

OBSERVATIONS ON WILDLIFE AND DOMESTIC ANIMALS EXPOSED
TO THE GROUND MOTION EFFECTS OF UNDERGROUND NUCLEAR DETONATIONS

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Las Vegas, Nevada

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ABSTRACT

Domestic animals and wildlife have frequently been observed or intentionally stationed in close proximity to surface ground zero at the time of underground nuclear detonations at the Nevada Test Site and at other test locations within the contiguous United States. This report gives subjective summaries of large animal involvement with specific nuclear events and notes that physical damage from ground motion has not been reported. Recommendations are made for experimental verification of these subjective observations.

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INTRODUCTION

The proposed widespread use of nuclear detonations for stimulation of natural gas production from gas-bearing geological formations of low permeability has caused concern among ranchers, sportsmen and ecologists about possible physical damage to livestock and wildlife from the subsequent ground motion. A literature search revealed a lack of published information on this subject.

The author has personal knowledge of one study designed to determine ground motion effects on cattle. Unfortunately, the documentation of this effort was inadequate and the data were not reported in the open literature. However, over the years a number of animals on the Nevada Test Site have been exposed to varying degrees of earth movement from nuclear detonations. A beef herd of approximately 100 grade Herefords has been grazing over the Nevada Test Site since 1957. A dairy herd of approximately 45 Holstein and Jersey cows and three saddle horses have been maintained in the corrals at Areas 6 or 15 since 1964. An estimated 15 to 30 feral horses graze freely in Areas 2, 12, and 17 and a migratory mule deer herd spends the spring, summer, and fall months in the higher elevations of Areas 12, 15, 17, 18, 19, 20, 29, and 30 (see Figure 1). All areas identified numerically are located on the Nevada Test Site.

For the period January 1951 to June 30, 1973, there have been 344 announced underground detonations at the Nevada Test Site. In addition there have been several detonations held at other locations under the Plowshare or Vela Uniform programs.

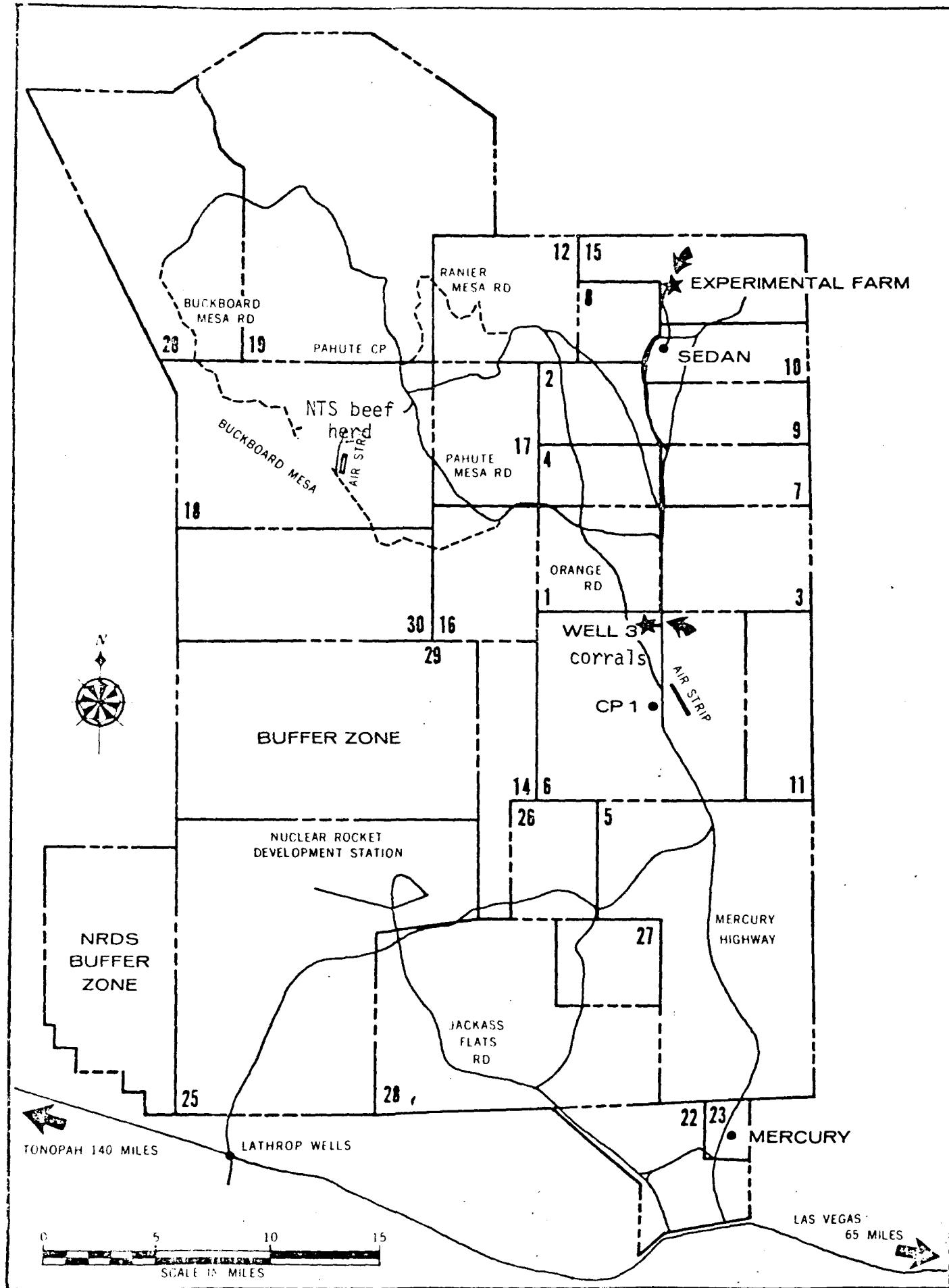


Figure 1. Location of Domestic Animals on the Nevada Test Site.

Observations discussed in this report pertained to nuclear detonations at sites within the contiguous United States. Effects from the test conducted on Amchitka Island were not included as they were discussed in considerable detail in technical reports prepared by other organizations. There have been no reported injuries to the domestic animals or wildlife, residing on the Nevada Test Site, as a result of the ground shock from the detonations. The Office of the Chief Counsel of the Nevada Operations Office of the Atomic Energy Commission has no knowledge of any claims for damages, from the ground motion effects of nuclear detonations, to livestock owned by offsite ranchers or farmers⁽¹⁾.

SUBJECTIVE EVALUATIONS

There have been several opportunities for the observation of ground motion effects on wildlife or domestic animals. During certain nuclear events, animals have been stationed or observed in close proximity to surface ground zero* at the time of detonation. Except for one case discussed immediately below, they were placed for experimental objectives not concerned with ground motion. The following represents subjective summaries of large animal involvement in these specific events.

Project Clearwater

On October 16, 1963, the Clearwater device (with a yield between 20 and 200 kt**) was detonated at a depth of 548 meters (1,800 feet) beneath Rainier Mesa. Three Hereford cow-calf pairs were stationed on Rainier Mesa at distances of 91 meters (300 feet), 213 meters (700 feet), and 426 meters (1,400 feet) from surface ground zero (SGZ). No film record was recovered showing the ground motion effects at 91 meters, but the reactions to the ground movement by the cow-calf

*As used in this report, surface ground zero (SGZ) is the point on the surface of land vertically above the center of a nuclear explosion.

**kt = kiloton

pairs located at the 213-meter and 426-meter stations were recorded on movie film. Unfortunately, the quality of these films was poor but they did show the animals riding the shock wave which threw them into the air. The cow located at 213 meters was momentarily knocked to her knees. No ill effects to any of the cattle were noted by the veterinarian conducting the experiment when the animals were removed from the three test positions several hours after the detonation.

Although ground motion instruments were not positioned at precisely the same locations as the cattle, interpolation of data obtained nearby gives the following approximations⁽³⁾:

<u>Cattle Station Horizontal Range From SGZ, ft.</u>	<u>Peak Upward Acceleration, g</u>	<u>Peak Upward Velocity cm/sec</u>	<u>Peak Upward Displacement cm</u>
300	4	230	46
700	2.7	160	30
1400	2.5	140	23

Project Salmon

Project Salmon was a nuclear test detection research experiment (Vela Uniform). The 5.3 kt device tamped in place at the bottom of a 822-meter (2,700 feet) hole in the Tatum Salt Dome near Hattiesburg, Mississippi, was detonated on October 22, 1964.

Approximately 350 cattle were located within a 2.7 kilometer (1-3/4 mile) radius of surface ground zero. The values of peak vertical ground surface motion parameters at 1.6 kilometers from SGZ were⁽⁴⁾:

Acceleration	2.5 g
Velocity	40 cm/sec
Displacement	2.2 cm

No damage to livestock or wildlife was reported.

Project Sulky

Project Sulky was a nuclear cratering experiment in hard rock executed as part of the Plowshare Program for development of nuclear excavation. The device was fired December 18, 1964, in Area 18 of the Nevada Test Site. The depth of burial was 27.4 meters and the resultant yield was 0.085 ± 0.015 kilotons. It produced a mound of broken rock with a depression in the center.

At the time of detonation, two groups of six mature lactating Holstein cows were stanchioned on the 1.2-kilometer (4,000-foot) and 6.7-kilometer (22,000-foot) arcs from surface ground zero. Ground motion data are not available for the cow locations. No physical damage to the cows in either group was noted by researchers upon their entry several hours after detonation⁽⁵⁾. These animals continued to produce milk and to reproduce normally for the rest of their lives.

Project Palanquin

Project Palanquin was a nuclear excavation experiment executed as a part of the Plowshare program. It was detonated in Area 20 of the Nevada Test Site on April 14, 1965, with a yield of 4.3 ± 0.4 kt. As part of the radionuclide studies mounted by the National Environmental Research Center-Las Vegas, called at that time the Southwestern Radiological Health Laboratory, seven adult Holstein cows were stanchioned 4.5 kilometers (2.8 miles) down wind from the surface ground zero⁽⁶⁾. The values of peak vertical ground surface motion parameters at 4.5 kilometers from SGZ were⁽⁷⁾:

Acceleration	0.015 g
Displacement	0.13 cm

All animals were in good condition, upon reentry of researchers, 31 hours after detonation. Three of the cows were sacrificed at 62, 76, and 125 hours post-detonation and were extensively necropsied. No physical effects (bruising, fractures, etc.) were noted on these animals. The other four cows remained in the Area 15 milking herd from two to seven years and produced well during this period.

Project Pile Driver

The Pile Driver Event was detonated on June 2, 1966, within a mine shaft located approximately 2.4 kilometers (1-1/2 miles) from the Area 15 experimental dairy farm. The device was emplaced in gravit 462 meters (1,518 feet) underground. The yield of the device was 56 kt.

Instruments of the Environmental Research Corporation recorded the following seismic data for the farm⁽⁸⁾:

Slant distance	2.4 km
Ground acceleration	0.36 gravity units
Velocity	28.6 cm/sec
Displacement	4.6 cm

The experimental dairy herd of 30 animals remained at the farm during the detonation. Upon reentry, no abnormalities among the cows were noted and the milk production that evening and the following day was within normal limits. Also, there were no delayed effects upon production that could be ascribable to this event. Some minor damage to the barn was noted, i.e., an air conditioner was jarred from its supports, ceiling tiles were dislodged, and a wall mounted-telephone was shaken to the floor.

Project Gasbuggy

Project Gasbuggy was a joint experiment by the U. S. Atomic Energy Commission, the Department of the Interior, and the El Paso Natural Gas Company to investigate the feasibility of using an underground nuclear explosion to stimulate production and increase ultimate recovery of natural gas from a gas-bearing geologic formation of low permeability. The nuclear explosive was equal to about 29 kt and was detonated on December 10, 1967, 1.29 kilometers (4,240 feet) underground in the Lewis shale formation, 88.5 air kilometers (55 miles) east of Farmington, New Mexico.

Following detonation, local veterinary practitioners, ranchers, county extension agents, wildlife regulatory personnel and members of the Jicarilla Apache Indian tribe were contacted. No damage to domestic animals or wildlife was reported.

Project Rulison

Project Rulison was a joint experiment sponsored by Austral Oil Company, Incorporated, of Houston, Texas, the U. S. Atomic Energy Commission, and the Department of the Interior with program management provided by CER Geonuclear Corporation. The purpose was to study the economic and technical feasibility of using an underground nuclear explosion to stimulate production of natural gas from the low permeability gas-bearing Mesa Verde formation in the Rulison Field of western Colorado. Surface ground zero was about 9.7 kilometers (six miles) southeast of the town of Grand Valley, Colorado. The Rulison device was detonated on September 10, 1969. The 40 kt yield nuclear explosive was exploded at a depth of 2.57 kilometers (8,431 feet).

At the time of detonation approximately 20 horses were at the North Fork Wallace Deer Camp located 5.6 kilometers (3-1/2 miles) south of surface ground zero on top of Battlement Mesa. These animals were examined by the author after detonation and no injuries were noted. Also, several deer and elk were observed during the helicopter flight back into the area and they appeared normal.

Approximate peak vertical values of ground motion at 5.6 km from Rulison SGZ⁽⁹⁾:

Acceleration	1 g
Velocity	25 cm/sec
Displacement	0.7 cm

The Grand Junction Daily Sentinel in its feature article on the event in the September 11, 1969, issue made the following comment: "Horses and cattle grazing in pastures near the road gave no indication that anything unusual had occurred."

No reports of physical damage to domestic livestock were made to any of the claims representatives.

Project Rio Blanco

Project Rio Blanco was a Government-industry natural gas reservoir stimulation experiment which was jointly sponsored by CER Geonuclear Corporation and the AEC. On May 17, 1973, three 30-kiloton nuclear explosives were detonated simultaneously within a single well bore at depths of 1.78 km (5,840 feet), 1.86 km (6,230 feet), and 2.04 km (6,690 feet). The emplacement well was located approximately 83.8 km (52 miles) northeast of Grand Junction, Colorado and 48.4 km (30 miles) southwest of Meeker, Colorado.

Bioenvironmental conditions around the surface ground zero were documented immediately pre- and post-detonation by consultants from Colorado State University and by representatives of the Colorado State Division of Wildlife. Their observations on large mammals within the area were reported as follows: "Cattle within 360 m (400 yards) of the emplacement well at detonation time showed no effects. On post-detonation surveys, deer were seen in nearly the same locations and in relatively the same numbers as before the detonation. Twenty-nine cattle, eight horses and four domestic goats were under observation about 10 km (6 miles) from the emplacement well at detonation time. Some of the animals became alert and moved about for a short time, but none demonstrated undue alarm."⁽¹⁰⁾.

Preliminary approximate values of peak upward ground motions at 360 meters⁽¹¹⁾ and at 10 kilometers⁽¹⁰⁾ are as follows:

<u>Distance From SGZ</u>	<u>Acceleration g</u>	<u>Velocity cm/sec</u>	<u>Displacement cm</u>
360 m (400 yds)	4	90	8
10 km (6 miles)	0.2	5	-

SUMMARY

Since 1963, several hundred cows, horses, deer and elk have been stationed or observed in close proximity to the surface ground zero of various underground nuclear experiments. Frequently these animals were closely observed for other research aims; however, no physical damage was noted from the ground motion they experienced.

It is the author's opinion that physical damage from the direct effects of ground motion is highly unlikely. Injuries to animals may result from

their being struck by overhead objects dislodged by the ground motion or from running into obstructions (i.e., barbed wire fences) because of excitement caused by the ground motion. However, this hypothesis should be tested by an experiment which will document any specific earth motion effects on domestic animals and wildlife stationed at varying distances from the SGZ of an underground nuclear explosion. The experimental design should include photographic and seismic documentation of the magnitude of the motion at each location of the experimental animals. Necropsies and selected histopathology should be performed to verify the presence or absence of physical damage.

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