CHRONOLOGICAL DEVELOPMENT OF SHALLOW UNDERWATER BURST

100 KILOTON SHALLOW UNDERWATER BURST--2 SECONDS

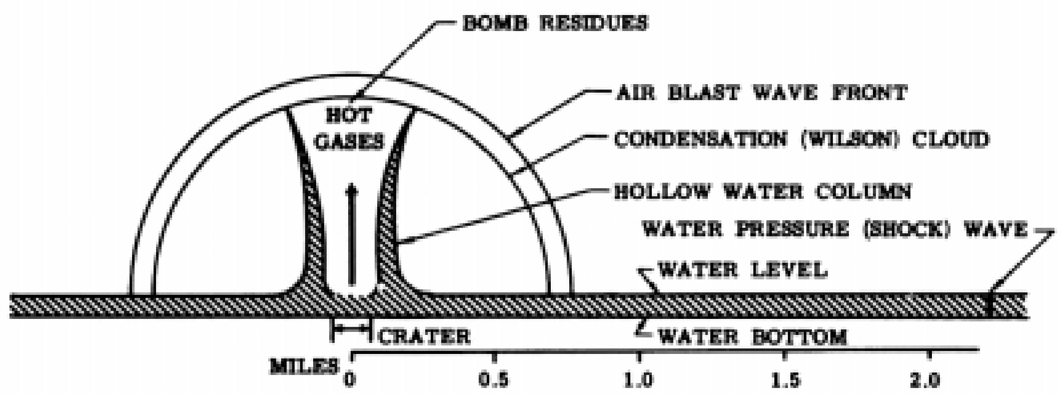

Figure 2.80a. Chronological development of a 100-kiloton shallow underwater burst: 2 seconds after detonation.

When a nuclear weapon is exploded under the surface of water, a bubble of intensely hot gases and steam is formed which will burst through the surface if the detonation occurs at a shallow depth. As a result, a hollow column of water and spray is shot upward, reaching a height of over 5,000 feet in 2 seconds after a 100-kiloton explosion. The gaseous weapon residues are then vented through the hollow central portion of the water column.

The shock (or pressure) wave produced in the water by the explosion travels outward at high speed, so that at the end of 2 seconds it is more than 2 miles from surface zero. The expansion of the hot gas and steam bubble also results in the formation of a shock (or blast) wave in the air, but this moves less rapidly than the shock wave in water, so that the front is some 0.8 mile from surface zero.

Soon after the air blast wave has passed, a dome-shaped cloud of condensed water droplets, called the condensation cloud, may form for a second or two. Although this phenomenon is impressive, it has apparently no significance as far as nuclear attack or defense is concerned.

For an underwater burst at moderate (or great) depth, essentially all of the thermal radiation and much of the initial nuclear radiation is absorbed by the water.

100 KILOTON SHALLOW UNDERWATER BURST--12 SECONDS

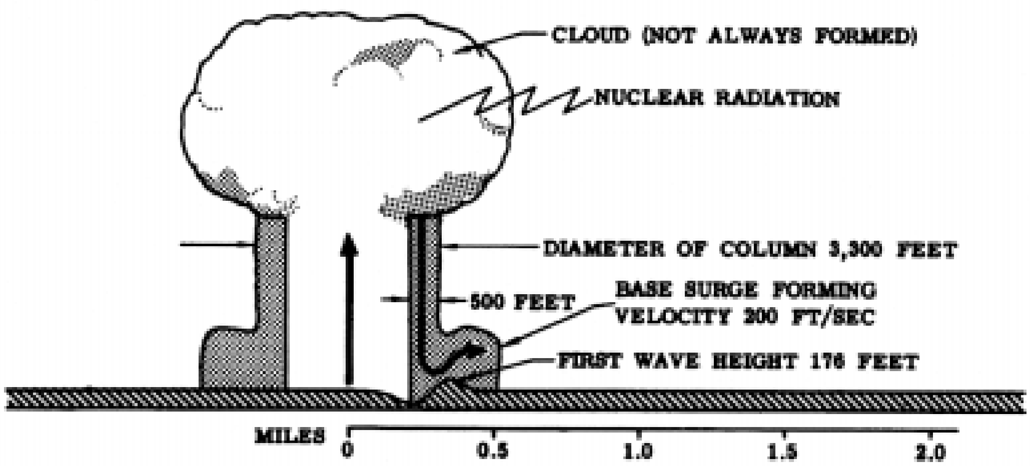

Figure 2.80b. Chronological development of a 100-kiloton shallow underwater burst: 12 seconds after detonation.

At 12 seconds after the 100-kiloton explosion, the diameter of the water column is about 3,300 feet, and its walls are some 500 feet. thick. The weapon residues venting through the hollow central portion condense and spread out to form the cauliflower-shaped cloud, partly obscuring the top of the column. The cloud is highly radioactive, due to the presence of fission products, and hence it emits nuclear radiations. Because of the height of the cloud these radiations are a minor hazard to persons near the surface of the water.

At 10 to 12 seconds after a shallow underwater explosion, the water falling back from the column reaches the surface and produces around the base of the column a ring of highly radioactive mist, called the base surge. This ring-shaped cloud moves outward, parallel to the water surface, at high speed, initially 200 feet per second (135 miles per hour). For underwater bursts at certain depths, the radioactive cloud may not be formed, although there will generally be a base surge.

The disturbance due to the underwater explosion causes large water waves to form on the surface. At 12 seconds after a 100-kiloton explosion, the first of these is about 1,800 feet (0.34 mile) from surface zero, and its height, from crest to trough, is 176 feet.

100 KILOTON SHALLOW UNDERWATER BURST--20 SECONDS

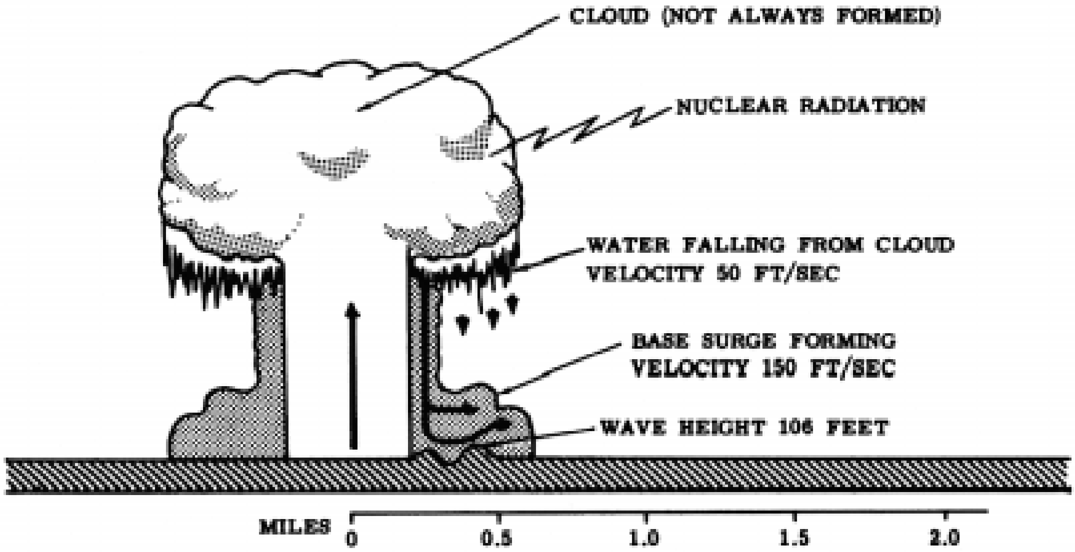

Figure 2.80c. Chronological development of a 100-kiloton shallow underwater burst: 20 seconds after detonation.

As the water and spray forming the column continue to descend, the base surge cloud develops, billowing upward and moving outward across the surface of the water. At 20 seconds after the 100-kiloton explosion the height of the base surge is about 1,000 feet and its front is nearly 1/2 mile from surface zero. It is then progressing outward at a rate of approximately 150 feet per second (100 miles per hour).

At about this time, large quantities of water, sometimes referred to as the massive water fallout, begin to descend from the radioactive cloud, if it is formed. The initial rate of fall is about 50 feet per second. The diameter of the column has now decreased to 2,000 feet.

By the end of 20 seconds, the first water wave has reached about 2,000 feet (0.38 mile) from surface zero and its height is roughly 106 feet.

100 KILOTON SHALLOW UNDERWATER BURST--1 MINUTE

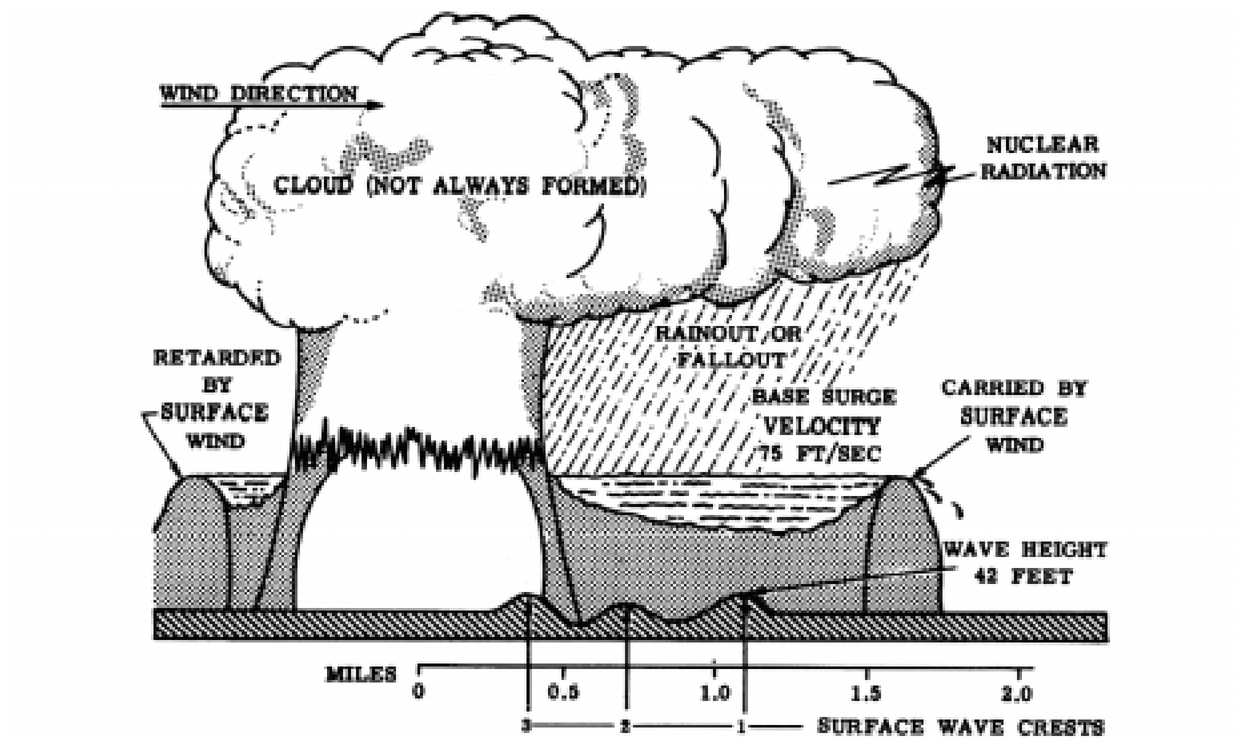

Figure 2.80d. Chronological development of a 100-kiloton shallow underwater burst: 1 minute after detonation.

At 1 minute after the underwater burst, the water falling from the radioactive cloud reaches the surface, forming a region of primary cloud fallout. There is consequently a continuous ring of water and spray between the cloud, if one has formed, and the surface of the water.

At about this time, the base surge has become detached from the bottom of the column, so that its ring-like character is apparent. The height of the base surge cloud is now 1,300 feet and its front, moving outward at some 75 feet per second (50 miles per hour), is about 1.2 miles from surface zero. Because of the radioactivity present in the base surge, the latter represents a hazard to personnel.

Several water waves have now developed, the first, with a height of 42 feet, being approximately 1 mile from surface zero.

100 KILOTON SHALLOW UNDERWATER BURST--2.5 MINUTES

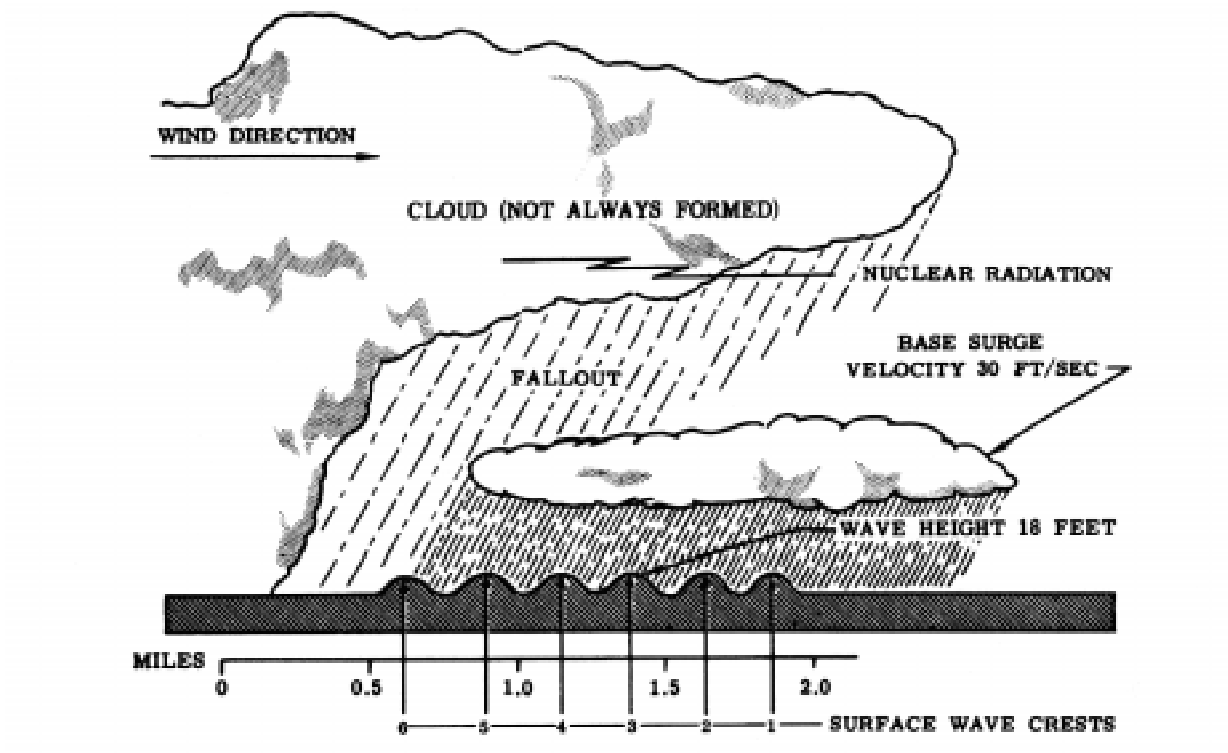

Figure 2.80e. Chronological development of a 100-kiloton shallow underwater burst: 2.5 minutes after detonation.

By 2 1/2 minutes after the 100-kiloton underwater explosion, the front of the base surge is nearly 2 miles from ground zero and its height is roughly 2,000 feet. The effective spread of the visible base surge cloud at 4 minutes is approximately 2 1/2 miles from surface zero, i.e., 5 miles across. The base surge now appears to be rising from the surface of the water. This effect is attributed to several factors, including an actual increase in altitude, thinning of the cloud by engulfing air, and raining out of the larger drops of water. Due to natural radioactive decay of the fission products, to rainout, and to dilution of the mist by air, the intensity of the nuclear radiation from the base surge at 2 1/2 minutes after the explosion is only one-twentieth of that at 1 minute.

The descent of water and spray from the column and from condensation in the radioactive cloud results in the formation of a continuous mass of mist or cloud down to the surface of the water. Ultimately, this merges with the base surge, which has spread and increased in height, and also with the natural clouds of the sky, to be finally dispersed by the wind.

After 4 or 5 minutes, the visible base surge will begin to disappear as the water droplets evaporate. However, radioactive particles will still be present and will spread out in the form of the invisible base surge.

From *The Effects of Nuclear Weapons*, Samuel Glasstone, ed., USAEC, Washington, DC, April 1962; Revised Edition reprinted February 1964.