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OPERATIONS
TOGGLE, ARBOR, & BEDROCK

EVENTS: DIAMOND SCULLS, DIDO QUEEN, HUSKY ACE, MING BLADE, HYBLA FAIR, & DINING CAR

20 July 1972 - 5 April 1975

[redacted]

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United States Underground Nuclear Weapons Tests
Underground Nuclear Test Personnel Review

Prepared by Field Command, Defense Nuclear Agency

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This report is a personnel-oriented history of DOD participation in underground nuclear weapons testing during OPERATIONS TOGGLE, ARBOR, & BEDROCK; EVENTS: DIAMOND SCULLS, DIDO QUEEN, HUSKY ACE, MING BLADE, HYBLA FAIR, & DINING CAR, 20 July 1972 - 5 April 1975. It is the fifth in a series of historical reports which will include all DOD underground nuclear weapons tests and all DOE underground nuclear weapons tests with significant DOD participation from 1962 forward. In addition to these historical reports, a restricted distribution report will identify all DOD and DOD affiliated participants (military, civilian and DOD contractors) and will list their radiation dosimetry data.

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HUSKY ACE
MING BLADE
HYBLA FAIR
DINING CAR

SUMMARY

Six Department of Defense (DOD)-sponsored underground test events were conducted from 20 July 1972 through 5 April 1975 to study weapons effects. All six were tunnel-type nuclear tests. The following table summarizes data on these events:

OPERATION	TOGGLE		ARBOR		BEDROCK	
TEST EVENT	DIAMOND SCULLS	DIDO QUEEN	HUSKY ACE	MING BLADE	HYBLA FAIR	DINING CAR
DATE	20 Jul 72	6 Jun 73	12 Oct 73	19 Jun 74	28 Oct 74	5 Apr 75
LOCAL TIME (hours)	1016 PDT	1000 PDT	1000 PDT	0900 PDT	0700 PST	1245 PDT
NTS LOCATION	U12t.02	U12e.14	U12n.07	U12n.08	U12n.09	U12e.18
TYPE	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
DEPTH (feet)	1,391	1,284	1,356	1,276	1,326	1,257
YIELD★	Low	Low	Low	Low	Low	Low

★LOW INDICATES LESS THAN 20 KILOTONS

No release of radioactive effluent was detected onsite or offsite after any test events discussed in this volume.

As recorded on Area Access Registers, 10,173 individual entries to radiation exclusion (radex) areas were made after the above DOD test events. Of this number 887 were by DOD-affiliated personnel (including military, DOD civilian, and DOD contractor). The remainder were United States Atomic Energy Commission (AEC)*, other government agency, and other contractor personnel.

The average gamma radiation exposure per entry for all participants was 3 mR. The average gamma radiation exposure per entry for DOD-affiliated participants was 10 mR. The maximum exposure of a non-DOD participant during an entry was 265 mR. The maximum exposure of a DOD-affiliated participant was 495 mR. These maximum exposures were during the HYBLA FAIR and DIDO QUEEN events, respectively.

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*The U.S. Energy Research and Development Administration (ERDA) succeeded the U.S. Atomic Energy Commission (AEC) on 19 January 1975.

PREFACE

The United States Government conducted 194 nuclear device tests from 1945 through 1958 during atmospheric test series at sites in the United States and in the Atlantic and Pacific Oceans. The U.S. Army's Manhattan Engineer District (MED) implemented the testing program in 1945, and its successor agency, the AEC, administered the program from 1947 until testing was suspended by the United States on 1 November 1958.

Of the 194 nuclear device tests conducted, 161 were for weapons related or effects purposes, and 33 were safety experiments. An additional 22 nuclear experiments were conducted from December 1954 to February 1956 in Nevada. These experiments were physics studies using small quantities of fissionable material and conventional explosives.

President Eisenhower had proposed that test ban negotiations begin on 31 October 1958, and had pledged a one-year moratorium on United States testing to commence after the negotiations began. The Conference on Discontinuance of Nuclear Weapons Tests began at Geneva on 31 October 1958, the U.S. moratorium began on 1 November, and the AEC detected the final Soviet nuclear test of their fall series on 3 November 1958. Negotiations continued until May 1960 without final agreement. No nuclear tests were conducted by either nation until 1 September 1961 when the Soviet Union resumed nuclear testing in the atmosphere. The United States began a series of underground tests in Nevada on 15 September 1961, and U.S. atmospheric tests were resumed on 25 April 1962 in the Pacific.

The United States conducted several atmospheric tests in Nevada during July 1962, and the last U.S. atmospheric nuclear test was in the Pacific on 4 November 1962. The Limited Test Ban Treaty, which prohibited tests in the atmosphere, in outer space, and underwater, was signed in Moscow on 5 August 1963. From resumption of United States atmospheric testing on 25 April 1962 until the last atmospheric test on 4 November 1962, 40 weapons development and weapons effects tests were conducted as part of the Pacific and Nevada atmospheric test operations. The underground tests, resumed on 15 September 1961, have continued on a year-round basis through the present time.

In 1977, 15 years after atmospheric testing stopped, the Center for Disease Control (CDC)* noted a possible leukemia cluster within the group of soldiers who were present at the SMOKY test event, one of the Nevada tests in the 1957 PLUMBBOB test series. After that CDC report, the Veterans Administration (VA) received a number of claims for medical benefits filed by former military personnel who believed their health may have been affected by their participation in the nuclear weapons testing program.

In late 1977, the DOD began a study to provide data for both the CDC and the VA on radiation exposures of DOD military and civilian participants in atmospheric testing. That study has progressed to the point where a number of volumes describing DOD participation in atmospheric tests have been published by the Defense Nuclear Agency (DNA) as the executive agency for the DOD.

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*The Center for Disease Control was part of the U.S. Department of Health, Education, and Welfare (now the U.S. Department of Health and Human Services). It was renamed The Centers for Disease Control on 1 October 1980.

On 20 June 1979, the United States Senate Committee on Veterans' Affairs began hearings on Veterans' Claims for Disabilities from Nuclear Weapons Testing. In addition to requesting and receiving information on DOD personnel participation and radiation exposures during atmospheric testing, the Chairman of the Senate Committee expressed concern regarding exposures of DOD participants in DOD-sponsored and Department of Energy (DOE)* underground test events.

The Chairman requested and received information from the Director, DNA, in an exchange of letters through 15 October 1979 regarding research on underground testing radiation exposures. In early 1980, the DNA initiated a program to acquire and consolidate underground testing radiation exposure data in a set of published volumes similar to the program under way on atmospheric testing data. This volume is the fifth of several volumes regarding participation and radiation exposures of DOD military and civilian participants in underground nuclear test events.

SERIES OF VOLUMES

Most volumes in this series discuss DOD-sponsored underground test events, in chronological order, after presenting introductory and general information. These volumes cover all except one category of underground test events identified as DOD-sponsored in <u>Announced United States Nuclear Tests</u>, published each year by the DOE Nevada Operations Office, Office of Public Affairs. The category of events not covered includes events conducted as nuclear test detection experiments in a program named VELA-UNIFORM. Generally, reentries after these tests were not

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*The U.S. Department of Energy succeeded the U.S. Energy Research and Development Administration (ERDA) in October 1977.

performed, so significant exposure of participants to radiation did not occur.

A later volume will discuss general participation of DOD personnel in DOE-sponsored underground test events, with specific information on those events which released radioactive effluent to the atmosphere and where exposures of DOD personnel were involved.

A separate set of books (comprising one volume) is a census of DOD personnel and their radiation exposure data. Distribution of this volume is limited by provisions of the Privacy Act.

METHODS AND SOURCES USED TO PREPARE THE VOLUMES

Information for these volumes was obtained from several locations. Security-classified documents were researched at Headquarters, DNA, Washington, D.C. Additional documents were researched at Field Command, DNA, the Air Force Weapons Laboratory Technical Library, and Sandia National Laboratories in Albuquerque, New Mexico. Most of the radiation measurement data were obtained at the DOE, Nevada Operations Office (DOE/NV), and its support contractor, the Reynolds Electrical & Engineering Company, Inc. (REECo), in Las Vegas, Nevada.

Unclassified records were used to document underground testing activities when possible, but, when necessary, unclassified information was extracted from security-classified documents. Both unclassified and classified documents are cited in the List of References at the end of each volume. Locations of the reference documents also are shown. Copies of most of the unclassified references have been entered in the records of the Coordination and Information Center (CIC), a DOE facility located in Las Vegas, Nevada.

Radiation measurements, exposure data, event data, and off-site reports generally are maintained in hard copy or microfilm form at the REECo facilities adjacent to the CIC or as original documents at the Federal Archives and Records Center, Laguna Niguel, California. The Master File of all available personnel exposure data for nuclear testing programs on the continent and in the Pacific from 1945 to the present also is maintained by REECo for DOD and DOE.

ORGANIZATION OF THIS VOLUME

A summary of this test event volume appears before this preface and includes general objectives of the test events, characteristics of each test event, and data regarding DOD participants and their radiation exposures.

An introduction following this preface discusses reasons for conducting nuclear test events underground, the testing organization, the NTS, and locations of NTS underground testing areas.

A chapter entitled "Underground Testing Procedures" explains the basic mechanics of underground testing, purposes of effects experiments, containment features and early containment problems, tunnel and shaft area access requirements, industrial safety and radiological safety procedures, telemetered radiation exposure rate measurements, and air support for underground tests.

A chapter on each test event covered by this volume follows in chronological order. Each test event chapter contains an event summary, a discussion of preparations and event operations, an explanation of safety procedures implemented, and listings of monitoring, sampling, and exposure results.

A reference list and appendices to the text, including a glossary of terms and a list of abbreviations and acronyms, follow the event chapters.

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CHAPTER 1

INTRODUCTION

The first United States nuclear detonation designed to be fully contained underground was the RAINIER tunnel event conducted by the University of California Radiation Laboratory (UCRL) for the AEC in Nevada on 19 September 1957. This was a weapons-related experiment with a relatively low yield of 1.7 kilotons (kt). The second tunnel event with a significant nuclear yield was a safety experiment on 22 February 1958, also conducted in Nevada by UCRL for AEC. This experiment, the VENUS event, resulted in a yield of less than one ton. These two tunnel events and five additional underground safety experiments with zero or only slight yields were the beginning of the United States underground nuclear testing program, currently the only type of nuclear detonation testing permitted by treaty. The first DOD-sponsored underground nuclear weapons effects test was the 5.7 kt HARD HAT event conducted by the Defense Atomic Support Agency (DASA) on 15 February 1962 in Nevada.

1.1 HISTORICAL BACKGROUND

While technical conferences between the United States and the Soviet Union on banning nuclear detonation tests continued, and concern regarding further increases in worldwide fallout mounted, a number of nuclear tests were conducted underground during 1958 in Nevada. Prior to the United States testing moratorium, six safety experiments in shafts, five safety experiments in tunnels, and four weapons development tests in tunnels were conducted by user laboratories. Radioactive products from several of these tests were not completely contained underground.

Containment of nuclear detonations was a new engineering challenge. Understanding and solving the majority of containment problems would require years of underground testing experience.

When the United States resumed testing on 15 September 1961, the first 32 test events were underground, including a cratering experiment with the device emplaced 110 feet below the surface. The DOMINIC I test series in the Pacific and the DOMINIC II test series in Nevada (also called Operation SUNBEAM by DOD) during 1962 included the last atmospheric nuclear detonation tests by the United States.

The commitment of the United States to reduce levels of worldwide fallout by refraining from conducting nuclear tests in the atmosphere, in outer space, and underwater was finalized when the Limited Test Ban Treaty with the Soviet Union was signed on 5 August 1963.

1.2 UNDERGROUND TESTING OBJECTIVES

The majority of United States underground tests have been for weapons-related purposes. New designs were tested to improve efficiency and deliverability characteristics of nuclear explosive devices before they entered the military stockpile as components of nuclear weapons.

In addition to weapons-related tests, safety experiments with nuclear devices also were conducted by user laboratories. These experiments tested nuclear devices by simulating detonation of conventional high explosives in a manner which might occur in an accident during transportation or storage of weapons.

Weapons effects tests sponsored by the DOD were conducted to determine the vulnerability or survivability of military systems or components when exposed to one or more effects of a nuclear detonation. The nuclear devices for these tests were provided by the AEC weapons development laboratories and were designed to be similar to the nuclear components used in nuclear weapons. Actual weapon configurations were used in a few test events. Military systems, structures, materials, electronics experiments, and other related experiments were provided by DOD and AEC agencies. Many of these tests were very complex and involved greater numbers of participants than other categories of tests previously mentioned. Personnel from DASA, other government organizations, user laboratories and contractors, and DOD contractor agencies were involved.

Some tests were designed to study the response of hardened structures or geologic formations to shock waves generated by nuclear detonations. Many tests were designed to study the response of military components to effects of radiation produced by nuclear weapons. Such tests required a direct line of sight between the nuclear device and the experiments. Many of the radiation effects tests required the simulation of high altitude (up to exoatmospheric) conditions. These tests involved installation of experiments inside large steel line-of-sight (LOS) pipes, hundreds of feet in length, with maximum diameters of several feet. Large vacuum pumps were utilized to reduce pressure inside the pipes to the desired level.

DOD weapons effects tests DIAMOND SCULLS, 20 July 1972, through DINING CAR, 5 April 1975, conducted during Operations TOGGLE, ARBOR, and BEDROCK are discussed in this volume.

1.3 DOD TESTING ORGANIZATIONS AND RESPONSIBILITIES

Administering the underground nuclear testing program was a joint AEC-DOD responsibility. The similar nature of the AEC-DOD organizational structure is shown in Figure 1.1.

1.3.1 Defense Nuclear Agency

Headquarters of the Defense Nuclear Agency is located near Washington, D.C., and is composed of personnel from each of the Armed Services and civilian DOD employees. It was originally established as the Armed Forces Special Weapons Project (AFSWP) to assume residual functions of the Manhattan Engineer District (MED), through issuance of a joint Army-Navy memorandum, dated 29 January 1947, which was retroactive to 1 January 1947 (when the Atomic Energy Commission was activated). The responsibility for DOD nuclear weapons effects testing was assigned to AFSWP. The National Security Act of 1947 had become law when the Secretary of Defense issued a memorandum on 21 October 1947 to the three Service Secretaries confirming the previous directive of 29 January, and thus, AFSWP officially represented all of the services. AFSWP was charged with providing nuclear weapons support to the Army, Navy, and Air Force. As originally chartered, AFSWP was directly responsible to each of the three Service Chiefs. In 1951, the Air Force Special Weapons Center (AFSWC) located at Kirtland Air Force Base (KAFB), Albuquerque, New Mexico, was assigned by DOD the responsibility to provide specific support to the AEC for continental nuclear testing (see Section 1.3.2). This command was not directly related to AFSWP; however, the two organizations coordinated several support tasks.

By issuance of General Order No. 2, Headquarters, DASA, dated 6 May 1959, AFSWP was redesignated the Defense Atomic Support Agency. Under its new charter, DASA was responsible to the Secretary of Defense through the Joint Chiefs of Staff. DASA's five major areas of responsibility for the DOD included:

A. Staff assistance to the Office of the Secretary of Defense, through the Joint Chiefs of Staff.

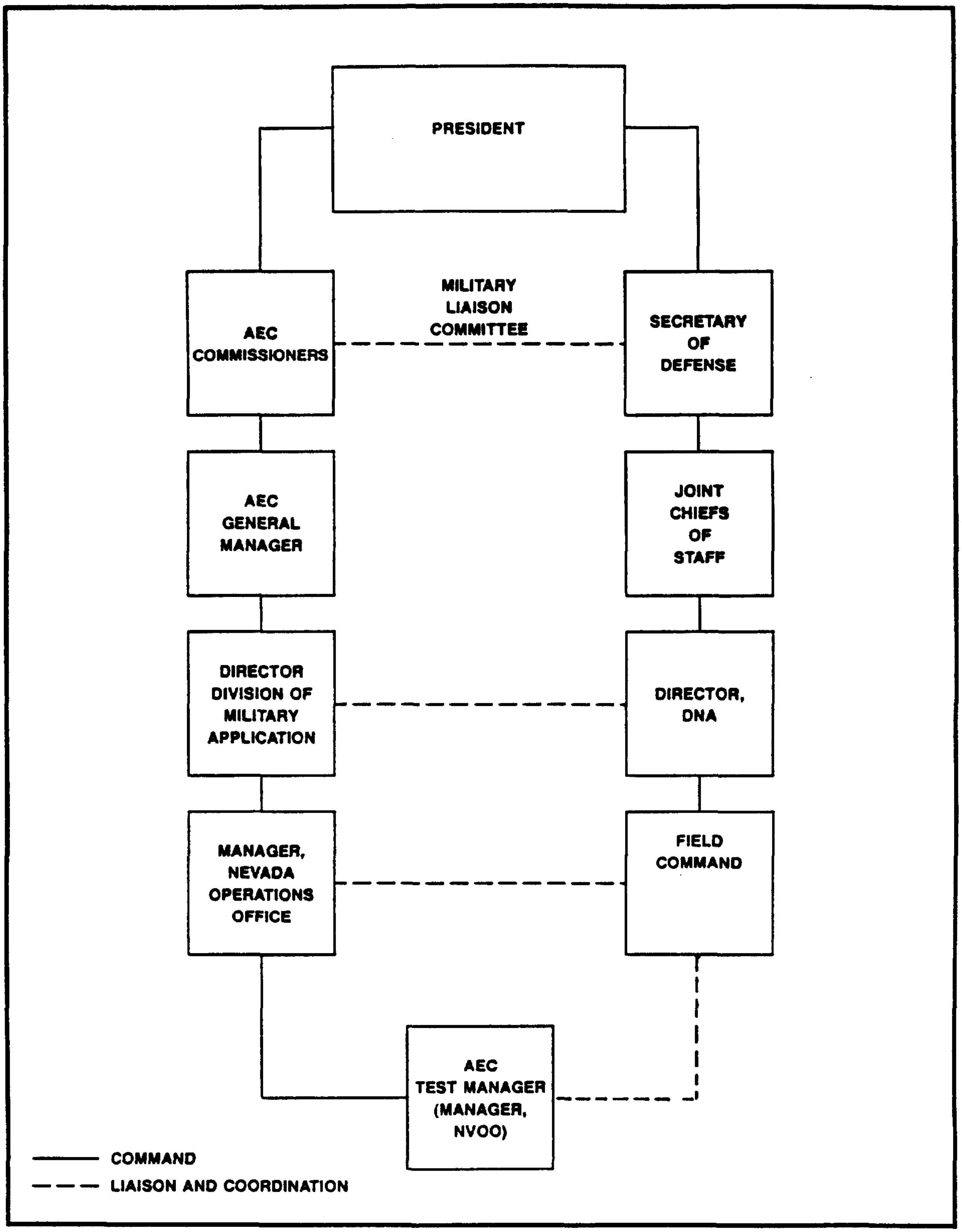


Figure 1.1 Federal Government Structure for Continental Nuclear Tests (1972)

B. Research in weapons effects.

C. Atomic tests.

D. Weapons development.

E. Assistance to the Services.

Responsibilities of Headquarters, DASA (HQ/DASA), included providing consolidated management and direction for the DOD nuclear weapons effects testing programs, while technical direction and management of field operations of DOD nuclear weapons effects testing activities were delegated to Field Command, DASA (FC/DASA), located at Sandia Base (now KAFB) in Albuquerque, New Mexico. From 6 May 1959 until 1 July 1964 the Weapons Effects Tests Group (WETG) of FC/DASA was responsible for nuclear weapons effects testing and seismic detection research responsibilities (VELA-UNIFORM) for the Director, DASA. This organization maintained close liaison with the AEC/Nevada Operations Office (NVOO). Personnel from FC/DASA became the military members of the joint AEC-DOD testing organization at the Nevada Test Site (NTS) and at other Continental United States test locations. Participation of DOD agencies and their contractors in nuclear field tests was coordinated and supported by FC/DASA. On 1 July 1964, the testing organization in Albuquerque was designated as the Weapons Test Division (WTD), a division of HQ/DASA. On 1 August 1966, WTD was changed to Test Command (TC/DASA), a separate command under HQ/DASA, but remained in Albuquerque. The responsibilities for technical direction and management of field operations for nuclear weapons effects tests remained in effect during these changes in organization. During this period, WTD and TC maintained an engineering and support branch (designated Nevada Branch) at the NTS and a liaison office at AEC/NVOO. The Nevada Branch maintained liaison with AEC/NVOO and supervised FC/DASA activities at NTS. On 12 May 1970, the Commander, FC/DASA, assumed additional command of TC/DASA.

On 29 March 1971 (effective 1 July 1971), the Deputy Secretary of Defense directed the reorganization of DASA as a result of cutbacks recommended by the "Blue Ribbon Panel" survey of agency activities. In his Executive Memorandum, DASA was retained as a defense agency under the new title, "Defense Nuclear Agency." On 1 July 1971, FC/DASA was redesignated as FC/DNA, and TC/DASA became TC/DNA. While the responsibilities and manning levels at Field Command were reduced during this transition, Test Command remained essentially the same.

On 1 January 1972, TC/DNA was disestablished and personnel were transferred to FC/DNA. The responsibilities for technical direction and management of field operations for nuclear weapons effects tests were transferred to the newly formed Test Directorate [Field Command Test (FCT)] of FC/DNA. The Nevada Branch of TC was changed to the Test Construction Division of Test Directorate (FCTC), and the responsibility for the liaison office at AEC/NVOO was transferred to FCTC (see Figure 1.2).

1.3.2 Air Force Support

Until 1 July 1974, AFSWC provided air support to the Nevada Test Site Organization (NTSO) during nuclear tests at the NTS. Detachment 1 of the 4900th Test Group provided aircraft for shuttle service between KAFB, New Mexico, and Indian Springs Air Force Auxiliary Field (ISAFAF) in Nevada. They also provided aircraft and crews to perform low-altitude cloud tracking, radio relay support, and courier missions. On 1 July 1974, Detachment 1, 4900th Test Group, was consolidated with the 57th Fighter Weapons Wing, Tactical Air Command, at Nellis Air Force Base. Detachment 1 was inactivated at ISAFAF, and personnel, aircraft, equipment, and supplies were transferred to the 57th Fighter Weapons Wing (FWW). Operations provided by Detachment 1 and the 57th FWW after the transfer were:

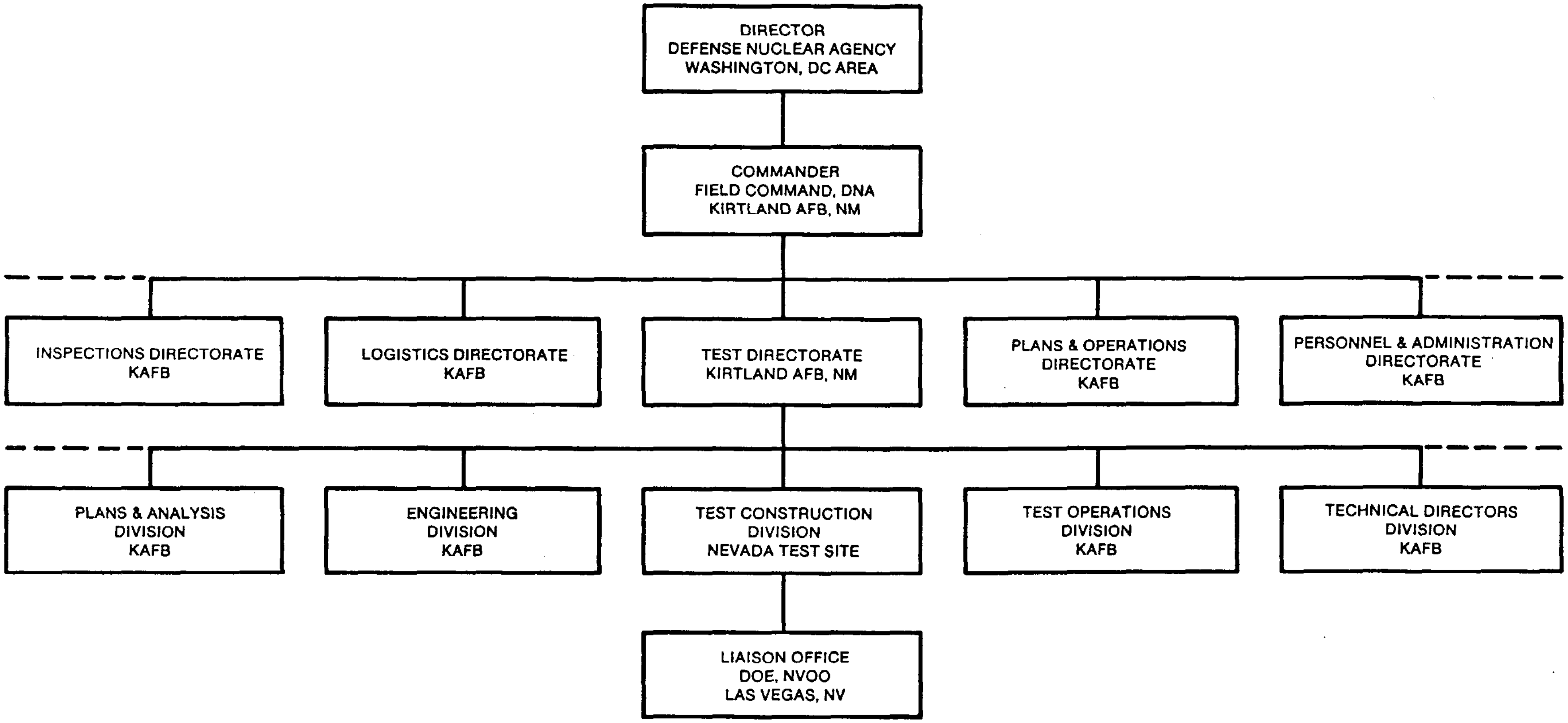


Figure 1.2 Partial Organization Chart of Field Command, Defense Nuclear Agency (1972)

A. Normal technical support and laboratory photography flights as required, including preevent areas, postevent documentation, and new construction.

B. Security perimeter sweeps to cover the NTS boundary, check the local barricades, and look for areas where intruders could gain access to the NTS unobserved.

C. Operational orientation tours and management surveillance flights, as required, or as requested by the hierarchy of either group.

D. Security sweeps of closed areas on D-1 day.

E. Airborne closed-circuit television for check-out operations on D-day.

F. D-day helicopter safety sweeps and Test Controller standby missions to be flown prior to zero time and cover the downwind area for personnel and livestock locations to facilitate rapid evacuation of personnel and/or reentry of scientific personnel as necessary.

G. D-day helicopter airborne closed-circuit television support to provide a stable platform for both television and color photography coverage of surface ground zero (SGZ) at zero time.

H. D-day helicopter cloud surveillance. This mission (not to be considered "cloud tracking") provided intitial data for immediate onsite decisions for any needed safeguard actions.

I. Damage survey flights as required.

J. Other support flights as requested by the AEC Test Controller and approved as operationally feasible.

Other Air Force organizations providing support to the NTSO under AFSWC control on a temporary basis were as follows:

K. Elements of the 1211th Test Squadron (Sampling), Military Airlift Command, McClellan AFB, were detached to ISAFAF. Their primary task was cloud sampling. Personnel from this unit also assisted NTSO radiological safety personnel in providing support at ISAFAF, including decontamination of crews, equipment, and aircraft.

L. Elements of the 4520th Combat Crew Training Wing, Tactical Air Command, Nellis AFB, Nevada, provided support functions, such as housing, feeding, and logistics, to the units operating from ISAFAF and Nellis AFB. In addition, they conducted security sweep flights over NTS and control tower operations, fire-fighting, and crash rescue services at ISAFAF, and equipment was provided and maintained for the helicopter pad at the NTS Control Point (CP) and other helicopter pads at each Forward Control Point (FCP).

M. The 55th Weather Reconnaissance Squadron, Military Airlift Command, McClellan AFB, supplied one aircraft and crew to perform cloud tracking.

N. The Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson AFB, provided aircraft and crews to perform technical projects.

1.3.3 AEC-DOD Relationships

DOD was responsible for establishing criteria for nuclear weapons, developing and producing delivery systems, developing nuclear weapons plans and forces, providing defense against nuclear attack, and obtaining nuclear weapons effects data through DNA. The AEC was responsible for research and development, production, and supply of nuclear weapons to the Armed Forces in quantities and types specified by the Joint Chiefs of Staff. Quantities and types of weapons were described in the Nuclear Weapon Stockpile Memorandum, signed jointly by the Secretary of Defense and the Chairman of the Atomic Energy Commission, and approved by the President. The AEC, in association with the DOD, also was responsible for providing field nuclear test facilities in the Continental United States and overseas.

The principal points of field coordination between the AEC and the DOD were at NVOO in Las Vegas and at NTS. From the beginning of the DOD underground nuclear weapons effects test program (the first test was HARD HAT in February 1962) until the present, Field Command (or Test Command) was the fielding agency for DOD-DNA and served as primary point of contact with AEC/NVOO. AEC/NVOO and its predecessors represented AEC in the field for all Continental tests. The AEC nuclear weapons development laboratories fielded underground tests as part of the weapons development program; DNA fielded underground tests at NTS to obtain weapons effects data. Because the NTS was an AEC installation, the Manager, NVOO, was responsible for all operations there.

For each DOD-sponsored test, HQ/DNA coordinated requirements with the military services. Requirements for testing to determine the nuclear vulnerability or hardening of military systems or components were submitted by these organizations. As part of long-range underground nuclear weapons effects test planning, HQ/DNA developed a schedule of specific events designed to satisfy military requirements. One or more of the DOD agencies were cosponsors and, usually, active participants in each DOD underground test. The initial approval of DOD experiments and the selection of the nuclear source (device) for each test was accomplished at the HQ/DNA level. A request for the appropriate nuclear device and associated support was forwarded by HQ/DNA to the Director, Division of Military Application, AEC. The AEC assigned one or more of the weapons development laboratories to provide the device support.

Following initial planning, the responsibility for detailed planning, engineering, fielding, execution, and reporting was assigned to FC/DNA. Field Command formed a Test Group staff for each test. The Technical Director (normally a military officer assigned to FC/DNA or AFWL) was appointed by HQ/DNA. The Test Group Director and other members of the staff were appointed by FC/DNA. The Test Group Engineer normally was selected from Field Command Test Construction (FCTC), Nevada Branch.

The Test Group staff developed detailed test plans and schedules. Engineering and construction plans were developed by Nevada Branch and coordinated with NTSO. Final engineering designs were developed by AEC contractors at NTS - Holmes & Narver, Inc. (H&N), and/or Fenix & Scisson, Inc. (F&S). Engineering drawings were approved by FCTC and NTSO prior to actual construction. Construction was performed by the principal AEC support contractor - Reynolds Electrical & Engineering Co., Inc. (REECo). FCTC and members of the Test Group staff monitored construction activities. The FC/DNA Test Group staff coordinated development of technical experiments and initiated action to obtain required support equipment (e.g., steel LOS pipe and mechanical closures). The Test Group staff reviewed the technical support requirements submitted by experimenter agencies and transmitted consolidated requirements to Nevada Branch which, in turn, advised the NTSO of future requirements.

During the construction phase, Nevada Branch began collecting containment-related information. During drilling or mining operations, rock cores were analyzed for bulk density, moisture content, grain density, porosity (determined by the difference between bulk and grain densities), unconfined compressive strength, triaxial compression (for a variety of confining pressures), ultrasonic shear and compressive wave velocities, carbon dioxide content, presence of clay which could swell, and other features. Testing was done for DNA primarily by the H&N Testing Lab at NTS (Mercury) and Terra Tek, a DNA contractor located at Salt Lake City, Utah, as part of the DNA containment research program.

Geologic features of the tunnels were examined and mapped as construction progressed, usually by an AEC contractor. Several months prior to planned event execution, FC/DNA prepared a document which contained a general description of the test, site geologic information, types and locations of mechanical closures, details of concrete plugs, a summary of analytical calculations, and other related test history. This document was reviewed by Containment Evaluation Panel (CEP, see section 2.1.3) members and formally presented by FC/DNA to the CEP for categorization and recommendation for execution.

The FC/DNA Test Group staff normally moved to NTS a few months prior to the planned event execution date (three to six months depending upon the complexity of the test). Prior to arrival of DOD experimenter personnel, Nevada Branch made arrangements to provide required instrumentation and recording facilities, office space and equipment, communications equipment, vehicles, photographic, and other support items. Housing and food services for DOD personnel at NTS were provided by REECo. Upon arrival at NTS, DOD personnel were briefed on safety and security by the Test Group staff and other DOD and AEC personnel. Experimenter agencies were provided with copies of FC/DNA security and safety plans. These briefings included radiation safety control policies, procedures, and equipment.

Under the supervision of the Test Group staff, experimenter personnel installed experiments and checked out instrumentation cables and recording systems. A series of electrical dry runs were conducted from the user laboratory control room and DNA monitor room at the Control Point (CP) complex (see 1.5) to determine that all signals and remotely-controlled equipment were functioning properly. After all systems were declared ready, permission was requested from the AEC to install the nuclear device. Installation and check out were conducted by the participating device development laboratory with AEC security safeguarding the device and other classified materials. The next activities consisted of placing stemming materials in preplanned locations and checking all containment features.

When the test facility was ready for event execution, control of the entire test and experiment area was transferred to the AEC/NVOO Test Controller and his staff. When the Test Controller was satisfied that all conditions were satisfactory to detonate the device, he gave permission to the user laboratory to arm the device and initiated the final countdown.

The Test Controller and his staff at the CP monitored the countdown, detonation, and postevent response of remotely controlled radiation monitoring equipment. When released by the Test Controller, REECo Radiological Safety (Radsafe) teams entered the area to monitor for radiation and other safety hazards. After assurance that reentry could be accomplished, the Test Controller released experimenters to collect recorded data from surface areas. All of these operations were conducted in accordance with preevent plans developed by the AEC Test Controller staff, the DOD test group staff, and Nevada Branch personnel, unless postevent conditions required modifications.

For tunnel events, initial reentry into the tunnel was authorized by the AEC Test Controller after he determined that conditions were safe for reentry operations. Tunnel reentry was controlled by Nevada Branch personnel with assistance from Sandia Laboratories, Albuquerque (SLA), health physicists, REECo Radsafe personnel, and REECo construction personnel. After the tunnel was declared safe for experiment recovery, the Test Group staff assumed control of the area. Based on REECo Radsafe monitoring data, FC/DNA personnel determined when it was safe to remove the experiments. Experimenters then removed experiments for analysis and documentation of results.

1.4 AEC ORGANIZATIONS, CONTRACTORS, AND RESPONSIBILITIES

1.4.1 Atomic Energy Commission

The AEC was created by the Atomic Energy Act of 1946 in July, the same month the Joint Chiefs of Staff were conducting Operation CROSSROADS with assistance from the U.S. Army's Manhattan Engineer District. MED was disestablished and the AEC and AFSWP assumed MED functions on 1 January 1947. The Atomic Energy Act was revised in 1954 and has been amended extensively since.

The AEC established headquarters (AEC/HQ) offices in Washington, DC, and operations offices in areas which were centers of AEC operations. In areas of lesser activity, area offices, branch offices, and field offices were established. The Director of the Division of Military Application (DMA) in AEC/HQ was delegated responsibility for the nuclear weapons development and testing program. The Director of DMA was always a flag officer of one of the armed forces, as specified by the Atomic Energy Act of 1954, and he was an Assistant General Manager in the AEC organization.

In 1951, the Director of DMA designated and delegated his responsibility for conduct of on-continent tests to the Test Manager who also was Manager of the AEC Santa Fe Operations Office (SFOO) near Los Alamos Scientific Laboratory. Later in 1951, SFOO was moved to Albuquerque. With delegated authority from the Director of DMA, the Manager, SFOO, designated Test Managers for on-continent tests. The same authority applied when SFOO became the Albuquerque Operations Office (ALOO) in 1956. The AEC Las Vegas Field Office (LVFO), established in 1951, managed the Nevada Test Site (called the Nevada Proving Ground from 1952 to 1955) for the Test Manager. LVFO became a Branch Office in 1955, an Area Office in 1960, and the Nevada Operations Office (NVOO) in 1962, with the Manager, NVOO, or his representative designated as Test Manager. In 1972, the Test Manager became the Test Controller.

The Director of DMA initiated the chain of authority and approval for detonating each nuclear device by requesting that each user laboratory and DNA submit proposed test programs to DMA. This request was made in the spring of each year for tests to be conducted in the next fiscal year. DMA consolidated proposed test programs, developed a test program proposal while consulting with DOD, and generated a program approval request. DMA then presented the proposed test program to the National Security Council (NSC) Ad Hoc Committee on Nuclear Testing. Chaired by the NSC, this committee included representatives of the DOD, Joint Chiefs of Staff, Department of State, Arms Control and Disarmament Agency, Office of Management and Budget, Office of Science and Technology, and Central Intelligence Agency. After incorporating informal Committee comments, DMA forwarded the proposed program from the Secretary of Energy to the President through the NSC. The NSC solicited and incorporated formal comments in its recommendation to the President.

Test program approvals were requested at six-month intervals. Approval of tests for the first six months was received at the beginning of each fiscal year. The process was repeated six months later for tests in the last half of the fiscal year. Presidential approvals were signed by the Assistant to the President for National Security Affairs. Subsequently, test program authority messages were sent from the Director of DMA to the device development (user) laboratories, DNA, and AEC/NVOO.

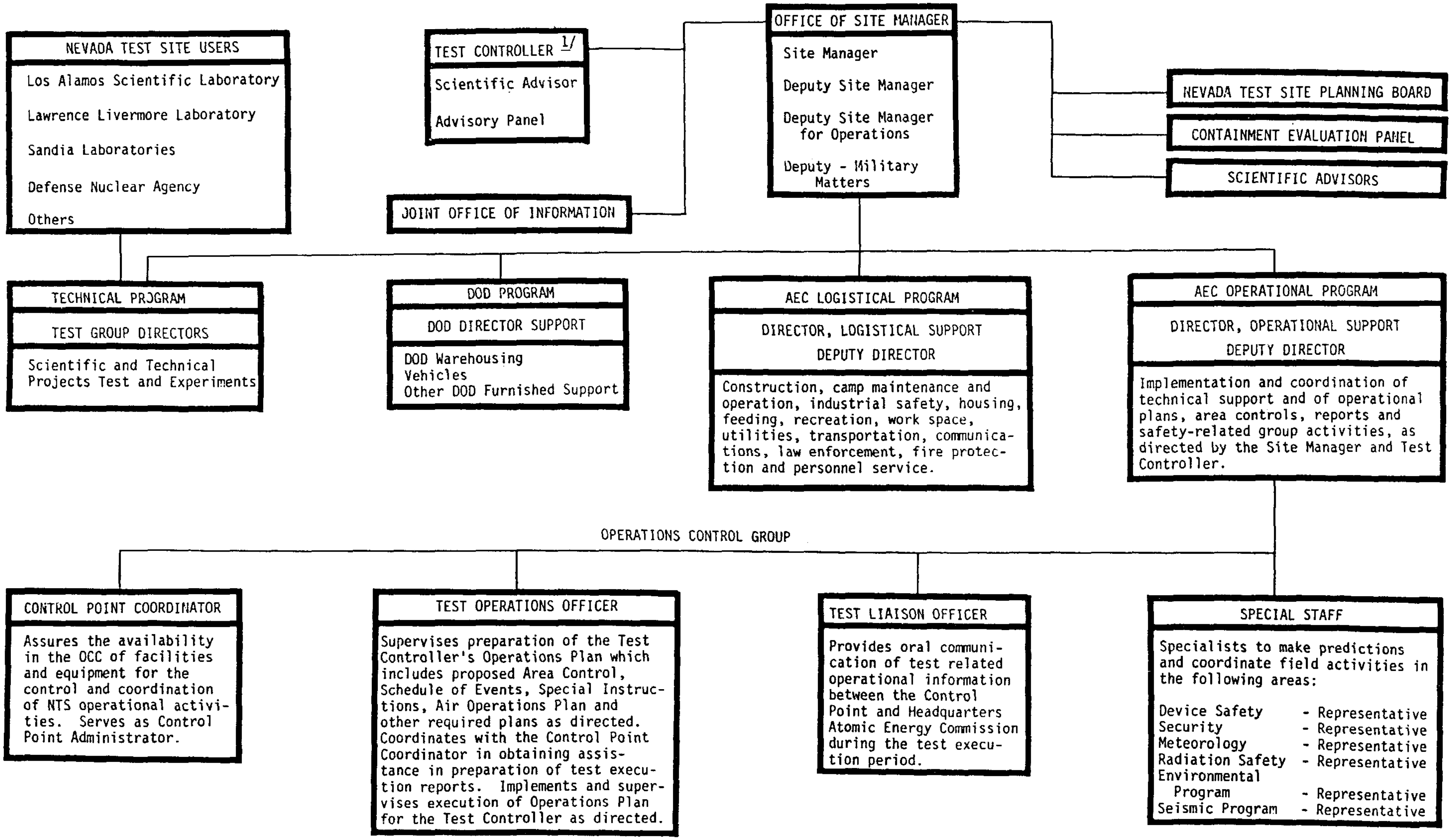
Authority to detonate each nuclear device was handled separately and individually. The technical content of detonation authority requests originated in presentations to the CEP by the user laboratory or DNA. After recommendations by the CEP, the Manager, NVOO, requested detonation authority from DMA. Required information in each request included statements on compliance with treaties, environmental impact, public announcement plans, test program authority, and any particularly noteworthy aspects of the test. After DMA and additional AEC reviews, the Manager, NVOO, was notified of detonation authority approval.

The Manager, AEC/NVOO, was named the Test Controller in 1972, and he or the representative he designated as Test Controller was responsible for conducting each test event in this volume. The Energy Research and Development Administration (ERDA) succeeded the AEC on January 19, 1975. The DINING CAR event (see Chapter 8 of this volume) was conducted by ERDA.

1.4.2 Nevada Test Site Organization

As stated in Chapter 0101 of the Nevada Test Site Organization Standard Operating Procedure (NTSO SOP) Chapter 0101-01 (see Appendix E), the NTSO included AEC, DOD, user laboratory, contractor, agency, and organizational personnel who participated in or provided support for test operations at the NTS. The Manager, NVOO, headed the NTSO. (Figure 1.3) The NTSO was a

NEVADA TEST SITE ORGANIZATION



Construction, camp maintenance and operation, industrial safety, housing, feeding, recreation, work space, utilities, transportation, communications, law enforcement, fire protection and personnel service.

Implementation and coordination of technical support and of operational plans, area controls, reports and safety-related group activities, as directed by the Site Manager and Test Controller.

Assures the availability in the OCC of facilities and equipment for the control and coordination of NTS operational activities. Serves as Control Point Administrator.

Supervises preparation of the Test Controller's Operations Plan which includes proposed Area Control, Schedule of Events, Special Instructions, Air Operations Plan and other required plans as directed. Coordinates with the Control Point Coordinator in obtaining assistance in preparation of test execution reports. Implements and supervises execution of Operations Plan for the Test Controller as directed.

Provides oral communication of test related operational information between the Control Point and Headquarters Atomic Energy Commission during the test execution period.

Specialists to make predictions and coordinate field activities in the following areas:

[1] Designated for each test or special experimental effort. Assumes operational control of NTS when directed by Manager, NVOO.

Figure 1.3 Nevada Test Site Organization (1972) continuing task organization whose composition could be readily changed in response to the needs and technical objectives of each test. The Continental Test Organization (CTO) was part of the original NTSO; however, it was disestablished on 1 August 1962 with its responsibilities (e.g., Military Deputy to the Manager, NVOO) being assumed by FC/DASA, WETG and subsequently by FC/DNA, Test Directorate. The Military Deputy to the Test Manager, as shown in Figure 1.3, was from Field Command and was responsible for coordinating DOD programs and support to NTSO.

1.4.3 NTSO Radiological Safety

The Test Controller was responsible for protection of participating personnel and offsite populations from radiation hazards associated with activities conducted at NTS. By mutual agreement between the Test Manager and a scientific user (see section 1.4.4), control of radiation safety within the area assigned for a particular activity was delegated to the user's Test Group Director during the period of time when such control could have had a direct bearing on the success or failure of the scientific program.

The onsite radiological safety support contractor (Radsafe) was responsible to the Test Manager for both routine and test event radiological safety onsite as detailed in Appendix D, USAEC NTSO SOP Chapter 0524, "Radiological Safety." During test events, as shown in Figure I of Appendix D and as discussed above, the Test Manager delegated control of radiation safety in the immediate test area to the user Test Group Director when the Director requested control. When this occurred, Radsafe was responsible to the Test Group Director through his radiological safety organization for support in his test area.

The U.S. Environmental Protection Agency (EPA), was responsible to the Test Manager for operation of the offsite radiological safety program in accordance with procedures listed in Appendix D.

1.4.4 NTS Scientific Users

The NTS scientific users were DNA (for nuclear weapons effects) and the development laboratories: Los Alamos Scientific Laboratory (LASL), Lawrence Livermore Laboratory (LLL), and Sandia Laboratories, Albuquerque (SLA). LASL and LLL were primarily involved in testing for weapons development while SLA conducted a limited number of weapons effects tests and supported weapons development tests. A brief description of these laboratories follows:

A. LASL was established early in 1943 as Los Alamos, Project Y, of the MED for the specific purpose of developing an atomic bomb. Los Alamos scientists supervised the test detonation of the world's first atomic weapon in July 1945 at the TRINITY site in New Mexico. Los Alamos became LASL in January 1947, when the AEC and AFSWP were activated to replace the MED. The Laboratory's continuing assignment was to conceive, design, test, and develop nuclear components of atomic weapons. The contract under which LASL performed work for the AEC was administered first by the Commission's Santa Fe Operations Office and later by the Albuquerque Operations Office. The Laboratory was operated by the University of California.

B. LLL (originally the University of California Radiation Laboratory and then the Lawrence Radiation Laboratory) was established as a second AEC weapons laboratory at Livermore, California, in 1952. The Laboratory's responsibilities essentially were parallel to those of LASL. Devices developed by LLL first were tested in Nevada in 1953, and LLL-developed devices were tested in each Continental and Pacific series since. The contract under which LLL performed work for the AEC was administered by the AEC San Francisco Operations Office. This Laboratory also was operated by the University of California.

C. SLA at Sandia Base (now KAFB), Albuquerque, New Mexico, was the AEC's other weapons laboratory. It was established in 1946 as a branch of Los Alamos, but in 1949 assumed its identity as a full-fledged weapons research institution operated by the Sandia Corporation, a non-profit subsidiary of Western Electric. SLA's role was to conceive, design, test, and develop the non-nuclear phases of atomic weapons and to do other work in related fields. In 1956, a Livermore Branch of Sandia Laboratories was established to provide closer support to developmental work of the LLL. Sandia Laboratories also operated ballistic test facilities for the AEC at the Tonopah Ballistics Range (now Tonopah Test Range) near Tonopah, Nevada.

1.4.5 Test Support Organizations

In keeping with its policy, the AEC used private contractors for maintenance, operations, and construction (including military and civil defense construction) at the NTS. NVOO personnel administered all housekeeping, construction, and related services activity, but performance was by contractors. Major support contractors were the following:

<u>Reynolds Electrical & Engineering Company, Inc.,</u> was the principal AEC operational and support contractor for the

NTS, providing electrical and architectural engineering, state-of-the-art large diameter and conventional shaft drilling, heavy-duty construction and excavation, mining and tunneling, occupational safety and fire protection, radiological safety, toxic gas and explosive mixture monitoring, communications and electronics, power distribution, occupational medicine, and other support functions. REECo maintained offices in Las Vegas and extensive facilities necessary to operate NTS.

Edgerton, Germeshausen & Grier, Inc., of Boston, Massachusetts, was the principal technical contractor, providing control point functions such as timing and firing, and diagnostic functions such as scientific photography and measurement of detonation characteristics. In addition, EG&G personnel manned the DOD monitor room. EG&G support facilities were maintained in Las Vegas and at NTS.

Holmes & Narver, Inc., performed architect/engineer services for the NTS and was the principal support contractor for the Commission's off-continent operations. H&N had a home office in the Los Angeles area, and also maintained offices in Las Vegas and at NTS.

Since 1963, Fenix & Scisson, Inc., Tulsa, Oklahoma, was a consultant architect/engineer for drilling and mining operations in connection with underground nuclear testing. The company was involved in design of many underground structures and in the field of deep, large-diameter, hole drilling. Las Vegas Branch activity was conducted from offices in Las Vegas and Mercury, Nevada.

Numerous other contractors, selected on the basis of lump-sum competitive bids, performed various construction and other support functions for the AEC and the DOD.

1.5 THE NEVADA TEST SITE

An on-continent location was selected for conducting nuclear weapons tests; construction began at what was called the Nevada Test Site in December 1950, and testing began in January 1951. The name was changed to the Nevada Proving Ground (NPG) in March of 1952 and again changed to the Nevada Test Site in 1955.

The original boundaries were expanded as new testing areas and projects were added. Figure 1.4 shows the present NTS location bounded on three sides by the Nellis Air Force Range. NTS encompassed about 1,350 square miles in 1975. This testing location was selected for both safety and security reasons. The arid climate, lack of industrialization, and exclusion of the public from the Nellis Air Force Range resulted in a very low population density in the area around NTS.

The only paved roads within the NTS and Nellis Air Force Range complex were those constructed by the government for access purposes. NTS testing areas were physically protected by surrounding rugged topography. The few mountain passes and dry washes where four-wheel drive vehicles might enter were posted with warning signs and barricades. NTS security force personnel patrolled perimeter and barricade areas in aircraft and vehicles. Thus, unauthorized entry to NTS was difficult, and the possibility of a member of the public inadvertently entering an NTS testing area was extremely remote.

Figure 1.5 shows the NTS, its various area designations, and the locations of the six test events covered by this volume. In a location designation such as "U12n.07," the "U" signifies an underground location, "12" identifies the area at NTS, "n" denotes the tunnel, and "07" indicates the number of the drift.

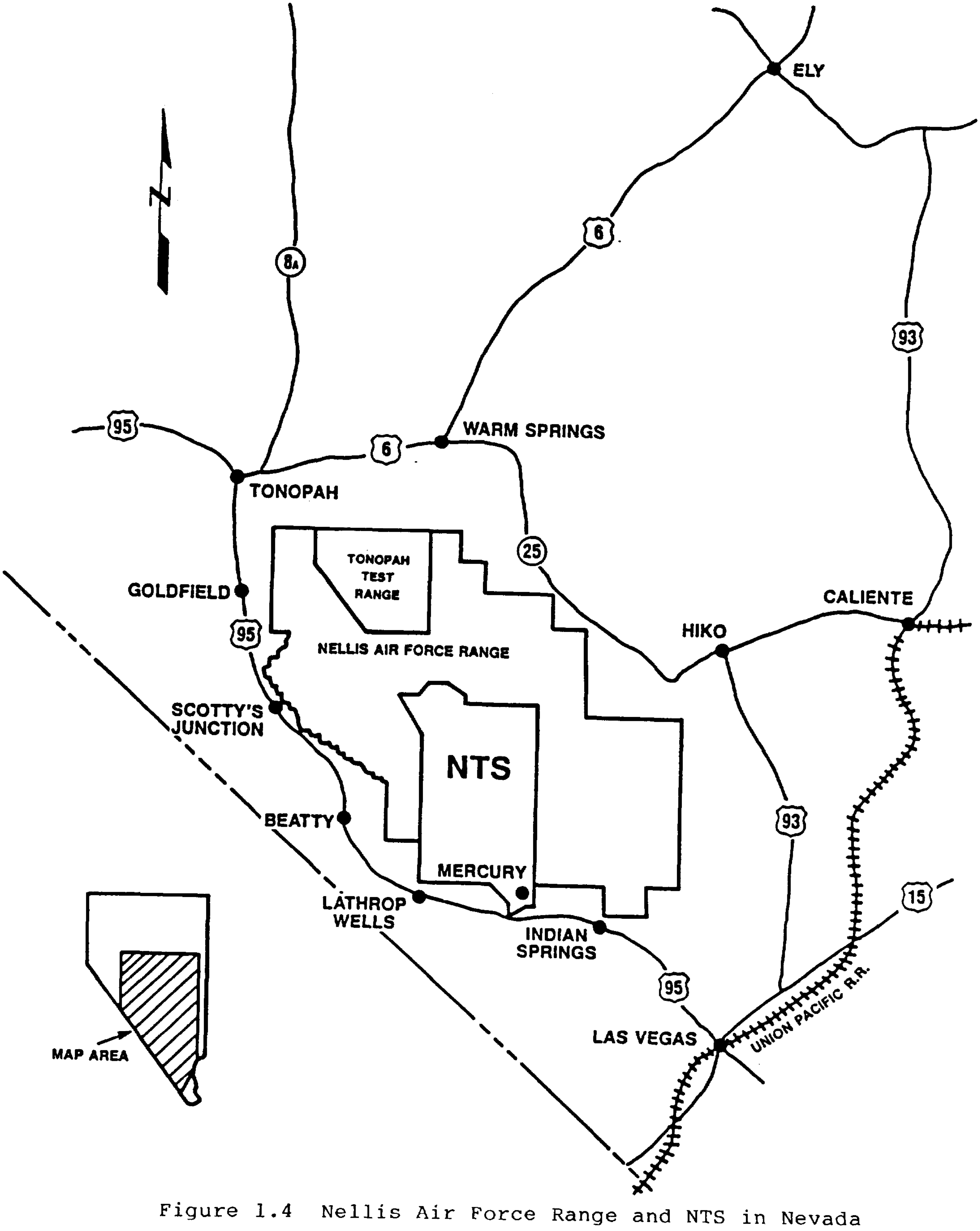


Figure 1.4 Nellis Air Force Range and NTS in Nevada

ADDENDUM

For

DNA 6324F

OPERATIONS TOGGLE, ARBOR, & BEDROCK
EVENTS: DIAMOND SCULLS, DIDO QUEEN, HUSKY ACE, MING BLADE, HYBLA FAIR &
DINING CAR - 20 July 1972 - 5 April 1975

Enclosed, for your convenience, is an enlargement of Figure 1.5 The Nevada Test Site. Please insert before page 43 of your report.

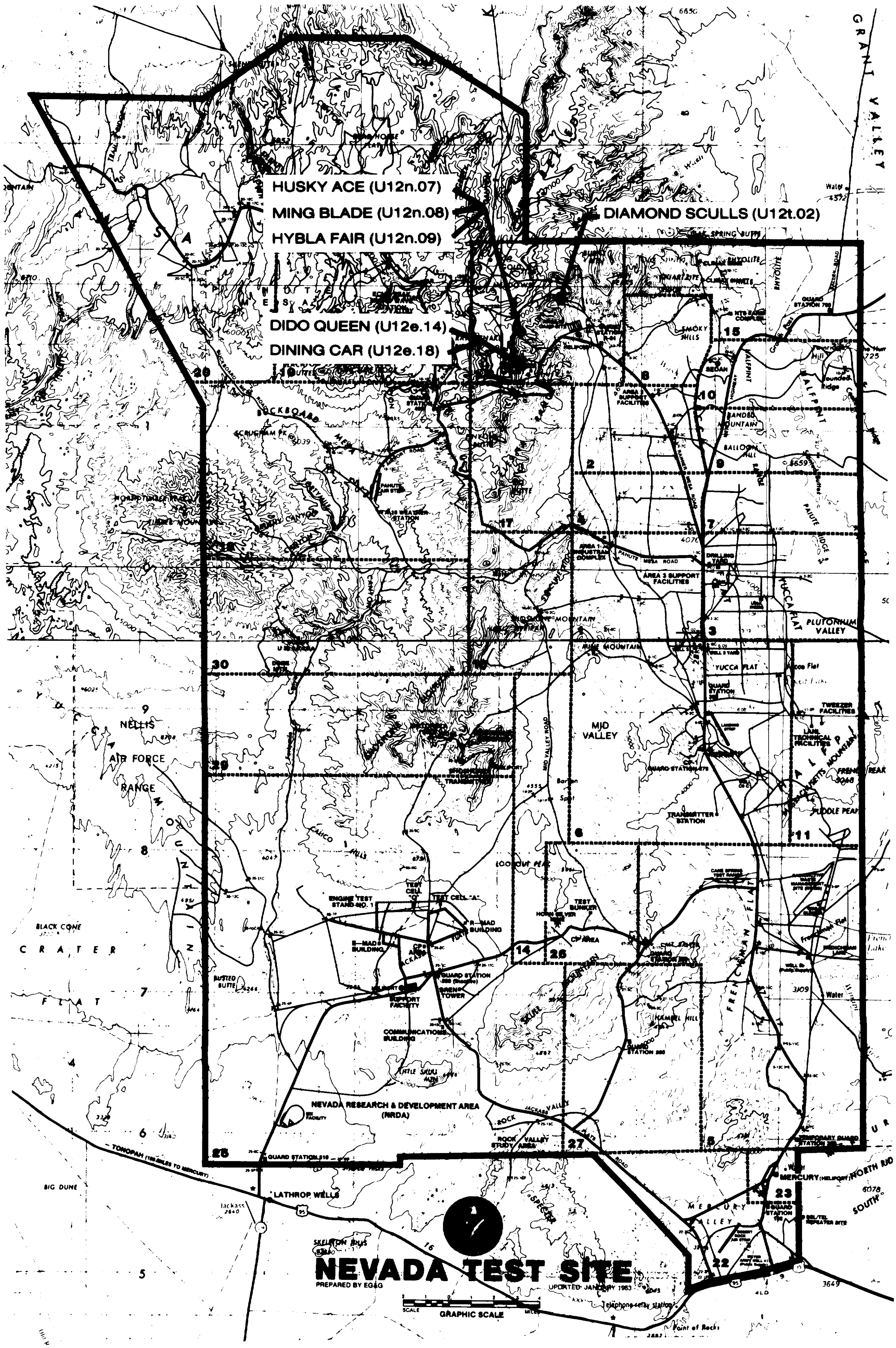


Figure 1.5 The Nevada Test Site

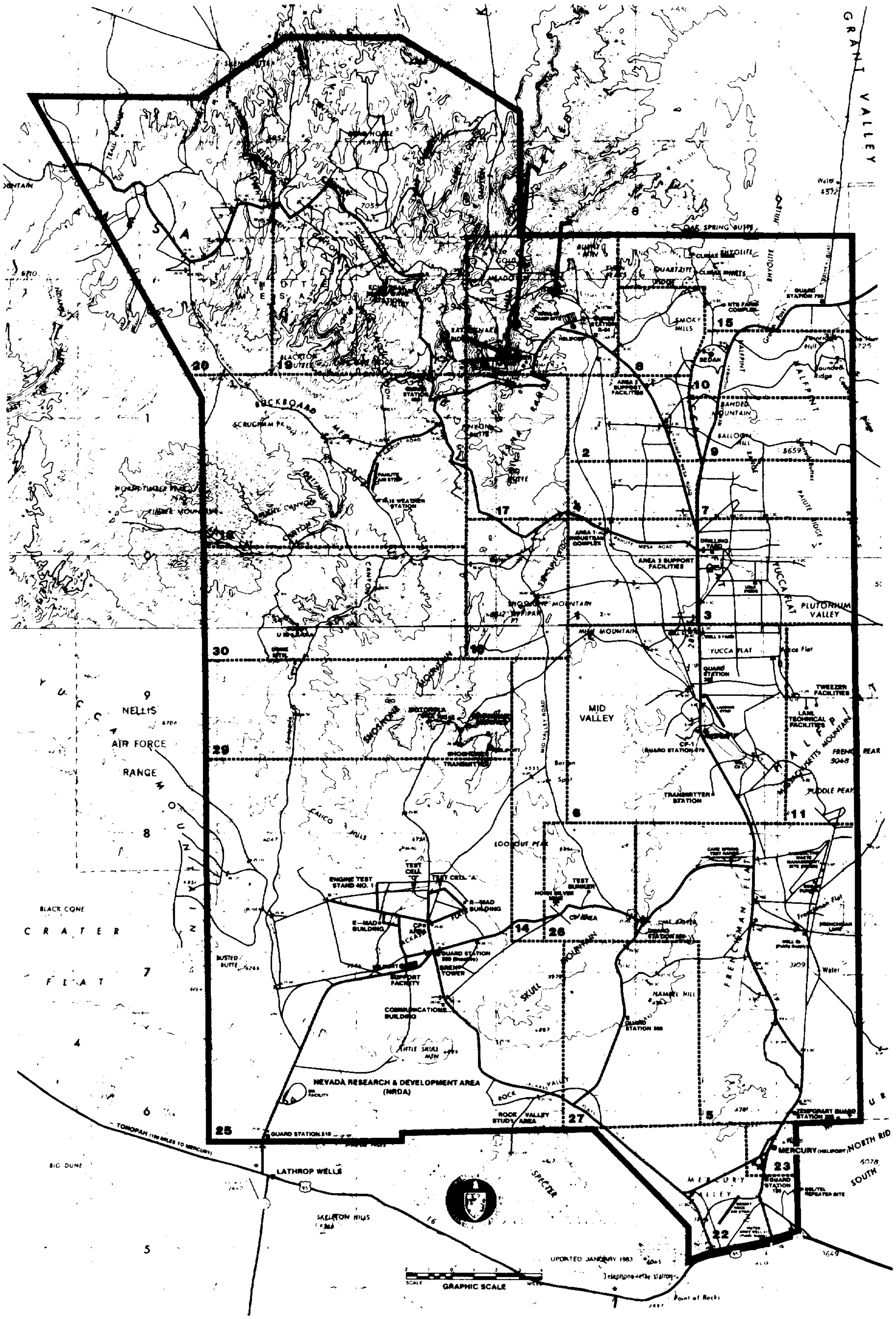


Figure 1.5 The Nevada Test Site

A low mountain range separated the base camp, Mercury, from the location of early AEC and DOD atmospheric tests at Frenchman Flat in Area 5. Frenchman Flat also was later used for DOD underground testing. The elevation of Frenchman Dry Lake in the middle of the Flat is about 3,100 feet.

A mountain pass separates Frenchman Flat from Yucca Flat testing areas. The pass overlooks both Frenchman and Yucca Flats and contains the CP complex of buildings including Control Point Building 1 (CP-1) where timing and firing for most atmospheric tests were performed, and Control Point Building 2 (CP-2) where radiological safety support was based.

Yucca Flat testing areas include Areas 1, 2, 3, 4, 7, 8, 9, and 10. Underground tests were conducted in some of these areas and generally were shaft emplacement types. The elevation of Yucca Dry Lake at the south end of Yucca Flat is about 3,900 feet. To the west of Yucca Flat, in another basin, is the Area 18 testing location. Some DOD atmospheric tests were conducted in Area 18, and one DOD cratering event, DANNY BOY, was conducted on Buckboard Mesa in this area at an elevation of about 5,500 feet. Area 16 is in the mountains west of Yucca Flat toward Area 18. The single Area 16 tunnel complex (at an elevation of about 5,400 feet) was a DOD underground testing location.

Rainier Mesa is in Area 12, northwest of Yucca Flat. The top of the Mesa is at an elevation of about 7,500 feet. All DOD tunnel-type emplacement events on NTS that were not in the Area 16 tunnel complex or the Area 15 shaft and tunnel complex were in Rainier Mesa and the adjoining Pahute Mesa. (Parts of T tunnel were constructed in the adjoining Pahute Mesa.) The major Rainier Mesa tunnel complexes were B, E, G, N, and T tunnels.

Area 15 is in the foothills at the north end of Yucca Flat. The deeper of the two access shafts drops 1,500 feet below the surface elevation of 5,100 feet. There were three events conducted in Area 15, all sponsored by DOD. HARD HAT and TINY TOT were discussed in Report DNA 6320F, Operations NOUGAT and WHETSTONE, while PILE DRIVER was discussed in Report DNA 6321F, Operations FLINTLOCK and LATCHKEY.

CHAPTER 2

UNDERGROUND TESTING PROCEDURES

Underground tests conducted at the NTS prior to 1962 were primarily for weapons development or were safety tests. These tests were controlled by the AEC and conducted by LASL or LLL. Experience gained in the area of containment of radioactivity underground during these tests provided the basic concepts for the development of containment plans for the DOD/DNA sponsored underground nuclear weapons effects tests which followed. These DOD tests were generally more complex than earlier AEC tests and required the development of new containment concepts and hardware.

A primary consideration in all underground tests was the safety of test participants and the general public, especially regarding exposures to radioactive materials. This chapter discusses, in general terms, the basic mechanics of underground testing, containment and procedures, types of emplacement, diagnostic techniques, area access requirements, industrial and radiological safety, and radiation measuring systems.

2.1 CONTAINMENT, PROBLEMS, AND PROCEDURES

Completely containing radioactive material underground while accomplishing diagnostic measurements and effects experiments proved to be a major engineering challenge. Original efforts considered only detonation containment in competent rock formations. It was necessary to modify the original efforts to consider zones of weakness in rock caused by faults and containment failures resulting from diagnostic and experiment structures. Under certain conditions, particularly the presence of clay or a high water content in the rock near the detonation point, greater than normal stresses could be generated and these stresses could adversely affect containment. Some containment failures were partially attributable to additional overpressure from secondary gas expansion, i.e., steam pressure. The major containment features and problems that evolved are discussed below.

2.1.1 Vertical Shaft Containment

Some of the first shaft-type safety experiments were in unstemmed shafts with concrete plugs penetrated by cable and instrumentation holes. When nuclear yields were produced, these emplacements did not completely contain the radioactive debris. The first method used to fully contain nuclear detonations in shafts was stemming, e.g., filling the shaft with aggregate and sand after device emplacement.

Keyed concrete plugs at different depths in the shaft stemming sometimes were used. The shaft diameter was enlarged at the plug construction location so the poured concrete plug would key into the ground surrounding the shaft and provide more strength against containment failure. Combinations of concrete and epoxy were used later, and epoxy replaced concrete as a plug material for some shaft-type emplacements.

Radiochemical sampling pipes, LOS pipes, and other openings in stemming and plug containment features had to be closed rapidly after the detonation to prevent venting of radioactive effluent to the atmosphere. Closure systems driven by high explosives or compressed air were developed to seal the openings. After some of these early systems did not prevent releases of effluent to the atmosphere, use of openings to the surface for diagnostic or experiment purposes was discontinued for several years until technology improved.

Scientific and other cables from the device emplacement to the surface were another source of containment problems. While cables could be embedded in concrete and epoxy, which helped prevent leakage along the outside of the cables, radioactive gases under high pressure traveled along the inside of cables as a conduit to the surface. This problem was solved by embedding the inner components of cables in epoxy at appropriate locations (such as in concrete plugs) in a technique called gas blocking.

The most serious containment problems were caused by unanticipated geologic and hydrologic conditions at particular test locations. Even careful and rigorous calculations, engineering, construction, and preparations were inadequate when the presence of a geologic zone of weakness near the detonation point toward the surface was unknown.

Another similar problem was the presence of higher water content than anticipated in rock formations surrounding or near the detonation point. This problem caused greater shock transmission plus secondary gas expansion when the water turned to steam. In addition, presence of sufficient iron in the test configuration caused the disassociation of water with subsequent greater secondary gas expansion from hydrogen gas. A result was much higher and longer sustained pressure from the detonation point toward the surface, and possible subsequent failure of geologic or constructed containment mechanisms.

Recognizing and understanding geologic and hydrologic conditions at each test location was necessary before these containment problems could be solved. As additional information became available through drilling and intensive geologic studies, these problems were lessened by investigations of proposed detonation locations and application of detailed site selection criteria.

2.1.2 Tunnel-Type Containment

As with shaft-type detonations, containment methods used for tunnel events were designed keeping basic characteristics of a nuclear detonation in mind. Tunnel configurations were constructed with device emplacements strategically located to cause sealing of the access tunnel by force of the detonation. Additional containment features were used to contain radioactive debris.

One of the original user laboratory stemming configurations consisted of one or more sandbag plugs installed a short distance from the projected self-sealing location toward the tunnel entrance (portal). Two plugs, each about 60 feet in length, were a typical installation. The sandbag plugs were later changed to solid sand backfill plugs several hundreds of feet long from the device location. In many cases, the sand stemming had short sections of air voids between the plugs. Closer to the portal a keyed concrete plug with a metal blast door was constructed. The blast door was designed to contain any gases [with pressures up to 75 pounds per square inch (psi)] that might penetrate the sandbag plugs.

Also as with shaft-type detonations, the unknown presence of undesirable geologic and hydrologic conditions sometimes caused venting of radioactive effluent either through the overburden (rock above the tunnel) to the surface, through fissures opened between the detonation point and the main tunnel, or through the plugs and blast door to the main tunnel vent holes and portal. More substantial containment features evolved as containment problems became better understood and tunnel events became more complex.

The first DOD tunnel test was MARSHMALLOW (1962). Stemming for that event consisted of four sandbag plugs extending out to a distance of a few hundred feet from the nuclear device (similar to earlier AEC-sponsored events). A gas seal door (blast door) was installed in the main access drift. The next DOD tunnel test used sand backfill (with a few air gaps) out to a few hundred feet. As DOD tunnel testing continued, sand plugs gradually were replaced with various grout mixtures. Some grout mixtures were designed to match the strength and shock propagation of the native tunnel material (usually ash-fall tuff), while other grout mixtures were designed to be weaker and to form a solid stemming plug shortly after device detonation.

Also, as tunnel testing continued, the gas seal (blast) door no longer was used as a containment device and was augmented by strong concrete plugs 10 to 20 feet long between the door and the zero point. These plugs were keyed into the tunnel wall and were designed to withstand overpressures up to 1000 psi. Some of the plugs were penetrated with electrical cables and steel pipes, and a small access hatch was constructed. All of these penetrations were gas sealed (or capped) to provide protection against possible gas seepage through the plug.

Use of horizontal line-of-sight (HLOS) pipes in tunnel events necessitated development of additional closure systems. The HLOS pipe tunnel and its access tunnels generally were separated from the main tunnel by one or more concrete plugs. The additional closure systems primarily were for protection of the experiments inside the HLOS pipe, but they also were considered useful features for the formation of a stemming plug.

The tunnel volume outside of the pipe was filled by stemming or grouting, while the experiments inside the HLOS pipe were protected by mechanical closure systems. Various closure systems were used, including compressed air or explosive-driven gates and doors which closed off the HLOS pipe from the detonation within a small fraction of a second after detonation time. One of these mechanical closures was the tunnel and pipe seal (TAPS) unit, first used on the DOOR MIST event. The TAPS was a heavy steel door that was released at shot time and fell to the closed position in less than one second.

Gas blocking techniques similar to those used in shaft events were used to prevent leakage of radioactive gases along or through cables from the diagnostic and experiment locations to the surface. Additionally, a gas seal door usually was installed in the main drift nearer the portal than the concrete plug. Utility pipes, such as for compressed air, that passed through stemming and plugs also were sealed by closure systems.

2.1.3 Containment Evaluation Panel

When containment problems were particularly difficult, the AEC began to change its emphasis on conditions under which nuclear detonations should be conducted.

AEC had primary responsibility for the underground containment of radioactivity from underground tests. Containment of DOD tests was a joint effort on the part of AEC, DOD, and contractor scientists and engineers. To carry out this responsibility, AEC/NVOO established a Test Evaluation Panel (TEP) on 17 December 1963 to review plans for each test as presented by user testing organizations for each test program. The chairman of this panel represented the Manager, NVOO, and membership consisted of two representatives (one voting member plus an alternate) from each of the user testing organizations (LASL, LLL, SL, and FC/DNA) plus specialists from contractor and other government organizations such as the U.S. Geological Survey (USGS). Other AEC/NVOO contractor personnel were available to present information in their areas of expertise (e.g., mining and drilling operations).

On 19 March 1971, while testing was suspended because containment failure had caused serious venting of a laboratory test (BANEBERRY Event), the TEP was changed to the Containment Evaluation Panel (CEP). The CEP was instructed to give increased emphasis to containment of radioactive material, and the panel membership was enlarged by the addition of a hydrologist, a scientist with expertise in underground nuclear phenomonology (both selected by the Manager, AEC/NVOO), and advisors from organizations representing additional areas of expertise. These permanent advisors were representatives of the EPA, National Oceanic and Atmospheric Administration's Air Resources Laboratory (NOAA/ARL), and REECo. Each underground testing organization was represented as before.

Prior to a formal meeting of the CEP, each user planning a nuclear test prepared written documents describing their proposed tests, with particular emphasis on containment considerations, and submitted these documents to each panel member for review. This information then was presented by the individual users to the CEP, generally at the following meeting (meetings were held about ten times a year). Details of containment plans were reviewed and comparisons to previous successful experiences were reviewed by the CEP. Each CEP member (or alternate) was requested to submit a written statement describing the details considered favorable or unfavorable to successful containment.

Evaluations to estimate the probability of successful containment conformed to specific guidance from the DMA at AEC/HQ. Each CEP member used this guidance to categorize each test as one of the following:

CATEGORY I

> Underground nuclear tests which, on the basis of experience and judgment, will be contained satisfactorily.

CATEGORY II

Underground nuclear tests which are designed to be contained satisfactorily but which, in the judgment of the CEP, cannot be assigned to Category I because of location, configuration or other factors. It is expected that experiments in this category will require special consideration and approval before being conducted.

CATEGORY III

Underground nuclear tests which are expected to release a significant amount of radioactive material. Experiments in this category will require special consideration and approval before being conducted.

A written report on each CEP meeting, containing the statement of each panel member and consultant, was forwarded to AEC/HQ for review and recommendations for approval to execute each event.

2.1.4 Test Manager's Advisory Panel

Careful consideration of each test event by the CEP to avoid releases of radioactive effluent to the atmosphere was followed by additional precautions prior to test event execution. If an unanticipated release of effluent from an underground detonation occurred, it was necessary to assure protection of onsite participants and the offsite population. The Test Manager's Advisory Panel was composed of a Scientific Advisor and representatives from each organization which could contribute information to this protection goal.

This panel met at readiness briefings in advance of each event and in the Control Room prior to and during execution of each event. Panel members briefed the Test Controller on aspects of test activities and meteorological conditions which he considered in his decision on when a test should or should not be conducted. Information presented by the panel included the status of test participants in the test area. In particular, permission to arm and detonate the nuclear device was not given until all participants not at approved manned stations were clear of the controlled test area.

Weather conditions were considered in detail. Wind speeds and directions at increasing altitudes above ground were measured with weather balloons at stations around NTS, both preceding and during each test, to calculate and present information on where an unanticipated release of effluent might be transported off NTS, and what the levels of radiation might be in the predicted effluent cloud directions.

Locations of population centers, locations of each dairy cow, and numbers of people at ranches and mines in the projected effluent cloud directions were presented and evaluated. EPA personnel in offsite areas notified mining people to be above ground for safety purposes at the anticipated detonation time of each test which might cause a ground shock hazard. This information and numbers of people who might need to be advised to stay under cover or be evacuated were presented for consideration. EPA personnel started offsite air samplers and placed radiation dosimeters in offsite locations before detonation time. Readiness information included capability for advising state officials to institute a milk diversion program if cattle feed or milk might become contaminated, and capability to replace milk and dry feed for localized family dairy cows.

Status of standby aircraft for effluent cloud sampling and tracking was presented. Communications between offsite weather stations and EPA personnel were checked to assure proper operation.

Radsafe personnel onsite assured that remote radiation monitoring stations in the test area and in other NTS areas were functional. Data from these stations, the weather stations, offsite EPA personnel, and personnel clearing the test area were displayed in the Control Room for continued visual examination by the Test Controller and the Advisory Panel. In addition, closed-circuit television cameras were operational in the test area on the ground and in helicopters to detect any visual indications of possible effluent release and provide capability for immediate response action by the Test Controller and the Advisory Panel members.

If the Test Controller decided that the projected effluent direction was close to populated areas, or weather conditions were not stable enough to determine the direction of any released effluent after detonation, the approval to arm and detonate was not given, and the test was either postponed for another day or placed on hold until conditions were favorable.

Conditions were considered favorable when projected effluent direction was toward sparsely populated areas, weather conditions were relatively stable, EPA personnel could contact the few residents in the projected effluent direction, and impact on milk supply from dairy cattle would be minimal. In addition, all essential equipment, personnel, and procedures were required to be in readiness status or to have been initiated before permission to arm and detonate was given.

Permission to arm usually was given at least two hours before detonation to allow time for arming, securing of the test configuration and containment systems, and departure of the arming party from the test area. The detonation, however, could be delayed at any moment up to detonation time, or postponed until another day when conditions were favorable.

The Test Controller and Advisory Panel received information, watched visible displays, and communicated with their field personnel up to and after detonation for a sufficient time to assure that venting had not occurred. Remote radiation detection instrument readings and closed-circuit television of the test area were monitored to detect any indication of effluent release.

When all other indications of venting were negative and the Test Controller decided personnel could approach the test location, (e.g., subsidence craters had formed for shaft-type detonations, and cavity collapse had occurred for tunnel-type emplacements, as indicated by geophones) initial radiation survey teams entered the test area to assure that effluent had not been released or that any radiation levels were low enough for experiment data recovery to begin. For tunnel-type tests, reentry of the tunnel itself, after initial survey of surface areas and recovery of data, was a matter for separate and careful consideration by the Test Group Director and radiological safety personnel.

2.1.5 Effluent Release Procedures

If radioactive effluent were to be released from an underground test event, established procedures were initiated in accordance with NTSO 0524, "Radiological Safety" (see Appendix D), "Protection of Participating Personnel and Off-Site Population from Radiation Hazards Associated with Activities Conducted at the NTS." Immediately upon detection of possible venting and effluent release after a detonation, the following procedures were initiated:

A. For some tests, Radsafe survey teams were at manned stations in the test area. These teams, or those standing by outside the cleared area for other tests, were released to make radiation measurements to be used in determining direction and radiation levels of radioactive effluent.

B. Aircraft were standing by to sample and track the effluent. Data reported were used to further refine information on effluent direction and radioactivity concentrations.

C. EPA monitors in offsite areas, previously stationed in the projected path of any released effluent, were advised of actual effluent direction and radioactivity measurement data and directed to move sampling and dosimeter equipment, perform ground radiation surveys, and notify residents and workers in the effluent path of any necessary precautionary measures, such as remaining in buildings or evacuating the area temporarily.

D. Capabilities were held in readiness to advise state officials to implement a milk diversion program. If this were necessary, Nevada and neighboring state officials could be advised to impound and replace milk supplies possibly contaminated through the cattle feed pathway, and hold impounded milk for decay of the probable contaminants (radioiodines) before using it for other purposes. On a localized basis, EPA personnel were ready to replace family dairy cow milk with fresh milk, and analyze milk for concentrations of specific radionuclides. Dry feed supplies also could be replaced for family dairy cattle if required.

E. Capabilities were in readiness for thyroid monitoring of offsite individuals possibly exposed to radioiodines from the effluent. Mobile monitoring stations were ready to be transported to and used in offsite areas for screening measurements to determine if any offsite residents or workers exhibited thyroid radioactivity and should be transported to Las Vegas facilities for more precise thyroid measurements and dose assignment.

Each of the above procedures was established to avoid or minimize exposure of the offsite population and maintain any such exposures below the radiation protection standards for individuals and population groups in uncontrolled areas, as established in NTSO 0524, "Radiological Safety" (see Appendix D).

While the above procedures were to be initiated, additional onsite procedures also were to be implemented. Radsafe survey teams, when released by the Test Controller, surveyed the test area in sufficient detail to plot gamma radiation isointensity lines on NTS maps and provide specific intensity measurements at experiment stations on the surface and at other locations of interest. These data were used by the Test Controller in releasing personnel to enter radiation areas in the controlled area and by the Test Group Director in determining when surveys of his immediate test area and recoveries of experiment data could be accomplished. These decisions were based on calculations of personnel gamma radiation doses from survey data, radiation intensities at recovery locations, and estimated times in area to assure that exposures would be limited only to those necessary and below the standards established in NTSO 0524.

Some tunnel-type tests that did not result in venting of radioactive effluent to the atmosphere did have a failure of the containment system within the tunnel. High radiation levels then existed in locations that reentry personnel needed to enter to accomplish data recovery. Procedures developed to minimize exposures of reentry and recovery personnel included the placement of remote radiation detectors located at strategic tunnel complex locations, tunnel atmosphere remote samplers that removed tunnel air to locations outside the tunnel for analysis, and tunnel air filters that would allow ventilation of tunnels before reentry with only controlled gaseous radionuclide releases to the atmosphere.

Remote monitoring and sampling equipment provided information on radiation levels, toxic gases, and explosive mixtures necessary to determine whether tunnel ventilation should be accomplished before reentry. Tunnel ventilation filters stopped particulate radioactivity, and activated charcoal in the filters absorbed most of the radioiodines, thus allowing primarily only radionuclides of noble gases, such as xenon, to be released to the atmosphere. (Inhaling radionuclides of noble gases results in far less internal exposure than inhaling other fission products.) Release of this radioactive material to the atmosphere in a gradual, controlled manner during tunnel ventilation to protect reentry personnel was subject to approval by the Test Controller.

2.2 EMPLACEMENT TYPES

The DOD conducted six underground nuclear tests in this report period. Table 2.1 lists the six tunnel-type events during Operations TOGGLE, ARBOR, and BEDROCK and pertinent data. This emplacement type is discussed in this section along with the shaft-type emplacement sometimes used by DOD (but not for events in this report). An emplacement type not discussed in this volume was one that resulted in the excavating or ejecting of material from the ground surface to form a crater (see Crater Experiment in the Glossary of Terms). A DOD cratering event, DANNY BOY, was conducted in 1962 during Operation NOUGAT.

Table 2.1 DOD Test Events - 20 July 1972 through 5 April 1975

OPERATION	TOGGLE		ARBOR		BEDROCK	
TEST EVENT	DIAMOND SCULLS	DIDO QUEEN	HUSKY ACE	MING BLADE	HYBLA FAIR	DINING CAR
DATE	20 Jul 72	5 Jun 73	12 Oct 73	19 Jun 74	28 Oct 74	5 Apr 75
LOCAL TIME (hours)	1016 PDT	1000 PDT	1000 PDT	0900 PDT	0700 PST	1245 PDT
NTS LOCATION	U12t.02	U12e.14	U12n.07	U12n.08	U12n.09	U12e.18
TYPE	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
DEPTH (feet)	1,391	1,284	1,356	1,276	1,326	1,257
YIELD★	Low	Low	Low	Low	Low	Low

★LOW INDICATES LESS THAN 20 KILOTONS

2.2.1 Vertical Shaft-Type Emplacement

A vertical shaft-type nuclear detonation was intended to be contained underground. The shaft was usually drilled, but sometimes mined, and it may have been lined with a steel casing or have been uncased. The nuclear device was emplaced at a depth calculated to contain the explosion. At detonation time, a cavity was formed by vaporized rock. Pressure from the hot gases in the cavity held surrounding broken rock in place until the cavity area cooled sufficiently to decrease pressure. As broken rock fell into the cavity formed by the detonation, a chimney was formed. If the chimney of falling rock reached the surface, a subsidence crater was formed. Figure 2.1 shows a typical subsidence crater.

If a device was emplaced too deeply in the alluvium of Frenchman or Yucca Flat for the detonation yield, or the depth was correct but the yield was much less than anticipated, a subsidence crater might not form; that is, the chimney might not reach the surface. This was a problem during early years of underground testing when it was necessary to move drill rigs into subsidence craters soon after tests for the purpose of obtaining core samples from the bottom of the cavity. If a subsidence crater did not form, drill rigs could not be moved to surface ground zero (SGZ). When directional drilling from outside the crater was implemented, lack of a subsidence crater in alluvium became less of a problem. Experience gained with depth of device burial also reduced the chance of subsidence craters not forming in alluvium.

Each vertical shaft-type underground test conducted by DOD included a vertical line-of-sight (VLOS) pipe system to the surface and a mobile tower on the surface that contained the weapons effects experiments (see Figure 2.2). The VLOS pipe system contained several mechanical closures designed to prevent the release of radioactivity into the atmosphere. These closures were

Figure 2.1 A Typical Subsidence Crater

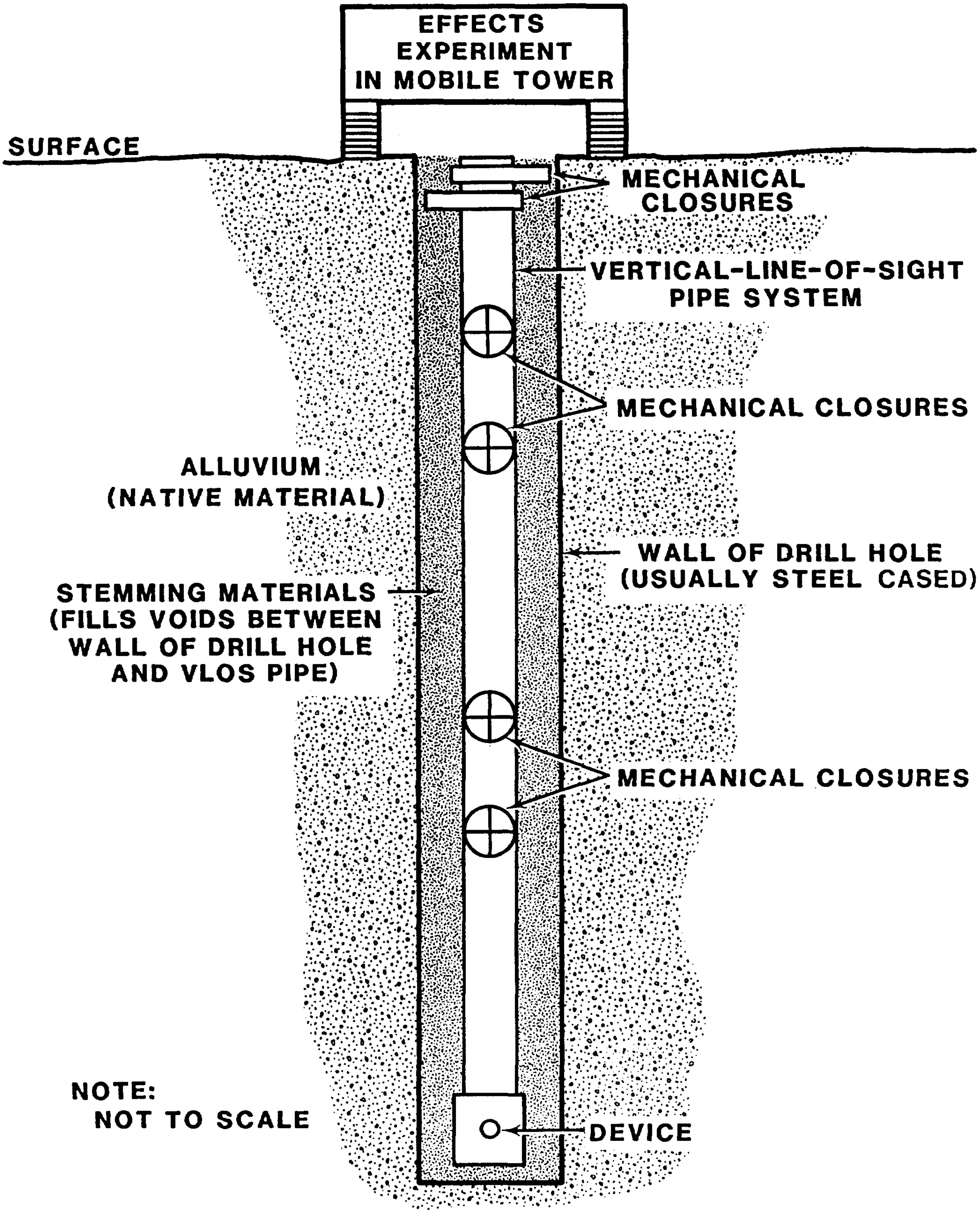


Figure 2.2 Vertical LOS Pipe Configuration

open at the time of detonation but closed within milliseconds to stop the flow of material up the pipe. The open volume between the VLOS pipe and the wall of the drill hole was filled with sand and other materials. One or more non-porous material plugs were placed around the pipe. Electrical cables which went downhole were gas blocked to prevent gas seepage to the surface. Effects experiments were contained in a mobile tower on the surface that was moved away from the hole after device detonation but before surface collapse (formation of the subsidence crater). One potential problem was the possibility of seepage after surface collapse if some pathway to the surface developed. Some radioactive effluent was released into the atmosphere on several VLOS-type DOD tests.

2.2.2 Tunnel-Type Emplacement

Tunnel-type nuclear detonations were intended to be completely contained. The nuclear device was emplaced in a mined drift (tunnel) at a depth designed to contain the detonation. The native material at tunnel elevation (for events covered in this volume) was ash-fall tuff. Chimneying of broken rock to the surface was rare, primarily because there was a layer of welded rhyolitic ash-flow tuff at the top of Rainier Mesa. This tuff has a higher density than ash-fall tuff and is more competent (has more strength) than the alluvium of Frenchman and Yucca Flats. Tunnel-type emplacements were in one of several configurations: at the end of a single horizontal tunnel into a mountain or mesa, at the end of a drift (tunnel) within a tunnel complex, at the end of a horizontal tunnel driven from a vertical shaft, or in a cavity mined from a horizontal tunnel or vertical shaft.

During the period covered by this volume, the six tunnel-type emplacements included HLOS pipe systems placed in horizontal drifts in tunnel complexes (see Figure 2.3). Each device was

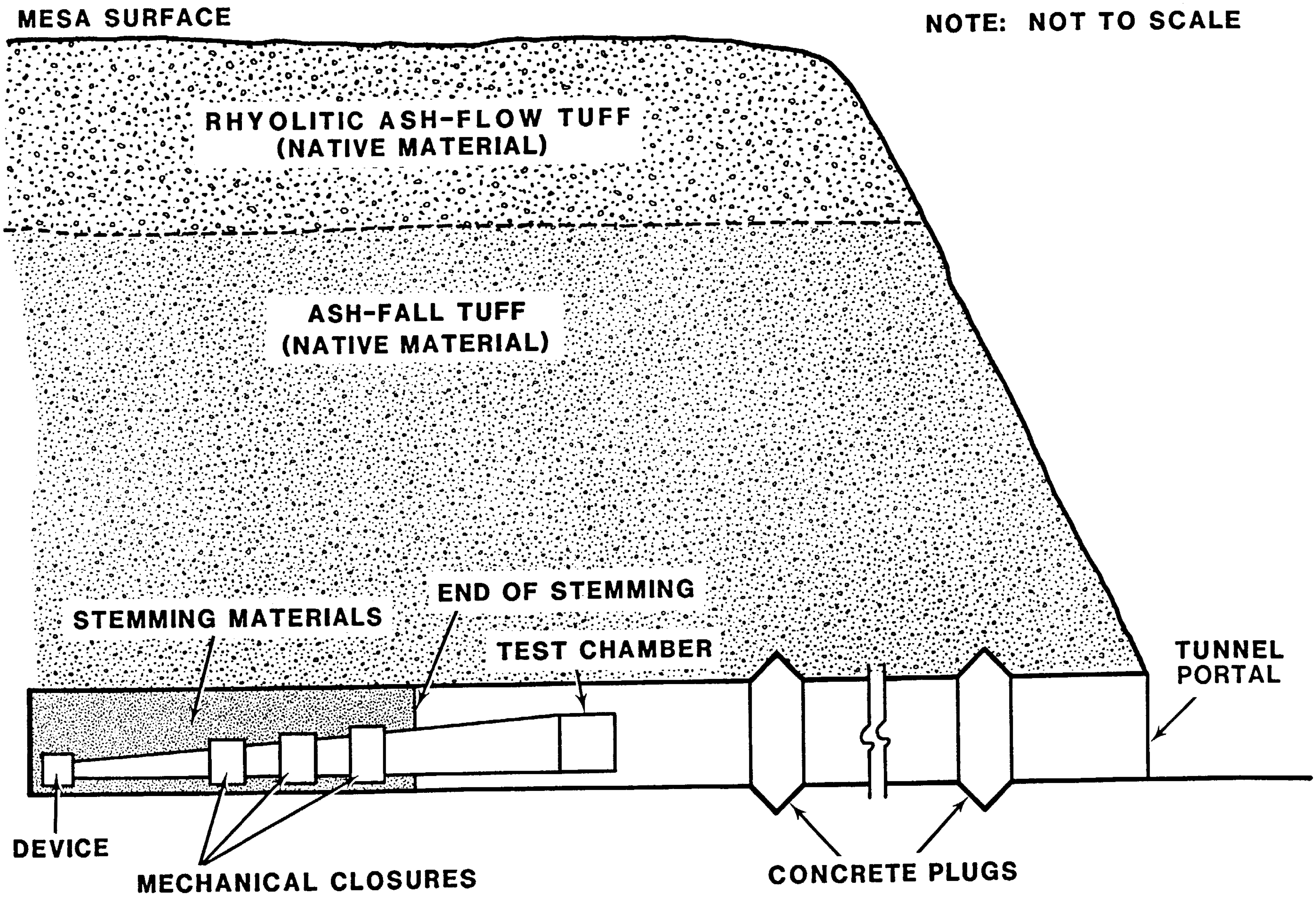


Figure 2.3 Horizontal LOS Pipe Configuration

placed close to the end of a drift inside a tunnel complex. An HLOS pipe system, including several mechanical closures and one or more test chambers (which contained effects experiments), were installed in the drift. The void space between the tunnel walls and the HLOS pipe was filled (stemmed) with different mixtures of grout as plugs and/or sand plugs out to a distance of several hundred feet from the device location. Two or more concrete plugs were keyed into the tunnel walls between the test chamber and main drift of the complex.

The primary containment system was the closure of the tunnel in the stemmed area. Ground shock and expansion of the gaseous cavity material exerted pressure on the tunnel walls and stemming materials to form a stemming plug (closing the tunnel and HLOS pipe). All electrical cables and other penetrations within the stemmed area were gas blocked carefully to prevent or minimize seepage of radioactive gases through the stemming plug. The mechanical closures were designed primarily to protect the effects experiments; however, they also had some effect on the formation of the stemming plug. The concrete plugs were backup containment features. In the event the stemming plug did not contain the radioactive gases, the concrete plugs were designed to withstand the maximum expected pressure and temperature.

FC/DNA has led the development of tunnel containment systems and has maintained continuing research and development programs to improve containment of tunnel events.

2.3 DIAGNOSTIC TECHNIQUES

The transition from atmospheric to underground testing substantially reduced the release of radioactive materials to the atmosphere, and required the development of new device diagnostic techniques. During atmospheric tests, high-speed photography recorded fireball growth, and aircraft collected samples from the radioactive cloud for diagnostic measurement analysis. Because such systems could not be used during underground tests, several new diagnostic techniques were developed (some of which are discussed in the following subsections).

2.3.1 Radiation Measurements

Measurements of radiation from an underground detonation were made possible by developing a system of remote detectors and cabling that sent signals to recording facilities located at the surface. Detectors, utilizing various physical characteristics of the radiations to be measured, were installed near the nuclear device. High-specification coaxial cable and connectors carried the measurement signals to the surface where electronic equipment, film, and magnetic tape recorded the signals.

The detector signals were on the way to recording equipment in billionths of a second after a detonation, before the detectors were destroyed. These measurement systems required the most advanced electronic technology available. Considerable research and development were necessary to acquire and refine these capabilities.

2.3.2 Radiochemical Measurements

Because clouds from atmospheric detonations no longer were available to sample for diagnostic purposes, techniques were developed to obtain samples of debris from underground detonations for radiochemical analyses and subsequent yield determinations. The first systems were radiochemical sampling pipes leading directly from the device emplacements to filtering equipment at the surface. These pipes required closure systems to prevent overpressure from venting radioactive effluent into the atmosphere after samples were collected.

While these systems functioned as intended for most detonations, the systems did not function properly during all tests, and some radioactive effluent was released into the atmosphere. Subsequently, regular use of radiochemical sampling pipes to the surface was discontinued for a time until technology improved.

A major radiochemistry sampling method which continued in use for shaft and tunnel detonations was postevent core drilling. The objective of this drilling was to obtain samples of solidified radioactive debris, which had collected in a molten pool at the bottom of the cavity produced by the detonation. This method required and resulted in the development of precise directional drilling techniques and several advancements in the science of core drilling.

2.4 EFFECTS EXPERIMENTS

DOD/DNA events were conducted primarily to obtain nuclear weapons effects data. The effects of blast, shock, and thermal and nuclear radiations had been investigated earlier during atmospheric and underwater tests. Military equipment, structures, and materials had been exposed to various nuclear effects. The transition to underground testing required development of new test techniques. One important new technology was simulation of high altitude (to exoatmospheric) conditions for radiation effects experiments.

This simulation technique involved placing experiments inside test chambers and providing a low-pressure atmospheric condition from the nuclear device to the experiments. This was achieved by using large vacuum pumps to reduce pressure inside the steel LOS pipe to match the pressure of the desired altitude.

Experiments were catagorized as passive or active (diagnostic). Passive experiments involved placing experiment equipment in test chambers, exposing it to the desired nuclear environment, removing equipment, and analyzing it to obtain effects results. Active experiments utilized various sensors and high-speed electronic recording equipment to obtain data. Many active experiments also involved recovery and analysis to obtain effect results.

2.5 TUNNEL AND DRILLING AREA ACCESS REQUIREMENTS

Access to underground work and drilling sites was controlled for a number of reasons. During construction, safety of both workers and visitors in these locations could have been jeopardized by carelessness or seemingly harmless activities of untrained and uncontrolled workers or visitors. When security-classified materials were in these locations, only personnel with appropriate security clearances were permitted access to the controlled areas. The presence, or anticipated presence, of radioactive material in a location required access control for radiological safety purposes. Access requirements established for the above purposes are discussed below.

2.5.1 Tunnel Access Control

During construction and preparations for a DOD event in a tunnel or other underground work site, the tunnel Superintendent was responsible to the REECo Project Manager for safety of personnel underground. From 1962 forward, Radsafe and tunnel logbooks usually were used to record names and radiation exposure information for only those persons entering a tunnel during postevent reentry and recovery operations. In the early 1970s, as a result of the Mine Safety and Health Act, tunnel logbooks were expanded to list all persons entering the tunnels (i.e., mining, drilling, Radsafe, etc.). Visitors and other personnel not assigned to work in the tunnel obtained permission for entry from the superintendent, or his representative, and were apprised of tunnel conditions and safety regulations. In the event of an accident or other emergency condition, the logbook provided information on numbers of personnel and their locations underground.

When classified material was in the tunnel prior to a test event and during initial reentry after an event, the DOD Test Group Director, or his representative, was responsible for entry and safety of personnel underground. Security personnel checked for proper security and entry clearances, maintained records of all personnel entering the tunnel, and safeguarded classified material and the device. The check point was often well inside the portal thus allowing several activities at various work sites to be conducted simultaneously.

Control of tunnel access reverted to tunnel management personnel after tunnel reentry and recoveries. Entry procedures and use of the tunnel logbook, if appropriate, were then implemented as discussed above.

Additional access controls were instituted for radiological safety purposes after an event or during construction and event preparation when radioactivity from a previous event could be encountered. Part or all of a tunnel complex could be established as a radiation exclusion (radex) area.

All persons entering radex areas were logged on a form called the "Area Access Register." Names and organizations represented were listed. Radiation exposures from reports for the year and quarter were listed upon entry. Self-reading pocket dosimeter measurements were added upon exit. This was to assure that personnel approaching radiation exposure guide limits would not be allowed to enter radex areas when they could accumulate exposures above guide amounts.

Before entry, personnel were dressed in anticontamination clothing and respiratory protection as needed for the particular radiological conditions in the tunnel. Upon exit, anticontamination clothing was removed, personnel were monitored for radioactive contamination, and decontamination was accomplished if necessary.

2.5.2 Drilling Area Access Control

Access to drilling areas was controlled by the drilling superintendent and the DOD Test Group Director for the same reasons as access to underground workings was controlled. During emplacement shaft drilling and during postevent drillback operations to recover radioactive core samples, personnel safety and compliance with safety regulations were emphasized continuously.

During preevent drilling activities, all visitors were required to contact the drilling superintendent before entry to the drilling site. Names of visitors and the purpose of each visit were entered in the daily drilling report, and it was assured that visitors wore hard hats and understood safety regulations.

The laboratory which provided the device controlled access to the area, assisted by security force personnel, when classified materials (including the nuclear device) were brought into the area for emplacement. After the event, when the drill site was a radex area, during classified material removal, or during postevent drilling, both security and radiological safety access controls were in effect as discussed under "Tunnel Access Control."

2.6 INDUSTRIAL SAFETY CONSIDERATIONS

Implementation of an effective industrial safety program was an important part of any heavy construction operation. Mining and drilling operations had a particularly high accident potential. These operations at the NTS involved additional safety problems resulting from detonation-induced unstable ground conditions and potential for encountering toxic gases, explosive mixtures, and radioactivity.

Miles of underground workings were constructed during mining operations. More depth of big holes (three-foot diameter or larger) were drilled during drilling operations than the known total drilled in the rest of the world. Directional and core drilling to recover radioactive debris samples after underground nuclear detonations advanced the science of these drilling techniques. These operations often were accomplished under unusual conditions with accompanying difficult safety problems.

However, the lost-time accident frequency for the NTS support contractor employing most of the NTS personnel (REECo) was only one-tenth of the frequency for the heavy construction industry at large (as determined by annual surveys and reports for 300 heavy construction corporations). This excellent safety record was attained by continuing attention to indoctrinating and training NTS personnel, investigating and determining causes of accidents at the NTS, implementing and enforcing safety regulations, and, most important, maintaining the safety awareness of NTS personnel.

This was a joint effort by DOE, DNA, and their predecessors, and by the many other government agencies and contractors at NTS. Administered by REECo, the safety program enjoined all NTS personnel to conduct operations safely, and was exemplified by the sign on the portal of a typical DOD tunnel complex as shown in Figure 2.4, which states, "Safety With Production is our Goal."

The safety procedures for all NTS operations are voluminous and cannot be included in this report. Appendix C of this volume is an example of a pertinent safety procedure: General Tunnel Reentry Procedures for Department of Defense and Sandia Laboratory Tests. As this procedure indicates, several aspects of industrial safety are interrelated. Information on monitoring levels of radioactivity and personnel exposures to radiation is presented in section 2.7, "Radiological Safety Procedures."

Monitoring of toxic gases and checks for explosive mixture were an important aspect of safety in underground workings, on drill rigs, and in drillhole cellars (the excavated area under the drill rig platform used for valving and other equipment). Toxic gases and explosive mixtures were created by both the nuclear detonations and the mining and drilling operations. Draeger multi-gas detectors and MSA explosimeters were used to detect such gases and mixtures. Fyrite or J&W oxygen indicators were also used to determine the oxygen content of the working atmosphere. Requirements were that tunnel and drill rig breathing atmosphere contain at least 19.5 percent oxygen. During the period covered by this volume, it was required that the breathing atmosphere contain less than the following levels of toxic gases and explosive mixtures:

Gases	Maximum Concentration
Carbon monoxide, CO	50 ppm
Carbon dioxide, CO_2	5000 ppm
Nitric oxide plus nitrogen dioxide, $NO + NO_2$	25 ppm
Nitrogen dioxide, NO_2	5 ppm
Explosive mixtures	10% of LEL (lower explosive limit, 5% methane calibration)

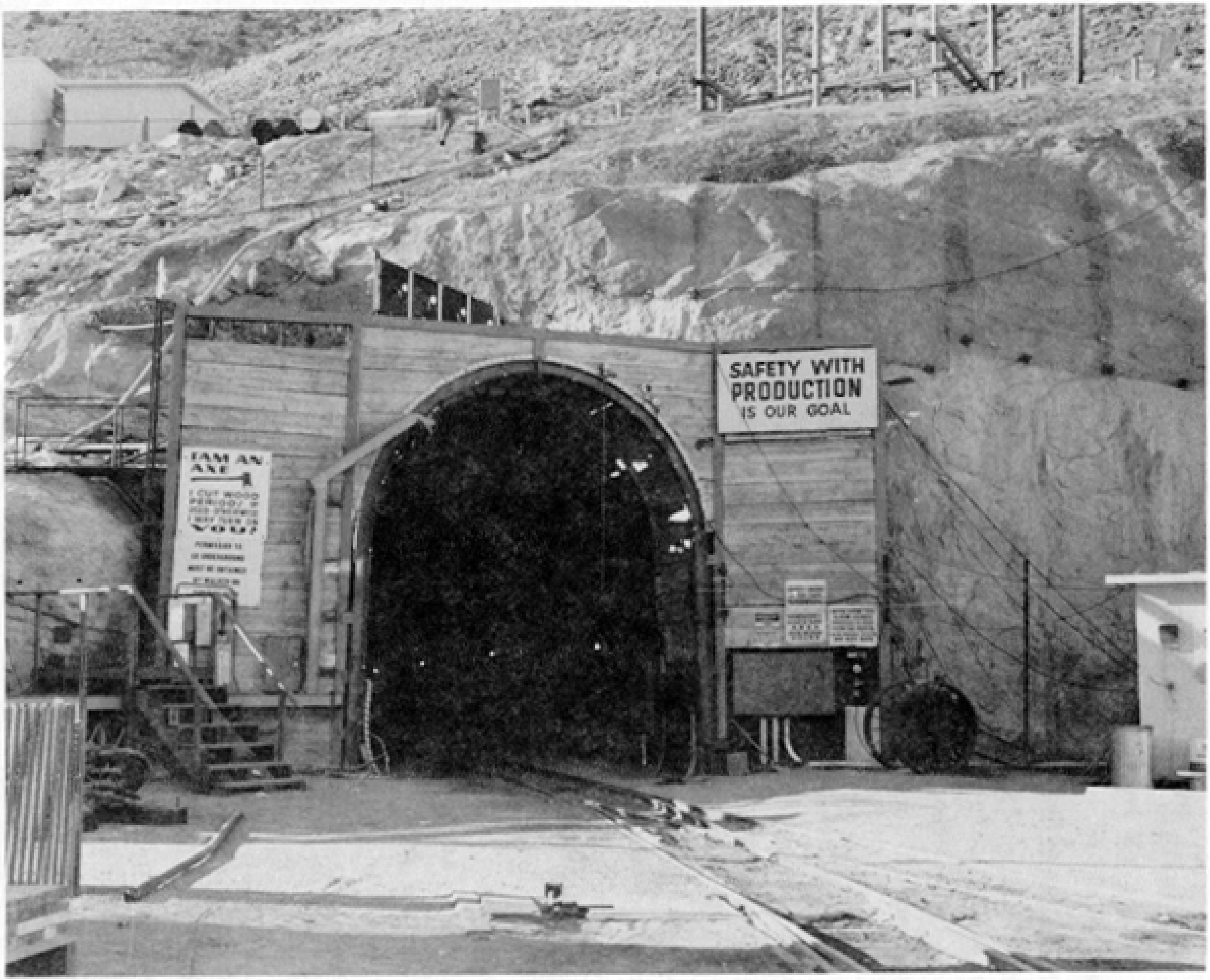


Figure 2.4 Portal of a Typical DOD Tunnel Complex

Procedures for controlling explosive mixtures and toxic gases after each test event are discussed in the event chapters as appropriate.

2.7 RADIOLOGICAL SAFETY PROCEDURES

Procedures were developed in an effort to evaluate radiological, toxic, and other hazards, and protect workers and the public from unnecessary exposures. The following were the primary written procedures and implementation methods used at the NTS from 1972 through 1975.

2.7.1 The U.S. Atomic Energy Commission, Nevada Test Site Organization - Standard Operating Procedure (NTSO SOP)

Chapter 0524, Radiological Safety, of this procedure (which appears as Appendix D to this volume) defined responsibility and established criteria and general procedures for radiological safety associated with NTS programs. Some of the major areas discussed were film badge procedures, radiation surveys, entry into controlled areas, and radiation exposure guides. Roles of the onsite REECo Environmental Sciences Department and the offsite United States Environmental Protection Agency are defined in NTSO SOP Chapter 0524.

2.7.2 The Standard Operating Procedures for the Environmental Sciences Department, REECo

These were prepared and updated annually to address in more detail the radiological safety aspects discussed in the latest revision of NTSO SOP Chapter 0524.

2.7.3 Implementation of Radiological Procedures

The required equipment, devices, and capabilities for monitoring radiation levels in the environment and monitoring external and internal exposures of personnel are described below:

A. Portable Radiation Detection Equipment

- Eberline PAC 4G (alpha)
- Eberline PAC 1SA (alpha)
- Jordan AGB-500B-SR Radector (gamma)
- Jordan AGB-10K-SR Radgun (beta and gamma)
- Eberline E-500B survey meter (beta and gamma)
- Eberline E-520B survey meter (beta and gamma)
- Ludlum Model 101 survey meter (beta and gamma)
- Technical Associates and Hanford Cutie Pie survey meter (beta and gamma)
- Technical Associates Juno survey meter (alpha, beta, and gamma)
- Precision Model P-111 Scintillator (gamma)
- T-290 Military Air Sampler (tritium)
- T-446 Tritium Alarm Monitor (tritium) (Sandia/Bendix)
- NR-3 Portable Radioactive Gas Detector (tritium) (Sandia)

B. Air Sampling Equipment

- Model 102 semi-portable sampler
- Satellite sampler
- Hurricane high-volume portable sampler (Gelman)
- Vacuum pump low-volume portable sampler (Gelman)

C. Laboratory Analysis Capability

The Environmental Sciences Laboratory analyzed air, soil, water, surface swipe, nasal swab, urine, and wound swab samples for some or all of the following radioactivities: gross alpha and beta, gross fission products, tritium, strontium-90, plutonium-239, and spectrographic analysis for specific gamma-emitting radionuclides. The laboratory also analyzed some of the above-mentioned samples for nonradioactive materials, such as beryllium, through use of an emission spectrograph and by wet chemistry procedures. A spectrophotometer was used to perform additional analyses.

D. Monitoring of Personnel Exposures

The NTS combination personnel dosimeter and security credential holder was placed in use in 1966 to provide increased personnel dosimetry capability necessary to monitor radiation exposure problems associated with nuclear rocket testing and underground nuclear detonations. The holder was designed to accommodate a Du Pont type 556 film packet, a fast neutron packet, an identification plate, criticality accident components, the security credential, and a snap-type clip. The complete package had capabilities for determining beta, gamma, x-ray, thermal neutron, fast neutron, high-range gamma, and high range neutron doses. Components for criticality accidents (unintentional or accidental nuclear fissioning of device critical materials) included materials which could detect and measure neutron and gamma radiation exposures above the ranges of the film packets. The Du Pont 556 film packet contained two component films, type 519 (low range) and type 834 (high range). Gamma exposure ranges of the two components were 30 mR to 10 R and 10 R to 800 R, respectively. The NTS combination personnel dosimeter and security credential holder is shown in Figure 2.5.

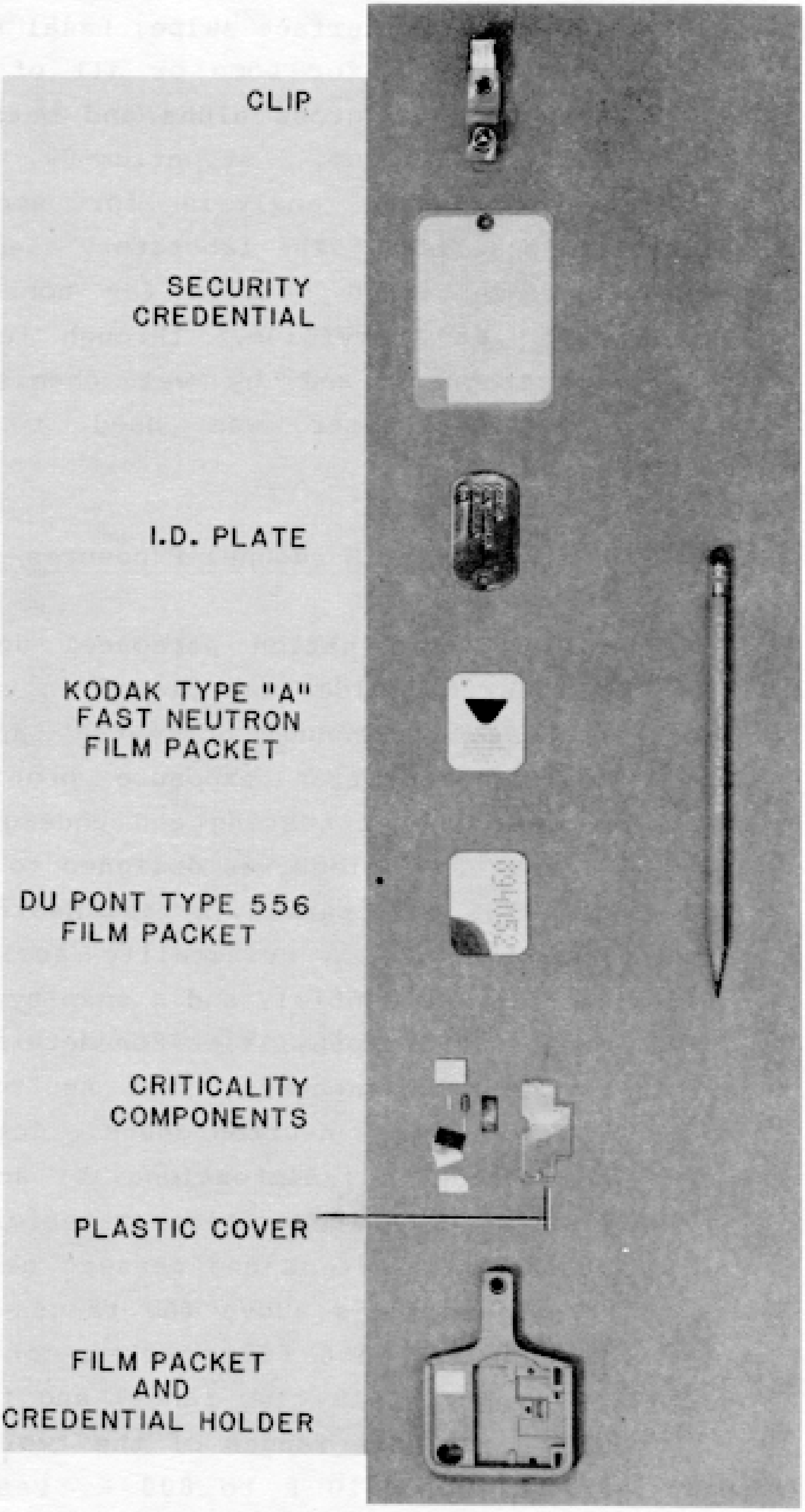


Figure 2.5 NTS Combination Personnel Dosimeter and Security Credential Holder

Film badges were exchanged routinely each month for all individuals and upon exit from a radex area when it was suspected that an individual had received 100 mR or more of exposure.

Personnel entering radex areas also were issued self-reading pocket dosimeters which indicated accumulated exposure. Upon exit, pocket dosimeter readings were entered on an Area Access Register and added to the yearly and quarterly accumulated exposures from the automated daily NTS radiation exposure report for use until results of film packet processing were included. Pocket dosimeter readings were used as estimates because such readings were less accurate than the doses of record determined by processing film packets.

This use of Area Access Registers helped to maintain personnel exposures below the whole body exposure guides in Chapter 0524: 3000 mrem per quarter and 5000 mrem per year. Personnel whose accumulated exposure was in excess of 2500 mrem per quarter or 4500 mrem per year (as recorded on the report plus any pocket dosimeter reading since the report was published) were advised not to enter radex areas, and their supervisory personnel were so notified.

2.7.4 Additional Methods Used for Control of Radex Areas

To help control radex areas and prevent spread of contamination to uncontrolled areas, the following procedures were used.

A daily logbook was maintained by Radsafe monitors for each radex area location. These logs were used to record the following information:

A. Work accomplished - Which people worked where and what work was accomplished were briefly described. Any unusual conditions, such as equipment failure and operational difficulties, were listed.

B. Visitors - First and last names of visitors were entered. Their destination and the reason for their visit were included where possible. The time they entered and exited the area and results of personnel monitoring were recorded.

C. Unusual occurrences - Any unusual events which occurred during the shift were recorded. Included in this type of entry were accidents, high-volume water seepage, or any other occurrence of an unusual nature.

D. Surveys and samples - Information collected was recorded as follows:

Survey type - Routine or Special*
Sample type - Routine or Special*

*The requester's name was indicated for Special type.

E. Date and signature - The date and shift were entered at the beginning of the work period and the logbook was signed before leaving the shift.

Personnel leaving radex areas removed anticontamination clothing and equipment and placed them in special containers for later laundering or disposal at the designated NTS burial site. Personnel then were monitored to assure radiation levels were below those listed in Appendix D, Part I of AEC NTSO SOP Chapter 0524, "Radiological Safety." Personnel decontamination was accomplished if radiation levels were above specified limits.

Decontamination usually was accomplished by vacuuming, removing radioactive particles with masking tape patches, washing hands or localized skin areas with soap and water, or showering with soap and water.

Vehicles and equipment removed from radex areas were monitored to assure that they met acceptable radiation levels for release on the NTS [less than 25 mrad/h beta plus gamma at contact and 250 counts per minute (cpm) non-removable alpha]. Limits for release of vehicles and equipment off the NTS were 0.3 mrad/h beta plus gamma radiation at contact and no detectable alpha activity. Vehicles and equipment normally were decontaminated by vacuuming and steam cleaning with water or detergent solutions.

2.8 TELEMETERED MEASUREMENTS OF RADIATION LEVELS

Beginning in the early 1960s, various applications of radiation measurement telemetry were developed at the NTS to determine radiation levels at critical underground and surface areas following nuclear detonations. Multi-detector systems with range capabilities from as low as 0.5 mR/h to 1000 R/h (well-logging units) to as high as 100 mR/h to 100,000 R/h (extended range units) continuously monitored locations of concern after being calibrated and emplaced prior to each test event. Ion chamber detectors were hard-wire linked by telephone trunk lines to exposure rate meters at a central console in CP-2. Detector locations were as far as 35 miles from this console.

These remote radiation monitoring systems provided data for reentry personnel participating in radiation surveys and recovery operations after a nuclear device detonation. The systems aided in substantially reducing exposure of personnel involved in reentry programs and were useful in detecting any venting or leakage of radioactive effluent to the atmosphere from an underground detonation.

2.8.1 Telemetry System in Use

The radiation telemetry systems developed and used at NTS had specific applications depending upon distance, terrain, environment, and operational needs. The detection units and components in use in 1972 for DOD events were part of the remote area monitoring system (RAMS). The principal piece of equipment used to form a RAMS was the RAMP-4. The RAMP-4 was a multi-channel, hard-wire linked, remote area gamma radiation monitoring (telemetry) system designed and modified by Radsafe and produced by Victoreen Instrument Corporation. It consisted of a probe (Figure 2.6) which used a Neher-White radiation sensing element, hard-wired to communicate with the readout console (Figure 2.7) up to 35 miles away, and components of Victoreen Radector instruments with recorders for readout.

The readout covered six logarithmic decades (two three-decade scales) to provide a usual range of 1 mR/h to 1,000 R/h with a relative accuracy of ± 15 percent over the temperature range of -10°F to 150°F. Extended range RAMS unit provided a range from 100 mR/h to 100,000 R/h.

A permanent array of 20 to 35 telemetry stations throughout the NTS, as designated by the AEC, was maintained and operated continuously. Temporary telemetry arrays for DOD events varied between 20 and 50 stations depending upon the area or tunnel event location.

2.8.2 Remote Area Radiation Detection Monitoring Support

Approximately 200 remote radiation detector channels were available to continuously monitor radiological conditions and

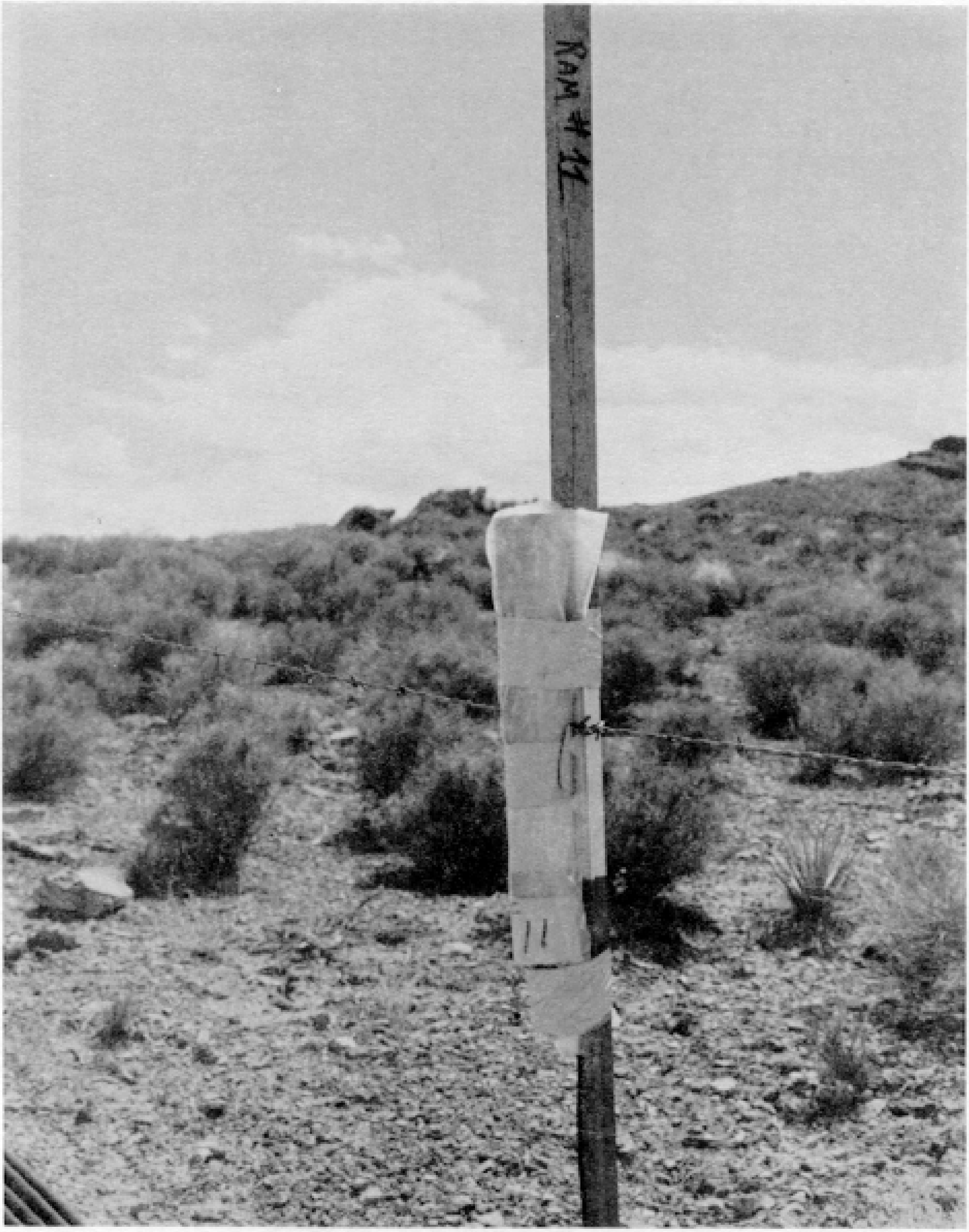


Figure 2.6 Neher-White RAMS Probe

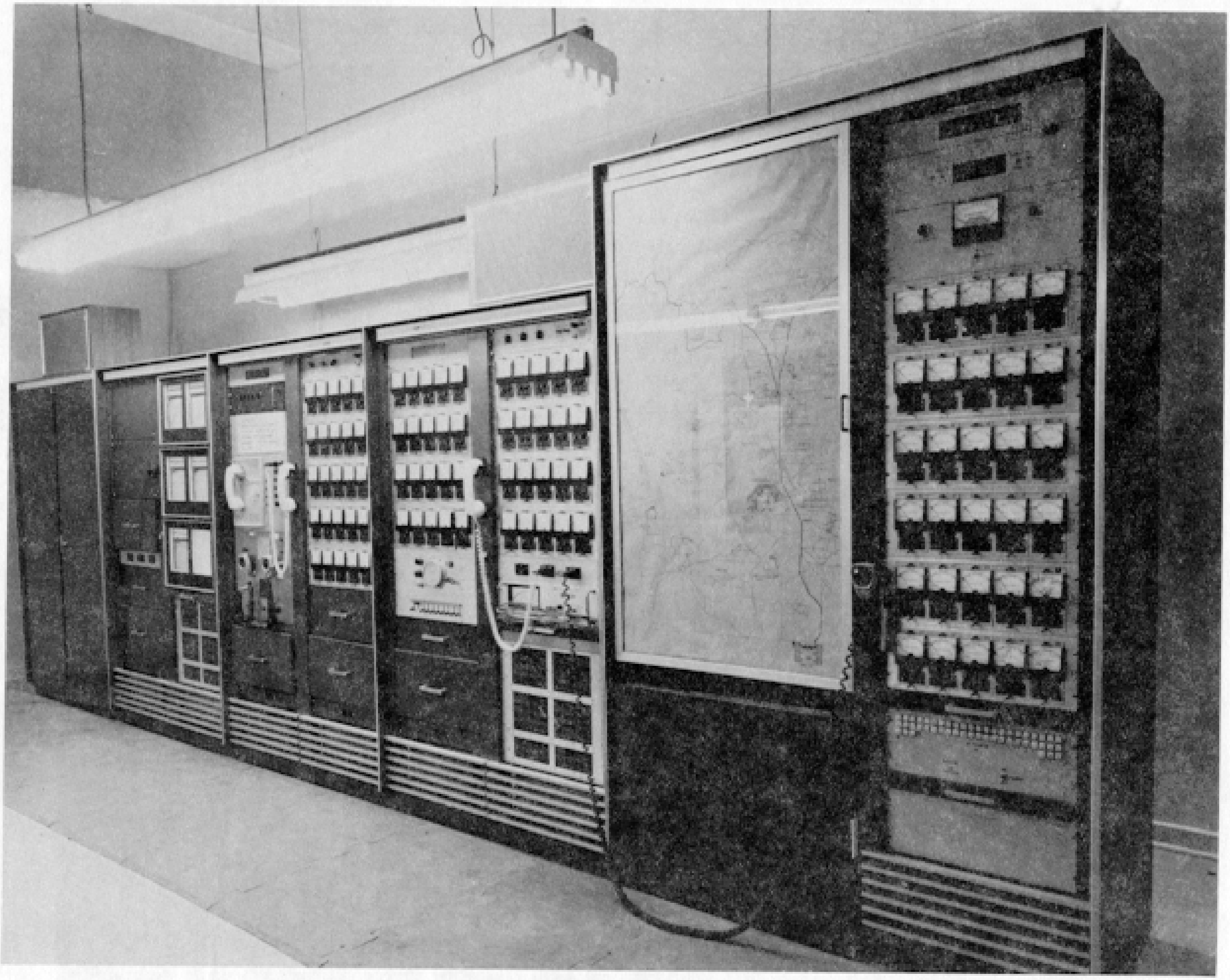


Figure 2.7 RAMS Readout Console

determine exposure rates before the test area was entered after detonation. Approximately 20 detector units were positioned in the test area before a shaft-type event. Detectors were placed in circular arrays at appropriate distances from SGZ which varied with device yield and predicted wind direction (See Figure 2.8). Variable numbers of detectors (20-50) were used aboveground and underground during tunnel-type events. An additional 20 to 35 permanently established remote radiation detector stations operated continuously at living areas, work areas, and other locations throughout NTS (Figure 2.9). The large number of remaining channels was available for additional detector locations and substitute channels. Event-related telemetry detectors operated from zero time until it was determined that release of radioactivity probably would not occur, or until any released radioactivity had decayed to near-background levels at the telemetry stations. For some events, readout locations were positioned near the forward control point (FCP), or at locations where telephone lines were available, in addition to the readouts located at CP-2.

Radiation telemetry data were supplemented with information collected through a mobile air sampling program. Model 102 air sampling units were used to obtain samples of any radioactive effluent released at event time or during the postevent drilling operations. Test groups used an average of 21 units during each test event. Prior to each nuclear detonation experiment, these samplers were placed at specified locations around the test area, and units remained in position until drillback operations were completed or the Test Group Director authorized removal of the units.

2.9 AIR SUPPORT REQUIREMENTS

Direct support was provided to NTSO by AFSWC for DOD underground tests, and other Air Force organizations provided support

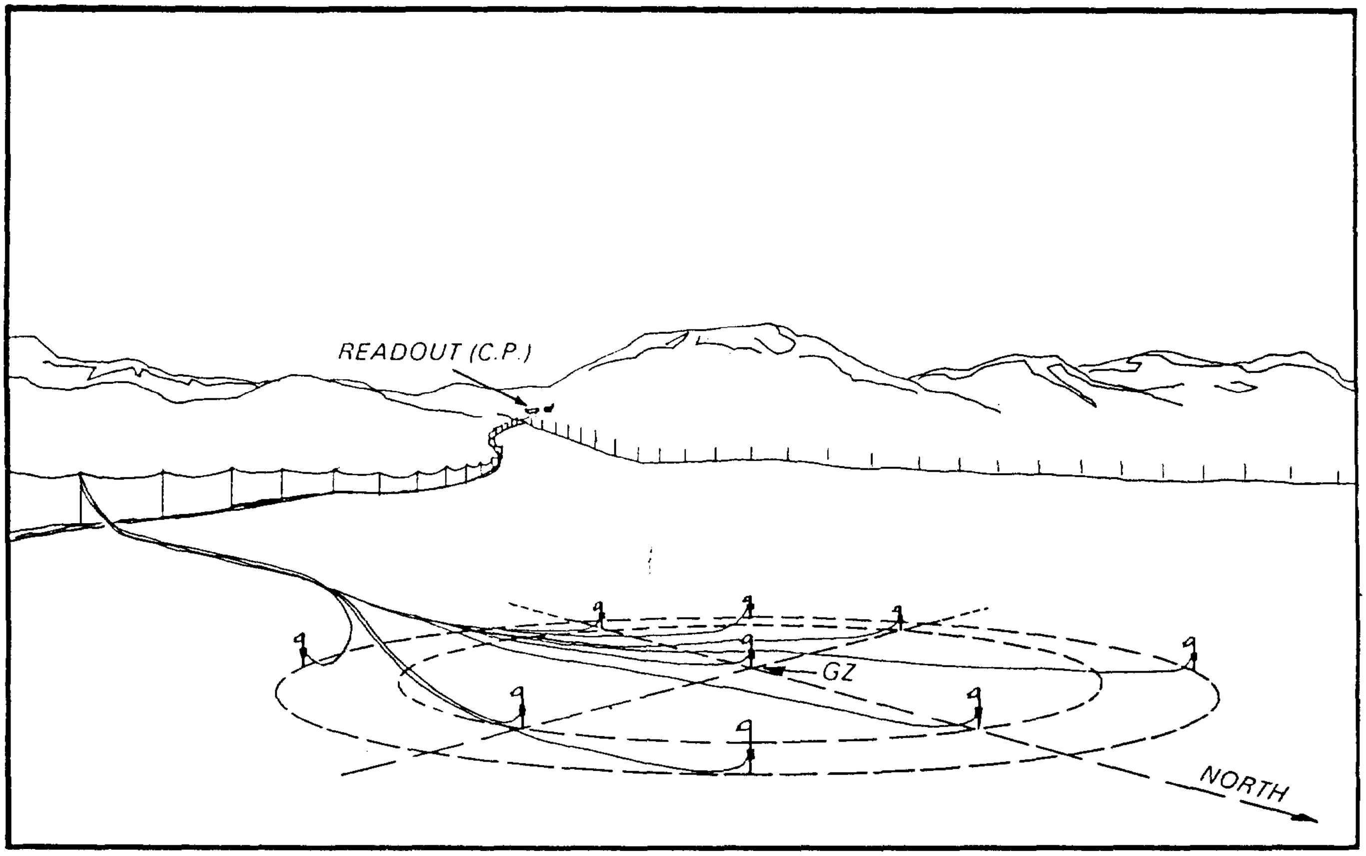


Figure 2.8 Typical Remote Radiation Detection Monitoring System for Shaft-Type Emplacement Site

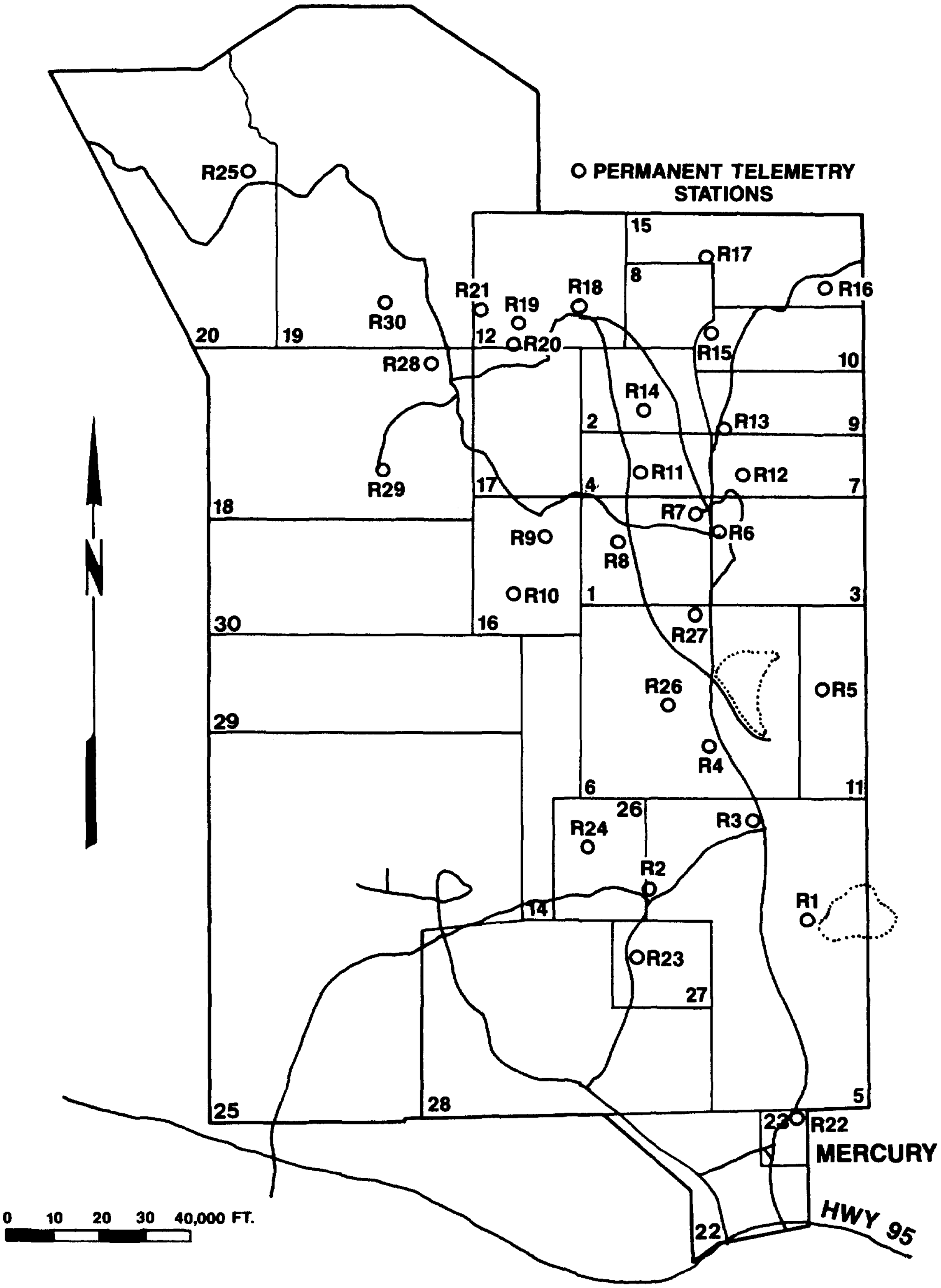


Figure 2.9 Typical Permanently-Established Remote Radiation Detector Stations Operated Continuously Throughout the NTS

under AFSWC control as described in section 1.3.2 of this volume. Less air support was required, however, as the probability of venting radioactive effluent to the atmosphere decreased with development of more effective containment techniques.

2.9.1 Changes in Air Support Requirements

After 1962, Air Force cloud-sampling and cloud-tracking aircraft generally were not required except for AEC cratering events where radioactive effluent clouds were anticipated. Passage of the radioactive effluent through variable amounts and temperatures of rock and other media selectively retained some radionuclides underground. The known fission product ratios previously used during calculation and analysis of atmospheric detonation cloud samples were no longer valid. Thus, value of analyzing particulate and gaseous cloud samples to determine characteristics of a detonation decreased.

The first change in cloud sampling and tracking support was to a lighter Air Force aircraft, the U-3A, with an Air Force pilot and EPA monitor. The EPA monitor also performed aerial monitoring of selected locations near surface ground zero and along the path of any effluent cloud. This air support later was performed by EPA and contractor personnel in their own aircraft.

Perimeter sweeps with helicopters continued to be conducted daily by Air Force and Security personnel, during reasonable flying weather, to assure that unauthorized vehicles were not entering the NTS over rough terrain or around security barricades on secondary roads. Air security sweeps of the immediate test area were conducted by helicopter for a few hours before each detonation to assist in clearing the test area and to assure that unauthorized vehicles were not approaching it from directions not controlled by manned security stations.

Air support for photography missions during test events and initial radiation surveys after each event did not change. Generally, helicopters were used with Air Force pilots, contractor and military photographers, and Radsafe monitors.

2.9.2 Radsafe Support for Indian Springs Air Force Auxiliary Field (ISAFAF)

Radsafe support facilities had been established about 20 miles southeast of Mercury at Indian Springs Air Force Base (ISAFB became ISAFAF in 1968) during atmospheric nuclear device testing series. During 1962 tests, and subsequent DOD underground tests requiring support aircraft staged from ISAFAF, REECo provided all Radsafe support functions available at the NTS. This included monitors stationed at the ISAFAF Radsafe quonset facility and a complete stock of film dosimeters (badges), radiation detection instruments, and anticontamination clothing and equipment for use by aircrews and ground crews.

Radsafe monitors issued and exchanged film dosimeters (badges), issued self-reading pocket dosimeters, provided anticontamination clothing and respiratory protection equipment, monitored aircraft and personnel after events, decontaminated personnel, and assisted ground crew personnel with decontamination of aircraft.

2.9.3 Radsafe Support for Helicopters

Although ISAFAF Radsafe support extended to all participating aircraft, special helicopter radsafe procedures were implemented because these aircraft landed at NTS and staged from helicopter pads located east of Mercury Highway near the CP area and near the Test Controller's FCP established for a particular underground event. Helicopter pilots usually landed at these locations and were briefed on their scheduled or other operational missions there.

If the mission involved possible contamination of the aircraft, Radsafe monitors lined the floor of the aircraft with plastic (or kraft paper) and masking tape to facilitate decontamination. Pilots and crew members were dressed in anticontamination clothing and provided with film badges, pocket dosimeters, and respiratory protection equipment if airborne radioactive material was anticipated and oxygen masks were not worn.

Upon completion of missions, helicopters returned to the landing pads where they were decontaminated by Radsafe monitors. Pilots and crew members were decontaminated at an adjacent forward Radsafe base station (or at CP-2) where the pocket dosimeters were collected and read and film badges were exchanged if exposures of 100 mR or more were indicated by pocket dosimeters.

CHAPTER 3

DIAMOND SCULLS EVENT

3.1 EVENT SUMMARY

DIAMOND SCULLS was a DOD-sponsored underground test detonated at 1016 hours Pacific Daylight Time (PDT) on 20 July 1972 with a yield less than 20 kilotons (kt). The device was detonated in T tunnel (U12t.02 drift, see Figure 3.1) at a vertical depth of 1,391 feet. DIAMOND SCULLS had the largest LOS pipe and tunnel excavation in the history of NTS underground testing. The pipe was 1,900 feet long, diverging from less than one foot outside diameter at zero point interface to about 26 feet at test chamber No. 1. (See Figure 3.2 to view the size of the sections of LOS pipe assembled for the event and Figure 3.3 which shows the size of the portal end of the LOS pipe after assembly.) The objective of this test was to determine the response of materials and equipment to a nuclear detonation environment. Government agencies and contractors conducted 38 projects to obtain the desired weapons effects information.

Stemming was successful and containment was complete. No radioactive effluent was released to the atmosphere.

3.2 PREEVENT ACTIVITIES

3.2.1 Responsibilities

Safe conduct of all DIAMOND SCULLS project activities in Area 12 was the responsibility of the DOD Test Group Director. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DNA, and AEC/NVOO.

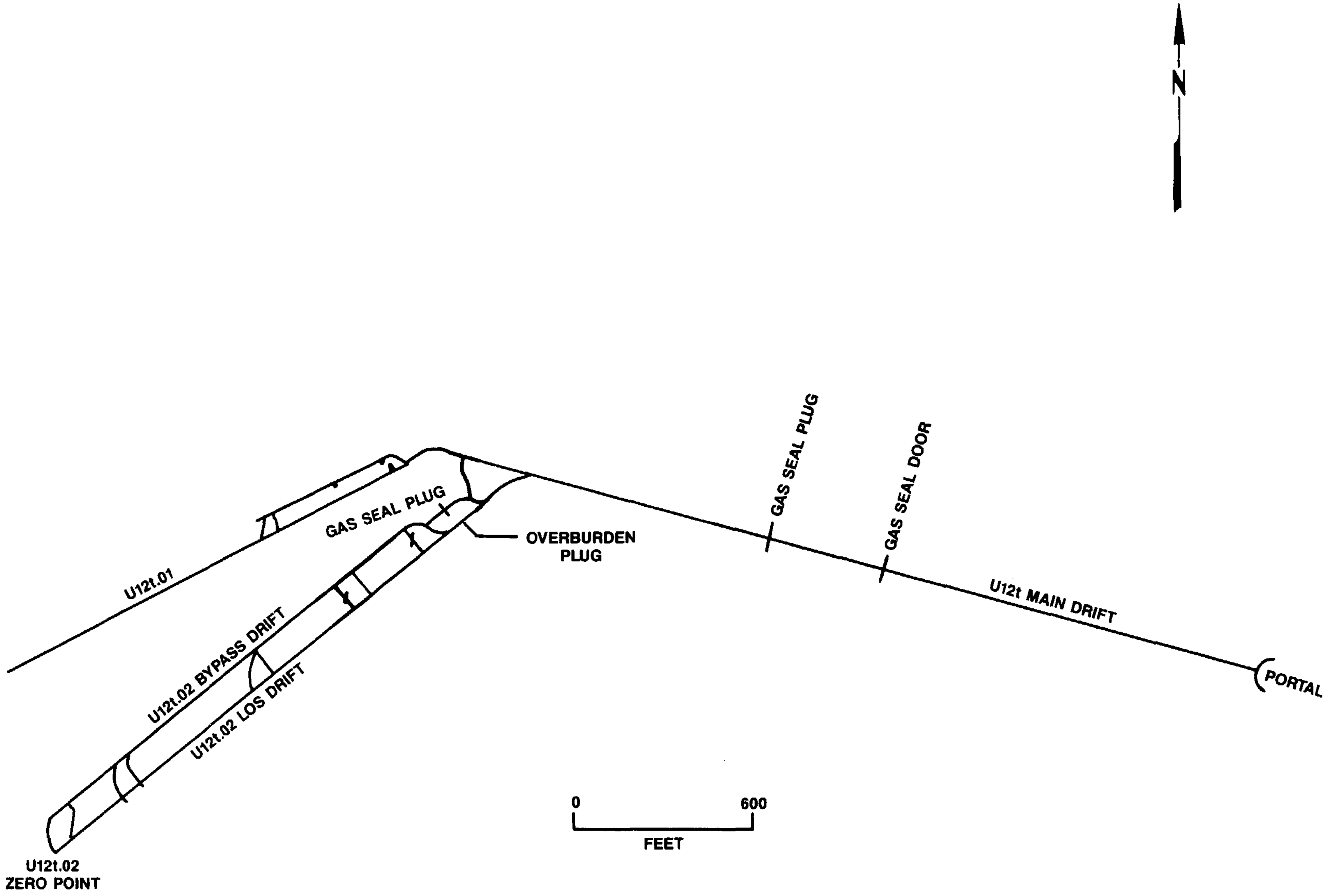


Figure 3.1 DIAMOND SCULLS Event - Tunnel Layout

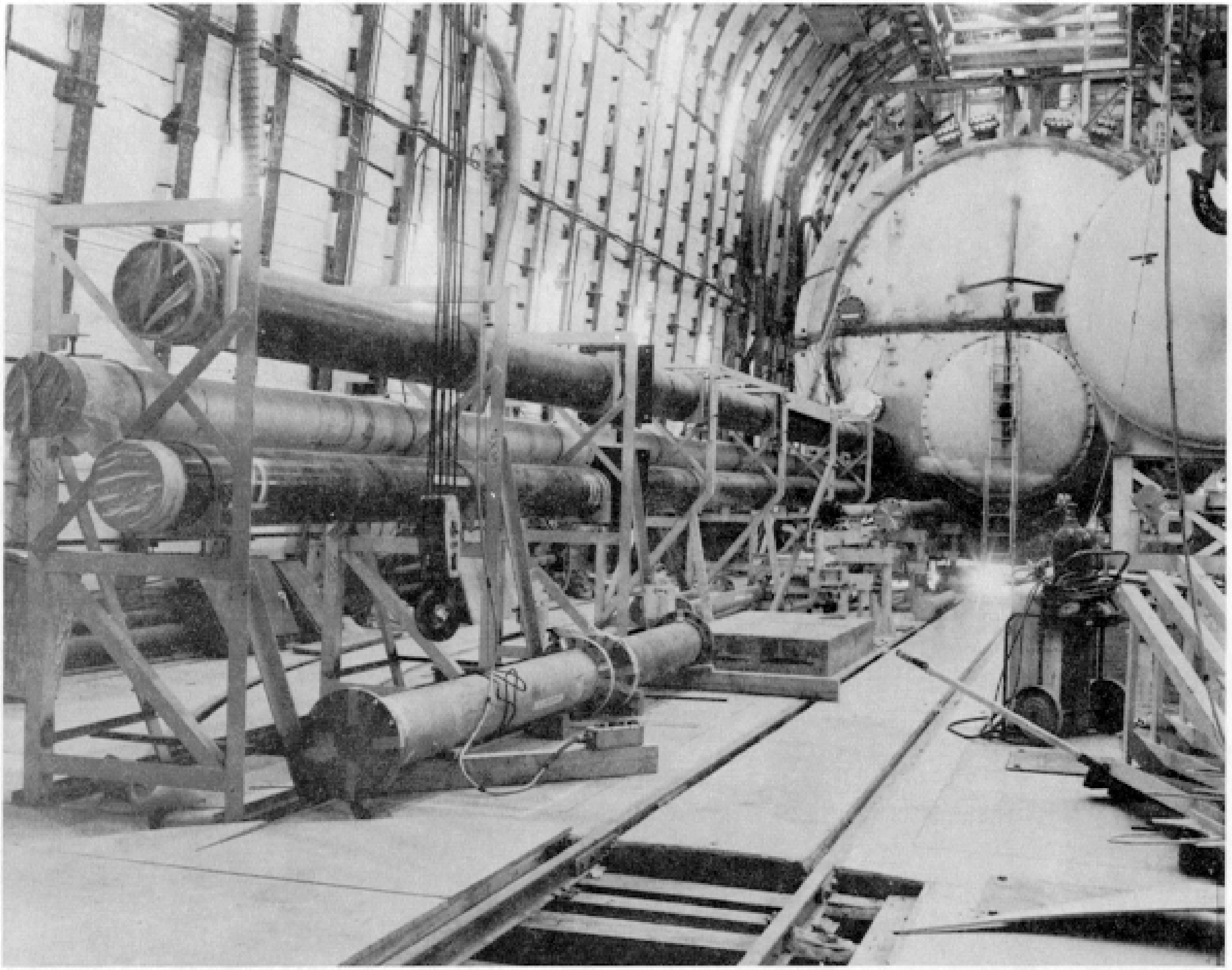


Figure 3.2 DIAMOND SCULLS LOS Pipe Sections Prior to Assembly

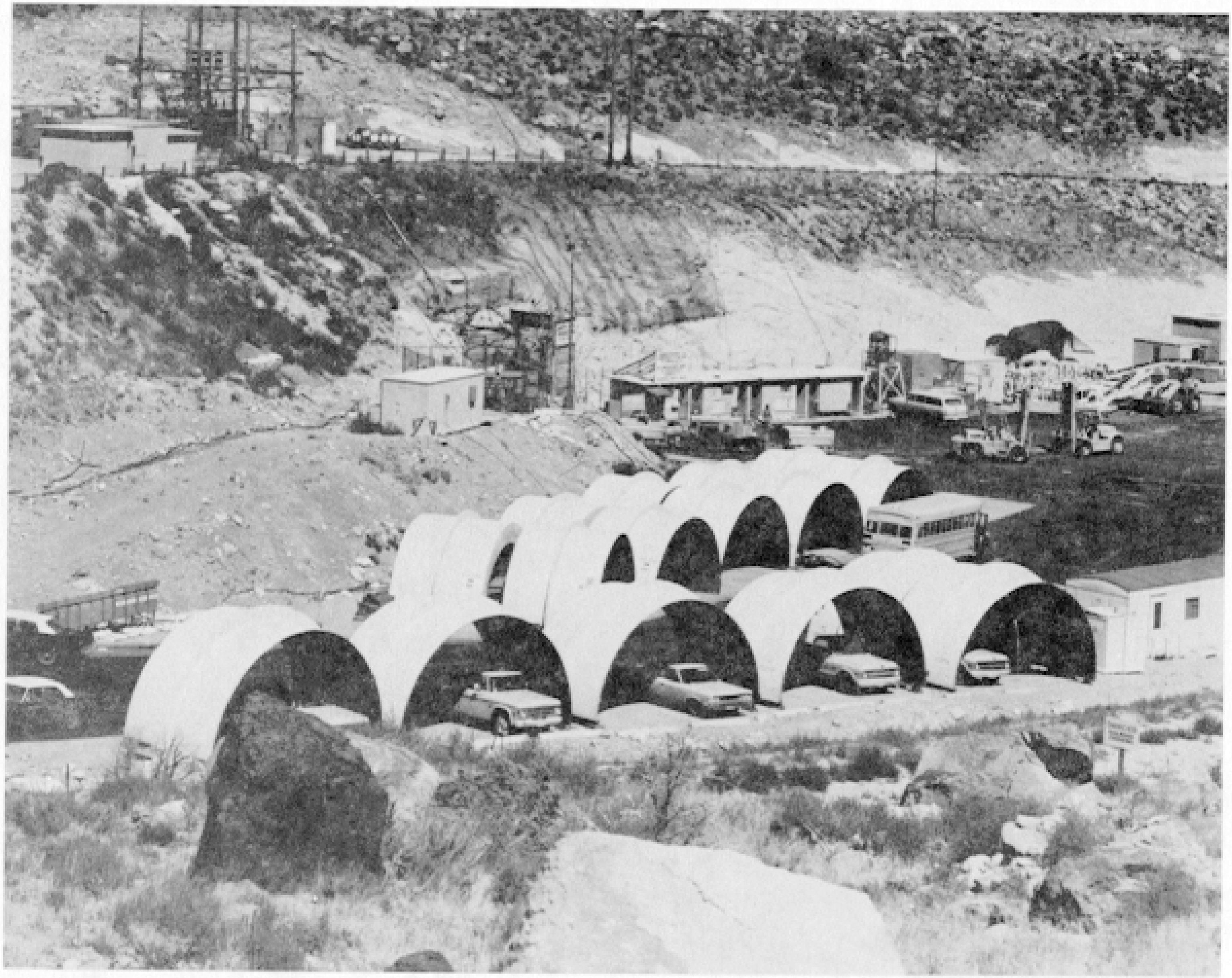


Figure 3.3 Stubs Area of the DIAMOND SCULLS Event LOS Pipe

Project agencies were responsible for designing, preparing, and installing their experiments, or delivering them to the installation contractor. After the event, these agencies were responsible for removing samples, analyzing instrument and sample data, and preparing project reports on experiment results.

Device safety and security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Because LLL fielded the device, the LLL Test Group Director was responsible for radiological safety prior to the event within a 6,000-foot radius of the zero point. This responsibility was in effect from device emplacement until device detonation. After detonation, the Test Controller relieved the LLL Test Group Director of responsibility. When the Test Controller had determined that venting had not occurred, he delegated responsibility for radiological safety in the test event area to the DOD Test Group Director.

3.2.2 Planning and Preparations

A. Tunnel Facilities Construction

From initial conception to actual execution, DIAMOND SCULLS spanned a period of more than three years. Mining of the U12t.02 drift began on 2 August 1969. At a meeting held on 6 and 7 January 1970, the readiness date was set for 1 June 1971. To meet this schedule, it was decided that four different crews would mine on a three-shift day, seven days a week, beginning 1 June 1970. A labor strike, which did not end until mid-September 1970, halted mining on 9 June. From July 1971 to February 1972, several effects and diagnostic experiment meetings were held to discuss and refine experiment details and test chamber layouts. A subsequent June 1972 readiness date was set.

Mining the U12t.02 drift allowed many facilities installed for the U12t.01 MINT LEAF event to be reused. Among these facilities were the gas seal door, cable alcove (which included two downhole cable runs from Rainier Mesa trailer park to the cable alcove), and T tunnel portal facilities and trailer park.

The experiment drift complex consisted of an LOS pipe drift and a bypass drift connected by eight crosscuts (see Figure 3.1). The crosscuts, in conjunction with the bypass drift, provided (1) late-time access for installation of the Sandia Auxiliary Closure (SAC); (2) alcove space to be used by experimenter agencies for housing power supplies and signal conditioning equipment; (3) experiment preparation and working space; and (4) access for early grouting of the main LOS pipe.

All cables installed on the zero point side of the TAPS were gas blocked inside the grout using bulkhead feed-through connectors. Cables installed in the stemmed region of the bypass drift were gas blocked using bulkhead feed-through connectors mounted on a fiberglass frame. The majority of the cables passed through the OBP in the bypass drift enroute to the cable alcove. These cables were gas blocked by installing bulkhead feed-through connectors on fiberglass bulkheads inside a grout plug.

DIAMOND SCULLS used a multiplex (multiple switching) system to control and monitor the reentry ventilation valves, fans, and electrical power distribution system. The system employed two similar control panels, one at the tunnel portal and one at the DOD monitor room at CP-1. All the valves through the gas seal door were electrically operated, but the ventilation valves through the gas seal plug and the OBP required manual operation. The gas sampling system allowed air samples to be drawn remotely from the zero point side of the gas seal door, gas seal plug, and OBP into a plastic bag. The gases could then be analyzed for radioactivity and for the presence of any explosive mixture, and returned through the system to the inside of the respective plug. Ventilation and gas sampling systems could be operated manually at all points during tunnel reentry.

Multiconductor and coaxial cables were laid in elevated metal trays from the Rainier Mesa splice shack to the 38 instrumentation trailers which were arranged in the Mesa trailer park. These trailers, along with three instrumentation trailers at the portal, were shock mounted and electrically isolated from the ground. The Mesa instrumentation trailers contained oscilloscopes, tape recorders, and oscillographs on which diagnostic and other measurement data were recorded. Operational functions in the Mesa trailer park and in the tunnel would be controlled from CP-1 by timing signals during the 15-minute countdown. These timing signals would be transmitted by microwave and hardwire from CP-1 to the timing and firing trailer in the Mesa trailer park. Critical functions in the tunnel and portal instrumentation trailers would be monitored at CP-1 in the LLL control room and the DOD monitor room.

B. Radiological Safety Support

Procedures for radiation exposure and contamination control during this event were in accordance with AEC Manual Chapter 0524 and requirements of responsible DOD representatives. Radsafe provided monitoring and equipment support, air sampling, and telemetry.

Prior to the test event, detailed radiological safety reentry plans were prepared and issued to participating agencies. Air sampling equipment was positioned in the test area. Radsafe monitors were briefed regarding surface reentry, manned stations, and security station requirements.

Radsafe monitoring teams and supervisory personnel were provided to perform surface initial radiation surveys, conduct aerial surveys by helicopter, and participate in reentry parties as needed. Radsafe personnel also were standing by at Gate 300 prior to detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment and material, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Available anticontamination materials and equipment included head covers, coveralls, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, plastic bags, gloves, and masking tape.

C. Telemetry and Air Sampling Support

In addition to permanent RAMS units, 42 temporary units provided coverage for the DIAMOND SCULLS event as shown in Table 3.1 and Figures 3.4 and 3.5. A single air sampling unit was located at the portal. All RAMS units and the air sampling unit were installed a minimum of five days prior to scheduled device detonation.

D. Security Coverage

Device security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Beginning on D-1, all personnel entering or exiting the controlled area were required to stop at muster or control stations for issue of stay-in badges or issue and return of muster badges. After area control was established, all through traffic was diverted around the controlled area by use of screening stations.

In accordance with the "Test Controller's Operations and Security Plan," contractors and agencies were to have all personnel not connected with the event out of the controlled area before the final security sweep began.

E. Air Support

One UH-1F and two UH-1N helicopters with USAF pilots and crews were available to provide support for aerial closed-circuit television coverage, cloud surveillance (should venting occur), and security sweeps. One Turbo Beech aircraft was airborne at the NTS for use if needed for cloud sampling and tracking. An EPA Turbo Beech aircraft was standing by at McCarran Airport in Las Vegas to undertake a sampling and tracking mission if required.

TABLE 3.1

DIAMOND SCULLS EVENT RAMS UNIT LOCATIONS
20 July 1972

Station	Location
	SURFACE
	From portal:
1	At portal
2	208 feet S 81° W azimuth on filter system
3	222 feet S 75° W azimuth on ventilation line
4	222 feet S 75° W azimuth on ventilation line
5	332 feet N 09° W azimuth
6	345 feet N 68° E azimuth
7	346 feet S 55° E azimuth
8	388 feet S 07° E azimuth
9	324 feet S 43° W azimuth
10	564 feet N 74° W azimuth
11	650 feet S 82° E azimuth on tunnel drain line
12	2,020 feet S 89° E azimuth
13	1,710 feet S 57° E azimuth
14	1,275 feet S 01° E azimuth
15	1,995 feet S 60° W azimuth
16	1,370 feet N 37° W azimuth
17	1,740 feet N 50° E azimuth
	From cable downhole:
18	At cable downhole
19	264 feet N 04° W azimuth
20	219 feet N 62° E azimuth
21	150 feet S 17° E azimuth
22	165 feet S 87° W azimuth
	From SGZ:
23	260 feet N 51° E azimuth
24	380 feet S 02° E azimuth
25	280 feet N 45° W azimuth

TABLE 3.1 (Concluded)

Station	Location
	UNDERGROUND
	From the main drift unless otherwise indicated:
31	1,450 feet into U12t.02 LOS drift
32	1,000 feet into U12t.02 LOS drift
33	650 feet into U12t.02 LOS drift
34	900 feet into U12t.02 bypass drift
35	300 feet into U12t.02 bypass drift
36	450 feet into U12t.02 drift
*37ER	450 feet into U12t.02 drift
38	300 feet into U12t.02 drift
39	400 feet into U12t.01 bypass drift from the U12.01 LOS drift
40	Cable alcove (400 feet into the U12t.02 LOS drift)
	From the portal:
41	2,800 feet into U12t main drift
42	2,240 feet into U12t main drift
*43ER	2,240 feet into U12t main drift
44	1,800 feet into U12t main drift
45	1,600 feet into U12t main drift
46	900 feet into U12t main drift
47	100 feet into U12t main drift

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*ER - Extended Range (instrument capable of reading 100 mR/h to 100,000 R/h)

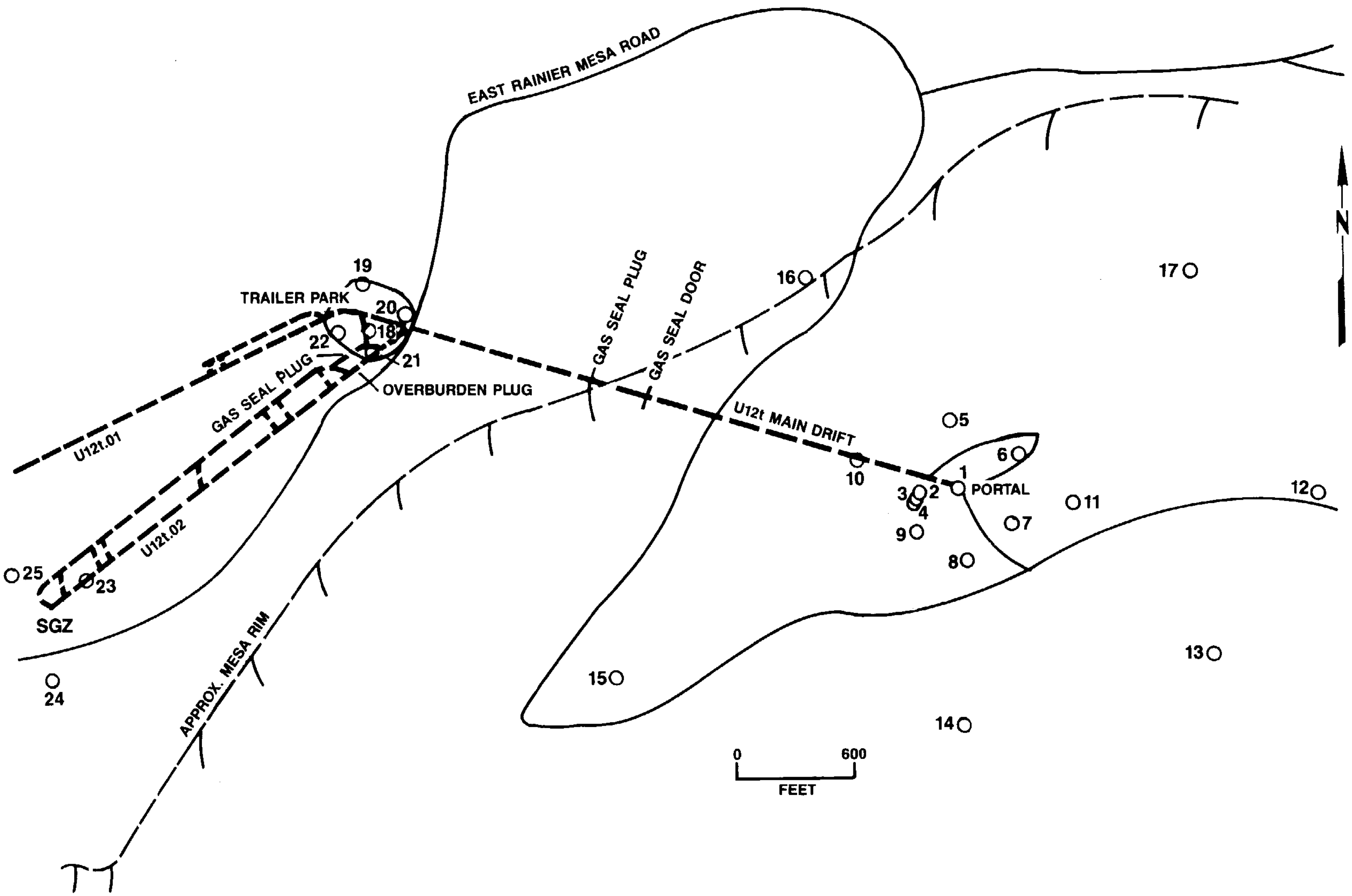


Figure 3.4 DIAMOND SCULLS Event - Surface RAMS

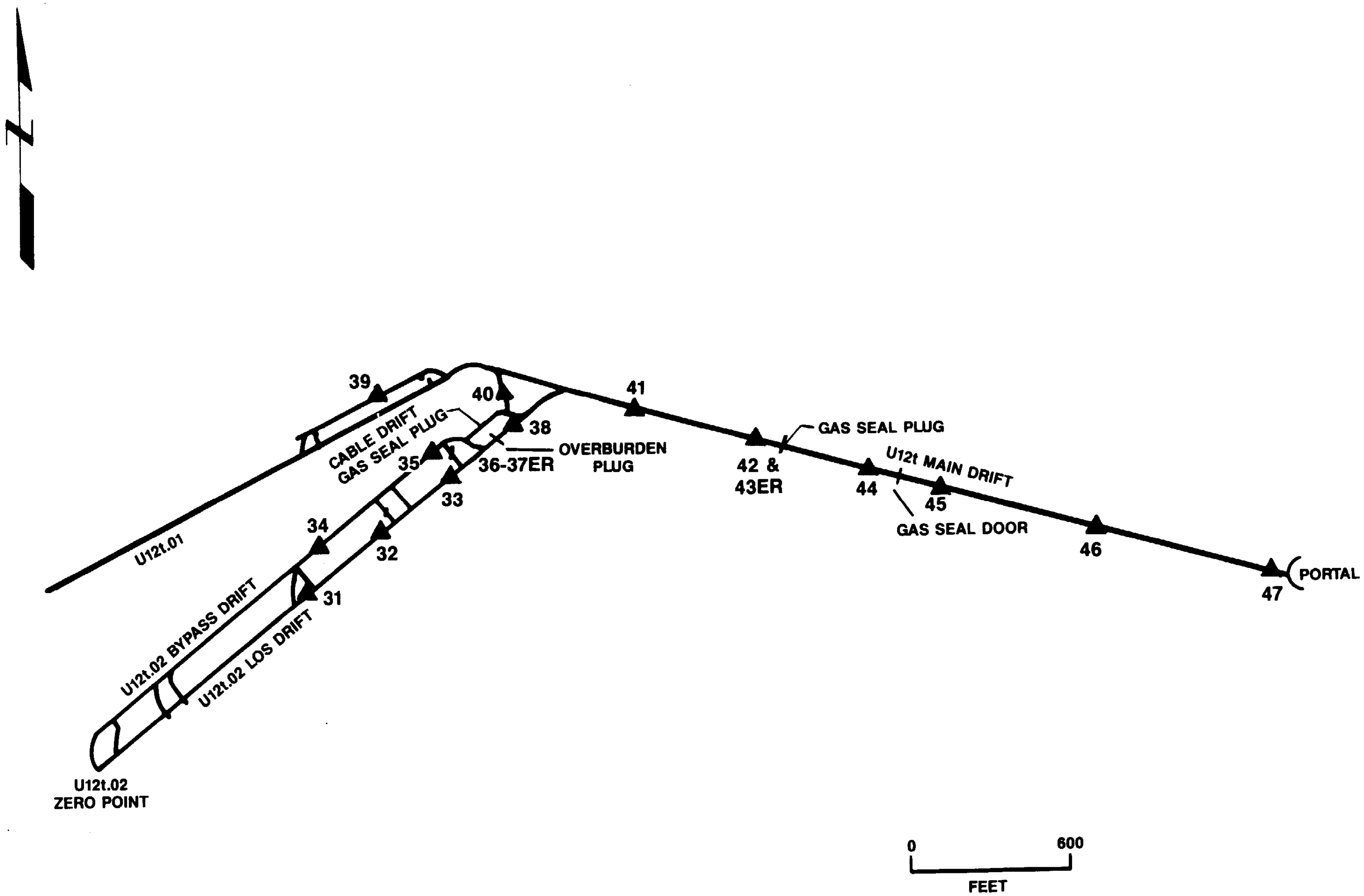


Figure 3.5 DIAMOND SCULLS Event - Underground RAMS

3.2.3 Late Preevent Activities

The final dry run (FDR) was completed at 1514 hours on 17 July. After only one hold in the countdown, all monitoring equipment was functioning properly; however, DIAMOND SCULLS detonation was delayed for 48 hours so the Test Group staff could reevaluate a technical problem and deal with an air leakage problem which had occurred at the OBP. During this time, two additional FDRs were conducted. Another 24-hour delay in test execution occurred because AEC/HQ approval had not been given.

At a readiness briefing conducted on 19 July, test execution was scheduled for 0800 hours on 20 July. All weather conditions appeared favorable.

3.3 EVENT-DAY ACTIVITIES

On D-day (20 July 1972), several minor problems were encountered from the time of the FDR to detonation, as would be expected because the system had been in event-ready configuration for five days. The 0800 zero time was delayed until security guards accounted for all personnel in the forward areas. Countdown started again at 0955 hours. All systems were operating properly. A hold was activated approximately nine minutes into the countdown to discuss an experiment problem. The countdown resumed, and all other monitoring equipment indicated proper operation at zero time.

The DIAMOND SCULLS device was detonated at 1016 hours on 20 July 1972.

3.3.1 Test Area Monitoring

Telemetry measurements began at 1017 hours on 20 July. At

H+1 minute, RAMS unit No. 31 showed a maximum reading of 300 R/h. RAMS unit Nos. 32, 33, 36, 37, and 38 also showed radiation readings, with the highest being 200 R/h at H+1 minute. This was as expected because these RAMS units were located along the LOS pipe and responded to neutron activation of the LOS pipe and its contents. All RAMS units except Nos. 3 and 4 (on the surface vent line and filter system), and 31, 32, and 33 underground were secured at 1416 hours on 24 July. RAMS Nos. 3 and 4 on the vent line filter system continued to operate at AEC request, but the remaining functioning stations were secured at 1300 hours on 26 July. No indications of radioactive effluent release were observed by underground, surface, or airborne monitoring systems.

3.3.2 Rainier Mesa Initial Radiation Survey and Reentry Activities

An aerial survey of postevent surface conditions showed that the Mesa could be accessed via the East Mesa Road with minimal delays for removal of rock fall. Surface reentry began at 1145 hours and ended at 1600 hours on D-day. All measurement records were recovered without incident. No radiation level above background was detected in the area.

3.3.3 Portal Initial Radiation Survey Activities

Radiation readings during reentry of the portal area were 0.05 mR/h (background). Remote gas sampling on the zero point side of the OBP indicated that no evidence of explosive mixture or above-background radioactivity levels were present. Gas chromatograph samples collected remotely on D-day from the LOS pipe area indicated a maximum of 25 percent of the LEL and 0.05 percent hydrogen. Ventilation was established on the portal side of the gas seal door at 1840 hours on D-day. Also at 1840 hours, a valve was opened to allow water to drain from the zero point side of the OBP towards the portal side.

3.4 POSTEVENT ACTIVITIES

3.4.1 Tunnel Reentry Activities

On D+1, members of initial tunnel reentry team No. 1 entered the portal (see Figure 3.6) at 1035 hours and traveled to the gas seal door. All team members were dressed in anticontamination clothing and wearing Draeger self-contained breathing apparatus. No tunnel damage was observed along the way. Upon arrival, permission was granted to open the large gas seal door. As a first step in performing this task, team members opened the access door and installed sump pumps to remove water approximately 1 1/2 feet deep from the zero point side of the door. Team members partially opened the large gas seal door before exiting the tunnel at 1319 hours. A reading of 600 ppm carbon dioxide was detected, radiation readings were background, and no evidence of explosive mixture was detected.

Team No. 2 entered the tunnel at 1342 hours and traveled through the gas seal door to the gas seal plug. The radiation reading at that location was background (0.05 mrad/h). Team members installed a vent line through the gas seal plug, then returned to the gas seal door, opened it, and reinstalled train tracks. The requirement for Draeger self-contained breathing apparatus was discontinued near the end of this reentry. Team No. 2 exited the tunnel at 1615 hours. The maximum radiation reading detected was 0.05 mrad/h (beta plus gamma), and 1,000 ppm carbon dioxide was measured. No evidence of any explosive mixture was detected.

On D+2, a reentry team left the portal at 0855 hours and traveled to the gas seal plug. Radiation levels between the portal and the gas seal door remained at background. Team members were dressed in anticontamination clothing, and Draeger self-contained breathing apparatus again was required for

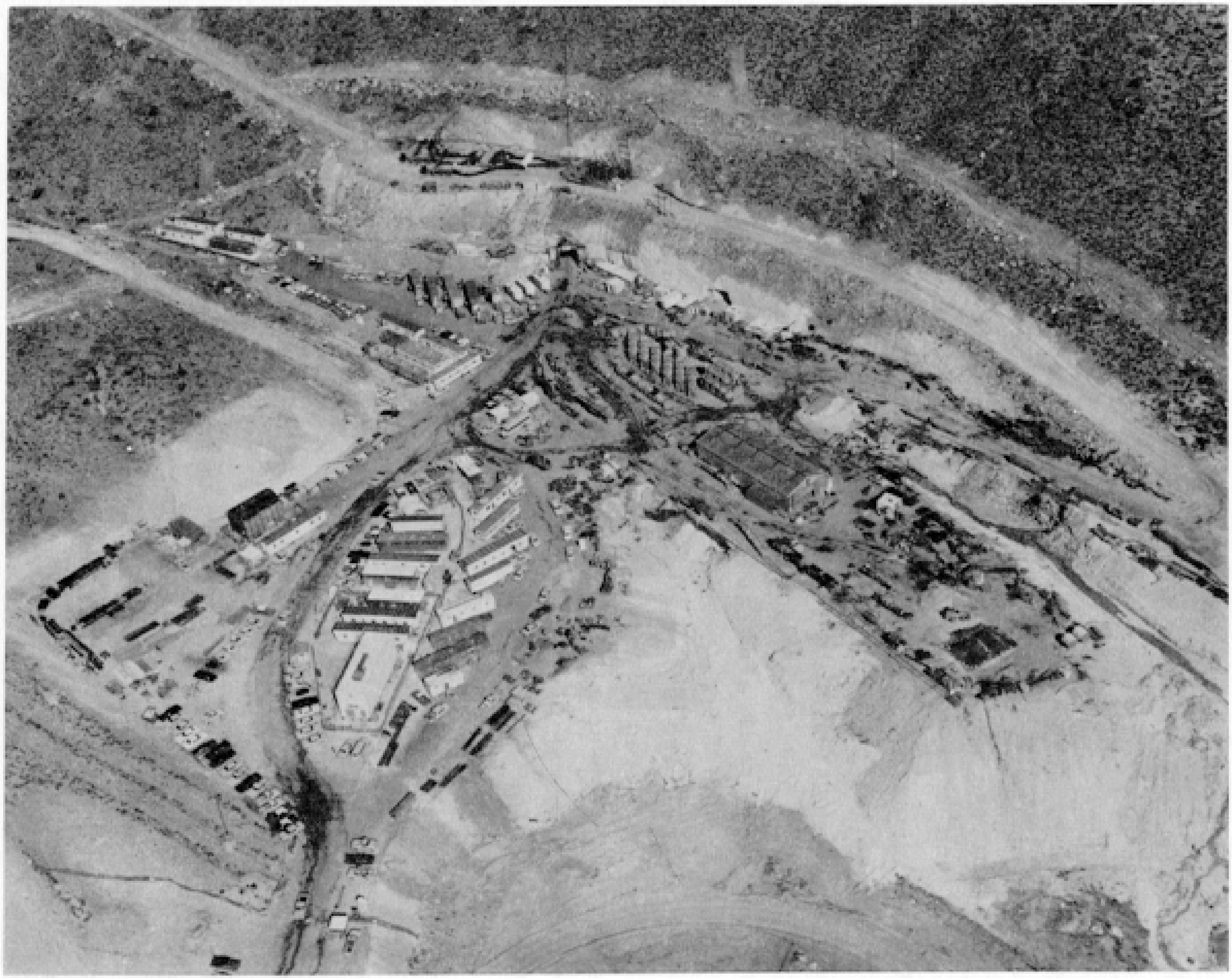
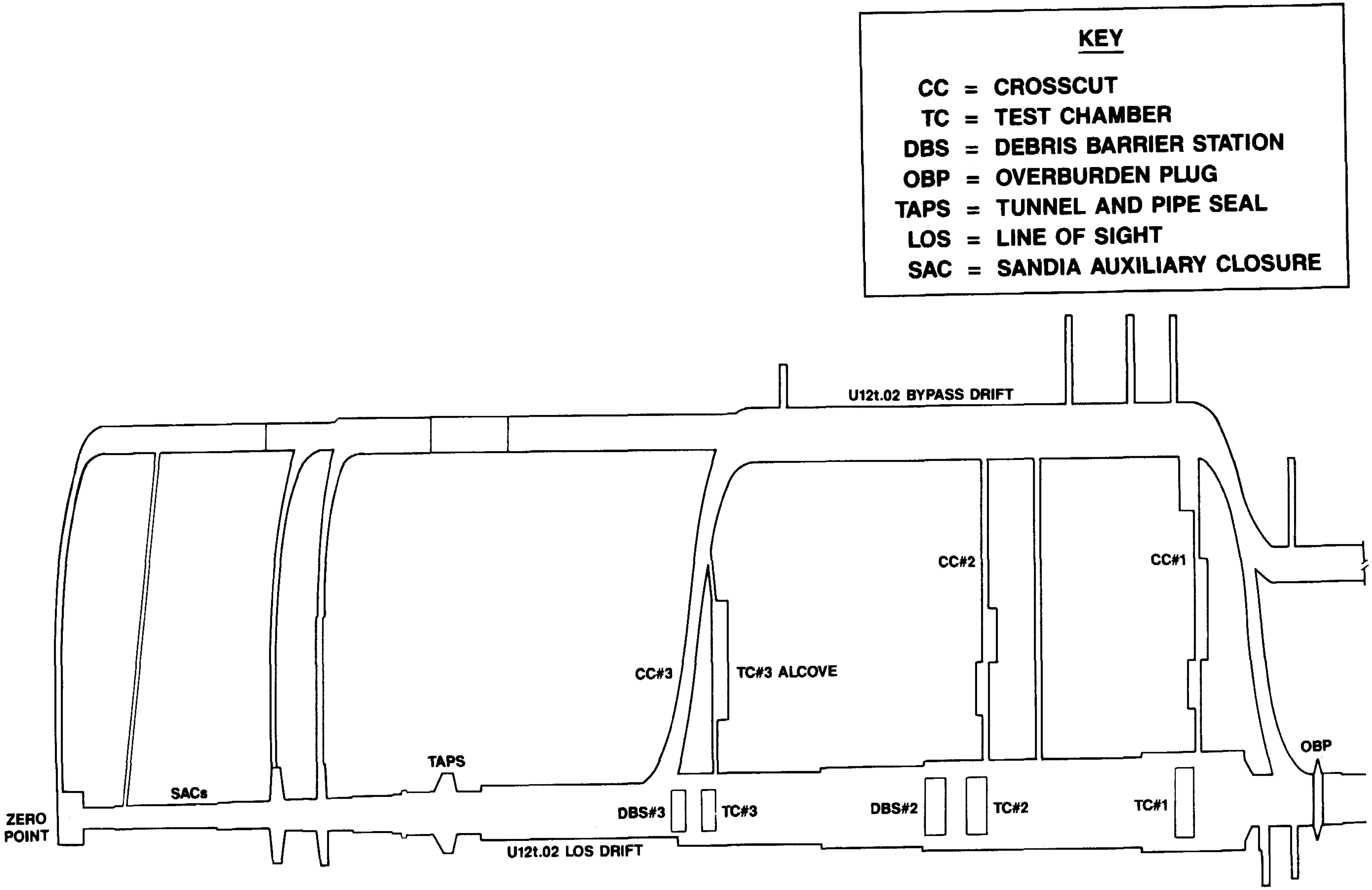


Figure 3.6 DIAMOND SCULLS Event - Aerial View of T Tunnel Portal

reentry. A hazard and damage survey of the tunnel to the OBP was conducted, which included sending one team member through the OBP to check for water on the zero point side. No water was found. A vent line was installed and team members exited the tunnel at 1140 hours. The maximum radiation reading detected at the OBP was 0.05 mR/h. No evidence of explosive mixture or toxic gases was detected.

On 23 July, a reentry team, a rescue team, and support personnel entered the tunnel at 0829 hours and proceeded toward the OBP. The purpose of this reentry was to walk through the LOS pipe drift and bypass drift as far as possible (to the end of stemming if possible), make a hazard and damage survey, and establish ventilation in the LOS pipe (Figure 3.7). Team members arrived at the portal side of the OBP, which appeared to be in good condition, and the rescue team and support personnel remained on the portal side of the OBP while the reentry team proceeded through it. A radiation level of 0.05 mR/h was measured on the zero point side and no evidence of explosive mixture was detected. The same conditions were found in the bypass drift at crosscut No. 1. By 0938 hours, team members had reached the stemming plug at the end of the cable drift. All radiation readings taken were less than 1 mR/h. At 0948 hours, team members had returned to the LOS drift/cable drift junction and were preparing to proceed into the LOS drift. Test chamber No. 1 was reached at 0957 hours. The exposure rate at the door was 6 mR/h, test chamber No. 2 had an exposure rate of 7 mR/h, and test chamber No. 3 had an exposure rate of 15 mR/h. Team members reached the end of stemming at 1022 hours.

The team returned to the TAPS area, and the door to test chamber No. 3 was opened at 1031 hours. An exposure rate of 25 mR/h was measured at arm's length inside the chamber. Team members then traveled to test chamber No. 2 and opened the door. An exposure rate of 19 mR/h was detected at arm's length inside



NOT TO SCALE Figure 3.7 DIAMOND SCULLS Event - Tunnel and Pipe Layout this chamber. The door to test chamber No. 1 was opened at 1110 hours and an exposure rate of 24 mR/h was measured at arm's length into the chamber. Swipes were taken at each test chamber door. At 1126 hours, the face mask requirement was removed, and team members began exiting the tunnel, reaching the portal side of the OBP at 1135 hours. Team members exited the portal at 1150 hours and reentries were completed for the day.

On 24 July, two personnel entered the LOS pipe to perform a scientific assessment of the experiments. They were the only persons who entered the pipe for this purpose and both wore anti-contamination clothing and full-face masks with supplied air. One person took air samples which were analyzed for beryllium: none was detected. Pan American World Airways (Pan Am) photographers began station photography, and LASL personnel entered the pipe to lower one experiment to the floor of the test chamber in an effort to protect it from damage. All personnel wore anticontamination clothing and full-face masks with self-contained breathing apparatus.

On 25 July, the face mask and anticontamination clothing requirement was removed based on results of swipes for beryllium and air samples taken in the test chambers; however, this protective equipment was available if desired by users. Pan Am station photography continued. Pan Am personnel elected to wear anticontamination clothing, but not face masks. LASL personnel entered the pipe to look through the debris and take photographs. These personnel elected to wear anticontamination clothing and face masks.

A reentry to the TAPS was performed on 26 July. The TAPS was reached by entering the LOS pipe through a porthole on the zero point side of debris barrier station (DBS) No. 3. The radiation reading at contact with the TAPS door was 0.7 mR/h. A trace of carbon monoxide was detected.

3.4.2 Experiment Recovery Activities

Recovery of the smaller experiments began on 31 July. No anticontamination clothing or face masks were required. Almost all of the small experiments were recovered by 2 August.

Recovery of major experiments began on 7 August and continued through 10 August. During this time, preparations to begin mining a reentry drift were made.

3.4.3 Postevent Mining Activities

On 21 August, a toxic gas survey of drill holes at the reentry drift face showed one hole (with water running from it) which measured 500 ppm carbon monoxide in the ambient air. The area was cleared for about one hour to allow the ventilation system to dissipate the gas. The vent line was then extended to the face. No more problems with toxic gases were experienced on day shift and through the first part of swing shift. At about 1815 hours, 10-20 percent of the LEL and 100-250 ppm carbon monoxide were detected in a drill hole in the face. Work at the face was stopped until the drill holes were ventilated. No other problems were encountered on this shift.

At about 0200 hours on 22 August, an explosive mixture was detected in a 16-foot probe hole in the heading and in several holes drilled for dynamiting operations at the heading. Greater than 100 percent of the LEL and more than 3,000 ppm carbon monoxide were detected. Later, a high range carbon monoxide tube was used to check the holes, and a 5,500 ppm concentration was detected. The heading was evacuated for the remainder of the shift although routine toxic gas and explosive mixture checks were made at the face and in the probe hole.

During day shift, a reentry inside the LOS pipe to the TAPS door to collect gas samples and measure pressure on the zero point side was performed. Team members wore anticontamination coveralls and Draeger self-contained breathing apparatus. The reentry lasted approximately 30 minutes. Based on these sample results, AEC/NVOO gave permission to begin bleeding pressure from the zero point side of the TAPS into the vent line. Team members returned to the TAPS plug. The valve was opened at 1700 hours and gas was bled into a vent line. An explosimeter measured three percent of the LEL in the vent line approximately ten feet from the TAPS plug. Samples, taken from the gas sampling system through the vent line out to the portal, indicated the absence of any explosive mixture. The system was allowed to operate for approximately 40 minutes. The vent line at the TAPS plug was resurveyed and three percent of the LEL still was indicated. The system was allowed to continue ventilating, all personnel were evacuated from the tunnel, and the portal gates were locked at 1800 hours.

On 23 August, a reentry team (with a rescue team on standby) was organized to:

A. Check the pressure on the gauge at the TAPS door, open the valve, and watch to see if air flow had been established.

B. Take a gas sample and close off the valve (if the flow had been established).

C. Sample gas from behind the TAPS door.

D. Close the valve at the TAPS and watch for an increase in air pressure.

E. Check the face in the reentry heading and the pressure on the gauge in the 1/2-inch line into the 16-foot probe hole.

F. Attach a nitrogen bottle to the line in the reentry heading and pressurize the 16-foot probe hole with nitrogen.

Reentry team members were required to dress in the same manner as the previous day. Reentry began at 1130 hours. The reentry heading was checked; no pressure was noted on the gauge, but a bag sample could be filled slowly from the line. The valve at the TAPS was left in the "open" position, and reentry was aborted. Tunnel gates were locked at 1430 hours.

All personnel working in the reentry drift from 24 August to 27 August wore full-face masks with all-purpose canisters.

On 28 August, a work party entered the tunnel and prepared to drill into the LOS pipe. Personnel in the heading during drilling wore supplied-air respiratory protection equipment. Drilling began at 1510 hours, and at 1830 hours 10,000 ppm carbon monoxide and greater than 100 percent of the LEL were detected. Personnel were evacuated from the heading even though the vent line was pulling the toxic and explosive gases from the working area into the ventilation system. Four persons wearing Draeger self-contained breathing apparatus entered the working area to connect a flex-line to the vent line and place the flex-line over the hole. Air samples from the vent line indicated explosive mixture at seven percent of the LEL and carbon monoxide at 35 ppm. All personnel exited the tunnel by 1930 hours and the portal gate was locked.

On 29 August, tunnel areas near the Red Shack were checked. An SLA party traveled to the 01 drift to remove an experiment.

Later, an attempt was made to sample gas from the reentry heading and from the zero point side of the TAPS door. Party members were unable to get a sample from the reentry heading because air pressure was lacking, but were able to pump a sample from the line at the TAPS door. Toxic gas surveys indicated concentrations of 4,300 ppm carbon monoxide and 1,800 ppm carbon dioxide. At approximately 1100 hours, it was decided that because there was no pressure on the zero point side of the TAPS door the opportunity should be taken to remove the gas sampling plug from the TAPS door. This would provide a 1 1/2-inch diameter hole into the void instead of the 1/4-inch diameter hole then available. The task was performed by personnel wearing Draeger self-contained breathing apparatus. No problems were experienced during this operation, which lasted approximately 20 minutes. At 1415 hours, personnel began pumping water out of the drill hole at the reentry heading. During this operation, air quality checks reflected concentrations approaching 60 percent of the LEL and 2,000 ppm carbon monoxide. After the hole was drained, a closed ventilation system was reestablished with exhaust pumped through the vent line. The vent line was then sampled about every half hour throughout the night.

During the morning of 30 August, two REECo industrial hygiene personnel performed a survey of the tunnel because a noxious odor could be smelled in the area from the Radsafe station to the reentry drift heading. All working areas were checked for the presence of hydrogen sulfide, but none was detected. The gas sample line had been modified so that samples could be taken from the collar pipe in the drill hole to monitor gases coming from the LOS pipe. Because this system was available and the odor had not been identified, the DOD representative in charge elected to continue efforts to identify the odor, remove people from the tunnel, and allow tunnel entry only when necessary.

On 5 September, preparations were made to resume the mining operation. Two personnel again took samples in an effort to identify the noxious odor experienced the previous week. No further problems were noted during swing shift, but graveyard shift personnel detected the odor while drilling probe holes toward the LOS pipe. A face-mask requirement was instituted.

On 12 September, work to drill through the LOS pipe wall continued. A hole was drilled into the lower portion of the pipe, and water and a noxious odor were encountered. Drillers were wearing supplied-air masks and the Radsafe monitor wore a face mask with MSA Type N canister. Work was stopped except for pumping water into tank-type mine cars and moving these cars to the portal for dumping. This work was performed by personnel wearing masks and supplied air equipment.

On 13 September, mining resumed in the reentry heading with no evidence of the odor, and the mask requirement was removed. The drift face was drilled during swing shift and the odor occurred again in the work area. Face masks again were required until the odor dissipated.

The LOS pipe was reached on 14 September. Personnel cutting into the pipe wore full-face masks with self-contained breathing apparatus. Water four to six inches deep was present in the pipe, as well as the noxious odor previously discussed. Work was discontinued until REECo industrial hygiene and SLA personnel collected more air and water samples. After taking samples, the hole into the pipe was enlarged to three feet by five feet to provide access into the LOS pipe. A miner wearing hip boots, a rubber coat, and a full-face mask with supplied air entered the LOS pipe to install a sump pump behind the TAPS door.

Routine mining operations continued until 2 November when drilling of a probe hole (the first of two) was begun in an effort to delineate the cavity radius. All personnel working at the drill face wore supplied-air breathing apparatus. Maximum readings were 5 mrad/h, a trace of carbon monoxide, and 3 to 20 percent of the LEL at the second probe hole on 13 November 1972. Drilling of the two holes was completed, and work in the U12t.02 drift was discontinued on 16 November 1972.

3.4.4 Postevent Drilling Activities on Rainier Mesa

Postevent drilling toward the underground zero point from the surface of Rainier Mesa was delayed due to problems with the drilling rig, finally beginning at 0047 hours on 26 August 1972. The maximum exposure rate detected during drilling operations was 0.5 mrad/h from 0700 hours to 1600 hours at PS-1A on 28 August. Core sampling operations were conducted from 1725 hours on 27 August to 1615 hours on 28 August. Eighteen samples were collected, with a maximum gamma reading for a single core sample of 2.5 R/h. No alpha radiation was detected. The drill hole was cemented to the top at 0010 hours on 30 August after coring operations were completed.

3.4.5 Industrial Safety

Measurements of radiation levels, toxic gases, and explosive mixtures were made on each shift. These measurements were recorded in the Radsafe monitors' logbook.

Appropriate safety measures were taken to protect mining personnel and prevent unsafe conditions. Industrial safety codes, including specific codes for mining and drilling, were established by REECo and emphasized during all operations. A written standard operating procedure was required for each operation involving explosives, toxic material, or any other operation with the potential for personal injury. Each individual involved in such an operation was required to know the contents of the applicable procedure.

The portal construction area and the tunnel were mandatory hard hat and foot protection areas (safety shoes, safety boots, miners boots, or toe guards). Each participating agency provided its own safety equipment. All personnel on the initial tunnel reentry teams were certified in the use of McCaa two-hour breathing apparatus and had used Draeger self-contained breathing apparatus. Standard safety rules and regulations, as outlined in the "U.S. Bureau of Mines Manual," were observed.

All explosives, electro-explosive components, solid propellants, toxic material, and radioactive material were handled, stored, and transported in accordance with applicable sections of the following documents:

A. Army Materiel Command Regulations (AMCR 385-224).
B. AEC Manual 500 Series for the Nevada Test Site.
C. Individual Safe Operating Procedures (by experimenter organization).
D. DIAMOND SCULLS Safety Regulations.

All personnel engaged in handling, storing, assembling, or installing explosives, propellants, or electro-explosive devices (or observers of those operations) were required to wear safety glasses or other eye protection which had been approved by the DOD Safety Coordinator.

3.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 1017 hours on 20 July 1972. The maximum gamma radiation level detected was 300 R/h at H+1 minute by RAMS unit No. 31. This was attributed to neutron activation of the LOS pipe. No uncontained effluent was detected inside or outside the tunnel complex. All RAMS units had been secured by 1300 hours on 26 July.

The initial postevent survey began at 1145 hours and ended at 1600 hours on D-day. No radiation levels above background were detected. Initial tunnel reentry began at 1035 hours on D+1 and was completed at 1319 hours. Maximum gamma radiation and toxic gas concentrations measured during this reentry were 0.05 mR/h and 600 ppm carbon monoxide, respectively. No indications of explosive mixture were detected. Tunnel reentry and mining operations continued until 16 November 1972. Maximum readings were 10,000 ppm carbon monoxide and greater than 100 percent of the LEL during the drilling of a probe hole into the LOS pipe on 28 August 1972. Beginning 30 August, a noxious odor was noted at times in the reentry heading. Because this odor was never identified, a face mask requirement was instituted when the odor occurred. After 14 September, the LOS pipe had been reached and supplied air apparatus was required at all times.

Mesa postevent drilling began at 0047 hours on 26 August 1972 and was completed at 0010 on 30 August 1972. The maximum gamma radiation measured was 2.5 R/h at contact with a single core sample. No alpha radiation was detected.

Personnel gamma radiation exposures received during individual entries to DIAMOND SCULLS radex areas from 20 July 1972 to 24 October 1972 are summarized below. The average exposures are from self-reading pocket dosimeter readings as recorded on Area Access Registers. No positive exposures were recorded by film dosimeters during these entries because the minimum reportable gamma exposure for NTS film dosimeters was 30 mR per film packet.

	No. of Entries Logged	Average Exposure (mR)
All Participants	943	0.05
DOD Participants	51	0.10

There were no cumulative whole body external or internal exposures which exceeded established limits.

CHAPTER 4

DIDO QUEEN EVENT

4.1 EVENT SUMMARY

DIDO QUEEN was a DOD-sponsored underground test detonated at 1000 hours PDT on 5 June 1973 with a yield less than 20 kt. The device was detonated in E tunnel (U12e.14 drift, see Figure 4.1) at a vertical depth of 1,284 feet. The objective of this test was to determine the response of materials and equipment to a nuclear detonation environment. Government agencies and contractors conducted 37 projects to obtain the desired weapons effects information.

Stemming was successful and containment was complete. No radioactive effluent was detected by surface or airborne monitoring systems.

4.2 PREEVENT ACTIVITIES

4.2.1 Responsibilities

Safe conduct of all DIDO QUEEN project activities in Area 12 was the responsibility of the DOD Test Group Director. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DNA, and AEC/NVOO.

Project agencies were responsible for designing, preparing, and installing their experiments, or delivering them to the installation contractor. After the event, these agencies were

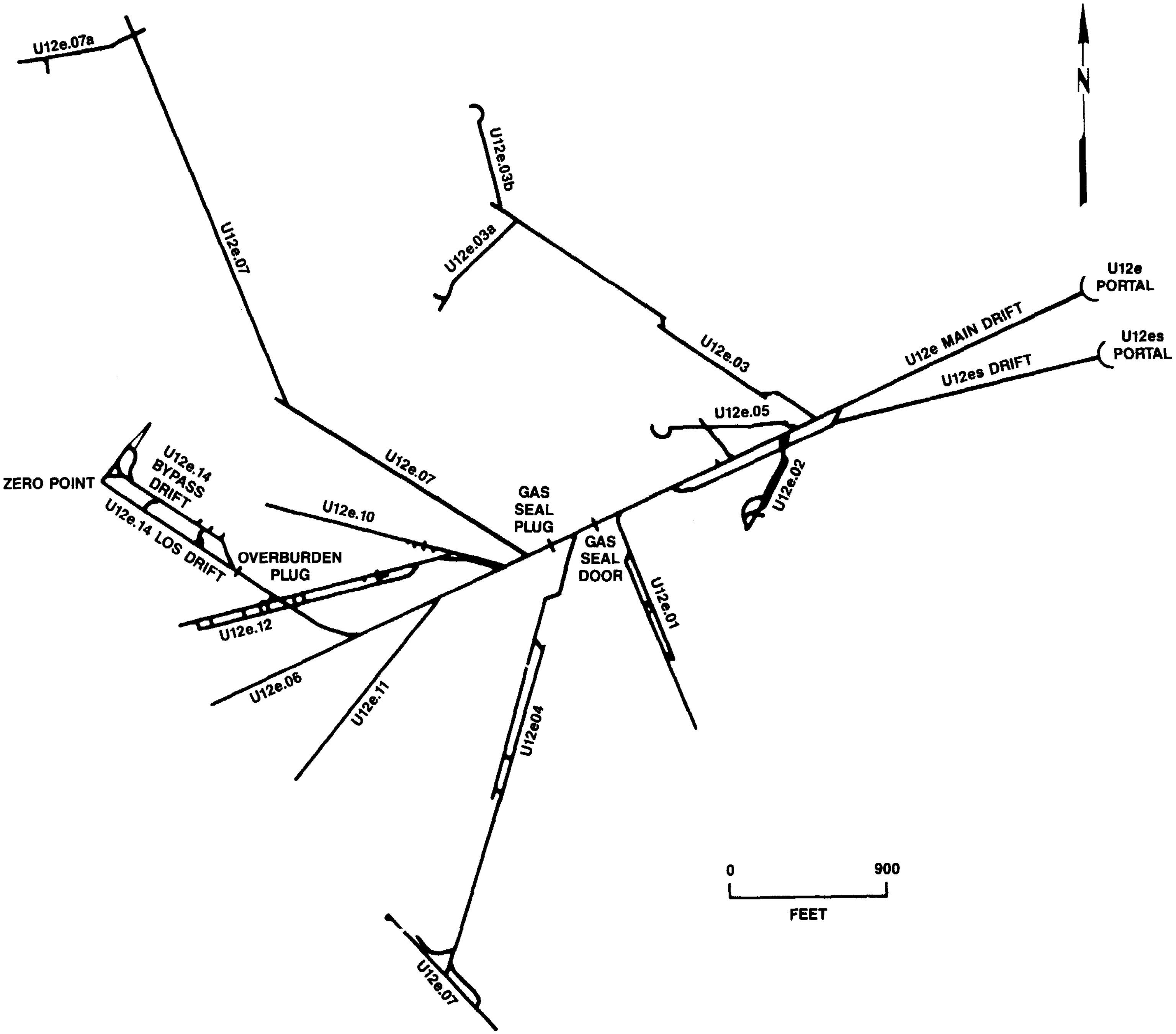


Figure 4.1 DIDO QUEEN Event - Tunnel Layout

responsible for removing samples, analyzing instrument and sample data, and preparing project reports on experiment results.

Device safety and security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Because LLL fielded the device, the LLL Test Group Director was responsible for radiological safety within a 6,000-foot radius of the zero point prior to the event. This responsibility was in effect from device emplacement until detonation. After detonation, the Test Controller relieved the LLL Test Group Director of responsibility. When the Test Controller had determined that venting had not occurred, he delegated responsibility for radiological safety in the test event area to the DOD Test Group Director.

4.2.2 Planning and Preparations

A. Tunnel Facilities Construction

Mining the U12e.14 drift permitted the reuse of many facilities installed for previous events. Additional facilities required for DIDO QUEEN were the experiment and bypass drifts, a new OBP with a gas blocking alcove, a gas seal plug between the OBP and the gas seal door, and new facilities for a second LOS pipe for high fluence recoverable (HFR) experiments. Also included were a new Rainier Mesa HFR trailer park and a new vertical downhole cable run. The U12e.14 drift complex consisted of the main experiment (LOS pipe) drift (1,065 feet long), a bypass drift connected by crosscuts to the main LOS pipe drift, and an auxiliary LOS pipe drift (see Figure 4.1). The bypass drift in conjunction with its crosscuts provided: (1) access for installation of the DNA Auxiliary Closures (DACs); (2) access for experiment installation in the test chambers; (3) access to alcove space used by experimenters to house power supplies, contain signal conditioning equipment, and provide experiment preparation working space (called the "Dance Hall"); (4) capability for early grouting around the main LOS pipe prior to device installation; (5) access for experiment installation in the HFR LOS pipe; and (6) access for device installation.

Cables used by experimenters were routed from Mesa trailers through the Mesa splice shack, into the underground cable alcove, through gas blocks, then along the right rib of the previous HUDSON MOON event (U12e.12) reentry drift, through the OBP and a gas blocking alcove, and across the bypass drift in a trench to the Dance Hall.

Multiconductor and coaxial cables were laid in elevated metal trays from the Mesa splice shack to the 21 instrumentation trailers which were arranged in clusters at the E tunnel main Mesa trailer park. These trailers, along with instrumentation trailers at the HFR pad and at the portal, were shock-mounted and electrically isolated from the ground. Mesa and HFR pad instrumentation trailers contained oscilloscopes, tape recorders, and oscillographs on which diagnostic data were recorded.

B. Radiological Safety Support

Procedures for radiation exposure and contamination control during this event were in accordance with AEC Manual Chapter 0524 and requirements of responsible DOD representatives. Radsafe provided monitoring and equipment support, air sampling, and telemetry.

Prior to the test event, detailed radiological safety reentry plans were prepared and issued to participating agencies. Air sampling equipment was positioned in the test area. Radsafe monitors were briefed regarding surface reentry, manned stations, and security station requirements.

Radsafe monitoring teams and supervisory personnel were provided to perform surface initial radiation surveys, conduct aerial surveys by helicopter, and participate in reentry parties as needed. Radsafe personnel also were standing by at Gate 300 prior to detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment and material, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Available anticontamination materials and equipment included head covers, coveralls, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, plastic bags, gloves, and masking tape.

C. Telemetry and Air Sampling Support

In addition to permanent RAMS units, 41 temporary units provided surface and underground coverage for the DIDO QUEEN event as shown in Table 4.1 and Figures 4.2 and 4.3. A single air sampling unit was placed near each portal (the U12e main portal and the U12es portal). All RAMS units and the two air sampling units were installed a minimum of five days prior to scheduled device detonation.

TABLE 4.1

DIDO QUEEN EVENT RAMS UNIT LOCATIONS
5 June 1973

Station	Location
	SURFACE
	From U12es (new) portal:
1	195 feet at N 66° W azimuth (at vent filter system)
2	195 feet at N 66° W azimuth (at vent filter system)
3	195 feet at N 66° W azimuth (at vent filter system)
4	898 feet at N 13° E azimuth
5	572 feet at N 62° E azimuth
6	476 feet at S 71° E azimuth
7	382 feet at S 22° E azimuth
8	415 feet at S 34° W azimuth
9	492 feet at N 44° W azimuth
10	870 feet at N 22° W azimuth
11	1,290 feet at N 31° E azimuth
12	1,885 feet at N 89° E azimuth
13	981 feet at S 59° E azimuth
14	940 feet at S 49° W azimuth
15	1,630 feet at N 32° W azimuth
16	End of tunnel drain line (at new portal)
	From the Mesa cable splice shack:
17	Cable splice shack
18	209 feet at N 04° E azimuth
19	275 feet at S 88° E azimuth
20	190 feet at S 08° E azimuth
21	235 feet at S 87° W azimuth
	From SGZ unless otherwise indicated:
22	443 feet at S 89° E azimuth
23	459 feet at S 39° W azimuth
24	561 feet at N 29° W azimuth
25	510 feet at N 39° E azimuth at HFR cable downhole

TABLE 4.1 (Concluded)

Station	Location
	UNDERGROUND
	From the U12e.06 drift unless otherwise indicated:
31	1,240 feet into U12e.14 LOS drift
32	1,095 feet into U12e.14 LOS drift
33	1,170 feet into U12e.14 bypass drift
34	900 feet into U12e.14 drift
35ER*	900 feet into U12e.14 drift
36	450 feet into U12e.14 drift
37	700 feet into U12e.06 drift from the U12e main drift
38	500 feet into U12e.12 reentry drift from the U12e.12 main drift
	From the U12e portal unless otherwise indicated:
39	Cable alcove (at main drift/06 drift junction)
40	3,800 feet into U12e main drift
41ER*	3,800 feet into U12e main drift
42	3,575 feet into U12e main drift
43	3,300 feet into U12e main drift
44	1,950 feet into U12e bypass drift
45	50 feet into U12e main drift
46	90 feet into U12es main drift from the U2es portal

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*ER - Extended Range (instrument capable of reading 100 mR/h (to 100,000 R/h).

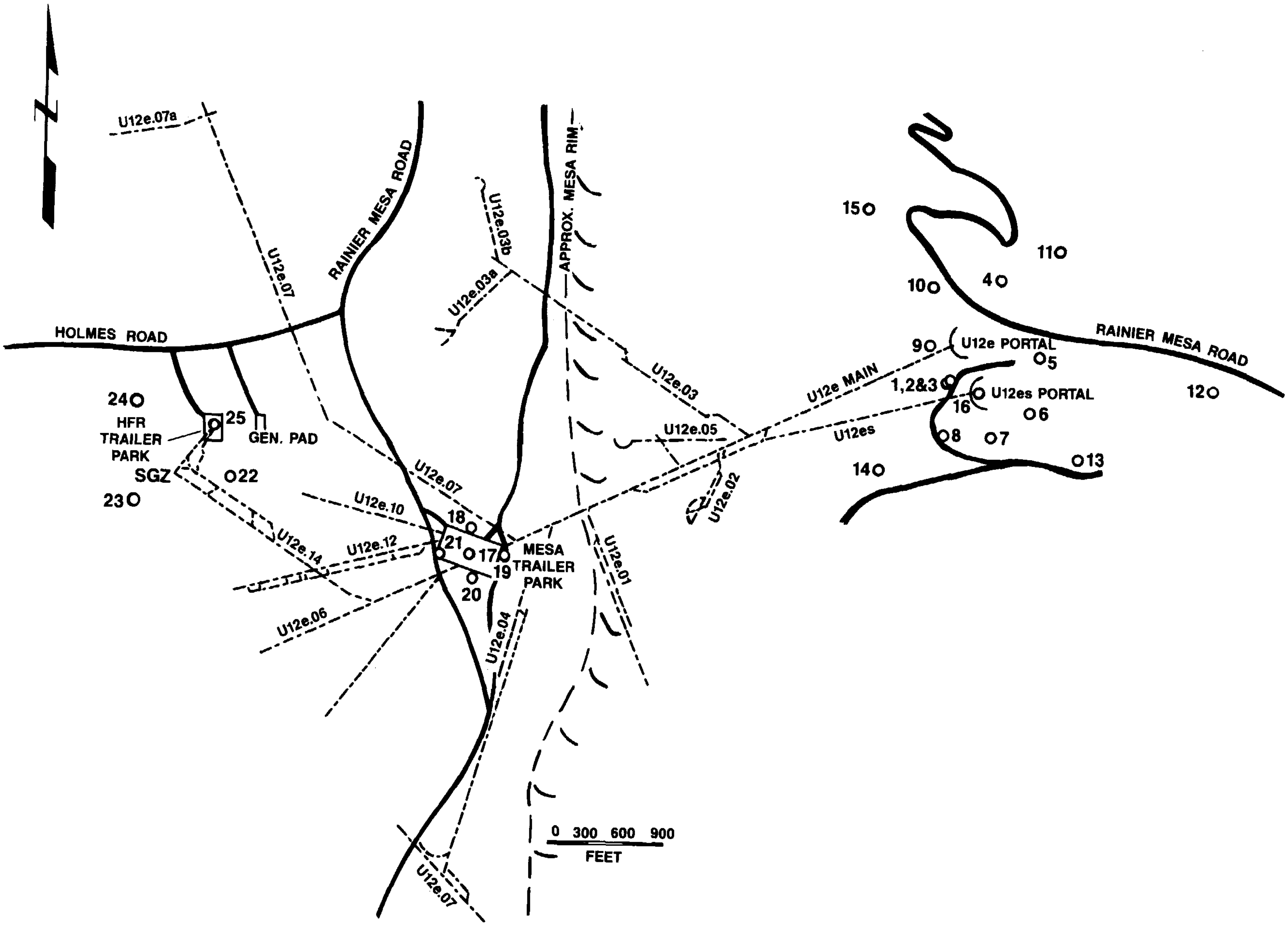

Figure 4.2 DIDO QUEEN Event - Surface RAMS

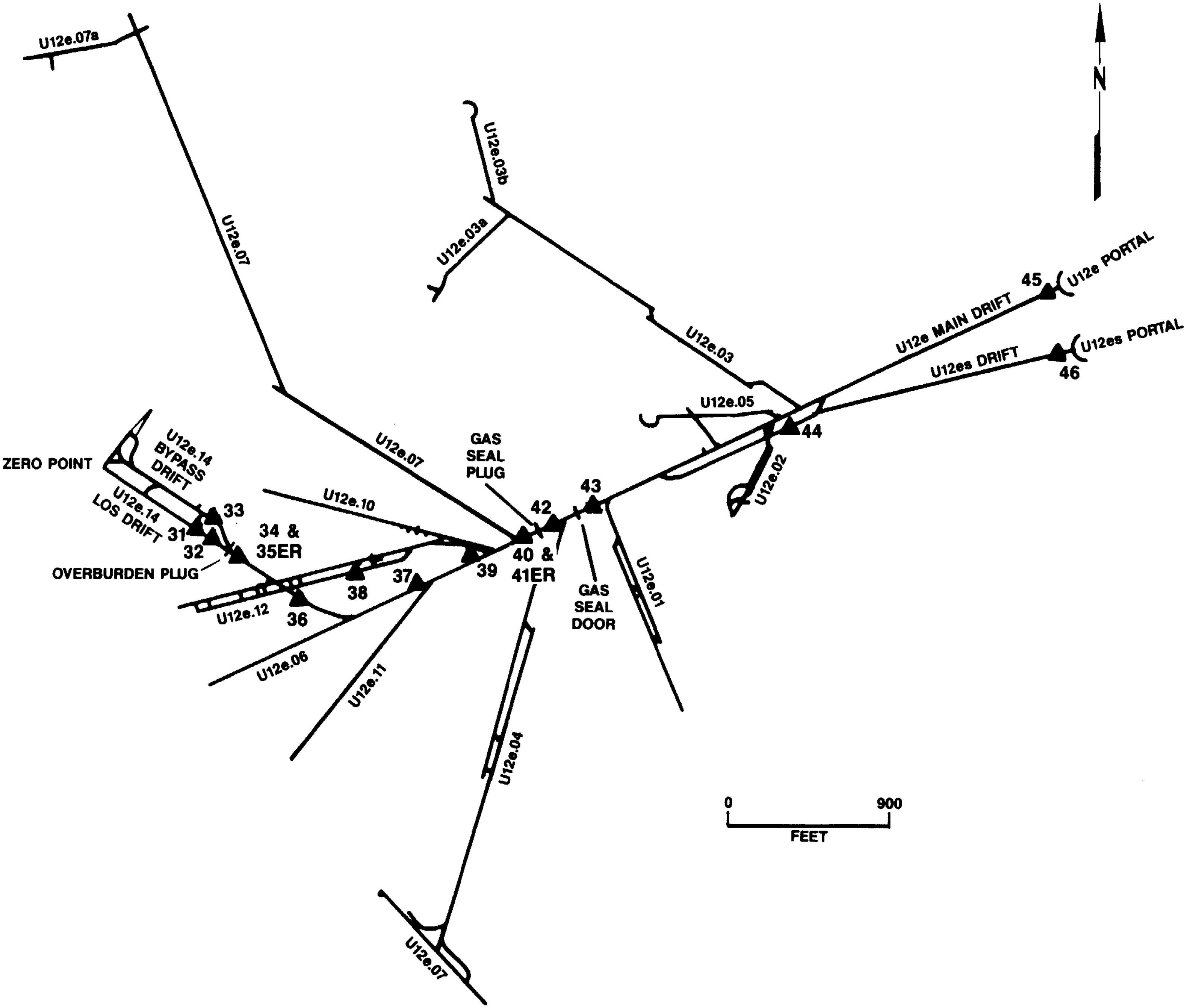

Figure 4.3 DIDO QUEEN Event - Underground RAMS

EPA personnel operated 48 air sampling stations and 30 gamma rate recorder stations in the offsite area. Twenty-two personnel were fielded for offsite surveillance.

D. Security Coverage

Device security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Beginning on D-1, all personnel entering or exiting the controlled area were required to stop at muster or control stations for issue of stay-in badges or issue and return of muster badges. After area control was established, all through traffic was diverted around the controlled area by use of screening stations.

In accordance with the "Test Controller's Operations Plan," contractors and agencies were to have all personnel not connected with this event out of the controlled area before the final security sweep began.

E. Air Support

One UH-1F and two UH-1N helicopters with USAF pilots and crews were available to provide aerial support for closed-circuit television coverage, cloud surveillance (should venting occur), and security sweeps. One of these also was on standby for the Test Controller's use if needed. EPA provided one Turbo Beech aircraft, pilot, and crew to be airborne for cloud tracking and sampling, if required, and one on standby at McCarran Airport in Las Vegas if needed.

4.2.3 Late Preevent Activities

The first mandatory full participation (MFP) dry run was conducted on 15 May 1973 at 0940 hours. Thirty minutes prior to the dry run zero time, there was a one-hour delay to allow time for the timing and firing microwave receiver to be replaced in the timing and firing van on the Mesa. The 20-minute countdown began at 1040 hours and included several holds before its completion. Shortly after the first run was finished, a second run was scheduled for 1530 hours. The problems which occurred during the first run were solved before the second run began. The second run was successfully completed without complications or holds.

The LLL full-power full-frequency (FPFF) dry run was then scheduled for 1500 hours on 16 May 1973. This countdown was completed after one five-minute hold. After solving some problems, another FPFF was successfully completed on 17 May 1973.

On 4 June, after several holds due to technical problems, the full dry run (FDR) was successfully completed. A readiness briefing was held at 1430 hours. Conditions were found to be favorable and a detonation time of 0900 hours on 5 June was established. Another readiness briefing at 2130 hours confirmed the scheduled detonation time.

4.3 EVENT-DAY ACTIVITIES

Routine security sweeps and experimenter button-up operations were performed. Device arming began approximately four hours prior to scheduled device detonation. The 0700-hour readiness briefing indicated favorable winds. Problems with button-up activities caused a delay of one hour in device detonation.

DIDO QUEEN zero time was 1000 hours PDT on 5 June 1973.

A geophone system was used to monitor postevent seismic disturbances. Signals were routed to CP-1 for audible and recorded readout.

4.3.1 Test Area Monitoring

Telemetry began at 1001 hours on D-day. RAMS units located along the LOS pipe responded to neutron activation of the LOS pipe and its contents. At 1001 hours, RAMS unit Nos. 31 and 32 indicated greater than 1,000 R/h (gamma). At 1010 hours, unit No. 31 was still reading greater than 1,000 R/h, but No. 32 had decreased to 150 R/h. These two units and No. 34 (29 mR/h) were the only units with readings above background levels at 1010 hours. RAMS unit No. 31 became inoperative at 1030 hours. No indications of radioactive effluent release were detected by the underground, surface, or airborne monitoring systems. Stations 1 through 25 on the surface indicated only background readings from 1001 hours until telemetry was secured. All telemetry was secured at 1000 hours on 18 June 1973.

4.3.2 Trailer Parks and Portal Initial Radiation Survey and Reentry Activities

The Rainier Mesa trailer parks initial radiation surveys were conducted between 1025 and 1240 hours. Team No. 1 conducted a survey of the main trailer area between 1025 and 1111 hours, and team No. 2 conducted a survey of the HFR trailer park between 1106 and 1240 hours. All radiation readings were background.

The portal initial radiation survey was conducted between 1041 and 1130 hours with a maximum of 0.07 mrad/h (beta plus gamma) detected in the general portal area. Figure 4.4 shows the U12es tunnel portal. Recovery teams were released to perform

Figure 4.4 DIDO QUEEN Event - ES Tunnel Portal

their assigned functions at 1054 hours. At 1105 hours, an SLA health physicist authorized surface reentry and data recovery teams to proceed without wearing anticontamination clothing.

Gas sampling drain valve operations and ventilation to the portal face of the gas seal plug were accomplished by 1300 hours. Gas chromatograph sampling was conducted between 1310 and 1337 hours. No radioactive or toxic gases were detected in the underground complex. Tunnel ventilation began at 1445 hours, and ventilation to the gas seal door was established at 1457 hours.

4.4 POSTEVENT ACTIVITIES

4.4.1 Tunnel Reentry and Experiment Recovery Activities

Reentry team No. 1 entered the tunnel at 1002 hours on 6 June (D+1), wearing anticontamination clothing and Draeger self-contained breathing apparatus. Members of team No. 2 also were dressed in anticontamination clothing and standing by for deployment as needed. Team No. 1 reached the gas seal door at approximately 1017 hours, and radiation readings of 0.2 mR/h were observed but no indications of explosive mixture or toxic gases were encountered. The team proceeded through the gas seal access door and continued toward the gas seal plug, reaching it at 1036 hours. No indication of toxic gas or explosive mixture was found, and the radiation reading was background. Ventilation was reestablished and this area became a fresh air station. Self-contained breathing apparatus was no longer required from the portal to the gas seal plug, and Team No. 1 removed their breathing gear. Air and water samples were collected remotely from the zero point side of the gas seal plug. The team started back to the portal at 1230 hours, reaching it at 1250 hours.

Reentry team No. 2 entered the tunnel at 1310 hours and proceeded to the gas seal plug where they donned Draeger self-contained breathing apparatus, passed through the gas seal plug, and continued into the tunnel complex to check the status of the cable alcove and the OBP. Team No. 3 was dressed out and standing by. Radiation levels continued at background, and no explosive mixture or carbon monoxide was detected; however, 800 ppm carbon dioxide was measured on the portal side of the OBP. Between 1506 and 1530 hours, both the 24- and 36-inch doors of the manway through the OBP were opened. After reinstalling the vent line at the OBP, all personnel returned to the gas seal plug at 1553 hours and from there exited the tunnel at 1616 hours. The portal gate was locked at 1640 hours. Vent line filters (located exterior to the portal) were checked every half hour. At the request of an SLA health physicist, explosive mixture and toxic gas readings were taken every hour during swing and graveyard shifts as a precautionary measure.

Reentry team No. 1 (accompanied by a rescue team) entered the tunnel at 0835 hours on 7 June with self-contained breathing apparatus and traveled to the OBP. Measurements taken from the zero point side of the OBP at 0935 hours indicated radiation levels of 1 mrad/h with no evidence of toxic gases or explosive mixture. The team members donned their Draeger self-contained breathing apparatus, passed through the OBP, and continued through the tunnel complex to the junction of the LOS and bypass drifts. Readings taken at this junction indicated 20 percent of the LEL. After the explosimeter used was checked to make sure it was operating properly, the area was surveyed a second time and no evidence of explosive mixture was detected. Vent lines in both drifts were checked for damage, but only the one in the LOS pipe drift required repair work. A radiation level of 0.2 mR/h was measured. Team members continued to survey the area for damage and hazards while waiting for a piece of flex-line to be brought in to repair the vent line. Readings taken at 1003 hours in the Dance Hall area reflected a 20 percent oxygen level, 0.2 mrad/h, and no evidence of toxic gases or explosive mixture. Crosscut No. 1 was inspected and found to have considerable damage. Team members removed sandbags in this crosscut and at the entrance to test chamber No. 1. Measurements indicating 15 percent of the LEL, 50 ppm carbon monoxide, 800 ppm carbon dioxide, and 0.2 mR/h were obtained in crosscut No. 1. The team departed for the portal at 1119 hours.

Reentry team No. 2 entered the tunnel at 1135 hours and arrived at the OBP at 1145 hours. After donning Draeger self-contained breathing apparatus, team members passed through the OBP to inspect the high-strength grout plug which they reached at 1226 hours. A radiation level of 20 mrad/h was measured. The air inside the 24-inch vent line in the high-strength grout plug measured 80 percent of the LEL. The permanent vent line was reinstalled. At 1330 hours, the vent line was resampled on the portal side of the OBP. Measurements indicated 5 percent of the LEL, 25 ppm carbon monoxide, 1,000 ppm carbon dioxide, and 20 percent oxygen. After air flow through the vent line was established, concentrations were reduced to 15 ppm carbon monoxide and 600 ppm carbon dioxide, with no evidence of any explosive mixture. At 1500 hours, a reading of 1 R/h was detected in the work area on top of the LOS pipe. The maximum radiation level detected in the area around test chamber No. 1 was 1.1 R/h. Radiation exposure levels decreased with increased distance from the test chamber, indicating neutron activation of the LOS pipe rather than stemming failure. The doorway to test chamber No. 1 was opened at 1516 hours and a radiation reading of 1.2 R/h was detected at arm's length inside the LOS pipe. No evidence of an explosive mixture was detected. Team No. 2 exited the tunnel at 1554 hours. At 1630 hours, 18 miners, accompanied by a Radsafe monitor, began work to mine out the gas seal plug. This work continued on an around-the-clock basis until the task was completed.

On 8 June, reentry team members, dressed in double sets of anticontamination clothing, departed from the OBP at 0930 hours and proceeded to test chamber No. 1 (see Figure 4.5). A radiation survey, taken at the zero point end of test chamber No. 1 at 0955 hours, showed a radiation level of 900 mR/h. After obtaining this measurement, team members moved inside the LOS pipe to the zero point end of test chamber No. 2 where a reading of 700 mR/h was obtained at 0958 hours. Team members then traveled to the TAPS door which was found to be ajar approximately one inch. Readings of 7 mR/h, 75 ppm carbon monoxide, and 5 percent of the LEL were observed at the TAPS. Team members then began to proceed back through the LOS pipe, reaching test chamber No. 2 at 1015 hours. A radiation reading taken at the center of test chamber No. 2 was 1.4 R/h, and a reading taken at the doorway was 500 mR/h. Returning to test chamber No. 1, a reading of 4 R/h was observed near one of the experiments at 1023 hours.

By 1038 hours, team members had reached the LOS pipe drift/bypass drift junction, and were preparing to walk through the bypass drift. No problems were encountered in the bypass drift and all personnel had returned to the zero point side of the OBP by 1056 hours. Team members removed one set of anticontamination clothing before returning to the portal side of the OBP at 1109 hours. Exit from the tunnel began at 1112 hours. This completed initial reentries into the E tunnel complex. A Radsafe station was established at the pipefitters' alcove to control entry to and exit from the LOS pipe drift. No anticontamination clothing requirements were in effect on the portal side of the Radsafe station. From 1300 to 1430 hours, LLL and DNA photo parties entered the LOS pipe drift for documentation purposes.

From 9 to 11 June, work to remove the OBP was conducted. Cleanup and rehabilitation of the bypass drift and Dance Hall

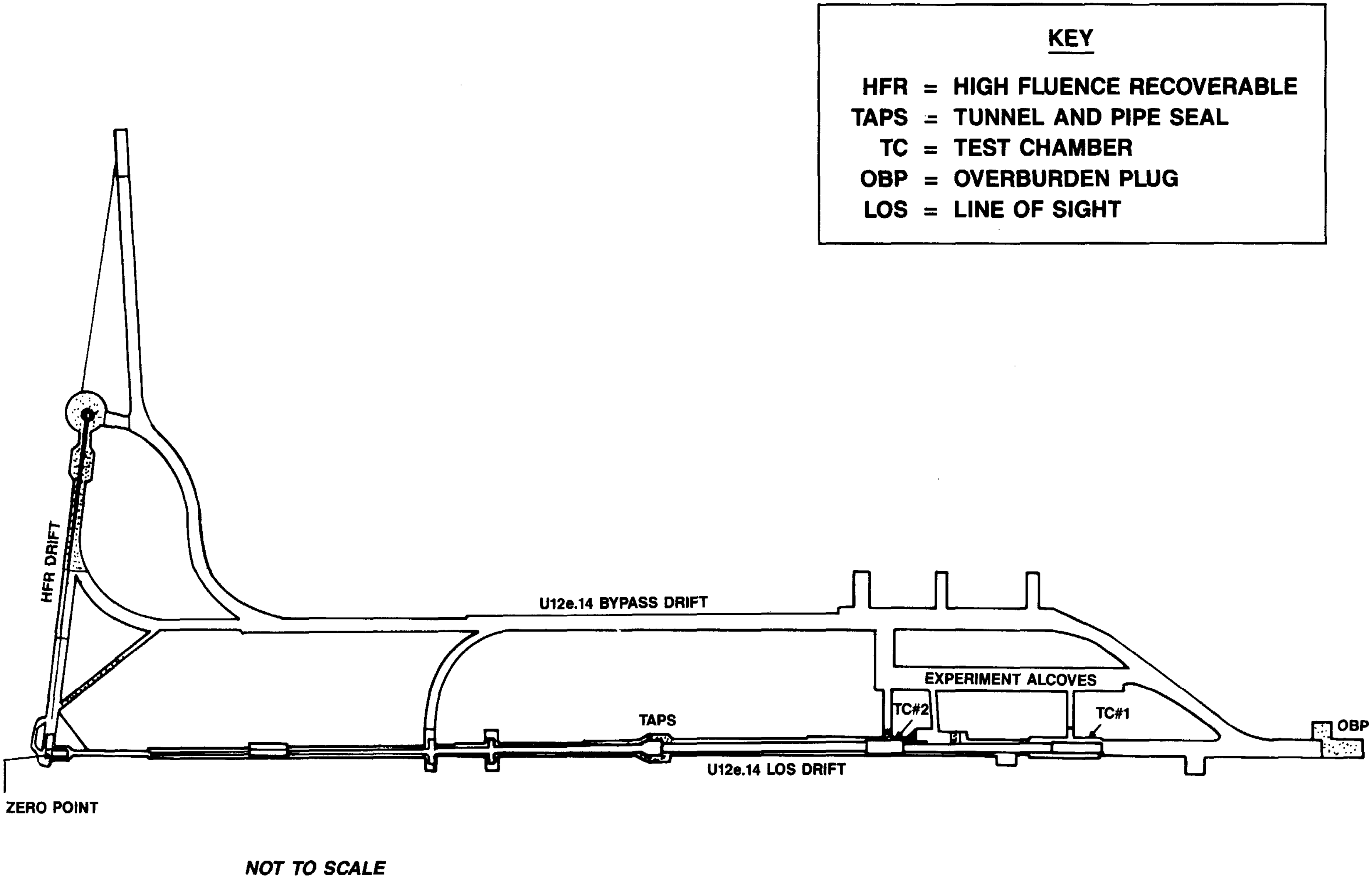

Figure 4.5 DIDO QUEEN Event - LOS, HFR, & Bypass Drifts

area prior to experiment recovery operations also were in progress. Between 1130 and 1320 hours on 11 June, five LLL representatives entered the LOS pipe drift to recover experiments from the pipe stubs at the portal end of test chamber No. 1. Single pairs of coveralls, boots, and gloves were the anticontamination clothing requirement; respirators were not required. At 1330 hours, an SLA health physicist and a DNA representative, accompanied by two Radsafe monitors, entered the LOS pipe and traveled to test chamber No. 2. Entry of the team was necessary to check the condition of the scatterer station and to establish ventilation into the station. Each person entering the LOS pipe wore coveralls (with openings taped), two pairs of boots and gloves, a hood, and a full-face respirator with Type N canister. About 200 to 500 ppm carbon monoxide, 5 percent of the LEL, and 20 percent oxygen concentration were measured along the back of the LOS pipe.

These same conditions were found at the scatterer No. 2 pipe stub. An SLA health physicist entered the pipe stub area to check the air in the scatterer station. Five to ten percent of the LEL, 200 to 250 ppm carbon monoxide, and 18 to 19 percent oxygen were detected inside the station. After about five minutes, the task was completed and the SLA health physicist exited the pipe stub. The station appeared to be in excellent condition. Team members next walked to the TAPS plug to view a piece of metal which had prevented the TAPS door from fully closing. Team members returned to test chamber No. 2, performed a radiation survey, then traveled to test chamber No. 1 to perform a radiation survey at that location. Radiation levels measured in the LOS pipe during these operations were:

Outside test chamber No. 1 - 10 mR/h
Outside scatterer No. 1 - 20 mR/h
Test chamber No. 1, inside station - 150 mR/h

Test chamber No. 1 experiments (average near contact) - 400 mR/h

Test chamber No. 1 experiments (maximum near contact) - 1.5 R/h

LOS pipe between test chamber Nos. 1 and 2 - 6 mR/h

Test chamber No. 2 (exposure rate inside test chamber) - 140 mR/h

Test chamber No. 2 experiments (average near contact) - 400 mR/h

Test chamber No. 1 experiments (maximum near contact) - 1 R/h

LOS pipe between test chamber No. 2 and TAPS - 1 mR/h

TAPS door (maximum near contact) - 6 mR/h

Boeing experiment, test chamber No. 1 (maximum near contact) - 250 mR/h

Ventilation was established inside the LOS pipe during swing shift. Flex-line was brought through an 18-inch port on the bottom of the LOS pipe to the zero point side of test chamber No. 1 and extended along the floor of the LOS pipe to test chamber No. 2. During this time, rehabilitation work in the Dance Hall and bypass drift continued.

On 12 June at 0030 hours, miners began sandbagging a walkway in the LOS pipe drift and clearing the train tracks in the bypass drift. The LOS pipe was opened for experiment recoveries from test chamber No. 1 and scatterer No. 1. Recovery personnel each wore two pairs of coveralls, gloves, and boots, and a hood; those entering test chamber No. 1 additionally wore a respirator with a dust filter. Each person working at scatterer No. 1 or outside the LOS pipe at test chamber No. 1 wore a single pair of coveralls, boots, and gloves. No anticontamination clothing requirements were in effect for persons working in the alcoves or for miners working in the bypass drift and Dance Hall. Organizations represented during this reentry included Lockheed Missile and

Space Corporation (LMSC), LLL, SLA, Hughes Aircraft Co. (HAC), DNA, Harry Diamond Laboratories (HDL), Kaman Sciences Corporation (KSC), Raytheon, AVCO, Boeing, and Physics International (PI). Maximum survey readings were 500 ppm carbon dioxide and 10 mR/h at test chamber No. 1 at 1600 hours.

Experiment recovery continued on 13 June from test chamber Nos. 1 and 2, and scatterer No. 1. Anticontamination clothing required for each of the recovery personnel included one pair of coveralls and a hood, two pairs of gloves and boots, and either an Acme or MSA face mask. Recovery personnel included representatives of LMSC, DNA, KSC, General Electric (GE), LLL, SLA, AFWL, and Intelcom Rad Tech (IRT). At 1300 hours, a fire started in scatterer alcove No. 1. All personnel were evacuated from the LOS pipe drift until the fire was extinguished, the smoke cleared, and the area surveyed. Work resumed in test chamber No. 1 at 1345 hours and at scatterer No. 1 at 1445 hours. At 1745 hours, personnel checked the TAPS to determine how the TAPS door could be raised. Concentrations of 15 percent of the LEL and 500 ppm carbon monoxide were measured on the zero point side of the TAPS door. Since there was no way to determine if this sample was representative, it was decided to wait at least until 15 June to begin pumping compressed air into the TAPS area, allowing the pressure to be bled off into the vent line during the following weekend. Experiments in test chamber No. 1 were surveyed and the maximum radiation level was 2.5 R/h at contact with one of the experiments. The personnel exposure rate was 100 to 150 mR/h in the area. At 1830 hours, the ventilation system was turned off to repair a fan line at the gas seal plug. All personnel were evacuated from the zero point side of the OBP while air was not circulating. Ventilation was reestablished at 2300 hours after the fan line repair was completed.

Experiment recovery activities in the LOS pipe and at scatterer station No. 1 continued during the early morning hours and throughout the day on 14 June. Each person entering the LOS pipe wore a single pair of coveralls and a hood, two pairs of gloves, two pairs of boots, and a full-face mask. Each person working at scatterer station No. 1 was required to wear only a single pair of coveralls, shoe covers, and gloves. Organizations represented during these activities were LMSC, HAC, LASL, SLA, IRT, LLL, GE, PI, MDAC, EG&G, and DNA. At 0835 hours, three Radsafe monitors traveled to the TAPS door to check for the presence of toxic gases or any explosive mixture. Gas concentration levels on the zero point side of the TAPS door were 110 ppm carbon monoxide, 1,600 ppm carbon dioxide, and 21 percent oxygen; the radiation level was 6 mR/h. Survey of one experiment indicated the possible presence of alpha contamination. All personnel were evacuated from the LOS pipe until the situation could be assessed. Swipes were taken from the surrounding area and analyzed for alpha contamination, but none was detected. Personnel were allowed to return to work at 1245 hours with no change in anticontamination clothing requirements. At 1400 hours, a barricade was placed to block access to test chamber No. 1. Experiment recoveries were nearly completed that day, and all recovery personnel were out of the tunnel complex by 1600 hours. Rehabilitation efforts continued in the bypass drift.

Cleanup work continued in crosscut No. 2 on 15 June from 0015 to 0530 hours. At 0800 hours, two LMSC personnel, accompanied by Radsafe monitors and dressed in double sets of anticontamination clothing, entered the test area. From 0900 to 1635 hours, personnel representing LMSC, LLL, SLA, and FC/DNA entered the test area. Work continued on removal of an experiment from test chamber No. 1. After this work was completed for the day, test chamber No. 1 was sealed, and compressed air was bled off through a small hole in the center of the TAPS door. This operation continued throughout the weekend.

During graveyard shift on 18 June, miners continued working in the Dance Hall and at crosscut No. 2 in the bypass drift. Surveys in these areas indicated 800 ppm carbon dioxide, 0.06 mrad/h, and no evidence of explosive mixture in the Dance Hall; and 1,000 ppm carbon dioxide, 60 ppm carbon monoxide, 0.05 mrad/h, and no evidence of explosive mixture in the bypass drift at crosscut No. 2. At 0850 hours, recovery personnel began dressing in anticontamination clothing to enter test chamber No. 1 and remove the remaining two major experiments. Each person working in the test chamber wore double coveralls, boots, and gloves; a hood; and a full-face mask with dust filter. Both experiments were removed from the test chamber by 1200 hours. Miners continued working in crosscut No. 2 for the remainder of the day.

4.4.2 Postevent Mining

On 19 June 1973, reentry mining to evaluate the performance of the TAPS and the DNA auxiliary closures and to recover experiments from the HFR station began. This work continued, without interruption, until 5 June 1974. During this time, several seams of radioactive material were encountered. Precautions (i.e., anticontamination clothing and respiratory protection equipment, as needed) were taken to protect personnel.

On 22 June, pipefitters and miners raised the TAPS door enough to allow access to the zero point side of the door. A damage and hazard survey of the LOS pipe on the zero point side of the TAPS was conducted. No indications of explosive mixture or toxic gases were detected, and the maximum radiation reading was 13 mR/h. The LOS pipe was closed off approximately 100 feet on the zero point side of the door. Each person involved in this survey wore a single pair of coveralls, a hood, two pairs of boots and gloves, and a full-face mask with supplied air.

Between 2 August and 7 September, drilling to probe the DIDO QUEEN chimney and cavity and mining of the HFR reentry drift continued. On 7 September, an exploratory hole was drilled from the reentry heading face toward the HFR station. All personnel were dressed in anticontamination clothing and full-face masks with supplied air.

On 21 September, miners broke through into the HFR LOS drift. Instrumentation was recovered from the HFR station on 8 October. Recovery personnel wore full anticontamination clothing and supplied-air respiratory protection gear. A security gate was constructed at crosscut No. 1 which was closed and locked until after the detonation of the HUSKY ACE event.

The reentry drift was reopened on 5 November. Work to reestablish ventilation, air, and water lines was performed. Water had to be pumped from several of the crosscuts.

During mining operations on 6 November, an odor which smelled very faintly of ammonia was noticed in an HFR reentry crosscut. Ventilation to the area was increased because many workers were complaining of headaches. Industrial hygiene personnel were requested to take samples to attempt to identify the odor, but the odor was never identified.

On 9 November, experiment removal from the HFR station began. Each person in the area wore two sets of anticontamination clothing and supplied-air breathing appraratus. The exposure rate one foot from the experiments was 50 mR/h. On 13 November, experimenters were given permission to enter the HFR. Each experimenter wore a single pair of coveralls and two pairs of shoe covers and gloves; no face masks or hoods were required. Several people knelt on the brattice cloth pad in the HFR and contaminated their street clothing, so a requirement of two pairs of coveralls was instituted. No other problems were encountered.

The radiation exposure rate was 30 mR/h. Recovery work in the HFR heading was discontinued for one week at Thanksgiving, restarting 26 November. Work to remove one experiment with difficult logistics problems continued until it was successfully removed on 29 November. During removal of this experiment, each person dressed in two sets of anticontamination clothing, a hood, and a full-face mask with supplied air. Other recovery work continued after this date. Experiment recovery from the HFR drift was completed on 5 December.

Cleanup activities were conducted during the month of January 1974. Throughout February, miners worked in the area of DAC No. 1, mining around the housing for the DAC so it could be removed and repaired for future use. Each miner was required to wear one pair of coveralls, gloves, and shoe covers or miners boots. No contamination problems were experienced.

Crosscut No. 7A was mined out from 19 March to 5 April. On 5 April, experiments were removed from the crosscut, completing work in this area. During these activities, the maximum exposure rate measured was 5.5 mrad/h.

Some additional evaluation work was performed during October 1974. No radiation problems were encountered.

4.4.3 Postevent Drilling

Postevent drilling from the Rainier Mesa toward the underground zero point began at 1100 hours on 29 August 1973. The maximum exposure rate detected during drilling operations at PS-1 was 0.06 mrad/h. No alpha radiation, evidence of explosive mixture, or toxic gases were detected. The drill hole was capped at 1355 hours on September 13.

4.4.4 Industrial Safety

Surveys to measure radiation, toxic gas, and explosive mixture levels were made each shift. These measurements were then recorded in the monitors' logbook.

Appropriate safety measures were taken to protect mining personnel and prevent unsafe conditions. Industrial safety codes, including those for mining, tunneling, and drilling, were established by REECo and emphasized during all operations. A written standard operating procedure was required for each operation involving explosives, toxic materials, radioactive material, or any other operation with a potential for personal injury. Each individual involved in these operations was required to know the contents of the applicable procedures.

The portal construction area and tunnel were mandatory hard hat and foot protection areas (safety shoes, safety boots, miners boots or toe guards). Each participating agency provided its own safety equipment. Each participant in tunnel reentry operations was certified by the Bureau of Mines as having successfully completed training in the use of the two-hour McCaa breathing apparatus and had used the Draeger self-contained breathing apparatus. Standard safety rules and regulations, as spelled out in the "U.S. Bureau of Mines Manual," were observed.

All explosives, electro-explosive components, solid propellants, toxic material, and radioactive material were handled, stored, and transported in accordance with applicable sections of the following documents:

A. Army Materiel Command Regulations (AMCR 385-224).
B. AEC Manual 500 Series for the Nevada Test Site.
C. Individual Safe Operating Procedures (by experimenter organization).

D. DIDO QUEEN Safety Regulations.

All personnel engaged in handling, storing, assembling, or installing explosives, propellants, or electro-explosive devices (or observers of those operations) were required to wear safety glasses or other eye protection which had been approved by the DOD Safety Coordinator.

4.5 RESULTS AND CONCLUSIONS

DIDO QUEEN telemetry measurements began at 1001 hours on 5 June 1973. The maximum gamma exposure rate measured was greater than 1,000 R/h at underground RAMS unit Nos. 31 and 32 at 1001 hours on D-day. This was an expected response to neutron activation of the LOS pipe. No effluent release was detected. Telemetry was secured at 1000 hours on 18 June 1973.

The initial radiation survey teams entered the area at 1025 hours and completed survey operations at 1240 hours on 5 June 1973. Maximum radiation levels detected were background for the areas. No alpha radiation was detected. Remote air samples taken on 5 June 1973 and analyzed by gas chromatograph indicated the absence of any toxic gases or explosive mixture.

Reentry of the tunnel began at 1002 hours on 6 June 1973. The maximum radiation measurement detected was 4 R/h near one of the experiments in test chamber No. 1 at 1023 hours on 8 June 1973. During the reentry, maximum air concentrations of 15 percent LEL, 500 ppm carbon monoxide, and 1000 ppm carbon dioxide were detected at various survey points along the reentry route. No alpha radiation was detected.

Postevent mining began on 19 June 1973 and continued until 5 June 1974. The maximum radiation level measured was 13 mrad/h in the LOS pipe, zero point side of the TAPS, on 22 June 1973. No alpha radiation was detected.

Postevent drilling began at 1100 hours on 29 August 1973. The maximum radiation level detected during drilling operations at PS-1 was 0.06 mrad/h. No alpha radiation was detected. The drill hole was capped at 1355 hours on 13 September 1973.

Personnel exposures received during individual entries to DIDO QUEEN radex areas from 5 June 1973 to 16 October 1974 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	No. of Entries Logged	Maximum Exposure (mR)	Average Exposure (mR)
All Participants	5,055	495	4
DOD Participants	410	495	12

CHAPTER 5

HUSKY ACE EVENT

5.1 EVENT SUMMARY

HUSKY ACE was a DOD-sponsored underground test detonated at 1000 hours PDT on 12 October 1973 with a yield less than 20 kt. The device was detonated in N tunnel (U12n.07 drift, see Figure 5.1) at a vertical depth of 1,356 feet. The objective of this test was to determine the response of materials and equipment to a nuclear detonation environment. Government agencies and contractors conducted 29 projects to obtain the desired weapons effects information.

Stemming was successful and containment complete. No radioactive effluent was released to the atmosphere.

5.2 PREEVENT ACTIVITIES

5.2.1 Responsibilities

Safe conduct of all HUSKY ACE project activities in Area 12 was the responsibility of the DOD Test Group Director. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DNA, and AEC/NVOO.

Project agencies were responsible for designing, preparing, and installing their experiments, or delivering them to the installation contractor. After the event, these agencies were responsible for removing samples, analyzing instrument and sample data, and preparing project reports on experiment results.

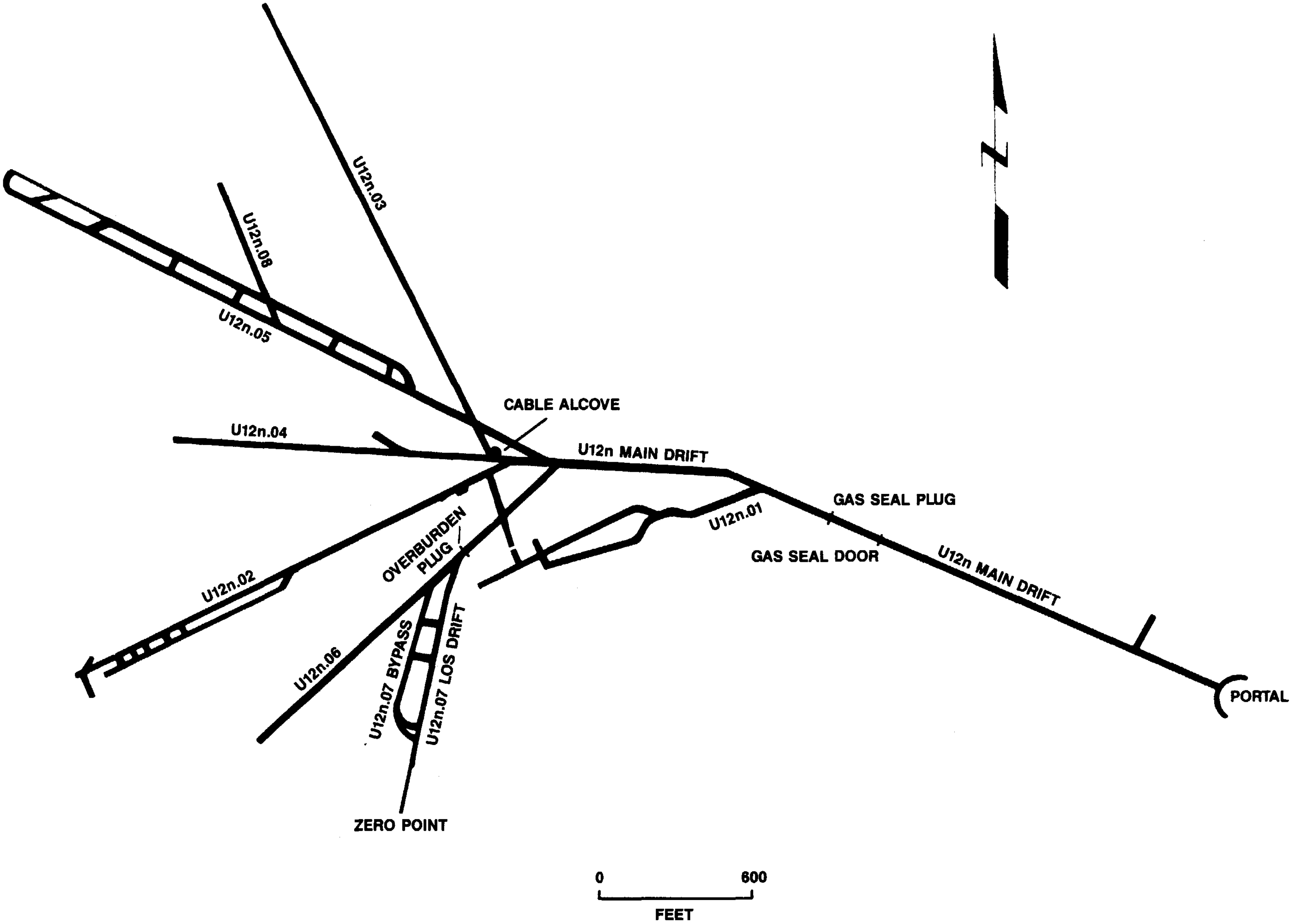

Figure 5.1 HUSKY ACE Event - Tunnel Layout

Device safety and security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Because LASL fielded the device, the LASL Test Group Director was responsible for radiological safety within a 6,000-foot radius of the zero point prior to the event. This responsibility was in effect from device emplacement until detonation. After detonation, the Test Controller relieved the LASL Test Group Director of responsibility. When the Test Controller had determined that venting had not occurred, he delegated responsibility for radiological safety in the test event area to the DOD Test Group Director.

5.2.2 Planning and Preparations

A. Tunnel Facilities Construction

The first HUSKY ACE planning meeting was held at HQ/DNA on 9 and 10 May 1972, and the initial project officers' meeting was held 31 August and 1 September at NTS.

Utilizing the U12n.07 drift enabled DNA to reuse 200 feet of a previously mined drift as the beginning of the LOS pipe drift and approximately 520 feet of previously mined drift as the start of the bypass drift. HUSKY ACE used all common facilities of the N tunnel complex including portal equipment, main tunnel, Mesa trailer park, and the downhole instrumentation cable system with few, if any, modifications. A new overburden plug (OBP) and gas seal plug were constructed for this event.

According to the DOD Test Execution Report for DIDO QUEEN, most of the hardware concepts and technologies used on HUSKY ACE were evolutions and refinements of those used in previous DOD tests. The vacuum pipe, muffler, TAPS, test chambers, experiment mounting methods, and vacuum monitoring and pump control were all similar to those developed for, and used in, prior programs. The vacuum pumps had been used for DIAMOND SCULLS, recovered, and reused for HUSKY ACE.

Mining of the experiment drift began on 21 August 1972. The first 300 feet were mined 16 feet wide by 16 feet high using conventional mining techniques. Mining operations for the experiment drift were completed on 3 November 1972. Two access drifts were mined from the bypass drift to the experiment drift. Crosscuts were mined in the vicinity of test chamber Nos. 2 and 3. These subsequently were divided into experimenter alcoves.

Large components for the HUSKY ACE test bed facility were shipped by truck from their point of manufacture to the U12n portal. At the portal, each component was offloaded and transported by special transport carriage into the U12n.07 drift.

Installation of the LOS pipe, electrical equipment, experiment cables to the cable alcove from the Mesa, and pipe stubs was completed in June 1973. Signal dry runs (SDRs) began on 21 August and generally were held every working day with a minimum of two per week being designated as mandatory runs. Experiment installation was completed on 6 September. A successful mandatory full participation (MFP) dry run was held on 25 September.

B. Radiological Safety Support

Procedures for radiation exposure and contamination control during this event were in accordance with AEC Manual Chapter 0524 and requirements of responsible DOD representatives. Radsafe provided monitoring and equipment support, air sampling, and telemetry.

Prior to the test event, detailed radiological safety reentry plans were prepared and issued to participating agencies. Air sampling equipment was positioned in the test area. Radsafe monitors were briefed regarding surface reentry, manned stations, and security station requirements.

Radsafe monitoring teams and supervisory personnel were provided to perform initial radiation surveys and conduct aerial surveys by helicopter, and to participate in reentry parties as needed. Radsafe personnel also were standing by at Gate 300 prior to detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment and material, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Available anticontamination materials and equipment included hoods, coveralls, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, plastic bags, gloves, and masking tape.

C. Telemetry and Air Sampling Support

In addition to permanent RAMS units, 42 temporary RAMS units provided surface and underground coverage for the HUSKY ACE event as shown in Table 5.1 and Figures 5.2 and 5.3. A single air sampling unit was located near the U12n portal. All RAMS units and the air sampling unit were installed a minimum of five days prior to scheduled device detonation.

TABLE 5.1

HUSKY ACE EVENT RAMS UNIT LOCATIONS
12 October 1973

Station	Location
	SURFACE
	From portal:
1	At portal
2	445 feet at N 40° W azimuth (on filter system)
3	445 feet at N 40° W azimuth (on vent line)
4	445 feet at N 40° W azimuth (on vent line)
5	69 feet at S 31° E azimuth (on tunnel drain line)
6	399 feet at N 16° E azimuth
7	275 feet at N 89° E azimuth
8	364 feet at S 16° E azimuth
9	482 feet at S 12° W azimuth
10	558 feet at S 48° W azimuth
11	417 feet at N 69° W azimuth
12	647 feet at N 27° W azimuth
13	1,316 feet at N 20° E azimuth
14	1,369 feet at S 43° E azimuth
15	2,938 feet at S 79° W azimuth
16	2,765 feet at N 44° W azimuth
	From cable hole #2:
17	At cable downhole
18	177 feet at N 43° E azimuth
19	135 feet at S 33° E azimuth
20	335 feet at S 12° E azimuth
21	675 feet at S 28° W azimuth
22	375 feet at N 31° W azimuth
23	78 feet at S 89° W azimuth

TABLE 5.1 (Concluded)

Station	Location
	SURFACE (Cont'd)
	From SGZ:
24	409 feet at N 22° E azimuth
25	416 feet at S 10° W azimuth
26	420 feet at N 77° W azimuth
	UNDERGROUND
	From the U12n.06 drift:
31	490 feet into U12n.07 LOS drift
32	345 feet into U12n.07 LOS drift
33	210 feet into U12n.07 LOS drift
34	400 feet into U12n.07 bypass drift
	From the U12n main drift unless otherwise indicated:
35	725 feet into U12n.06 LOS drift
*36ER	725 feet into U12n.06 LOS drift
37	350 feet into U12n.06 drift
38	At the cable alcove
	From the portal:
39	2,600 feet into U12n main drift
40	2,050 feet into U12n main drift
*41ER	2,050 feet into U12n main drift
42	1,700 feet into U12n main drift
43	1,475 feet into U12n main drift
44	900 feet into U12n main drift
45	In the vent line raise
46	200 feet into U12n main drift

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* ER - Extended Range (instrument capable of reading 100 mR/h to 100,000 R/h)

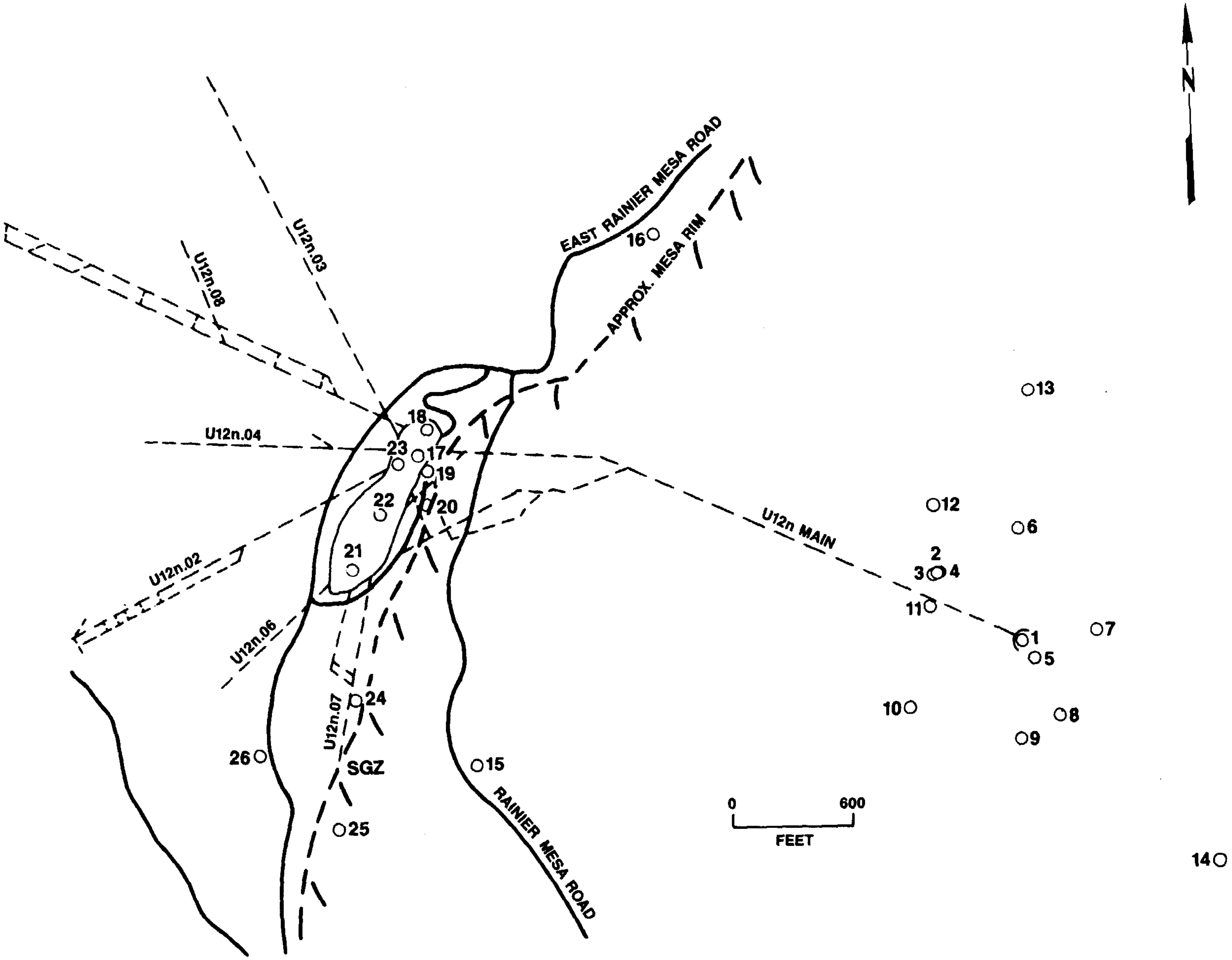


Figure 5.2 HUSKY ACE Event - Surface RAMS

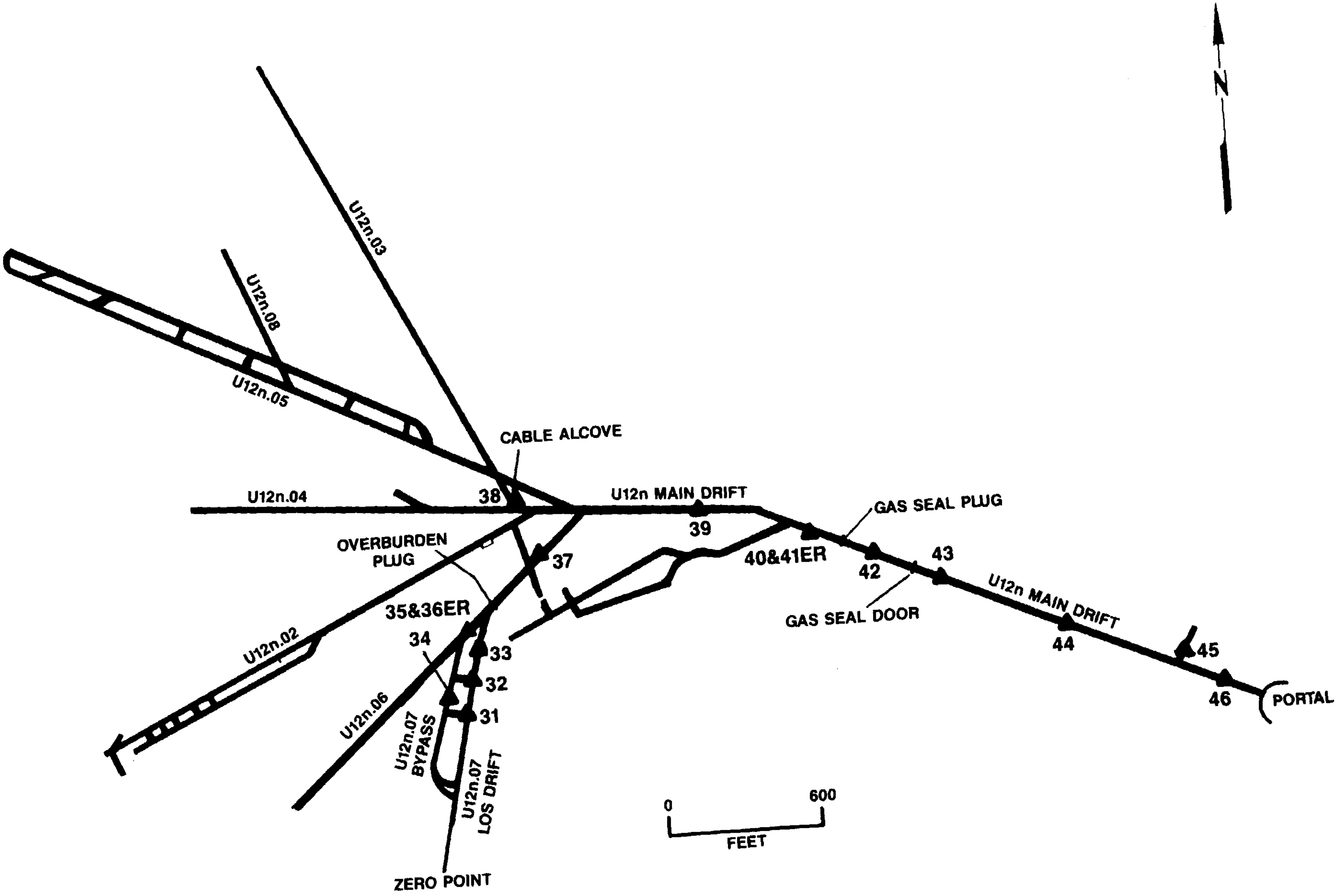


Figure 5.3 HUSKY ACE Event - Underground RAMS

The EPA had 49 air sampling stations and 30 gamma rate recorder stations operating in the offsite area. Twenty-two EPA personnel were fielded for surveillance activities.

D. Security Coverage

Device security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Beginning on D-1, all personnel entering or exiting the controlled area were required to stop at muster or control stations for issue of stay-in badges or issue and return of muster badges. After area control was established, all through traffic was diverted around the controlled area by use of screening stations.

In accordance with the "Test Controller's Operations and Security Plan," contractors and agencies were to have all personnel not connected with this event out of the controlled area before the final security sweep began.

E. Air Support

An EPA Turbo Beech aircraft was airborne at the NTS for cloud sampling and tracking of any effluent. Another EPA Turbo Beech aircraft was standing by in Las Vegas to undertake a sampling and tracking mission, if required. In addition, two USAF-provided UH-1N helicopters with military crews provided support for aerial closed-circuit television coverage, any cloud surveillance needed, and security sweeps.

5.2.3 Late Preevent Activities

The final SDR was held on 9 October; however, technical problems coupled with unfavorable wind forecasts forced a delay in test execution. Wind forecasts for 11 October were uncertain and the decision was made to attempt to detonate on 11 October if conditions became favorable. The device was armed, final tunnel button up completed, and all personnel evacuated from the area. As it turned out, the wind direction remained unfavorable and a decision was made to disarm the device and reschedule test execution for 12 October.

5.3 EVENT-DAY ACTIVITIES

Unfavorable weather conditions ultimately forced a three-day total delay in test execution until 12 October. However, on 12 October 1973 at 0945 hours the fifteen-minute countdown began and continued with no holds.

The HUSKY ACE device was detonated at 1000 hours on 12 October 1973.

5.3.1 Test Area Monitoring

Telemetry measurements began at 1001 hours on D-day. RAMS unit Nos. 19, 21, 24, 25, 31, and 32 were lost at zero time. RAMS units located along the LOS pipe responded to neutron activation of the LOS pipe and its contents. The maximum reading detected was 650 R/h at unit No. 33 at 1002 hours on D-day. All but RAMS unit No. 33 read background within five hours of detonation. All functioning RAMS units were secured at 0801 hours on 15 October except unit Nos. 3 and 4, which were located on the vent lines, and unit No. 5 which was on a drain line.

5.3.2 Initial Radiation Survey and Reentry Activities

Initial survey teams were released from the FCP at 1135 hours to survey the Rainier Mesa trailer park (Figure 5.4) and the portal area (Figure 5.5). The Mesa trailer park survey was completed at 1200 hours with no radiation readings above background, no toxic gases, and no evidence of an explosive mixture detected. The portal survey was completed at 1210 hours with the same background readings as the Mesa survey. After both areas were pronounced clear for data recovery parties to enter and perform their assigned tasks, data recoveries began at 1220 and were completed at 1400 hours. A Radsafe base station was set up at the portal in preparation for tunnel reentry on D+1.

5.4 POSTEVENT ACTIVITIES

5.4.1 Tunnel Reentry

Initial entries into the N tunnel complex began at 0805 hours on 13 October 1973 (D+1). All reentry team members were dressed in full anticontamination clothing and were wearing Draeger self-contained breathing apparatus. The team traveled to the gas seal door, observing that tunnel damage was minor. No radiation readings above background levels and no indications of explosive mixture or toxic gases were detected. The small access door was opened and secured in the open position, and the team proceeded toward the gas seal plug, reaching it at 0834 hours. Readings taken on the portal side of the gas seal plug continued at background levels. Samples taken through the gas seal plug indicated that the atmosphere on the zero point side was normal. The manway door in the plug was opened, allowing team members to observe the presence of water on the zero point side. A sample of the water was taken. Ventilation lines were reinstalled through the

Figure 5.4 HUSKY ACE Event - Rainier Mesa Trailer Park

Figure 5.5 HUSKY ACE Event - N Tunnel Portal

gas seal plug, and the air flow was checked and found adequate. At this time, 0912 hours, the team proceeded through the plug. A radiation reading of 0.05 mrad/h was measured and no evidence of explosive mixture or toxic gases was detected. After walking to the U12n.01 drift/main drift junction, team members returned to the gas seal plug at 0928 hours. The portal side of the gas seal plug was established as a fresh air station. At 0930 hours, team members returned to open the gas seal door and reestablish train tracks. This task was completed and team No. 1 exited the tunnel complex at 1022 hours.

Team No. 2 boarded the train and entered the tunnel at 1029 hours, proceeding to the gas seal plug where they disembarked and walked to the main drift/06 drift junction. Some minor rock fall on the tracks and along the travel route was noted as the team approached the OBP. There was no structural damage on the portal side of the OBP, and no radiation readings above background were detected. After surveying for toxic gases and the presence of any explosive mixture, checking the air flow, and finding conditions to be acceptable, the area was established as a fresh air station and team members removed their self-contained breathing apparatus. Routine cleanup work was completed at 1138 hours and team members returned to the gas seal plug. At 1212 hours, all personnel relocated from the gas seal plug to the newly established fresh air station at the OBP.

At 1235 hours, team members again donned self-contained breathing apparatus and continued into the tunnel complex through the OBP crawlway. No water or tunnel damage was found on the zero point side of the OBP. A radiation reading of 0.1 mR/h was measured, but no indications of explosive mixture or toxic gases were detected. The Recorder and Oscilloscope Sealed Environmental System (ROSES) area was checked and only background levels were detected. The door to test chamber No. 1 (Figure 5.6) was surveyed. A reading of 90 mR/h was obtained, but no explosive

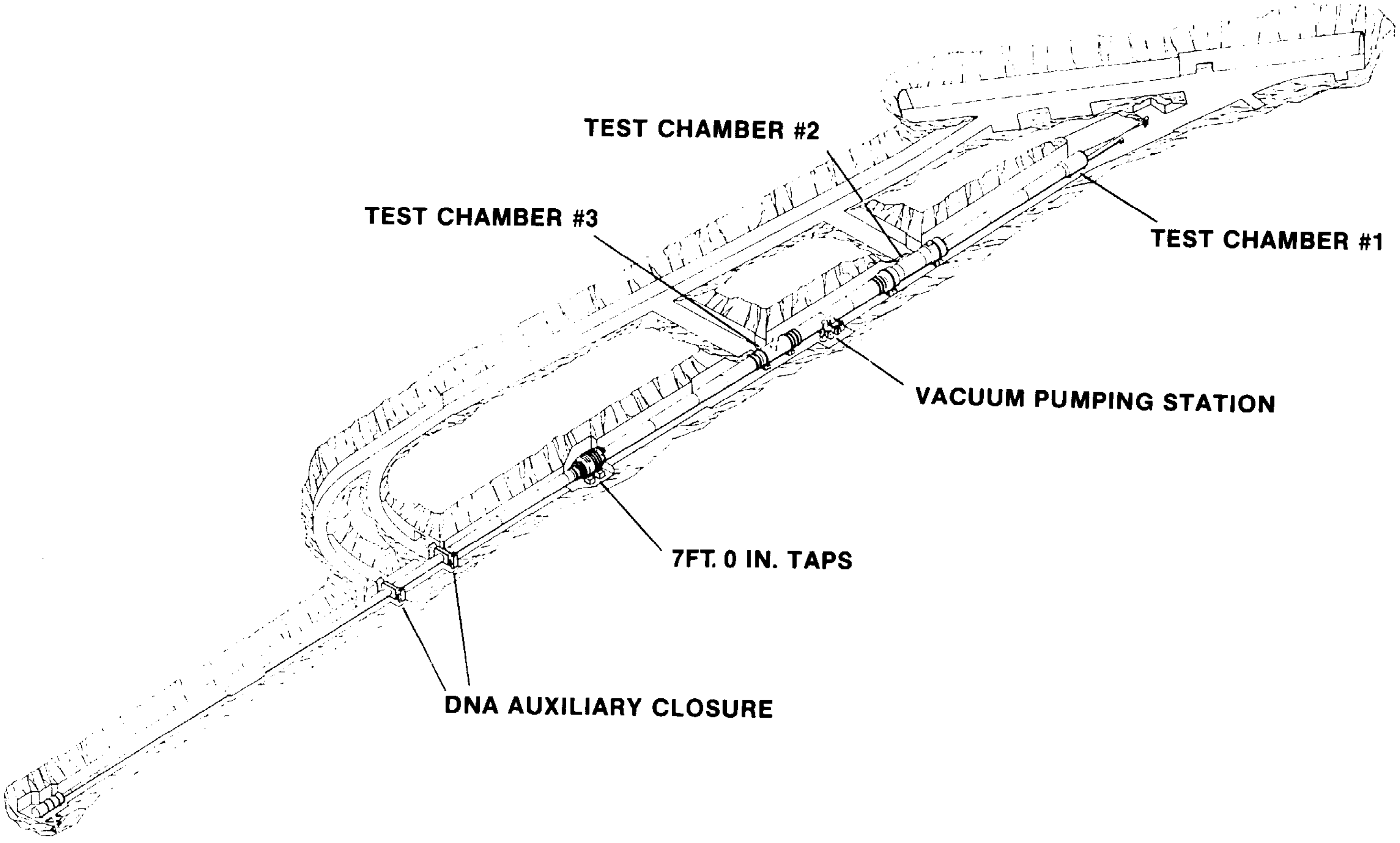


Figure 5.6 HUSKY ACE Event - System Configuration

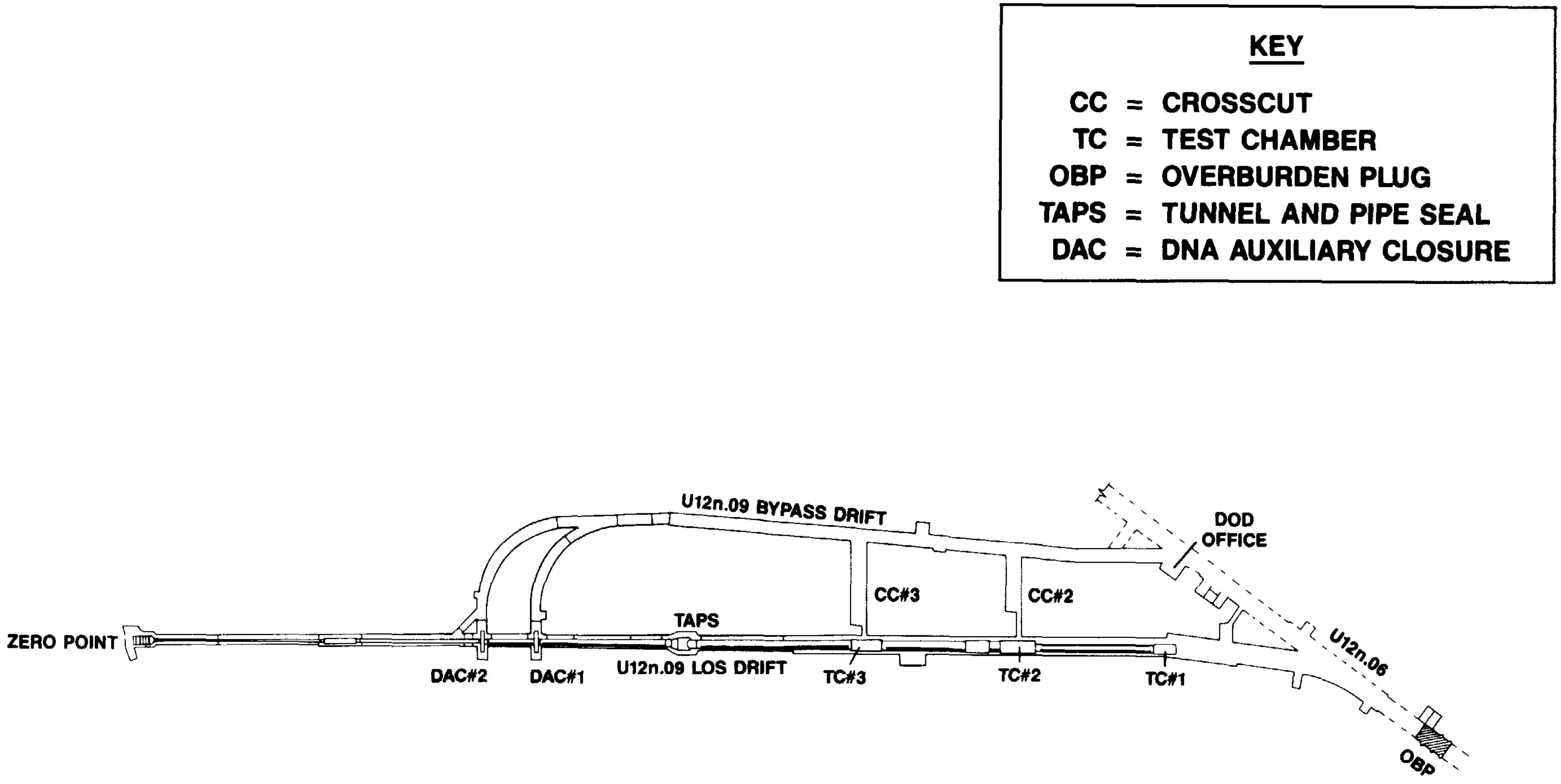
mixture or toxic gases were detected. Next, crosscut No. 2 was checked and team members began removing sandbags. The maximum reading taken over the top of the sandbags was 4 mR/h with no indications of toxic gases or explosive mixture detected. Between 1310 and 1325 hours, crosscut No. 3 was checked. The alcoves were extensively damaged and the tunnel was partially collapsed. The maximum radiation reading taken near the doorway to test chamber No. 3 was 130 mR/h. At the zero point end of the test chamber outside the pipe the maximum reading was 250 mR/h. At 1335 hours, the door to test chamber No. 3 was opened and readings of 1,200 ppm carbon monoxide, 2 percent of the LEL, and 600 mR/h were measured inside the test chamber. Subsequently, team members began to exit the tunnel complex, reaching the portal at 1404 hours.

Team No. 1 reentered the tunnel at 1420 hours and proceeded through the OBP to perform temporary repairs on the vent line before traveling on to test chamber No. 1 (which now measured 100 mR/h at the door). The valve on top of the LOS pipe at test chamber No. 1 was opened to allow ventilation of the pipe. Sampling indicated 1,000 ppm carbon monoxide, a trace of carbon dioxide, and no evidence of explosive mixture. Between 1520 and 1542 hours, test chamber Nos. 1, 2, and 3 were checked. Readings of 300 ppm carbon monoxide and 120 mR/h were detected inside test chamber No. 1; 300 ppm carbon monoxide, 110 mR/h, and no explosive mixtures inside test chamber No. 2; and 200 ppm carbon monoxide at test chamber No. 3. Team members returned to the portal side of the OBP at 1605 hours and this completed initial reentries in the N tunnel complex. By 1625 hours, all personnel had exited the tunnel.

Train tracks were reestablished through the gas seal plug early on 15 October 1973 (D+3). A reentry team went to check the condition of the LOS pipe (carbon monoxide concentrations) before the scientific assessment team entered the LOS pipe. The flex line above test chamber No. 1 and inside test chamber Nos. 1, 2, and 3 were checked, and the valve on the zero point side of test chamber No. 3 was opened and that line checked. No carbon monoxide was detected. The maximum exposure rate inside the LOS pipe was 90 mR/h in test chamber No. 3. No anticontamination clothing or face masks were required for this evaluation survey because the team did not enter the LOS pipe but surveyed from test chamber doorways.

The scientific assessment team entered the LOS pipe at test chamber No. 2, walked to test chamber No. 1, and returned to test chamber No. 2. They next traveled to test chamber No. 3, experiment station No. 4, the TAPS (see Figure 5.7) where a radiation reading of 3 mrad/h was detected, and then returned to test chamber No. 2 to exit the pipe. Anticontamination clothing required for this entry into the LOS pipe included one pair of coveralls (with openings taped), a hood, two pairs of gloves and shoe covers, and a full-face mask with a canister to filter organics, acid, particulate, and radioactive (OAP/R) materials. Upon exit from the LOS pipe, the first pair of shoe covers was removed. The scientific assessment lasted approximately 1-1/2 hours, followed by photographers who performed station photographic documentation, and a damage and hazard survey of the LOS pipe conducted by personnel from HQ/DNA. All persons entering the LOS pipe were dressed in anticontamination clothing and subject to the same requirements as the scientific assessment team.

On 16 October 1973 (D+4), train tracks were reinstalled through the OBP. KSC personnel began recovering experiments. Each person recovering experiments in the LOS pipe wore anticontamination coveralls (with openings taped), two pairs of gloves and shoe covers, a hood, and a full-face mask with OAP/R canister. A Radsafe monitor accompanied a Sandia health physicist into the LOS pipe to obtain samples from the zero point side



NOT TO SCALE

Figure 5.7 HUSKY ACE Event - Tunnel and Pipe Layout of the TAPS door. They were dressed in the same anticontamination gear as the other recovery personnel entering the LOS pipe. A survey of toxic gas and explosive mixture levels indicated 5 percent of the LEL and 7,000 to 8,000 ppm carbon monoxide on the zero point side of the TAPS door.

5.4.2 Experiment Recovery Activities

On 17 October (D+5), experiment recovery from all test chambers began. Each person recovering experiments inside the LOS pipe wore anticontamination coveralls (with openings taped), two pairs of gloves and shoe covers, a hood, and a full-face mask with OAP/R canister. Exceptions to this rule were the Lockheed experimenters who were recovering experiments at the end of the LOS pipe (swipes were taken from the experiments to determine beryllium contamination levels). Because it was not necessary for any persons recovering experiments from this station to be exposed to the atmosphere inside the area for longer than a few minutes, face masks were not required. Another exception to the face mask requirement involved Pan Am photographers taking photographs of KSC experiments at test chamber No. 1. No other personnel were allowed in the pipe at the same time as the Lockheed and Pan Am personnel in an effort to minimize airborne particulate matter. This exposure lasted approximately 15 minutes. Agencies recovering experiments from pipe stubs and alcoves had no anticontamination clothing requirement.

Experiment recoveries continued on 18 October (D+6) in test chamber Nos. 1, 2, and 3. Each person recovering experiments wore one pair of anticontamination coveralls with openings taped, two pairs of gloves and shoe covers, a hood, and a full-face mask with OAP/R or dust canister. The majority of the experiments were recovered by 1200 hours. Additional instrumentation was being recovered from the alcoves by miners, electricians, and experimenters. No anticontamination clothing was required for these personnel. At the request of the DOD Test Group Director, samples were taken from the zero point side of the TAPS. Results were as follows:

- higher than 100 percent of the LEL (calibrated to a 5% methane equivalent),
- 7 percent oxygen, and
- 1.2 percent carbon monoxide.

Additional samples were taken and sent to the laboratory to be analyzed using a gas chromatograph. Results were:

- 22 percent hydrogen
- 8 percent oxygen
- 65 percent nitrogen
- 500 ppm methane, and
- 1.2 percent carbon monoxide (using a Draeger tube)

After discussing the results of this sampling effort with other test group staff members, the Test Group Director requested permission from the Test Controller to begin ventilation through the TAPS after first assuring that all nonessential personnel had exited the area. Permission was granted. At 1845 hours, a Sandia health physicist and a Radsafe monitor entered the LOS pipe at test chamber No. 3 to check conditions in the LOS pipe. Each wore anticontamination coveralls (with openings taped), a hood, two pairs of gloves and shoe covers, and full-face masks with Type N canister. Concentrations detected were 55 percent of the LEL and 600 ppm carbon monoxide just inside the door to test chamber No. 3, and 40 percent of the LEL and 650 ppm carbon monoxide at test chamber No. 1. All major experiments had been recovered by 1635 hours on 18 October. Work to raise the TAPS door continued until 25 October 1973.

5.4.3 Postevent Mining

The major objectives of the postevent mining effort were to evaluate the performance of the TAPS, DACs, and stemming. Mining began on 28 February 1974 and continued until 7 April 1975. Test chamber Nos. 1, 2, and 3 were washed down with water on 9 May 1974, and all reentry mining activities were then halted until 15 July 1974. Between 15 July 1974 and 7 April 1975, mining efforts concentrated on removing the bulkheads from test chamber No. 1 and exposing DAC Nos. 1 and 2 for analysis. The maximum radiation level detected during the mining effort occurred on 1 August 1974 at 1700 hours. The reading, 9 mrad/h (beta plus gamma), was at contact with a length of pipe in the 07 reentry drift at 213 feet from the heading. The highest exposure rate in a work area was observed during cleanup operations in test chamber No. 2. Pipe fitters washed down the inside of the test chamber in a 0.5 mR/h environment. In general, the exposure rate remained near or at background levels during mucking and mining operations. No alpha radiation was detected.

5.4.4 Postevent Drilling

There was no postevent drilling into the zero-point area for sample recovery.

5.4.5 Industrial Safety

Surveys to determine radiation levels and to check for the presence of toxic gases and any explosive mixture were made on each shift. The measurements were recorded in the Radsafe monitors' logbook.

Appropriate safety measures were taken to protect mining personnel and prevent unsafe conditions. Industrial safety codes including specific codes for mining, tunneling, and drilling were established by REECo and emphasized during all operations. A written standard operating procedure was required for each operation involving explosives, toxic material, or any other operation with the potential for personal injury. Each individual involved in these operations was required to know the contents of the applicable procedure.

The portal construction area and the tunnel were mandatory hard hat and foot protection areas (safety shoes, safety boots, miners boots, or toe guards). Each participating agency provided its own safety equipment. All personnel on the initial tunnel reentry teams were certified in the use of the McCaa two-hour breathing apparatus and had used the Draeger self-contained breathing apparatus. Standard safety rules and regulations, as spelled out in the "U.S. Bureau of Mines Manual," were observed.

All explosives, electro-explosive components, solid propellants, toxic material, and radioactive material were handled, stored, and transported in accordance with applicable sections of the following documents:

A. Army Materiel Command Regulations (AMRC 385-224).
B. AEC Manual 500 Series for the Nevada Test Site.
C. Individual Safe Operating Procedures (by experimenter organization).
D. HUSKY ACE Safety Regulations.

All personnel engaged in handling, storing, assembling, or installing explosives, propellants, or electro-explosive devices (or observers of those operations) were required to wear safety glasses or other eye protection which had been approved by the DOD Safety Coordinator.

5.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 1001 hours on 12 October 1973 and ended at 0801 hours on 15 October 1973. The maximum reading detected was 650 R/h at underground RAMS unit No. 33 at 1002 hours on D-day.

Initial radiation survey teams were released from the FCP at 1135 hours. The Mesa survey was completed at 1200 hours and the portal survey at 1210 hours. No radiation above background, no toxic gases, and no explosive mixture were detected.

Initial tunnel reentry was performed from 0805 until 1605 hours on 13 October. Maximum readings were 600 mR/h, 1,200 ppm carbon monoxide, and 2 percent of the LEL inside test chamber No. 3 at 1335 hours.

Experiment recovery activities were conducted on 17 and 18 October. Maximum explosive mixture and toxic gas readings in work areas were 55 percent of the LEL, and 650 ppm carbon monoxide, as identified in section 5.4.2.

Postevent mining began on 28 February 1974 and continued intermittently until 7 April 1975. The maximum radiation rate measured during reentry mining was 9 mrad/h (beta plus gamma), near contact with an exposed pipe in the 07 reentry drift on 1 August 1974 at 1700 hours. The highest work area exposure rate recorded was 0.5 mR/h, read while the inside of test chamber No. 2 was being washed down by pipe fitters. No alpha radiation was detected.

No postevent drilling activities on the Rainier Mesa or underground were conducted for this event.

Personnel gamma radiation exposures received during individual entries to HUSKY ACE radex areas from 13 October through 19 October 1973 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. No positive exposures were recorded by film dosimeters during these entries because the minimum reportable gamma exposure for NTS film dosimeters was 30 mR per film packet.

	No. of Entries Logged	Average Exposure (mR)
All Participants	89	4
DOD Participants	39	6

CHAPTER 6

MING BLADE EVENT

6.1 EVENT SUMMARY

MING BLADE was a DOD-sponsored underground test detonated at 0900 hours PDT on 19 June 1974 with a yield less than 20 kt. The device was detonated in N tunnel (in the U12n.08 drift, see Figure 6.1) at a vertical depth of 1,276 feet. The objective of this test was to determine response of materials and equipment to a nuclear detonation environment. Government agencies and contractors conducted 24 projects to obtain the desired weapons effects information.

Stemming was successful and containment was complete. No radioactive effluent was released to the atmosphere.

6.2 PREEVENT ACTIVITIES

6.2.1 Responsibilities

Safe conduct of all MING BLADE project activities in Area 12 was the responsibility of the DOD Test Group Director. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DNA, and AEC/NVOO.

Project agencies were responsible for designing, preparing, and installing their experiments or delivering them to the installation contractor. After the event, these agencies were responsible for removing samples, analyzing instrument and sample data, and preparing project reports on experiment results.

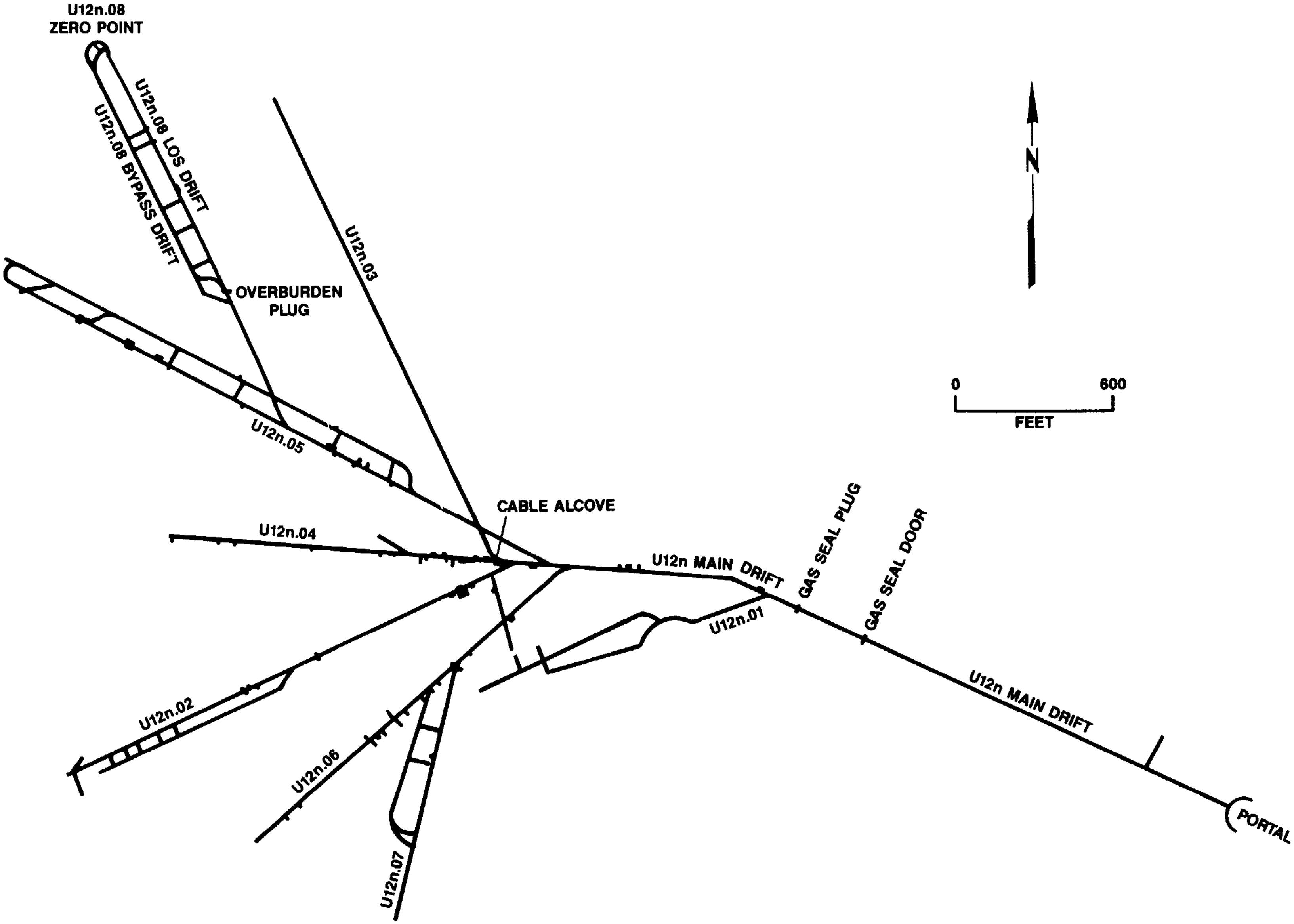


Figure 6.1 MING BLADE Event - Tunnel Layout

Device safety and security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Because LASL fielded the device, the LASL Test Group Director was responsible for radiological safety within a 6,000-foot radius of the zero point prior to the event. This responsibility was in effect from device emplacement until detonation. At that time, the Test Controller relieved the LASL Test Group Director of responsibility. When the Test Controller had determined that venting had not occurred, he delegated responsibility to the DOD Test Group Director.

6.2.2 Planning and Preparations

A. Tunnel Facilities Construction

Mining of the U12n.08 drift began on 18 June 1973. Mining this drift allowed many facilities installed for previous events to be reused, including the cable alcove, three downhole cable runs from the Mesa trailer park to the cable alcove, the N tunnel Mesa trailer park, and portal facilities. Additional facilities required for MING BLADE were experiment (LOS) and bypass drifts which made up the U12n.08 drift complex; a new overburden plug (OBP); a cable gas-blocking alcove and plug; a cable drift; a gas seal plug between the gas seal door and the OBP; and three short, side pipe drifts close to the zero point. The bypass drift and the adjoining crosscuts provided access for (1) installation of the DACs; (2) experiment installation at the test chambers and the side pipes; (3) alcove space which was used by the experimenter agencies to house power supplies, signal conditioning equipment, and experiment preparation working space; (4) early grouting of the main LOS pipe prior to device installation; and (5) device installation.

ROSES units were used for MING BLADE. The ROSES provided an underground recording system for data and reduced the lengths and cost of cable runs. MING BLADE used a hardwire multiplex system to control and monitor the reentry electrical power distribution. The tunnel ventilation system employed two control panels, one at the portal and one at the DOD monitor room at CP-1. Remotely-controlled ventilation was an aid to early tunnel reentry. Remote controls for the gas sampling system were located at the portal and allowed gas to be sampled from the zero point sides of the gas seal door, gas seal plug, and OBP as well as from inside the LOS pipe. Gas sampling also could be manually performed from the portal side of each plug.

Mining was halted on 26 September to provide support for HUSKY ACE preevent activities and was resumed on 15 October. Mining of the new cable and experiment drifts began in November 1973 and was completed by 22 January 1974. Installation of the LOS pipe began on 4 February 1974. Mining of the bypass drift and zero point area were completed 26 February 1974. Prestemming of the main drift began on 13 March, and on 5 April the LOS pipe installation was completed. Experiment installation began on 22 April. Experimenter organizations represented were SLA, LASL, Space and Missile Systems Organization (SAMSO), AFWL, Lockheed Palo Alto Research Laboratory (LPARL), IRT, KSC, LMSC, DNA, Science Applications, Inc. (SAI), PI, DOD, and LLL. On 24 April, instrumentation vans were installed at the Mesa trailer park and prestemming of the LOS drift was completed. By 8 May, the first mandatory signal (FMS) dry run was accomplished, and on 15 May, experiment installation was complete. Verification of experiment alignment was accomplished 18 May, necessitating some minor adjustments of experiment positions.

A mandatory full-participation (MFP) dry run was held on 4 June, but was unsatisfactory. A rerun was successfully completed on 5 June, and device emplacement and button-up activities were begun. A labor strike occurred at the NTS on 6 June. By using supervisory personnel and nonstriking craft personnel, button-up activities continued. Final placement of all stemming materials was completed on 12 June.

B. Radiological Safety Support

Procedures for radiation exposure and contamination control during this event were in accordance with requirements of AEC Manual Chapter 0524 and responsible DOD representatives. Radsafe provided monitoring and equipment support, air sampling, and telemetry.

Prior to the test event, detailed radiological safety reentry plans were prepared and issued to participating agencies, air sampling equipment was positioned in the test area, and Radsafe monitors were briefed regarding surface reentry, manned stations, and security station requirements.

Radsafe monitoring teams and supervisory personnel were provided to perform postevent initial radiation surveys, conduct aerial surveys by helicopter, and participate in reentry parties as needed. Radsafe personnel also were standing by at Gate 300 prior to detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment and material, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Available anticontamination materials and equipment included hoods, coveralls, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, plastic bags, gloves, and masking tape.

C. Telemetry and Air Sampling Support

In addition to permanent RAMS units, 35 temporary units provided surface and underground coverage for the MING BLADE event as shown in Table 6.1 and Figures 6.2 and 6.3. An air sampling unit was placed near the U12n portal. All RAMS and the air sampling unit were installed a minimum of five days prior to scheduled device detonation.

D. Security Coverage

Device security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Beginning on D-1, personnel entering or exiting the controlled area were required to stop at muster or control stations for issue of stay-in badges or issue and return of muster badges. After area control was established, all through traffic was diverted around the controlled area through use of screening stations.

In accordance with the "Test Controller's Operations Plan," contractors and agencies were to have all personnel not connected with this event out of the controlled area before the final security sweep began.

TABLE 6.1

MING BLADE EVENT RAMS UNIT LOCATIONS
19 June 1974

Station	Location
	SURFACE
	<u>From the portal</u>:
1	At portal
2	445 feet at N 40° W azimuth (on filter system)
3	445 feet at N 40° W azimuth (on vent line)
4	445 feet at N 40° W azimuth (on vent line)
5	69 feet at S 31° E azimuth (on tunnel drain line)
6	399 feet at N 16° E azimuth
7	275 feet at N 89° E azimuth
8	364 feet at S 16° E azimuth
9	482 feet at S 12° W azimuth
10	558 feet at S 48° W azimuth
11	417 feet at N 69° W azimuth
12	1,369 feet at S 43° E azimuth
	<u>From cable downhole</u>:
13	At cable downhole
14	177 feet at N 43° E azimuth
15	135 feet at S 33° E azimuth
16	375 feet at S 31° W azimuth
17	78 feet at S 89° W azimuth
	<u>From SGZ</u>:
18	578 feet at N 01° E azimuth
19	535 feet at S 67° E azimuth
20	415 feet at S 60° W azimuth

TABLE 6.1 (Concluded)

MING BLADE EVENT RAMS UNIT LOCATIONS
19 June 1974

Station	Location
	UNDERGROUND
	From the U12n.05 main drift unless otherwise indicated:
21	1,070 feet into the U12n.08 LOS drift
22	790 feet into the U12n.08 LOS drift
23	1,150 feet into the U12n.08 bypass drift
24	970 feet into the U12n.08 bypass drift
25	85 feet into the U12n.08 into the bypass from the LOS drift S-curve
*26ER	85 feet into the U12n.08 into the bypass from the LOS drift S-curve
27	435 feet into the U12n.08 drift
28	600 feet into the U12n.05 drift from the U12n.04 drift
	From the portal:
29	2,600 feet into the U12n main drift
30	2,050 feet into the U12n main drift
*31ER	2,050 feet into the U12n main drift
32	1,700 feet into the U12n main drift
33	1,200 feet into the U12n main drift
34	On vent line raise
35	200 feet into the U12n main drift

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* ER - Extended Range (instrument capable of reading 100 mR/h to 100,000 R/h)

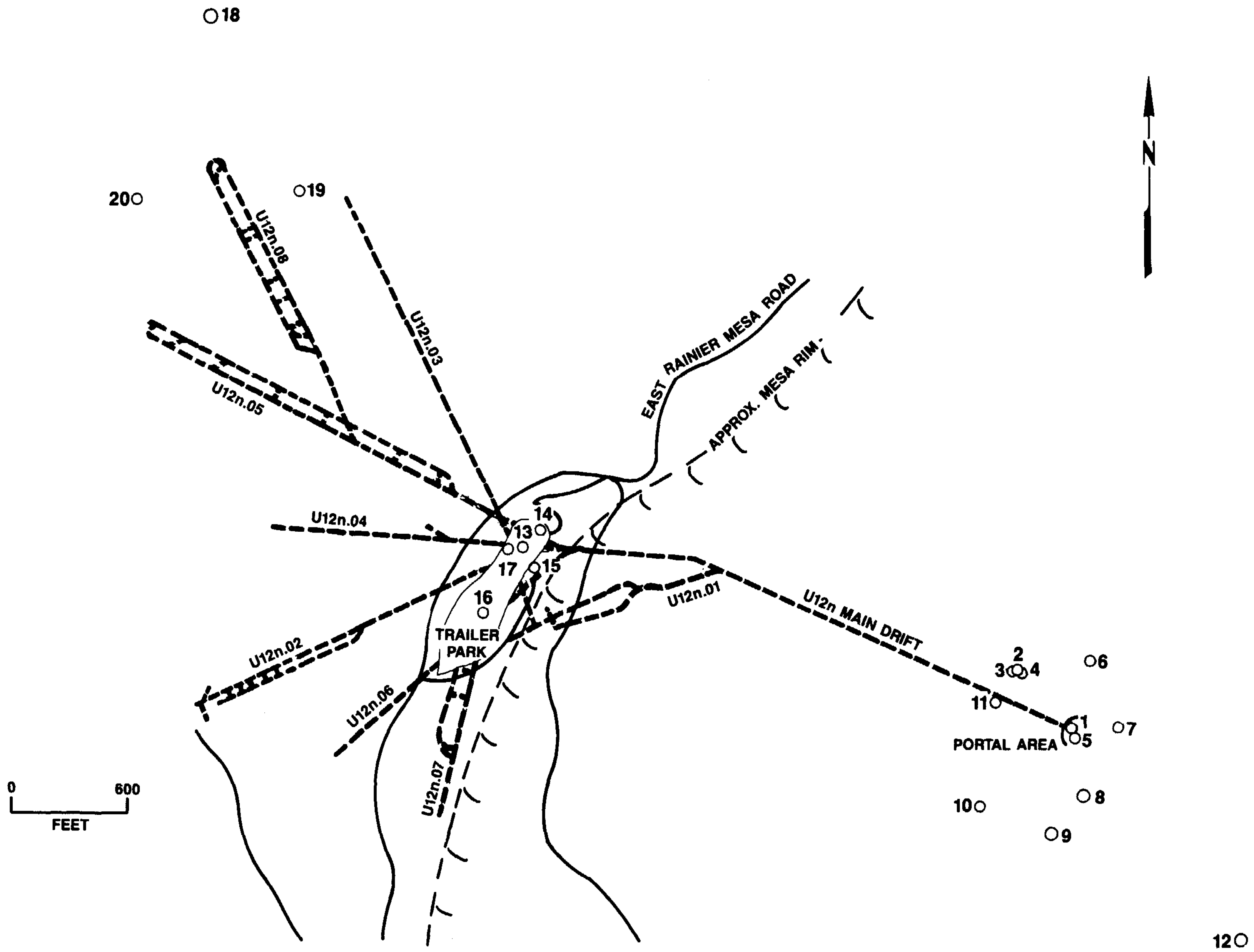

Figure 6.2 MING BLADE Event - Surface RAMS

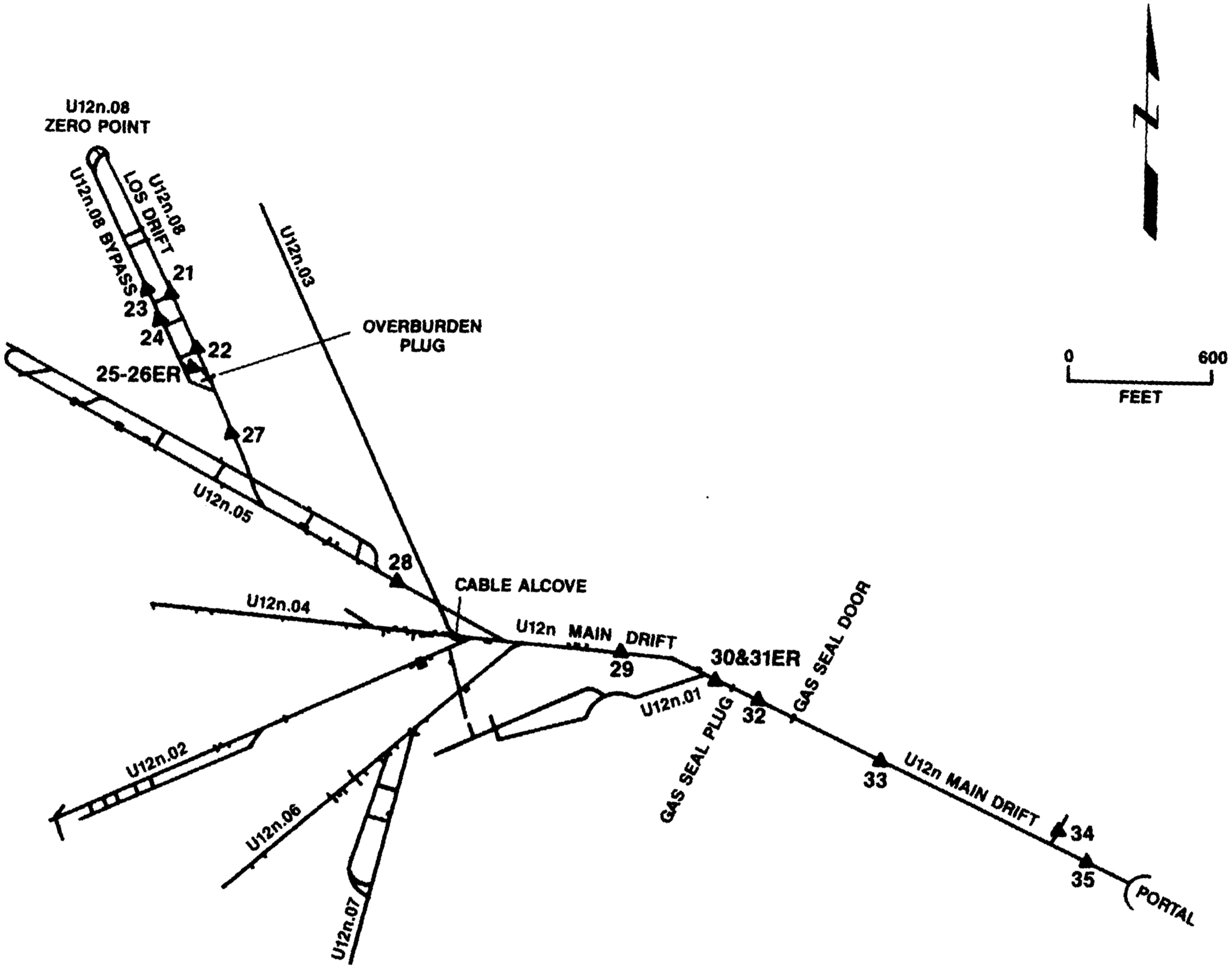

Figure 6.3 MING BLADE Event - Underground RAMS

E. Air Support

One UH-1F and two UH-1N helicopters with USAF pilots and crews provided support for aerial closed-circuit television coverage, any cloud surveillance required, and security sweeps. One of the three was on standby for the Test Controller's use, if needed. EPA had a Turbo Beech aircraft available for cloud tracking and sampling, if this were to be necessary.

6.2.3 Late Preevent Activities

Shortly after the first security sweep was completed, personnel from experimenter organizations made final instrumentation checks at the portal, in the tunnel, and at the Rainier Mesa trailer park. Film was loaded into the event recording equipment before personnel left the area.

Final button up of the tunnel complex began at 1700 hours on 18 June and was completed without problems.

6.3 EVENT-DAY ACTIVITIES

All projects were rechecked to assure that instruments were functioning properly. At the 0700-hour readiness briefing, conditions were reported to be favorable for an 0900-hour detonation.

MING BLADE zero time was 0900 hours PDT on 19 June 1974.

6.3.1 Test Area Monitoring

Telemetry coverage began at 0901 hours. Other than the expected neutron activation in the LOS pipe, no radioactivity above background was detected inside or outside the tunnel complex. All multiplex RAMS units went off line at zero time except No. 18 which was positive, possibly as a result of ground shock. RAMS unit Nos. 21 and 22 were on line immediately; Nos. 13, 14, 15, 16, 17, 19, and 20 were negative for less than one minute. This negative response of the detectors was a result of the electromagnetic pulse associated with device detonation. All other RAMS units came back on line as follows:

RAMS Unit No.	Time
2	0910
3	0912
4	0909
6	0918
7	0913
8	0913
9	0918
10	0905
11	0905
12	0913
23	Did not return
24	0908
27	0905
28	0906
29	0906
32	0903
33	0905
34	0907
35	0905

The No. 23 unit appeared to be lost as a result of cable failure caused by tunnel collapse. The maximum radiation level detected was 900 R/h at RAMS unit No. 21 at 0901 hours. Other positive readings at 0901 hours were 250 mR/h at 0901 hours on

RAMS unit No. 22 and 50 mR/h at RAMS unit No. 25. Both of these readings were the result of expected LOS pipe neutron activation. All other on-line RAMS indicated background levels of radiation immediately after device detonation. Telemetry was discontinued at 1600 hours on 20 June 1974 at which time the maximum reading was 155 mR/h at RAMS unit No. 21.

6.3.2 Initial Radiation Survey and Data Recovery Activities

Initial radiation survey teams Nos. 1 through 4 were released at 0933 hours from Gate 300 and traveled to the FCP. The portal survey began at 0950 hours and was completed at 1010 hours. The Mesa trailer park survey was conducted from 0950 to 1015 hours. No readings above background were detected at either location. Data recovery personnel were released from the FCP at 1040 hours, completed their assigned tasks, and exited the area by 1310 hours.

6.4 POSTEVENT ACTIVITIES

6.4.1 Tunnel Reentry and Experiment Recovery Activities

Remote gas sampling from the zero point side of the OBP was conducted from 0602 to 0620 hours on D+1 (20 June). No indication of toxic gases or explosive mixture was detected outside the LOS pipe; however, 150 ppm carbon monoxide was detected inside the pipe. Conditions were judged to be favorable for initial reentry, and reentry team No. 1 entered the tunnel portal at 0726 hours. Each team member was dressed completely in anticontamination clothing and was wearing Draeger self-contained breathing apparatus. They arrived at the gas seal door at 0730 hours. A 0.04 mrad/h radiation level was measured at the gas seal door, but no toxic gases or explosive mixture was detected. Water was found seeping under the door. Gas samples collected remotely from the zero point side of the gas seal door showed no indication of toxic gases or explosive mixture. Permission was granted to open the access door. Because the water level was above the bottom of the door when it was opened, a pump was installed to remove the water. Team members were allowed to remove their Draeger units while waiting for the water level to lower. Work to loosen the bolts on the large gas seal door was begun at 0750 hours.

The large gas seal door was opened at 0817 hours. One team member was sent to the portal to pick up the work party and lengths of rail so track could be laid through gas seal door. At 0850 hours, team members again donned Draeger self-contained breathing apparatus and passed through the gas seal door toward the gas seal plug. No structural damage was observed between the gas seal door and the gas seal plug, which was reached at 0858 hours. The oxygen content of the air was found to be at normal levels and there was no indication of toxic gases or explosive mixture. By 0914 hours the team had reached the zero point side of the gas seal plug. Standing water about six inches deep was observed, so team members were directed to install a pump prior to leaving the area. The reentry team moved on to the 01 drift/main drift junction, removed a cover which had been placed over the train and prepared to move the train to the gas seal plug. The gas seal plug was reached at 0927 hours, the water pump was installed, and team members returned to the portal side of the gas seal plug at 0944 hours. As the team exited the tunnel, they stopped at the gas seal door to open a valve in one of the vent lines so the water could drain. All personnel exited the tunnel at 0955 hours.

Team No. 2 entered the tunnel at 1012 hours, accompanied by a rescue team and support personnel. After stopping at the gas seal door to put on Draeger units, Team No. 2 reached the gas seal plug at 1039 hours and continued toward the OBP, while the rescue team and support personnel remained on the portal side of the gas seal plug. At 1045 hours, Team No. 2 had reached the intersection of the 04 and 06 drifts, both of which appeared to be in good condition. There were no indications of toxic gases or explosive mixture at this location. Team members traveled into the 05 drift to its junction with the 08 drift and inspected the ROSES units, which appeared to be in good condition. They reached the 08 OBP (Figure 6.4) at 1115 hours. There were no evidence of toxic gases or explosive mixture, and only background radiation levels were measured. The 36-inch manway door was then sandbagged open. It was noted that the air flow through the manway was toward the portal. Standing water about eight inches below the manway door was found on the zero point side, so a pump was set up. A fresh air station was established on the portal side of the OBP, and rescue and support personnel were moved to this location.

At 1245 hours, team members again donned their Draeger self-contained breathing apparatus and traveled through the OBP toward test chamber No. 1. Team members had been cautioned to avoid getting wet if at all possible; however, wading through water a few inches deep was required to proceed. The radiation level at the door to test chamber No. 1 was 40 mR/h, and no toxic gases or explosive mixture were detected. Team members next traveled through the bypass drift to crosscut No. 2. The condition of crosscut No. 2 was good, although the bypass drift was collapsed approximately 30 feet to the zero point side of the vacuum pump alcove.

Team members began to remove sandbags from crosscut No. 2 in an attempt to reach the LOS drift. When enough sandbags were removed to provide a crawl space, this pathway was used to reach the LOS drift. There was no evidence of toxic gases or explosive mixture, but 130 mR/h was measured. Test chamber No. 2 was reached at 1337 hours and the door was opened. Readings of 150

KEY

DAC = DNA AUXILIARY CLOSURE
TAPS = TUNNEL AND PIPE SEAL
TC = TEST CHAMBER
OBP = OVERBURDEN PLUG

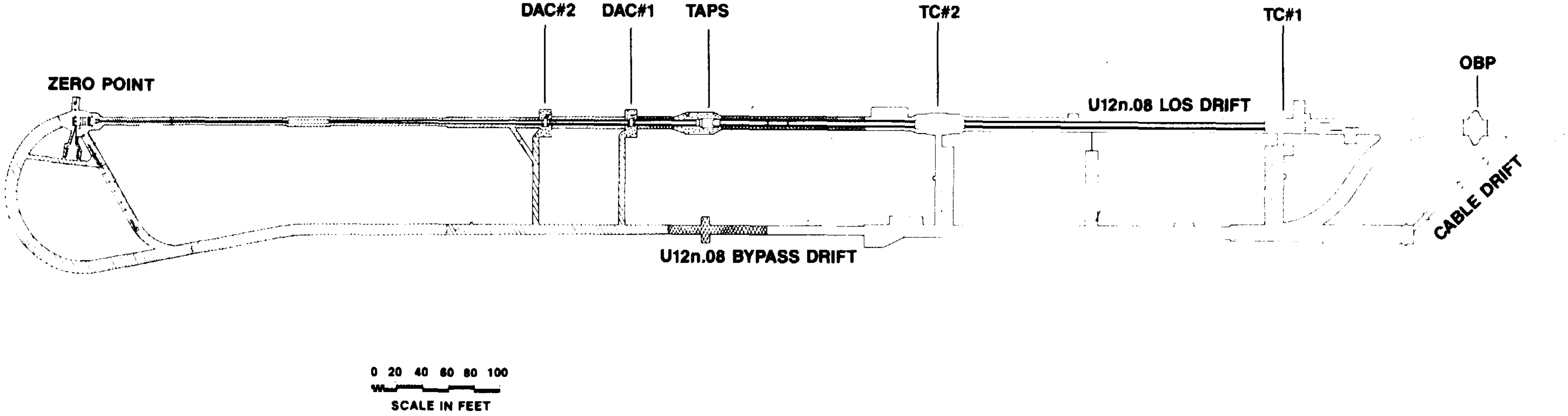

Figure 6.4 MING BLADE Event - Tunnel and Pipe Layout

mR/h and 120 ppm carbon monoxide were obtained, but no indication of explosive mixture was detected inside the chamber. A small amount of debris was on the test chamber floor; otherwise, conditions were good. At 1343 hours, the team returned to test chamber No. 1 and opened the door. A reading of 130 mR/h and 100 ppm carbon monoxide was measured, but there was no evidence of explosive mixture inside the chamber. Draeger breathing units were removed before the group returned to the portal side of the OBP at 1430 hours. While exiting the tunnel, the train ran out of fuel, forcing team members to leave their equipment on the train and walk to the gas seal plug. Initial tunnel reentry activities were completed at 1500 hours.

Immediately following initial reentry, a scientific assessment team and ROSES recovery teams entered the tunnel complex to perform data recovery. Each person entering the LOS pipe was dressed in two pairs of anticontamination coveralls, shoe covers, and gloves, and wore a full-face mask with Type N canister. The exposure rate at the data recovery area was 40 to 50 mrad/h (beta plus gamma). A DNA representative, accompanied by a REECo industrial hygienist and a Radsafe monitor, walked to the TAPS door to see if it had sealed. No toxic gases were detected at the TAPS door but the explosive mixture level was 5 percent of the LEL. Preparations to remove the OBP and the gas seal plug began.

On 21 June (D+2) at 1500 hours, a DNA and KSC inspection party entered the LOS pipe to check test chamber Nos. 1 and 2. Each person wore a full-face mask and two sets of coveralls, shoe covers, gloves, and hoods. The inspection was completed at 1700 hours.

Removal of the gas seal plug and the OBP was completed on 24 June (D+4). A Radsafe station was set up at the intersection of crosscut No. 1 and the bypass drift. Limited experiment recovery was conducted in the LOS drift. A vent line was installed in the LOS pipe to the TAPS. All work party members wore anticontamination clothing and full-face masks with Acme canisters. After the vent line was in place, a REECo industrial hygienist and an SLA health physicist, each dressed in anticontamination clothing and wearing full-face masks with Type N canisters, entered the LOS pipe to take gas samples from the zero point side of the TAPS. Sample results showed an air mixture of 68 percent nitrogen, 25 percent hydrogen, 5 percent oxygen, 1 percent methane, and 1 percent carbon monoxide. It was decided that ventilation to remove this explosive mixture (25% of hydrogen is equal to 625% of the LEL for hydrogen) would not be attempted until all recovery and mining personnel were out of the area.

Experiment recoveries began on 25 June (D+5) and were conducted in accordance with the schedule established by the Test Group staff. All experiment recovery personnel wore single pairs of anticontamination coveralls; double sets of gloves, shoe covers, and hoods; and a full-face mask with Acme canister. The maximum radiation levels surveyed in test chambers No. 1 and 2 were 3 mrad/h and 10 mrad/h, respectively. Recovery operations continued through 27 June, which was a Friday, and then were suspended for the weekend. During swing shift on 27 June, ventilating of the LOS pipe on the zero point side of the TAPS was begun. Surveys of the ventilation line showed concentrations of 1.5% carbon monoxide and greater than 100% of the LEL at the start of the shift. By the end of the shift, there was no evidence of explosive mixture or toxic gases, and the oxygen was at normal (21%) levels. Hourly checks were made throughout the weekend with no change in these concentrations.

Recoveries continued on 1 and 2 July with personnel dressed in single sets of anticontamination clothing and wearing full-face masks with Acme canisters. The TAPS door was opened on 8 July. Industrial hygiene personnel checked for the presence of toxic gases and explosive mixture; none were detected. An assessment team entered the LOS drift to check the DACs. After this was completed, the area was secured until 5 November 1974.

6.4.2 Postevent Mining

Postevent mining to recover DAC No. 1 began on 5 November 1974 with mining through the TAPS concrete. By 22 November, miners had reached the DAC No. 1 area. All radiation readings in this area were background. Although Radsafe coverage was not required, the heading was monitored once per shift to assure that potential problem locations were not overlooked. On 10 December, an area large enough to allow removal of DAC No. 1 had been mined. The DAC was subsequently removed for possible future reuse. Work on MING BLADE was halted on 13 December so that miners could work on operations in the U12n.11 drift and in the U12n.10 LOS drift.

6.4.3 Postevent Underground Drilling

Drilling equipment was set up underground on 4 August 1975 in the DAC No. 1 excavation. Urine samples were obtained from drill crew members to establish background radioactivity levels for these personnel in case any internal deposition should occur during drilling activities. Drilling of exploratory hole RE No. 1 toward the MING BLADE chimney began on 12 August. All radiation, toxic gas, and explosive mixture levels were normal until 10 September when readings of 10 ppm carbon monoxide and 10 percent of the LEL were detected at the drill stem. Radsafe monitors checked for tritium with negative results. This drilling activity was secured on 30 September. No radiation readings above background levels had been detected.

Drillers began setting up drilling equipment hole RE No. 2 on 2 October. Tritium monitoring was conducted during this operation. On 9 October, a core which read 40 mrad/h at contact was extracted. The area immediately was roped off as a radex area and urine samples were collected from all personnel. Drill crew members were dressed in anticontamination coveralls, shoe covers, and gloves. The hole was ultimately drilled to a total length of 446 feet with some cores reading greater than 200 mR/h. On 10 October, tritium measurements of 55 microcuries per cubic meter of air were measured with a T-446 and 30 microcuries per cubic meter were measured with an NR-3. Urine sample results indicated no significant tritium uptakes occurred as a result of this drilling activity. This drilling was completed on 10 October.

6.4.4 Cavity Study

Underground drill hole RE No. 2 was reopened on 25 February 1976 to conduct a cavity study. Drillers were dressed in coveralls, boots, and rubber gloves. Tritium samplers (T-446s) were set up in the drilling area. No readings above background were detected, and work was completed on 1 March. On 2 March, RE No. 1 was reopened. The radiation level rate at the drill hole was 1.8 mrad/h. Drillers were dressed in coveralls, boots, and rubber gloves while in the general work area and wore rubber suits while participating in the drilling operation. Maximum readings measured during this cavity study were 1.8 mrad/h at drill hole RE No. 2, 200 ppm carbon monoxide, and 10 percent of the LEL. Again, urine samples taken from workers in the area indicated no significant tritium uptakes. The cavity study was completed on 5 March 1976.

6.4.5 Industrial Safety

Measurements to determine radiation levels and check for the presence of any toxic gases or explosive mixture were made each shift. These measurements were then recorded in the monitors' logbook.

Appropriate safety measures were taken to protect mining personnel and prevent unsafe conditions. Industrial safety codes for mining, tunneling, and drilling were established by REECo and emphasized during all operations. A written standard operating procedure was required for each operation involving explosives, toxic materials, radioactive material, or any other operation with the potential for personal injury. Each individual involved in such an operation was required to know the contents of the applicable procedure.

The portal construction area and the tunnel were mandatory hard hat and foot protection areas (safety shoes, safety boots, miner's boots, or toe guards). Each participating agency provided its own safety equipment. All personnel on the initial tunnel reentry teams were certified in the use of the McCaa two-hour breathing apparatus and had used the Draeger self-contained breathing apparatus. Standard safety rules and regulations, as spelled out in the "U.S. Bureau of Mines Manual," were observed.

All explosives, electro-explosive components, solid propellants, toxic material, and radioactive material were handled, stored, and transported in accordance with applicable sections of the following documents:

A. Army Materiel Command Regulations (AMCR 385-224).
B. AEC Manual 500 Series for the Nevada Test Site.
C. Individual Safe Operating Procedures (by experimenter organization).
D. MING BLADE Safety Regulations.

All personnel engaged in handling, storing, assembling, or installing explosives, propellants, or electro-explosive devices (or observers of those operations) were required to wear safety glasses or other eye protection which had been approved by the DOD Safety Coordinator.

6.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 0901 hours on 19 June 1974 and ended at 1600 hours on 20 June 1974. The maximum gamma exposure rate measured was 900 R/h at underground RAMS unit No. 21 at 0901 hours on D-day.

Initial radiation survey teams Nos. 1 through 4 were released to begin their surveys at 0933 hours, completed the portal survey at 1010 hours, and completed the Mesa survey at 1015 hours on D-day. No radiation above background was detected.

Initial tunnel reentry was conducted from 0726 to 1500 hours on 20 June. Maximum readings were 150 mR/h and 120 ppm carbon monoxide in test chamber No. 2 at 1337 hours.

Experiment recovery activities were conducted from 25 June to 8 July. The maximum radiation levels during the recovery period were 3 mrad/h in test chamber No. 1 and 10 mrad/h in test chamber No. 2.

Postevent mining began on 5 November 1974 and was halted on 13 December. No radiation above background levels was detected.

Postevent drilling was conducted underground between 4 August and 10 October 1975. Maximum readings were 10 percent of the LEL and 10 ppm carbon monoxide on 10 September at the drill stem, and greater than 200 mrad/h at contact with a core sample on 9 October and again on 10 October. No Mesa surface drilling to recover core samples was conducted.

Personnel exposures received during individual entries to MING BLADE radex areas from 19 June to 3 July 1974 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	No. of Entries Logged	Maximum Exposure (mR)	Average Exposure (mR)
All Participants	223	205	9
DOD Participants	88	205	12

CHAPTER 7

HYBLA FAIR EVENT

7.1 EVENT SUMMARY

HYBLA FAIR was a DOD-sponsored underground test detonated at 0700 hours Pacific Standard Time (PST) on 28 October 1974 with a yield less than 20 kt. The device was detonated in N tunnel (U12n.09 drift, see Figure 7.1) at a vertical depth of 1,326 feet. The objective of this test was to determine the response of materials and equipment to a nuclear detonation environment. Government agencies and contractors conducted ten projects to obtain the desired weapons effects information.

Stemming was not completely successful, but containment inside the tunnel complex was complete. No radioactive effluent was released to the atmosphere.

7.2 PREEVENT ACTIVITIES

7.2.1 Responsibilities

Safe conduct of all HYBLA FAIR project activities in Area 12 was the responsibility of the DOD Test Group Director. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DNA, and the AEC/NVOO.

Project agencies were responsible for designing, preparing, and installing experiments or delivering them to the installation contractor. After the event, these agencies were responsible for removing samples, analyzing instrument and sample data, and

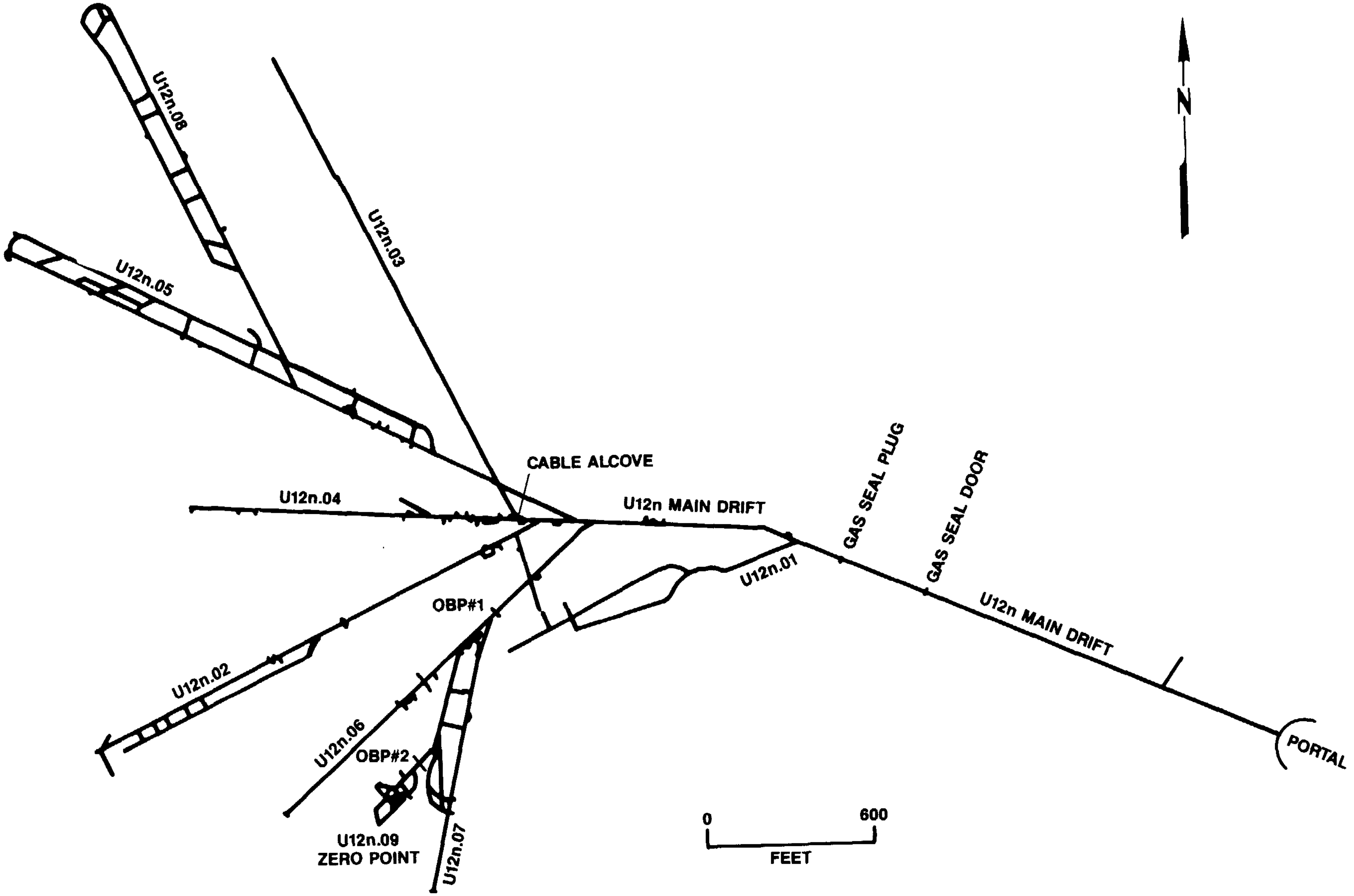

Figure 7.1 HYBLA FAIR Event - Tunnel Layout

preparing project reports on experiment results.

Device safety and security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Because LLL fielded the device, the LLL Test Group Director was responsible for radiological safety within a 6,000-foot radius of the zero point prior to the event. This responsibility was in effect from device emplacement until detonation. After detonation, the Test Controller relieved the LLL Test Group Director of responsibility. When the Test Controller had determined that venting had not occurred, he delegated responsibility to the DOD Test Group Director.

7.2.2 Planning and Preparations

A. Tunnel Facilities Construction

In late February 1974, mining personnel began to prepare a bypass drift and an experiment (LOS pipe) drift which were connected by various crosscuts. (See Figures 7.2 and 7.3 for exterior views of the HLOS pipe.) Two of these crosscuts were used as experimenter alcoves; one was used for access purposes. Mining operations were completed on 9 May 1974. Cable installation began on 20 May and was scheduled for completion on 2 August, although the actual completion date was delayed until 11 September by labor problems. Experiment installation began on 5 August 1974.

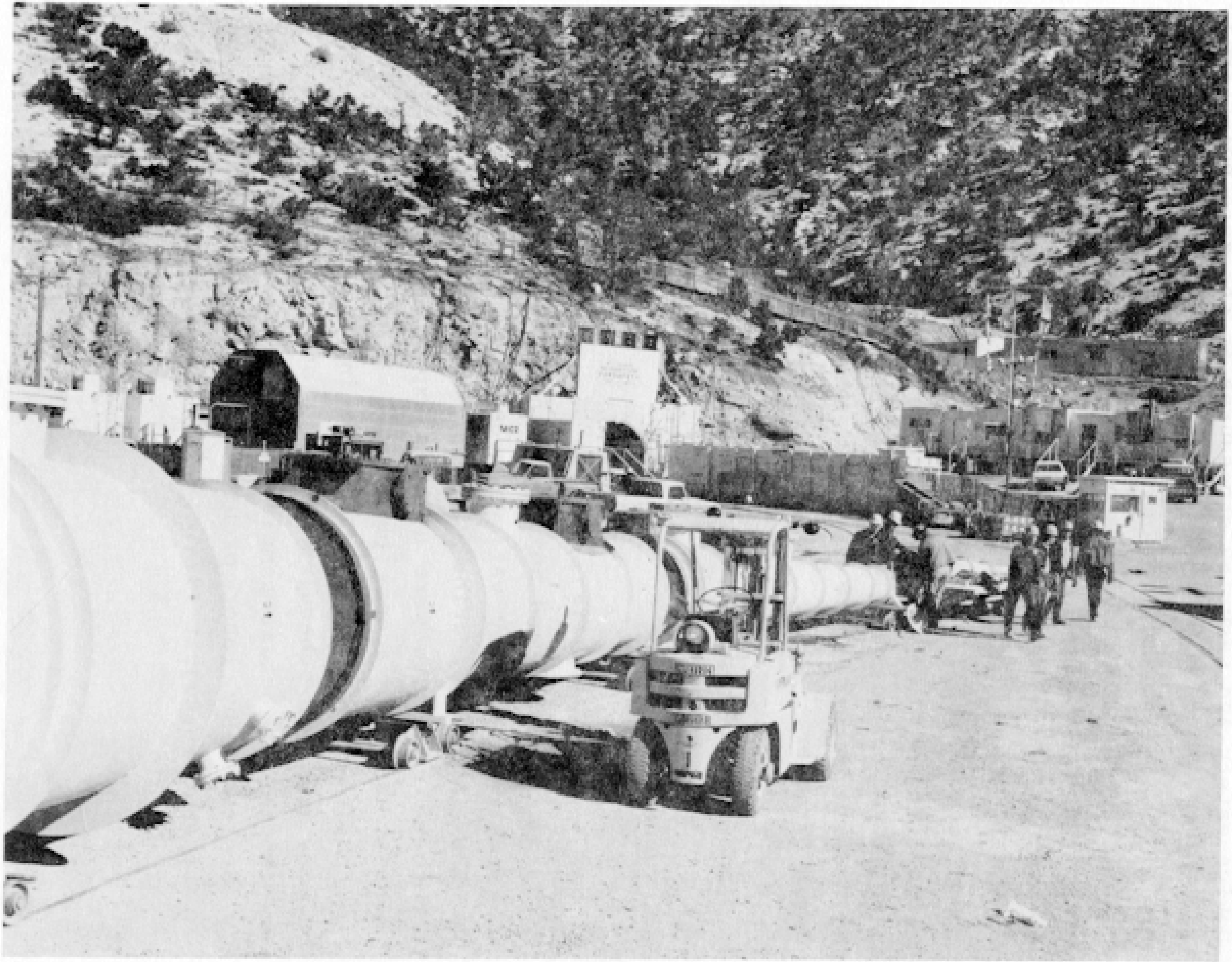

Figure 7.2 HYBLA FAIR Event - Closeup of HLOS Pipe Sections

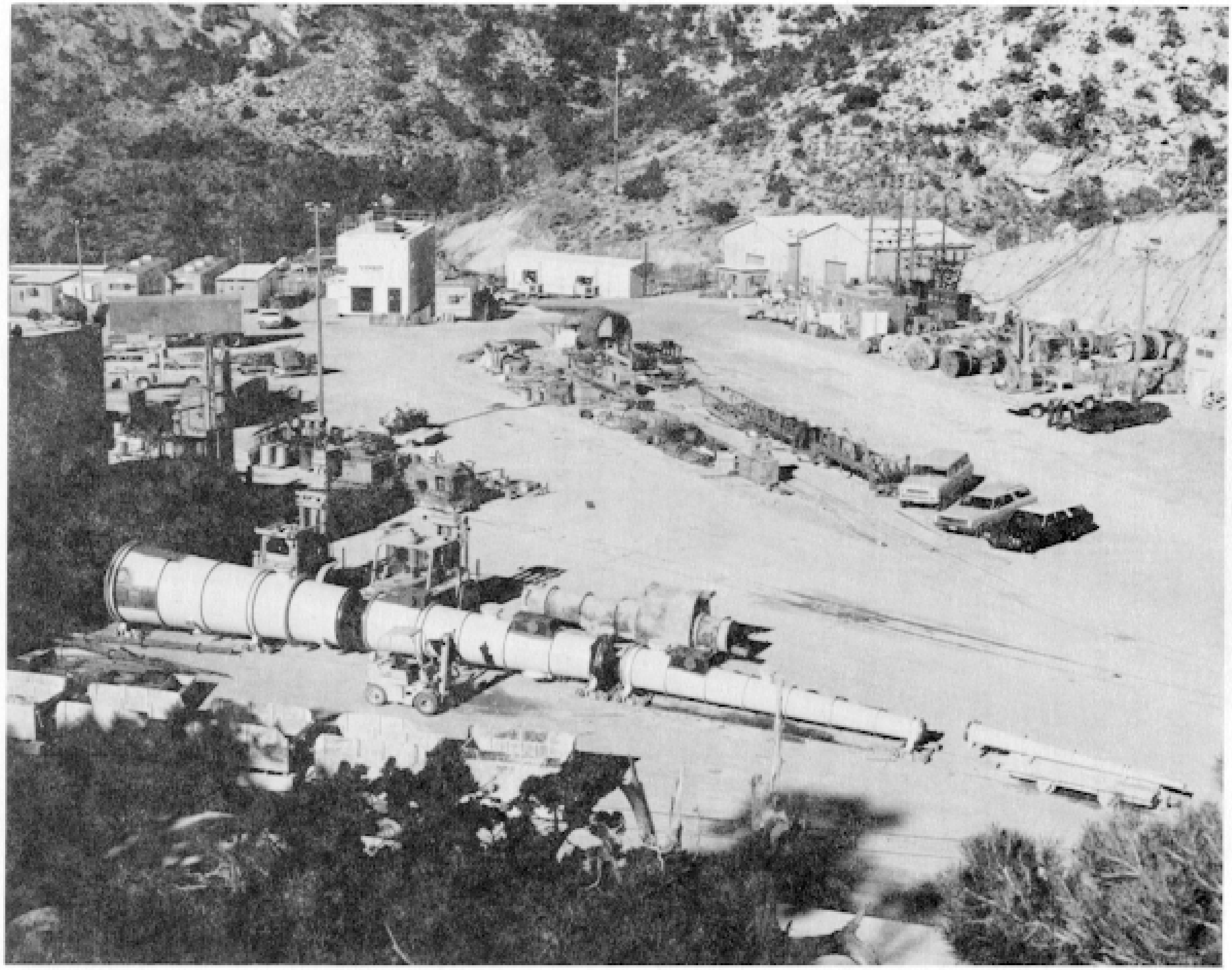

Figure 7.3 HYBLA FAIR Event - HLOS Pipe Sections

B. Radiological Safety Support

Procedures for radiation exposure and contamination control during this event were in accordance with requirements of AEC Manual Chapter 0524 and responsible DNA representatives. Radsafe provided monitoring and equipment support, air sampling, and telemetry.

Prior to the test, detailed radiological safety reentry plans were prepared and issued to participating agencies. Air sampling equipment was positioned in the test area. Radsafe monitors were briefed regarding surface reentry, manned stations, and security station requirements.

Radsafe monitoring teams and supervisory personnel were provided to perform initial radiation surveys, conduct aerial surveys by helicopter, and participate in reentry parties as needed. Radsafe personnel also were standing by at Gate 300 prior to detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment and material, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Available anticontamination materials and equipment included hoods, coveralls, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, plastic bags, gloves, and masking tape.

C. Telemetry Support

In addition to permanent RAMS units, 35 temporary RAMS units provided surface and underground coverage for the

HYBLA FAIR event as shown in Table 7.1 and Figures 7.4 and 7.5. All RAMS units were installed a minimum of five days prior to scheduled device detonation.

D. Security Coverage

Device security procedures in the zero point area and the timing and firing control room were in accordance with AEC Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations."

Beginning on D-1, all personnel entering or exiting the controlled area were required to stop at muster or control stations for issue of stay-in badges or issue and return of muster badges. After area control was established, all through traffic was diverted around the controlled area by use of screening stations.

In accordance with the "Test Controller's Operations and Security Plan," contractors and agencies were to have all personnel not connected with this event out of the closed area before the final security sweep began.

E. Air Support

One UH-1F and two UH-1N helicopters with USAF pilots and crew members provided support for aerial closed circuit television coverage, any cloud surveillance (if venting should occur), and security sweeps. One of the three was on standby for the Test Controller's use, if needed. EPA had a Turbo Beech aircraft available for cloud tracking and sampling of any effluent, and a USAF C-118 aircraft also was on standby at Nellis Air Force Base if needed for cloud tracking.

TABLE 7.1

HYBLA FAIR EVENT RAMS UNIT LOCATIONS
28 October 1974

Station	Location
	SURFACE
	From portal:
1	445 feet at N 40° W azimuth (on filter system)
2	445 feet at N 40° W azimuth (on vent line)
3	445 feet at N 40° W azimuth (on vent line)
4	69 feet at S 31° E azimuth (on tunnel drain line)
5	399 feet at N 16° E azimuth
6	275 feet at N 89° E azimuth
7	364 feet at S 16° E azimuth
8	482 feet at S 12° W azimuth
9	558 feet at S 48° S azimuth
10	417 feet at N 69° W azimuth
11	1,369 feet at S 43° E azimuth
	From cable downhole:
12	At cable downhole
13	177 feet at N 43° E azimuth
14	135 feet at S 33° E azimuth
15	375 feet at S 31° W azimuth
16	78 feet at S 89° W azimuth
	From SGZ unless otherwise indicated:
17	300 feet North
18	270 feet at S 64° E azimuth
19	300 feet at S 60° W azimuth
20	On DIANA MIST cavity drill hole

TABLE 7.1 (Concluded)

HYBLA FAIR EVENT RAMS UNIT LOCATIONS
28 October 1974

Station	Location
	UNDERGROUND
	From the U12n.09 LOS drift/bypass drift junction:
21	255 feet into the U12n.09 LOS drift
*22ER	255 feet into the U12n.09 LOS drift
23	240 feet into the U12n.09 bypass drift
*24ER	240 feet into the U12n.09 bypass drift
	From the U12n.06 drift:
25	400 feet into the U12n.07 bypass drift
	From the U12n.04 drift:
26	600 feet into the U12n.06 LOS drift
*27ER	600 feet into the U12n.06 LOS drift
28	350 feet into the U12n.06 drift
	From the portal unless otherwise indicated:
29	2,600 feet into the U12n main drift
30	2,050 feet into the U12n main drift
*31ER	2,050 feet into the U12n main drift
32	1,700 feet into the U12n main drift
33	1,200 feet into the U12n main drift
34	50 feet into the vent line raise
35	200 feet into the U12n main drift

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* ER - Extended Range (instrument capable of reading 100 mR/h to 100,000 R/h)

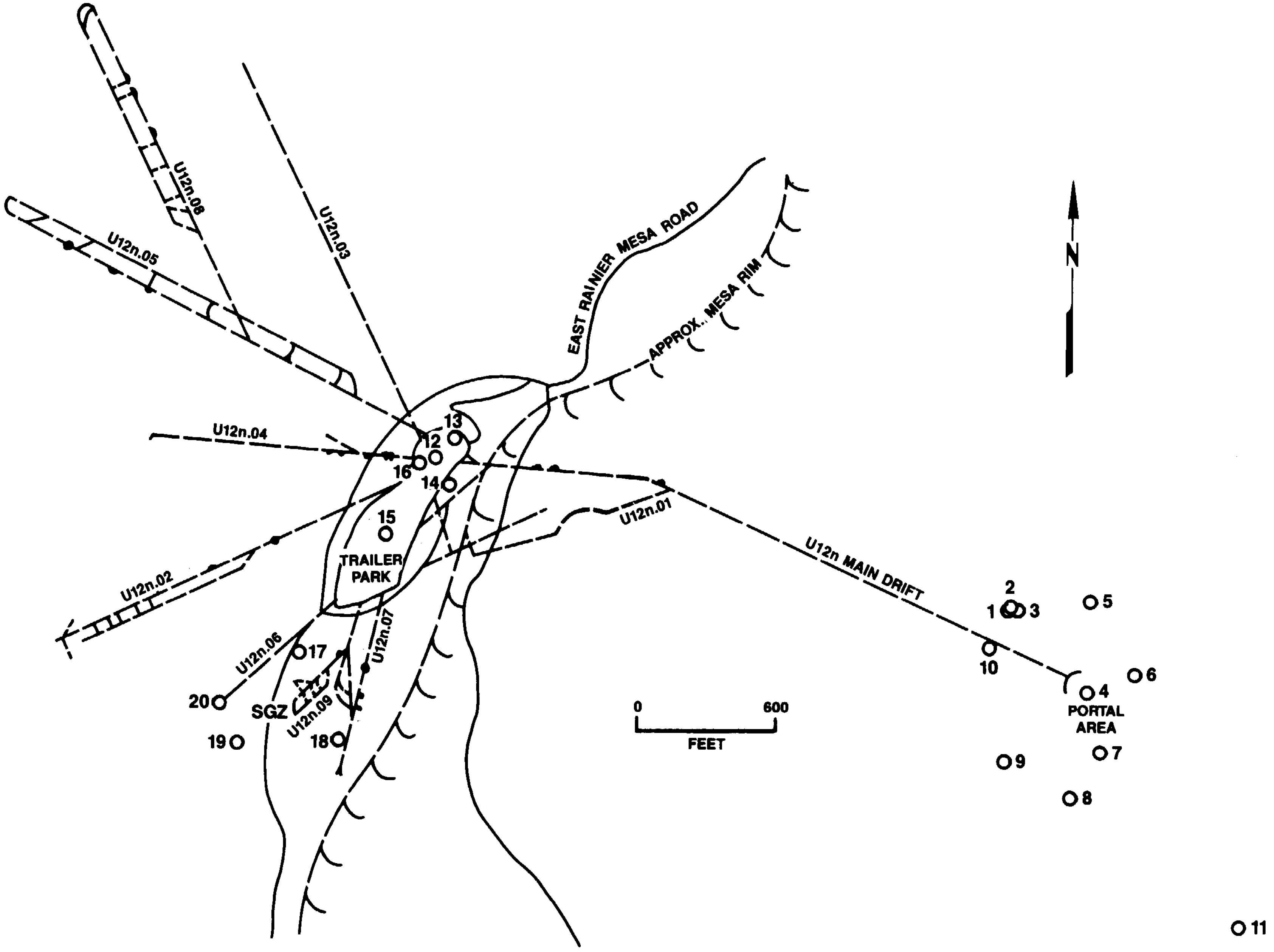

Figure 7.4 HYBLA FAIR Event - Surface RAMS

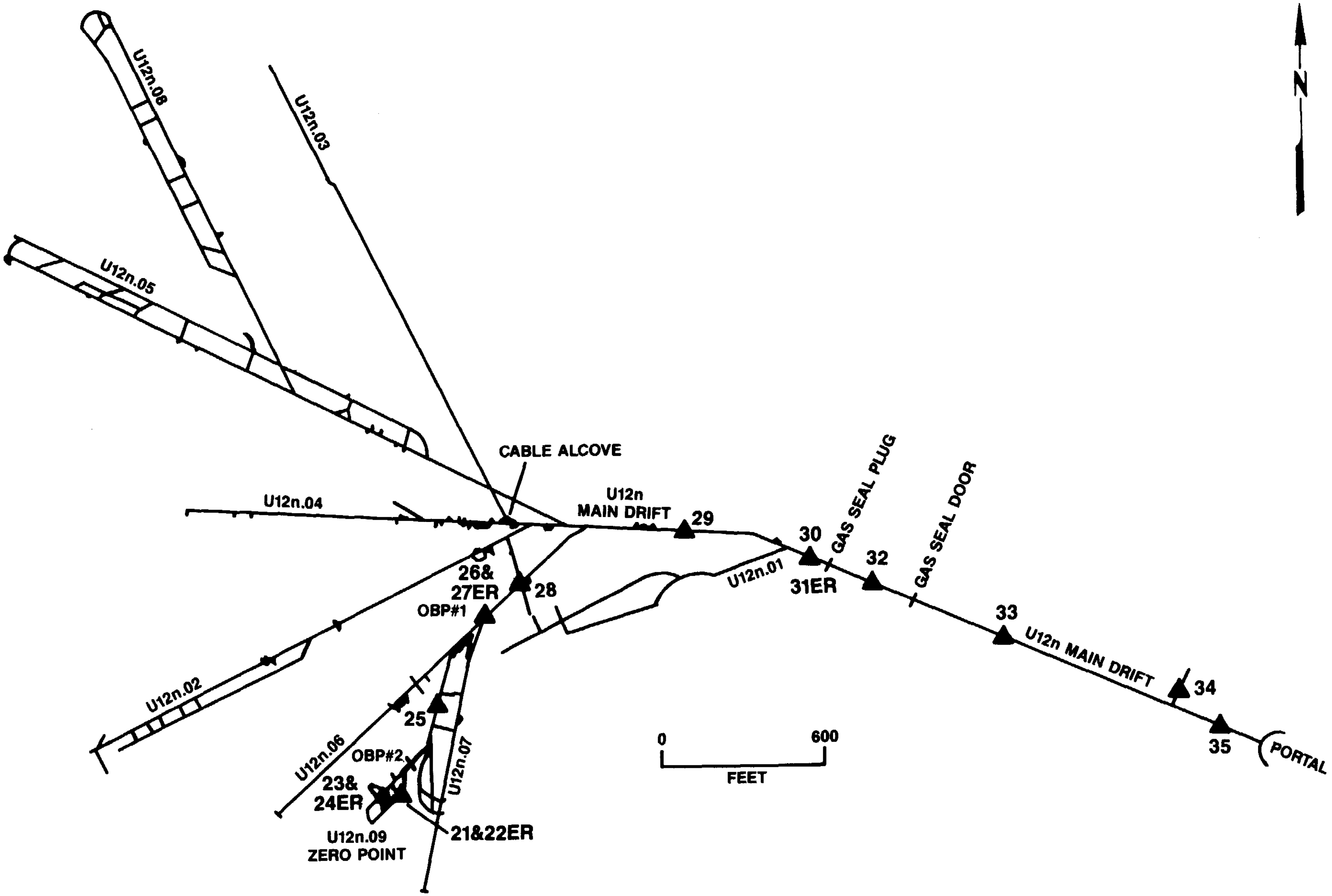

Figure 7.5 HYBLA FAIR Event - Underground RAMS

7.2.3 Late Preevent Activities

The first signal dry run (FSD) was held on 12 September. On 15 October, an unsuccessful mandatory full participation (MFP) dry run was performed. A second attempt conducted that afternoon, however, was successful. Event preparations continued, with the final dry run (FDR) held on 25 October in anticipation of the scheduled 26 October detonation. Marginal weather, culminated by a lightning strike resulting in the loss of microwave and monitoring systems, caused event postponement until 28 October. In the meantime, another FDR was successfully completed on the afternoon of 27 October.

Shortly after the first security sweep was completed on 27 October, personnel from SLA, PI, LPARL, IRT, LLL, EG&G, Bendix, and DNA made final instrumentation checks at the portal, in the tunnel, and at the Rainier Mesa trailer park. They loaded film into the event recording equipment before leaving the area.

7.3 EVENT-DAY AND CONTINUING ACTIVITIES

All projects were rechecked to assure that instruments were functioning properly. Permission to arm the device was granted, arming procedures were completed, and the arming party cleared the area by 0400 hours. A readiness briefing was held at 0500 hours and all factors were judged to be favorable for an 0700 test execution.

HYBLA FAIR zero time was 0700 hours PST on 28 October 1974.

7.3.1 Test Area Monitoring

The test failed to fully contain in the stemmed region. Shortly after zero time, RAMS units located between the HYBLA

FAIR overburden plug (OBP No. 2) and the HUSKY ACE OBP (OBP No. 1, see Figure 7.1) detected radiation which had penetrated the HYBLA FAIR OBP. Long-term seepage of radioactive gas occurred. The seepage did not pose a threat to ultimate containment of these gases underground because pressures and temperatures between the two OBPs never differed significantly from ambient preevent levels. Readings varied from 175 R/h on the portal side of the HYBLA FAIR OBP, to 2.5 R/h on the zero point side of the HUSKY ACE OBP. These readings decreased to 800 mR/h, and 240 mR/h respectively, by D+1.

At zero time, RAMS unit Nos. 1 and 15 were not on line, unit 21 and 22ER were lost, and all other units were functioning. Both unit Nos. 23 and 24ER indicated radiation levels greater than their respective 1,000 R/h and 100,000 R/h detection capacities. Unit No. 25 increased to 5 R/h and then began to decrease. At approximately two minutes after zero time, readings from unit No. 25 began to increase, reaching a maximum of 175 R/h at H+17 minutes after which levels began to decrease continuously.

RAMS unit No. 26 began showing an increase at approximately H+11 minutes, increasing to 15 mR/h at H+13 minutes. It then showed a decay with a half-life of approximately seven minutes. At about H+38 minutes, it began showing a rapid increase, rising to 175 mR/h at H+40 minutes, and continuing to increase until H+210 minutes.

RAMS unit No. 24ER came back on line with a reading of 100,000 R/h at H+55 minutes. RAMS unit No. 23 in SLA alcove No. 6 came back on line reading 1,000 R/h at H+210 minutes.

No indication of radioactive effluent was detected by RAMS unit Nos. 28 through 35 located on the portal side of the HUSKY ACE OBP. RAMS unit No. 30 increased to approximately 1 mR/h when remote gas samples taken at the portal were discharged back to the zero point side of the gas seal plug.

All telemetry was secured at 0800 hours on 19 December 1974.

7.3.2 Initial Radiation Survey and Reentry Activities

Between 0809 and 0825 hours, a Radsafe base station was established beyond the FCP. All readings were background at that location. The initial radiation survey of the portal was conducted between 0915 and 0934 hours and all readings were at background. A survey of the Mesa trailer park was conducted between 0915 and 0948 hours, and only background radiation levels were detected. Data recovery teams were released and performed their tasks from 1130 to 1245 hours.

7.4 POSTEVENT ACTIVITIES

7.4.1 Tunnel Reentry and Experiment Recovery Activities

Reentry team No. 1 entered the tunnel portal area at 0900 hours on 29 October (D+1) and received a briefing and smoke check of their masks. Teams were staged from approximately 50 feet inside the portal to stay out of the snow and rain. Team members proceeded to the gas seal door at 0920 hours dressed in complete sets of anticontamination clothing and wearing Draeger self-contained breathing apparatus. The gas seal door was reached at 0930 hours and the drain valve was opened so that any water on the zero point side of the gas seal door could be pumped out. A survey indicated 400 ppm carbon dioxide, and a background reading of 0.05 mrad/h (beta plus gamma) was measured. No carbon monoxide or explosive mixture was detected. Work to open the access door in the gas seal door began at 0940 and was accomplished at 0943 hours. Standing water at about eight inches below the sill of the access door was found, and the sandbag walkway had water a few inches deep over it. Toxic gas, explosive mixture, and radiation levels remained the same.

Permission was given for team members to pass through the door and proceed to the gas seal plug, which was reached at 0952 hours. Water from the zero point side of the plug was being pumped into the drain line on the portal side of the plug without overflowing from the ditch there into the drift. Team members confirmed a positive air flow toward the portal, measured a radiation level of 0.05 mrad/h, and detected no toxic gases or explosive mixture. Between 1000 and 1006 hours, both the 24-inch and 36-inch manway doors were opened. A team member passed through the 36-inch manway to check on the water level behind the plug, which he reported as between one and two inches below the manway opening and extending to the U12n.01 drift/main drift junction. He then returned to the portal side of the gas seal plug. Team members removed their Draeger breathing apparatus and returned to the gas seal door to establish a fresh air station. At 1045 hours, a rescue team, work party, and Radsafe personnel entered the tunnel complex to open the large gas seal door, lay railroad track, and establish a "hot line." By approximately 1115 hours, the large gas seal door was open and secured, and railroad tracks were reestablished through the door.

Reentry team No. 1 again entered the tunnel complex and reached the gas seal door at 1140 hours, where they put on Draeger self-contained breathing apparatus before continuing into the tunnel complex. They reached the portal side of the gas seal plug at 1203 hours. The water level was now between six and eight inches below the bottom of the manway opening when team members went through the gas seal plug at 1206 hours. The U12n.01 drift/main drift junction was reached at 1210 hours. The train which had been left at this location was uncovered and backed out, and team members then traveled by train toward OBP No. 1 (HUSKY ACE). The tunnel was virtually undamaged in the 01 drift, and OBP No. 1 was reached at 1225 hours. A reading at contact with the portal side manway door was 0.5 mrad/h, 10 mrad/h was measured at contact with the inside of the manway crawl space, and 1 mrad/h was measured two feet from the zero point side manway door. No alpha radiation was detected. The drain line was opened to obtain a water sample, but there was no water in the line. Gas which measured 200 mrad/h flowed from the drain line. The valve was closed and team members departed to check the U12n.05 (MISTY NORTH) drift at 1258 hours. No damage was found in the U12n.05 drift or at the 03 drift/05 drift junction. The ROSES units were checked at 1303 hours; levels of 0.1 mrad/h and 400 ppm carbon dioxide were measured, but no carbon monoxide or explosive mixture was detected. Team members next traveled to the cable splice alcove, where only background radiation readings were obtained and there were no indications of toxic gases or explosive mixture. By 1340 hours, team members had returned to the portal side of the gas seal plug. Monitoring of reentry team members indicated no personnel contamination. All reentry team members were at the portal by 1345 hours.

Between 1350 and 1445 hours, a party entered the tunnel complex to recover data from the ROSES units. No anticontamination clothing was required for this recovery operation. By 1455 hours, all personnel had exited the tunnel complex and the tunnel was secured for the night.

On 30 October (D+2), a reentry to OBP No. 1 was made to collect a gas sample. [An additional reentry to the same location was performed on 31 October (D+3) for the same reason.] Other than gas sampling, only work on the removal of the gas seal plug was conducted. Removal of the gas seal plug was completed on 4 November (D+7).

An attempt was made on 6 November (D+9) to pump water from the zero point side of OBP No. 1 through a line which had been run to the edge of the muck pile created by the mining out of the gas seal plug. Because there were problems with the line, pumping was conducted for only 30 minutes.

On 13 November (D+16), a reentry team prepared to establish ventilation through OBP No. 1. Team members were dressed in anticontamination coveralls (taped at the wrists and ankles), gloves, shoe covers, and were wearing supplied-air breathing apparatus. By 1055 hours, the 36-inch manway door was opened. Observation through the 36-inch manway showed very little water on the zero point side of OBP No. 1. Work at this location was completed at 1135 hours. Reentry team members removed their anticontamination clothing near this OBP to minimize the spread of contamination. Their gloves were contaminated, reading 2 mrad/h; no alpha activity was detected. The glove having the highest reading was sent to the Radsafe laboratory for analysis. At 1140 hours, a hole in the vent line, about 100 feet on the portal side of OBP No. 1, was surveyed with the following results: 2,300 ppm carbon monoxide, 30 percent of the LEL, and 3.5 mrad/h at contact with the ventilation line.

A Radsafe station was set up in the U12n.06 drift in preparation for reentry to OBP No. 2. On November 15 (D+18), reentry was made from OBP No. 1 to OBP No. 2 (Figure 7.6) to check the condition of the tunnel and take samples from the zero point side of OBP No. 2. Each reentry team member was dressed in two sets of coveralls (the first pair taped at the ankles and wrists), two sets of shoe covers, two sets of gloves, a hood, and was wearing Draeger self-contained breathing apparatus. Team members suited up at the fresh air station (located approximately 100 feet on the portal side of OBP No. 1). At 1012 hours, reentry team members departed the fresh air station. As they proceeded, a few small puddles were noticed, and a reading of 2

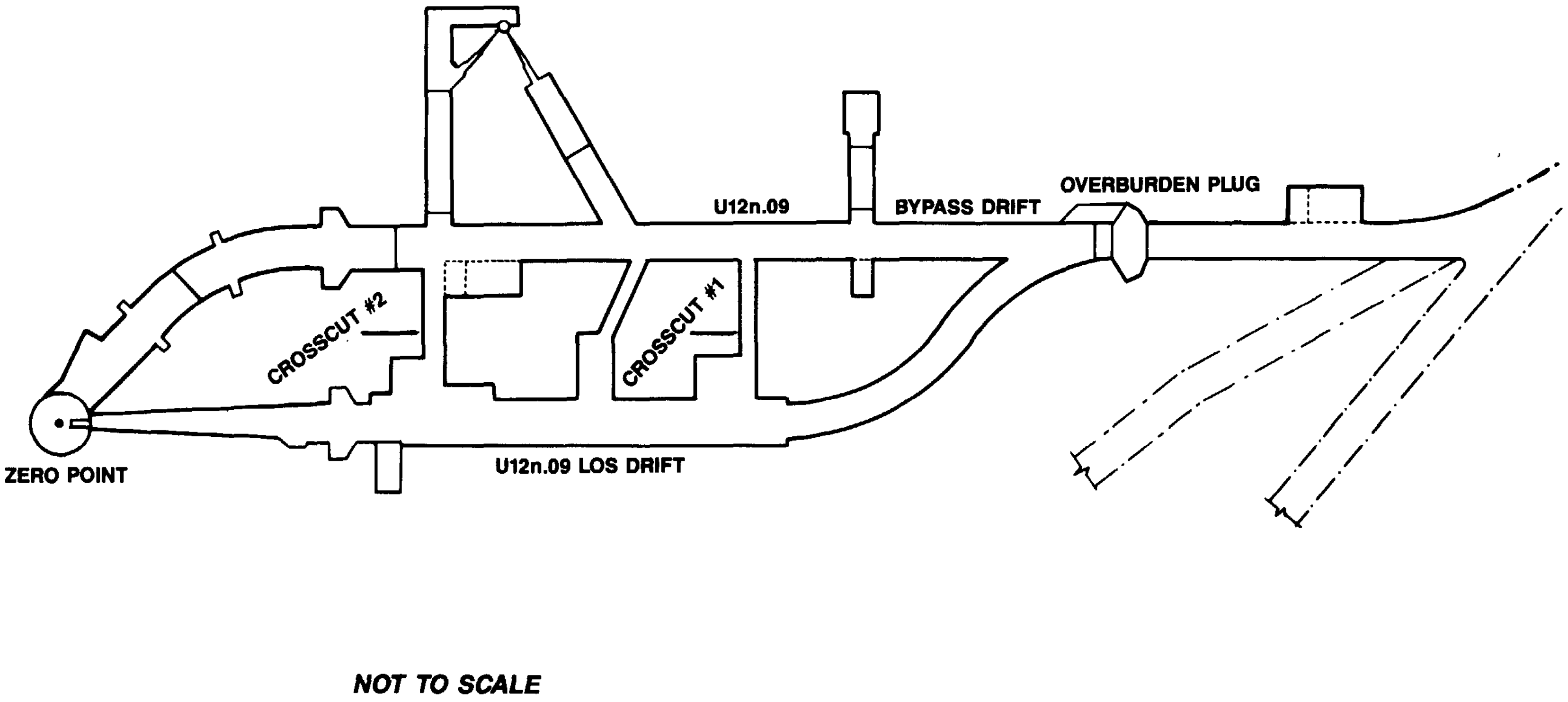

Figure 7.6 HYBLA FAIR Event - Tunnel and Pipe Layout

mR/h was detected at the HUSKY ACE LOS drift/bypass drift junction and at the entrance to the U12n.07 bypass drift. They continued toward the IRT alcove (located about 40 to 50 feet into the 07 bypass drift). Radiation levels increased to 4 mrad/h, although no explosive mixture or toxic gases were detected. As they continued toward the U12n.09 drift, about 75 feet from the 07 bypass drift/09 drift junction the reading was 13 mR/h. The U12n.09 drift was entered at 1021 hours where minor spalling was noted on the right rib of the drift. The radiation level at SLA alcove No. 1 was 20 mR/h. OBP No. 2 looked undamaged. A filter system was connected to a manual gas sampling line and team members began sampling through this plug at 1038 hours. No toxic gases or explosive mixture were detected. The general exposure rate in this area was 80 mR/h. No water was available for sampling purposes.

Between 1130 and 1139 hours, the area of the HUSKY ACE DAC No. 1 was checked (the maximum reading was 2 mR/h). At 1139 hours, team members returned to the IRT alcove to recover tapes, then returned to the fresh air station at 1150 hours. Reentry to OBP No. 2 was completed at this time. Maximum contamination levels on clothing of reentry team members were:

1 to 2 mrad/h on coveralls
15 mrad/h on shoe covers
5 to 6 mrad/h on gloves

Requirements for additional reentries beyond the fresh air station included single coveralls, a full-face respirator, a hood, gloves, and shoe covers.

On 19 November at 1046 hours, a team entered the tunnel complex to check OBP No. 2 to ascertain where seepage had come through the plug. Air samples were collected to help determine respiratory protection equipment requirements for continued reentry and recovery operations. Each team member wore a full-face respirator (with OAP/R canister), single coveralls (with openings taped), double shoe covers, double gloves, and a hood. The team left OBP No. 1 at 1045 hours and collected air samples in the IRT and SLA alcoves. A survey of OBP No. 2 indicated carbon monoxide and an explosive mixture were coming from several locations. A contact reading of 700 mrad/h was obtained above the 24-inch manway door. Additionally, experimenter alcoves and the HUSKY ACE DAC No. 1 area were checked. The maximum radiation level measured was 150 mrad/h on the portal side of OBP No. 2 at 1113 hours.

On 20 November, a team left the fresh air station at 0930 hours and traveled to OBP No. 2 to collect gas samples. Each team member was dressed in single coveralls (with openings taped), two pairs of gloves and shoe covers, a hood, and a full-face mask with an OAP/R canister. Levels of 1,000-1,500 ppm carbon monoxide and approximately 15 percent of the LEL were measured seeping from various locations at this OBP. No radiation readings greater than the 50 mrad/h (background) in the vent line were detected. Team members returned to the fresh air station at 1020 hours and crews were sent in to remove OBP No. 1. All work was terminated at 1600 hours and the security gate was locked for the day.

From 21 November to 2 December, routine tunnel cleanup operations were performed. On 2 December, preparations began to decontaminate the area between the two OBPs. On 3 December, the decision was made to use water to decontaminate about 100 feet of the drift along the left rib. Decontamination using water was not as effective as had been hoped; therefore it was decided to fix the contamination by spraying the area with a sealing agent. At the same time, an experiment recovery team went to work in SLA alcove No. 1. Participants were dressed in double coveralls, shoe covers, and gloves. Each wore a full-face mask with OAP/R canister. Recovery operations took approximately two hours.

Decontamination efforts on the zero point side of OBP No. 1 continued on 4 December. Anticontamination clothing and respiratory protection requirements were the same as for the previous day.

A survey of the U12n.07 reentry drift was conducted on 9 December 1974 between 0930 and 0940 hours. Complete sets of anticontamination clothing and full-face masks with OAP/R canisters were required. Preparations were made to begin rehabilitating the tunnel in the HUSKY ACE DAC area so that a probe hole into the U12n.09 LOS drift could be drilled. Exposure rates were 5 mrad/h at DAC No. 1 and 2 mrad/h at DAC No. 2. Rehabilitation efforts were completed on 10 December. Drilling began at 1430 hours, and, by 1500 hours, two feet had been drilled. Drilling activity was terminated for the day. When drilling resumed on 11 December, the radiation level in the DAC No. 2 area had increased to 4 mrad/h. The drill crew, accompanied by Radsafe and industrial hygiene personnel, entered the area at 1305 hours. All personnel were dressed in full anticontamination clothing and wore full-face masks with either Type N canisters or supplied air. The hole was drilled to 32 feet by the end of the shift. Drilling continued on subsequent days, with personnel dressed as on 11 December. The hole was drilled to 50 feet when drilling was stopped to put a blowout preventer on the collar pipe. The blowout preventer installed on 17 December leaked, so a new one was requested. During this time, a carbon monoxide monitor with alarm was installed near the blowout preventer. After drilling resumed, the hole was drilled to 108 feet before the end of shift. No other problems were encountered. On 18 December, drilling resumed, but problems with the drilling operation occurred, causing work to be stopped for the day.

Drilling into the U12n.09 drift was completed at 1135 hours on 19 December 1974. No indications of explosive mixture or toxic gases were detected in the work area. During an attempt to recover a core sample for analysis, with 124 feet of drill pipe left in the hole, 3,000 ppm carbon monoxide and greater than 100 percent of the LEL were detected coming from the hole. The operation was stopped, the hole was closed off, and the vent line blower was started. All personnel departed the area at 1545 hours.

On 20 December 1974, an SLA health physicist and a Radsafe monitor traveled to OBP No. 2 to inspect the portal face of the plug and to take gas samples through the plug. They were dressed in full anticontamination clothing and wore full-face respirators with Type N canisters. Following this entry, operations were suspended for the Christmas holidays and no entries were scheduled until 6 January 1975.

EG&G technicians, dressed in full anticontamination clothing with full-face masks, began recovering equipment from the IRT alcove on 8 January 1975. No radiation problems occurred.

On 10 January 1975, miners, dressed in single anticontamination coveralls, single hoods, and double sets of shoe covers and gloves, entered the U12n.09 drift to begin work at OBP No. 2. When the damper on the vent line was opened, 3,000 ppm carbon monoxide was detected above the crawlway door at OBP No 2. Personnel were immediately evacuated from the area. The maximum radiation level was 30 mrad/h (at 1115 hours). When work resumed at 1300 hours, personnel were wearing supplied-air equipment. The vent line was extended to the face of OBP No. 2 and left in that configuration for the weekend. On 13 January, another attempt was made to work at OBP No. 2; this was unsuccessful, however, because unacceptable levels of toxic gases and explosive mixture were present.

Workers, dressed in single sets of coveralls and hoods and double sets of shoe covers and gloves, traveled to OBP No. 2 on 14 January 1975. No carbon monoxide was detected at the start of work and the radiation level measured was 20 mrad/h. After two hours, 500 ppm carbon monoxide and 45 percent of the LEL were detected. Work continued with no problems.

On 15 and 16 January, work continued with the same Radsafe requirements. Sandia personnel, each wearing a single set of coveralls, a hood, double shoe covers and gloves, and a full-face mask with dust canister, entered SLA alcove No. 1 to remove electronic gear. Recovery operations took approximately two hours. Maximum levels measured were 4,500 ppm carbon monoxide and 60 percent of the LEL at a fissure in the upper portion of the right rib at OBP No. 2. No problems were noted in the working area. Experiment recovery also was accomplished by one PI representative dressed in a single set of coveralls, a hood, double shoe covers and gloves, and a full-face mask with a dust canister. This recovery effort took less than one hour.

7.4.2 Reentry Mining

On 29 January 1975, miners and electricians worked in the U12n.09 drift in preparation of mining the U12n.09 reentry drift. The exposure rate in this work area was 3 mrad/h. All personnel were dressed in full anticontamination clothing and wore full-face masks. Reentry mining began on 31 January.

Reentry mining operations were conducted during the months of February and March. Some core drilling also was performed. During coring operations, drillers, Radsafe, and industrial hygiene personnel dressed in anticontamination clothing and full-face masks with supplied air. The radiation level measured was 2 mrad/h. Alpha contamination measuring 500 cpm was encountered in the reentry heading.

On 15 and 16 April, the reentry heading was sprayed with a sealing agent to fix the alpha contamination. An exposure rate of 35 mR/h was encountered during mining operations conducted from 17 April to 4 May. Additional precautions taken to protect workers included more spraying of the area and sandbagging. These efforts reduced the exposure rate to 0.15 mR/h.

Drilling into SLA No. 6 alcove began on 5 May. The carbon monoxide reading from one probe hole was 20,000 ppm. Six more probe holes were drilled during day shift that day with ventilation on the first hole keeping negative pressure on the holes being completed into the alcove. During the shift change, compressed air was blown into the probe hole allowing the air to exit through the new holes in the face. Swing shift continued drilling, at one point detecting 5,000 ppm carbon monoxide in the flex line. At 1900 hours a decision was made to flush the chamber with compressed air and ventilate for 30 minutes. After this ventilation effort, the carbon monoxide level was reduced to 10 ppm. Work was continued without respiratory protection equipment. At approximately 2200 hours, however, a miner became light-headed and slightly faint, complaining that he smelled the odor of rotten eggs. Personnel working at the access hole face were immediately instructed to begin wearing supplied air equipment. Nothing was detected in the area to account for the miner being affected.

No personnel were allowed into the work area on 6 May until industrial hygiene personnel checked the air quality for acceptability. Readings were 10 ppm carbon monoxide; no other gases were detected which would account for the previous day's problem. Radiation levels at arm's length into the SLA alcove were 20 mR/h and 80 mrad/h. Since the alcove had about 6 to 8 inches of water on the invert, it was decided that personnel entering the alcove would not be required to wear respiratory protection equipment. (The dampness would minimize airborne dust particles). At 1115 hours, two personnel entered the SLA alcove to remove film and photograph the area. When work was completed (about 35 minutes later), one person's hands were contaminated because he had removed his gloves in order to feel the edge of the film in a camera. The initial reading from his hands was 1.3 mrad/h; however, repeated washings reduced this to 0.3 mrad/h. The person was instructed to wear a plastic glove on the contaminated hand until he reached Area 6 and further decontamination could be performed. A urine sample was requested and was submitted on 16 May. This sample showed no indication of any internal deposition of radionuclides.

On 8 May, miners began enlarging the access hole into SLA alcove No. 6 to facilitate equipment removal.

Underground sampling operations for radiochemical analysis began on 9 May. The exposure rate in the area after the first core had been removed (at 1030 hours) was 8 mR/h. An hour later, the exposure rate in the area had increased to 11 mR/h. A swipe of the drill hole cuttings indicated alpha contamination; however, this positive indication could not be reproduced later, indicating the possibility that this actually had been a beta reading. As a precautionary measure in the event alpha contamination did exist, the following procedures were instituted:

A. Full-face respirators with supplied-air or high-efficiency particulate filters for all personnel in the work area were required.

B. A double brattice cloth curtain was hung to delineate the hot line area, separating the area into "hot," "warm," and "cold" work areas.

C. An absolute filter was installed in the vent line.

D. Double anticontamination clothing was required for all personnel inside the second brattice cloth curtain.

Drilling was halted between 1345 and 1800 hours while these procedures were implemented. A swipe survey of the work area at the time indicated no alpha contamination. During drilling operations, all personnel forward of the double curtain were required to wear double anticontamination clothing and supplied air. Radchem drilling operations were completed on 5 June.

Preparations to drive a drift to reach the LOS drift began on 9 June. Workers wore full-face masks and hoods in addition to normally required anticontamination clothing. The exposure rate in the heading was 15 mR/h on 10 June. Mining continued until the LOS drift was reached on 17 June.

On 30 June 1975, preparations to enter the LOS drift were made. Reentry personnel wore double coveralls and gloves, waders, a hood, and full-face masks with supplied air. Personnel were in the drift a maximum of one hour. The maximum reading for this entry (750 mR/h) was obtained near the stemming plug. Water was on the invert. When the team members exited the drift, each member's clothing exceeded established contamination guides. Two additional personnel were contaminated helping the team members undress. All personnel were decontaminated to acceptable levels using standard decontamination techniques.

Each person working in the LOS drift on 1 July wore a single set of coveralls, rubber pants and jacket, double shoe covers and gloves, a plastic hood, and a full-face mask with supplied air. These clothing requirements continued through 3 July for all recovery personnel.

The face mask requirement was lifted 11 July. At the end of day shift on 16 July 1975, nasal swabs were taken from miners who had worked in the 08 reentry heading. The policy of not requiring face masks continued. One person had contamination of 0.3 mrad/h on his clothing, and two people who had not been wearing hoods showed radioactive contamination of their hair. As of 17 July, miners working in the U12n.09 reentry heading wore coveralls, shoe covers, gloves, and hoods. On 21 July, the radiation level had increased to 55 mrad/h, and the contact reading at the face was greater than 200 mrad/h. A check of mining personnel indicated some contamination in the nostrils as well as on hard hats. All personnel were removed from the heading. Three personnel were selected as a representative sample and sent to Mercury for whole body counts to see if internal deposition of radionuclides had occurred. No internal deposition was detected, and all miners were allowed to return to work with no change in radsafe requirements. Upon checking out at the hot line, some personnel again were noted to have some nasal contamination, and a maximum reading of 2 mrad/h was found on them after anticontamination clothing had been removed. All personnel were decontaminated to less than 0.2 mrad/h, and a mask requirement for work in the heading was reestablished.

On 22 July 1975, miners dressed in single coveralls, hoods, gloves, and double shoe covers for work in the U12n.09 reentry drift. All personnel in the reentry work area, zero point side of the end of the vent line, also wore supplied-air equipment. All personnel working in the U12n.07 muck dumping area wore full-face masks with high-efficiency particulate filters.

Work on the 09 reentry drift continued on 23 July. Just before 1500 hours, when the train was being prepared to leave the heading, it was surveyed and found to be contaminated. The decision was made to spray the reentry area with a sealing agent to prevent further spreading of contamination, then close it down until ventilation could be improved. Spraying of the drift was conducted from the beginning of swing shift to 2315 hours.

On 24 July 1975, the drift was closed off until ventilation could be improved.

Operations in the U12n.09 reentry drift resumed on 4 August 1975. Work began on crosscut No. 3 on 5 August. Miners wore coveralls, gloves, and shoe covers, but no self-contained breathing apparatus was required. This effort, as well as work in the other crosscuts, continued until 15 August 1975 when all work was suspended.

The U12n.09 drift was reopened on 1 December for core drilling into the zero point area and to check the ventilation and general condition of the drift. No carbon monoxide was detected.

Work was conducted between 1 and 15 December in preparation for emplacement of a sandbag plug before closing the drift. These operations were completed, the security gate was locked, and the facility was secured on 15 December 1975.

7.4.3 Industrial Safety

Measurements to determine radiation levels and check for the presence of any toxic gases or explosive mixture were made each shift. These measurements were then recorded in the monitors' logbook.

Appropriate safety measures were taken to protect mining personnel and prevent unsafe conditions. Industrial safety codes including specific codes for mining, tunneling, and drilling were established by REECo and emphasized during all operations. A written standard operating procedure was required for each operation involving explosives, toxic materials, radioactive material, or any other operation with the potential for personal injury. Each individual involved in such operations was required to know the contents of the applicable procedures.

The portal construction area and the tunnel were mandatory hard hat and foot protection areas (safety shoes, safety boots, miners boots, or toe guards). Each participating agency provided its own safety equipment. All personnel on the initial tunnel reentry teams were certified in the use of the McCaa two-hour breathing apparatus and had used the Draeger self-contained breathing apparatus. Standard safety rules and practices, as spelled out in the "U.S. Bureau of Mines Manual," were observed.

All explosives, electro-explosive components, solid propellants, toxic material, and radioactive material were handled, stored, and transported in accordance with applicable sections of the following documents:

A. Army Materiel Command Regulations (AMCR 385-224).
B. AEC Manual 500 Series for the Nevada Test Site.
C. Individual Safe Operating Procedures (by experimenter organization).
D. HYBLA FAIR Safety Regulations.

All personnel engaged in handling, storing, assembling, or installing explosives, propellants, or electro-explosive devices (or observers of those operations) were required to wear safety glasses or other eye protection which had been approved by the DOD Safety Coordinator.

7.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 0701 hours on 28 October 1974 and ended at 0800 hours on 19 December 1974. The maximum gamma reading was greater than 100,000 R/h at RAMS unit No. 24ER, immediately after zero time. Stemming was not completely successful.

Initial radiation survey teams entered the area at 0809 hours and completed the survey at 0948 hours on 28 October 1974. All measurements were area background. No alpha radiation was detected.

Tunnel reentry and experiment recovery activities were conducted from 29 October 1974 to 16 January 1975. Maximum readings were 80 mR/h general exposure rate at OBP No. 2 on 15 November 1974, greater than 100 percent of the LEL at a core hole drilled into U12n.09 on 19 December 1974, and 4,500 ppm carbon monoxide at a fissure in the upper right rib of the drift at OBP No. 2 on 16 January 1975.

Reentry mining was conducted from 31 January 1975 to 15 August 1975. Maximum readings were 55 mrad/h at the U12n.09 reentry heading on 21 July, 750 mrad/h at contact with the LOS pipe near the stemming plug on 30 June, and 20,000 ppm carbon monoxide at a probe hole drilled into SLA alcove No. 6 on 5 May.

No drilling from the Mesa was conducted after this event, although underground core sampling was performed. Coring to obtain radiochemical samples was performed in February, March, May, June, and December, 1975. The highest radiation reading recorded during these operations was 11 mR/h. Some alpha contamination in drill hole cuttings was indicated by portable survey instruments, and special clothing requirements were instituted, but no alpha emitters were detected during laboratory analysis of representative samples.

Recorded personnel exposures received during individual entries to HYBLA FAIR radex areas from 29 October 1974 to 15 December 1975 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	No. of Entries Logged	Maximum Exposure (mR)	Average Exposure (mR)
All Participants	3,399	265	3
DOD Participants	204	260	6

CHAPTER 8

DINING CAR EVENT

8.1 EVENT SUMMARY

DINING CAR was a DOD-sponsored test conducted at 1245 hours PDT on 5 April 1975 with a yield less than 20 kt. The device was detonated in the U12e.18 drift of the U12e tunnel complex (Figure 8.1) at a vertical depth of 1,257 feet. The purpose of the event was to test the response of materials and equipment to a nuclear detonation environment. Government agencies and contractors conducted 31 projects to obtain the desired weapons effects information.

Stemming was successful and containment was complete. No radioactive effluent was released to the atmosphere.

8.2 PREEVENT ACTIVITIES

8.2.1 Responsibilities

Safe conduct of all DINING CAR project activities in Area 12 was the responsibility of the DOD Test Group Director. Responsibilities of ERDA* and ERDA contractor personnel were in accordance with established ERDA-DOD agreements or were the subject of separate action between Field Command, DNA, and the ERDA/Nevada Operations Office.

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*ERDA (Energy Research and Development Administration) succeeded the AEC on 19 January 1975.

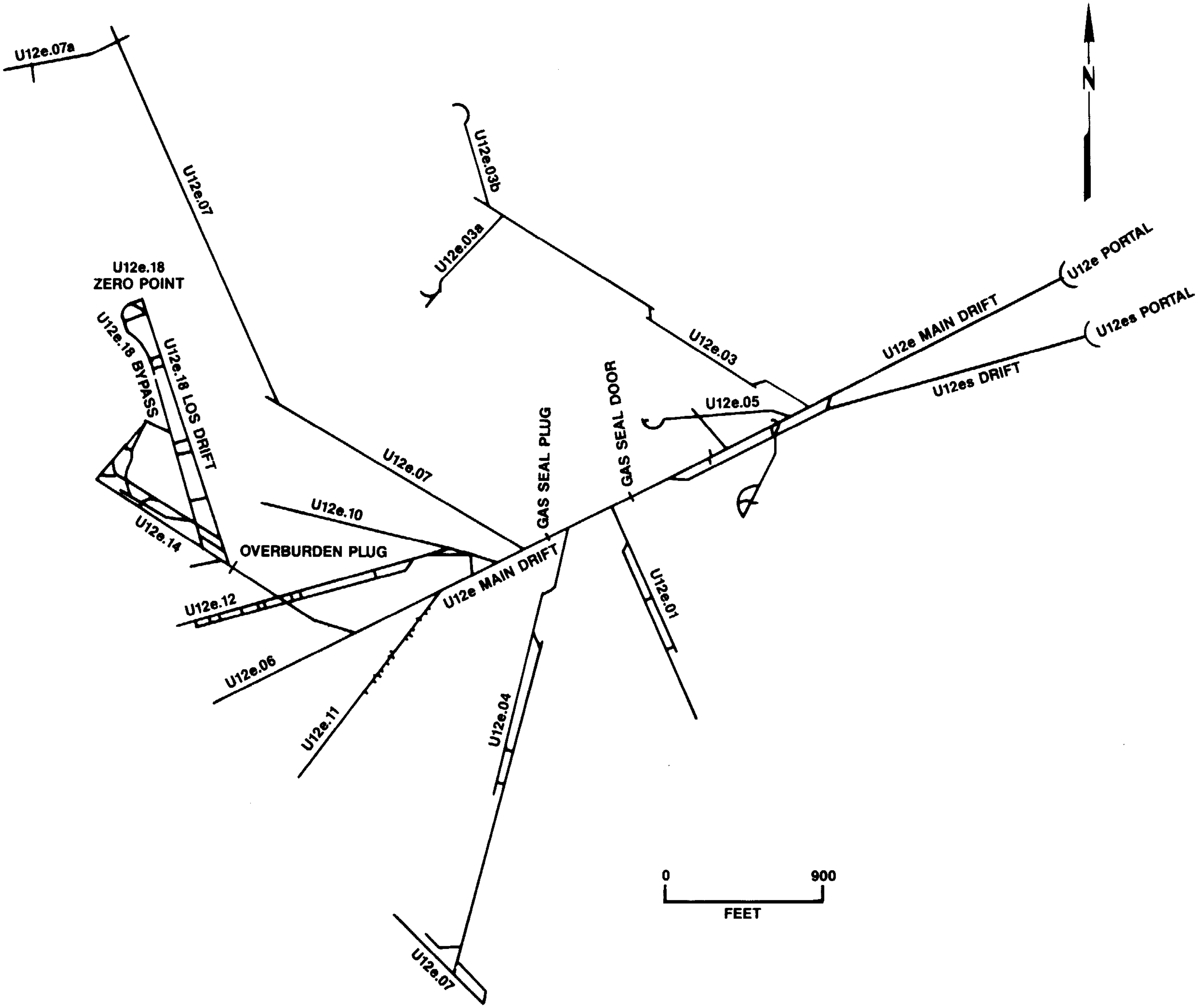

Figure 8.1 DINING CAR Event - Tunnel Layout

Project agencies were responsible for designing, preparing, and installing experiments, or delivering them to the installation contractor. After the event, these agencies were responsible for removing samples, analyzing instrument and sample data, and preparing project reports on experiment results.

Device safety and security procedures in the zero point area and the timing and firing control room were in accordance with ERDA Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Because LLL fielded the device, the LLL Test Group Director was responsible for radiological safety within a 6,000-foot radius of the zero point from device emplacement until detonation. After detonation, the Test Controller relieved the LLL Test Group Director of responsibility. When the Test Controller had determined that venting had not occurred, he delegated responsibility to the DOD Test Group Director.

8.2.2 Planning and Preparations

A. Tunnel Facilities Construction

The U12e.18 complex consisted of the main LOS pipe drift, a bypass drift, several crosscuts connecting the main LOS and bypass drifts, a side pipe drift, and an access drift. Mining also was required to make use of the old DIDO QUEEN cable facility. A new drift, U12e.19, was mined to house the ROSES units. Experiment protection features included two DACs and a TAPS. Containment features included an overburden plug (OBP) and a gas seal plug.

Construction activities began in October 1973 with removal of the old DIDO QUEEN OBP and tunnel cleanup in preparation for mining the U12e.18 complex. LOS drift mining was completed when the zero point was reached on 5 April 1974, at which time mining of the side pipe drift began. The bypass and side pipe drifts were completed in June 1974. Mining of the ROSES drift began on 3 July and was completed on 23 August 1974. Installation of the LOS pipe began in late July 1974 and was completed at the end of November 1974. Experiments were installed between 4 December 1974 and the middle of February 1975.

Signal dry runs (SDRs) began on 20 January. The first two mandatory signal dry runs (MSDs) were conducted on 4 and 6 February. Generally, two MSDs were held each week thereafter. A successful full-power, full-frequency (FPFF) dry run was held on 20 March and a final dry run (FDR) was held on 2 April.

B. Radiological Safety Support

Procedures for radiation exposure and contamination control during this event were in accordance with ERDA Manual Chapter 0524 and requirements of responsible DOD representatives. Radsafe provided monitoring and equipment support.

Prior to the test, detailed radiological safety reentry plans were prepared and issued to participating agencies. Air sampling equipment was positioned in the test area. Radsafe monitors were briefed regarding surface reentry, manned stations, and security station requirements.

Radsafe monitoring teams and supervisory personnel were provided to perform initial radiation surveys, conduct aerial surveys by helicopter, and participate in reentry parties as needed. Radsafe personnel also were standing by at Gate 300 prior to detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment and material, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Available anticontamination materials and equipment included head covers, coveralls, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, plastic bags, gloves, and masking tape.

C. Telemetry and Air Sampling Support

In addition to permanent RAMS units, 37 temporary units provided surface and underground coverage for DINING CAR as shown in Table 8.1 and Figures 8.2 and 8.3. An air sampling unit was placed near each portal (U12e and U12es). All RAMS units and air sampling units were installed a minimum of five days prior to scheduled device detonation.

Forty-six air sampling stations and 30 gamma rate recorder stations were operated by EPA in the offsite area. Twenty-seven EPA personnel were fielded for surveillance activities.

D. Security Coverage

Device security procedures in the zero point area and the timing and firing control room were in accordance with ERDA Manual Chapter 0560, "Program to Prevent Accidental or Unauthorized Nuclear Explosive Detonations." Beginning on D-1, all personnel entering or exiting the

TABLE 8.1

DINING CAR EVENT RAMS UNIT LOCATIONS
5 April 1975

Station	Location
	SURFACE
	<u>From the U12es portal</u>:
1	On filter system
2	On vent line
3	On vent line
4	897 feet at N 13° E
5	572 feet at N 62° E
6	476 feet at S 71° E
7	382 feet at S 22° E
8	415 feet at S 34° W
9	492 feet at N 44° W
10	870 feet at N 22° W
11	Tunnel drain line
12	1885 feet at N 89° E
	<u>From cable downhole</u>:
13	At cable downhole
14	209 feet at N 4° E
15	275 feet at S 88° E
16	190 feet at S 9° E
17	235 feet at S 88° W
	<u>From SGZ unless otherwise indicated</u>:
18	501 feet at N 26° E from SGZ
19	474 feet at S 14° E from SGZ
20	414 feet at S 59° W from SGZ
HFR	At U12e.14 HFR cable downhole

TABLE 8.1 (concluded)

Station	Location
	UNDERGROUND
	From the U12e.14 drift:
21	875 feet into the U12e.18 LOS drift
22	515 feet into the U12e.18 LOS drift
23	215 feet into the U12e.18 LOS drift
24	900 feet into the U12n.18 bypass drift
25	600 feet into the U12n.18 bypass drift
	From the U12.06 drift unless otherwise indicated:
26	1,050 feet into the U12e.14 LOS drift
*27ER	1,050 feet into the U12e.14 LOS drift
28	450 feet into the U12e.14 LOS drift
29	500 feet into the U12e.12 reentry drift from the U12e.14 drift
30	700 feet into the U12e.06 drift from the U12e main drift
	From the U12e portal unless otherwise indicated:
31	3,800 feet into the U12e main drift
*32ER	3,800 feet into the U12e main drift
33	3,565 feet into the U12e main drift
34	2,500 feet into the U12e main drift
35	50 feet into the U12e drift
36	95 feet into the U12es drift from the U12es portal

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* ER - Extended Range (instrument capable of reading 100 mR/h to 100,000 R/h)

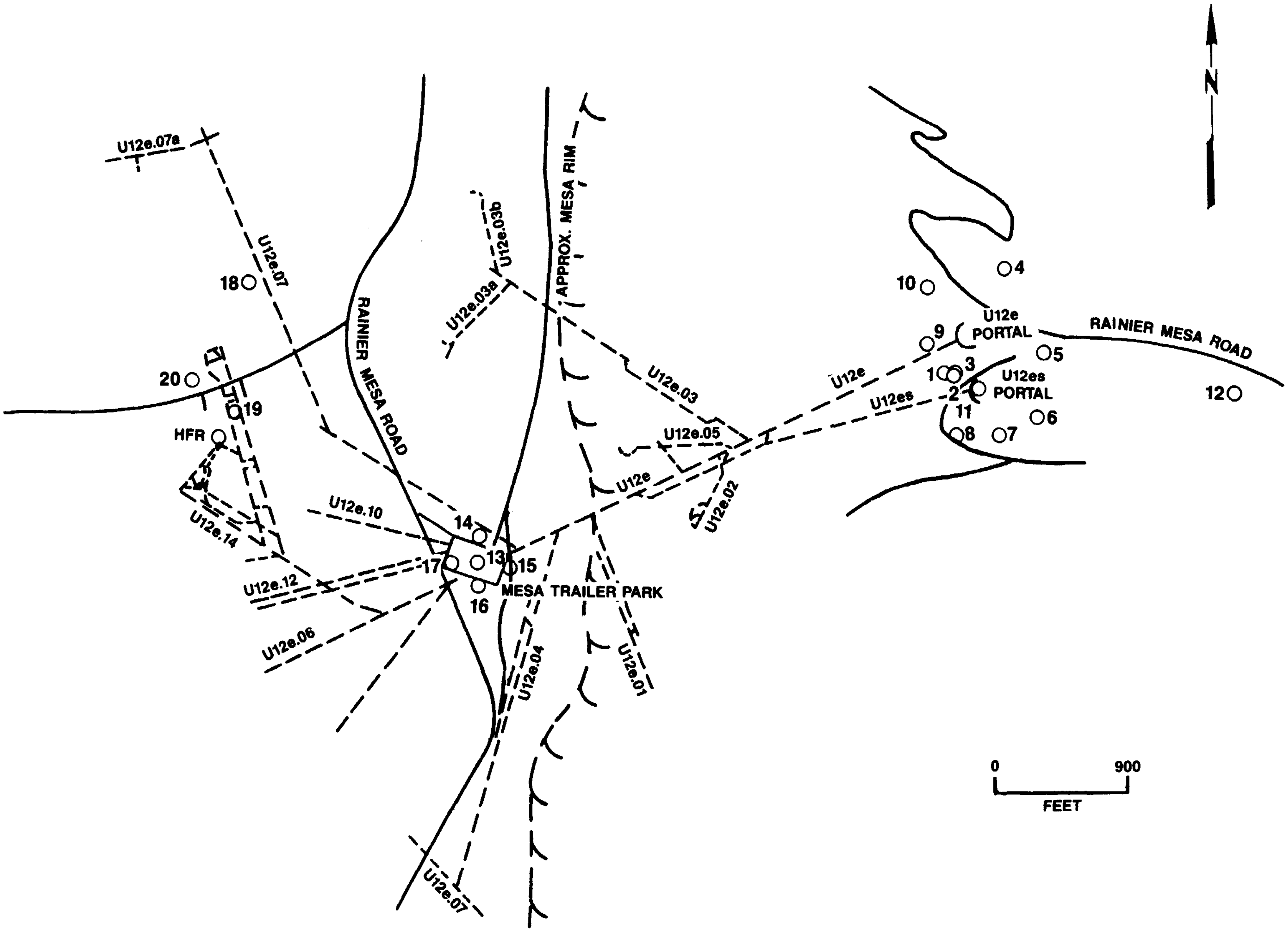


Figure 8.2 DINING CAR Event - Surface RAMS

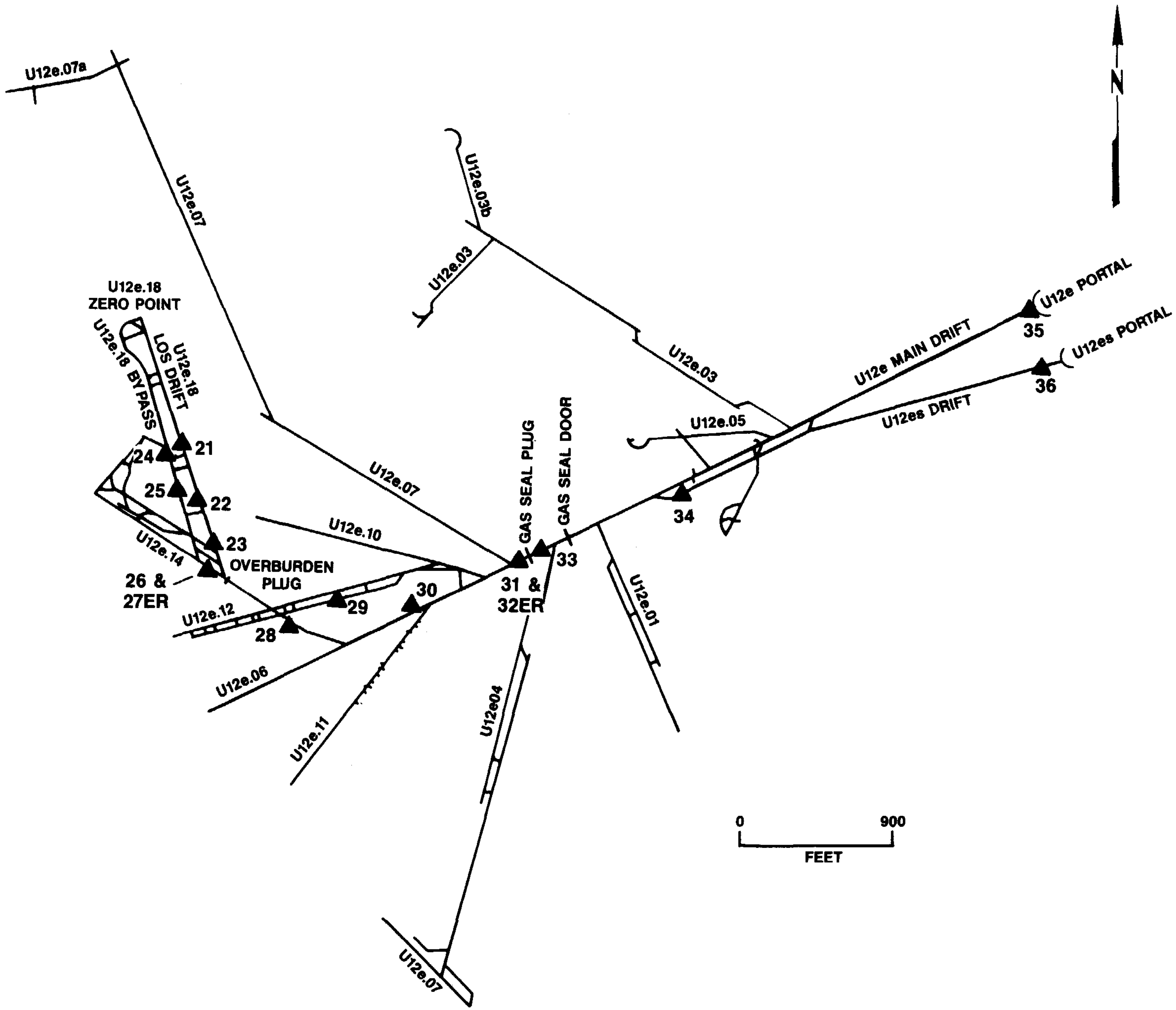


Figure 8.3 DINING CAR Event - Underground RAMS

controlled area were required to stop at muster or control stations for issue of stay-in badges, or issue and return of muster badges. After area control was established, all through traffic was diverted around the controlled area by use of screening stations.

In accordance with the "Test Controller's Operations and Security Plans," contractors and agencies were to have all personnel not connected with this event out of the closed area before the final security sweep began.

E. Air Support

One UH-1F and two UH-1N helicopters with USAF pilots and crew members provided support for aerial closed circuit television coverage, any cloud surveillance (if venting should occur), and security sweeps. One of the three was on standby for the Test Controller's use, if needed. EPA had a Turbo Beech aircraft available for cloud tracking and sampling of any effluent, and a USAF C-118 aircraft also was on standby at Nellis Air Force Base if needed for cloud tracking.

8.2.3 Late Preevent Activities

A readiness briefing was held at 1430 hours on 2 April in anticipation of planned test execution on 3 April. Because conditions for the test were unfavorable at that time, another readiness briefing was scheduled for 0800 hours on 3 April. At the 0800 briefing on 3 April, test execution was set for 1230 hours; however, problems during dry runs caused a further delay until 4 April. On 4 April at 0630 hours, a readiness briefing was held and test execution was again postponed because additional technical problems were encountered. Two more readiness briefings were held on 4 April, one at 1400 hours and one at 1700 hours. The FDR was scheduled for 2100 hours, with a new proposed test execution time of 1100 hours on 5 April.

Experimenter organizations represented during button up were SLA, EG&G, LLL, LASL, DNA, and PI.

8.3 EVENT-DAY ACTIVITIES

At 0130 hours on 5 April, experimenter personnel were evacuated from the tunnel, and the button-up crew arrived at the OBP. By 0200 hours, experimenters had departed the Mesa trailer parks, and the arming party had departed CP-1 enroute to the U12e.18 zero point area. The arming party requested permission to arm the device at 0430 hours, performed their functions, and exited the area by 1000 hours. A readiness briefing had been held at 0800 hours, at which time weather conditions were found favorable, and no further technical problems had been encountered. Because final button up and arming had proceeded more slowly than planned, the final countdown was not initiated until 1230 hours.

The DINING CAR device was detonated at 1245 hours PDT on 5 April 1975.

8.3.1 Test Area Monitoring

Stemming was successful and the pressures and temperatures inside the tunnel complex remained normal. Telemetry measurements began at 1246 hours on 5 April. The RAMS units located along the LOS pipe responded to neutron activation of the LOS pipe and experiments. Normal radioactive decay of this activation was observed. No indications of radioactive effluent were detected by any tunnel, surface, or airborne radiation monitoring units. All RAMS units were secured at 1245 hours on 14 April 1976.

An aerial survey of the roads to Rainier Mesa indicated that reentry to the Mesa trailer parks could be performed along the East Rainier Mesa Road without delays for removal of rocks.

8.3.2 Initial Radiation Surveys and Recovery Activities

Reentry to make radiation surveys and recover data from the Mesa trailer parks and the portal area began at 1325 hours. The portal survey was completed at 1415 hours, and the Mesa survey was completed at 1430 hours. No readings above background were measured. Data recovery was conducted between 1430 and 1845 hours. Gas samples were obtained remotely from the zero point side of the OBP at 1447 hours. These samples indicated normal air composition. D-day reentry operations were terminated at 1845 hours.

8.4 POSTEVENT ACTIVITIES

8.4.1 Tunnel Reentry Activities

At 0826 hours on 6 April (D+1), a work party entered the tunnel complex portal (Figure 8.4). Personnel were not required to wear anticontamination clothing or respiratory protection equipment. They moved to the gas seal door at 0838 hours and established communications with personnel at the portal. No toxic gases, explosive mixture, or radiation problems were encountered. The gas seal access door was opened and members of the party proceeded through it to the gas seal plug. Readings of 5 ppm carbon monoxide and 500 ppm carbon dioxide were measured, but no explosive mixture was detected. Some work party personnel then returned to the portal side of the gas seal door to open the large door and begin reestablishing train tracks. No radiation reading above background (0.05 mrad/h) was detected. The work party completed its assignment and exited the tunnel at 1015 hours.

Reentry and rescue teams again entered the tunnel complex at 1030 hours and proceeded toward the OBP. Team members wore complete anticontamination clothing with Draeger self-contained

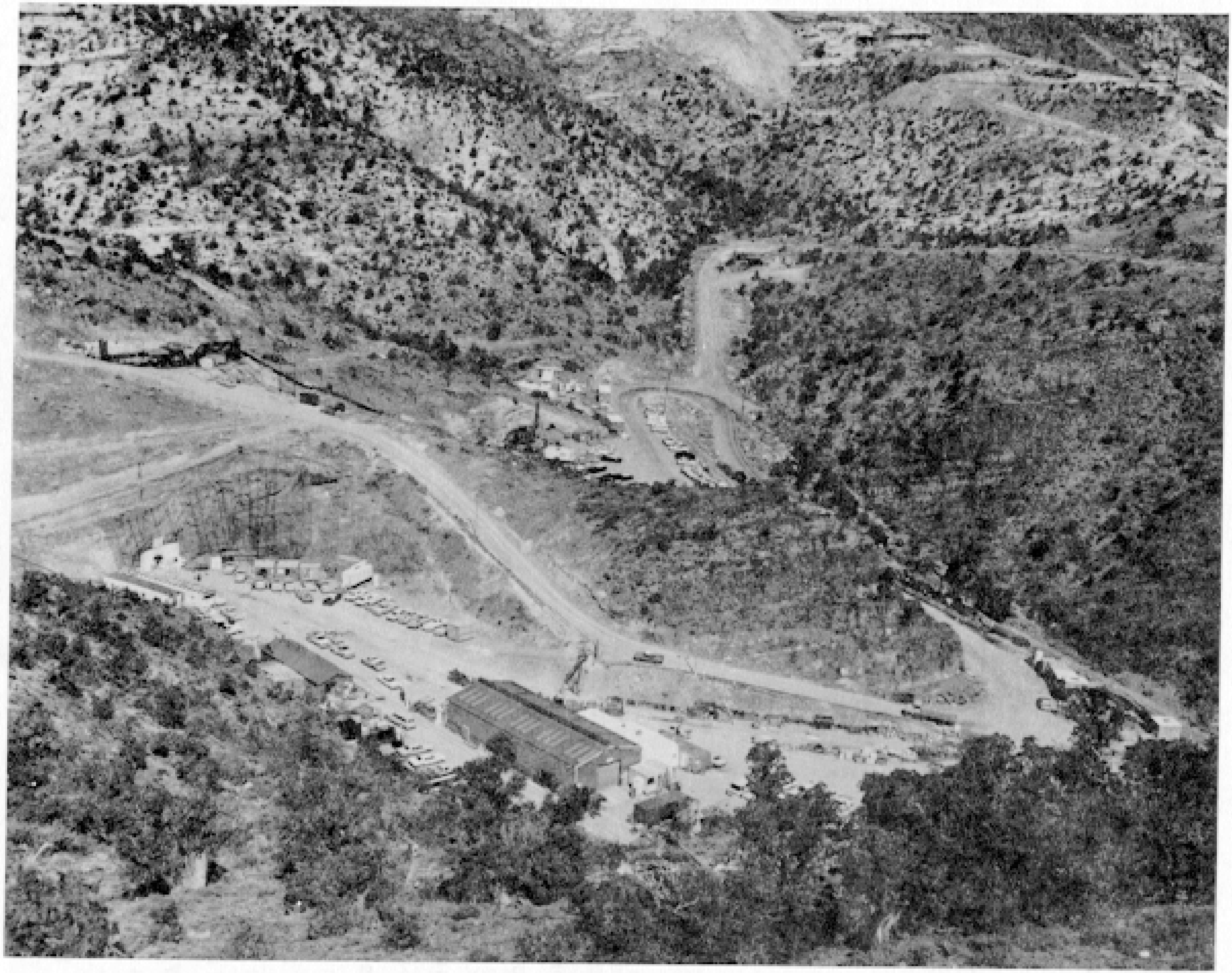
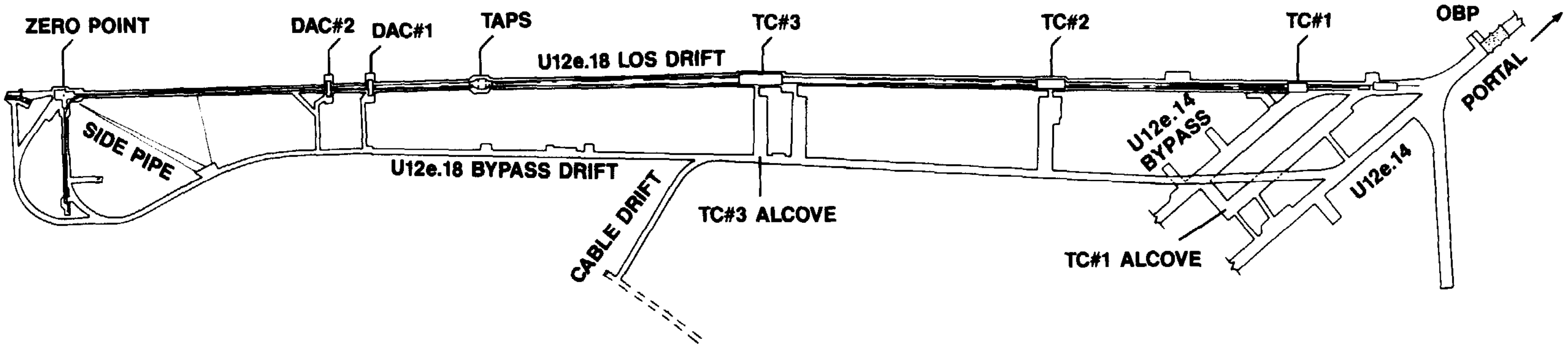


Figure 8.4 DINING CAR Event - E Tunnel Portal

breathing apparatus. At 1105 hours, they reached the 11 drift/06 drift junction where they found minor rock spall on the tracks. The tunnel appeared to be otherwise in good condition. Similar conditions existed at the 14 drift/06 drift junction, in the U12e.06 drift, and in the U12e.12 reentry drift. Team members arrived at the OBP at 1114 hours and observed that the portal side of the plug was in good condition. No explosive mixture or toxic gases were detected and 0.03 mrad/h was measured. Team members opened and secured the OBP manway door. The ROSES units were checked at 1205 hours and found to be in good condition. Some rock spall was evident in this area. The Dance Hall area was in good condition with only minor damage suffered. A reading of 10 ppm carbon monoxide was measured at the Dance Hall. Next, the SLA No. 1 alcove was checked and also found in good condition. At 1213 hours, test chamber No. 1 was reached (see Figure 8.5). A reading of 150 mR/h was obtained at the door before it was opened. The door was opened, and 400 mR/h and 50 ppm carbon monoxide were measured inside the door. Debris was found in the bottom of the test chamber, but no alpha radiation was detected. Team members then traveled to test chamber No. 2 crosscut where a radiation reading of 0.1 mR/h was obtained. They began moving sandbags in an effort to reach the test chamber No. 2 door. A reading of 400 mR/h was detected at the closed door to test chamber No. 2 at 1305 hours. At this time, ground motion was felt by rescue team members located at the OBP. All personnel were advised to exit the tunnel and had done so by 1348 hours. The ground motion later was attributed to cavity collapse.

Rescue and reentry teams departed the portal at 0756 hours on 7 April (D+2) and traveled to the OBP where they donned Draeger self-contained breathing appratus before progressing further. At 0836 hours, team members proceeded through the OBP and traveled to test chamber No. 3 via the bypass drift, reaching crosscut No. 3 at 0845 hours. A radiation level of 0.05 mR/h was



NOT TO SCALE

KEY

DAC = DNA AUXILIARY CLOSURE
TAPS = TUNNEL AND PIPE SEAL
TC = TEST CHAMBER
OBP = OVERBURDEN PLUG

Figure 8.5 DINING CAR Event - Tunnel and Pipe Layout measured. The ROSES unit at this location appeared to be in good condition. It was not possible to reach the door to test chamber No. 3 safely at that time because the ground was in very poor condition. At about 100 feet to the zero point side of crosscut No. 3 the drift was found to be completely closed off.

Team members returned to crosscut No. 2 and opened the door to test chamber No. 2. An exposure rate of 150 mR/h was measured with a trace of carbon monoxide, but no explosive mixture or alpha contamination was detected. The general condition of the experiments was good. Team members next traveled to the ROSES drift through the bypass drift. Only three team members traveled all the way to the end of the ROSES drift. After checking the ROSES units, team members exited the tunnel at 1111 hours.

The first group of personnel to recover ROSES data entered the tunnel at 1255 hours. This group consisted of about 30 people including representatives from Radsafe, industrial hygiene, miners, and communications support. After performing their assigned tasks, they exited the tunnel at 1420 hours. They were immediately followed by a second group of data recovery personnel who entered at 1423 hours and exited at 1630 hours. No respiratory protection equipment was required for personnel on either of these reentries.

On 8 April (D+3), the scientific assessment team entered the LOS drift to assess the condition of experiments in test chamber No. 1 and recover KSC experiments at that location. Complete anticontamination clothing (with openings taped) and full-face masks were required. The scientific assessment team exited the tunnel at 1315 hours, after which ventilation of the LOS pipe was authorized. The average exposure rate at test chamber No. 1 was 30 mR/h, with a maximum reading of 100 mR/h. Three personnel performed a damage and hazard survey of the LOS pipe from test chamber No. 1 to test chamber No. 2. The general condition of the experiments was good. During this same time, a work crew continued to remove sandbags from crosscut No. 2.

Mining through the gas seal plug was completed and train tracks were established on 9 April (D+4). Scientific assessment continued at test chamber Nos. 2 and 3. Anticontamination clothing requirements included double sets of coveralls and shoe covers, one pair of gloves, a hood, and a full-face respirator with dust canister. Team members traveled through the LOS pipe to test chamber No. 3 and then to the TAPS. Workers continued to remove sandbags from crosscut No. 2. No anticontamination clothing requirements were in effect at crosscut No. 2. During swing shift, mining work began at the OBP.

On 10 April (D+5), a LASL reentry party entered test chamber No. 2 and went through the LOS pipe to test chamber No. 3 where they worked for about two hours. All personnel wore complete anticontamination clothing (including double sets of coveralls and shoe covers) and full-face masks with dust filters. The radiation level in this area was 18 mrad/h. At 1510 hours, two persons reentered the LOS pipe to continue cleaning up at test chamber No. 2. They wore coveralls, shoe covers, and gloves, but because results from previous swipes were negative, no masks were required. At 1600 hours, KSC personnel recovered some experiments from test chamber No. 2. The same Radsafe requirements applied as for the previous crew. When a decision was made to inspect test chamber No. 3, those personnel performing the inspection donned face masks in addition to other anticontamination clothing they were wearing. The group exited the area at 1830 hours.

Work continued on 11 April (D+6) to remove sandbags from crosscut Nos. 2 and 3. The Radsafe station was moved to crosscut No. 1. No work was conducted in the LOS pipe.

On 12 April (D+7), miners continued to prepare the tunnel for experiment recovery. Work also continued in crosscut Nos. 2 and 3.

Ventilation was established in test chamber No. 3 on 14 April (D+9). Fresh air was then available in the LOS pipe on the zero point side of test chamber No. 3. No face mask requirement was in effect anywhere in the LOS pipe at that time.

Sandia and LASL parties dressed for work in the LOS pipe. A LASL party entered test chamber No. 3 to assess the condition of the experiments. Exposure rates measured were: 1 mR/h on the portal side of the test chamber; 4 mR/h at the center of the LOS pipe at the test chamber door; and 4 mR/h on the zero point side of the test chamber.

On 15 April (D+10), the LOS pipe was opened to experimenters for recovery. Only four persons were allowed in each test chamber at any one time. No anticontamination clothing was required inside the LOS pipe. Recovery of instrumentation from alcoves was performed simultaneously with LOS pipe recoveries. All test chambers were secured by 1800 hours with experiment recovery activities between 75 and 90 percent complete.

Experiment recovery from the LOS pipe continued on 16 April (D+11), again with no anticontamination clothing requirements. All three test chambers were locked at 1500 hours; however, personnel stood by for LASL experimenters to arrive to complete their recoveries. LASL personnel arrived at 1645 and had completed their recoveries by 1745 hours.

Experiment recovery continued on 17 April (D+12) with no anticontamination clothing requirements. At 1135 hours, two persons entered test chamber No. 3 to go to the TAPS and remotely sample gases behind the TAPS door. Both wore Draeger self-contained breathing apparatus with full-face masks. Sampling was completed at 1210 hours. Results indicated two percent carbon monoxide, five percent oxygen, and greater than 100 percent of the LEL.

On 18 April (D+13), two persons wearing Draeger self-contained breathing apparatus entered the LOS pipe to remove sampling valves from the TAPS door and to connect a compressed air line to the door. Readings taken at this time indicated 20 percent oxygen, 10 percent of the LEL, and 90 ppm carbon monoxide. A check at the OBP showed vent line concentrations of one percent of the LEL, and five ppm carbon monoxide.

Routine operations continued until 1440 hours on 28 April when the TAPS door was opened slightly and water flowed from behind the door. A reading taken at contact with this water indicated background levels of radiation. No explosive mixture or toxic gases were detected behind the door.

At 1345 hours on 29 April, the TAPS area was surveyed. No toxic gases or explosive mixtures were detected, and the contact reading at the bottom of the LOS pipe was 0.4 mrad/h. DNA, Lockheed, and Radsafe personnel, wearing anticontamination coveralls, shoe covers, and gloves, entered the zero point side of the TAPS at 1420 hours. They returned to the portal side at 1445 hours. The average radiation level was 0.5 mrad/h. Readings of 10 ppm carbon monoxide and 20 percent oxygen were measured, and no explosive mixture was detected. Minor experiment recoveries continued between 30 April and 6 May. On 7 May, a damage and hazard survey of the LOS pipe from the TAPS to DAC No. 1 was conducted. No anticontamination clothing was required inside the LOS pipe. Routine clean-up work continued in the LOS pipe until 18 July when entry was made into U12e.14 to look at tunnel damage. Levels of 1,500 ppm carbon dioxide and 20 percent oxygen were measured. The U12e.14 reentry drift had collapsed and was impassable beyond the DAC area.

During May, June, and July, efforts were concentrated on removal of the LOS pipe and rehabilitation of the U12e.18 bypass drift to reach the end of the stemming.

8.4.2 Postevent Mining

On 28 August, reentry mining in the U12e.18 bypass drift began. The reentry drift was to follow the bypass drift to DAC No. 2 crosscut, then cut over to the main drift and continue toward the zero point. No anticontamination clothing requirements were imposed during this time. During September and October, routine reentry mining operations continued, with reentry to the DAC No. 1 crosscut accomplished on 30 October 1975. The DAC No. 2 crosscut was reentered on 5 November. Readings were 30 ppm carbon monoxide, 4 ppm nitrous oxide plus nitrogen dioxide, and 0.05 mrad/h. No explosive mixture was detected. Experiment removal from the two crosscuts was conducted on 11 and 12 November. Final reentry mining and experiment recovery were conducted during January 1976, and all event-related operations were completed on 16 January.

8.4.3 Industrial Safety

Measurements to determine radiation levels and check for the presence of toxic gases and explosive mixture were made each shift. These measurements were then recorded in the monitors' logbook.

Appropriate safety measures were taken to protect mining personnel and prevent unsafe conditions. Industrial safety codes including specific codes for mining, tunneling, and drilling, were established by REECo and emphasized during all operations. A written standard operating procedure was required for each operation involving explosives, toxic materials, radioactive material, or any other operation with the potential for personal injury. Each individual involved in such an operation was required to know the contents of the applicable procedures.

The portal construction area and the tunnel were mandatory hard hat and foot protection areas (safety shoes, safety boots, miners boots, or toe guards). Each participating agency provided its own safety equipment. All personnel on the initial tunnel reentry teams were certified in the use of the McCaa two-hour breathing apparatus and had used the Draeger self-contained breathing apparatus. Standard safety rules and regulations, as spelled out in the "U.S. Bureau of Mines Manual," were observed.

All explosives, electro-explosive components, solid propellants, toxic material, and radioactive material were handled, stored, and transported in accordance with applicable sections of the following documents:

A. Army Materiel Command Regulations (AMCR 385-224).
B. ERDA Manual 500 Series for the Nevada Test Site.
C. Individual Safe Operating Procedures (by experimenter organization).
D. DINING CAR Safety Regulations.

All personnel engaged in handling, storing, assembling, or installing explosives, propellants, or electro-explosive devices (or observers of those operations) were required to wear safety glasses or other eye protection which had been approved by the DOD Safety Coordinator.

8.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 1246 hours on 5 April 1975 and all telemetry stations were secured at 1245 hours on 14 April 1975. No radiation other than that from normal activation products was detected.

The initial radiation survey began at 1325 hours on 5 April and was completed at 1430 hours. No radiation above background was detected at the Mesa trailer park area or at the tunnel complex portal.

Reentry into the tunnel began at 0826 hours on 6 April 1975. The maximum reading of 400 mR/h was inside test chamber No. 1 and at the test chamber No. 2 door. No airborne radioactive contamination was detected by air sampling equipment, and respiratory protection equipment was required inside the LOS pipe during initial reentry only. Most experiment recoveries were completed between 10 and 29 April 1975.

On 28 August 1975, reentry mining began in the U12e.18 by-pass drift. This effort was completed on 16 January 1976.

No drilling from the Mesa for core sampling was performed for this event.

Personnel exposures received during individual entries to DINING CAR radex areas from 5 April to 29 April 1975, when the use of Area Access Registers was discontinued, are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	No. of Entries Logged	Maximum Exposure (mR)	Average Exposure (mR)
All Participants	464	205	8
DOD Participants	95	205	15

REFERENCE LIST

References are not indicated within the text of this report, but are included in this list by chapter or part. Most references are available for review at or through the DOE/NV Coordination and Information Center (CIC). Security-classified references are located at the DNA/HQ Technical Library in Alexandria, Virginia, but are available only to persons with appropriate security clearances and a need for classified information contained in the references.

The CIC is operated by REECo, the custodian of nuclear testing personnel dosimetry and other radiological safety records for DOE/NV, and the custodian for DNA of reference documents for reports on DOD participation in atmospheric, oceanic, and underground nuclear weapons testing events and series. Arrangements may be made to review available references for this report at the CIC by contacting one of the following:

Health Physics Division
U.S. Department of Energy
Nevada Operations Office
2753 South Highland Avenue
Post Office Box 14100
Las Vegas, NV 89114

Commercial: (702) 295-0961
FTS: 575-0961

or

Manager, Coordination and Information Center
Reynolds Electrical & Engineering Co., Inc.
Post Office Box 14400
Las Vegas, NV 89114

Commercial: (702) 295-0731
FTS: 575-0731

Major source documents also are available through the National Technical Information Service (NTIS) and may be purchased from NTIS at the address and telephone number listed below:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Commercial: (703) 487-4650
(Sales Office)

References available through public bookstores and libraries, through the U.S. Government Printing Office, and only at the CIC are listed without asterisks. Asterisks after references or groups of references indicate availability as follows:

*	Available through the NTIS and also located at the CIC.
**	Located in the REECo Technical Information Office adjacent to the CIC, available through the CIC, and may be subject to Privacy Act restrictions.
***	Located in the DNA/HQ Technical Library, and subject to security clearance requirements.

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12. Atomic Energy Commission, Nevada Operations Office, NVOO Completion Report, Operation Toggle, 1 July 1972 through 30 June 1973, NVO-141, February 1974***

13. Atomic Energy Commission, Nevada Operations Office, NVOO Completion Report, Operation Arbor, 1 July 1973 through 30 June 1974, NVO-150, February 1975***

14. Energy Research and Development Administration, Nevada Operations Office, NVOO Completion Report, Operation Bedrock, 1 July 1974 through 30 June 1975, NVO-162, January 1976***

15. REECo Environmental Sciences Department field record archives are maintained chronologically and by test event and include the following:

    a. Procedures, Reentry Plans, Radsafe Plans, and Schedules of Events **

    b. Correspondence **

c. Reports, including onsite Radsafe and offsite USEPA event reports **

d. Exposure reports, Radsafe logbooks, Area Access Registers, radiation survey forms, telemetry forms, and other sampling and dosimetry forms **

APPENDIX A

GLOSSARY OF TERMS

Activity	The rate of decay of radioactive material, usually expressed in disintigrations per minute (dpm)
Access Drift	This is passageway tunnel, usually parallel to the LOS drift, also known as the bypass, cable, reentry, or work drift, in which cables from various experiments in the LOS pipe were laid on their way to being connected to the downhole cables in the cable alcove and which was used for access to the main experiment (LOS) drift during construction and recovery phases of a test.
Activation Products	These are nuclides made radioactive by neutrons from a nuclear detonation interacting with usually nonradioactive nuclides. Also called "induced activity."
Advisory Panel	This was a group of experts formed to advise the Test Manager (and later the Test Controller) concerning operational factors affecting a test detonation.
AFSWC	The Air Force Special Weapons Center, located at Kirtland Air Force Base, Albuquerque, New Mexico, provided air support to the AEC Test Manager for NTS testing activities.

AFSWP	The Armed Forces Special Weapons Project was activated on 1 January 1947, when the AEC was activated, to assume residual functions of the U.S. Army Manhattan Engineer District (see DASA and DNA).
Air Support	This included aircraft, facilities, and personnel required for various support functions during testing, including cloud sampling, cloud tracking, radiation monitoring, photography, and transport of personnel and equipment.
All-Purpose Canisters	These are combination canisters made up of a charcoal bed and a HEPA filter.
Alpha Particle	This is a particle emitted spontaneously from the nucleus of a radionuclide, primarily a heavy radionuclide. The particle is identical to the nucleus of a helium atom, having an atomic mass of four units and an electric charge of two positive units.
Anticontamination Clothing	This is outer clothing worn to prevent contamination of personal clothing, contamination of one's body, and the spread of contamination to uncontrolled areas.

Atmospheric Test Series	This included several series of U.S. tests conducted from 1945 through 1962, when nuclear device detonations and experiments were conducted primarily in the atmosphere.
Attenuation	This is the process by which photons or particles from radionuclides are reduced in number and energy while passing through some medium.
Back	The top (ceiling) of a tunnel.
Background Radiation	There are three meanings for this term, the applicable meaning is determined by the context. The definitions are: 1) The radiations of man's natural environment, consisting of cosmic rays and those radiations which come from the naturally radioactive atoms of the earth, including those within one's body. 2) A level of radiation (above natural background radiation) that existed in a test area or location prior to a test. 3) Radiation levels extraneous to an experiment (the area exposure rate).

Ball Valve	This is a rotating spool valve designed to close off and provide a gas seal in an LOS pipe in less than one second after detonation. Can be pneumatic, hydraulic, or spring driven.
Beta Particle	This is a negatively charged particle of very small mass emitted from the nucleus of a radionuclide, particularly from fission product radionuclides formed during nuclear detonations. Except for origin, the beta particle is identical to a high speed electron. This may also be a positively charged particle of equal mass called a positron.
Bypass Drift	See Access Drift.
BJY	This is the intersection of Mercury Highway with roads originally constructed for the BUSTER-JANGLE 1951 atmospheric test series, located at the NW corner of Area 3 on the NTS. It was previously called the "Y."
Brattice Cloth	This is a plastic, cheese-cloth reinforced sheeting used to control the spread of contamination.
Bulkhead	This is a wall or embankment constructed in a mine or tunnel to protect against earth slides, fire, water, or gas.

Button-Up Activities	These are procedures which consist primarily of completing the stemming; accomplishing the electrical checklist of tunnel portal and trailer park facilities; closing the OBP, gas seal plug, and gas seal door inside the tunnel; clearing the controlled area; and preparing command post and monitoring stations for the actual nuclear detonation.
Cable Drift	See Access Drift.
Cal-Seal	This is a high-density, quick-drying, high-strength, and resilient commercial sealant.
Cassette	This is a holder or container for a sample, an experiment, or a group of experiments.
Cellar	This is the excavated, large-diameter part of a drilled hole over which the drill rig is placed and where valving and other equipment are located.
Chamber	This is a natural or man-made enclosed space or cavity.
Check Points or Check Stations	These are geographic locations established and staffed to control entry into and exit from restricted areas.

GLOSSARY OF TERMS (continued)

Chimney	This refers to the volume of broken rock above an underground cavity formed by a nuclear detonation that falls downward when decreasing cavity gas pressure can no longer support the rocks' weight.
Chromatograph	This a a piece of equipment used to separate and analyze mixtures of chemical substances by chromatographic absorption.
Cloud Sampling	This is the process of collecting particulate and gaseous samples from an effluent cloud to determine the amount of total airborne radioactivity and specific radionuclides in the cloud for subsequent analysis of detonation characteristics. This type of sampling usually was accomplished by specially equipped aircraft.
Cloud Tracking	This is the process of monitoring and determining the drift and movement of an effluent cloud, usually performed by radiation monitoring and visual sighting from aircraft.
Collar	See "Shaft Collar"
Console	This is a cabinet or panel containing instrumentation for monitoring or controlling electronic or mechanical testing devices.

Construction Station	This is the distance in feet along the tunnel from the portal or a particular junction, usually expresed in hundreds of feet plus remaining whole feet. Construction station 350 is expressed as CS 3+50.
Containment	This is the act of preventing release of any radioactive effluent into the atmosphere or parts of a tunnel complex beyond the stemming and other containment features. It is used in reference to the stemming, TAPS, OBP, or the gas seal plug. An event is said to have been "contained" if no effluent is released to the atmosphere or if no radioactive material is released beyond the stemmed portion of the tunnel.
Containment Assessment Drift	This is another name for access or reentry drift.
Contamination	This is defined in two ways as follows: 1) The term may refer to the presence of fixed or removable of radioactive material in a location. This is usually caused by the spread of fission and activation products of a nuclear detonation or fissionable material from a device incorporated with particles of dust or device debris.

	2) The term may also refer to the depositing on, or spreading of, radioactive materials to undesirable locations, personnel, structures, equipment, or other surfaces outside a controlled area.
Crater	This is the depression formed on the earth's surface by a near-surface, surface, or underground detonation. Crater formation can occur by the scouring effect of airblast, throw-out of broken surface material, or surface subsidence resulting from underground cavity formation and subsequent rock fall, or chimneying, to the surface.
Crater Experiment	This is a test designed to breach and excavate the ground surface, thereby forming an ejecta crater (as opposed to a sink or subsidence crater).
DAC	The DNA Auxilliary Closure is a closing system found in the LOS pipe which closes milliseconds after device detonation.
Dance Hall	This is a large alcove used for data recording equipment.
DASA	AFSWP became the Defense Atomic Support Agency (DASA) in 1959. See AFSWP and DNA.

GLOSSARY OF TERMS (continued)

D-day	This is the term used to designate the day on which a test takes place.
D+1	This is the first day after a test event. D+2 is the second day after detonation, D+3 is the third day, etc.
Decontamination	This is the reduction or removal of contaminating radioactive material from a structure, area, object, or person. Decontamination may be accomplished by (1) treating the surface to remove or decrease the contamination, (2) letting the material stand so that the radioactivity is decreased as a result of natural decay, or (3) fixing and covering the contamination to attenuate the radiation emitted.
Device	This is comprised of nuclear fission (or fission and fusion) materials together with arming, fusing, firing, high-explosive, canister, and diagnostic measurement equipment that have not been configured into an operational weapon.
DNA	This is an acronym for the Defense Nuclear Agency, successor to DASA in 1971.
DOD	This is an acronym for the U.S. Department of Defense, the federal executive agency responsible for the defense of the United States. Included

	in this group are the military services and special joint defense agencies.
Dose	This is the quantity (measured or accumulated) of ionizing radiation energy absorbed into the medium it passes through. In a person, dose is measured in rems or rads.
Dose Rate	This is the amount of ionizing radiation energy that an individual or material could absorb per unit of time. Dose rates are usually expressed as rad or rem per hour. Subdivisions of a rad or rem also are used, e.g., mrem/h means millirem per hour. (A millirem equals one thousandth of a rem).
Dosimeter	This is a device used to measure radiation doses. Devices worn or carried by individuals are called personnel dosimeters.
dpm	This stands for disintegrations per minute to which are a measure of the activity of material.
Draeger Breathing Apparatus	See Scott-Draeger.
Draeger Multi-Gas Detector	This is an instrument used to detect toxic gases. A sample of the ambient atmosphere is drawn through a selected chemical reagent tube which indicates the concentration of a particular toxic gas.

Dressed Out	This means one is dressed in anti-contamination clothing and associated equipment.
Drift	This is a horizontal or inclined passageway excavated underground with one access opening. It is used interchangeably with the term "tunnel" at the NTS.
Drill Hole Designations	These are defined as follows: From the surface - PS-1V: Post-shot drill hole number 1 - vertical PS-1D: Post-shot drill hole number 1 - directional PS-1A: Post-shot drill hole number 1 - angle Each 'S' added after any of the above notations indicates a "sidetrack" or change of direction in the drill hole. From underground locations sample recovery core holes are referred to as RE (Reentry) No. 1, RE No. 2, etc.
Dry Run	This is a simulation of the functions occurring in the minutes before, during, and after the event. All timing and firing signals are sent in

	the proper sequence from the Control Room at CP-1. Each run begins with the first required timing and firing signal (normally minus 15 minutes) and ends with the firing signal. The audio countdown is transmitted over Net 1 (DNA) and on other nets as agreed upon with appropriate agencies. There are various types of dry runs depending on the degree of participation required of the agencies involved.
Dutchman	This is part of the tunnel ventilation system.
Effects Experiments	These are experiments with the purpose of studying the effects of a nuclear detonation environment on materials, structures, equipment, and systems. They include measurements of the changes in the environment caused by the nuclear detonation, such as ground movement, air pressures (blast), thermal radiation, nuclear radiation, and cratering.
Exoatmospheric	This refers to the area outside the gaseous mass which envelopes the earth.
Explosimeter	This is a battery-operated detector calibrated to indicate the concentration in the ambient atmosphere of explosive gases and vapors as percent of the lower explosive limit (LEL) of methane gas (5 percent concentration in air).

Exposure	This is a measure, expressed in roentgens (R), of the ionization produced by gamma rays or x rays in air [This may also be represented by subdivisions of R; e.g., 1/1000 R = 1 milliroentgen (mR).]
Exposure Rate	The exposure rate is the exposure per unit of time, usually per hour, but it is sometimes stated in smaller or larger units (e.g., R/min, mR/h, R/day).
Face	This is the surface area of a tunnel heading.
FDR	A successful final dry run is the last dry run before a test is detonated.
Film Badge	This is a dosimeter used for the indirect measurement of exposure to ionizing radiation. It generally contains two or three films of differing sensitivity. Films are wrapped in paper or other thin material that blocks light but is readily penetrated by radiations or secondary charged particles resulting from the radiations to be measured. Film packets generally have at least one metal filter or may be in holders with multiple filters. After being worn as a film badge or film dosimeter, films are developed and the degree of darkening (or optical density) measured indicates the radiation exposure. Film dosimeters commonly are used to indi-

	cate gamma and x-ray exposures, and also can be designed to determine beta and neutron doses.
Fission	This is the process whereby the nucleus of a particular heavy element splits into (generally) two nuclei of lighter elements, with an accompanying release of energy. The most important fissionable, or fissile, materials are uranium-235 and plutonium-239. Fission is caused by the absorption of a neutron in a nucleus.
Fission Products	This is a general term used for the complex mixture of radioactive nuclides (see Radionuclides) produced as a result of nuclear fission.
Fissionable Material	This is a synonym for fissile material, also extended to include material that can be fissioned by fast neutrons only, such as uranium-238. Used in reactor operations to mean reactor fuel.
Flex Line	This is a temporary flexible plastic tubing used to ventilate areas in which the main ventilation system did not provide adequate circulation of the air.
Forward Control Point	A geographic location in the forward test area, usually adjacent to the closed (or secured) test area.

Full Power Full Frequency (FPFF) Dry Run	This is similar in intent to a mandatory full participation dry run. The FPFF is sometimes combined with the hot dry run (HDR). This run is optional with the device engineer. When conducted, the LOS pipe is under vacuum, telephones and intercoms are disconnected, and tunnel utility and instrumentation power are operated in event-day configuration. Also all instrumentation is hooked up and operated in event-day configuration (simulators are not used).
Fusion	The combination of two very light nuclei (of atoms) to form a relatively heavier nucleus, with an accompanying release of energy is called fusion. (It is also known as thermonuclear fusion).
Gate 300	This refers to the permanent security station set up in Area 6 near the Control Point facilities at which reentry and recovery personnel waited during the detonation of an event. After reentry parties were released from this gate, they moved to the FCP and again awaited release.
Gamma Photons	These are electromagnetic radiations of high energy that are emitted from the nuclei of radionuclides. These photons are sometimes referred to as bundles of energy, and usually accompany other

	nuclear reactions, such as fission, neutron capture, and beta particle emission. Gamma photons, or rays, are identical with x rays of the same energy, except that x rays result from orbital electron reactions rather than being produced in the nucleus.
Gamma Shine	This occurs when a measurable gamma radiation intensity from an approaching radioactive cloud or passing cloud is noted, as opposed to measurements from or in gamma emitting fallout. This also includes gamma radiation scattered by air molecules, as opposed to direct radiation from a gamma source.
Gas Seal Door	This is a steel door on the portal side of the gas seal plug. It is closed during button up with about a 10 psi gas pressure applied between the gas seal plug and the gas seal door as an additional reassurance against low-pressure leaks.
Gas Seal Plug	This is one containment feature within the tunnel complex; generally it is designed for 500° F and 500 psi. The gas seal plug is sometimes referenced as the "hasty plug." This plug is similar to a lower pressure overburden plug, but is is placed closer to the portal and seals off the entire tunnel complex from the portal.

Geiger-Mueller Counter	This is an instrument consisting of a Geiger-Mueller tube and associated electronic equipment used to detect, display, and sometimes record nuclear radiation levels.
Geophone	This is an instrument used to detect vibrations in rock or soil. At NTS, it is used remotely to detect rock falls, earth movement, and cavity collapse underground while providing audible signal and visual display data.
Ground Zero	This is a term used during atmospheric testing to denote a point on the surface of the ground directly below or coinciding with an atmospheric detonation (see surface ground zero and zero point).
Heading	This is the furthest point one can walk into a drift or tunnel.
High-Efficiency Particulate Canisters	These are canisters used with a face mask to filter organic vapors out of breathing air. These canisters were called "absolute" filters because they filtered 99.97% of particulate matter greater than 0.3 micrometers in size. These were later referred to as HEPA filters (high-efficiency particulate aerosol).

H-hour	This is "time zero" or the exact time of detonation to the minute, second, or fraction of a second; as opposed to H + 1 which implies one hour after detonation (unless otherwise noted in seconds or minutes).
Horizontal Line-of-Sight (HLOS)	This is a general term used to refer to a family of events conducted in a horizontal tunnel. The term was sometimes used to refer to the pipe and vacuum system for some events.
Hot Line	This is a location on the edge of a radex area where personnel exiting remove anticontamination clothing and equipment, and monitoring for contamination and decontamination is performed as necessary. This term also was used to denote the centerline of a fallout pattern.
Invert	The bottom (floor) of a tunnel.
Ion	This is an atomic particle or part of a molecule bearing an electric charge. Usually a positively charged ion and a negatively charged ion are formed as a pair (e.g., a negatively charged electron is displaced from an atom so the remaining atom is positively charged).
Ionizing Radiation	This includes any particulate or electromagnetic radiation capable of producing ions, directly or indirectly,

	in its passage through air or matter. Alpha and beta particles produce ion pairs directly, while the electrons of initial ion pairs produced by gamma rays and x rays in turn produce secondary ionization in their paths. Neutrons may displace a positively charged part of a nucleus, such as a proton or alpha particle which produces secondary ionization.
Isotopes	This refers to different types of atoms within the same element, all reacting approximately the same chemically, but differing in atomic weight and nuclear stability. For example, the element hydrogen has three isotopes; normal hydrogen (the most abundant) heavy hydrogen (called deuterium), and radioactive hydrogen (called tritium).
Keyed Concrete Plug	This refers to a concrete plug placed in an excavated area of greater diameter than the shaft or tunnel cross section such that the concrete is poured into the surrounding rock, thus providing greater strength against overpressure from the nuclear detonation.
LEL	The lower explosive limit refers to a mixture of explosive gases and air that is at the minimum concentration necessary to cause an explosion if ignited. The MSA explosimeter is used to deter-

	mine percentages of the LEL, and is calibrated with a 5% methane gas and air mixture. A minimum explosive mixture is 100% of the LEL.
Leukemia Cluster	An apparent but unexpected or extraordinary group of leukemia cases within some number or group of persons.
Long Line	This is the longest sampling line into the tunnel which does not connect to the LOS pipe.
LOS Pipe	This is an evacuated pipe that extends from the device to the test chambers. It may be either horizontal or vertical, and in it are experiment protection devices and hardware.
Mandatory Full Participation (MFP) Dry Run	This is a dry run peculiar to DOD events. Its purpose is threefold: first, to check all experiments with the event site electrical system in its shot configuration; second, to check for crosstalk between experiments; and third, to operate all recording, timing, and monitoring equipment as closely to shot configuration as is possible. The pipe is under vacuum and the tunnel and portal instrumentation trailers are cleared of personnel. After a successful MFP dry run, all interconnections necessary to place experiments into shot configuration from the MFP configuration are made.

	Timing, firing, and monitoring system junction boxes are locked and no changes are made except with the express approval of device systems personnel and the Technical Director.
Manhattan Engineer District	This was the U.S. Army predecessor organization to the U.S. Atomic Energy Commission and the Armed Forces Special Weapons Project.
Manned Stations	These are locations inside the closed and secured area which are occupied by authorized personnel during an event.
Manway	This is a crawl space or other passageway through the gas seal plug, the overburden plug, and other structures.
McCaa Two-Hour Breathing Apparatus	This is a self-contained respiratory device that supplies two hours of breathing oxygen.
MFP	See Mandatory Full Participation Dry Run
mR	This stands for milliroentgens, a radiation exposure term meaning a thousandth of a roentgen (R). (Also, see Exposure.)
mrad/h	This is a radiation intensity term used to show that both gamma and beta levels were being measured.

Mucking	This refers to the removal of loose rock from drilling and mining operations.
Noble Gases	These are those inert gases which do not react with other elements at normal temperature and pressure (i.e., helium, neon, argon, krypton, xenon, and sometimes radon).
Nuclear Device (vs. weapon or bomb)	This refers to a device in which most of the energy released in a detonation results from reactions of atomic nuclei, either fission, or fission and fusion. A device under development (see Device) is not considered a weapon or bomb. Both A- (or atomic) bombs and H- (or hydrogen) bombs could be called atomic weapons because both involve reactions of atomic nuclei. However, it has become customary to call weapons A-bombs if the energy comes from fission, and H-bombs if most of the energy comes from fusion (of the isotopes of hydrogen or other light nuclides - see definition). A developmental nuclear device is not a weapon or weapon component until it can be mated to a delivery system.
Nuclear Device Tests	These are tests carried out to supply information required for the design, improvement, or safety aspects of nuclear weapons, and to study the

	phenomena and effects associated with nuclear explosions.
Nuclear Weapon Tests	These are tests that provide development and weapons effects information, and may or may not utilize a deliverable nuclear weapon.
OAP/R Canister	This is a canister used with a face mask to filter out organics, acids, particulates, and radioactive material from breathed air.
Offsite	Radiation detected offsite is radioactivity occurring outside the Test Range Complex, an area that includes both the Nevada Test Site and the adjacent Nellis Air Force Range.
Onsite	A notation that radioactivity was detected onsite only is made for tests from which there was an unplanned release of radioactivity into the atmosphere that was not detectable beyond the boundaries of the Test Range Complex.
Overburden	As used in connnection with NTS tunnels, this is the consolidated and unconsolidated rock above a tunnel vertically to the surface; thus, it is the burden of rock over a tunnel.
Overburden Plug (OBP)	This is a containment feature within the tunnel complex. It is now a high-

	strength concrete plug keyed into the tunnel rock near the test location and is generally designed to withstand 1000° F and 1000 psi. It originally was named because it was constructed to represent the same containment strength as the rock above the tunnel, or overburden.
Party Monitors	These are radiation (Radsafe) monitors assigned to reentry and recovery parties or groups.
Privacy Act	The Privacy Act of 1974 is part of Public Law 93-579. This was an Act to amend Title 5, U.S. Code, by adding Section 552a, which was to safeguard individual privacy from the misuse of federal agency records, to provide that individuals be granted access to records concerning them which are maintained by federal agencies, to establish a Privacy Protection Study Commission, and for other purposes.
ppm	The term parts per million is used when determining concentrations of toxic gases or other materials. It refers to either relative weight, such as micrograms of a material per gram of medium, or relative volume, such as cubic centimeters or milliliters per cubic meter.
rad	This is an acronym for "radiation absorbed dose," a unit of an absorbed

	dose of ionizing radiation. A dose of one rad means the absorption of 100 ergs of energy from ionizing radiation per gram of absorbing material (e.g., body tissue).
Radex Area	A radiation exclusion (radex) area is any area which is controlled for the purpose of protecting individuals from exposure to radiation and/or radioactive material.
Radiation Exposure	Exposure to radiation may be described by a number of terms. The type of radiation one is exposed to is important in establishing doses. External exposure can be from beta particles, neutrons, gamma rays and x rays; internal exposure is received from radionuclides deposited within the body which may emit alpha, beta, gamma, or x radiation and irradiate various body organs. (see Dose and Exposure).
Radioactive Effluent	This includes the radioactive material, steam, smoke, dust, and other particulate debris released to the atmosphere from an underground nuclear detonation.
Radioactive or Fission Products	This is a general term for the complex mixture of radionuclides produced as a result of nuclear fission (see Activation Products).

Radionuclides	This is a collective term for all types of radioactive atoms of a given element, as opposed to that element's stable nuclides (see Isotopes).
Recovery Operations	This is the process of finding and removing experiments, by-products, or data from the test area after a test event.
Red Shack	This is an underground (usually) intermediate point provided for the device laboratory's use in checking out and exercising the arming and firing system.
Reentry Drift	See Access Drift.
rem	This is an acronym for "roentgen equivalent man or mammal." A rad of radiation absorbed dose multiplied by the quality factor (QF) of a particular radiation equals the rem dose. Current QF values are one for x, gamma, and beta radiations, 10 for neutrons, and 20 for alpha particles.
Rib	This refers to the side of the drift. The right or left rib is determined with one's back to the portal.
roentgen	This is a special unit of exposure to ionizing radiation. It is defined precisely as that quantity of gamma (or x) rays that, when completely stopped

	in air, will produce positive and negative ions with a total charge of 2.58 x 10^{-4} coulombs in one kilogram of dry air under standard conditions.
Safety Experiments	Device tests conducted to determine the safety of nuclear weapons during transportation and storage. Elements of the conventional high explosive portions of the devices were detonated to simulate accidental damage and to determine the potential for such simulated to result in significant nuclear yield. Data gained from the tests were used to develop devices that could withstand shock, blast, fire, and other accident conditions without producing a nuclear detonation.
Sandbag Plugs	These were barriers used in tunnels, constructed of sandbags, to help contain underground detonations and minimize damage to underground workings.
Sandia Auxiliary Closure (SAC)	This is a device used to seal an HLOS pipe after a nuclear detonation.
Scatterer Station	A point along a LOS pipe where the radiation flux is deflected into an area off the LOS pipe as required for the testing or exposure of scatterer area experiments.
Scientific Station	This is the distance in feet along the HLOS pipe measured from the zero point.

	These distances are generally expressed in hundreds of feet plus whole numbers or to the nearest complete hundredths of feet (if fractional). Scientific Station 650 is expressed as SS 6+50; Scientific Station 390.65 is expressed as SS 3+90.65.
Scott-Draeger Self-contained Breathing Apparatus	This includes a self-contained recirculating unit, complete with "full view" facepiece, compressed oxygen cylinder, breathing bag, carbon dioxide absorber, and pressure demand regulator. It is used when an extended exposure to an extremely hazardous or oxygen deficient atmosphere, or both, is required. This unit is capable of sustaining the wearer, under normal usage, for four to four and one-half hours; however, pertinent approved schedules limit NTS use to 2 hours.
Seismic Motion	This is earth movement caused by an underground nuclear detonation, similar to that of a minor earthquake.
Shaft	This is a long narrow passage sunk into the earth, usually vertically, but inclined for some mining operations. Shafts for device emplacement, ventilation, or access to underground workings may be drilled or mined.
Shaft Collar	This is the the area immediately around a shaft at ground level, usually ce-

	mented, which supports the headframe and other equipment.
Shielding Walls	These are walls or barriers used to protect equipment or instrumentation from heat, blast, and radioactivity.
Slushing Operations	The process of moving broken rock with a scraper or scraper bucket. May be used on the surface or underground, where ore or waste rock is slushed into hoppers or other locations for removal.
Spalling	This is rock disintegration evidenced by flaking, chipping, peeling, or loosening of layers on the outside edges. It may be caused immediately after detonation by rock stressing to rock near the detonation point. It also may result later, after continued stressing from temperature change expansion and contraction. Spalling also may result or begin when rock containing moisture is raised to a high temperature and expanding vapor creates fractures.
Stemming	This is the various materials used to back-fill or plug the emplacement shaft, drift, or LOS drift to contain overpressure and radioactive material from a nuclear detonation.
Stubs	This refers to a variable number of smaller diameter LOS pipes which

	protrude from the portal side end of the main LOS pipe and contain experiments to be exposed to the radiation flux during event execution.
Surface Ground Zero	The location on the ground surface directly above an underground zero point (see ground zero and zero point).
Survey	In the tunnels, a survey might include taking radiation readings with a portable instrument, checking for the presence of an explosive mixture with an MSA explosimeter, determinig toxic gas levels with Draeger tubes, and/or checks for tunnel hazard and damage (also called a "walk-through" or "walk-out"). Radsafe personnel made the radiation surveys, Radsafe or industrial hygiene personnel (both in the REECo Environmental Sciences Department) checked for toxic gases and explosive mixture, and tunnel mining and construction personnel performed walk-throughs usually accompanied by Radsafe and/or industrial hygiene support (see tunnel walk-out).
TAPS	The tunnel and pipe seal (TAPS) is an experiment protection feature along the LOS pipe which allows the experiments to be exposed to the desired levels of radiation while being protected from debris. It contains a massive steel door which closes after ground shock

	passes to form a 1000° F and 1000 psi seal.
Test Chamber	This is a section of the LOS pipe in which experiments are placed. It may or may not be enlarged, depending upon the test design.
Test Controller	This was an AEC/ERDA/DOE official designated by the Manager, Nevada Operations Office, to assume responsibility for the field operations involved in conducting a nuclear test at the Nevada Test Site.
Test Event	This includes the preparations, including arming and firing, and the actual testing of a nuclear device, including detonation, concurrent measurements and effects, and later measurements and studies.
Testing Organizations	These are organizations conducting nuclear tests at the NTS (see DOD, DNA, LASL, LLL, and SLA).
Tonopah Test Range	The TTR is located in the northwest corner of Nellis Air Force Range near Tonopah, Nevada.
Trailer Park	These are areas near a tunnel portal or on the Mesa where instrumentation or instrumentation support trailers are parked.

Tunnel	At NTS, this refers to a horizontal underground excavation driven on a predetermined line and grade to some specific target.
Tunnel Access	This refers to entering to a tunnel or tunnel complex upon approval of the Test Director during test operations, or upon approval of the Tunnel Superintendent during routine operations.
Tunnel Complex	This refers to the complete set of drifts and support equipment comprising one tunnel complex.
Tunnel Walk-Out	This is a visual, walking inspection of the tunnel or tunnel complex, usually performed as a part of the initial reentry after a detonation, to check for damage and hazards prior to allowing general access to the underground workings.
Type N Canisters	These canisters are used with face masks to filter out carbon monoxide.
Underground Structures Program	This refers to the construction and fabrication of test structures underground for the purpose of detonation effects evaluation.
User	This is defined as any organization conducting tests at the NTS (See Testing Organizations).

Vela Uniform Project	This was a Department of Defense (DOD) program designed to improve the capability to detect, identify, and locate underground nuclear explosions.
Venting	This is defined as a dynamic release of radioactive material, steam, smoke, dust and other particulate debris through a zone of weakness from the detonation-formed cavity into the atmosphere.
Weapons Effects Experiments	These are experiments with the purpose of studying the effects of a nuclear detonation environment on materials, structures, equipment, and systems. They include measurements of the changes in the environment caused by the nuclear detonation such as ground movement, air pressures (blast), thermal radiation, nuclear radiation, and cratering.
Weather Briefings	These are a part of the readiness briefings, which are meetings of test-associated administrators, advisors, and other technical personnel prior to each test event to evaluate weather conditions and forecasts on event day, and make decisions on any necessary operational schedule changes.
Work Drift	See Access Drift.

Workings	This refers to an excavation or group of excavations made in mining, quarrying, or tunneling. It is used chiefly in the plural, such as "the workings extended for miles underground."
x rays	These are electromagnetic radiations produced by electron reactions, as opposed to emission of gamma photons given off by nuclei. Otherwise, high energy x rays are identical with gamma photons of the same energy.
Yield	This is the total effective energy released by a nuclear detonation. It is usually expressed in terms of the equivalent tonnage of TNT required to produce the same energy release in an explosion. The total energy yield is manifested as nuclear radiation (including residual radiation), thermal radiation, and blast and shock energy; the actual distribution depending on the medium in which the explosion occurs and the type of weapon.
Zero Point	At the instant of detonation, this is the center of an underground explosion of a nuclear device or weapon.

APPENDIX B

ABBREVIATIONS AND ACRONYMS

The abbreviations and acronyms in the following list are used in this fifth volume of DOD underground testing reports. Additional information and definitions may be found in the text and in the Glossary of Terms.

AEC	Atomic Energy Commission
AES	Auxiliary Experiment Station
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
AFWL	Air Force Weapons Laboratory
ALOO	Albuquerque Operations Office
AMC	Army Materiel Command
ASN	Air Surveillance Network
AVCO	AVCO Corporation
BAC	Boeing Aircraft Corporation
Bkg	Background Radiation Measurement
BJY	BUSTER-JANGLE roads intersection with the Mercury Highway
CC	Crosscut
CCTV	Closed Circuit Television
CDC	Centers for Disease Control (formerly the Center for Disease Control)
CEP	Containment Evaluation Panel
CIC	Coordination and Information Center
CP	Control Point
CP-1	Control Point Building 1
CP-2	Control Point Building 2
CTO	Continental Test Organization
D-day	The day a nuclear detonation takes place
DAC	DNA Auxiliary Closure
DASA	Defense Atomic Support Agency
DMA	Division of Military Application
DNA	Defense Nuclear Agency
DOD	Department of Defense
DOE	Department of Energy
dpm	Disintegrations per minute
EG&G	EG&G, Inc. (formerly Edgerton, Germeshausen, & Grier)
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ES	Experiment Station
FAC	Fast Action Closure
FCDASA	Field Command, Defense Atomic Support Agency

ABBREVIATIONS AND ACRONYMS (continued)

FCDNA	Field Command, Defense Nuclear Agency
FCP	Forward Control Point
FCTC	Test Construction Division of Test Directorate
F&S	Fenix & Scisson, Inc.
FDR	Final dry run
FPFF	Full Power Full Frequency
ESD	Environmental Sciences Department, REECo
GE	General Electric Corporation
GM	Geiger-Mueller
GSAC	Gas Seal Action Closure
GZ	Ground Zero
HDL	Harry Diamond Laboratories
HE	High explosives (conventional)
HFR	High Fluence Recoverable
H&N	Holmes & Narver, Inc.
HLOS	Horizontal line-of-sight
HAC	Hughes Aircraft Co.
IRT	Intelcom Rad Tech
ISAFAF	Indian Springs Air Force Auxiliary Field (formerly ISAFB)
ISAFB	Indian Springs Air Force Base
JCS	Joint Chiefs of Staff
KAFB	Kirtland Air Force Base
KOA	Ken O'Brien Associates
KN	Kaman Nuclear
KSC	Kaman Sciences Corp. (formerly Kaman Nuclear)
kt	Kilotons
LANL	Los Alamos National Laboratory
LASL	Los Alamos Scientific Laboratory (now Los Alamos National Laboratory)
LEL	Lower explosive limit
LLL	Lawrence Livermore Laboratory (formerly LRL)
LLNL	Lawrence Livermore National Laboratory
LMSC	Lockheed Missile and Space Corporation
LOS	Line-of-sight
LPARL	Lockheed Palo Alto Research Laboratory
LRL	Lawrence Radiation Laboratory (now Lawrence Livermore National Laboratory)
LVFO	Las Vegas Field Office
MAC	Mechanical Action Closure
MDAC	McDonald-Douglas Aircraft
MED	Manhattan Engineer District
MFP	Mandatory Full Participation
MPC	Maximum permissible concentration
mrem/qt	Millirem per quarter
mrem/yr	Millirem per year
mR/h	Milliroentgens per hour
MSA	Mine Safety Appliance
MSL	Mean sea level
NO_2	Nitrogen dioxide
$NO+NO_2$	Nitric oxide plus nitrogen dioxide
NPG	Nevada Proving Ground
NRDS	Nuclear Rocket Development Station

ABBREVIATIONS AND ACRONYMS (continued)

NTIS	National Technical Information Service
NTS	Nevada Test Site
NTSO	Nevada Test Site Organization
NVOO	Nevada Operations Office
OBP	Overburden Plug
Pan Am	Pan American World Airways
PDT	Pacific Daylight Time
PI	Physics International
ppm	Parts per million
psi	Pounds per square inch
PST	Pacific Standard Time
QF	Quality Factor
Radex Area	Radiation Exclusion Area
rad/h	Radiation absorbed dose per hour
Radsafe	Radiological Sciences Department (formerly Radiological Safety Department), REECo
radsafe	Radiological safety, in general
RAMS	Remote area monitoring system
RCG	Radioactivity concentration guide
REECo	Reynolds Electrical & Engineering Company, Incorporated
rem	Roentgen equivalent man or mammal
R/h	Roentgens per hour
ROSES	Recorder and Oscilloscope Sealed Environmental System
RPG	Radiation protection guide
SAC	Sandia Auxiliary Closure
SAI	Science Applications, Inc. (now Science Applications International Corp., SAIC)
SAMSO	Space and Missile Systems Organization
SC	Sandia Corporation (now Sandia National Laboratories)
SGZ	Surface Ground Zero
SFOO	Santa Fe Operations Office
SLA	Sandia Laboratories, Albuquerque (now Sandia National Laboratories)
SNL	Sandia National Laboratories
SOP	Standard operating procedures
STU	Special Test Unit
TAPS	Tunnel and Pipe Seal
TC	Test Chamber
TCDASA	Test Command, Defense Atomic Support Agency
TEP	Test Evaluation Panel
TGD	Test Group Director
TGS	Test Group Staff
TNT	High explosive chemical (trinitrotoluene)
TTR	Tonopah Test Range
UCRL	University of California Radiation Laboratory (now Lawrence Livermore National Laboratory)
USAF	United States Air Force
USGS	United States Geological Survey
VA	Veterans Administration
VLOS	Vertical line-of-sight

ABBREVIATIONS AND ACRONYMS (concluded)

WETG	Weapons Effects Test Group
WSI	Wackenhut Services, Incorporated
WTD	Weapons Test Division

APPENDIX C

SC-M-68-227

GENERAL TUNNEL REENTRY PROCEDURES FOR DEPARTMENT OF DEFENSE AND SANDIA LABORATORY NUCLEAR TESTS

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ABSTRACT

This document describes preshot preparations and postshot procedures for safe and economical reentry into a tunnel area after a nuclear detonation. Associated responsibilities, possible hazards, reentry ground rules, preshot preparations, communications, reentry parties and equipment, initial tunnel reentries, and recovery of scientific experiments are explained.

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LEGAL NOTICE

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GENERAL TUNNEL REENTRY PROCEDURES FOR DEPARTMENT OF DEFENSE AND SANDIA LABORATORY NUCLEAR TESTS

1. Introduction

The Health Physics Division began tunnel reentries in 1962. The procedures that are given in this document represent a compilation of a series of tunnel reentry procedures that have been continually improved based upon experience and better instrumentation. The reentry plan presented describes preshot preparations and postshot procedures for safe and economical reentry and scientific recovery in a tunnel area.

2. Responsibilities

Responsibilities for safe and economical tunnel reentry procedures after a nuclear detonation indicated herein for AEC or AEC contractor (i.e., Sandia Laboratory) personnel are in accord with established AEC/DOD agreement or are the subject of separate action between TC/DASA and NVOO.

a. AEC-NVOO

(1) The Test Manager is responsible to the AEC for the safety of all the participating personnel at sites under the jurisdiction of NVOO and has approval authority over decisions effecting the safety of these personnel. (Ref: NTSO Draft 0524-013a.)

(2) The NVOO Operational Safety Division will advise the DOD Test Group Director (TGD) and the Reentry Control Group on all problems pertaining to health and safety.

b. Sandia Laboratory

(1) The Sandia Laboratory Health Physics Division has three responsibilities: it specifies the necessary measuring devices and equipment to indicate the postshot condition of the tunnel; it provides the Reentry Control Group; and it documents any release of radioactive material.

(2) The Chief of the Reentry Control Group will act as advisor to the TGD on surface and tunnel reentry safety until the tunnel has been cleared for normal operation.

(3) The Reentry Control Group will provide consultants who will advise on tunnel reentry procedures. These consultants will be familiar

with the experimental setup and with possible postshot tunnel conditions and hazards.

(4) The Reentry Control Group will arrange the necessary support for reentry and recovery, e.g., it will provide mine rescue trained personnel, Rad-Safe support (see Annex A), Industrial Hygiene Support, etc.

c. TC/DASA or Sandia Laboratory Test Group Director

(1) The TGD is responsible for the safe conduct of all activities in the tunnel area. He will authorize and initiate both a tunnel condition survey and reentry and recovery operations with the concurrence of the Test Manager.

(2) The TGD will be responsible for initiating all action for the preshot installation and postshot removal of equipment and services required for Test Group support activities except those items covered as AEC responsibilities in the AEC/DOD agreement.

3. <u>Possible Hazards</u>

a. Radiation. Radiation in tunnel reentry areas may result from any one of the following:

(1) Leak of radioactive gases or materials through fissures or fractures from ground zero.

(2) Failure of the tunnel stemming.

(3) Activation and/or dispersion of samples in the experimental chamber.

b. Explosive or toxic gases. Various explosive and toxic gases released as direct or secondary products of the detonation may be present in concentrations dangerous to personnel.

c. Explosives. Undetonated HE may remain either intact or scattered in the tunnel.

d. Toxic materials. Beryllium may pose a toxic problem to personnel particularly if it becomes dispersed in the air and/or deposited on recovery samples.

e. Tunnel damage. Damage to the tunnel may result from the device generated shock wave.

(1) Collapse of the tunnel would not normally be expected beyond the stemming; however, partial or total collapse may occur at greater distances from ground zero. Reentry through collapse zones must be preceded by mining through broken ground or by driving a new parallel drift.

(2) Heave of the tunnel floor may cause slabbing or spallation of the rock and failure of utility lines, railroad track, tunnel sets, and lagging. This damage will create safety hazards which must be removed prior to experimental recoveries.

f. High pressure gas. High pressure (2200 psi) gas cylinders normally exist within the tunnel complex.

4. Reentry Ground Rules

a. Initial reentry and each subsequent phase will be initiated upon authorization of the TGD with concurrence of the Test Manager, and control will be retained by the TGD until all recovery operations are completed and tunnel access is returned to AEC control. Only those personnel authorized by the TGD and the Chief of the Reentry Control Group will be permitted in the portal area and tunnel.

b. Tunnel communications will be by a hard wire portable phone system.

c. Tunnel parties will be controlled by the Chief of the Reentry Control Group who is located at the tunnel portal. Tunnel parties may be recalled at his direction. Only one team will be in the tunnel at any single time unless directed otherwise by the Chief of the Reentry Control Group.

d. A tunnel party will return to the portal under any of the following conditions:

(1) Upon decision of the Team Chief.

(2) When any member of Teams 1, 2, 3, and 4* show a McCaa oxygen supply less than 30 atmospheres or a Draeger pressure less than 450 psi.

(3) Upon loss of communications with the Reentry Control Group at the portal.

e. Team 4 (Rescue Team) will be dispatched upon direction of the Chief of the Reentry Control Group, the Team Chief in the tunnel, or if communications should be lost with any team in the tunnel (allowing a reasonable time for the team to exit after loss of communications).

f. All observations during reentry will be communicated through the Chief of Party to the Chief of the Reentry Control Group and recorded for future reference.

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* See Paragraph 7, "Reentry Parties and Equipment," for a description of the personnel, function, and equipment of each team.

g. Personnel radiation exposure limits are those set by NTS SOP Chapter 0524. The radiation dose limit for the operation is 3 Rem per calendar quarter. A person's exposure, however, will be terminated when his pocket dosimeter reaches 2.0 Rem, assuming his exposure history would allow 3 Rem during this operation.

h. Tunnel reentry will not be made before the tunnel ventilation has been turned on and samples of the air monitored at the portal. Evaluation of the sample must indicate that reentry can be made within the limitations of this procedure.

i. Reentry will not be made beyond ventilation, 10R/hr, 1000 ppm CO, or 10 percent of the lower explosive limit of explosive gas mixtures. Teams 1, 2, 3, and 4 may be exempted from these requirements under extenuating circumstances by mutual decision of the Chief of the Reentry Control Group and the Chief of the Party.

j. The Rescue Team will always be stationed near the portal with a train for immediate dispatch.

5. Summary of Preshot Preparations for Reentry

a. Stemming should provide fireball containment and should reduce radioactivity and explosive gas in the reentry area. The overburden plug should contain any debris that may pass the stemming. The gas seal door should contain any gases that penetrate the overburden plug.

b. Remote radiation sensing instruments will provide knowledge of tunnel radiation levels, while tunnel condition indicators (geophones, pressure and temperature gages, and explosimeters) remotely monitor the tunnel.

c. Air sampling lines for gas chromatography are normally installed through both the gas seal door and the overburden plug. Each installation is provided with suitable remotely operated valves. Samples may be drawn from the inside of the gas seal door, from both sides of the overburden plug, and from near the stemming. Sampling from these lines will help determine the explosive and toxic gas concentrations in the tunnel prior to reentry.

d. Valves are normally installed in the vent lines and makeup ports in the gas seal door and overburden plug. An axial vane fan is located on the makeup valves to reduce negative pressure. The valves and fan are remotely operated from a manned location and will have position monitors to indicate whether they are fully open or fully closed. The position monitors will also show whether the fan power is on or off.

e. The following items ordinarily have power turned on through and after zero time:

(1) Tunnel utilities and instrumentation. Power to these items will be turned off near zero time.

(2) Geophone transmitter trailer. This supplies power to the geophone and the pressure and temperature amplifiers which must be left on to monitor for cavity collapse and pressure changes.

(3) Ventilation fans. Power will be controlled remotely.

(4) Radiation detectors.

(5) Explosimeters.

(6) Ventilation and gas sampling valves. Power will be controlled remotely.

f. The Sutorbilt fans will be installed so they will pull air through the vent line filter system before it is released to the atmosphere. One Sutorbilt fan will be used for a back-up in case the other fan fails.

g. Ventilation.

(1) The ventilation system is installed so that all areas of the tunnel that are not closed off are swept with fresh air from the portal.

(2) After zero time and when the TGD gives his approval (with the consent of the Test Manager), the tunnel ventilation system will be turned on, exhaust and makeup air will be supplied from the portal through valves in the gas seal door and, if possible, the overburden plug. There will be valves that can be remotely operated in both vent lines at the gas seal door and, if possible, at the overburden plug. Vent line samples will be taken to monitor for radioactive, explosive, and/or toxic effluents.

6. Communications

A communication system with the necessary wire on a portable reel will be used during initial reentry. A back-up reel will be available. All conversation between the reentry party and reentry control will be recorded.

7. Reentry Parties and Equipment

The reentry parties will consist of the personnel and equipment described in the following table:

Party Name	Equipment
a. Teams 1, 2, and 3 - Tunnel Reentry Party (1) Chief of Party (2) Rad-Safe monitor (3) Industrial Hygiene monitor (May be performed by Rad-Science personnel) (4) Tunnel safety (5) Scientific Advisor (as required)	Full Radex clothing Bureau of Mines approved 2-hour self-contained oxygen breathing apparatus Radiation detectors Explosive gas meter Toxic gas detectors Oxygen percent meter Hard wire communications
b. Team 4 - Tunnel Rescue Party (1) Chief of Party (2) Three to six REE Co. Mine Rescue (3) Two monitors for Rad-Safe and Industrial Hygiene	Full Radex clothing Bureau of Mines approved 2-hour self-contained oxygen breathing apparatus Radiation detectors Toxic gas detectors Explosive gas meters Wire litters Hard wire communication
c. Team 5 - Tunnel Scientific Assessment Team (as required) (1) Chief of Party (2) Rad-Safe and Industrial Hygiene monitors (3) Scientific Advisors (4) Mine support	Full Radex clothing Respiratory protection (as required) Radiation detectors Toxic gas detectors Explosive gas meter Hard wire communications
d. Team 6 - Tunnel Work Party (1) Chief of Party (2) Rad-Safe and Industrial Hygiene monitors (3) REE Co. miners	Full Radex clothing Respiratory protection (as required) Radiation detectors Toxic gas detectors
e. Team 7 - Tunnel Scientific Recoveries to Experimental Chamber (see Para. 9 for details)	Full Radex clothing Respiratory protection (as required)
f. Team 8 - HE Disposal Group (as required)	Full Radex clothing Respiratory protection (as required)
g. Team 9 - Medical Support M. D. and medical technician	Necessary medical equipment Ambulance

8. Initial Tunnel Reentries

a. After the event the TGD will review radiation and tunnel condition monitors. When he determines that it is safe, and with the agreement of the Test Manager, the tunnel ventilation system will be turned on EXHAUST. Makeup air will be supplied from the portal through the valves in the plugs.

b. Prior to entry into the tunnel, all experimental cables and all electrical and telephone lines going into the tunnel through the portal will be either locked open or disconnected. All other cables going into the tunnel will be disconnected and taped or cut and grouted as necessary. Along with the pressure, temperature, and geophone instruments, the remote radiation monitoring system and the remote explosimeters will be left connected. No circuit into the tunnel or into the instrumentation trailers will be closed when personnel are either in the tunnel or directly in front of the portal (including an area extending 50 feet on either side of the portal).

The Chief of the Reentry Control Group will advise the TGD on tunnel conditions by reviewing surface conditions, exhaust gas information, tunnel radiation, tunnel condition indicators, and seismic information. This review will determine when tunnel reentry may actually begin.

When cleared by the TGD and the Test Manager and when all surface recoveries and power checks are complete, Team 1 will be allowed to make the initial tunnel reentry. There will be no change in the tunnel ventilation setup or in utilities while Teams 1 through 5 are underground. The number of people in the portal area and trailer parks will be held to a minimum.

c. Team 1 will be the first group to reenter and will proceed to the gas seal door. A train may be used to supply transportation to the gas seal door, conditions permitting. Team 1 will continuously monitor for radioactivity and for toxic and explosive gases. Pressure gages at the gas seal door will be checked, and if no pressure is observed, a sample will be taken through the door to determine the environment on the other side of the door. Under safe conditions, Team 1 will then open the gas seal door. They will inspect the tunnel to the overburden plug. The pressure gages at the overburden plug will be checked and if no pressure is observed, a sample will be taken through the plug to determine the environment on the other side of the plug. Team 1 will then withdraw to the portal area. If remote ventilation has not been established previously behind the overburden plug, the work party (Team 6) will then reenter and take the necessary steps to establish ventilation through the plug. They will then exit the tunnel, and samples will be taken from the vent line to verify earlier remote sampling. A second work party may be required to open the overburden plug door and remove the material from the manway.

Team 2 will reenter with an engine and car containing necessary equipment to open the overburden plug door. This group will take in the reel of communication wire and connect it up to the existing communication line jack at the overburden plug to reestablish communications with the reentry control group at the portal. Team 2 will open the manway door and will continuously monitor for radioactivity and for toxic and explosive gases. They will then withdraw to the portal with the engine.

Team 3 will reenter to the overburden plug and reestablish communications using the reel connected to the communication line jack. The team will walk out the remaining drift continuously monitoring for radioactivity and for toxic and explosive gases. They will also observe the vent lines to assure themselves that the lines are intact. Team 3 will proceed to the stemming, if possible, noting tunnel and pipe conditions. They will then return to the end of the experimental pipe and establish ventilation in the pipe if time and conditions permit. Swipes will be taken on the vent port of the test chamber and checked for contamination. These will be later analyzed for Be and isotope identification.

The mission of Teams 1, 2, and 3 is to verify that the tunnel complex is within acceptable levels for toxic and radioactives gases and to check the condition of the pipe and tunnel.

d. If Teams 1, 2, and 3 determine that tunnel rehabilitation may be safely conducted, they will leave the tunnel and Team 6 will make temporary repairs as needed to the vent line or tunnel. A Rad-Safe monitor will remain with Team 6 while in the tunnel and continue to monitor for radiation and toxic gases.

e. The object of Teams 1 and 3 will be to explore as much of the tunnel on one reentry as possible. Previous experience has shown that McCaa or Draeger Teams can explore up to 4300 feet in 1-1/2 hours with a 1/2 hour safety margin. If an additional initial reentry is required to fully explore the tunnel, Team 4 (with Rad-Safe and Industrial Hygiene monitors) will complete the tunnel exploration with Team 1 standing by as Tunnel Rescue.

9. Tunnel Scientific Recoveries from the Experimental Chamber

a. Scientific recoveries in the tunnel will not be permitted until Team 1, 2, or 3 has searched all drifts and verified that the tunnel is clear of dangerous amounts of toxic, explosive, and radioactive gases.

b. Before scientific recoveries may begin, repair of the tunnel along the recovery route to the experimental chamber must be complete. This activity may include repairing broken lagging and removing hazardous obstacles as well as repairing railroad track and vent lines. The tunnel lights will be turned on before all scientific recoveries except film recoveries begin. All cabling extending into a crushed zone will be cut.

c. Team 5 will conduct a technical survey and perform the necessary actions to begin scientific recoveries.

d. Team 7 will then be permitted to proceed to the experimental chamber and begin the removal of samples in order of priority. A Rad-Safe/Industrial Safety monitor will be present at all times. This monitor will advise the Chief of the Reentry Control Group, who is responsible for terminating scientific recovery, whenever the tunnel environment becomes dangerous. A Rad-Safe check station will be established at each Scientific Station to control contamination.

APPENDIX D

U. S. ATOMIC ENERGY COMMISSION
STANDARD OPERATING PROCEDURE
NEVADA TEST SITE ORGANIZATION

NTSO-05240-01

Chapter 0524 RADIOLOGICAL SAFETY

0524-01 Radiological Safety

011 Purpose

The purpose of this Standard Operating Procedure is to define responsibility and to establish criteria and general procedures for radiological safety associated with NTS programs. Additional operational instructions relating to radiological safety for particular activities may be published as a part of the Test Manager's Operational Plan.

012 Responsibilities

a. Manager, NVOO. The Manager, NVOO, is the AEC official to whom the NTSO reports. The Manager, NVOO, as a Test Manager, is responsible for administering, preparing, and executing all programs and projects. The Test Manager may delegate operational control of the NTSO to specifically-identified Deputy Test Managers for the execution of approved programs, projects, and experiments. Only the Test Manager or the Deputy Test Manager is authorized to approve or disapprove the field execution of approved programs, projects or experiments.

b. Test Manager. The Test Manager is responsible for the protection of participating personnel and off-site population from radiation hazards associated with activities conducted at the NTS. By mutual agreement between the Test Manager and a scientific user, control of radiological safety within the area assigned for a particular activity may be delegated to the user's Test Group Director during the period of time when such control could have a direct bearing on the success or failure of the scientific program. The provisions of AEC Manual Chapter 8401 shall apply to reactor tests or sustained reactor operations.

c. Test Group Director. Whenever operational radiological safety control is delegated to a Test Group Director under provisions of 012a above, he is responsible to the Test Manager for establishment and implementation of radiological safety criteria within the assigned area. He will be responsible for submitting a detailed radiological safety operational plan to the

Test Manager for review and concurrence. This plan shall be submitted as Standard Operating Procedures (SOP) to cover all routine operations. Variances from the SOP for non-routine operations shall be presented to the Test Manager for review and concurrence. Upon termination of need for the Test Group Director to retain radiological safety control within an assigned area, the Test Group Director will be relieved of radiological safety responsibility.

d. Director, Nevada Test Site Support Office (NTSSO). Supervises the approved NTS on-site radiological safety programs, except for those periods in which operational control of specified areas may be delegated to others (i.e., Test Manager, Test Group Directors, etc.).

e. Radiological Safety Advisor. The NTSO Radiological Safety Advisor is responsible to the Test Manager for staff supervision of radiological safety policies and procedures at the NTS. Monitoring of the radiological safety policies and direction of procedures at NTS, during non-operational periods, rests with the Director, NTSSO.

f. Chief, Safety Branch (SB), NTSSO. The Chief, Safety Branch, NTSSO, will be responsible to the Director, NTSSO, for conducting field inspections at the NTS to assure that NTS contractors execute safety programs in accordance with approved safety procedures and plans as well as with AEC and NVOO directives. Recommends corrective actions where necessary. Assures that radioactive waste management and disposal are accomplished in accordance with approved procedures. Coordinates and administers NTS activities relative to the Radiological Assistance Program. Provides day-by-day coordination and monitoring of NTS radiological safety activities, except for those periods during which operational control of specified areas may be delegated to others.

g. Director, Safety Evaluation Division (SED), NVOO. Provides for staff development of safety programs of NVOO for use at NTS. Develops safety programs which are coordinated with NTSSO and site user agencies and organizations to meet public and operational safety requirements for the conduct of nuclear detonations, reactor test programs, chemical explosives tests, or other NVOO activities. Arranges for radiological studies as may be appropriate.

h. Chief, Radiological Safety Branch (RSB), NVOO. Provides staff assistance in all matters relating to radiological safety. Reviews and evaluates for technical adequacy radiological safety procedures and operational plans submitted by user organizations. Acts as Radiological Safety Advisor (or provides a representative) to the Test Manager during all NVOO activities requiring such coverage.

i. Off-Site Radiological Safety Officer. The Director, Southwestern Radiological Health Laboratory, U. S. Public Health Service, or his representative, will be designated as the Off-Site Radiological Safety Officer and its responsible to the Test Manager for the operation of the off-site radiological safety program.

j. User Organizations. The official in charge of each agency or organizational group participating in NTS field activities or using NTS facilities is responsible for compliance by his personnel with established radiological safety policies, procedures, and controls. Each official in charge of a participating group is also responsible at all times to his parent organization for the radiological safety of personnel under his supervision. Operational safety plans will be submitted by the user organization to the Test Manager for review and approval, with a copy to the Director, NTSSO.

k. Operations Coordination Center (OCC). Shipment of radioactive materials, radioactive waste disposal, and access to areas contaminated with radioactive debris require prior coordination through the Operations Coordination Center, CP-1, telephone Mercury 986-2781.

l. On-Site Radiological Organization. On-site radiological safety support services for user organizations and the routine operation of NTS will be provided by the on-site radiological safety support contractor as directed by the NTSSO. Routing radiological safety support services at NTS will be requested in writing by the user organization through the Director, NTSSO. The on-site radiological safety support contractor is responsible to the Test Manager, through the Director, NTSSO, for the following routine on-NTS radiological safety support.

1. Providing radiological safety support, including certified monitors to user organizations.

2. Making radiological surveys, documenting radiation levels from events on the NTS, mapping and properly marking all contaminated areas, and furnishing this survey information for distribution by the Chief, Safety Branch, NTSSO.

3. Conducting a personnel radiation dosimetry program and disseminating the results of the program to respective organizations covered under this program, and as appropriate under AEC Manual Chapter 0525 and Appendix. This program to include providing and maintaining a repository for records and source documents pertaining to personnel dosimetry for all NVOO activities requiring such dosimetry.

4. Maintaining and calibrating radiation detection equipment.

5. Procuring, issuing, and decontaminating protective clothing, supplies, and equipment.

6. Providing radioactive materials and waste disposal control (including receiving, storage, on-site movement and shipping).

7. Maintaining and operating personnel and equipment decontamination facilities.

8. Providing advice and assistance in matters pertaining to radiological safety.

9. Conducting an on-site environmental surveillance program.

10. Providing necessary support services for the off-site radiological safety program.

11. Conducting radiological safety training courses.

12. Preparing final on-site reports following each test operational period, interim reports for each event, special reports and detailed operational plans for each future program.

13. Providing Radiological Assistance Teams to respond to radiation incidents.

14. Conducting analysis of samples for radioactivity and for certain toxic materials.

15. Providing and maintaining a current manual containing the Standard Operating Procedures (SOP) for providing radiological safety support, as outlined above, to users and contractors at the NTS.

m. Other. Other responsibilities as well as more detailed versions of the above, are spelled out in NTSO-0103.

0524-02 Organization

The chart showing the organizational relationship of the NTS radiological safety activities is shown in Figure 1 on the following page.

0524-03 Definitions

a. Radiological Safety. The protection of personnel, population groups, and the environment from the effects of ionizing radiation.

b. Ionizing Radiation. Electromagnetic radiation (consisting of photons) or particulate radiation (consisting of electrons, neutrons, protons, etc.) usually of high energy, but in any case capable of ionizing air, directly or indirectly.

c. NTS. The Nevada Test Site.

d. On-Site. Areas within the NTS boundaries, including Mercury.

e. Certified Monitor. Any person certified to the Test Manager or his designated representative as a qualified monitor by a Test Group Director or the Radiological Safety Representative of the radiological safety services.

f. Radiation Exclusion Area (Radex). A limited access area designated and posted for radiological safety purposes.

g. Controlled Area. Any area to which access is controlled by the AEC or AEC contractors.

h. User. Any organization or test participant having a NVOO-approved technical program for conduct at the NTS.

i. Radiation Incident. Any alleged radiation accident, which if true, could result in property damage or loss, injury, over exposure, or excessive release of radioactive materials.

j. Roentgen. A unit of exposure to X or gamma radiation. 1 mR (one milliRoentgen) is one-one thousandth of one Roentgen.

k. Rad. A unit of absorbed dose equivalent to 100 ergs/gram.

Revised: February 9, 1968

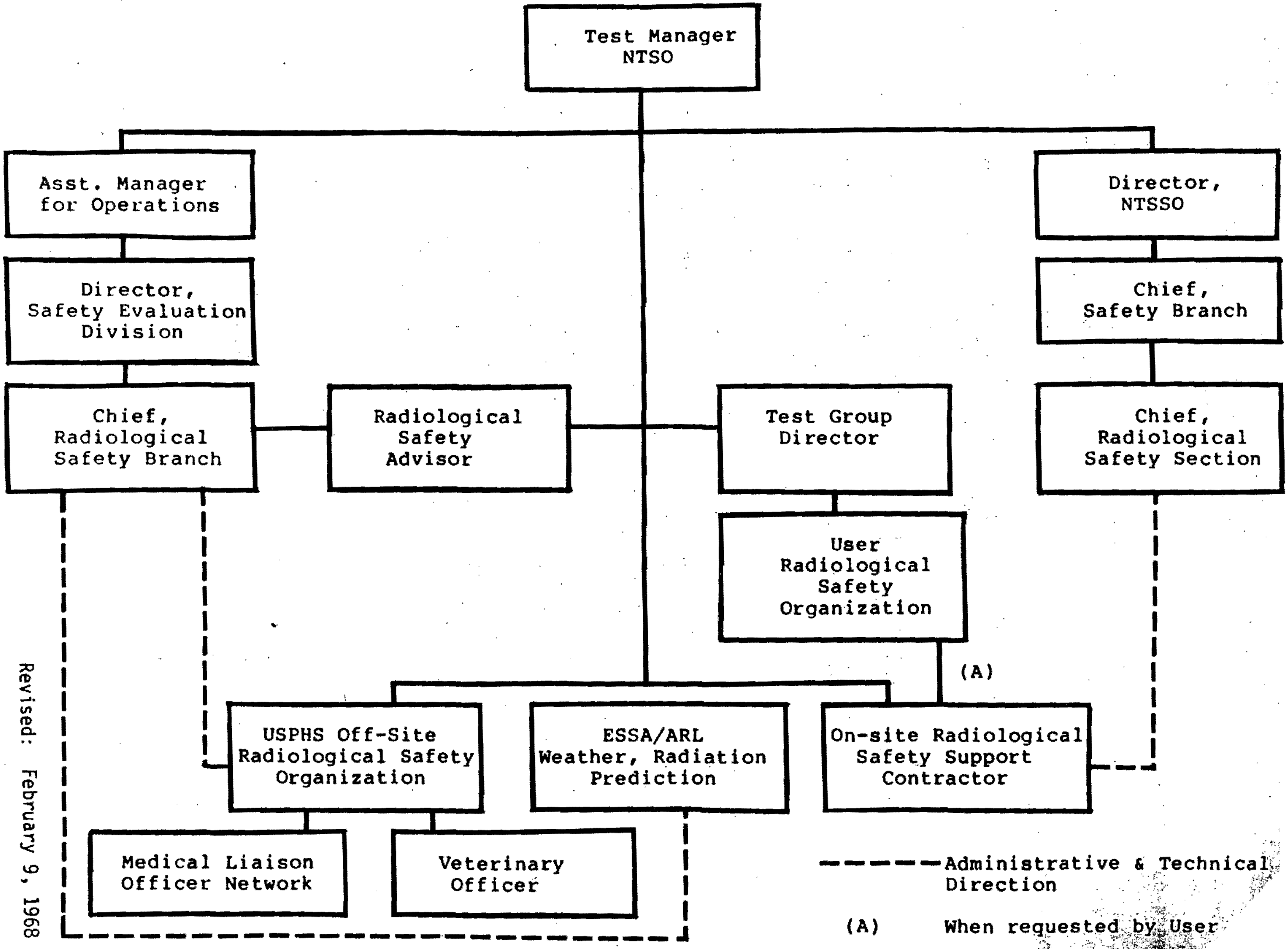

Figure I. Organization Chart
Radiological Safety Activities

l. Rem. A unit of dose equivalent. It is a unit found convenient in practice to express exposures to different types of ionizing radiation in terms that combine both the magnitude of the absorbed dose and its biological effectiveness. The dose equivalent is numerically equal to the dose in rads multiplied by the appropriate modifying factors.

m. Exposure Rate or Dose Rate. The time rate at which exposure or dose is measured or administered, i.e., dose or exposure per unit time, such as R/hr, rem/min, rad/hr, R/sec, etc.

0524-04 Radiation Protection Standards

041 Coverage. These standards shall govern ionizing radiation exposure to AEC and AEC contractor personnel and to other individuals who may be exposed to ionizing radiation from operations of the AEC and AEC contractors. These standards do not apply to radiation exposures resulting from natural radiation, medical and dental procedures, nor do they apply to the general population when the activities involved are essential to national security, such as nuclear weapons testing. The latter types of activities are covered by separate criteria. Safety criteria for each Plowshare event will be considered separately until such time as over-all policy for the Plowshare program is established. No operation shall be conducted until the radiological hazard has been evaluated and it has been determined to the satisfaction of the Test Manager, or the Test Group Director (when he has been delegated the radiological safety responsibility for the operation) that radiation exposures should not exceed the radiation protection standards established in AEC Manual Chapter 0524 (repeated below). Except for emergencies, written requests to expose personnel in excess of these limits should be directed to the Test Manager.

I. RADIATION PROTECTION STANDARDS FOR INDIVIDUALS IN CONTROLLED AREAS[1]

A. Radiation from sources external to the body

Type of Exposure	Period of Time	Dose (rem)
Whole body, head and trunk, active blood-forming organs gonads, or lens of eye.	Accumulated dose	5 (N-18)[2]
	Calendar quarter[3]	3[4]
	Year	30
Skin of whole body and thyroid	Calendar quarter[3]	10[4]
	Year	75
Hands, and forearms, feet and ankles	Calendar quarter[3]	25[4]

B. Radiation from emitters internal to the body

1. Except as provided in 2, below, the radiation protection standards for airborne radioactivity specified in annex I, table I, shall be followed. The concentration standards are based upon continuous exposure to the concentrations specified for forty hours per week (a "week" being seven consecutive days). For the purpose of applying these standards, radioactivity concentrations may be averaged over periods up to 13 consecutive weeks provided work areas are appropriately monitored and exposure histories are maintained for each individual working in such areas.

2. If it is not feasible to govern exposures to internal emitters by applying airborne radioactivity concentration standards, the following radiation protection standards shall apply:

Type of Exposure	Dose rem/year	rem/quarter
Whole body, active blood-forming organs, gonads.	5	3
Thyroid	30	10
Bone	Body burden of 0.1 microgram of radium-226 or its biological equivalent[5]	--
Other organs	15	5

The calculation of organ dose shall be based on methods recommended by the Federal Radiation Council and the International Commission on Radiological Protection.

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[1] An individual under age 18 shall not be employed in or allowed to enter controlled areas in such manner that he will receive doses of radiation in amounts exceeding the standards applicable to individuals in uncontrolled areas. Exposures to individuals under age 18 may be averaged over periods not to exceed one calendar quarter.

[2] N equals the age in years at last birthday. An individual employed at age 18 or an individual beyond age 18 who had no accrued unused exposure shall not be exposed during the ensuing year to doses exceeding (a) 1.25 rem for the first calendar quarter, (b) 2.5 rem total for the first two calendar quarters, (c) 3.75 rem total for the first three calendar quarters and (d) 5 rem for the year, but in not case will exposure be more than 3 rem per quarter.

[3] A calendar quarter may be taken as a predetermined period of 13 consecutive weeks or any predetermined quarter year based on the calendar.

[4] Personnel monitoring equipment shall be provided each individual who receives or is likely to receive a dose in any calendar quarter in excess of 10% of these values.

[5] Exposure must be governed such that the individual's body burden does not exceed this value (a) when averaged over any period of 12 consecutive months and (b) after 50 years of occupational exposure.

II. RADIATION PROTECTION STANDARDS FOR INDIVIDUALS AND POPULATION GROUPS IN UNCONTROLLED AREAS

A. Radiation dose standards for external and internal exposure

	Dose (rem/year)	
Type of Exposure	Based on exposure to individuals	Based on an average exposure to a suitable population sample
Whole body, gonads or bone marrow	0.5	0.17
Thyroid or bone	1.5	0.5
Bone (alternate standard)	Body burden of 0.003μg of radium 226 or its biological equivalent.	Body burden of 0.001μg of radium 226 or its biological equivalent.

B. Radioactivity in effluents released to uncontrolled areas

1. Except as provided in 2. below, radioactivity in effluents released to uncontrolled areas shall not exceed the radiation protection standards specified in annex I, table II. The point of release of such effluents shall be considered to be the point at which the effluents pass beyond the site boundary. Where such effluents are discharged through a conduit such as a stack or pipe, the point of release may be considered to be the conduit discharge. For the purpose of applying these standards, radioactivity concentrations in effluents may be averaged over periods up to one year.

2. Radioactivity in effluents may be released to uncontrolled areas in excess of the radiation protection standards specified in annex I, table II, provided it is reasonably demonstrated that in uncontrolled areas:

   (a) individuals are not exposed in excess of the standards specified in A. above.

   (b) individuals are not exposed in excess of annex I, table II standards, or

   (c) the average exposure of a suitable sample of an exposed population group is not in excess of one-third of annex I, table II standards. Radioactivity concentrations in the environment may be averaged over periods up to one year.

3. In any situation in which the contribution to radioactivity in the environment from effluents discharged by one or more activities of the AEC or AEC contractors is likely to result in exposures in excess of the standards specified in II.A. and B. above, lower effluent concentration limits may be set for these Operations. In such cases, the manager of the field office may take the necessary corrective action if all activities concerned are within his area of responsibility. Otherwise, each case will be referred to the Director, Division of Operational Safety, for appropriate action.

ANNEX I

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column 1 Air (µc/ml)	Column 2 Water (µc/ml)	Column 1 Air (µc/ml)	Column 2 Water (µc/ml)
Actinium (89)............	Ac 227	S	2×10^{-12}	6×10^{-5}	8×10^{-14}	2×10^{-6}
		I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228	S	8×10^{-8}	3×10^{-3}	3×10^{-9}	9×10^{-5}
		I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Americium (95)...........	Am 241	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
Antimony	Sb 122	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	2×10^{-8}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A 37	Sub[2]	6×10^{-3}	....	1×10^{-4}	....
	A 41	Sub	2×10^{-6}	....	4×10^{-8}	....
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-2}	1×10^{-8}	5×10^{-4}
	As 74	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	1×10^{-7}	2×10^{-3}	4×10^{-9}	5×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	As 77	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-5}	2×10^{-10}	2×10^{-6}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-5}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-2}	3×10^{-11}	6×10^{-4}
		I	1×10^{-7}	2×10^{-2}	4×10^{-9}	6×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	1×10^{-6}	5×10^{-2}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
	Bi 207	S	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
		I	1×10^{-8}	2×10^{-3}	5×10^{-10}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
		I	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Bi 212	S	1×10^{-7}	1×10^{-2}	3×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	7×10^{-9}	4×10^{-4}
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	3×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
		I	7×10^{-8}	5×10^{-3}	3×10^{-9}	2×10^{-4}
	Cd 115m	S	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
	Cd 115	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Ca 47	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-4}	5×10^{-14}	4×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cf 250	S	5×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 252	S	2×10^{-11}	7×10^{-4}	7×10^{-13}	2×10^{-5}
		I	1×10^{-10}	7×10^{-4}	4×10^{-12}	2×10^{-5}
Carbon (6)	C 14	S	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	(CO_2)	Sub	5×10^{-5}	....	1×10^{-6}	....
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	3×10^{-3}	5×10^{-9}	9×10^{-5}
	Ce 143	S	3×10^{-7}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	Ce 144	S	1×10^{-8}	3×10^{-4}	3×10^{-10}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Cesium (55)	Cs 131	S	1×10^{-5}	7×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-6}	3×10^{-2}	1×10^{-7}	9×10^{-4}
	Cs 134m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Cs 134	S	4×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	4×10^{-5}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
	Cs 135	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	9×10^{-8}	7×10^{-3}	3×10^{-9}	2×10^{-4}
	Cs 136	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
	Cs 137	S	6×10^{-8}	4×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-8}	2×10^{-3}	8×10^{-10}	6×10^{-5}
	Cl 38	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
Chromium (24)	Cr 51	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	2×10^{-6}	5×10^{-2}	8×10^{-8}	2×10^{-3}
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-2}	1×10^{-7}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	6×10^{-9}	4×10^{-4}
	Co 58m	S	2×10^{-5}	8×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	6×10^{-2}	3×10^{-7}	2×10^{-3}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-8}	3×10^{-3}	2×10^{-9}	9×10^{-5}
	Co 60	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	9×10^{-9}	1×10^{-3}	3×10^{-10}	3×10^{-5}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-4}	4×10^{-12}	2×10^{-5}
		I	2×10^{-10}	7×10^{-4}	6×10^{-12}	3×10^{-5}
	Cm 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	5×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cm 244	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cm 245	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 246	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Europium (63)	Eu 152	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	(T/2=9.2 hrs)	I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Eu 152	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-5}
	(T/2=13 yrs)	I	2×10^{-8}	2×10^{-3}	6×10^{-10}	8×10^{-5}
	Eu 154	S	4×10^{-9}	6×10^{-4}	1×10^{-10}	2×10^{-5}
		I	7×10^{-9}	6×10^{-4}	2×10^{-10}	2×10^{-5}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-4}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Germanium (32)	Ge 71	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
Gold (79)	Au 196	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
	Au 198	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Au 199	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	8×10^{-7}	4×10^{-3}	3×10^{-8}	2×10^{-4}
Hafnium (72)	Hf 181	S	4×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
		I	7×10^{-8}	2×10^{-3}	3×10^{-9}	7×10^{-5}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Hydrogen (1)	H3	S	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		Sub	2×10^{-3}	....	4×10^{-5}	....
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-2}	3×10^{-7}	1×10^{-3}
		I	7×10^{-6}	4×10^{-2}	2×10^{-7}	1×10^{-3}
	In 114m	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
	In 115m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
	In 115	S	2×10^{-7}	3×10^{-3}	9×10^{-9}	9×10^{-5}
		I	3×10^{-8}	3×10^{-3}	1×10^{-9}	9×10^{-5}
Iodine (53)	I 125	S	5×10^{-9}	4×10^{-5}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-3}	1×10^{-9}	2×10^{-5}
	I 129	S	2×10^{-9}	1×10^{-5}	2×10^{-11}	4×10^{-7}
		I	7×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
	I 131	S	9×10^{-9}	6×10^{-5}	1×10^{-10}	3×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	I 132	S	2×10^{-7}	2×10^{-3}	3×10^{-9}	8×10^{-6}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	I 133	S	3×10^{-8}	2×10^{-4}	1×10^{-10}	7×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	I 134	S	5×10^{-7}	4×10^{-3}	2×10^{-9}	1×10^{-5}
		I	3×10^{-6}	2×10^{-2}	1×10^{-7}	6×10^{-4}
	I 135	S	1×10^{-7}	7×10^{-4}	1×10^{-9}	2×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	9×10^{-10}	4×10^{-5}
	Ir 194	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-2}	3×10^{-8}	8×10^{-4}
		I	1×10^{-6}	7×10^{-2}	3×10^{-8}	2×10^{-3}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	5×10^{-5}
Krypton (36)	Kr 85m	Sub	6×10^{-6}	....	1×10^{-7}	....
	Kr 85	Sub	1×10^{-5}	....	3×10^{-7}	....
	Kr 87	Sub	1×10^{-6}	....	2×10^{-8}	....
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	1×10^{-7}	7×10^{-4}	4×10^{-9}	2×10^{-5}
Lead (82)	Pb 203	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-4}
	Pb 212	S	2×10^{-8}	6×10^{-4}	6×10^{-10}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Mn 54	S	4×10^{-7}	4×10^{-3}	1×10^{-9}	1×10^{-4}
		I	4×10^{-8}	3×10^{-3}	1×10^{-9}	1×10^{-4}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
	Hg 203	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
Molybdenum (42)	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-12}	7×10^{-5}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-5}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-5}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-4}
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-5}	1×10^{-13}	3×10^{-6}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
Nickel (28)	Ni 59	S	5×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	8×10^{-7}	6×10^{-2}	3×10^{-8}	2×10^{-3}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	7×10^{-4}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium (Columbium)(41)..	Nb 93m	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Nb 97	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	7×10^{-5}
	Os 191m	S	2×10^{-5}	7×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	7×10^{-2}	3×10^{-7}	2×10^{-3}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-5}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-2}	5×10^{-8}	3×10^{-4}
		I	7×10^{-7}	8×10^{-3}	3×10^{-8}	3×10^{-4}
	Pd 109	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Phosphorus (15)	P 32	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	8×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-5}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Pt 193m	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Pt 197m	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Plutonium (94)	Pu 238	S	2×10^{-12}	1×10^{-4}	7×10^{-14}	5×10^{-6}
		I	3×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 239	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 240	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-12}	2×10^{-4}
		I	4×10^{-8}	4×10^{-2}	1×10^{-9}	1×10^{-3}
	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-5}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	8×10^{-4}	7×10^{-12}	3×10^{-5}
Potassium (19)	K42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column 1 Air (µc/ml)	Column 2 Water (µc/ml)	Column 1 Air (µc/ml)	Column 2 Water (µc/ml)
	Pr 143	S	3x10^{-7}	1x10^{-3}	1x10^{-8}	5x10^{-5}
		I	2x10^{-7}	1x10^{-3}	6x10^{-9}	5x10^{-5}
Promethium (61)	Pm 147	S	6x10^{-8}	6x10^{-3}	2x10^{-9}	2x10^{-4}
		I	1x10^{-7}	6x10^{-3}	3x10^{-9}	2x10^{-4}
	Pm 149	S	3x10^{-7}	1x10^{-3}	1x10^{-8}	4x10^{-5}
		I	2x10^{-7}	1x10^{-3}	8x10^{-9}	4x10^{-5}
Protoactinium (91)	Pa 230	S	2x10^{-9}	7x10^{-3}	6x10^{-11}	2x10^{-4}
		I	8x10^{-10}	7x10^{-3}	3x10^{-11}	2x10^{-4}
	Pa 231	S	1x10^{-12}	3x10^{-5}	4x10^{-14}	9x10^{-7}
		I	1x10^{-10}	8x10^{-4}	4x10^{-12}	2x10^{-5}
	Pa 233	S	6x10^{-7}	4x10^{-3}	2x10^{-8}	1x10^{-4}
		I	2x10^{-7}	3x10^{-3}	6x10^{-9}	1x10^{-4}
Radium (88)	Ra 223	S	2x10^{-9}	2x10^{-5}	6x10^{-11}	7x10^{-7}
		I	2x10^{-10}	1x10^{-4}	8x10^{-12}	4x10^{-6}
	Ra 224	S	5x10^{-9}	7x10^{-5}	2x10^{-10}	2x10^{-6}
		I	7x10^{-10}	2x10^{-4}	2x10^{-11}	5x10^{-6}
	Ra 226	S	3X10^{-11}	4X10^{-7}	3X10^{-12}	3X10^{-8}
		I	5X10^{-11}	9X10^{-4}	2X10^{-12}	3X10^{-5}
	Ra 228	S	7X10^{-11}	8X10^{-7}	2X10^{-12}	3X10^{-8}
		I	4X10^{-11}	7X10^{-4}	1X10^{-12}	3X10^{-5}
Radon (86)	Rn 220	S	3x10^{-7}	....	1x10^{-8}	....
	Rn 222		1x10^{-7}	....	3x10^{-9}	....
Rhenium (75)	Re 183	S	3x10^{-6}	2x10^{-2}	9x10^{-8}	6x10^{-4}
		I	2x10^{-7}	8x10^{-3}	5x10^{-9}	3x10^{-4}
	Re 186	S	6x10^{-7}	3x10^{-3}	2x10^{-8}	9x10^{-5}
		I	2x10^{-7}	1x10^{-3}	8x10^{-9}	5x10^{-5}
	Re 187	S	9x10^{-6}	7x10^{-2}	3x10^{-7}	3x10^{-3}
		I	5x10^{-7}	4x10^{-2}	2x10^{-8}	2x10^{-3}
	Re 188	S	4x10^{-7}	2x10^{-3}	1x10^{-8}	6x10^{-5}
		I	2x10^{-7}	9x10^{-4}	6x10^{-9}	3x10^{-5}
Rhodium (45)	Rh 103m	S	8x10^{-5}	4x10^{-1}	3x10^{-6}	1x10^{-2}
		I	6x10^{-5}	3x10^{-1}	2x10^{-6}	1x10^{-2}
	Rh 105	S	8x10^{-7}	4x10^{-3}	3x10^{-8}	1x10^{-4}
		I	5x10^{-7}	3x10^{-3}	2x10^{-8}	1x10^{-4}
Rubidium (37)	Rb 86	S	3x10^{-7}	2x10^{-3}	1x10^{-8}	7x10^{-5}
		I	7x10^{-8}	7x10^{-4}	2x10^{-9}	2x10^{-5}
	Rb 87	S	5x10^{-7}	3x10^{-3}	2x10^{-8}	1x10^{-4}
		I	7x10^{-8}	5x10^{-3}	2x10^{-9}	2x10^{-4}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-8}	2×10^{-3}	3×10^{-9}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S	8×10^{-8}	4×10^{-4}	3×10^{-9}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-5}
		I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-5}
	Sm 151	S	6×10^{-8}	1×10^{-2}	2×10^{-9}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	8×10^{-10}	4×10^{-5}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-4}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	1×10^{-6}	6×10^{-3}	3×10^{-8}	2×10^{-4}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	8×10^{-8}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-8}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	9×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Na 24	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Strontium (38)	Sr 85m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
		I	3×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
	Sr 89	S	3×10^{-8}	3×10^{-4}	3×10^{-10}	3×10^{-6}
		I	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Sr 90	S	3×10^{-10}	1×10^{-5}	3×10^{-11}	3×10^{-7}
		I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
		I	3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-4}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-5}
Technetium (43)	Tc 96m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-3}
		I	3×10^{-5}	3×10^{-1}	1×10^{-6}	1×10^{-2}
	Tc 96	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Tc 99m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	1×10^{-5}	8×10^{-2}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column I Air (μc/ml)	Column 2 Water (μc/ml)	Column I Air (μc/ml)	Column 2 Water (μc/ml)
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	2×10^{-3}	9×10^{-10}	6×10^{-5}
Thorium (90)	Th 228	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	6×10^{-12}	4×10^{-4}	2×10^{-13}	10^{-5}
	Th 230	S	2×10^{-12}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}
	Th 232	S	3×10^{-11}	5×10^{-5}	10^{-12}	2×10^{-6}
		I	3×10^{-11}	10^{-3}	10^{-12}	4×10^{-5}
	Th natural	S	3×10^{-11}	6×10^{-5}	10^{-12}	10^{-6}
		I	3×10^{-11}	6×10^{-4}	10^{-12}	10^{-5}
	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-8}	5×10^{-4}	10^{-9}	3×10^{-5}
Thulium (69)	Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
	Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram)(74) ..	W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	4×10^{-9}	3×10^{-4}
	W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)	U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
		I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
	U 232	S	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
		I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
	U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 234	S	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 235	S	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	U 238	S	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
	U-natural	S	7×10^{-10}	1×10^{-3}	3×10^{-12}	2×10^{-5}
		I	6×10^{-10}	1×10^{-3}	2×10^{-12}	3×10^{-5}
Vanadium (23)	V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
		I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)	Xe 131m	Sub	2×10^{-5}	....	4×10^{-7}	....
	Xe 133	Sub	1×10^{-5}	....	3×10^{-7}	....
	Xe 135	Sub	4×10^{-6}	....	1×10^{-7}	....
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)	Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	Y 91m	S	2×10^{-5}	1×10^{-1}	8×10^{-7}	3×10^{-3}
		I	2×10^{-5}	1×10^{-1}	6×10^{-7}	3×10^{-3}
	Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-4}
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-2}	4×10^{-9}	8×10^{-4}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND-continued

(See notes at end of annex)

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column I Air (μc/ml)	Column 2 Water (μc/ml)	Column I Air (μc/ml)	Column 2 Water (μc/ml)
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in an infinite cloud of gaseous material.

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Annex should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Annex I for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's, are MPC_A, and MPC_B and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \frac{C_C}{MPC_C} \leq 1$$

2. If either the identity of the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Annex I shall be:

a. For purposes of Table I, Col. 1-1 X 10^{-12}

b. For purposes of Table I, Col. 2-3 X 10^{-7}

c. For purposes of Table II, Col. 1-4 X 10^{-14}

d. For purposes of Table II, Col. 2-1 X 10^{-5}

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identify of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Annex I for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identify of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Annex I are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Annex I for any radionuclide which is not known to be absent from the mixture; or

c. Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
If it is known that Sr 90, I 129, Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th 232, and Th-nat, are not present......................	....	$9x10^{-5}$	....	$3x10^{-6}$
If it is known that Sr 90, I 129, Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Ra 231, and Th-nat, are not present........	....	$6x10^{-5}$	....	$2x10^{-6}$
If it is known that Sr 90, Pb 210, Ra 226, Ra 228, are not present..	....	$2x10^{-5}$	....	$6x10^{-7}$
If it is known Ra 226 and Ra 228, are not present...........	....	$3x10^{-6}$	....	$1x10^{-7}$
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 249 are not present..	$3x10^{-9}$	....	$1x10^{-10}$	....
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228 and Pu 241, are not present.......................	$3\text{-}10^{-10}$	....	$1x10^{-11}$	....
If it is known that alpha-emitters and Ac 227 are not present..	$3x10^{-11}$	....	$1x10^{-12}$	....
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, and Cf 249, are not present.............	$3x10^{-12}$	....	$1x10^{-13}$	....
If Pa 231, Pu 239, Pu 240, Pu 242 and Cf 249 are not present.	$2x10^{-12}$	....	$7x10^{-14}$	....

4. If the mixture of radionuclides consists of uranium and its daughter products in ore dust prior to chemical processing of the uranium ore, the values specified below may be used in lieu of those determined in accordance with paragraph 1 above or those specified in paragraphs 2 and 3 above.

a. For purposes of Table I, Col. 1-1 X 10^{-10} μc/ml gross alpha activity; or 2.5 X 10^{-11} μc/ml natural uranium; or 75 micrograms per cubic meter or air natural uranium.

b. For purposes of Table II, Col. 1-3 X 10^{-11} μc/ml gross alpha activity; or 8 X 10^{-13} μc/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

5. For purposes of this note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Annex I (MPC_A) does not exceed 1/10,

$$\text{i.e.}\quad \frac{C_A}{MPC_A} \leq \frac{1}{10}$$

and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed 1/4.

$$\text{i.e.}\quad \frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \dots \leq \frac{1}{4}$$

APPENDIX E

U.S. ATOMIC ENERGY COMMISSION
STANDARD OPERATING PROCEDURE
NEVADA TEST SITE ORGANIZATION

NTSO-0101-01

CHAPTER 0101 THE NEVADA TEST SITE ORGANIZATION (NTSO)

0101-01 General

011 The Nevada Test Site

The Nevada Test Site (NTS) is a facility provided by the Atomic Energy Commission and managed by the AEC Nevada Operations Office (NV). The NTS supports the field test programs of the AEC and its contractors, the Department of Defense, and others authorized to be conducted at the NTS.

012 The Nevada Test Site Organization (NTSO)

The Nevada Test Site Organization (NTSO) includes AEC, DOD, Laboratory, contractor, agency and organizational personnel who participate in, or provide support for, test operations at the Nevada Test Site (NTS). The Manager, NV, as the Site Manager, heads the NTSO (see Appendix "A").

0101-02 Organizational Concept and Policies

021 Nevada Test Site Organization (NTSO)

The Nevada Test Site Organization is a continuing task organization whose composition may be readily changed in response to the needs and technical objectives of the test program.

022 The NV staff, for the Manager, provides for the approval and coordination of program proposals, approvals for project support, funding and/or authority for financial agreement, legal counsel, contract authority and administration, engineering, accounting, classification and security policy and guidance, safety policy and guidance, environmental safety analyses, industrial relations, and public information policy to the NTSO.

023 Test execution shall conform to statutory, regulatory, and other responsibilities in accordance with delegations to the Manager, NV, by the General Manager of the Atomic Energy Commission.

024 Technical users are allowed maximum technical latitude in the conduct of their scientific programs and are responsible for their technical readiness.

025 User groups may be assigned areas in which to conduct their operations and exercise technical control subject to operational site coordination and control exercised by the Site Manager or, during a Test Execution Period, the Test Controller.

026 The Site Manager, NTS, has the authority to approve or disapprove the field execution of tests that have been approved by Headquarters AEC. During the Test Execution Period, authority to proceed with or postpone the field execution of approved activities or tests is delegated to the Test Controller in accordance with his Delegation of Authority from the Manager, NV.

0101-03 Responsibilities

031 The Site Manager is responsible for administering the NTS, for all preparations required for the safe execution of programs and projects at the NTS and for providing construction and logistic support services and facilities required to support the technical users.

032 The Test Controller is responsible to the Manager, NV, for the conduct of those experiments and test events in the testing program to which he is assigned by the Manager, NV.

033 The Deputy, Military Matters (Director, Test Directorate, FCDNA), serves as deputy for the Site Manager on operational, administrative and support matters pertaining to all DNA activities.

034 The Scientific Manager's Advisory Panel is chaired by a Scientific Advisor designated by the Manager, NV, as nominated by the technical user. Members of the panel provide advice on matters relative to on- and off-site safety.

035 The Test Group Directors (TGD) are assigned by the scientific sponsor to direct the fielding and technical aspects of experiments and tests. He reports to the Test Controller on operational matters relating to test execution.

036 The Director, Logistics Support, is responsible for the direction and control of construction and logistical support activities at the NTS and during Test Execution Periods, supports the Test Controller directly in the field execution of experiments and test events.

037 The Director, Operational Support, aided by the Operations Control Group and Special Staff assigned from NV as required, provides advice, assistance and serves as principal operations coordinator for the Site Manager and during the Test Execution Period, as Director of Operations for the Test Controller.

038 The Control Point Coordinator assures the availability in the OCC of facilities and equipment for the control and coordination of NTS operational activities.

039 The Test Operations Officer supervises the preparation of the Test Controller's operation and security plan and other required plans as directed. He coordinates preparations for the test execution and forward area support. During the Test Execution Period, he assists the Director of Operations in supervising and coordinating execution of the operations and security plan as directed by the Test Controller.

040 The Test Liaison Officer provides oral communication of test-related operational information from the operational control point (NTS) to NV and the Test Operations Center (TOC) AEC HQ during the Test Execution Period.

041 The FCDNA, Test Construction Division, is responsible for directing DOD furnished support.

042 The Technical Program Groups consist of organizational units and staff to satisfy the program objectives of their parent organizations.

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1. PA CONTROL NUMBER: PA 13-385
1a. SUSPENSE:
2. PM / PHONE / EMAIL: Dr. Paul Blake,
2a. DATE: 10 May 2013
3. BRANCH CHIEF / PHONE /EMAIL: N/A
3a. DATE: N/A
4. DIVISION CHIEF / PHONE: N/A
4a. DATE: N/A
5. DEPARTMENTS / PHONE: N/A
5a. DATE: N/A
6. JDir/ OFFICE / PHONE: Byron L. Ristvet, DTRA Dep STI Mgr
6a. DATE: 06 June 2013
7. PUBLIC AFFAIRS: Richard M. Idle
7a. DATE: 10 Jun 2013

8. TITLE: DNA 6322F; DNA 6323F; DNA 6324F; DNA 6325F: DNA 6327F
9. CONTRACT NUMBER:
10. ORIGINATOR: DNA
11. TYPE OF MATERIAL: ☒ PAPER ☐ PRESENTATION ☐ ABSTRACT ☐ OTHER

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REMARKS CONT:

The following DNA Reports have been carefully reviewed and are recommended for public release. These reports are a part of the DoD/ DTRA Nuclear Test Personnel Records program. In 1979, Admiral Robert Monroe, DNA Director directed that any DNA, DASA, or AFSWP reports supporting the NTPR program were to be reviewed, extracted, sanitized, etc., in order to provide them the public, such that appearance that the Agency was hiding relevant data could be adverted. The documents listed below are personnel-oriented histories of DoD participation in underground nuclear weapons testing during specific AEC, ERDA or DoE operations. Why these documents, which were originally assigned Distribution C, Critical Technology, but not included in that review direction is unknown. However, I, as UGT SME, and Herb Hoppe have reviewed and in our judgement see no reason for restricted distribution. We recommend their immediate public release. The five reports are:

DNA 6322F, Operations CROSSTIE and BOWLINE, 31 August 1967 - 20 November 1968.
DNA 6323F, Operations MANDREL and GROMMET, 12 September 1969 to 02 May 1972
DNA 6324F, Operations TOGGLE, ARBOR, and BEDROCK, 20 July 1972 - 05 April 1975
DNA 6325F, Operations ANVIL, CRESSET, TINDERBOX, and GUARDIAN, 24 October 1975 - 31 October 1980
DNA6227F, Operations PRAETROIAN, PHALANX, FUSILLEER, AND GRENADIER, 23 September 19882 - 06 April 1985
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Byron L. Ristvet, Ph.D.
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