debris Depth Contour Map (Air blast only)

DAMAGE TO BRIDGES AND OVERPASSES

Bridges and overpasses are important elements of accessibility in most urban areas. Emergency plans should take into account the vulnerability of these structures. The loss of a bridge not only blocks the road or rail route using the bridge, but also may obstruct the waterway or expressway over which the bridge passes.

Railway and highway truss bridges are quite resistant to blast, collapse occurring generally at 12 to 20 psi. Freeway overpasses are more vulnerable to destruction and may fail at overpressures of 7 to 10 psi. The photograph shown here is of freeway interchange damage resulting from the 1971 California earthquake.



FREEWAY INTERCHANGE DAMAGE
1971 CALIFORNIA EARTHQUAKE

DAMAGE TO VEHICLES

Destruction of transportation vehicles, fire trucks, and earthmoving equipment can hamper emergency operations. Damaged vehicles can impede movement on streets and make debris removal more difficult.

Damage to mobile equipment located inside or adjacent to buildings is dependent almost totally on damage to the buildings. Fire stations and garages are usually lightly constructed and fail at low overpressures. Moderate damage requiring several hours of repair work will usually occur at 2 to 4 psi. Above 4 psi, mobile equipment will generally be inoperable and trapped in building debris.

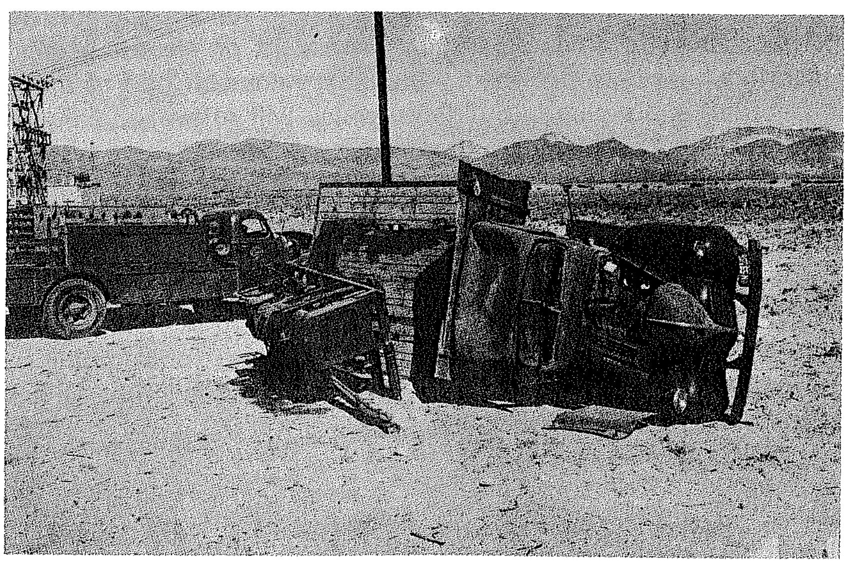
Vehicles parked in the open are significantly less vulnerable as shown on this chart. The amount of damage depends strongly on orientation to the blast. Vehicles broadside to the blast are likely to be overturned while vehicles end-on are not. The photograph shows typical damage at 5 psi in a Nevada test. Both trucks were operable.

A case study made of a 5-MT detonation in Albuquerque indicated that, with fire trucks parked in fire stations, 23 of 27 pieces of equipment were damaged, 11 of them beyond repair. If parked in an open parking lot with random orientation, only 11 were damaged, 7 of which could have been repaired.

The concept of a "multi-purpose" staging area has developed from considerations of this kind. Fire trucks, utility repair trucks, and debris-removal equipment would be parked at, say, a large shopping center, with the operating personnel taking shelter in the building basements. Coordinated emergency operations could then be undertaken following attack. even in areas of substantial damage.

VEHICLE DAMAGE

Type	Moderate Damage (psi)	Inoperable (psi)
Automobiles	3 - 5	5 - 6
Buses	6 - 10	10 - 12
Fire Trucks	6 - 10	10 - 12
Repair Trucks	6 - 10	10 - 12
Earth and Debris Moving Equipment	20 - 30	30 - 35
Truck-Mounted Engineering Equipment	12 - 15	15 - 17
Railroad Cars	15	25
Locomotives	30	80



Vehicle damage at 5 psi, Nevada Test Site; both vehicles operable.

DAMAGE TO URBAN UTILITY SYSTEMS

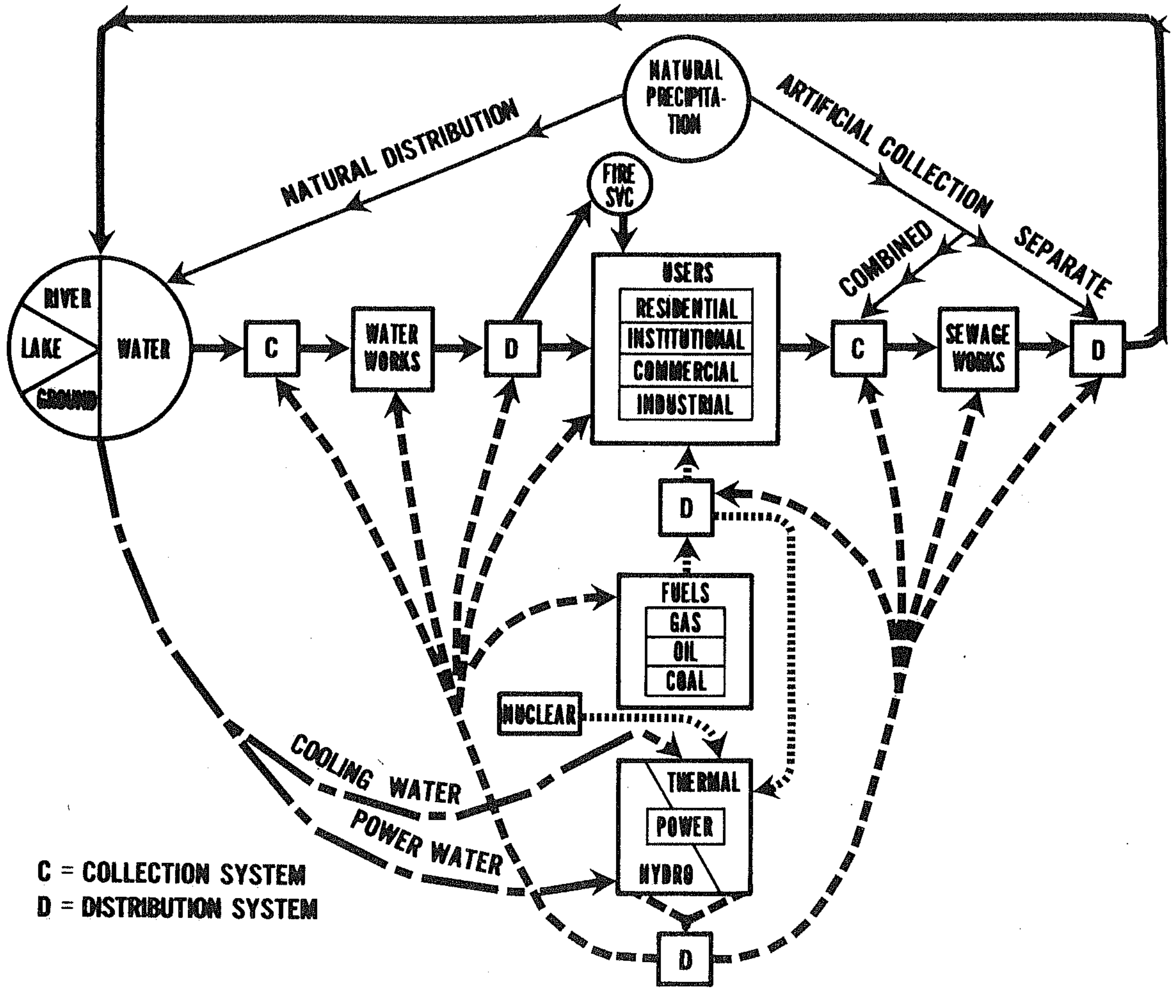
As shown in this flow chart, an urban utility system consists of inter-dependent elements, so that damage to some facilities can cause larger disruptions throughout the system. This makes it difficult to describe simply the consequences of blast damage.

Electric power is needed not only to supply light, heat, and operate motors for the main users (residential, institutional, commercial, and industrial) but also to maintain the flow of water and treatment of sewage. In general, no power should be expected above 5 psi, because of extensive damage to substations and distribution lines. In the moderate damage region, 2 to 5 psi, availability would depend on specific circumstances and early restoration of much of the service could be accomplished by isolation of damage and minor repairs. Beyond 2 psi, the distribution system would be substantially intact and power should be available.

Water treatment plants and pumping stations should remain operable at overpressures less than 5 psi, but these facilities are totally dependent on electric power unless on-site emergency generators have been provided. The most vulnerable part of the water system is the service connections and piping in buildings, which will suffer sporadic damage at 1 psi and general failure above 2 psi. If fire hydrants are served by the same system, loss of water for firefighting is likely in the moderate damage region.

Some elements of the sewage treatment system will suffer damage at low overpressures, but pumping stations will be operable up to at least 5 psi if electric power is available.

The supply of fuels is also dependent on electric power for pumping gas and oil and handling machinery for coal. Gas distribution is most vulnerable at the service connections and in buildings, much as is water piping.

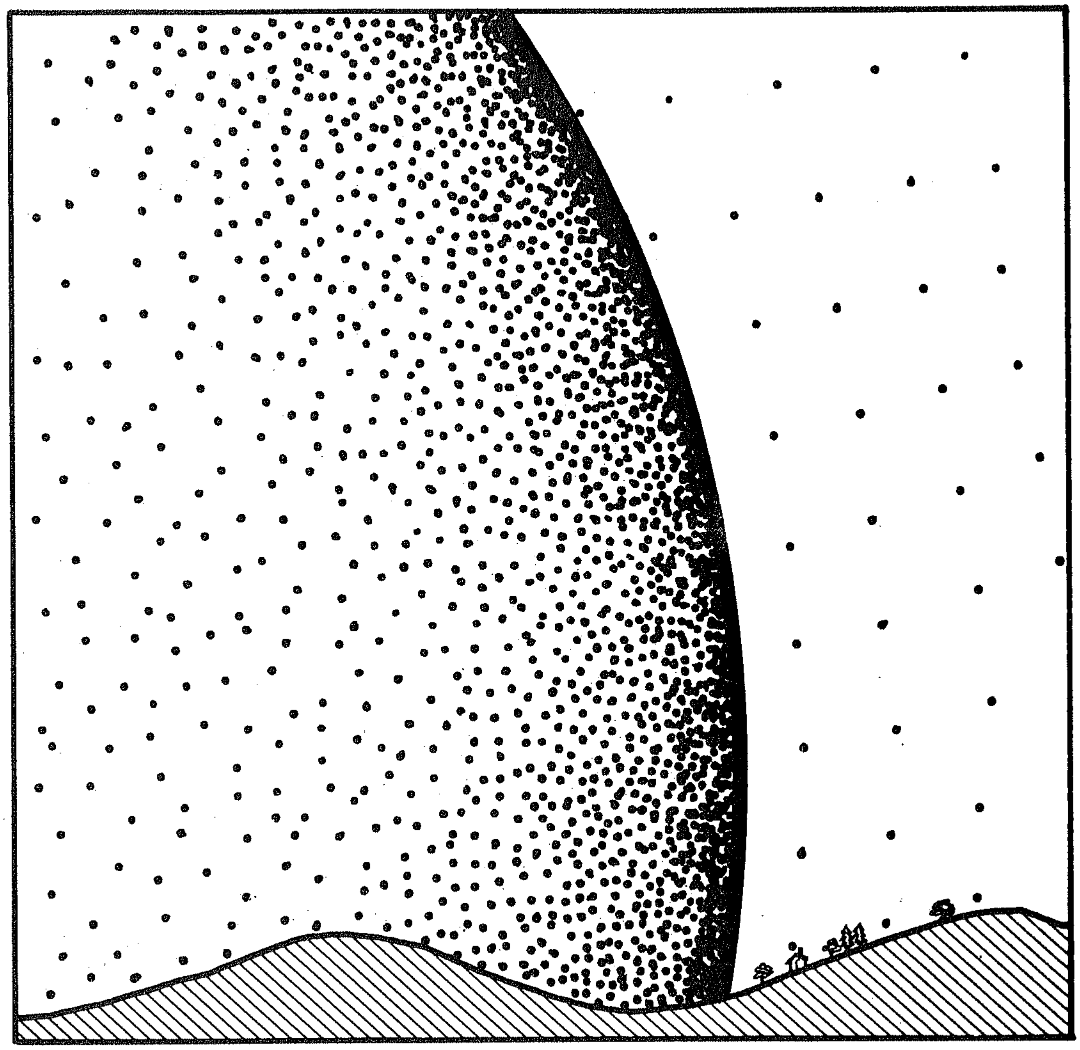


C = COLLECTION SYSTEM
D = DISTRIBUTION SYSTEM

WHAT ABOUT HILLS?

The blast wave from a nuclear detonation is little affected by hills and other terrain features. The blast wave will exert force on the far side of a hill just as it does on the rear wall of a large building. There will be some reflection from the near side of a steep hill that could augment overpressures by perhaps 10 percent, with a corresponding reduction on the far side, but these minor changes will be of little consequence.

As the sketch shows, the blast wave from a megaton-yield explosion is so large and extends so high into the atmosphere that even prominent terrain features are small in comparison. Although hills and buildings can shield people against other weapons effects, particularly for surface bursts, little reduction in blast damage to structures may be expected. However, considerable protection from the blast wind and missiles carried by it may be achieved for vehicles and people by placing them in trenches and excavations or behind steep earthmounds (revetments).

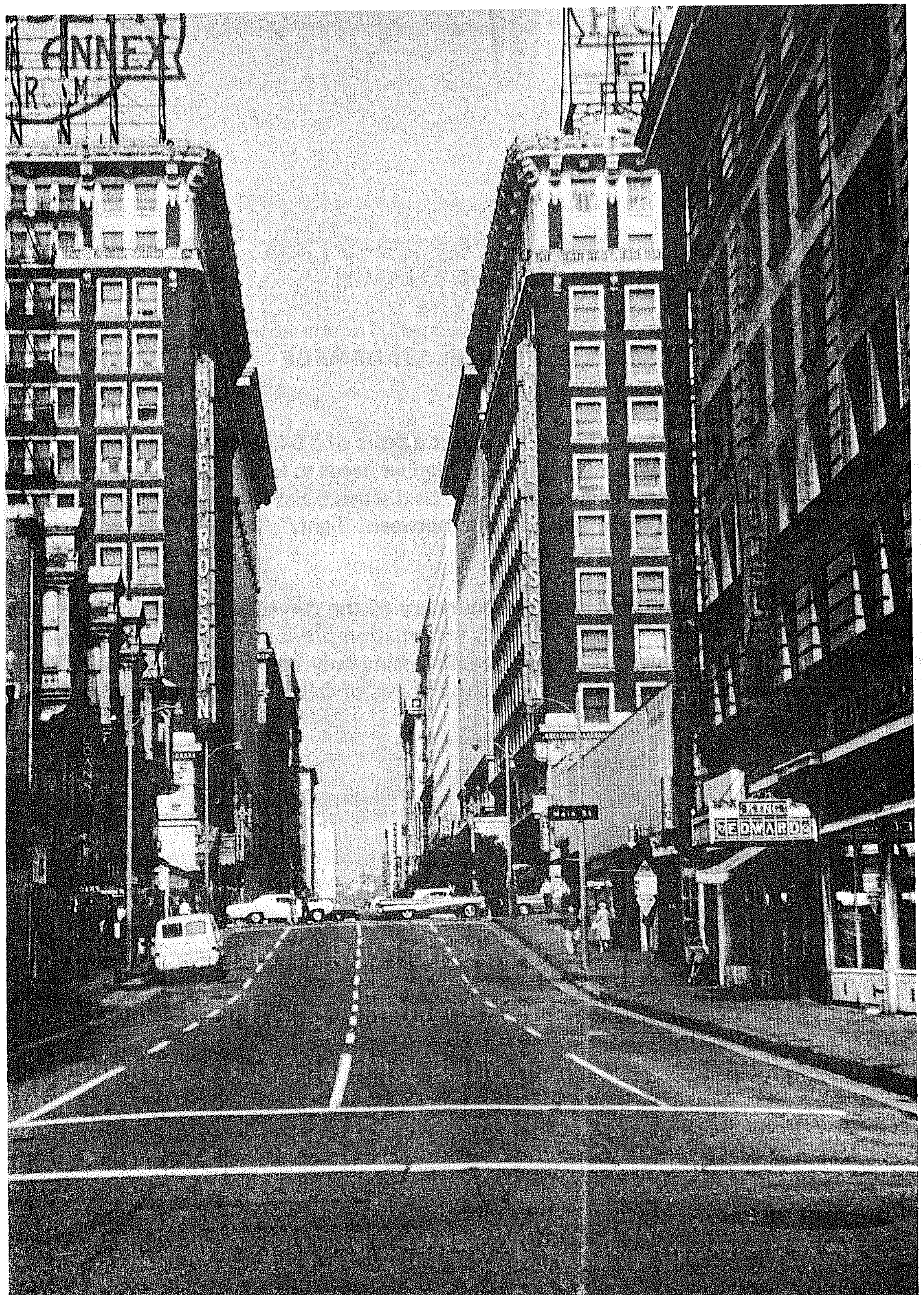


PANEL 31

BUILT-UP AREAS

The question is often raised as to whether the energy in the blast wave is not used up in the process of knocking down buildings and spreading debris. Obviously, energy is consumed and work done in the demolition process but the energy available in the blast wave is so vast that the crushing of puny man-made structures is "noticed" even less than terrain features. A locality cannot expect, then, that the blast arriving after many miles of intervening damage will be significantly diminished compared to travel over an open, featureless area.

There will be, however, considerable "self-shielding" of structures in major downtown areas. Taller buildings will reduce the effect on smaller buildings and on each other. A building in the middle of a block in the midst of other built-up city blocks will not experience the same overpressure—and, particularly, dynamic pressure—that it would standing by itself on a featureless plain. Calculations of possible effects suggest that in areas where building heights are double or more the street widths, the incident overpressure in the 10 to 20 psi region could be reduced to 75 percent of the unimpeded overpressure. That is, the damage in such areas would be more nearly like that expected at overpressures of 7 to 15 psi. This would not apply to the exposed upper floors of the taller buildings. Beyond the downtown area, the impulse in the blast wave will have been restored within a distance equal to about 5 times the average building height in the downtown area. At lower overpressures and where streets are wider than the building heights, little alteration in the blast wave can be expected.



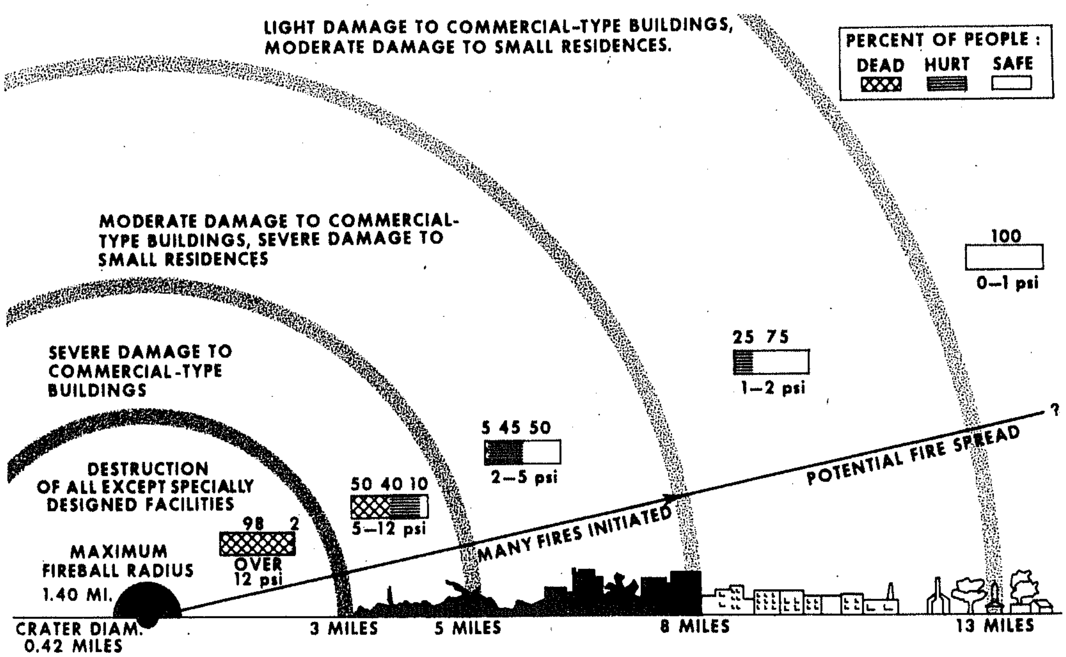
PANEL 32

A SUMMARY OF BLAST DAMAGE

Earlier, we showed this sketch of the direct effects of a 5-MT surface burst. The next few panels will summarize what the emergency planner needs to know about blast and shock effects. The same damage bands shown here will be discussed although one should recognize that there will never be a sharp dividing line between "light," "moderate," and "severe" damage.

The summary will progress from the boundary of the damaged area inward. In each damage ring, all of the damage and casualty information previously given will be brought together and related. Remember that we are discussing only blast damage in this chapter. The additional damage caused by fire and the hazards of fallout will be covered in subsequent chapters.

DIRECT EFFECTS OF 5 MT. BLAST (SURFACE BURST)

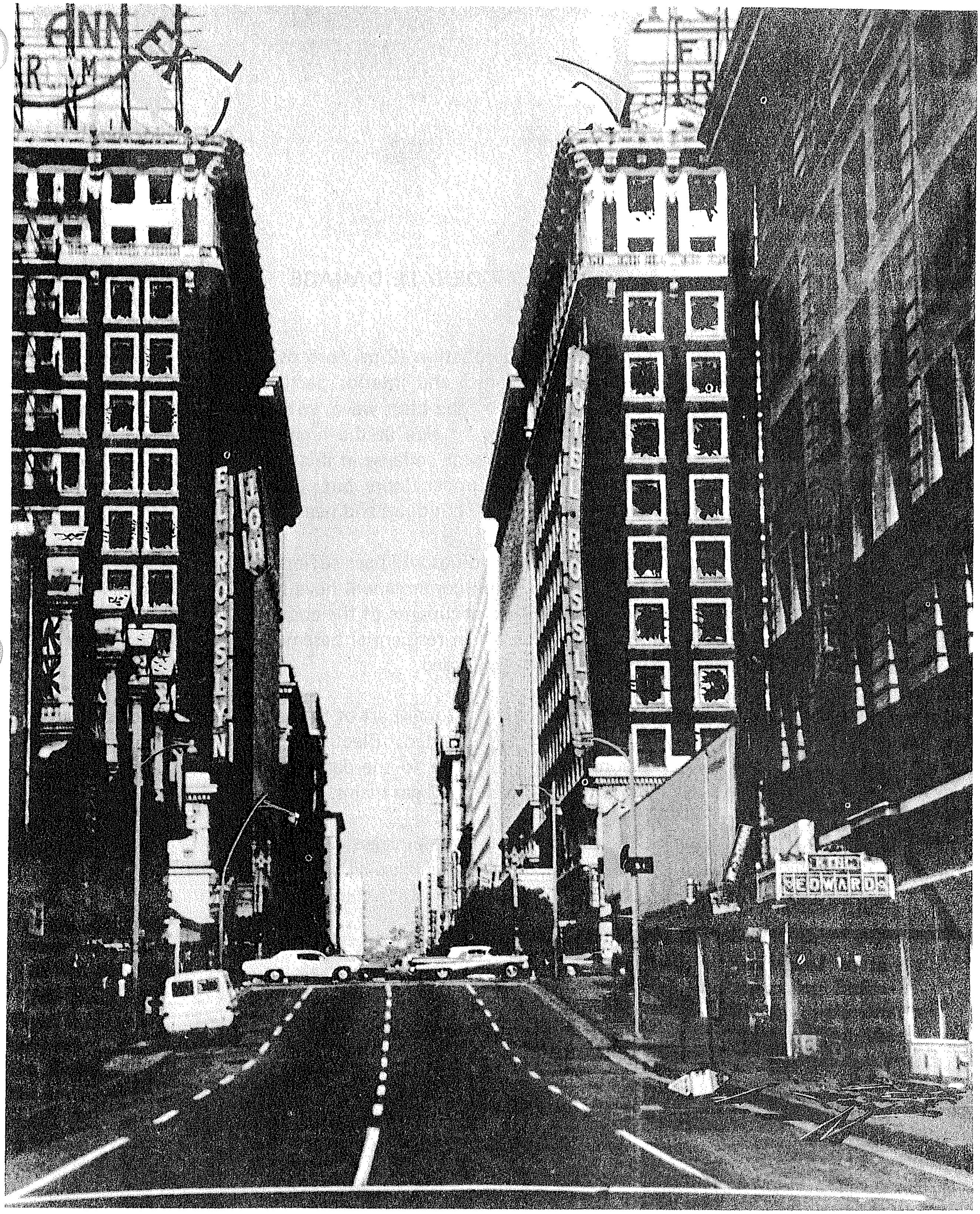


IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 8 MILES TO 13 MILES.

AREA OF LIGHT DAMAGE

From 13 miles in to 8 miles from a 5-MT surface detonation (1 to 2 psi), large structures would suffer broken windows and doors, and damage to light interior partitions. Most one- and two-family dwellings could be occupied but broken studs, rafters, plaster and damaged roofs would be commonplace. Some tree limbs would be down, causing minor damage to overhead wires. Gas and water service connections and interior piping would be wracked and, in many instances, broken. Street debris would be minor and limited to light signs and building ornamentation dislodged by the 35 to 70 miles per hour wind gust. Light corrugated metal siding on industrial buildings would be disrupted.

People in basements should be uninjured. Aboveground, many injuries from flying glass, other missiles, and impact against walls would occur, but most injuries would be minor cuts and abrasions. Almost everyone should survive and the simplest precautions could reduce injuries to a low level.



PANEL 34

THE AREA OF MODERATE DAMAGE

From 8 miles in to 5 miles from the detonation (2 psi to 5 psi), most large buildings would have lost their windows, window frames and interior partitions. Those with light exterior walls will have been swept through by the blast wave, with most of the walls and contents of the upper floors ejected out the far side at the higher overpressures. Load-bearing masonry buildings will have suffered some collapse in this area. There will be many injuries and some deaths among people on the upper floors, but people in basements should survive relatively uninjured except in some brick buildings and near basement entrances.

Most one- and two-family residential buildings will have suffered damage ranging from severe damage to collapse. Building debris and contents will have been blown over a large area in an outward direction. Up to half the occupants of the aboveground parts will have been killed and the remainder injured. People in residential basements will survive for the most part, although the first floor may have collapsed.

Trees and utility poles will be down over the inner part of the area. Service connections to residences and industrial buildings will be disrupted. Electric power may be available in the outer part but water pressure will be lost due to the damage to service connections. Some sporadic failures will occur in buried water and gas mains.

Debris will be substantial in cross streets but radial streets should be mostly clear except in narrow downtown streets. Tree and pole damage will occasionally block vehicular traffic on otherwise traversable streets. Pedestrian movement should be feasible throughout the area.

PANEL 35

AREA OF SEVERE DAMAGE

From 5 miles in to 3 miles from the detonation (5 psi to 12 psi), the damage to structures becomes increasingly severe. Small wood-frame and brick residences have been destroyed and distributed as debris over hundreds of feet. Load-bearing masonry-walled buildings have collapsed over most of the area, with the exception of monumental buildings. Framed buildings with relatively weak walls will have been gutted throughout the area and, in the inner region, the framing will have collapsed away from the blast. Of the people aboveground, there will be many survivors, particularly between 4 and 5 miles, but few uninjured survivors. People in good basement shelter will survive with few injured in the outer part of the area, with casualties increasing toward the 3 mile circle. There will be few survivors inside of 4 miles in basements with flat-plate floors overhead and in load-bearing wall masonry buildings of the ordinary type.

Traffic into this area would be greatly hampered or impossible without debris clearance. The debris in areas of lightly-constructed buildings would probably not block radial streets severely, but large and small chunks of masonry and construction steel would make clearance in densely built-up areas a major undertaking. The feasibility of pedestrian movement would be variable throughout the area, with radial streets most likely accessible.

There would be no electricity or water pressure in this area and increasing numbers of breaks in gas and sewer mains. Radio antennas and telephone lines would be damaged such as to make communication unlikely. Automobiles would be inoperable and other vehicles would be damaged or trapped in debris except in open areas.

Closer in toward the detonation, destruction would rapidly become complete, with survivors only in the strongest underground facilities.

PANEL 36

SUGGESTED ADDITIONAL READING

The following sources provide additional background on the material in this chapter:

Effects of Nuclear Weapons, Revised Edition 1964, Glasstone, S., (editor), Chapters III, IV, V, XI, and XII, Superintendent of Documents, GPO.

Andersen, Ferd E., Jr., et al., **Design of Structures to Resist Nuclear Weapons Effects**, ASCE Manual of Engineering Practice No. 42, 345 E. 47th St., New York, New York. 1961.

Davisson, M.T., et al., **Air Force Design Manual**, University of Illinois, AFSWC-TDR-62-138, December 1962, National Technical Information Service, Springfield, Va.

Coulter, G.A., **Flow in Model Rooms Caused by Air Shock Waves**, Ballistic Research Laboratories Memorandum Report 2044, July 1970. (AD 711 885).

Wilton, C., and B. Gabrielson, **Shock Tunnel Tests of Wall Panels**, URS Research Company, January 1972. (AD 747 331).

Wiehle, C.K., and J.L. Bockholt, **Blast Response of Five NFSS Buildings**, Stanford Research Institute, October 1971. (AD 738 547).

Wiehle, C.K., and J.L. Bockholt, **Existing Structures Evaluation, Part IV. Two-Way Action Walls**, Stanford Research Institute, September 1970. (AD 719 306).

White, C.S., **The Nature of the Problems Involved in Estimating the Immediate Casualties from Nuclear Explosions**, CEX 71.1, NTIS, U.S. Department of Commerce, Springfield, Virginia.

Longinow, A., et al., **Civil Defense Shelter Options: Deliberate Shelters**, IIT Research Institute, December 1971. (Volume I, AD 740 174; Volume II, AD 740 175).

PANEL 37

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DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 3

WHAT THE PLANNER NEEDS TO KNOW
ABOUT FIRE IGNITION AND SPREAD

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 3

This description of the fire environment following nuclear attack is intended to provide the operational planner with the basic information needed to plan realistic fire defense actions. It presumes that the reader is familiar with the material in Chapters 1 and 2 of the Manual. Knowlege of the material in subsequent chapters is not necessary.

Information is presented in the form of "panels," each consisting of a page of text and an associated sketch, photograph, chart, or other visual image. Each panel covers a topic. This preface is like a panel with the list of topics in Chapter 3 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with one introductory panel, followed by three on the thermal hazards to people. There are five panels on ignitions and initial fires. Five subsequent panels discuss the impossibility of firestorms in nuclear attack. There follow ten panels on the dynamics of fire growth and spread. Six panels describe life safety in the fire environment and one deals with damage to property. Finally, three panels summarize the general fire defense problem. There is a list of suggested additional reading for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 3

"WHAT THE PLANNER NEEDS TO KNOW ABOUT FIRE IGNITION AND SPREAD"

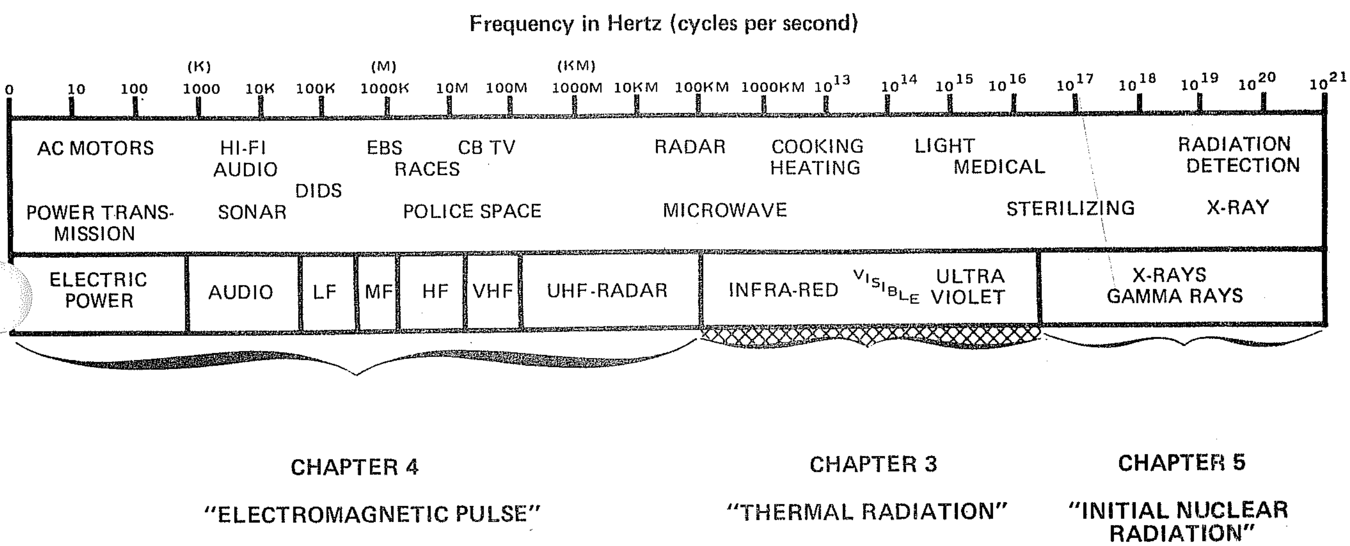
THE THERMAL PULSE

The blast wave discussed in Chapter 2 can cause fires by damaging electrical and gas lines in or near buildings. Another important cause of fires in nuclear attack is the "thermal pulse" or "heat flash" emanating from the fireball formed by an exploding weapon. An enormous amount of energy is very suddenly released in a rather small mass and volume, creating extremely high temperatures. Every hot body radiates energy. The character or "frequency" of this radiation depends on the temperature of the radiating source. At the temperature of ordinary flames, the radiation is in the infra-red, visible light, and ultraviolet region of the electromagnetic radiation spectrum shown here. But the exploding nuclear weapon is so much hotter that 80 percent of the energy is initially radiated as invisible X-rays, shown at the extreme right of the spectrum. These X-rays are very quickly absorbed in the surrounding air, heating it to form the nuclear fireball. The fireball in turn reradiates about one-third of its energy as visible light and infra-red "heat" radiation.

At Hiroshima, 80 percent of the energy emitted had been radiated outward at the speed of light by one second after the detonation. At megaton yields, the rate of emission is much slower. For a 5-MT weapon, less than 5 percent of the heat radiation is emitted in the first second. Twenty seconds are required for more than 80 percent of the pulse to be emitted. This can hardly be called a "flash"of light. The thermal pulse is sufficiently slow that its double-peaked nature is clearly evident. There is a brief flash of perhaps a tenth of a second, followed by a slower growth to full brilliance at about 2 seconds, after which the heat and light very gradually fade away. The reason for this behavior is the formation of the shock wave very shortly after the detonation, which is initially so dense as to block out the heat and light rays until it has expanded somewhat.

Most of the information in this chapter is for the planning of fire defense measures. But, first, we will describe the effects on people.

THE ELECTROMAGNETIC RADIATION SPECTRUM



PANEL 1

EFFECTS ON PEOPLE IN THE OPEN

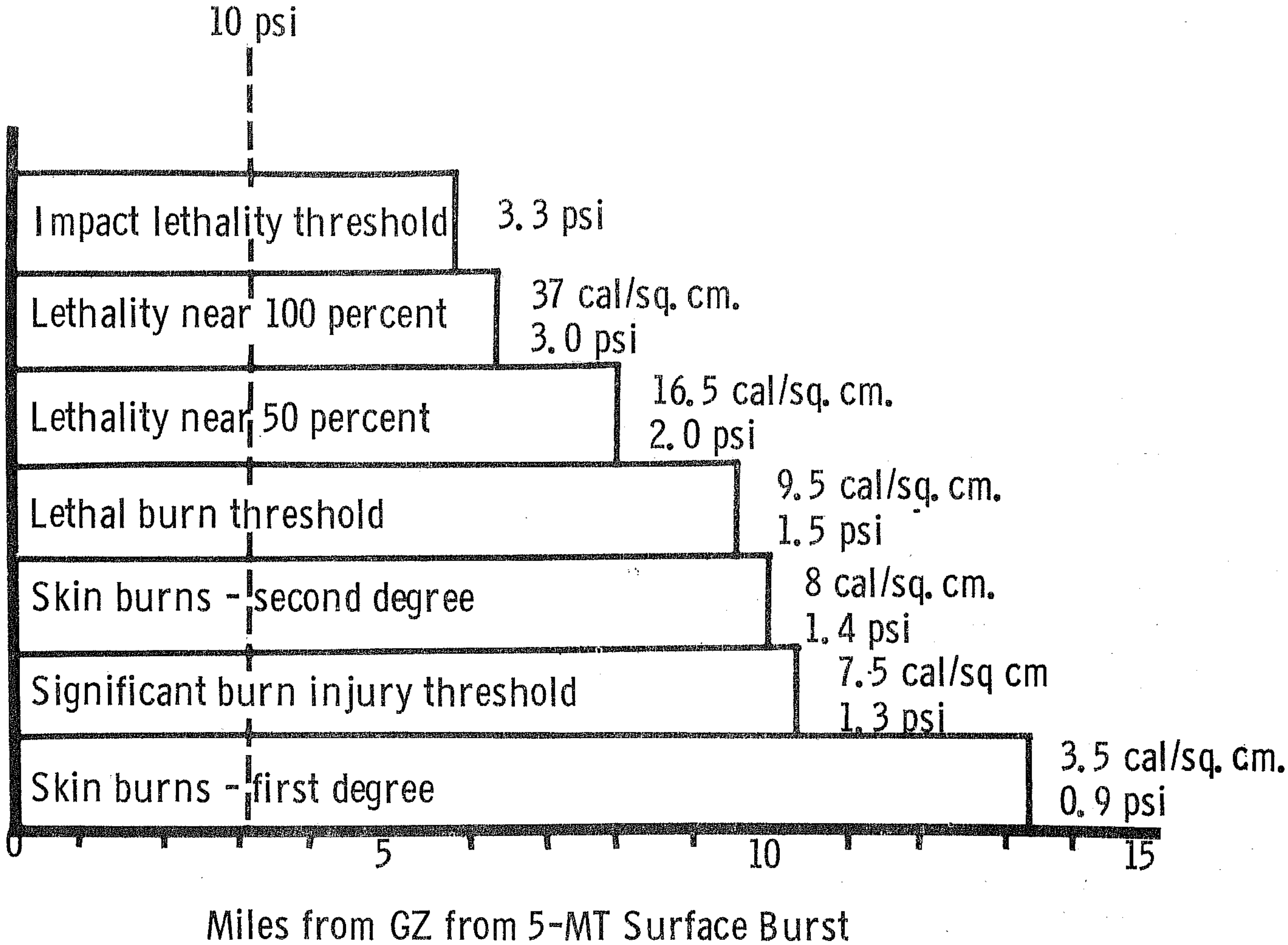
Remember the person in Chapter 2 who was standing in the open three and one-third miles from the detonation of a 5-MT ground burst? You will recall that he was engulfed in an overpressure of 10 psi about 7 seconds after the detonation and hurled by the blast wave with such violence as to cause injury and, possibly, death when he struck the ground.

Before the blast wave had reached him, he would have received lethal burns on his exposed skin and his clothing would have burst into flame. Whether the blast wind injured him critically would have been inconsequential. He could not have survived the heat from the thermal pulse.

Burns caused by heat radiation from the fireball can be the most far-ranging consequence of the immediate weapons effects. On a clear day, first degree burns can be received somewhat beyond the reach of 1 psi overpressure. A first degree burn is a burn that is painful but does not blister, like a moderate sunburn. Significant burns can be received in the area of light blast damage (1 to 2 psi). About 50 percent of those fully exposed to the fireball at 2 psi would eventually die. Death from thermal burns is almost certain at 3 psi, short of the overpressure necessary to cause impact lethality.

Notice that blast effects are expressed in English Units, such as pounds per square inch (psi). Thermal radiation effects, on the other hand, are invariably expressed in metric units, such as calories per square centimeter (cal/sq.cm.). A calorie is the amount of heat necessary to raise the temperature of a gram of water one degree centigrade, and a square centimeter is about one-sixth of a square inch.

BURN INJURIES IN OPEN ON A CLEAR DAY



From White, C.S., **The Nature of the Problems Involved in Estimating the Immediate Casualties from Nuclear Explosions**, CEX 71.1, Lovelace Foundation, July 1971.

THERMAL SHIELDING

Of course, hardly anyone lives in an area where they would be certainly exposed to thermal radiation if a weapon should detonate while they were outside. There would be buildings, trees, hills, and other objects that might block out the radiation. Virtually any opaque material will serve to shield against the thermal pulse. And the shielding will have its main effect before the blast wave strikes.

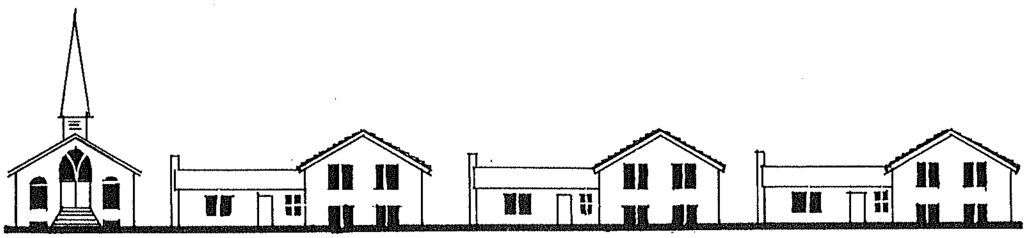
Our hypothetical person in the open at 10 psi received about 60 percent of the total thermal radiation at his location before the blast wave arrived at 7 seconds. At lower overpressures, nearly all of the radiation would be shielded out by objects before they are damaged or moved by the blast wave.

The sketch shows the current estimate of the likelihood of being shielded from thermal radiation by some structure when on the street or sidewalk. The more densely builtup the area, the more likely the shielding. These estimates are the result of thousands of observations made in typical locations in many cities. Results of these observations have also been used to estimate the likelihood that room furnishings and other fuels would be exposed to the heat radiation from the fireball.

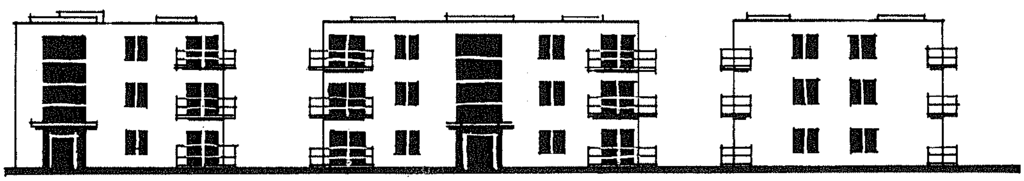
Persons caught in the open or near windows can also take advantage of the relatively slow pace of the thermal pulse from large-yield weapons. Our hypothetical person at 10 psi would have had a second or so after the initial brief flash to drop behind an embankment or into a ditch to shield himself from the main pulse. Further out, even more time would be available. In the light damage area (1 to 2 psi), evasive action within the first four seconds would avoid significant burn injury. Therefore, "duck and cover" is still good civil defense advice.

A further implication for civil defense planning is that prompt and effective warning of an impending attack will be useful in minimizing the possibility of large numbers of people in the open at the time of a nuclear detonation.

LIKELIHOOD OF THERMAL SHIELDING



ONE AND TWO FAMILY HOMES 27-34%



THREE STORY APARTMENTS 46-54%

TENEMENTS, COMMERCIAL, HIRISE 88-92%

PANEL 3

VARIATIONS IN THERMAL HAZARD

Unlike the blast wave, the thermal pulse from a nuclear detonation is one of the most "fragile" weapon effects. As we have seen, almost any opaque substance shields against the heat from the thermal pulse. In addition, window glass (clean or dirty) and window screens reduce the amount of heat transmitted by 20 to 60 percent.

Natural variations in the atmosphere and weather conditions can reduce the effectiveness of the heat pulse markedly. In these days of environmental awareness, the smoggy conditions in most of our cities is well publicized. As shown here, a medium hazy day would reduce the transmitted heat to one-half that of a clear day. In other words, the range of first and second degree burn injuries would be reduced about 2 miles over those shown previously for a clear day. Significant burns to people in the open would occur only within the moderate damage region (2 to 5 psi).

In the table, we have equated thin fog to light clouds to illustrate that if a nuclear weapon were detonated as an air burst rather than on the surface, cloud cover between the burst and the ground would have a significant effect in reducing the amount of heat transmitted. Heavy clouds would shield like heavy fog. Heavy clouds above a surface burst, however, would reflect some of the heat radiation back to the ground.

In this chapter, we will use the heat effects as they would be transmitted on a clear day (or night), since this represents the most severe case to be planned for. The emergency planner should be aware of this practice and remember that the hazard will often be less severe. He should familiarize himself with the weather and visibility characteristics of his locality and should plan that information on local weather be available in the EOC for operational use in time of emergency.

EFFECT OF VISIBILITY
ON TRANSMISSION OF THERMAL PULSE

Weather	Transmitted Energy
CLEAR DAY (visibility = 12 miles)	100%
LIGHT HAZE (visibility = 6 miles)	70%
MEDIUM HAZE (visibility = 3 miles)	50%
THIN FOG or LIGHT CLOUDS (visibility = 1.2 miles)	30%
HEAVY FOG (visibility less than 1/2 mile)	10%

From Gibbons, M., **Transmissivity of the Atmosphere for Thermal Radiation from Nuclear Weapons,** USNRDL, August 1966, AD 641 481.

IGNITABLES

In general, anything that can be set afire by the application of a single match is potentially ignitable by the thermal pulse of a nuclear weapon. This means that thin fuels, such as newspapers and curtains, are necessary as tinder for igniting other combustible materials. On the other hand, these tinder fuels do not usually contain sufficient energy by themselves to cause a sustained fire. What is needed is a "fuel array" containing both tinder and other burnables.

In this chart, we show three basic groups of ignitables and their relative sensitivity to ignition by the thermal pulse. The numbers shown are the critical ignition energies, in calories per square centimeter, that are required to cause ignition of the material. Note that the energy required for ignition increases with the weapon yield, due to the increasing length of the thermal pulse. Whether a fuel will ignite and burn depends on the **rate** of energy supplied to it. After all, the sun delivers about 700 calories per square centimeter on a hot day, but much too slowly to cause things to burst into flame. If the daily energy of the sun were delivered in about 25 minutes, then there would be ignitions.

The Group I items shown are among the most sensitive kindling fuels. And yet, these ignitables are of little concern. Hardly anyone puts black curtains at their windows. In the thousands of sites that have been surveyed, none have been found. Crumpled newspaper and dry leaves are found in urban areas but, like people in the streets, they are very often not in a position to "see" the fireball and rarely are they located with other burnables to form a sufficient fuel array to cause a building fire.

Detailed surveys of urban areas have shown that essentially all fuel arrays that could produce a sustained fire are in rooms within buildings. The materials shown in Group II are typical of materials found in commercial, industrial, and residential occupancies that are reasonably susceptible to thermal ignition and that could occasionally cause a sustained fire.

The Group III ignitables are those that by themselves have a high probability of causing a sustained fire, if ignited. That is, they contain both tinder and sufficient burnables to form a fuel array. Some fire analysts consider only upholstered furniture and beds as the fuel arrays of significance. About 35 to 40 calories per square centimeter are required for ignition by a 5-MT weapon.

COMMON KINDLING FUELS

	WEAPON YIELD (MT)		
	1	5	25
	(calories per square centimeter)		
GROUP I			
Crumpled newspaper, dark picture area	7	9	15
Black lightweight cotton curtains	6	8	11
Dry rotted wood and dry leaves	6	7	10
GROUP II			
Beige lightweight cotton curtains	32	42	55
Kraft corrugated paper carton	19	22	32
White typing paper	30	42	60
Heavy dark cotton drapes	22	27	50
GROUP III			
Upholstered Furniture	28	40	56
Beds	22	34	52

INTENSITY OF THERMAL PULSE

Since we have gained an appreciation of the range of damage from blast in Chapter 2, it will be useful to relate the ignition capabilities of the thermal pulse to the key overpressures for light, moderate, and severe blast damage. As can be seen from the table, there may be occasional fires caused by Group I kindling fuels in the light damage area. Most significant fires, however, will be confined to within the 2-psi blast region. In the simplified charts of the direct effects included in Chapters 1 and 2, the 2-psi level was used as the practical limit of fire ignition.

Note that, as weapon yield increases, the thermal radiation is less in the region of low overpressure and higher in the close-in area. Megaton-yield weapons deliver about 100 calories per square centimeter at the 5-psi overpressure level almost independent of the precise weapon yield.

Recall also that on a medium hazy day, these values would be reduced to about one-half those shown.

RELATIONSHIP OF BLAST AND HEAT
(Surface Burst on a Clear Day)

BLAST OVERPRESSURE (psi)	HEAT RADIATION (cal. /sq. cm.) 1 MT	5 MT	25 MT
1	6	4	2.5
2	21	18	14
5	100	100	105
12	350	440	620
20	560	900	1500

EFFECT OF BLAST WAVE ON IGNITIONS

At Hiroshima, there was some evidence that the blast wave that followed the thermal pulse may have extinguished many ignitions. Most fires were traced to overturned charcoal braziers in residences. The 1950 **Effects of Atomic Weapons** cited the evidence for the blast wind suppression of ignitions and concluded that few of the numerous fires were due directly to thermal radiation. But, by the 1957 edition, called **The Effects of Nuclear Weapons**, this position had been so altered by scientific debate that it was generally concluded that the blast wind had no significant effect in extinguishing ignitions.

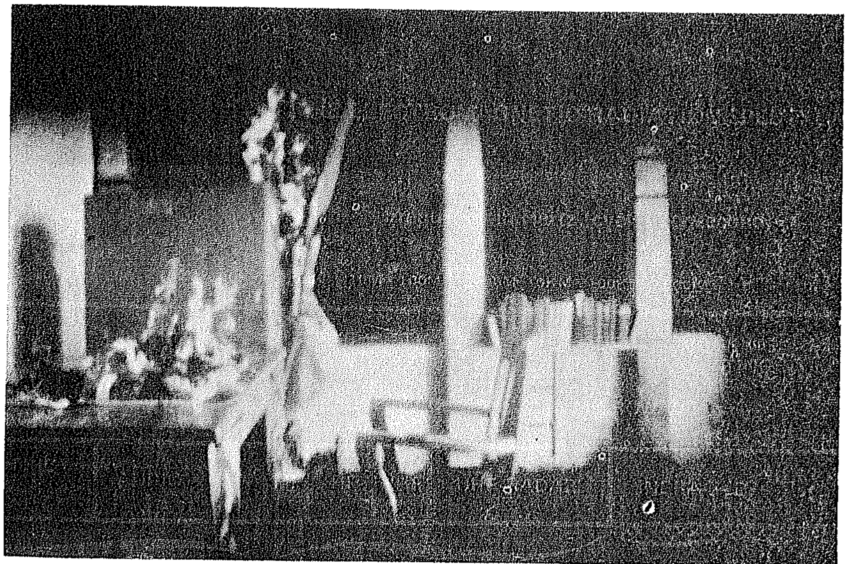
By 1970, DCPA had developed a blast simulator in which whole rooms could be accommodated. Living rooms, bedrooms, and offices were tested to see if the blast wave could blow out the fires. The upper photograph shows an office, with curtains and papers ablaze. Then, in the middle picture, the blast wave hits. And the flames are extinguished.

Overpressures of 1 psi failed to extinguish ignitions in upholstered furniture and beds and only half of the ignitions of curtains, one example being that shown here. Tests have been run at 2.5, 5, and 9 psi as well and the flames have been extinguished in all instances. However, mattresses and furniture cushions with cotton padding continued to smoulder, rekindling at times ranging from 15 minutes to several hours.

High-speed motion pictures suggest that the flames and hot gases above the burning surface are abruptly translated by the blast wind. The burning surface is thus deprived of heat from the flame and, at the same time, is brought in contact with the cooler air following the shock front, which brings the surface below the temperature required to sustain ignition. Smouldering combustion is characteristic of porous or fibrous materials in which slow combustion can persist beneath the surface after the extinguishment of flame. Since the blast wind used in the experiments to date does not persist as long as the "real" blast wind, new experiments are being designed to investigate further the problem of smouldering materials.

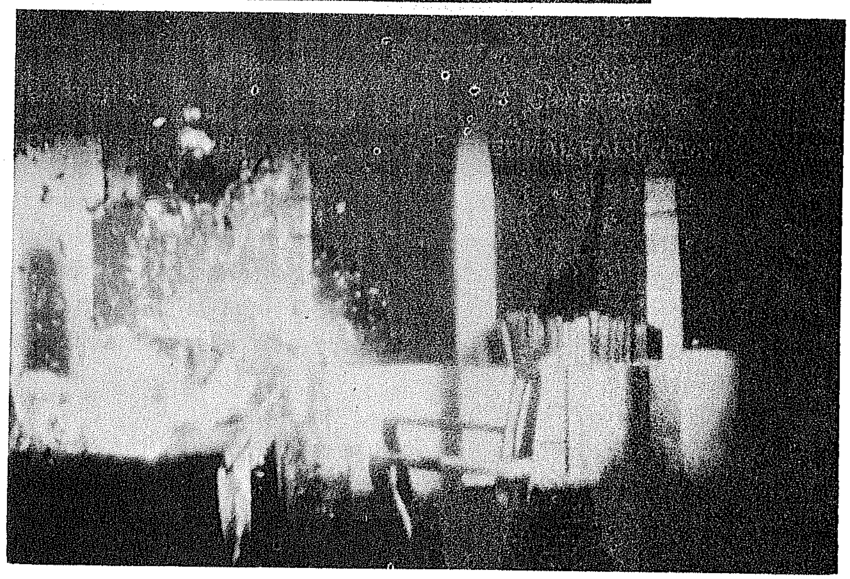
On the basis of these recent results, we conclude that many ignitions by the thermal pulse will be extinguished by the blast wind, greatly reducing the threat of fires. In addition, the progress of fire growth will be slowed, while those that remain continue to smoulder. In the absence of effective emergency action to suppress the smouldering fires, ultimate burnout could occur upon rekindling of the smouldering debris.

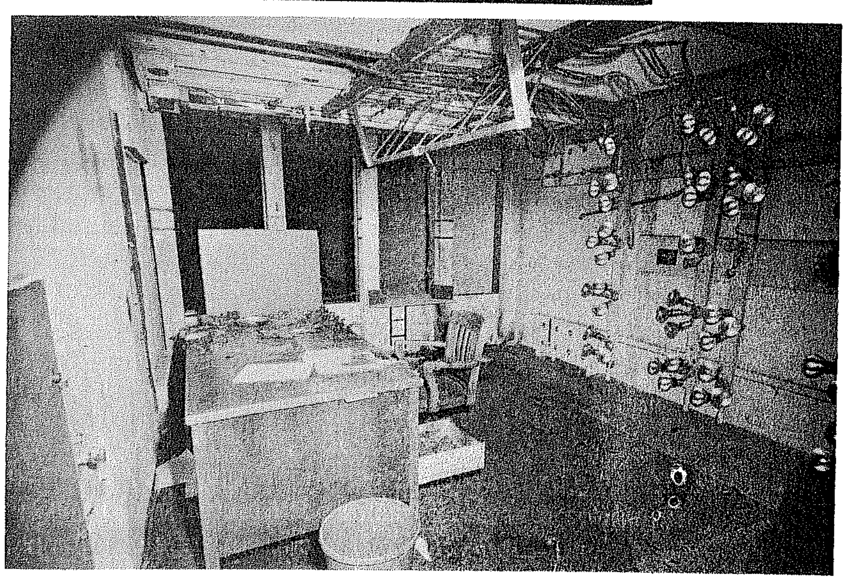
These results also suggest that, prior to attack, curtains and drapes should be closed rather than removed, as they do not represent a significant hazard and would shield upholstered furniture and beds from the thermal pulse.



EFFECTS OF 1PSI OVERPRESSURE ON IGNITIONS

From: Goodale, Effects of Air Blast on Urban Fires URS 7009—14 Dec. 1970





PANEL 7

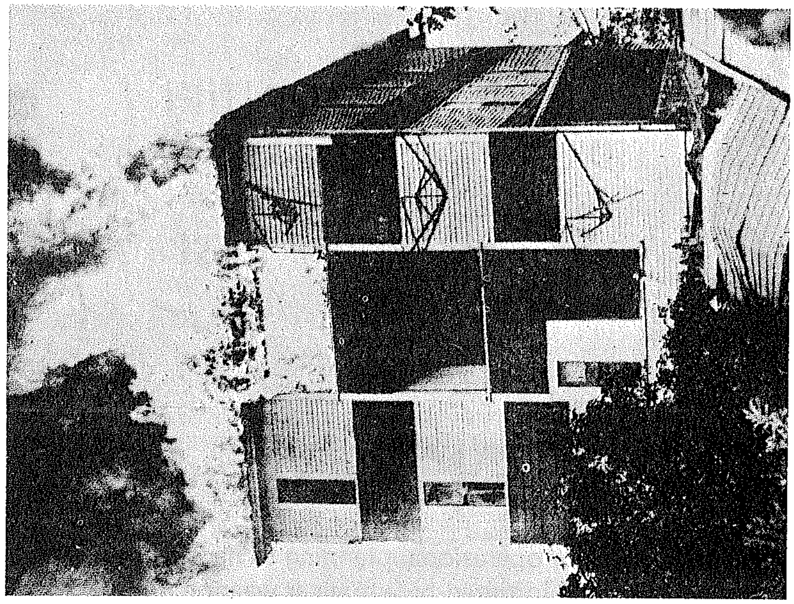
BLAST-CAUSED FIRES

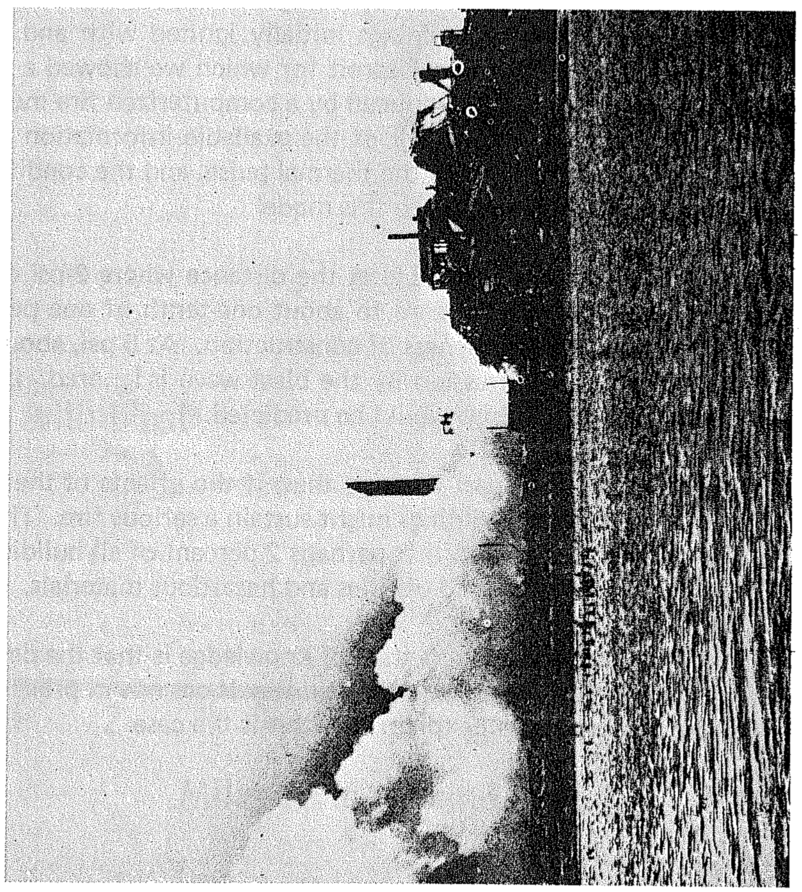
As we have just seen, the arrival of the blast wave has beneficial effects in blowing out ignitions before they have had time to become firmly established, resulting at least in considerable delay in fire development and probably a large reduction in the number of sustained fires that ensue. The blast wave can also cause fires in buildings through the damage that it does.

Study has been made of the incidence and cause of "damage-caused" fires at Hiroshima, Nagasaki, peacetime explosions such as Texas City, earthquakes, tornadoes, and World War II bombings. The results indicate that flying debris and building collapse are the major causes of these "secondary" fires. Electrical wiring and equipment and gas piping and equipment are about equally vulnerable. As we saw in Chapter 2, considerable debris is formed at about 2 psi or somewhat less. Wood-frame and brick load-bearing walled buildings are weakest but industrial and special storage facilities for hazardous materials are the most vulnerable occupancies.

The upper photograph shows a major industrial fire caused by damage to phosphorus containers in the South Amboy explosion of 1950. The lower picture shows a building fire caused by tornado damage in Worcester, Massachusetts in 1953.

Overall, a review of past experience suggests that about six significant "secondary" fires can be expected in each million square feet of building floor area in the damaged area. Thus, in an area 25 percent builtup with 2-story buildings, one might find about 80 building fires per square mile from this cause. Although the basis for this estimate is less than adequate, blast-caused fires could be an important factor in the moderate damage area. If the evidence on blast-extinguishment of thermal ignitions is correct, or if poor visibility inhibits the delivery of thermal radiation, defense against blast-caused fires may be the main problem in the moderate damage region.





1950 SOUTH AMBOY EXPLOSION

From McAuliffe and Moll, **Secondary Ignitions in Nuclear Attack**, Stanford Research Institute, July 1965, AD 625 173.

HOW MANY FIRES?

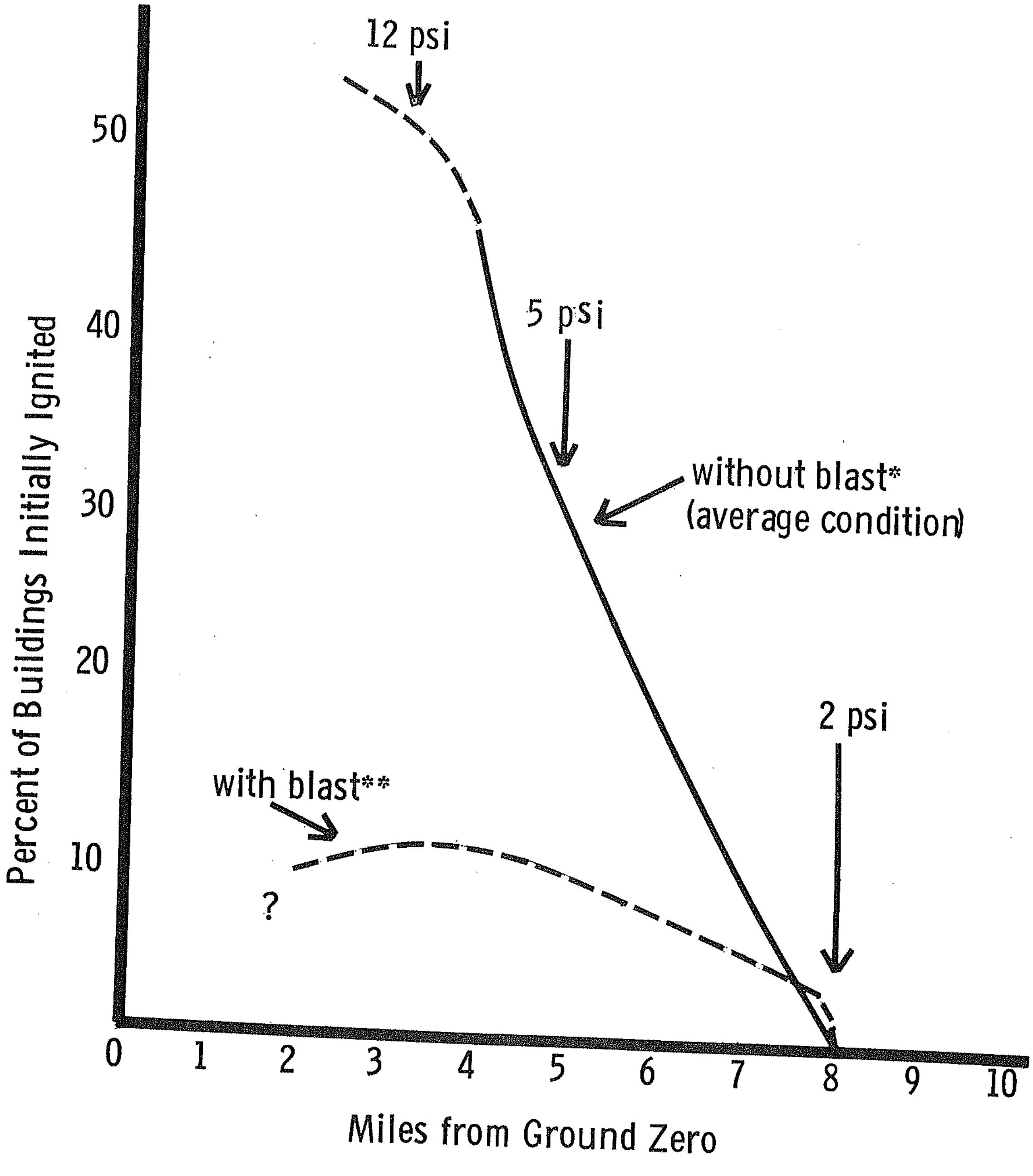
Obviously, it is important for operational planning to have a good estimate of the number of fires one can expect to be initiated by a nuclear weapon detonation. The recent evidence on the blast-wave suppression of thermal ignitions, incomplete though it is, suggests a radically different fire problem than was visualized only a few years ago. The chart shows estimates of the average percentage of buildings initially ignited with and without blast effects for the same 5-MT surface burst in Detroit for which we showed a debris map in Panel 27 of Chapter 2. These results were produced by a computerized fire model developed for DCPA by the IIT Research Institute. All of the available information on ignition of materials, their chances of being exposed to the thermal pulse, and the conditions for a sustained building fire have been incorporated into this model.

Note that building fires become negligible at the distance where 2-psi overpressure is experienced, the exact value ranging from zero to about one-tenth of one percent, depending on the type of buildings and their closeness of construction. At 5 psi, about one-third of the buildings might be ignited, if suppression by the blast wave is ignored. Inside the 5-psi region, ignition of about half the buildings would be predicted.

The lower dashed curve on the chart suggests that, if the effects of the blast wave are considered, only about 10 percent of buildings might sustain a serious fire. The steep rise at about 2 psi results from the consideration that perhaps 2 percent of all buildings would sustain "secondary" fires from blast damage to utilities and hazardous materials.

An important implication of the current state of knowledge is that the devastating "fire storm" situations that occasionally occurred in World War II are **not** in prospect in event of nuclear attack. The next few panels will explain why this is the case.

INITIAL FIRES FROM A 5-MT SURFACE BURST IN DETROIT



*From Takata and Salzberg, **Development and Application of a Complete Fire Spread Model**, IITRI, June 1963, AD 684 874.

Based on Miller, R.K., et al., **Analysis of Four Models of the Nuclear-Caused Ignitions and Early Fires in Urban Areas, The Dikewood Corporation, August 1970, AD 716 807.

PANEL 9

CASUALTIES IN LARGE FIRES

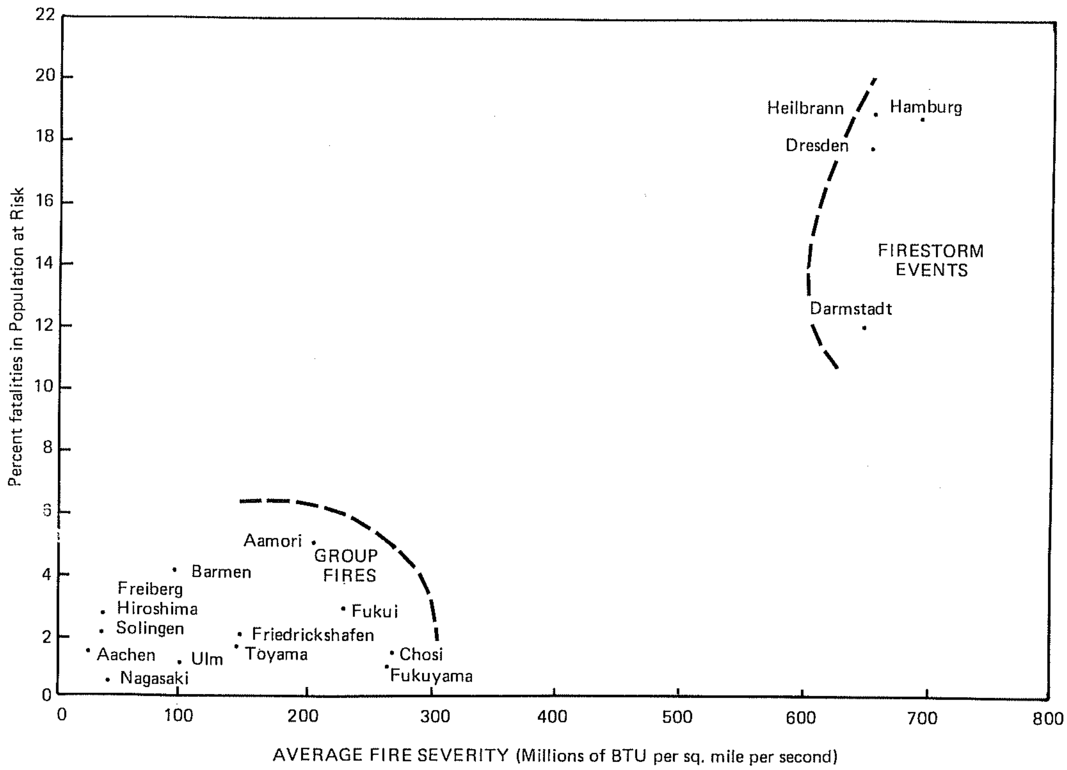
Loss of life in the large fires of World War II was considerable. The term "firestorm," coined by a German journalist, dramatically expressed the awesome nature of some of these mass fires. It took little imagination to transfer the worst of these occurrences to the event of nuclear attack. Numerous writers were led to postulate great areas of fire in which survival was unthinkable.

To gain a more objective understanding of the fire threat, DCPA has sponsored a number of studies of World War II fire experience in considerable detail. One of the results of this analysis is shown here. The loss of life among the population at risk for a large number of war fires was found to be related to the fire severity. The severity of a large fire was expressed in terms of the average heat output as measured in millions of BTU per square mile of fire area per second. [A BTU (British Thermal Unit) is similar to a calorie, being the amount of heat necessary to raise the temperature of a pound of water 1 degree Fahrenheit. A BTU is equal to 252 calories.]

Note that a large number of wartime fires are classed as "group fires." The fire severity ranged up to about 300 million BTU per square mile per second and the loss of life ranged up to 5 percent of the population at risk. Note also that the fires caused by the nuclear detonations at Hiroshima and Nagasaki are among the least severe.

At the other end of the chart are a relatively few war fires labeled "firestorm events." These cases generated a fire severity between 600 and 700 million BTU per square mile per second. The corresponding loss of life ranged between 12 and 20 percent of the population at risk. All of these "firestorms" occurred in German cities.

FATALITIES IN WORLD WAR II FIRES*



*Lommasson and Keller, **A Macroscopic View of Fire Phenomenology and Mortality Predictions,** Dikewood Corporation, DC-TN-1058-1, December 1966.

FIRESTORM POSSIBILITIES

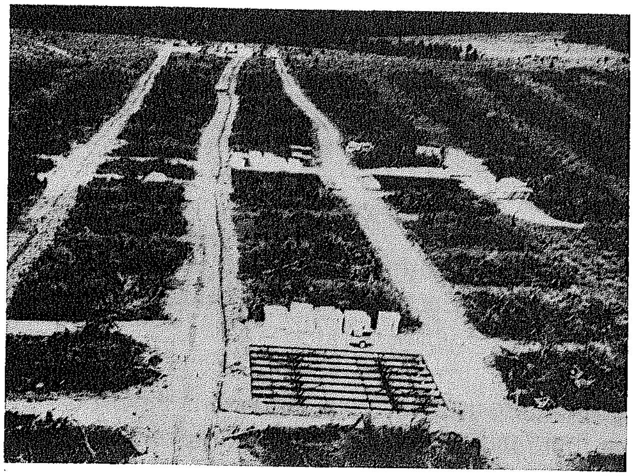
The marked increase in loss of life found in "firestorm events" focused early attention on the nature of these fires and the necessary conditions for their occurrence. The fire research community is not entirely agreed on what constitutes a firestorm, except in broad qualitative terms. What is generally meant is a mass fire characterized by high-velocity inrushing winds, a well-developed convection or smoke column reaching high into the atmosphere, and little spread beyond the area that contained the initial fires. It has been considered significant that the only clear-cut firestorm events in World War II occurred in German cities, of which the Hamburg fire was the most extreme and the most studied.

Research has been done relating fire-induced inrush wind velocities to the energy release rate of these large fires. In Germany, velocities of 50 miles per hour or greater were associated with firestorms. Winds of 40 mph or less were associated with group fires. Peak fire-induced winds at Hiroshima were estimated to reach 35 mph, which places it well down in the group fire category.

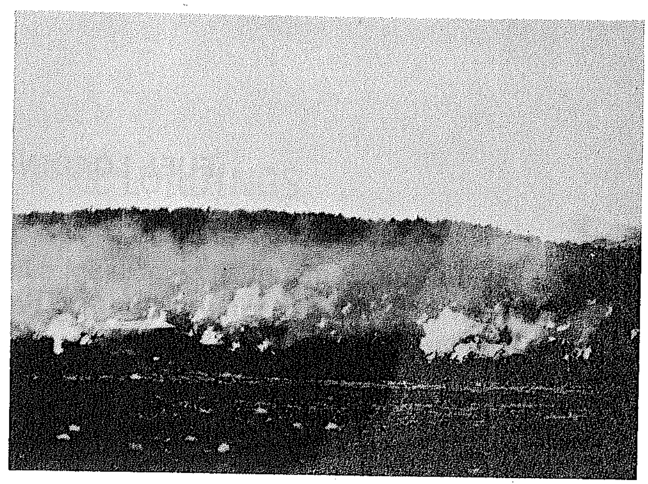
Group fires burn outward with spread from the initial fires determined by the closeness of buildings and the wind conditions prevailing at the time. Firestorms apparently involve rapid spread within the firestorm area to initially unignited structures, aided most probably by the high inrush winds. This one hundred percent involvement in firestorms is confirmed by observer reports.

From 1963 to 1967, OCD participated jointly with the U.S. Forest Service and the Defense Nuclear Agency in a series of mass fire experiments called Operation FLAMBEAU. Slash timber was piled in large arrays representing houses and burned to measure the resulting fire environment. The left-hand picture shows the largest array, occupying 40 acres, before the burn. The right-hand picture shows the array at the height of the burn. Through these tests and other work, it was confirmed that the energy release from a large fire depended on the amount of fuel available, the burning rate of the individual buildings, and the weather conditions at the time of the fire. The table indicates the conditions thought necessary for production of a firestorm.

Since we now estimate that only about 10 percent of the buildings will be ignited by a nuclear detonation, one of the criteria for firestorm conditions, that at least 50 percent be on fire initially, is not met. In other words, present evidence suggests that the most severe nuclear fire situation will be similar to that which occurred in Hiroshima. The information in the next few panels confirms this view.



Flambeau plot before burning



Flambeau plot during burning

CRITERIA FOR PREDICTING FIRESTORMS*

- Greater than 8 pounds of fuel per square foot of fire area.
- Greater than 50 percent of structures on fire initially.
- Surface wind less than 8 miles per hour initially.
- Fire area greater than 0.5 square mile.

*Rodden, R.M., et al, **Exploratory Analysis of Fire Storms**, Stanford Research Institute, 1965, AD 616 638.

FUEL LOADING AND BUILTUPNESS

The total amount of combustibles in a building, including both structure and contents, has an important bearing on the potential severity of fires. Each pound of combustibles typically generates about 8000 BTU upon burning.

An estimated range of fuel loadings in typical building uses or "occupancies" is shown here. Whether a particular structure would have a fuel loading near the high or low end of the range shown depends mainly on the type of construction of the building. For example, the typical combustible contents of residences averages about 3.5 pounds per square foot of floor area, so a total fuel loading near 20 would indicate a home constructed largely of wood whereas a fuel loading of 10 pounds per square foot would be appropriate to brick or other masonry construction.

Similarly, the combustible contents of office and commercial space ranges from 7 to 10 pounds per square foot of floor area. Combustible contents of industrial and storage buildings vary quite widely depending on the nature of the operations involved.

Another important factor in fire growth and spread is the density of construction. This factor is called "building density" or "builtupness" and is expressed usually as the fraction of the total area, including streets, parks, and the like, that is under roof. Typically, the building density in residential tracts ranges from about 10 to 25 percent; that in commercial and downtown areas up to 40 percent. Industrial and storage areas can vary widely in building density. Those with very high density are often referred to as "massive industrial" areas.

The combination of builtupness and fuel loading per square foot of building gives the fuel loading per square foot of fire area. The firestorm area at Hamburg was about 45 percent builtup with buildings having a fuel loading of about 70 pounds per square foot. This would mean about 32 pounds of fuel per square foot of fire area, four times the 8 pounds per square foot estimated as the minimum necessary for firestorm conditions.

In contrast, a residential area 10 percent builtup with single-story wood-frame detached homes would have a fuel loading of only 2 pounds per square foot, well below the criterion.

ESTIMATED RANGE OF FUEL LOADINGS

OCCUPANCY	FUEL LOAD PER STORY* (pounds per square foot)
Hi-Rise Residential (Fire Resistive)	3 - 5
Brick or Frame Residential	10 - 20
Office and Commercial	10 - 40
Industrial	0 - 30
Storage	20 - 80

*Includes building structure and contents.

BURNING TIMES

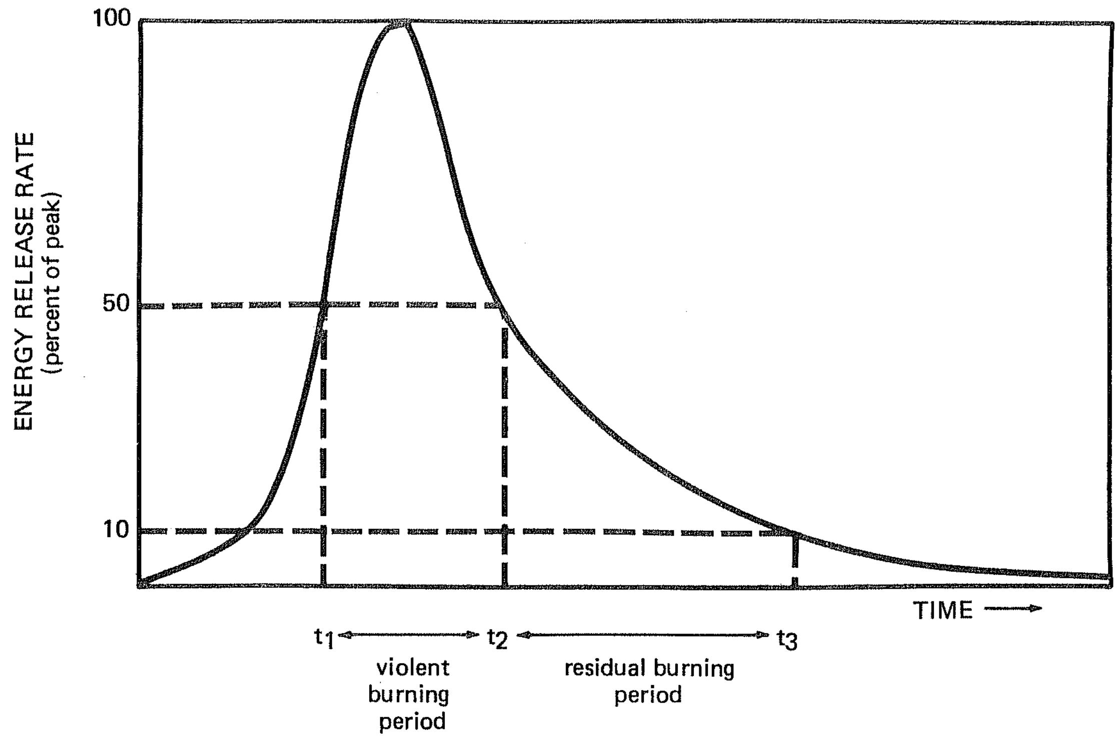
Perhaps the most important factor in fire severity is the rate at which buildings burn. either singly or in combination. This factor is also the most difficult to estimate because good measurements are rarely made in peacetime fire incidents. A study of the available information was made in the early 1960s, the results of which are shown here.

The burning time of a building is generally divided into two periods: (1) the violent burning period, and (2) the residual burning period. The violent burning period is defined as the period of time between the instant when the rate of energy release reaches 50 percent of the eventual peak release rate and the instant when the rate drops once more to 50 percent of the peak level, as shown in the diagram. The heat output during the time period prior to the 50 percent level is ignored. Although the heat output outside the buiding is small during this initial stage, the period of time can be long. Since this period is where fire defense can be most effective, we will give it considerable attention beginning with Panel 15, though it is ignored here.

The residual burning period is taken to be the period of time between the instant when the rate of energy release, having peaked, reaches 50 percent of the peak value and the instant when the rate reaches 10 percent of the peak level. This is the period between time, t_2, and time, t_3, in the diagram. Note in the table that the residual burning period contributes little to the total energy release when lightly constructed houses burn but is a major source of heat output in the heaviest types of construction. Moreover, the total burning time is very much longer for heavy construction than it is for light construction, being about 3 hours for "downtown" massive construction.

Regrettably, our knowledge of burning times is deficient. Most of the good data are for the controlled burning of undamaged, individual buildings. As we have seen in Chapter 2 blast damage can alter radically the structures that could later burn. We are just beginning to gain an understanding of the effects of blast damage on the subsequent fire threat. Some results are given in later panels. The available information suggests that the burning times shown here are appropriate for blast-damaged buildings.

ESTIMATES OF BURNING TIMES



BURNING TIMES FOR URBAN STRUCTURES*

CONSTRUCTION TYPE	VIOLENT BURNING TIME (min.)	VIOLENT BURNING ENERGY RELEASE (percent)	RESIDUAL BURNING TIME (min.)	RESIDUAL BURNING ENERGY RELEASE (percent)
Light Residential	10	80	12	20
Heavy Residential	13	70	20	30
Commercial	25	60	60	40
City Center and Massive Manufacturing	55	30	120	70

*From Chandler, et al., **Prediction of Fire Spread Following Nuclear Explosions,** Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service, 1963.

FIRE SEVERITY

We have now covered the chief factors involved in estimates of fire severity in nuclear attack. These are: (1) the fuel loading in individual buildings, (2) the builtupness or building density of the area, (3) the burning rate of buildings, and (4) the proportion of buildings burning at the same time. It will be useful to summarize what this information means.

We have already mentioned that, in the Hamburg "firestorm" area, there was a fuel loading of about 32 pounds of fuel per square foot of fire area. Using the heat value of combustibles as about 8000 BTU per pound, and a burning time of 2 hours and 55 minutes for buildings in city centers, we can calculate an average energy release rate, or "power density" as the fire research community prefers to call it, of about 685 million BTU per square mile per second—which is not far from the estimate in the World War II fire casualty chart shown in Panel 10.

At Hamburg, at least 50 percent of the structures were initially set on fire and the burning period was so long that the others also were burning at the same time as those initially on fire. The upper calculation shown here assumes this.

Now, take another example—2-story brick residences, perhaps many row houses, so that the area is 25 percent built-up. As we have seen, such houses might have about 10 pounds of fuel per square foot per story or 20 pounds per square foot for 2-story buildings. At 25 percent builtupness, this would be 5 pounds of fuel per square foot of fire area, less than the "magic number" of 8 pounds previously given as the threshold for possible firestorm events. Using a burning period of 33 minutes (1980 seconds) for "heavy residential" construction and 10 percent of the buildings burning simultaneously, we obtain a fire severity of about 56 million BTU per square mile per second, somewhat higher than that estimated for Hiroshima. In Japan, the burning time of most buildings was short, since there was a great deal of light construction. Only a portion of buildings were burning at the same time, and hence, firestorms did not result. This appears to be the situation in American cities as well and perhaps is the case for all nuclear detonations.

Fire defense can be planned for the fire environment expected in nuclear attack. What measures will be effective can be determined from the details of fire growth and spread described in the next series of panels.

SOME TRIAL CALCULATIONS

The Hamburg Case:

Fire Severity - 8000 BTU per pound of fuel times 32 pounds of fuel per square foot of fire area times 28 million square feet per square mile divided by 10, 500 seconds burning time for "city center and massive manufacturing" areas

or

Fire Severity = about 685 million BTU per square mile per second average rate of energy release.

Heavy Residential Case in Nuclear Attack

Fire Severity - 8000 BTU per pound of fuel times 10 pounds of fuel per square foot per story in brick buildings times 2 stories average building height times 0.25 fraction of the area covered by buildings times 28 million square feet per square mile divided by 1980 seconds burning time in "heavy residential" construction times 1/10 of the buildings burning at one time,

or

Fire Severity = about 56 million BTU per square mile per second average rate of energy release.

ROOM FLASHOVER

The ignition of kindling fuels does not immediately result in a room fire. In fact, isolated small quantities of fuel, such as a curtain or drape, are very likely to be completely consumed with no further fire spread. Sometimes even major furniture items may burn without any large flame buildup. But, for the most part, ignition of major upholstered furniture or beds, either by the thermal pulse directly, or by spread from other kindling fuels, will result in room "flashover."

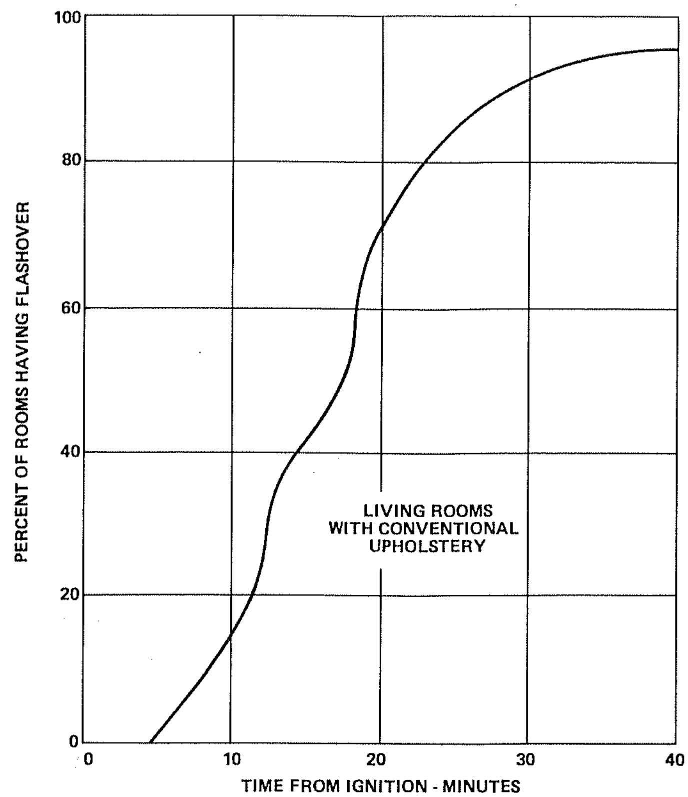
"Flashover" is a rapid stage of the growth of a room fire when the uninvolved combustibles suddenly ignite. When this occurs, as is usual in residential fires, the whole room appears to burst into flame almost explosively. Flashover does not mean that the fire has spread to adjoining rooms, but involvement of additional rooms usually takes place shortly thereafter. Flashover is significant in two ways: (1) it signals the end of the time when simple self-help measures suffice to extinguish the fire, and (2) it is about the time when the fire is evident from the street or at a distance because flames and smoke emerge from the windows.

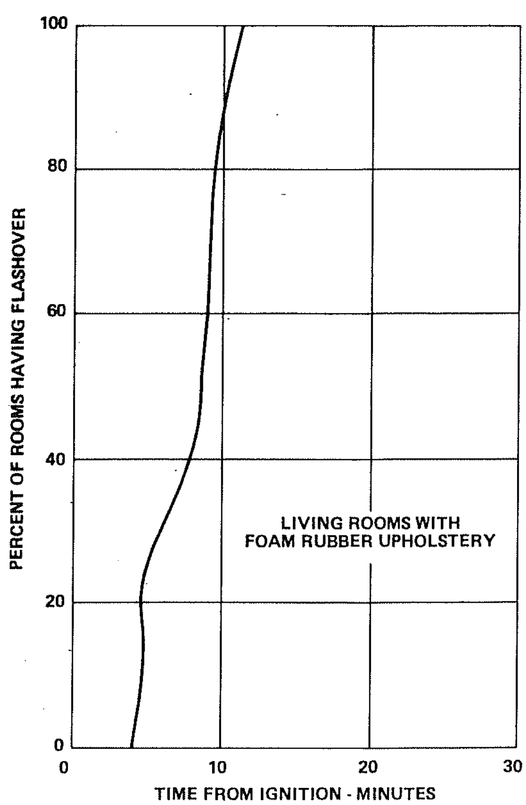
DCPA has sponsored experiments on the time interval between ignition and subsequent flashover to aid in determining the number and training of teams required to extinguish the fires. Living room and bedroom furniture was placed in a test room. About 80 separate experiments were conducted to get the information shown here.

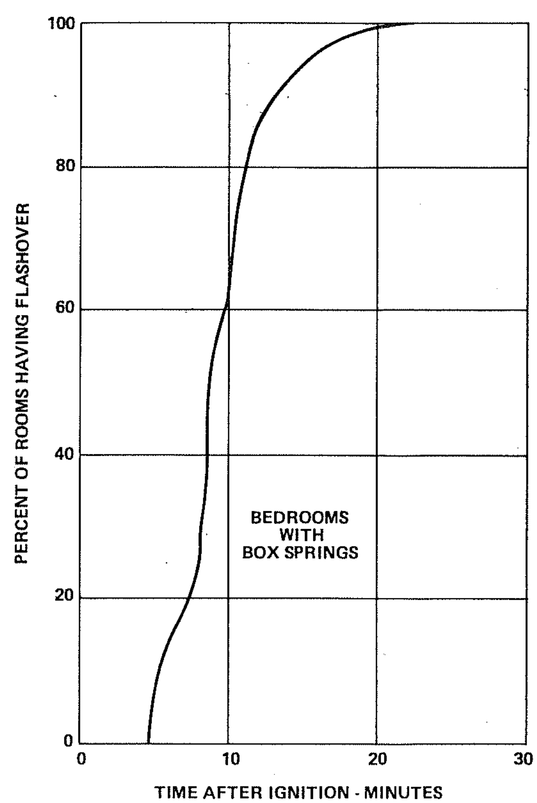
The upper chart shows the results for living room furniture with conventional cotton felt or fiber padding. Some rooms flash as early as 5 minutes, but only 16 percent have flashover at 10 minutes, 50 percent at 16 minutes, and some rooms never flash. In contrast the lower left chart shows that foam rubber upholstery results in rapid flashover between 5 and 12 minutes after ignition. Beds with box springs flash nearly as rapidly, as shown at lower right. Beds with open coil springs never result in room flashover.

The difference in rate of fire growth between conventional and foam rubber upholstered furniture and between mattresses on box springs and mattresses on open coil springs is marked. Your local fire service may be interested in reviewing this information as it may have application to peacetime fire defense.

TIME TO ROOM FLASHOVER*







*From Vodvarka and Waterman, **Fire Behavior, Ignition to Flashover**, IITRI, 1965, AD 618 414.

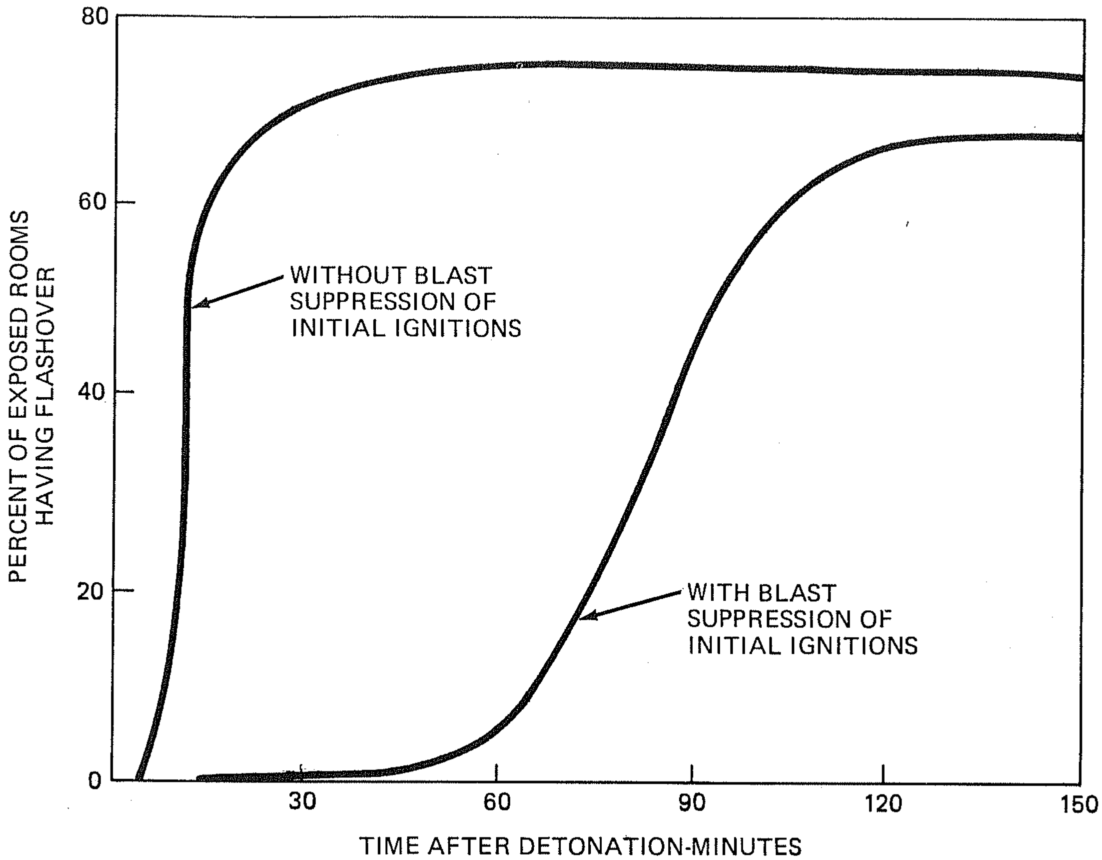
PANEL 15

FLASHOVER TIMES IN RESIDENTIAL AREAS

The typical residential area will have a mixture of upholstery types and bedspring types. Shown here is an example composite of the flashover results of Panel 15, assuming one living room for every three bedrooms. Without blast suppression of initial ignitions, nearly three-quarters of the exposed rooms would be expected to have flashover, half of these in the first 10 minutes after detonation.

With blast suppression of initial ignitions, much more time would be available to institute self-help measures to locate and remove smouldering furniture and other items. Furniture with foam rubber upholstery would not smoulder, but the remainder could rekindle. Assuming that flaming reoccurred randomly between 15 minutes and two hours after detonation, it would appear from this example that self-help firefighting organized within 30 minutes to one hour could have a major effect on the suppression of these incipient fires.

RESIDENTIAL ROOM FIRES



Composition of Rooms:

- 1/4 Living Rooms
  - 2/3 Conventional Upholstery
  - 1/3 Foam Rubber Upholstery
- 3/4 Bedrooms
  - 2/3 Box Springs
  - 1/3 Open Coil Springs

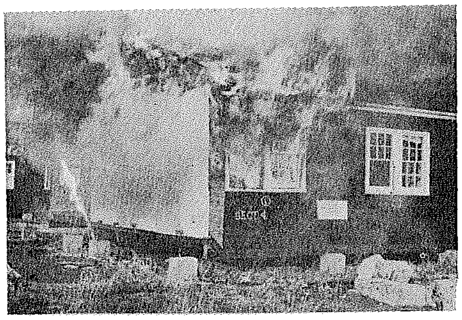
FIRE GROWTH IN RESIDENCES

This series of photographs of the burning of a test structure representative of a wood-frame residence will illustrate the course of events following flashover of a single room. The first photograph, taken at 12 minutes after ignition, shows the situation shortly after flashover of the ignition room. The fire has penetrated into the attic space above the room. At 20 minutes after ignition, the fire has spread rapidly throughout the attic space, part of the roof is ablaze, and rooms neighboring the ignition room have flashed over.

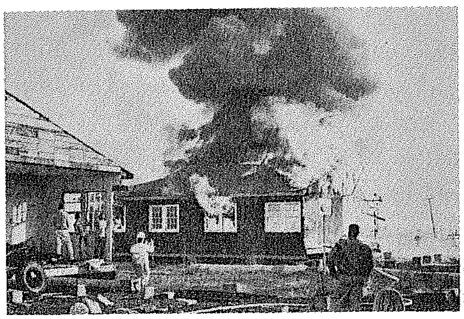
The third photograph shows the building totally involved at approximately the time of peak burning, as measured by the heat received by radiometers located outside the building. At this time, 27 minutes after ignition, the roof has burned through and collapsed. Roof collapse is often associated with the peak radiation from a burning structure. The final photograph, taken at 40 minutes after ignition, shows the building with essentially all the fuel above the floor level burned away.

The maximum burning rate for this test at the DCPA Research Facility, Camp Parks, California, occurred at about 26 minutes after ignition and the violent burning period was approximately 20 minutes. In addition to test burns of the type shown, the IIT Research Institute has instrumented and burned a number of two-story wood-frame residences being removed in urban renewal and highway construction programs. Violent burning periods have ranged from 19 to 28 minutes, depending on wind conditions, whether the ignition was in an upwind or downwind room and whether the ignition was on the second story or the ground floor. In general, violent burning periods in undamaged residences have averaged about twice as long as the 10 to 13 minutes we used in calculating firestorm potential.

A useful generalization that comes from this experimental work is that the fire tends to double in volume every 3 to 7 minutes after the initial flashover under conditions of moderate wind or upward spread. Thus, if rooms are nearly the same size, an adjacent room will flash about 5 minutes after the first. Five minutes later, about 4 rooms would be engulfed and shortly thereafter the entire building would be involved. For very low winds or where upward spread cannot occur, the doubling time is longer—from 9 to 14 minutes.

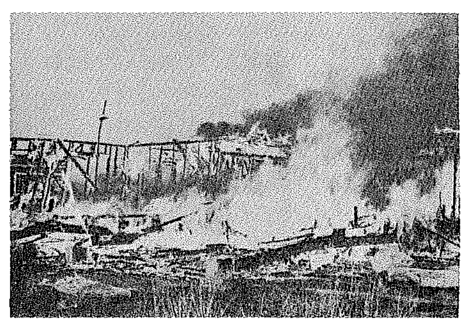


12 MINUTES AFTER IGNITION



20 MINUTES AFTER IGNITION

27 MINUTES AFTER IGNITION



40 MINUTES AFTER IGNITION

From Butler, C.P., **Measurements of the Dynamics of Structural Fires,** Stanford Research Institute, August 1970, AD 716 327.

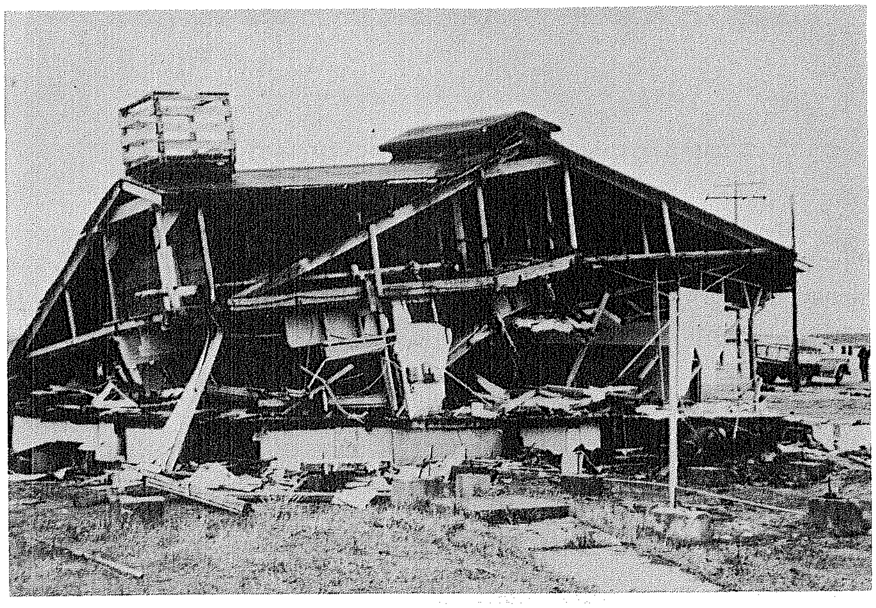
PANEL 17

FIRE GROWTH IN DAMAGED RESIDENCES

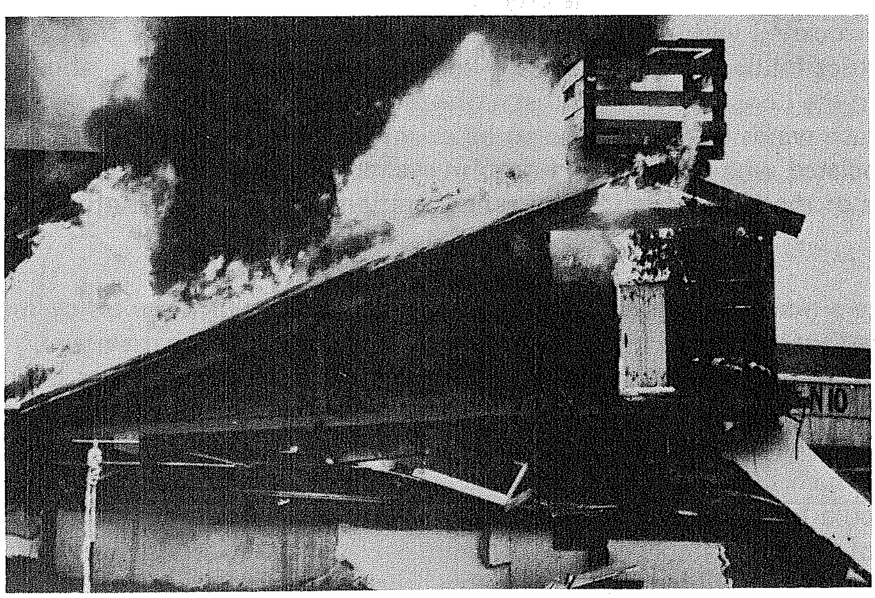
Only a few fire experiments have been performed in which the buildings have been damaged as they would be under most nuclear attack conditions. The upper photograph shows a damaged test structure, otherwise identical to the one on the previous page. The roof has been collapsed onto the floor on one side of the building. The lower photograph shows the damaged structure totally involved in flame.

In this experiment, the time required for the flames to spread from the ignition site to the far end of the building was about the same as observed before for flame spread in the attic but, in the damaged building, the spread was rapid throughout the whole volume. As a consequence, the fire peaked very rapidly, once the building was involved. The violent burning period was only seven minutes long and the rate of fuel consumption at peak burning was about twice that of the undamaged structure.

Two other experiments, in which dynamite was used to damage wood-frame houses prior to burning, gave violent burning periods of 9 minutes and 12 minutes. On the basis of such limited evidence, it would appear that a 10-minute estimate for the violent burning period for "light-residential" buildings is a good approximation in the 2- to 3-psi region of a nuclear detonation.



DAMAGED TEST BUILDING



BURNING OF DAMAGED BUILDING

FIRE GROWTH IN LARGER BUILDINGS

Our knowledge of fire growth in larger buildings is limited to observations of peacetime fires in undamaged buildings. These observations confirm that undamaged buildings burn slowly, with the following time factors considered average:

(a) 13 minutes from compartment flashover to stair flashover.

(b) 10 minutes from stair flashover to stair flashover on all floors above.

(c) 30 minutes from stair flashover to flashover of stairwell on next lower story.

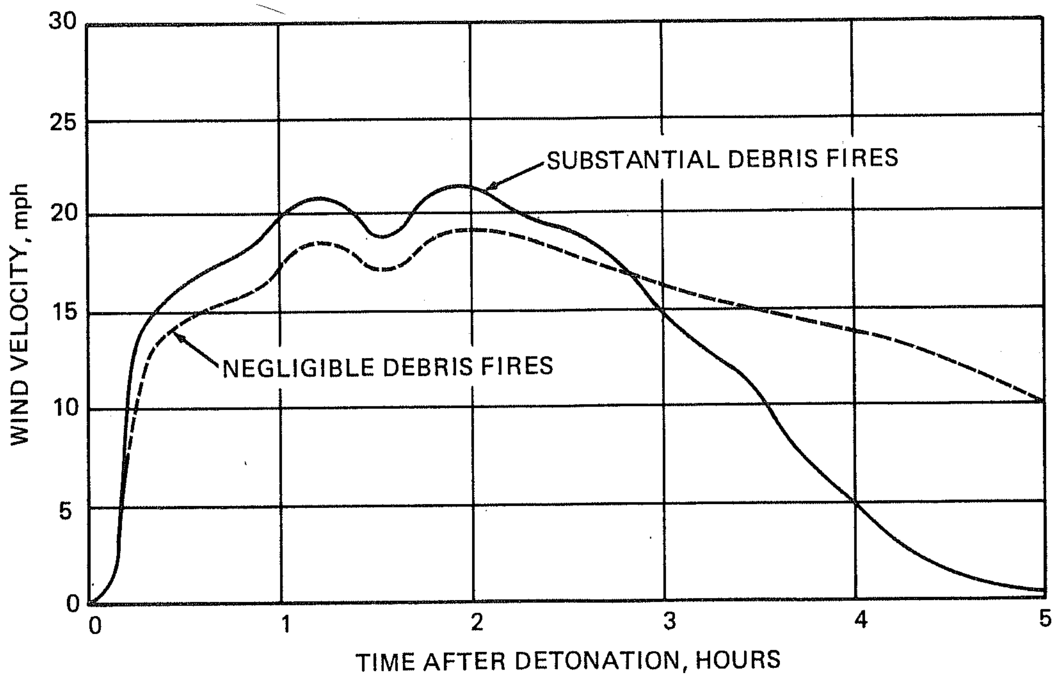
(d) 42 minutes from compartment flashover to ceiling penetration to next story.

(e) 51 minutes from top compartment flashover to roof collapse.

The upper photograph shows a view of the Loop District of Chicago. Similar concentrations of tall buildings make up the city center of most large U.S. cities. Despite the high fuel loading associated with multi-story buildings, a detailed analysis of the fire history in the Loop District following a 5-MT surface burst at a distance of 5 miles (about 5-psi blast overpressure in the Loop) did not forecast a firestorm event. The lower chart shows that the maximum inrush winds were estimated to be about 20 miles per hour, far below the wind velocities associated with the German firestorm events. The recently-developed information on the effects of the blast wave in suppressing ignitions was **not** taken into account in this analysis.

There are a number of reasons for this outcome. Modern high-rise office buildings are among the least susceptible to fire and fire spread. Because of the great amount of shielding provided by the taller buildings, ignitions are largely confined to the upper floors of most buildings. Most of the buildings are of fire-resistive construction. It is estimated that about one hour and 15 minutes would be required after flashover for fire to penetrate to the next floor below in such buildings. As a consequence, those buildings that could support a sustained fire would burn slowly from the upper floors down. However, a substantial part of the contents of the upper floors will have become debris in the streets at 5-psi blast overpressure. Smouldering items might start fires in this debris.

DOWNTOWN CHICAGO



ESTIMATED FIRE WINDS IN CHICAGO LOOP*
(from 5-MT surface burst at 5 miles)

*From Takata, A.N. **Fire Spread in High Density High-Rise Buildings**, IITRI, February 1971, AD 719 731.

FIRE SPREAD BETWEEN BUILDINGS

Growth of fires within buildings represents only part of the fire problem. Fire spread between buildings is a major factor in wartime fires. There are three basic ways in which fires may spread from burning buildings to buildings not yet ignited. The first, called "convection," consists of heating of nearby combustibles by direct flame contact or hot gases of an active fire until sustained ignition occurs. This is a very short-range mechanism, of interest mainly for buildings closely adjoining or with common walls. Convection is the main means of fire spread within buildings and is of concern in peacetime fires where a taller building may be at hazard from its smaller neighbor, as shown in the upper sketch. As we have seen, it is far more likely in nuclear attack that ignitions will be confined to the upper floors of the taller building.

The second means of fire spread is radiation. The flaming mass of a burning building radiates heat, which, in sufficient quantity, can raise the temperature of exposed elements of nearby buildings to the kindling point. Through this mechanism, though on a much smaller scale, the flaming building causes ignitions much like the nuclear fireball does and our previous discussion of ignitables and their behavior is pertinent. In particular, it is **rate** of heat input, usually measured in calories per square centimeter **per second**, that determines whether ignition will occur.

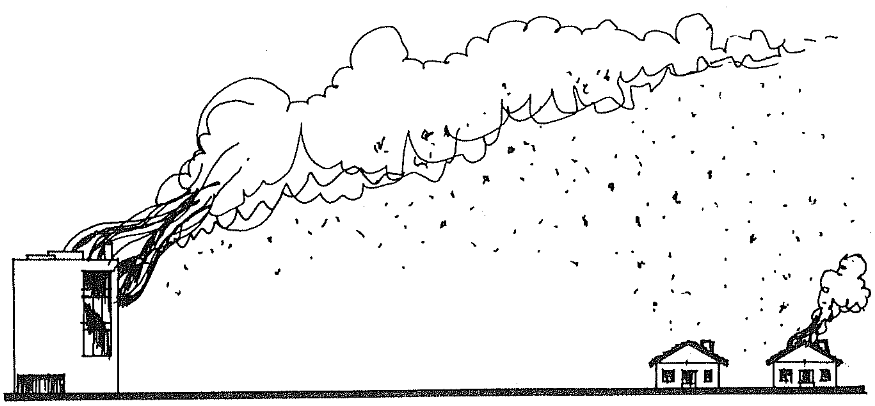
The threat of fire spread through radiation is common in peacetime fires. "Control of exposure" is a major firefighting measure, which means to play a hose on the exposed surfaces of nearby structures to cool them below the kindling temperature. This activity is shown in the middle sketch.

The final means of fire spread is by the transport of "firebrands" by the wind. This can be a very long-range mechanism under many circumstances. Spot fires from firebrands are common in forest fires. In the great Baltimore fire of 1904, firebrands caused new building fires over one-half mile downwind of the burning fire front.

FIRE SPREAD BETWEEN BUILDINGS

FIRE SPREAD BY CONVECTION

FIRE SPREAD BY RADIATION



FIRE SPREAD BY FIREBRANDS

FIRE SPREAD BY RADIATION

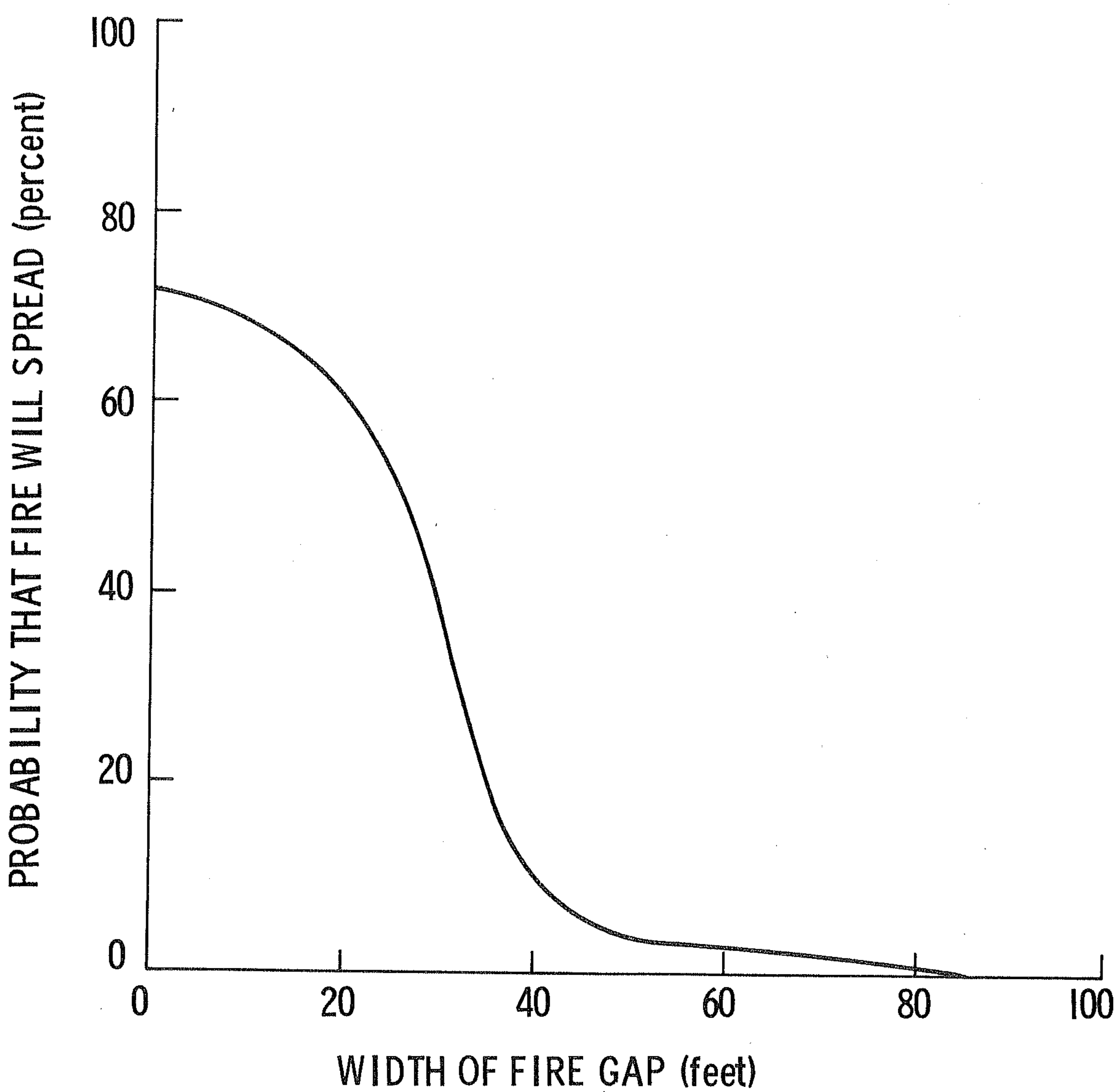
Of the three mechanisms of fire spread, spread by radiation is likely to be the most important. An understanding of this mechanism can be gained from common experience. If one stands within a few feet of a campfire or a well-laid fire in a fireplace, one may experience an unpleasant sensation or pain from the radiated heat on exposed skin. If one were observing a burning building, the same heat sensation might be felt at a distance many tens of feet from the much larger fire. More precisely, the rate of heat energy received by radiation depends entirely on the **fraction** or **proportion** of the **field-of-view** that is occupied by the flames.

The flames emit heat radiation at a rate of about 4 calories per square centimeter per second. If an object, such as a piece of wood, is placed in contact with the flames so that flames occupy the entire hemisphere that the face of the object can "see," the object receives the full 4 calories per square centimeter per second. If the object were moved away from the flames so that only half the field-of-view was occupied by flames, then only 2 calories per square centimeter per second would be received by the face of the object. It so happens that wood can be ignited by a heat input rate of about 0.4 calories per square centimeter per second, so that whenever the flame area from a neighboring fire occupies more than about 10 percent of the field of view, ignition of wood by heat radiation can occur.

From this simple idea, a whole series of practical consequences follow. A burning building is the greatest threat to its neighbors at peak burning when the flame area is greatest. The closer neighbor will ignite earlier than the farther neighbor. A large building or a row of buildings burning is a greater threat than a single or small building. Buildings with large window area may pose a greater fire spread threat than one with small or few windows. Combustible walls are a greater threat than masonry walls. Buildings knocked down by the blast wave may burn with smaller flame area and less fire spread than undamaged areas. Very little fire spread by radiation may occur from smouldering debris fires.

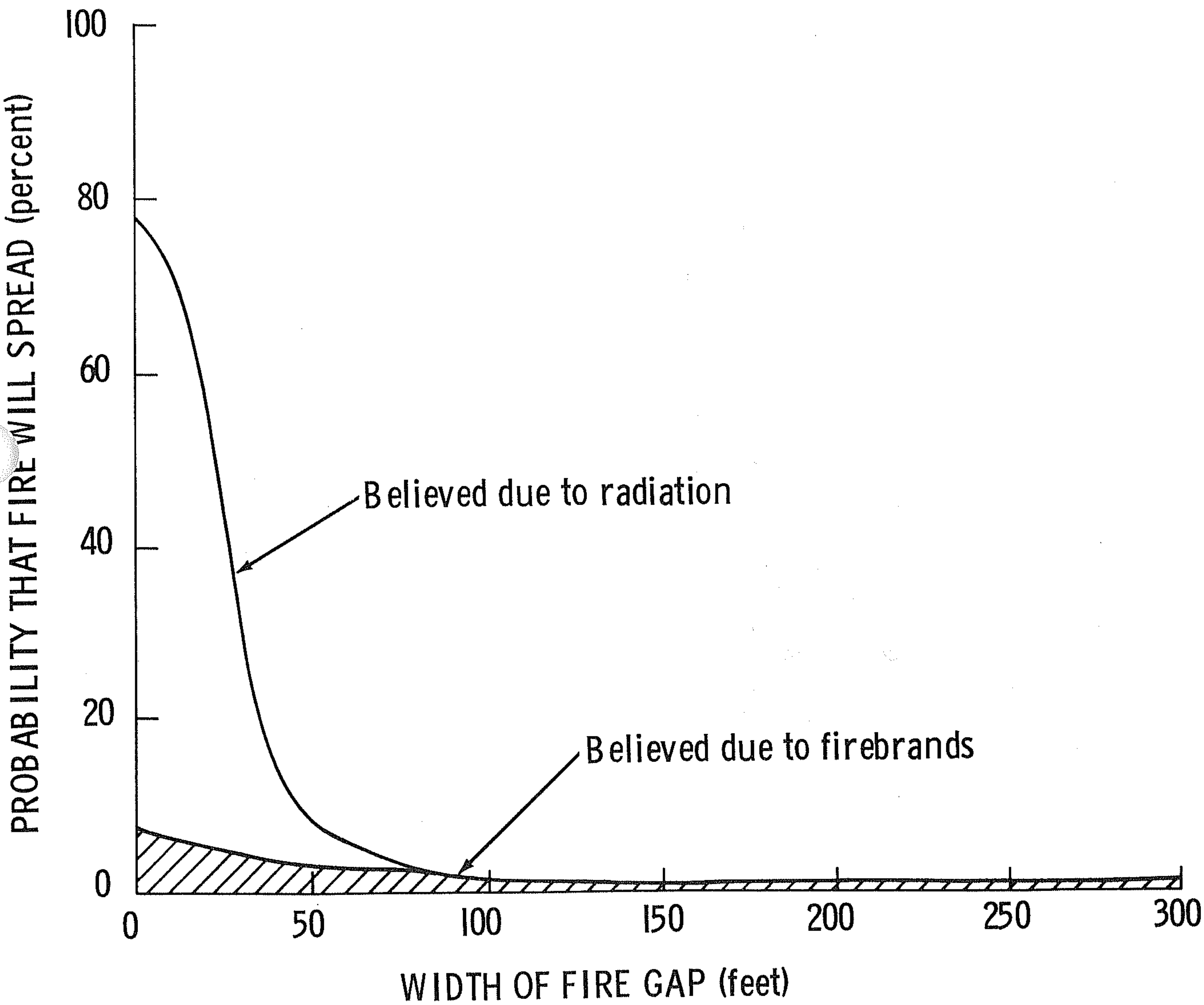
Thus, the curve shown here, which was developed from experience in the World War II fire at Darmstadt in which spread by fire brands was negligible, must be regarded as "average" or "typical." Calculations of radiant energy do indicate that fire spread by this means beyond about 85 feet is most unlikely, even for large windowed buildings. This means that fire can spread between buildings on a block by heat radiation, but generally not from block to block. Detailed surveys of residential areas indicate that the critical "view factor" of 10 percent would be exceeded two times out of three if the house next door were burning, only one time in seven if the house across the backyard were burning, and never if the house across the street were burning.

FIRE SPREAD IN THE DARMSTADT FIRE*



*From Takata and Salzberg, **Development and Application of a Complete Fire-Spread Model**, IITRI, June 1968, AD 684 874.

FIRE SPREAD AT HIROSHIMA*



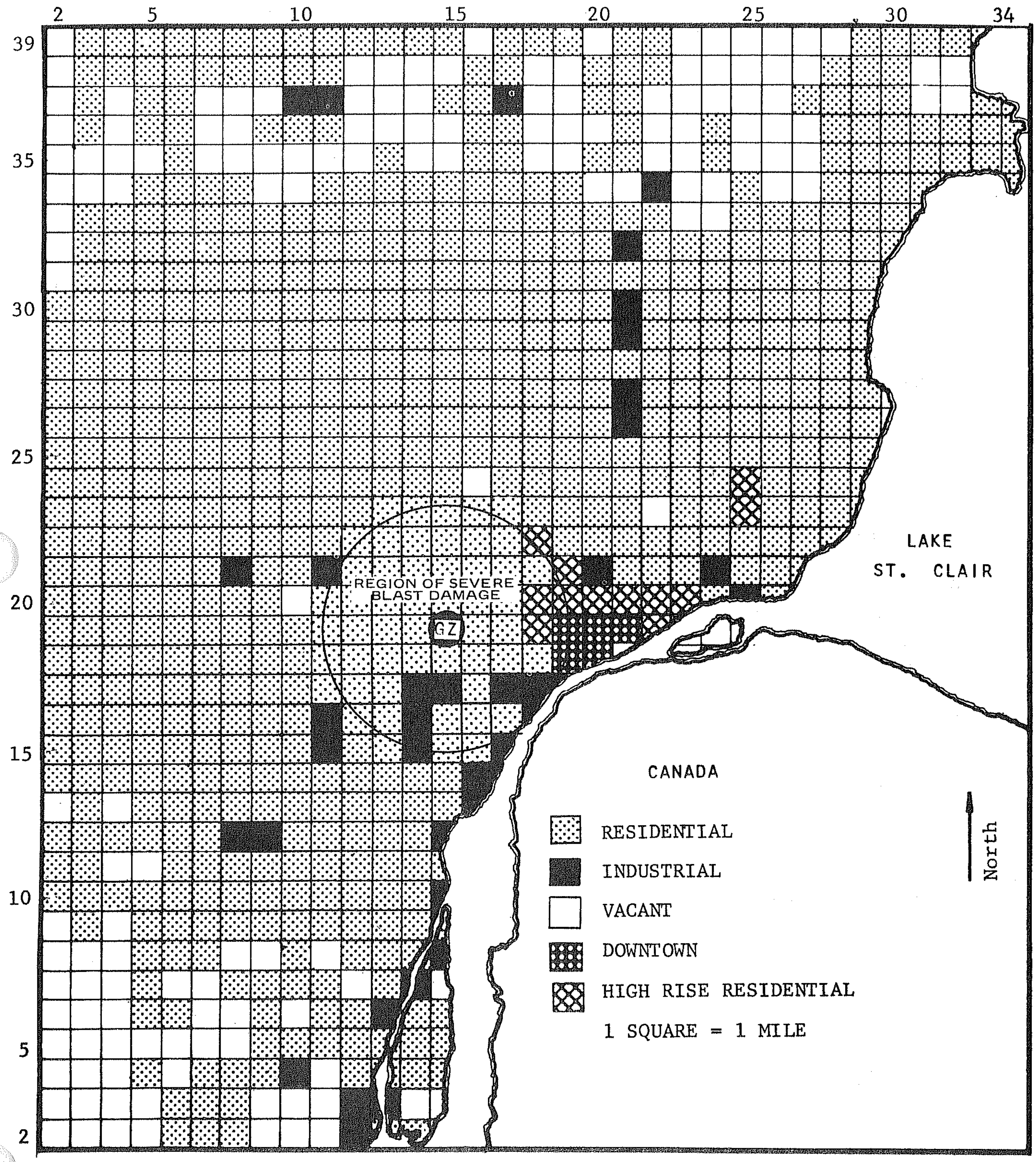
*From Takata and Salzberg, **Development and Application of a Complete Fire-Spread Model**, IITRI, June 1968, AD 684 874.

THE CHARACTER OF URBAN FIRE SPREAD

Fire spread from building to building in urban areas occurs primarily through heat radiation from the flames and through the production of firebrands. As we have seen, spread by radiation is primarily within blocks and block-to-block spread is mainly by firebrands. Fire spread depends on the nature of the buildings and their separation distances.

This map of the Detroit area shows the general character of land use in tracts one mile on a side. Most tracts are residential in nature. The square marked "GZ" marks the ground zero for the 5-MT surface burst for which debris depth contours were given in Chapter 2. You will recall that except within the downtown area, debris depths averaged one-half to one foot over most of the blast area.

A gross description of land use, as shown here, is insufficient to permit estimates of fire spread. The current DCPA fire spread model defines 24 separate tract types within the category "Residential." These range, in Detroit, from Type 1, which consists of all single-story homes having an average base dimension of 30 feet and an overall building density of 15 percent, to Type 24, which consists of apartment buildings—60 percent 3-stories, 20 percent 4 stories, and 20 percent 5-stories—having an average base dimension of 50 feet and an overall building density of 25 percent. This type of information is needed to estimate average "view-factors" for spread by radiation and the likelihood of spread by firebrands.


2
5
10
15
20
25
30
34
39
35
30
25
20
15
10
5
2
REGION OF SEVERE BLAST DAMAGE
GZ
LAKE
ST. CLAIR
CANADA
RESIDENTIAL
INDUSTRIAL
VACANT
DOWNTOWN
HIGH RISE RESIDENTIAL
1 SQUARE = 1 MILE
North

PANEL 23

THE DIMENSIONS OF FIRE SPREAD

To illustrate the overriding importance of fire spread, let us use the example of the 5-MT surface burst at the location shown on the previous panel. For the moment, we will **ignore** two important factors: (1) the **effect of the blast wave on fire ignitions**, and (2) the **effect of any fire countermeasures, either before the attack or after the fires are started.**

For this example, we will assume that all buildings experiencing at least 6 psi blast overpressure are destroyed at the outset. Since most of the buildings with the blast circle shown on Panel 23 are residential or industrial buildings, this assumption is not unrealistic. These immediately destroyed buildings comprise about 14.5 percent of all the buildings in the Detroit area shown on the tract map. Outside the 6-psi line, an additional 3.76 percent of all the buildings are initially ignited.

As can be seen in the table, although less than 4 percent of the undestroyed buildings are initially ignited by the fireball, almost half of the buildings are eventually burned. Together with the nearly 15 percent assumed to be destroyed by blast, almost two-thirds of all buildings are lost by the end of the first day. At 28 hours after detonation, about 1 percent of all buildings are still burning around the periphery of the damaged area, so the destruction shown in the table is not the complete story.

The loss of property due to fire spread dominates the picture, even though a "fire storm" never occurs. Spread by radiation from nearby burning buildings appears to be the most prevalent mechanism, but one should not lose sight of the fact that most of the losses outside the area of high initial ignitions were originated by the firebrands.

We do not know how accurate this picture of the fire spread is, except that it probably represents the upper limit of what might occur without any fire defenses. The reason that it may represent an upper limit is that the effects of the blast wave, ignored here, will generally reduce initial ignitions and may impede fire spread. The main thing that blast effects will provide is additional time to control the fire situation, for even if the initial ignitions do not exceed 10 percent throughout the blast area, these fires can eventually spread as shown here. Thus, if control is not successful in the first few hours, new fires may be set for days following the attack.

Finally, a major implication for operational planning is that mutual aid from nearby localities will have time to play an important role in fire defense.

FIRE SPREAD HISTORY IN DETROIT
(Percent of all buildings ignited and burned*)

TIME (hours)	IGNITED BY FIREBALL	IGNITED BY RADIATION	IGNITED BY FIREBRANDS	TOTAL BURN
0	3.76	—	—	3.76
1	3.76	2.78	—	6.54
3	3.76	8.93	5.50	18.19
10	3.76	17.55	11.50	32.81
28	3.76	28.01	18.16	49.93

* In addition, 14.46 percent of all buildings destroyed by blast, for a total destroyed and burned of 64.39 percent.

From Takata and Salzberg, **Development and Application of a Complete Fire-Spread Model**, Vol. II, IITRI, June 1968, AD 684 874.

LIFE SAFETY IN FIRE AREAS

The traditional fire service priorities are (1) preservation of life, (2) prevention of fire spread to other premises (exposure control), and (3) extinguishment of fires. For peacetime fires, men and equipment are provided to bring to the scenes of fires an overwhelming extinguishment capability, plus salvage and rescue equipment. Any fire company is committed to only one fire at a time, with support available from the remainder of the department and from mutual aid arrangements. Thus, priorities (1) and (2) are almost always achieved, and priority (3) accomplished quite often.

In nuclear attack, unless citizen self-help measures are effective in locating and suppressing smouldering ignitions and firebrands, the first two priorities will represent a challenging task, with priority (1), preservation of life, the controlling requirement.

With respect to life safety, the planner will be concerned with where the people are—in public shelters or in residences in areas where sufficient public shelter is not available. Preservation of this sheltered population is the fundamental goal of emergency operations.

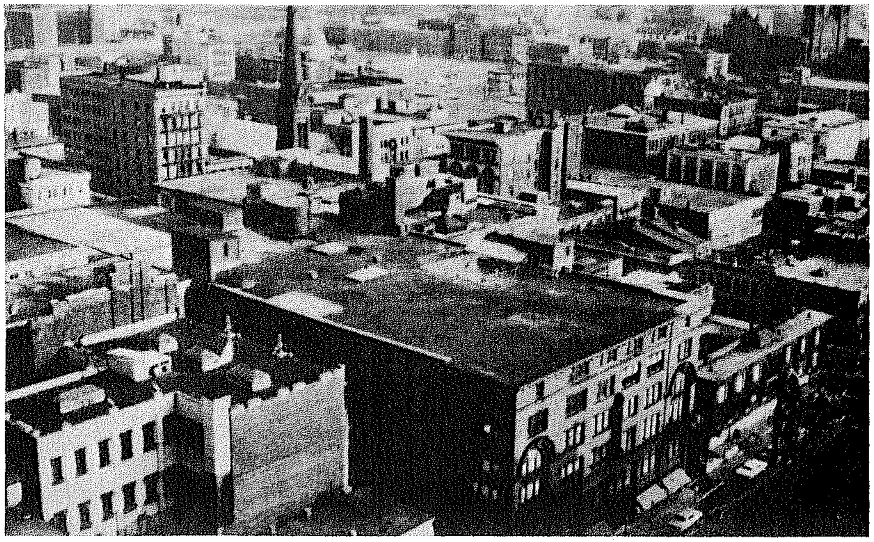
The information in this chapter on fire spread leads to the idea of distinguishing among shelter buildings on the basis of fire risk. For each building or other facility planned for shelter use, the essential question to be asked is: "Assuming that occupants suppress ignitions and fires in the building proper, is the building likely to become untenable from fires in the surrounding area?" Field tests have shown that experienced fire officers have little difficulty in making this judgment. The information in this chapter should assist in any local fire-risk survey.

The upper photograph shows a typical high-risk shelter facility. The lower photograph shows a facility judged to be at low risk from its surroundings.

The implications for planning are:

(1) In areas where surplus shelter exists, community shelter plans should incorporate low-risk shelters in preference to high-risk shelters.

(2) In urban areas where insufficient basement space exists, the basements of high-risk buildings should be used but nearby low-risk buildings should be designated as the relocation sites for the occupants of the high-risk facilities, should one or more become untenable.



TYPICAL HIGH-RISK SHELTER FACILITY

TYPICAL LOW-RISK SHELTER FACILITY

Washingtonian Towers, Gaithersburg, Md., (lower photograph) courtesy of Loewer, Sargent & Associates.

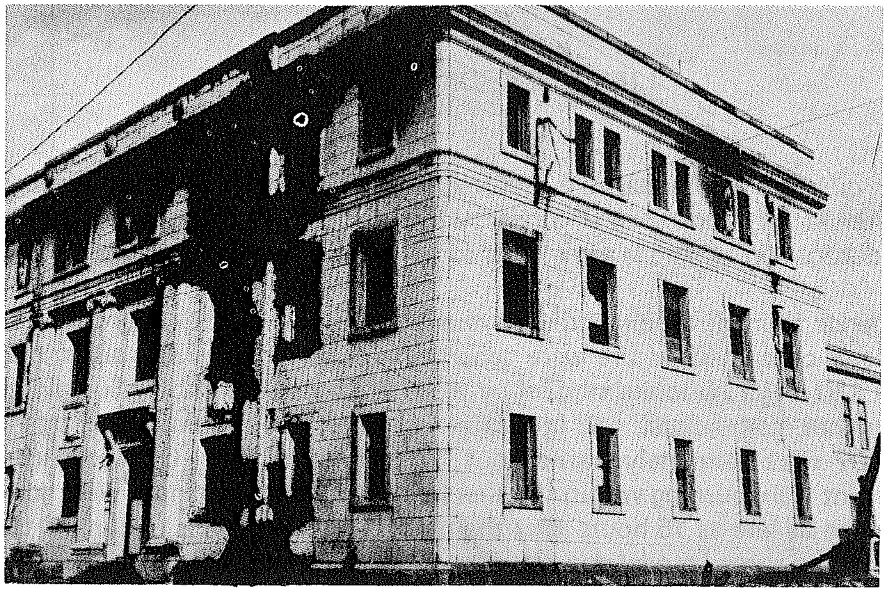
SOME JAPANESE EXPERIENCES

One might question at this point whether it is reasonable to assume that the survivors in a "low-risk" shelter facility can suppress ignitions and fires in an area damaged by a nuclear detonation. The most nearly parallel situation and, hence, best evidence comes from the nuclear attack on Hiroshima at the close of World War II. All of the evidence we have cited in this chapter suggests that the fire situation we must expect would be similar to that experienced at Hiroshima.

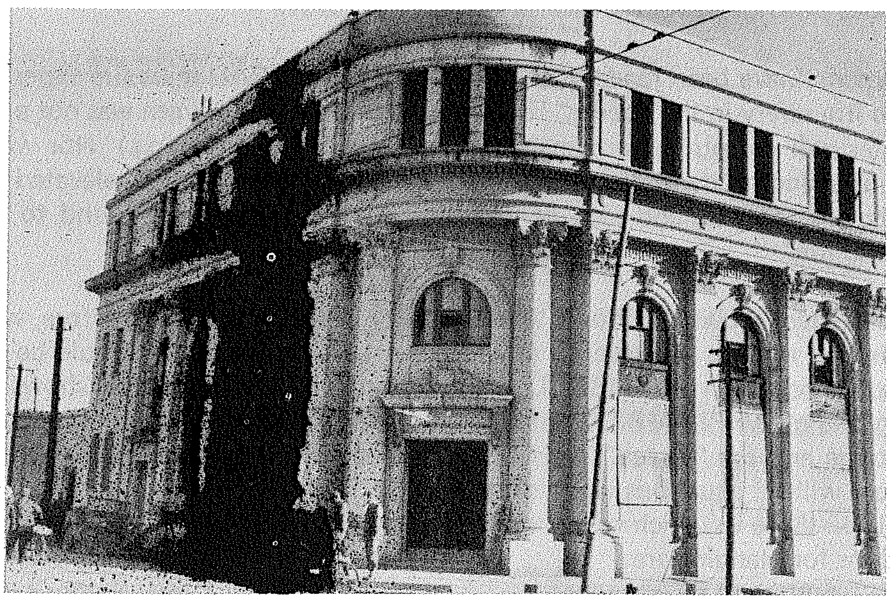
The upper photograph shows the Hiroshima branch of the Bank of Japan, a 3-story reinforced-concrete frame building of earthquake-resistant design. This building was only 1300 feet from ground zero, where an overpressure of about 18 psi occurred. About 100 people were in the bank at the time, of which about half were killed. Only four of the survivors are said to have been uninjured. Whether because the detonation was high above the building, whether because there were metal shutters at the windows, or whether because of effects of the blast wave, no initial ignitions occurred. About 1-½ hours afterward, a fire started in a room on the second floor from a firebrand. The nearest burning building was only 25 feet distant but the brand was said to come from nearby burning trees on another side. The survivors extinguished the blaze with water buckets, preventing further damage. A little later, a fire was started on the third floor. It was beyond control when discovered and the third floor burned out. But the fire did not spread to the lower floors.

The lower photograph shows another bank building, farther away, that experienced about 8 psi blast overpressure. Again, no initial ignitions were reported. However, at about 10:30 A.M., over 2 hours after the detonation, firebrands from the south exposure ignited a few pieces of furniture and curtains on the first and third stories. The fires were extinguished with water buckets by the building occupants. Negligible fire damage resulted.

These are but two of several examples of successful fire defense taken from the U.S. Strategic Bombing Survey report of events at Hiroshima. If one assumes that Americans can do what the unsuspecting residents of Hiroshima did, self-help measures by shelter fire-guard teams would appear to be effective.



BANK OF JAPAN BUILDING AFTER ATTACK ON HIROSHIMA



GEIBI BANK CO. BUILDING AFTER ATTACK ON HIROSHIMA

LIFE HAZARDS IN STREETS

Another question is whether it is reasonable to assume that occupants of a threatened high-risk shelter facility can move to a nearby low-risk facility through the damage caused by a nuclear detonation. There is some basis for an answer to this question.

The evidence from Hiroshima indicates that blast survivors, both injured and uninjured, in buildings later consumed by fire were generally able to move to safe areas following the explosion. Of 130 major buildings studied by the U.S. Strategic Bombing Survey (these were hospitals, churches, commercial, and industrial buildings, not the smaller wooden Japanese residences), 107 were ultimately burned out, in total or in part. Of those suffering fire, about 20 percent were burning within the first half hour. The remainder were consumed by fire spread, some as late as 15 hours after the blast. This situation is not unlike the one our computer-based fire spread model described for Detroit (Panel 24).

We have also seen, in Chapter 2, that, except in densely builtup areas of multistory buildings, debris depths will average only a foot or so. This debris would immobilize wheeled vehicles but not pedestrian traffic.

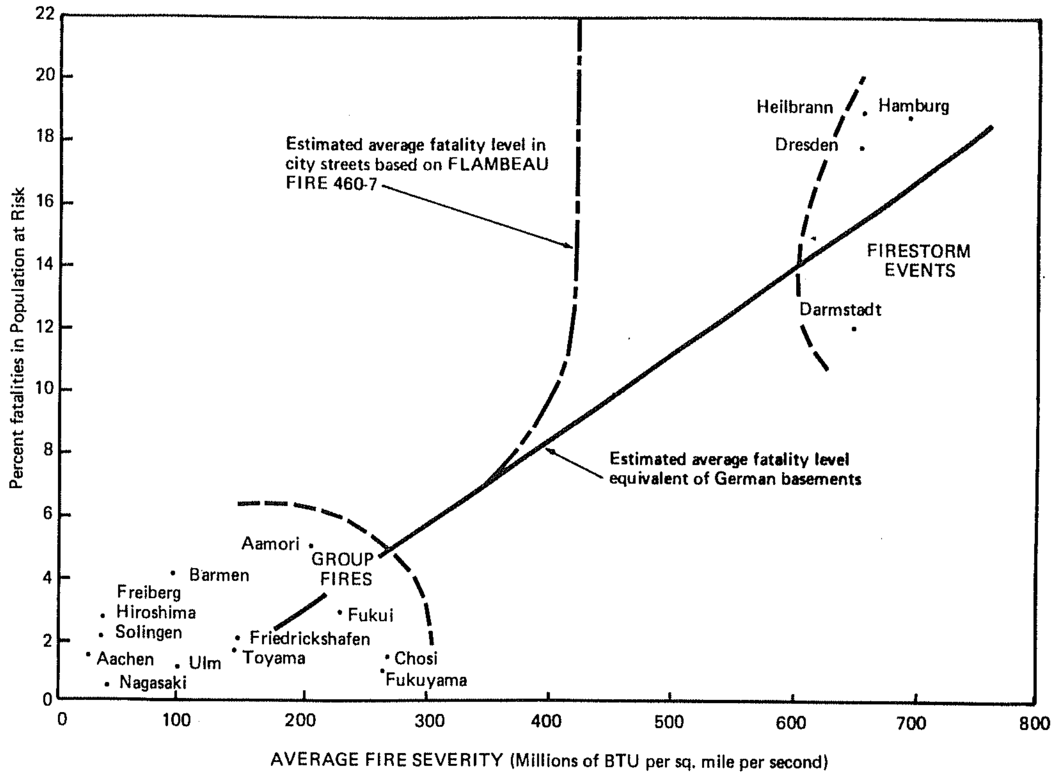
Measurements have been made at the Operation FLAMBEAU mass fire experiments of the hazards to life safety in the streets. It was found that lack of oxygen was not a problem. (Indeed, flames will die out before the air gets too thin for breathing.) Nor was carbon dioxide, a combustion product, found to present a hazard. Heat radiation, elevated air temperatures, carbon monoxide, and lack of visibility due to smoke were found to present a serious threat to life.

The upper chart shows the World War II fatality chart we have seen before, with a line added to show the average fire severity at which mortality in the streets would be expected to become total, based on FLAMBEAU measurements. The table below shows the time period during one of the FLAMBEAU fires when the hazard threshold was exceeded. These fires were intense and the "streets" were only 25 feet wide. Nonetheless, the evidence suggests that there will be situations when people in the streets would be in great peril. These situations will be those in which congested areas with narrow streets are burning violently. The implications for planning are:

(1) Areas where intense conflagrations could occur should be identified in the fire defense plan, and

(2) Decisions to evacuate survivors from these potential conflagration areas should be made as soon as uncontrolled fires are observed, to allow the maximum escape time before radiation intensities, air temperatures, carbon monoxide, and limited street visibility build up to lethal levels.

FATALITIES IN WORLD WAR II FIRES*



* Lommasson and Keller, DC-TN-1058-1, December 1966

HAZARD PERIODS DURING FLAMBEAU 760-12*

HEAT RADIATION	Over 3 Hours
AIR TEMPERATURE	90 Minutes
CARBON MONOXIDE	80 Minutes
STREET VISIBILITY**	60 Minutes

From Butler, C.P., **Operation Flambeau, Civil Defense Experiment and Support,** USNRDL, June 1968, AD 682 476.

** In addition, smoke conditions causing severe eye pain persisted for about 6 hours.

CONFLAGRATION ASSESSMENT

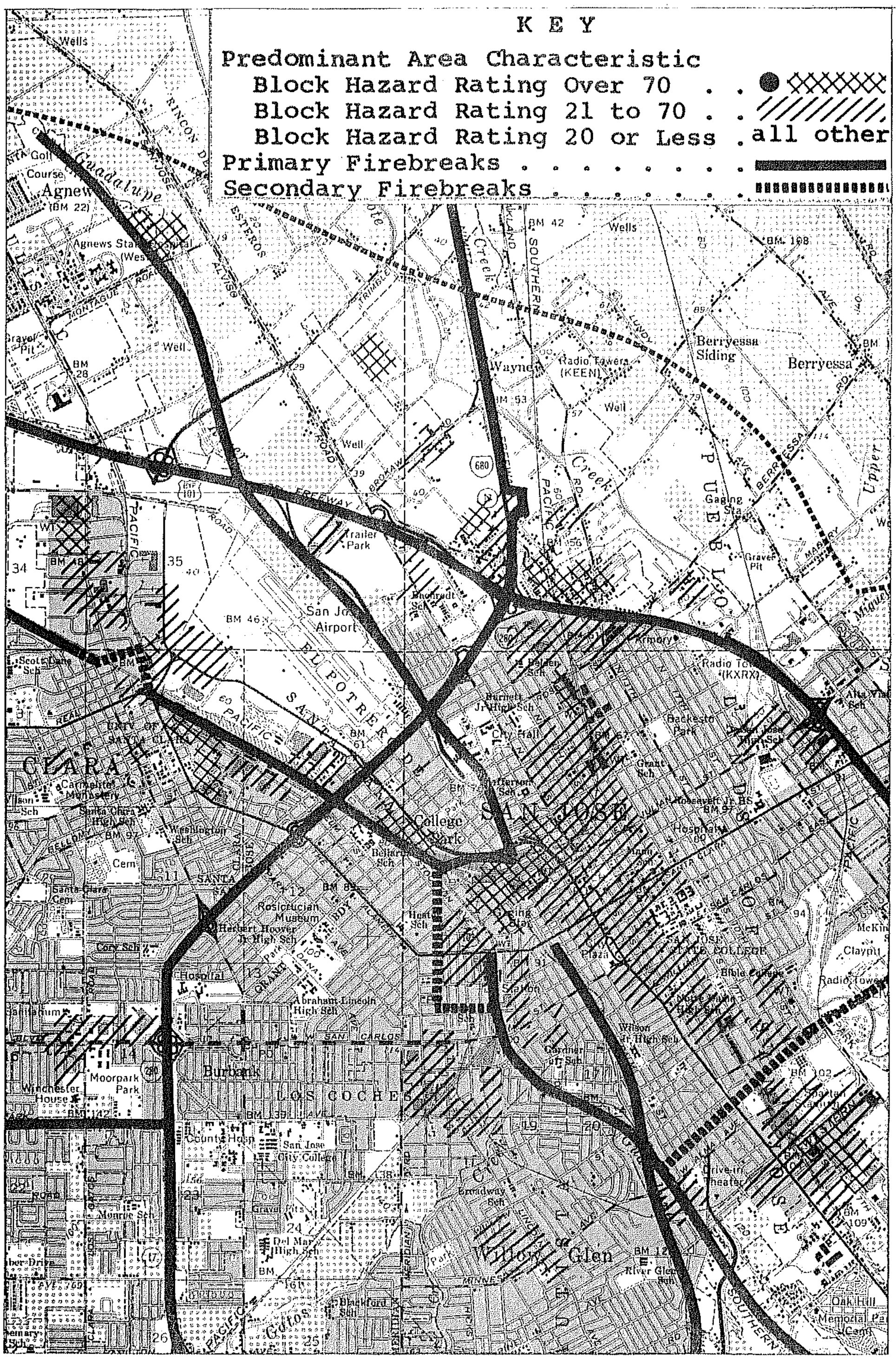
An assessment of the conflagration potential of various tracts in a city will provide a basis for planning fire defense measures, as well as indicating where high-risk shelter facilities should be abandoned as potentially untenable as soon as significant fires are observed in the area. A method has been developed by which such assessment can be made by fire service personnel and others who have a working knowledge of the technology and terminology of fire protection and who are able to identify the various types of building construction. No specialized training is required to use this method, which has been made available as Annex 1 to Appendix E-10-1 of the Federal Civil Defense Guide. The map shown here records the results of an application of the method to a portion of San Jose, California.

The method results in a block hazard rating for each block or group of similar blocks in the city. These ratings, which are based on the fuel loading and builtupness of each block, are meant to represent relative hazard rather than an absolute measure of risk. The higher the block rating, the greater the likelihood of simultaneous burning of many buildings on the block to create a conflagration. Blocks receiving a hazard rating over 70 (the numbers themselves have no physical meaning) are assessed as having a high conflagration potential, shown here as a limited number of cross-hatched areas. Blocks with ratings between 21 and 70 are assessed as having low to moderate conflagration potential but with moderate to high potential for fire spread to adjacent buildings. As we have seen, fire can burn down many buildings, a few at a time, without being considered a conflagration.

A conflagration assessment can form a basis for choice of shelter facilities to be included in the Community Shelter Plan as well as a basis for identifying those tracts that should be abandoned rapidly, should fires occur.

In peacetime, identification of conflagration areas can help in improving assignment of firefighting personnel and equipment. It can contribute to community planning and urban renewal by pointing to existing substandard structures whose razing would reduce peacetime fire hazards in the city. It should also prove useful in planning for emergency operations in natural disasters, such as earthquakes.

CONFLAGRATION ASSESSMENT FOR SAN JOSE*



*From Cohn, B.M., The Conflagation Potential in San Jose and Albuquerque, Gage-Babcock & Assoc., Inc., October 1966

FIRE SURVIVAL IN RESIDENTIAL BASEMENTS

In Chapter 2, it was noted that home basements provide a considerable measure of blast protection. Basements of wood-frame and brick-veneer residences were rated about half-way down the list of best available locations for blast survival. Fire survival in residential basements will require active fire defense on the part of the basement occupants. Only above 5-psi blast overpressure, where the residence is expected to be blown clear of the basement, is fire unlikely to pose a significant threat to the survivors. This situation is shown in the upper illustration.

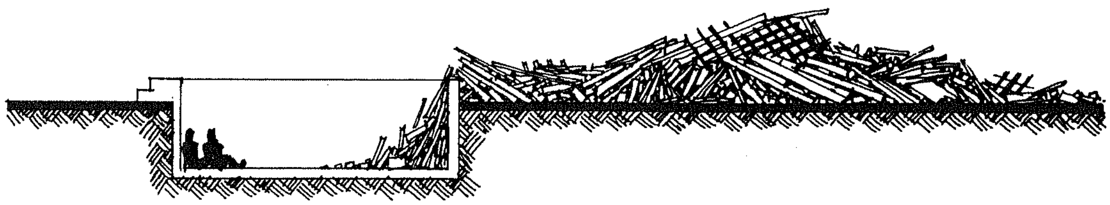
The most serious threat would occur in the moderate damage area at perhaps 2 to 5 psi blast overpressure, shown in the lower illustration. Because residential occupancies are the most vulnerable to fire ignition, basement occupants must search the damaged aboveground portion for smouldering ignitions and secondary fires, should they occur. Secondary fires could be minimized by shutting off the gas and electric utilities prior to attack where they enter the house. Thermal ignitions can also be minimized by preattack closing of blinds and drapes and by dabbing the windows with whitewash, paint, or other opaque materials. Despite these precautions, an immediate search for incipient fires would be necessary.

The blast wind, as we have seen, is likely to delay the development of fire from thermal ignitions for many minutes. The threat of fire from damaged utilities would be the most immediate. Later, the threat of fire spread from neighboring homes may require a fire watch for brands and burning embers. Experiments at the Camp Parks Fire Research Facility have shown that once a fire becomes established beyond the control of self-help firefighting, basement occupants have about 10 minutes to get out of the building, preferably through a basement window, before hazardous amounts of carbon monoxide are likely to be present. The collapse of burning structure would follow shortly thereafter.

It can be seen that, where the best available shelter is in residential basements, there would be significant operational advantages to the grouping of neighboring families in the best basement on the block—best with respect to closeness to other buildings, for example. Most basements will hold 5 to 10 families. Able-bodied people could form fire teams to care for the group more effectively than could each family attempting to cope separately.

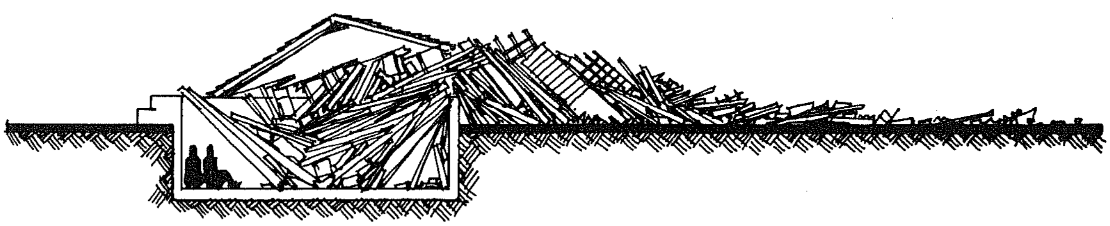
FIRE HAZARDS IN RESIDENTIAL BASEMENTS

over 5 psi



SITUATION OF LEAST FIRE RISK

2 - 5 psi



SITUATION OF GREATEST FIRE RISK

FIRE RISK IN LARGE BASEMENTS

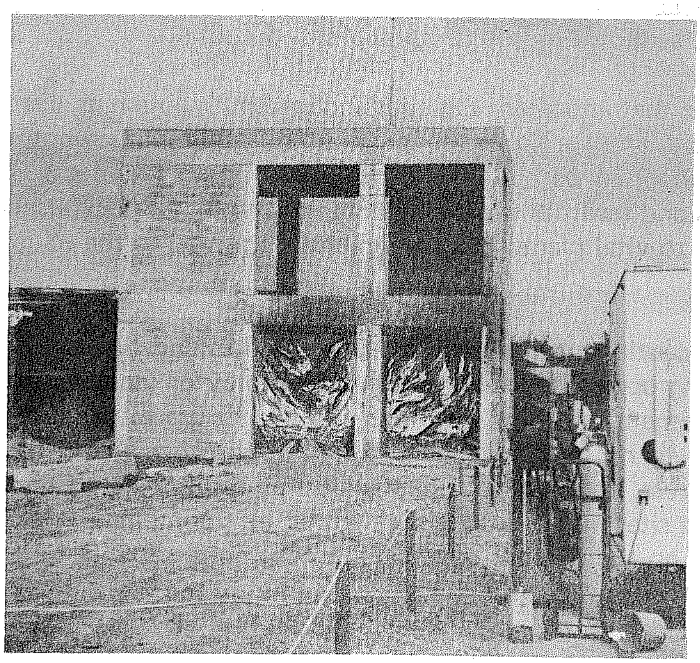
Shelters in the basements of large buildings, particularly those described as "good shelters" in Chapter 2, offer a substantial degree of protection against fire. An example from Hiroshima, the Fukoku Building, is shown in the upper photograph. This seven-story reinforced-concrete frame building was near the Bank of Japan building and experienced about 20 psi blast overpressure. Subsequently, the building was gutted by fire. Three panels of the ground floor were depressed by the blast but fire did not penetrate into the basement of the building. This failure of the fire to involve the basement was a common occurrence at Hiroshima.

Since the Hiroshima basements were not occupied as shelters, no evidence exists as to whether heat and noxious gases would have prevented survival inside them. There were numerous instances of loss of life in German basements during the "firestorms," mainly due to excessive heat and carbon monoxide poisoning. On the other hand, the majority of basement occupants in these areas survived. To gain a better understanding of the life hazard in basements, experiments have been conducted for the past several years in a reusable building located in Gary, Indiana. This fire-test facility, shown in the lower photograph, has two stories and a basement. The walls are designed to permit openings to simulate varying degrees of blast damage. Combustibles can be placed in one or both stories to represent the room contents for various occupancies—residential, office, commercial, library, and the like. The ground floor slab can be adjusted in thickness and in tightness to simulate openings that might exist.

Experiments to date indicate toxic gases from most debris fires will not penetrate a ventilated shelter sufficiently to cause a substantial hazard. Heat transmitted through the floor slab can present a serious problem, however. For a slab 5 inches thick, which is a common thickness over basements offering "good" blast protection, the heating reaches an equivalent of four added occupants for every shelter space, given a residential fire loading above. The added heat load would make the basements untenable in a matter of an hour or so. An important finding has been that as little as one-third gallon of water per square foot of floor area applied in the first half hour after the start of a fire on the ground floor will reduce the heating effect to about one-quarter of what it would otherwise be. Since broken water piping in the above-ground part of a large building might very well provide such cooling, basements might remain tenable for considerably longer periods than one hour.

Nonetheless, the potential threat of debris fires on the floor above the basement should be guarded against. In addition to possible preattack measures to reduce the fire loading there, "fire guard" teams should be planned for each shelter facility so that incipient fires can be promptly suppressed.

FUKOKU BUILDING FOLLOWING THE HIROSHIMA ATTACK AND FIRE



FIRE ABOVE BASEMENT IN GARY FIRE TEST FACILITY

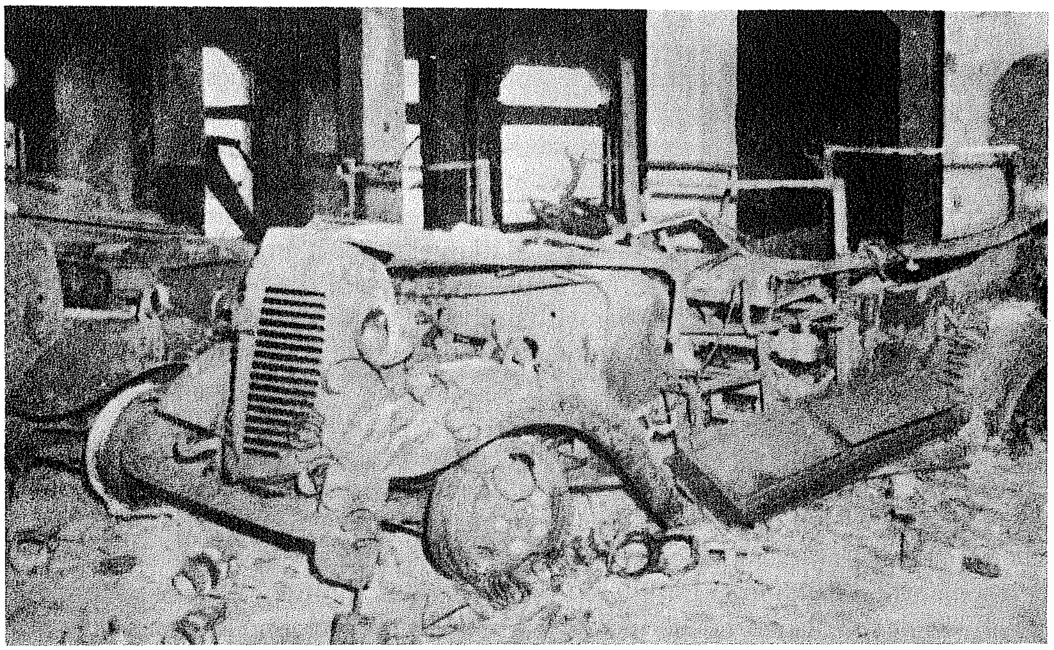
EFFECT OF FIRE ON PROPERTY

Nearly all of the discussion in this chapter has emphasized the saving of life as the objective of fire defense measures. While this is as it should be, the emergency planner should be fully aware of the damaging effects of fire on community resources and productive facilities.

We have seen that fires will occur mainly in the area already damaged by the blast wave. This being the case, one might reach the conclusion that the ensuing fire could add little to the damage that had already occurred. This would be a false conclusion. Blast-damaged equipment, vehicles, and buildings retain much of their original value. Many can be readily repaired and those damaged beyond repair can be salvaged for parts and materials of value in postattack recovery. The consequence of fire, however, is to reduce the salvageable remains to the category of junk, as shown in this photograph.

Studies have shown that important facilities and equipment, such as electric power substations, pumping stations, and the like, must be completely replaced if swept by fire, whereas blast-caused damage can often be quickly repaired. We saw in Chapter 1 that emergency repairs to vital utilities and facilities was a civil defense function spelled out in the law. Prevention of fire damage to vital plants and equipment is essential to the achievement of this objective.

In addition to precautionary measures to minimize fires and fire spread, there appear to be two main planning options available. One is to deploy or maintain professional firefighters and their equipment at critical facilities where their use in fire defense would not depend on the ability to move through the streets. The other would be to locate fire companies at staging areas, together with debris clearing equipment, so that movement to one or more threatened sites might be feasible. Either or a combination of them might be appropriate, depending on the number of critical facilities in the area and the availability of fire equipment and manpower.



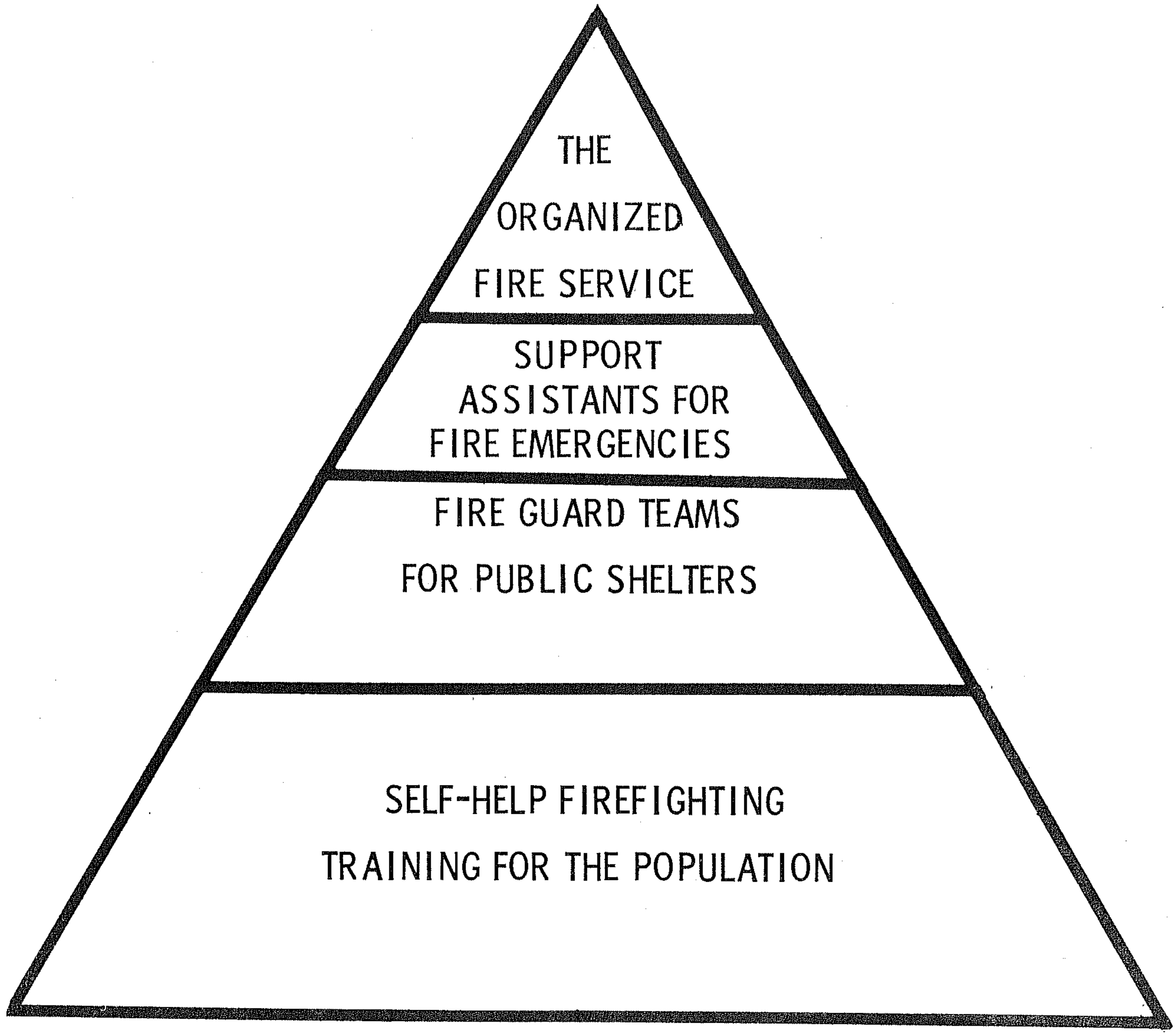
Hiroshima Industrial Company Building showing destruction of fire trucks in public fire department substation in first story. Building was gutted by fire although it suffered only 14 percent superficial blast damage.

THE BASIC FIRE DEFENSE PROBLEM

Whether or not the recent experimental evidence on the effect of the blast wave on thermal ignitions is further substantiated, there would be so many buildings initially on fire that they could not be handled by the professional fire service, even under ideal conditions. In urban areas, there are typically several thousand buildings in each square mile. The average fire company services about two square miles of urban area. Should as few as 1 percent of the buildings be set on fire, each fire company would face 30 to 80 simultaneous building fires. Even near the edge of the fire area, established mutual support arrangements would be insufficient to result in extinguishment of more than a fraction of the fires. When losses of equipment and injuries to personnel, together with probable loss of electric power and water pressure and blast-caused debris blockage of streets are considered, conventional fire defense in the damaged area does not appear feasible.

Clearly, some expanded fire defense capability is necessary if initial fires are not to grow and spread unchecked. A practical fire defense must be based on a knowledge of how unattended fires develop and spread. We have seen that preventive measures prior to attack can have a major impact on the number of ignitions that may occur. We have also seen that undamaged rooms will not flashover until 5 to 20 minutes after ignition. It appears that the blast wave will extinguish flames for periods of 15 minutes to several hours, thus adding to the time available for the application of simple suppression measures.

On the basis of the information at hand, the elements shown in this chart would appear necessary. The professional fire service must assume a broad responsibility for leadership, planning and training, recognizing that in a nuclear emergency the organized fire companies would be restricted to defense of vital facilities and major fire breaks. Fire prevention measures and extinguishment of incipient fires would depend on a broad base of training for self-help emergency firefighting among the population. As specialized parts of a widespread fire defense capability, there is a need for fire guard teams in public shelters, and brigades of trained support personnel (SAFE) to expand the professional cadre.



ELEMENTS OF A FIRE DEFENSE ORGANIZATION

PUBLIC CAPABILITIES FOR FIRE DEFENSE

In this country, self-help emergency firefighting by householders has been seen mainly in the periodic brush fires that plague central and southern California. This photograph of self-help firefighting is from the Oakland-Berkeley fire of 1970. People such as these have defended their homes from fire without training. The experience of the Forest Service suggests that the effectiveness of householders in fighting fire can be increased about 50 percent by modest training.

The International Association of Fire Chiefs has prepared an intensive 6-hour training course in Self-Help Emergency Firefighting for the Defense Civil Preparedness Agency. The IAFC is prepared to assist by encouraging local fire departments to offer this training in their communities. A reasonable training target, as in Medical Self-Help training, is one trained person in every household.

Citizen fire defense can be effective both in preventing and suppressing fire ignitions. In addition to periodic cleanup campaigns, such as those widely conducted during National Fire Prevention Week, preparations can be made to mobilize the community during a crisis period. Appropriate fire prevention activities in order of priority are:

1. Move ignitable items, especially bedding, upholstered furniture, and rugs, to areas that would not be exposed to thermal radiation (about 1 man-hour required).

2. Cover or coat all windows with opaque materials, such as whitewash, paint, flour and water mixture, or aluminum foil (about 3 man-hours required).

3. Clean up garage, basement, and attic, disposing of loose combustible materials (about 1 man-hour required).

4. Clean up trash and ignitable items from exterior of house (about 3 man-hours required).

Extinguishment advice and training should emphasize use of garden hoses, wet mops and blankets, and sand or loose dirt to knock down ignitions to the point where smouldering items can be carried or thrown outside, clear of the house. Experiments conducted by the IIT Research Institute indicate that self-help extinguishment can be near 100 percent effective up to a minute or so before room flashover.

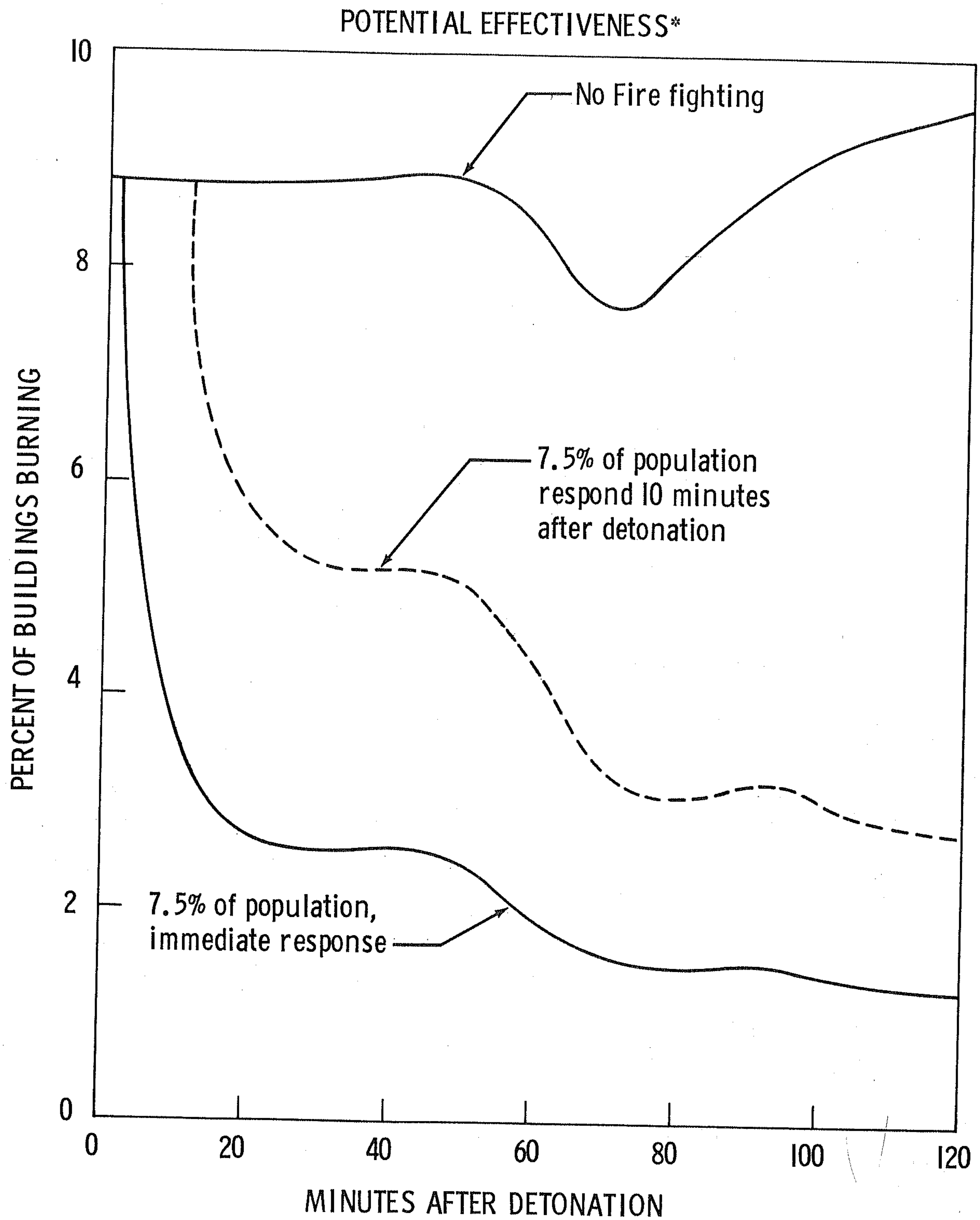
UPI Photo.

POTENTIAL EFFECTIVENESS OF FIRE DEFENSES

While the real effectiveness of the sort of fire defenses discussed here cannot be estimated in advance, calculations have been made, using the computer-based fire spread model and some reasonable assumptions on fire defense performance. A typical result is shown here. As you may recall, the fire spread model does not yet include the effects of the blast wave in snuffing out ignitions and delaying room flashover. In addition, no preattack fire prevention measures are assumed.

It is reasonable to assume that at least one able-bodied person is potentially available in each household for firefighting. This would represent a work force of 25 percent of the population. Many of these people would be in public shelters, however. For this example, about 30 percent of the assumed work force is assumed to be available for self-help firefighting in residential areas. The firefighting units are assumed to be of three kinds. First, mechanized fire department units are assumed to be at vital facilities or at staging areas on routes likely to be relatively free of debris. These regular units are augmented by some four-man "brigades" with training similar to the Support Assistants for Fire Emergencies (SAFE) program. Dispersed throughout the residential areas are the self-help units of two men each, supported by SAFE brigades to handle electrical and gas fires and other special problems.

Among the key operating assumptions used in this example were that self-help teams could move from building to building at a speed of 4 miles an hour, that every building had to be searched for ignitions, that search of a residence required 12 seconds, and that one-half minute was needed to suppress each ignition found. It can be seen from the illustration that immediate response by 7.5 percent of the population is very effective in controlling fires and fire spread in the first hour. Once fires start to grow, a delay of as much as 10 minutes can nullify much of this performance. If, however, we introduce the delaying effect of the blast wave, the necessity for "immediate response" is lessened. Nonetheless, the need for prompt and purposive action based on proper training and leadership is evident. Fire defense in a nuclear attack appears feasible but not automatic.



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DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 4

WHAT THE PLANNER NEEDS TO KNOW ABOUT ELECTROMAGNETIC PULSE

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 4

This discussion of EMP effects is aimed at the emergency planner and operator rather than the engineer or communications specialist. It is assumed that the reader is familiar with the material in the three preceding chapters. Since equipment damage from the electromagnetic pulse (EMP) is most significant for a detonation outside the earth's atmosphere, other effects of high-altitude bursts (radio blackout and thermal radiation) have been included. Chapter 4 is the only chapter in this Manual that discusses these high-altitude attack effects.

Information is presented in the form of "panels" each consisting of a page of text and an associated sketch, photograph, chart or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 4 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with two introductory panels, followed by five panels on the general nature of the electromagnetic pulse. There follow five panels summarizing the likely effects on various communications and power systems. One panel describes ways to minimize EMP damage to these systems. Finally, two panels discuss the accompanying high-altitude effects of radio blackout and thermal ignitions. A list of suggested additional reading is included in the summary panel.

CONTENTS OF CHAPTER 4

"WHAT THE PLANNER NEEDS TO KNOW ABOUT ELECTROMAGNETIC PULSE"

WHAT IS "EMP"?

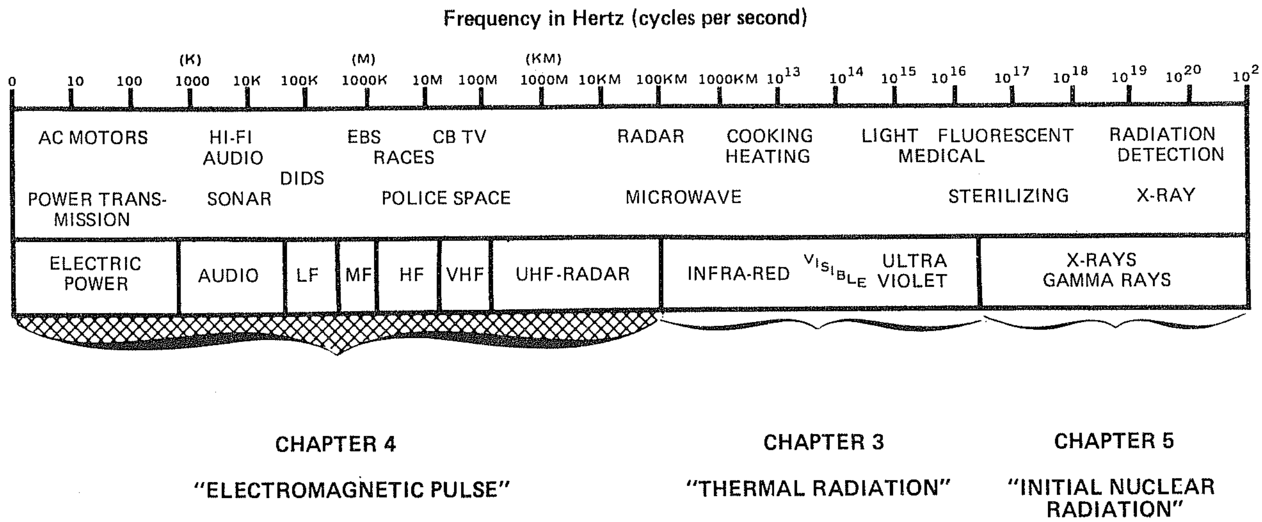
In Chapter 3 we discussed the capability of the thermal radiation pulse to burn the skin of exposed people and to ignite thin flammable materials within the area damaged by the blast wave. We loosely called this radiated energy "heat radiation" to appeal to the human senses. The radiation itself, of course, is merely a form of electromagnetic radiation, such as is sunlight, which manifests itself by a rise in temperature as it is absorbed in or near the surface of objects it strikes.

A nuclear detonation also emits electromagnetic radiation of longer wavelengths (lower frequency) than the infra-red and visible light of the thermal pulse. Most of this energy is radiated in the frequency bands commonly used for radio and TV communications. For this reason, it could also be called the "radio flash."

It is in the electric power and radio frequencies that the electrical and magnetic aspects of electromagnetic radiation have been prominent. If the reader were an electrical or electronic engineer or a communications expert, it would be appropriate to describe the complexities of the phenomena involved in the EMP from a nuclear explosion. We will not do this partly because we cannot assume the reader is an expert and partly because the planner does not really need to know the technical details to recognize and include the EMP threat in his emergency operating plans.

PANEL 1

THE ELECTROMAGNETIC RADIATION SPECTRUM



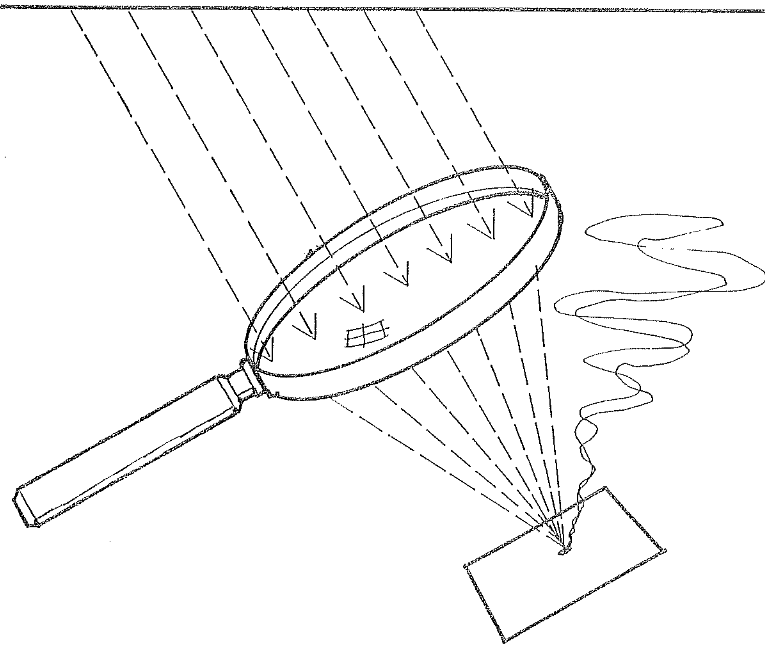
WHY WORRY ABOUT EMP?

Few people have ever heard of EMP or "radio flash." It might be called the "forgotten" nuclear weapon effect. It was not mentioned in either the 1950 "**Effects of Atomic Weapons**" or the 1957 "**Effects of Nuclear Weapons.**" EMP was first mentioned in a chapter on radio and radar effects in the 1962 version of the "**Effects of Nuclear Weapons**" but the description was brief and no hint was given as to its damaging effects.

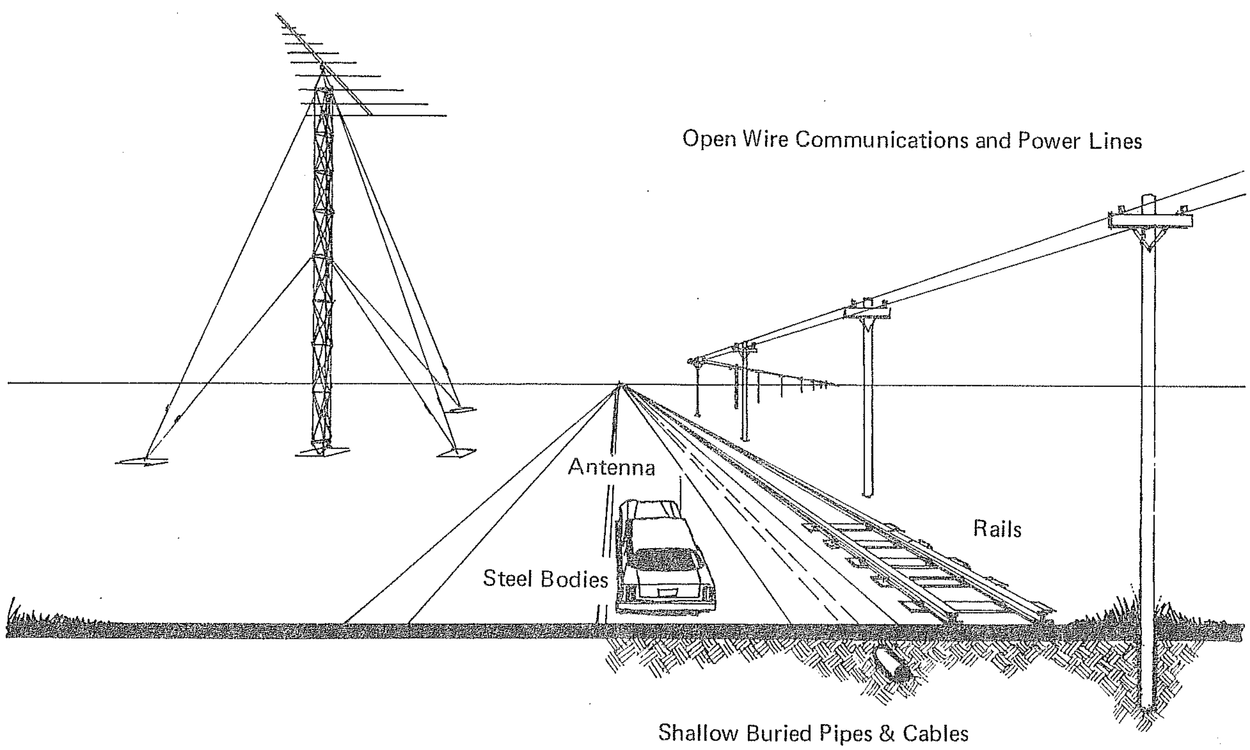
One reason for this lack of attention has been that the energy contained in the "radio flash" is much smaller than that in the thermal pulse. We saw in Chapter 3 that where the blast overpressure is 5 psi, the thermal energy is about 100 calories per square centimeter. At the same distance from a surface burst, the radio flash energy is equivalent to much less than one calorie per square centimeter.

We know that sunlight can be focused by a magnifying glass so as to ignite paper. If magnifying glasses or their equivalent were common in target areas, we would need to be concerned about very low levels of thermal radiation in nuclear attack. Fortunately, this is not the case. But natural energy collectors for radio frequencies are widespread. They magnify the weak "radio flash" somewhat as a magnifying glass does sunlight.

Anyone who has hooked up an old radio to a bedspring knows that almost any metallic object can collect energy from radio waves. Any long wire can pick up the energy in the electromagnetic field and then deliver it in the form of current and voltage pulses to the attached equipment. The larger or longer the conductor, the greater the amount of energy collected. For example, the short antenna of an automobile radio will collect less energy than a large broadcast station transmitting antenna. Typical collectors of EMP energy include long exposed cable runs, piping or conduit, large antennas, metallic guy wires, power and telephone lines, and even shallow-buried pipes and cables, long runs of electrical wiring in buildings, and the like. Sufficient energy can be collected by these means to cause damage to attached electrical and electronic equipment.



A THERMAL ENERGY COLLECTOR



EMP ENERGY COLLECTORS

PANEL 2

SURFACE BURST EMP

There are two burst conditions of major concern with respect to EMP: (1) the surface or near-surface burst, and (2) the high altitude detonation above the earth's atmosphere. Detonations at altitudes between these two conditions produce much lower intensities of EMP.

For a tiny fraction of a second before the fireball is formed, the X-rays from the exploded nuclear weapon create an oscillation of electrical charges in the air molecules surrounding the explosion. This region, somewhat smaller than the subsequent fireball, is called the "source region." A brief pulse of electromagnetic energy is radiated outward as shown in the upper illustration.

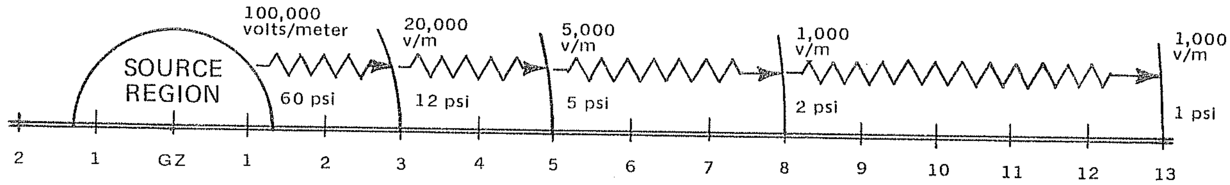
The strength of a radio wave is measured in terms of the voltage stress produced in space by the electric field of the wave, usually expressed in microvolts (millionths of a volt) per meter. This measure is also the voltage that the magnetic field of the wave induces in a conductor 1 meter long when sweeping across this conductor with the speed of light. (A meter is a little over 39 inches or about 10 percent longer than a yard.)

But the field strength in the EMP pulse is not measured in microvolts. Rather, thousands of volts or "kilovolts" per meter is a more appropriate measure. The table shows a comparison of the maximum EMP field strength with more common sources, in every case close to the "source region," whether it be detonation, transmitter, or power line.

Ordinary radio receivers are designed to sense very low levels of electromagnetic energy. Under some circumstances, signal strengths as low as 0.1 microvolt per meter are usable. Occasionally, signal strengths exceeding 1000 microvolts (1 millivolt) per meter are required to assure satisfactory radio reception. In most cases, the weakest useful signal strength lies between these extremes.

The thousands of volts per meter in the EMP pulse is in a different "ballpark" compared to signal strengths used in communications.

EMP FROM A 5–MT SURFACE BURST



DISTANCE FROM GZ, MILES

COMPARISON OF ELECTROMAGNETIC FIELDS

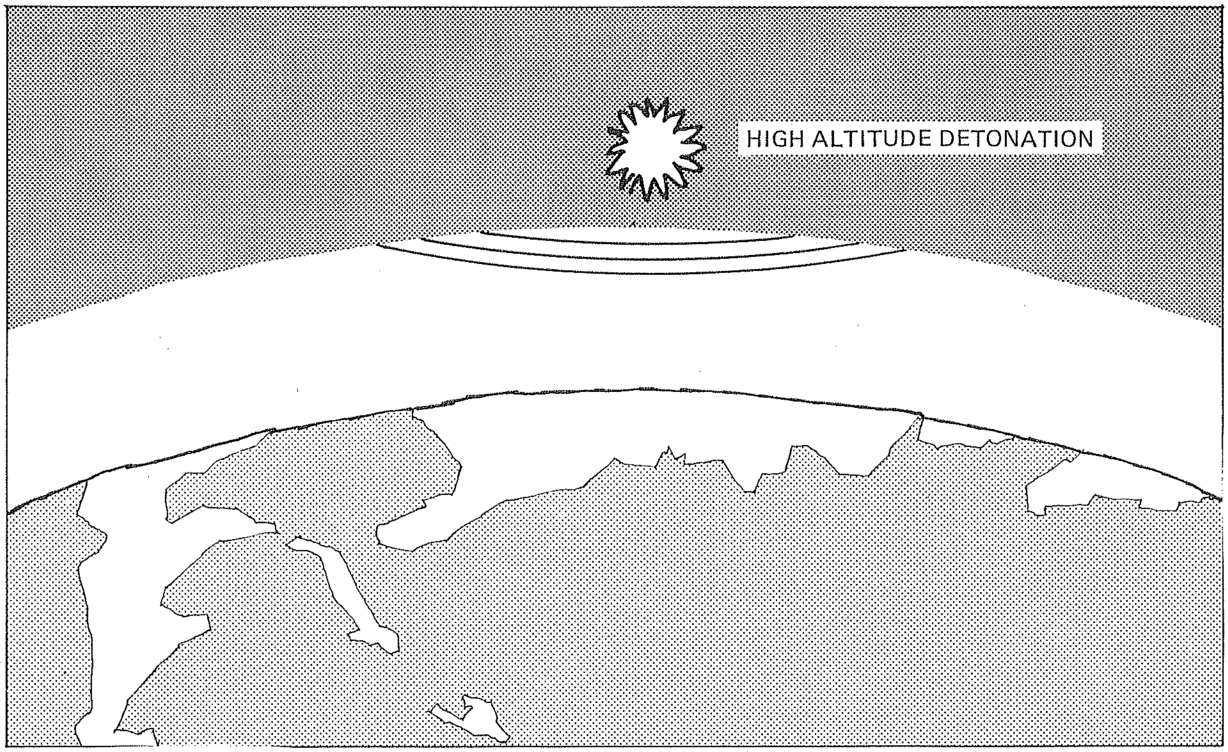
SOURCE	INTENSITY (volts per meter)
EMP	UP TO 100,000
RADAR	200
RADIO COMMUNICATION	10
METROPOLITON "NOISE"	0.1

Source: Defense Nuclear Agency

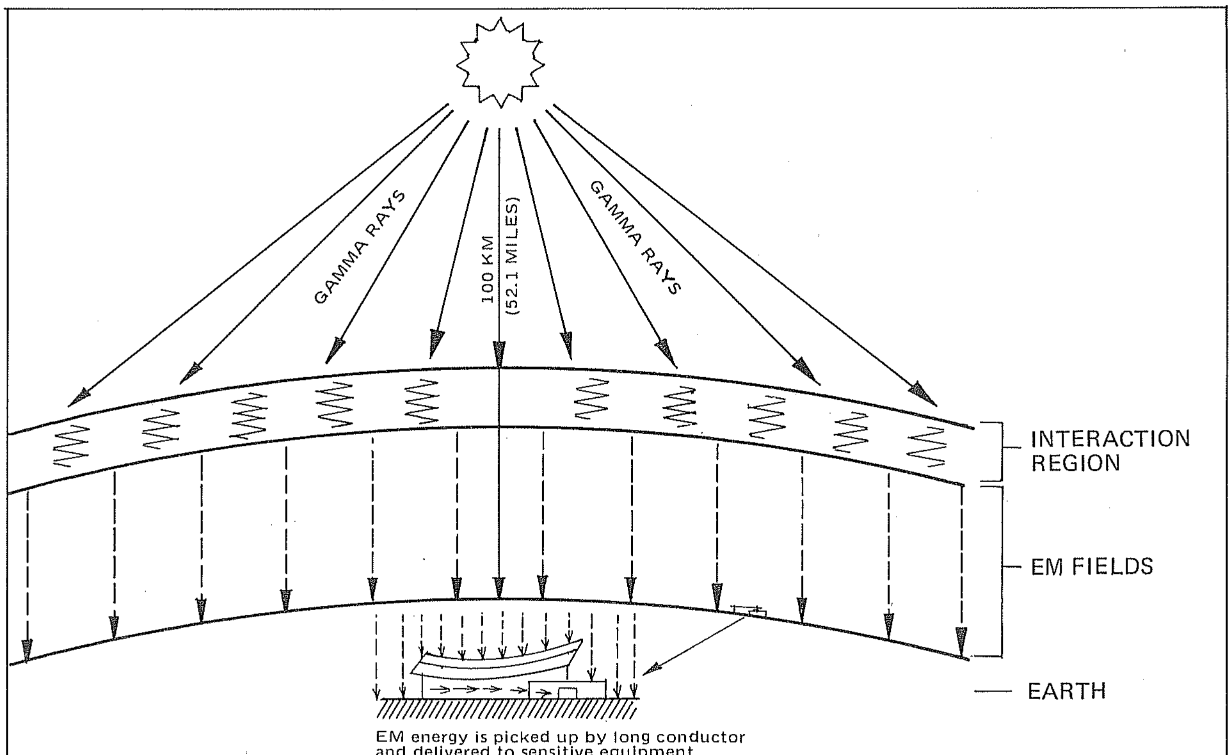
HIGH-ALTITUDE BURST EMP

If a nuclear weapon is detonated high above the earth's atmosphere (an exoatmospheric burst), the X-rays and gamma rays emitted downward from the explosion will be absorbed in a big "pancake" layer of the atmosphere between 12½ and 25 miles above the earth's surface, as shown in the upper view.

The gamma energy is converted into lower-frequency electromagnetic energy in this interaction region and propagated downward to the earth's surface as a very brief but powerful electromagnetic pulse. The strength of this pulse on the ground is in the order of tens of thousands of volts per meter, much the same as the field strength in the moderate damage area of a surface burst. However, very large areas, otherwise undamaged, can be affected by the high altitude detonation, as the lateral extent of the "interaction region" is generally limited only by the curvature of the earth.



Source: Defense Nuclear Agency



EMP ENERGY FROM HIGH ALTITUDE BURST.

PANEL 4 From Survive, November-December 1969.

EMP COVERAGE

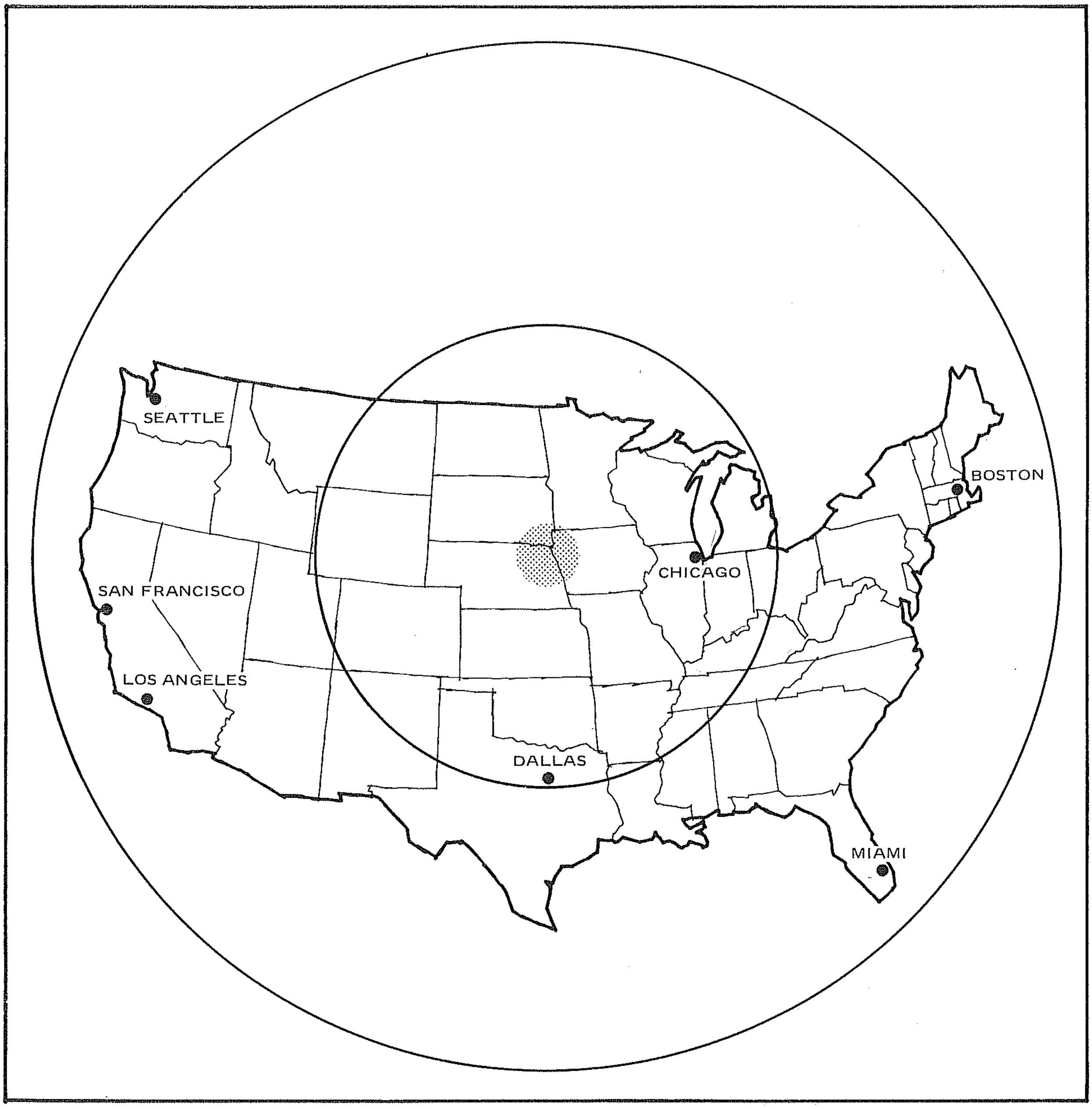
In the case of an exoatmospheric burst, blast damage does not occur and other effects are minor except for the EMP. The source region at 12½ to 25 miles above the earth's surface can be quite large, perhaps a thousand miles in diameter. As a consequence, the radiated fields from this source region can cover a substantial fraction of the earth's surface.

A typical high-altitude burst over Omaha, Nebraska, is shown here. Within the circle passing through Dallas, Texas, ground-level fields of a few tens of thousands of volts per meter would be created. The outer circle shows that a few kilovolts per meter would occur everywhere within the contiguous 48 states.

That these pulses can cause damage to electrical and electronic equipment is not a matter of scientific theory. The failure of approximately 30 strings of street lights on Oahu at the time of the Starfish detonation about 750 miles away over Johnson Island was the most publicized effect during the weapons test series Operation FISHBOWL in 1962.

High-altitude bursts are no longer unlikely. The deployment of those ballistic missile defenses permitted by the recent treaty with the Soviet Union would include the use of megaton-yield warheads to intercept incoming weapons outside the atmosphere. Even if this were not in prospect, the effectiveness of EMP in interrupting communications would make it probable that some of the thousands of warheads discussed in Chapter 1 would be used for this purpose.

An implication for operational planning is that a potential EMP threat must be anticipated in every locality during the first minutes and perhaps hours after a nuclear attack is initiated.



EMP GROUND COVERAGE OF HIGH ALTITUDE BURSTS

Source: Defense Nuclear Agency

PANEL 5

DAMAGE FROM EMP

Two kinds of damage can be caused by the EMP pulse:

(1) Functional damage, requiring replacement of a component or piece of equipment. Examples would be the burnout of a radio receiver "front end" or blowing of a fuse.

(2) Operational upset, a temporary interruption or impairment of electrical equipment such as opening of circuit breakers or erasure of a portion of the memory of a computer.

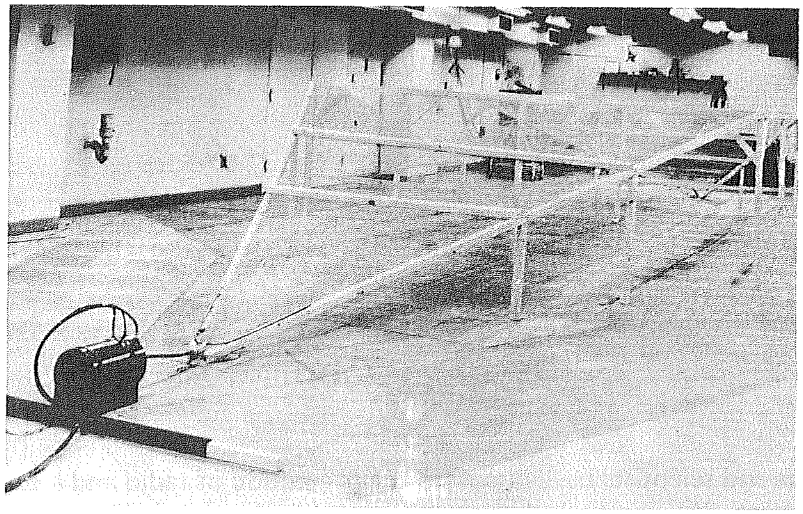
Functional damage is of greatest significance to civil defense operations since temporary interruptions of communications or power are not likely to be crucial.

The response of an electronic or electrical system to EMP is often highly dependent on obscure details. They may include defects in welds, minute cracks and seams, the quality of soldered joints, or the type of grounding system. Because these obscure details often determine the actual vulnerability, experimental facilities have been relied upon since the atmospheric test ban to simulate the EMP from a nuclear weapon. One such experimental facility, used to test pieces of equipment, is shown in the upper photograph. Equipment placed within the enclosure is subjected to "threat-level" EMP pulses, usually repeatedly, to determine whether either functional damage or operational upset is likely to occur.

Experiments have shown that civil defense radiation detection equipment is not susceptible to direct damage nor are hand-held Citizens Band walkie-talkies or FM radio receivers. Generally, the relative vulnerability of components shown in the lower chart has been determined, with transistorized equipment most susceptible.

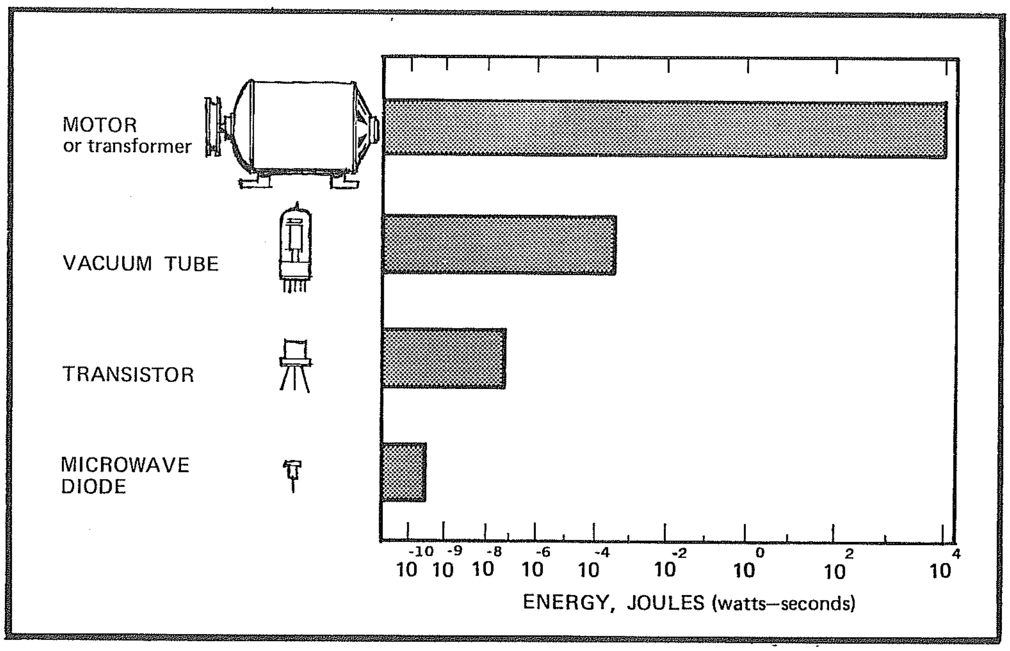
It has been found that communications equipment employing bipolar transistors with self-contained batteries and loop antennas are not susceptible to direct EMP damage. Similar equipment with stick antennas up to 40 inches long can be operated safely. Equipment using field-effect transistors may suffer damage if connected to an antenna exceeding 30 inches in length.

The general implication of these results is that mobile communications equipment is relatively survivable while radio base stations are vulnerable unless protected against EMP.



ONE TYPE OF EMP SIMULATOR

IITRI Laboratory photograph.



SENSITIVITY OF VARIOUS COMPONENTS

NOTE: 300 feet of wire can absorb about 1/10 to 40 joules of energy depending on orientation and proximity to other conductors.

Source: Defense Nuclear Agency

PANEL 6

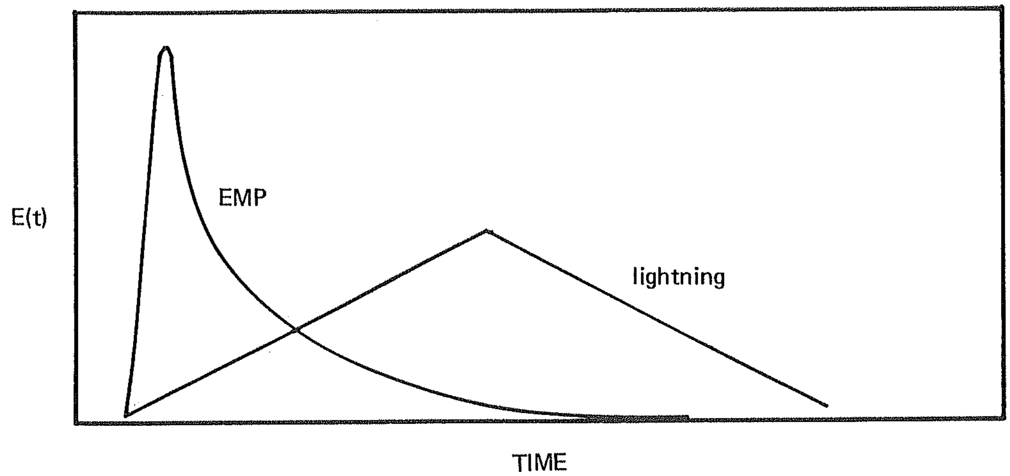
EMP AND LIGHTNING

Engineers and scientists have discussed the protection of radio and electrical equipment from EMP effects by comparing this problem with that of protection against lightning. Lightning is the only naturally occurring phenomenon that has electrical currents, voltages, and fields associated with it that are in any way comparable to the electromagnetic effect of a nuclear explosion. Everyone has heard the electromagnetic "static" produced in radio reception by distant lightning strokes. Most people are aware that large antennas and other tall structures are protected by "lightning arrestors" to prevent damage to sensitive equipment.

The upper sketch shows that EMP occurs much more rapidly than does a lightning stroke. Thus, devices, such as spark gaps, that are suitable for lightning protection may permit large EMP-induced overvoltages to pass before they operate.

The lower sketch shows that EMP is a broadband pulse with frequencies ranging from almost zero to more than one hundred megahertz. It therefore spans all of the communications frequencies. The electromagnetic waves associated with lightning are confined to the lower frequencies. Thus, filtering out the EMP frequencies is more difficult than is the case with lightning.

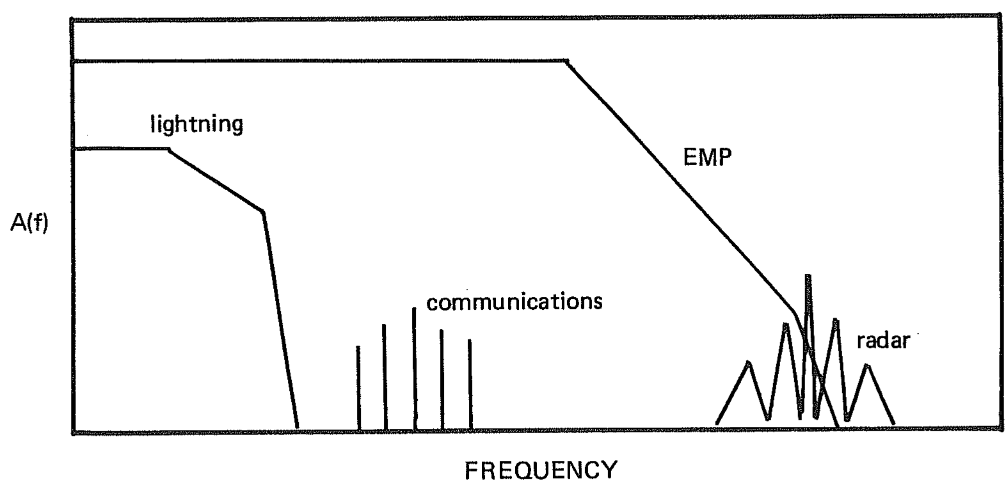
TIME HISTORY
COMPARISON WITH LIGHTNING



NOTE: Rapid rise of EMP pulse

Source: Defense Nuclear Agency

SPECTRUM COMPARISON



NOTE: Broad frequency range of EMP

Source: Defense Nuclear Agency

PANEL 7

VULNERABILITY OF BROADCAST RADIO

EMP poses a potential threat to AM, FM, and TV broadcast transmitters. There are three areas of concern regarding EMP damage to radio station operation: (1) pulse energies collected by large broadcast antennas; (2) conducted pulses from power lines and other long external conductors; and (3) directly induced transient currents in transmitter circuits.

Although the energy collected by a large antenna may be less than from an average direct lightning stroke, the limited protective action of the usual spark gap may place a strain on transmitter, antenna insulators, transmission lines, and matching network components exceeding that of lightning. Since lightning frequently damages high-voltage capacitors, it may be concluded that EMP would cause capacitor damage and perhaps damage to other components as well.

Damage from commercial power connections is also possible since about one-quarter of the voltage collected by the power lines will pass the nearby distribution transformers. And damage from power lines could be more serious than from antenna coupling as the damage could be harder to diagnose and rectify. A standby electric generator would solve this problem, provided the station can be disconnected from commercial power before the first detonation. Because this must be done manually, station personnel should make provisions to react promptly to attack warning.

Broadcast station wiring and circuits can act like loop and wire antennas, collecting radiated energy. Transistors are especially susceptible to low-level energy pulses induced in connected circuits. Vacuum-tube transmitters are much less vulnerable.

There are many known ways to protect broadcast stations from possible EMP damage. Technical training is required to understand these protective measures. The planner should assure that local broadcast station operators have access to the DCPA publication TR-61-C, **EMP Protection for AM Radio Broadcast Stations.** This document contains much detail on low-cost corrective actions that can be taken. (See Panel 16.)

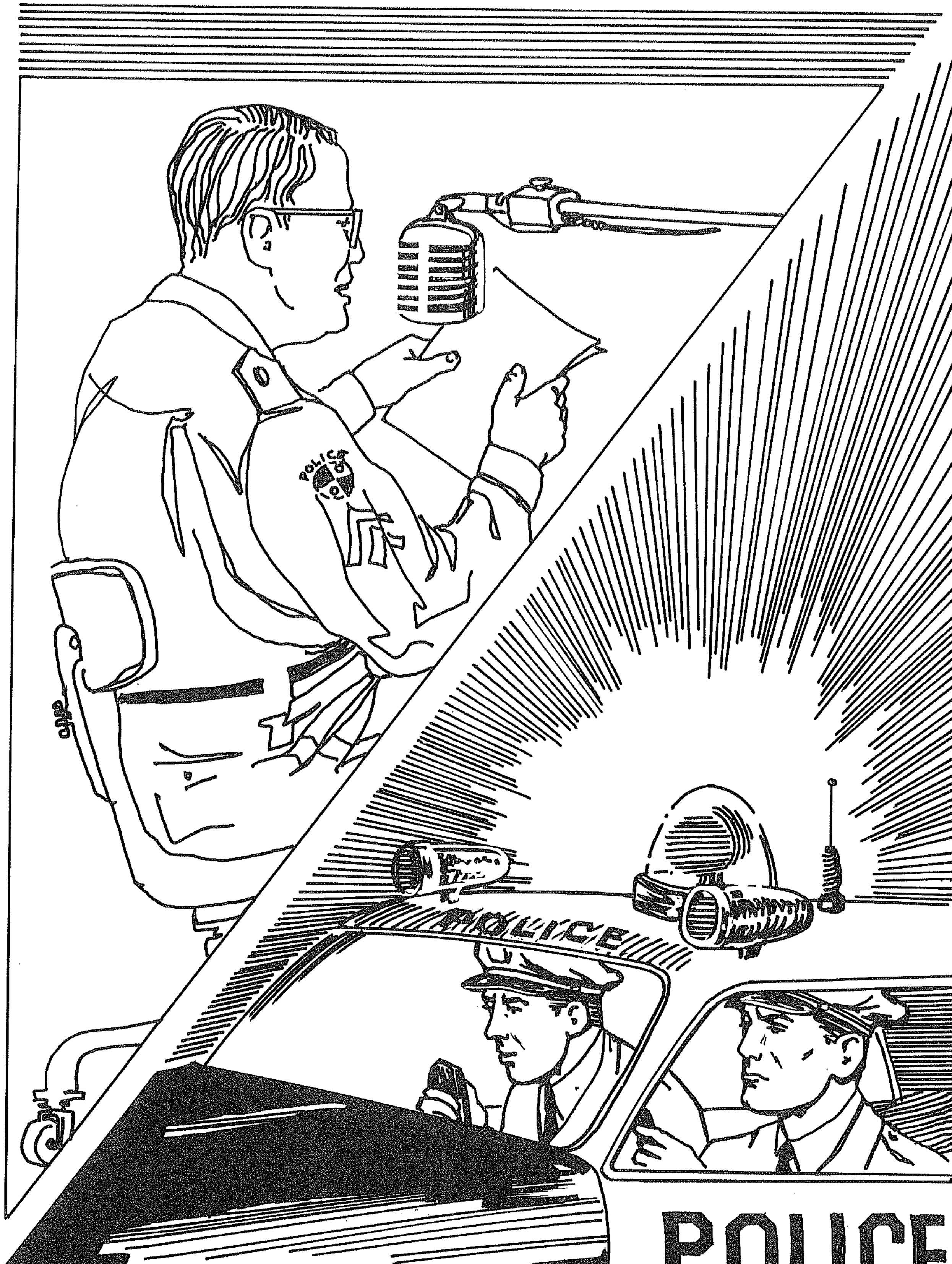
AM BROADCAST STATION ANTENNA AND TRANSMITTER BUILDING

PANEL 8

VULNERABILITY OF PUBLIC SAFETY RADIO

Police, fire, public works, and other local government radio nets usually perform a crucial role in disaster operations. To these systems can be added emergency amateur radio organizations, such as RACES. The base stations (and relay stations) in these networks have the same general vulnerability to EMP as do commercial broadcast stations. Even at high frequencies where antennas are short, long cables are often used to connect the antenna to the transmitter. Furthermore, many base stations cannot operate in the absence of commercial power. Unless these facilities are equipped with standby electric power and EMP protective devices, they are likely to go off the air in a nuclear emergency.

Mobile units in these systems have battery power supplies and relatively short antennas. They are most likely to remain operable. The implication for emergency planners is that arrangements to permit mobile-to-mobile communications will be important as an alternative in the event of loss of a base station.

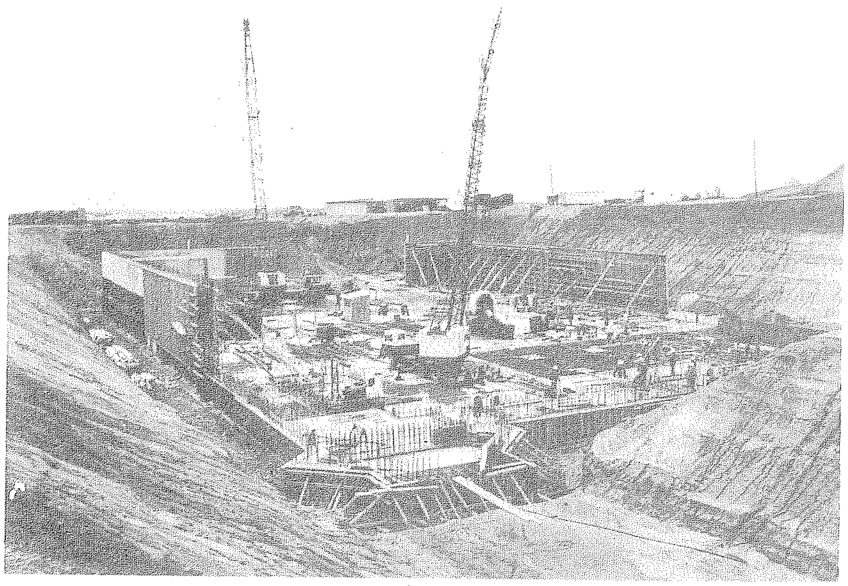


PANEL 9

VULNERABILITY OF TELEPHONE SYSTEMS

Telephones are another important communication resource for emergency operations. In addition to the public telephone system, telephone lines are often used in public safety radio nets to connect dispatchers to transmitters and to interconnect transmitters. The American Telephone and Telegraph Company has taken strong measures to render transcontinental and other critical land lines relatively invulnerable to nuclear attack, including EMP effects. The vulnerability of local telephone exchanges is less well defined but certain characteristics are favorable. Local exchanges do not depend on commercial power. Increasingly, lines are being placed belowground rather than on poles. Nonetheless, some components of conventional telephone plants are very sensitive to the effects of EMP. Despite the rugged and conservative design and construction used in telephone systems, these are not sufficient to give high confidence that telephone service will operate reliably immediately after exposure to EMP.

Despite these problems, the use of the local telephone system should hold a key place in local emergency planning. Local radio nets are used mainly to communicate with mobile units in the field. During the major part of the nuclear attack period, these units should be parked as discussed in Chapter 2, with the personnel taking refuge in the best available shelter. Moreover, the telephone system is the one system that cannot be disconnected in the way a radio transmitter can. Therefore, it would be prudent to plan for maximum use of telephone service between temporarily immobilized field units and dispatchers so long as service continues, reserving the radio service until the main threat of EMP damage is past.



PROTECTED FACILITY FOR AT&T LONG LINES DEPARTMENT UNDER CONSTRUCTION

Bell Laboratory Record, January 1969.

PANEL 10

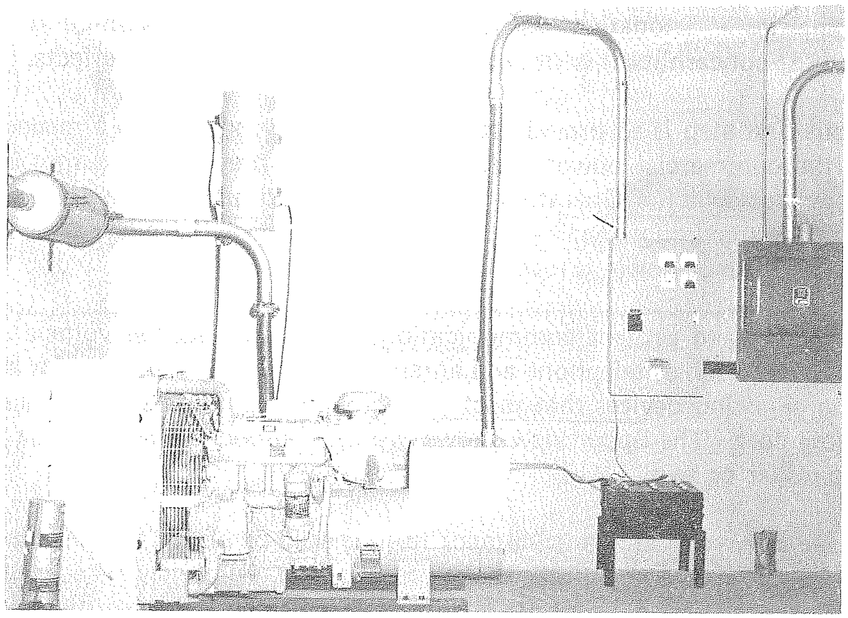
VULNERABILITY OF ELECTRIC POWER

Power lines exposed to EMP will have induced in them currents and associated voltage surges in much the same way that antennas collect radio signals. For power systems, this means that a high altitude detonation will induce surges on all the myriad of power conductors, control and communication cables, interconnecting wires, and other conductors virtually simultaneously throughout the entire system. Probably the largest surges will occur on overhead power lines because they are located well above the earth and are essentially unshielded. Moreover, overhead "ground wires" that are used to shunt lightning strokes have little effect on the magnitude of EMP-induced surges. Surge voltages on overhead power lines may be sufficiently large to cause arcing in substations and at branches or changes in direction along the lines. Insulators can be damaged and circuit breakers locked out.

System "instability" is a probable result of these outages. Since the major blackout of the Northeastern part of the U.S. in 1965, most people are aware of the catastrophic and widespread effects of system instability. The cumulative weight of EMP effects thus makes likely widespread power failure on a national scale at the very beginning of a nuclear attack.

Recall that in Chapter 2, Panel 30, we described the effects of blast damage on the electric power system. Blast damage would be extensive above 5 psi. In the moderate damage region, early restoration of power seemed likely and, beyond the reach of 2 psi, the distribution system would be essentially intact. Even here, however, the availability of electric power would depend on the amount of EMP damage and measures taken to repair the damage that occurred.

The implication for emergency planning is that no reliance should be placed on the presumed availability of electric power during and immediately following a nuclear attack.



TYPICAL VIEW OF A STANDBY EMERGENCY GENERATING PLANT FOR AN EOC OR EBS STATION

VULNERABILITY OF EMERGENCY OPERATING CENTERS

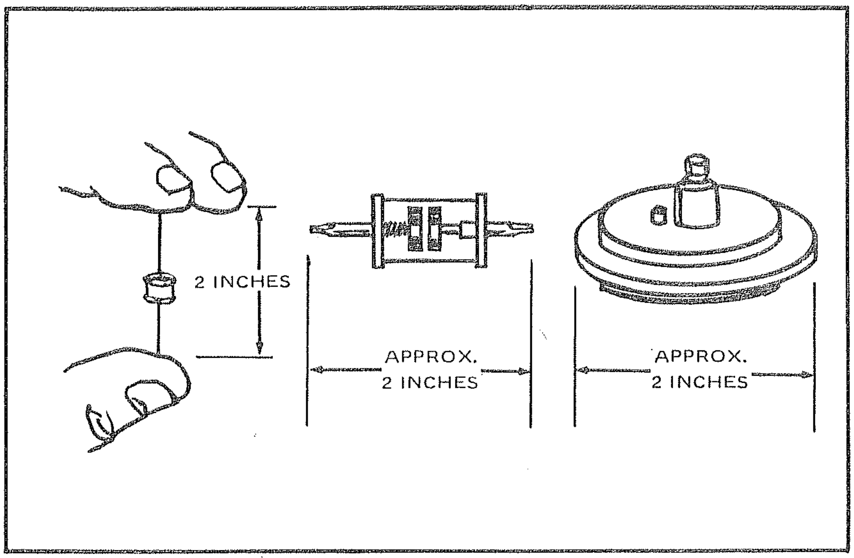
The local EOC represents a key nerve center for emergency operations. As such, it must be in a position to communicate with others during and after a nuclear attack. Since EMP from high-altitude detonations can cripple communications anywhere in the country, every locality must concern itself with protection of its EOC from EMP effects.

An obvious first step is to provide standby emergency power and a means for disconnecting from the commercial power that will effectively prevent line surges from passing through the transfer switch. Operating procedures should provide for switching to emergency power at the maximum readiness condition or at Attack Warning rather than waiting until weapons detonate or power is lost.

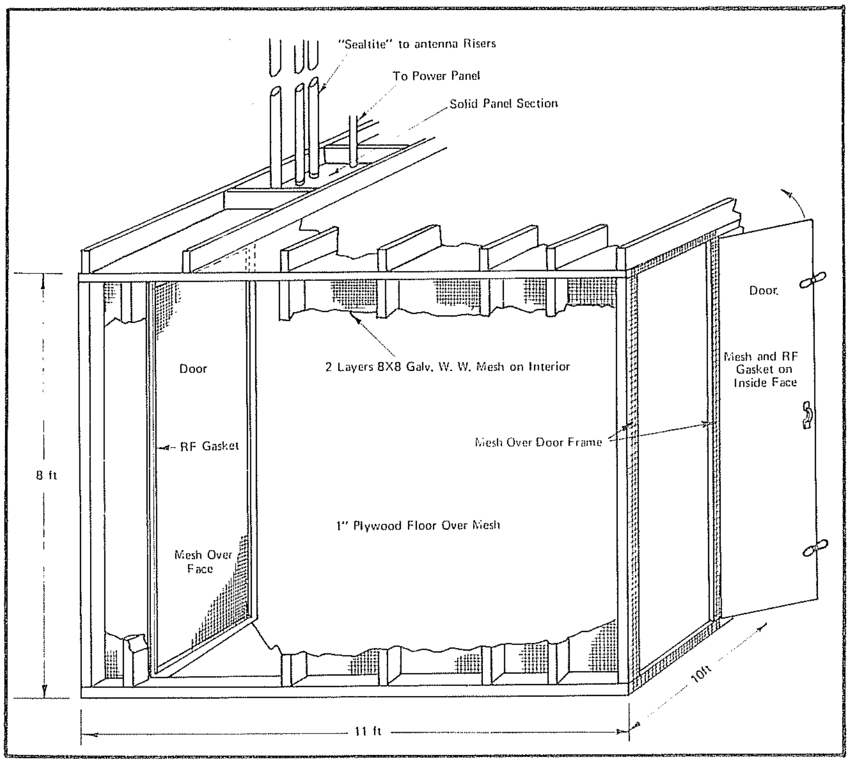
The next step is to protect communications equipment against voltage surges from other incoming lines, such as telephone and antenna lead-in cables. Devices for this purpose, such as gas-gap shunting devices that react very rapidly, are now becoming available commerically at low cost. The upper view shows typical components of this sort that can be obtained for a dollar or two.

Finally, the communications equipment itself should be placed in a shielded enclosure. A solid metal lining for the communications room is best, but a galvanized steel-wire mesh enclosure, properly grounded, is also satisfactory. One such enclosure that can be locally constructed is shown in the lower view.

Of course, it is simpler, cheaper, and more effective to incorporate EMP protection in the design of a new EOC than it is to retrofit an existing facility. When planning a new EOC, this should be done. The Engineering Support Group at the nearest DCPA Regional Operating Center is available for advice in these matters. Additionally, the DCPA TR-61 series of technical guidance reports will be found useful. (See Panel 16.)



GAS-GAP SURGE ARRESTOR (also called spark-gaps)



SHIELDED BOX

PANEL 12

OPERATIONAL EMP DEFENSES

Whether or not physical EMP hardening has been accomplished in local EOC and communications facilities, there are a number of low-cost operational actions that should be incorporated into emergency operating plans to deal with the possibility of EMP damage. These actions can help minimize the possibility of catastrophic communications failure. Some of the actions shown here can be undertaken readily; others may require some modifications in equipment before they can be incorporated in plans and SOPs.

Maintain an extra supply of spare parts and standby components so that EMP damage, should it occur, can be rectified as quickly as possible. Elements most likely to be affected are identified in DCPA publications or can be identified by assistance from the DCPA Region. If vulnerable elements are located in unprotected or unmanned areas, repair actions should be planned as essential emergency actions.

The need for specific plans to shift to emergency power as early as possible and desirability of relying on telephone reporting during the early shelter phase have been mentioned before.

If telephone service fails or if there is no alternative to continued use of certain radio nets, the use of existing facilities in a coordinated way should be investigated and planned for. There are a variety of ways in which coordinated communications can be achieved. If the community or area has set aside a common emergency frequency, as many base stations as possible should be equipped to transmit on this frequency in addition to normal frequencies. Then, plan to use only one base station at a time for essential communications to all services. Alternatively, essential field units can be equipped to monitor and/or transmit on several nets, such as police, fire, and public works. Again, only one base station would be used at a time during the threat period. Those not required should be disconnected from antennas, power lines, and other long conductors to avoid EMP damage.

Also, plan to back up the normal transmitter capability by mobile-to-mobile communications. For systems that use one frequency for transmitting from base stations and another for mobile response, this backup capability would require mobile communications vans or the equipping of a limited number of mobile units to transmit on both frequencies. Such backup arrangements have been found useful in hurricanes, tornadoes, and other natural disasters.

Finally, emergency operations plans should be designed so that they are not completely dependent on communications with the EOC or normal dispatching procedures. The ways to do this are described in Chapter 9.

PANEL 13

SEVEN ANTI-EMP ACTIONS

1. Maintain a supply of spare parts.

2. Shift to emergency power at the earliest possible time.

3. Rely on telephone contact during threat period so long as it remains operational.

4. If radio communication is essential during threat period, use only one system at a time. Disconnect all other systems from antennas, cables, and power (do not use low-voltage switches but pull the plug).

5. Disconnect radio base stations when not in use from antennas and power line.

6. Plan for mobile-to-mobile backup communications.

7. Design emergency operating plans so that operations will "degrade gracefully" if communications are lost.

RADIO BLACKOUT

Since this Chapter is the only one in which we will consider directly the effects of high-altitude nuclear detonations, the planner should be aware of some effects other than EMP that might affect emergency operations. One of these "lesser effects" is radio "blackout."

Radio blackout occurs when the debris and radiations from a nuclear weapon cause major alterations in the electrical properties of the high atmosphere upon which some radio communications depend. This region, called the "ionosphere," extends from about 40 to 300 miles above the earth's surface. High-altitude detonations produce a large amount of electrical "fog" in the ionosphere, although surface and near-surface bursts in the megaton yield range can also have some effect.

As shown here, long-distance communications in the high-frequency (HF) band can be interrupted for several hours since they depend on the bending of radio waves back toward the earth for distant communication. Short-range communications within a city or county are unlikely to be affected by radio blackout. The current trend toward use of very-high-frequency (VHF) and ultra-high-frequency (UHF) bands for public safety and amateur broadcasts decreases the likelihood of blackout of these communications.

The "20-meter" and "40-meter" bands are still popular for long-distance amateur communications, however. Since radio blackout can be confused with EMP damage to equipment, the planner should take account of its existence. Radio blackout will not cause damage to equipment, merely interfering temporarily with receipt of radio transmissions. This is unlikely to be of serious consequence to emergency operations.

SUSCEPTIBILITY TO RADIO BLACKOUT

Radio Band	Frequencies	Example	Effects
LF	30 - 300 KHZ	DIDS	Least affected
MF	300 - 3000 KHZ	EBS	Some distant interference
HF	3000 - 30,000 KHZ	RACES	Many hours
VHF	30,000 KHZ - 300 MHZ	High-band Public Safety	Few seconds to minutes
UHF	300 - 3000 MHZ	TV, Latest Public Safety	Little effect
SHF	3 - 30 GHZ	Microwave and Satellite	Virtually no effect

HIGH-ALTITUDE THERMAL EFFECTS

Below a height of about 20 miles above the earth's surface, the thermal radiation pulse accompanying a nuclear detonation has the characteristics described in Chapter 3 and corresponding effects. Above 20 miles, however, the rarefied atmosphere in which the burst occurs results in most of the thermal radiation being emitted in a brief pulse of about a second's duration. In other words, the "heat flash" from a 25-MT detonation at high altitude could be similar to that which occurred from kiloton-yield weapons at Hiroshima and the Nevada Proving Grounds.

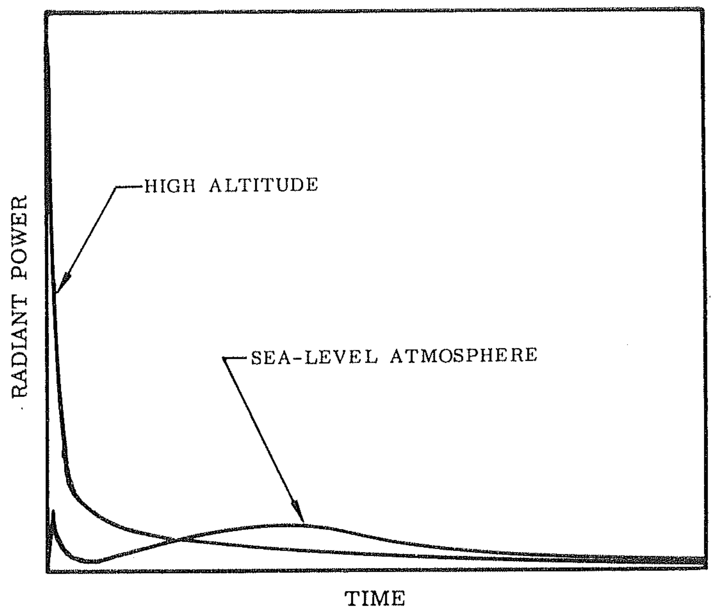
The importance of this behavior lies in the fact brought out in Chapter 3 that it is the **rate** of energy delivery that determines whether ignitions will occur. As a consequence, common kindling fuels could ignite at about half the total energy delivery (in calories per square centimeter) described in Chapter 3. Of course, the detonation itself occurs at a great distance from the earth's surface and this compensates a great deal for the added susceptibility of kindling fuels.

If a 25-MT weapon were detonated at a height of 60 miles, which is a "good" altitude for causing EMP damage, the thermal energy reaching the ground on a clear day would be about 4 calories per square centimeter directly under the explosion. This would be just enough to cause ignition of exposed ignitables of the most sensitive class. But the high-altitude burst could not "see" into rooms within buildings except at great distances where the thermal energy would be much reduced. If the weapon were detonated at a significantly lower altitude, the EMP effectiveness would be less, the thermal ignition effectiveness greater.

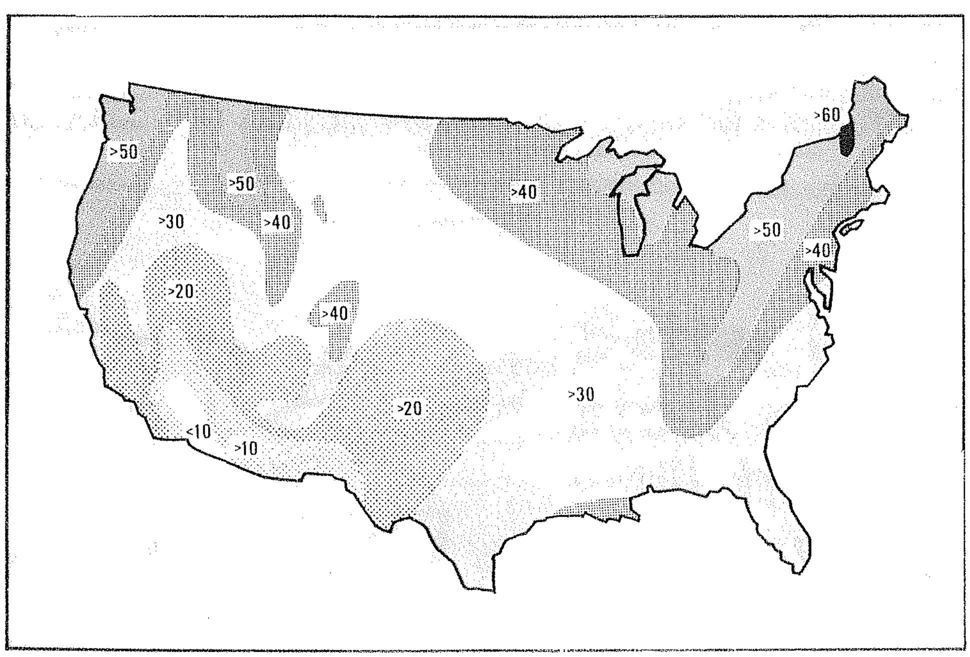
A blast wave would not result from a high-altitude burst to suppress ignitions but neither would windows and screens be blown out. No debris would block firefighting activities and men and equipment would be fully operational. When the facts are added that clouds prevail over a substantial portion of the country nearly every day and it is cloudy in most localities a substantial part of each year, the conclusion has been reached that the use of high-altitude detonations to cause ignitions is a most unlikely tactic.

Nonetheless, weapons might be detonated at high altitudes to cause EMP damage or as a result of missile defense measures. The implication for emergency planning is that possible ignitions should be expected, searched out, and suppressed if found, no matter how remote a nuclear detonation appears to be.

PANEL 15



COMPARISON OF RATES OF THERMAL ENERGY RELEASE FOR MEGATION WEAPONS



PERCENTAGE OF ANNUAL "OPAQUE" CLOUDINESS

PANEL 15

SUMMARY

One final point should be made about EMP effects. We do not have to concern ourselves about the effects upon people as we did in Chapters 2 and 3. Without considerable focusing, the EMP energy is totally harmless to living things. Standing in the open, one would literally not feel a thing with respect to the strongest EMP pulse. However, the energy collected in a long wire might cause electrocution or a burn, if a person were touching it at the time. Such conditions are not generally expected.

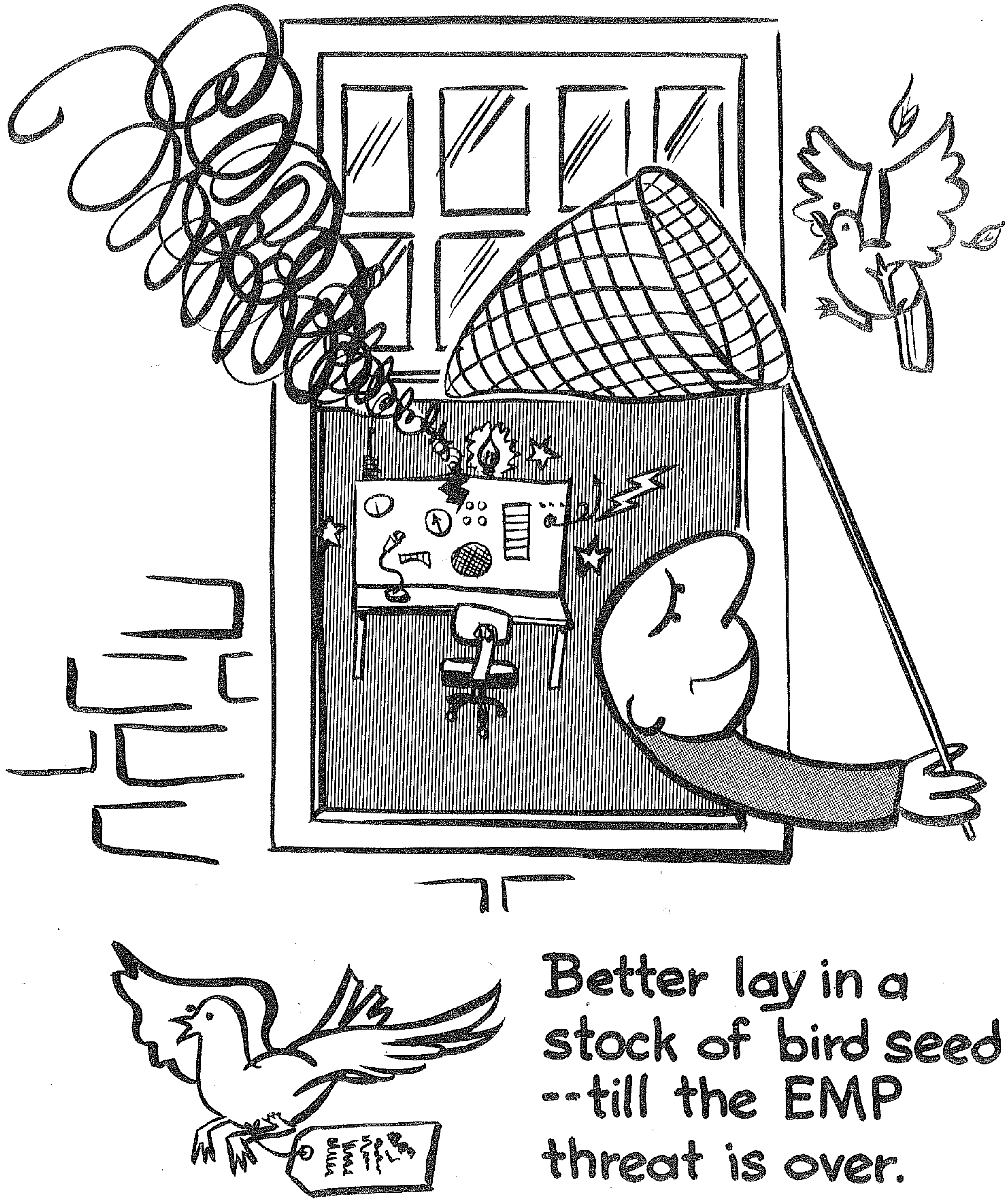
With respect to the protection of communications and electrical equipment, recent research results have been incorporated into the following publications:

EMP Threat and Protective Measures, DCPA TR-61, August 1970.

EMP Protection for Emergency Operating Centers, DCPA TR-61A, May 1971.

EMP Protective Systems, DCPA TR-61B, revised July 1972.

EMP Protection for AM Radio Broadcast Stations, DCPA TR-61C, May 1972.



Courtesy of Don Clark, U.S. Naval Civil Engineering Laboratory.

PANEL 16

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DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 5

WHAT THE PLANNER NEEDS TO KNOW ABOUT INITIAL NUCLEAR RADIATION

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

PREFACE TO CHAPTER 5

This discussion of initial nuclear radiation also introduces the planner and emergency operator to the biological effects of brief exposures to ionizing radiation. It is assumed that the reader is familiar with the material in the preceding chapters. Since initial nuclear radiation is most significant for low-yield nuclear detonations (ranging up to 1 megaton), other effects of detonations from 40 to several hundred kilotons (changes in blast and fire effects) have been included. Chapter 5 is the only chapter in this Manual that discusses the effects of "small" nuclear weapons.

Information is presented in the form of "panels," each consisting of a page of text and an associated sketch, photograph, chart, or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 5 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with two introductory panels, followed by five panels on the nature of radiation injury. Two panels summarize the relationship of the initial nuclear radiation (INR) threat to blast effects for megaton-yield weapons and the protection afforded by shelter areas. There follow three panels on the more serious INR threat from "small" nuclear weapons. Two panels discuss how the blast and fire effects of these "small" weapons differ from the effects described in Chapters 2 and 3. Finally, the planning implications of initial nuclear radiation are summarized. A list of suggested additional reading is included for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 5

"WHAT THE PLANNER NEEDS TO KNOW ABOUT INITIAL NUCLEAR RADIATION"

INITIAL NUCLEAR RADIATION

In Chapter 3, the effects of a pulse of electromagnetic radiation in the "thermal," mainly infra-red, band of frequencies were explained. This thermal pulse of radiant energy could cause burns to exposed people and start fires in light combustible materials. In Chapter 4, the effects of the electromagnetic pulse of frequencies below the infra-red band were discussed. This "EMP" energy was found to be collected by electrical conductors so that it could cause damage to electronic and electrical equipment. In this Chapter, we will be concerned mainly with gamma radiation, electromagnetic radiation of extremely high frequency, and consequent very short wavelength, as shown on this chart.

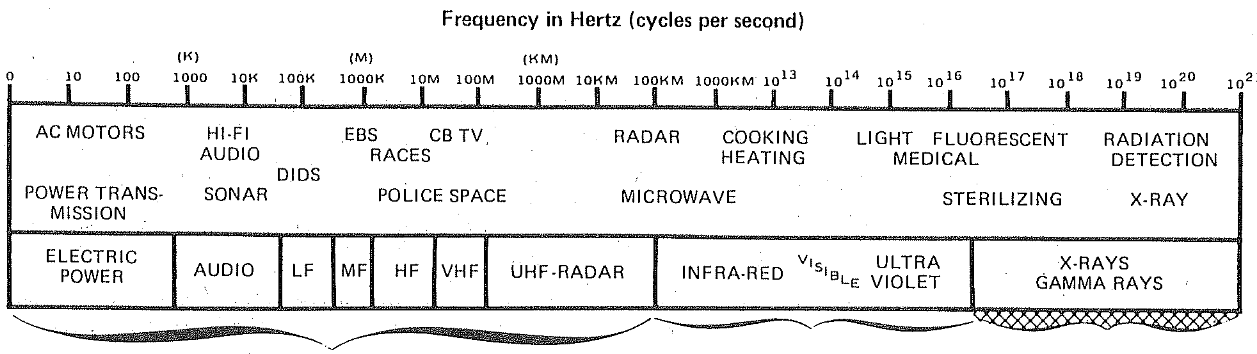
Most people are familiar with the medical use of X-rays. X-rays are produced when a stream of high-energy electrons is directed against an object. Each element of matter gives off X-rays of characteristic frequencies when bombarded in such fashion. X-rays affect a photographic plate in a way similar to light. The absorption of X-rays in matter depends on the density and composition of the material. Thus, bones absorb more X-rays than the surrounding tissue. This makes it possible to take an X-ray photograph of the bones and organs of a living person. Most people have had such "X-rays" taken at one time or another.

It has been customary to classify electromagnetic radiations by their cause or mode of origin. But the interaction of these radiations with matter is independent of the mode of origin. For practical purposes, gamma rays are like X-rays but they are emitted as the result of changes in the nucleus of the atom. Gamma rays are **nuclear** radiation whereas X-rays are not. The consequences are much the same except that gamma rays are generally more penetrating and, indeed, photographic film is used to measure quantities of gamma radiation as well as X-radiation.

Initial nuclear radiation has been somewhat arbitrarily defined as that nuclear radiation emitted during the first minute following the detonation of a nuclear weapon. This time interval was initially chosen on the basis that by one minute the rising fireball and nuclear cloud would be too remote from the earth's surface to cause any significant effects. Actually, the main exposure to initial nuclear radiation occurs in a much shorter time interval.

PANEL 1

THE ELECTROMAGNETIC RADIATION SPECTRUM



CHAPTER 4
"ELECTROMAGNETIC PULSE"

CHAPTER 3
"THERMAL RADIATION"

CHAPTER 5
"INITIAL NUCLEAR RADIATION"

PANEL 1

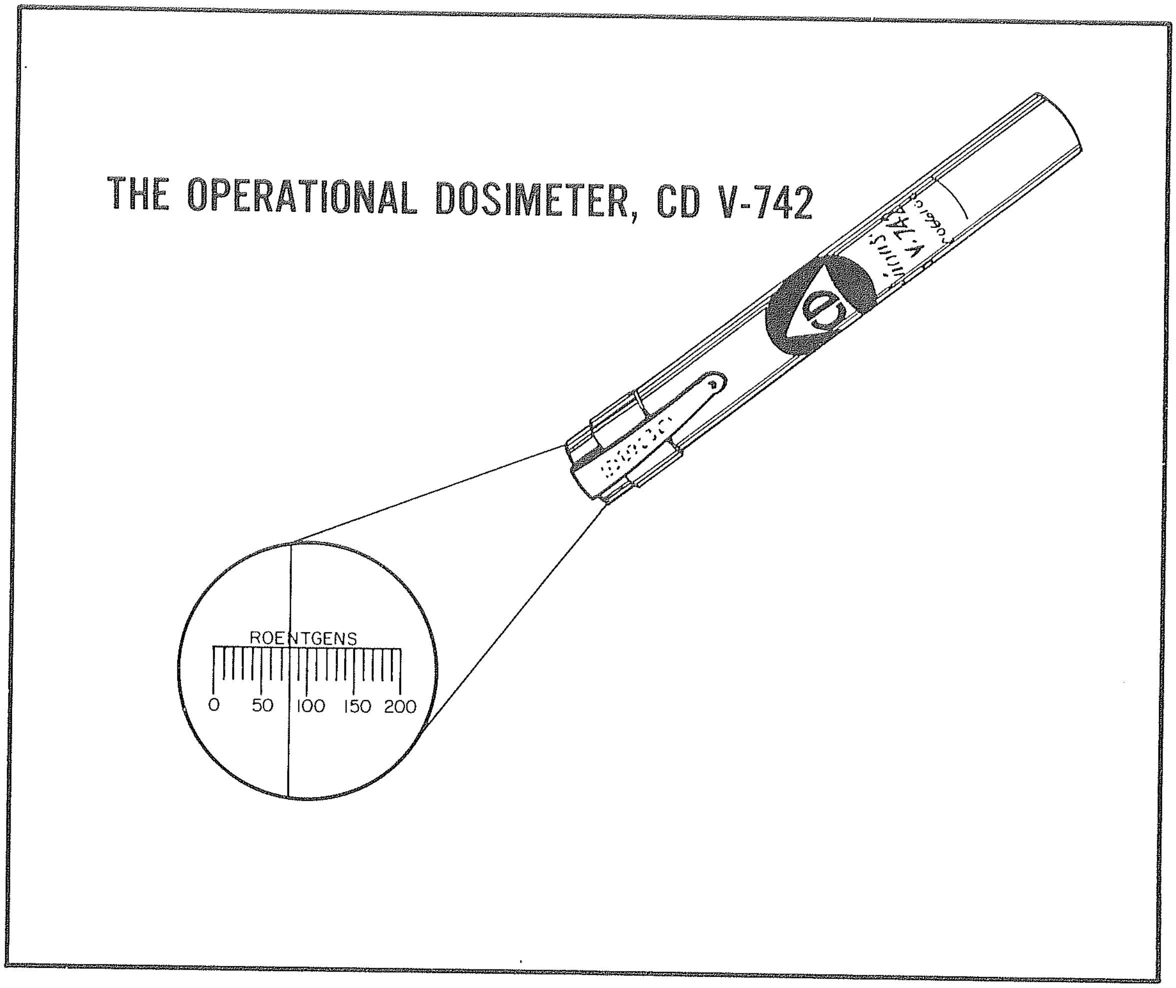
GAMMA RADIATION

Gamma rays are the main initial nuclear radiation from megaton and larger nuclear detonations. We saw in Chapter 3 that thermal radiation is largely absorbed in the surface layers of materials and living things. Thus, thin combustibles may flame but thick materials merely char. Gamma radiation, on the other hand, is highly penetrating; even large masses of earth or concrete will not completely absorb it.

In penetrating materials, including air, gamma rays may be absorbed or changed in direction (scattered) through interaction with the atoms of the material. When gamma rays are absorbed, ions are formed. An ion is an electrically charged atom or group of atoms. Gamma radiation is a form of **ionizing** radiation.

Exposure to gamma radiation is measured by the amount of ionization produced in air. The special unit of exposure is the Roentgen (R). The device shown here, called a dosimeter, reacts to the ionization produced by gamma radiation and, hence, measures the radiation exposure in Roentgens.

PANEL 2



The Operational Dosimeter, CD V-742

PANEL 2

RADIATION INJURY

Emergency planners will be concerned with gamma radiation because of its capacity to injure people. Injury is caused by the ionization produced in the body by gamma radiation. Broadly speaking, ionizing radiation acts more like cumulative chemical poisons than like physical causes of injury, such as blast, missiles, and thermal radiation. Like chemicals, large single doses can cause severe acute sickness or death, depending on the size of the dose and individual susceptibility. On the other hand, small daily doses can be incurred over extended periods of time without causing illness, although delayed consequences may become apparent in later life.

Initial nuclear radiation is a single brief pulse of ionizing radiation. Most of the available information about acute radiation injury is based on experience with single, large doses. Although much of the information is indirect, more is known about radiation than about most other injurious agents, such as war gas, blast, and the like.

Radiation injury is a collective term used to describe all kinds of biological effects grading in severity from the undetectable to the fatal. The effects of a brief exposure that are known with greatest confidence are shown on this table. Lethal doses—those that are likely to kill 10 percent, 50 percent, or 100 percent of those exposed, are known with less confidence. A given dose of radiation will not have the same effect on everyone. Differences in susceptibility among individuals is characteristic of all living creatures. In laboratory studies of the effects of radiation and toxic chemicals on animals, this variation in response makes it useful to determine the dose that will kill half the animals exposed. This is called the median lethal dose (MLD). The best estimate of the MLD for humans is 450R. The dose that causes few deaths (odds of surviving about 20 to 1) is about half the MLD. The 95 percent lethal dose (odds of surviving are 1 in 20) is less than twice the MLD.

It will be noted that the term, "dose," is used for radiation as it is for toxic chemicals. Another term that the planner may encounter is the "rad," the standard unit for absorbed radiation. For gamma radiation, the rad is about equal to the Roentgen measure of exposure. The emergency planner can regard these terms as interchangeable, for practical purposes.

EFFECTS OF A BRIEF GAMMA DOSE*

Smallest exposure detectable by statistical study of blood counts of a large group of exposed people	15R
Smallest exposure detectable in an exposed individual by laboratory means	50R
Smallest exposure that causes vomiting on day of exposure in about 10 percent of exposed people	75R
Smallest exposure that causes loss of hair in second week in about 10 percent of exposed people	100R
Largest exposure that does NOT cause illness severe enough to require medical care in majority of exposed people	200R

*Adapted from National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

PANEL 3

RADIATION SICKNESS

The short-term consequences of over-exposure to gamma radiation have been called radiation sickness. Signs and symptoms associated with the digestive system are those seen earliest and at the lowest exposure levels. The table shows the exposures that will cause a 50 percent incidence of various symptoms of radiation sickness, based on clinical data from irradiated hospital patients.

The blood-forming organs, mainly the bone marrow, are also sensitive parts of the body. Observable signs of blood changes develop later and at higher exposures. These changes result in lowering of the resistance to infection. When fatalities occur, they are often the result of complicating infection. At very high levels of exposure, the central nervous system can be affected.

Radiation sickness is not a communicable disease. It cannot be transmitted to others. In this respect, it is similar to chemical or food poisoning. Indeed, the problem is not protecting others from the radiation victim, but rather protecting the radiation victim from infection from others.

Another point to be noted in the table is that the symptoms that occur earliest and after lowest exposures—particularly nausea and vomiting—are symptoms also of simple anxiety, stress, and fear. Moreover, one or two persons exhibiting these symptoms in a crowded, close environment can induce nausea and vomiting in others. Since radiation injury itself is not painful or otherwise apparent until symptoms of sickness appear, random reactions to the stress of the emergency could be erroneously interpreted as radiation sickness.

ESTIMATED SINGLE RADIATION EXPOSURES THAT WILL CAUSE 50 PERCENT INCIDENCE OF SYMPTOMS

Signs and Symptoms of Radiation Sickness	Single Exposure (Roentgens)	95 Percent Confidence Range (R)
Loss of Appetite	180	150 - 210
Nausea	260	220 - 290
Fatigue	280	230 - 310
Vomiting	320	290 - 360
Diarrhea	360	310 - 410

PANEL 4

LEVELS OF SICKNESS

The general course of radiation sickness can be described in understandable terms. It is described here because most people have little knowledge of it and some familiarity may aid in emergency planning. Grim as some of the description is, it is no more grim than the consequences of massive burns or blast injury.

Unapparent radiation injury occurs when the brief exposure is less than 50R. Level I radiation sickness occurs in the exposure range of 50R to 200R. At this level, less than half the persons so exposed will vomit within 24 hours. There are either no subsequent symptoms, or, at most, only easy fatigability. Less than 5 percent will require medical care for radiation injury. Others can perform their customary tasks. Deaths that occur are caused by complications such as blast and thermal injuries or infections and debilitating disease.

At Level II shown in the table, more than half the persons will vomit soon after exposure and will be ill for several days. This will be followed by a period of one to three weeks when there are few or no symptoms. At the end of this latent period, epilation (loss of hair) will be seen in more than half, followed by a moderately severe illness due primarily to the damage to the blood-forming organs. Most of the people in this group require medical care. More than half will survive, with the chances of survival being better for those who received the smaller doses. Note that early and widespread illness does not necessarily make survival unlikely.

The Level III illness is a more serious version of that described for Level II. The initial period of illness is longer, the latent period shorter, and the ensuing illness is characterized by extensive hemorrhages and complicating infections. Hospitalization is desirable and less than half will survive.

Level IV is an accelerated version of Level III. All in the group will begin to vomit soon after exposure and this will continue for several days or until death, which occurs before the end of the second week, and usually before the appearance of hemorrhages or epilation. Level V is an extremely severe illness in which damage to the brain and nervous system predominates. Symptoms, signs, and rapid prostration come on almost as soon as the dose has been received. Death occurs in a few hours or a few days. Illness of this type has been seen after accidents involving exposure to gamma radiation in excess of several thousand Roentgens.

SUMMARY OF RELATIONSHIP BETWEEN EXPOSURE AND LEVEL OF RADIATION SICKNESS*

Exposure Range	Type of Injury	Probable Mortality Rate Within 6 Months of Exposure
0 - 50R	No observable signs or Symptoms	None
50 - 200R	Level I Sickness	Less than 5 percent
200 - 450R	Level II Sickness	Less than 50 percent
450 - 600R	Level III Sickness	More than 50 percent
More than 600R	Levels IV & V Sickness	100 percent

*Adapted from National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

PANEL 5

LATER CONSEQUENCES OF RADIATION INJURY

In addition to radiation sickness during the emergency period, other signs of radiation injury can occur many months or years after exposure. These late effects are categorized as somatic effects, those occurring in the individual exposed, and genetic effects, those occurring in children of exposed individuals and in subsequent generations.

Late somatic effects include those listed here. None of these conditions is caused uniquely by radiation. What the addition of radiation does, apparently, is to increase the probability of these effects over the standard rate for people of a given age.

Sterility or reduced fertility occurs in many cases of non-fatal radiation sickness, but is temporary in most people. Recovery of fertility may take as long as several years. The risk of developing leukemia is definitely increased by exposure to gamma radiation. Leukemia has appeared in some of the Japanese who were exposed to initial nuclear radiation at Hiroshima and Nagasaki, with the majority of excess cases occurring in the first ten years. The increased incidence appears to be proportional to the dose received. Among the Japanese who survived the largest doses (that is, those who were closest to the detonation) the incidence was about 50 times the standard rate. For future heavily-exposed survivors, this would mean that about 1.5 percent of those aged 25 to 34, for example, might develop leukemia during a 10-year period instead of 0.03 percent, which is the standard 10-year risk rate for leukemia in this age group in the United States.

Among the Japanese who survived at Hiroshima and Nagasaki, there were about as many cases of cataracts as leukemia—about 100 to 150 cases. All but two of these consisted of minor opacity of the lens that did not interfere with vision. Other late effects, such as life-shortening, are not based on human evidence. Experiments on animals suggest that each Roentgen of total-body gamma radiation may shorten life by one to ten days. As to fetal irradiation, most pregnant women in Japan who suffered radiation sickness had a miscarriage as a consequence. A few babies were delivered successfully, but there is no reliable basis for predicting the consequences of radiation injury to unborn children.

LATER SOMATIC EFFECTS

Reduced Fertility

Sterility

Leukemia

Cataracts

Other Cancers

Life Shortening

Fetal Injury

PANEL 6

SOMATIC AND GENETIC EFFECTS

The statements shown here were made in 1967 by Dr. Charles L. Dunham, Chairman of the Division of Medical Sciences, National Research Council. He was summarizing the views of the professional community at a symposium on the consequences of a nuclear war in which about 3500 megatons were assumed to be detonated in the United States. As we saw in Chapter 1, an attack perhaps twice as heavy could be delivered today. In the larger war, the number of survivors would be less but the average radiation dose received by the survivors would be much the same as Dr. Dunham's assumption of 200R. The first quotation refers to the late somatic effects discussed in the previous panel. For perspective, about 20,000 new cases of leukemia are diagnosed each year in the U.S. About 69,000 deaths occurred from lung cancer in 1971, most due to smoking.

The second quotation refers to the genetic effects—those affecting future generations. Genetic injury does not affect the health of exposed individuals in any way and can be detected only by statistical studies of their descendents. So far, searches for evidence of abnormalities in children conceived after one or both of the parents were irradiated have been unsuccessful. Using pessimistic assumptions, calculations have been made that suggest that major defects in newborn babies of succeeding generations might increase to 5 percent from the present rate of 4 percent, assuming that all parents received a dose of 200 to 250R following attack.

Both somatic and genetic effects are believed to be directly related to the dose received by the surviving population. Thus, if by effective civil defense planning, the protection provided the population could be doubled, the numbers shown here would be cut in half.

PANEL 7

GENERAL PREDICTIONS*

"20,000 additional cases per year of leukemia during the first 15 or 20 years postattack followed by an equal number of cases of miscellaneous cancers, added to the normal incidence in the next 30 to 50 years, would constitute the upper limiting case. They would be an unimportant social, economic, and psychological burden on the surviving population."

"The genetic effects would be lost as at Hiroshima and Nagasaki, in all the other 'background noise.'"

*From Proceedings of the 1967 Symposium on Postattack Recovery from Nuclear War, National Academy of Sciences, April 1968 (AD 672 770).

RANGE OF INITIAL NUCLEAR RADIATION

The threat of exposure to injurious amounts of initial nuclear radiation is confined within a radius of about 3 miles from a nuclear detonation. Thus, our hypothetical person standing in the open at 3-1/3 miles from the ground zero of a 5-MT surface burst would be subject to an altogether negligible exposure of less than 1 Roentgen. In this table, the radiation exposure in the open is related to blast overpressure for the 1-, 5-, and 25-megaton surface bursts we have been considering. Significant exposures are limited to the severe damage region where survivors would be expected only in basements or other belowground shelter areas and are most significant for the lowest-yield weapon (1 megaton).

The amount of initial nuclear radiation at a given location on the earth's surface is related to the slant range from the detonation. If a burst were to occur at higher altitudes rather than near the surface, the initial nuclear radiation would be reduced at the given point. The extent of blast overpressures could be increased, moreover. Therefore, the near-surface burst presents the most severe initial nuclear radiation threat with respect to concurrent blast effects.

It will be noted in the table that the initial nuclear radiation from surface and near-surface bursts is not greatly different. For 1-megaton detonations, the exposure in the open approaches lethal levels above 12 psi. In Chapter 1, we saw that the majority of Soviet missile warheads have a yield of about 1 megaton. In Chapter 2, we saw that there were many potential shelter areas, mainly in basements, where people could be expected to survive at overpressures of 12 psi or more. Moreover, initial radiation exposures would be additive to subsequent exposure to fallout radiations, which is discussed in Chapter 6. Therefore, an understanding of the protection afforded by basements and underground shelter areas against initial nuclear radiation is important.

PANEL 8

RELATIONSHIP OF BLAST AND INITIAL NUCLEAR RADIATION

(Near-Surface and Surface Bursts)

Blast Overpressure (psi)	Nuclear Radiation (Roentgens)		
	1 MT	5 MT	25 MT
1	Neg.	Neg.	Neg.
2	Neg.	Neg.	Neg.
5	Neg.	Neg.	Neg.
12	280 (260)*	7 (7)	Neg.
20	3600 (3200)	430 (420)	10 (10)

*Values in parentheses are for surface bursts.

PANEL 8

PROTECTION AGAINST INITIAL GAMMA RADIATION

Here we show again the table of relative blast protection given in Chapter 2. A measure of the protection afforded against initial nuclear radiation (INR) has been added in parentheses.

The measure is given in terms of an "INR protection factor (IPF)," which is the ratio of the dose in the open to the dose in the location described, at the same distance from a nuclear detonation. A high protection factor means good radiation protection.

The lower number shown relates to locations near entrances, windows, and other openings where protection is least; the higher number pertains to locations remote from such openings. Since blast protection is also least near such openings, avoiding these areas for the sheltering of people, as described in Chapter 2, will increase the protection against initial nuclear radiation.

It can be seen that aboveground parts of buildings offer little protection—about a factor of 5 at the most. Most survivors in the region above 12 psi will be in basements, subbasements, and underground areas. Here, the protection factor is at least 10 and can be as high as 10,000, except in residential basements where a factor of 10 is the most to be expected. Survivors in residential basements could thus receive as much as several hundred roentgens.

Except in these areas, initial nuclear radiation does not appear to be an important threat to life so long as the large nuclear weapons ascribed to the Soviet Union in Chapter 1 constitute the major threat. The emergency planner needs to know the facts about initial nuclear radiation largely because smaller nuclear weapons may become important in the foreseeable future.

PANEL 9

TYPICAL INR PROTECTION FACTOR RANGES RELATIVE TO BLAST PROTECTION

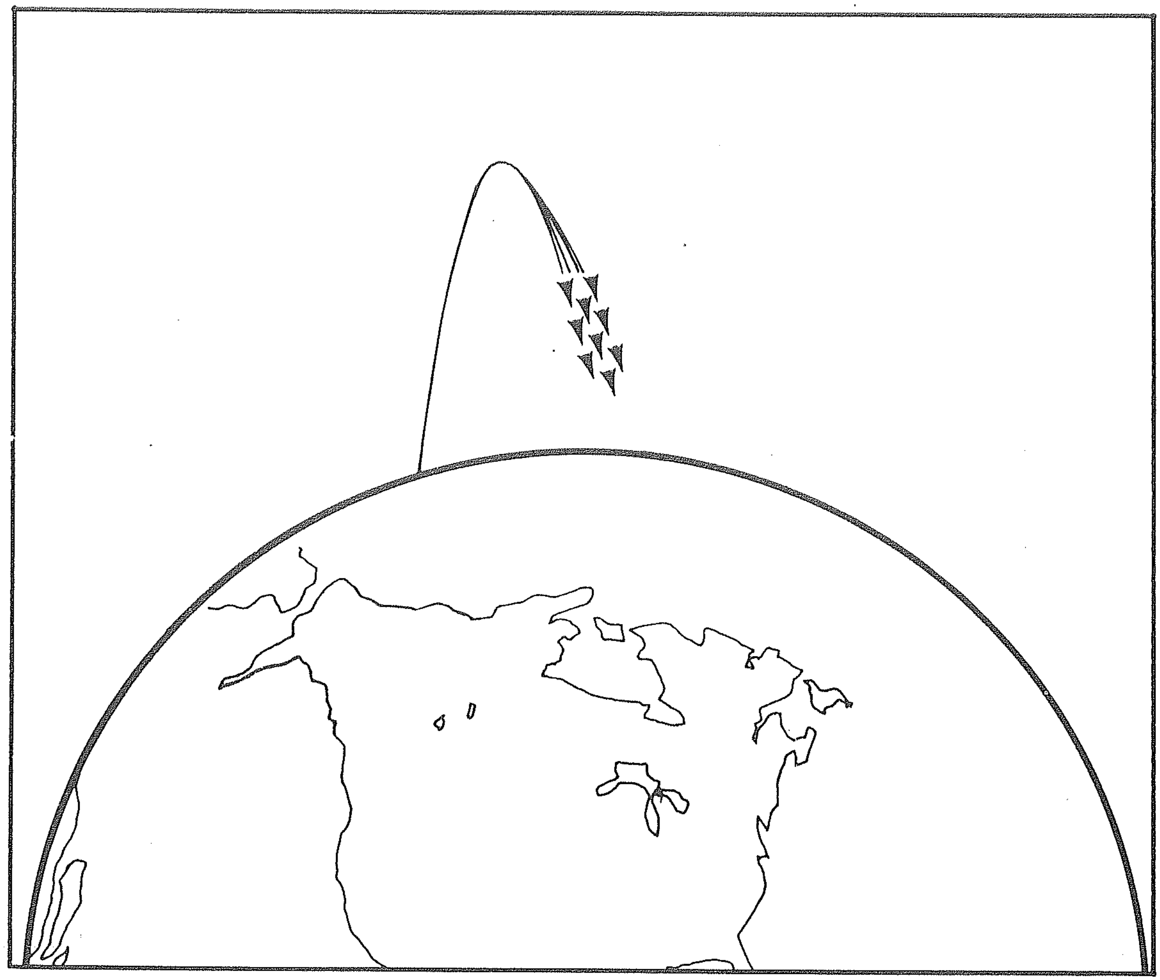
Blast Preference	Description
A	Subway stations, tunnels, mines, and caves with large volume relative to entrances. (10 - 10,000)
B	Basements (10 - 100) and sub-basements (100 - 1000) of massive (monumental)masonry buildings.
C	Basements (10 - 100) and sub-basements (100 - 1000) of steel and reinforced-concrete framed buildings having flat slab or slab and beam ground floor construction.
D	First three floors of buildings with "strong" walls. (2 - 5)
E	Basements of wood-frame (4 - 8) and brick veneer residences. (5 - 10)
F	Fourth and higher floors of buildings with "strong" walls. (1 - 5)
G	Basements of steel and reinforced-concrete framed buildings with flat plate ground floor. (10 - 100)
H	First three floors of buildings with weak walls, brick buildings and residences. (2 - 5)
I	Fourth and higher floors of buildings with weak walls. (1 - 5)

THE POSSIBLE USE OF "SMALL" WEAPONS

In Chapter 1 we alerted the emergency planner to the fact that there has been and likely will continue to be a trend toward larger numbers of smaller-yield nuclear weapons fitted on missiles as multiple warheads. We noted that many U.S. missile systems have already been modified in this fashion and that the Soviets may be beginning to do so.

Some of the motivation to use multiple warheads has stemmed from a perceived need to complicate the task of developing ballistic missile defense systems, commonly called ABM systems, by providing many separate incoming warheads. But this objective is not the whole motivation Although the total megatonnage that can be delivered in the form of multiple warheads is substantially less than that delivered as single weapons, the sum of the separate direct effects areas are very much the same. The blast effects would be somewhat lessened; the thermal effects would be somewhat increased. As we shall see, the relative effects of initial nuclear radiation are greatly increased, so that survival in ordinary structures may be limited by the lack of initial radiation protection. Since many smaller detonations may cover a sprawling metropolitan area more efficiently or permit more effective attack against separated industrial facilities, airports, and other key targets, the trend toward warheads in the kiloton-yield range may continue despite agreements to limit the deployment of missile defense systems.

Small-yield nuclear weapons in the range of tens to hundreds of kilotons also may differ from large megaton-range weapons in the nuclear processes employed in creating an explosive release of energy. About half the energy in large-yield weapons comes from fission of heavy elements like uranium. The remainder comes from fusion of light elements, such as hydrogen. Small-yield weapons may use only the fission process, as was the case at Hiroshima and Nagasaki. In describing large-yield weapons, we have assumed 50 percent fission yield. In describing small weapons, we will assume 100 percent fission yield.



PANEL 10

INITIAL NUCLEAR RADIATION FROM "SMALL" WEAPONS

When the explosive power of a nuclear weapon is changed, the extent of blast overpressure varies as the cube root of the change in explosive power. Thus, the extent for a 5-KT detonation is 1/10 that of a 5-MT detonation (one that has 1,000 times more explosive power) and the extent for a 40-KT detonation is 1/5 that of a 5-MT burst. The extent of initial nuclear radiation is reduced somewhat but not nearly as much as are the blast overpressures. Consequently, the INR exposure becomes increasingly large at a given overpressure as the weapon yield is reduced, as shown here.

At these short ranges (5-psi overpressure occurs at a mile or two from ground zero), neutrons are an important constituent of initial nuclear radiation in addition to gamma radiation. Whereas gamma radiation is electromagnetic radiation, neutrons are extremely tiny particles of matter ejected from the nuclei of atoms involved in the nuclear detonation. Neutrons have about the same effectiveness in causing biological damage as gamma rays. The use of Rem (Roentgen-equivalent-man) in the table merely signals that radiation other than gamma radiation is contributing to the exposure.

For 40-KT detonations, initial nuclear radiation is significant in the moderate damage region (2 to 5 psi). Further, our imaginary person in the open at 10 psi (about 7/10 mile from Ground Zero) is exposed to about 8000 Rem. The protection afforded by a residential basement (5 to 10 IPF) would be insufficient. Only the better parts of large building basements, sub-basements, and subways would permit survival.

At higher yields (over 100 KT), INR doses in the area of severe damage would not be as high but basement protection would be essential and survival possibilities are clearly limited by the initial nuclear radiation exposure.

RELATIONSHIP OF BLAST AND INITIAL NUCLEAR RADIATION

(Near-Surface Bursts)

Blast Overpressure (psi)	Nuclear Radiation (Rem)		
	40 KT	100 KT	1 MT
1	1	Neg.	Neg.
2	5	Neg.	Neg.
5	560	170	Neg.
12	10,000	5,500	280
20	34,000	23,000	3,600

PANEL 11

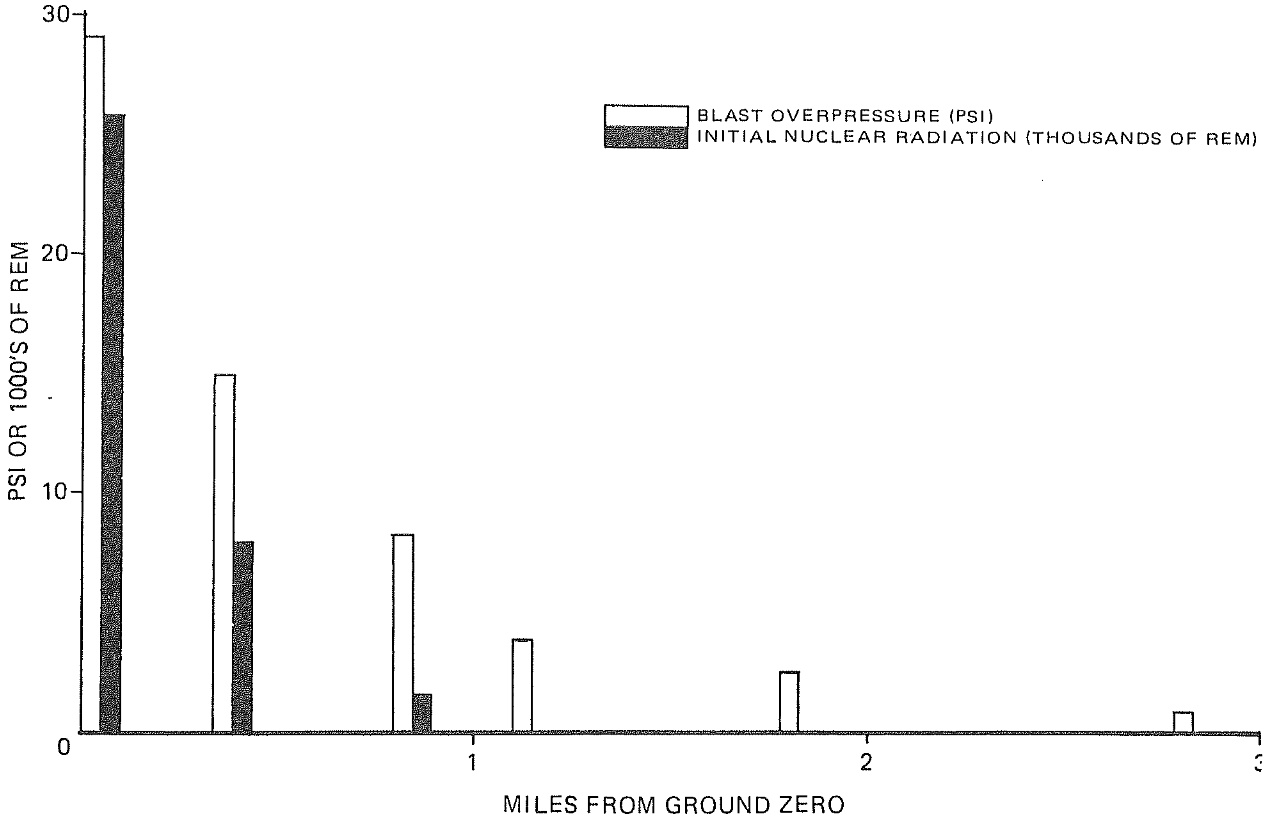
WHAT HAPPENED AT HIROSHIMA

At Hiroshima, casualties were the result of a combination of the three major "direct" effects (blast, thermal radiation, and initial nuclear radiation) but blast and thermal radiation seemed to be the dominant causes. The weapon was relatively small (about 12 KT) and exploded very high (about 1900 feet) relative to its size. It was a clear morning with a large number of people in the streets at the time. The maximum blast overpressure was about 30 psi on the ground directly under the bomb and the initial nuclear radiation dose there was about 26,000 Rem. However, the initial nuclear radiation exposure reduces rapidly with increased distance from the weapon. Both the overpressures and INR doses for several distances at Hiroshima are shown in this bar chart.

At 8-psi blast overpressure, where more than half the people in Japanese houses were killed, the initial nuclear radiation exposure was about ½ percent of its maximum or 155 Rem, too low to cause death. If the weapon had been detonated nearer the ground (within a few hundred feet), initial nuclear radiation would have been a more important cause of death than either blast or thermal radiation. For example, at 8 psi, the initial nuclear radiation exposure in the houses would have been 2800 Rem.

In discussing the threat of initial nuclear radiation, we have assumed that surface or near-surface detonations would occur. If this is not the case, this threat will be greatly diminished.

BLAST AND INR* AT HIROSHIMA



*From Auxier, J.A., et al., **Free-field Radiation-dose Distributions from the Hiroshima and Nagasaki Bombings**, Health Physics, Vol. 12, 1966.

PANEL 12

BLAST EFFECTS OF "SMALL" WEAPONS

Although the use of multiple warheads consisting of many small nuclear weapons by the Soviet Union is a possibility that may not materialize, the emergency planner should keep in mind the ways in which the other direct effects of small weapons differ from those in the megaton-yield ranges that have been emphasized so far. In addition to initial nuclear radiation, there will be changes in the blast and thermal effects. These changes will be most apparent in the 40 to 100 kiloton range.

Shown here is the general picture of the blast protection afforded by ordinary buildings. The median lethal overpressure values given in Chapter 2 for megaton-yield weapons is shown in parentheses. One can see that, in general, people survive at higher overpressures for low-yield explosions. At 40 KT, the blast wind persists for about one second. Debris is not blown about as violently as in megaton detonations. Since people are injured mainly by blast wind effects, casualties are significantly reduced at corresponding overpressures.

It should be kept in mind, of course, that a table such as this is approximate. The variations due to strong or weak walls and to the design of ground floors over basements would still influence the blast protection afforded by specific buildings. However, the hazard of being blown out of upper stories would be greatly reduced, as would the effects of air blast penetrating into basement rooms. Debris, of course, would tend to remain on site, with less interference with movement but more problems in search and rescue of trapped survivors.

And, because of the generally increased survivability at given overpressures, the potential threat from initial nuclear radiation would be increased.

BLAST PROTECTION IN CONVENTIONAL BUILDINGS

(From Low-Yield Weapons)

Location	Median Lethal Overpressures	
	Residences	NFSS Buildings
Aboveground	7 psi (5)	9 psi (7)
Belowground	12 psi (10)	14 psi (12)

PANEL 13

FIRE EFFECTS OF "SMALL" WEAPONS

The extent of thermal radiation from kiloton-yield weapons is less at corresponding blast overpressures than for megaton-yield weapons, as shown in the upper table. On the other hand, the thermal energy is delivered in a much shorter time period. Hence, the critical ignition energies are lower. The result is that the limit of significant ignitions remains about the same—approximately the range of 2 psi blast overpressure.

Visibility conditions affect low-yield weapons less than large-yield weapons because of the short ranges involved. Air bursts of low-yield weapons extend the range of low overpressures more than the thermal effect. The experimental evidence on the extinguishment of ignitions by the blast wave applies to low-yield weapons as well as high-yield weapons.

PANEL 14

RELATIONSHIP OF BLAST AND HEAT
(Surface Burst on a Clear Day)

Blast Overpressure (psi)	Heat Radiation (cal/sq cm) 40 KT	100 KT	1 MT
1	4	4.5	6
2	10	13	21
5	35	46	100
12	105	137	350
20	175	270	560

IGNITION ENERGIES FOR KINDLING FUELS
(cal/sq cm)

	Weapon Yield 40 KT	100 KT	1 MT
GROUP I			
Crumpled newspaper, dark picture	5	6	7
Black lightweight cotton curtains	3	4	6
Dry rotted wood & dry leaves	4	5	6
GROUP II			
Beige lightweight cotton curtains	10	15	32
Kraft corrugated paper cartons	16	18	--
White typing paper	24	26	30
Heavy dark cotton drapes	12	13	22
GROUP III			
Upholstered Furniture	12	16	28
Beds	8	11	22

SUMMARY

We can summarize what the planner needs to know about initial nuclear radiation by pointing up the following facts:

(1) Given the large-yield weapons that the Soviets have at present, initial nuclear radiation is mainly of interest to the designers of blast-resistant structures and in the survey of best available shelter from direct weapons effects.

(2) If multiple-warhead weapons of low yield should be deployed by the Soviets, many areas that would offer good blast protection may not offer sufficient protection against initial nuclear radiation. In effect, there would be less "all-effects" protected space in existing buildings.

(3) As will be seen in the next Chapter, radiation doses from initial nuclear radiation and fallout are additive. Thus, less than lethal exposures to initial nuclear radiation can make subsequent exposure to fallout radiation a very serious matter under current fallout protection standards. This will be of significance for survivors inside the 12-psi region from the many 1-MT weapons that currently are part of the Soviet threat.

PANEL 15

INITIAL NUCLEAR RADIATION
IS IMPORTANT:

(1) CURRENTLY, MAINLY TO DESIGNERS OF BLAST-RESISTANT STRUCTURES AND IN ALL-EFFECTS SURVEYS.

(2) IF AND WHEN LOW-YIELD MULTIPLE WARHEADS BECOME A THREAT.

(3) BECAUSE ANY INITIAL RADIATION EXPOSURE WILL REDUCE THE ABILITY TO COPE WITH SUBSEQUENT FALLOUT RADIATION EXPOSURE.

SUGGESTED ADDITIONAL READING

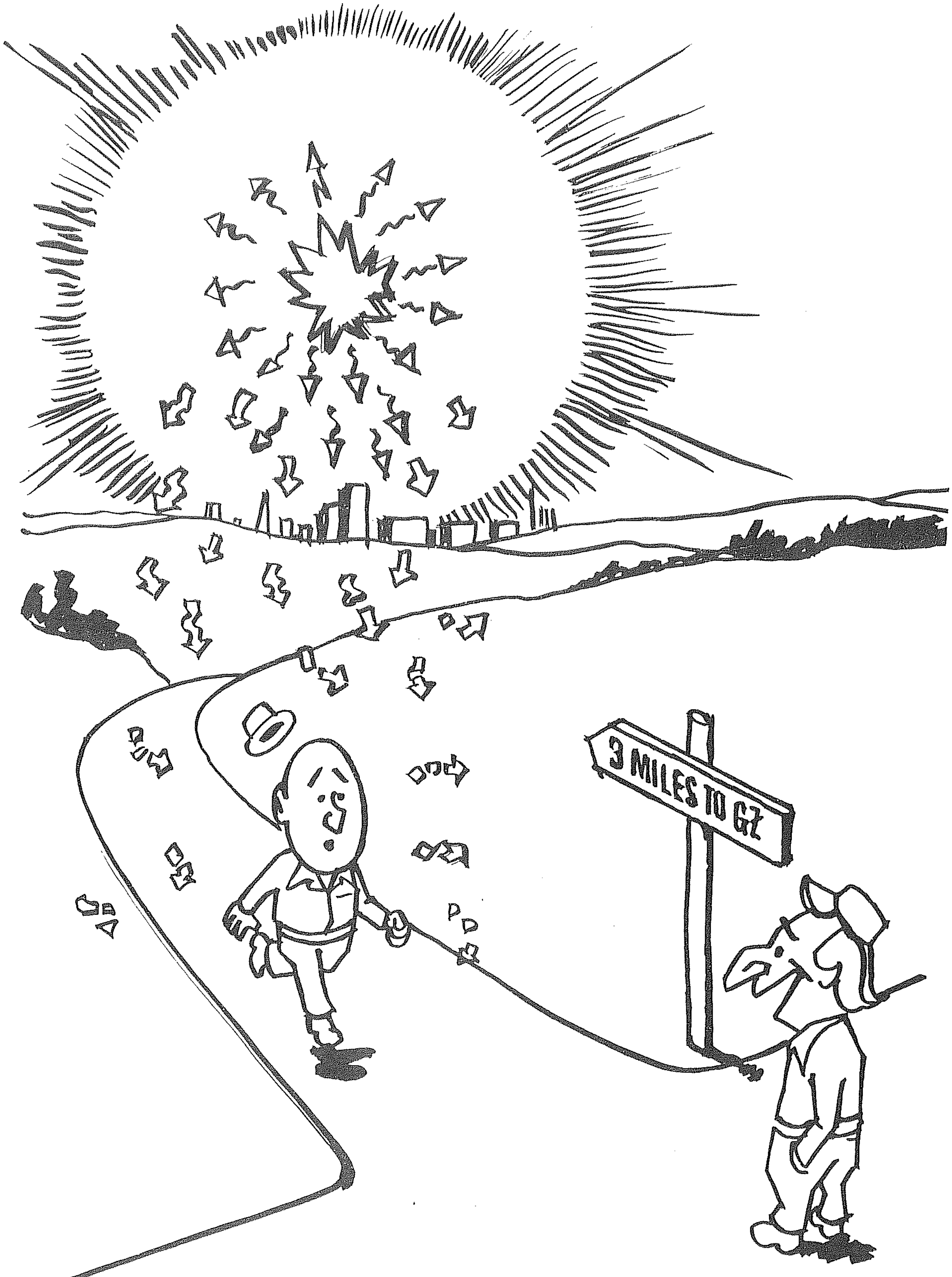
Effects of Nuclear Weapons, Revised Edition 1964, Glasstone, S., (editor), Chapters II VIII, and XII, Superintendent of Documents, GPO.

French, R.L., and Mooney, L.G., **Initial Radiation Exposure from Nuclear Weapons**, Radiation Research Associates, Inc., Report RRA-T7201, July 1972 (AD 745-906).

National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

Proceedings of the 1967 Symposium on Postattack Recovery from Nuclear War, National Academy of Sciences, April 1968 (AD 672-770).

Auxier, J.A., et al, **Free-field Radiation-dose Distributions from the Hiroshima and Nagasaki Bombings**, Health Physics Vol. 12, 1966.



PANEL 16

CPG 2-1A6
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 6

WHAT THE PLANNER NEEDS TO KNOW
ABOUT FALLOUT

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 6

This description of the fallout effects of surface-burst nuclear weapons is intended to provide the operational planner with the basic information needed to plan realistic actions to be taken in fallout areas. It presumes that the reader is familiar with the material in earlier chapters, especially the information on the biological effects of brief exposures to ionizing radiation contained in Chapter 5—"What the Planner Needs to Know about Initial Nuclear Radiation."

Information is presented in the form of "panels," each consisting of a page of text and an associated sketch, photograph, chart, or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 6 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with two introductory panels, followed by four panels on basic aspects of radioactivity in fallout. Five panels summarize the basis for predicting the fallout event from surface-burst nuclear weapons. There follow six panels on what would be observed in the fallout area by eye and with radiation detection instruments. Four panels discuss fallout radiation shielding and two the changes to be expected from winds and various weapon sizes. Contact and internal hazards of fallout radiation and its effects on animals and plants are covered in five panels. The special problems of urgent emergency operations in damaged areas where fallout also is deposited occupy the next five panels. Finally, four panels address the most common questions raised about fallout. A list of suggested additional reading is included for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 6

WHAT THE PLANNER NEEDS TO KNOW ABOUT FALLOUT

RADIOACTIVITY IN FALLOUT

Nuclear radiation is the major attack effect that is unique to nuclear weapons. The other effects differ from conventional weapons only in degree. Some aspects of the effects of ionizing radiation were considered in Chapter 5. In a real sense, however, it is fallout from nuclear weapons that poses special problems that make civil defense today quite a different thing from civil defense of World War II.

About half the energy produced in the detonation of megaton-yield nuclear weapons results from nuclear fission, a process in which radioactive substances are produced. When detonations occur on or near the earth's surface, these radioactive substances or "fission products" are incorporated into the materials scoured from the crater. Much of this material is carried high into the atmosphere by the rising fireball. The subsequent fall of particles of earth, concrete, and the like has been called "fallout."

In Chapter 1, it was noted that the fallout from a single 5-MT surface burst could produce hazardous radiation exposures several hundred miles downwind of the detonation point. This threat was demonstrated rather dramatically in 1954 when fallout from a test explosion more than a hundred miles away caused injuries among the crew of a Japanese fishing boat and among natives on Rongelap Atoll. The quotation shown here indicates the effect that this incident had on civil defense planning in the mid-1950s.

At first, very little was known about the potential hazards from fallout. Research since that time has reduced the uncertainties involved. But many of the older ideas and assumptions still persist as misconceptions. In this chapter, these misconceptions are dealt with. An attempt is made to present a rather complex subject in simple terms. Even when all useful simplifications are made, the information needed for emergency planning is complex, especially since few are expert in nuclear physics and radiobiology.

The first part of this chapter emphasizes the fallout problems in areas distant from nuclear detonations. Then, the effects of fallout will be described in the area of blast and fire discussed in earlier chapters.

PANEL 1

"The advent of the thermonuclear weapon, with its terrifically augmented power of destruction and dangerous fallout, capable of reaching hundreds of miles from a target area, brought virtually the entire country into the civil defense picture and called for wholesale revision of Federal, State and local civil defense planning. The year 1955 was mainly given to this task."

<u>1955 FCDA Annual Report</u>

TWO KINDS OF NUCLEAR RADIATIONS

At the time of a nuclear detonation, over 200 different radioactive substances are formed by fission. Additional ones are created by neutron irradiation of weapon parts, soil, and other close-by materials. These "fission products" and "induced activities" are potentially harmful because they emit two kinds of nuclear radiation—beta particles and gamma rays. Some emit only one type, but most emit both.

The nature of gamma rays was introduced in Chapter 5. Gamma radiation is electromagnetic radiation like light, radio waves, and X-rays. As such, it travels with the speed of light and spends its energy through interactions with the atoms that make up the atmosphere, materials, structures, or human bodies. Gamma radiation has an effective range in air of many hundreds of feet. It takes a considerable thickness of a heavy material, such as concrete or even lead, to stop this radiation.

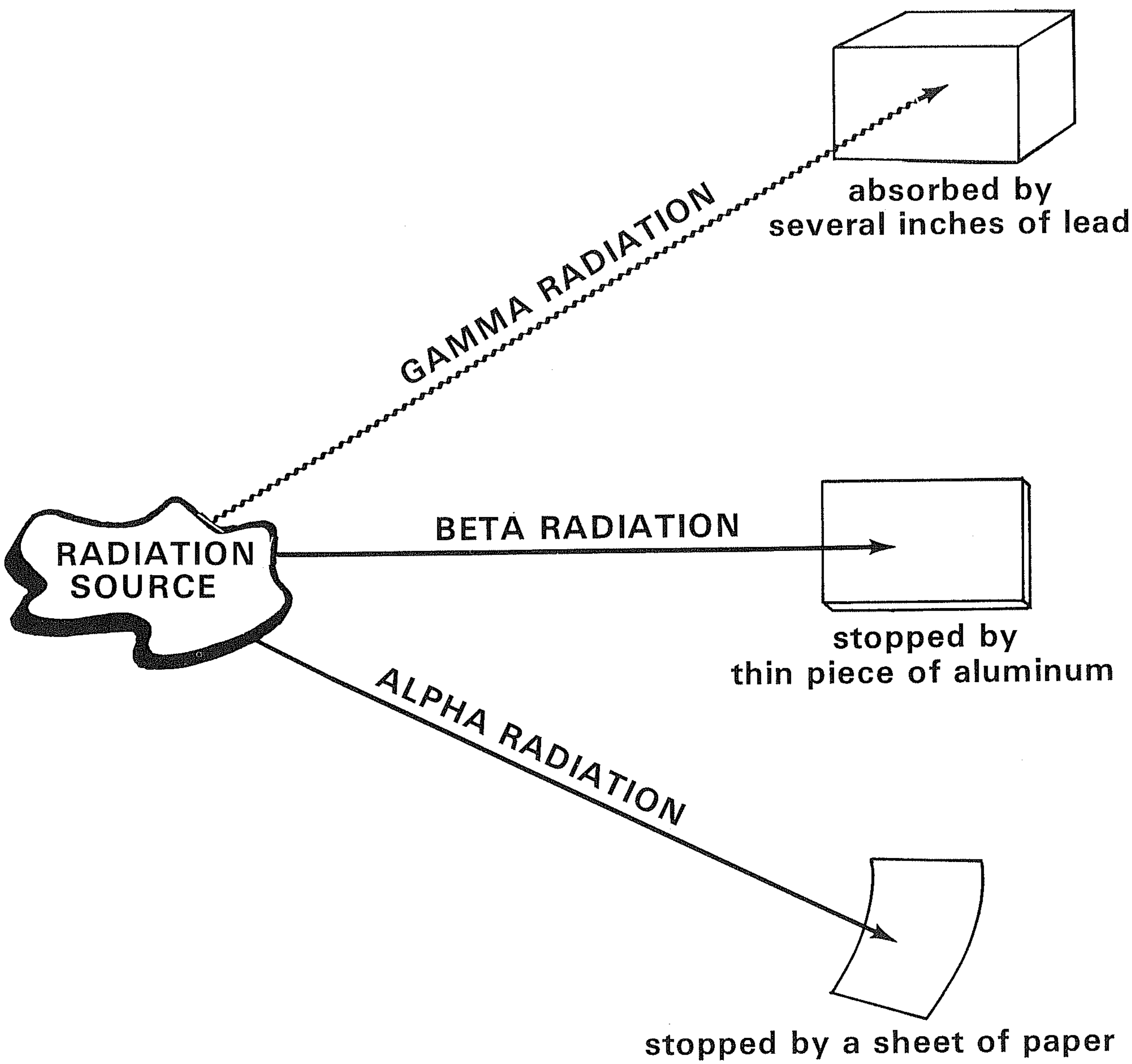
Beta particles are electrons ejected by radioactive substances. Although traveling initially at nearly the speed of light, beta radiation is much less penetrating than gamma radiation. The beta particle's energy is expended in air in a few millionths of a second within a distance of about 10 feet from its source. A thin piece of aluminum or heavy clothing stops beta radiation.

It is perhaps unfortunate that nuclear physicists have called beta radiation "particles" to distinguish it from electromagnetic radiation. This has given rise to the misconception that "beta particles" are granules of sensible size and permanence that could be "swallowed" or "brushed off." These radiations cannot be detected by the human senses and should not be confused with the fallout "particles" containing the radioactive material that emits them.

There is a third type of nuclear radiation shown on this chart—alpha radiation. Alpha particles are emitted by the leftover fissionable material—uranium or plutonium—not used up in the fission process. The amount of leftover fissionable material is inconsequential and the alpha hazard will not be discussed further. Only in the immediate neighborhood of an unexploded nuclear weapon would this type of radiation be of significance. Civil defense planning may be undertaken as if it did not exist.

PANEL 2

NUCLEAR RADIATION



RADIOACTIVE DECAY

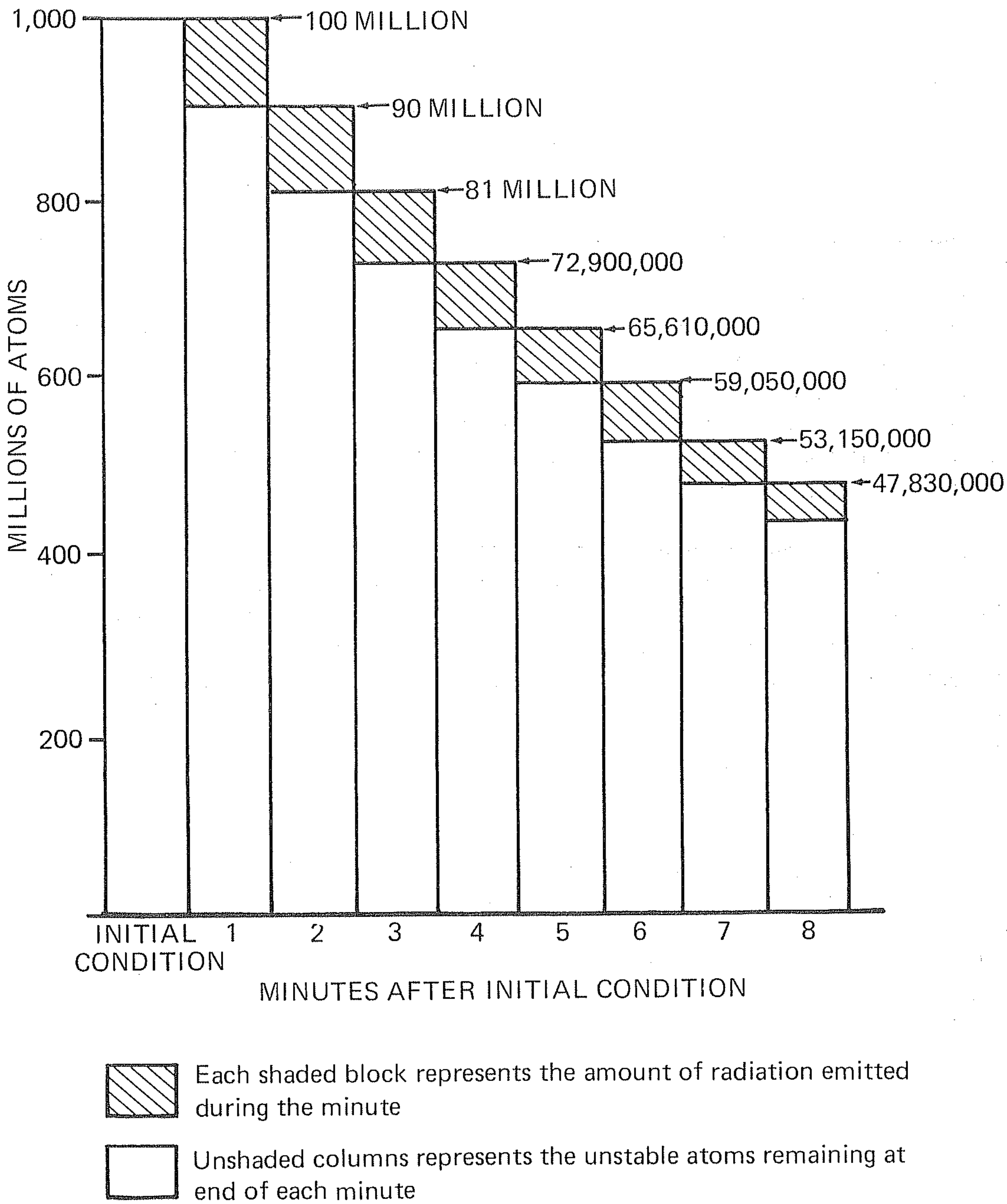
Atoms of the natural element, uranium, and an artificial element, plutonium, when struck by a neutron "projectile," will split in two, releasing energy. Each of the two pieces or "fission fragments" is like the nucleus of an atom of some element of medium weight—except for a surplus of neutrons. Because of this condition, such atoms are unstable and sooner or later they adjust by emitting beta particles and gamma rays. After this adjustment, they have become atoms of still another element. It is this process of adjustment that is called "radioactivity" and the unstable atoms are called "radioactive."

Radioactive atoms have an interesting and important characteristic. The process of adjustment does not occur at a set time or in a set pattern. Rather, some atoms of a particular kind adjust quickly; others of the same kind take a long time. At any point in time, every atom of the group has the same chance of adjusting in the next instant, and this chance does not change as time goes on.

Think of a speck of an imaginary radioactive element consisting of a billion unstable atoms. In any given minute, every atom of this imaginary element has, let us say, a 10 percent chance of adjusting by giving off one beta particle and one gamma ray. Then, during the first minute, 100 million atoms would adjust (10 percent), giving off 100 million beta particles and 100 million gamma rays. There would be only 900 million unstable atoms left. In the second minute, 10 percent of these would adjust, emitting 90 million beta particles and an equal number of gamma rays. In the third minute, 10 percent of the remaining 810 million would adjust and so on. As time passed, there would be fewer and fewer unstable atoms remaining and the number of beta particles or gamma rays emitted each minute would get smaller and smaller. This continuous decrease in the radiation emitted is called radioactive decay.

During the first 7 (more accurately 6.93) minutes, half the atoms of our imaginary element would have adjusted to become atoms of a stable element. The radiation being emitted per minute by the remaining half would be only half as much as in the beginning. In another 7 minutes, only one-quarter would be left and so on. We would say that this imaginary radioactive element has a "half-life" of 7 minutes.

HYPOTHETICAL RADIOACTIVE MATERIAL HAVING 10 PERCENT DECAY PER MINUTE



PANEL 3

DECAY OF THE FISSION-PRODUCT MIXTURE

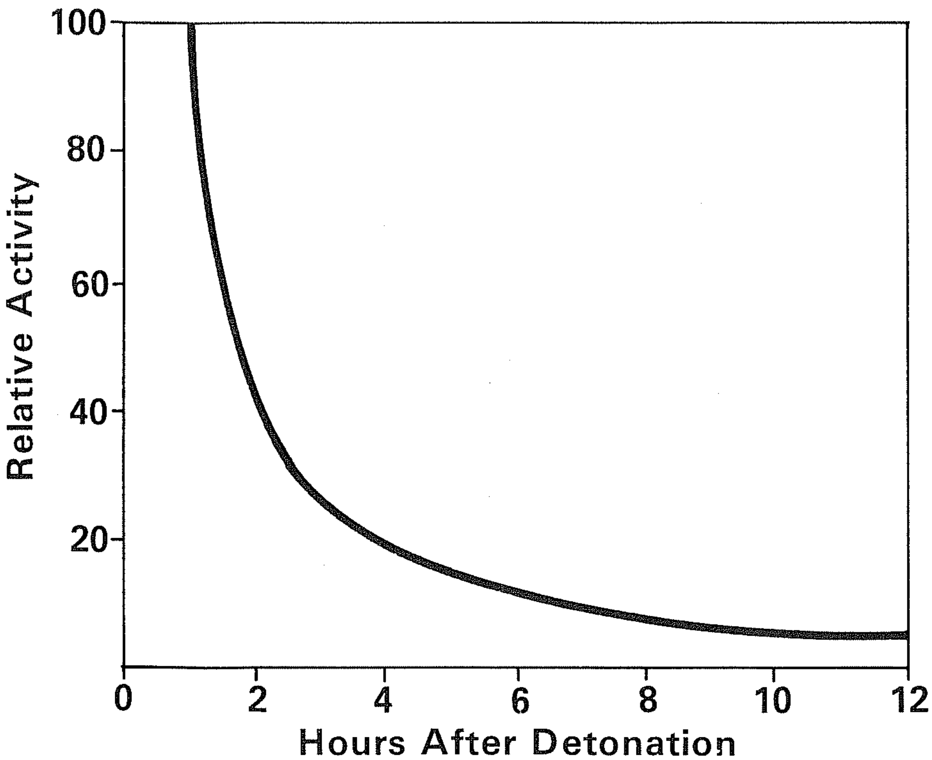
Each of the 200 or so radioactive materials created as the result of nuclear fission has its own characteristic half-life that defines its rate of decay. One substance of special concern that will be discussed later, radioactive iodine, has a half-life of about 8 days. Another that has received much publicity, strontium, has a half-life of about 28 years.

Naturally, at very early times after fission, those radioactive elements with very short half-lives contribute most of the radiation, and the decay of the fission-product mixture is very rapid. As these elements are depleted through the adjustment process, the longer-lived elements become more and more dominant. The overall decay of the mixture becomes slower and slower as time passes. A very rough rule-of-thumb for emergency planners is that the half-life of the fission-product mixture is about equal to the time of measurement. In other words, if a fallout radiation measurement is made at, say, four hours after detonation, the radiation intensity would be reduced by one-half about four hours later. Actually, fallout radiation decay is somewhat faster than this rule-of-thumb would suggest.

A more accurate estimator of radioactive decay of mixed fission products is the "7-10 Rule." This rule says that the radiation intensity is reduced ten-fold for each seven-fold passage of time after detonation. For example, if a fallout radiation measurement is made at four hours after detonation, the intensity would be one-tenth as much at 28 hours after detonation. It would be one-hundredth of the original reading at 7 times 28 hours or a bit over 8 days after detonation. The 7-10 Rule gives reasonably good estimates up to about six months after attack. Subsequently, the dose rate decreases at a much more rapid rate than is predicted by this rule.

As we have seen in Chapter 5, the fission-product radiation is a component of initial nuclear radiation (INR) during the first minute after fission. At one hour after fission, the radioactivity of the fission-product mixture is about 125 times less than it was at one minute. The illustration shows the rate of decay from one hour to 12 hours, using an arbitrary level of 100 at one hour. Note that the level is down to 10 at about 7 hours as the 7-10 rule would predict.

RATE OF DECAY OF FISSION PRODUCTS AFTER A NUCLEAR DETONATION



PANEL 4

WHAT FALLOUT IS

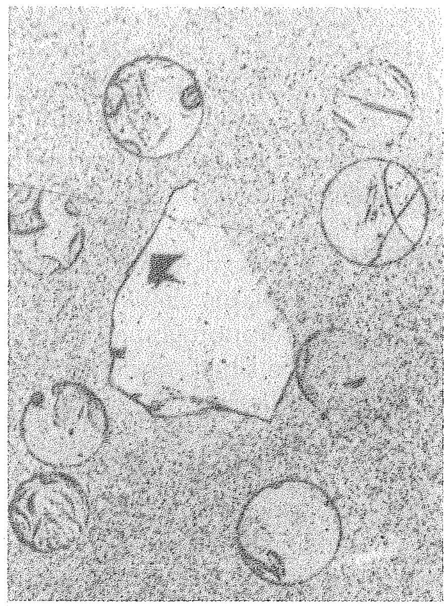
Each megaton of fission yield produces about 100 pounds of fission products. Thus, a 5-MT surface burst of 50 percent fission-50 percent fusion would produce about 250 pounds of fission products. At one minute after fission, each ounce of these products is emitting gamma rays comparable to those from 15,000 tons of radium.

In addition, an explosion of any kind, occurring near the surface of the earth, causes material to be thrown up or drawn into the "chimney" of hot rising gases. A 5-MT surface burst carries aloft about 2 million tons of soil and other surface materials in the stem and mushroom cloud of the detonation. Thus, the material that ultimately returns to earth as "fallout" is almost entirely soil. The radioactive residues incorporated in this soil are actually "trace elements" in a concentration of less than one-tenth part per million.

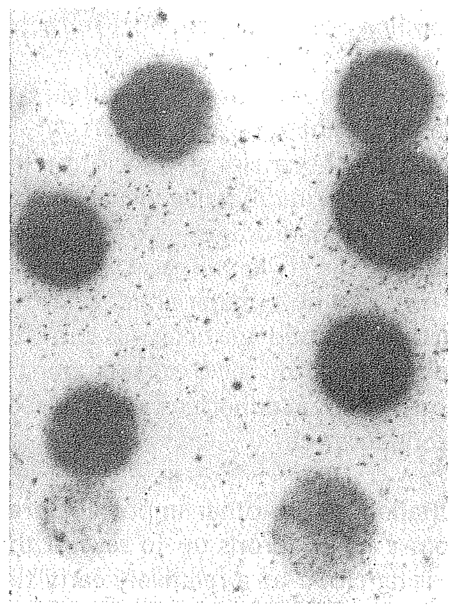
Soil drawn into the very hot fireball is vaporized. As the rising fireball cools, material entering later is only melted, and as the fireball cools further and forms the mushroom cloud, some material reaching the cloud level is virtually unchanged. As the fireball cools below the boiling point of the vaporized soil material, it begins to condense into liquid droplets, which eventually solidify into glass-like particles.

These particles are tiny. The size of fallout particles is generally measured in microns, which is a length equal to one millionth of a meter. To put these sizes in perspective, consider that 1000 microns—a millimeter—is about the thickness of a thin dime. A human hair 100 microns thick can be seen with the naked eye but a spherical particle of the same size is difficult to see without a microscope. Tobacco smoke consists of many very fine particles less than a micron in diameter. Fallout particles deposited in fallout areas defined by a dose rate exceeding 0.5 Roentgens per hour generally range from about 50 microns to several millimeters in size.

The left-hand photograph shows a microscope picture of some fallout particles from a small-yield surface burst at the Nevada Test Site in 1951. The right-hand picture is a "radiograph" of the same particles showing the effect of radioactivity on a photographic film. The radioactive particles are a transparent green-yellow glass with the radioactivity distributed more or less uniformly throughout their volumes. Note that the large irregular particle in the left-hand picture, which does not show up in the right-hand picture, does not seem to contain radioactivity.



PHOTOMICROGRAPH OF
THIN–SECTIONED PARTICLES
(greatly magnified)



RADIOGRAPH OF THE
SAME PARTICLES

From Miller, C.F., **Fallout and Radiological Countermeasures, Vol. I**, Stanford Research Institute, Project No. IMU-4021, January 1963. (AD 410-522)

PANEL 5

WHY ALL FALLOUT IS NOT ALIKE

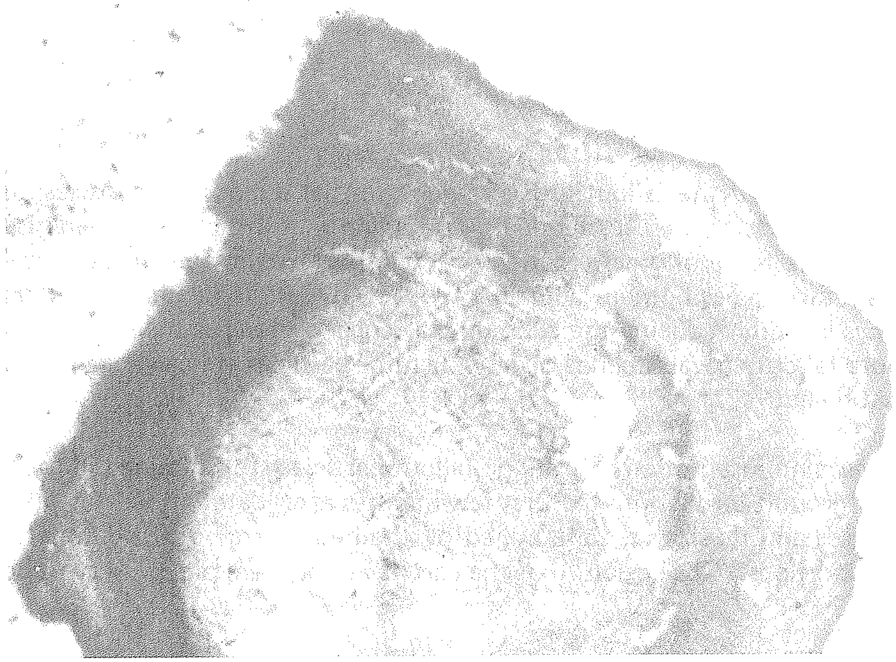
Let us pursue the matter of how fallout is formed a bit further. The formation of fallout is complicated because each of the many elements involved possesses characteristic properties that determine the temperatures at which it changes from a gas to a liquid and from a liquid to a solid. Those with low boiling points are termed, "volatile," whereas those with very high boiling points are termed, "refractory."

In general, entrapment of the radioactive materials, which are present in minute quantities compared to the soil, will occur only after condensation has occurred. Thus, as the fireball cools, the first major step in formation of fallout occurs when the vaporized soil condenses. Then those radioactive elements that have already condensed are readily incorporated into the liquid droplets, as we saw in the previous photograph. The more volatile elements are at this stage still gaseous and not available. Some elements do not interact significantly until the bulk material has solidified. Hence, these volatile elements tend to lodge on the surface of solid particles, as shown in this microscope photograph of a particle of fallout from a megaton-yield surface burst at Eniwetok. The small, black spheres (which are radioactive) shown adhering to the surface of a much larger coral sand grain were formed by vapor condensation.

Simultaneously, another important process is taking place. The particles formed range in size from a few microns up to several thousand microns. The larger particles fall away from the rising cloud at a relatively early time under the influence of gravity and the turbulent motion of the fireball. As a consequence, they are found to be deficient in the more volatile elements and their decay products, such as strontium, while the smaller particles that continue to rise with the nuclear cloud are enriched with the volatile species. Technically, this is known as "fractionation."

In simple terms, it means that all fallout is not alike. The heavier particles that fall to the ground in a matter of hours contain most of the radioactivity produced by the explosion, but they are deficient in the more volatile radioactive elements and, furthermore, most of the radioactive atoms are locked within the glassy particles. The smaller particles, on the other hand, which are enriched in the volatile species, fall to earth very slowly over a period of weeks, months, and even years.

The change in the fission-product mixture with particle size (and, hence, distance from the detonation) is not so great as to invalidate the radiation decay rates we have already discussed but is of great importance to the questions of whether contaminated water can be drunk or whether food can be grown in fallout areas. Many myths have been born from observations made on "worldwide" fallout or at great distances from test explosions, without recognition that "all fallout is not alike."



PHOTOMICROGRAPH OF SECTION OF PART OF A CORAL SAND GRAIN SHOWING ADHERING SMALL SPHERES
(Greatly magnified)

From Miller, C.F., **Fallout and Radiological Countermeasures, Vol. I**, Stanford Research Institute, Project No. IMU-4021, January 1963. (AD 410 522)

PANEL 6

THE MUSHROOM CLOUD

A simple description of the fallout process might be that a cloud of particles, such as just described, is formed as the result of the explosion and that this cloud is then dispersed by the wind and by the force of gravity acting on these particles to return them to earth. Until the particles return to earth, their radioactivity is too remote to be harmful. Moreover, radioactive decay is steadily reducing the subsequent danger so long as they are aloft. This time interval before fallout arrival depends on how high the particles are carried and how fast they fall from that height.

A natural beginning assumption is that the fallout particles are contained in the visible cloud formed over ground zero within the first few minutes after detonation. The height to which this cloud rises and its size are determined by the heat energy of the detonation and the atmospheric conditions. The structure of the earth's atmosphere plays a very important role in this regard.

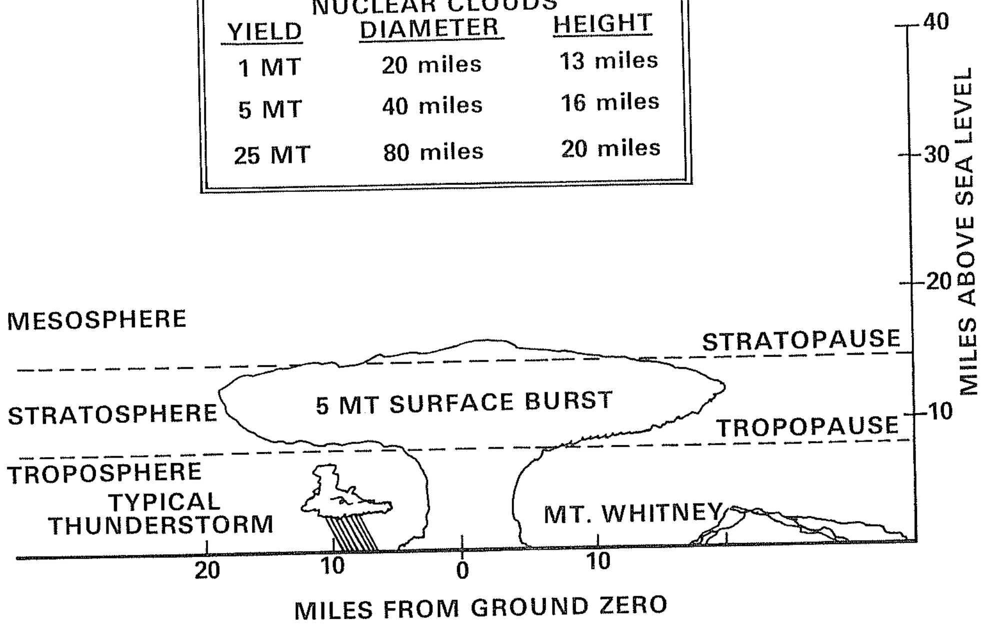
The lowest layer of the earth's atmosphere, known as the "troposphere," is a turbulent layer of winds, clouds, and storms. Over the United States, the troposphere extends up about 8 miles, somewhat higher in the summer than in the winter. A key feature of the troposphere is that the air gets colder with increasing altitude. Thus, the buoyancy of the rising cloud is maintained, even though it is losing its heat energy as it rises. The top of the troposphere, called the "tropopause," is marked by an air temperature minimum, above which temperatures increase in the stratosphere and mesosphere up to an altitude of 30 miles. As the rising cloud penetrates the stratosphere, it rapidly loses buoyancy and spreads laterally to a more-or-less stable size within 5 to 10 minutes after detonation.

Early attempts to explain the subsequent fallout on the ground by assuming that the radioactive particles fell from the visible cloud proved that the fallout near and around the detonation must have come from the region of the stem below the visible cloud. So both the mushroom cap and its stem had to be taken into account. This illustration shows the average dimensions of the visible clouds from explosions in the megaton yield range. The diameter of the mushroom stem is about one-fifth that of the mushroom cloud.

THE VISIBLE CLOUD

NUCLEAR CLOUDS

YIELD	DIAMETER	HEIGHT
1 MT	20 miles	13 miles
5 MT	40 miles	16 miles
25 MT	80 miles	20 miles



FALLOUT PREDICTION MODELS

Measurement of the fallout resulting from nuclear detonations has been done for a relatively few surface detonations during weapon tests in Nevada and in the Pacific. All of the megaton-yield tests were done at Eniwetok and Bikini Atolls where most of the fallout area was open ocean. Fallout researchers have tried to fit various models to these limited data in order to predict what the fallout situation would be for other weapon yields, burst conditions, and wind conditions. One of the key problems has been to assess the size and location of the radioactive cloud from which the fallout particles originate in their fall to earth.

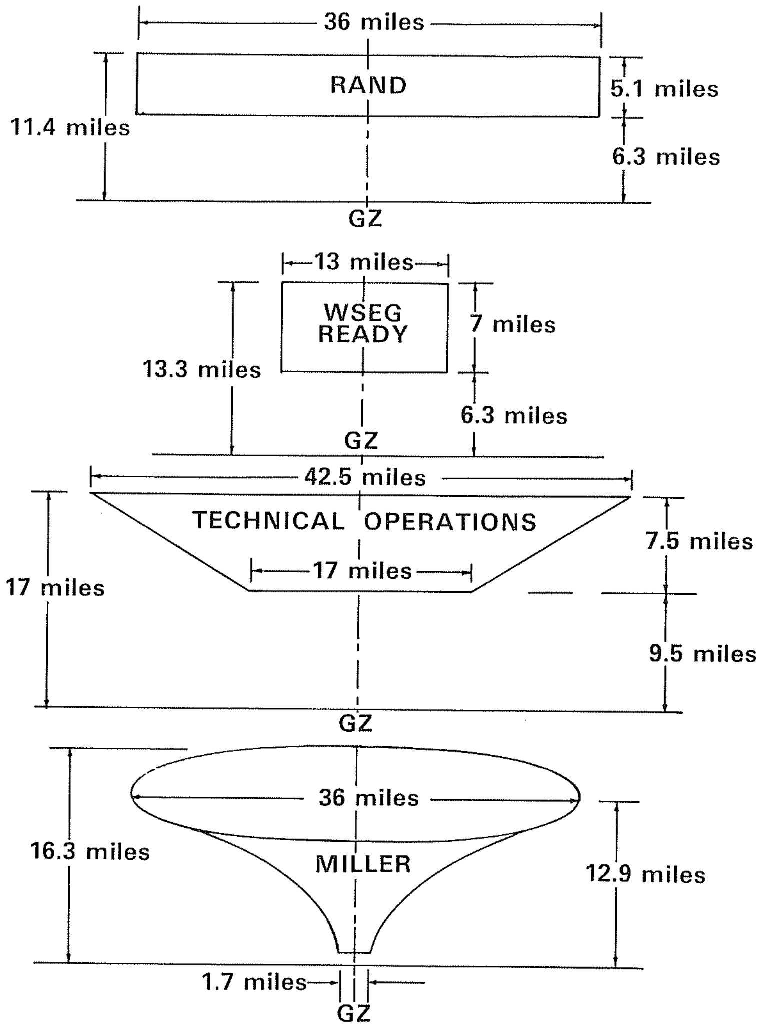
Shown here are the fallout clouds assumed in several of the fallout prediction models that have been developed. It can be seen that they vary considerably. The RAND model was developed in the early 1960s and is still in use at the Rand Corporation. The fallout cloud is seen as a disk having a diameter of 36 miles and a thickness of about 5 miles for a 5-MT detonation, somewhat smaller than the visible cloud dimensions shown in the previous panel. There is no stem in this model. Rather, the whole disk is placed lower in the atmosphere than the visible cloud, with the top at 11.4 miles rather than 16 miles.

The second model shown was developed for the Weapon System Evaluation Group (WSEG) and also forms the basis for the READY I fallout model used by the Office of Emergency Preparedness. It also is a cloud disk without a stem. It has a much smaller diameter, 13 miles, than the RAND model but the disk is thicker. In both models, the bottom of the disk is a little over 6 miles above the ground.

A model developed at Technical Operations, Incorporated, is in the shape of an inverted truncated cone. The height of this cone above the earth corresponds approximately to that of the visible cloud. The final model, the Miller model, was developed for DCPA. The cloud portion is in the shape of an oblate spheroid with dimensions approximating those of the visible cloud. Additionally, there is a horn-shaped "stem," which actually represents the volume swept out by the expanding fireball and cloud as it rises into the stratosphere.

The fallout information in this chapter is based on the Miller model, which is able to match more characteristics of fallout than the other models. It has been used to generate the fallout information used in CDEX-67 and other civil defense exercises.

SEVERAL FALLOUT CLOUD MODELS FOR A 5-MT SURFACE BURST



PANEL 8

AN EXAMPLE FALLOUT SITUATION

The Miller fallout model is also called the OCD (DCPA) fallout model because its formulation was first published as an internal OCD research report in June 1962 by Dr. Carl Miller, who was head of the OCD Postattack Research Division at that time. The model grew out of analysis of a great deal of data on the amounts, particle sizes, and chemical and radiological characteristics of fallout collected at nuclear weapons tests.

This illustration shows the cloud part of the model for a 5-MT surface detonation. The radiological cloud is about 5 times wider than it is thick. The center of the cloud is nearly 13 miles above the ground, with the bottom 9.5 miles high and the top over 16 miles high. Fallout particles and radioactivity are assumed to be mixed uniformly throughout the cloud volume and the fallout particles are assumed to begin to fall at detonation time. This is a simplified version of a much more complicated actual situation, but it fits the experimental results quite well.

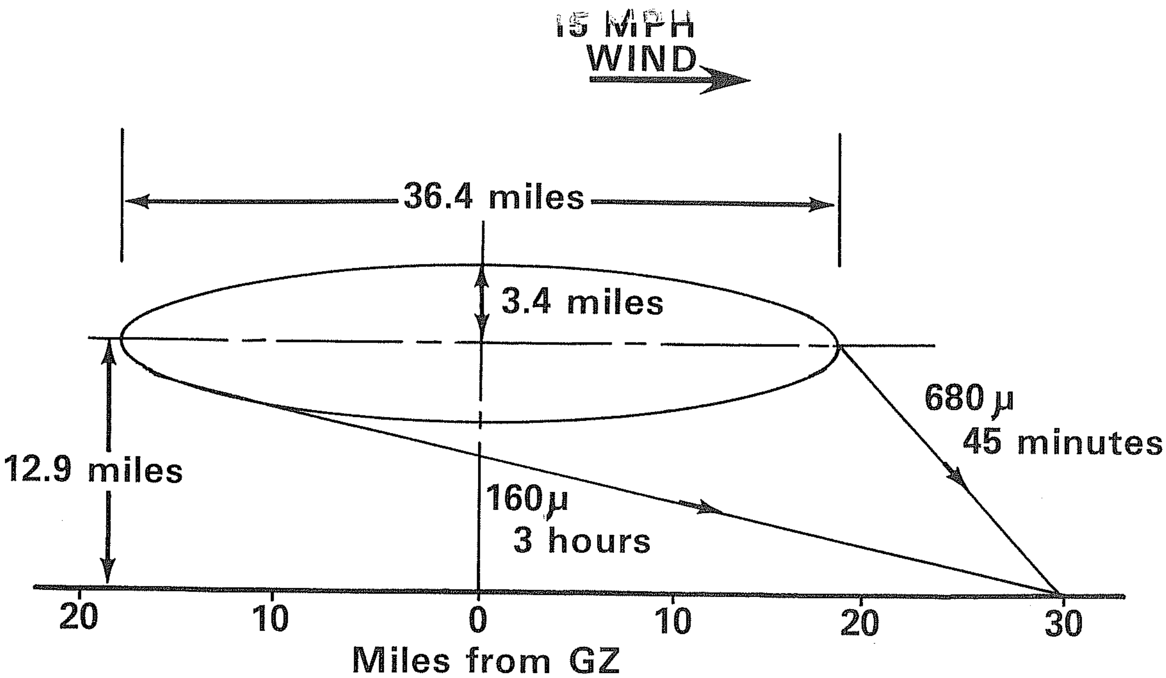
Consider a point on the ground 30 miles directly downwind from the detonation, assuming that a 15 mile per hour wind is blowing in the same direction at all altitudes. The model predicts that the first fallout particle to arrive will be the largest particle deposited at this location, 680 microns. It will have come from the high forward edge of the cloud, about 13.4 miles up, and will arrive about 45 minutes after the detonation, as shown in the illustration. Larger particles will have fallen more rapidly and so will have been deposited closer in. Particles of the same size elsewhere in the cloud will have followed parallel paths to closer-in locations.

The last particle will arrive about 3 hours after detonation. It will be the smallest particle to arrive, 160 microns, and will have come from the low rear edge of the cloud, about 11 miles altitude, as shown. Smaller particles and particles the same size elsewhere in the cloud will be deposited further downwind. All particles deposited during the 2 hours and 15 minutes between fallout arrival and cessation will be between these two sizes, with the mid-range size about 420 microns, about half the thickness of a dime.

At 30 miles, there will be almost an ounce of fallout particles deposited on each square foot of horizontal surface. If a 40-pound bag of fertilizer intended to cover 5000 square feet was to be spread according to directions, the weight of fertilizer particles per square foot of lawn would be only about one-eighth of an ounce. Of course, fertilizer particles are rather large (about 1000 microns, perhaps) but the more numerous fallout particles would be as readily visible.

CLOUD FALLOUT

(5 MT Surface Detonation)



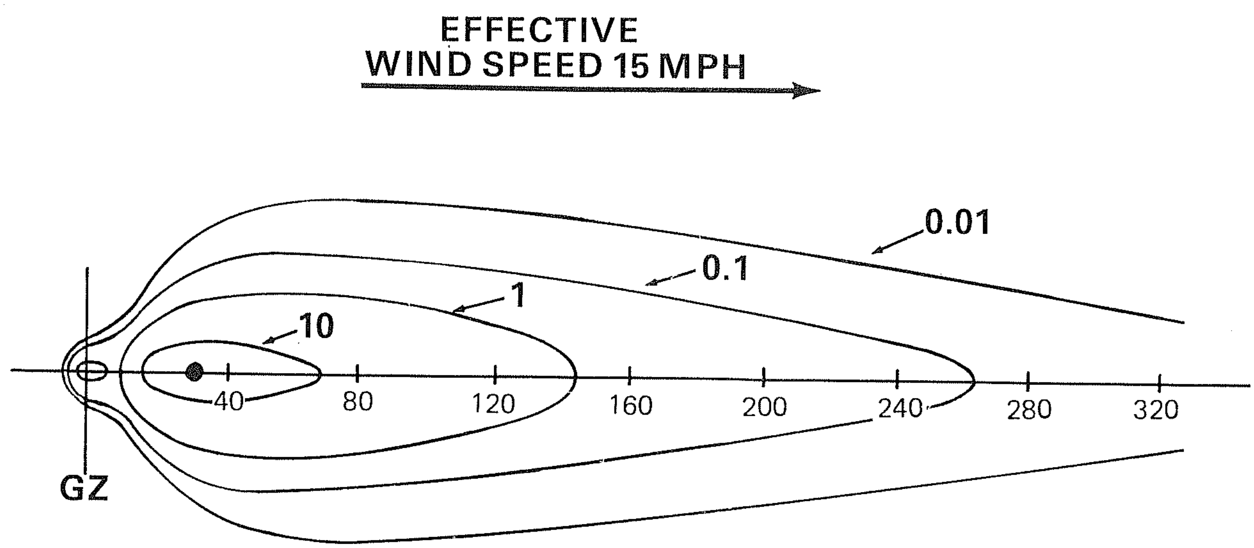
THE FALLOUT PATTERN

Fallout deposition from a 5-MT surface burst is shown here in the form of contours of equal weight of fallout. The unit of measurement is grams of fallout material per square foot of horizontal surface, which is the usual way fallout deposition is expressed. The effective wind speed is a uniform 15 miles per hour. The location 30 miles directly downwind, used in the previous example, is marked by a black dot. A set of contours of equal value, such as shown here, is commonly called a fallout "pattern."

The pattern of the weight of fallout deposited per unit area of ground will be new to most readers, even those who have had RADEF training, because most fallout patterns used in training and exercises show the intensity of the radiation that might be observed as the result of fallout deposition. We chose to show the contours of mass deposition first in order to emphasize that fallout consists mainly of silicacious particles of sensible size. It is these particles that fall through the air and are blown by the wind. They would have fallen and been blown downwind according to their physical nature whether or not they were radioactive. The amount of material deposited is quite substantial and is readily seen with the naked eye. Like desert sand, it can drift into gutters and sift into cracks under the action of wind and rain. It can be vacuumed, brushed off, flushed away, and filtered out just as any particles of the same size range.

The pattern can be thought of as an elongated "shadow" of the mushroom cloud and stem. The relatively small knob around ground zero represents the stem and the much larger "cigar" shapes represent the cloud. Note that the 1 and 10 grams per square foot contours are separate in the stem and cloud fallout regions. The stem fallout pattern is nearly the same width as the visible stem but the cloud fallout pattern is very much wider than the 35- to 40-mile cloud described in Panels 7 and 8. The reason is that atmospheric winds never blow uniformly even though the **effective** wind is in a single direction. Fallout particles follow a more circuitous route in falling to the ground and, hence, are spread more widely. The outermost contour shown here is about 100 miles across at its widest point.

MASS DEPOSITION PATTERN
(5 MT SURFACE BURST)



- Distances in miles
- Contours in grams per square foot

MAXIMUM DOSE RATES

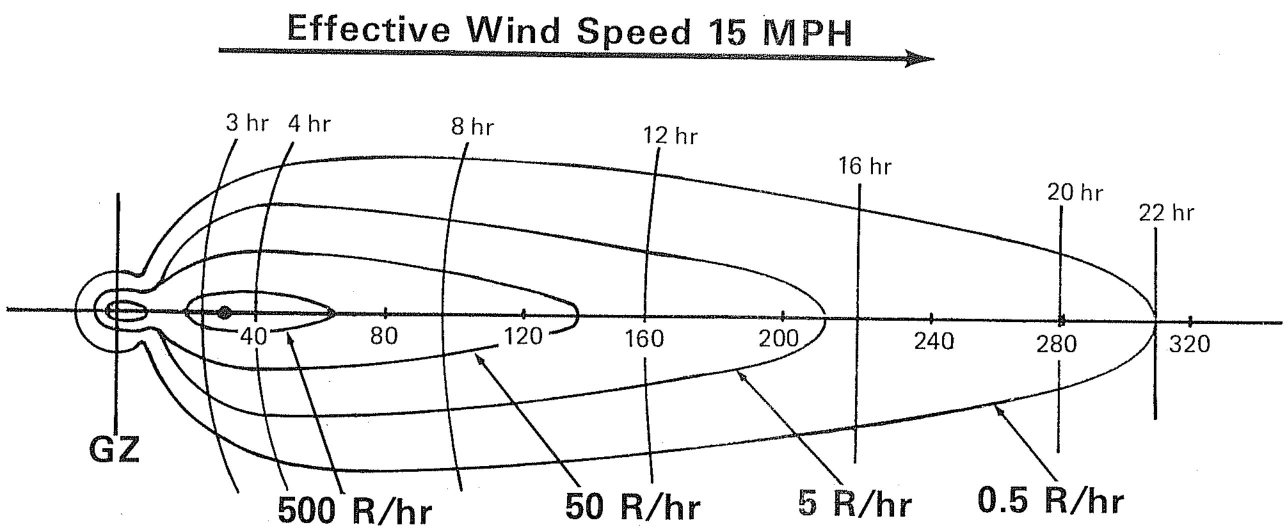
When fallout particles first arrive at a place on the ground and begin to accumulate, the radiation intensity in that area increases. Although radioactive decay is reducing the rate of exposure from those particles that have fallen, additional fallout generally arrives so rapidly that the total intensity continues to increase. Shortly before the time of fallout cessation, a maximum or "peak" dose rate occurs, after which the intensity of radiation begins to decrease through radioactive decay.

If the fallout were deposited rather uniformly on a glassy-smooth surface of a very large extent, the maximum or peak dose rate three feet above the smooth surface following the 5-MT surface detonation would be as shown by these contours. The more-or-less vertical lines across the pattern give the time after detonation at which the peak occurs. This deposition on a glassy-smooth surface would rarely, if ever, occur in reality but, as subsequent panels will show, actual conditions are so variable that the "smooth, infinite plane" situation is used as a base case for fallout models and calculations. Adjustments can be made from this base case to particular conditions that would actually occur.

It can be seen that a peak dose rate of 0.5 R/hr, which is the accepted level above which a fallout threat is recognized, extends to a distance of about 310 miles downwind. The areas of "stem" and "cloud" fallout are clearly evident and these contours are very similar to those shown in Panel 10; for example, the 50 R/hr contour, which delimits the area of severe fallout as defined in Chapter 1, covers almost the same area as the one gram per square foot deposition contour of Panel 10.

There are two contours enclosing areas where the peak dose rate will exceed 500 R/hr, one in the stem region and one in the cloud region. Our example location 30 miles downwind is within the downwind peak area. Here, the "true" dose rate three feet above a smooth, infinite plane would reach a maximum of about 1200 R/hr. This would occur near the time of fallout cessation, about three hours after the detonation.

PEAK DOSE-RATE PATTERN
(5 MT Surface Burst)



- Distances in miles
- Contours in roentgens per hour (true ionization rate at three feet above a smooth infinite plane)
- Vertical curves show peaking time in hours after detonation
- Fission yield 50%.

VISIBLE ASPECTS OF FALLOUT

In weapons tests, personnel were removed to safe distances before firing and kept out of fallout areas until it was safe to enter. Upon reentry the fallout areas were usually marked by a coloration of ground and foliage. Observations of the fallout event itself was often marked by visible fallout and "lowering of the sky" similar to that observed in rain showers.

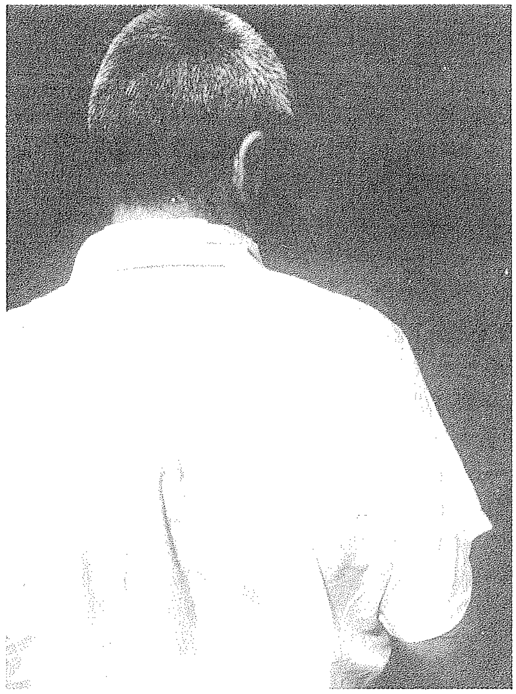
In 1964, the eruption of the volcano Irazu in Costa Rica provided an opportunity to observe fallout that was remarkably similar to fallout from nuclear weapons except that it was not radioactive. This permitted immediate on-site observations not possible in nuclear tests. It was found that deposits of fallout were easily visible when they amounted to 1 to 3 grams per square foot of surface. This level corresponds to the HIRAD fallout area where dose rates may exceed 50 R/hr. (See Chapter 1 for a discussion of fallout situations.)

The upper photograph shows the back of an individual exposed in such a situation. The first sensation when fallout begins arriving is the impact of particles on the nose and forehead. After a few minutes, the second sensation is a gritty feeling on the lips and teeth. (Fallout particles are too large to enter the nose by normal breathing.) On clothes, the particles collect in the folds, in cuffs, and under belts. Women with open-necked blouses feel the particles sifting into underthings. So long as clothes are dry, the particles are readily removed by shaking. They are not so readily removed from damp cloth.

The lower photograph shows a fallout deposit on an automobile. Dry particles are, to a large extent, cleaned by the winds but washing is required to remove all particles from the surfaces.

It may be too strong a statement to say that under all conditions fallout will be readily visible whenever a significant radiation hazard exists. Proper use of radiation instruments will remain the basic tool for control of radiation exposure. But it can be said that, whenever fallout is evident as described here, a significant radiation exposure is in prospect.

WHAT FALLOUT LOOKS LIKE*



* From Miller, C.F., **The Contamination Behavior of Fallout-Like Particles Ejected by Volcano Irazu**, Stanford Research Institute, Project No. MU-5779, April 1966. (AD 634 901)

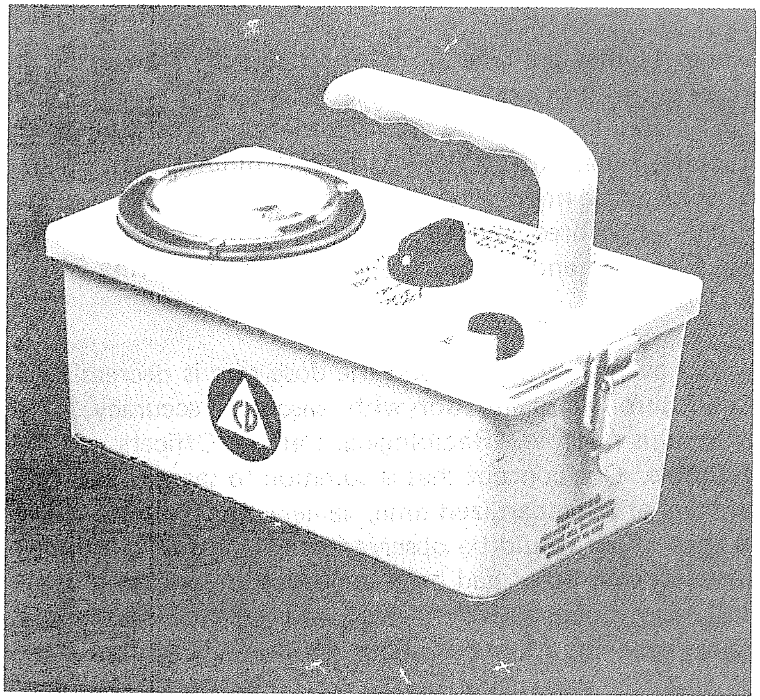
PANEL 12

MEASURING FALLOUT RADIATION

Although the fallout particles themselves will be apparent to the alert observer under most circumstances, the preferred basis for control of radiation exposure is measurement of the radiation itself. Gamma radiation is the chief threat, as outlined in Chapter 5. The dosimeter, used to measure the amount of radiation received, was described in that chapter. Shown here is the CD V-715, which measures the dose rate. This is the "work-horse" instrument for exposure control, since knowledge of the dose rate and radioactive decay permits estimates of current and future radiation exposure, whereas the dosimeter simply records the exposure already received.

For the 5-MT surface detonation, a properly calibrated CD V-715, held at waist height over a glassy-smooth surface of large extent, would measure approximately the peak dose rates shown in Panel 11. The scale on the instrument ranges from 0 to 5. The knob under the handle can be rotated to four scale settings: 0.1, 1, 10, and 100. The full-scale reading when the knob is set to 0.1 is 0.5 R/hr; at a setting of 1, 5 R/hr; at a setting of 10, 50 R/hr; at 100, 500 R/hr. Thus, the contours in Panel 11 are the full-scale readings for the four scale settings on the CD V-715. This means that throughout the area within the 500 R/hr contour, the dose rate would be "off-scale," too high for the instrument to read. This would be true if the real world were a glassy-smooth surface with no obstructions. As will be seen in Panel 16, the real world is quite different. One consequence is that the situations in which the dose rate will exceed the measuring capacity of the CD V-715 will be rare and momentary.

A very similar instrument, the CD V-717, has the sensitive element (that measures the ionization caused by gamma radiation) enclosed in a probe attached to 25 feet of cable. The operating characteristics are the same as the CD V-715, except that the removable probe can be prepositioned outside a shelter so that measurements can be made from within a protected area.



THE OPERATIONAL SURVEY METER, CD V-715

DOSE-RATE MEASUREMENT AND PREDICTION

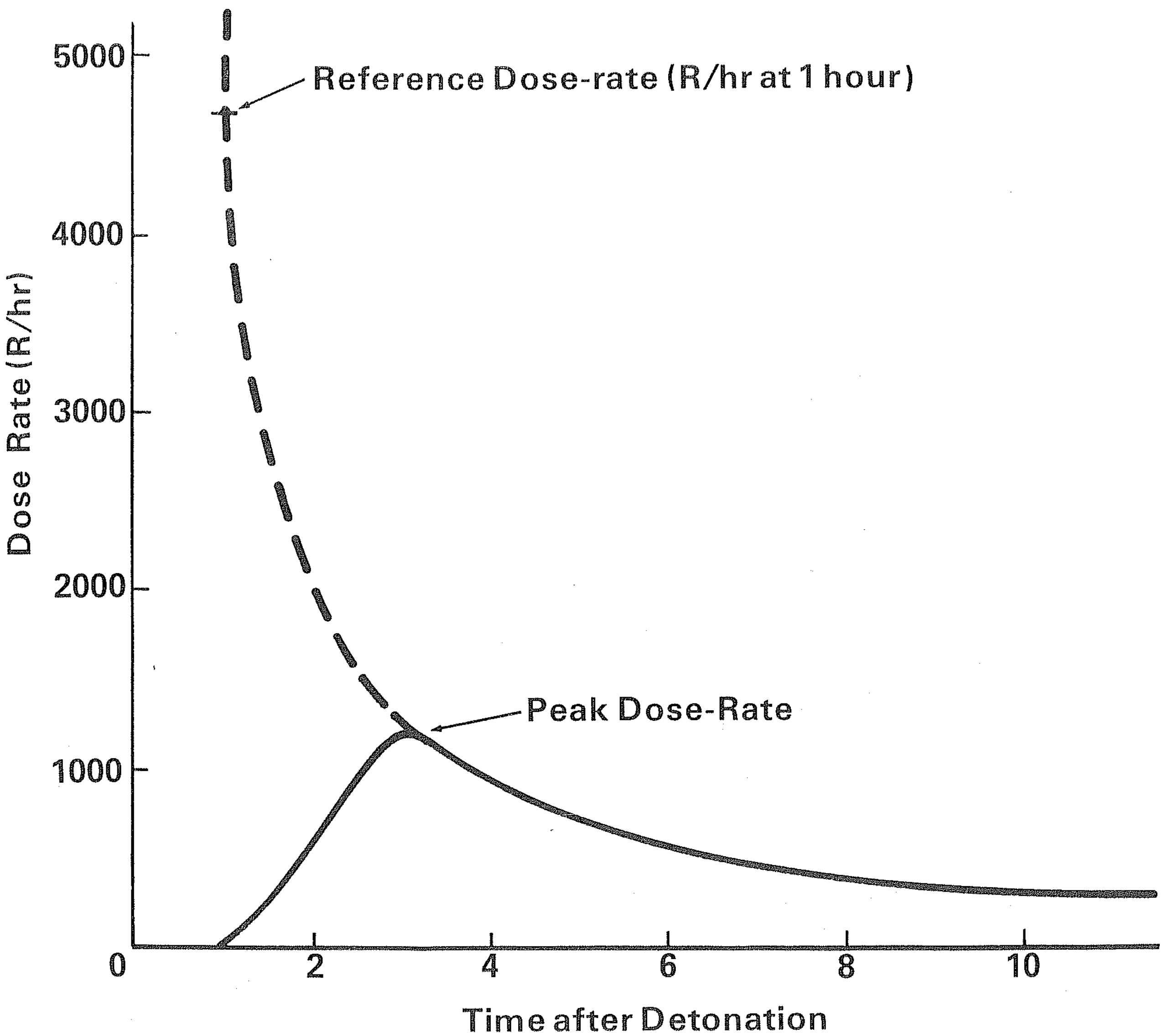
We saw in Panel 11 that the location 30 miles directly downwind from the 5-MT surface detonation was in the "hottest" part of the fallout pattern, and, in Panel 9, that fallout would begin to arrive about 45 minutes after detonation. As shown on this graph, the dose rate would rise rapidly, exceeding 50 R/hr within 10 minutes. The dose rate would peak at about 1200 R/hr, some three hours after detonation and then decrease, quite rapidly at first and more slowly later on. Three hours after peak (six hours after detonation), the dose rate would drop below 500 R/hr and a remote reading instrument (the CD V-717) could again indicate the dose rate.

Once the fallout event is complete and the dose rate is decreasing, it is generally possible to predict the future fallout situation with reasonable accuracy. Charts, sliderules, and nomograms exist for this purpose. Radiological Defense Officers and monitors are trained in the use of these tools. One concept that is common to these calculating devices is the use of a reference dose rate at a standardized time; namely, one hour after detonation. This dose rate is defined as that which would be observed at a location if all the fallout which contributes to the dose rate at that point had been deposited by one hour after detonation. The reference dose rate (also variously called "standard intensity" and "dose rate at H + 1") for the location we have been considering is about 4600 R/hr. As shown by the dashed curve, this is a fictitious dose rate since deposition of fallout has barely begun at one hour. This is generally true throughout the fallout area for megaton-yield weapons.

By use of the reference dose rate and the appropriate calculating rules, it can be determined that the dose rate at 30 miles directly downwind at the end of the first day would be about 100 R/hr; at one week, about 10 R/hr; at one month, a little less than 2 R/hr; and at four months after attack, about 3/10 R/hr (or 300 mR/hr, an mR or milliRoentgen being one one-thousandth of a Roentgen).

As we saw in Chapter 5, it is the dose that injures people and, since the dose rate is constantly changing in a fallout situation, special calculations must be made to predict future doses. To get a general idea of how this is done, the emergency planner might read the **Handbook for Radiological Monitors**, or better still, enroll in the home study course, **Introduction to Radiological Monitoring**, available through the DCPA Staff College. The methods taught would tell us that the potential unprotected dose at 30 miles downwind would be about 1200 R at time of peak dose rate, 7500 R at the end of one day, 11,400 R at one week, 13,500 R at one month, and about 15,000 R at four months.

FALLOUT SITUATION AT 30 MILES DIRECTLY DOWNWIND FROM 5 MT SURFACE BURST
(15 MPH WIND SPEED)



PANEL 14

PROTRACTED EXPOSURE AND BIOLOGICAL RECOVERY

In Panel 13 of Chapter 1, we exhibited the dose-penalty table shown opposite. In Chapter 5, we described what is known about the biological consequences of "brief" doses of gamma radiation. The doses shown in the "1-Week" column are consistent with those given in Chapter 5 for the same medical consequences. Therefore, a one-week exposure may be considered "brief," especially as the dose estimates of the previous panel indicate that two-thirds of the one-week dose is received in the first day. The reason why the doses shown in the "1 Month" and "4 Months" columns are larger is because the human body has some capacity to repair the damage caused by ionizing radiation.

In Panel 3 of Chapter 5, it was noted that large single doses can cause acute sickness or death, whereas small daily doses may be tolerated without causing illness. A dose of 600 R will be lethal when received as a brief exposure. The same dose accumulated over a period of 20 years, if delivered in equal daily amounts (less than 0.1 R/day), probably will not cause any recognizable effect. The dose-penalty table recognizes this recovery principle by "allowing" greater exposures, if spread over a period of many weeks or months. It is believed, also, that most of the later signs of radiation injury (Panel 6 of Chapter 5) are also less likely if exposure is protracted.

The lower table shows the situation at 30 miles directly downwind. The doses in the open are those noted in the previous panel. Now imagine a shelter at this location that has the capability of reducing the unprotected dose by a factor of exactly 46. (The characteristics of real shelters are described in Panels 18 to 22.) The column labeled "In Shelter 46" shows the one-week calculated dose to be 248 R, just short of the 250 R shown in the dose-penalty table. Few, if any, deaths would be expected. If one were to remain in "Shelter 46" for a month, the dose would be 294 R and one would have 56 R "to spare," according to the second row in the table. However, since the dose rate over the smooth infinite plane would be nearly 2 R/hr at one month, not much time could have been spent outside in the interim without exceeding the body's repair capability. It might have been wiser, in this circumstance, to have used the "spare" dose during the second week to move out of the heavy fallout area.

It can also be seen that staying in Shelter 46 for four months would have left 174 R to spare (500 R - 326 R). This would appear to be a good deal, but would allow only about an hour a day outside the shelter, on the average.

The final column represents a nearby shelter having the capability of reducing the unprotected dose by a factor of 76. The one-week dose is held to 150 R. The one-month dose leaves 22 R to spare without exceeding the criteria in the first row of the table, and the four-months' dose is 103 R below the penalty dose.

Being in Shelter 76 is better than being in Shelter 46, but, in either case, the table indicates that biological recovery is insufficient to allow much time outside the shelter.

DOSE-PENALTY TABLE

Acute Effects \ Roentgen Exposure Dose in Any	1 Week	1 Month	4 Months
Medical Care Not Needed	150	200	300
Some Need Medical Care Few if Any Deaths	250	350	500
Most Need Medical Care 50% + Deaths	450	600	*

*Little or no practical consideration.

DOSES AT 30 MILES DOWNWIND
(5-MT surface burst; 15 MPH wind)

Time	In Open	In Shelter 46	In Shelter 76
1 Week	11,400	248	150
1 Month	13,500	294	178
4 Months	15,000	326	197

ACTUAL DOSE RATES

Under actual operating conditions, measured dose rates and consequent exposure of people will be generally lower than those implied in previous panels for two main reasons: (1) most real surfaces are not smooth, and (2) many contaminated areas (roofs, streets, and the like) are of limited extent. Typical reductions to be expected are shown in these sketches.

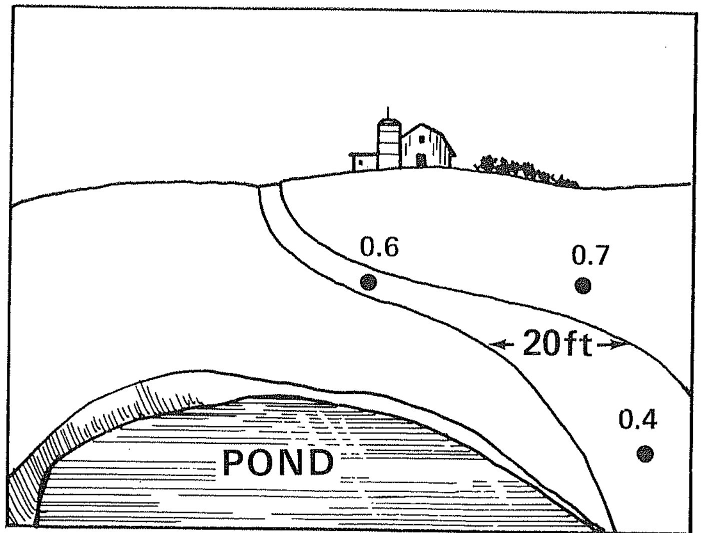
Smooth paved areas, unbroken by curbs, gutters, and the like, offer little reduction due to surface roughness. This is also true of packed snow or ice. Macadam and rough pavement will result in a "reduction factor" of about 0.8. Sand, bare soil, and grassy areas offer a reduction factor of about 0.7. Gravelled roads and roofs will reduce the dose rate about one-half, a reduction factor of 0.5. Fallout on very rough or plowed ground will produce a dose rate only about 0.4 of that on a smooth, infinite plane.

In the sketch of rural America, most of the reduction is due to the roughness of grassy fields and macadam or gravel roads. An exception is the value of 0.4 on the road next to the pond where the fallout has sunk to the bottom of the pond, thereby limiting the extent of the contaminated area at that point.

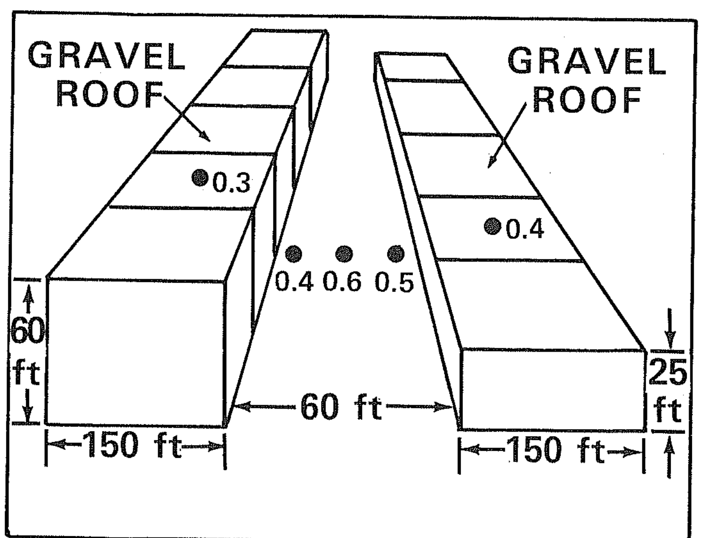
In Main Street USA, the buildings restrict the extent of the area contributing to the dose rate. Here we have assumed that the street is smooth pavement without curbs. The reductions shown in the street are due to the presence of the buildings, being greater near the buildings than in the center of the street. The reduction factors on the roofs are due both to the rough gravel surface and the fact that the height of the buildings reduces the contribution from the surrounding ground.

An operational implication is that measurements reported by radiation monitors are unlikely to allow the drawing of smooth contours, such as those shown in Panel 11, since the measurements will vary considerably depending on the environment in which the measurements are made.

REAL WORLD DOSE RATES
(for 1 R/hr on smooth infinite plane)



RURAL AMERICA



MAIN STREET USA

ANOTHER VARIABILITY—WEATHERING

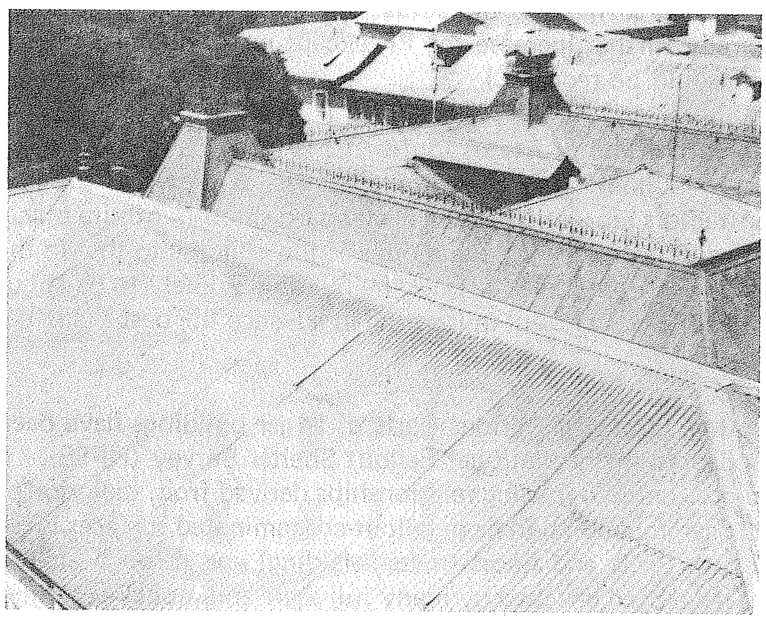
In Panel 16, it was pointed out that measured dose rates would vary according to the roughness of the surfaces upon which fallout had deposited, as well as the unbroken extent of these surfaces. The net result would be measured dose rates generally ranging from 30 to 70 percent of what would have been measured if the same amount of fallout had been deposited uniformly on the "standard" (and imaginary) smooth, infinite, plane surface.

Another variability that will occur in practice results from the movement of fallout particles by the action of wind and rain, generally called "weathering." This effect can be quite marked on smooth surfaces. The upper photograph shows a view of street and sidewalk contamination in San Jose, Costa Rica, after the volcanic fallout particles had been redistributed by wind and passing vehicles. The particles have accumulated near the curb and in cracks and small depressions in the concrete pavement. Often, a concentration of fallout particles will occur at a wind-protected corner, as shown here. If this fallout had been radioactively contaminated, this pedestrian would have been approaching a "hot spot," a limited area of concentrated fallout in which the dose rate could have been considerably higher than average.

The lower photograph shows the distribution of fallout-like particles on roofs. Particles tended to be scoured off the windward sections and to accumulate on the lee side of the roof just below the ridge, as shown. The particles drifted into roof gutters and other wind-protected places. Rain would wash particles toward the drains and ultimately into the storm sewers where they would become shielded from the surface above. Thus, in the long run, weathering acts to further reduce the hazard to people. But, in the process, hot spots are created and great variability introduced into radiation measurements.

Wind and rain do not tend to move fallout particles from natural soil or grassy areas. Consequently, radiation measurements in rural America will be much less variable than in urban areas.

WEATHERING EFFECTS*



*From, Miller, C.F., **The Contamination Behavior of Fallout-Like Particles Ejected by Volcano Irazu**, Stanford Research Institute, Project No. MU-5779, April 1966. (AD 634 901)

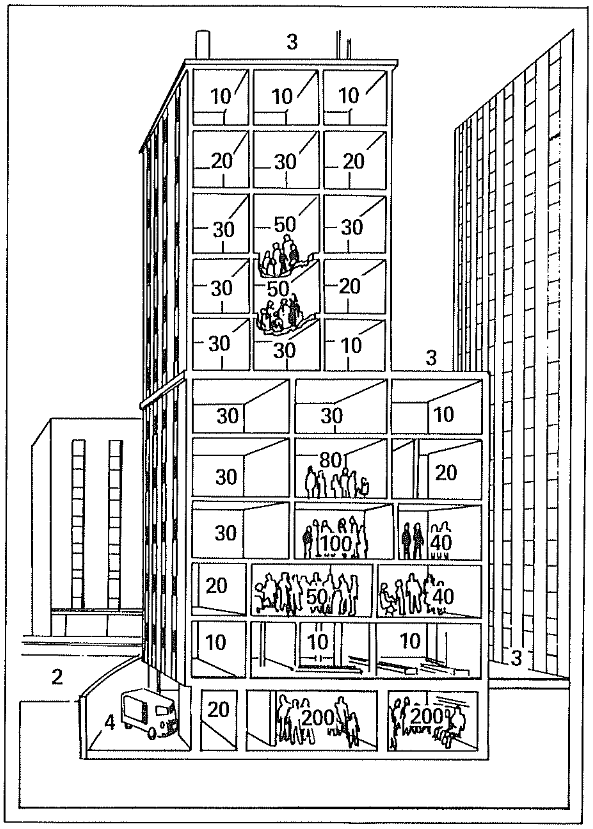
PROTECTION FACTOR

The two previous panels have emphasized that fallout radiation dose rates will vary from place to place within a relatively small area, especially in urban areas, because of the variable roughness of surfaces, the shielding afforded by nearby buildings, and the action of wind and rain. It is for this reason that fallout patterns used in peacetime vulnerability analyses and in training courses are defined for an imaginary standard surface; namely, a mathematically smooth, infinitely large, absolutely plane (flat) surface. Real situations are approximated by what is called a "protection factor" (PF).

The PF is an estimate of the ratio of the dose rate that would be measured at a height of three feet above the imaginary standard surface to the dose rate that could be expected in a given location in the "real world," assuming the uniform deposit of the same amount of fallout in both cases. Thus, when we noted that measured dose rates in the open would be 30 percent to 70 percent of what would have been measured over the standard surface, we were also saying that the outside protection factor would vary from about 1.5 to 3; that is, the hypothetical dose rate over a smooth infinite plane would be 1.5 to 3 times higher than that observed over real surfaces in the actual operating situation. (The action of wind and rain would generally further increase the PF except near "hot spots" or concentrations of fallout, where it would be reduced.)

The most common use of protection factor is to give a measure of the amount of protection afforded by buildings and other shelter areas, as shown in the upper sketch. Since these protection factors are all keyed to the standard smooth infinite plane, the PF does **not** represent the ratio between the dose rate outside the building to that in the shelter area. As we have seen, the PF in the street outside the building is likely to be about 2. Nonetheless, the protection factor is very useful in locating in advance the best available shelter from fallout radiation.

The protection factors in various parts of larger buildings have been calculated from building data collected in the National Fallout Shelter Survey (NFSS). These calculations were performed on a computer using relationships derived from radiation penetration theory that describe how gamma radiation from fallout-contaminated surfaces is reduced in intensity as it passes through walls and floors (mass shielding) and through air (distance shielding). The calculations have been checked by many full-scale and model experiments, of which one is shown in the lower photograph. Here a model building with measuring devices inside was exposed to radiation from a radioactive capsule that traveled around and around through the plastic tubing, thus simulating fallout on the ground. Incidentally, the scientist in the picture is Dr. Eric Clarke, an authority on radiation shielding, who also is an Executive Reservist attached to DCPA Region I.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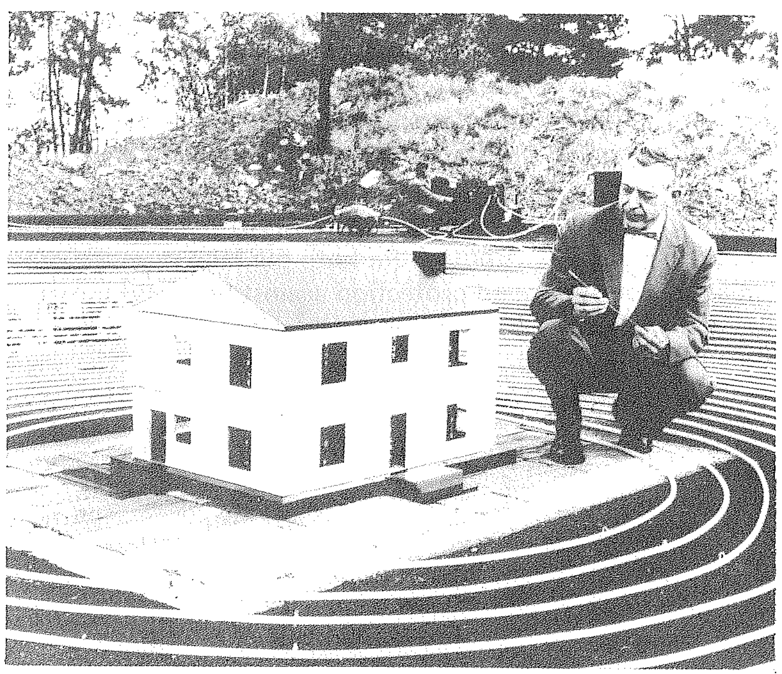


PANEL 18

PROTECTION AGAINST FALLOUT RADIATION

Once more we show the table of relative blast protection given in Chapter 2. We used this table in Chapter 5 to show how the protection afforded against initial nuclear radiation compared with the relative blast protection. Here we have added in parentheses the typical range of fallout protection factors that could be expected in the locations described. As before, a high protection factor means good radiation protection.

The lower of the numbers in each parentheses relates to locations near entrances, windows and the outer portions of aboveground floors; the higher number pertains to locations remote from openings and in core areas. In aboveground locations, the topmost floor will also offer lesser protection because of fallout deposited on the roof. Plans of each floor, showing protection factors and shelter areas, are available for NFSS buildings that have been surveyed for fallout protection.

Recall that protection factor calculations for buildings assume that fallout is deposited uniformly on ground and roof surfaces. The shielding effect of nearby buildings is taken into account, but the movement of fallout by wind and rain is not. The effect of building damage by blast also is not considered. These effects are highly variable. This is an important reason why radiation measuring kits should be provided in large shelters to permit the occupants to locate those areas having the lowest dose rates in the actual fallout situation.

One point to note in this table is that the middle floors of tall buildings offer good fallout protection mainly because they are remote from both the fallout on the ground and that on the roof. These areas do not offer good protection against blast and initial nuclear radiation. In localities that are unlikely to experience direct effects, this fallout protection is a valuable resource for planners.

TYPICAL FALLOUT PROTECTION FACTOR RANGES RELATIVE TO BLAST PROTECTION

Blast Preference	Description
A	Subway stations, tunnels, mines, and caves with large volume relative to entrances. (1000 - 10,000)
B	Basements ans sub-basements of massive (monumental) masonry buildings. (100 - 1000)
C	Basements and sub-basements of steel and reinforced-concrete framed buildings having flat slab or slab and beam ground floor construction. (100 - 1000)
D	First three floors of buildings with "strong" walls. (20 - 80)
E	Basements of wood-frame and brick-veneer residences. (10 - 50)
F	Fourth and higher floors of buildings with "strong" walls. (20 - 100)
G	Basements of steel and reinforced-concrete framed buildings with flat plate ground floor. (100 - 200)
H	First three floors of buildings with weak walls, brick buildings and residences. (20 - 80)
I	Fourth and higher floors of buildings with weak walls. (20 - 100)

HOW MUCH PROTECTION IS NEEDED?

In Panel 15, we showed how much protection shelters having protection factors of 46 and 76 gave in the "hot area" 30 miles directly downwind of the 5-MT surface burst. To measure the usefulness of the protection factors shown in the previous panel, we need to consider the needs in the areas of more moderate fallout as well. We should also consider how fallout patterns might overlap and build up when many weapons are detonated in an area. The results shown on this chart consider the doses resulting from a major attack with the enemy arsenal described in Chapter 1.

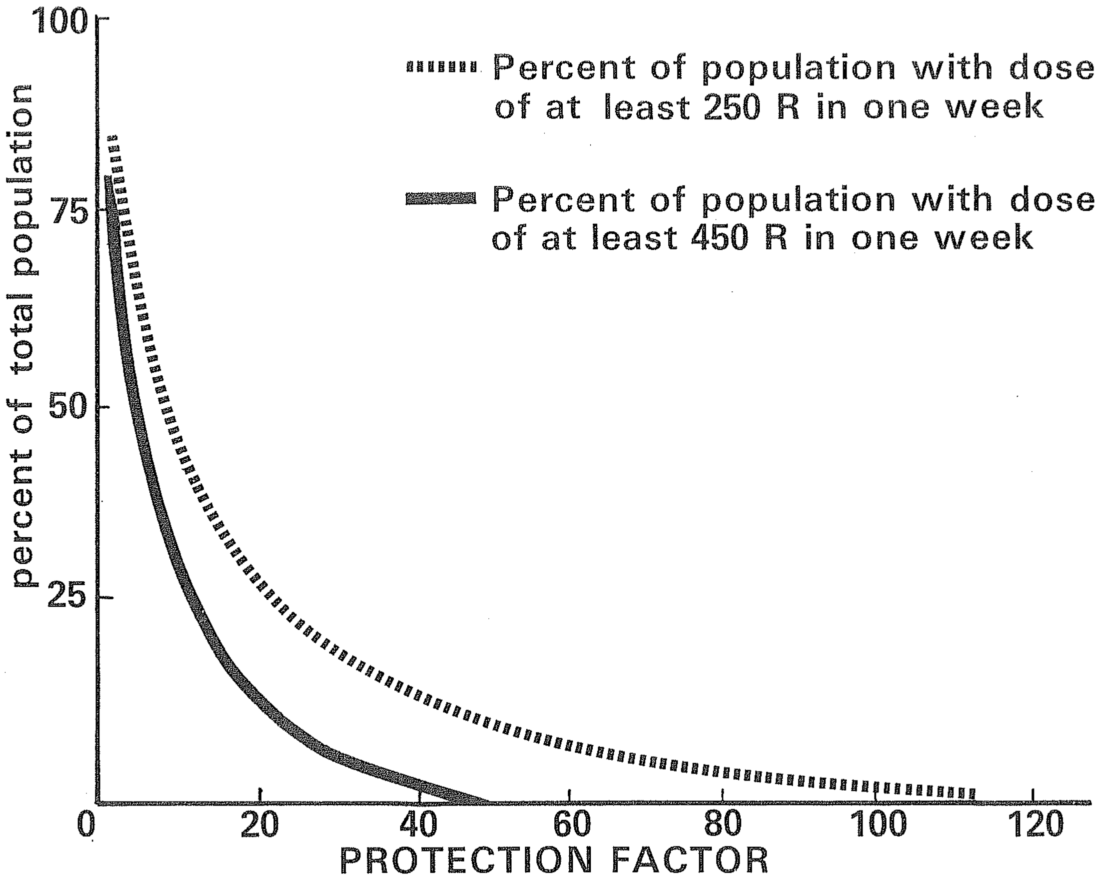
As a starting point, consider the population as if they were all located outside (or in small wood-frame residences) during the first week after attack. We found in Panel 16 that the "real world" outside dose rate was about half of the smooth-infinite-plane dose rate, or equivalent to having a PF of 2. For this condition, the dashed curve indicates that about 80 percent of the population of the U.S. would receive a one-week dose in excess of 250R; alternatively, only 20 percent would have received a dose less than 250R. Only 25 percent of the population would have a better than even chance of surviving, since 75 percent would have received a dose in excess of 450R.

The efficacy of higher protection factors is dramatic. At a PF of 20, 75 percent of the population would receive less than 250R and all but 10 percent would receive a dose less than 450R. At PF 40, less than 2 percent would receive a dose of at least 450R; over 85 percent would receive less than 250R. At PF 100, less than 2 percent would receive as much as 250R.

These percentages account for the whole preattack population, even those that would most probably have been killed by blast. You can find similar curves, for blast survivors only, in Appendix 1 to Part A, Chapter 1, of the Federal Civil Defense Guide. The message you find there will be the same. Appendix 1 is titled, "Policy on the National Goal for a Minimum Protection Factor of 40 for Public Fallout Shelters." When one is attempting to build and improve protection capabilities, **goals** are important. When one is an emergency planner, such goals are meaningless. One needs to plan to use the best shelter available, even if it offers less protection than the goal. The data shown here demonstrate that protection factors of 20, or even 10, are greatly to be preferred over leaving some part of the population unsheltered.

One final point—the very best protection is really better than the next best. If a PF of 100 keeps most doses below 250R, a PF of 1000 will keep them below 25R. Refer to Panels 3 through 5 in Chapter 5 for reasons why exposures should be kept as low as possible.

ONE-WEEK DOSE AFTER LARGE ATTACK FOR VARIOUS PROTECTION FACTORS



PROTECTION IN RESIDENTIAL BASEMENTS

We noted in Chapter 2 that home basements could play an important role in improving survival from blast effects. They can also play an important role in providing protection against fallout radiation. In most parts of the country outside of the downtown areas of cities, the amount of fallout shelter identified in the National Fallout Shelter Survey (NFSS), which is located in large buildings, is insufficient for the population that needs shelter.

About half the homes in the United States have basements, but, as shown on this map, they tend to be concentrated in the northern part of the country. A small proportion of homes have basements in the South, Southwest, and Far West sections. Even these could be of great value if neighbors shared with neighbors. The average residential basement has an area greater than 1000 square feet. The standard shelter space in the NFSS buildings is 10 square feet. The usual emergency housing space allotment in peacetime natural disasters is 40 square feet. Thus, from 25 to 100 persons could be sheltered in the average home basement, if necessary.

The fallout protection afforded by home basements can be estimated in the following way:

(1) Single-story homes with average basement wall exposures (i.e., above ground) less than 2 feet will provide at least PF 20 throughout the basement.

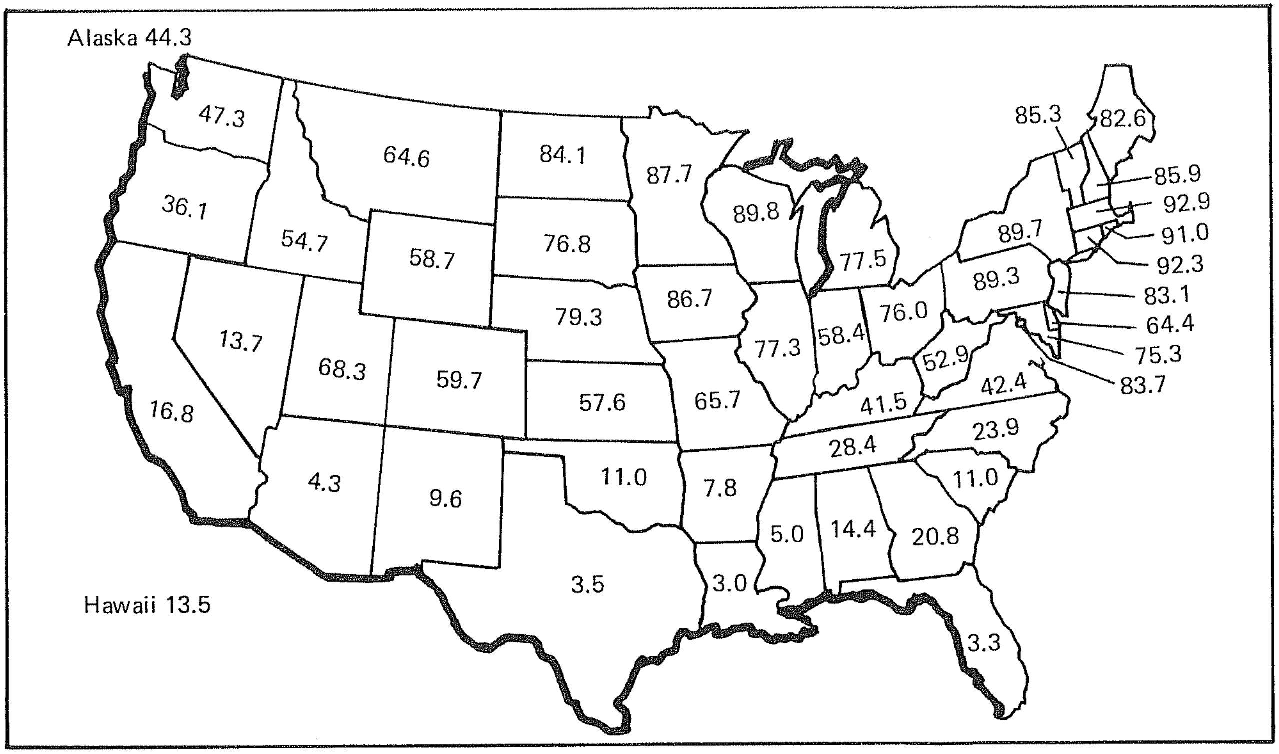
(2) Homes with 2 or more stories and 2 feet or less average basement wall exposure will provide at least PF 40 throughout the basement.

(3) Single-story homes with average basement wall exposure greater than 2 feet can be improved to PF 20 by sandbagging the exposed walls or mounding earth against them.

(4) Similarly, multi-story homes with basement wall exposure greater than 2 feet can be improved to PF 40 by sandbagging or mounding earth.

Generally, fallout protection in home basements is least in the center of the basement and greatest in the corners and along the walls.

PERCENTAGE OF HOMES WITH BASEMENTS



PANEL 21

EFFECT OF SIZE OF WEAPON

Throughout this manual, effects have been described mainly for a 5-MT nuclear weapon because it represents the middle range of the current Soviet arsenal. For comparison, we show here the general character of the fallout patterns from 1-MT and 25-MT surface bursts as well. This covers the yield range of current Soviet missile warheads. (See Chapter 1.)

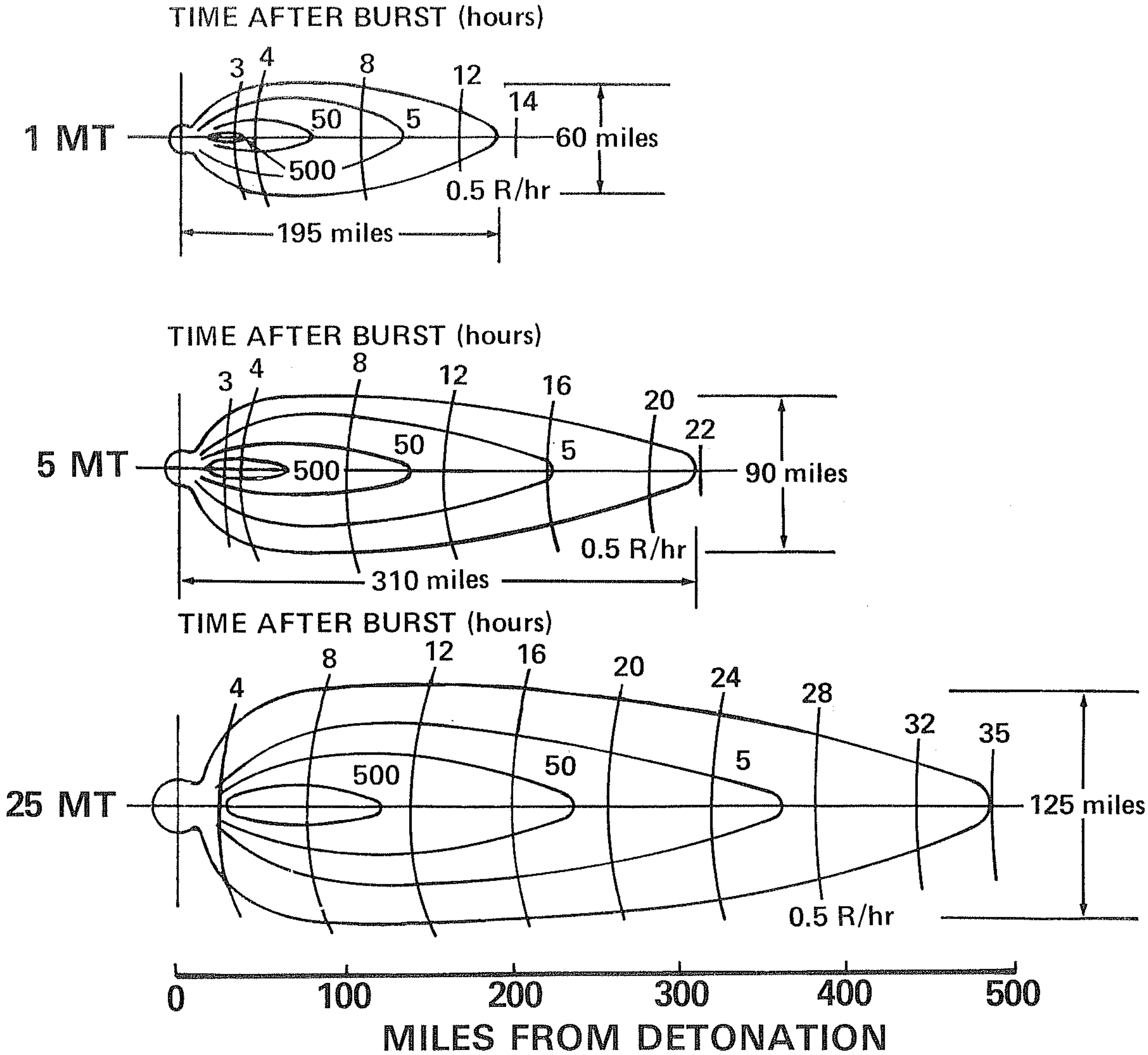
Shown are the maximum dose rates that would be observed by measurements taken at three feet above a smooth, infinite plane. As we saw in Panel 16, the actual dose rates would be less than shown here by a factor of 2 or perhaps more because of the roughness of the surfaces on which fallout had deposited, as well as the limited extent of these surfaces. Also shown, by curved vertical lines, is the time after detonation, in hours, at which the dose rate would attain its maximum.

The fallout pattern for a 25-MT surface burst is about twice as wide as that for a 1-MT detonation. It is about 2½ times as long. The 5-MT pattern is intermediate in size. The highest dose rate in the downwind area (within the 500 R/hr contour) varies by about the same factor. For a 1-MT burst, the most severe fallout situation in this area has a maximum dose rate in the neighborhood of 1000 R/hr. For the 25-MT burst, it is over 2000 R/hr. As we have seen, the maximum for a 5-MT burst is about 1500 R/hr.

The fallout process occurs most rapidly for the smallest weapon yield. Fallout deposited later than about 14 hours after detonation of a 1-MT weapon will not produce a dose rate exceeding 0.5 R/hr on a smooth, infinite plane. In contrast, dose rates will peak above 0.5 R/hr as late as a day and a half after the detonation of a 25-MT weapon. Significant fall-out from a 5-MT weapon may continue to arrive for about a day.

Note that the point 30 miles downwind, used as an example in previous panels, is always in the heaviest fallout area. As the weapon size increases, fallout arrives earlier and ceases later. Shown here are the times of fallout cessation (peak dose rate). At 1-MT, the peak at 30 miles occurs less than three hours after detonation. At 5-MT, the peak occurs at about three hours. At 25-MT, four hours elapse before the maximum dose rate occurs at 30 miles downwind.

FALLOUT PATTERNS
(PEAK DOSE RATES AND TIME OF PEAK) FOR 15 MPH EFFECTIVE WIND



EFFECT OF WINDS

To this point, we have presented fallout patterns for a very simple wind condition; namely, winds at all altitudes blowing from west to east at an effective velocity of 15 miles per hour. Shown here is an actual fallout pattern from a test detonation of about 5 megatons in the South Pacific (Eniwetok Proving Grounds). Shown are the contours for "dose rate at H + 1." As discussed in Panel 14, these are therefore "fictitious dose rates" because fallout deposition is not complete for many hours after the detonation in most of the area.

The winds in this case were quite variable, blowing in differing directions and speeds at various altitudes up to the top of the mushroom cloud. Nonetheless, the features we have described are still discernible. One can note the stem fallout area around the burst point and the down-wind peak area about 35 to 60 miles north. The heavier fallout particles appear to be influenced mainly by lower altitude winds blowing from south to north, while smaller particles also appear to be influenced by winds from east to west at higher altitudes.

In general, winds over the United States are not as complex as those affecting the fallout pattern shown here. Nonetheless, simple, regular, "cigar-shaped" patterns would be unlikely. Very generally, wind speeds increase with altitude up to the upper troposphere, where a "jet stream" having wind speeds of 50 to 150 or 200 miles per hour often exists over parts of the country. Average wind speeds from the surface to the top of the mushroom cloud vary widely but can range from around 5 miles per hour in the summer to around 40 miles per hour in the wintertime. The effective wind speed used in this chapter, 15 miles per hour, can be considered near the average. Higher wind speeds elongate the fallout pattern, with a corresponding reduction in width.

Because of the thinness of the atmosphere, fallout particles fall faster in the upper altitudes than they do near the earth's surface. Winds from the surface to, say, 5000 feet thus play an important role in the spread of fallout. These winds are affected by terrain and surface temperatures. For example, near-surface winds tend to flow up valleys in daytime and down valleys at night. Onshore and offshore winds in coastal areas are another case in point.

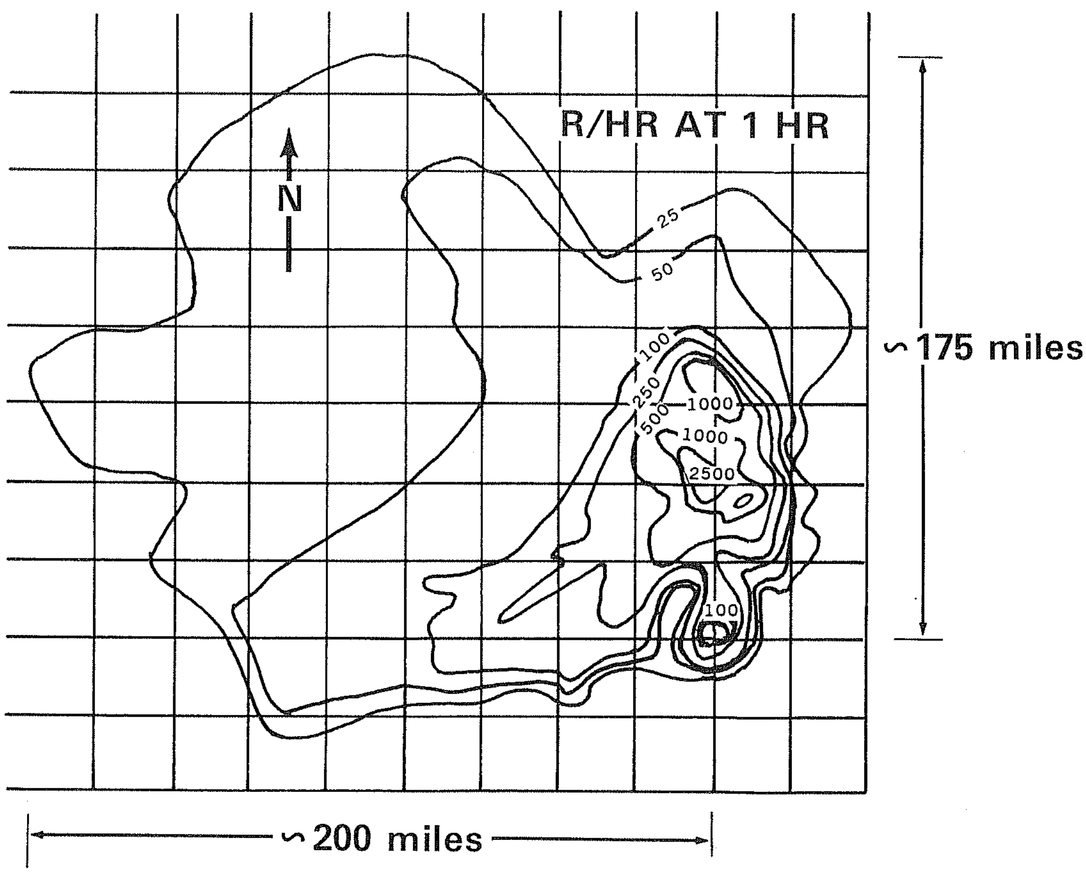
The implications for planning are:

(1) Fallout predictions based solely on wind data are not likely to be accurate in the early hours after detonations. The most reliable indicators of potential fallout arrival are actual fallout measurements reported from locations 20 to 40 miles away.

(2) The fallout "front" will move relatively slowly, from 5 to 40 miles each hour.

(3) Plans to move people from the presumed path of fallout are not practical.

FALLOUT PATTERN FROM A WEAPON TEST OF ABOUT 5 MT



From: **Congressional Hearings**, "Biological and Environmental Effects of Nuclear War," p 80, June 1959.

SKIN BURNS FROM FALLOUT

The fallout discussion thus far has emphasized the gamma radiation emanating from deposited fallout particles, which is the chief threat to survival outside the direct effects area. Another potential source of injury is from the beta radiation also given off by the fallout particles. Beta radiation was described in Panel 2. Because it is not very penetrating, beta radiation becomes a potential hazard when fallout is lodged on the skin or light-weight clothing. In close proximity to the skin, the beta radiations are absorbed in growing layers, causing burnlike lesions if present in sufficient quantity for a sufficient interval of time.

In 1954, residents of Rongelap Atoll in the Marshall Islands were exposed to fallout that arrived four to 6 hours after a test detonation on Bikini Atoll about 100 miles to the west. Fortunately, they were located near the edge of the fallout pattern, where they received only about 175R (gamma) during the two days before they were evacuated. About two-thirds of the people experienced nausea and loss of appetite and a few vomited and had diarrhea. Otherwise, the signs of injury from gamma radiation exposure were only disclosed by blood tests, which showed a gradual return to normal.

Nearly all of the people experienced itching and burning of the skin during and after the time fallout was deposited. They were, of course, lightly dressed. About two weeks after exposure, beta burns appeared on the skin, largely on parts of the body not covered by clothing. One such case is shown here. About 90 percent of the people exposed on Rongelap had these burns, and a smaller number developed spotty loss of hair from the scalp. Most of the burns were superficial. Rapid healing occurred in these cases. Some burns were deeper and more painful. A few burns became infected and had to be treated with antibiotics. For the most part, burns had healed and hair grown back by six months after exposure.

Experiments and calculations show that beta burns are likely only if fallout is deposited on the skin during the first day or two following detonation and mainly during the fallout event itself. Emergency operations after cessation of fallout (peak dose rate) do not generally result in significant contamination of people. Handling of contaminated objects without gloves would be the principal hazard.

An implication for operational planning is that to delay sending people to shelter until fallout is first detected is unwise. A person traveling on foot to shelter at our example point 30 miles downwind of a 5-MT detonation would receive about 175 roentgens in the first 15 minutes after fallout arrival. He would also have accumulated fallout particles on the scalp, collar or neck area, belt and shoe-top area that could cause painful burns and possible infection if not removed promptly.

BURN FROM BETA RADIATION *

* From Cronkite, E.P., et al., **Some Effects of Ionizing Radiation on Human Beings**, U.S. Atomic Energy Commission, July 1956.

CONTAMINATION OF WATER AND MILK

The 64 Marshallese on Rongelap Atoll were not aware that they were being exposed to fallout radiation, nor of its significance. They remained out of doors and took no special precautions. They continued to drink water from cisterns that received rain water from roofs. Analysis of urine samples taken after the people were removed from the island showed internal absorption of radioactive materials. The body levels were most serious for two radioactive materials, **strontium and iodine**. At the time, the estimated concentrations were believed to be too low to result in any serious effects. Body levels fell rapidly; by six months radioactivity in the urine was barely detectable. To this day, some 19 years later, the general health of the exposed adults has been good and about the same as that of the unexposed population, but nearly all children have suffered serious thyroid injury.

Radioactive elements follow the same metabolic processes in the body as chemically similar stable elements. Thus, strontium, which is chemically like calcium, is deposited in the bone, where it can irradiate the blood-forming cells of the bone marrow. Young growing bones incorporate calcium more rapidly than adult bones. Iodine, on the other hand, is absorbed in the thyroid gland. It is estimated the thyroids of adults received about 160 rads from the absorbed radio-iodine. (The **rad** is a unit of absorbed dose used for both beta and gamma radiation.) The smaller thyroid glands of the young children, however, received an estimated 525 to 1225 rads from the radio-iodine.

In 1963, nine years after exposure, a thyroid nodule was first detected in a 12-year-old girl (who was 3 at the time of exposure). Since then, thyroid abnormalities, many requiring surgery, have appeared in nearly all of those who were less than 10 years of age when exposed. Retardation in growth of the children has also been observed, which has been corrected by thyroid hormone treatment. One example is shown here. These findings indicate the seriousness of ingestion of radioactive iodine. Because of its short half-life, the iodine hazard would exist, at most, for a month postattack. It is an important hazard as a contaminant in water and milk, especially to the very young.

The implications for operational planning are:

(1) Water from sources other than open reservoirs should be used during the first month postattack, if possible.

(2) Young children should not be fed milk from cows that have grazed on contaminated pasture during the first month, and

(3) Stocking shelters with "pre-war" water can help avoid the iodine hazard.

One of the two boys showing most retardation of growth with development of hypothyroidism. Left: near the beginning of thyroid hormone treatment (1966, age 13); right: after 3 years of treatment (1969), showing remarkable spurt in growth and development with disappearance of hypothyroid symptoms.

From Conard, R.A., et al., **Medical Survey of the People of Rongelap and Utirik Islands Thirteen, Fourteen, and Fifteen Years after Exposure to Fallout Radiation**, Brookhaven National Laboratory BNL 50220 (T-562), June 1970.

PANEL 25

EFFECTS ON LIVESTOCK

The survival of livestock is an important element of an assured food supply, as is the ability to grow crops, treated in the next panel. The contamination of food, other than fresh milk, by fallout represents, on the other hand, a relatively unimportant problem. The grains of fallout are readily removed from cans, food packages, and the surfaces of fruits and vegetables by wiping or rinsing. Besides, fallout is gritty and no one likes "sand in his spinach." In other words, fallout contamination of food is readily recognized and dealt with.

Fallout radiation affects livestock much as it does people. Shown here are the gamma radiation exposures to the main food-producing animals that would result in about 50 percent deaths over a period of 60 days following exposure. The first column (In Barn) represents the effects of gamma radiation only. Most animals are about as vulnerable as people. Poultry are much more resistant than other animals.

Animals in open pens would receive not only gamma radiation but also skin burns from fallout deposited on their backs. The combined effect has been accounted for (second column) by a modest reduction in the amount of gamma exposure required to kill half the animals.

Finally, animals on pasture are subjected to the combined effects not only of gamma radiation and beta burns to the skin but also the internal injury resulting from eating contaminated grass. The ingested fallout can cause damage to the stomach and intestines. As a result, lethality occurs at much lower doses than otherwise.

The Department of Agriculture, Atomic Energy Commission, and DCPA have joined in sponsoring research on livestock effects and protection for a number of years. The information shown here suggests the sort of actions that should be planned to preserve this valuable food resource. Local planners can get more details from their USDA County Emergency Board Chairman and the county extension agent.

DOSE IN ROENTGENS TO KILL HALF THE ANIMALS IN BARNS, PENS, OR PASTURE*

Animal	In Barn (R)	In Open Pen (R)	On Pasture (R)
Cattle	500	400	170
Sheep	400	320	240
Pigs	660	(550)**	(400)
Horses	670	(600)	(350)
Poultry	850	(780)	(730)

*From current Department of Agriculture estimates.

**Parentheses indicate no experimental data available.

EFFECTS ON CROPS AND CROPLAND

Not too many years ago, it was believed that, following a nuclear attack, large areas of valuable farmland would have to be abandoned for generations because of fallout contamination. This view was based on early estimates of the availability of radioactive strontium in soluble form and the amount that would be taken up by the roots of growing plants. As explained in Panel 6, we now know that radioactive strontium is depleted in heavy fallout areas and, moreover, most of the radioactive material is locked within the glassy particles. In addition, it has been found that crops in the open field do not take up strontium as readily as was assumed. Thus, even though radioactive strontium has a long half-life (about 28 years), crops grown the year following an attack are expected to be fit for human consumption. Moreover, by a year after attack, radiation exposure to farm workers would no longer be of consequence.

On the other hand, the yield of growing crops can be severely reduced or the plants killed by the levels of gamma radiation to be expected over wide areas following nuclear attack. Gamma doses that would reduce crop yield by 50 percent on the average are shown here for some important food and forage crops. Beta radiation from fallout particles adhering to various parts of the plant or on the ground will add to the dose, amounting to from one to twenty times the gamma dose depending on the crop and stage of growth. Young, actively-growing plants are most vulnerable; those near maturity are least vulnerable. Severe damage to crops may therefore be expected where the gamma one-week dose is only a few hundred to a thousand or so roentgens.

Much more is known about the effects of gamma radiation on plants than about the effects of beta radiation. Consequently, the ability to predict injury to plants from fallout is highly unsatisfactory. It will probably remain so for some years to come. This situation is of operational significance in agricultural areas if one is to avoid committing manpower and scarce fuel and fertilizer to the growth of crops that have already been injured beyond the point of economic yield. As information in this area is gained by experiment, it will be made available through the County Emergency Boards of the Department of Agriculture and the county extension agents.

GAMMA DOSE IN ROENTGENS TO REDUCE CROP YIELD BY 50 PERCENT*

Crops	YD-50 Dose
Peas, Broadbeans	less than 1000R
Rye, Barley, Onion	1000 to 2000R
Wheat, Corn, Oats, Cucumber	2000 to 4000R
Peanut, Alfalfa, Fescue, Sorghum	4000 to 6000R
Cotton, Sugar Cane, Melons, Celery	6000 to 8000R
Soybeans, Beets, Broccoli, Red Clover	8000 to 12, 000R
Rice, Turnips, Sweet Potatoes, Strawberries	12, 000 to 16, 000R
Squash	16, 000 to 24, 000R

*Based on estimates in NATO document AC/25-WP/79, **The Effects of Radioactive Fallout on Food and Agriculture**, November 1972.

EFFECTS ON THE HUMAN ECOSYSTEM

The study of the interrelationships among members of a community of animals and plants is called **ecology** and the community itself is usually referred to as an **ecosystem.** Today's environmentalists tend to call the human ecosystem, the "ecology." Concern has been expressed since the development of nuclear weapons that a nuclear war might have a catastrophic effect on the biological environment insofar as it affects humans. The concerns have stemmed mainly from the perceived characteristics of fallout and the radiations emanating from it.

In his novel, **On the Beach**, Neville Shute had to invent an impossible kind of fallout, one that did not settle out or undergo significant radiological decay, in order to cause the end of mankind. Others, not intending fiction, have forecast a new Ice Age or, alternatively, the melting of the polar ice caps, raising the level of the oceans to flood the eastern United States—and most of the populated part of the rest of the world. Which should occur depends on the presumed particle size and shape of that part of the fallout that is injected into the stratosphere and mesosphere (Panel 7). Particle clouds circling the earth could upset the earth's heat balance. Whether the earth would cool off or heat up would depend on whether the dust particles interfered with the sunlight striking the earth more or less than it interfered with the heat loss to outer space. Large volcanic eruptions offer the closest natural analogy. It is said that the huge eruptions of 1815, involving quantities of volcanic dust equivalent to the detonation of 50,000 MT or more, may have been responsible for an unusually cool summer the following year, some 13 degrees below normal. Indeed, the three major historic volcanic eruptions were all followed by exceptionally cold years. But only one year was affected. It has been concluded that the earth's climate is exceptionally stable despite severe temporarily imbalancing effects. Continued pressure of change over decades and centuries are required to produce an Ice Age.

Similarly, observation that insect predators, such as birds, are more vulnerable to fallout radiation has led to predictions that the insects will inherit the earth after a nuclear war. Analysis shows, however, that heavy fallout areas are rarely more than 50 to 100 miles from areas of negligible fallout. Since the population of the various species is controlled largely by food supply, there would be a rapid invasion of predators into the temporarily insect-rich areas. In sum, no nuclear attack can induce gross and permanent changes in the "balance of nature" anything like those that human civilization has already produced through agriculture and urbanization.

On the other hand, there could be ecological changes that might require governmental control action in the early postwar years. World-wide fallout could increase rainfall over normal amounts by acting as a "cloud-seeding" mechanism. This would have adverse effects in flood-plain areas but would delay the onset of fire hazard from radiation-killed trees in areas of moderate-to-heavy fallout. Failure to log dead trees (which would be useful for housing and firewood) would sooner or later result in forest fires and erosion damage. Over a period of several years, silting could destroy the usefulness of reservoirs and irrigation works. Finally, degraded sanitation and public health measures in damaged urban areas could create conditions favorable to outbreaks of disease-carrying insect and rodent populations. All these consequences are subject to human planning, intervention, and control.

IMPLAUSIBLE CATASTROPHES

1. End of all life on the planet Earth.
2. A new Ice Age.
3. Melting of the polar ice caps.
4. Insects inherit the Earth.

MORE LIKELY ECOLOGICAL CONSEQUENCES

1. Temporarily increased rainfall.
2. Fire hazard in dead pine forests.
3. Longer-term threat of increased erosion and silting.
4. Outbreaks of disease-carrying insects and rodents in damaged urban areas.

FALLOUT IN THE DAMAGED AREA

Most of the fallout from megaton-yield nuclear detonations is carried tens to hundreds of miles by the wind before it is deposited on the ground. For this reason, we have emphasized the fallout environment outside the area of blast damage and fire. Fallout from surface bursts will also occur in the direct-effects area, making firefighting, rescue, and medical aid more difficult and urgent. The next six panels describe the fallout threat in the damaged area, as defined by the Miller fallout model. Weapons test data supporting these estimates are quite limited.

Fallout does not arrive immediately in the damaged area. Particles begin to fall from the rising fireball when the rate of cloud rise decreases to less than the falling velocity of the particles. The time of arrival of first fallout from the mushroom stem is shown in the table for 1-, 5-, and 25-MT detonations.

The somewhat complex pattern below the table shows the time of arrival of close-in fallout for the example 5-MT surface burst used previously. Fallout arrives almost simultaneously at 22 minutes after burst over nearly all of the direct effects area. (For reference, the extent of 2-psi blast overpressure is shown as a dotted circle.) Thereafter, fallout progresses downwind at the assumed effective wind speed of 15 miles per hour, reaching a distance of about 16 miles at one hour after detonation. For other wind speeds, the distances shown would obviously be different.

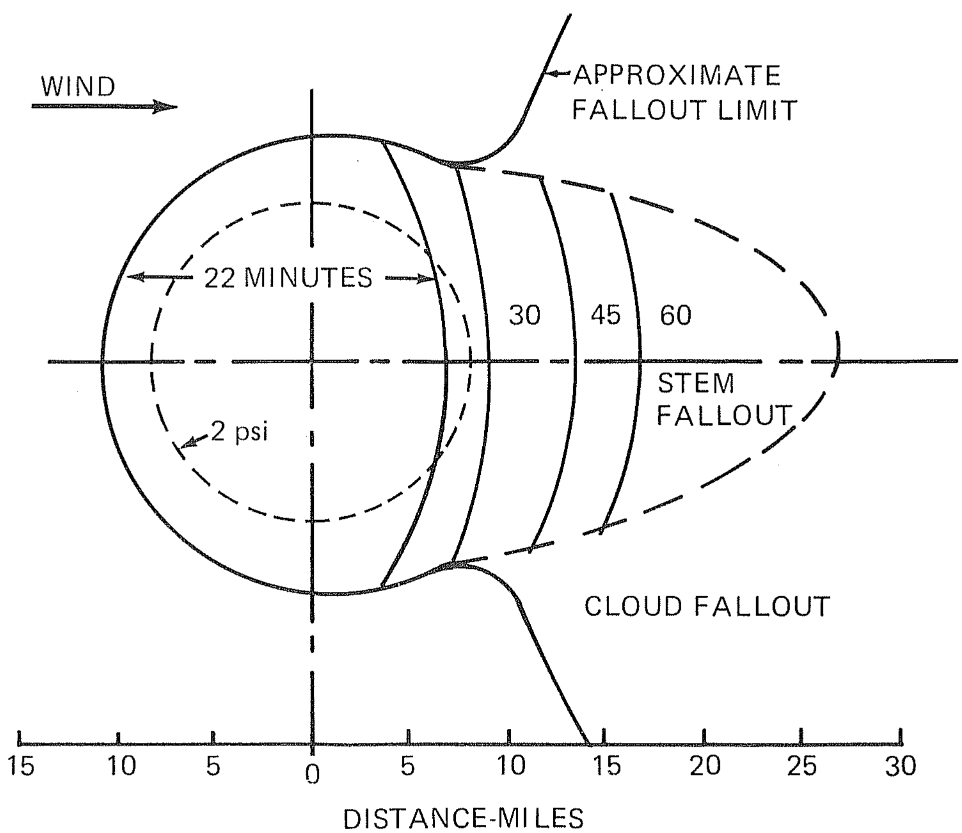
One might ask how it could be that fallout would not arrive at 16 miles downwind until one hour after detonation when, in Panel 9, we saw that fallout arrived 30 miles downwind at 45 minutes after burst. The reason is that the point at 30 miles, shown by a black dot, is in the cloud fallout region, not the stem fallout region. In the upwind portion of the cloud fallout region, fallout from the bottom of the cloud arrives before that from the main portion of the cloud. The earliest arrival of cloud fallout is beyond 30 miles and arrival times increase toward ground zero. Fallout arrival at 25 miles is later than at 30 miles, increasing to about one hour inside 20 miles where cloud and stem fallout arrive almost simultaneously. Therefore, stem fallout arrival times are not shown beyond one hour.

EARLIEST FALLOUT ARRIVAL

Weapon Yield	Fallout Arrival Time
1 MT	16 Minutes
5 MT	22 Minutes
25 MT	30 Minutes

FALLOUT ARRIVAL FOR 5 MT BURST

(15 MPH WIND SPEED)



PANEL 29

EARLY OPERATIONAL DOSES

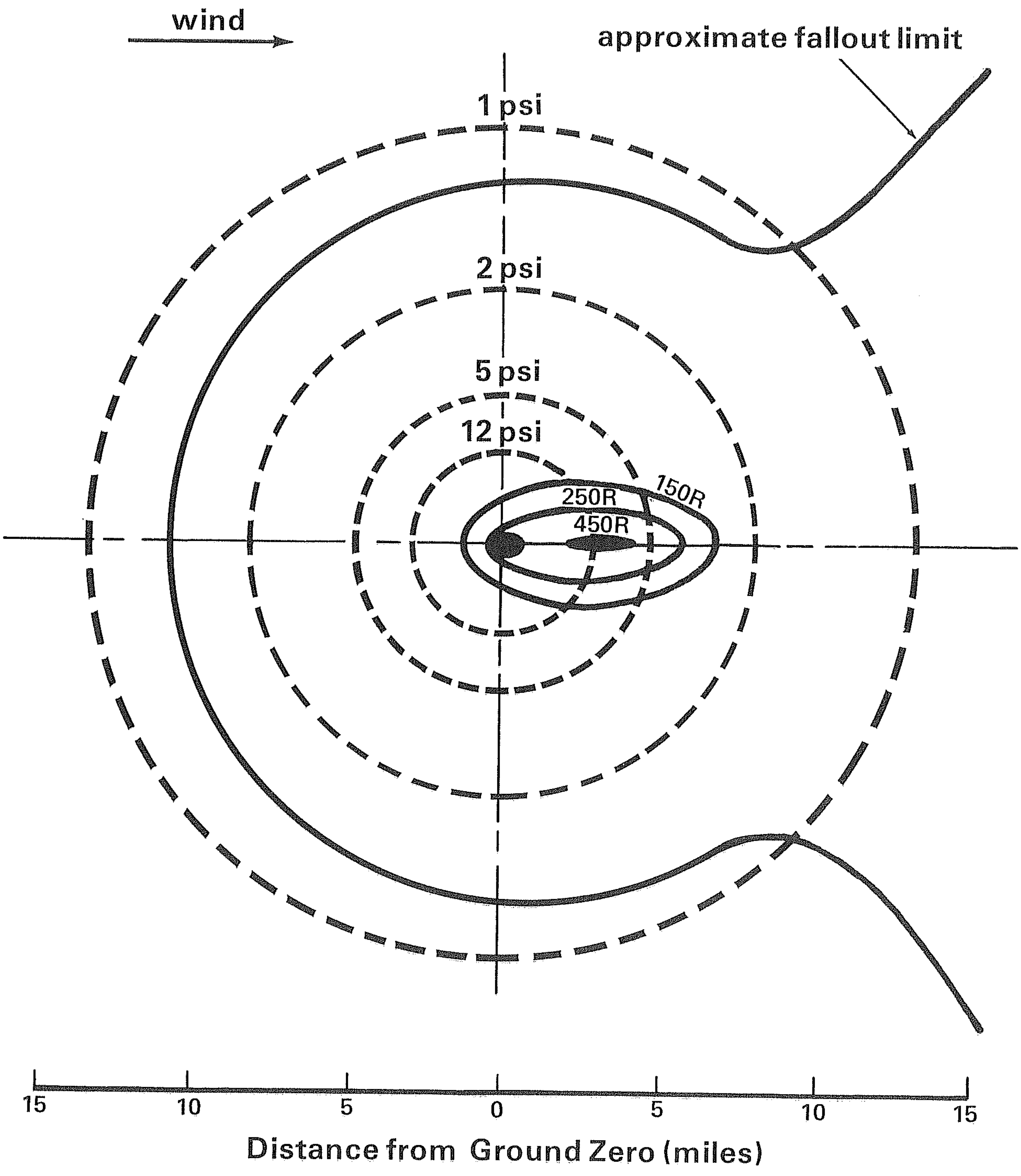
Although fallout will arrive in the damaged area within 15 to 30 minutes after detonation, fallout radiation exposures during the critical first hour will generally be nominal. The region affected by the doses defined in the Dose Penalty Table of Panel 15 is shown here. This region is confined to a small downwind area in the moderate and severe damage areas. There is a small area astride the 12-psi circle where exposures in the first hour would be in excess of 450R. Practically all of the area where suppression of smouldering ignitions, fire-fighting, rescue, and medical aid would be urgent tasks would experience outside doses of less than 150R during the first hour.

The doses shown are not those that would be received over a smooth, infinite plane. As we saw in Panel 16, exposures under actual operating conditions would be lower than the smooth, infinite-plane case because real surfaces are rough and of limited extent. Debris caused by blast damage would make most of the damaged area quite "rough." How "rough" these areas might be can be appreciated by reviewing Panels 35 and 36 of Chapter 2.

For this example, it has been assumed that the "real world" exposures would be about one-third those predicted for the smooth, infinite-plane situation. This is probably a conservative estimate of the effect of blast damage, and actual exposures would likely be even lower. Radiation exposures would vary even more widely than suggested by Panel 16. To aid in control of such exposures, at least one member of each emergency team should be equipped with a dosimeter.

One additional point to be considered is that, although gamma radiation exposures might be nominal during the first hour, fallout would be occurring during most of this period. Emergency teams should be dressed to avoid accumulation of fallout particles on the skin. A "Man-from-Mars" suit is not necessary. A coat with hood or hat and gloves are desirable. The usual fireman's "running gear" is excellent for the purpose.

DOSE DURING THE FIRST HOUR
(5MT SURFACE BURST -15 MPH WIND)



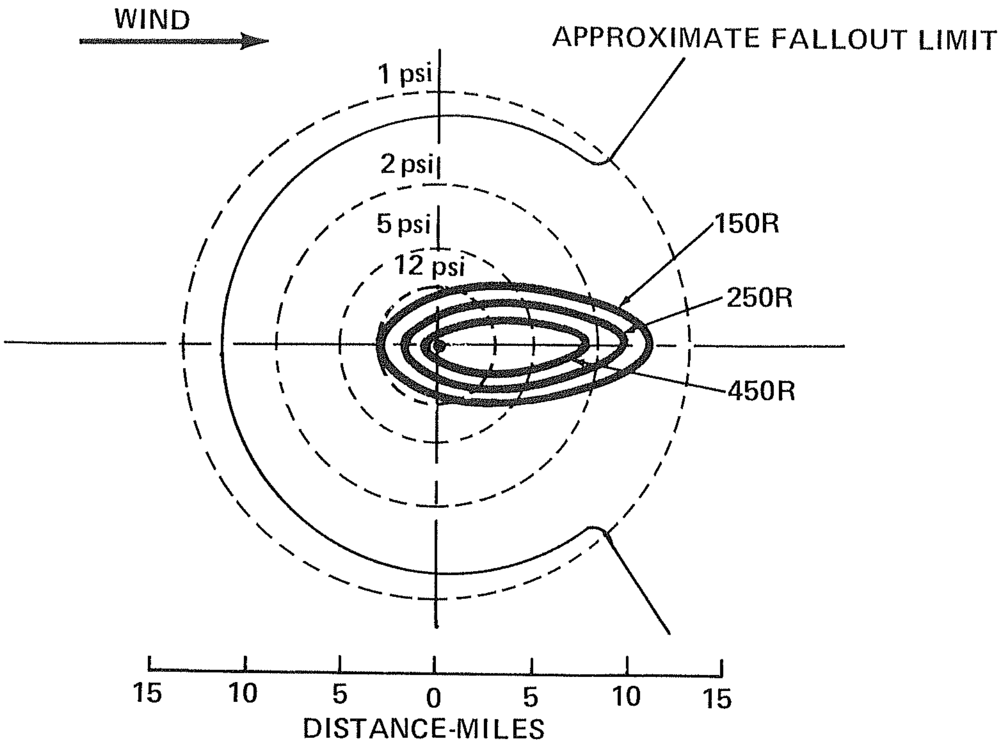
LATER OPERATIONAL DOSES

Urgent tasks of fire defense, rescue, medical aid, and remedial movement of people from threatened shelters may require continued operations beyond the first hour after a detonation. Shown here are the areas in which 150R, 250R, and 450R doses might be expected during the first two hours (upper sketch) and first four hours (lower sketch). The assumption as to the roughness of the debris-strewn area is the same as in the previous panel.

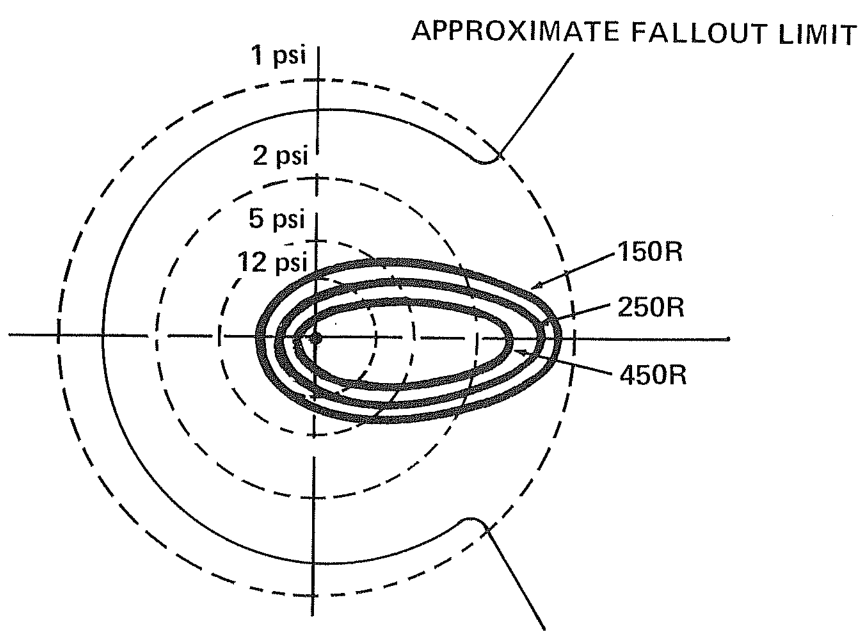
At two hours, the area enclosed by the 450R dose contour extends from about 1 mile upwind to about 8½ miles downwind and is about 4 miles wide at its widest. By the end of four hours, this area extends from 1½ miles upwind to 10 miles downwind and is 5 miles wide. As can be seen, doses above 150R are likely only in the downwind sector of the damaged area and affect less than one-third of the potential fire area.

In contrast to the situation in the cloud fallout area further downwind, the dose rate in the stem fallout area will peak well before the cessation of fallout. This is because of the rapid decay of radioactivity at early times. The dose rate can be expected to peak within the first hour throughout most of the damaged area. Only a small part of the subsequent dose is received during the "buildup period." Hence, the observed peak dose rate can be used to guide emergency operations. For example, where the dose rate peaks at, say, 125 R/hr, the anticipated dose in the first two to four hours is predicted to be about 125R. Similarly, if the CD V-715 goes off-scale on the high range (greater than 500 R/hr), potentially lethal outside exposures are to be anticipated. Since the direction of down-wind fallout may not be related to the observed surface winds, use of radiation measurements is to be preferred in operational planning.

DOSE DURING FIRST TWO HOURS
(5 MT SURFACE BURST-15 MPH WIND)



DOSE DURING FIRST FOUR HOURS



EFFECT OF FIRES ON FALLOUT DEPOSITION

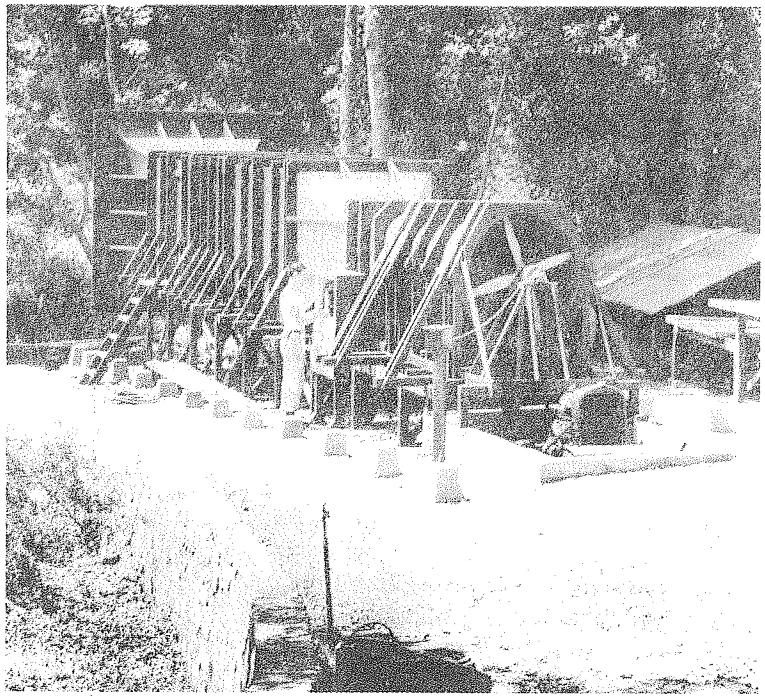
In Chapter 3, the fire environment in the damaged area was described. Mass fires are marked by "in-rush" winds and a rising "convection column" above the fires. Theoretical analyses of convection columns above large-scale fires indicate that the updraft from even moderate rates of heat output exceeds the falling velocities of most fallout particles. It would appear, then, that convection columns induced by fires set by the detonation could have an effect on the fallout pattern.

A time lapse occurs between the time of ignitions and the time when massive fires can be burning. Experience from World War II incendiary raids indicates this time period may vary from 25 to 45 minutes. The effect of the nuclear blast wave in suppressing ignitions to a smouldering condition would increase this time delay substantially. Thus, it is unlikely that the fires resulting from a megaton-yield surface burst would alter significantly the deposition of stem fallout in the damaged area.

Analyses and experiments have been done to assess the effect of well-established fires on fallout deposition from the cloud or from later fallout from upwind detonations. The main experiments were conducted in the low-velocity wind tunnel shown here. Gas burners were used to simulate the fire area and simulated fallout was introduced upwind of the fire near the top of the wind tunnel. As predicted by theory, the fire updraft buoyed up the fallout, causing it to fall much further downwind than otherwise would be the case. There was also much lateral dispersion of the fallout so the effect would be to lower markedly the high dose rates in the downwind area and increase somewhat the lower dose rates over a much larger area.

Other experiments conducted in the mid-1950s showed that rapidly burning fires in already contaminated areas as small as one tenth of an acre resulted in removal of perhaps a third of the deposited fallout, and the removed material was dispersed so that there was no significant concentration in any other region. This process may have some effect in further reducing radiation hazards during firefighting operations.

LOW-VELOCITY WIND TUNNEL USED IN FIRE-FALLOUT EXPERIMENTS*



* From Broido, A., and McMasters, A.W., **The Influence of a Fire-Induced Convection Column on Radiological Fallout Patterns**, California Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, February 1959. (Library of Congress PB 149923)

EFFECT OF DAMAGE ON FALLOUT PROTECTION

The fallout protection afforded by buildings (Panel 18) is estimated on the basis that the roof and surrounding ground areas are uniformly contaminated with fallout and that fallout does not lodge on the sides of the buildings nor do fallout particles penetrate into the interior of the building. In effect, the calculation is made as if the fallout fell vertically onto the surfaces below. In the real world, winds or breezes are blowing near the ground most of the time. If windows were broken or walls blown in, some fallout could penetrate into the interior of buildings.

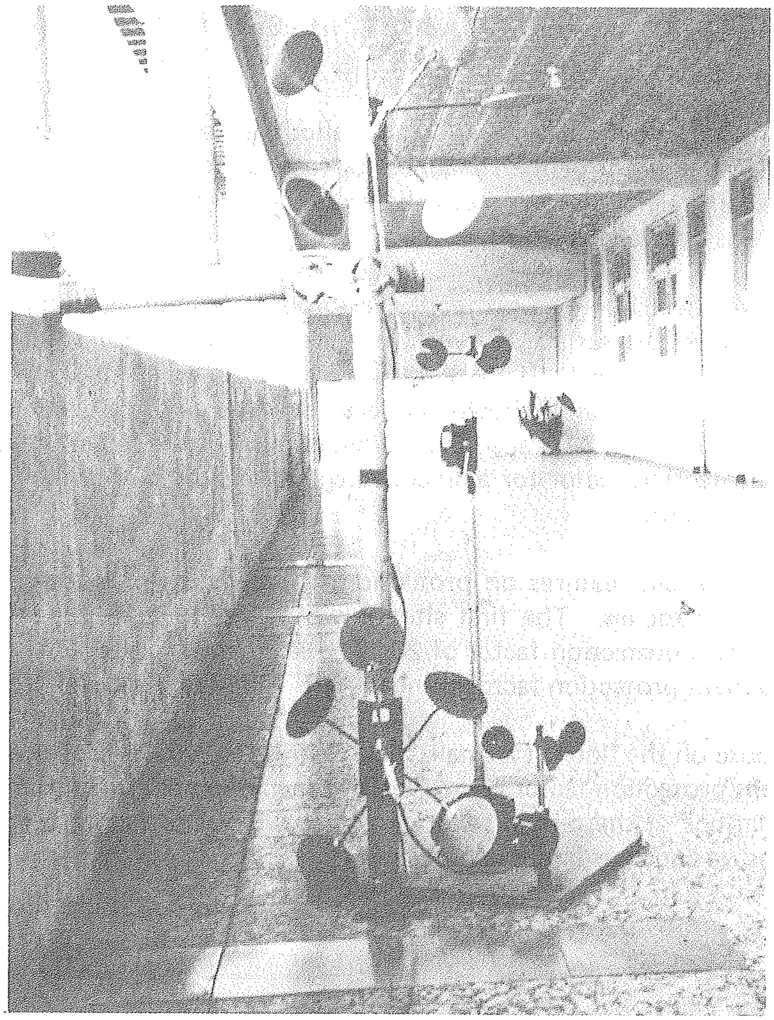
A number of calculations have been made of the effect of "fallout ingress" on the protection afforded by buildings. These estimates have been necessarily highly idealized and are not very useful. The small amount of experimental evidence available does indicate, however, that large reductions in fallout protection are not to be expected in most instances.

The best evidence comes from the volcano fallout in Costa Rica described in Panel 12. Shown here is a fallout situation where most of the wall is open. Visible fallout is concentrated in a band about 20 inches wide below the sill. (The devices shown are for collecting fallout and measuring air movement.) Measurements indicated that the deposition near the sill was about 5 percent of that on the ground in the open and about 1 percent elsewhere in the corridor. Other measurements near smaller open windows indicated deposition near the windows of about 1 percent of the exterior amounts. Calculation of the effect of this amount of ingress on the mid-floors of tall buildings indicate a reduction of about 5 percent in the protection factor (e.g., 38 PF rather than 40 PF). Measurements under covered walkways where both sides were completely open indicated that as much as one-tenth of the outside deposit level could be deposited. Thus, where walls are completely blown in as shown in the upper sketch of Panel 14 in Chapter 2, the protection factor in the middle floors could be reduced by perhaps 10 percent or more (e.g., 35 PF rather than 40 PF).

The deposition of building debris on the floor above basements would tend to increase the protection below in most cases.

The most serious degradation of fallout protection due to blast damage would occur in residential basements and the basements of other lightly constructed buildings under the circumstance where the building is blown clear of the basement (lower sketch in Panel 12 of Chapter 2). Fallout would be deposited in the basement, reducing the protection factor from 20 to 40 down to about 4 or 5. It would be necessary for basement occupants to prop sections of flooring or walls against the basement wall, lean-to fashion, and to cover the lean-to with nearby pieces of masonry for fallout protection. This need is another reason why it may be desirable to plan for group occupancy of residential basements in urban areas rather than single families.

OPEN CORRRIDOR ON THIRD FLOOR OF SCHOOL CONTAMINATED BY FALLOUT-LIKE VOLCANIC DEPOSIT IN COSTA RICA*



* From Clark, D.E., Jr., and Sartor, J.D., **Operation Ceniza-Arena: Techniques for the Measurement of Deposition and Redistribution of Fallout Around Structures**, Stanford Research Institute Project No. MU-5779, December 1966. (AD 647 242)

WHAT ABOUT HILLS?

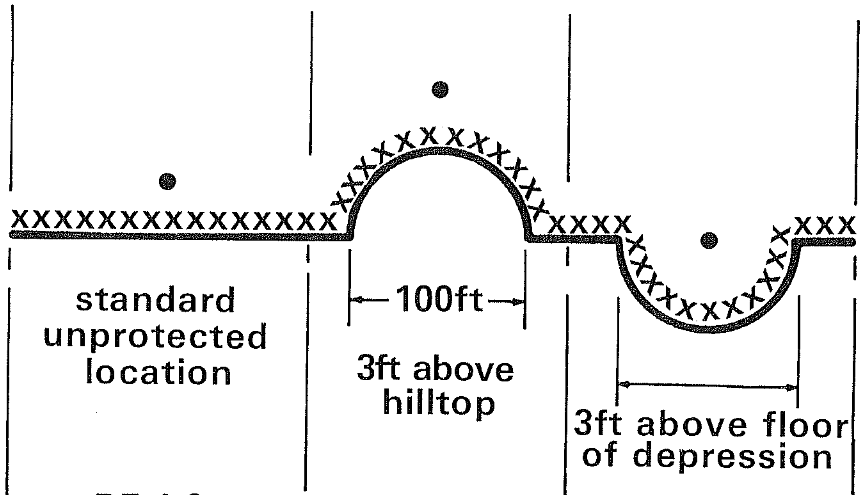
Protection factor calculations assume that fallout is deposited on smooth plane surfaces. In Panel 16, the effect of the roughness of real surfaces was discussed, but again in terms of level terrain. The question might be raised as to the effect of prominent terrain features, such as hills and valleys.

The upper sketches show the protection afforded a person standing in the open on smooth surfaces. When the surface is level, we have the standard unprotected location for which the protection factor is 1. If the person were on top of a small, steep hill that falls away in all directions (the example shown here is a hemisphere with a diameter of 100 feet), the PF is increased to nearly 2 because the hill hides much of the fallout beyond the immediate area. The protection factor for a small, steep depression is not much improved over the infinite-plane situation.

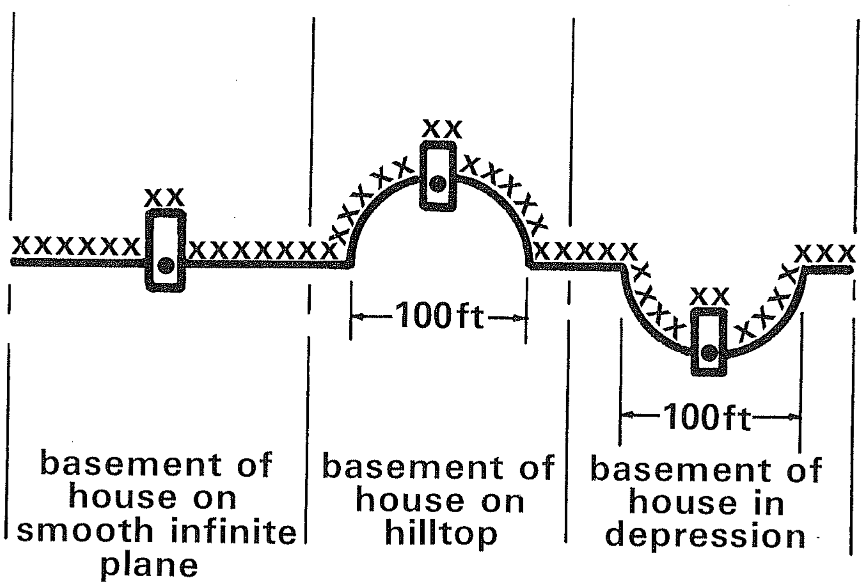
The effect of terrain features on protection in basements is much more marked, as shown in the lower sketches. The first situation shows a home basement on a smooth, infinite plane having a protection factor of 20. The same house on top of a small, steep hill would have a basement protection factor of nearly 70. Many rural houses are built on hills.

The same house on the floor of a small, steep depression would also have a substantially increased basement protection factor. However, not many homes are built in such locations. In general, undulations of the terrain tend to restrict the area of fallout that can contribute to radiation exposure and thus improve protection.

EFFECT OF TERRAIN FEATURES



PF 1.0 PF 1.8 PF 1.2



PF 20 PF 67 PF 50

A NOTE ON DECONTAMINATION

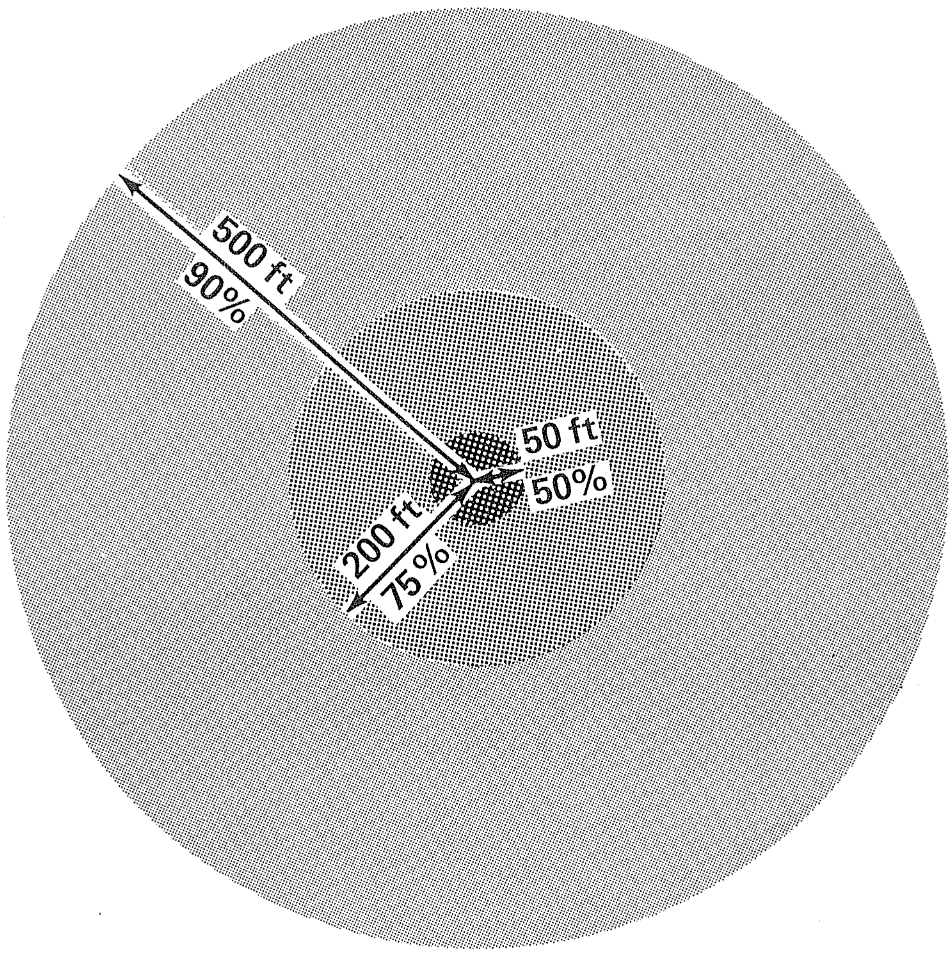
Surfaces on which fallout particles have fallen are called **contaminated** surfaces. Being sand-like material, fallout can be cleaned from most surfaces by readily available means. The process of removing fallout particles from exposed surfaces and disposing them where they cannot harm people is called **radiological decontamination**. Paved areas can be decontaminated with firehoses, street flushers, or with street sweepers. Roofs can be decontaminated with firehoses. Unpaved areas can be decontaminated by scraping off or plowing under the top layer of soil.

As shown in this sketch, half of the radiation received at a point 3 feet above a large, smooth, unbroken surface comes from fallout within 50 feet. On rough surfaces, the area contributing half the exposure is much less. In an area covered with 6 inches of debris, a depth indicated in Chapter 2 as quite common, half the radiation comes from fallout within about 10 feet.

The sketch shows that three-quarters of the radiation comes from fallout within 200 feet on smooth surfaces (100 feet or less on rough or debris-strewn surfaces). But at least 10 percent of the exposure comes from fallout radiation originating many hundreds of feet away. This suggests that, if large reductions of exposure are desired, not only must the work or living area be decontaminated but also a "buffer zone" around it to a distance of several hundred feet in most instances.

For this reason, decontamination as a measure to improve the fallout protection of people in shelter is not generally practical except, possibly, for the sweeping up of visible fallout near broken windows or near entrances to a shelter area. Decontamination can be important, however, in speeding postattack recovery in fallout areas. Hence, decontamination is covered in more detail in Chapter 8.

DOSE CONTRIBUTION vs DISTANCE



WHAT ABOUT BOATS?

The fact that a large part of the radiation from fallout comes from contaminated areas a considerable distance away has suggested that boats and ships located on bodies of water (lakes, rivers, and bays) might provide good fallout protection. Fallout particles will settle rather quickly to the bottom. Three to five feet of water will provide ample shielding from this fallout. Thus, if a boat is anchored or lying at least several hundred feet offshore, nearly all of the radiation exposure will come from fallout actually deposited on the boat. Most fishing and pleasure boats are quite small, and the protection factor from being on the water would be about 4 or 5, better than in a house but not as good as most home basements.

The protection can be greatly improved by rigging a tarpaulin or awning over cockpit areas and shaking or sluicing the canvas to dislodge the fallout particles when visible deposits appear. Exposed decks can also be sluiced by hose or bucket. Thus, a combination of lying offshore and early decontamination can generally result in an equivalent protection factor of 20 to 40. If no better fallout protection is available, boats may be considered in localities where they are plentiful.

Ships may also be useful in many circumstances. They can carry large numbers of people. Because they are larger than boats, the radiation levels from fallout deposited on the decks more nearly approaches the level that would occur on shore. The steel construction will offer significant shielding but prompt decontamination is also necessary to achieve a reasonable amount of fallout protection. The topside areas of ships are readily flushed off. Most naval ships and some merchant ships have washdown equipment to accomplish rapid decontamination. A washdown system in action is shown here.

PHOTOGRAPH OF USS KITTY HAWK UNDER WASHDOWN
(Courtesy of Office of Chief of Naval Operations)

PANEL 36

FACTS ABOUT RADIATION AND FALLOUT

During the average lifetime, every person receives about 10 Roentgens of ionizing radiation from nature and about an equal amount additionally from dental and chest X-rays and even the luminous dials of wrist watches. Yet radiation effects and fallout remain mysterious and misunderstood threats to both the average citizen and government employee. Emergency planning should include informing the public on the basic facts shown here if an unwarranted paralysis of action during a fallout emergency is to be avoided. The basis for these statements is contained in the panels of this chapter and those of Chapter 5.

SOME BASIC FACTS

1. Everyone receives some radiation exposure in peacetime. It is when large doses are absorbed in a short period that sickness or death results.

2. Radiation sickness is neither contagious nor infectious. But people made sick by radiation are temporarily more susceptible to infection.

3. Radiation exposures that cause sickness are much lower than those that cause death. Being sick does NOT indicate that one is necessarily going to die.

4. Fallout radiation cannot make anything radioactive. Fallout itself consists of sand-like particles too large to be inhaled.

5. Dangerous amounts of fallout can generally be seen but special instruments are needed to measure the danger of radiation exposure.

6. Radiation exposure can be kept below sickness levels by using good fallout shelter; by delaying outside activities until decay has reduced the exposure rate; and by limiting the time of exposure on urgent tasks.

7. No one should thirst or starve for fear of contaminated water or food. Illness can be caused as readily by malnutrition and poor sanitation as by radiation injury.

SUGGESTED ADDITIONAL READING

The following sources provide additional background on the material in this chapter:

Effects of Nuclear Weapons, Revised Edition 1964, Glasstone, S., (editor), Chapters 1, 2, 6, 9, 10, and 11, Superintendent of Documents, GPO.

National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

Miller, C.F., **Fallout and Radiological Countermeasures, Volumes I and II**, Stanford Research Institute, January 1963. (Vol. I—AD 410 522, Vol. II—AD 410 521)

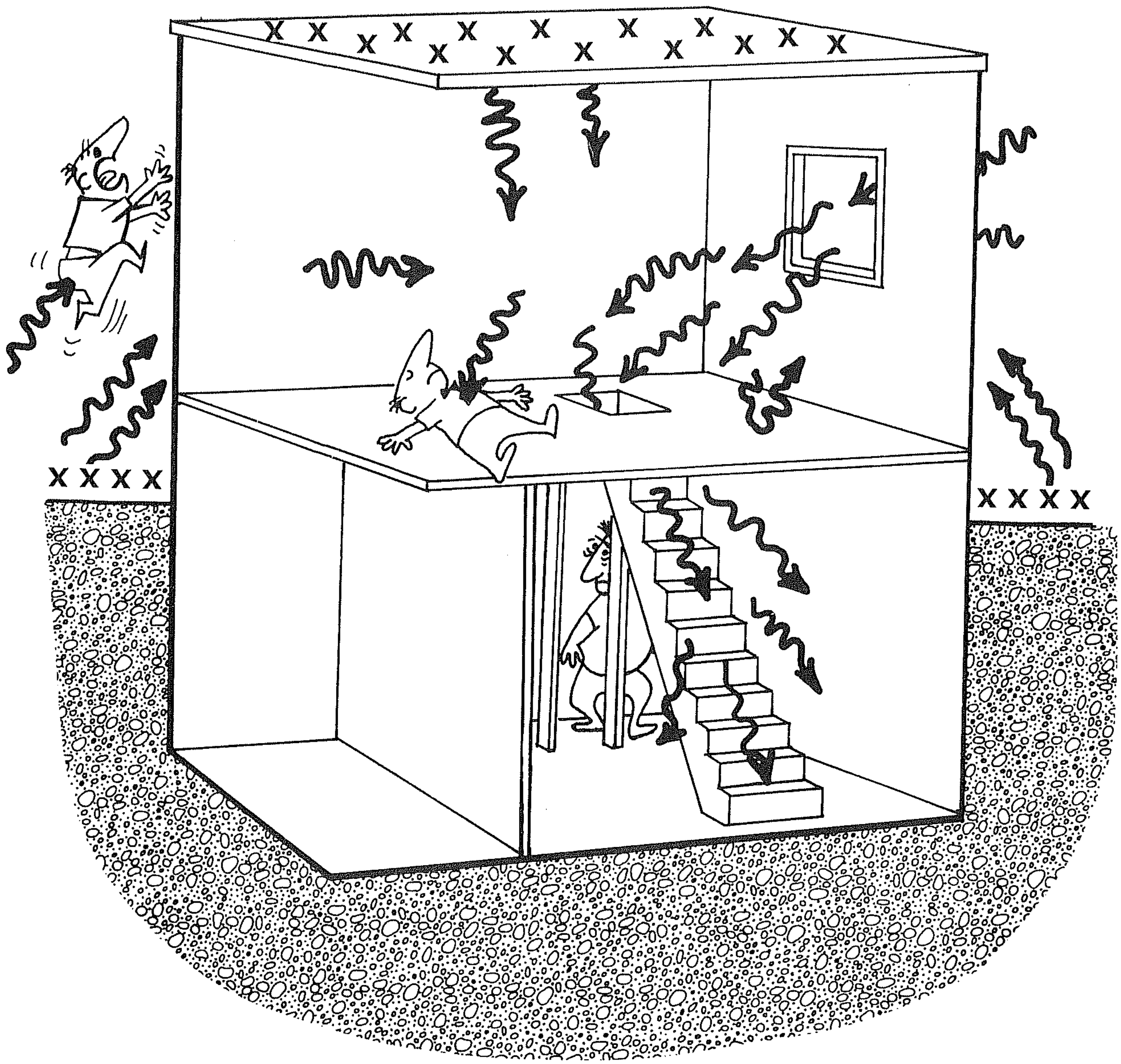
Casarett, A.P., **Radiation Biology**, Prentice-Hall, 1968.

Upton, A.C., **Radiation Injury: Effects, Principles, and Perspectives**, University of Chicago Press, 1969.

Bensen, D.W., and Sparrow, A.H.,(editors), **Survival of Food Crops and Livestock in the Event of Nuclear War**, No. 24 of AEC Symposium Series, CONF-700909, December 1971.

Radiological Defense Textbook, SM-11.22.2, Office of Civil Defense, June 1968.

Radiological Health Handbook, U.S. Department of Health, Education and Welfare, Public Health Service, Rockville, Maryland 20852, January 1970.



PANEL 38

CPG 2-1A7
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 7

WHAT THE PLANNER NEEDS TO KNOW ABOUT THE SHELTER ENVIRONMENT

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 7

This discussion of the shelter environment is aimed at the emergency planner rather than the person who has shelter management experience or training. It is assumed that the reader is familiar with the attack environment information presented in the six preceding chapters.

Information is presented in the form of "panels" each consisting of a page of text and an associated sketch, photograph, chart, or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 7 shown opposite. If the graphic portion is converted to slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with an introductory panel, followed by nine panels addressed to the basic needs, in addition to protection against the attack environment, that must be satisfied if people are to survive in shelters for an extended period of time. There follow three panels describing the various kinds of shelters that might be available. The next five panels discuss how the basic needs described earlier are to be met in shelters in ordinary buildings built for peacetime purposes. Seven panels deal with the survival actions required when attack effects occur. There are three panels concerned with prolonged shelter occupancy and preparations for leaving the shelter. Finally, three panels discuss the need for trained leadership and shelter use plans. A list of suggested additional reading is included for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 7

"WHAT THE PLANNER NEEDS TO KNOW ABOUT THE SHELTER ENVIRONMENT"

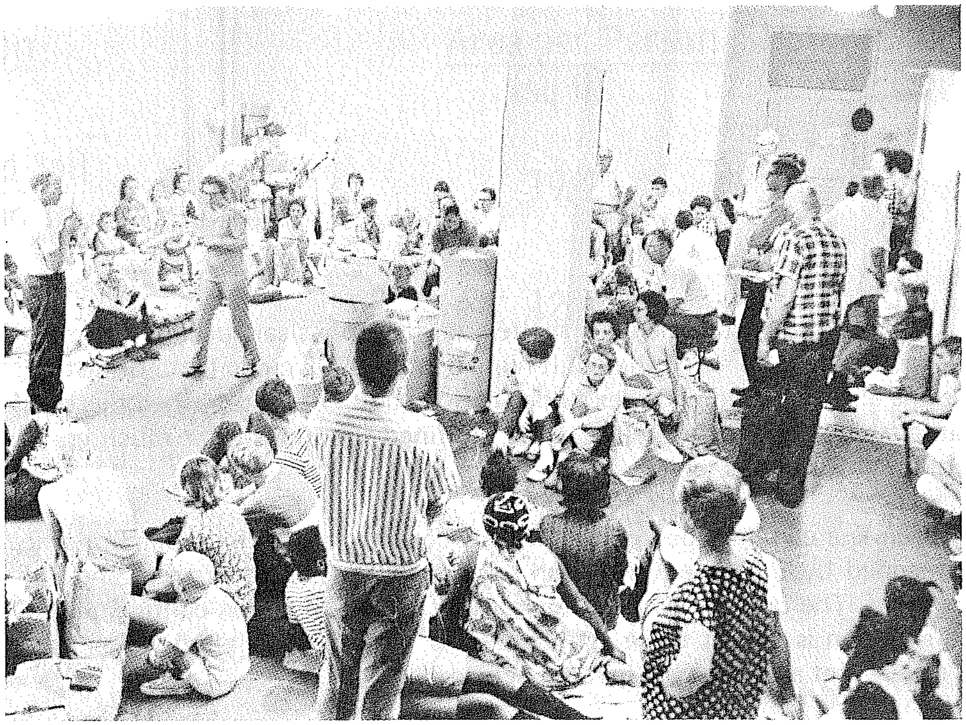
THE SHELTER ENVIRONMENT

Shelter plays the central role in protecting people from the hostile environment created by a nuclear attack. This is true whether one is remote from the scene of nuclear detonations (fallout risk) or nearby (all-effects risk). But shelters must do more than shield from weapons effects. They must provide a habitable environment from which the survivors can later emerge in good condition to deal with the postattack world. Moreover, if people are to use shelters when warned of attack, they must believe that shelters will protect and that shelters will be livable. In earlier chapters, the best available areas for protection from weapons effects have been identified. In this chapter, the environment in shelter will be described.

Some of the conditions to be expected in shelter are the result of physical characteristics. Some are due to the behavior of people. The physical and behavioral aspects are closely related. There is much shelter experience from past wars although few, if any, Americans have had this experience. Shelters have also been used in many natural disaster situations. In both wartime and disaster situations, sheltering has been necessary for only a few hours to a few days. Fallout (see Chapter 6) presents a persistent threat that might require shelter for many days to several weeks. This need for prolonged occupancy introduces a new dimension that past wartime shelter experience does not address.

Thus, one of the first questions asked was whether American citizens (men, women, and children) could or would endure the confinement of a shelter for a period as long as two weeks. The answer obtained in early experiments was an emphatic "Yes." Actually, most of the volunteers for these experiments enjoyed the experience and said they would volunteer again. In part, this response was due to the inclusion of creature comforts, such as bunks, prepared foods, furniture, good sanitary facilities, and the like. It was not until the mid-1960s that shelter-living experiments were made sufficiently austere and uncomfortable that a significant proportion of volunteers decided to leave during the experiment.

By 1968, nearly 7,000 volunteers had participated in over 22,000 man-days of shelter living in occupancy tests ranging from family size to over 1,000 people and for periods ranging from one to 14 days. The results have been used in training materials for shelter manager courses, during which an additional 90,000 have gained some shelter experience. In this chapter, we will summarize the important facts that the emergency planner should know and that should be communicated to local officials and the public.



SHELTER ENVIRONMENT*

SCENE IN SHELTER EXPERIMENT IN
WHICH 722 MEN, WOMEN, AND CHILDREN PARTICIPATED

*Hammes, J.A., et al., **Shelter Occupancy Studies at the University of Georgia**, 1968 (AD 688 099).

SPACE

An elemental requirement in shelters is mere physical space for human occupancy. The approximate volume of the adult human body is 2.3 cubic feet. In history, there have been some alleged crowding for extended periods that have approached this space allocation —in slave-trade ships, for example. Most confined situations offer much greater space per person, as shown in this table.

Prison is a common peacetime form of confinement. The minimum space allotment recommended by the American Prison Association is 38.5 square feet and 287 cubic feet per prisoner. The table is headed by a crowded version of prison confinement. This crowded jail situation is almost twice as "roomy" as the DCPA standard shelter space allotment of 10 square feet and 65 cubic feet per person.

And yet, the DCPA shelter standard is spacious compared to other (and particularly wartime) experience. European nations that have had such experience currently recommend one-half square meter (about 5.4 square feet) as a minimum and have conducted occupancy tests at this allotment. World War II experience in shelters and prisoner-of-war camps was even more confining.

An implication for emergency planning is that the DCPA recommended shelter space allotment of 10 square feet of usable space per person is a desirable goal but not a practical minimum. Reduced space allotments up to one-half the standard are practical where suitable shelter space is inadequate to serve the population.

AVAILABLE SPACE IN SELECTED SITUATIONS

Situation	Area per Person (sq ft)	Volume per Person (cu ft)
Crowded Jail (two men in one-man cell)	19.2	145
Railroad Coach (60 seated passengers)	12.0	96
100-person, Two-week Shelter experiment, NRDL 1959	12.0	117
DCPA Standard	10.0	65
30-person, Two-week Shelter experiment, AIR 1960	8.0	58
Civil War Prison	8.0	40
Local Bus filled to seating capacity only	6.3	42
160-person, Two-day Shelter experiment, U. of Ga. 1966	6.0	60
West German five-day shelter experiment	5.5	--
Swedish recommended shelter minimum	5.4	--
London WWII shelter sleeping 200 people	4.0	30
Belsen Concentration Camp barracks WWII	3.0	22
Black Hole of Calcutta	1.7	22

PANEL 2

AIR

Air quality is essential to human life. The need for oxygen for breathing is well known. Fresh air contains about 21 percent oxygen. No noticeable or harmful effects occur should the oxygen content drop as low as 14 percent. At 10 percent, people experience dizziness, shortness of breath, deeper and more rapid respiration, and quickened pulse. At 7 percent, stupor sets in and about 5 percent oxygen is the minimum concentration compatible with life. However, only a small amount of fresh air is needed to keep the oxygen concentration in the safe region. For example, 0.4 cubic feet of fresh air per minute per person will maintain the oxygen concentration at 17 percent. If each person is allocated 65 cubic feet of volume (the DCPA standard), one air change in the shelter every two and one-half hours would be sufficient.

A more serious problem is the increase in carbon dioxide concentration. Each person, on the average, exhales about two-thirds of a cubic foot of carbon dioxide every hour while at rest. If ventilation is inadequate, the carbon dioxide can increase markedly over the 0.04 percent present in fresh air. The consequences of higher concentrations are shown in this table.

Many years ago, 3 percent carbon dioxide was considered a permissible limit. Experience on submarines and experiments under prolonged exposure have indicated the desirability of keeping the carbon dioxide concentration below 1 percent. For civil defense purposes, the goal has been to limit the buildup of carbon dioxide in shelters to not more than 0.5 percent of inhaled air. This limit requires about 3 cubic feet of fresh air per minute per person. Again, if each person is allocated 65 cubic feet of air space, this would require a change of air every 22 minutes. In other words, the amount of fresh air needed to limit the carbon dioxide concentration will also keep the oxygen supply at normal levels.

An alternative to supplying sufficient fresh air is to provide other means for assuring air quality, such as bottled oxygen and materials for removing the excess carbon dioxide from the air. Such means, which are used on submarines, spacecraft, and the like, are quite costly. Ventilation with fresh air will be the usual practice in shelters. No special filters are necessary to exclude fallout as the particles are too large to be breathed or to be drawn in and deposited in sufficient quantity to alter the fallout protection afforded by the shelter area.

EFFECTS OF CARBON DIOXIDE*
(Oxygen Content Normal)

Carbon Dioxide Content of Inhaled Air (percent)	Effects
0.04	Normal air; no effects.
2.0	Breathing deeper, volume increased 30 percent.
4.0	Breathing much deeper; rate quickened; considerable discomfort.
4.5 - 5	Breathing extremely labored; almost unbearable for many; nausea may occur.
7 - 9	Limit of tolerance.
10 - 11	Inability to coordinate; unconsciousness in 10 minutes.
15 - 30	Diminished respiration; fall of blood pressure; coma; gradual death after some hours.

*From Soloman, T., **Systematic Action of Gases—A Manual of Pharmacology**, W.B. Saunders Co., Philadelphia, 1948.

TEMPERATURE CONTROL

In addition to using up oxygen and exhaling carbon dioxide, each shelter occupant gives off heat—about 500 BTU per hour. [Recall from Chapter 3 that a BTU (British Thermal Unit) is the amount of heat necessary to raise the temperature of a pound of water 1 degree Fahrenheit.] Several hundred people congregated in a shelter produce the heat output of the heating system of an average home.

Part of the heat given off by the body is "sensible" heat—warmth as would be measured by a thermometer. Part is water vapor or evaporated moisture. This is called "latent" heat in that sensible heat is produced only when the water vapor condenses on a cool surface. Actually, a person's sensation of heat or cold is related not only to the air temperature, as measured by a thermometer, but also to air moisture (humidity) and air movement. So long as the air temperature is well below skin temperature, the body can radiate heat to maintain normal body temperature. At higher temperatures, the body must rely on evaporative cooling by perspiration. If the air is humid and air movement low, evaporative cooling loses its effectiveness and the body temperature will rise. The upper limit of body temperature for survival is 108—110°F. The loss of life in the Black Hole of Calcutta incident (Panel 2) was not caused by lack of space but by lack of temperature control.

The most widely-used measure of the effects of heat and moisture on the human body is "effective temperature." It combines the effect of air temperature, air moisture, and air movement to yield equal sensations of warmth or cold and approximate equal amounts of heat strain. The effects on people of the temperature and humidity conditions represented by effective temperature (ET) are shown in the table.

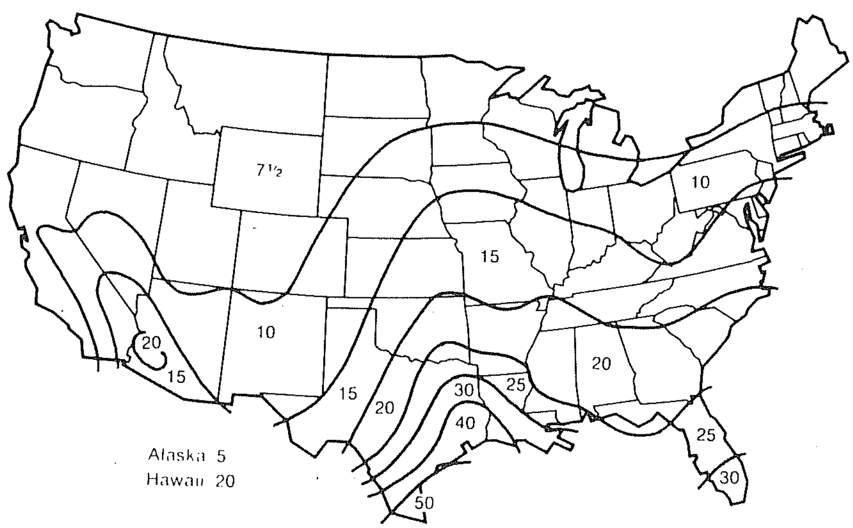
The numerical value of ET is the reading on an ordinary thermometer when the air is completely saturated with moisture (100% relative humidity). At lesser humidities, the thermometer reading would be higher than the equivalent effective temperature. For a relative humidity of less than 50 percent, which is a common summertime climatic condition, an effective temperature of 82 degrees would correspond to air temperatures in the mid-90s. An effective temperature of 82 degrees approximates the condition under which the Federal Government sends people home who work in non-air-conditioned offices. It is also the design limit established by DCPA for the shelter environment.

Even where buildings offering shelter protection are air-conditioned, prospective crowding of people and probable lack of electric power indicate that temperature and humidity control must be accomplished by ventilation with fresh air. The map shown here defines the zones of required ventilation (in cubic feet per minute per person) to provide 90 percent reliability of maintaining the shelter effective temperature at 82 degrees or less. It can be seen that the required ventilation rates are all greater than the 3 cubic feet per minute per person needed to control the buildup of carbon dioxide.

EFFECTS OF HEAT AND HUMIDITY
(for low air movement)

Effective Temperature	Sensation	Reaction	Consequences
50–60	Uncomfortably cold	Shivering	Muscular pain; impairment of circulation
60–70	Cool	Urge for more clothing or exercise	Normal health
70–75	Comfortable	Normal heat regulation	Normal health
75–82	Warm	Regulation by sweating	Normal health
82–85	Uncomfortably hot	Increasing stress and dehydration	Cardio-vascular strain
85–90	Very uncomfortable; Very hot	Increasing stress	Danger of heat stroke
90–95	Limited tolerance	Failure of regulation; body heating	circulatory collapse

ZONES OF EQUAL VENTILATION RATES IN CFM PER PERSON FOR 90 PERCENT RELIABILITY OF NOT EXCEEDING 82° ET



WATER

If people are to be confined in shelter more than a few days, drinking water is an essential requirement. Water is a major component of the body, accounting for about 60 percent of a person's weight. But water is by no means a static component; it moves in and out of the body at the rate of more than five pounds a day normally. It is the fluid vehicle for body waste, which is filtered from the blood by the kidney. Water is also evaporated from the skin as a means of losing body heat.

When water intake is restricted or negligible, the bodies of healthy people compensate first by reducing the amount of urine excretion by about half, from about three pounds (pints) in adults to about 1½ pints. Unless people are required to perspire to lose body heat, about one quart of water a day suffices to maintain the water balance. If the shelter temperature is warm, however, the amount of water needed to avoid dehydration increases rapidly, as shown in the chart. This is another reason to be concerned about temperature control in shelters.

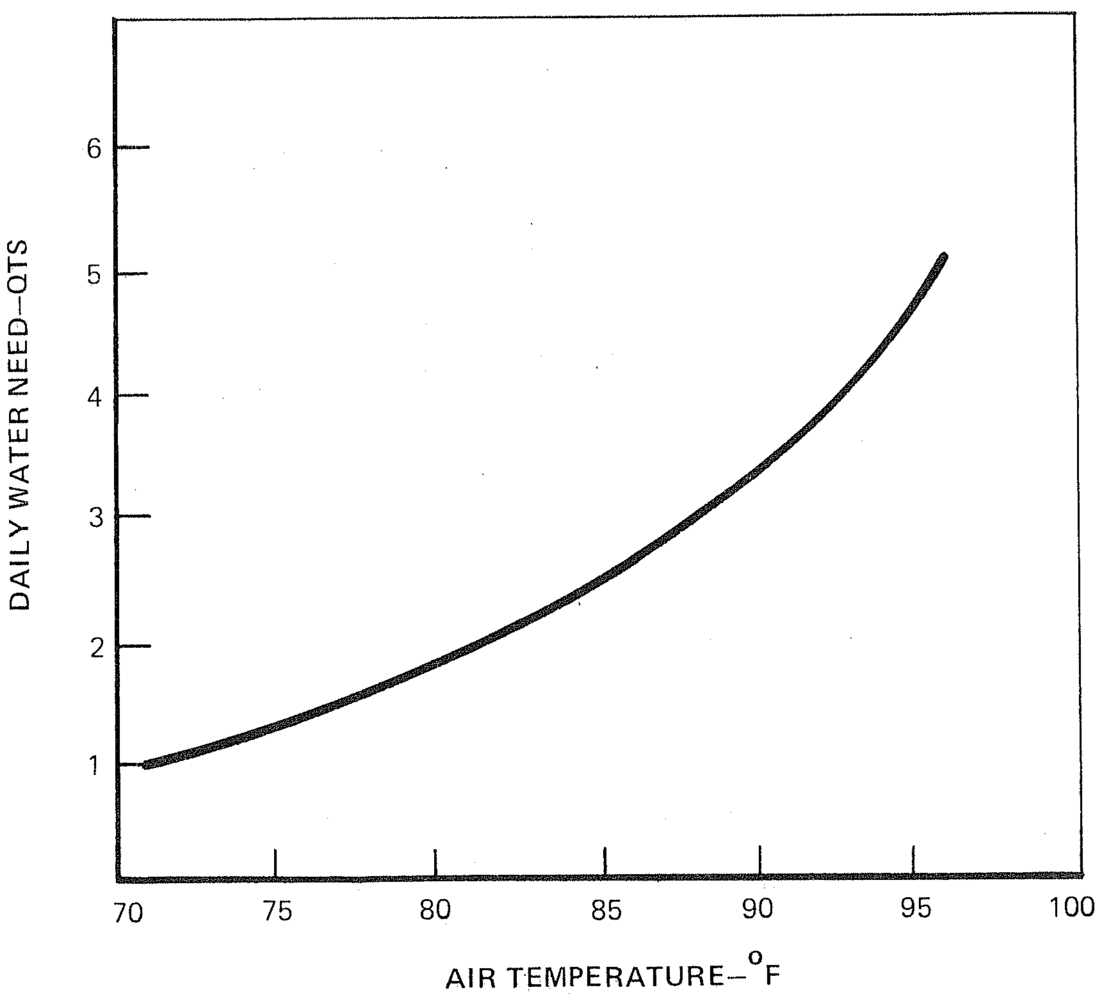
Water deficiency begins to cause trouble as soon as one or two percent of the body weight is lost. Thirst, the earliest symptom, is followed by behavioral changes—a sense of oppression, impatience and emotional instability, and, in some, weariness and apathy. Severe symptoms, such as heat exhaustion, headache, labored breathing, and increasing weakness, occur when six to ten percent of body weight has been lost. Delirium and death result from greater dehydration.

Experiments have shown that the consequences of dehydration vary widely among individuals, with the very young, very old, and ill being especially vulnerable. Pregnant women, for example, require more water than normally and must avoid dehydration if injury to the unborn child is to be avoided. Experiments have also shown that there is nothing to be gained by stretching out an inadequate water supply to cover a presumed shelter stay. Health is best maintained by delaying any dehydration as long as possible. Therefore, water management in shelters **should be aimed at ensuring adequate intake and preventing waste rather than at rationing the available supply,** particularly since there is no way to determine a "fair share" for each man, woman, and child except by satisfying thirst.

Water for washing has been shown to be an amenity and not a necessity, even for extended shelter stays.

MINIMUM WATER REQUIRED FOR NEGLIGIBLE DEHYDRATION

(APPROXIMATE AVERAGE FOR MEN, WOMEN, and CHILDREN)



PANEL 5

SANITATION

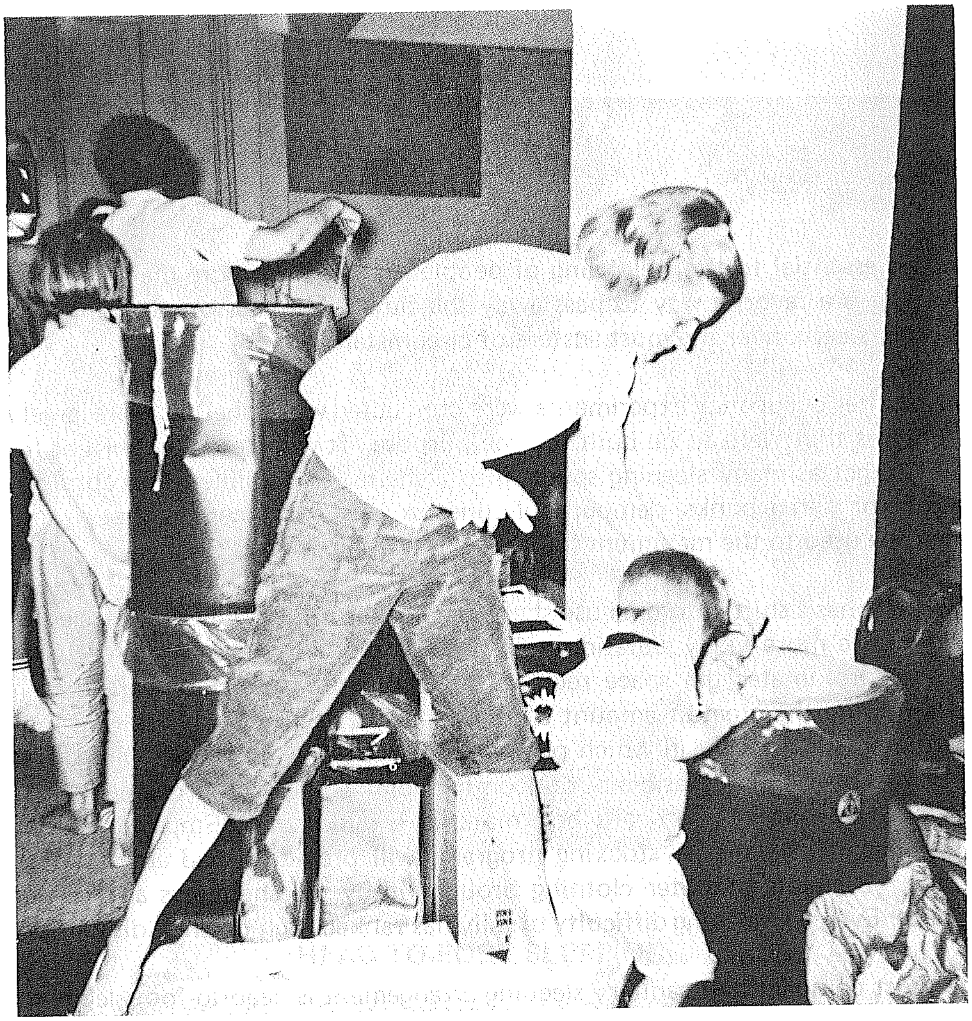
Minimal sanitary arrangements are also necessary in a shelter. At the very least, some sort of toilet facility must be available. If continued operation of conventional flush toilets cannot be assured, containers for collecting and storing human wastes must be provided. As a rough rule of thumb, waste storage capacity must be able to handle about one-half gallon of sewage per person per day.

Closely associated with availability of toilet facilities is the need for privacy arrangements. If conventional toilets are not available, existing closets or partitions may be adapted for the purpose. In open shelter areas, enclosures may need to be created by stacking of furniture or supplies.

Many shelter occupancy tests have been conducted in which no water has been provided for washing. While this demonstrates that bathing is not a necessity, the lack of water for personal hygiene has invariably ranked No. 1 or No. 2 in the list of discomforts encountered in shelter. Moreover, some provisions of this sort are essential for those engaged in food handling and sanitation activities.

Another aspect of shelter living that ranks high on the "discomfort index" is dirt. Substantial amounts of litter and trash tend to accumulate in a crowded shelter. Lack of janitorial supplies can contribute significantly to this sanitation problem.

One problem that prospective shelterees anticipate would cause great discomfort is odors. Yet odors have never ranked very high among the discomforts experienced. When they are remarked at all, they are usually associated with toilet facilities of the container type. The reason is that the olfactory organs quickly become dulled and the odors are not noticed except by persons entering the shelter from the fresh air. One exception is stale cigarette smoke, which is unpleasant even to smokers.



SANITATION*

EMPTIED WATER DRUM BEING USED FOR TRASH

*Hammes, J.A., et al., **Shelter Occupancy Studies at the University of Georgia**, University of Georgia, 1968 (AD 688 099)

PANEL 6

SLEEP

Sleep is essential to the well-being of people confined for more than a day or two. Indeed, sleeping is a favorite way to pass away the time. And, fortunately, most people are able to nap or sleep under the most austere of circumstances.

Early shelter occupancy experiments were conducted when shelters were largely thought of as structures that were to be built for the purpose. It was clearly important from a cost standpoint to get as many sleeping spaces into a shelter as possible. This consideration led to provision for tiered bunks, demountable ones in most instances, so that all the available space might be used to the maximum for both day and night activities.

When emphasis shifted to dual-use shelters, largely in existing buildings, sleeping on the floor became the more likely situation. The DCPA standard shelter space of 10 square feet per person approximates the space required by the recumbent adult person. The shelter function requiring the greatest amount of floor space is sleep. Many experiments have now been conducted successfully in which people sleep upon the floor. Sleeping on a bare concrete floor has been found feasible but uncomfortable. A major improvement occurs where carpeting exists or when fiberboard box material is laid down. Emptied fiberboard food boxes, supplied in the shelter stocking program, will provide a pad about 6 feet long by 2 feet wide. Blankets or outer clothing brought in by the shelterees also can be used as sleeping pads. Even so, sleeping difficulty usually has ranked high on the "discomfort index."

The most compact and sanitary sleeping arrangement is head-to-foot sleeping as shown in this photograph. A recommended practice is to locate single men on one side of the shelter area and single women on the other, with family groups in between.

Noise is a shelter characteristic that is closely related to sleeping difficulty. Noise levels during waking hours in shelter experiments have been found to range from 50 to 85 decibels; that is, from the noise level associated with a business office to that inside an automobile. The psychological pressure of noise is such that shelterees welcome occasional "quiet periods" during the day. Therefore, if only a single open space is available, all people should observe the same sleeping hours. When separate rooms are included in the same shelter area, shift sleeping can be considered. This usually results in more individual sleeping space and less crowded areas for non-sleeping activities.

HEAD-TO-FOOT SLEEPING

(NOTE USE OF FIBERBOARD FOR SLEEPING PAD.)

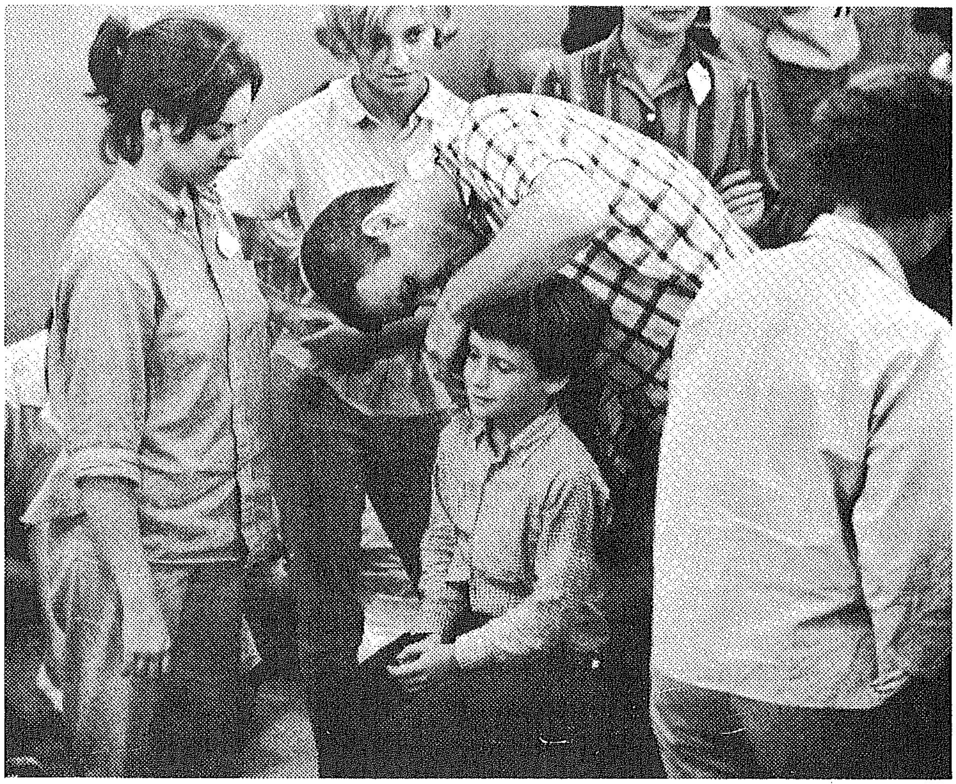
HEALTH

The medical problems of a shelter are three-fold: (1) the chronic illnesses, such as diabetes or heart ailments, with which some proportion of the population is afflicted; (2) the possible spread of communicable diseases, respiratory infections, and other illnesses; and (3) the injuries and illnesses caused by the attack environment.

Natural disaster experience has demonstrated that many chronically ill persons, who are dependent on continued medication with specialized medicines, enter shelters established for evacuated flood or hurricane victims without these essential medical supplies. The problem apparently is caused by a last minute decision to leave their homes. In natural disasters, alternative sources are usually available, but in the nuclear attack situation, the lack of on-hand drugs could have serious consequences. Current civil defense educational materials emphasize the importance of bringing such supplies to the shelter. But plans should be made for **crisis information** to reinforce this need.

Minimizing the spread of disease or infection in crowded shelters requires constant attention to sanitation measures, cleanliness of toilet areas, careful handling of water and food, and establishment of a sick bay or isolation area for persons who are ill. These are management problems. In addition, minimal medical supplies to treat headaches, respiratory symptoms, and waste elimination difficulties should be available. It would be ideal if every shelter had a doctor or nurse assigned to it and, to the extent possible, emergency plans should attempt such assignments. In many cases, competent medical assistance will not be available. The next best solution is to train citizens in emergency health care. Over 17 million people have completed the Medical Self-Help Training Course available to localities through the State Public Health Office. A reasonable readiness goal is to train one person in each family through this course.

Medical care for persons injured by attack effects is discussed in Panel 18. But minor cuts and bruises can occur in a shelter not suffering attack effects. Therefore, a modest supply of bandages and antiseptics should be available in any event.



MEDICAL CARE

SICK CALL IN A SHELTER OCCUPANCY TEST

FOOD

Food is near the end of the list of essential shelter needs. Healthy individuals should be physically able to survive a several-week shelter stay without any food. If shelterees are expected to participate in post-shelter recovery operations, however, they will require food during the confinement period. Moreover, food has tremendous emotional significance and failure to provide what is commonly perceived as a basic need can make the keeping of people in shelter very difficult.

What foods should be provided in or brought to a shelter is more than a matter of taste. Foods high in protein and fat greatly increase the amount of drinking water required to eliminate wastes. At the same time, a diet composed entirely of carbohydrates is undesirable. Heating or cooking of foods adversely affects temperature control, requires an assured source of heat, and usually constitutes a potential hazard in a crowded shelter. Foods that require cooking or eating utensils or that produce garbage or trash offer sanitation problems, unless special facilities exist in the shelter area. In the shelter stocking program, where long shelf-life is needed in addition to the foregoing, DCPA has provided a baked whole-wheat cracker and a fruit-flavored hard candy that meet these requirements. Augmentation by food products that are mostly liquid is desirable, provided glass containers are avoided. Broken glass is a hazard in crowded shelters.

SHELTER RATIONS

DISPENSING "SHELTER BISCUITS"

PANEL 9

LIGHTING

Some lighting is essential for effective shelter operations. Providing light is assuming greater importance in view of the increased emphasis on use of basement areas and the recognition that attack effects, such as EMP (Chapter 4), make loss of commercial electric power a widespread possibility.

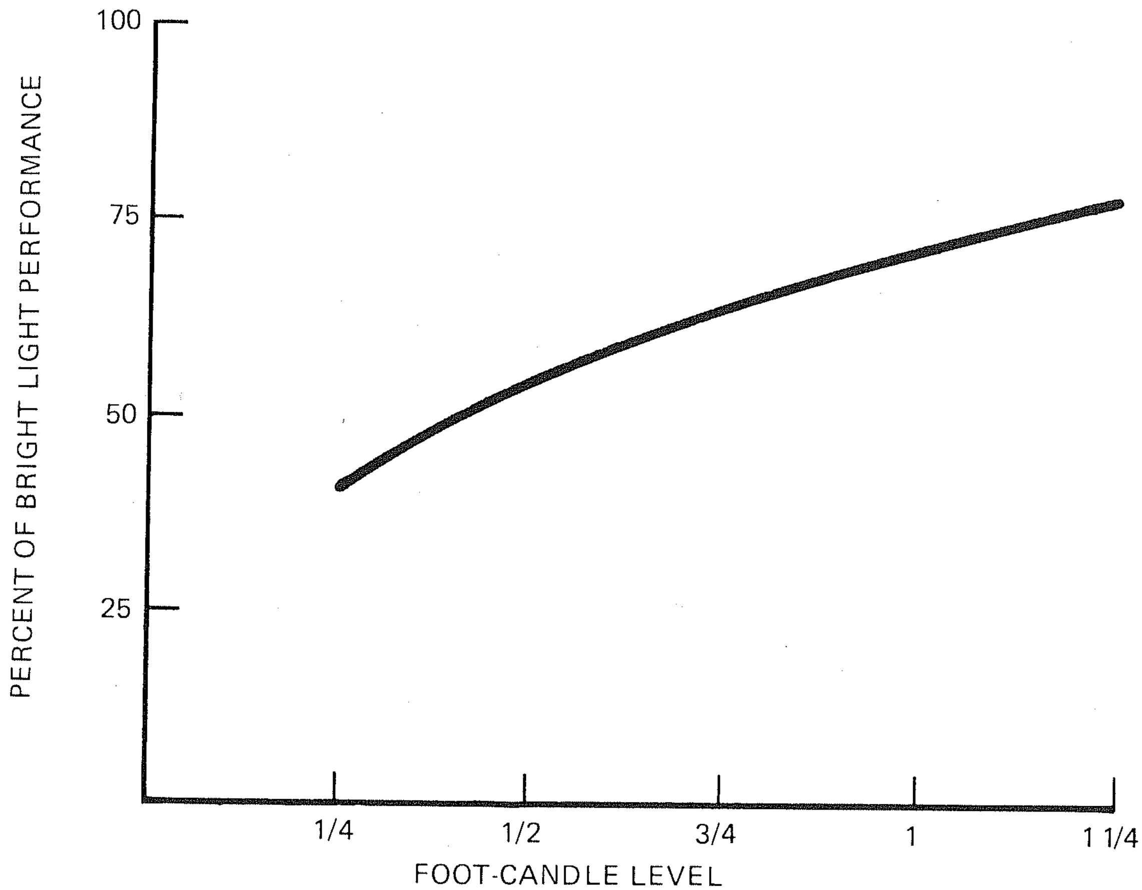
General lighting should provide a sufficient level of illumination for movement about the shelter and performance of shelter tasks. A higher level of illumination may be necessary for special functions, such as medical treatment, reading instructions, and equipment maintenance. The measure of illumination is the foot-candle. Recommended emergency lighting levels range from two foot-candles in sleeping areas to five foot-candles for general lighting to twenty foot-candles for medical treatment and equipment maintenance.

Shelter experiments have been performed, however, at very much lower lighting levels. Tests of visual acuity and performance tests, such as needle threading, nut, washer, and bolt assembly, and newspaper reading, showed that ordinary tasks, such as food preparation, reading, and sewing, could be performed at lighting levels as low as ¼ foot candle. Depth perception was one faculty most reduced by low levels of light. Shown here is the average performance of a group of tests as compared with performance in bright (45 foot-candles) light.

One example of low illumination levels commonly encountered is moonlight, which provides about 0.02 foot-candle. A dark motion picture theater provides about 0.2 foot-candle while the picture is being shown. A well-lighted business street provides about 2.5 foot-candles.

One shelter test involving 15 people has been conducted without any light whatsoever. The volunteers realized they would be spending a 24-hour period in total darkness and apparently adjusted very well. None requested to leave before completion of the experiment. Food and water preparation were done quite adequately by inexperienced people although they often needed "hints" from more experienced members of the group. The shelterees, expecting darkness, found shelter existence in the dark to be less uncomfortable than they had anticipated. Entering the dark shelter initially was the most upsetting experience. Light of some kind would seem desirable upon entering the shelter and during the initial setting up of shelter supplies, particularly in the absence of trained leadership.

AVERAGE PERFORMANCE UNDER LOW LEVELS OF LIGHTING*
(compared to 45 foot-candle level)



*Smith, M.C. and Wendel, W.J., **Illumination in Group Shelters,** Sanders and Thomas, Inc., January 1963 (AD 404 090).

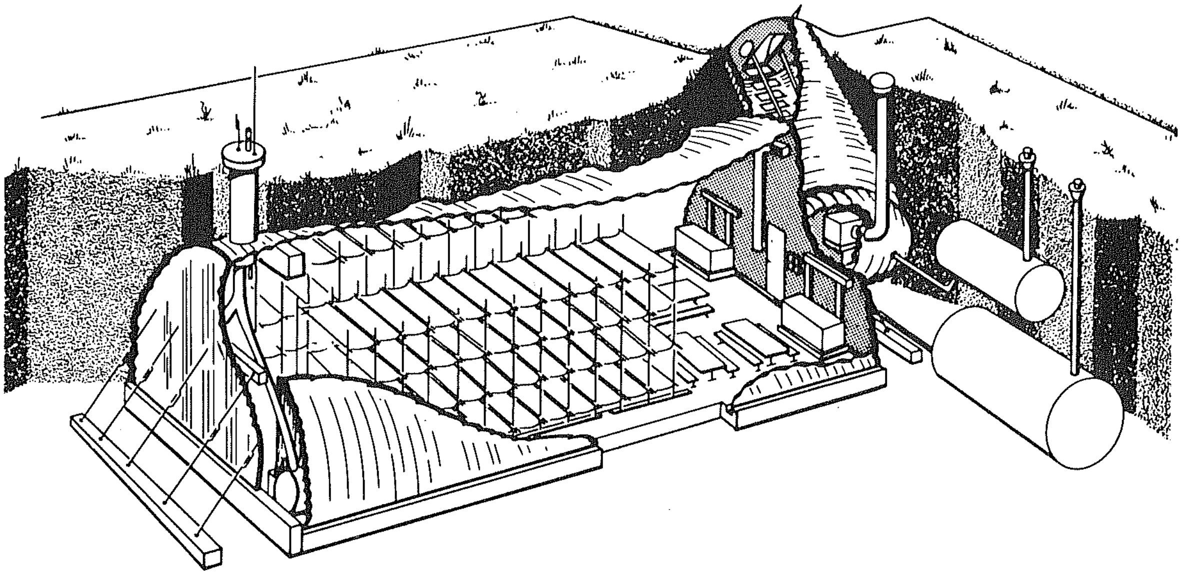
SINGLE-PURPOSE SHELTERS

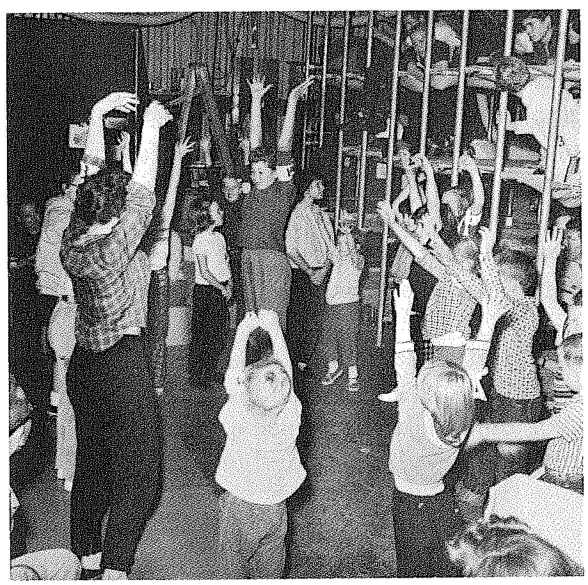
If shelters are built for the purpose, it is relatively easy to provide not only protection against attack effects but also the essential elements of a habitable shelter environment. Many such single-purpose shelters have been designed and a few have been built and tested. The designs cover a variety of sizes, construction materials, and degrees of protection.

One example of a single-purpose shelter is shown here. It uses a corrugated steel arch building buried below ground. Space is available for at least 100 persons. Buried tanks alongside the shelter provide an ample water supply and a fuel supply for the emergency generator, which provides an assured power supply for ventilation and lighting. Tank-type toilet facilities are provided at the rear of the shelter area near the combination air-exhaust and emergency escape hatch. Demountable stretcher-type bunks are provided for the whole shelter population as well as tables and benches in the food preparation area. The photograph shows the shelter occupied by 100 men, women and children. The shelterees have decided to leave half the bunks in place during the daytime.

Although many single-purpose shelters have been constructed for operational use as emergency control centers, very few have been constructed to shelter the population. Most emergency planners will need to rely on protection provided by structures built for some peacetime purpose. Where such space is insufficient, plans must be laid to construct "expedient" shelters during a crisis period.

A SINGLE-PURPOSE SHELTER*





*Strope, W.E., et al., **The Family Occupancy Test, 4-6 November 1960**, U.S. Naval Radiological Defense Laboratory, Aug 1962. (AD 288 228).

EXPEDIENT SHELTERS

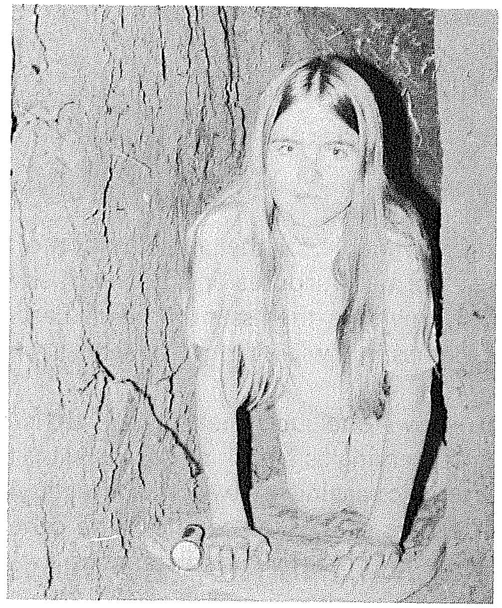
Where available shelter space is insufficient for the population, plans can be made to create good shelter during a crisis period. Single-purpose shelters of this type are called "expedient shelters." They are necessarily crude since they must be constructed of whatever is readily at hand. They can, however, be designed as a shelter and most offer substantial direct-effects protection as well as fallout protection.

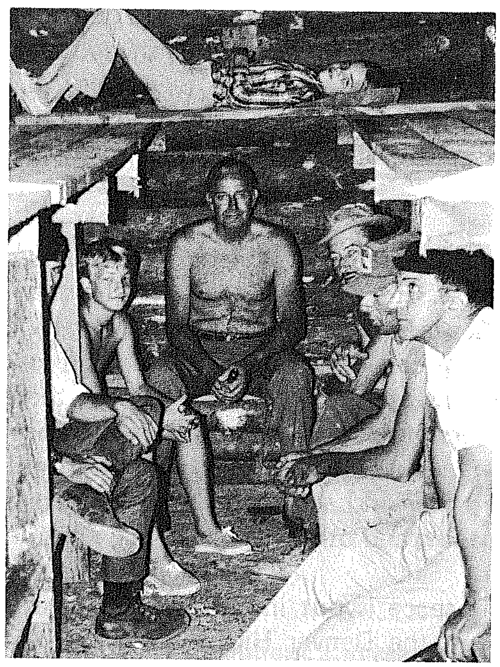
The upper photograph shows the interior of a simple two-family shelter. The girl is looking from the angled entrance trench into the main shelter room. The roof is of small logs covered with earth. Using only common hand tools, shelters like this have been built by untrained rural families in less than 30 hours elapsed time.

The lower photograph shows the interior of a larger 30-person shelter built with about 100 man-hours of effort, aided by power excavating equipment widely available in rural areas. The design uses logs and scrap lumber. Air comes in the entranceway and exhausts through a small wooden ventilating box located above the girl lying on the upper bunk. Water is provided in a water barrel. A covered pail serves as a toilet. Food and other essential supplies are brought to the shelter by the people who will use it.

Instructions to permit untrained people to build these log shelters have been developed and tested. Where wooded areas are not readily available, other construction materials can be used. Instructions for building shelters using the interior doors from houses or using farm fencing and sod are under development and test.

HASTY SHELTERS USING LOGS*





*From Kearny, C.H., **Hasty Shelter Construction Studies**, Oak Ridge National Laboratory Annual Progress Report, March 1970–March 1971.

DUAL-USE SHELTER SPACE

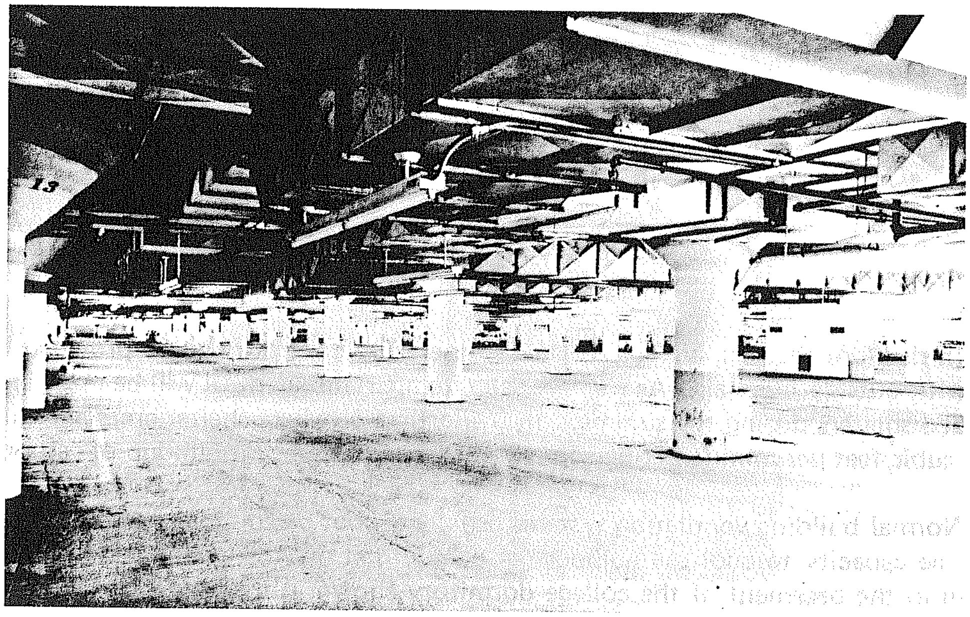
Most of the shelter space available for the consideration of local emergency planners is located in buildings built for normal purposes and not with shelter use in mind. This fact complicates the problems of providing the essential needs described in earlier panels. For one thing, this shelter space comes in a wide variety of shapes and sizes.

The upper photograph shows one such shelter area. It is one of three sub-basements below the Denver Hilton Hotel serving as a parking garage. It is a very large open space with very good protection characteristics against all weapons effects. At 10 square feet per person, it has a capacity to hold in excess of 12,000 people. The other two sub-basements are of similar construction, capacity, and protective characteristics.

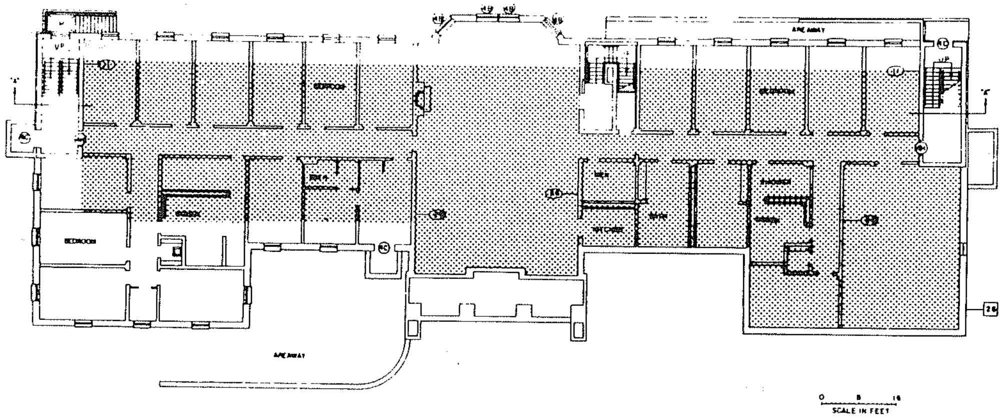
The lower sketch shows the basement of a college dormitory in Greensboro, North Carolina. Although there is one sizable common room, most of the space is broken up into individual rooms off corridors. Because of areaways and exposed basement wall with windows, not all of the basement provides good fallout protection. The area offering at least PF 40, according to the shelter survey, is shown as shaded area. These boundaries will not be marked in the building but, as we saw in Chapter 6, this is unlikely to be important since the best-protected parts should be determined by a radiation detection instrument, should fallout actually occur. Based on the survey, however, protected space is available for 800 persons.

It has been found that the wide variety of shelter spaces in the NFSS inventory fall into a limited number of categories. They are: (1) the basic single room, of which the Denver Hilton garage is an example; (2) a large area with small adjoining rooms; (3) areas partitioned into rooms of comparable size; (4) corridors with rooms off the corridor; and (5) corridors joining two large areas with rooms off the corridors. Finally, there are those of complex configuration with large numbers of rooms that form combinations of the foregoing categories. Clearly, these configurations offer both problems and opportunities in terms of providing air and temperature control, water and sanitation, sleeping arrangements and noise control, health and medical care, feeding and other activities, and lighting.

The use to which the space is put in peacetime is another important consideration. Depending on circumstances, the Denver Hilton garage is filled to greater or lesser degree with automobiles. The Bennett College dormitory basement contains bedroom and sitting room furniture. Other occupancies will have office furniture, merchandise, or stored supplies. Some of these items will find a shelter use. Others will interfere with use of the protected spaces as a shelter.



A VIEW OF THE SECOND BASEMENT OF THE DENVER HILTON GARAGE*



A COLLEGE DORMITORY BASEMENT**

*Gilmore, John S., **Pilot Study of Establishment and Maintenance of Community Shelters by Special Districts**, Denver Research Institute, Jan 1962.

Hedgecock, R.L., et al., **Documentation for Selected NFSS Buildings, Research Triangle Institute, Nov 1968.

VENTILATION

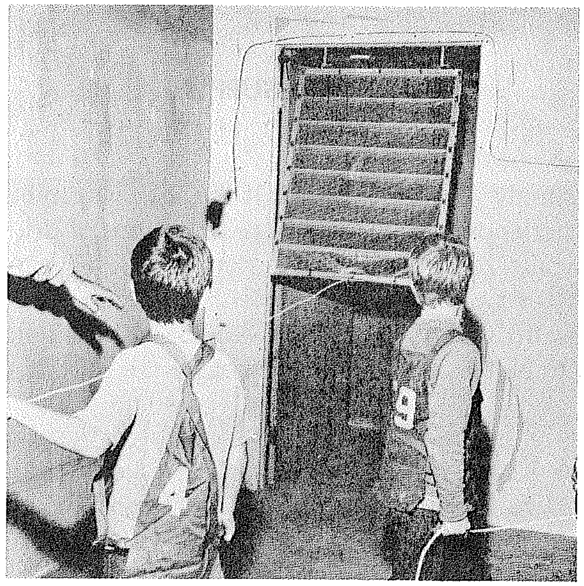
In dual-use shelters, air quality and temperature control must be provided by ventilation with outside fresh air. As we have seen, temperature control will be most important in crowded shelters during the summer. In wintertime or where shelter areas are not crowded, three cubic feet per minute per person will be needed to prevent buildup of carbon dioxide.

Normal building ventilation systems usually cannot be counted on because they do not have the capacity to cool the numbers of people that might be sheltered. The ventilation system in the basement of the college dormitory shown in the preceding panel is designed for the 40 students living there, not the 800 people that could be sheltered there. Since commercial electric power is unlikely to be available (See Chapter 4), emergency generators would be needed—they do not exist now— or plans would be needed to convert locally available equipment into generators during a crisis. (See Chapter 8 for information on how expedient electric power generation might be accomplished.)

For the most part, adequate ventilation can be provided by aiding natural ventilation forces with manually-powered ventilation devices. DCPA has developed a bicycle-type ventilating fan that could be stocked in shelters. Several thousand units were deployed in a pilot procurement in 1967 but these are not widely available.

A simple air pump that can be readily assembled by untrained volunteers in a crisis has been developed by C.H. Kearny of the Oak Ridge National Laboratory. The upper photograph shows one version of the Kearny pump, as it is called, being used in a shelter occupancy test. The device consists of a frame covered with a wire netting on which overlapping horizontal strips of plastic film are attached at their upper edges. Hung in the doorway of a windowless room, for example, and set swinging by pulling on a long cord, the plastic flaps press against the frame when swung in one direction, pushing air into or out of the room. On the back swing, the flaps open up so that air is pumped in only one direction. The lower photograph shows a group of citizens building a crude but serviceable pump of this type.

Natural ventilation occurs because of wind forces and also because warm air tends to rise. We believe that natural ventilation will be adequate in above-ground shelter areas if a sufficient number of windows are opened. In basements, ventilation is improved if cooler fresh air can be allowed to flow in through a stairway or windows at one end while warm shelter air exhausts up an elevator shaft or tall stairwell to higher windows at the other end. Air pumps can be used to facilitate this flow and to move air from corridors into adjoining rooms.



AIR PUMPS

KEARNY PUMP HUNG IN DOORWAY OF SHELTER ROOM*

*Anderson, J.A. and Meeker, S.D., **"People-Equipment" Application Evaluations—Test Results**, General American Research Division, April 1970.

LADIES BUILDING A CRUDE KEARNY PUMP TO VENTILATE AN EXPEDIENT SHELTER*

*Kearny, C.H., **Hasty Shelter Construction Studies**, Oak Ridge National Laboratory Annual Progress Report, March 1970—March 1971.

WATER SUPPLY

An assured water supply is very important if the shelter is to be occupied for an extended period. DCPA recommends supplying at least 3.5 gallons of drinking water per shelteree. In winter weather or where the shelter area is uncrowded, this recommended supply should be sufficient for as long as two weeks (See Panel 5). Under adverse weather conditions, it may be sufficient for as little as three days. Even so, water should **not** be rationed. Moreover, resupply is likely to be feasible in fallout areas by the third day after attack.

Most buildings to be used as shelter are served by the local water service. If electric power is required to pressurize the system, water is unlikely to be available after attack. If the pressure is provided by gravity flow from a water tank tower or reservoir, water may remain available in areas not subject to direct weapons effects. In areas potentially subject to blast effects, continued water service should not be expected.

Providing an assured water supply is largely a container problem. Many buildings may have hot and cold water storage tanks of various kinds, indoor swimming pools, and water of potable quality in heating systems and fire protection systems. Non-potable water supplies would be useful for sanitation purposes. On the whole, however, surveys have found that the amount of water normally stored in a building is insufficient for the numbers of people that could take shelter there. Moreover, water stored in aboveground parts of buildings should not be counted in the assured supply in blast-prone areas.

When shelter supplies were provided to local governments by OCD in the 1960s, metal water drums and plastic liners were provided for water storage. Each drum holds 17.5 gallons, the recommended supply for five persons. As can be seen from this photograph, the drums are quite bulky to store. To minimize the need, planners should base requirements on the number of people expected to occupy the shelter according to the community shelter plan rather than on the shelter capacity. It would also be desirable to establish, by on-site inspection, the amount of stored water already available in the shelter area. In one such inspection of a large office building, a 25,000-gallon tank of drinkable water, of which the building manager was unaware, was discovered in the basement.

Other implications for operational planning are:

(1) Plan to augment stored water in shelters during a crisis by collecting and distributing suitable containers, such as galvanized trash cans and plastic bags for liners, and having these filled in the shelters.

(2) No matter how good the shelter water supply is, plan for organized resupply by municipal forces in the early postattack period.

(3) Leave the shelter occupants to forage for additional water only as a last resort.

WATER DRUMS

WATER DRUMS STORED ALONG WALL IN SHELTER OCCUPANCY TEST
(For best blast protection, the drums should be placed in the center of the space with shelterees along the walls.)

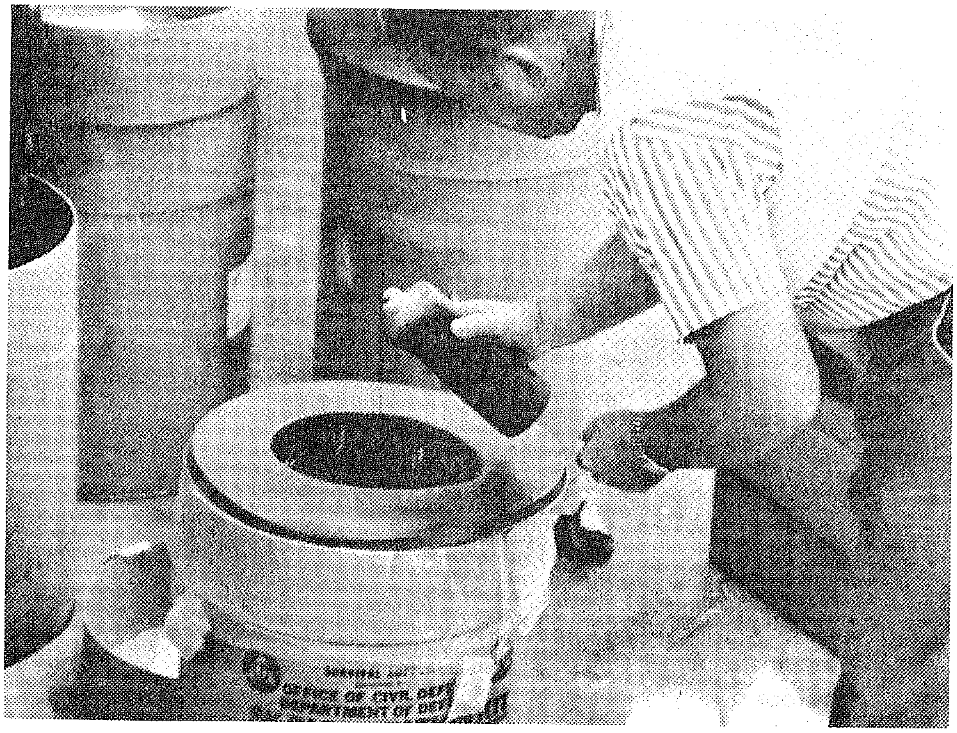
SANITARY ARRANGEMENTS

Whether a dual-use shelter area has the essentials needed for shelter sanitation depends very much on its peacetime use. The two examples shown in Panel 13 both have conventional toilet facilities. There are four toilets on the second basement level of the Denver Hilton and about the same number in the dormitory basement. If the shelters were filled to capacity, these would be inadequate to serve 12,000 and 800 people respectively. DCPA recommends one toilet per 50 occupants.

Under most circumstances, continued availability of the normal water service should not be expected. Therefore, flush toilets could not be operated in the normal manner. Thus, this aspect of sanitation becomes largely a container problem, as was noted with respect to water supply. The existence of minimal toilet facilities is still useful. Containers used as toilets can be dumped once a day into the sewer system through the conventional toilet. If non-potable water is available in heating or fire protection piping, it could be used for final flushing after the daily dumping. Otherwise, large numbers of containers must be available that can be properly sealed when filled.

In the shelter stocking program previously mentioned, a sanitation kit was provided in a fiber drum, the drum to be used as the initial chemical toilet for up to 50 people. Metal water drums are intended to be used in the same way after the water is consumed. The kit contains a plastic commode seat, toilet paper, commode chemical (shown here in action), and other basic essentials. Unless the shelters are so stocked, equivalent facilities must be planned for crisis implementation.

Keeping the toilets and toilet areas clean is an important part of preventive medicine in a crowded shelter. Unless the shelter space is not occupied by people in its peacetime use, janitorial supplies, such as trash cans, brooms, mops, and the like, are usually available. Even if the shelter space does not have such supplies, they may be found in other parts of the building for relocation to the shelter area.



THE CHEMICAL COMMODE

THE CHEMICAL TOILET PROVIDED IN THE FEDERAL STOCKING PROGRAM.

SLEEPING ARRANGEMENTS

It is rarely possible to provide beds, cots, or other conventional furniture for sleeping in a dual-use shelter. Indeed, such equipment takes up too much space if the shelter is filled to capacity. In experiments where shelterees were allowed to bring sleeping equipment if they desired, air mattresses were a popular item. However, they tended to take up more than the allotted space, as shown in the photograph, and created problems between the "haves" and the "have-nots" in the shelter. Blankets and sleeping bags were found to be more suitable.

Depending on its peacetime use, the shelter area is likely to have a greater or lesser amount of furniture and equipment. A little imagination can convert much of this equipment to shelter uses. The relatively few beds in the Bennett College dormitory would best be used in a sick bay or for the infirm. Since most rooms have rugs, the discomfort of sleeping on a bare floor can be avoided for the most part. The Denver Hilton garage is a large barren space offering few opportunities for adaption. Automobiles parked therein could be slept in or on. Otherwise, only the bare concrete floor is available in the shelter area. The structure above, however, houses a major department store and a large hotel, both sources of large quantities of bedding. This fact points up the importance and usefulness of individualized planning for the use of large shelter facilities, based on an on-site inventory of potential resources in the shelter environs.

USE OF AIR MATTRESSES IN A SHELTER EXPERIMENT

PANEL 17

PROVISIONS FOR MEDICAL CARE

Medical care needs in public shelters were described in Panel 8. It does not seem desirable or feasible for the government to provide for treatment of chronic medical conditions in shelter, since the medications should be prescribed for each patient by his doctor. But as noted earlier, chronically ill persons must be advised to bring their own medications with them. As shown in this table, the numbers of such persons in a "typical" group shelter could be quite substantial.

Medical care provisions for the illnesses likely to exist in the normal "healthy" population are important to the continued well-being of a confined shelter population. As shown in the lower part of the table, the incidence of acute (short-term) illnesses is much higher in winter than in summer. In other words, respiratory and infective illnesses are at their low ebb during the period when hot, humid shelter conditions may place additional strain on the body.

As part of the shelter stocking program of the 1960s, medical kits were placed in many dual-use shelter areas to serve the basic health needs of a confined group during a critical period of unsafe radiation levels outside. The items selected were those of fundamental necessity that would be reasonably safe to use without professional supervision. The U.S. Public Health Service has developed augmentation lists of priority medical supplies for childbirth and child care in shelters, contents of an expanded physician's medical bag, and the like. As a general policy, shelters should not be stocked with items that could be used effectively and safely only by physicians or highly-trained paramedical personnel.

On the other hand, it is good planning to arrange for assignment of local physicians to major shelters. This would greatly increase the prospects for adequate in-shelter medical care and, presumably, would improve the chances of survival of medical personnel needed post-attack. Where this is done, reasonable plans can be made to cope with treatment of attack casualties that might occur. Such treatment requires the availability of medical supplies, the attendance of persons possessing surgical skills, and adequate space and lighting. Only where these criteria can be met should formal casualty treatment be considered. Otherwise, the treatment taught in the Medical Self-Help course must suffice.

INCIDENCE OF ILLNESS IN THE POPULATION*

	Percent Affected
CHRONIC CONDITIONS	
Asthma and Hay Fever	3
Arthritis and Rheumatism	10
High Blood Pressure	6
Heart Conditions	4
Peptic Ulcer	2
Diabetes	2
Chronic Bronchitis	3
Epilepsy	0.5
One or More Chronic Conditions that Limit Activity	12
Pregnancy	2
ACUTE ILLNESSES IN THREE-MONTH PERIOD	
Respiratory Ailments, Winter	47
Respiratory Ailments, Summer	15
Infective and Parasitic Diseases, Winter	7
Infective and Parasitic Diseases, Summer	5
Digestive Ailments	3
Other	16

*From **Report of Ad Hoc Committee on Medical Care in Public Fallout Shelters**, National Academy of Sciences, August 1964.

PRIORITY INITIAL ACTIONS IN RISK AREAS

Since people are most likely to be advised to seek shelter upon warning that an attack on the country has been detected (ATTACK WARNING), not more than 15 to 30 minutes may be available before detonations occur. In areas potentially subject to direct attack (risk areas) this suggests not only that the shelter must be close at hand but also that certain initial in-shelter actions must be accomplished very quickly.

The most important initial action upon loading a shelter in response to attack warning is to place the occupants in the best locations to survive direct weapons effects. As discussed in Chapter 2, such areas are mainly in basements, although core areas aboveground may be used when it is the best available. Review Panels 20 and 21 of Chapter 2 for suggestions on the best protective positions for people to take in the shelter area. Since this "maximum protective posture" generally involves sitting around the periphery of the shelter area, shelter supplies should be moved to the central area, if not already done.

After locating people where they are least vulnerable to direct effects, the next most important initial action is to organize and instruct **fire guard teams.** These teams, formed from able-bodied adult shelterees, must be prepared to carry out a rapid reconnaissance of aboveground parts of the shelter building if a close-by detonation should occur, locating and suppressing any smouldering ignitions found (see Panels 26 and 30 of Chapter 3).

People can adapt to crowding in the best protective locations for several hours at least. Our best estimate is about 6 hours. Since this period of time is likely to be the period of maximum threat from detonations in the vicinity, crowding into basements is a viable option for increased life-saving. The main limiting factor on the practicability of staying in the maximum protective posture is the adequacy of ventilation to maintain temperature control. This will be a more serious problem in hot summer weather than in cooler seasons. A team should be organized to monitor the shelter environment and promote natural ventilation (Panel 14) as necessary. As long as electric power is available, the building ventilation system should contribute. If manual ventilation devices, such as the Kearny pumps, have been provided, the ventilation watch should be charged with setting these up, should a need exist.

Maintaining order is essential to the survival of the shelter occupants. People will generally follow the instructions of visible and trained shelter leaders under stress conditions. The only concession to "creature comforts" should be provision of minimum toilet facilities, preferably in or adjacent to the best protected areas. Except for safety tasks (fire, police, medical, RADEF, and ventilation) and minimal sanitary arrangements, it is best to defer other life-support activities for several hours until the protective posture can be relaxed.

PRIORITY PROTECTIVE ACTIONS (DIRECT EFFECTS)

1. Place the people in the maximum protective posture to survive direct weapons effects.
2. Organize shelter fire guard teams.
3. Organize a ventilation watch.
4. Maintain law and order.
5. Provide minimal sanitation facilities.

INITIAL ACTIONS IN NON-RISK AREAS

In rural and small city areas where the occurrence of direct attack effects is unlikely, much more time is available for shelter-taking and initial in-shelter organization. Fallout, should it occur, will begin to arrive several hours or more after distant weapon detonations are observed (see Chapter 6). It is still desirable to send people to fallout shelter upon ATTACK WARNING since loss of electric power and communications due to EMP effects (see Chapter 4) may make it difficult to advise them later of impending fallout arrival.

Maintaining law and order to promote the survival of the shelterees should be the first priority for shelter management. Shelter-taking is a basic action for obtaining closer control over the population for its own safety. Police should prohibit unauthorized movement not associated with the shelter plan. In shelters, one or more Fire, Safety, and Security Teams should be recruited immediately from early arrivals by a law enforcement officer, if available, or other person experienced in handling movement of large numbers of people. This team should prevent the bringing in of pets, bulky items, and other unneeded materials into the shelter and should distribute the arriving people throughout the building without regard for preferred fallout protection. Later, this team can dispose of flammables that could create a fire hazard, move equipment that might be a safety hazard, open windows to improve ventilation, and locate the radiation detection instruments.

Organizing the shelter occupants into manageable groups should be accomplished next. Depending upon the size of the shelter and its configuration, this may require recruitment of temporary group leaders to carry the word throughout the facility. Leaders should be **visible**; a uniform is best, no matter what kind; an arm band is next best; and, lacking that, a handkerchief should be tied around the left arm. Through these leaders, the shelterees need early "orientation" concerning the existing situation as it can best be determined, the plan for organization of the shelter, and the critical safety, health, sanitation, and other rules that must be observed.

The population of the shelter is best organized into units of about 10 persons, based on kinship, friendship, and common interests. In small shelters (less than 100 persons), the elected unit leaders are the only formal organization required except for task teams. In larger shelters, 5 or 6 units should be grouped into a section, sections into divisions, etc., letting the size of the community groups conform to the separate rooms and floors of the shelter building.

Except for safety tasks (fire, police, medical, ventilation, and RADEF) and minimal sanitary and water arrangements, it is best to defer other life support activities until several hours after shelter occupancy, unless it proves desirable to proceed further. If and when the fallout threat becomes actual, shelterees should be placed in those sections of the facility having the best fallout protection based on measurement of radiation levels, even if this means crowding. And, whether or not fallout occurs, people should remain in shelter under organized control and support at least until notified that further attack is unlikely.

PRIORITY ACTIONS (FALLOUT ONLY)

1. Organize Fire, Safety, and Security Teams.
2. Distribute the people throughout the shelter building as necessary and maintain order.
3. Organize the occupants into manageable groups.
4. Provide minimal sanitary and water arrangements.
5. When fallout occurs, crowd people into best protected areas, based on measurements.

EMERGENCY RESPONSE TO DAMAGE

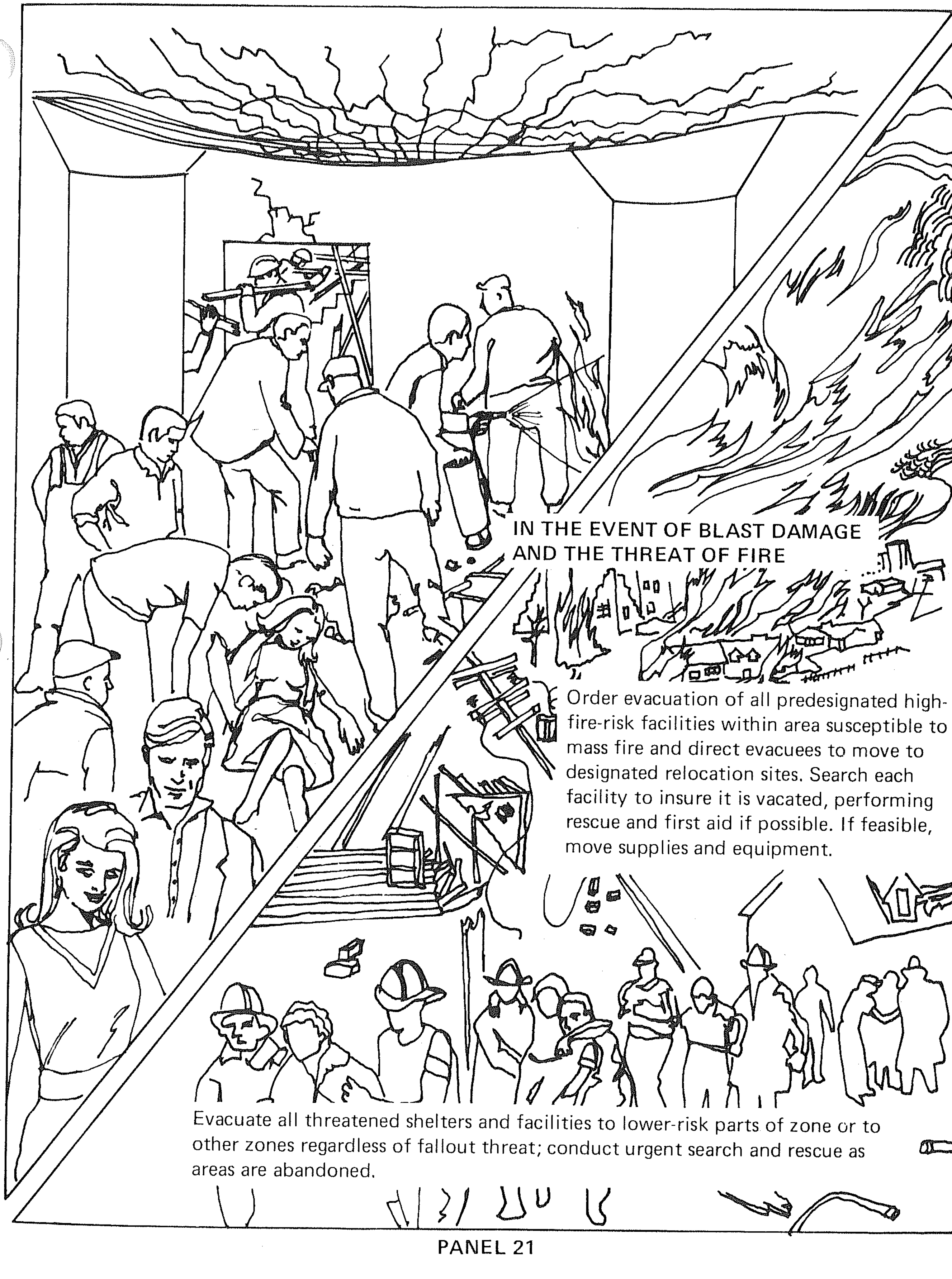
Shelters are intended to provide substantially better prospects of survival in an attack than otherwise might be the case. But no shelters, even specially-built shelters, are proof against a "direct hit." In areas of moderate to severe damage, dual-use shelter areas will experience a greater or lesser degree of damage, with possible injuries and entrapment.

Where damage is minor, the shock and sounds of breaking glass and displacement of furniture outside the shelter area will be impressive. If the shelter area is dusty, a cloud of dust may be raised. At somewhat higher overpressures, light fixtures and false ceilings, if they exist, may fall to the floor. These may cause injuries, mostly minor in nature. Exterior doors may be blown in and interior partitions damaged. Stairways and other access routes may become blocked. Review Chapter 2 to become familiar with the kinds of damage that can occur in areas where survival may remain high.

Should damage occur, fire guard teams should emerge to assess the situation and to suppress incipient fires, if found. Those remaining should render aid to the injured. The shelter area should not be abandoned unless it is obviously untenable or unless a reconnaissance indicates that an uncontrollable fire situation is in prospect. If the suggestions of Panel 25, Chapter 3, have been incorporated into local emergency plans, the leadership in so-called high-risk shelter facilities will be aware of the need for prompt evacuation and will have a designated low-risk shelter facility to which the survivors should go.

In many cases, egress may be blocked by debris. Therefore, basic rescue tools, such as wrecking bars, saws, ropes, and jacks, are desirable supplementary shelter equipment in risk areas. Dual-use shelters will vary widely in their susceptibility to damage. Hence, those in shelters that suffer only minor damage should be aware of the existence of other shelters in the immediate vicinity and should take the initiative to examine the condition of their neighbors and to aid in rescue to the extent necessary. In particular, task teams from low-risk facilities should go out to meet those abandoning high-risk facilities when advised that relocation is required. As shown in Chapter 6, fallout radiation should not restrict these early life-saving operations in most of the damaged area.

A special problem may be presented to occupants of basements of residences and other lightly constructed buildings. As noted in Chapter 2 and Panel 33 of Chapter 6, the building may be blown clear of the basement, greatly reducing the protection from subsequent fallout. Emergency actions must be directed toward improving the fallout protection, using the nearby debris as a source of materials.


IN THE EVENT OF BLAST DAMAGE AND THE THREAT OF FIRE
Order evacuation of all predesignated high-fire-risk facilities within area susceptible to mass fire and direct evacuees to move to designated relocation sites. Search each facility to insure it is vacated, performing rescue and first aid if possible. If feasible, move supplies and equipment.
Evacuate all threatened shelters and facilities to lower-risk parts of zone or to other zones regardless of fallout threat; conduct urgent search and rescue as areas are abandoned.

PANEL 21

EMERGENCY RESPONSE TO FALLOUT

Just as in the case of blast and fire, dual-use shelters vary widely in the protection afforded against fallout radiation. Should fallout occur, the basic objective should be to keep the average radiation exposure of the shelterees as low as possible. As discussed in Chapter 5, there is no completely safe exposure, however low. People should be crowded into the areas showing the lowest dose rates as measured by a CD V-715. Additional shielding can be achieved by crowding people together. People in the most exposed locations should be rotated periodically with people less exposed, except that children and persons of child-bearing age should be given preferential protection. If ventilation is inadequate, groups of shelterees may be rotated into cooler areas for relief.

In heavy fallout areas, the most intense period of fallout radiation will persist for the better part of a day. See Chapter 6 for rules of thumb on radiological decay. If, despite the measures described above, substantial exposures are received, these should be evident by the occurrence of nausea and vomiting during the first day. As noted in Panel 3, Chapter 5, these symptoms occur at doses well below those that result in severe sickness and death. Moreover, nausea and vomiting are symptoms also of simple anxiety, stress, and fear. If exposures of 75 to 100R or more have indeed been received, this fact will be confirmed by temporary loss of hair from the head during the second week. Confirming measurements by dosimeters are also helpful. Identification of overly exposed groups while in shelters is important because these people must be shielded from further radiation exposure to the extent possible. They are of no use as workers at urgent tasks in a fallout environment. There is no specific treatment for radiation sickness available. However, since one aspect of radiation injury is the lowering of resistance to infection, rest, good sanitation, and prevention of infection is indicated.

People should not be led to fear radiation exposure blindly, as this may immobilize any attempts to deal with other threats to life safety. They should be reassured that radiation sickness is not contagious and that the occurrence of symptoms does not portend inevitable death. Respect and caution, not fear, is appropriate in a fallout environment.

PANEL 22

GETTING FAMILIAR WITH RADEF

INITIAL ACTIONS IN RESIDENTIAL BASEMENTS

As emergency plans for in-place protection in urbanized areas are updated to recognize all hazards in the attack environment rather than just fallout, the use of residential basements for shelter will become increasingly important. Chapter 2 demonstrated that just getting people belowground in a basement had major lifesaving potential. Moreover, people are generally less vulnerable at home as compared to being at work where they are more concentrated in commercial and industrial areas. On the other hand, there are few large building basements in residential areas and not every home has a basement. Thus, sharing of those basements that exist may be the best sheltering plan.

The average residential basement has about 1200 square feet of area. Some of this space is occupied by furnace, hot water heater, laundry tubs, and the like, but generally as many as 100 people could be sheltered readily. Only in some parts of the South and Southwest would such intensive use seem necessary. In most cases, the use by several families rather than just one family would be sufficient. There is considerable merit, however, in encouraging 5 to 10 families to use the best basement, even if several are available. People seem to weather crises better as a group rather than separately. A wider range of skills, including leadership, can be found in the group of 20 to 50, and the young and elderly can receive better care. The chance to have trained people in the shelter and to be able to communicate with local authorities is also greater. The list of emergency actions suggested here is an indication of why group use of residential basements makes sense.

Upon ATTACK WARNING, neighbors would go to the selected basement, bringing with them the agreed-upon supplies. The supplies would be stacked in the center of the basement along with movable furniture and equipment. As one can see from the middle sketch of Panel 12, Chapter 2, placing a heavy table or work bench beneath the center of the span of floor joists would prevent the joists from being pushed all of the way into the basement, if broken by a blast wave.

As soon as the basement walls are cleared, people should sit along the basement wall, the best protective position. If blankets or mattresses have been brought, they should be placed over the body to shield against flying bits of debris. Then an emergency team should be organized, whose first task would be to break out the basement windows to remove the possibility of flying glass. As this is being done, water can be drawn and the utilities turned off to minimize secondary fires. Then the emergency team should be ready to perform the tasks described in the previous panels, should attack occur.

PRIORITY ACTIONS IN RESIDENTIAL BASEMENTS

1. Send everyone to the basement.
2. Move all furniture, shop benches, and equipment to central part of basement and deposit supplies with them.
3. Have people sit along basement wall.
4. Organize an emergency team, who:
   (a) break out basement windows, sweeping up glass pieces,
   (b) draw water in laundry tubs and other containers,
   (c) shut off electric, gas, and water utilities,
   (d) prepare to suppress fires and rebuild fallout protection.
5. Provide pail or other toilet facility.
6. Maintain protective posture for at least 6 hours.

SOME POINTS ON HUMAN BEHAVIOR

The popular image of how people behave in disaster is filled with lurid scenes of society and human nature in the process of disintegration. According to this image, people trample one another and lose all sense of concern for their fellows. Many people, so it is believed, become hysterical or are so stunned as to be helpless. Others turn to looting and other forms of selfish behavior. The aftermath is widespread immorality, social conflict, and mental derangement. This grim picture is continually reinforced in popular fiction, movies, television dramas, and journalistic accounts.

Scientific disaster field studies have demonstrated that these popular images are false. In contrast, they show that, under disaster conditions, people have a heightened sense of concern for others and that mutual aid and acts of unselfishness are much more common than under normal conditions. The sharing of a common threat to survival and widespread public suffering produce a dramatic increase in social solidarity that helps people to quickly overcome the usual disorganizing effects of trauma and stress. In general, the scientific studies show that communities and nations typically demonstrate amazing toughness and resiliency in coping with the destructive effects of disaster and unusual speed in restoring and revitalizing their social institutions.

People become attentive in time of crisis. But the crisis and warning periods have their behavioral problems. The public has come to believe pronouncements that nuclear war means complete annihilation. When asked in a recent survey what they would do should warning of an impending attack occur, fully 40 percent responded that they would do nothing but sit quietly at home to await their fate.

When the threat becomes clearly defined and danger is imminent and personal, people usually take actions to protect themselves and others rather than engage in irrational acts that increase the danger. The notion that people typically "panic," become "hysterical," or "go to pieces" in the presence of danger is not supported by disaster research findings. Of course, whether their behavior is appropriate depends to a great extent on the information and training they receive in the period preceding the warning of danger.

Disasters do not render people a dazed and helpless mass, completely dependent on outside help. To the contrary, the immediate and pressing tasks of rescue and aid are usually accomplished by the survivors themselves and, if a group is isolated for some time, it will develop the necessary emergency organization to cope with the problems at hand.

Finally, people directly affected respond to purposeful leadership. They rapidly shift from self-interest to motivation for common survival. Injured disaster victims are almost invariably quiet, calm, undemanding, and concerned for the welfare of others. Uninjured survivors will aid the injured and helpless, almost without regard to self, if they are in a position to do so, and have the necessary equipment and training. (Peacetime disaster field studies show that disaster victims have been able to cope with all immediate disaster problems except those that require special equipment or advanced medical skills.)

PEOPLE IN DISASTER

1. DO NOT panic or "go to pieces."
2. DO take actions to protect themselves and others.
3. ARE NOT rendered dazed and helpless.
4. DO accomplish essential rescue and relief tasks.
5. DO develop ways to cope with pressing needs.
6. RESPOND to purposeful leadership.
7. ARE motivated for the common survival and speedy recovery.
8. ARE quiet, calm, and undemanding, if injured
9. WILLINGLY aid the injured and helpless, if they are capable of doing so.
10. DO need information and direction and the necessary pre-disaster training in specialized survival, rescue, and medical treatment skills.

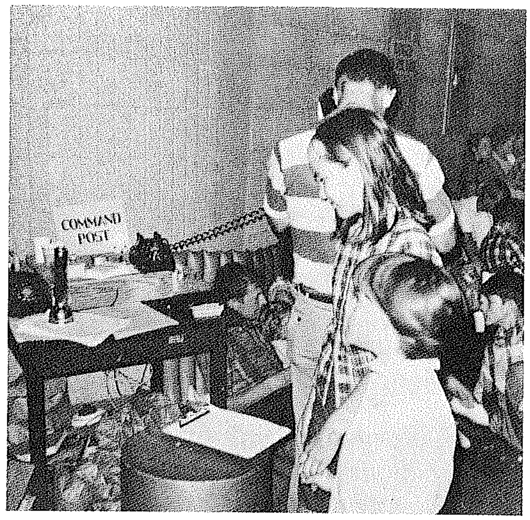
DIRECTION AND CONTROL

People under stress need direction and control. They tend to follow the instructions of anyone having a symbol of authority, if the instructions appear sensible. Maintaining order to promote the survival of the shelterees (through proper positioning, for example) is the first priority upon taking shelter. Maintaining social standards may also become important if the degree of threat from weapons effects remains low for an extended period. As has been noted, the priority of actions to be taken against direct effects differs from those in fallout areas, but the requirements for direction and control are essentially the same.

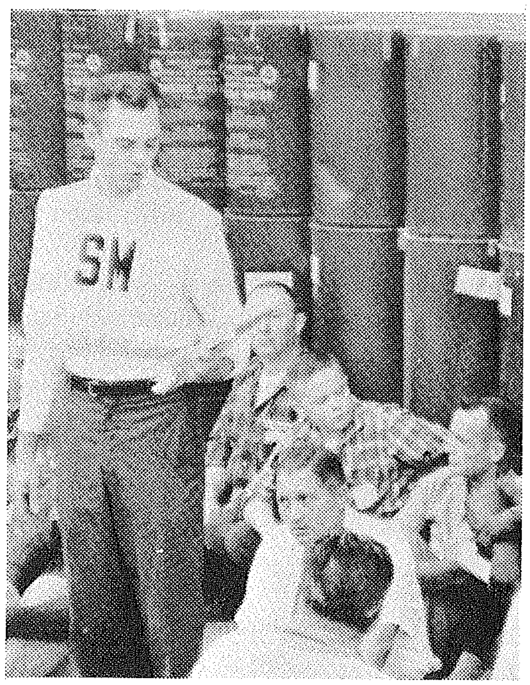
If the people in a particular shelter area are completely isolated from contact with the "outside," the organization and functions within the shelter must cover the whole gamut of emergency functions discussed in Chapter 1: police, fire, medical, welfare, and resource control, all organized through direction and control. Successful sheltering is greatly aided by external communications. The status of shelter occupants, facility conditions, and supplies can be reported to the local Emergency Operating Center (EOC) throughout the shelter occupancy. It is preferable that shelters short of drinking water, for example, be resupplied by organized public works teams, with foraging by teams of shelterees used only in event communications fail or damage, debris, or fire preclude resupply. If the shelter becomes untenable, the EOC can organize aid for relocation to an alternate facility. Guidance on fallout conditions and probable shelter stay time can be given. And information on general conditions and what is being done about it will be important to shelteree morale.

Management of public shelter facilities, including groups in residential basements, should not depend entirely on one-way information heard on commercial radio (EBS). Two independent means of two-way communications are desirable in risk areas—telephone and Citizens Band or amateur radio, for example. Where many public shelters exist in a local jurisdiction, plans should designate a more limited group of shelters as "Shelter Complex Headquarters," with which other shelters in the vicinity communicate.

Internal communications are also necessary for direction and control. Sometimes, operable public address systems are available in dual-use shelter facilities. But, more likely, internal communications will be by announcement of information and instructions. In large shelters, organization of the population into manageable groups and selection of group leaders are necessary for this purpose.



EXTERNAL COMMUNICATIONS



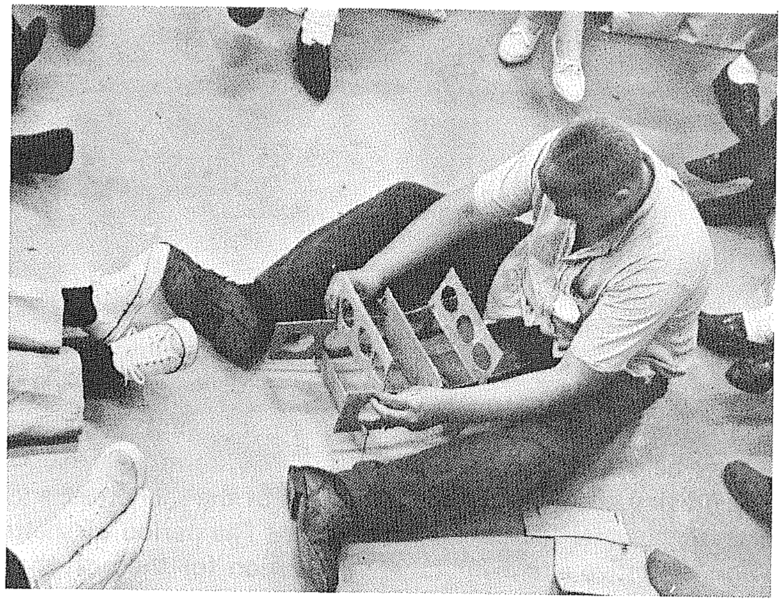
INTERNAL COMMUNICATIONS

LIFE SUPPORT TASKS

Once the emergency tasks directed toward survival of the shelter occupants are no longer critical, the more routine functions of shelter living can be organized. When the maximum protective posture in risk areas and heavy fallout areas can be relaxed, the occupants can be organized into units, sections, etc., if not already accomplished, and task teams formed to accomplish the necessary functions. Shelter occupancy tests have shown the importance of giving every shelteree a job he can call his own. This applies to children and the elderly as well, except for the very young and the disabled.

"Life support" tasks are among the most essential: food and water distribution, sleep, health, and sanitation. Continued ventilation of the shelter area must also be accomplished. Specific arrangements must be adapted to the shelter configuration and the available facilities and equipment. In small shelters, occupants can go to pick up food and water at a distribution point; in large shelters, food and water is best delivered to groups of shelterees where they "live." There are many detailed chores to be accomplished. In the upper photograph, for example, a rack for water cups is being constructed from a cardboard carton.

Toilet facilities must be set up and kept clean. Trash and litter must be disposed of. A sick bay should be designated and a daily sick call scheduled. A 24-hour communication and safety watch should be established (lower photograph). All this leads to a schedule of daily activities that becomes routine if a lengthy shelter stay is required. Shelter occupancy tests have shown that shelterees solve the problems of shelter living and make the necessary adjustments in the first 48 hours. Thereafter, they can remain indefinitely so long as the shelter environment remains habitable and essential supplies are adequate.



MAKING A CUP RACK

COMMUNICATION AND SAFETY WATCH

MORALE SUPPORT ACTIVITIES

In addition to the essential life-support tasks, other organized activities are desirable in shelters. These may be called "morale support activities," although they usually contribute to the physical well-being as well as the mental health of the shelterees, and often are directed at preparing the occupants for shelter emergence. The period of shelter stay should be viewed as a period of active and productive preparation for the post-shelter environment, not as a period of listless "waiting-it-out."

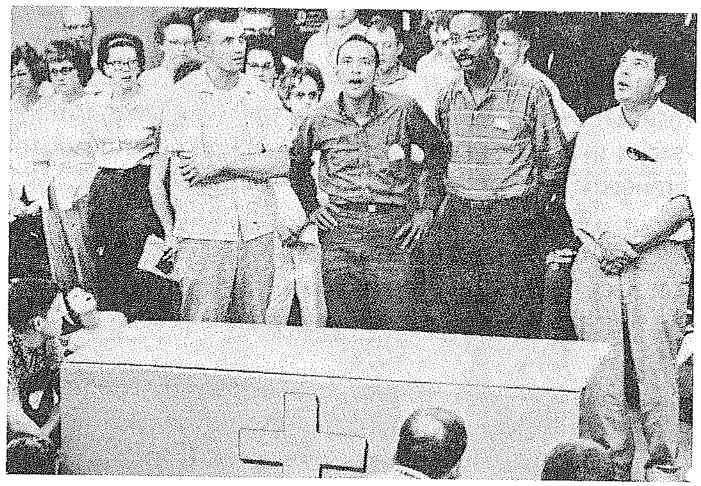
It is both psychologically and practically unrealistic to view the period of shelter stay as one of soothing "hearts and flowers" music, leisurely recreation, and the conspicuous consumption of pre-stocked fruits of a beneficient society. People in shelters will be anxiously oriented toward the future, and the more realistic and meaningful the fit between the shelter activity and the future needs of the society, the greater the likelihood will be of channeling this anxiety into socially useful form.

Organized nurseries or "day-care" arrangements are useful to provide parents with relief from child care and to allow attendance at adult activities. Adults take turns supervising the children, organizing their games, and providing informal entertaining. Sometimes, little school classes are instituted.

One form of adult activity of importance is training sessions on subjects relating to shelter confinement and postattack conditions. Information of the type covered in Chapter 8 but based on the real situation in the locality, State and Nation, should be presented to the shelterees in preparation for participation in post-war reconstruction and recovery. Even in peacetime shelter experiments, participants have been found eager to learn of these matters. The motivation in an actual emergency should be even higher.

EXERCISE SESSION

RELIGIOUS SERVICE



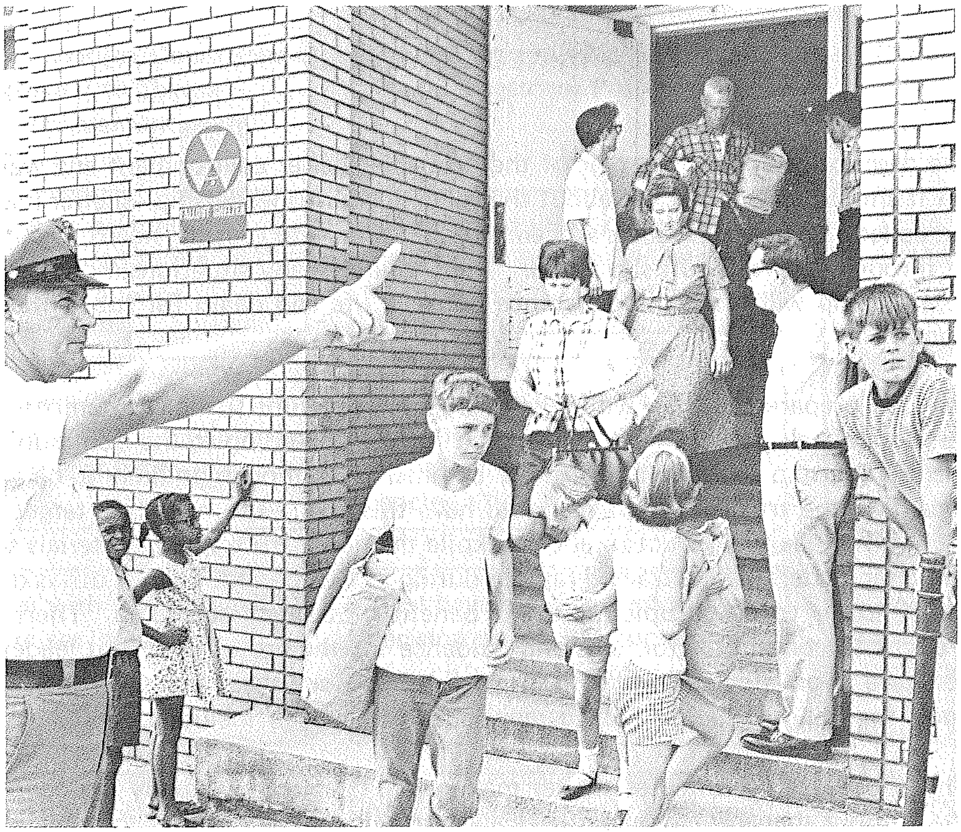
TRAINING SESSION

SHELTER EMERGENCE

Even in areas that experience no attack effects, the population should remain in shelter until notified by the authorities that the danger of further attack and fallout is unlikely. This period may be several days or more, during which time the shelterees can be informed as to what to expect in the post-shelter period. Because a particular locality escapes damage or significant fallout does not mean that the population can scatter from the shelters and resume their pre-war way of life. A disrupted economic system elsewhere will mean that normal means of livelihood may have vanished, food, fuel, medical supplies, and other necessaries may not be available in the market, and not too far away there will be fellow citizens in need of help.

Where fallout radiation persists, shelter emergence may be delayed, and people may need to sleep and live in shelters when not at work. In a sense, shelter emergence will be gradual so that unnecessary radiation exposure is avoided.

Many details of the post-shelter environment are described in Chapter 8. These will dictate how shelter emergence should be planned for. In general, shelterees should not be released until instructions are received from the local authorities to do so. Much preparatory activity is required, even in the best of circumstances. The local government would need to take control of essential resources, conduct an inventory, set up rationing or other means of equitable distribution, resume public safety and utility services, and complete arrangements for support of the population and survivors from other areas, should they be under the responsibility of the local government.



LEAVING THE SHELTER

TRAINED LEADERSHIP

The description in this Chapter of the probable shelter environment and ways of coping with it should leave no doubt about the value of trained leadership—shelter managers, as they are called. Of course, leaders will emerge in response to pressing needs, and groups can muddle through very difficult situations. There will be many situations, however, in which trained leadership will make the difference between life and death for substantial numbers of citizens.

The ideal preparedness goal would be to train in peacetime sufficient numbers of shelter managers to staff all public shelters scheduled for use according to the Community Shelter Plan, including group shelters in residential basements. Although unlikely to be achieved in most localities, the training program should have this goal. The next best target is to train enough shelter manager instructors and stockpile the necessary training materials so that the needed shelter leaders can be trained rapidly during a crisis period. Even if this is done, some shelters are likely to be occupied without benefit of trained leadership. Therefore, each shelter ought to contain instructions and guidance for the use of emergent leaders. Where facilities have been stocked with Federally-furnished supplies, the OCD booklet, H-16, **Handbook for Fallout Shelter Management**, has often been included.

Who should be recruited as shelter managers? It appears virtually impossible to take someone without management experience and turn him into a manager through exposure to a short course of training. It is, however, quite feasible to take someone with a strong management background and in a short time give him the technical information required to manage a shelter effectively. This suggests that upper-level executives from organizations housed in structures designated as shelter facilities are potential candidates. The ideal manager appears to be one who is capable of working in ill-defined situations; one who can provide structure and direction and then proceed with the tasks at hand; a person who is creative in the face of unique, unprecedented problems; a person used to the tumult of situations demanding decisions; an effective communicator who has practice in dealing with people. As shown on this chart, these desirable characteristics **may** be associated with certain types of positions within the average business organization.

RELATIONSHIP OF MANAGERIAL SKILLS

Skills/knowledges/Conditions Relevant to Shelter Management	Implications for Desired Management Positions	Some Likely Job Titles
Must manage a situation that is unprecedented in the manager's experience.	Must show ability to react to problems in innovative creative fashion.	SALES MANAGER
Must make a great number of critical decisions in a relatively short period of time.	Must demonstrate competence in managing situations requiring response to daily emergencies.	LABOR RELATIONS MANAGER
Must deal with trade-offs and compromises in decision making.	Must have had experience in decision making where results of decision have impact on more than one factor.	PRODUCTION MANAGER
Must be an effective communicator, to forestall the development of rumors and to motivate the shelter populace.	Must have experience involving frequent verbal interaction with peers and subordinates, must be an effective public speaker.	PLANT MANAGER
May be temporary lack of a formal functioning sub-organization.	Must have experience in dealing with highly ambiguous situations, must show ability to impose structure and direction in confused situations.	DIRECTOR OF PUBLIC RELATIONS

WHO MAKES A GOOD SHELTER LEADER?

There appear to be two main characteristics desired in a shelter manager—management ability and ability to perform despite physical threat stress. In both areas, selection of individuals can best be accomplished at the present time by examination of experience rather than through the use of sophisticated psychological tests.

Most people with the sort of experience desired will be mature, middle-aged persons. Physical health is also clearly important to consider. As noted in the previous panel, the best sources of people with management ability are those who currently hold executive management positions. If the shelter building houses appropriate businesses, there is the further advantage of procuring managers who are generally familiar with the shelter area and its surroundings and who know and have the respect of at least some of the possible shelter occupants. Alternate sources of those with management experience are organizations committed to public service, key governmental employees, and neighborhood Federal agencies.

Experience showing tolerance to the stress of physical threat is more difficult to define. One kind is military combat experience, particularly in a leadership role. A subtle but important difference is the need to interact with civilians not under military discipline. Two other kinds of experience are useful. One is the reaction to threatening situations that may have confronted him, such as natural disasters or serious accidents. The second is the tendency to choose an avocation that involves some danger or personal risk.

All this is difficult to put on a rating sheet. Nonetheless, we have done so just to make these ideas more concrete. Test yourself!

RATE YOURSELF AS A POTENTIAL SHELTER LEADER

		Points
1.	Age: Under 30, 5 points; 30–60, 10 points; over 60, 5 points.	______
2.	Physical Health: Excellent, 10 points; Good, 5 points; Poor, 0 points.	______
3.	Have you ever succeeded as a sales manager? 10 ppints; High school teacher or principal? 8 points; Actor, PTA president, or clergyman? 6 points; Supervisor of at least 30 people? 4 points. (If more than one, choose highest points and add 2 points.)	______
4.	Have you ever led men in combat (not just military experience)? Yes, 8 points; No, 0 points.	______
5.	Have you ever played an active role in dealing with a natural disaster you were directly involved in? 8 points; serious accident? 5 points.	______
6.	Have you successfully practiced any of the following avocations for at least a year? Mountain climbing, cave exploring, auto racing, power boat racing, scuba diving, white-water canoeing? Yes, 6 points; No, 0 points.	______
7.	Do you believe you could manage a shelter effectively after reading this chapter? Yes, 5 points; No, 0 points.	______
	Total	______

RATING:		
	Over 50 points	– Perfect Choice
	35 to 50 points	– Likely Success
	25 to 35 points	– Better than Average
	Less than 25 points	– Probably Not

(What's that? You say you're a middle-aged spinster who teaches English at the high school, scuba dives on weekends, and thinks managing a shelter would be a blast? You'd make a good choice. Take me to your shelter, leader!!)

THE SHELTER USE PLAN

Since any shelter can be used more effectively with a plan, every major shelter facility should have a use plan prepared for it. Both shelter use plans **and** trained leadership are needed for proper sheltering of the population. For example, a definite ventilation plan should be available before occupancy. The best protective locations for occupants should be identified. Potential destinations for relocation should be planned in advance in the event the shelter area must be abandoned as untenable.

In smaller shelters, merely filling in the blanks in the Immediate Action Instructions of H-16, **Handbook for Fallout Shelter Management**, will satisfy most of the need for a shelter use plan. In larger shelters or those having special characteristics, a more detailed plan is desirable. An integral part of the shelter use plan should be a detailed sketch of the shelter areas, showing significant features, including location of supplies and equipment. The use plan should also contain information on the location of survival resources and other shelters in the vicinity.

A listing of the essential elements of information that should be in a typical shelter use plan are shown on this chart. Why these elements are important has been outlined in this Chapter. The ordering is intentional. The last 5 elements are "operational." If the shelter were to be used without prior preparation (the "surprise attack" situation), one would start with element 6. Why aren't these last elements listed first? In Panel 26, Chapter 1, some planning assumptions are listed. The first is "A period of crisis will most likely precede a nuclear conflict." It seems prudent to plan on the basis that trained leadership may be able to man their shelters prior to ATTACK WARNING, that familiarization can occur, that furniture and supplies may be acquired or moved about, and that preparations may be completed before the population begins to move to the shelters.

WHAT'S IN A SHELTER USE PLAN

1. Where the best protected areas are.
2. What needs to be done to shift from peacetime use to shelter use.
3. Essential supplies and equipment, where they are, and how to use them.
4. What professionals (doctors, nurses, policemen, firemen, building engineers, etc.), if any, are assigned and who they are.
5. Suggested organization for THIS shelter, including how many fire-guard teams to form, and the like.
6. Specific initial action schedule upon loading the shelter, preferably a checklist.
7. Who NEXTUP* is, his phone/call number, and reporting instructions.
8. What to do if the shelter must be abandoned for any reason.
9. Resupply resources in the environs, in event NEXTUP* cannot help.
10. Location of nearby shelters and mutual aid arrangements.

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*NEXTUP = Shelter Complex Headquarters or local Emergency Operating Center.

SUGGESTED ADDITIONAL READING

Hammes, J.A., et al., **Shelter Occupancy Studies at the University of Georgia**, University of Georgia, Athens, Georgia, December 1968. (AD 688 099 and **Appendices**, AD 688 100).

Hammes, J.A., et al., **Community Fallout Shelter Handbook for Untrained Management**, (Eighth Edition), University of Georgia, Athens, Georgia, December 1969. (AD-699 418).

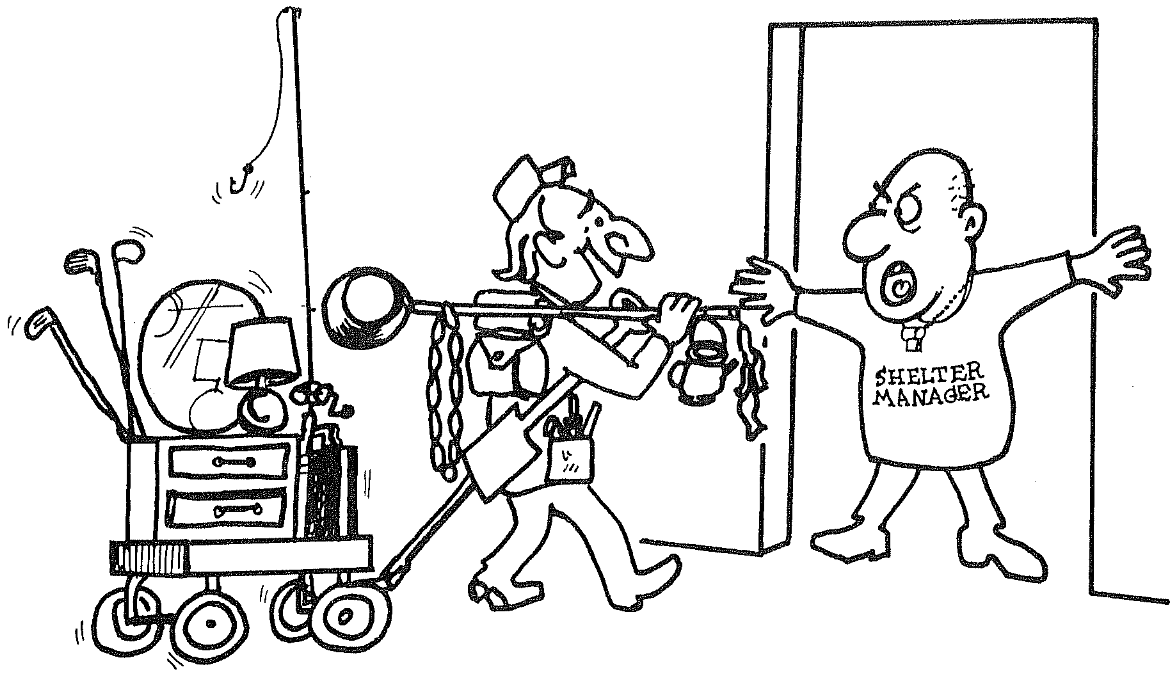
Anderson, J.A., and Meeker, S.D.,**"People-Equipment" Application Evaluations Test Results**, General American Research Division, Niles, Illinois, April 1970, GARD Report 1477.

Smith, Robert W., and Jeffreys, Frank B., **Integrated Guidance for Shelter Management: The Selection and Recruitment of Shelter Managers**, American Institutes for Research, Pittsburgh, Pennsylvania, June 1965. (AD-629 914).

Bend, Emil, and Collins, Robert A., **Integrated Guidance for Shelter Management: Vol. I, Introduction to Shelter Management**, American Institutes for Research, Pittsburgh, Pennsylvania, June 1965. (AD-629 939).

Smith, Robert W., and Lasky, Mary Ann, **Integrated Guidance for Shelter Management: Vol. II, Planning a Group Shelter,** American Institutes for Research, Pittsburgh, Pennsylvania, June 1965. (AD-629 940).

Brandegee, Ada S., and Bend, Emil, **Integrated Guidance for Shelter Management: Vol. III, Shelter Manager's Guide**, American Institutes for Research, Pittsburgh, Pennsylvania, June 1965. (AD-629 941).



PANEL 32

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DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 8

WHAT THE PLANNER NEEDS TO KNOW ABOUT THE POST-SHELTER ENVIRONMENT

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 8

This description of the post-shelter environment focuses on the barriers to well-being that must be coped with if nuclear emergency operations are to be fully effective. It presumes that the reader is familiar with the material in earlier chapters. The information presented, along with that in other chapters, is applied in Chapter 9 to the problem of contingency planning for nuclear emergencies. A secondary purpose of Chapter 8 is to introduce the planner to some of the technical basis for confidence that postattack recovery can be planned for.

Information is presented in the form of "panels," each consisting of a page of text and an associated sketch, photograph, chart, or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 8 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The first two panels present the general nature of the post-shelter problems that must be dealt with. The next two panels emphasize the importance of communications with the public, the emergency organization, and other governmental levels. Two panels discuss the operational limitations imposed by fallout and what can be done about it. Then three panels discuss the needs for life support, and three the needs for health and medical support. There follow two panels on restoring energy supplies and two on manpower needs. Five panels deal with restoring production and two with preventing longer-term injuries to the survivors and their habitat. Two panels are devoted to social and psychological aspects of recovery. The next four panels treat the special problems of recovery in damaged areas. Finally, the case for postattack recovery is summarized. A list of suggested additional reading is included for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 8

"WHAT THE PLANNER NEEDS TO KNOW ABOUT THE POST-SHELTER ENVIRONMENT"

WILL SURVIVORS ENVY THE DEAD?

This rhetorical question headed one of the chapters in Herman Kahn's 1960 book, **On Thermonuclear War**, a book that was an outgrowth of a Rand Corporation civil defense study of the late 1950s. Kahn's answer, based on the Rand study, was that though the amount of human tragedy would be increased in the postwar world, the increase would not preclude normal and happy lives for the majority of survivors and their descendants. Said Mr. Kahn, "My colleagues and I came to this conclusion reluctantly; not because we did not **want to** believe it, but because it is so **hard** to believe. Thermonuclear bombs are so destructive, and destructive in so many ways, that it is difficult to imagine that there would be anything left after their large-scale use."

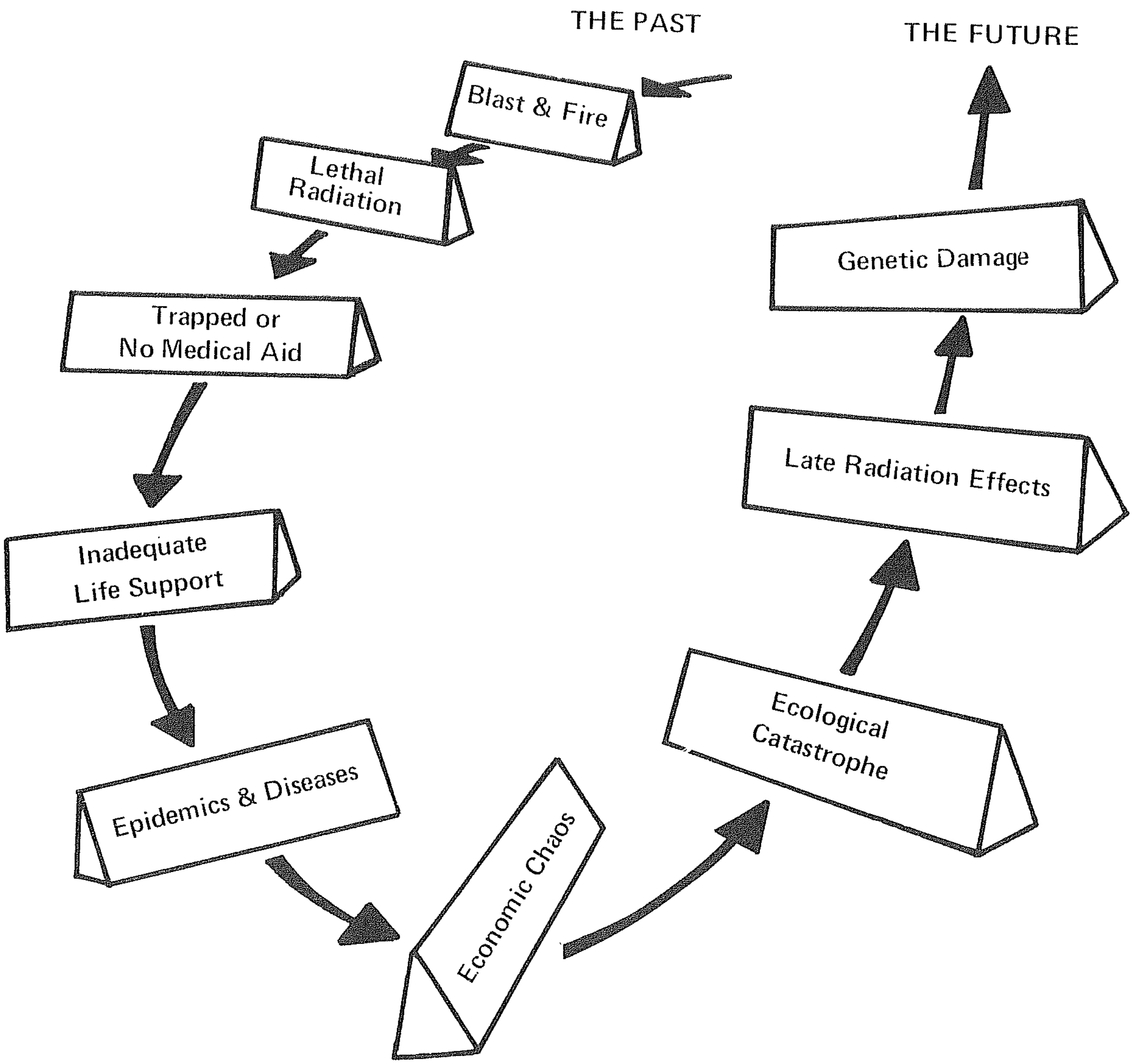
In Chapter 1 of this Manual, we saw that most of the U.S. population could survive the immediate effects of an attack such as the Soviet Union can now deliver, **especially if the defensive knowledge we have is fully applied in civil preparedness planning.** But this is only part of the problem. Will the post-shelter environment be so hostile that we or our descendents might prefer not being alive? To what measure can we restore the prewar conditions of life? Will more people die of disease and starvation than were lost in the attack itself?

As suggested by this allegorical sketch, the Nation's people, individually and as a society, have a series of hurdles or barriers barring their way that must be surmounted if they and their descendents are indeed to enjoy normal and happy lives. Most civil defense planning has focused on the first three of these barriers: all-effects shelter or crisis relocation to cope with the direct effects barrier, fallout shelter and radiation detection instruments to cope with potentially lethal fallout radiation, and rescue and medical care preparations to succor the trapped and injured. This is as it should be. Failure to surmount the initial barriers would make the remaining problems academic. But, in a very real sense, all **nine** of these barriers must be surmounted. If there is catastrophic failure at any hurdle, there will have been little value in success at the others. When some people conclude that nuclear attack means total annihilation or that post-shelter life won't be worth living, they usually have singled out one or more of the later barriers as insurmountable.

In this Chapter, we will discuss what is known about these barriers to well-being, particularly the last six, and what the planner can reasonably plan to do about them.

PANEL 1

NINE BARRIERS TO WELL-BEING*



*Based on Greene, J.C., **The Case for Civil Defense**, DCPA Research Report No. 16, 1972 (AD 758 452).

PANEL 1

POSTATTACK RECOVERY

Another useful viewpoint for coping with the post-shelter environment is shown here. It is the view that might occupy the attention of the Nation's leaders or that might be described in a history of the aftermath of a nuclear war.

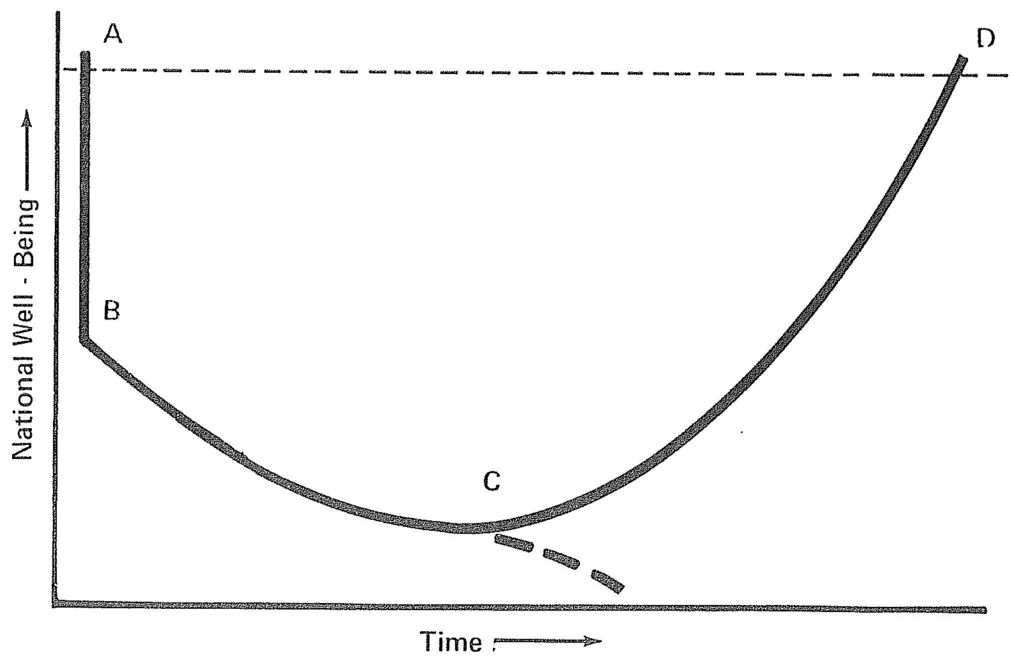
National well-being may be considered as a composite of population, material resources, and social and economic institutions—the basic elements that make for a viable country. Prior to the attack, the national well-being is high, as shown at Point A. The immediate consequence of the attack is a sharp drop in well-being (Point B), with millions of dead and injured, great destruction of resources, and disorganization of institutions, such as government, banking, private ownership, and the like.

It is reasonable to expect that the initial sharp drop would be followed by a further decline in well-being because of continuing fallout radiation exposure, deterioration of abandoned factory machinery, wastage of scarce resources, inadequate mutual aid, lack of communications, and general disruption of normal patterns of living. Initial coping efforts would attempt to "stabilize" the situation and satisfy the most pressing wants so that sooner or later a minimum or "bottoming out" should occur (Point C), after which the Nation would begin its upward path to recovery (Point D).

There is a possible alternative history that the national leadership will strive to avoid. It is indicated by the downward dashed line at Point C, which implies that deterioration is so severe or management so inept or misdirected that national recovery does not occur at all, and the country degenerates into chaos and anarchy.

This viewpoint focuses on the need for national goals, goals widely shared at all levels of government and among the public at large. No local government nor wider region can recover by itself. The emergency planner must recognize in his planning that, while localities can (and may need to) deal with the first three barriers without outside help, adequate life support (food, water, and protection from the elements) may require inputs from outside the jurisdiction. Surviving organizations must consciously "coalesce" into wider and wider communities of common action if disease epidemics are to be controlled and economic chaos avoided.

A POSSIBLE CHAPTER IN AMERICAN HISTORY



PANEL 2

SOCIAL AND PSYCHOLOGICAL NEEDS

As will be seen in this Chapter, there is little question that the surviving physical and human resources following an attack that could be delivered at this time are sufficient to permit a meaningful recovery. A good deal, however, will depend on the will and cooperation of the survivors.

The people, who are the most valued part of the National entity, are at the same time the source of one of the critical post-shelter resources: **manpower**. Therefore, the social and psychological effects of undergoing a massive attack by nuclear weapons could play a decisive role in determining whether the survivors would have the will and capacity to accomplish what appears to be possible. Recently, a panel of behavioral scientists, government officials, and military staff officers, who had experience in studying or planning for the nuclear attack contingency, developed a consensus on the social and psychological factors they felt would significantly influence the behavior of people after a heavy attack on this country. It is significant that the panel, virtually unanimously, put at the top of the list the early satisfaction of the psychological needs shown here. The near unanimity of the panel on these priorities focuses the attention on the need for **communications between the government and its constituents.**

As noted in Chapter 7, the process of providing leadership, information, reassurance, and instruction should be initiated in the shelter environment. This would be aided greatly by trained shelter managers and communications with the local EOC. Reliable one-way communication from various levels of government to the people is essential. There are over 8000 privately-owned AM, FM, and TV broadcast stations in the United States. Several thousand of these participate in the Emergency Broadcast System (EBS), designed to provide the President, the Federal Government, and State and local authorities a means of communicating with the general public during the preattack, transattack, and postattack periods. However, only about 600 broadcast stations have been provided with emergency electric power and a fallout-protected broadcast studio. Many have facilities for remote programming from the local or State EOC. In view of the potentially damaging effects of the electromagnetic pulse on operating transmitters (see Chapter 4), it would be good planning to arrange with even non-participating broadcast stations to take EMP protective measures when they go off the air in an emergency. These stations could provide an important resource for communicating information, reassurance, and instructions in the post-shelter environment.

PRIORITY NEEDS*

1. People would need leadership.
2. People would need information.
3. People would need reassurance.
4. People would need instructions.

*From Allnutt, Bruce C., **A Study of Consensus on Psychological Factors Related to Recovery from Nuclear Attack**, Human Sciences Research, Inc., May 1971. (AD 730 360)

WHAT THE WAR WAS LIKE

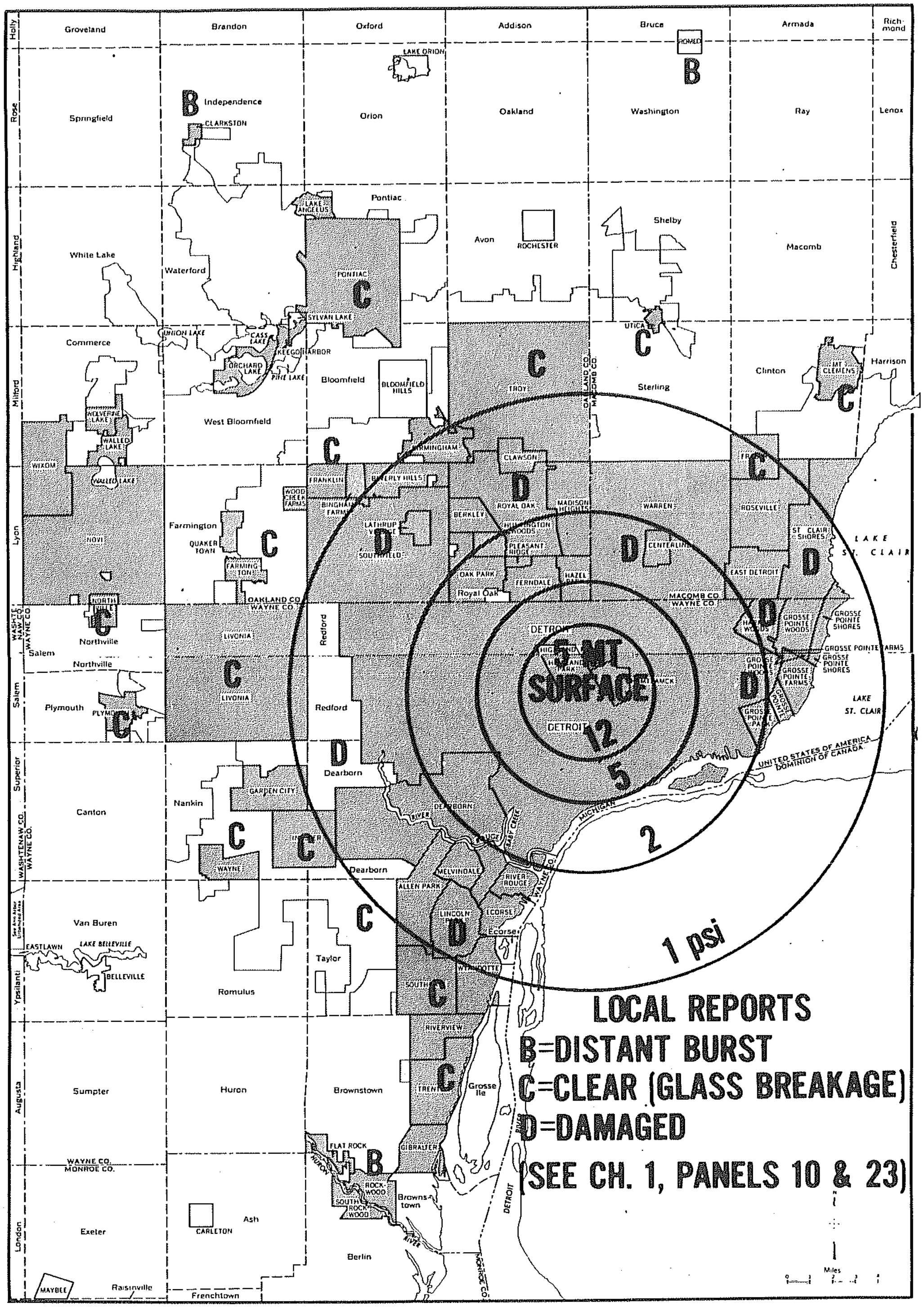
One of the problems of planning for a potential nuclear conflict is that the attack could take on a variety of forms. We do not know in advance whether cities will be struck, which military bases will be attacked, or whether detonations will be fallout-producing surface bursts or air bursts. We do not know whether EMP damage will be widespread, whether fires will get out of hand, or how well radiation injuries will be avoided. It is because of these basic uncertainties that nuclear emergency planning must be **contingency planning** that takes into account all reasonable possibilities.

The post-shelter environment has a significant feature: we will **know** what the war was like. Or, more accurately, what has occurred is knowable. We can learn which cities have been spared and which are in ruins, where the fallout is and where it is not, and how many have survived and their condition. Fallout radiation will be measured and the effects of radiation on people will be observed, thereby replacing the peacetime research findings given in Chapters 5 and 6. Damage to buildings, utilities, supplies, and industrial machines will be observable and may or may not conform to the estimates of Chapters 2 and 3. In other words, **damage assessment** will be a necessary first step to provide the essential information upon which local, State, and national post-shelter operations can be based.

The earliest and simplest attack effects information will be reported during the in-shelter period in the form of Basic Operating Situation (BOS) information (see Panels 20 and 23 of Chapter 1) or equivalent reports of "glass breakage," "structural damage," and color-coded fallout situation reports. Using these reports, damage assessors at State and Federal Regional EOCs can "fit" direct effects templates to include localities that report damage and exclude those that report only glass breakage, as shown here. Once an approximation of the locations and sizes of damaged areas is available, these can be laid over "lattices" of population, housing, and similar pre-attack data to get a first estimate of "what probably happened." At the national level, damage estimation would be done by computer because of the size of the task.

The urgent need to know "what happened," so that aid and recovery efforts can be planned, focuses the attention on the need for **communications between various levels of government** and **between mobile units (and the people) and the local authorities in the EOC.** Since communications are almost certainly to be disrupted by the attack, early restoration of communications is a priority task to be planned for in the post-shelter environment.

DETROIT URBANIZED AREA



PANEL 4

THE FALLOUT CONSTRAINT

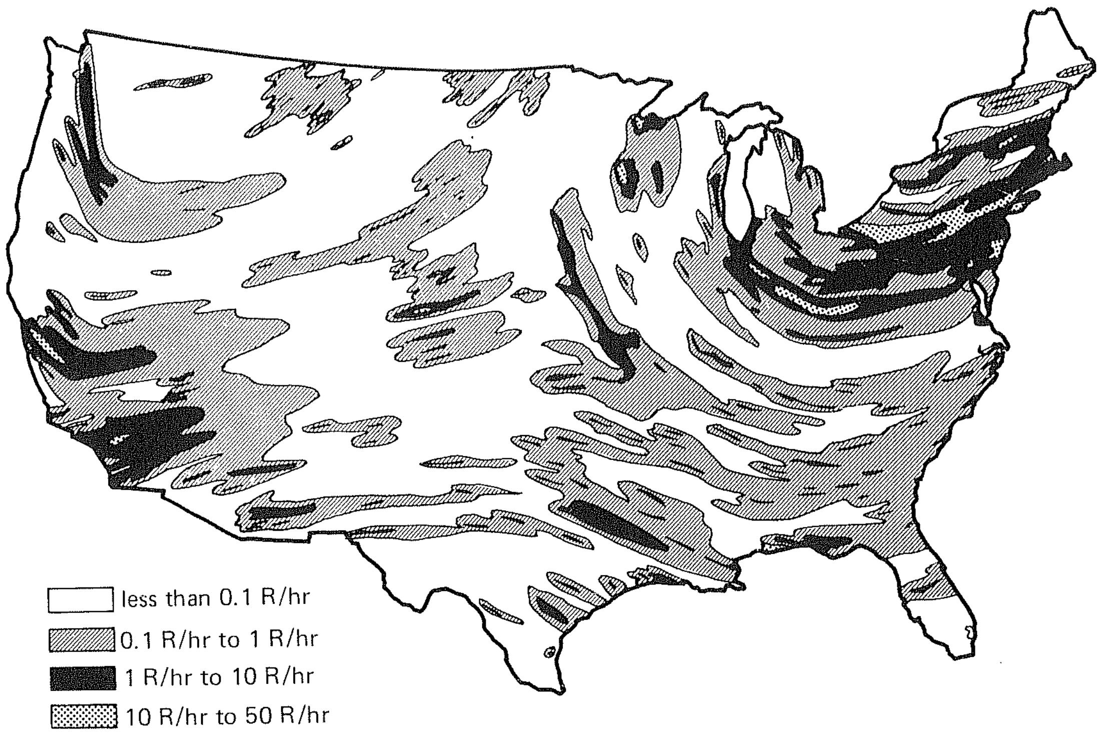
Gamma radiation from fallout is the attack effect that may persist in the post-shelter environment in amounts sufficient to cause injury or death. Studies of possible attacks in which fallout-producing surface bursts are assumed to occur indicate that, by one week after the last detonation, no part of the U.S. would be in a HIRAD situation (dose rate in excess of 50 R/hr).

The example fallout map shown here indicates the areas of the United States in which dose rates at the end of the first week could restrict post-shelter operations, as estimated by the Miller fallout model for the winds of a particular Spring day. An attack is assumed in which a portion of the weapons, amounting to about 2500 megatons, is detonated on the surface to cause fallout. In the clear areas, the dose rates at the end of the first week are estimated to be less than 0.1 R/hr (100 mR/hr). The dose rates in the lined area would range from 0.1 R/hr to 1R/hr. The black areas would have dose rates between 1R/hr and 10 R/hr. There are several stippled areas on the map where the one-week dose rates would be over 10 R/hr.

Time would further reduce the fallout radiation hazard. Using the 7-10 Rule discussed in Chapter 6, seven weeks after the attack the lined areas would become clear, the black areas would become lined areas, and the stippled areas would be black areas. To achieve a further factor-of-10 reduction would require, according to the rule, another seven-fold passage of time (49 weeks, or nearly one year after attack). Actually, increasingly rapid decay after six months and the effects of weathering would leave few, if any, areas outside the bomb craters above 100 mR/hr at year's end.

If the people are instructed and guided to limit exposures so as to avoid post-shelter radiation sickness, the principal effect of fallout radiation during the early months would be to delay the accomplishment of recovery activities. Delay would occur for several reasons. Recovery workers would need to restrict their exposure outside shelter to a shorter work-week in most cases. Survivors most able to participate in the recovery work force would be those in the best fallout shelters or those coming from areas experiencing little fallout, thereby limiting the size of the work force. Survivors manifesting symptoms of radiation sicknes during the first week would have to remain in shelter or be transported to less-contaminate areas. It can be seen from the map that the distances to be traveled from heavy fallout are to areas of much lower hazard are not great in most instances.

EXAMPLE FALLOUT MAP
(DOSE RATES AT ONE WEEK)



PANEL 5

DECONTAMINATION

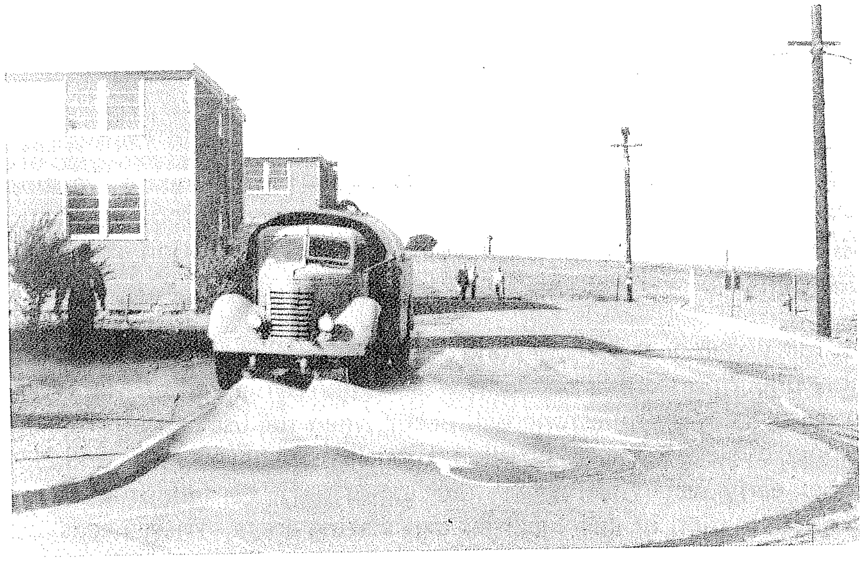
As noted in Chapter 6, the delays caused by fallout radiation can be reduced greatly by decontamination, a process in which the deposited fallout is removed from surfaces and placed where it can no longer irradiate people. Thus, if 90 percent of the fallout material affecting a workplace could be removed in the first few weeks, a situation would be created that would not occur otherwise until many months later. Halving the dose rate would permit recovery workers to work twice as long as would otherwise be the case.

Outside damaged areas, decontamination can be accomplished using a variety of common methods. Flushing fallout particles from roofs and paved surfaces and into the storm drains by means of a firehose has been found to remove over 90 percent of the fallout material. An hour's work by three men with a firehose will clean 1800 square feet of roof or 15,000 square feet of paved area. Motorized street flushers and street sweepers are more effective on paved areas and three to five times faster. Open ground areas can be scraped by earth-moving equipment: scrapers, graders, or bulldozers. These methods typically remove a slice of native soil amounting to several hundred times as much as the thin coating of fallout removed with it. The scrapings must be dumped at a remote corner of the cleared area. With room to maneuver, these methods are as effective as the paved area methods and almost as fast.

In damaged areas, widespread debris will complicate the decontamination process. If water pressure has been restored, the preferred decontamination procedure is to fire-hose an area 30 to 50 feet in radius around the debris-clearing equipment, flushing the exposed fallout down into or under the debris piles. Then, the street or area can be cleared of debris, and the remaining fallout in the cleared area can be flushed into the drains. Without water, debris removal must occur first, followed by motorized sweeping or vacuuming of the fallout.

Because of the specialized equipment and operator skills required by most decontamination techniques, widespread decontamination of whole cities does not appear practical during the first month or so. Decontamination will be useful to permit key utility plants, staging areas, and supply warehouses to be operated safely in the first weeks after attack. Later, a large part of the population can be usefully employed in mass clean-up efforts, using household brooms, garden hoses, and shovels. Calculations have shown that such efforts can result in significant reductions in population exposure to radiation over the long term.

SOME DECONTAINATION OPERATIONS*



Decontaininating with a street flusher

Removing fallout from an unpaved area.

*From Owen, W.L., and Sartor, J.D., **Radiological Recovery of Land Target Components - Complex III**, U.S. Naval Radiological Defense Laboratory, November 1963 (AD 433 141).

RESTORING THE WATER SUPPLY

The first post-shelter hurdle that must be overcome is inadequate life support for the surviving population. The essential life-support needs are water, food, protection from the elements (housing and clothing), and health care. Of these, restoration of an adequate water supply is the most urgent.

The need for water goes well beyond the provision of potable water for drinking. Water, preferably under pressure, is needed for sanitation, which, in turn, is essential to public health. An early recovery milestone will occur when the use of flush toilets is regained, baths and personal hygiene become possible, utensils can be cleaned, and clothes can be washed. Another early water need is for fighting of fires. In fallout areas, water will be needed for decontamination of key facilities and staging areas. These needs justify making restoration of waterworks operations the first recovery goal.

In undamaged areas, restoration of the water supply may depend only on the availability of electric power to operate pumps and chlorinators. See Chapter 4 for the reasons why widespread loss of electric power is likely as the result of an attack. Since electric utilities normally serve broad geographical areas, plans should be made to obtain from the State an estimate of the time that power is likely to be restored in undamaged areas. If restoration of electrical service is not likely during the second week after attack, portable emergency generators in the vicinity should be moved to the waterworks on a priority basis. Plans should define the power needs of each water facility and where auxiliary sources of generators and fuel are to be obtained. If portable generators are unavailable, induction motors can be converted into generators as described in Panel 14. Other actions may be needed to restore the water supply, such as decontamination of the works to minimize radiation exposure of essential operators. Supplies for water treatment facilities may need to be replenished.

Water quality control in the immediate post-shelter period may not be of crucial importance in undamaged areas since boiling and other measures can be instituted to improve potability. Much of the population is served by water systems that use ground water from wells that should be free of fallout contamination. Even where this is not the case, there are usually a number of commercial concerns, such as breweries, that have their own water supplies independent of the municipal supply. Also, older maps of an area may show locations of wells and springs no longer used that might be potential sources of supply.

The emergency planner needs to know where these sources are so that safe drinking water can be provided, especially for the children, during the first month (see Chapter 6). In damaged areas or where water sources are polluted, water may be hauled in and distributed by tank truck until undamaged portions of the utility distribution system can be put back in use through rerouting, isolation of damaged piping, and repair of the works itself.

PANEL 7

WATER IS URGENTLY NEEDED FOR:

- Drinking
- Flushing Toilets
- Bathing and Washing
- Cleaning and Scrubbing
- Laundering
- Firefighting
- Decontaminating
- Industrial Processes

PANEL 7

ESTABLISHING THE FOOD SUPPLY

As noted in Chapter 6, fallout radiation may injure or kill many growing crops and food animals and may prevent farm workers from caring for them for a period of time. No essential agriculture need be delayed beyond the following year's growing season. Whether surviving food stocks would be sufficient to carry the population through the harvest of the next year's crops has been the subject of several studies, results from one of which are shown here.

These statistics could lead to considerable optimism unless it is noted at once that only the last two items constitute the immediately available food supplies, processed for human consumption. About 70 days of supply is available. Some of this supply may be lost in the attack, of course, but, on the other hand, the supply has been measured in terms of the pre-attack population.

Since crops in the field and farm animals are vulnerable to attack effects, the biggest potential source of supply is grain stocks. These stocks fluctuate from season to season and from year to year, depending on world market conditions. The bulk of these stocks is not located near the population centers and requires some processing before reaching the consumer. Emergency transportation of food will be a critical post-attack problem. Estimates indicate that surviving rail and truck transport will be adequate for priority food shipments. Food processing plants may be located where damage is likely. Other grinding facilities may need to be adapted to the milling of grain. Grain normally grown for animal feed may have to be diverted to human use. The U.S. Department of Agriculture is responsible for post-attack management of "primary" food resources and for the complex processing and distribution of them. State and local governments must control the use of "secondary resources" of food in the hands of local wholesalers, retailers, in households. As discussed more fully in Panel 19, current plans involve consumer rationing of essential items, including food, even in undamaged localities where supplies would appear to be ample.

In effect, the local government takes charge, using private food organizations and personnel as feasible. So long as much of the population is retained in public shelters (whether the attack environment demands this or not), delivery of food based on shelter head-count is an automatic form of rationing. Individual families surviving in residential basements will be dependent on household stocks during this period. As shelter emergence becomes desirable, food distribution may continue as a mass feeding program based on the shelters, work places, elementary schools, and staging areas. Only when housing is re-established and necessary utilities and fuels are judged to be in adequate supply is over-the-counter rationing and home preparation of meals likely to be feasible.

NATIONAL FOOD SUPPLY*

	Days Supply**
Farm Crops in the Field (Grains only on July 1st)	1163
Grain Stocks	
Food Processors and Private Storage	457
Government (CCC) Inventory	103
Farm Animals (Cattle, Hogs, Poultry)	105
Food Processors and Interstate Warehouses	45
Local "Secondary" Resources of Food (Wholesalers, Retailers, and Households)	25
Grand Total	1898***

*Based on 1969 data in A.F. Shinn, **Vulnerability of the U.S. Food Supply and Food Distribution to Nuclear Attack**, Oak Ridge National Laboratory, 1969.

**Assumes 3000 calories daily for 203 million people.

***Neglecting crops in the field and farm animals leaves 630 days of supply or nearly two years of food, mostly grain.

PANEL 8

EMERGENCY HOUSING

To the extent that people have survived the attack environment, both direct effects and fallout, the areas where they were sheltered may continue to offer adequate protection against the elements. We saw in Chapter 2 that people can survive blast and fire effects better than houses. Thus, millions of homeless survivors can be expected after a nuclear attack. Some portion of these will have been driven from untenable shelters during the emergency period and will have had to seek shelter elsewhere. Nonetheless, providing of emergency housing is unlikely to be as urgent in the post-shelter environment as would be assuring the survivors that water will be available for drinking and personal hygiene and that no family or small group need forage on their own for the next meal.

Post-shelter emergency housing will be important to plan for not only for health reasons but also for morale purposes. Just as the opportunity to take a bath is likely to mark an early postattack milestone, so will the opportunity to sleep once more in a bed in the privacy of one or more rooms assigned to a family. As shown in this chart, such relative comfort is likely through use of only surviving housing units because Americans presently enjoy housing accommodations that are quite roomy compared to those in many other countries of the world.

A measure of adequacy in emergency housing would likely be the criterion of 40 square feet per person used following peacetime disasters. This is four times the DCPA shelter space allotment but far short of the space normally available in U.S. housing units, the majority of which have five or more rooms. In areas nearby nuclear detonations, a major repair task will be to cover in various ways the window openings that have been blown out by the blast wave. In fallout areas, occupancy of emergency housing during the first month may require converting multi-story office buildings into dormitories by bringing beds from the less protective residences or decontamination and intensive use of selected multi-unit dwellings until the rest of the housing can be safely used. In any event, occupancy of emergency housing will entail the restoration of electric power, water, and the availability of fuel for heating and cooking.

Ultimately, the housing destroyed in the attack will have to be replaced to the extent the survivors require it. A standard of housing approaching the preattack situation is consistent with recovery goals and with the need to assure the public of the return of private property to its rightful owners at the earliest possible time and the replacement of losses through some system of loss sharing. This is a longer-term matter that will be planned for at the Federal level in conjunction with recovery of industrial production.

PANEL 9

HOUSING SPACE IN VARIOUS COUNTRIES*

Place	Persons per Room	Relative to U. S.
United States	0.6	1.0
Canada, United Kingdom	0.7	1.2
France, West Germany	0.9	1.5
Puerto Rico, Italy	1.1	1.8
Czechoslovakia, Finland	1.3	2.2
Soviet Union, Greece	1.5	2.5
Poland, Yugoslavia, China	1.7	2.8
India, Guatemala	2.6	4.3

* From United Nations Statistical Yearbook, 1971.

PUBLIC HEALTH

Survivors of nuclear attack may be exposed to endemic diseases capable of rapid development to epidemic proportions in an uncontrolled post-shelter environment. There are some 14 diseases of man that may increase sharply unless early priority is given to adequate sanitation and public health measures. The need for disposal of human wastes and personal cleanliness was referred to in Panel 7 as an important reason for early restoration of water service. This implies that provision of electric power for sewage treatment plants and sanitary lift stations must be given equal priority. Where damage has occurred, repairs to the sanitary waste-disposal system must be scheduled concurrently with repairs to the water system, if people are to be housed or sheltered in the area.

In addition to human waste disposal, major public health problems will be created, especially in damaged areas, by the creation of breeding areas for flies, rodents, mosquitoes, and other disease-carrying species. In all but the winter season, intestinal (enteric) diseases, such as Shigellosis, Salmonellosis, and infectious Hepatitis, could erupt to epidemic proportions because of greatly-increased numbers of flies. A large increase in the fly population can be expected if organic wastes are left uncollected for more than a week.

Garbage and rubbish produced incidental to feeding the population will constitute a relatively small part of the putrefying organic matter. In blast areas, the bodies of the deceased must be collected and buried. Animal corpses must also be disposed of. Solid organic wastes are likely in damaged industrial plants, warehouses, food and produce markets and in households. If electric power has been out for more than a week or so, frozen and refrigerated products will have begun to deteriorate. Food that is beyond reclaiming must be treated as organic waste.

Studies have shown that a supply of insecticides and poisons can be expected to remain available for vector control following attack. The most important single operation is that of collecting and disposing of solid organic wastes. Next in priority is the control of houseflies, along with mosquito control. The table suggests a post-shelter schedule of activities to be undertaken.

POST-SHELTER SANITATION NEEDS*

DESIRED SCHEDULE	ORGANIC WASTE COLLECTION	FLY CONTROL	RODENT CONTROL	MOSQUITO CONTROL
First Week	Undertake at High Priority	Begin Adulticide	Wait	Wait
Second thru Fourth Week	Continue as Necessary	Continue as Necessary	Place Poisons & Traps	Begin Larvacide
Second thru Twelfth Month	Return to Normal Collection	Return to Normal	Return to Normal	Return to Normal

*Based on **Postattack Sanitation, Waste Disposal, Pest and Vector Control,** Engineering-Science, Inc., January 1967 (AD 645 599).

TREATMENT OF INJURED SURVIVORS

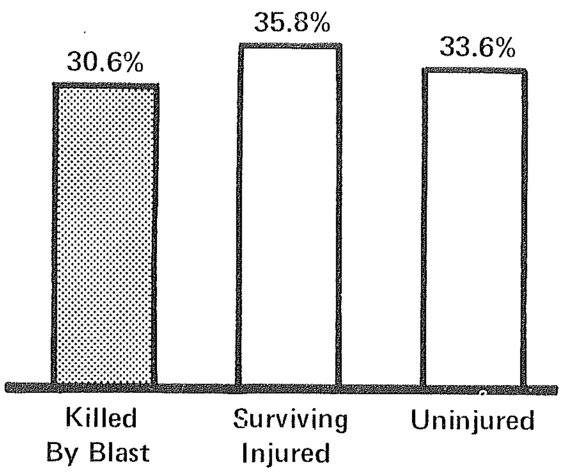
It is sometimes useful to consider post-shelter medical care needs in two time periods: (1) an "immediate postattack period," lasting the first month, in which the treatment of injured survivors is the most important medical problem; and (2) a "late postattack period," covering the remainder of the first year, in which treatment of victims of communicable diseases is the central health care need.

In the immediate postattack period, treatment of trauma (wounds and broken bones) and burns creates the greatest demand for professional care by physicians and surgeons. There is no specific treatment for radiation sickness beyond bed care, cleanliness, and replacement of fluids. This can be provided by relatively untrained personnel. Proper treatment of injuries and burns, however, places a heavy demand on those who possess specialized medical skills. A characteristic of nuclear attack is that the numbers of surviving injured are expected to equal or exceed those killed by blast. This could mean tens of millions of injured survivors throughout the nation. Since today there are only about 1.5 physicians and 10 auxiliary medical personnel (dentists, veterinarians, nurses, etc.) per 1000 population, case loads would be many times normal even if emergency plans placed medical personnel in the most survivable shelter locations.

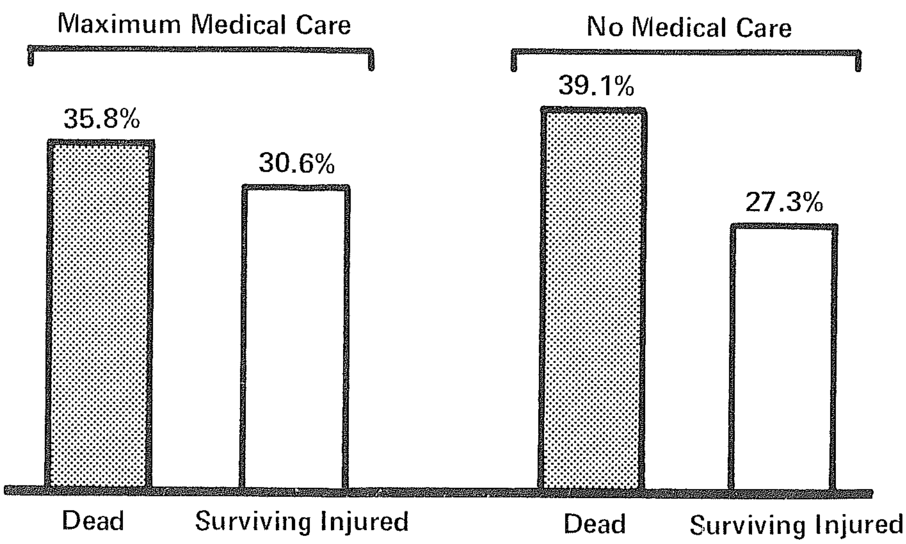
Studies, such as the one illustrated here, have indicated that medical care would have only a limited effect on the number of fatalities because most of the injured either would be beyond help when they could be treated or would survive in any event. The example shown is a detailed case study of casualties following an assumed attack on the Detroit metropolitan area. The upper bar chart shows an estimate of the situation 24 hours after the attack. The lower bar chart shows the estimate for 30 days after attack, assuming on the one hand peacetime levels of medical treatment and no treatment on the other. The estimates were formed by defining injury types in detail and then consulting hospital and medical records to predict outcomes. The complicating effect of fallout radiation injury was also taken into account.

The results show about three-quarters of the surviving injured would have survived without medical care. About 15 percent of the surviving injured would succumb during the 30-day period despite maximum medical care. Approximately 10 percent of the surviving injured could be saved by such medical treatment. In the study cited here, the medical care judged to have been available after the assumed attack did not save any significant number of the surviving injured. Later analyses have indicated that post-shelter medical treatment might have an important effect on the "quality of survival" and how rapidly the injured can be returned to a useful place in society.

EFFECT OF MEDICAL TREATMENT*



ESTIMATE AT ONE DAY



ESTIMATE AT THIRTY DAYS

*Based on Pyecha, J.N., et al., **Alternative Designs for Systems for Providing Postattack Medical Care**, Research Triangle Institute, October 1970 (AD 718 081).

TREATMENT OF DISEASE

Degradation of the public health measures discussed in Panel 10, difficulties in maintaining personal cleanliness, poor nutrition, and radiation injury could lead to post-shelter increases in communicable diseases, possibly of epidemic proportions. In contrast to attack injuries, where the availability of doctors is the limiting factor in effective treatment, the critical element in treatment of communicable diseases appears to be the adequacy of medical supplies, particularly drugs and medicines. Like attack injuries, communicable diseases can affect a large fraction of survivors. But, unlike attack injuries, effective medical treatment can be achieved and will have a great impact on preventing further loss of life in the first postwar year.

In addition to the public health measures already discussed (water and sewage control, organic waste disposal, and insect and rodent control), one set of post-shelter medical and public health priorities is shown here. Isolation of infectives when diagnosed is of greatest importance. In addition, maintenance of the "external quarantine" to prevent entry of diseases such as yellow fever and typhus into the country is needed, since the population is defenseless against many diseases that no longer are endemic in this country. Some diseases, such as plague and tularemia, are transmitted from wild rodent reservoirs. The general rural relocation of survivors that may occur either preattack or postattack could increase contact with the animal reservoir. Close surveillance of these threats may be necessary.

Physicians are normally dependent on laboratory tests to aid in diagnosis of disease so that the proper treatment can be instituted. Many, if not most, of these medical laboratories may be unusable by attack effects. An early post-shelter need will be to establish surviving laboratories to service the medical diagnostic needs of a much larger area than was common prior to attack. Lacking adequate diagnostic tools, broad-spectrum antibiotics to treat an uncertain range of possible diseases will be in great demand. Early production of these preparations in quantity will be necessary.

After the first few months, measures will need to be taken to provide as well-balanced a diet as possible, with attention to sources of protein and vitamins, without which people will become more susceptible to infection and suffer more severely from illness.

PRIORITIES FOR COMMUNICABLE DISEASE CONTROL*

1. Isolation and Quarantine.
2. Disease Surveillance.
3. Establishing Regional Diagnostic Laboratories.
4. Drug Production, especially Antibiotics and Disinfectants.
5. Production of Immunologicals.
6. Food Quality Control.

*Based on H.H. Mitchell, M.D., **Guidelines for the Control of Communicable Diseases in the Postattack Environment**, R&D Associates, July 1972 (AD 748 343).

RESTORING ENERGY SUPPLIES

Virtually all activities in the immediate post-shelter period needed to provide life support and health care to the surviving population will require sources of energy: electric power, gas, petroleum fuels, and the like. Of these, electric power is the energy source of widest immediate use. Electric power will be needed for the all-important communications among organized civil defense forces and between the government and the people. Except for limited use of gravity systems, water service cannot be restored nor can sewage disposal become effective without an electric water supply.

Recovery activities would largely be limited to daylight hours unless building and street lighting is available. Treatment of injured survivors also will be difficult unless electric power is available. One special problem of immediate significance in the postattack period is the fate of food, mainly meat, in cold storage and freezers at wholesale, retail, and household levels. These supplies of protein will be of great nutritional value to the survivors. Moreover, unless power for refrigeration is available within about a week of power loss, these potentially valuable supplies will become organic wastes constituting a health hazard until collected and disposed of.

Electric power will be needed to operate fuel pumps so that public safety vehicles, repair vehicles, and essential transport can continue to operate. Many of the tools and equipment used in the repair of communications, water, sewage, and other key facilities also require electric power. Finally, electric power will be needed in undamaged industrial plants where essential survival items such as pharmaceuticals must be produced.

Restoration of electric power in damaged areas is likely to be a slow process. Power outages in undamaged or lightly-damaged areas may not take many days to correct since many power generating stations are located where they are likely to survive and the power systems are well interconnected. Inventories of coal and other fuels needed for power generation may, however, be in short supply. Many key facilities, such as emergency control centers, radio transmitters, and hospitals already have installed emergency generators to substitute temporarily for electric power service. Thousands of portable generator sets also exist that could be brought to key facilities not so equipped. Should sources of emergency power be unavailable or insufficient, there are **expedient** ways to produce electric power. These are discussed in the following panel.

ELECTRIC POWER IS NEEDED URGENTLY FOR:

- COMMUNICATIONS
- WATER SUPPLY
- WASTE DISPOSAL
- LIGHT
- MEDICAL TREATMENT
- FOOD PRESERVATION
- FUEL PUMPS AND REPAIR TOOLS
- ESSENTIAL SURVIVAL ITEM PRODUCTION

EXPEDIENT ELECTRIC POWER

Standby power plants installed in communication centers, hospitals, and some other key locations serve important but limited purposes. Portable engine-generator sets are rather widely available but the total capacity they represent is small compared to the potential demands for electric power in the immediate post-shelter period. What most emergency planners do not know is that most electric motors (the induction motors) can be converted into electric generators to provide power to drive other motors, the pumps in waterworks and sanitary lift stations, for example. The number of unessential motors suitable for conversion is enormous and could, theoretically, provide virtually all the emergency power needs of the nation.

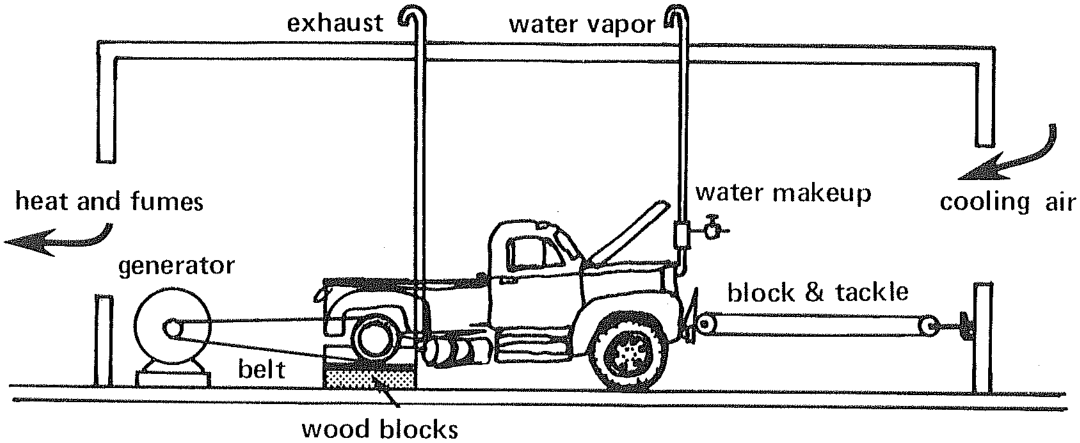
An induction generator is an induction motor that is driven by an engine (the prime mover) so that, instead of working as a motor, it becomes a generator of electric power, as shown in the upper sketch. Some electrical components are also needed but they are usually to be found in factories or office buildings. The information presented in the lower sketch is intended only to convey a general idea of what an expedient induction generator setup might be like. **How-to-do-it information** that can be understood by electricians or power engineers can be found in the reference cited below the sketches, **which should be consulted, especially for safety advice.**

The major components of an induction generator are:

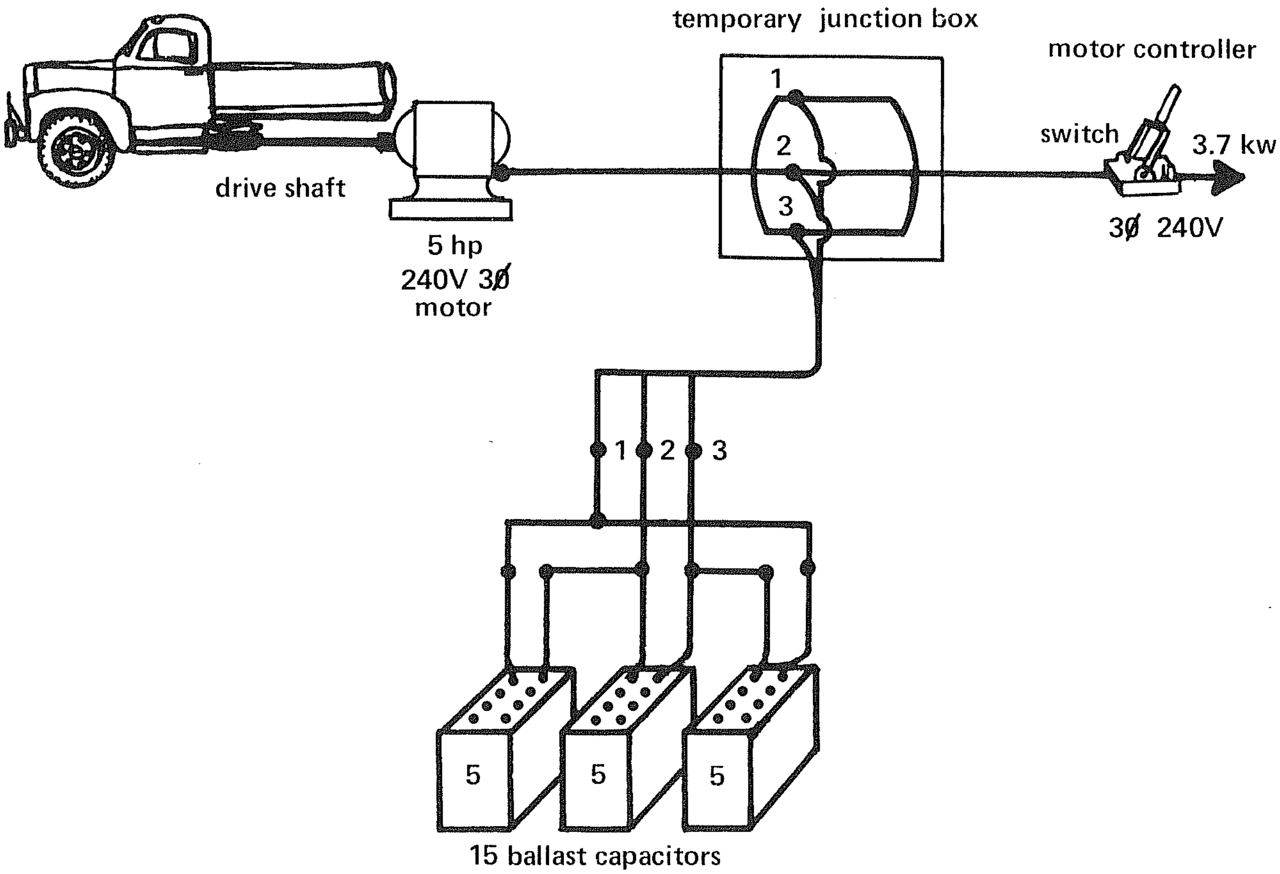
(1) **An induction motor** to be used as the generator. It should be about four times as large as the largest motor to be started. That is, a 5-hp pump motor needs a 20-hp induction generator to start it.

(2) **The prime mover** must be an internal-combustion engine about three times the generator's size. In other words, a 20-hp induction generator needs a 50 to 60 horsepower truck or tractor engine to drive it. An adjustable speed governor on the engine is most desirable. The engine can be coupled to the induction motor by belt drive from a rear wheel (upper sketch), directly from the drive shaft (lower sketch) or through the "power takeoff unit" with which many trucks and tractors are equipped.

(3) **A source of excitation**, usually a capacitor of about the same rating as the induction motor. Heavy-duty power capacitors are often used to improve "power factor" and thus can be found near large motors or near the distribution panel in many facilities. Another source of capacitors is the ballasts in fluorescent lighting units. The lower sketch shows a 5-hp induction generator excited by 15 capacitors from such ballasts. This generator will produce over 3.5 kilowatts of electric power.



EXPEDIENT INDUCTION GENERATORS*



*From Black, R.H., **Guidelines for Generating and Using Electric Power During Prolonged Emergencies**, URS Research Company, September 1971 (AD 739 945).

EXPANDING PUBLIC SAFETY FORCES

Most regular public safety functions of local government must be resumed before the release of the general population from shelters after an attack. Outside of damaged areas, existing public safety forces should be sufficient to perform these functions in their normal manner, whenever fallout conditions permit the release of the sheltered population. However, if the normal population has been greatly increased by an influx of survivors from areas more severely affected, most of the regular public safety tasks will require longer work shifts, increased manpower, or both.

In addition, there will be many special public safety needs to be met. Most of these would impact on the police force, since they are normally associated with the peacetime law-and-order function. A large expansion in numbers of auxiliary police, guards, and watchmen would be necessary. These people would not need much training in most cases, but they would need to be selected and recruited and would need professional supervision. In many cases, professional peace officers would need to devote most of their time to supervision and training of a greatly-expanded public safety force.

Control of access into damaged areas and areas of fallout radiation should be planned. Control points would be needed on major access routes. Minor streets and roads should be blocked completely and posted with warning signs. Locations of special hazard because of concentrations of fallout or because of damage to buildings and structures would need barriers and warning signs. A program of demolition and correction of hazardous conditions should be planned. Finally, areas vacated during or before the attack should be patrolled, if and when feasible.

Another class of special needs arises from the requirement to control rigorously the use of critical resources. The most critical are food, fuel, and pharmaceuticals. Construction supplies, household supplies, and transport are also essential survival items. Guards and watchmen will be needed to prevent pilferage and unauthorized use. One means of minimizing opportunities for circumventing control of scarce resources is to limit unauthorized travel, especially vehicular travel. Requiring special identification for such movement will also conserve the limited fuel supply.

A specialized problem will also arise in directing the movement of incoming refugees, mutual aid teams, and supply transports to staging areas and warehouses with which they will be unfamiliar.

POST-SHELTER PUBLIC SAFETY NEEDS

REGULAR

1. Fighting Fires
2. Controlling Traffic
3. Investigating Crimes and Complaints
4. Responding to Accidents and Other Emergencies

SPECIAL

1. Controlling Access to Damaged Areas
2. Controlling Access to Fallout Areas
3. Marking Hazardous Areas
4. Correcting Hazardous Conditions
5. Patrolling Vacated Areas
6. Guarding Essential Resources
7. Preventing Unauthorized Travel
8. Directing Refugees and Aid Teams

REDEPLOYMENT

In preparing the defense, we must aim at readiness for all likely contingencies in every locality. For example, every locality should be prepared for fallout, with shelters, RADEF instruments, and people trained to use them. But we know, in reality, that some cities and counties are better prepared than others and are likely to remain so. In the post-shelter environment, we would know where the damage occurred and where the fallout was (see Panel 4). We saw in Panel 5 that some areas of the country would have negligible fallout while other areas, not too far distant, would have a persistent radiation threat. In areas of negligible fallout, trained RADEF personnel and instruments would not be needed. Their know-how would be invaluable in the fallout areas. What would be needed would be a redeployment of specialized personnel and equipment to areas of need.

This partial listing of valuable specialties emphasizes the point that "know-how" is the most important aspect of redeployment. The stricken areas would not be without resources but experience and knowledge may be in short supply. An extra shift of trained operators could permit the existing equipment to be worked around the clock. In most cases, the specialized equipment needed could be carried with the personnel.

Trucks and heavy construction equipment would necessarily move by road or rail. Most everything else could be brought in by air. Regular commercial aircraft generally have been earmarked for military support missions, but the Civil Air Patrol (CAP) and most private and corporate aircraft would be available for urgent recovery needs. Most States have SARDA plans for this purpose. (SARDA means State And Regional Defense Airlift.)

Local emergency plans should provide for assessment of the need for specialized help in the immediate post-shelter period. No locality should attempt to "go it alone" with inadequately trained advisors when making known deficiencies to the State would often bring help. Alternatively, for the lesser contingencies, plans should call for notifying the State of available skills and equipment that might be used in more severely affected jurisdictions. Only in this way can the State and Region "put it all together."

SKILLS AND EQUIPMENT NEEDED IN SOME AREAS MORE THAN IN OTHERS

1. Radiological Defense Officers, monitors, and radiation detection equipment.
2. Doctors, nurses, and medical people.
3. Utility repair crews and trucks.
4. Public health experts, exterminators, and supplies.
5. Leaders and planners, including experienced construction managers.
6. Bulldozers, cranes, loaders, and their operators
7. Skilled construction crews and tools.

RESTORING INDUSTRIAL PRODUCTION

Civil defense measures that would increase the short-run survival of the population in a nuclear war would be of little value if the war would so cripple the nation's economic system that the survivors could not be supported in the long run. In a sense, there would be a race between resumed production of essential survival items and the depletion of inventories from which essential needs were being met in the meantime. Whether the race could be won would depend on how long the inventories could last, how many factories survived, what kinds of things they could produce, whether damaged factories could be repaired or "cannibalized" to create new factories, and how long it would take to build new sources of supply.

Understanding the economic recovery problem is immensely complicated because of the interdependence of modern industry. An example is shown here. Suppose all of the economic activities that go to make up a modern industrialized society were lumped into 15 classes or "sectors" of economic activity. Then it would be found that each sector depended on goods and services obtained from all the other sectors in order to produce whatever that sector was intended to accomplish. For example, the Motor Vehicles sector, according to recent census figures, buys $1.39 worth of goods from the Food and Textiles sector for every $100 of motor vehicles made and sold. (Presumably this is for upholstery and the like.) A big supplier is Primary Metals—steel and aluminum. Another is Fabricated Metals. The biggest dependence is on parts suppliers within the Motor Vehicles sector itself. Altogether, the Motor Vehicles sector pays out about 70 percent of its gross sales to suppliers of goods and services. With what is left the Motor Vehicles "industry" has to pay its own employees. pay taxes, and make a profit.

What this means is that even if Detroit were spared in an attack, whether it could produce motor vehicles would depend on how much damage and destruction occurred in other sectors. The other sectors, in turn, are dependent upon their own suppliers, who are again dependent on the surviving sources of their supply. Thus, merely totting up how much of each industry survived will not tell how much can be produced by a post-shelter industrial base that has been damaged to various degrees in its many interlocking parts.

PURCHASES BY THE MOTOR VEHICLES SECTOR

	SECTORS	Purchases Per $100 of Sales
1.	Food and Textiles	$ 1.39
2.	Wood and Paper	0.15
3.	Chemicals	0.62
4.	Petroleum Refining	0.17
5.	Rubber and Leather	2.23
6.	Stone, Clay, and Glass	1.12
7.	Primary Metals	10.00
8.	Fabricated Metals	6.33
9.	Machinery, except Electrical	4.34
10.	Electrical	2.15
11.	Motor Vehicles	32.96
12.	Aircraft and Transportation Equipment	0.09
13.	Instruments and Optics	0.64
14.	Trade and Services	5.13
15.	Diffuse*	3.08
	Total Intermediate Purchases	$ 70.40

*Includes Agriculture, Mining, Construction, Transportation, Utilities, and Imports.

ECONOMIC RECOVERY

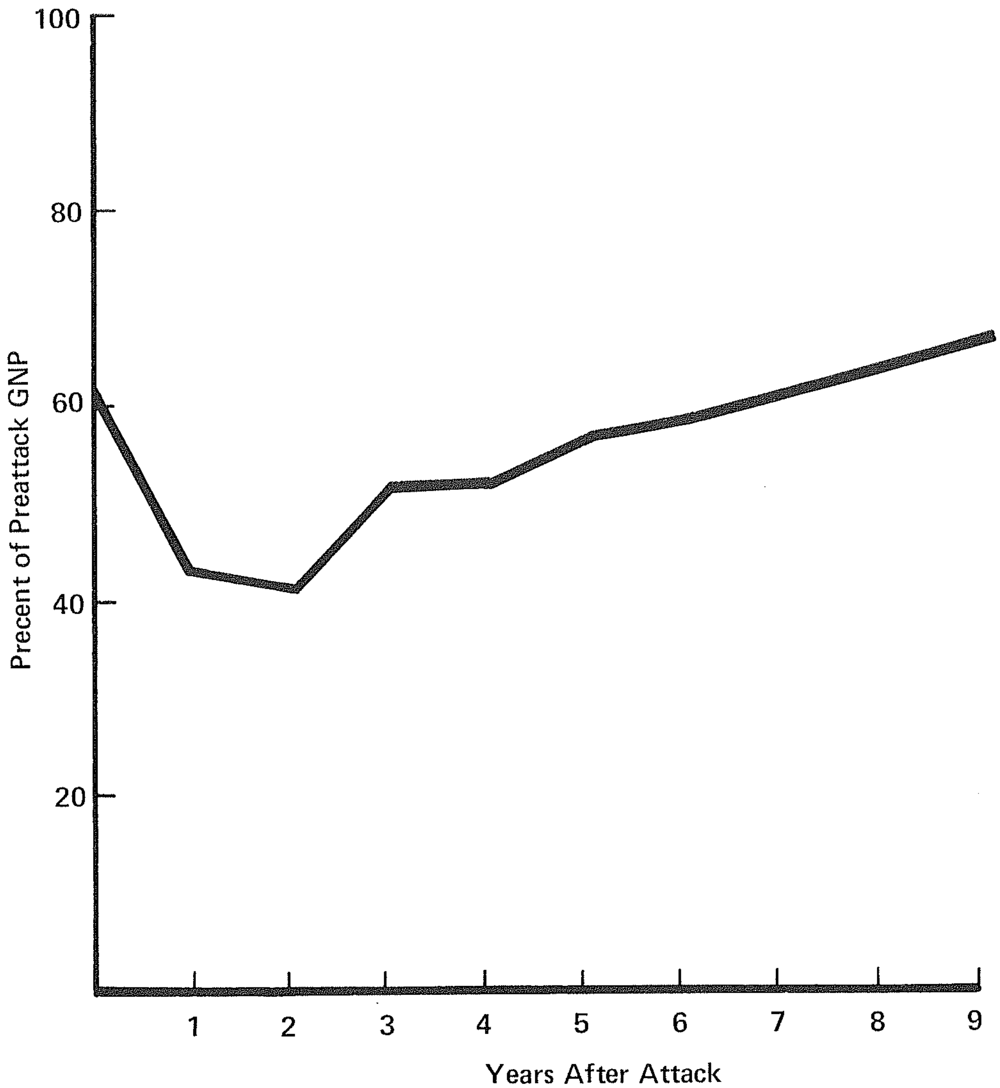
A measure of all the goods and services produced by the peacetime economy to satisfy the final purchasers is the Gross National Product (GNP). One way to judge the potential viability of the war-damaged economy is to compare its capability in terms of Gross National Product with the undamaged preattack GNP. To do this, the inter-industry transactions for each "sector" are established from census data (such as shown in the previous panel), damage to each sector is estimated for a given presumed attack, and the possible end-product production calculated on a computer. This is known as an "input-output" analysis; the results of one such analysis are shown here.

The computer model used in this analysis is based on the 15-sector economy shown in the previous panel. Final demand on the surviving industry is composed of consumption requirements of the population and investment in building new facilities to replace those lost in the attack. The model attempts to use the surviving capacity (limited by inter-industry requirements for intermediate products) as much as possible to meet consumption requirements and to allocate investment in critical sectors in such a way that the stream of GNP into the indefinite future is as great as possible. Investment of $2 in new construction was assumed to produce $1 of increased capacity two years later.

The results shown here are based upon an assumed attack in which, in addition to military and other targets, about one-third of the Soviet weapons shown in Chapter 1 are targeted to maximize damage to all economic sectors. The surviving capacity is estimated to be about 60 percent of the preattack GNP but limits on available resources further reduce production to about 40 percent of the preattack level at the end of the second year. Then, the investments made in the interim begin to pay off and the economy begins to grow. By the ninth year, the economy is estimated to be about two-thirds of the preattack level and growing at about 4 percent each year. (Note the similarity between this projection and that of Panel 2.)

Larger attacks would further limit the surviving industrial capacity. Also, an attack of the same magnitude that aimed at destroying a critical sector, such as petroleum refining, would leave much of the surviving capacity in other sectors unusable until substitute refining capacity could be developed. Thereafter, there would be a very rapid increase in overall production. Finally, the lumping of production facilities into a relatively few economic sectors assumes that the products are readily substituted for each other or that the facilities can be readily converted. This is not always the case. So most analyses use 80 or more sectors. These analyses predict economic viability over a wide range of size and kind of nuclear attack.

ONE PROJECTION OF ECONOMIC RECOVERY*



*From Dresch, F.W., and Baum, S., **Analysis of the U.S. and USSR Potential for Economic Recovery Following a Nuclear Attack,** Stanford Research Institute, October 1972 (AD 755 552).

EARLY PRODUCTION PROBLEMS

Economic models, such as that described in the previous panel, estimate what is physically capable of being done with the available productive resources if these resources are used efficiently to achieve some stated goal. In peacetime, those who have immediate control over productive resources tend to use them in ways each thinks will maximize his private gain. In a "free enterprise" economy, this is also considered to be in the national interest. In postattack recovery analyses, it is assumed that what people do with the resources over which they have immediate control will be determined for them by general rules and specific orders that fit a national recovery plan.

It seems most likely that, for at least the first few months after a nuclear attack, national authorities would lack the information, staff, and experience to be able to do much central management of the economy. Therefore, official planning provides for a set of prepositioned regulations that become effective upon attack and that (1) delegate Federal authority to heads of regional offices of the Federal Government and to State and local authorities, and (2) freeze prices, wages, and rents, institute consumer rationing, and establish a priority system. Federal authorities have made up a list of survival items (mostly medical, food, shelter, and fuel) that would be attached to the proclamation of the priority system by the State Governor or his legal successor. These excerpts are from the proclamation that appears in virtually all State plans. Each producer of an item on the priority list need merely certify on his orders that the supplies are needed for production of the priority goods. Local heads of government will be directed to initiate the controls. It is expected producers and suppliers, impressed with the gravity of the emergency, will comply with the published rules without need for extensive surveillance.

Associated with the price and wage-rate freezes will be a freeze on interest rates. At these rates, there will be unlimited credit from banks, backed by the Federal Reserve System, for priority activities. Most other bank deposits would be frozen for the time being.

It is reasonable to expect that sometimes there will be insufficient supplies to satisfy all priority orders and other important needs. Federal regional offices, State Resource Priority Boards, and State departments will assist in adjudicating these problems. But the emergency planner should recognize that the local government is expected to play a key role during the immediate post-shelter period in assuring that resources are carefully conserved and channeled into the most urgent uses and activities.

EXCERPTS FROM GOVERNOR'S PROCLAMATION*

To: Executive Heads of All Political Subdivisions in this State

I hereby proclaim these policies and guidance in effect throughout this State . . .

Facilities in your jurisdiction which produce or distribute items or provide services essential for local, State, and National survival . . . have been identified . . .

You are requested to authorize essential local users . . . to use the following certification on their purchase orders . . .

Please advise local employment offices to act . . .

You are to inform secondary suppliers of essential survival items in your jurisdictions that they are prohibited . . .

If supplies of essential survival items available . . . are inadequate, you are to restrict further their use to those needs which, in your judgment, are most urgent . . . and request . . . resupply to make up local deficiencies.

You are to inform persons engaged in essential local activities or operating essential facilities how to obtain emergency credit . . .

As soon as possible, you are requested to arrange for rationing of designated essential consumer items.

Governor

*From **Example of a State Plan for Emergency Management of Resources,** Executive Office of the President, September 1965.

CRISIS ACTIONS FOR ECONOMIC RECOVERY

A period of extreme crisis could provide both the time and the sense of urgency that would be necessary for taking action to improve the prospects for postattack economic recovery. Local government, working cooperatively with local industry, could make the essential peacetime plans without which the task of implementing crisis actions would be much more difficult. Mobilization during times of international tension is compatible with current estimates of a low probability of sudden attack (see Chapter 1).

Many major corporations have made peacetime arrangements for protected alternate corporate headquarters. In a crisis, most other businesses could relocate essential records and management personnel outside the large cities. Management will recognize such plans as insurance that they can "stay in business."

Hundreds of billions of dollars of economic assets are located in potential target areas in the form of finished inventories, parts, and specialized equipment. In a crisis, many of these resources could be loaded on trucks, railroad cars, and delivery vehicles and removed from the area where they could be placed in temporary open storage or parked in the loaded vehicles. Equipment and parts needed to sustain production, should this be necessary, could be buried later on the premises to protect them against blast and heat damage. This could be done in a few hours' time in many instances. Delicate and irreplaceable control equipment should be wrapped in plastic before burial. Machine tools and bulky equipment that cannot be moved can be made less vulnerable to damage by sandbagging and other protective measures so that they could be recovered even if the building is demolished. A large proportion of business assets could be preserved with the use of these measures.

Facilities outside the cities for bulk storage of fuels, chemicals, grains and other essential commodities could be brought at full capacity despite seasonal demands. As noted in the next panel, fuel, fertilizers, and pesticides will be of particular importance in assuring early recovery of agricultural production. Needless to say, expedient fallout shelter should be planned for at industrial and supply facilities that are intended for continued operation or for early postattack use.

Finally, government can contribute to early economic recovery by offering RADEF equipment and crisis training and by preparing plans and materials for implementing rationing and other control measures.

CRISIS PREPARATIONS*

- Remove records and management to safer locations.
- Relocate valuable equipment and inventories.
- Bury critical movable items.
- Protect machine tools and special equipment.
- Augment inventories of fuel, chemicals, and other stocks outside urban areas.
- Accelerate production and safe stockpiling of essential survival items.
- Provide shelter and alternate locations for work force and dependents.
- Expand RADEF capabilities outside urban areas.
- Mobilize postattack control measures.

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*Based in part on Rockett, F.C., and Brown, W.M., **Crisis Preparations for Postattack Economic Recovery**, Hudson Institute, July 1966 (AD 639 387).

AGRICULTURAL PRODUCTION

In his major study, **Economic Viability After Thermonuclear War: The Limits of Feasible Production,** Rand economist Sidney G. Winter, Jr., came to this conclusion: "If measures could be devised and preparations made to assure that agriculture would not be drastically altered, then it appears that all other economic problems could be managed." Dr. Winter was considering attacks of the size that could now be delivered at a time when lack of knowledge about fallout created a grave uncertainty as to how much farmland would remain suitable for growing crops. As discussed in Chapter 6, this is no longer believed to represent a serious problem. Nonetheless, recovery of agriculture remains crucial to post-attack viability.

In the United States, less than 5 percent of the population produces peacetime surpluses on a fraction of the arable land. This means that agriculture is dependent on other sectors of the economy to support its mechanized and intensive operations. The most critical needs are fuel and fertilizer. Without petroleum products, field crop production would be virtually impossible. All major food and feed crops are mechanically planted and harvested. Livestock, which accounts for nearly half the caloric value of the food produced, depends on the availability of feed, which is itself dependent on petroleum. The petroleum refining industry, which is highly concentrated, is potentially vulnerable. However, the use of farm machinery is seasonal and petroleum storage on or near farms is substantial. Post-attack, a greater share of the surviving fuel could be directed to agriculture and plans should be made to allocate petroleum to those areas where immediate use of machinery is essential and where high yields are to be expected.

It has been estimated that about one half of U.S. food production can be attributed to applied fertilizers. Lack of fertilizers can be accommodated partially by emphasizing crops and farm regions not requiring fertilizer and by bringing more land under cultivation. The latter course, however, requires more fuel. Nitrogen is the principal nutrient required. Nitrogen production facilities are located throughout the country and considerable excess capacity exists today. Sufficient production is expected to survive a major nuclear attack.

Major field crops are grown without pesticides in many places. Lack of pesticide availability would be most strongly felt in the yields of potatoes, fruits, and vegetables. Irrigation is also important for these crops, as well as for rice and sugar beets. Availability of electricity is most critical to dairy and poultry production.

Studies have shown that capabilities for transportation, storage, and food processing of basic agricultural commodities should survive as well or better than food production, except for wholesale warehousing. Good management, based on adequate plans, appears to be the key to recovery of food production.

PANEL 21

CRITICAL NEEDS FOR FOOD PRODUCTION*

- Fuel and Lubricants
- Fertilizer
- Pesticides
- Seeds
- Irrigation and Drinking Water
- Equipment and Parts
- Feed
- Electricity
- Transportation, Storage, and Processing

*From Brown, S.L., et al., **Agricultural Vulnerability to Nuclear War,** Stanford Research Institute, February 1973. (AD 765 725)

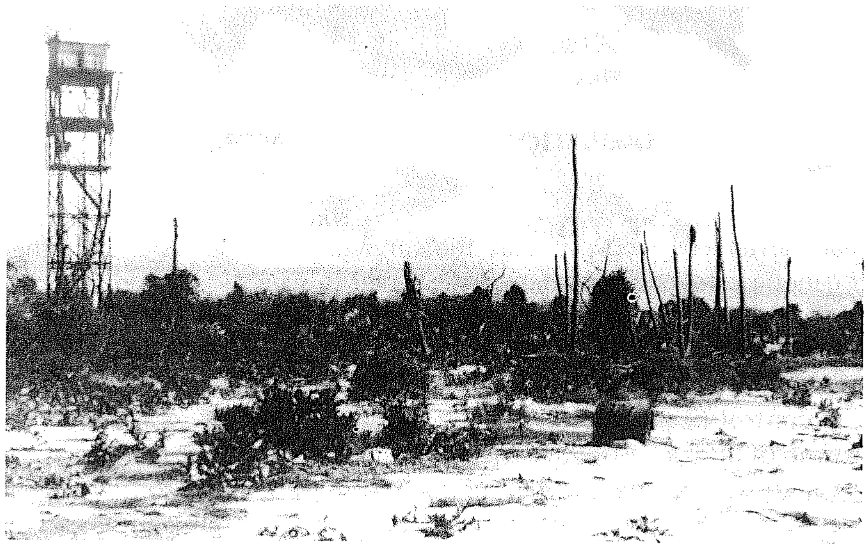
ECOLOGICAL DEFENSE

In Chapter 6, Panel 28, the possibilities of ecological catastrophe were discussed. Speculation that the attack environment might cause drastic upsets in the "balance of nature" have assumed that changes that exist for a relatively short time can induce permanent ecological damage. This is not borne out by experience. For example, some of the atolls in the South Pacific have experienced repeated direct effects and fallout from weapons tests comparable to the worst that could occur in a nuclear war. As these illustrations show, the tropical ecosystem has survived and recovered. The native population has returned to live on Bikini and Rongelap Atolls. Long-term consequences require continuous pressure over centuries of time, of which the impact of human habitation is the outstanding example.

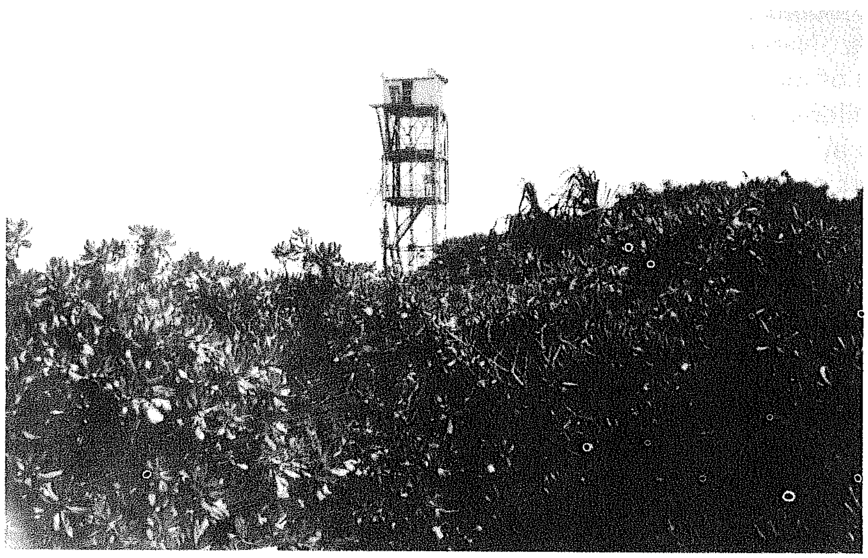
Some significant consequences that may well occur as part of the post-shelter environment are also discussed in Chapter 6. These potential ecological consequences (one cooler growing season, temporarily increased rainfall, fire in dead pine forests, increased erosion and silting, and outbreaks of insect and rodent pests) could have an indirect effect on agriculture and forestry.

Trees, especially pines, are vulnerable to fallout radiation. The loss of a forest can be regained only after many decades. Dead trees are a valuable resource for wood products if they are harvested. If not harvested, they become a refuge for insect pests and plant diseases. They become a fire hazard. Forest fires destroy both trees and ground litter, resulting in increased surface runoff and erosion, excessive silting of streams, reservoirs, and irrigation works, loss of water for crops, and loss of crop yield. Prompt harvesting and reforestation are postattack actions needed to control these consequences.

Fallout radiation effects on insects and wild animals could affect agricultural production. For example, bees are essential to the pollination of certain agricultural crops, particularly fruits. A large reduction in the natural population of birds and preying insects could produce severe crop infestation by parasitic insects. But man is not helpless. He can move bee colonies where they are needed. He can import or otherwise assist the repopulation of fallout areas with beneficial species. All of these actions could well be called, "ecological defense."



Bikini Island, November 1955



View of same area as above in 1967. Some coconut trees had reached 20 feet and were bearing fruit.

RADIATION EXPOSURE CONTROL

The final barriers to recovery that the survivors must surmount are the possible late somatic and genetic effects of irradiation discussed in Chapters 5 and 6. The key to these problems is good radiation exposure control. Exposure control in the post-shelter environment will be greatly aided by the advice of trained Radiological Defense Officers.

Exposure control begins, however, with effective warning and sheltering of the population at the time of attack. Effective sheltering involves the use of the **best** available fallout shelter, not just those that meet some minimum criterion, such as PF 40. That is, the planner must be concerned not only with preventing lethal exposures but also with keeping the radiation **burden** of the survivors as low as possible. To this end, a protection factor of 400 is vastly better than a protection factor of 40. Crisis plans to build expedient shelters (Chapter 7) and to improve the protection in existing shelter areas can contribute to exposure control.

People should be encouraged and instructed to remain in shelter as long as possible in fallout areas. Naturally, this advice must be balanced against the need to get on with the urgent tasks of recovery. But many, especially children, are not needed for these early tasks outside. Children and young adults should be given maximum protection to minimize genetic damage in subsequent generations. Late radiation injury is of minimal concern to those over 40 years of age. Even so, the shelter areas should be used as off-duty quarters for the workers.

An important control measure during the first month after attack will be to limit the intake of radioactive iodine by children (see Chapter 6, Panel 25). They should be provided with stocked water or water from wells or areas of low contamination and kept from drinking contaminated milk.

Even in areas of moderate fallout, decontamination will be important to limit the continued exposure to radiation over the months and years ahead. In the process, the necessary radiation exposure should be spread among the able-bodied survivors by rotation and work shifts so that the radiation burden of individuals is kept as low as possible.

PANEL 23

ELEMENTS OF EXPOSURE CONTROL

- Make sure there is a RADEF person on the staff who is well-trained and qualified.
- Make use of best available fallout shelter.
- Keep the population in shelter as long as possible.
- Preferentially protect children and young adults.
- Use shelters for lodging after "shelter emergence."
- Provide children with uncontaminated drinking water for the first month.
- Decontaminate living and working areas.
- Spread the necessary radiation exposure among the work force.
- Keep on decontaminating.

MOTIVATING THE SURVIVORS

In Chapter 7, Panel 24, some points are made about human behavior in disaster. We can expect the survivors' motivations to be dominated by concern for the safety of self and family from the time they believe an attack is imminent until they understand the attack to be over. After the attack is over, survivors would try to learn of the fate of separated family members and would seek information about the national and local situations. One can expect most behavior to focus on the problem of supplying the basic needs for food, water, and shelter for the family.

Individual and small group foraging and hoarding of found supplies consume available resources and do nothing to bring about future resupply. A significant implication for planning is that means must be found for satisfying the survivors' basic needs while, at the same time, motivating and directing the efforts of survivors in other critical recovery activities. Most students of this problem believe that local authorities should take charge of all critical supplies in order to satisfy equitably the subsistence needs of the survivors, to eliminate competing ways of meeting these needs, and to provide meaningful rewards for productive work in critical recovery activities. The survivors are apt to welcome positive action of this kind and are likely to place a high social value on opportunities to participate in activities clearly associated with improving personal and national well-being. The recovery management precepts recommended by one of the knowledgeable research groups on this subject are presented in this listing.

One observation from disaster research is that communities of survivors tend to develop strong bonds of solidarity and to look for guidance and support to the leaders who have brought them through difficulties. After nuclear attack, the most immediate and acceptable authority structure is that which developed during the shelter stay. This suggests that a good plan is to continue the shelter organization into the post-shelter environment, rather than allowing it to dissolve while attempting to build a wholly new organization to provide for the subsistence needs of the survivors. Emergent shelter leaders should be welcomed into the "official" organization and encouraged to continue to care for and represent the groups in their charge.

RECOVERY MANAGEMENT PRECEPTS*

1. Exercise strict control over existing supplies of food, housing, and other critical supplies and provide security for these supplies of goods.
2. Satisfy the subsistence needs of the survivors so as to release manpower for participation in critical recovery activities.
3. Reward work in critical recovery activities (in a way that is linked to increased distribution of goods to the worker's family).
4. Perpetuate family and group solidarity and leadership developed in shelter into the post-shelter period.
5. Communicate survival and recovery goals and foster expectations of improvement in well-being as goals are achieved.
6. Publicize plans for insuring continued ownership of private property, for relieving, at least temporarily, individuals of pre-attack economic obligations, and for providing some degree of restitution for losses when national production affords a surplus.
7. Establish recovery management under the auspices of the highest constitutional authorities, oversee its performance by elected representatives at all levels, and plan for return to political and social institutions acceptable to the survivors as soon as feasible.

*Based on Chenault, W.W., and Nordlie, P.G., **Consumer Behavior and Worker Participation in Recovery Activities**, Human Sciences Research, Inc., February 1967 (AD 651 098).

RE-ESTABLISHING INSTITUTIONS

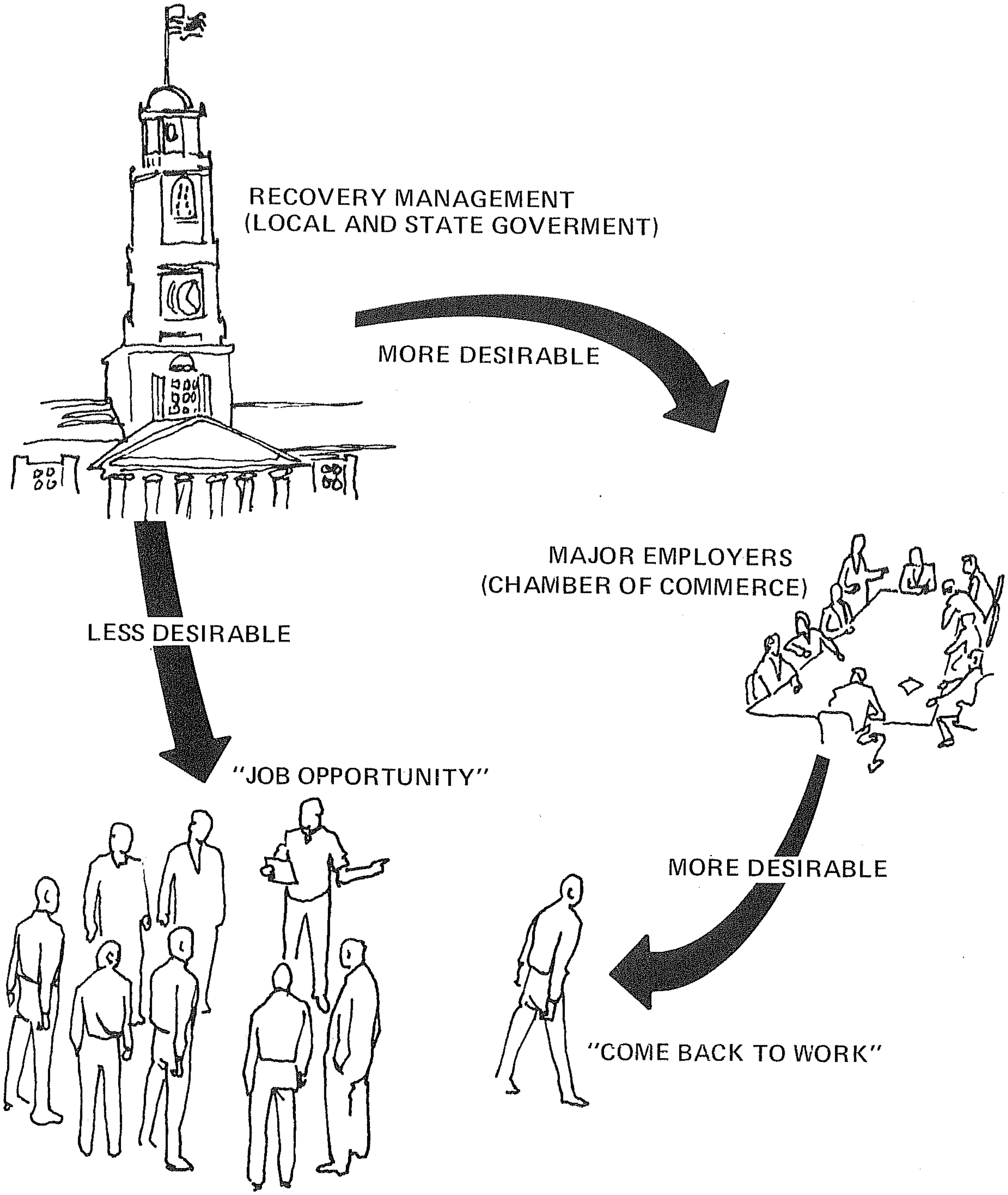
During most peacetime disasters, certain organizational activities cease to be important —an industrial plant may be closed for the duration—while the worker often is expected to engage in "emergency" or unusual activities. He may help rescue victims or care for refugees. He and his family may use different lodgings, supermarkets, or stores. But these changes are usually temporary. When things "return to normal," most affected people are once more performing work and consumer activities that closely approximate their pre-disaster routines of living. In sum, the disaster is over when most organizations (and therefore their employees) again are operating as part of larger networks of organizations and institutions.

In contrast to peacetime disaster, a widespread nuclear attack will damage the entire system of interlocking organizations. Post-shelter relationships often will not be the same as before the attack. In other words, there will be less of a "normal" pattern to return to.

The emergency planner should understand that most family heads and, hence, families, "anchor" their daily lives around their job affiliations. In many respects, anticipating a "return to normal" means resuming the pre-disaster work affiliation. And this job affiliation is also the principal link between the individual and the organized distribution of work activities throughout the economy. After all, an early goal in postattack recovery management must be to reconstitute a routine procedure by which goods and services are produced, distributed, and exchanged. One means of achieving this goal is to emphasize organizational continuity during crisis and emergency periods.

A working organization can remain reasonably "intact" for a while even if it is not functioning. If damage assessment and planning eventually indicate that the organization has no place in the post-shelter world, then employees can be systematically placed in similar work elsewhere. One should plan in the interim to maintain the communications link with the individual worker through his preattack work organization. Preserving the integrity of economic organizations—all of them, not just critical industries—is probably the most efficient approach to organizing the postwar labor force. The alternative—allowing people to lose their work identity and hiring more or less anonymous "workers" through employment agencies—is likely to make more difficult the psychological process of "returning to normal."

LABOR : EMPLOYED OR UNEMPLOYED



POST-SHELTER PROBLEMS IN DAMAGED AREAS

The information in Chapter 8 to this point is broadly applicable to all nuclear emergency planning. In addition, there are some recovery operations that are peculiar to damaged areas. The next four panels deal with these operations.

The immediate survival needs at the time of initial shelter emergence will be water, food, and accommodations. As radiation levels decline to levels permitting outside operations, the first step will be to establish a number of "staging areas" as bases from which to conduct early operations and to which can be brought aid from the nearby undamaged areas. (The idea of using a staging area was first discussed in Chapter 2, Panel 29.)

Routes would need to be cleared through the debris to permit vehicular access from the staging areas to the undamaged region, to the shelters where survivors are located, and to water, sewage, and power facilities.

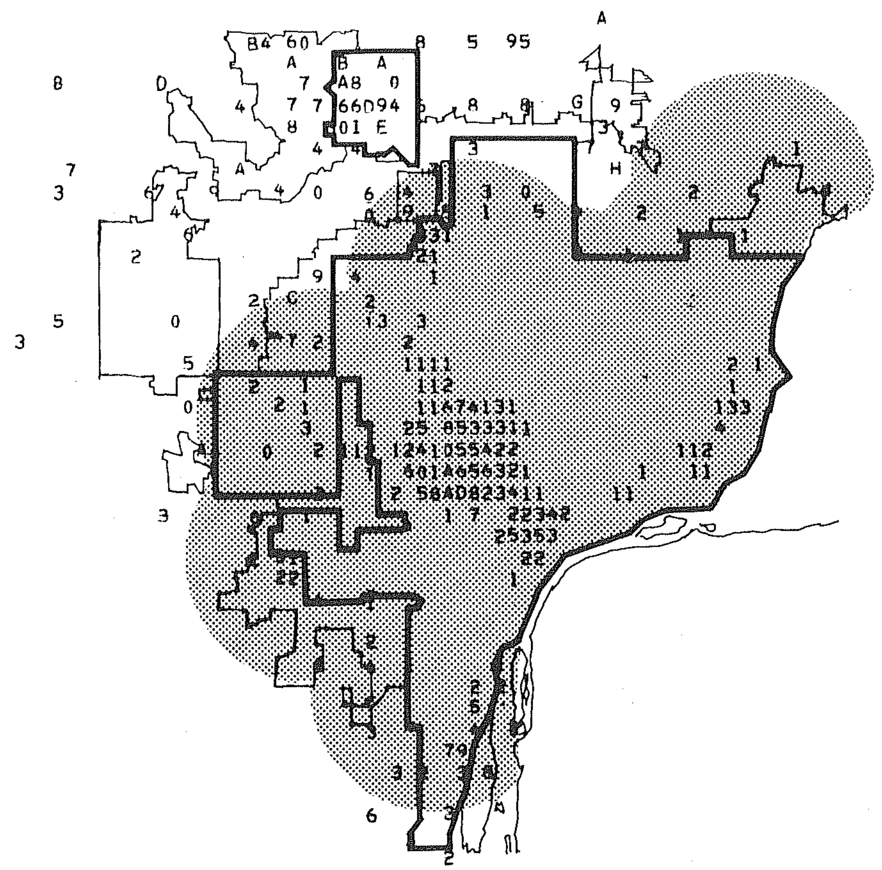
Water, food, and medical aid may need to be provided to the sheltered population prior to the time that they could be relocated. At the appropriate time, survivors would be brought to the staging areas where buses would move the homeless to housing in the light-damage and undamaged areas.

Housing experiencing in excess of about 3-psi blast overpressure generally would not be repairable for habitation. The areas in Detroit where housing would be lacking are shown here for the same heavy attack presented in Chapter 1, Panel 12. Outside these areas, housing may need decontamination and some repairs. Utility services may also need restoration. In cold weather, broken windows would need to be covered throughout the metropolitan area.

Vital facilities would need repairs if such would permit early return to operation. Surviving equipment and materials in more heavily damaged utility and industrial facilities would need to be protected from further damage until they could be removed for use elsewhere.

Studies have been made that show that these initial post-shelter recovery activities are feasible to complete in about one week, using surviving equipment and a fraction of the able-bodied male survivors.

SURVIVORS WITHOUT HOUSING*
(15 - 5MT WEAPONS ON UNWARNED NIGHTTIME POPULATION)



*See Chapter 1 for attack description

DEBRIS CLEARANCE

Clearing of debris is a common activity required after most natural disasters. In the aftermath of such disasters, contracts are let with private construction firms who set to work cleaning up the mess, drawing equipment and equipment operators from as wide an area as is necessary for the job. Some inefficiency can be tolerated because of the abundance of resources. The photograph, from Hurricane Camille, shows a truck loaded about one-quarter full, partly because the tailgate has been removed to ease the dumping process, Chunks of debris drop off the trucks en route to the dumping site, where, because of inadequate organization, they often wait in line to dispose of their loads.

Debris clearance after nuclear attack can draw on peacetime experience but research has indicated that efficient use of surviving construction equipment and manpower will be necessary if essential clearance is to be accomplished in a timely manner. Construction trade officials (Associated General Contractors of America) have recognized this need and have prepared "Plan Bulldozer" as an aid to local government. This plan is designed to mobilize construction contractors to furnish materials, operate equipment, and supply skilled personnel as long as necessary under the direction of civil or military authority in event of natural disaster or nuclear attack.

As noted in Chapter 2, debris created by a nuclear detonation is expected to be distributed off-site where it will block access by wheeled vehicles. Clearance of streets will be a major post-shelter task upon which most other activity will depend. Pre-attack estimates of probable debris conditions, supported by post-attack reconnaissance, are needed so that proper groups of equipment can be assembled to handle the task. The nature of the task, and, hence, the equipment required, depends on the size and content of the debris chunks, the general depth of debris, the extent to which automobiles, trees, and utility poles are included in the debris, the width of road to be cleared, and similar factors. These factors have been analyzed into a limited number of basic tasks, for each of which appropriate "equipment groups" have been defined. A typical equipment group is summarized in the lower chart. This group is designed to clear light structural debris, which may include chunks up to 30 inches in size. The group can clear 1000 feet per 24-hour day of 50-foot roadway through debris five feet deep. Similar information is contained in the reference below the chart. The equipment codes shown are those set up in Plan Bulldozer.

*From Black, R.H., **The Effects of Hurricane Camille on Industry, Public Utilities, and Public Works Operations,** URS Research Co., March 1970 (AD 708 568).

TYPICAL EQUIPMENT GROUP*

1 Crawler-type Bulldozer, 250-300 H. P. (Code 286)

1 Front-End Loader (Side Dump) (Code 174)

2 Dump Trucks, 10 - 15 cu. yd. (Code 313)

1 Night Lighting Equipment (Code 602)

1 Tools and Supplies (Codes 620 and 621)

Supporting Resources Needed: Availability of fuel and lube truck (about 40 gal. of diesel fuel per hour), repair truck, equipment operators, and 2 unskilled laborers per shift.

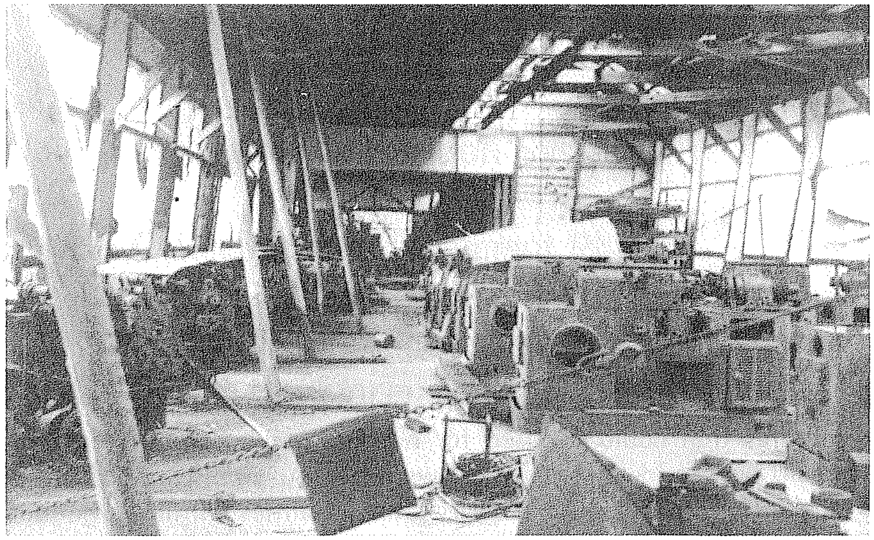
*Based on Wickham, G.E., **Debris Removal Civil Defense Operations,** Jacobs Associates, March 1969 (AD 693 885).

ASSET PRESERVATION AND SALVAGE

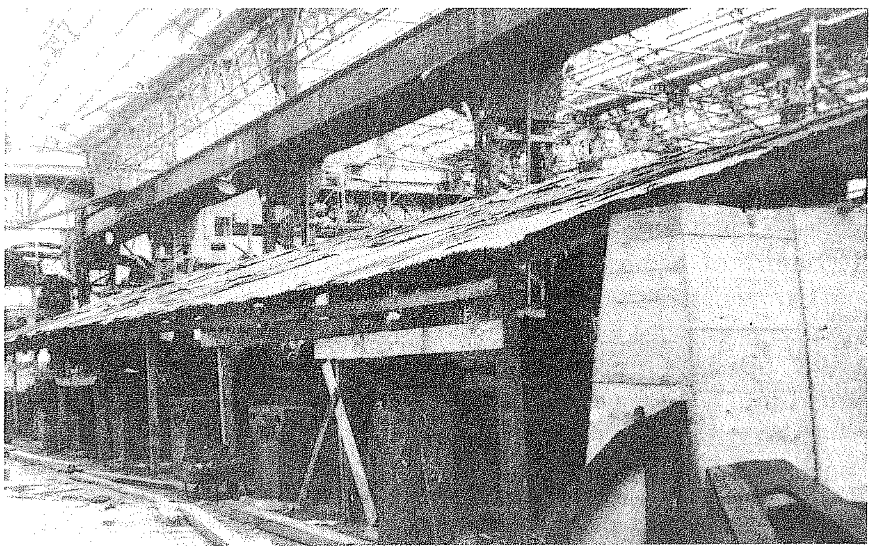
Most production equipment and supplies are much more resistant to blast damage than the buildings that house them. For example, heavy-duty machine tools have survived over 10-psi blast overpressure during weapons tests. Sandbagging or other protection, as suggested in Panel 20, will further improve survival possibilities. Subsequent fire can warp and melt delicate parts, as well as remove grease and paint so that corrosion can occur. Corrosion and rusting of neglected assets caused much damage at Hiroshima and Nagasaki. On the other hand, much damage was avoided by protective actions taken during the first few weeks after the detonations.

The upper photograph shows a wood-frame machine shop with windows and roof damaged by blast. The machine tools are essentially undamaged. Sheets of corrugated iron have been placed on some of the machines to protect them from the weather. The lower photograph shows a more advanced form of weather protection in a Nagasaki industrial plant.

As soon as feasible after shelter emergence, work parties should be formed from employees of commercial and industrial concerns in the damaged area. These teams should conduct an assessment of damage at each work site to determine whether the facility is operable or can be repaired. Surviving equipment should be coated with grease (usually available on the site) and covered by tarpaulins or sheets of stripped roofing. Supplies may be removed for immediate use or preserved on site, depending upon their nature. Salvage of usable equipment and supplies will probably be appropriate in residential areas as well. There will be a need for surviving beds, mattresses and bedding, canned goods, cooking utensils, water containers, and the like.



Undamaged machine tools at Hiroshima. Sheet metal is being used to protect against weathering.



Arrangement of temporary weather protection in Nagasaki industrial plant.

EMERGENCY REPAIRS

Assessment of damage to buildings and equipment in blast areas should be limited initially to structures that could be used for housing and to "vital facilities." A list of facilities that could be considered vital is shown here. An implication for emergency planning is that each jurisdiction should identify those facilities within its boundaries such as those on this list and should establish emergency planning and operating relationships with managers of those facilities under private ownership.

Damage assessment should be accomplished by plant engineers and operators who are knowledgeable of the facility. Decisions will usually have to be made as to whether the facility can be repaired or whether salvage of usable equipment and supplies is preferable. Repair requirements will need to be estimated. Generally, this assessment will be feasible in over 90 percent of the damaged area by the second week after attack.

As noted in Chapter 1, Congress has included in the definition of "civil defense," all activities and measures designed or undertaken to effectuate emergency repairs to, or the emergency restoration of, vital utilities and facilities. To assist emergency planners in preparing to undertake these actions following an attack, DCPA has conducted research to define the likely nature of damage to most of the vital facilities on the list, the best repair procedures and strategies, and estimates of repair requirements in terms of manpower, skills, equipment and supplies, and time. One such study, **Civil Defense Aspects of Water Works Operations**, has been republished and widely distributed. Results from others have been incorporated into a variety of industrial preparedness manuals prepared in cooperation with the Departments of Commerce and Interior. Some of the most useful research reports are listed in Panel 31, Suggested Additional Reading.

VITAL FACILITIES

- Water Works and Distribution Systems.
- Sewage Collection and Treatment Plants.
- Electric Power Distribution Facilities, including substations, transformers, and switching stations.
- Telephone System.
- Public Safety Radio Transmitters.
- Petroleum Refineries and Pipelines
- Natural Gas Production and Distribution.
- Pharmaceutical and Vaccine Plants.
- Food Processing Plants, especially grain mills and canneries, Food Container Factories, and Warehouses.
- Chemical Plants, especially producers of fertilizer, insecticides, and disinfectants.
- Plants Producing Other Survival Items.
- Defense Production Plants.
- Air, Rail, Truck, and Water Transportation Facilities.

SUMMARY

Prediction of the aftermath of a nuclear conflict—a war that has never occurred—is an enormously difficult task. Nonetheless, the areas of uncertainty gradually are being reduced. In addition to hundreds of individual research reports on specific aspects, there has been a number of major studies of national viability following nuclear attack. Those for which results have been summarized in the open literature are shown here. Several more have been classified for security reasons.

The significant point can be made that all of these major studies are highly affirmative as to whether the surviving physical and human resources are sufficient to permit a meaningful recovery. Indeed, they indicate that, if by some magic we could prevent all loss of life, the basic wherewithal for continued survival of the entire population and ultimate recovery would exist. It is not true that one could save too many. On the other hand, these studies attempt to evaluate the physical aspects of postattack viability only. They do not predict that the economy will be managed well, that people will behave in a constructive way, or that confidence would be maintained in the monetary system. It is likely that survivors would behave constructively and that the numerous management problems could be solved if reasonable plans are laid to give the public leadership, information, reassurance, and instructions and if preparations are made to carry out the tasks that seem necessary.

As with initial survival itself, much of the planning and preparations for coping with the post-shelter environment must be done in the local jurisdiction. In other words, if you, the emergency planner, do your job well, the survivors need not "envy the dead."

POSTNUCLEAR ATTACK STUDIES

STUDY	YEAR	FOR	ESTIMATED LOSSES POPULATION	ESTIMATED LOSSES INDUSTRY
The Rand Study	1958	USAF	35%	55%
The SRI Study	1963	DoD	42%	45%
PAVUS-75	1967	Army	45%	35%
DAL-67	1967	DoD	45%	42%
PONAST II	1973	JCS	46%* / 11%**	63%

* With present civil preparedness capability.
** With crisis relocation and expedient fallout shelter.

SUGGESTED ADDITIONAL READING

Proceedings of the 1967 Symposium on Postattack Recovery from Nuclear War, National Academy of Sciences, April 1968. (AD 672 770)

Goen, R.L., **The Magnitude of Initial Postattack Recovery Activities**, Stanford Research Institute, December 1971. (AD 741 389)

Bensen, D.W., and Sparrow, A.H., **Survival of Food Crops and Livestock in the Event of Nuclear War**, U.S. Atomic Energy Commission, December 1971. (CONF 700-909)

Van Horn, W.H., et al., **Repair and Reclamation of Gas and Electric Utility Systems**, URS Research Co., July 1967. (AD 665 307)

Walker, F.E., **Estimating Production and Repair Effort in Blast-Damaged Petroleum Refineries**, Stanford Research Institute, July 1969. (AD 697 717)

Staackmann, M., et al., **Damage to the Drug Industry from Nuclear Attack and Resulting Requirements for Repair and Reclamation**, URS Research Co., July 1970. (AD 714 304)

Fernald, O.H., **Critical Industry Repair Analysis, Food Industry**, Advance Research, Inc., April 1965. (AD 614 908)

Pyecha, J.N., et al., **Postattack Medical Care Measures of Effectiveness**, Research Triangle Institute, September 1971. (AD 730 945)

PHOENIX RISING FROM THE ASHES

PANEL 31

CPG 2-1A9
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 9

APPLICATION TO EMERGENCY OPERATIONS PLANNING

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 9

This Chapter draws on the content of the first eight chapters to help the local emergency planner apply the information effectively. The planning advice is keyed to the checklist format of the ALFA NEOP and the BOS system described in Chapter 1, and the BRAVO NEOP described in Panel 3. Although these concepts and formats have not been fully deployed, they are useful organizing tools.

Information is presented in the form of "panels," each consisting of a page of text and an associated sketch, photograph, chart, or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 9 shown opposite. If the graphic portion is converted into slides or Vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with three introductory panels. The next four panels review the "infrastructure" needed for in-place protection of the population and emergency forces. Seven panels are devoted to a discussion of emergency organization. There follow nine panels describing the content of an effective nuclear emergency operations plan. Three panels emphasize the planning process and its relationship to natural disaster planning and exercises. The BRAVO planning for evacuation is discussed in the next five panels. Finally, the full spectrum of emergency planning is summarized. Guidance is given in the concluding panel on how to obtain the reports that have been suggested for additional reading.

Obviously, the coverage of this chapter is very broad, and not every panel can go into detail as much as one might wish. We cannot, for example, provide a fully developed "model" plan in the space available. Those with limited resources or training and who therefore use it as a general reference will probably find it offers a useful approach to structuring their program. For others already familiar with BOS and NEOP approaches, it should provide useful insights regarding the larger relationships of planning.

CONTENTS OF CHAPTER 9

"APPLICATION TO EMERGENCY OPERATIONS PLANNING"

THE IMPORTANCE OF PLANNING

In Chapter 1, it was said that realistic operational planning is the foundation of operational readiness. This quotation of President Eisenhower, from a speech to a group of National Defense Executive Reservists, argues that it is the **process** of planning, rather than plans themselves, that is all-important. Written plans have substantial value as bases for training and exercising, for familiarizing new local officials with their emergency duties, and as checklists of necessary actions. But a written plan, devised "in the back room" by an emergency planner, however knowledgeable and dedicated, does not assure that actual operations will be effective since the key operators have not participated in the planning **process.**

The emergency plan, whether for nuclear attack or peacetime disaster, should document and reflect a planning process conducted by a team of representatives from each agency of government having an emergency mission, and each non-government group with such a mission (e.g., news media, medical associations, industry representatives, and American Red Cross Chapter). The local chief executive, who has the ultimate operating responsibility, should review progress periodically, and participate in appropriate portions of the planning and decision process.

The emergency planning process should be led by the local Civil Defense Director/Coordinator. His main contribution should be specialized expertise. The National Plan for Emergency Preparedness states in part:

> "It is an operational assumption of the Civil Defense Program that existing agencies of government will perform emergency activities related to those they perform in peacetime. A basic purpose of civil defense organizations is to coordinate these activities and to provide those unique civil defense skills and capabilities not available in existing government organizations. The civil defense structure (agencies) will also inform their sister agencies of government of those special conditions arising out of a nuclear attack which would call for a modification of traditional operating techniques."

That is what this Attack Environment Manual is all about. It is designed to help you inform your "sister agencies" of the special conditions that could arise in nuclear war (or natural disaster) as part of the all-important planning process.

"Plans are worthless, but planning is everything. . . . keep yourself steeped in the character of the problem you may one day be called upon to solve--or to help to solve."

President Dwight D. Eisenhower, 1957

THE UNCERTAINTIES OF RISK

Chapter 1 also emphasized the need for contingency planning to develop operational readiness in each locality to cope with the range of attack environments that could reasonably occur. Subsequent chapters made clear that in areas remote from the sites of nuclear detonations, only fallout was a hazard to life and EMP a threat to electronic and electrical equipment. The direct effects of nearby detonations—blast, fire, and initial nuclear radiation—posed a threat as well. Nuclear emergency operations would be more complex and demanding in these "risk" areas.

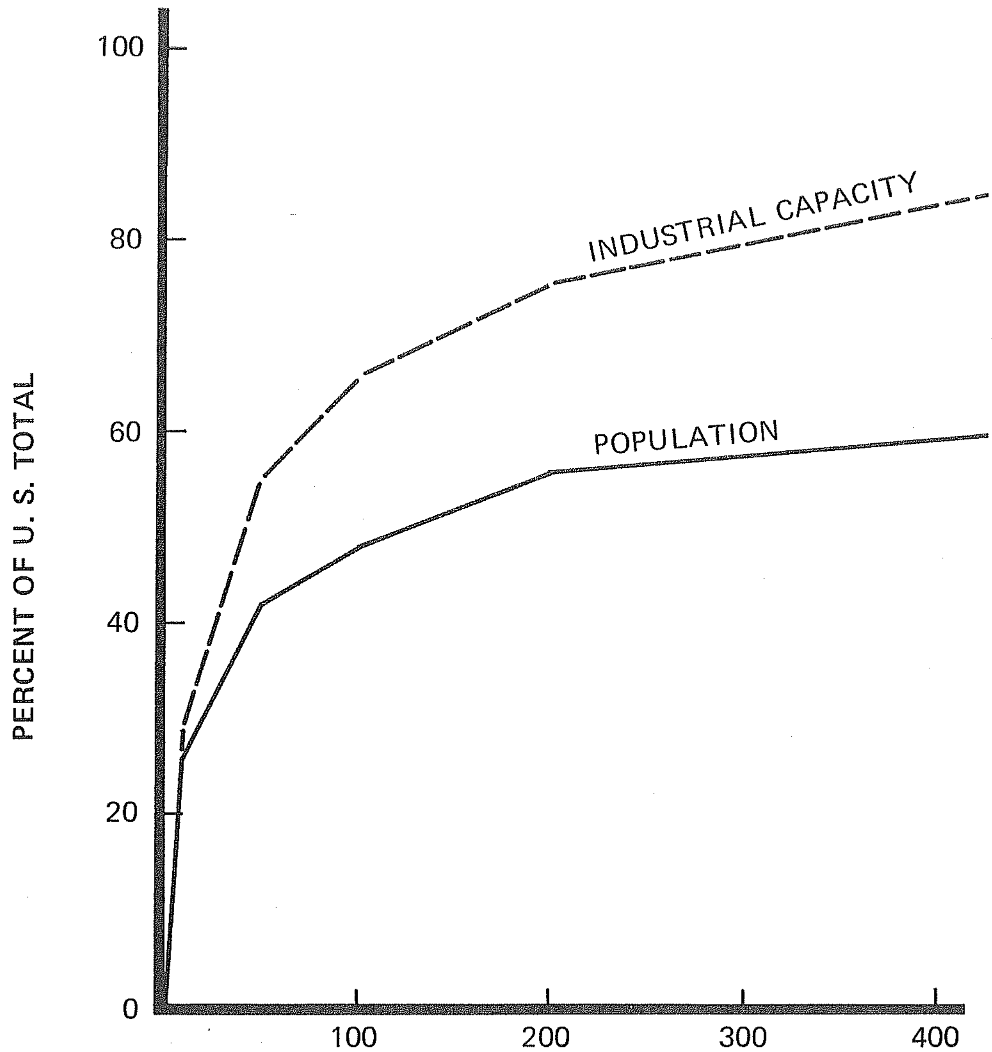
It would be advantageous to know in advance where nuclear detonations will occur in event of war. Emergency planning would be much simpler. But the uncertainties will not permit more than a judgment that some localities are more at risk than others, and, of course, no weapon has been made perfectly reliable or accurate. Hence, no place can be "written off" as certain of devastation. For another thing, we do not know how many enemy weapons would be burst on or near the surface. Hence, we do not know how severe the fallout threat will turn out to be. Of course, we do not know what the winds will be like and, thus, where the significant fallout will occur. And, finally, we do not know what targets an enemy will select.

Perhaps the most authoritative statement of Soviet targeting doctrine is contained in the Russian book, **Military Strategy**, by Marshal V.D. Sokolovsky, where it is stated:

> "The targets in a modern war will be the enemy's nuclear weapons, his economy, his system of government and military control, and also his army groups and his navy in the theaters of military operation."

This listing is repeated several times in this book. People as such are never mentioned as a legitimate target. But, as this chart shows, U.S. industry is mainly located in the larger cities—and that is where much of the population lives as well. That is why it was argued in Chapter 1, Panel 14, that all localities needed to plan for the possibility of potentially serious fallout radiation exposure, and those near important military and industrial facilities needed to plan for direct weapons effects as well.

INDUSTRIAL CONCENTRATION



Number of U.S. populated areas.
(Ranked by population from largest to smaller.)

PANEL 2

BRAVO COMES AFTER ALFA

ALFA is the first letter in the international phonetic alphabet. BRAVO is the second letter. We use ALFA to denote an emergency plan based on protecting the population in place—where they normally live. BRAVO plans are based on relocating masses of the population from the places of highest risk (cities, in nuclear attack planning; coastal areas in hurricane planning) in advance of attack or disaster. This table shows how the population might be located if a BRAVO relocation had occurred as compared with that shown in Chapter 1, Panel 14. Clearly, preattack dispersal and evacuation could save millions of lives.

Evacuation was the basic civil defense plan in the 1950s when nuclear weapons could be delivered only by bomber aircraft. Several hours could be expected after detection of the aircraft before nuclear detonations could occur in U.S. cities. Evacuation planning concentrated on means to move city-dwellers out of the cities during this short time interval. The deployment of ballistic missiles made evacuation after attack warning impractical, and means for protection of the population in-place were given much consideration.

By the time of the Cuban Missile Crisis of 1962, it had become accepted that a "bolt-out-of-the-blue" surprise attack was highly unlikely. Evacuation of cities during a crisis appeared feasible. But planning for this contingency was de-emphasized because strategic warning indicators were notoriously ambiguous, and because a decision to evacuate cities might not be compatible with the President's objective of resolving the crisis short of nuclear conflict.

However, in the past few years, crisis evacuation has emerged as the basis for Soviet civil defense. Other countries, such as Sweden and Norway, publish evacuation and other defense plans in their telephone books as guidance for the populace. Plans to evacuate our cities if the Soviets should do so—BRAVO plans—are now important if the President is to have additional time to negotiate the differences that generated the crisis. Nonetheless, the carrying-out of such plans will remain uncertain. Therefore, the strategy of protection in place, by shelter in existing buildings, remains the primary basis for nuclear emergency operations planning and will be considered first in this chapter. That is, A comes before B!

DISTANCE FROM NEAREST WEAPON
(Military-Industrial Attacks)

Distance (miles)	Percent of Population (ALFA*)	(BRAVO)
10	45	12
20	65	25
40	75	50
100	95	95
200	99	99

*ALFA column is from Chapter 1, Panel 14.
BRAVO column assumes 75 percent relocation from major cities for the same sort of attack pattern.

SHELTER SURVEY

An invaluable product of emergency planning is the detailed arrangements for coping with anticipated problems, within the resources available to the community. If advance arrangements are not made, decision makers must react to immediate problems in the stress of the actual emergency. Inevitably, some actions are taken or not taken that increase the amount of hardship, suffering, and loss of life and property. Nowhere is planning more important than in the provision and use of shelter, for it plays the central role in protecting people from the injurious effects of the attack environment. Thus, emergency plans must be built around the available shelter.

During the 1960s, sheltering the entire population from fallout radiation was taken as the goal, since it was believed that only specially constructed shelters would save lives in damaged areas threatened by fire, and that their cost would be prohibitive. Only recently, as described in Chapters 2 and 3, has our knowledge reached the stage where planning to increase survival from direct effects as well as fallout radiation appeared to be practical.

The chapters in this manual can aid the emergency planner in understanding where the better shelter is likely to be, but identification of the best available shelter actually is a task for technically trained people. The National Shelter Survey, begun in 1961 as the National Fallout Shelter Survey, was accomplished by training thousands of architects and professional engineers in the radiation shielding technology of the day. By June 1972, the survey had identified over 200 million shelter spaces through the country having a protection factor of at least 40. Research on radiation shielding continued after the survey was begun. As more became known about the complexities of shielding, the survey methods were improved and made simpler. It became feasible to train architectural and engineering students to work on the survey during summer vacations.

Recently, direct-effects survey procedures have been added to the well-established fallout-shielding survey. The first "all-effects" shelter survey occurred in the urbanized part of the Colorado Springs metropolitan area. Some 360 buildings, other than homes, were found to have shelter possibilities. The blast-protection ratings used are quite similar to those shown in Chapter 2, Panel 19, although somewhat more technical in the description of the categories. The results for Colorado Springs are shown here. Space above the third floor (Preferences F and I) is not included. (The large amount of Preference F space is located in wall-bearing buildings offering similar protection to higher floors of strong-walled buildings.) Over 370,000 spaces were estimated to offer better protection than a home basement.

Fire vulnerability was also estimated, based on building construction, occupancy, and surroundings. About 57 percent of the buildings were judged at low risk; 43 percent at high risk. Natural disaster considerations are similar in many cases.

RELATIVE BLAST PROTECTION
IN COLORADO SPRINGS
(Basements and First Three Floors of NFSS Structures)

Preference	Description	Spaces	Approximate Percentage of Total
A	Subway stations, tunnels, mines and caves with large volume relative to entrances.	1,305	less than 1
B	Basements and sub-basements of massive structures	None	0
C	Basements and sub-basements of steel and reinforced concrete framed buildings having flat-slab or slab-and-beam ground floor construction.	78,715	12
D	First three floors of buildings with "strong" walls.	293,747	46
E	Basements of commercial buildings similar to residences	3,815	1
F	Intermediate wall-bearing buildings.	111,567	17
G	Basements of steel and reinforced concrete framed buildings with flat plate ground floor.	19,970	3
H	First three floors of buildings with weak walls, brick buildings and residences.	129,462	20
I	Fourth and higher floors of buildings with weak walls.	None	0

PANEL 4

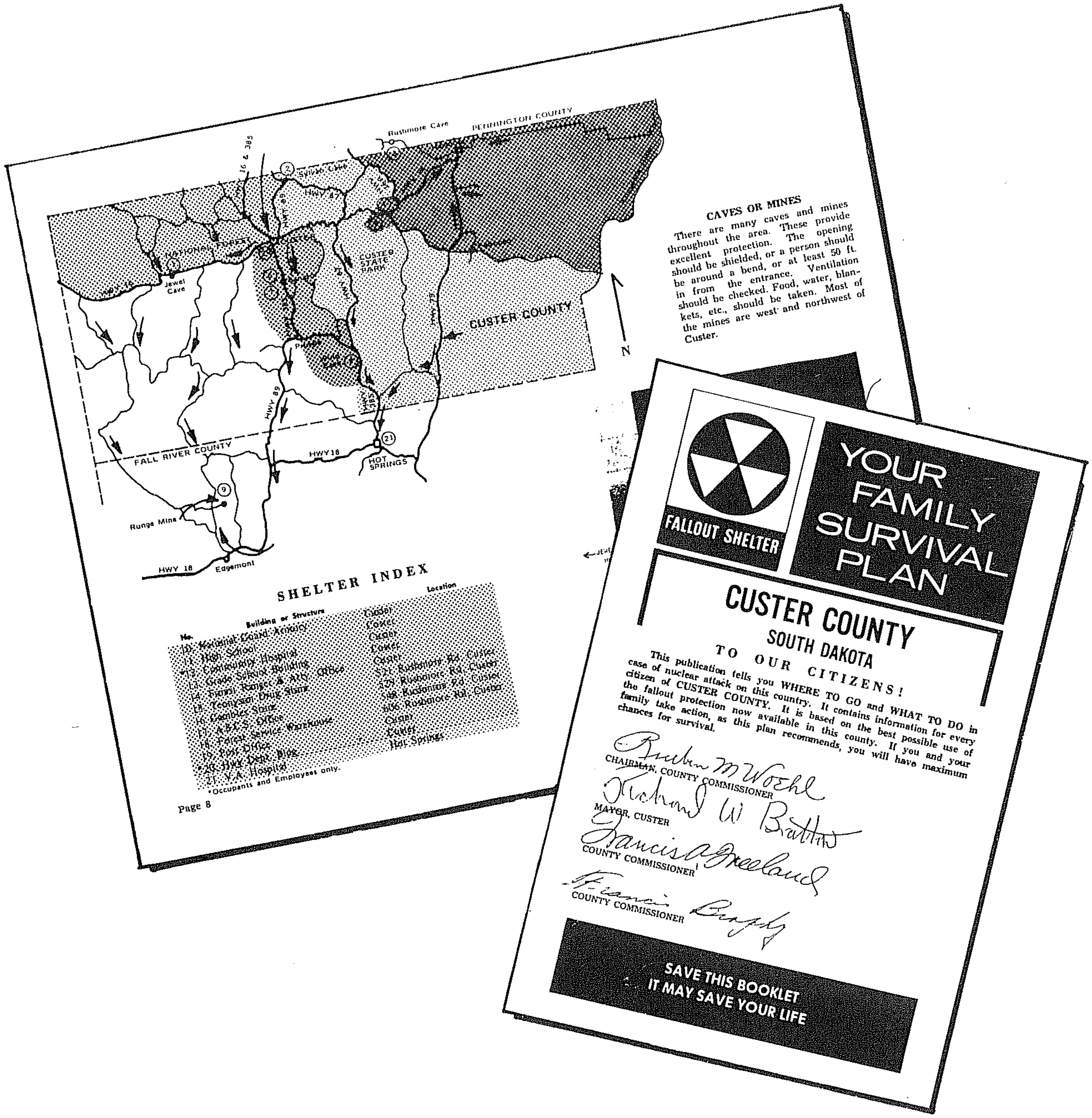
THE COMMUNITY SHELTER PLAN

Once the shelter protection existing in a community has been identified, whether in larger buildings or in home basements, a plan must be developed to make the best use possible of the protection. This is done by "community shelter planning," a process that matches the people in the community with the best-protected space available to them. Community Shelter Planning (CSP) became a major element of the National Civil Defense program in the mid-1960s as survey results became available.

Panel 3 suggests that about one-quarter to one-third of the population lives in areas that are relatively remote from likely targets. A review of Chapter 6 will show that from one hour to many hours would be available for moving to shelter in these areas, in addition to the warning time available before any detonations occur. People could travel considerable distances by automobile to utilize fully all available shelter. One such plan is shown here. The cover asks the citizenry to save the plan booklet, but research has shown that this is not often done in peacetime. Hence, current practice is to prepare the instructions for the citizens on "where to go and what to do" on newspaper mats, to be distributed in a crisis when needed. Federally-funded "CSP Officers" exist in most states to aid counties and municipalities in preparing these plans and keeping them up to date.

CSPs for metropolitan areas with a central city of 50,000 or greater population will stress protection against direct effects as well as fallout, as the results of the "all-effects" shelter survey become available. Because of the dimensions of the task of matching people to shelter in large urban areas, a computerized procedure has been developed to assist in developing a workable plan. Since people must be in shelter before detonations occur to receive protection against direct effects, movement to distant shelters is not feasible. The flight time of Soviet ICBMs is about 30 minutes and modern warning systems can detect an attack in its very early stages. Pedestrian movement of not more than a half-mile would be the rule. Moreover, it would be wise to assume that most people would be at home at the time of attack warning, since even the work force is home almost 70 percent of the time and could be encouraged to be there in an extreme crisis. These considerations will substantially reduce use of downtown public shelters as compared to fallout-only plans. As a consequence, much of the blast protection found in Colorado Springs (Panel 4) may not be accessible to the resident population. Use of home basements is a necessary part of the plan.

ONE OF MANY COMMUNITY SHELTER PLANS



PANEL 5

SHELTERS AND STAGING AREAS

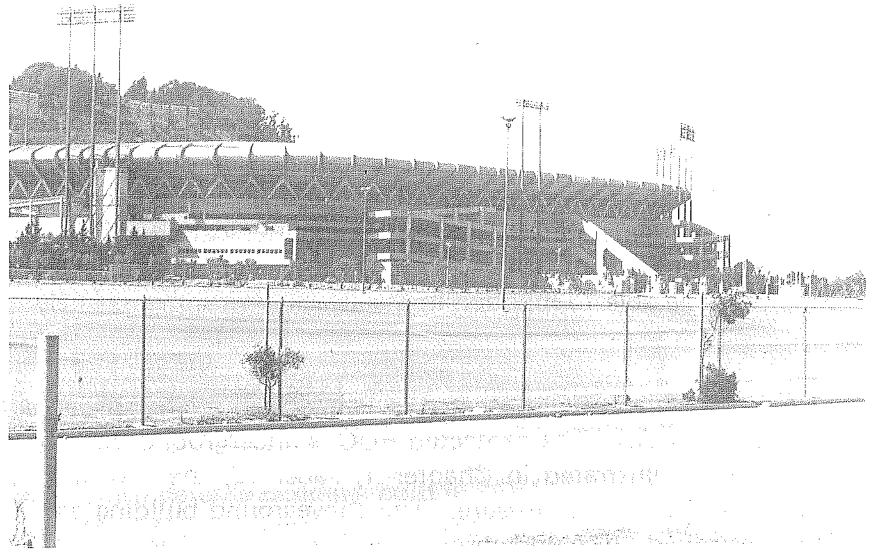
A review of Chapters 7 and 8 will indicate that allocating people to best available shelter and preparing to tell them where to go and what to do represents only part of the emergency planning problem. In particular, it is wise to consider at an early stage how the community will mobilize to emerge from shelter and to undertake critical post-shelter recovery activities.

The design of the Community Shelter Plan has an important bearing on the feasibility of emergency operations. For example, there are many localities in the northern tier of States (see Chapter 6, Panel 21) where nearly every home has a basement. There could be a strong temptation to avoid planning for public shelters by simply telling the citizens to seek shelter in their residences. It is very difficult, however, to imagine how shelter emergence and recovery could be carried out in a fallout environment with the whole population fragmented into family groups. Post-shelter operations must be initiated from larger shelters where organization, skills, radiation instruments, and communications are most likely to exist. It may be necessary to plan to tell isolated families by radio to remain where they are until organized teams seek them out. Alternatively, a neighborhood and block organization can be planned to provide leadership in those areas where residents are instructed to remain in home basements because of insufficient public shelter. In any event, plans should utilize public shelter capacities in or near residential areas as fully as possible.

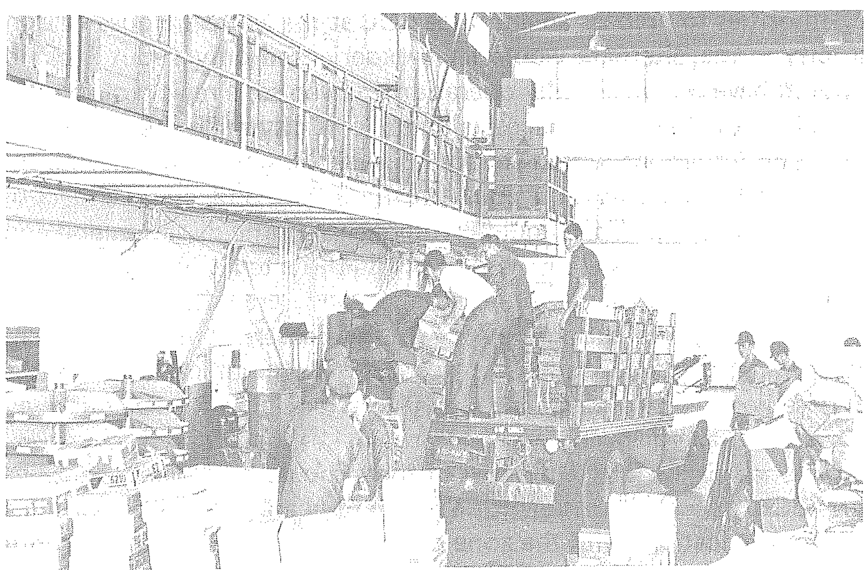
A closely associated requirement is the need for staging areas convenient to public shelters that can serve as bases for post-shelter operations (see Chapter 8, Panel 25). By preselecting locations having large paved parking areas for parking of vehicles and equipment and ease of decontamination and having good shelter for operators, one can provide bases for coordinated emergency operations, rally points for mutual aid coming into the locality, and a staging area for population support or evacuation. Major shopping centers, educational institutions, and recreational facilities are good candidates. One such planned location for a staging area is shown in the upper photograph.

Planned staging areas would also be useful in major natural disasters. Without them, disaster teams waste much time hunting for needed supplies and equipment while aid from the outside tries to find a useful delivery point. Staging areas often are created by necessity. A military airfield became an impromptu staging area (lower photograph) during the aftermath of Hurricane Camille. In Harrisburg, Pa., after Agnes, the courthouse parking lot "took on the aspects of a World War II supply dump." Well-publicized locations of planned staging areas for nuclear emergency operations could serve peacetime disaster purposes as well.

STAGING AREAS



Location Selected for Use As Staging Area in San Francisco Emergency Operations Plan.
Photo by Craig White



Emergency supplies at Keesler Air Force Base during Hurricane Camille.
Photograph courtesy of Keesler Air Force Base.

EMERGENCY OPERATING CENTERS

Shelters and staging areas are essential elements of the "infrastructure" of local nuclear emergency operations; that is, essential elements of the physical facilities and equipment upon which the conduct and control of necessary emergency operations can be based. A third essential element is the control center. The community-wide control center is called an Emergency Operating Center (EOC): a central communication facility from which key local officials can coordinate and control the operations of all local emergency forces. Obviously, the EOC must be able to function in the attack environments likely to occur in the community.

Shown here is the Detroit EOC, located in Palmer Park. The aboveground building is used for day-to-day activities. The protected EOC is underground directly below. In the heavy attack on Detroit illustrated in Chapter 1, Panel 12, the Detroit EOC would have experienced over 15 psi blast overpressure. The aboveground building and antenna towers would have been destroyed. The underground EOC would have protected the key officials, although communications would have been limited until temporary antennas could be rigged.

Recognition of the importance of continued leadership, direction, and control has led the Detroit authorities to prepare an alternate EOC at the Detroit House of Correction to the west of the city. The alternate would have experienced only about 1 psi in the example attack and would have remained fully operational. Even so, a review of the Detroit situation as well as Panel 21 of Chapter 1, suggests that a large city might be faced with a wide range of Basic Operating Situations within its boundaries. A jurisdiction having an area less than about 25 square miles (5 miles on a side), on the other hand, could expect one, or at most two, BOS at any one time. This would greatly simplify the direction and control problem. Hence, a large city would be well-advised to partition its territory into zones, when feasible, based on existing divisions such as fire districts, police precints, or other integrated operational basis, and to provide subordinate operating centers in these zones capable of independent, decentralized operations in event of loss of communications with the EOC. To be functional, these zone control centers must have attack effects protection, a self-contained source of power, and adequate communications, just as the EOC. If large numbers of public shelters are included in the CSP, a portion of these should be designated as Shelter Complex Headquarters (SCH), each responsible for a group of nearby shelters. Staging areas and SCH should have communications with the zone control center or EOC, as appropriate.

The Detroit civil defense building, built in 1954, is used for administrative purposes. The EOC is directly below. Note radio communications tower.

Operations room in blast-protected Detroit EOC. This room is supported by police and fire dispatchers, 85 radio nets, over 200 telephone lines, and an 85 KW emergency power generator.

PANEL 7

EMERGENCY ORGANIZATION

Fifteen emergency functions that might be required before, during, or after nuclear attack are defined in Chapter 1, Panel 16. Creating a separate organization to perform each of these functions would result in an unwieldy and impractical emergency organization. On the other hand, an emergency is defined as a situation in which the routine ways of coping with problems no longer work. It would be a mistake to assume that the normal municipal or county government agencies can undertake emergency operations without adaptation.

One solution to this dilemma is to build a streamlined and readily coordinated emergency organization on the hard core of operationally oriented local organizations and people. The ideal organization thus is bound to vary from community to community. We recommend consideration of the basic functional organization shown here. It consists of the major overall management group, called Direction and Control, and five operating services: Police, Fire, Medical, Shelter, and Resource. Choice of a more complex or diffuse emergency organization should be based on special local conditions of personnel or infrastructure; such a step must make full recognition of the fact that coordination requirements increase with increasing complexity.

Two of the five emergency services are based on, and largely staffed by, peacetime public-safety forces: Police and Fire.

The other basic emergency services—Medical, Shelter (often called "Welfare") and Resource—often have no day-to-day counterpart in local government and offer the greatest challenges to the attainment of local operational readiness. Disaster experience shows that, during the most stressful periods, all groups are likely to get involved in almost all tasks; sound planning minimizes the confusion that results from this very natural reaction. Key aspects of the organization of each of the six groups are contained in Panels 9 — 14.

THE FIVE BASIC OPERATING SERVICES

POLICE

MAINTAIN LAW AND ORDER THROUGH TRAFFIC AND CROWD CONTROL BOTH OUTSIDE AND IN SHELTER; PROVIDE SECURITY FOR VITAL FACILITIES AND SUPPLIES; CONTROL ACCESS TO OPERATING SCENES AND VACATED AREAS.

FIRE

PREVENT AND SUPPRESS OR CONTROL FIRE; LEAD SEARCH AND RESCUE OF ENTRAPPED PERSONS; ASSIST IN RELOCATION OF POPULATION THREATENED BY FIRE.

MEDICAL

PROVIDE EMERGENCY MEDICAL CARE BOTH OUTSIDE AND IN SHELTER; INSTITUTE SANITATION MEASURES; COORDINATE INTERMENT OF THE DEAD.

SHELTER

PROVIDE SHELTER LEADERSHIP AND ORGANIZATION; PROVIDE SUPPORT FOR PERSONS DISPLACED FROM OTHER ZONES; PROVIDE FOR THE IMMEDIATE NEEDS OF PEOPLE UPON SHELTER EMERGENCE, INCLUDING WELFARE SERVICES.

RESOURCE

CONTROL ESSENTIAL SUPPLIES AND EQUIPMENT; PROVIDE EMERGENCY SUPPLIES OF WATER, POWER, TRANSPORT, AND OTHER SERVICES; COORDINATE REPAIR AND RESTORATION OF VITAL FACILITIES; DEMOLISH HAZARDOUS STRUCTURES; REMOVE DEBRIS; AND DECONTAMINATE AREAS AS REQUIRED.

PANEL 8

THE POLICE SERVICE

The emergency mission of the Police Service is within the traditional scope of law enforcement activities: primary responsibility for movement control, for peacekeeping, and for maintaining security including suppressing crimes against people and property, as shown in this Table. The Task Assignments further define the areas of basic responsibility, and can be used as a checklist to develop specific plans and personnel assignments. The tasks shown are not inclusive. Some possible additional tasks are discussed in later panels. A capability to measure and control exposure to radiation is essential to the accomplishment of the mission.

The general character of police operations in a nuclear emergency can be understood best by considering the accomplishment of the police mission in light of the information in earlier chapters of this manual. In a period of severe international tension, preferably prior to receipt of warning that an attack has been detected, manpower and equipment must be deployed to positions where movement of the population to best available shelter can be expedited. Upon completion of movement to shelter, police forces must also be sheltered. Part of the police manpower must be distributed among the population shelters to assist shelter managers in maintaining order within these shelters. Another part of the police manpower, together with police vehicles, must relocate to the staging areas. As pointed out in Chapter 2, vehicles will generally survive direct weapon effects more readily in the open than when parked in lightly constructed buildings or adjacent to buildings. Officers assigned to these vehicles would take shelter at the staging areas.

If the situation forces abandonment of some or all of the shelters, the shelter-based police and staging-area-based police must coordinate and control the movement of the affected survivors, either to predesignated alternate shelters (see Chapter 3), or to the staging areas for transport out of the untenable area. In the post-shelter environment, the police service must control unauthorized movement and establish security for vital facilities and essential supplies. Manning guard posts and barriers to hazardous areas will be necessary.

Organizational components of the Police Service will vary among jurisdictions. Not all localities will have access to all of the organizations shown. Most of the functions to be performed do not require armed officers; a uniform or other badge of authority will suffice. Hence, plans should include incorporation of private security guards and watchmen into the Police Service, and should consider military support possibilities. The legal and jurisdictional aspects of such plans must be well worked out in advance.

POLICE SERVICE

MISSION STATEMENT	Maintain law and order through traffic and crowd control both outside and in shelter, provide security for vital facilities and supplies, and control access to operating scenes and vacated areas.	
BASIC RESPONSIBILITIES:	MOVEMENT CONTROL	PEACEKEEPING: MAINTAINING SECURITY
TASK ASSIGNMENTS:	1. Providing traffic and crowd control in accordance with CSP during the movement to shelter period. 2. Providing mission support to shelter managers, both in shelter and in event of remedial movement from untenable shelters. 3. Establishing security for vital facilities and supplies. 4. Controlling access to operating scenes and vacated areas, and preventing looting. 5. Protecting and controlling inmates of correctional institutions.	
POSSIBLE ORGANIZATIONAL COMPONENTS:	Police Department Sheriff's Department Constable's Department Department of Public Safety Auxiliary Police Private Security and Guard Services Military Units	

THE FIRE SERVICE

While the emergency mission of the Fire Service is quite similar to the peacetime functions of fire departments, the means to carry out the mission in a nuclear emergency are necessarily quite different from the traditional means, as pointed out in Chapter 3. Essentially, the peacetime fire department can control fires in disaster areas only if it has assumed a broad responsibility for leadership and planning and is able, either in peacetime or in crisis, to train most able-bodied citizens in fire prevention measures and in extinguishing incipient fires. As part of a widespread fire defense capability, there is a need for fire-guard teams in public shelters and brigades of trained fire auxiliaries to augment the professional cadre. Areas that rely largely on volunteer firefighters have a planning task somewhat different from areas with a fixed command and jurisdictional system.

Rescue is most often a peacetime function of fire departments. Some jurisdictions may have assigned rescue functions to the police or sheriff's department. In the nuclear emergency organization, the rescue task could as well be assigned to the Police Service, especially in connection with remedial movement.

Fire Service operations will emphasize a great deal of crisis-oriented organizing and training, as well as fire prevention measures. Prior to receipt of attack warning, manpower and equipment must be deployed to positions best suited to operations in an attack environment. Choices must be made as to whether to locate equipment and on-duty personnel at staging areas, at vital facilities, or at potential fire breaks. A combination will often be the best choice. Reliable sources of water for firefighting will be a key consideration.

Rescue units should be assigned to staging areas. Off-duty firemen would be most useful if assigned to major shelters to organize and lead fire guard teams. Rotation of personnel can be planned for postattack. Arrangements must be made to watch for accidental fires in vacated premises when the people have left to take shelter. Street patrols and observation from upper floors of the taller buildings are possible fire-watch procedures.

Should attack-caused fires occur, fire defense must be initiated wherever ignitions are found, without relying on normal concentrating of forces. Assistance from conventional fire equipment will require some debris removal from streets in most areas. Units arriving from undamaged areas are likely to be effective in limiting fire spread. If shelters must be abandoned because of fire threat, the Fire Service must make prompt determinations of risk and assist in removal of injured and able-bodied survivors. A capability to measure and control exposure to radiation is essential to the accomplishment of the Fire Service Mission.

FIRE SERVICE

MISSION STATEMENT:	Prevent and suppress or control fire, lead search for, and rescue of, entrapped persons, and assist in relocation of population threatened by fire.	
BASIC RESPONSIBILITIES:	FIRE DEFENSE	RESCUE
TASK ASSIGNMENTS:	1. Organizing and enforcing fire prevention measures to reduce the vulnerability of buildings and areas to fire. 2. Providing leadership and training of the public and self-help teams in suppressing smouldering ignitions. 3. Providing leadership and training of teams to locate and rescue entrapped persons. 4. Suppressing or controlling fire at staging areas and vital facilities, and maintaining firebreaks. 5. Assisting the Police Service in the relocation of those threatened by fire.	
POSSIBLE ORGANIZATIONAL COMPONENTS:	Fire Department Auxiliary Fire and Rescue Units Private Fire and Safety Personnel	

THE MEDICAL SERVICE

In contrast to the Police and Fire Services, most communities do not have a local government official whose peacetime functions cover all the medical and public health missions of the Medical Service. Medical care is usually provided by a network of private medical services, often highly organized to meet peacetime emergencies. Local Health Departments often are mainly concerned with public health matters, including inspection and licensing functions. Building on these capabilities is a major planning requirement. Individual hospitals must have an emergency plan, and must conduct exercises periodically for accreditation. Some large cities have mobile medical emergency units for handling peacetime problems. Some local civil defense directors have exerted leadership in developing emergency medical capabilities. Often medical communications are deficient or nonexistent. Many physicians, nurses, and allied medical personnel have emergency assignments to their own hospitals or agencies.

Most organizational problems can be resolved with the aid of local medical and allied professional societies. The assignment of medical personnel to public shelters and staging areas to provide in-shelter medical care and support is a major step. Medical manpower should not be concentrated in too few locations, such as only in hospitals. Designation of planned treatment centers to augment normal hospital beds is desirable. A capability to measure and control exposure to radiation is essential to the accomplishment of the medical mission.

Health and sanitation measures are normally undertaken by local governments quite independently of medical treatment facilities. In the shelter and immediate post-shelter environments, these measures must be much more closely coordinated with medical care. Thus, all tasks shown on this chart should be brought together under local leadership, uniting the medical and public health aspects to a degree not usually contemplated in peacetime. A possible exception is the operation of an ambulance service where this service is normally provided in peacetime by the police or fire department.

MEDICAL SERVICE

MISSION STATEMENT:	Provide emergency medical care both outside and in shelter, institute environmental sanitation measures, and coordinate interment of the dead.	
BASIC RESPONSIBILITIES:	MEDICAL CARE	HEALTH AND SANITATION
TASK ASSIGNMENTS:	1. Providing medical care and sanitation supervision in public shelters. 2. Establishing post-shelter treatment centers, including hospitals, and defining treatment standards in consonance with available manpower and supplies. 3. Inspecting and analyzing water supplies, sewage treatment, food stocks, and feeding facilities. 4. Reinstituting environmental sanitation measures, including control of disease agents. 5. Identifying the dead and coordinating interment. 6. Operating an ambulance service.	
POSSIBLE ORGANIZATIONAL COMPONENTS	Health Department Coroner; Medical Examiner Local Medical, Dental, and Veterinary Associations Hospitals and Clinics Ambulance Companies Local Morticians Mosquito Control Board Sanitation Department Private Exterminators	

THE SHELTER SERVICE

This Service combines the functions of what are often considered to be two separate jobs: (1) operating the shelters; and (2) providing food, clothing, housing, and other "welfare" services after shelter emergence. The closest analogy to the Shelter Service is offered by the functioning of agencies such as the Red Cross during and after a peacetime disaster. Shelter operations and post-shelter care are sequential operations that both involve providing for the immediate needs of people who lack the resources or the organization to care for themselves. Because they are sequential, they should be handled by a single basic organization—otherwise a large increase in trained manpower would be required. For example, it is inefficient to keep the "welfare" organization on standby until shelter emergence and to disband the shelter organization at that time because the emphasis of the task has shifted.

As with the other Services, considerable effort might be needed during a crisis period if peacetime recruitment and training prove inadequate. Plans should be made for shelter staffs to man their shelters prior to attack warning, ready to receive the population according to the CSP. Vital support will come from police, fire, and medical personnel assigned to the shelters. See Chapter 7 for a description of necessary in-shelter actions, including RADEF. Necessary resupply of water and other necessities should be provided from the staging areas. As the time for shelter emergence approaches, preparations for the support of the sheltered population outside the shelters must be made. Often this will be a gradual process, especially in fallout areas, with the shelters used part-time for many weeks. The external support arrangements must be based on neighborhood welfare centers, generally in such places as schools. As long as people do not have the means of providing for their own needs independently, the shelter organization must provide some leadership.

A special problem arises when many families in the community have taken shelter in the basements of their homes. It is good planning in this circumstance to develop an arm of the Shelter Service consisting of selected individuals in these areas who are trained to contact their neighbors, to provide leadership, and to act as a means of requesting help from the local authorities.

SHELTER SERVICE

MISSION STATEMENT:	Provide shelter leadership and organization, provide support for persons displaced from other zones, and provide for the immediate needs of people upon shelter emergence, including welfare services.	
BASIC RESPONSIBILITIES:	SHELTER MANAGEMENT	WELFARE
TASK ASSIGNMENTS:	1. Providing organized shelter leadership, including control of in-shelter supplies. 2. Directing shelter remedial actions where sheltered groups are threatened by the attack environment or other hazards. 3. Providing for the immediate needs of people on emergence from shelter, including feeding, lodging, clothing, registration, counseling, and reuniting of families.	
POSSIBLE ORGANIZATIONAL COMPONENTS:	Welfare Department Personnel and Employment Service American Red Cross School Board Disaster Relief Groups Retail Trade Associations Church and Religious Groups	

THE RESOURCE SERVICE

Many governments have found it desirable to establish organizations to handle the supply of resources that are required more or less in common by their other departments and agencies. At the Federal level, the General Services Administration and the Defense Supply Agency are examples. Equivalent organizations are being set up by many States and large cities. These organizations generally provide such services as: (1) purchase, storage, and distribution of common supplies, (2) construction, maintenance, and operation of buildings, (3) contracting for services, and (4) procurement, maintenance, and operation of transport. Such organizations are established to promote efficiency in the use of resources. Whether or not your locality has seen fit to establish a central peacetime resource agency, emergency operations and postattack management make a "single manager" for the mission shown here highly desirable. In many localities, it may not be feasible to group all the agencies listed under a single service, but in any case a centralized approach to management will be dictated by circumstances eventually. Thus, planning for common tasks becomes especially important, regardless of the formal label applied to the Service or groups.

Making the Resource Service a part of the emergency organization creates a single source of supply and support for the other Services, who are, in fact, claimants for the allocation of available resources, other than the specialized vehicles, equipment, and trained manpower that are organic to them. The Resource Service also provides a single point of contact with the "outside," able to make non-duplicative requests, expedite deliveries and anticipate shortages.

The focal point for Resource Service operations should be the staging areas. At maximum readiness, debris-clearance equipment, filled water- and fuel-tank trucks, emergency power units, and utility repair vehicles should be deployed at the staging areas. Support of the population and the public-safety forces must be initiated from these locations. As emergency operations are completed, the Resource Service must prepare to undertake debris removal and decontamination as needed, repair housing, and institute rationing and other controls on the use of surviving resources, as outlined in Chapter 8. A capability to measure and control exposure to radiation is essential to this mission.

The organizations listed on this chart are indicative of the resource-related groups that should be included in and responsive to coordination by the Resource Service on behalf of the chief executive of the jurisdiction.

RESOURCE SERVICE

MISSION STATEMENT:	Control essential supplies and equipment; provide emergency supplies of water, power, transport, and other services; coordinate repair and restoration of vital facilities; demolish hazardous structures; remove debris; decontaminate areas as required.	
BASIC RESPONSIBILITIES	CONTROL AND SUPPLY OF RESOURCES	REPAIR AND REHABILITATION
TASK ASSIGNMENTS:	1. Supplying and resupplying shelters, staging areas, and medical facilities. 2. Maintaining inventory control (including procurement) of food, water, medical supplies, petroleum products, transport, and other essential supplies and equipment. 3. Providing emergency supplies of water, power, transport, and other essential services to authorized users. 4. Removing debris and decontaminating. 5. Coordinating damage assessment, demolition, and repair of roads, housing, and vital facilities. 6. Providing manpower support for other Services.	
POSSIBLE ORGANIZATIONAL COMPONENTS:	Department of Public Works Streets, Parks, Water, and Sewerage Departments Department of Finance, Assessor, Licenses and Permits Taxicab and Trucking Companies Planning Authority Public and Private Utilities Construction Industry Associations USDA County Emergency Board Industry Committees USDL Employment Service	

PUTTING IT ALL TOGETHER

People involved in major disasters have knowledge only of the situation in their immediate vicinity. Each tends to regard himself as at the center of the worst havoc. Responsible officials who rush to the scene can get out-of-touch, and often obtain only a partial understanding of the situation and its needs. Experience has shown that, if the responsible local official and his chief advisors are located in an EOC with adequate communications to subordinate control centers, staging areas, and shelter complex headquarters as well as to news media, neighboring jurisdictions, and State authorities (called NEXTUP in this manual), the situation can be assessed, priorities established, and actions taken in a timely way. Nuclear attack will place great demands on the local capability to coordinate operations, preserve resources, and adapt plans to public needs.

Direction and Control (D&C) can make an important contribution to the saving of life and property **IF** it can assemble a broader and more useful picture of the operating situation than can subordinate units in the field, **IF** it is staffed by professionals who, by superior training or experience, are able to evaluate the situation more readily than field units, and **IF** it can communicate this knowledge concisely to those who need it. Two factors are of critical importance: the first is the existence of an adequate infrastructure (protected operating sites, effective warning devices, and survivable or redundant communications); the second is operationally oriented planning and training (the specification and practice of actions to be taken in response to events, either observed or reported). Until D&C can plan for management by exception, exercising control only through adjustments to actions planned and understood in advance, a locality is not operationally ready in the fullest sense. Flexibility of response is a mark of sound planning, while a too rigid approach does not take advantage of the usually excellent performance of the population and governmental system under disaster conditions.

DIRECTION AND CONTROL

MISSION STATEMENT:	Assign missions and tasks, direct planning, monitor the attack environment, inform the public, and control emergency operations.	
BASIC RESPONSIBILITIES:	COMMAND	INFORMATION
TASK ASSIGNMENTS:	1. Providing emergency information and guidance to the public, including attack warning. 2. Acquiring information on the attack environment, including RADEF, analyzing information, and informing Services of Basic Operating Situation. 3. Monitoring execution of planned actions and directing modified actions as necessary. 4. Keeping NEXTUP informed of situation, requirements for aid, and availabilities. 5. Setting priorities, resolving conflicting demands for resources, and authorizing major operations, such as population movement or shelter emergence.	
POSSIBLE ORGANIZATIONAL COMPONENTS:	Chief Executive of Jurisdiction (Command) Service Chiefs Commissioners or other Elected Officials Civil Defense Director and Staff, Especially RADEF Communications Resources News Media Legal Advisors	

PANEL 14

WHAT'S IN A PLAN

In Panel 1, President Eisenhower was quoted as saying that plans are worthless, but planning is everything. Like most thought-provoking statements, this proposition is a purposeful exaggeration to emphasize an important idea. Planning—steeping oneself in the nature of the problem to be solved—is essential. But planning is likely to be fuzzy unless focused on the target of a workable written plan. And, as noted in Panel 1, plans **are** useful; they can be studied by newcomers, rehearsed by the emergency organization, and "tested" in exercises. Of course, the job is not over when the plan is written, for all plans must be reviewed and updated as the local scene changes.

DCPA and its predecessor agencies have always believed that plans are useful. Indeed, the preparation and approval of a written local plan has been a long-standing requirement to qualify for Federal assistance. There is no required format for the emergency operations plan but models have been suggested over the years. The outline suggested by OCD in 1968 is shown here. The "umbrella" part is known as the Basic Plan, giving a relatively brief statement of legal authority providing the basis for the plan; assumptions as to the contingencies that could face the community in event of attack, especially whether direct effects are likely to be experienced; the missions, concepts, and policies governing operations during all contingencies; and an outline of the further content of the plan. Emergency functions are assigned to specific government or non-government agencies and mutual aid or other support arrangements defined. The structure of the plan, whether locally designed or patterned on examples such as those used by the military, is of itself unimportant; it is the structuring of operations that is beneficial, and a format or checklist helps avoid important omissions.

For the most part, operational details are expected to be developed in a series of annexes and Standing Operating Procedures (SOPs) prepared by the agencies assigned to specific functions. An Annex covering direction and control and communications, with emphasis on details of EOC operations is absolutely essential. However, an evaluation of a random sample of 420 local government emergency operations plans made in 1969 and 1970 disclosed that these all-important annexes were often non-existent or consisted of little more than what the military calls a table of organization and equipment. An emergency operations plan that is devoid of operational content is, indeed, useless.

OUTLINE OF A BASIC PLAN*

Authority

I. Situation and Assumptions

II. Mission

III. Execution

  A. Concept of Operations

  B. Assignment of Emergency Functions

  C. Support

IV. Administration and Logistics

V. Direction and Control

*From **Example of a Local Government Civil Defense Emergency Plan for a Municipality of Approximately 20,000 Population,** Federal Civil Defense Guide, Part G, Chapter 1, App. 2, Ann. I, June 1968.

CONTINGENCY PLANNING—THE CHECKLIST APPROACH

A local emergency operations plan that is devoid of operational content cannot be of use in training or in guiding operations under attack conditions such as those represented by the example scenario shown here. Moreover, such plans indicate that the emergency planning that is so important has in all likelihood not been done.

Recognition that local emergency plans should provide for specific actions to be taken in response to a number of possible situations or contingencies led OCD in 1968 to recommend that emergency plans in order to provide full coverage be organized as follows:

Basic Plan (including annex on Direction and Control and Communications).
Part A—Increased Readiness Operations
Part B—Shelter Operations.
Part C—Emergency Control and Use of Resources Following a Nuclear Attack.
Part D—Natural Disaster Operations.

Emphasis was placed on Parts A and B, with Part A to be written after Part B was well in hand. Part B was to spell out the priority actions to be taken during the period when prompt response by local forces would be vital to ensure maximum survival of the population. The starting point would be the CSP. Operations were to be outlined for the nine Basic Operating Situations described in Chapter 1 of this manual. The concept of operations summarized in Chapter 1 was recommended. Naturally, many localities have their own formats and approaches to planning. The best approach for a given place must be defined during the planning process.

More recently, a checklist of priority actions keyed to **triggering events** of the type shown in this scenario has been developed to aid in providing operational content for Parts A and B. Called ALFA NEOP, as a short title for "inplace Nuclear Emergency Operations Plan," this checklist guide can be used in conjunction with the DCPA Attack Environment Manual to guide the planning that can result in realistic Service Annexes and SOPs. The essential features of this checklist approach are summarized in the next few panels, with frequent references to the scenario shown here.

Checklists of triggering events and recommended planned actions for Part C are currently under development. Checklists for corresponding operations in event of natural disaster have also been developed as outlined in Panel 25.

A NUCLEAR WAR SCENARIO

DATE/TIME	EVENT
5 AUG 1700	Threatening international development.
6 AUG 1000	Decision to commence alerting forces and expanding local capabilities.
15 AUG 1300	Decision to commence mobilizing emergency forces.
15 AUG 1600	Advised by NEXTUP to attain maximum readiness posture.
15 AUG 1745	ATTACK WARNING received.
15 AUG 1800	Distant weapon detonation observed to west.
15 AUG 1845	Movement to shelter is completed.
15 AUG 2015	Advised by NEXTUP fallout is likely in 1 hour.
15 AUG 2120	First report of fallout measurement.
15 AUG 2130	Monitor station reports 0.5 R/hr and increasing.
15 AUG 2315	All monitor stations have reported peak about 30 R/hr and decreasing.
16 AUG 0100	Building shakes, windows shatter, lights go out until generator takes over.
16 AUG 0109	Significant damage and developing fires reported.
16 AUG 0115	Fire Service reports eastern part of city safe from fire.
16 AUG 0120	Monitor station reports dose rate now increasing.
16 AUG 0130	Monitor station reports 50 R/hr and increasing.
16 AUG 0140	All monitor stations have reported peak about 200 R/hr and decreasing.
16 AUG 0230	Fire Service reports fires have been brought under control.
16 AUG 0305	All monitor stations have reported 50 R/hr and decreasing.
16 AUG 0430	Fire Service reports fires present negligible threat.
16 AUG 1900	Advised by NEXTUP that further attack is unlikely.
16 AUG 2400	Advised by NEXTUP that additional fallout is unlikely.
19 AUG 0900	All monitor stations report dose rates decreased to less than 0.5 R/hr.

INCREASED READINESS OPERATIONS

In the ALFA NEOP checklist, the increased readiness section is called "Plan A—Alert." There are eight triggering events defined for Plan A as shown here. Another possible event—nuclear detonation observed or reported—would call for immediate implementation of a subsequent plan section. Thus, Plan A contains all triggering events short of a nuclear detonation. The progression of events follows the Increased Readiness "ladder" presented in Federal Civil Defense Guide Chapter G-5, **Actions for Increasing Local Government Civil Defense Readiness.** Review of Chapter G-5 is included in the first planned action in response to the triggering event—Threatening International Development.

Local actions recommended in response to the first two events are unlikely to result in more than minimum public concern, even if they are reported in the news media. The action statements constitute a reminder list or agenda for the local chief executive, who should authorize those determined appropriate, exercising his own good judgement, if specific advice is not received from the State or Federal level.

The decisions represented by the third and fourth events entail actions that "go public" to a greater or lesser degree. Nonetheless, no real augmentation of capabilities nor readiness to use existing capabilities can be achieved unless these actions are undertaken. Moreover, it is likely that most localities will be in a position at the early stages of a crisis where expansion of capabilities and mobilization of emergency forces will be imperative. Of course, crisis events as reported in the news media may precipitate public concern and demands for affirmative action. Local governments must be prepared at an early stage to satisfy public inquiries and needs for action. Communicating decisions, or even the existence of a threat, to the public is by no means a certain or easy accomplishment.

The ultimate stages of crisis are represented by deployment of forces and movement to shelter. At any stage, however, the crisis may be resolved or eased. The last triggering event can occur at any stage. It is placed last to account for the possibility of false alerts, enemy shows of force, and other unlikely scenarios where shelter-taking may occur without subsequent attack.

As noted before, increased readiness actions should be planned after the subsequent emergency actions have been developed, as priorities will vary with the capabilities and readiness existing in each community.

ELEMENTS OF PLAN A

TRIGGERING EVENT	THEME OF PLANNED ACTIONS
Threatening International Development	Limited to accelerating ongoing CD programs and to internal actions by each Service to update assignments and increase readiness of cadre.
Decision to Commence Internal Government Readiness Actions	Brief key government and non-government officials and make ready to initiate actions to materially increase capabilities.
Decision to Commence Alerting Forces and Expanding Local Capabilities	Carry out actions to augment forces, improve shelter, and prepare to issue emergency information to the public.
Decision to Commence Mobilizing Emergency Forces	Initiate actions to reduce fire vulnerability, distribute CSP and self-help information, and continue to augment forces.
Advised by NEXTUP to Attain Maximum Readiness Posture	Deploy all forces to shelters, traffic control points, and staging areas; initiate hospital plans and industry shut-down.
ATTACK WARNING Received	Warn public and Services, expedite move to shelter, position for maximum protection, and take EMP precautions.
Movement to Shelter is Completed	Redeploy forces to shelters and staging areas.
Advised by NEXTUP to Decrease Level of Readiness (can occur at any stage).	Initiate actions to return to level recommended and to resume normal activities as appropriate.

THE DISTANT IMPACT PLAN

In the ALFA NEOP checklist, "Part B—Shelter Operations," referred to in Panel 16, is replaced by a series of plan sections corresponding to the nine Basic Operating Situations described in Chapter 1 of this manual. The first of these plan sections is called "Plan B—Distant Impact." The use of Plan B is triggered by a report or observation of a distant nuclear detonation. A "distant impact" is defined as one that causes no direct effects in the locality, not even broken windows. Hence, it would be observed mainly as a brilliant source of light, as described in Chapter 3.

Since a distant impact could occur shortly after ATTACK WARNING or without warning, taking of shelter must be expedited if not already completed. When movement to shelter is completed, traffic control forces are redeployed to shelters and staging areas and maximum protective positions maintained for at least six hours. At that time, unless advised to the contrary by NEXTUP, feeding and sleeping arrangements can be set up in shelters and essential supply and security missions can be undertaken. (NEXTUP is a planner's word for the next higher EOC. A chain of communications ultimately goes to the headquarters of the North American Air Defense Command—NORAD). When advised by NEXTUP that further attack is unlikely, actions can be taken leading to shelter emergence. Of course, during this period, the locality may be requested to dispatch emergency units to the distant impact area or to receive, shelter, and care for survivors from that area.

A nuclear detonation in the immediate vicinity could occur at any time. This event would call for leaving Plan B and activating Plan C (Panel 20). But the table in Panel 3 suggests that localities comprising at least 25 percent of the U.S. population would never leave Plan B. The only attack effects that these communities might encounter would be EMP and fallout. The severity of fallout would have an important impact on emergency operations. Fallout contingency plans are described in the next panel.

ELEMENTS OF PLAN B

TRIGGERING EVENT	THEME OF PLANNED ACTIONS
Distant Weapon Detonation Observed or Reported	Inform NEXTUP, expedite movement to shelter, estimate likelihood of fallout, and prepare to care for evacuees or dispatch aid, if requested.
Movement to Shelter is Completed	Redeploy forces to shelters and staging areas.
Six Hours Elapse Without Attack in NEXTUP Area	Relax maximum protective posture, establish shelter feeding and sleeping arrangements, and initiate resupply missions and security patrols.
Advised by NEXTUP that Danger of Attack is Over	Advise Services and public to remain in shelter until fallout is no longer a hazard and post-shelter controls are in effect. When appropriate, authorize shelter emergence.
Observation or Report of Nuclear Detonation in Vicinity (can occur at any time)	Immediately activate Plan C.

PANEL 18

THE RADIATION CONTROL PLAN

Fallout radiation is the main threat to survival in localities where only distant impacts are observed. Radiation from fallout in sufficient amounts can also impede emergency operations outside shelters for a period of time. As noted in Chapter 1, it is sufficient to plan for three fallout contingencies: (1) NEGRAD, in which the measured dose rate never exceeds 0.5 R/hr; (2) LORAD, in which dose rates peak between 0.5 R/hr and 50 R/hr; and (3) HIRAD, the situation where dose rates exceed 50 R/hr.

NEGRAD is a situation in which fallout radiation is of negligible consequence. LORAD requires protection of the population and control of the exposure of emergency workers, and HIRAD suggests the suspending of all outside activity. Only the most serious emergencies in a Plan B situation are so urgent that they could not be postponed. But fallout also can be deposited in damaged areas. Fighting fires that threaten the sheltered population is essential in a HIRAD contingency because, unless fires are controlled, the people must leave the shelters and be exposed to the fallout environment.

The radiation control plans summarized in this table apply equally to the Distant Impact Plan and to direct-effects contingencies. In ALFA NEOP, duplication is avoided by a split-page format, with direct-effects plans on the left and radiation control plans on the right. Thus, any of the nine Basic Operating Situations can be displayed, showing all pertinent triggering events and the planned actions for each. The Service planner can observe not only those actions for which his Service is responsible but also all other planned actions that would be undertaken at the same time.

The NEGRAD plan takes effect upon the occurrence of a nuclear detonation. If a fallout measurement exceeding 0.5 R/hr is reported, the LORAD plan is operative. A report of dose rate in excess of 50 R/hr would call for the HIRAD plan. In the example scenario of Panel 16, the NEGRAD plan would apply beginning at 1800 (6 p.m.) on August 15, and the LORAD plan at 2130 (9:30 p.m.). The HIRAD plan would become effective at 1:30 a.m. the following morning. All plans continue throughout fallout decay and into the post-shelter period.

FALLOUT CONTINGENCIES

TRIGGERING EVENT	THEME OF PLANNED ACTIONS
NEGRAD	
Distant Weapon Detonation Observed or Reported	Plot direct effects areas, fallout reports, and estimate likelihood of fallout based on weather data.
Advised by NEXTUP Fallout is Likely	Advise Services and public, and schedule termination of outside activities.
First Report of Fallout Measurement	Start monitoring total dose to units and shelter groups.
All Monitor Stations Report Dose Rates Peak Less than 0.5 R/hr and Decreasing	Advise Services fallout hazard is negligible; prepare to receive evacuees.
Advised by NEXTUP that Additional Fallout is Unlikely	Continue emergency operations without concern for fallout. Plan for shelter emergence.
LORAD	
Monitor Station Reports Dose Rate in Excess of 0.5 R/hr and Increasing	Unless fighting fire, suspend outside operations and prepare for HIRAD situation; occupy shelter areas having lowest dose rates.
All Monitor Stations Report Dose Rates Less than 50 R/hr and Decreasing	Poll units for total dose received, evaluate hazard, and establish exposure criteria for essential operations.
All Monitor Stations Report Dose Rates have Decreased to Less than 0.5 R/hr	Suspend radiation dose controls.
Advised by NEXTUP that Additional Fallout is Unlikely	Maintain necessary dose controls and schedule shelter emergence.
HIRAD	
Monitor Station Reports Dose Rate in Excess of 50 R/hr and Increasing	Unless fighting fires, suspend outside operations; occupy shelter areas having lowest dose rates.
All Monitor Stations Report Dose Rates Peak Greater than 50 R/hr and Decreasing	Poll units for total dose received, evaluate hazard, and estimate shelter stay-time.
All Monitor Stations Report Dose Rates have Decreased to Less than 50 R/hr	Establish exposure criteria and undertake shelter resupply and other essential operations.
Advised by NEXTUP that Additional Fallout is Unlikely	Maintain necessary dose controls and plan shelter emergence.

THE NEARBY BURST PLAN

As noted in Panel 18, a nuclear detonation in the immediate vicinity would call for the actions in "Plan C—Clear." The immediate response would be to find out if the weapon had caused significant damage and, more importantly, if fires had been ignited. Operating units and shelter fire guard teams would conduct a quick survey, regardless of the fallout situation. Any ignitions found, of course, should be extinguished if possible. Reports of significant damage and developing fires would call for implementation of Plan D (Panel 21). Otherwise, the events and general actions shown on this panel would be appropriate. Referring again to Panel 3, and keeping in mind the damage and fire information of Chapters 2 and 3, it would appear that localities comprising about 25 percent of the U.S. population might be nearby nuclear detonations—beyond the area of significant debris and fire ignitions but within the range of minor damage and glass breakage.

Emergency forces and equipment would remain operational. Immediate aid to the neighboring area of more severe damage would be the central theme of actions. Aid to suppress fires would be of highest priority since fires could spread into the "clear" area. Consistent with the neighboring fire threat, mutual aid teams should also conduct search, rescue, and medical aid (in accord with the radiation control plan if fallout has occurred). Localities in a Plan C situation also should prepare to provide shelter and care for survivors from the damaged area.

If the locality remains in Plan C when advised that further attack is unlikely, actions must be taken to control local resources, support the population as necessary, and act as a base for recovery in adjacent damaged jurisdictions. The Staging Areas will be of great value for the latter purpose.

ELEMENTS OF PLAN C

TRIGGERING EVENT	THEME OF PLANNED ACTIONS
Observation or Report of Nuclear Detonation in Vicinity—Effects Uncertain	Deploy all Service units to survey and report situation.
Survey Indicates Damage and Fires Present Negligible Threat	Unless radiation controls do not permit, dispatch aid to damaged area and prepare to receive refugees and injured.
Six Hours Elapse Without Additional Attack	Relax protective posture, establish shelter feeding and sleeping arrangements, and initiate resupply and security missions in accord with radiation control plan.
Advised by NEXTUP that Further Attack is Unlikely	Advise Services and public to remain in shelter until fallout is no longer a hazard and post-shelter controls are in effect. When appropriate, authorize shelter emergence.

THE DAMAGE CONTROL PLAN

When a nuclear detonation occurs in the vicinity, Plan C calls for a rapid survey of the situation. Reports of significant damage or developing fires is the triggering event for "Plan D—Damage." The need for Plan D is likely to become obvious very quickly. For example, in the scenario of Panel 16, Plan B would be applicable beginning at 6 p.m. August 15. Plan C would be activated at 1 a.m. on the 16th, and Plan D adopted 9 minutes later as reports of damage and fires were made.

In an almost literal sense, every able-bodied person must be a fireman until fires threatening the sheltered population are under control. Controlling the fire situation is the priority action regardless of the fallout situation. (See Chapter 3 for the likely course of fire development and Chapter 6 for the timing of close-in fallout deposition.) Fires are under control when fire spread has been contained, the fire threat is diminishing, and the surviving shelters are judged to be tenable.

Fires are "controllable" until the Fire Service determines otherwise. If debris, damage, or insufficient manpower makes control of the developing fire situation highly unlikely, it may be advisable to implement Plan E promptly to give as much time as possible to evacuate the threatened shelters. This would be especially important in areas judged to have high conflagration potential (see Chapter 3, Panel 28).

In Plan D, Staging Areas should be used as rally points and work organization bases after the initial fire suppression effort. Incoming aid should be directed to the Staging Area for assignment of tasks. The Fire Service should plan to establish fire defense lines as appropriate and to direct evacuation of untenable shelters and other facilities as necessary. When fire is a negligible threat, search, rescue, and medical aid operations should be conducted consistent with the fallout threat. The surviving population should be maintained in the best remaining shelter unless relocation to the clear area is feasible. If the locality remains in Plan D when advised that further attack is unlikely, NEXTUP should be advised of needs and asked to coordinate aid in caring for survivors and in recovery of useful assets in the jurisdiction.

ELEMENTS OF PLAN D

TRIGGERING EVENT	THEME OF PLANNED ACTIONS
Significant Damage and/or Developing Fires Reported	Deploy all units and shelter teams to suppress incipient fires; conduct search, rescue, and medical aid; suspend radiation exposure controls.
Fire Service Advises Fires Have Been Brought Under Control	Reinstate necessary radiation exposure controls, maintain control of residual fires, and continue search, rescue, and medical aid.
Fire Service Advises Fires Present Negligible Threat	Continue search, rescue, and treatment of injured under appropriate radiation control plan.
Advised by NEXTUP that Further Attack is Unlikely	Seek aid in caring for or relocating survivors and in recovery operations.

THE REMEDIAL MOVEMENT PLAN

In densely built-up parts of cities under conditions of moderate to severe damage, control of developing fires may not be successful despite self-help training of the citizenry. In these circumstances, there is no alternative but to remove the population from the threatened area in a timely manner. If this remedial movement must be accomplished under a severe fallout hazard, the most difficult Basic Operating Situation, BOS 9, has been encountered. Situations of this kind appear hopeless but the information in this manual should convince the emergency planner that lives can be saved, even in this contingency, if a realistic "Plan E—Escape" is prepared.

A conflagration assessment of the jurisdiction (see Chapter 3) will prove invaluable in defining the areas that may have to be abandoned and the nearest relocation areas available. Availability of shelter in low fire-risk areas and fire breaks where fires could be contained will influence the detailed planning of the actions suggested in this panel.

ELEMENTS OF PLAN E

TRIGGERING EVENT	THEME OF PLANNED ACTIONS
Fire Service Advises that Fires are Uncontrollable in Areas Susceptible to Mass Fire	Evacuate all threatened shelters to lower-risk area regardless of fallout threat.
Fire Service Advises Mass Fire Contained	Reinstitute radiation controls; maintain fire lines; and initiate search, rescue, and treatment of injured.
Fire Service Advises Residual Fires Present Negligible Threat	Search burned area for surviving groups, support survivors in relocation area.
Advised by NEXTUP that Further Attack is Unlikely.	Request aid in care of survivors.

ANNEXES AND SOPS

The ALFA NEOP checklist is not a substitute for a local emergency operations plan. Rather, it is intended as a guide in developing or improving service annexes and standing operating procedures tailored to the locality's characteristics, resources, and authority structure. A good way to proceed is as follows:

(1) Conduct a number of desk-top or seminar exercises with the unaltered ALFA NEOP, using a set of suitable scenarios like that in Panel 16. Participants should include the chief executive, key operating officials, and the planning staff. The purpose of this step is to familiarize the responsible officials with the general character of the emergency actions involved and to identify those that may need modification to fit local conditions.

(2) The planning staff should review each action for pertinence to the locality, modify as appropriate, and particularize the action statements wherever possible. Actions peculiar to the locality, such as measures needed in low areas in event of damage to dams or levees, should be added. Action responsibilities should be adjusted to fit the local emergency organization and capabilities. Reporting arrangements should be adjusted to conform to State practice and NEXTUP identified, including alternates.

(3) Several desk-top or seminar exercises using the adapted checklist should be held to obtain the concurrence of the chief executive and key operating officials.

(4) The planning staff should then analyze each action statement to establish who or what unit will take what steps, using what equipment or resources, to accomplish the action. Reflect these in supporting annexes or SOPs. Identify those actions that cannot be undertaken with current resources for peacetime readiness development and for correction, if possible, during the Increased Readiness period.

An example of a possible format for the task assignment part of a Service Annex is shown here. In this particular case, three actions have been identified as Fire Service responsibilities in the event of ATTACK WARNING. The assignments reflect local conditions. Note that one action is a "conditional" action, the condition being "If not already accomplished." The same action appears for the event, "advised by NEXTUP to attain maximum readiness posture." (See Panel 17.) In this case, the routes to the Staging Areas have been identified in collaboration with the Police and Shelter Services to minimize interference with the movement to shelter.

AN EXAMPLE SET OF TASK ASSIGNMENTS*

EVENT: ATTACK WARNING RECEIVED

Fire Service Actions

A-47 AUTOMATIC Sound public attack warning signal.	A-50 CONDITIONAL If not already accomplished. . ., complete deployment of equipment and personnel to duty stations.	A-53 AUTOMATIC Initiate fire watch; direct actions of shelter fire guard teams.

TASK ASSIGNMENTS

1(A) DISPATCHER Notify all fire stations to sound attack warning signal on fixed sirens.	1(A) COMPANY A Move fire truck to Central High School Athletic field via Southmore and Higgins. Park vehicle and take shelter in basement of high school. (SA-1)	1(A) COMPANY A 3 persons establish fire watch on 7th floor of National Bank Building. Phone: 323-7091
2(B) ALL STATIONS When notified of attack warning, sound warning signal on fixed siren.	2(A) COMPANY B Move fire truck to Western Shopping Center via Otis Avenue. Park vehicle and take shelter in shopping center basement. (SA-2)	2(A) DISTRICT DEPUTIES Establish contact with fire personnel assigned to shelters (see Tab A) and expedite fire prevention measures.
	3(A) ALL PERSONNEL On attack warning signal, report to assigned duty station.	3(A) DISPATCHER If not all shelters have fire personnel assigned, request Shelter Service to instruct such shelters to form fire guard teams and take fire prevention action.

EVENT: Attack Warning received.	ACTIONS: A-47, A-50, A-53
EVENT: Movement to shelter is completed.	ACTIONS: A-59, A-62, A-63
EVENT: Advised by NEXTUP to decrease level or readiness.	ACTIONS: A-69

B-DISTANT IMPACT | C-CLEAR | D-DAMAGE | E-ESCAPE

* Adapted from Rainey, C.T., **Nuclear Emergency Operations Planning at the Operating Zone Level**, Stanford Research Institute, October 1970

PANEL 23

THE PLANNING PROCESS

In the preceding panel, a way to use the ALFA NEOP in the planning process was described. Written plans, if they have operational content, serve as useful records of decisions made in the planning process and as training documents. The preceding illustration is indicative of what is meant by "operational content." The process of developing the operational content is the critical planning process.

Effective plans cannot be developed by the local civil defense official and his staff (if any) in isolation from other local agencies. Plans done in isolation are of little or no value because they are not likely to be used in the emergency. Moreover, operational content usually requires the knowledge of specific capabilities that is possessed only by the operating organizations involved. Many existing emergency plans assume emergency response capabilities that do not in fact exist. The process suggested here will make it difficult for imaginary capabilities to creep in to otherwise sensible preparations. Of course, deficiencies will exist. These must be identified and actions undertaken to correct them. To hedge against delays, corrective actions also should be included in Plan A to be undertaken in a period of international tension.

The local government's emergency plan should therefore document and reflect a planning process conducted by a local planning team. This team should include representatives from each department of local government with an emergency mission, and from non-governmental groups to which emergency functions should be assigned. Many such groups are suggested in Panels 9 through 13.

The chief executive should participate as much as appropriate in the work of the planning team, at least to the extent suggested in Panel 23. The local civil defense director should lead the planning process. As part of this leadership, he should take the responsibility for informing the team members from other agencies of the special conditions arising out of nuclear attack that should influence the operational content of the plan. This manual has been designed for this purpose. Additionally, training and on-site assistance is available through the University Extension Program and from members of the State civil preparedness agency and the DCPA Regional office.

A LOCAL PLANNING TEAM IN ACTION

Civil Defense Directors of York City and York County (Pennsylvania) discuss status of CSP materials with other members of planning team.

NATURAL DISASTER PLANNING

This manual describes the nuclear attack environment and the planning tools that can help build local readiness to cope with the contingencies of nuclear war. These same planning tools, such as ALFA NEOP, can, with little adaptation, build readiness as well for peacetime disaster operations. To demonstrate that this is so, we exhibit here another nuclear war scenario and, below it, the scenario of the Lubbock, Texas, tornado of 11 May 1970.

The nuclear war scenario was adapted from the tornado incident by assuming an airburst detonation in weather so inclement that fire ignitions were negligible. The event structures of the two scenarios are quite similar, differing mainly in terminology and the length of the period of threat. More importantly, the planned actions in ALFA NEOP closely approximate those that were required and actually undertaken by the emergency forces of Lubbock. Indeed, Lubbock officials assert that the infrastructure, planning, and training exercises built and undertaken in their city for nuclear preparedness purposes contributed in a major way to the effectiveness of their disaster operations.

One way to explain why nuclear and natural disaster operations are so similar is to note that, in Chapter 1, Panel 15, "Damage or Fire" can be generalized to all disaster agents that have a destructive impact—detonations, explosions, earthquakes, tornadoes, and the like. Similarly, "Fallout" can be generalized to all disaster agents having a paralyzing effect on operations—fallout, releases of hazardous materials, torrential rains, winter storms, and the like. The latter can make outside operations difficult, and, in some cases, impossible, just as does fallout radiation. Finally, both kinds of agents can occur in the same disaster (e.g., an explosion resulting in release of a hazardous material, such as chlorine). Having shown this, it is a short step to the nine Basic Operating Situations, the idea of plans for distant impact, nearby disaster, etc., and the use of checklist guides for planning.

An ALFA NADOP (for Natural Disaster Operations Plan), modeled on ALFA NEOP, has been developed for DCPA. It is being used to prepare checklists for operations in tornadoes, earthquakes, and similar disasters. These checklists will be published in the future.

ANOTHER NUCLEAR WAR SCENARIO

DATE/TIME	EVENT
1 MAY 1400	Threatening international development.
1 MAY 1600	Decision to commence internal government readiness actions.
4 MAY 0900	Decision to commence alerting forces and expanding local capabilities.
11 MAY 1000	Raining steadily. Weather report indicates large stationary low will produce rain for next two days.
11 MAY 2015	Advised by NEXTUP to attain maximum readiness posture.
11 MAY 2146	Building shakes, windows break; EOC lights go out for seven seconds until emergency power established.
11 May 2149	D&C reports communications out with NEXTUP.
11 MAY 2157	Police Service reports severe damage.
11 MAY 2230	Fire Service reports negligible fires—due to rain?
11 MAY 2330	D&C reports communications link with alternate NEXTUP.
12 MAY 0350	Six hours have elapsed without additional attack.
12 MAY 1700	Advised by NEXTUP that further attack is unlikely.
12 MAY 1800	Advised by NEXTUP that additional fallout is unlikely.

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4 MAY 0900	Decision to plan for additional medical facilities in case of a tornado disaster.
11 MAY 1000	Weather report indicates thunderstorms expected late afternoon and early evening.
11 MAY 1950	Severe Thunderstorm Warning Bulletin received from Weather Bureau.
11 MAY 2015	Tornado Warning Bulletin received from Weather Bureau.
11 MAY 2146	Building shakes, windows break; EOC lights go out for seven seconds until emergency power established.
11 MAY 2149	D&C reports communications out with Weather Bureau.
11 MAY 2157	Police Chief reports severe damage in downtown area.
11 MAY 2230	Assistant Fire Chief reports negligible fires.
11 MAY 2330	D&C reports communications link with Weather Bureau; Tornado Warning cancelled.

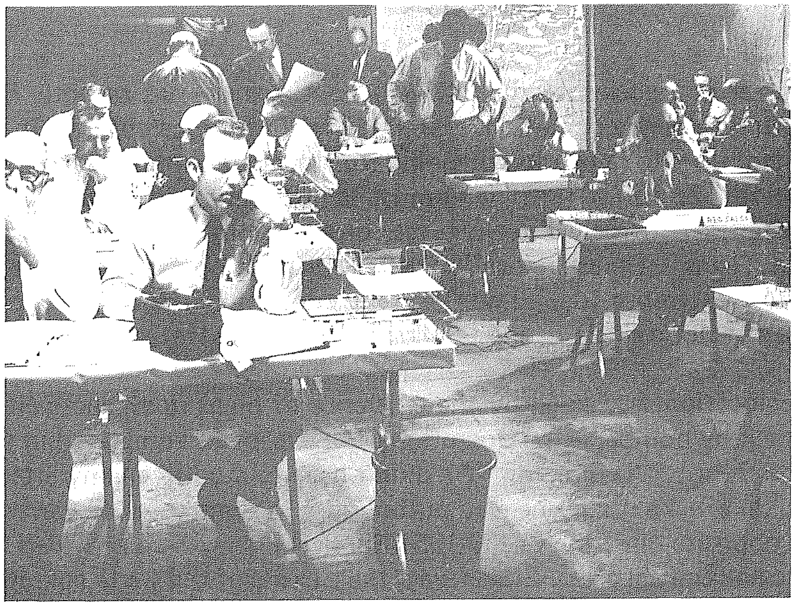
EXERCISES

Exercises are the mortar that binds the building blocks of infrastructure, people, and plans into the citadel of local emergency readiness shown in the very first panel of this manual (see Chapter 1). Plans and plan-writing in the absence of tests and exercises may be a fruitless activity. An emergency organization without exercise will soon decay.

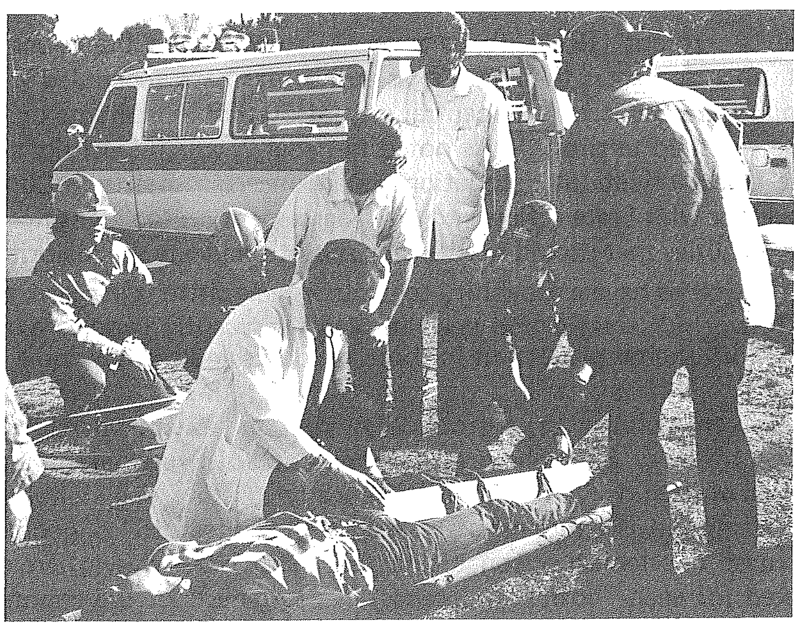
Exercises may be designed for a variety of purposes. The simplest and most basic is a "command post" exercise intended merely to **demonstrate** to local officials and agencies the need for coordinated operations in major emergencies, including the need for interagency planning (see Panel 24). The Emergency Operations Simulation (EOS) exercise, available through the University Extension Program, has proved a popular and effective means of motivating local officials to **initiate** the all-important planning process.

As plans are developed that reflect local conditions and capabilities, the need arises for more ambitious exercise goals. Exercises can assist in developing organizational assignments, contingency plans, and communications procedures. Exercises can aid in planning displays and developing procedures for EOC, Staging Area, and Shelter Complex Headquarters functions. An exercise of this kind is shown in the upper photograph.

Exercises also are useful in the training of field units in unfamiliar tasks or in unfamiliar patterns of working together. One such field exercise is shown in the lower photograph. The ever-present peacetime threat of natural disasters or man-made accidents offers a valuable scenario for many exercise purposes. Field exercises, especially, can be made more authentic to the "players" in a peacetime disaster context. A nuclear scenario, on the other hand, tends better to exercise the making of coordinated responses, to require maximum use of all existing local capabilities, and to bring out more fully the need for and to provide experience in multi-level operations (NEXTUP, for example) and lateral coordination with neighboring jurisdictions. A locality that presumes to be operationally ready will be wise to schedule about two full-blown exercises each year, one with a nuclear attack scenario, and one keyed to an appropriate peacetime disaster. Of course, should a disaster actually strike, the misfortune will test local readiness in ways no exercise could duplicate. Thus, every effort should be made to document, evaluate, and learn from these incidents how better to prepare for future emergencies.



EOC Exercise in Jackson, Mississippi.



Operational Exercise in San Bernardino, California.

THE BRAVO CONTINGENCIES

Planning for crisis relocation—the BRAVO contingency—has recently become an important element in emergency operations planning, for the reasons outlined in Panel 3. Many localities are no strangers to relocation planning for slowly developing natural disasters, such as hurricanes, floods, or forest fires. The most famous relocation occurred in advance of Hurricane Carla in 1961. Nearly three-quarters of a million Gulf Coast residents relocated in Louisiana and Texas. Texas' relocation, which was the major one, was begun around noon on Saturday, September 10, and was virtually complete by Sunday noon. In the entire movement, there was not a single traffic fatality or major accident.

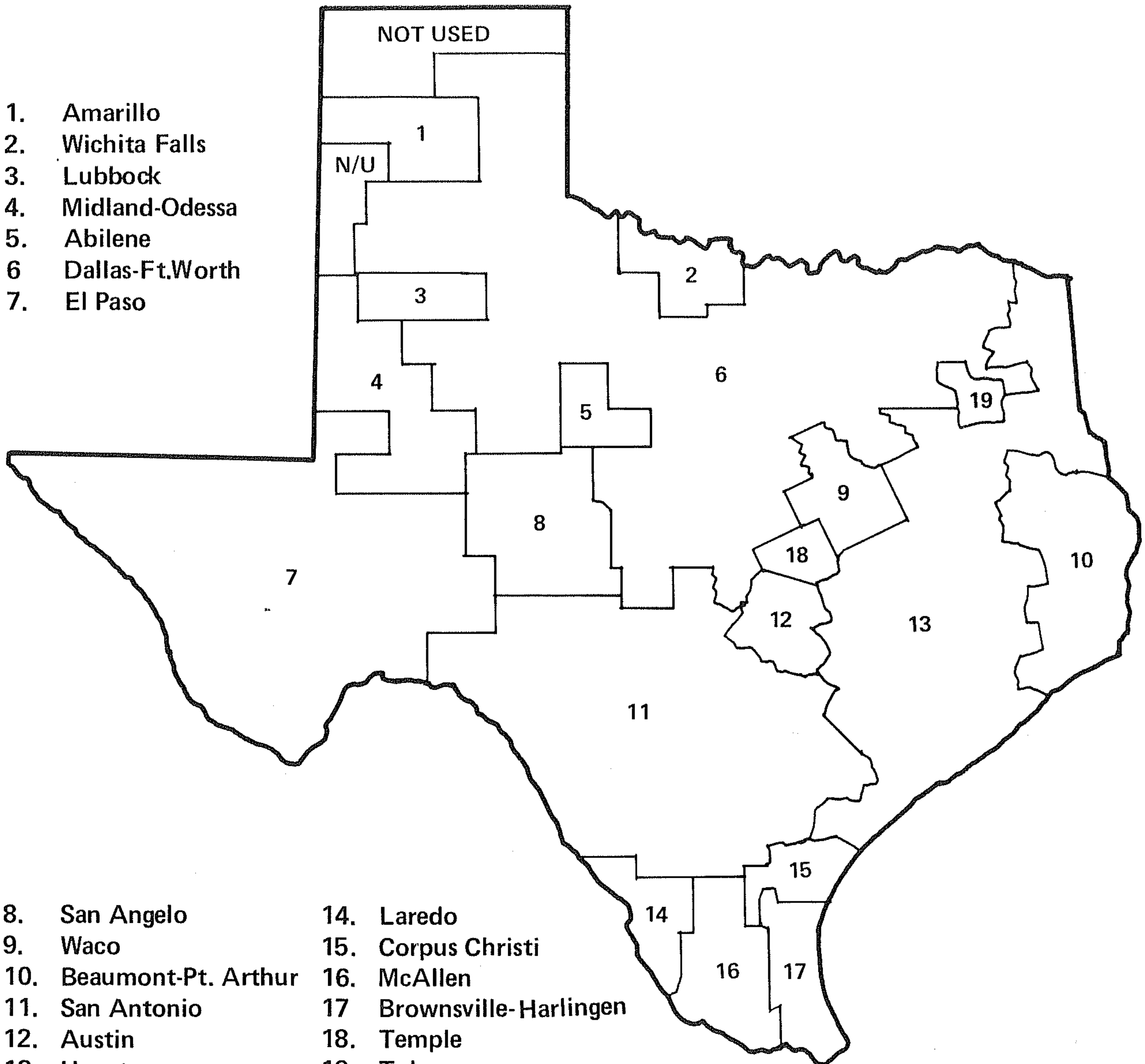
The Carla relocation was aided by the existence of plans to evacuate cities after warning of enemy attack by bombers—the Operational Survival plans completed in the late 1950s. Said the Jefferson County CD director, "We didn't have to modify enemy attack plans at all, except that we didn't make roads one-way outbound." In some cases, however, actual movement was in the opposite direction of the 1957 Survival Plan, which provided for evacuation of inland cities to the coastal areas. Either way, the success of the Carla operation was a convincing demonstration that mass relocation is a practical, cheap, and effective means of saving lives. Of course, a BRAVO relocation involves a longer stay-time and different problems to plan for.

Shown here is a recent (1973) Texas plan. The map shows the relocation (hosting) areas for the 23 urbanized areas that the Texas authorities have scheduled for crisis relocation. (An urbanized area consists of a central city of 50,000 inhabitants or more, and the surrounding closely settled territory.) As noted in Panel 2, which localities are likely to be subjected to the direct effects of detonations is an uncertain matter. Currently, DCPA officials work together with State officials to reach agreement on the identification of "high-risk areas," those localities that should have a capability to relocate the majority of the population in a crisis as well as have a capability to protect their citizens in place, considering all attack effects. "Low-risk" areas would need to plan for reception and care of people relocated, including fallout shelter protection for both residents and the newcomers.

Once risk areas are defined, the surrounding hinterland must be partitioned into hosting areas, shown on this map. Since the resident population of a rural county is a good measure of the amount of hosting "infrastructure" already existing (e.g., wholesale and retail outlets, housing, water and sewerage capacity, etc.), a "hosting ratio" of people relocated to residents is often used to establish reasonable hosting areas. Those shown here do not exceed 2 persons relocated for each "host." Of course, in many parts of the country, movement will be across State lines, necessitating inter-state planning teams.

TEXAS EVACUATION AREAS*

1. Amarillo
2. Wichita Falls
3. Lubbock
4. Midland-Odessa
5. Abilene
6 Dallas-Ft.Worth
7. El Paso



8. San Angelo
9. Waco
10. Beaumont-Pt. Arthur
11. San Antonio
12. Austin
13. Houston
14. Laredo
15. Corpus Christi
16. McAllen
17 Brownsville-Harlingen
18. Temple
19. Tyler

*Based on Sachs, A., **Nuclear Emergency Operation Planning for Evacuation of Urbanized Areas**, Institute for Defense Analyses, August 1973.

URBANIZED AREAS AND THEIR HINTERLANDS

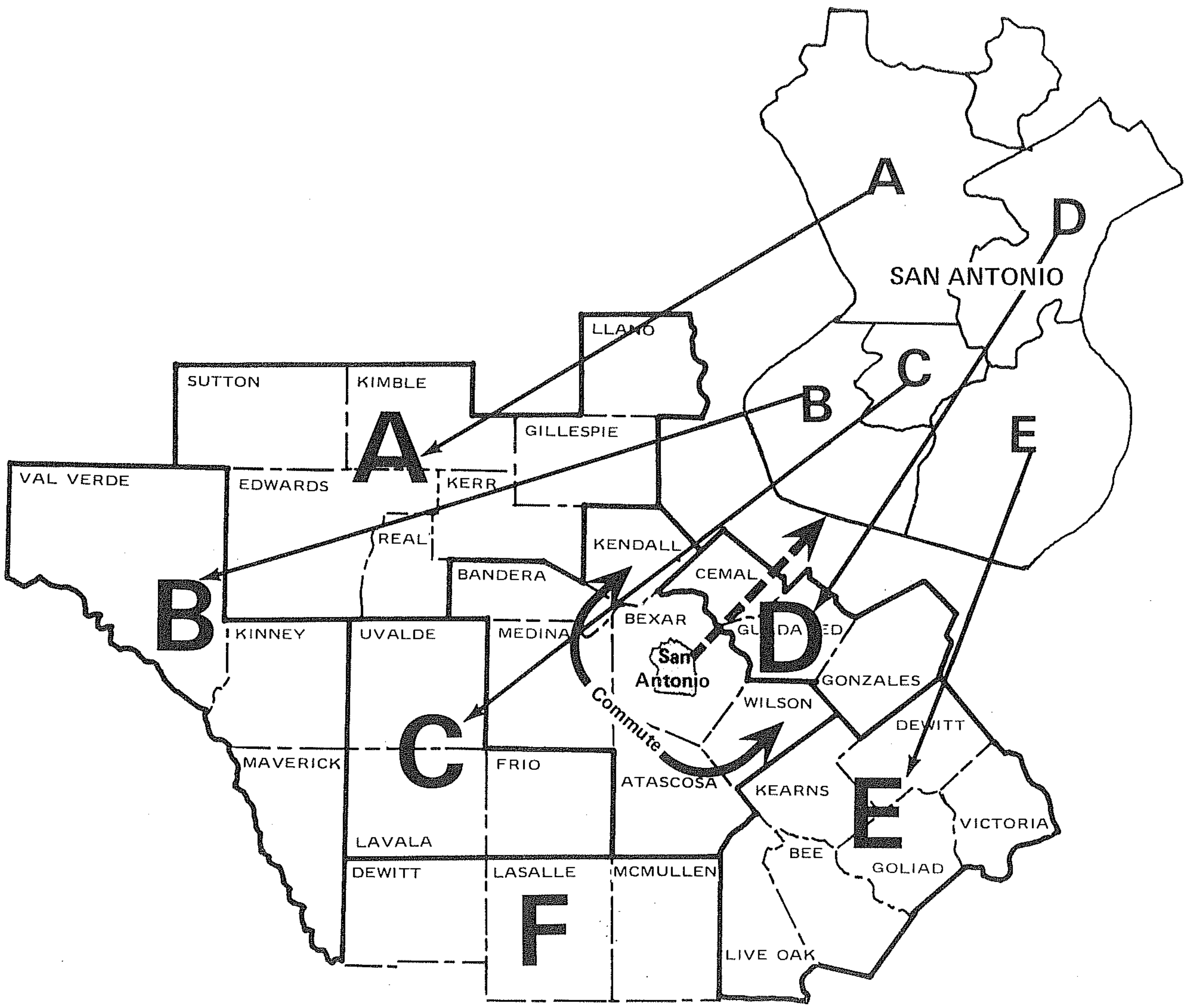
Once a general hosting area is defined for a city from which it is planned to relocate people, more detailed planning is needed to lay the basis for public information materials that could be published in a crisis to tell the citizens where they are to go, what preparations to make, and what to expect when they arrive at their relocation destination. War and disaster experience also indicate that many people make independent decisions to move on their own.

Crisis relocation differs from the "tactical" evacuation of the 1950s in that several days would be available to accomplish the movement, rather than the relatively few hours that were allowed in the earlier planning. Nonetheless, considerable attention must be given to the number and capacities of highways leading from the urbanized area to the host counties. Providing detailed assignments, such as telling residents of a given city block to go to a specific outlying town, would be very difficult and probably unnecessary. But residents of various areas of the city ought to know which routes to take and the host counties served by these routes. It appears more practical to plan for the Police Service in the host counties to direct incoming traffic to final destinations in an orderly manner.

The map shown here illustrates the way the San Antonio, Texas, planners assigned the population in various parts of the city to groups of host counties served by the existing highway net. San Antonio has been the site of one of the first prototype projects for crisis relocation (BRAVO NEOP) planning. One product of this planning has been the development of a set of planning checklists that perform the same function as the ALFA NEOP checklist described in Panel 16.

There appear to be several possible ways to subdivide a city and its suburbs so that citizens can learn where they are to go. One is simply a map, as shown here, with areas sized to reflect the capacities of highway routes and host counties. Since many people have difficulty locating themselves on a map, neighborhood names or zip codes or the first three digits of telephone numbers might be used. A basic objective, of course, is to communicate advice to the public that is easy to follow and that will result, if followed, in an orderly flow from the city to a host jurisdiction of the approximate number of people being planned for accommodation. Many employees and their families may be asked to relocate to specific places if their company or agency must keep in operation or be ready to resume operations quickly. In the San Antonio plan, close-in counties are reserved for organizations whose employees must commute to work in the city.

SAN ANTONIO HOST AREA ASSIGNMENT*



*Prepared by San Antonio Planning Department.

MOVEMENT PLANNING

The assignment plan discussed in the previous panel is the BRAVO equivalent of the in-place CSP described in Panel 5. Once available, it forms the basis for planning of the emergency operations needed to accomplish the movement. Generally, it can be assumed that movement will be by private automobile, supplemented by public transportation for those families without personal vehicles. Support in the host counties will be greatly eased if families are instructed to load the family automobile with at least three days' supply of food, any special medicines, clothing, bedding, and camping gear. Staging areas may be used for loading of buses with people needing transport.

Spontaneous evacuation can be expected during a crisis prior to an officially recommended or directed movement. Since many urban residents may have relatives or vacation homes in the host area, they will be the most likely persons to move spontaneously. It has been estimated that from 10 to 40 percent of the urban population may have a destination in mind for evacuation. Since most families that have a place to go would attempt to go there even in a directed movement, the assignment plan and movement control strategy should accommodate this choice to the maximum extent possible.

The relocation of the population to the hinterland should be anticipated by prior deployment of the emergency services to preassigned locations where they can be most effective. In addition to the manning of traffic control points by the Police Service, most of the Medical Service, Shelter Service, and a substantial part of the Fire Service should be redeployed to the host counties. Shelter RADEF equipment should be moved to the hosting area. Planning for operation of key utilities and services after the people are relocated is discussed in Panel 31.

SUGGESTED MOVEMENT GUIDANCE

Most residents move in family groups by private automobile, with supplies.

Those without transportation board buses at staging areas unless institutionalized; make special arrangements for hospitals and other institutions.

Advise those with relatives or vacation homes or other such facilities to proceed to their own accommodations rather than following the general assignment plan.

Redeploy emergency forces and their equipment to host counties, to staging areas, and to traffic control points as soon as the decision to relocate is made.

Plan to complete organized movement within 48 hours after start, or as soon as possible so that risk area access control and other security measures can be set up properly.

HOSTING ARRANGEMENTS

The BRAVO planning problem for a host county is basically how to provide for a population several times larger than normal for as long as several weeks. The critical problems will usually be housing, feeding, sanitation, and providing fallout shelter for the expanded population. A host county that has realistic plans to deal with these four problems can be considered ready for the BRAVO contingency.

In planning, full initial cooperation on the part of the evacuees should be assumed. Maximum use should be made of schools, churches, and similar facilities for lodging the relocated people. Red Cross experience and the material in Chapter 7 will be useful for planning congregate housing arrangements. In many instances, the number of larger buildings will be insufficient to house the added population. In this event, plans should include using schools and other suitable buildings as registration centers and staging areas, from which most visitors would be taken by local residents, who would have been requested to take a guest family, as occurs in short-term natural disaster evacuations. It is likely that some shifting of people might be required after initial allocation because of local conditions.

Increased deliveries of food to host counties is a problem that must be solved at the State level in conjunction with the major food wholesalers. Normally, foods are shipped into the central city and then distributed by food processors, chain stores, and other distributors, not only within the city but to outlying areas as well. Plans can be made to expand the deliveries to the host counties in lieu of the city. Host county planners need to work out arrangements for intensive use of available retail outlets and mass feeding as necessary.

Sanitation problems such as sewage disposal and provision of water may arise when population has increased. Planners must be able to augment water supplies or ration the available supplies; and must also make arrangements for temporary sanitary waste disposal and solid waste disposal systems for the duration of the relocation period.

The fourth major hosting problem is the provision of fallout shelter. Rural counties are often deficient in shelter for the indigenous population except where residential basements are common. Evacuee labor would be plentiful if plans and tools are available for shelter construction. Construction equipment from the urban area can also be moved in. As shelter is developed during a crisis, RADEF equipment and shelter supplies can be brought in from the cities from which people have been relocated.

BASIC HOSTING PROBLEMS

Housing for Evacuees.

Food Distribution, Feeding, and Sanitation Arrangements.

Water - Sanitation.

Expedient Fallout Shelter.

RESIDUAL OPERATIONS IN THE CITY

It is generally neither feasible nor advisable to completely abandon an urban area. A vacant city would likely experience considerable damage from accidental or natural fires, for one thing. Therefore, a skeleton public safety force is necessary at a minimum. Water service and electric power would also be necessary even though usage would be greatly curtailed.

Certain activities are also needed in the city to support the population in the hinterland. As noted in the previous panel, food distribution centers in the urban area probably must be kept operating. There may be other support activities of a medical or other essential nature as well.

Certain key industrial plants also may be slated for continued operation. As suggested in Chapter 8, Panel 20, it is probably desirable to accelerate production of essential survival items and to move these items out of the city. Some industrial processes, such as oil refining and basic metals, are not readily shut down. Other industrial plants may be critical to the national or regional economy.

Essential workers should be identified in the planning process and they and their families should be assigned nearby relocation areas from which it is feasible to commute to and from the critical work places. Note in Panel 28 that the nearby host counties have been reserved for San Antonio's critical work force.

Essential workers would spend their off-duty hours with their families, presumably near but outside the cities. (Experience shows that it is very difficult to separate key workers from their families, so plans must be flexible enough to respond to this type of problem.) Commuting would need to be on an organized basis—by bus or train, in most cases. The very best all-effects protection at the plant or in nearby structures should be identified for use by the working shift, should ATTACK WARNING be received. If suitable protection is not available, the building of expedient shelters at the work location should be planned.

CATEGORIES OF ESSENTIAL WORKERS

Key Government Officials

Police and Fire Units

Utility Operators

Food Distributor Employees

Other Essential Support Personnel

Manufacturers of Essential Survival Items

Workers in Facilities that Cannot Be
Properly Shut Down

Workers in Defense and Other Industries
of National or Regional Importance

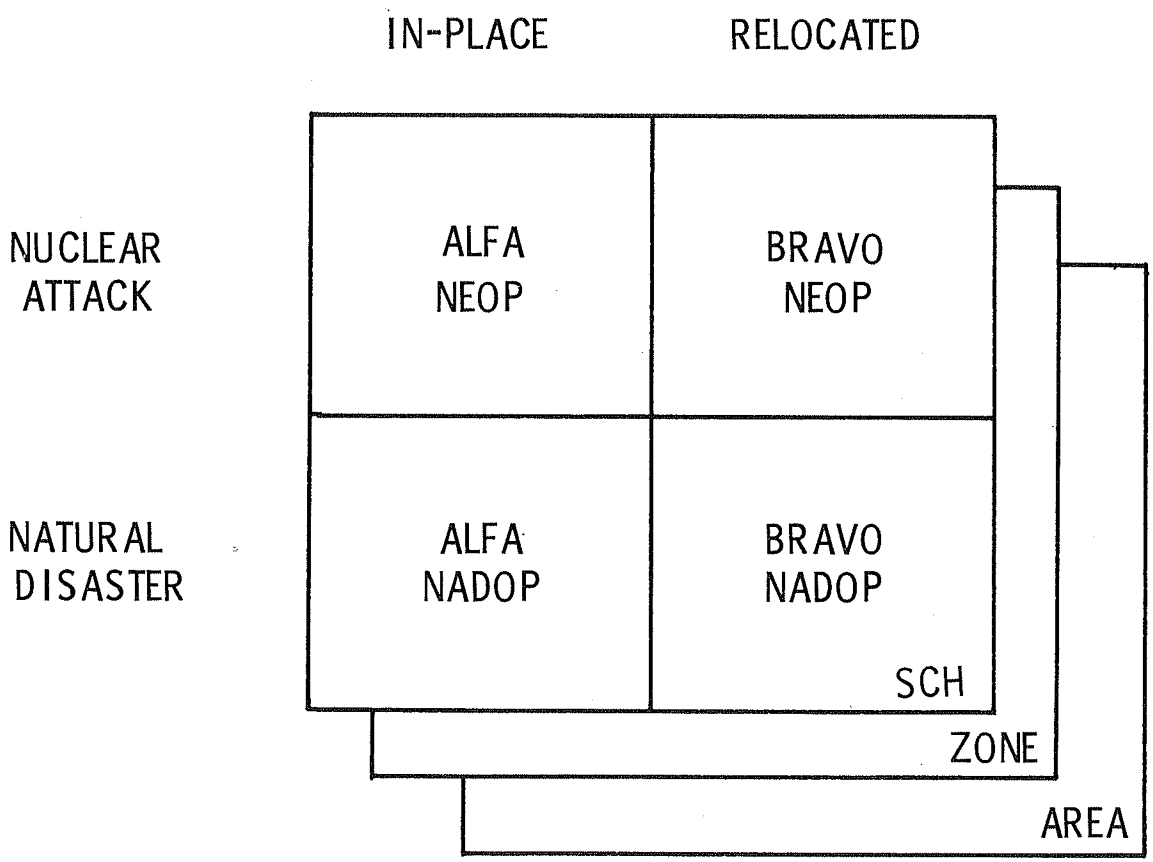
FULL-SPECTRUM CIVIL PREPAREDNESS

Beginning in 1972, the programs of the Defense Civil Preparedness Agency were broadened to cover operational readiness for all likely hazards. The threat to be considered includes peacetime hazards as well as all attack effects in event of nuclear war. Moreover, plans are to include both short-warning contingencies and crisis buildup. The basic lifesaving strategies for peacetime or attack hazards are (a) protection of the people in-place, or (b) leave the threatened area if circumstances permit.

This manual has been written to aid in preparing realistic nuclear emergency operating plans. Checklists, both ALFA NEOP and BRAVO NEOP, are available for local use. The BRAVO NEOP also includes a State-level checklist since key elements of evacuation planning must be accomplished at this level. An area-level version of ALFA NEOP is in preparation, emphasizing mutual aid and State support of local government. Lower echelons, such as Shelter Complex Headquarters and Multi-Purpose Staging Areas are covered in separate documents soon to be available.

The natural disaster planning checklists also have been developed and are undergoing field testing. They closely parallel the nuclear attack planning guides so that familiarity with one makes for familiarity with the other. Orderly development of plans and training based on these guides will lead to "full-spectrum" operational readiness for all emergencies that might arise. It is particularly important that planners think through their total problem, not merely the first hours or days of disaster but on through the days or weeks of coping with continuing problems, with or without outside help.

A COMPLETE SET OF PLANNING GUIDES



SUGGESTED ADDITIONAL READING

At the end of each chapter, we have listed additional reading for the planner who wishes to steep himself "in the character of the problem you may one day be called upon to solve." Many other information sources are cited in the various panels of the chapters. Some of these sources are readily available official publications. Most, however, are reports of research on a wide variety of topics. These are available for purchase from the National Technical Information Service if the citation includes the six-digit "AD number" or "CONF number" by which it can be identified. Hard copies of recent publications generally cost $3.00. Microfiche copies cost 95 cents and are to be preferred if a microfiche reader is available. Write the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia 22151, for information on how to order any of the reports cited.

"Grin and Bear It" by George Lichty
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"According to all my reports, men, the mock Atomic bomb test was a success . . . now we know how to cope with mock Atomic bombs . . ."

PANEL 33