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(WT-2725)

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OPERATION MILD WIND

SHOT PIN STRIPE

PROJECT OFFICERS REPORT—PROJECT 9.1

TECHNICAL DIRECTOR'S SUMMARY REPORT [redacted]

[redacted]

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Defense Nuclear Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

IMTS 23 August 1994

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OPERATION MILD WIND

SHOT PIN STRIPE

PROJECT OFFICERS REPORT—PROJECT 9.1

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TECHNICAL DIRECTOR'S SUMMARY REPORT [redacted]

E. E. Conrad, Technical Director

U. S. Army Harry Diamond Laboratories
Washington, D. C. 20438

A. T. Schiff

Nuclear Defense Research Corporation
Albuquerque, New Mexico 87108

Issuance Date: 15 October 1969

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ABSTRACT

[redacted] This report describes the planning, preparation and execution on 25 April 1966 of Pin Stripe, the third underground nuclear weapon effects test in the Department of Defense Silver Bell series. The experiments in this test were exposed to the [redacted]

[redacted] The objective of Pin Stripe was to more accurately simulate an operational nuclear environment than could be produced in a laboratory [redacted]

[redacted] The primary emphasis was placed on experiments directly related to the major military systems. However, considerable exposure space also was allocated to radiation effects physics experiments as well as to investigations of improved techniques for future field tests.

[redacted] In spite of the failure to completely contain the detonation products, nearly all of the major experimental goals were met.

[redacted]

[redacted]

Considerable [redacted] information of significant value also was obtained. Additionally, several experiments to improve underground test techniques provided the answers sought.

[redacted]

[redacted]

CONTENTS

[redacted]

TABLES

FIGURES

[redacted]

[redacted]

CHAPTER 1

INTRODUCTION

[redacted] Pin Stripe, an underground nuclear weapons effects test sponsored by the Department of Defense, was the third test in the Silver Bell series [redacted]. It was conducted on April 25, 1966, in Area 11 of the Atomic Energy Commission's Nevada Test Site (NTS). [redacted] The test configuration consisted of [redacted] vertical line-of-sight (LOS) pipe between the device buried at [redacted]. A series of closure mechanisms was placed at various distances along the pipe to prevent the release of gases and debris following the radiation. The experiments were placed on three floors of a tower. The radiation exposure for each experiment was determined by taking into account the shielding factor introduced by experiments on the lower floors as well as any additional shielding which was added to homogenize the radiation beam. In this way an exposure area of three times that produced by the pipe opening was obtained.

[redacted]

[redacted]

[redacted] The behavior of the various experiments was monitored during the exposure by oscilloscopes and tape recorders placed in trailers at a distance of [redacted] from the tower. Electrical cables were connected between the experiments on the tower and the recording apparatus in the trailer park. The trailers were unmanned during the test and were operated by a central timing system.

[redacted] The objective of the Pin Stripe test was to assist in establishing the validity of laboratory simulation and theoretical analysis of [redacted] The fundamental knowledge [redacted] that has been developed in the Defense Atomic Support Agency (DASA) sponsored research program and in the previous tests of this series was applied in this test. The validity of extrapolating vulnerability and hardening information as determined by laboratory results to the [redacted] environment of a simulated operational weapon detonation was to be verified. Experiments were included to confirm the design of hardened components, circuits, modules, and subsystems developed to meet the military requirement for system hardness. Basic experiments were conducted in radiation measurement and component response to provide fundamental information for the design of instrumentation and electronic equipment.

[redacted]

[redacted]

In each experiment, observed responses were correlated to laboratory responses, to provide an improved confidence in the prediction of operational system response based on exposure in a laboratory environment.

[redacted] The concept of the experiment departed from the previous shots in the series in several significant ways.

[redacted] The release of effluence in Diluted Waters* dictated a significant change in the vertical LOS closure and stemming systems and in turn a change in the geographical location of vertical LOS events. [redacted] All of the foregoing considerations and the circumstances leading to the departures from previous procedures are discussed in Chapter 2 of this report.

* Event No. 2 in Silver Bell/Mild Wind series.

[redacted]

[redacted]

[redacted] The administrative staff for Pin Stripe included Lt. Col. E. J. Willcox, USA, DASA Weapons Test Division as Test Group Director, Col. J. A. B. Bower, USAF, as Deputy Test Group Director, Edward E. Conrad, Harry Diamond Laboratories, as the Technical Director, and Capt. A. T. Schiff, USAF, as the DOD Program Director. Mr. R. D. Statler of Sandia Corporation was in charge of down-hole design and construction, and Mr. H. J. Schulein was in charge of surface design and construction. The DOD experimental program was assembled by Major W. A. Alfonte, USA, [redacted] his replacement Major J. J. McGee, USAF, Capt. A. V. Polk, USAF, [redacted] and E. E. Conrad, the Technical Director.

[redacted] As in previou [redacted] tests, space was shared with the Atomic Energy Commission (AEC) laboratories. In this particular test one-third of the exposure area was allocated to the AEC. The coordination of the AEC experiments was performed by A. W. Snyder of Sandia Corporation.

[redacted]

[redacted]

CHAPTER 2

TEST CHRONOLOGY

2.1 PLANNING

[redacted] Pin Stripe was added to the DASA test schedule in mid-1964 with a planned execution date of November 1965. In November 1964, a decision was made to drill the vertical emplacement hole for this event at a site designated U5c near the drilled holes to be employed for the Wish Bone and Diluted Waters events (see Figure 2.1). The hole was completed in December. At this point in time the planned configuration for Pin Stripe was [redacted] LOS [redacted]. The source was to be at a depth similar to that of Diluted Waters (~650 feet), and [redacted] experiment tower was being considered. Planning based on this configuration continued through the spring and summer of 1965, i.e., the period of execution of Wish Bone (February 1965) and Diluted Waters (June 1965) and the planning for the Sandia Corporation Derringer event then scheduled for September 1965 and configured similar to Pin Stripe.

[redacted] The experimental proposals for Pin Stripe were first considered in early March 1965, prior to the Diluted Waters event.

[redacted] [redacted]

[redacted]

Oral presentations of the service proposals were made and considered during the period of March 18 to 25, 1965. Each of the services had proposed elaborate experiments for their major systems. [redacted]

Additionally, numerous research-oriented experiments were proposed by the services and by DASA.

[redacted] The experimental program was assembled and the Pin Stripe program document prepared for the Director of Defense Research and Engineering (DDR&E) in July 1965 (Reference 1). DDR&E approved the Pin Stripe program in August 1965. The experiments included in Pin Stripe and a summary of their results are discussed in Chapter 3.

[redacted] The selection of the source for Pin Stripe was based upon the requirements of the major proposed system experiments;

[redacted] [redacted]

Page 13 removed

[redacted]

[redacted]

[redacted] During the summer and fall of 1965, several additional experiments were incorporated into the program. In addition to the loss of the Minuteman experiment, one other experiment was deferred to another test as it was determined that its requirements could not adequately be met on Pin Stripe, and one experiment was deleted. These changes in the experimental program are indicated in Table 3.1. In addition to the DOD experiments described above, Sandia Corporation participated with a number of experiments on their own and on LASL's behalf. LASL also performed device diagnostic measurements, and Sandia made measurements pertaining to the performance of the LOS pipe closure systems.

[redacted] After considerable study and discussion, it was determined

[redacted]

[redacted]

that Pin Stripe would employ the mobile tower concept initially tested on a small scale during Wish Bone. This concept is described in detail, and the philosophy regarding its use is discussed in Appendix A of this report.

[redacted] Subsequent to the Diluted Waters event in June 1965, a major reconsideration of the Pin Stripe configuration was undertaken to correct designs and procedures which were believed to have caused the containment problems of Diluted Waters (Reference 2). (A complete discussion of the LOS design and stemming considerations is contained in Appendix B.) This redesign of the test geometry which took place during the early fall of 1965 resulted in a considerably revised Pin Stripe configuration underground and consequently a slip in the test schedule.

[redacted] The new depth of burial was 970-feet, and the yield was [redacted]t the top of the LOS pipe. The increased depth required larger diameter pipe and thus closure mechanisms larger than those capable of being lowered into a reasonably sized, cased, drill hole, necessitating the mining of a [redacted] shaft, 980 feet deep. The increased depth also required a new test area at a surface elevation higher than available near the original Pin Stripe site (U5c). The chosen site was about 6 miles

[redacted]

[redacted]

north of U5c and was designated U11b at Nevada State coordinates N778,799.85, E712,299.59 at an elevation of 3586 feet above mean sea level and 1176 feet above the static water table (see Figure 2.1). The result of these changes in the test configuration was a change in the execution date from November 1965 to April 1966.

[redacted] The initial Pin Stripe project officers' meeting was held in late May 1965 to obtain the individual experimental support requirements and to investigate the interactions among them that would determine the overall requirements affecting the test configuration. After this first meeting, a second project officers' meeting normally would have been held in the summer of 1965 to finalize these requirements and to assist in integrating the experiment designs. In place of this second *meeting*, visits to the individual project agencies at their own laboratories were determined to be more beneficial. (This technique for information gathering and assistance in the design phases of experiment preparation has proven itself on Pin Stripe as well as on subsequent tests.)

[redacted] By September of 1965 the overall configuration of the Pin Stripe test, layout of experiments on the [redacted] tower and the trailers in the trailer park, as well as the general operational concepts, were firmly in hand. The configura-

[redacted]

tion of the test area is depicted in Figures 2.2 and 2.3 and the individual floor layouts are shown in Figures 2.4 through 2.7.

2.2 PREPARATION

[redacted] Construction at the new Pin Stripe site (U11b) started in October 1965, with preparation for the shaft mining. The construction activities schedule is summarized in Figure 2.8. Actual mining commenced in November, and the shaft was completed in early March 1966. [redacted]

[redacted] During this field construction phase, all of the experimenters were completing fielding preparations and fabricating their experiments in the laboratory. These activities were accomplished at a relatively easy pace due to the stretch out in the Pin Stripe test schedule. Experimenters started arriving on site in late

[redacted]

January 1966 to set up and check out their instrumentation trailers and prepare the experiments [redacted] in February and March.

[redacted] Early in the field installation phase, the advantages of electric motor-driven generators for furnishing isolated, regulated, power to the instrumentation trailers over the previously used diesel-engine-driven generators were considered. While the motor generators offered better overall reliability, there was some question as to possible difficult ground isolation and power losses during area power outages before and just after shot time. The controversy was settled when it became apparent that only a very few motor-driven generators could be made available. Thus, the majority of the instrumentation trailers was powered by the usual diesel generators while only a few, the 2.8, 2.11, and 2.12 trailers, were powered by motor generators. After a few initial problems with these generators, primarily due to unfamiliarity with them, their reliability was proven.

[redacted] The line-of-sight (LOS) pipe and the closure hardware were delivered several pieces at a time during February and March 1966 [redacted]

[redacted]

[redacted]

[redacted] Just prior to starting pipe installation it was discovered that the bolts to be used to fasten the pipe sections together were of sub-standard quality (lacking in tensile strength). Although no major problem was encountered, the pipe installation and the dry runs were delayed several days while new bolts were procured.

[redacted] Signal dry runs commenced in late February for a planned period of four weeks prior to the full power, full frequency dry run (FPFF). During this time instrumentation trailers and experimental sequencing systems were checked out with the test site timing system installed in a trailer parked near the control point (CP1). Near the end of this period and just prior to the FPFF, several electrical leakage paths between various signal cable shields and earth ground were discovered and subsequently eliminated. These and other cable problems are discussed in Appendix C. The detailed dry run procedures for the [redacted] tower, electrical timing, and data recovery are discussed in Appendix D.

[redacted]

[redacted] After the FPFF was successfully completed, the device was inserted and the stemming operation began. Due to uncertainties in the time required for stemming, three weeks were planned for this effort. Stemming proceeded slightly faster than anticipated; however, the majority of the three weeks was employed to emplace the stemming material and to check the line of sight pipe, hardware and closure systems, and to install the pipe diagnostics instrumentation and cabling.

[redacted] An intrusion into th[redacted]beam, apparently caused by a small offset in the lower pipe sections due to unsymmetrical stemming of the shaft, was observed during this final alignment check. The intrusion took the form of a vignette less than one inch in from the northwest edge of the LOS. Due to the umbra/penumbra considerations of the shadowing, a very small portion of the Project 2.4 and 2.5 experiments was affected by a radiation attenuation of less than 10 percent. Since this was not significant, remedial action was not considered necessary.

[redacted] Once the LOS pipe was installed and checked out, the walls were removed from the sides of the tower and access to the tower was reduced for safety reasons. [redacted]

[redacted]

[redacted] The cables leading from the experiments back to the instrumentation trailers were supported on scaffolding-type cable towers adjacent to the test tower (see Figure 2.9). Due to the movement of the tower and scientific cables and the long intervening time since the FPFF, a mandatory participation dry run was held to once more check the continuity and operation of the entire experimental and electrical system. Final checks were made on all systems, and the test was scheduled for April 19th. Unfavorable winds (both velocity and direction) plagued the test for six days. Although an attempt to fire on one other day was made, Pin Stripe was not executed until April 25th (portions of the AEC Test Manager's Readiness Briefing Notes are reproduced in Appendix E).

2.3 EXECUTION

[redacted] The readiness briefing on April 24 initially scheduled the shot for 1000 on the morning of April 25. However, undesirable wind direction and low wind speeds required continual postponement that morning. NTS and Pin Stripe surface wind criteria determined that a southerly wind of at least 5 knots was required to provide adequate fallout protection for the trailer park as well as the rest of the test site and to comply with the Limited Nuclear Test Ban Treaty. The 30-minute countdown finally was started at 11:08 and

[redacted]

proceeded uneventfully. Pin Stripe was detonated at 11:38:0.143 PDT with shot time surface winds of 6 mph from 190°.

[redacted] For approximately the first minute after the detonation all indications were as expected, i.e., the ground heaved and some amount of dust was thrown into the air. [redacted]

[redacted] At approximately the same time effluence began to emerge from the ground at a point some 150 feet southwest of SGZ (see Figure 2.10). The point of emergence lengthened into a line extending toward SGZ in a few seconds and further away from SGZ a few tens of seconds later. A gray cloud formed, growing until subsidence occurred at H+ 4 minutes and 25 seconds at which time the cloud had a volume of approximately 10^9 cubic feet. The subsidence crater was elliptical, approximately 135 by 245 feet, elongated in the direction of the surface crack from which the effluence emerged and a maximum of only 14 feet deep (see Figure 2.11). The crater volume was 33,000 cubic yards.

[redacted] The cloud rose to an altitude of about 2000 feet over the test area as it was blown by the winds in the NNE direction (see Figure 2.12). As planned for such an occurrence, the wind did not take the effluent material directly over the trailer park.

[redacted]

However, significant radiation dose was delivered to the trailers and to the recording equipment inside them by gamma shine from the radioactive material in the cloud. Winds continued to blow the cloud over the northeastern portions of the Nevada Test Site. It then progressed off site and over several western states (Reference 3).

[redacted] Remote area monitors (RAMS) provided readings of radiation levels in the trailer park of up to 400 R/hour for 2 to 3 minutes which rapidly decayed until at about H+ 20 minutes the readings were approximately 15 to 20 R/hour. According to plans (see Appendix D), permission was requested from the Test Manager to proceed with high priority data recovery and was granted at H+ 20 minutes. The initial hazards survey party and priority film recovery parties then departed the reentry assembly area with instructions not to enter areas where the exposure rate was greater than 17 R/hour. All high priority film recovery was completed by H+ 35 minutes. The remainder of the film and oscillograph paper was recovered by H+ 80 minutes.

[redacted] Since very little radioactive material actually was deposited in the Pin Stripe area the radiation readings dropped fairly rapidly [redacted]

[redacted]

[redacted] Radiation dosimetry on the tower was recovered, and several experiment packages were removed from the tower by H+ 7-1/2 hours. During the next day all experiments were recovered and were prepared for shipment to project agency laboratories. Long term work in the trailer park was begun on D+1 to read out tape data and prepare the trailers for shipment to other tests or back to agency laboratories.

[redacted] Initial data indicated that radiation exposures in the trailers varied with trailer location, trailer construction and location in the trailer from several R up to perhaps more than 50 R and presented a picture initially considerably blacker than that of Diluted Waters. Considerable data was recovered from many data films; however, some film data was lost. Processing of the recovered film and analysis of the film data are described in Appendix F.

[redacted] The first two months postshot were taken up with what initial data analysis could be accomplished by the experimenters and by preparation of the quick look film report on Pin Stripe (Reference 4). This latter activity was made considerably easier by the fact that a script writer was assigned to the film by Lookout Mountain Air Force Station quite early in the Pin Stripe program.

[redacted]

Thus the majority of the script preparation and background film production had been completed well before the event took place.

[redacted] Because of the wide variation among projects in the amount of film data recovered, some Project Officers Interim Reports (POIRs) were delayed to allow experimenters to incorporate in them what data might be obtained through careful film processing. The final results of each experiment are summarized in Chapter 3 of this report and are of course contained in the POIRs and PORs of the individual projects (see Table 3.1). The radiation environment to which the experiments were exposed also is discussed in Chapter 3.

[redacted] Postshot examination of the test area and re-examination of the preshot geological data led to the conclusion that the venting took place because the underground cavity pressures communicated through a geological fault with the tuff/alluvium interface at a depth of 190 feet. The pressures were too great to be held by the alluvium (see Appendix B and Reference 5).

2.4 BUDGET

[redacted] The original Pin Stripe budget as approved by DDR&E (Reference 1) was $4,415,000 and was sub-divided into construction, support, and experimental program costs. This initial

[redacted]

[redacted]

estimate was based on using a drilled emplacement hole (U5c) near the previous holes used for Wish Bone and Diluted Waters. In September 1965, after the revised test configuration was adopted, a new cost of $4,896,000 was estimated. The increase was primarily due to the additional construction costs anticipated for the shaft mining and the costs for several added experiments. The final Pin Stripe costs, at $4,982,000, were slightly higher than the pre-shot estimates but only about 10 percent higher than the originally approved budget for the drilled hole configuration. The breakdowns of these costs are summarized in Table 2.1.

[redacted]

[redacted]

TABLE 2.[redacted] PIN STRIPE BUDGET AND FINAL COSTS [redacted]

Item/Agency	September 1965 (Revised Configuration)	Final	Remarks
Construction			
Construction/REECo	$1,965	$2,249	Added U5c costs
Architect-Engineer/H&N	100	138	Underestimated
Architect-Engineer/F&S	25	65	Underestimated
[redacted] Tower/Boeing	50	52	
LOS Pipe/Sandia Corp.	437	500	Underestimated
U5c Costs	172	0	Included in REECo
Sub-totals	$2,749	$3,004	
Support			
Logistics/DASA	$ 20	$ 127	Some items previously included in REECo
Travel/Sandia Corp.	14	0	Included in LOS pipe
Reports/AEC - Oak Ridge	15	0	Funded separately
Radiation Safety/Sandia Corp.	5	6	
Geological Services/USGS	10	18	Increased scope
Technical Director/HDL	225	110	Overestimated
Photo/EG&G	*	12	Added
Timing Equip./EG&G	*	22	Added
Const. Inspector/Corps of Engr.	*	3	Added
Sub-totals	$ 289	$ 298	
Experimental Program**	$1,858	$1,680	
Totals	$4,896	$4,982	

* Not included in estimate

** See Table 3.2 for details

[redacted]

[redacted]

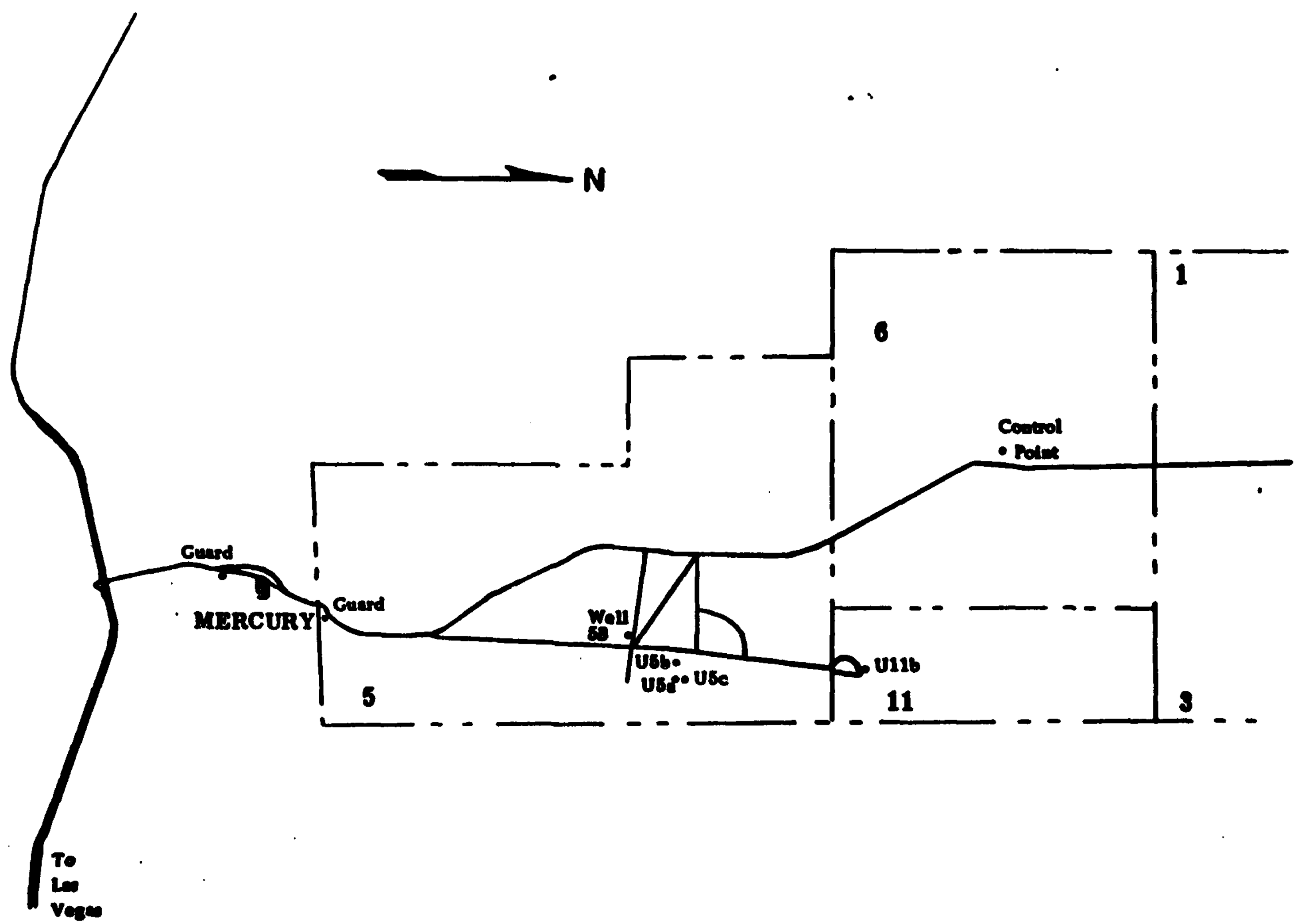


Figure 2.1 [redacted] Portion of Nevada Test Site showing Pin Stripe location. [redacted]

[redacted]

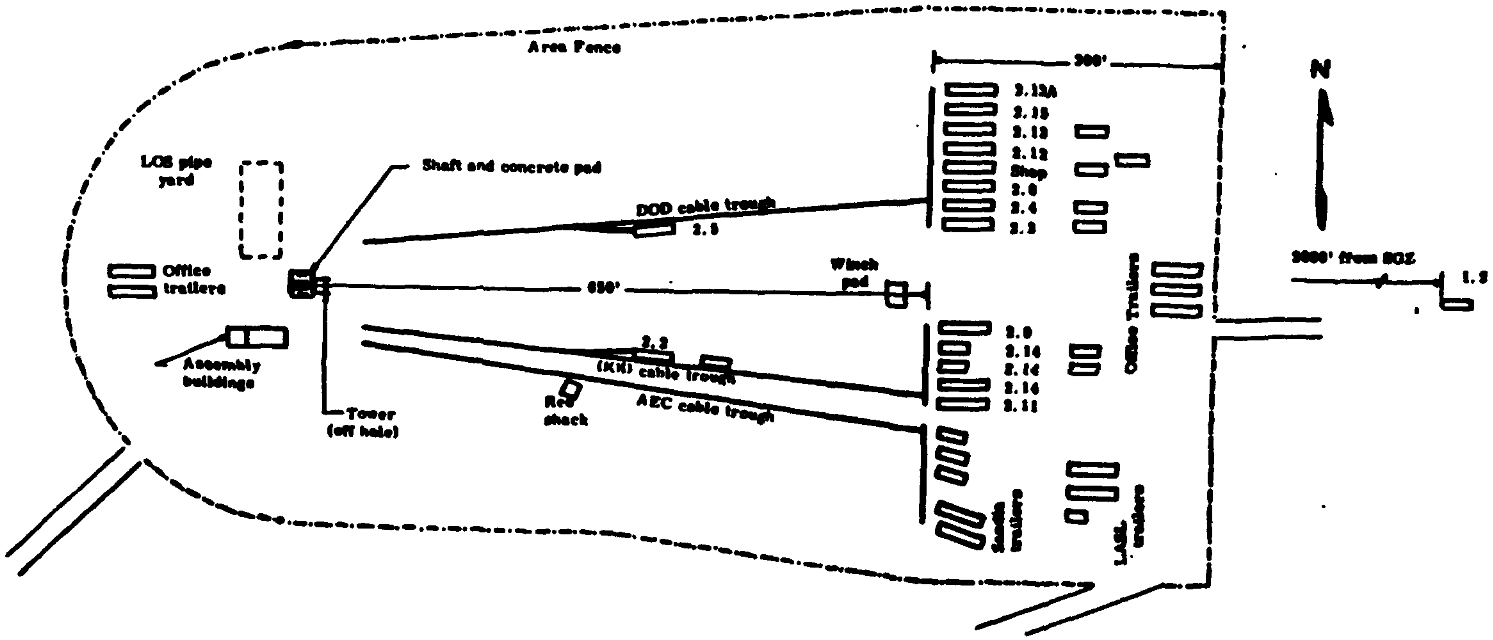


Figure 2.2 (U) Pie Stripe test layout. [redacted]

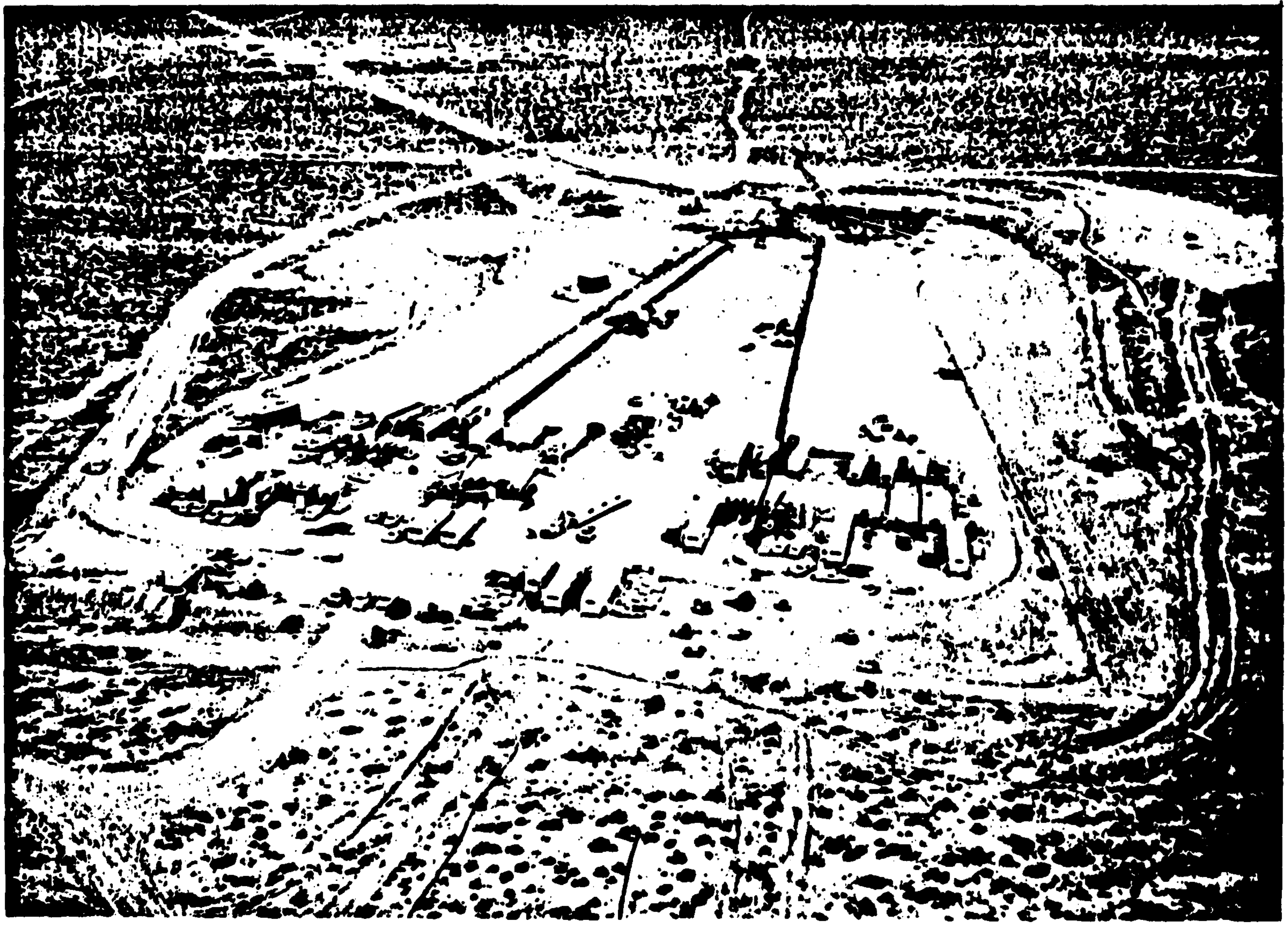


Figure 2.3 [redacted] Pin Stripe aerial photograph, preshot. (DASA 142-07-NTS-66) [redacted]

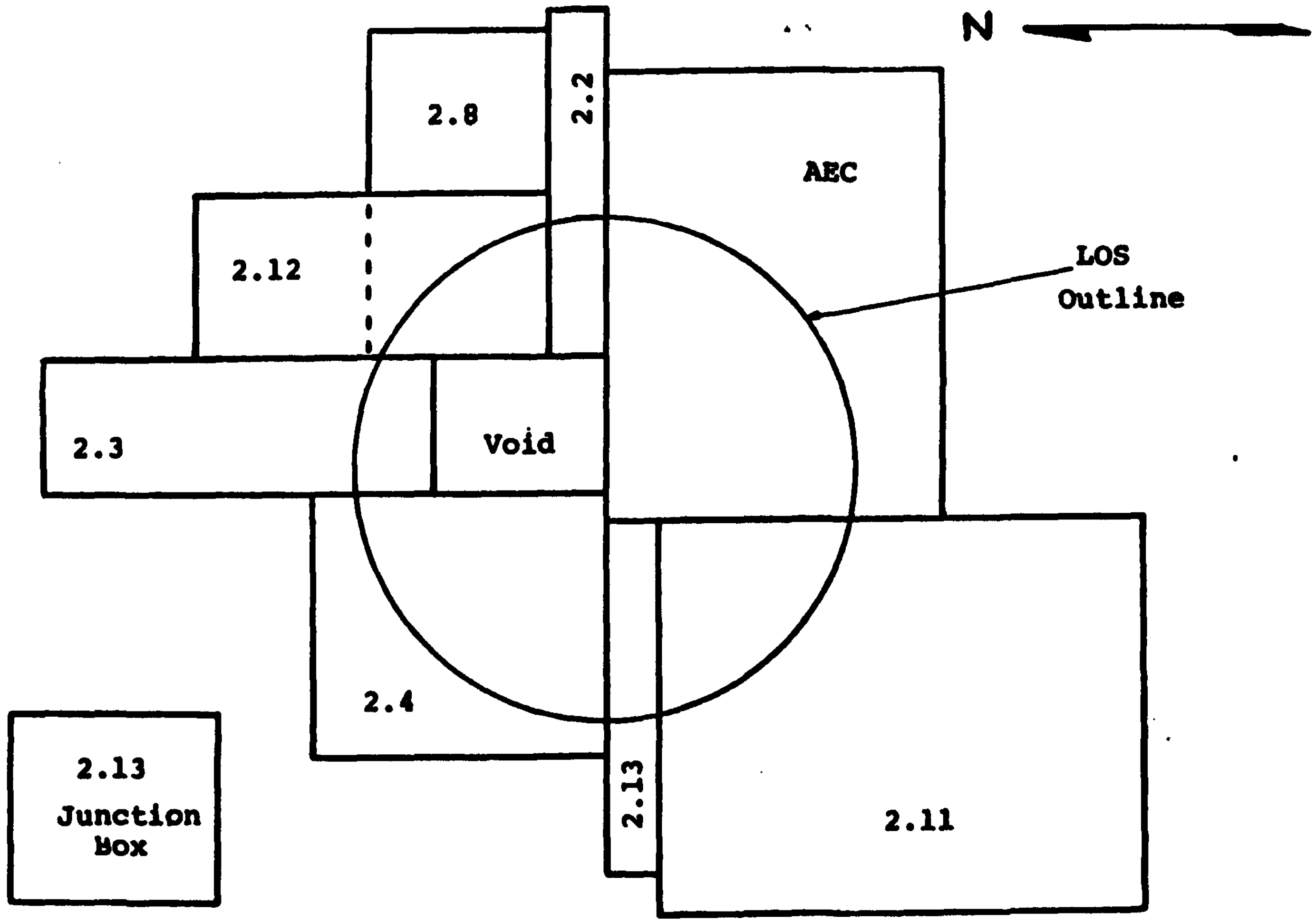


Figure 2.4 [redacted] First floor layout. [redacted]

[redacted]

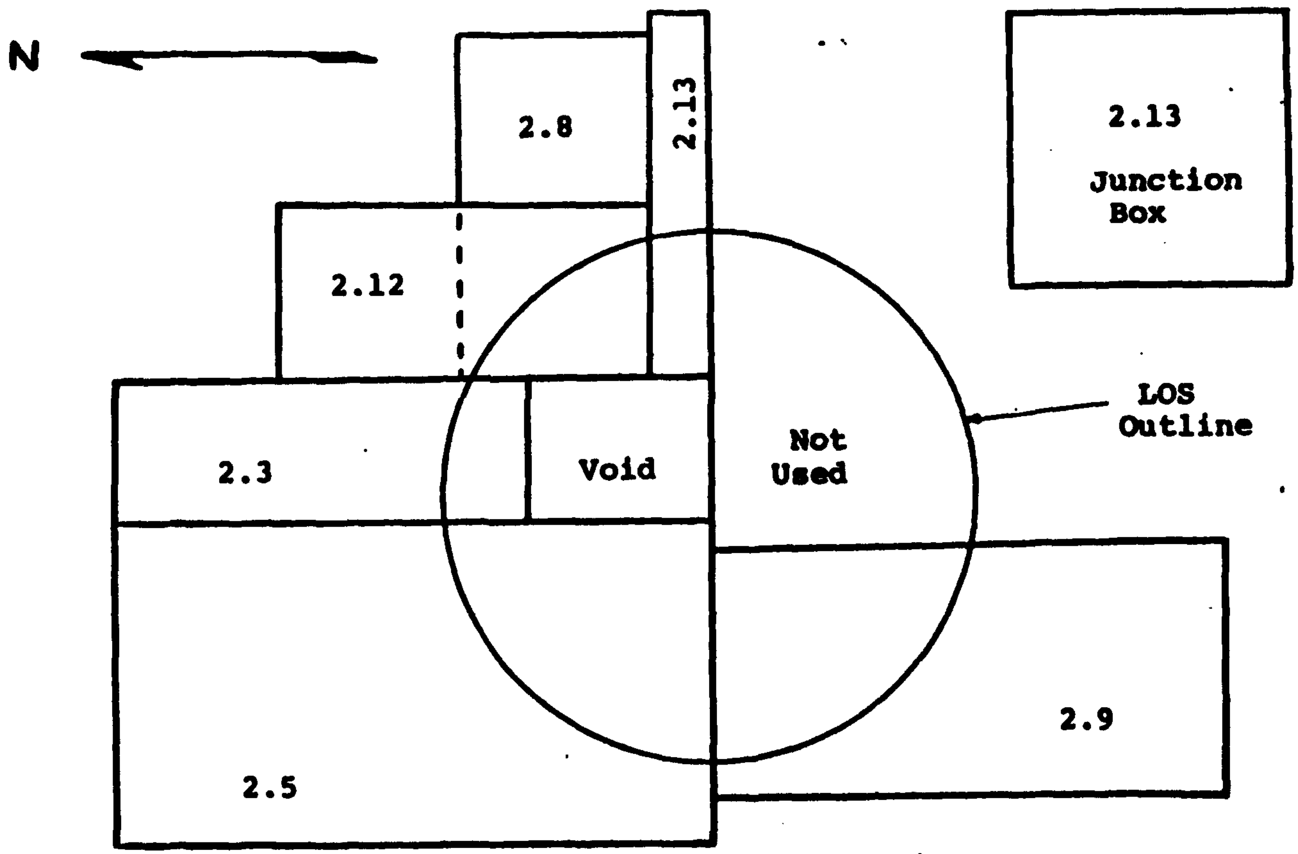


Figure 2.5 [redacted] Second floor layout. [redacted]

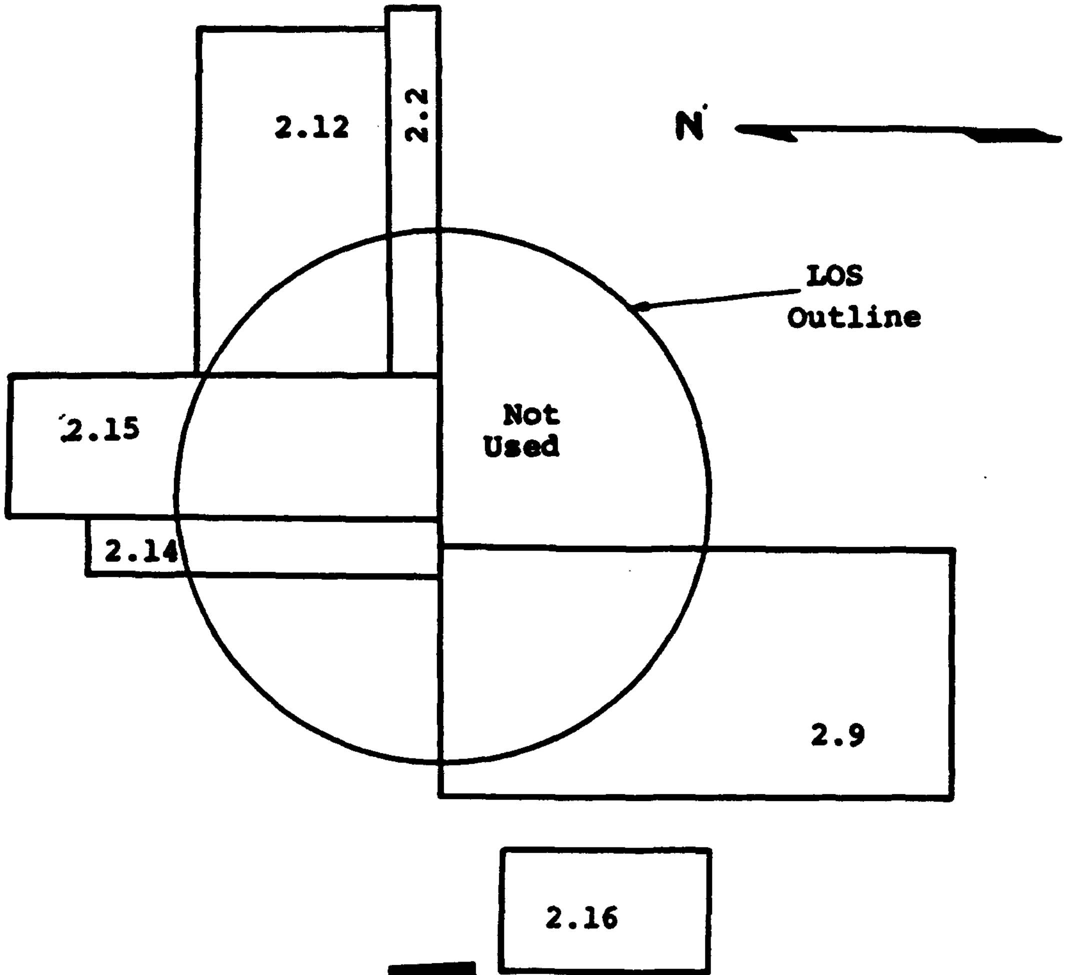


Figure 2.6 [redacted] Third floor layout. [redacted]

[redacted]

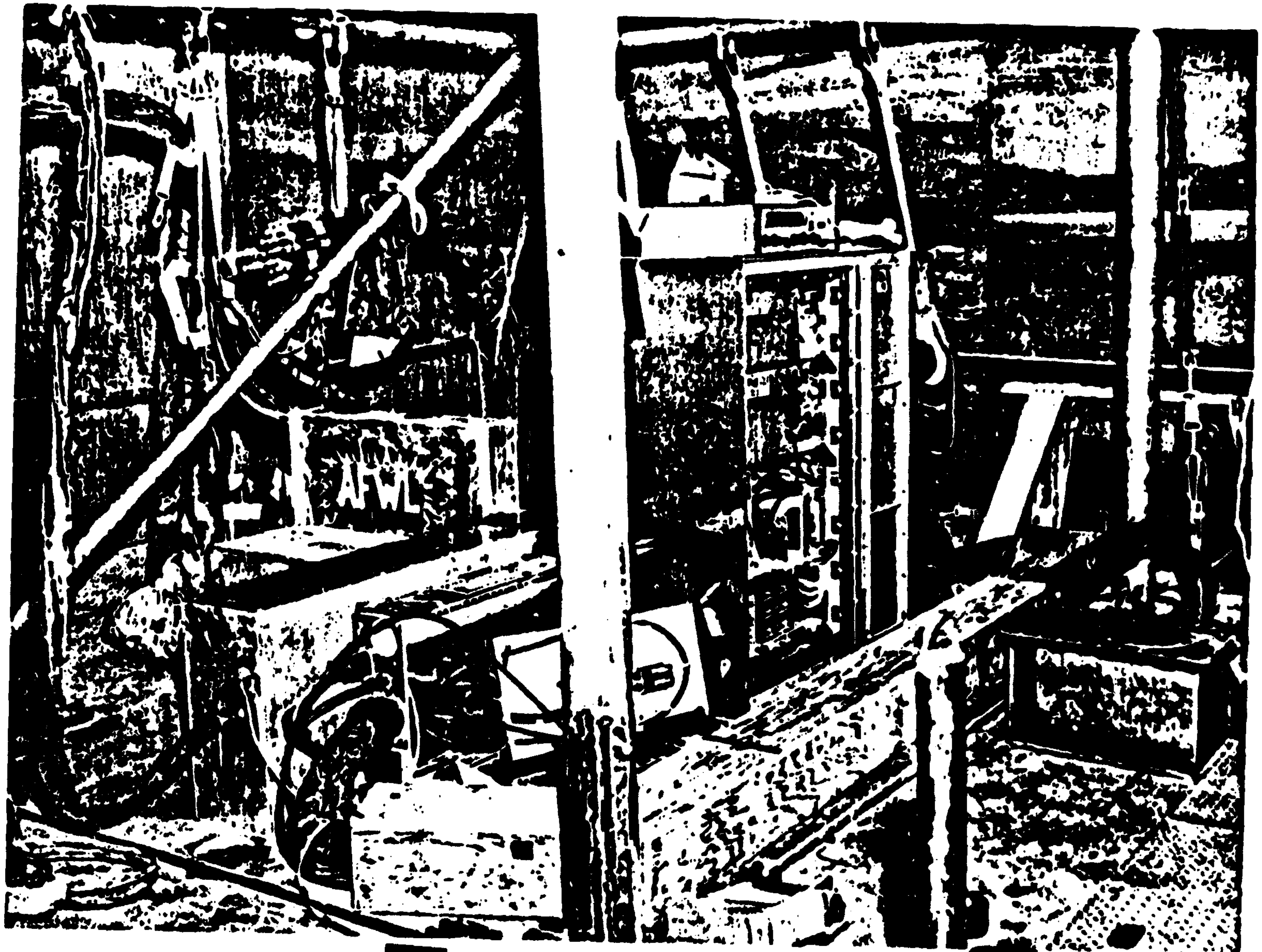


Figure 2.7 [redacted] Photograph of third floor. (DASA 73-12-NTS-66) [redacted]

[redacted]

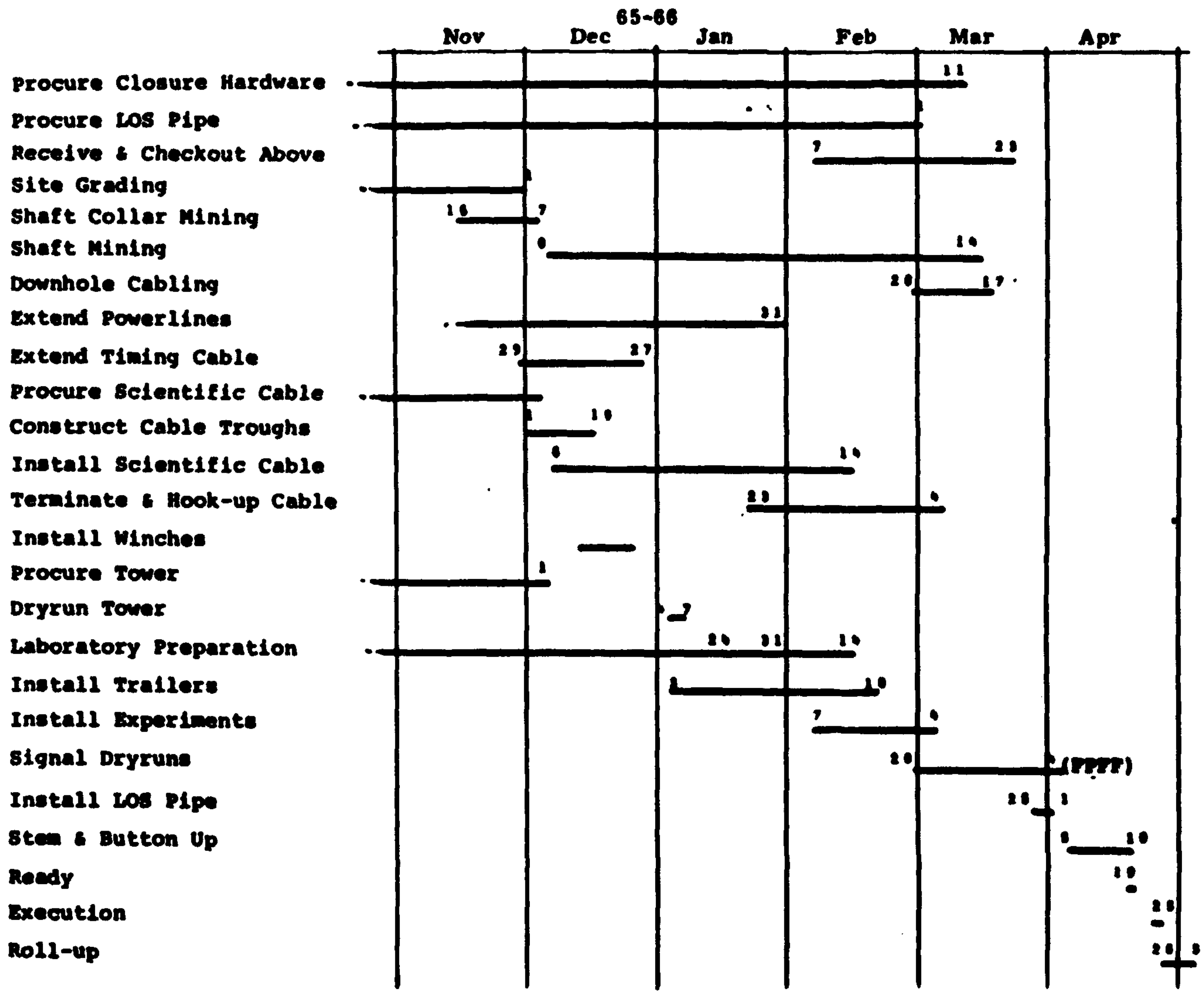
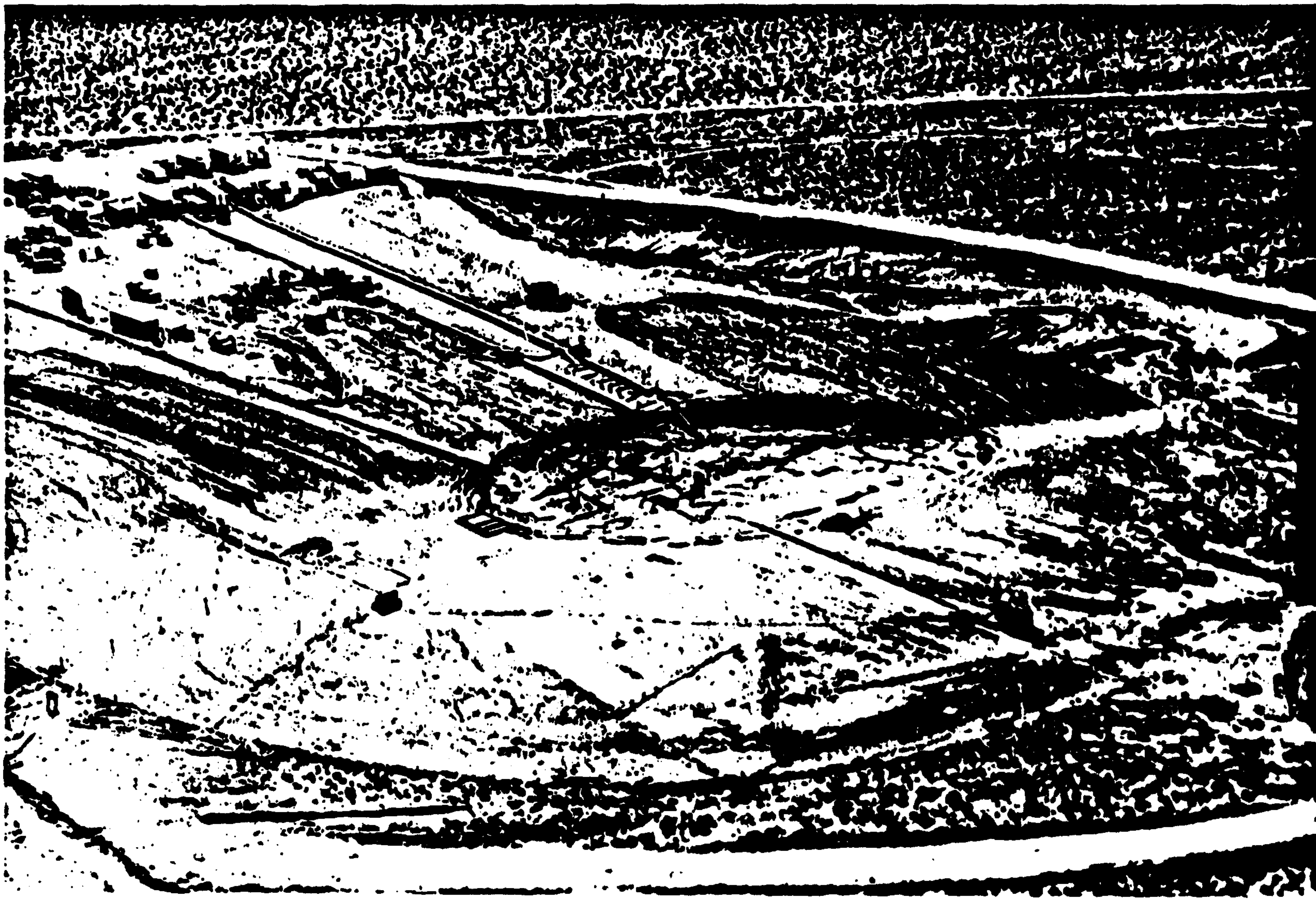


Figure 2.[redacted] Construction schedule summary.[redacted]

[redacted]

Pages 36 + 37 are deleted

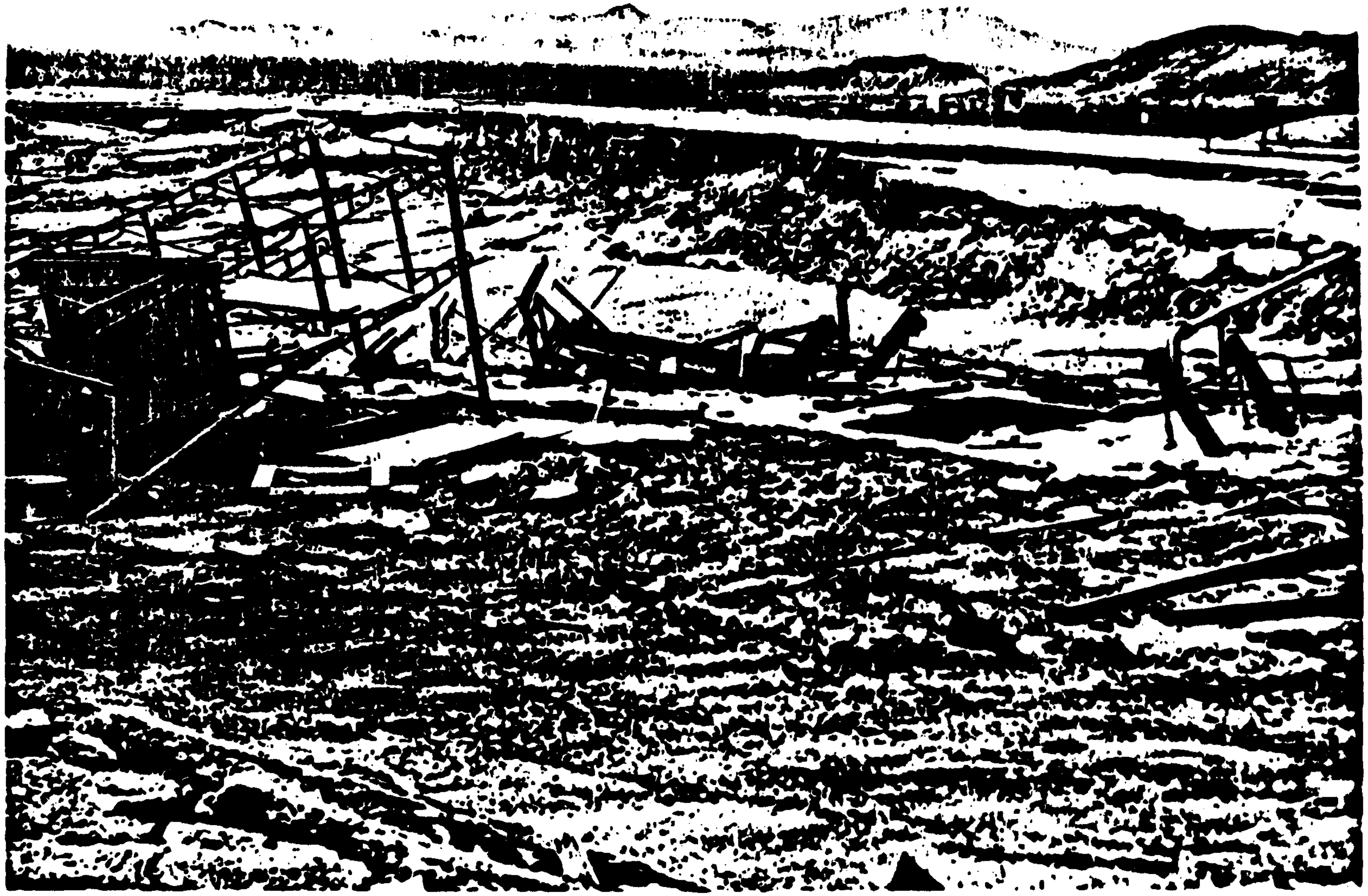
Figure 2.10 [redacted] Aerial photograph, H + 70 seconds showing venting from a point southwest of tower.
(DASA 150-1[redacted]-NTS-66)[redacted]



a. Aerial from NW. (DASA 154-04-NTS-66)

Figure 2.11 [redacted] Photographs of crater.[redacted]

[redacted]



b. View from NE edge of crater. (DASA 167-01-NTS-66)

Figure 2.11 [redacted] (Continued)

[redacted]

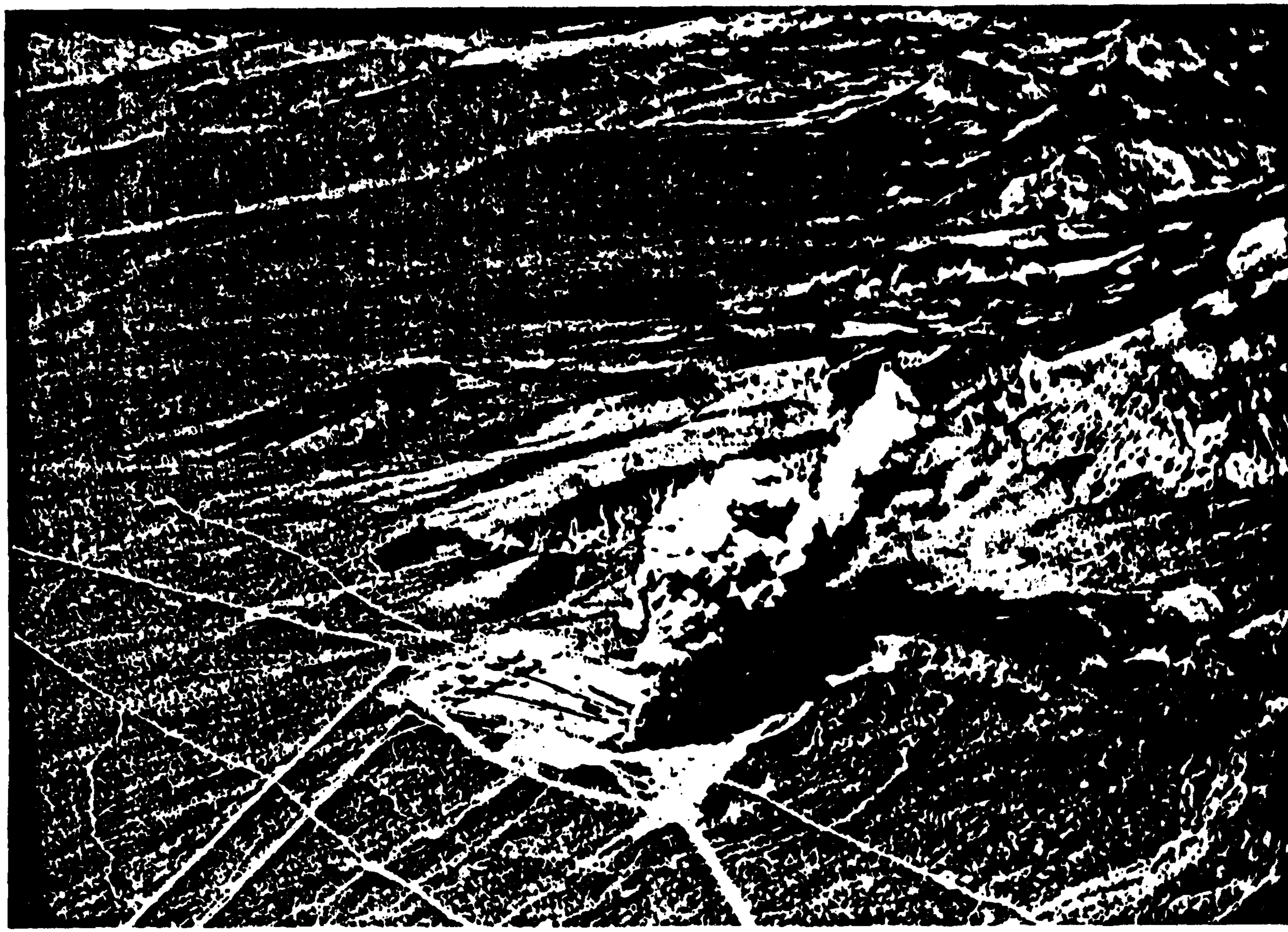


Figure 2.12 [redacted] Aerial photograph, H + 4 minutes. (DASA 150-28-NTS-66) [redacted]

[redacted]

[redacted]

CHAPTER 3

EXPERIMENTAL PROGRAM AND RESULTS SUMMARY

[redacted] It is not the intention of this chapter to present a detailed description of each experiment that was involved in Pin Stripe. Rather, the approach taken briefly describes the objectives of each project and presents a summary of the results obtained. The POR numbers of each project are referenced in Table 3.1 where other pertinent data also are presented. The PORs are listed as References 9 through 22. Funding data on the experimental program are contained in Table 3.2.

[redacted] The Pin Stripe experiments are described under the headings of Systems, Research, Test Improvement and Dosimetry, and AEC Experiments. The environment to which the experiments were exposed is presented first.

3.1 RADIATION ENVIRONMENT

[redacted] The radiation environment obtained in Pin Stripe was very close to that predicted. Several calculations had been made of the neutron fluence and spectrum and the gamma intensities expected to be observed by the first floor experiments. Although

[redacted]

[redacted]

these calculations were approximate [redacted]

3.2 SYSTEMS ORIENTED EXPERIMENTS

[redacted] 3.2.1 Sprint Missile Guidance and Autopilot Systems Components (Project 2.4). The primary objective of this test

[redacted] [redacted]

[redacted]

was to verify the ability of Sprint Missile-Borne Equipment to operate satisfactorily during and after exposure to a nuclear radiation environment approximating that envisioned for a tactical Sprint missile. Data necessary to provide corrective action for observed failures was sought.

[redacted] Selected circuits from the Sprint Missile Borne Guidance Equipment and Autopilot were exposed to the weapon radiation while in an operating state. The fifteen circuits tested were powered and operated to simulate missile operation and were expo[redacted]

[redacted] Signals to trigger the circuits were provided externally, and circuit operation was recorded on magnetic tape and photographs of oscilloscope traces. Instrumentation was located in an air conditioned, shock-mounted trailer positioned approximately 650 feet from surface zero.

[redacted] The test objectives were fully satisfied for 11 of the 15 units tested. Tests of the Triode Cavity Oscillator and the Single Pulse Generator of the Guidance Set and the Roll Channel Amplifier and Oscillator-Digital Exciter of the Autopilot failed to operate satisfactorily in the nuclear environment. These circuits have

[redacted] [redacted]

[redacted]

since been redesigned and satisfactorily passed subsequent radiation tests.

[redacted] 3.2.2 Coral Subsystems (Project 2.9). The objective of this test was the validation of the design of end-item type radiation-hardened electronics hardware for the Polaris A3 by exposure to a weapon radiation environment. Verification of the results of an extensive laboratory radiation test program to reduce the vulnerability of present Polaris A3 electronic equipment by redesign and new design was to be accomplished.

[redacted] Complete breadboard modules were tested before, during, and after exposure. An operational verification test and monitoring of test points was conducted immediately prior to, during, and after exposure to determine satisfactory operation. Two identical sets of experiments were exposed, [redacted] The following items of Polaris A3 electrical equipment were tested: (1) representative modules of the flight-control electronics package, (2) packages and breadboarded circuits of the electrical system, and (3) an exponential decay unit (EDU) for guidance-computer circumvention evaluation.

[redacted]

[redacted]

[redacted] The experiments were instrumented by oscilloscopes, oscillographs, and tape recorders: Instrumentation was mounted in an air conditioned, shock-mounted trailer located approximately [redacted] from surface zero.

[redacted] The Pin Stripe test verified the approaches used in prediction analysis and circuit desig[redacted] the total dose received, according to preliminary passive dosimetry data. This may be due to inadequ[redacted] A few anomalies in test data were apparent. Some were due to test operation difficulties, rather than the intended radiation environment. This was the case for the 19.5-second timer anomaly and is believed to be the case for the Donner accelerometer-comparator, integrator-comparator and flight-control analog section, since posttest operation indicated no permanent damage to the circuits. [redacted]

[redacted] It was concluded that all circuits tested would perform as required in their intended application.

[redacted]

[redacted]

[redacted]

[redacted] Two EDU's were teste[redacted], [redacted] Both units functioned perfectly, demonstrating conclusively the efficiency of the measures taken [redacted]

[redacted] <u>3.2.3 Lance Proximity Fuze Susceptibility (Project 2.5)</u>

The objective of this test was to investigate the susceptibility of the [redacted] oximity fuze to nuclear radiation [redacted]. A determination was to be made of permanent damage, false firing, and proper operations after irradiation. The [redacted] fuze, being transistorized, represented a modern fuzing approach, and its susceptibility was to be investigated in detail [redacted]

[redacted] The [redacted] uze was placed entirely within the radiation beam in the environment required. Both fuzing channels were monitored. Normal telemetry test points were used where available and pertinent. Additional test points were installed in those subassemblies [redacted]

[redacted] All data was to be recorded on magnetic tape recorders utilizing approximately 30 channels of information. [redacted]

[redacted]

[redacted]

[redacted] A malfunction of the recorder 20 seconds before the shot prevented the acquisition of [redacted] effects. The fuze was operated a short time after the shot and appeared to function normally. Subsequent laboratory tests indicated there was no permanent damage to the fuze operation.

[redacted] 3.2.4 Mk11A Arming and Fuzing Components (Project 2.15)

The purpose of this experiment was to confirm that the Mark 11A arming [redacted] of the warhead firing set.

[redacted] The Mark 11A cassette, which was located on the third floor of the [redacted] tower directly over the line-of-sight hole, was comprised of those components of the arming and fuzing

[redacted]

[redacted]

system which perform their intended functions during the reentry phase of flight — a safing and arming device, an inertial timer switch, impact detectors and trigger circuits, impact detector batteries, and electro-explosive devices.

[redacted] Monitoring of data channels provided information on the status (delivered or not delivered) of the warhead arming and warhead firing signals and on the condition (fired or unfired) of thermal batteries and explosive squib switches in the system.

[redacted] Dosimetry data indicate that the Mark 11A cassette was subjected to a neutron fluence of [redacted]

[redacted] Recorded data showed that no component in the experiment package [redacted] Postshot laboratory measurements on the irradiated components showed [redacted]

3.3 RESEARCH ORIENTED EXPERIMENTS

[redacted] <u>3.3.1 Hardened Circuit Studies (Project 2.2)</u>. The objective of this test was to establish the validity of research-developed hardening techniques incorporated in potential arming-fuzing and guidance-control circuits. Correlation with laboratory results and response prediction was also to be obtained. An

[redacted]

[redacted]

additional objective was the verification of the operatio[redacted]

[redacted]

nuclear radiation environment.

[redacted] Hardening and prediction techniques were verification-tested by exposing six advanced circuits to a weapon environment. The circuits tested were developed for potential system applications. Verification tests were performed [redacted] on the following circuits:

(1) Video High-Level Linear Amplifier

(2) Crystal Oscillator

(3) High Speed Pulse Forming Circuit

(4) Ultra High Speed Monostable

(5) Pulse Adder

All circuits were tested in the hardened and unhardened configuration for comparison. [redacted]

[redacted] Circuit response signals were recorded by a magnetic tape recorder and cameras mounted on dual beam oscilloscopes. Recording, sequencing and control equipment, power supplies, and pretest checkout equipment were mounted in an air conditioned, shock-mounted trailer located approximatel[redacted]feet from surface zero.

[redacted]

[redacted]

[redacted] Oscilloscope photographic data was lost by film fogging; [redacted] indicated a misfire at the higher test level. Misfiring in the fuze was found to be dependent on the initial fuze noise level settings. A minor modification can be made to the fuze to reduce this vulnerability.

[redacted]

[redacted] A response test was conducted on four versions of a microelectronic diode-transistor-logic gate circuit [redacted]. Although each device performed the same electronic function, nand/nor gate, each was constructed using a different technique as indicated below.

[redacted] [redacted]

[redacted]

Device	Construction
(1) MC 201	Diode Isolation, Diffused Resistors
(2) XC 201	Oxide Isolation, Diffused Resistors
(3) SC 965	Air Isolation, Diffused Resistors
(4) SC 966	Air Isolation, Thin Film Resistors

[redacted] A comparison of the response of the various devices was used to determine the level of hardening which can be obtained utilizing different construction techniques.

[redacted] Circuit response signals for this test were recorded by a tape recorder and by cameras mounted on oscilloscopes. Oscilloscopes, tape recorders, sequencing and control equipment power supplies, and pretest check-out equipment were mounted in an air-conditioned, shock-mounted trailer located approximatel[redacted] feet from surface zero.

[redacted] Project 2.3 could only draw conclusions from data collected on a backup tape recorder which was able to record some of the neutron-induced ionization responses. The loss of the film data by radiation fogging prevented any accurate assessment of [redacted]

[redacted] Conclusions drawn from analysis of the tapes were:

(1) [redacted]

[redacted]

Page 53-54 removed

[redacted] Test items were exposed [redacted]

Power was supplied from [redacted] batteries. All circuit components [redacted] were placed external to the radiation field. Data acquisition equipment was mounted in an air-conditioned, shock-mounted trailer located approximately [redacted] feet from surface zero.

[redacted]

Due to the venting on this shot, all photographs of secondary photocurrent were fogged. Hence, all data was masked by the fogging. Extensive effort was made to extract some data, but it was fruitless.

[redacted]

[redacted] The loss of film due to the venting precluded reaching any conclusions on the difference in neutron effectiveness in [redacted]

[redacted]

[redacted]

[redacted] 3.3.5 Radiation Effects Correlation Tests (Project 2.13)

[redacted]

[redacted]

[redacted]

[redacted]

3.4 TEST IMPROVEMENT AND DOSIMETRY EXPERIMENTS

[redacted] <u>3.4.1 Grounding and Shielding Tests (Project 2.14)</u>. The objective of this experiment was to provide cable effects data which would be useful to all experimenters planning time-resolved measurements at future underground nuclear tests. Data was sought to document the effects of radiation on cables in the direct radiation beam and outside it, in addition to covering the effects of various grounding and shielding techniques.

[redacted] A total of eleven experiments was performed on [redacted] cables. Cables were exposed both to the direct beam and to the scattered radiation from the t[illegible]r.

[redacted]

[redacted]

A large number of shielding and grounding techniques was investigated.

[redacted] Because of the venting which occurred, all trailers received an internal dose of between 15 and 20 roentgens. Readout of data was very difficult because of extreme film fogging, and special techniques had to be employed to develop data films. Even so, the data are fragmentary and do not admit to interpretation. This experiment was repeated on the New Point event as Project 2.16.

[redacted] 3.4.2 Telemetry Feasibility Test (Project 2.16). The purpose of this experiment was to determine the suitability of an unhardened multiplex telemetry system for transmission of test data from experiments on an exposure tower to a remote station.

[redacted]

[redacted]

[redacted]

[redacted] A manned receiving station was locate[redacted] from the transmission package which was on the edge of the third floor of the tower. The mixed signal was recorded on magnetic tape for laboratory analysis, and real time discriminated data was recorde[redacted] at zero time.

[redacted] All channels showed spurious pulse signals of total duration ranging from 0.6 to 2.0 milliseconds. Except for this perturbation, data transmission was continuous and accurate.

[redacted] The following conclusions are drawn:

(1) [redacted]

(2) [redacted]

(3) [redacted]

[redacted] 3.4.3 Ground Shock and Tower Motion Measurements (Project 1.2). The objective of this experiment was to measure fundamental surface ground motions in the vicinity of surface zero (SZ) resulting from a contained underground nuclear detonation and the response of the SZ instrument tower to these motions.

[redacted]

[redacted]

[redacted] Surface motions measured on Pin Stripe were somewhat less than had been predicted. This was a result of making quite conservative (i.e., large) predicted motions by assuming an all-tuff shot medium. Surface accelerations ranged from [redacted] and particle velocities varied from [redacted]

[redacted] All locations instrumented on the tower, except the concrete base pad, indicated fairly consistent motions, ranging from [redacted]

[redacted] <u>3.4.4 Neutron Fluence and Gamma Exposure Measurements (Project 2.10)</u>. The objective of this project was to provide neutron fluence and gamma exposure measurements [redacted]

Pages 62 + 63 are deleted

[redacted]

constant over the radial distance between 3 and 18 feet from the tower edge.

[redacted] It was recommended that similar experiments in the future should be performed to verify the radial mapping results obtained on Pin Stripe. In addition, [redacted]

[redacted] It was also recommended tha[redacted] techniques be employed extensively by individual experimenters[redacted]

[redacted] <u>3.4.5 Time Resolved Neutron and Gamma Flux Measurements (Project 2.11)</u>. The objective of these measurements was to provide data regarding the time resolved gamma and neutron flux. This information was required by other experiments for the proper interpretation and analysis of results. A secondary objective was to refine and improve techniques for making these measurements.

[redacted]

[redacted]

[redacted]

[redacted] In general, based on all the evidence available, the Project 2.11 detection and recording system seemed to perform about as predicted. There is no question that the system triggered. The analyses confirmed the correctness of the amplitude and time calibration of the system, based on the DASA/LASL predicted information.

[redacted] The data reclaimed tends to support other evidence that the nuclear device worked just about as predicted.

[redacted] The agreement between integrated active dose and passive dose was quite good. [redacted]

[redacted] The final conclusion was that there was a great amount of time spent in recovering one data trace. It would appear to have been a worthwhile expenditure of effort. However, further similar analysis of the remaining data film seemed to be an unreasonable expenditure of time and money.

[redacted] Additionally, a method was devised for the recovery of

[redacted] [redacted]

latent data images from sheet film which has been subsequently subjected to large doses of gamma radiation. This method was devised for Kodak 2475 film (a type similar to Kodak Royal-X-Pan film) [redacted]

[redacted] <u>3.4.6 LOS Pipe Diagnostics.</u> Measurements were made of various parameters associated with the functioning of the LOS pipe closure systems to determine if their operation was as designed and to provide data to determine the reasons for improper operation.

[redacted] The measurements consisted of pressure, temperature, radiation, acceleration, time of shock arrival, actuation time of closures, and position indication of closures. Recording was accomplished by instrumentation in two trailers in the trailer park. Other data was obtained during postshot physical examination of the accessible closure[redacted]. (See Appendix B for a description of the LOS pipe and closures.)

[redacted] The conclusions drawn from the data are:

[redacted]

[redacted]

Page 67 is deleted

[redacted]

(7) The pipe above the ball valves and the pipe cap were intact. The pipe cap showed several shrapnel impacts in the are[redacted]

(8) The LOS pipe string rose during the first 200 msec but not high enough to hit the tower. Upon cavity collapse and crater formation, the pipe settled 12 feet in the shaft. No evidence of venting in the shaft was discovered down to 420 feet from the surface.

[redacted] 3.4.7 Technical Photography. Normal and high speed motion pictures were taken by EG&G of th[redacted]tower and the shaft opening to more closely observe their relative motions during ground shock arrival at the surface. The pictures were taken by several cameras located in transportainers 625 feet west and northeast of the tower.

[redacted] While much of the film was fogged by radiation during the venting, some film showed tower motion and the rise of the LOS pipe.

3.5 AEC EXPERIMENTS

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] 3.5.2 Photoconductivity in Dielectrics. No data was obtained due to fogging of the scope photographs.

[redacted] 3.5.3 Radiation-Hardened Telemetry Experiment. A test to verify the predicted hardness of a telemetry package for rocket-borne application to the atmospheric testing readiness program was included in Pin Stripe. The experiment obtained good data which confirmed predictions and culminated testing of this package.

[redacted] 3.5.4 LASL Salvage Detectors. Several fission detectors were exposed in Pin Stripe [redacted] Although data from the active experiments were lost due to film fogging, the results of the passive experiments were in accordance with pretest predictions.

[redacted]

TABLE 3.1 [redacted] PIN STRIPE EXPERIMENTAL PROGRAM [redacted]

Project No.	Title	Organizations	Project Officer	POR* No.	Remarks
1.2	Ground Shock and Tower Motion Measurements	U. S. Army Waterways Experimental Station	J. D. Day	2724	Added in Dec 65
2.1	Minuteman Guidance & Control System	USAF Ballistic Systems Division; North American Aviation, Autonetics Division	Lt. Col. Zengel	-	Removed by BSD in June 65
2.2	Hardened Circuit Studies	USAF Weapons Laboratory	J.J. Ungvarsky	2711	
2.3	Microelectronic Circuit Studies	USAF Rome Air Development Center, Nortronics Applied Research Department	Lt. W.L. Duke	2712	
2.4	Sprint Missile Guidance & Autopilot Systems Components	U.S. Army Nike-X Project Office, Bell Telephone Laboratories, Martin-Orlando	J.H. Gwaltney	2713	
2.5	Lance Proximity Fuze Susceptibility	U.S. Army, Harry Diamond Laboratories	P. A. Trimmer	2714	
2.6	Blue Rock Instrumentation Packages	U.S.Army Ballistic Research Laboratories, Nortronics Applied Research Department	E. G. Schwartz	-	Removed by DASA in July 65
2.7	Adaption Kit Subsystems	U.S. Army Picatinny Arsenal, Nortronics Applied Research Department	R.K. Benson	-	Deferred to New Point in Nov 65
2.8	[redacted]	U.S. Army, Harry Diamond Laboratories	R.R. Puttcamp	2715	
2.9	Coral Subsystems	U.S. Navy Special Projects Office, Lockheed Missiles & Space Co., MIT Instrumentation Laboratory	Lt/JG J.T. Mitchell	2716	

[redacted]

[redacted]

TABLE 3.1 [redacted] (CONTINUED)

Project No.	Title	Organizations	Project Officer	POR* No.	Remarks
2.10	Neutron Fluence and Gamma Exposure Measurements	U.S. Army Nuclear Defense Laboratories	J. R. Jacobson	2717	
2.11	Time Resolved Neutron and Gamma Flux Measurements	U.S. Army Harry Diamond Laboratories	P.A. Caldwell	2718	
2.12	[redacted]	U.S. Army Harry Diamond Laboratories	D. R. Schallhorn	2719	Added by DASA in Aug 65
2.13	Radiation Effects Correlation Tests	U.S. Army Harry Diamond Laboratories, General Atomic	R. F. Overmyer	2720	Added by DASA in Aug 65
2.14	Grounding and Shielding Tests	U.S. Army Harry Diamond Laboratories, Hughes Aircraft Corporation	K. G. Kerris	2721	Added by DASA in Sept 65
2.15	Mk 11A Arming & Fuzing Components	USAF Ballistic Systems Division, AVCO RAD	A. B. Walters	2722	Transferred from Derringer in Nov 65
2.16	Telemetry Feasibility Test	U.S. Army Harry Diamond Laboratories	D. W. Finger	2723	Added by DASA in Jul 65 as Proj 6.1, renumbered in Dec 65
-	AEC Vulnerability Experiments	Sandia Corporation, Los Alamos Scientific Laboratory	A. W. Snyder	-	
-	Device Diagnostics	Los Alamos Scientific Laboratory	D. Westervelt		
-	LOS Pipe Diagnostics	Sandia Corporation	D. R. Breding	-	

* See References 9 through 22.

[redacted]

TABLE 3.2 [redacted] EXPERIMENTAL PROGRAM BUDGET AND FINAL COSTS ($000) [redacted]

Project/Agency	September 1965	Final	Remarks
1.2/WES	*	26	
2.1/BSD	*	*	Project deleted (was to be BSD funded)
2.2/AFWL	111	76	Instrumentation funded separately
2.3/RADC	372	365	
2.4/Nike-X	0	0	Nike-X funded
2.5/HDL	139	138	
2.6/BRL	*	*	Project deleted
2.7/PA	321	135	Project deferred to New Point
2.8/HDL	89	89	
2.9/N-SPO	264	264	
2.10/NDL	31	50	Increased scope
2.11/HDL	109	149	Increased scope
2.12/HDL	82	76	
2.13/HDL	150	172	Revised estimate
2.14/HDL	140	140	
2.15/BSD	*	0	BSD funded
2.16/HDL	0	0	DASA funded separately
AEC	0	0	AEC funded
Contingency	50	0	
Totals	1858	1680	

* Project not included in program.

[redacted]

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[redacted]

[redacted]

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

[redacted] In general, the systems experiments, with the exception of Project 2.5 were almost 100 percent successful. Since these experiments were performed [redacted] was recorded on magnetic tape or oscillographs. Hence very little was lost due to film fogging. Those experiments which attempted to look at ionization phenomena during the gamma pulse suffered varying amounts of data loss; in many instances the oscilloscope sweep speeds were slow enough to allow source data retention. Furthermore, many signals were backed up with tape recorders.

[redacted] The most serious loss was the time-resolved radiation measurements,but the one data channel recovered and the passive dosimetry indicated that fluxes and fluences were just about as predicted. A comprehensive mapping of the neutron and gamma fluences around the tower was accomplished for the first time.

[redacted]

[redacted]

[redacted] New techniques were developed for the recovery of data from radiation-exposed film and were employed to advantage on some experiments. [redacted]

[redacted] Several problems, not previously experienced, were encountered with cables and grounding. While the solutions applied were satisfactory, the problems were circumvented on subsequent tests by planning based on the experiences of Pin Stripe.

[redacted] The serious venting of radioactive material through a fissure in the earth was unfortunate and resulted in the loss of valuable data. This occurrence pointed out the necessity for even more careful geological evaluation in the selection of test areas than was performed for Pin Stripe. It is believed that the effects of the vent were lessened by the pretest recovery planning, resulting in a somewhat higher radiation vulnerable data yield

[redacted]

than might be expected for the magnitude luent release experienced.

[redacted] The detailed results of all the individual experiments, [redacted]

[redacted]

Pages 78-86 removed

[redacted]

APPENDIX B

LOS AND STEMMING DESIGN AND OPERATION

[redacted] After the unplanned venting of the Diluted Waters shot in June 1965 the LOS and stemming design originally planned for Pin Stripe (similar to that for Diluted Waters) was re-evaluated in the light of the time-limited understanding of the Diluted Waters containment failure. A primary factor was considered to be the scaled depth of burial. [redacted]

[redacted] Because of the shallow water table (about 800 feet) in the portion of Area 5 employed for Wish Bone and Diluted Waters, it was necessary to seek a somewhat higher elevation for Pin

[redacted]

[redacted]

Stripe such that the anticipated cavity would not intersect the water table. Such a spot was obtained in the south central section of Area 11 some 6 miles north of the Wish Bone and Diluted Waters sites. The surface el the selected point is 3586 feet above mean sea level and the depth to the water table is 1176 feet.

[redacted] In September 1965 an exploratory drill hole was started to determine the geology of the region. Based on core cuttings, the planned working point was established in moderately soft bedded tuff (see Figure B.1). This type of material extended upwards to 455 feet above the working point. From there welded tuff extended to 780 feet above the working point and an overlying layer of 190 ft of alluvium extended to the surface. Accompanying this exploratory drilling a comprehensive seismic survey was conducted in the area to determine the location of existing faults. No significant faults were discovered.

[redacted]

[redacted]

[redacted]

B.1 CONTAINMENT FEATURES

[redacted] Several mechanisms were employed at different positions in the LOS pipe to insure satisfactory containment (see Figure B.1).

[redacted]

[redacted]

Pages 90 - 92 deleted

[redacted]

[redacted]

[redacted] Predictions of the underground chimney height were made employing several assumed bulking factors for the rock. Dependent upon which assumption was closer to the actual value, the ultimate chimney height might or might not reach the surface. Thus it could not be assured preshot that subsurface subsidence would occur producing a surface cavity. Because of this unknown, both alternatives were considered in the design of the containment and shaft stemming. [redacted]

[redacted]

[redacted]

[redacted] Thus, 3 weeks were allowed in the planning schedule for this activity.

B.3 CONTAINMENT ACHIEVED

[redacted] Based upon the shot time visual and photographic observations described in Chapter 2, the analysis of the pipe and stemming diagnostics data discussed in Chapter 3, and a postshot examination of the SGZ area and the upper half of the LOS pipe, the following picture of the Pin Stripe venting was obtained (Reference 5).

[redacted] While not all of the pipe closure mechanisms operated as planned, the data shows that no venting took place through the LOS pipe. Indeed it was definitely established that all venting was through the one surface fracture along a line geographically oriented at 190° with a closest approach to the LOS shaft of 65 feet. Surface extensions of this fracture were found out to 650 feet SSW and 550 feet NNE of SGZ.

[redacted] Geophone data indicated that there may have been a partial cavity collapse at about H+ 25 or 30 seconds. This may have allowed the stemming material in the shaft, perhaps up to the ball valves, to fall into the cavity. Such an occurrence would put the high cavity pressures (a few hundred psi) into communication with any fracture intersecting the shaft below the ball valves. Once these pressures reached the tuff/alluvium interface through a

[redacted]

[redacted]

fracture, percolation through the 190 feet of alluvium occurred with little delay. Although this postulated sequence of events seems the most reasonable, one cannot exclude the possibility that the venting path was a fracture which passed directly through the original subsurface cavity.

[redacted] [redacted]

pages 96-104 deleted

[redacted]

APPENDIX D

DRY RUNS

[redacted] Three categories of dry runs were employed to prepare the experiments, equipment, and personnel for the Pin Stripe test. These were: check out of th[redacted] tower and its recovery system, the standard electrical timing signal dry runs, and preparation of the experimenters for reentry and data recovery.

D.1 [redacted]

[redacted]

[redacted]

[redacted]

D.2 SIGNAL DRY RUNS

[redacted] Electrical timing dry runs were planned for the 4 weeks prior to the FPFF which was scheduled near the end of March 1966. These dry runs were scheduled one or two per working day and were employed to allow all experimenters to exercise their electrical equipment to insure proper operation of the signal processing and recording instrumentation. The 4 weeks were increased to over 5 by the delay in the FPFF caused by the bolt problem (see Section 2.2 of the report).

[redacted] The FPFF on which all agencies participated was held on 4 April to determine that all systems were operating properly in as close to shot day electrical configuration as possible. The FPFF was successfully executed on the first attempt. Once the FPFF was declared successful, requested changes in electronic hardware or in the electrical configuration of the test were carefully evaluated. This was to prevent interference with other experiments or the device firing system or to in any way compromise the electrical integrity established by the FPFF. Although a few minor changes were allowed (principally the exchange of a malfunctioning part for a good one) complete concurrence was obtained between the Technical Director and the device arming and firing group. Additionally,

[redacted]

[redacted]

as discussed below, a mandatory participation dry run after the FPFF allowed a final check for experiments where a change was allowed.

[redacted] The usual signal dry runs were continued on a less frequent basis after the FPFF during the lengthy stemming of the LOS shaft. Since the stemming took nearly three weeks and also since the tower and, more important, the signal cables were moved and handled after the FPFF, a mandatory participation dry run was held upon completion of those critical activities. This dry run was in as close to shot time electrical configuration as was possible at that time. As is normal for these shots, a final dry run was held the night before the actual test, just prior to arming the device.

[redacted] During each of the signal dry runs critical items of most experiments (e.g., trailer power, temperature, or sequencer operation) were monitored by lights on the event control panel. Since some experiments were more important than others, a weighting factor was assigned to each project's light. Experience had indicated that holding the countdown for one experiment tended to cause problems with other experiments and that indeed the closer to zero that a hold occurred, the more damaging it could be

[redacted]

to other experiments even if the problem causing the hold were solved. To deal with this situation, a system was invoked which automatically summed the weighting factors applied to each experiment giving, in effect, a percentage of the total experiments in trouble. The time during the countdown at which a failure took place governed whether a hold would be declared or not. The intent of this point count system was to allow the Technical Director in the control room to more quickly evaluate the impact of a malfunction and to determine what course of action to recommend. Fortunately there were no malfunctions during the countdown,and the system was not tested except during dry runs.

[redacted] Although no major problems were encountered during any of the electrical dry runs, postshot re-evaluation indicates that perhaps too many dry runs were held prior to the FPFF. Fewer would have been adequate.

D.3 REENTRY AND DATA RECOVERY DRY RUNS

[redacted] One activity, the detailed preparation and practice of which paid particular dividends, was the postshot reentry for the recovery of data. The postshot reentry plan for data recovery was developed prior to the arrival of the majority of the experimenters in the field. The basic plan consisted of a tightly controlled, yet flexible, procedure for rapid reentry to the trailer

[redacted]

park, neutralization of hazards, recovery of high priority data (i.e., oscilloscope photographs) and rapid return to the reentry assembly area. A key point of the reentry plan was direct control of all reentry teams by the Deputy Test Group Director at the reentry assembly area and mobile control of the reentry teams by the Program Director in the trailer park (see Figure D.1). The plan could be employed in either extreme of complete containment or major release of radioactive effluent.

[redacted] The plan was completely rehearsed with the participating experimenters (dressed in rad-safe clothing), and the various activities were accurately timed by observers. The purpose of this rehearsal was to enable the Test Group Staff to demonstrate to the AEC Test Manager's staff that a well controlled, rapid reentry was possible if necessary. Key members of the AEC Test Manager's staff were invited and observed the entire reentry rehearsal.

[redacted] The dry run of the reentry procedure demonstrated the required capability and thus immediately after the test was executed and it was determined that the situation required rapid reentry for high priority data, the Test Manager allowed entry into the contaminated area (at approximately H+ 20 minutes) and

[redacted]

[redacted]

relaxed the standing NTS procedure that individuals would not be allowed to reenter areas where the radiation levels were greater than 10 R/hour. Indeed, controlled entries of limited groups were allowed into areas where radiation levels were up to 17 R/hour. By following the prepared reentry plan it was possible for all high priority data to be recovered in 15 minutes with minimum radiation exposures to personnel. (No one received more than 500 mR.) While the film had received a significant exposure during the actual vent, rapid recovery prevented still further radiation exposure to the film whose radiation damage threshold was not well known.

[redacted] While rapid recovery of high priority data was the major reason for rehearsal of the reentry procedure, recovery of the passive dosimetry packages and the experiments also was practiced. This practice likewise was valuable in minimizing the total radiation exposure to individuals.

[redacted]

[redacted]

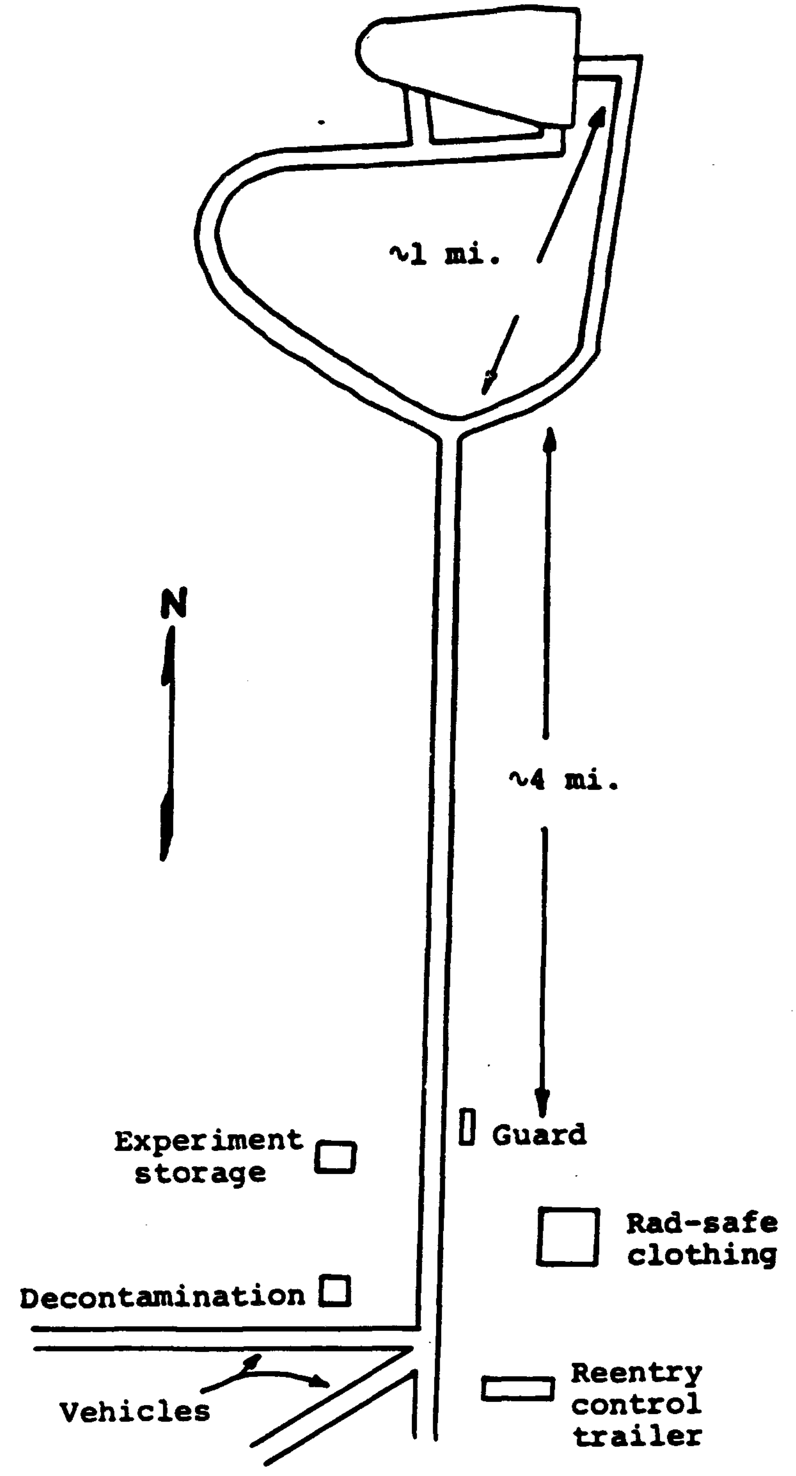

Figure D.1 [redacted] Reentry routes to Pin Stripe. [redacted]

[redacted]

[redacted]

APPENDIX E

TEST MANAGER'S READINESS BRIEFING NOTES

Time	Date	Summary
2000	4/18	Because of an ENE-SW oriented trough having passed the Test Site resulting in NW winds and the presence of a low over central Wyoming continuing to move eastward causing NW winds to continue to prevail over the Test Site at shot time, the weather was deemed to be completely unfavorable.
2000	4/19	Continuing NW winds and resultant unacceptable weather and trajectories.
1900	4/20	Because of the possibility of a narrow shot window recommended proceeding for a possible 0930 shot time.
0700	4/21	The winds had turned and become unfavorable but it was agreed to meet hourly as the wind runs were received. Conditions remained unfavorable throughout the day.
2000	4/21	Unfavorable winds continued and the prospects for the next day were gloomy. Asked for an informal look at 0115.
0115	4/22	Situation was unchanged. Shot delayed 24 hours.
2000	4/22	Unfavorable weather plus a predicted border crossing within 12 hours resulted in a decision to look again at 0530 in the morning, hoping the wind speed would change.

[redacted]

[redacted]

Time	Date	Summary
0530	4/23	Unfavorable wind pattern for this Event's characteristics (LOS and size of yield) made it a likelihood that Los Angeles would be able to detect any possible fallout. Shot was canceled for the day.
2000	4/23	Still N to NNW flow resulted in unacceptable wind pattern. Since the forecasts for Sunday indicated nothing unique to warrant a Sunday shot even though permission had been granted, it was decided to mee again Sunday evening at 2030.
2030	4/24	Winds predicted with 50% probability were for a southerly flow at about 5 knots after the morning heating of the surface. The trajectories of any effluent cloud would have a predicted 24 hour position from NE Arizona to central Utah. The test was tentatively scheduled for 1000 on 4/25 and an additional weather briefing set for 0730.
0730	4/25	Reports based on 0615 data reinforced the weather picture predicted previously. Shot time was set as 1000 with an additional delay possible until the surface southerly flow was definitely established with sufficient wind speeds.

[redacted]

[redacted]

APPENDIX F

RECOVERY OF DATA FROM RADIATION FOGGED FILM

[redacted] The severe damage to the photographic film which occurred in the Diluted Waters event prompted certain precautions for Pin Stripe:

(a) Typical signal photographs were obtained from each Pin Stripe project well before shot day. These test sample films were irradiated by cobalt-60 gamma rays at several exposures up to 6.4 R. This was done to establish the maximum allowable radiation exposure for the three types of film used: Polaroid types 107 and 410 and Eastman 2475. Furthermore, it was hoped that this information would provide a quantitative guide for the Test Manager and his staff in allowing recovery parties to enter a high radiation field if necessary to recover exposed film.

(b) It was agreed that in the event of a release, no Polaroid film would be pulled to initiate development but rather the whole film cassette would be removed and taken to the Polaroid Corporation for optimum development. This technique had been successful in recovering significant data from Diluted Waters.

[redacted]

[redacted] (c) A priority for rapid film recovery was prepared as part of the postshot reentry plan and was based upon the susceptibility of each project's photographs. Reentry for film cassette recovery was carefully rehearsed and timed so that personnel exposure during recovery could accurately be predicted.

(d) Finally, additional radiation monitors (RAMS units) were placed near certain critical trailers so that the extent of film spoilage could be assessed before committing personnel to large radiation exposures. In other words, if the film was obviously lost no one would be sent in to recover it. On the other hand, these radiation monitors enabled a determination of the latest possible time at which to effect recovery and minimize exposure to the recovery party.

[redacted] As a result of the release of effluence, the photographic data film was subjected to rather high radiation fields. Though the fields in the trailer park were minimized by the fact that the wind blew the cloud northward and not over the trailer park, some trailers recorded exposures as high as 33 R. Figure F.1 shows a sketch of the park and values of the trailer exposures. (The radiation exposure of the Project 2.2 trailer, 350 feet from SGZ, was estimated by integrating the time-resolved RAMS data.) The elaborate contingency

[redacted]

plans resulted in very early approval for rapid film recovery.

[redacted] As planned, no film was developed by the automatic process; all film cassettes were removed intact. The Polaroid film was taken directly to the Polaroid Corporation in Cambridge, Massachusetts, for optimum development. The Eastman 2475 was first examined by the Harry Diamond Laboratories photographic technicians and then subjected to a very long study. The descriptions of the elaborate procedures are best described by direct quotation from two of the project agency PORs:

Project 2.3 (Polaroid film)

[redacted] "Effluence from the detonation of the nuclear device resulted in a 100 percent loss of the Polaroid 410 film data which was exposed to an estimated 20 to 25 roentgens. (Project 2.3 did not have any passive dosimeters located in the trailer; however, trailers on either side of Project 2.3 had dosimeters, and the estimate was based on their results.) Several efforts were undertaken between Northrop and the Polaroid Corporation to recover the data by various photo-developing techniques and the use of microdensitometry. Immediately after the Pin Stripe event, 34 cameras

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[redacted]

(containing the irradiated film data) were handcarried to the Polaroid Corporation, Boston, Massachusetts, for special photoprocessing. Five data films were processed under the direction of Mr. Herman Erikson, who successfully recovered the Diluted Waters (Project 2.13) data films which had been exposed to approximately 5 roentgens. However, the existing process proved inadequate for the severely exposed data film of Pin Stripe. To thoroughly investigate the possibility of salvaging the experimental data it was decided to evaluate various developing techniques on exposed film other than that containing the Pin Stripe data.

[redacted] "Seven rolls of Polaroid type 410 film were exposed at the Northrop Co^{60} source to 0, 5, 10, 15, 20, 25 and 30 roentgens. Prior to exposure, pulse and grid reticules were recorded on each frame of the seven rolls. Subsequent to exposure the irradiated film was developed by Mr. Erikson.

[redacted] "Utilizing the existing developing process, it was possible to determine the grid lines (but no recorded pulses) on film exposed to 15 roentgens. At that time Mr. Erikson

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[redacted]

attempted several processes until an optimum process was successful in developing the 20 roentgen film with grids and pulses and the 30 roentgen film to a point where the grid lines were visible. The developed exposed films, as well as five of the original data films, were examined with a microdensitometer to determine if it was possible to reproduce the recorded data by the means of optical density scanning. Several attempts employing direct and reflected microdensitometry techniques yielded negative results. The densitometers used were: Magnaflux Corporation, Materials Testing Laboratories Division, Los Angeles, California; Beckman and Whitley, San Carlos, California.

[redacted] "Subsequently, five additional camera assemblies from Pin Stripe were developed by Polaroid with the optimum developing process; a microdensitometry check was performed, and again the results were negative. Then the remaining 24 data films were developed by Polaroid; no data were recovered."

Project 2.11 (Eastman 2475 film)

[redacted] "The data was recorded with film, and dosimetry. The film, after recording the data, underwent a gamma ray exposure of approximately 20 R."

[redacted] [redacted]

[redacted]

[redacted] "HDL Effort at NTS: Originally, the data film was to be processed by project personnel, using developer HC-110 in a dilution of three parts water to one part developer for six minutes. The films from the fastest writing oscilloscopes were to be pushed to higher writing speed by longer development and higher temperatures. This handling of the film had proved most successful in a laboratory test conducted before Diluted Waters and has been popular with other laboratories, notably the Lawrence Radiation Laboratory (LRL).

[redacted] "After the radiation accident occurred, dosimeters on the trailer walls indicated exposures as high as 22 R. Film, which had been placed in holders on the walls, was developed by the technique described above. These films were very opaque, of a density that would be useful in viewing an eclipse. Several more irradiated films (the backloads) were (post) exposed to the graticule on a 551 scope and these were developed. The graticule could be seen. Then several data films were processed, but nothing more than a hint of a baseline was evident. Several different times, dilutions, and developers were tried, with no success.

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[redacted] "At this time, photographers at other major laboratories were contacted. Particularly, discussions with EG&G (Field Support), LRL, and others led to the conclusion that no good process for saving film subjected to this level of radiation exposure had been developed. It was at this time that H. Erikson of Polaroid Corporation was contacted.

[redacted] "Polaroid Corporation Effort: In order to allow more experimentation before processing the data film, ac power was restored to the instrumentation trailer and more dry run traces were recorded on Kodak 2475 (from the same batch as the shot film). The films were then put in boxes and irradiated with a Co^{60} source at EG&G, Las Vegas. The exposures were chosen at 5, 10, 15 and 20 R.

[redacted] "Using these simulated films, Polaroid Corporation developed a process through which the simulated data could be retrieved. The process consisted of developing only a thin layer on the surface of the emulsion, based on the assumption that the emulsion is designed to absorb light, so that the greatest density of image should be near the

[redacted] [redacted]

surface. On the other hand, the background, being due to gamma rays, should be uniform throughout the emulsion, so that the signal-to-background ratio should be highest at the surface.

[redacted] "Upon processing the data film, it was found that the image did not respond to this development process nearly so well as did the image on the simulated films. No definite reason was found, although several suggestions were advanced. The most likely reason is that fogging phenomena are found to be rate-dependent, and it would be very difficult to reproduce in the laboratory the exposure rates experienced by the data film. These simulations were carried out at constant rates of less than 4 R/sec.

[redacted] "In addition to the developments attempted at Polaroid, it was suggested that the developed films be scanned by an isodensitracer, a form of microdensitometer. One such instrument was available at Technical Operations in Burlington, Massachusetts. This also proved unsuccessful because the mottled background provided too much optical noise to permit detection of the traces.

[redacted] "It should be noted here that Polaroid Corporation spent about one week working on the simulated data film at no cost to HDL and made a significant contribution to the eventual development of the Pin Stripe data film.

[redacted] "Technical Operations Effort: The use of the Technical Operations (Tech Ops) isodensitracer lead to further discussion with the Tech Ops staff. Subsequently, Tech Ops offered to accept a contract to perfect a process to develop the fogged data film.

[redacted] "HDL awarded a contract to Tech Ops in early fall of 1966 and followed this with a portion of the final set of simulated data films, again prepared by EG&G from the remainder of the shot film batch of Kodak 2475. The Tech Ops photochemistry group, under the direction of Mr. Leo Corbin, went to work on these simulated films and soon reported that they had a number of developers which worked reasonably well and that they were ready to start on the actual data film.

[redacted] "At this time the HDL project personnel had to make a decision. On the negative side was the New Point event, whose schedule had progressed to the fielding stage and was demanding almost continuous attention at NTS by

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[redacted]

project personnel. On the positive side were two significant factors, first, that the data film was getting older (and possibly harder to recover) and more unlike the simulated films with each week of refrigerated storage, and second, that any data which might be recovered could be extremely valuable in calibrating the New Point detectors (which were the Pin Stripe detectors, reworked).

[redacted] "The positive aspects carried the argument and, accordingly, HDL project personnel spent the week of 6 November 1966 at Tech Ops, arriving with the remainder of the simulated film and the remaining data film from Pin Stripe Projects 2.8, 2.11, 2.12 and 2.14. At Tech Ops the first day or so was spent reviewing the project status and experimenting with the various processes on the last of the simulated film.

[redacted] "The Tech Ops processing was based on a family of special film developers, originally developed under an Air Force contract, which worked with commercially available film emulsion to yield extended exposure latitude, up to approximately six orders of magnitude. These

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[redacted]

developers have the effect of drastically reducing the slope (film gamma) of the D log E curve (otherwise known as the H and D curve).

[redacted] "The Pin Stripe film had, in effect, been exposed twice. The first exposure was the relatively low exposure by the optical photons from the oscilloscope (the data trace). The second exposure was the relatively extreme exposure by the gamma ray photons emanating from the radioactive cloud (the background or fog level), this exposure being uniformly distributed throughout the film emulsion.

[redacted] "The effect of these extended latitude developers on the Pin Stripe film was to reduce the very great difference in image density between the data trace and the enveloping background, to the point that the data trace could not be distinguished from the background (or fog) level. Generally speaking, the results achieved by this technique were gratifying but not earth shaking. It is possible that further experimentation could have improved the contrast, but time was at a premium and, therefore, compromise was necessary.

[redacted] "As stated previously project personnel monitored the application of various Tech Ops developers and techniques to

[redacted]

the last of the simulated film. Some four different developers were used on the simulated films (having radiation levels of both 15 R and 20 R) for varying periods of time. After careful scrutiny of these test films, both project and Tech Ops personnel decided that developer GC909B for 3 minutes was the best choice, since this combination yielded the best background fog level density comparison between the simulated films and the backloads from the data film holders. Tech Ops personnel proceeded to develop the Pin Stripe data film, one or two sheets at a time, each developed film being carefully scrutinized by project personnel for data traces and constancy of processing. In this manner Tech Ops developed the remainder of the Pin Stripe data film for the aforementioned projects, a total of fifty-eight pieces of film. Project personnel then carried the developed film back to HDL and subsequently delivered it to the respective Project Officers."

[redacted] It is beyond the scope of this report to provide an extensive analysis of the susceptibility of photographic film to radiation exposure, but some general discussion is presented for information. First, one must conclude that the tolerance test conducted before Pin Stripe was not adequate. No Polaroid film was exposed to more than 6.4 R at

[redacted]

which point it appeared to be completely fogged, but this was with automatic development. Optimum processing brought out traces exposed to 8 to 13 R.

[redacted] The susceptibility of the film to fogging is a function of the oscilloscope sweep speed, the spot intensity, the ASA rating of the film, and the nature of the signal. One can conclude that the tolerance of typical traces on Polaroid 107 (ASA 3,000) is about 10 R when sweep speeds of about 0.1 μ sec/cm are used. Film of 10,000 speed should be avoided, and the practice of making the trace very thin should be abandoned for field tests. The signal should be burned in for maximum contrast. Obviously, no data was obtained from the close-in, Project 2.2, trailer due to the very high radiation exposure at that location.

[redacted] The Eastman 2475 film seemed to have a tolerance of about 15 R for sweep speeds of 0.1μ sec/cm and slowly varying signals. It should be emphasized that the above generalities apply to film that was developed and analyzed by the most elaborate and sensitive techniques now available, and tolerances would be much less for the more common methods.

[redacted] The film fogging experience on Pin Stripe encouraged several organizations to develop automatic, mechanical film pullers for

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Polaroid film during the months following the test. Automatic film pulling and development immediately after the scope photograph was taken would prevent fogging of the data from a subsequent radiation exposure. Several different types of pullers were tested on New Point.

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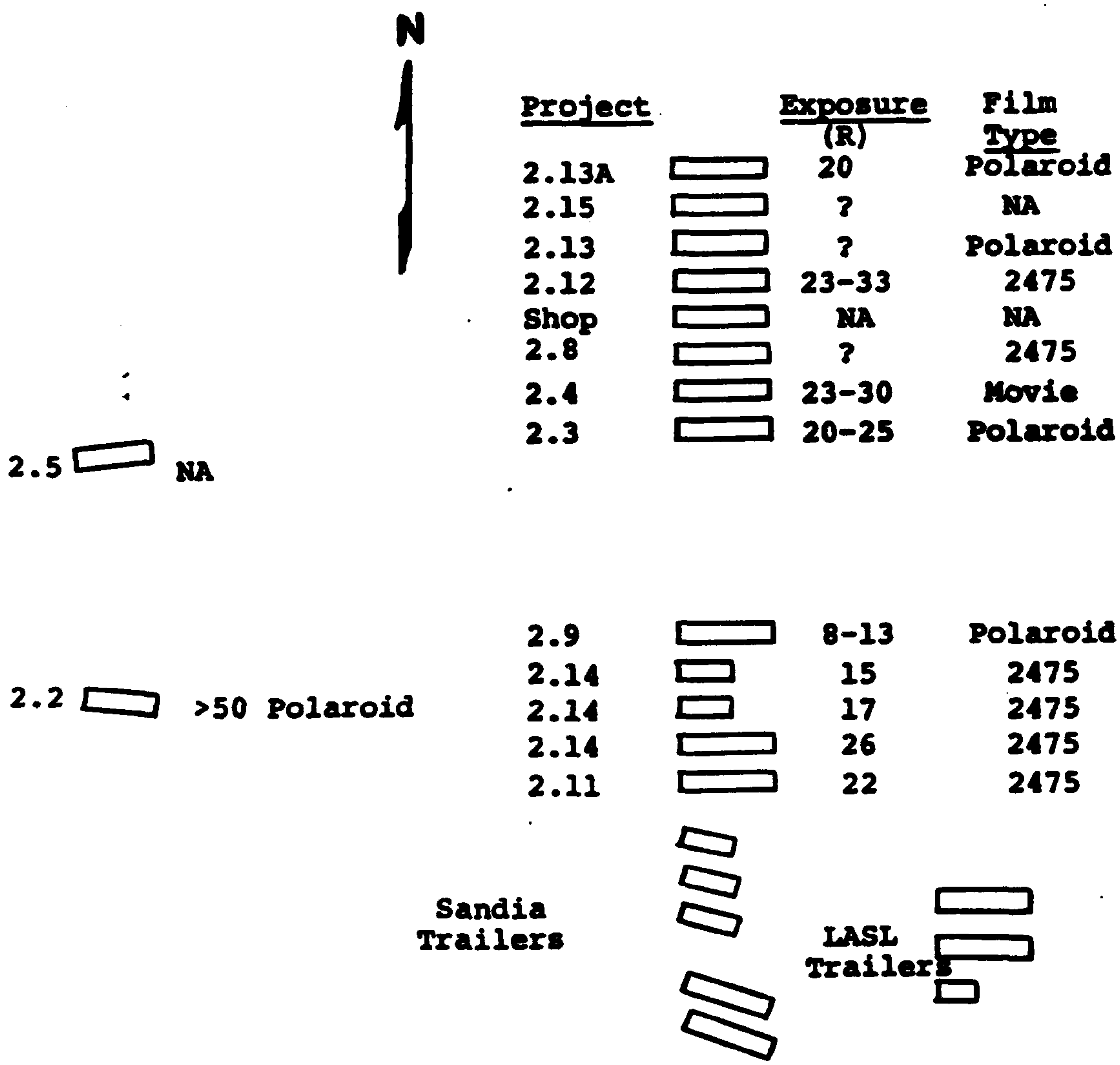

Figure F.1 [redacted] Radiation exposures in trailers. [redacted]

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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[redacted] This report describes the planning, preparation and execution on 25 April 1966 of Pin Stripe, the third underground nuclear weapon effects test in the Department of Defense Silver Bell series. [redacted]

[redacted] The objective of Pin Stripe was to more accurately simulate an operational nuclear environment than could be produced in a laboratory [redacted]

[redacted] The primary emphasis was placed on experiments directly related to the major military systems. However, considerable exposure space also was allocated to radiation effects physics experiments as well as to investigations of improved techniques for future field tests.

[redacted] In spite of the failure to completely contain the detonation products, nearly all of the major experimental goals were met. [redacted] Additionally, several experiments to improve underground test techniques provided the answers sought.

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