THE CHARACTERISTICS AND EFFECTS

OF

NUCLEAR WEAPONS

Introduction

1. In the background notes on war emergency planning, it has been postulated that the greatest single threat to our survival is the likelihood of a nuclear strike against this country. However, the probability of a two to three week period of conventional attacks during the initial phase of a major war cannot be ruled out; and some schools of thought believe that even chemical and/or biological warfare may pose a threat to the civilian population.

2. Despite the significant increase in the destructive power of conventional weapons, the sophistication and extraordinary accuracy (± 30 feet) of modern weapons aiming systems will automatically result in a considerable reduction in the number of human casualties, unless the weapons are specifically deployed against major centres of population. In fact, the official estimate is 30,000 casualties over the whole country during a three week period of conventional attack.

3. Biological warfare has never been waged; and it is argued that, even if conventions and treaties are ignored, the tactical, technical and political implications are hazardous enough to prevent the use of germ warfare. On the other hand, chemical weapons do pose a threat, in that they have been used in war, and are used in peace against humans to quell riots etc. However, there is strong evidence to suggest that these weapons lend themselves more readily for tactical rather then strategic use; and our armed forces are therefore afforded maximum protection against their use.

4. In light of these arguments, and other relevant intelligence, it is widely accepted that the major threat to the survival of our civilian population is posed by the deployment of nuclear weapons against targets in this country. Clearly, it is of the utmost importance that our people understand the basic characteristics and effects of these weapons, because such knowledge will greatly facilitate the implementation of recommended protective measures.

CHARACTERISTICS OF NUCLEAR WEAPONS

The Basic Weapon

5. Conventional weapons contain chemical high explosive which, when detonated, release energy in a familiar form - an explosion - and cause damage by blast and, to a lesser extent - heat. By contrast, nuclear weapons produce blast, heat, and radiation; the first two effects are significantly greater than in the case of conventional weapons, and the third is very harmful to all life over very large areas and protracted periods of time.

6. A nuclear weapon uses either the fission or fusion of certain chemical substances called elements. A fission bomb is often called the Atom Bomb, and this is the type which was used in World War II against the Japanese cities of Hiroshima and Nagasaki. The explosive energy or yield of a fission bomb is in the kiloton (thousand ton) range, and this type of bomb represents the bulk of nuclear weapons for tactical (or battlefield) use. A fusion or Hydrogen Bomb - sometimes referred to as a Thermonuclear weapon - has not yet been used inwar, but has been successfully tested and manufactured by a number of nations. Thermonuclear weapons produce explosive yields in the megaton (million ton) range, and are stockpiled for deployment mainly against strategic targets. During the last decade, improved technology has allowed the production of lower yield thermonuclear weapons, which are used primarily for the multiple warhead systems developed by both the U.S.A. and Russia.

Delivery Systems

7. Nuclear weapons can be despatched against selected strategic or tactical targets by several means, varying from the land based Intercontinental Ballistic Missiles (ICBMS) and Submarine Launched Ballistic Missiles (SLBMS) to the latest American device known as the Cruise Missile or the Russian SS 20. These major weapon systems are supported by free fall bombs, artillery shells, torpedoes, depth charges, land mines and numerous man carried or vehicle launched projectiles, all of which have been the facility for carrying a small nuclear device or warhead.

Distribution of Energy Released

8. There are three main types of "burst", categorised according to the height at which the weapon is detonated. A nuclear explosion at 2000 feet or above is termed an "air burst"; below this height and down to ground level, it is known as a "ground burst". There are also "sub surface" (below ground) and "under water" bursts. The point of detonation on the earth's surface; immediately below or above the point of detonation, is known as 'Ground Zero' (G.Z.).

9. In general terms, and depending on the type of burst, approximately 85 per cent of the energy released initially is in the form of intense heat; but a large portion of this heat, amounting to almost 50 per cent of the total energy is transformed immediately into blast. Five per cent of the remaining energy is released as "Initial Radiation"; and the final 10 per cent as "Residual Radiation" in the fallout dust in the immediate vicinity of the G.Z. and, eventually, in other areas downwind of the explosion.

Development of a Nuclear Explosion

10. The characteristic development of a nuclear explosion depends to a large extent on the height of burst; but, in almost every case, a blinding light flash is followed by a fireball which occurs simultaneously with the blast or shock wave, the development of a mushroom cloud, and finally radiation.

11. The Light Flash. A brilliant bluish white flash of light occurs at the moment of detonation. The duration of the flash varies from about one tenth of a second to several seconds depending mainly on the yield of the weapon.

12. <u>The Fireball</u>. The enormous pressure and tremendous heat (10 million degrees centigrade) generated at detonation causes the air to expand into an intensely hot, glowing sphere called a fireball. During its development, the fireball radiates about 35 per cent of the bomb's energy in the form of heat. This heat travels outwards at the speed of light (186,000 miles per second) but has no penetrative powers; and results in a corresponding decrease in the pressure and temperature of the fireball.

13. <u>The Blast or Shock Wave</u>. In much the same way that thunder follows lightning, the blast pressure wave travels at the speed of sound, and leaves a vacuum which is immediately filled by extremely high winds in excess of 600 miles per hour. In the case of the air burst, the blast wave is reflected from the earth's surface and reinforces itself, while in the case of the underwater shock wave, even more tremendous pressures are set up.

14. <u>The Mushroom Cloud</u>. The air which rushes in to fill the vacuum caused by movement of the shock wave is sucked up in the wake of the fireball at about 250 mph. If the fireball is near to the ground, or touches it, vast quantities of dirt, dust and debris are swept up into this rising chimney of hot gases, and eventually produce the familiar mushroom shaped cloud.

15. <u>Radiation</u>. Nuclear radiations are continuously emitted for long periods after the detonation of such a weapon; and, for definitive purposes a division between "Initial" and "Residual" radiation has been arbitrarily made at approximately one minute after radiation.

a.. <u>Initial Radiation</u>. The most significant radiation is in the form of neutrons and gamma rays which are emitted instantaneously on detonation, and can travel rapidly (100,000 - 186,000 mps) and great distances through the atmosphere. Both types of radiation can penetrate considerable thicknesses of water, soil, and other materials; but neutrons are stopped more rapidly and easily than gamma rays. However, it is worth noting that neutrons which are slowed down and then captured by particles in the atmosphere produce additional areas of significant radioactivity. More importantly, if the neutrons are captured by particles containing large elements of nitrogen, they produce intense radioactivity and very penetrating gamma radiation which increases the range of the initial gamma flash. Other rays (Alpha and Beta) are emitted during the initial radiation phase, but travel only a few inches and possess little or no penetrative powers.

b. <u>Residual Radiation</u>. This is mainly the result of the massive flood of neutrons, released at detonation, and which subsequently bombard the material vacuumed up by the rising fireball. After a process of vaporisation of the mixture, the vaporised mass condenses back into solid particles of intensely radioactive matter again, resembling snowflakes, ashes, fine sand or powder. All of this radioactive dust is called fallout, some of which descends almost immediately to earth in the vicinity of GZ.

The remainder is carried by the prevailing winds to great heights and distances, is subjected to weather and topography, and falls to earth days, weeks or even months later. Many different varieties of radioactive elements (radioisotopes or radionuclides) have been identified in fallout dust, all of which pose serious and differing problems to health.

Radioactive Decay Rates

16. All radioactive matter disintegrates and decays into stable non radioactive forms. The rate of decay is rapid at first, and then each isotope settles down to its own almost constant rate of decay, which cannot be influenced by heat, pressure or chemical reaction. A simple and convenient rule of thumb for measuring the general rate of decay for most purposes is known as the "seven tenths rule". This rule states that the intensity of radiation falls by a factor of 10 as the time lengthens by a factor of 7. For example, if the emission is 100 (roentgens) one hour after detonation, it will be 10 (roentgens) after 7 hours, and 1 (roentgen) after 49 hours, or approximately 2 days.

Effects of Nuclear Weapons

General

17. A nuclear explosion will seriously affect man and his environment in both the short and long term; and the characteristic development of the explosion will produce effects of varying degrees depending mainly on the explosive yield of the weapon, the height and type of burst (air, ground etc) topography, the prevailing wind and weather at the time and subsequently etc. A summary of the various immediate effects from a 2 Megaton ground burst is shown at Annex 'A'.

18. For convenience, the general effects of an ideal nuclear explosion are dealt with in the following order of importance

a. Biological Effects of Nuclear Radiation
b. Effects of the Light and Heat Flash
c. Air Blast Effects
d. Effects on Food, Water, Crops and Livestock
e. Effects on Communications

Biological Effects of Nuclear Radiation

19. The human body is a highly complex organisation of cells and delicate controlling mechanisms based on physical or chemical processes. In simple terms, nuclear radiation releases electrical charges which interfere with the vital functions of these cells and cause many secondary effects. The unit of radiation exposure is the roentgen, and the exposure dose rate at a given moment is known as the RAD (roentgen absorbed dose).

20. All living creatures possess different sensitivities to radiation; and, indeed, are all subject to small amounts of radiation in the environment in which we live. On average, everyone receives about .1 RAD per year, or a lifetime dose of about 7-RADS. However, although small radiation doses over a period of time is a part of the process of living, large doses given all at once will undoubtedly harm the body or even kill.

21. During and after a nuclear explosion, enormous amounts of radiation - principally in the form of gamma rays and neutrons - are emitted; and may enter the body by penetration, ingestion, inhalation or absorption through the skin. Significant increases in the radiation dosage up to 150 RADS can produce a two stage response. During the first stage, the average creature (human or animal) develops a rapid tolerance to radiation, but may display some symptoms of radiation sickness, viz., fatigue, nausea, and even vomiting, diarrhoea, and the discharge of blood. If no further radiation is absorbed, the rate of recovery in human beings during the second or slow response phase is about 10 roentgens per day. Above 150 RADS, the symptoms of radiation sickness are initially more severe, even to the point of death, which occurs 50 per cent of the time if the body receives 400 RADS or more. However, in certain cases, the cumulative effect of small doses over a period of time can cause serious biological damage resulting in anaemia, cancer, infertility and sterility, genetic mutation, decreased resistance to disease, and a shorter life span. Annex B illustrates typical clinical effects arising from varying doses of gamma radiation.

22. The lethal exposure dose rate which occurs around 400 RADS is called the LD50 dose level, and if these 50 per cent deaths occur within say 30 days, the factor is written as LD 50/30. Smaller or larger doses or periods of time before death follow a similar procedure; for example LD25/20 means that 25 per cent deaths occurred within 20 days.

<u>The Light and Heat Flash</u>

23. The brilliant white flash at the moment of detonation can cause temporary or, very occasionally, permanent blindness at distances up to several miles. The degree of injury and recovery depends on the explosive yield and altitude of explosion, time of day, visibility, and degree of eye shielding and blink reflex.

24. The intense heat generated vaporises most materials in the immediate vicinity of the explosion, and melts or ignites other materials several miles away. It can also inflict first, second and third degree burns on exposed skin, injure livestock, and "cook" plant life.

<u>The Air Blast</u>

25. The enormous pressures and extraordinarily high wind speeds leave a trail of wrecked buildings, masts, chimneys, power lines and broken bodies as a result of both implosion and explosion in structures and human tissue. In this context, it is interesting to note that the human body is surprisingly resistant to blast pressure, and the more likely causes of injury or death would be due to being hurled with great force against a building, or struck by potentially lethal projectiles.

26. Suck projectiles would include vehicles crushed by the initial blast and blown through the air by the "second phase" wind. Similarly, the collapse of structures would seriously damage public utility installations, distribution points and control units as well as the more delicate equipment in communications centres; and might even start secondary fires from burst gas mains. Finally, the problem of massive debris everywhere would severely restrict movement, including rescue, even without the hazard of radiation.

<u>Environmental Hazards</u>

27. Apart from the initial effects of heat and blast on the environment, additional hazards to humans might arise from the consuption of products obtained from cattle, crops, prepared/ stored food, and water. The extent of these hazards would be

governed by the level of radioactive fallout in the area, the particle sizes and degree of solubility of radioactive nuclides etc. However, in all cases, there would be some risk to health through ingestion of radioactive particles.

28. Food. After a nuclear attack, all sources of food will be of vital importance. Canned and even packaged foods are unlikely to be affected unless damaged by blast or heat, although packaged foods should be regarded with great suspicion unless in areas of minimal fallout. Raw meat, vegetables and fruit should be safe to eat providing that they are thoroughly washed, peeled, and thoroughly cooked as appropriate. The same is true of eggs, even if taken from hens fed on contaminated feedstock; but milk and milk products can prove dangerous. However, perhaps the significant risk to health may be due to eating perishable foodstuffs from refrigerators etc., which have been spoilt because of the disruption of electricity supplies.

29. Water. Gamma radiation does not affect the purity or impair the potability of drinking water. However, although underground sources of water or covered containers in the home may be largely free from contamination, water stored in open reservoirs is likely to be undrinkable initially because of the contaminated fallout particles on the surface. Many of these particles will eventually sink to the bottom or be trapped by mud and vegetation, and there should be a natural and rapid decontamination after about 14 days post attack.

30. Crops. Radioactive fallout will contaminate large areas of ripe or near ripe crops and pasture. This should be a short term problem, being at maximum immediately after deposition, and decreasing with time, wind and rain. Ultimately, normal processing of these foods would eliminate most of the risk. However, growing crops would be affected by environmental gamma and beta radiation on and around the crops. The effect on the crop would vary from type to type and depend on the stage in the growth cycle of each type. (Note: Beta radiation is most dangerous if ingested, as it mimics many of the chemicals the body uses; and the body readily accepts and stores these radioactive substances).

31. Livestock. Fallout particles are retained on the coats of grazing animals; and inhaled from or ingested when grazing. The animals then suffer the combined effects of external and internal beta radiation as well as environmental gamma radiation; causing among other things, stomach ulceration and, ultimately, starvation. However, few isotopes accumulate in the flesh, and animals exposed to radiation can be slaughtered before death occurs and eaten if certain simple precautions are taken.

Communications

32. When a nuclear device is exploded above the earth's atmosphere, it causes very large magnetic forces which produce high electric currents in any electrical conductors which are aligned with this field; hence the name electromagnetic pulse (EMP). A 1 MT burst at 100,000 feet can cause damage to radio, telephone and electrical equipment in excess of 400 miles from GZ. In essence, the pulse will be picked up by any electrical wiring system, aerial, telephone lines, or piping (gas, water etc.); fuses will blow, equipment burn out, and lights will fail. However, transistor radios with an internal aerial and batteries are unlikely to be affected.

CONCLUSION

33. Lack of knowledge and fear of the unknown have prompted many of the pessimistic statements we hear and read about nuclear war today; for example "Life After a War with No Survivors". This background paper on the Characteristics and Effects of Nuclear Weapons is a sincere attempt to provide potential Community Advisers with basic knowledge which they can build upon. Clearly, a nuclear explosion does not mean the end of the world; and, hopefully, you are more ready to believe that there will be survivors. More importantly, this knowledge will confirm that many more can survive if comparatively simple "protect and survive" precautions are taken in good time.