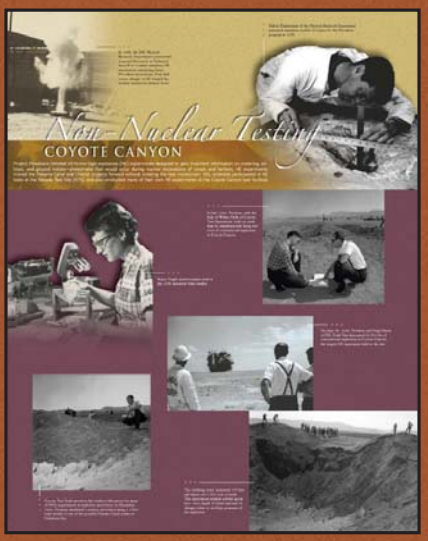
To view a poster, click on any of the icons below. To magnify an area within a poster, use the magnifying tool on the Acrobat Reader tool bar and drag a box over the area.

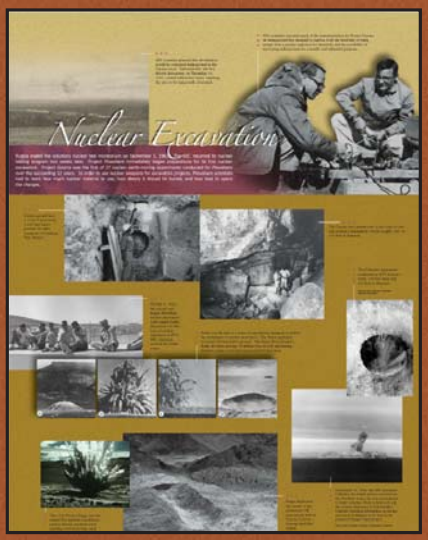
# Project Plowshare

**This exhibit highlights Sandia's role in the Project Plowshare exploration of peaceful uses of nuclear detonations.**







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In a 1953 speech to the United Nations, US President Eisenhower proposed that nuclear power be used for peaceful purposes.

Eisenhower's "Atoms for Peace" speech called for an International Atomic Energy Agency to hold in common the world's fissionable material. Reflecting the optimism that surrounded the discovery of the power released in splitting the atom, Eisenhower proposed that the material be used for transformative, peaceful programs rather than weapons.

Photo credit: The United Nations and the Dwight D. Eisenhower Library.

The Plowshare Project emphasized its peaceful mission by taking its name from the biblical exhortation, "And they shall beat their swords into plowshares," Isaiah 11:5. Evgeny Vuchetich's bronze statute, "Let Us Beat Swords into Plowshares," graces the sculpture garden of the United Nations, a gift from the Soviet Union in 1959.

Photo credit: The National Atomic Museum.

# Project Plowshare

In 1958, the Atomic Energy Commission (AEC) announced the creation of Project Plowshare, a government-sponsored program to develop peaceful uses for nuclear energy. Plowshare officials proposed using nuclear explosions to dig canals and harbors, mine oil and gas, and recover important information on cratering, radiation, and seismology. Between 1958 and 1975, the program conducted 35 nuclear tests, as well as numerous high explosives (HE) experiments simulating nuclear excavation. Lawrence Livermore National Laboratory (LLNL) directed Plowshare using the expertise of Sandia National Laboratories (SNL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), the US Geological Survey (USGS), and the US Bureau of Mines. SNL played a small but integral role in Project Plowshare.

As early as 1939, and with renewed vigor after WWII, scientists and social commentators touted the life-transforming potential of nuclear fission. Suggestions ranged from the practical to the fantastic.

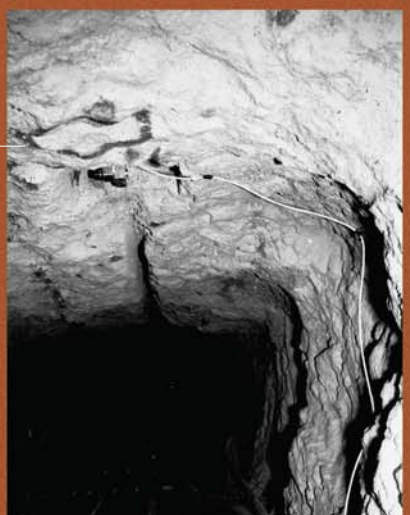
Photo credit: Newsweek

In October 1952, the AEC exploded Mike, the first large thermonuclear device, at Enewetak Atoll in the Pacific. Initially, radioactive fallout precluded many of the proposed peacetime applications of nuclear weapons. However, the successful detonation of thermonuclear weapons—which were considered cleaner and more efficient than the first atomic bombs—fed the optimism regarding research into peaceful uses.

In 1956, SNL president James McRae observed the Redwing nuclear test. When he returned home he asked Luke Vortman, of the Weapons Effects Department, to explore the feasibility of substituting nuclear devices for TNT in a proposed Canadian HE project to rid Seymour Narrows of Ripple Rock, a long-standing navigation obstacle in British Columbia.

Although conventional explosives were ultimately used in the Ripple Rock explosion, Vortman's analysis concluded that nuclear devices could be substituted for TNT cheaply and with little additional danger from either radiation or falling rock.

The strongest advocate for the use of nuclear devices in industrial applications was nuclear physicist Edward Teller. During WWII, Teller participated in the Manhattan Project. Then and after the war, he pushed for the development of thermonuclear weapons. His advocacy led to the creation of LLNL in 1952.



The 1957 Ranier shot, the first underground nuclear explosion, demonstrated that most radiation from a nuclear blast could be contained underground. Peaceful uses for nuclear explosives looked promising.

In 1957, LLNL invited scientists and engineers from SNL, LANL, and other entities involved in nuclear research, to a classified conference at Livermore on the peaceful uses of nuclear explosives. The next year, the AEC formally established Project Plowshare to coordinate efforts for the further development of peaceful applications for nuclear weapons; LLNL led the program.

Photo credit: Lawrence Livermore National Laboratory.

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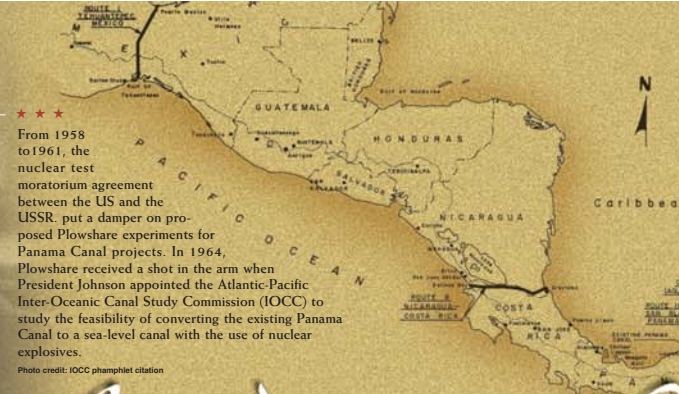
"...the United States should press forward...in plans and preparations for a sea level canal."

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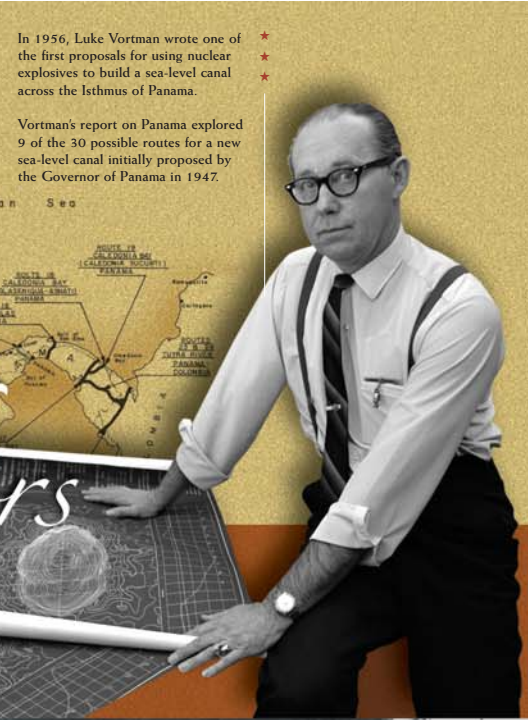
From 1958 to1961, the nuclear test moratorium agreement between the US and the USSR. put a damper on proposed Plowshare experiments for Panama Canal projects. In 1964, Plowshare received a shot in the arm when President Johnson appointed the Atlantic-Pacific Inter-Oceanic Canal Study Commission (IOCC) to study the feasibility of converting the existing Panama Canal to a sea-level canal with the use of nuclear explosives.

Photo credit: IOCC phamphlet citation

★ ★ ★

In 1956, Luke Vortman wrote one of the first proposals for using nuclear explosives to build a sea-level canal across the Isthmus of Panama.

Vortman's report on Panama explored 9 of the 30 possible routes for a new sea-level canal initially proposed by the Governor of Panama in 1947.



# Canals and Harbors

More than any other Plowshare program, the construction of a sea-level canal across the Isthmus of Panama fired the imagination of AEC officials, scientists, and engineers. In support of this vision, the AEC proposed a number of nuclear harbor-building projects as preliminary experiments. However, in 1958, due in part to growing international concerns over radioactive fallout, the US entered into a test moratorium with the USSR. All nuclear engineering and nuclear weapons tests were put on hold. Nevertheless, plans for nuclear-constructed harbors and canals proceeded on paper.

★ In 1958, officials from LLNL, SNL, and the AEC flew to Alaska to find a suitable site for the experiment. Chariot survey team members enjoyed a carribou barbeque. SNL scientist Melvin Merritt is seated on the right.

★ Project Chariot proposed detonating five nuclear devices in a row (a total of 2.4 megatons) to achieve a full-scale harbor at the mouth of Ogotoruk Creek near Cape Thompson in Alaska.


Photo credit: Lawrence Livermore National Laboratory

★ In 1958, Plowshare and Alaska Health Department officials met to discuss the potential health risks associated with nuclear explosives. Left to right: Richard Bice, SNL; Dr. Harold Fidler, AEC; Wallace Reynolds, University of California, Berkeley; Dr. Edward Teller, LLNL; Amos Alter, Alaska Dept. of Health.


★ Howard Rock, an Inupiat artist from Point Hope, founded the first statewide Native American newspaper, the *Tundra Times*, in response to the Project Chariot controversy.

Photo credit: Ukpeagvik Inupiat Corporation and Tuzzy Consortium Library of Barrow, Alaska.

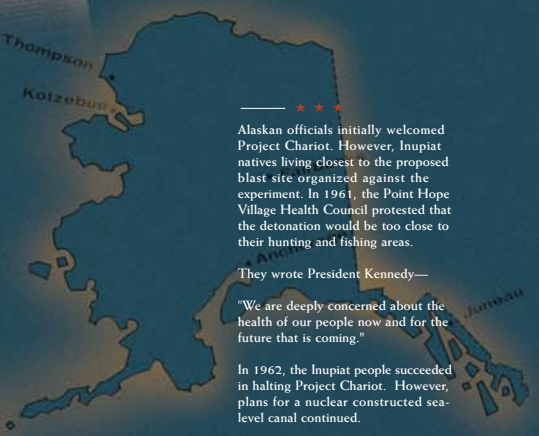
★ ★ ★

In 1966, SNL conducted meterological studies from Battery MacKenzie, a modified WWI coast artillery station near the Atlantic entrance to the Panama Canal, to assess possible damage from airblast in the proposed nuclear construction of a new canal.

★ ★ ★

In 1956, LLNL scientist Harold Brown considered using nuclear explosives to construct a sea-level canal through Israel to replace the outdated Suez Canal.

Photo credit: Lawrence Livermore National Laboratory

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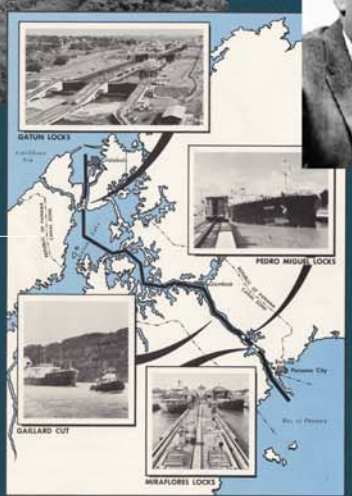
Alaskan officials initially welcomed Project Chariot. However, Inupiat natives living closest to the proposed blast site organized against the experiment. In 1961, the Point Hope Village Health Council protested that the detonation would be too close to their hunting and fishing areas.

They wrote President Kennedy—

"We are deeply concerned about the health of our people now and for the future that is coming."

In 1962, the Inupiat people succeeded in halting Project Chariot. However, plans for a nuclear constructed sea-level canal continued.

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As early as 1939, the United States' largest ships could no longer pass through the locks of the Panama Canal Zone. In 1942, Congress authorized the construction of larger locks as an interim solution, but lock construction stalled during WWII. After the war, building larger locks no longer seemed an adequate solution for modernizing the Panama Canal.

Photo credit: IOCC citation

★ ★ ★

SNL air blast studies predicted potential glass breakage in Medellin, Columbia, from the proposed Panama Canal nuclear engineering project.

In 1970, The Inter-Oceanic Canal Commission concluded that the technical feasibility of nuclear explosives was unproved and recommended traditional high explosives. Other concerns included the prohibition on atmospheric nuclear testing included in the 1963 Limited Test Ban Treaty, the formidable problem of removing existing populations in the canal zone, and the possible damage to the environment from nuclear explosives.

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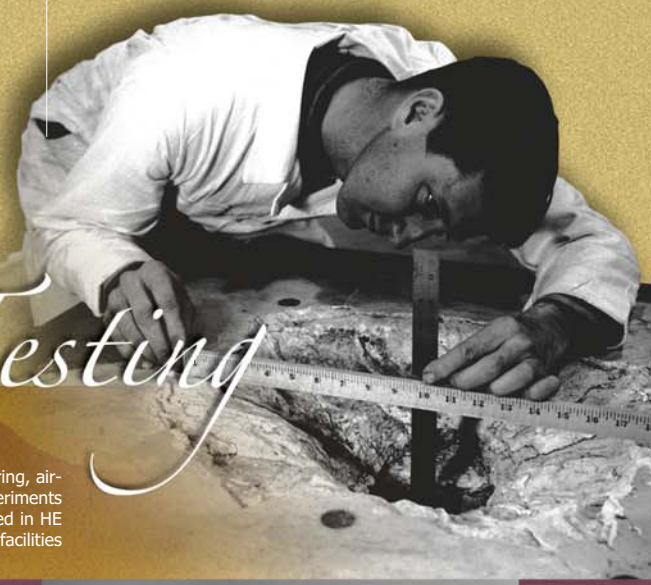
★ ★ ★

In 1959, the SNL Physical Research Department constructed a special laboratory in Technical Area III to conduct miniature HE experiments simulating future Plowshare excavations. Even half-ounce charges of HE formed the familiar mushroom-shaped cloud.

★ Milton Zimmerman of the Physical Research Department
★ measured miniature models of craters for the Plowshare
★ program in 1959.



# Non-Nuclear Testing

## COYOTE CANYON

Project Plowshare initiated 19 formal high explosives (HE) experiments designed to gain important information on cratering, air-blast, and ground motion—phenomena that would occur during nuclear excavations of canals and harbors. HE experiments moved the Panama Canal and Chariot projects forward without violating the test moratorium. SNL scientists participated in HE tests at the Nevada Test Site (NTS) and also conducted many of their own HE experiments at the Coyote Canyon test facilities

★ ★ ★

Nancy Feight mixed samples used in the 1959 miniature blast studies.

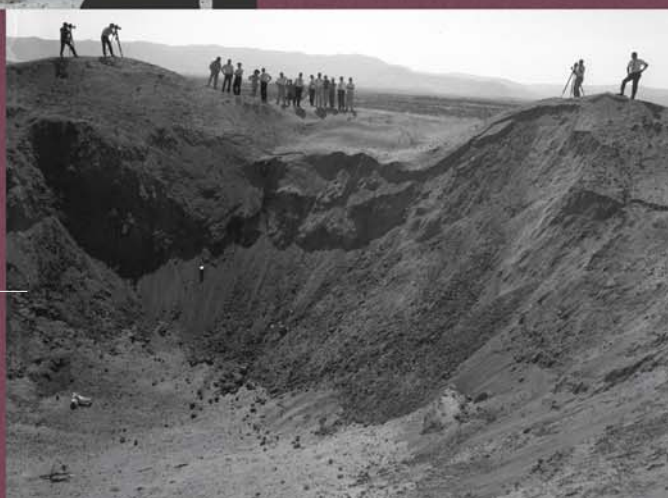
★ ★ ★

In July 1964, Vortman, with the help of Walter Hyde of Coyote Test Operations, built an earth dam by simultaneously firing two rows of conventional explosives in Coyote Canyon.

★ ★ ★

On June 28, 1968, Vortman and Virgil Harris of SNL Field Test detonated 30,500 lbs of conventional explosives in Coyote Canyon, the largest HE experiment held at the site.

★ Coyote Test Field served as the outdoor laboratory for many
★ of SNLs experiments in explosive excavation. In December
★ 1964, Vortman simulated a nuclear excavation using a 1/200 scale model of one of the possible Panama Canal routes at Caladonia Bay.



★ ★ ★

The resulting crater measured 105-feet and threw out 7,200 tons of earth. This experiment studied airblast geometry—how depth of burial and size of charges relate to air-blast pressures of the explosion.

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★ ★ ★

During Project Scooter, SNL engineers gathered information on crater dimensions, particle trajectory, throw-out characteristics, ground motion, dust cloud growth, and long-range airblast.

★ On October 13, 1960, SNL and LLNL scientists collaborated on Project Scooter, the
★ largest Plowshare HE experiment. *Left to right.* Don Shuster, SNL; Gerald Johnson, LLNL;
★ James Scott, SNL; A.Dean Thornbrough, SNL; Luke Vortman, SNL; Albert Chabai, SNL; Byron Murphy, SNL; and Milo Nordyke, LLNL.

# Non-Nuclear Testing

## NEVADA TEST SITE

The AEC's range of test facilities offered a variety of soils and rock for high explosive (HE) testing. In addition to the HE tests conducted in New Mexico at SNL's Coyote Canyon test facilities, smaller sites were used; for example, the Pre-Schooner II shot was done in Idaho. Larger cratering tests were conducted at NTS.

★ ★ ★

On September 30, 1965, SNL supplied blast measurement and microbaragraph readings for Pre-Schooner II, an 85-ton liquid nitrogen explosive detonation near Bureau River Canyon, 55 miles outside Twin Falls, Idaho. Pre-Schooner II provided preliminary information for Schooner, a 1968 nuclear event that studied the cratering and engineering properties of volcanic rock for future Plowshare excavation projects.

★ ★ ★

The AEC detonated 1,000,000-pounds of TNT at NTS in Project Scooter. The resulting crater measured approximately 300-feet in diameter and was 80-feet deep.

★ ★ ★

In 1966, H. Gerald Laurenson developed a new prototype balloon to measure airblast during HE experiments. The smaller balloon—72-feet long and 21-feet in diameter—handled easier and could lift as much as 400-pounds of equipment to an altitude of 500-feet.

★ ★ ★

Sixteen pressure-sensing stations were mounted on cables held aloft by a 140-foot helium balloon at Pre-Schooner II. Balloons acted as skyhooks, holding instrumentation used to obtain airblast measurements from HE excavation experiments.

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# Nuclear Excavation

Russia ended the voluntary nuclear test moratorium on September 1, 1961. The AEC resumed its nuclear testing program two weeks later. Project Plowshare immediately began preparations for its first nuclear excavation. Project Gnome was the first of 27 nuclear earth-moving experiments conducted for Plowshare over the succeeding 12 years. In order to use nuclear weapons for excavation projects, Plowshare scientists had to learn how much nuclear material to use, how deeply it should be buried, and how best to space the charges.

★ ★ ★

AEC scientists planned that all radiation would be contained underground in the Gnome event. Unfortunately, the five-kiloton detonation, on December 10, 1961, vented radioactive vapor, requiring the area to be temporarily evacuated.

★ SNL scientists operated much of the instrumentation for Project Gnome, an underground test designed to explore both the feasibility of using energy from a nuclear explosion for electricity and the possibility of recovering radioisotopes for scientific and industrial purposes.

★ ★ ★

Gnome ground zero, a 10 by 8-foot room, 1,200 feet below ground, 25 miles southeast of Carlsbad, New Mexico.

★ ★ ★

The Gnome shot melted over 2,400 tons of rock and created a hemispheric cavern roughly 160- to 170-feet in diameter.

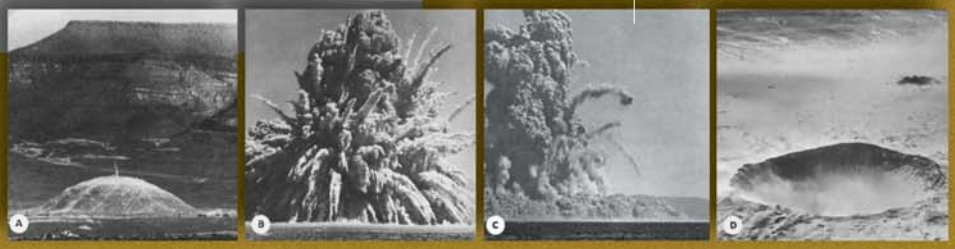
★ The Cabriolet experiment conducted at NTS formed a crater 125-feet deep and 400-feet in diameter.

Photo credit: Lawrence Livermore National Laboratory

★ ★ ★

On July 6, 1962, the second and largest Plowshare nuclear experiment, code-named Sedan, detonated 100 kilotons of nuclear explosives at NTS. SNL observers awaited the Sedan event.

★ Sedan was the first in a series of experiments designed to perfect the techniques of nuclear excavation. The Sedan explosion occurred 635-feet below ground. The desert floor formed a dome 290-feet, moving 12-million tons of rock and leaving behind a crater 1,200-feet across and 320-feet deep.



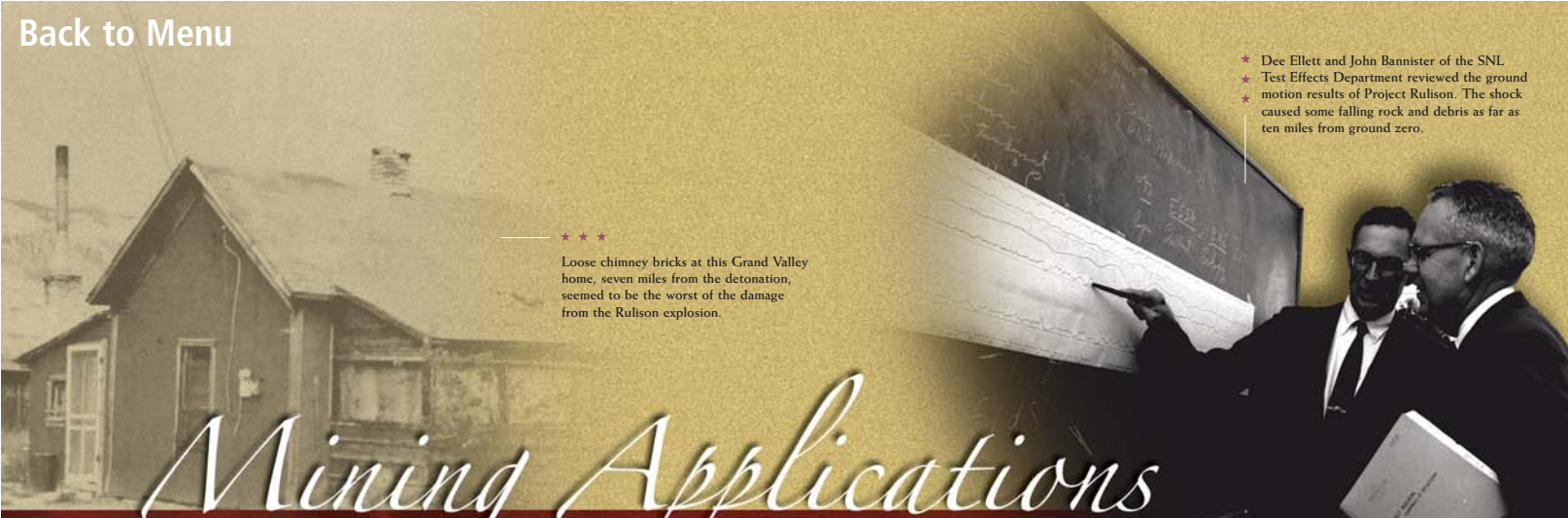

★ The 1968 Project Buggy test detonated five separate one-kiloton nuclear devices simultaneously, creating a 900-foot long canal, 300-feet wide and 80-feet deep.

★ ★ ★

Buggy duplicated the results of the preliminary HE experiments held at Coyote Canyon—forming ditch-like craters.

★ On January 26, 1968, the AEC detonated Cabriolet, the fourth nuclear excavation in the Plowshare series; the test was designed to study cratering effects in hard rock and the air-born dispersion of radionuclides. Cabriolet furnished information on nuclear excavation techniques to be used in the proposed Panama Canal project.

Photo credit: Reynolds Electrical & Engineering Company.



Loose chimney bricks at this Grand Valley home, seven miles from the detonation, seemed to be the worst of the damage from the Rulison explosion.

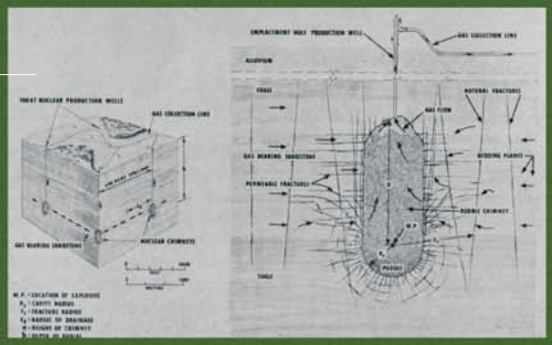
Dee Ellett and John Bannister of the SNL Test Effects Department reviewed the ground motion results of Project Rulison. The shock caused some falling rock and debris as far as ten miles from ground zero.

# Mining Applications

In 1968, Congress began cutting appropriations for Plowshare. Nuclear excavation projects like the new Panama Canal route began to seem prohibitively expensive and dangerous to the environment. As plans for nuclear excavation disintegrated, Plowshare shifted its focus to nuclear mining ventures. The AEC, in partnership with industry, planned experiments to increase the recovery of natural gas using nuclear explosions. The gas industry used conventional explosives to fracture sandstone reservoirs and release the gas trapped inside. Scientists theorized that nuclear explosives could double US gas reserves.

Rulison, the second natural gas nuclear mining experiment, was held on September 10, 1969, near Grand Junction, Colorado. The 40-kiloton nuclear device was detonated 8,430 feet underground with no venting of radiation.

SNL provided expertise in arming, firing, and earth motion studies for Gasbuggy, a December 10, 1967, Plowshare experiment to increase the production of natural gas mines in Farmington, New Mexico. Gasbuggy was the joint project of the AEC, El Paso Natural Gas, and the Department of the Interior.

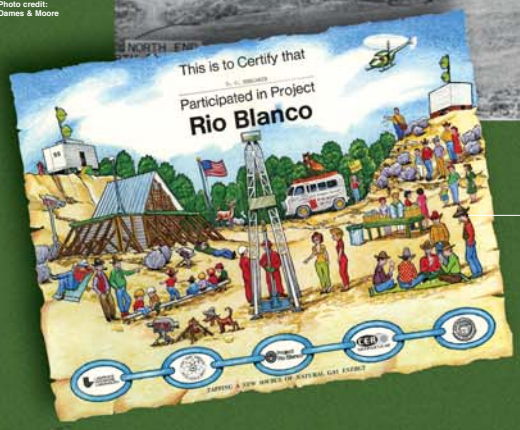


LLNL drawing of the gas reservoir to be created by the Gasbuggy nuclear test.

Dean List lowered canisters of SNL instrumentation 4,600 feet down into a drilling hole designed to measure the shock waves of the explosion.


El Paso Natural Gas and SNL instrumentation sites for Rio Blanco.

Photo credit: Dames & Moore




Amid local political protest, the AEC detonated three 33-kiloton devices on May 17, 1973. Rio Blanco, the third of the nuclear gas stimulation tests, was the last of the Plowshare experiments. Plowshare scientists had hoped that Rio Blanco would be the first of a series of new clean underground nuclear devices. However, post test water and gas samples from the site exhibited radioactive contamination.

Luke Vortman being interviewed in October 2000. Although the idea that nuclear devices could be used in digging and drilling seems fantastic today, at the time, the prospect that nuclear weapons could be put to non-military uses seemed a worthy venture. In hindsight, Vortman noted that Plowshare "…was a pretty wild idea." Yet, he explained he stayed with the program because "…if this effort was going to fly wouldn't it be great to be a part of it?"