AEC CONTROLLED AREA SAFETY PROGRAM

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ABSTRACT

The detonation of underground nuclear explosives and the subsequent data recovery efforts require a comprehensive pre- and post-detonation safety program for workers within the controlled area.

The general personnel monitoring and environmental surveillance program at the Nevada Test Site are presented. Some of the more unusual health physics aspects involved in the operation of this program are also discussed.

The application of experience gained at the Nevada Test Site is illustrated by description of the on-site operational and safety programs established for Project Gasbuggy.

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The general theme of this symposium is directed toward the public health aspects of the Plowshare program where public is in the context of non-program related residents living outside the test or project area. The health and safety of the workers within the on-site or controlled area are of equal concern to the Atomic Energy Commission.

For a better understanding of the operations at the Nevada Test Site (NTS), some knowledge of the site is necessary.

The first slide (Figure 1) shows the NTS and the general area around the NTS. The Nellis Air Force Range is closed to the public and therefore provides to some extent a buffer zone between test activities and the general public.

The next slide (Figure 2) shows the NTS proper. The site is located in Nye County about 65 miles northwest of Las Vegas. The main entrance to the site is at Mercury which contains the base camp with offices, laboratories, warehouses, living quarters, and recreational facilities for the workers who live there.

To the north of Mercury are the Frenchman and Yucca Flat areas. These were the primary testing areas for atmospheric detonations prior to the signing of the Limited Nuclear Test Ban Treaty. These areas are now used for underground testing in vertical holes with the bulk of the tests being conducted in Areas 3, 7, 9, 10, and 2. From the center of the forward test areas in Yucca Flat, it is some forty miles to the nearest off-site permanent residence.

The main control point is located midway between the Yucca and Frenchman Flat areas.

Area 12 contains the main tunnel complexes. These tunnels are mined into the side of Rainier Mesa to give larger work areas for more complex experiments than can be placed in the vertical holes.

Pahute Mesa provides facilities for testing at higher yields than are feasible in Yucca and Frenchman Flats.

The Nuclear Rocket Development Station is set aside for the testing of nuclear engines for rocket vehicle application.

Several nuclear excavation experiments have been conducted at the NTS, among them the Sedan event in Area 10, Buggy in Area 30, and the Cabriolet, Palanquin, and Schooner events in Area 20.

Before describing radiological safety procedures, a few words should be said about how releases of radioactive effluent at detonation time can occur in nuclear explosives testing. Since the signing of the Limited Nuclear Test Ban Treaty, all United States nuclear explosives tests have been conducted in an underground environment. The majority of the tests conducted since the treaty have been designed to be fully contained (that is, release no radioactivity to the atmosphere). Only in the case of such things as excavation or aggregate production-type experiments is any release of radioactive effluent at detonation time anticipated and even in this case the fraction of radioactivity released is designed to be small compared to the total amount of radioactivity produced.

For experiments designed to be fully contained it must still be recognized, however, that some radioactivity can be released by accident. Such releases are customarily separated into two rather loose categories referred to as "venting" and "seepage." Venting can be roughly defined as a prompt release of radioactivity usually occurring within a few minutes after the detonation and frequently resulting in a visible and radioactive dust cloud. Seepage may also start shortly after detonation but usually does not produce a visible cloud. It is characterized by a low-level, long-term release of highly fractionated fission products consisting primarily of noble gases and volatiles. The few ventings which have occurred, on the other hand, have generally been relatively unfractionated and have lasted for only a very short period of time. Causes of these effluent releases are not always readily determined. Seepage has been bound to occur through firing and diagnostic cables leading to the explosive, through fissures in the soil, or in and around the emplacement casing where stemming or grouting material has been shifted by the detonation.

Causes of ventings are even more difficult to determine than for seepages. It appears, however, that such things as shallow burial and local weaknesses in the geological medium can combine to produce ventings.

With this rather sketchy background, the more unusual portions of the on-site health protection program can be described. The industrial safety, fire protection, and medical problems encountered in testing programs are typical of the heavy construction and drilling industries and will not be discussed here.

At the present time the Nevada Operations Office has two contractors who provide on-site radiological safety services. At the Nevada Test Site the Reynolds Electrical and Engineering Company (REECO) provides these services. At sites other than the NTS our contractor is the Eberline Instrument Corporation. The services which both contractors provide are basically the same.

Each contractor maintains an active on-site environmental surveillance program, provides training as necessary, and controls and documents any radiation exposures to on-site workers by use of personnel dosimetry and bioassays.

Because some of the health physics problems which are encountered are unique to nuclear explosives operations, and particularly to drilling and tunneling operations, it is necessary that monitoring personnel receive at least a portion of their field experience working on drill rigs and in tunnels.

Prior to each test, air sampling units and remotely operated gamma exposure rate measuring units are placed around the surface ground zero. These units document any release of radioactive effluent. In addition, the exposure rate units which comprise what is more commonly referred to as a remote area monitoring system (or RAMS) provide an early indication of any release and can provide information on exposure rate levels at stations where re-entry is required. The RAMS units in current use normally have a six-decade readout capability from about one mR/hr to 1,000 R/hr. The output of these units is returned by hardwire or r-f telemetry to the control point for evaluation by the Test Manager and the testing laboratory. Should a release of radioactive effluent occur, standard procedures have been developed for estimating the quantity of radioactivity released to the atmosphere based on meteorological conditions and an assumed source geometry.

This equipment is, of course, installed, checked out, and calibrated well prior to the detonation.

Based on the meteorological and maximum credible radiation predictions presented at the first pre-shot weather briefing, areas around the immediate test area are cleared of all personnel not necessary for the final pre-shot preparations. Additional weather briefings prior to detonation time may expand or shift the areas to be cleared of personnel.

For tests which are predicted to cause significant motion from seismic effects, personnel may also be removed from tunnel or underground work areas, drill rigs may be shut down, and personnel generally required to be in non-precarious locations.

Prior to the event, geophones which monitor seismic activity are also placed in the vicinity of the surface ground zero. After the event, these geophones monitor the progress of the underground chimney as it works its way toward the ground surface. Personnel are kept outside the surface ground zero area until a surface subsidence occurs or until the geophones indicate the underground growth of the chimney is complete.

Following the detonation, and after geophone and RAMS readings indicate it is safe to re-enter the test area, an initial radiation survey is made of the detonation site. Monitoring personnel are equipped with anti-contamination clothing and respiratory protection equipment. The radiation survey includes the emplacement casing, any instrument holes, cables, and the diagnostic or timing and firing trailers. The radiation survey data is relayed to the control point, recorded, and evaluated. As soon as the evaluation has established that there are no significant radiological hazards, scientific personnel are permitted to re-enter to recover their data and equipment. For those rare cases where a radiological problem exists, monitors are provided for each recovery party to assure that they do not exceed permissible exposure standards. In such a case, scientific personnel are also appropriately dressed in anti-contamination clothing and provided with respiratory protection.

Prior to the detonation a radiological safety check station is established at the re-entry point to control personnel access and to assure that re-entry personnel are appropriately outfitted. Should a radioactivity release occur, personnel and equipment are monitored upon exit from the area and can be given preliminary decontamination at this check station if necessary.

Under normal conditions for those events designed for containment, no radiation problems exist and the check station or access control trailer is moved to within a thousand feet or so of surface ground zero as soon as the initial surveys and data recoveries are completed. Movement of the check station to a location close to the emplacement site reduces the size of the area under control and permits resumption of normal operations in those areas outside the immediate emplacement site.

Following the detonation it is normally necessary to re-enter the detonation zone (usually by drilling) to obtain samples of the radioactive debris. These samples are used for determination of explosive yield and for other diagnostic information.

The next slide (Figure 3) shows three methods of post-shot drilling used at the Nevada Test Site.

The next slide (Figure 4) depicts a general circulation system of the drilling fluid for the drill rig. This fluid circulates from a pump through a hose to the drill stem. It then flows down the drill stem and out through the drill bit thereby cooling and lubricating the bit. The fluid then returns to the surface through this annulus carrying the cuttings in suspension. Since several drilling fluids may be used such as mud, water, air (and in the case of gas fields, natural gas), the treatment at this point depends on the fluid used. At the NTS some form of mud is customarily used for post-shot drilling.

As drilling proceeds, a point is reached where circulation of the drilling fluid is lost. This is desirable since, if circulation is not lost, radioactive mud can be returned to the surface as the drilling nears the radioactive melt zone. Circulation is lost because the fluid flows out into the fractured zone near the detonation point.

In some cases radioactive gas, or radioactivity contained in steam produced by the fluid contacting the thermally hot detonation zone, forces its way to the surface through the annulus or drill stem. To reduce effluent releases to the atmosphere and minimize personnel exposures from this source, several treatment methods are available. One method consists of making this a closed system so that material returned to the surface is placed back down the hole. For cases where this method is not practical, the fluid or gases can be run through a ventilation system consisting of mud or chip traps, a charcoal filter system, and released to the atmosphere. This system removes essentially all radioiodine from the effluent so that for practical purposes only the noble gases are released. Quantities of radioactive effluent released are such that they are seldom detectable outside the immediate work area.

Personnel are assigned for radiation monitoring on and around the drill rig during the re-entry. At the same time air samplers and RAMS units are set up around and on the rig ventilation system to measure and document any release of radioactivity.

The next slide (Figure 5) shows one method of obtaining a sample of the radioactive debris. A coring tool is lowered on a wire line into the center of the drill string and forced out into the hole wall.

The coring tool is then raised to the surface with the sample wedged inside. At the surface radiation monitoring personnel remove the sample from the tool and package it for shipment to the laboratory sponsoring the test.

After recovery of samples, the post-shot sampling hole is sealed off, the drill rig and tools are decontaminated if necessary, and any radioactive waste is cleaned up.

Procedures similar to those described are used on almost all nuclear explosive tests regardless of whether they are conducted for weapons testing or Plowshare. Specific procedures will vary somewhat from event to event, depending on the type and purpose of the experiment and individual circumstances.

To show specific application of some of these procedures, the next slide (Figure 6) shows the exterior of the access control trailer used for Project Gasbuggy. Note the cribbing and tiedowns for protection of the trailer against ground motion.

One view of the interior of the access control trailer is shown in the next slide (Figure 7). The bins and cabinets are used for storage of protective clothing, spare parts, and miscellaneous equipment. Not visible in this view are a large hot water tank, sink, and shower for personnel decontamination.

The next slide (Figure 8) shows the Gasbuggy RAMS array used on the day of detonation. Note that on this particular event two units were placed in the downhole stemming. This procedure gives an early warning should radioactive effluent begin to work its way up through the stemming.

The final slide (Figure 9) shows the RAMS array used for the postshot drilling. The Gasbuggy nuclear explosive was placed in the 20-inch diameter emplacement hole by lowering the explosive on the end of a 7-inch diameter drill string. Stemming was then placed inside the 7-inch string and in the annulus between the 7-inch string and the 20-inch casing.

The initial re-entry into the Gasbuggy chimney was made by drilling with natural gas to a depth of about 3,260 feet at which point the drilling fluid was changed to a water-bentonite mixture because of wet-hole conditions and cement buildup on the drill pipe. Four RAMS units were placed on a circle of about 300-foot radius around the emplacement hole.

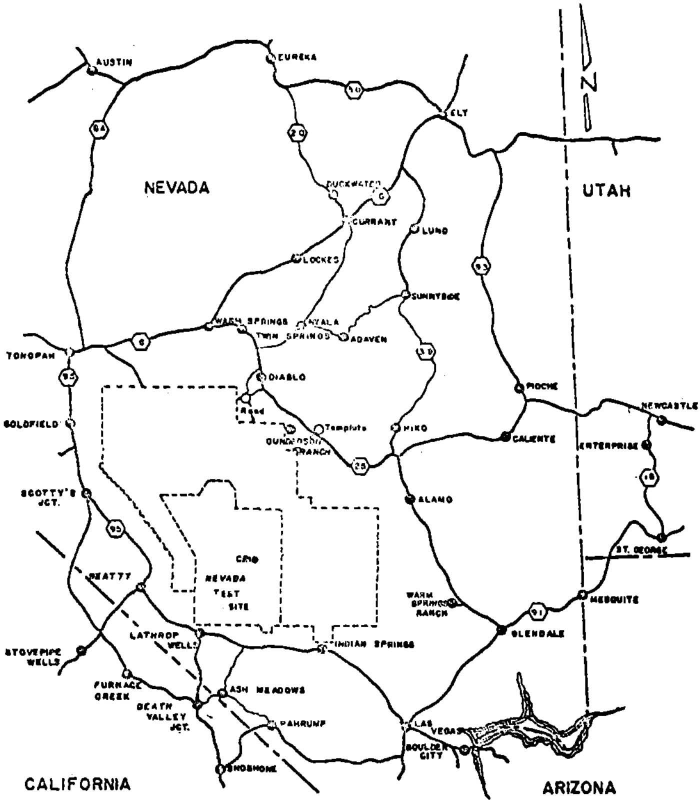
For that portion of the drilling which used natural gas as a drilling fluid, a gamma ray scintillation detector was placed on the exhaust line to detect any release of radioactivity in the gas. For that portion of the drilling which used the water-bentonite mixture, RAMS units were placed on the mud line and on the mud storage tank. The data from the downhole RAMS units and from other detectors mounted below the rig floor were also available.

In addition to the equipment shown, an air sampling array was established for zero time with equipment and facilities available for calibration, maintenance, and repair of electronic equipment as well as a mobile sample analysis laboratory.

Sample of the drilling fluid returns were collected and analyzed in these facilities as well as the usual air, soil, water, and vegetation samples.

The maximum radiation exposure of any on-site worker for the Project Gasbuggy detonation and subsequent post-shot drillback was less than 10% of the maximum permissible guidelines for the experiment.

In summary, the general Nevada Test Site radiological safety and documentation program is readily adaptable for use on Plowshare experiments conducted at sites other than NTS and will provide adequate control of employee radiation exposures.



SOUTHERN NEVADA AND NEVADA TEST SITE VICINITY

FIGURE NO. 1

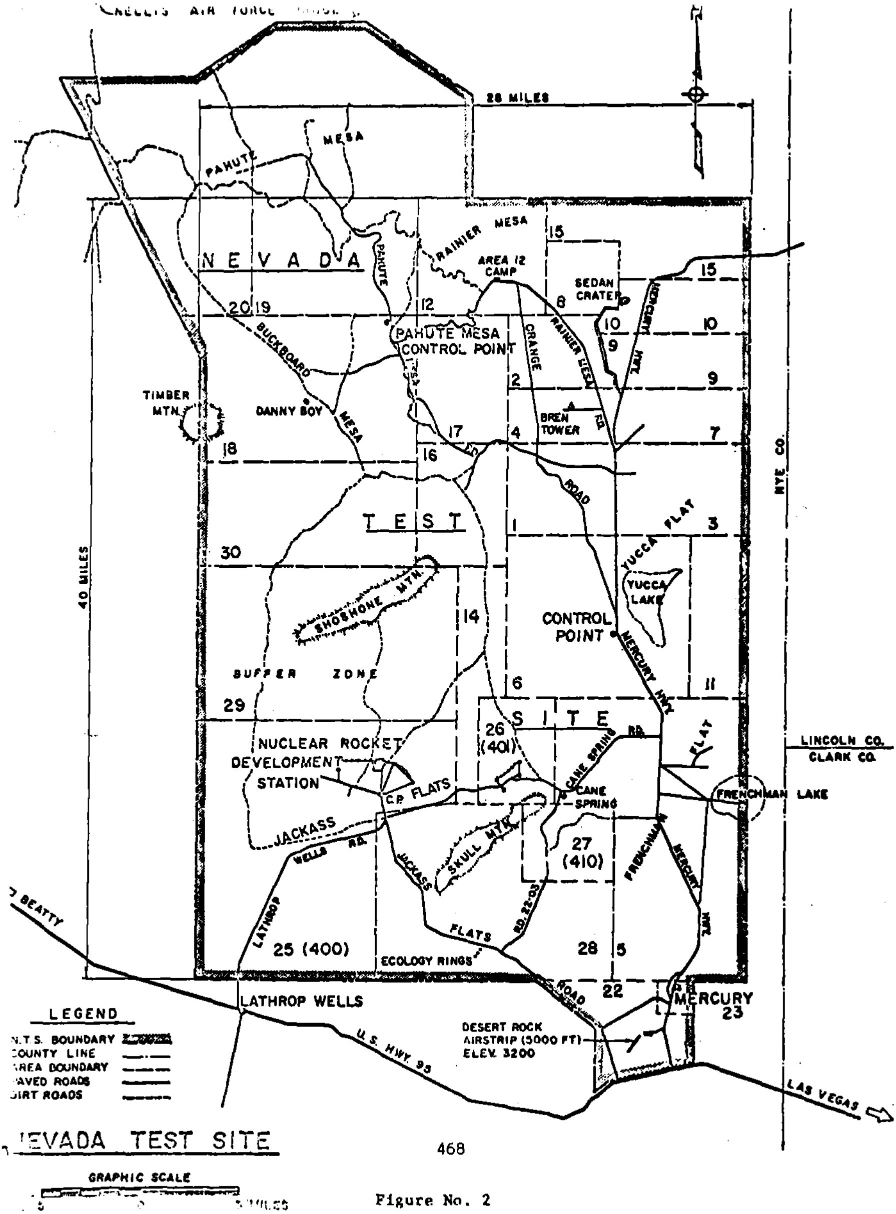
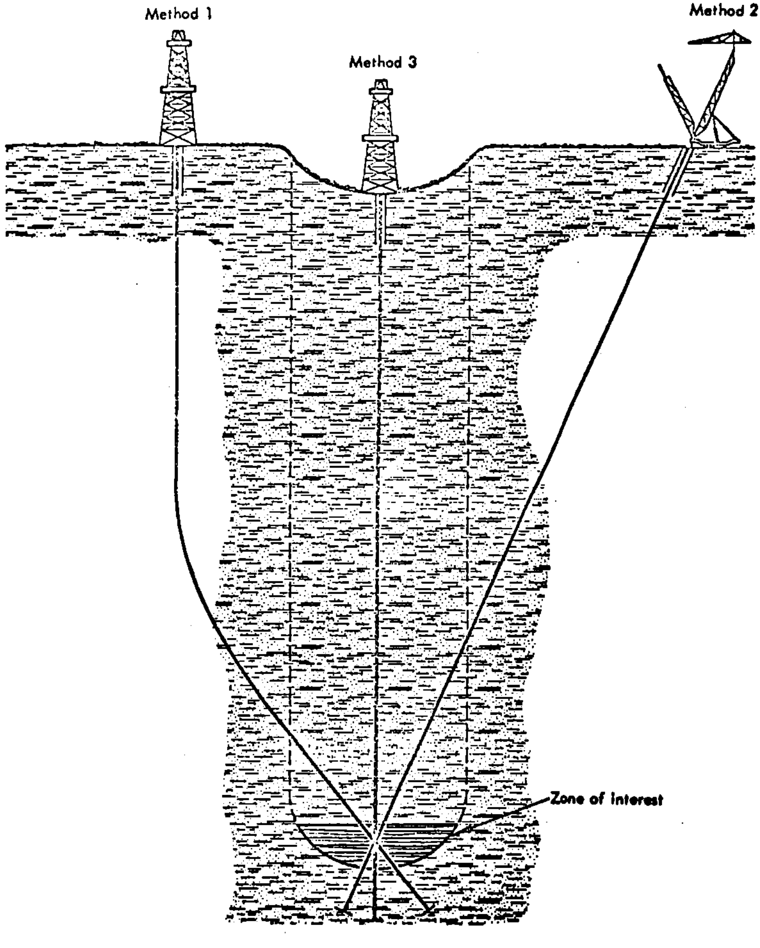
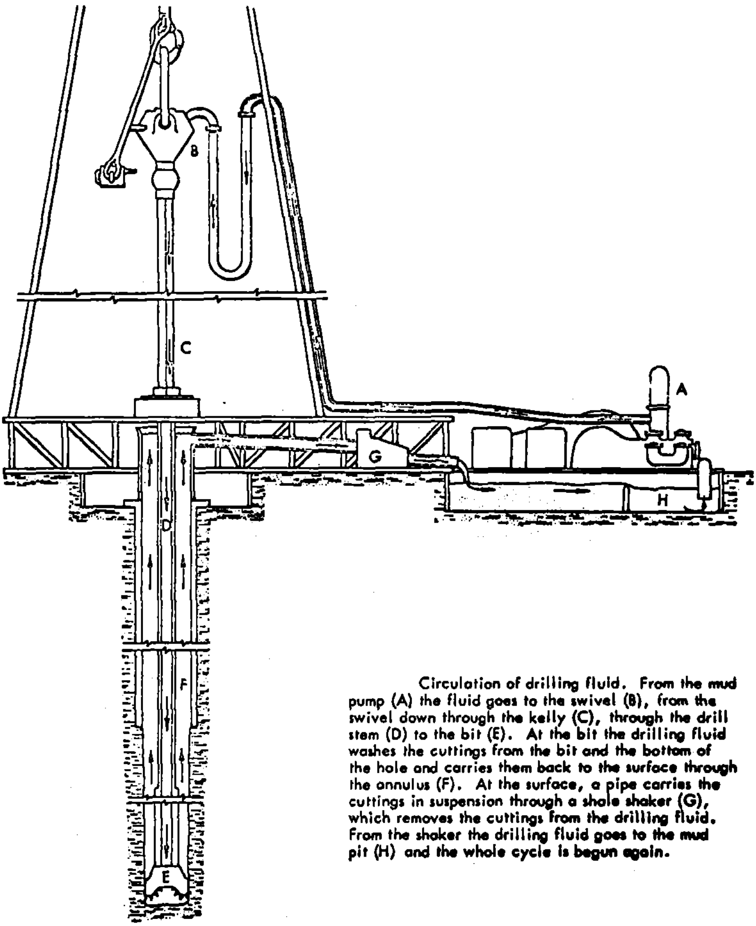

28 MILES
40 MILES
PAHUTE MESA
NEVADA
TEST
SITE
RAINIER MESA
AREA 12 CAMP
SEDAN CRATER
PAHUTE MESA CONTROL POINT
BUCKBOARD MESA
TIMBER MTN.
DANNY BOY
BREN TOWER
RAINIER MESA RD.
ROAD
YUCCA FLAT
YUCCA LAKE
CONTROL POINT
MERCURY HWY.
SHOSHONE MTN.
BUFFER ZONE
NUCLEAR ROCKET DEVELOPMENT STATION
C.P. FLATS
JACKASS
WELLS RD.
CANE SPRING RD.
CANE SPRING
SKULL MTN.
JACKASS FLATS ROAD
FRENCHMAN FLAT
FRENCHMAN LAKE
LATHROP
ECOLOGY RINGS
LATHROP WELLS
MERCURY
DESERT ROCK AIRSTRIP (5000 FT) ELEV. 3200
U.S. HWY. 95
LAS VEGAS
BEATTY
NYE CO.
LINCOLN CO.
CLARK CO.
20 19 12 15 8 10 9 2 4 17 16 18 7 1 3 30 14 6 11 29 26 (401) 27 (410) 25 (400) 28 5 22 23
LEGEND
N.T.S. BOUNDARY
COUNTY LINE
AREA BOUNDARY
PAVED ROADS
DIRT ROADS
NEVADA TEST SITE
GRAPHIC SCALE

Figure No. 2



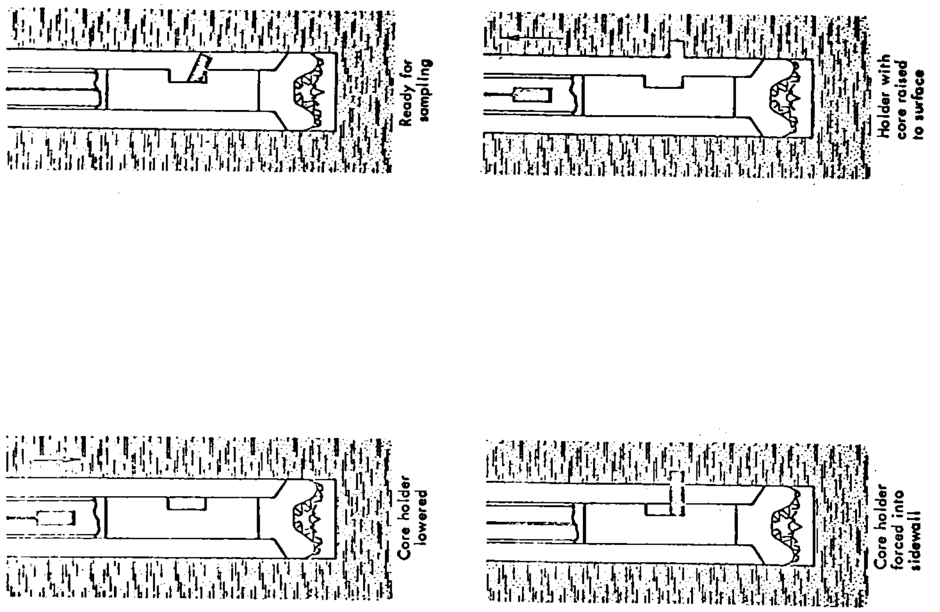
Three methods of postshot drilling at NTS.

FIGURE NO.3



Circulation of drilling fluid. From the mud pump (A) the fluid goes to the swivel (B), from the swivel down through the kelly (C), through the drill stem (D) to the bit (E). At the bit the drilling fluid washes the cuttings from the bit and the bottom of the hole and carries them back to the surface through the annulus (F). At the surface, a pipe carries the cuttings in suspension through a shale shaker (G), which removes the cuttings from the drilling fluid. From the shaker the drilling fluid goes to the mud pit (H) and the whole cycle is begun again.

FIGURE NO. 4



Four steps in taking a sidewall sample.

FIGURE NO. 5

Figure 6: OUTSIDE VIEW OF ACCESS CONTROL TRAILER

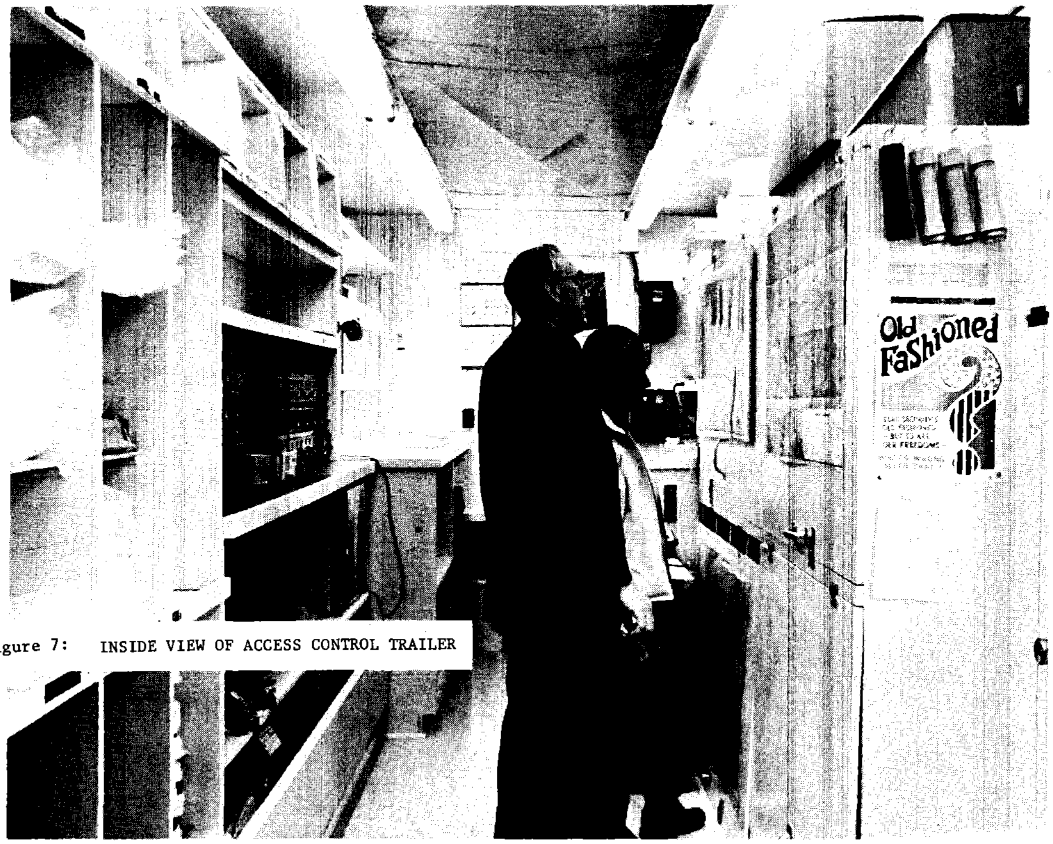


Figure 7: INSIDE VIEW OF ACCESS CONTROL TRAILER

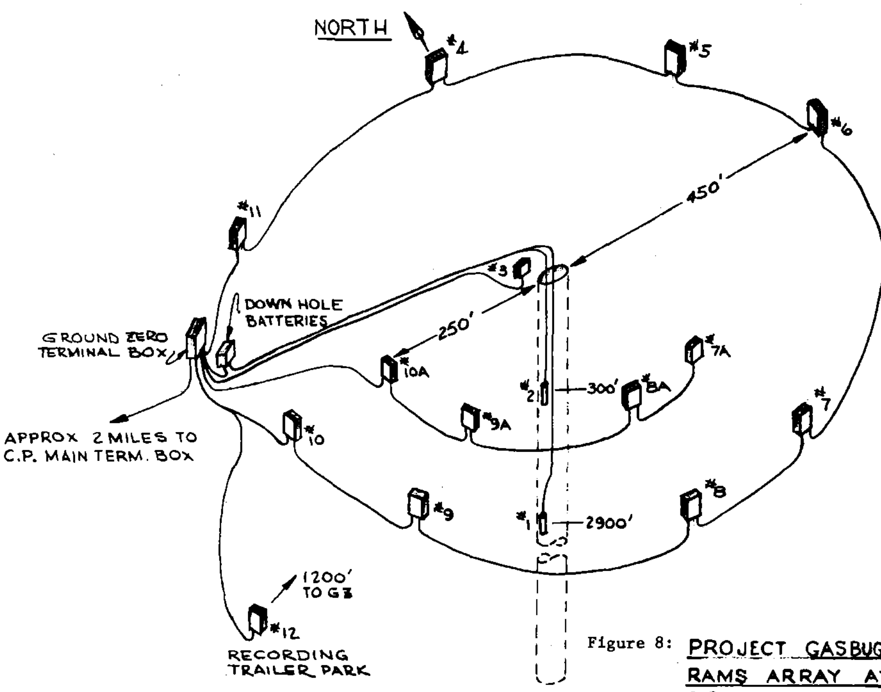


Figure 8: PROJECT GASBUGGY RAMS ARRAY AT SGZ

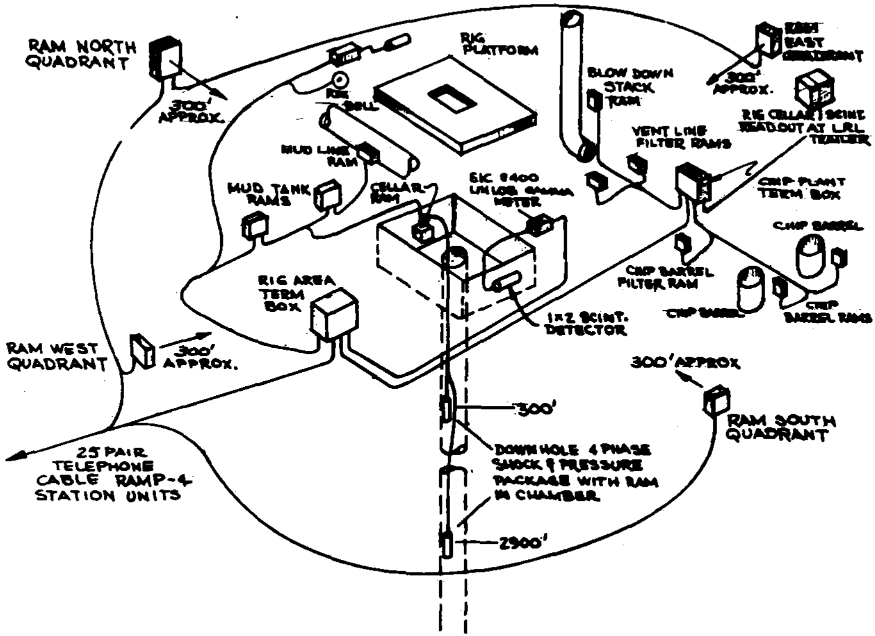


Figure 9: PROJECT GASBUGGY RAMS ARRAY FOR POST SHOT DRILLING

QUESTIONS FOR DONALD HENDRICKS

1. From Tom Rozzell:

   How long is monitoring for seepage continued after each shot?

   ANSWER:

   As long as necessary, sometimes the seepage has lasted for a few hours and other times it has lasted for a number of days. We try to monitor it until we are sure that it has stopped. I should mention that in some cases we are able to stop these seepages. It depends strictly on how they occur. If it is coming through the stemming inside the emplacement casing, we are able to put cement or something in there to try and stop it. If it's leaking from just broken ground or a crater, stopping it is not always possible. You can pour a cement pad over it and it will continue to leak around the edges and we will monitor it as long as it is seeping.

2. From Robert Karsh:

   Under your definition of a "contained" detonation, how much gaseous radiation release is permissible before you conclude the detonation was not contained?

   ANSWER:

   We, on occasion, have small releases as mentioned before from cables around the emplacement hole - in general they range from a few curies and by few I mean a few 10's to 100 curies or so and my personal opinion is that they are satisfactorily contained. They are not, in general, detectable outside the immediate ground zero area.

3. From Sidney Porter:

   You stated that a total of 10% of Gasbuggy allowed exposure was the maximum. What was this allowed exposure and how was the actual exposure measured?

   ANSWER:

   The guidelines which were used, and note I am addressing myself only to on-site workers here, the guidelines are those which are contained in AEC Manual, Chapter 0524 and are essentially similar to those contained in Part 20 with minor differences, but in this case it's three rem per year external exposure, five times N-18 and the rest of that. I didn't bring the exact numbers, but these are measured from film badges, pocket dosimeters and that sort of thing. There was also a urinalysis done on those people for whom any internal exposure of tritium was suspected.

4. From Robert Karsh:

A radioactive nature lover from Las Vegas recently tripped the monitoring device at Kennedy airport with dust in his pants cuffs. Does this imply excessive distribution of vented radiation?

ANSWER:

Well, I would like to know the details on the story. We heard the same rumor and checked it out and the last I heard there was no foundation to the story.

5. From Sydney Porter:

In Project Gasbuggy, what was the total exposure in man-rems? How was this exposure received? How can it be reduced in future operations?

ANSWER:

I guess I should clarify one thing, when those down-hole rams detected the leakage of gas, the radioactivity coming up through the stemming, rather, the first sign of this was seen at something like five hours, and when it indicated that the levels as measured by the down-hole rams were continuing to rise somewhat, the cables were cut and the hole was sealed off. Something less than a curie of noble gases was released. I believe it is in the neighborhood of one curie which is the reason, of course, the PHS monitors could not see it off-site. As far as the original question goes, only two individuals associated with the project received external exposures as measured by film badges. A radiological monitor received 70 mrem while one of the laboratory scientists received 105 mrem. The monitor's exposure is believed to have been incurred while working with radioactive sources during instrument calibration. The scientist's exposure was probably incurred at the Nevada Test Site while working on another project. Neither exposure is considered to be related to any release of radioactive material from the Gasbuggy detonation.

From the day of the detonation through April 1969, there have been no measurable internal exposures (as determined by urinalysis).