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THE ARCHAEOLOGY OF SCIENTIFIC EXPERIMENTS AT A NUCLEAR TESTING GROUND

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A hallmark of the twentieth century is the exponential growth of technological innovation. This rapid introduction of new technologies is unprecedented in history as are the accompanying cultural changes. With two world wars and a cold war, there has been international competition to develop the innovative weaponry and support technology to achieve military superiority. The most significant twentieth century invention has been the atomic bomb. Secretly developed by the United States, the world did not become aware of this technological achievement until the atomic bombs were dropped on Hiroshima and Nagasaki in August of 1945, ending World War II. The use of this weapon alerted the world to its existence and its devastating potential destructive power, changing world politics and the nature of international confrontations.

At the end of World War II, this new weapon had been detonated on only three occasions, during the Trinity test in New Mexico and twice in Japan. Many scientific and military questions remained to be answered about atomic detonations. To address these issues, the United States conducted tests in the Pacific Ocean following World War II. Logistically, for the United States, these tests were difficult and security issues were complex (Titus 1986:55). Slowly momentum built toward establishing a continental

nuclear testing location in the United States. This was a controversial proposal but the combination of the initiation of the Korean War in 1950, the detonation of a nuclear test by the Soviet Union, and an increasing concern regarding national defense, swayed political sentiment to go forward and identify potential locations in the United States (Ball 1986). The chosen continental testing location was about 65 miles northwest of Las Vegas, Nevada, in a sparsely populated region. This land was part of the Las Vegas-Tonopah Bombing and Gunnery Range, an Air Force training locale. On December 21, 1950, the Atomic Energy Commission established the Nevada Test Site (originally called the Nevada Proving Ground). The following month, on January 27, 1951, the Operation Ranger series of atmospheric tests began with an event called Able (Beck et al. 1996:13-17).

Overview of Nuclear Testing at the Nevada Test Site

During the Cold War, the primary mission of the Nevada Test Site was to conduct scientific experiments concerning nuclear detonations. Initially, the Nevada Test Site encompassed 680 square miles (1,761 square kilometers). However, over the years it grew to 1,350 square miles (3,496 square kilometers) through annexation of adjacent military lands. The terrain at the Nevada Test Site ranges from dry lake beds in a desert environment at an elevation of 3,500 feet (1,067 meters) to mountains and mesas more than 7,500 feet (2,286 meters) in height. Between January 27, 1951 and October 2, 1992, 904 nuclear tests were conducted at the Nevada Test Site, 880 by the United States and 24 joint tests between the United States and the United Kingdom. Of these, 100 were atmospheric tests and 804 were underground tests, including the 24 joint tests (Department of Energy 1994). Atmospheric tests were conducted on Frenchman Flat and Yucca Flat on the east side of the Nevada Test Site. Underground testing primarily occurred on Yucca Flat and in a series of high mesas at the north end of the facility.

Nuclear testing was not continual over the 41 years. No tests were conducted in 1954 (Friesen 1995:40- 42) and in 1958 the United States ceased testing on October 31 with the Soviet Union following this lead on November 3. These independent, self-imposed moratoriums were broken by the Soviet Union on September 1, 1961, and the United States resumed testing on September 15, 1961 (Ogle 1985). Atmospheric tests were conducted until the United States, the United Kingdom and the Soviet Union signed the Limited Test Ban Treaty on August 5, 1963, an agreement prohibiting these countries from testing nuclear weapons in the atmosphere, in outer space, and underwater (Friesen 1995:6). Subsequently, underground testing was continued by all parties. On October 2, 1992, nuclear testing ceased at the Nevada Test Site when the United States declared a moratorium.

The nuclear testing era at the Nevada Test Site was a primary component of the Cold War, a world political and military climate when no battles occurred between the United States, its allies, and the Soviet Union. But there was a constant onslaught of threatening postures, coupled with worldwide fear of a nuclear war. Weapon capabilities and stockpiles were a primary concern with each country's emphasis on developing the best and most effective nuclear weapons.

Nuclear Testing Materiel Remains

The nuclear testing remains at the Nevada Test Site form a unique class of historic buildings, structures, objects, artifacts and artificial landforms that are confined to only a few locations in the world. These remains can be assigned to three broad categories based on their association with: 1) atmospheric and near surface underground tests, 2) nonexplosive experiments related to radiation effects, and 3) contained underground tests. At first glance, there is no evidence of massive destruction and disturbance to the landscape at the Nevada Test Site. Instead, the land has the appearance of the desert and mountains outside the facility. Closer examination, however, reveals unusual objects, structures, buildings, landforms and craters. Even though the events that have taken place at the Nevada Test Site are very recent, the materiel remains already are in a fragmentary state due to the nature of the work. Besides the effects of the detonations, atmospheric testing locales often were cleared of testing remains and the location was reused again at a later date. A different mode of operation was employed with underground testing. Support structures no longer were destroyed or contaminated by the test. So portable facilities were designed that could be transferred from one test location to another.

During the era of atmospheric and near surface tests, the buildings, structures and objects were built to assist with the implementation of the tests, to record the scientific data, to test the effects of the detonations, and to visually observe and record the test. In addition, the shallow underground tests produced artificial landforms on the landscape. Film footage shows imported trees, buildings and objects as they were destroyed by the shock wave. Yet, metal, single pole towers still stand that held recording equipment and other instrumentation and probably served other purposes. In some places, four metal stanchions embedded in cement form a large square pattern, marking the ground zero of an atmospheric detonation. Attached to these stanchions were wires that stabilised a tower to which a balloon, buoying a nuclear device, was tethered until detonation. Some structures were built to house and protect equipment designed to record data from the tests. There are underground bunkers scattered across the land, some copper-lined, that still have the original wiring and pipes. Aboveground are an electromagnetic pulse tower, a ship's gun turret with its original base set below the surface. However, the gun has been reconfigured to detect and record blast information. Small rectangular concrete block buildings on the flats and on the mesas originally contained and protected scientific equipment. Small metal and wood containers scattered here and there may have been used for a similar purpose.

Experiments were conducted to study the effects of atmospheric tests on the terrain, vegetation, animals, buildings, structures and objects. Materiel remains pertaining to these aspects of testing research fall into the latter four categories. Boxes built of wire and wood that held animals, such as pigs, dogs, cattle, and rabbits, can be found at a few locations reflecting research regarding the effects of radiation, such as on skin and eyes. A variety of structures were built to test the durability of materiels and building types. In Frenchman Flat, there are domes constructed from aluminum and reinforced concrete that covered circular subterranean structures. The aluminum domes did not disintegrate but

were crumpled by the tests. The concrete domes are either intact or partially destroyed on the side facing the blasts. A segment of a Bailey Bridge with its beams twisted stands above the terrain. The cement and rebar casing on the outside of a Mosler bank vault is damaged but the vault itself is intact. Leading to an underground cement encased parking garage is a cement ramp. The concrete skeleton of a mock motel and a schoolhouse, a rectangular brick building, half-buried cement Quonset hut-shaped buildings and various large pieces of constructed metal objects also are dispersed across the landscape.

In some cases, identical structures were built in progressively increasing distances from a ground zero to measure the effects of the strength of the blast as it moved across the landscape. These types of studies told the scientists which materiels could survive and at what distance. A building type called the glass house falls into this category. The glass houses are two single-story wood-framed structures with various types of sheet glass framed into the sides of the buildings, the interior of the glass covered by different styles and types of window shades. As expected, the glass house furthest away from the test locations is more intact than the one closest to the ground zero.

On Yucca Flat are other examples of research on distance and effects indicating that a wide range of building materiels was studied. Placed in a line close together are slanted boards secured to posts, each one covered by a different type of roofing materiel. Five hundred yards (457 meters) further from ground zero is another line of these objects, called roof testers.

Complete towns, such as Survival Town and Doom Town, were constructed as part of civil defense research and

> included industrial buildings and shelters, electrical power system, communication equipment, a radio broadcasting station, trailer homes, fire equipment, cars, and food supplies placed at varying distances from ground zero . . . Only (two) two-story houses and the frames of a few ranch-style homes survived (Johnson and Beck 1995:46).

In response to military commanders concerns regarding the ability of troops to perform their duties in a nuclear battlefield situation, Camp Desert Rock was established near the entrance to the Nevada Test Site to train troops in offensive and defensive nuclear combat conditions. Army troops participated in atmospheric tests between 1951 and 1957 (Edwards 1997). None of the tanks or armored personnel carriers used by the troops have been found at the Nevada Test Site. However, some of the trenches that were built to shield troops from the atmospheric blasts are visible on the terrain.

Other data from the tests was recorded on film and photographs. Still standing is the original photographic station at a complex called the Control Point. This restricted access facility was the central location for monitoring the atmospheric and underground tests and was the place where the countdown to detonation was conducted. Situated in the saddle between two valleys, the Control Point had a commanding view of atmospheric tests in Frenchman and Yucca Flats. Remote camera and film stations near ground zero existed but have yet to be identified in the field. Other films and photographs were taken

at two places where military and civilian test observers, such as journalists, could safely watch the detonations. Old sagging wooden benches in orderly lines still sit in place overlooking Frenchman Flat. The other location is known as News Nob and is across from the Control Point, facing toward Yucca Flat. In addition to rows of benches, there are a picnic table and an antiquated sign explaining the location's history.

During the atmospheric testing era, nuclear devices were placed at a shallow depth so that the explosion would break through the surface. A series of these experiments was conducted under the Plowshare Program. This program was designed to develop peaceful applications for nuclear energy, e.g., its use in large earth moving projects. The largest of these tests was a 1982 experiment called Sedan (Matthews 1998). The force of the explosion moved approximately 12 million tons of soil, creating a crater 320 feet (97 meters) deep and 1,280 feet (390 meters) in diameter. Other similar tests were smaller in size and altered the land to a lesser degree.

On Yucca Flat, there were two major nonexplosive experiments pertaining to the effects of radiation. Operation BREN (Bare Reactor Experiment, Nevada) was conducted to determine the shielding characteristics of Japanese-style houses (Johnson et al. 1997:22). In 1962, this complex of structures, simulating typical Japanese dwellings, was constructed in the desert 2,250 feet from a tower that had a hoist car containing an open nuclear reactor. This tower, known as BREN tower is 1,527 feet tall and was the tallest government tower in the United States when it was built. The experiment was designed to determine the radiation doses received by the survivors of the atomic bombings of Japan in order to aid with their health care. The Japanese houses now are wood frame skeletons with only two left standing. BREN Tower was moved to another location on the Nevada Test Site in 1966.

At the north end of Yucca Flat, a 36-acre (14 hectares) experimental farm was built to study the effects of food exposed to radiation on animals, particularly cows. The farm contained a well, a reservoir, open paddocks, stalls, a milking barn and laboratory building. These studies yielded no evidence of excessive radiation levels in the animals consuming radiation foodstuffs. Used for 15 years and abandoned in 1981, the farm was dismantled in 1997, but the alterations to the natural landscape remain visible.

Contained Underground Nuclear Testing

There are two types of underground nuclear testing configured to contain radioactivity below the surface, horizontal tunnel tests and vertical drill holes. Built into the face of mesas at the north end of the Nevada Test Site, about 30 tunnels were built and used between 1957 and 1992 for a total of 67 tests. These horizontal shafts were built large enough to enable equipment and people to enter and work inside effectively. The detonations occurred at the end of the tunnels with containment plugs in place to hold the blast inside the structure. Materiel remains from this type of testing are the tunnels themselves and changes on the surface of the land above the tests. These types of nuclear explosions disintegrated the subsurface ground near the blast creating a chamber. When a chamber compressed, the surface above often sank producing a crater. In some cases,

no craters have appeared above some tunnel tests and these locations are called potential crater areas.

Contained underground testing utilizing vertical drill holes occurred on Yucca Flat and on the high mesas at the north end of the Nevada Test Site, taking advantage of different types of geology for various experiments. There were more than 600 of these tests. As mentioned earlier, portable buildings and structures were used in these tests and moved from one ground zero to another. At the time that the 1992 moratorium went into effect, these buildings, structures and drill rigs were either in place at a pending test location or sitting at a locale awaiting use. Trailers that sat near a ground zero are now gone. But ten-story rectangular towers, used to assemble and house equipment, complete the drill hole and lower the device into the hole, remain at two locations today. With the cessation of nuclear testing, excess equipment and some structures no longer of use were removed or dismantled from the Nevada Test Site.

The contained underground tests usually produced craters, more dramatic in appearance than those from the tunnels. The craters on Yucca Flat are the most impressive, probably a reflection of the geology in this region. From the air, Yucca Flat resembles a lunar landscape. Yet, none of these craters even closely compares in size to Sedan Crater mentioned previously. In the Sedan test, the sides of the crater were elevated by the soil as it came to the surface and redeposited. In the case of the vertical tests, the surface is sinking below its natural contour. Crater areas from both tunnel and drill hole tests are fenced or roped off for safety with appropriate signage.

A feature common at the drill hole craters is cable. At some locations, dozens of specialised cables emerge from the center of the crater and extend up the sides of the depression. Originally, these cables were attached to scientific equipment in diagnostic trailers and were used to convey signals to record experiment data. In addition to diagnostic cables other cables brought power and communications to and from each test site.

One unusual object, an aboveground chamber, can be seen on Yucca Flat. In a test, called Huron King, this chamber was placed over the drill hole. Radiation from the detonation reached and was contained in this chamber but by means of a network of mechanical closures, the pipe was sealed before the shock wave could reach the chamber and the chamber was winched away before collapse. Inside the chamber was a communications satellite and other experiments in an atmosphere that simulated a space environment.

Shock waves had a land alteration effect from both tunnel and drill hole tests. The detonation of the devices produced a shock wave similar to an earthquake. These shock waves from tests in and on the mesas has caused rock cliffs to crumble. This effect varied in different places. Sometimes a rock face may have only a few fractures and in other cases most of the face has fractured and fallen to the ground below.

In all of the nuclear testing areas of the Nevada Test Site, there are miscellaneous artifacts. These include empty cable spools, wood saw horses, rope, boxes, nails, lumber and other assorted metal, wood, glass and plastic objects. In some of the craters, large metal pipes protrude from the bottom where drill-back activities were conducted after the tests.

Significance, Value and Preservation

The Nevada Test Site figures prominently in the history of the Cold War. Through the efforts of the scientists, engineers, and technicians who worked there developing and testing nuclear weapons, these advances contributed enormously to the standoff between the United States, its Allies and the Soviet Union. The historical significance of the activities which took place at the Nevada Test Site is unquestionable.

The materiel remains from the experiments are not abundant. Pockets of testing structures exist today with isolated buildings and objects here and there across the landscape. Nuclear detonations are not commonplace in the world and, so far, have been confined to only a few locations in it, principally the Nevada Test Site, Semipalantinsk and Pacific Ocean. Therefore, these vestiges of the Cold War at the Nevada Test Site are of a very limited class of materiel remains. These remains are valuable because they are nuclear weaponry materiel culture. They are unique. They are irreplaceable. They are costly testaments to an era that could ultimately repeat itself.

When considering the applicability of preservation in regard to nuclear testing remains, the nature of the materiels needs to be carefully considered. Many of the artificial landscapes created by the tests continue to exist, slowly changed by the winds, rains and other natural processes. These structural changes to the earth are not easily remedied and, in all likelihood, will exist for eons with no organised preservation efforts. The remains built to survive tests, usually those related to test implementation, the acquisition of scientific data and the recordation of the tests are, in most cases, unique to nuclear testing. Their preservation is important because they convey the scientific innovativeness of the nuclear testing endeavor. Other remains were built to undergo a nuclear detonation. The materiel remains which have survived a nuclear test should be protected from deliberate destruction because of their inherent significance. Stabilization of these buildings, structures and objects is appropriate and desirable. However, restoration of structures that were built to be destroyed would not be in character with the intent of their construction. To see these nuclear testing remains is an experience that cannot be equaled through the written word, photographs or film. It brings home the cold, harsh reality of nuclear weaponry in the modern world and all that is influenced on the global front.

Conclusions

During the Cold War, there were two major continental nuclear testing grounds, the Nevada Test Site in the United States and Semipalantinsk in the Soviet Union. These two places on the Earth are the only locations where hundreds and hundreds of nuclear devices have been detonated. Although there were no battles of engagement between the

two Superpowers during the Cold War, a stalemate situation existed with each country testing nuclear weapons on their own soil as part of a strategy to maintain a strong defense and to be in possession of weapons superior to their counterpart.

Anyone who lived during this era remembers the specter of a mushroom-shaped cloud that hung over the world as people wondered when nuclear war and potentially the annihilation of the human race might occur. The devastating effects of the bombs dropped on Japan haunted everyone. Yet, the inevitable nuclear war did not materielise. Instead, it seems that the fear of the devastating effects of nuclear weaponry kept the United States and the Soviet Union from participating in a nuclear war. John Lewis Gaddis in his book on the Cold War (1997:85-86) has presented this reflective interpretation well. He points out in the history of warfare that improvements in weaponry, including the atomic bomb, have had the result of causing more devastation and death or, in other words, each invention is more efficient at what they are suppose to do. He believes that in the twentieth century, innovations in weaponry were major contributors to outbreaks of war, particularly in World War I and World War II. But as he states, "It comes as something of a surprise, then, to realise that the most striking innovation in the history of military technology has turned out to be a cause of peace and not war" (Gaddis 1997:85). Tens of thousands of nuclear weapons were built during the Cold War but none were used even though there were events that made military confrontations seemed unavoidable. "The ancient principle that if weapons are developed opportunities will be found to use them can, therefore, no longer be taken for granted, and that is a shift of major proportions in the long and lamentable history of warfare . . . (the) new rationality grew out of the simple realization that as weapons become more devastating they become less usable" (Gaddis 1997:86). The nuclear testing grounds in the United States and the Soviet Union strongly supported the stalemate situation and probably saved thousands of lives. The Cold War was the last worldwide conflict of the twentieth century and has few, associated remains because there were no battles and no use of weapons. This aspect of the Cold War increases the importance of the Nevada Test Site materiel remains. In a sense, the nuclear testing grounds were the Cold War's battlefields.

From a reflective standpoint, the increasing rapidity of new technological innovation in the twentieth century, especially in weaponry, has produced an era in which many more events and cultural changes have occurred than ever before. As a result of this increasing momentum of cultural change worldwide, it has become true that what is new today is old tomorrow. Events of this century, such as wars, although recent in terms of the number of years are not contemporary due to the current velocity of technological evolution and cultural change. As the world enters the twenty-first century, it is appropriate that archaeologists reflect on the events of the recent past and participate in the evaluation and preservation of these materiel remains. Archaeologists, more so than others, understand the interpretive potential and fragile nature of this physical record of international conflict. It is important to remember that the past the future will behold is now in our hands.

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