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COMPLETION REPORT

OPERATION HARDTACK, PHASE II

U. S. ATOMIC ENERGY COMMISSION CONTRACT AT(29-2)-460
NEVADA TEST SITE 1958

(HN-N-4-59)

Classification (Cancelled) (Changed to) JULY 1959
By Authority of JT Review DOE/DOC + DOD/DNA
By [illegible] Ch. ESH Date 27 July 1983

AEC FACILITIES DIVISION
HOLMES & NARVER INC
ENGINEERS CONSTRUCTORS

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FOREWORD

This report covers the integrated activities of Holmes & Narver, Inc., within the framework of Operation HARDTACK, Phase II, and includes Engineering and such field services as required by the United States Atomic Energy Commission at its Nevada Test Site. Preparation of this documentary is in accordance with the provisions of Modification 74 to Contract AT(29-2)-20.

In addition to recording the participation of Holmes & Narver, Inc., certain construction problems encountered by the CPFF Operating & Maintenance Contractor and Lump Sum Contractors are discussed. Also a summary of conclusions and recommendations directed toward the solution of problems experienced during this Operation is presented.

Operation HARDTACK, Phase II, was primarily a weapons development program, and the 37 events occurring within a six week period established a highpoint for an accelerated test series. The successful completion of the Operation within this brief time allowance demonstrated the capability and versatility of all participating and supporting agencies.

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CHAPTER I
GENERAL

SECTION 1
PARTICIPATING AGENCIES

AEC	Atomic Energy Commission
AFCRC	Air Force Cambridge Research Center
AFOAT-1	Air Force Office of Atomic Testing
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
ARA	Allied Research Associates
ARF	Armour Research Foundation
ASI	Aero-Neutronic Systems, Incorporated
ASRDL	Army Signal Research and Development Laboratory
BRL	Ballistic Research Laboratories
CETO	Civil Effects Test Operations
CONARC	Continental Army Command
CWL	Chemical Warfare Laboratory
DOD	Department of Defense
EG&G	Edgerton, Germeshausen and Grier, Incorporated
ERDL	Engineer Research and Development Laboratories
FCWT	Field Command Weapons Test
FSI	Federal Services, Incorporated
H&N	Holmes & Narver, Incorporated
LASL	Los Alamos Scientific Laboratory
LML	Lookout Mountain Laboratory
LRL	Lawrence Radiation Laboratory (formerly UCRL)
NRL	Naval Research Laboratory
OCDM	Office of Civil and Defense Mobilization
ORNL	Oak Ridge National Laboratory
REECo	Reynolds Electrical & Engineering Company, Incorporated
RW	The Ramo-Wooldridge Corporation
SC	Sandia Corporation
SRI	Stanford Research Institute
USC&GS	United States Coast & Geodetic Survey
USGS	United States Geological Survey
WADC	Wright Air Development Center
WES	Waterways Experiment Station
WRAIR	Walter Reed Army Institute of Research

SECTION 2
NARRATIVE SUMMARY

OPERATIONAL HISTORY

Following the completion of Operation PLUMBBOB in the Fall of 1957, advance planning was initiated by the AEC, the Scientific Users, and various participating agencies for conducting a series of weapons tests at NTS during the period 1958-60. Engineering design for major test structures and facilities was scheduled to be accomplished in the Los Angeles Office, while design changes to comply with field conditions, available equipment and material, and late criteria changes requested by the participants would be accomplished at Jobsite. The schedule for these tests had been defined by the end of February 1958, as follows:

OPERATION	PERIOD	NO. OF EVENTS
MILLRACE	Fall, 1958	11
TRUMPET	Spring, 1959	27
MILLRACE "A"	Fall, 1959	9
MILLRACE "B"	Fall, 1960	4

The possibility of a moratorium on the testing of nuclear weapons became apparent in June 1958; therefore, several events were advanced from the TRUMPET schedule to MILLRACE.

On 29 August, the Office of Information, AEC/ALOO, released the following public announcement relative to the program of nuclear weapons testing at NTS:

> "John A. McCone, Chairman of the Atomic Energy Commission, and Neil H. McElroy, Secretary of Defense, today announced plans for concluding programmed nuclear testing prior to the suspension of tests for one year starting October 31 proposed by President Eisenhower. The 1958 test program, which has been in progress at the Eniwetok Proving Ground and Johnston Island in the Pacific, will conclude with approximately 10 low-yield nuclear detonations at the Nevada Test Site.
>
> "The Nevada tests will be held during September and October and will be completed prior to October 31. Several of the test shots will be contained underground in tunnels which have been under construction for several months; the remainder will be fired from balloons or towers. More than half of the tests will be less than one kiloton; the highest yield will be in the nominal (20 kiloton) range. Certain information of interest to seismologists will be provided in advance of the underground detonations.
>
> "News media representatives will be invited to observe the Nevada detonations."

Concurrent with this announcement, the AEC initiated a revised program for NTS, designated Operation HARDTACK, Phase II. The Schedule of Events, as published on 10 September 1958, was based on a total of 20 shots: 6 vertical holes, 4 balloons, 9 tunnels, and 1 tower. The program was later revised and expanded to encompass the executed schedule as shown in Table 1.

Area	Tower	Tunnel	Balloon	Surface	Vertical Holes	Total
3	4				6	10
5	1		2			3
7	1		8			9
8	3					3
9	1		1	3		5
12		7				7
Totals	10	7	11	3	6	37

Table 1. NUMBER OF EVENTS BY AREA AND PLACEMENT.

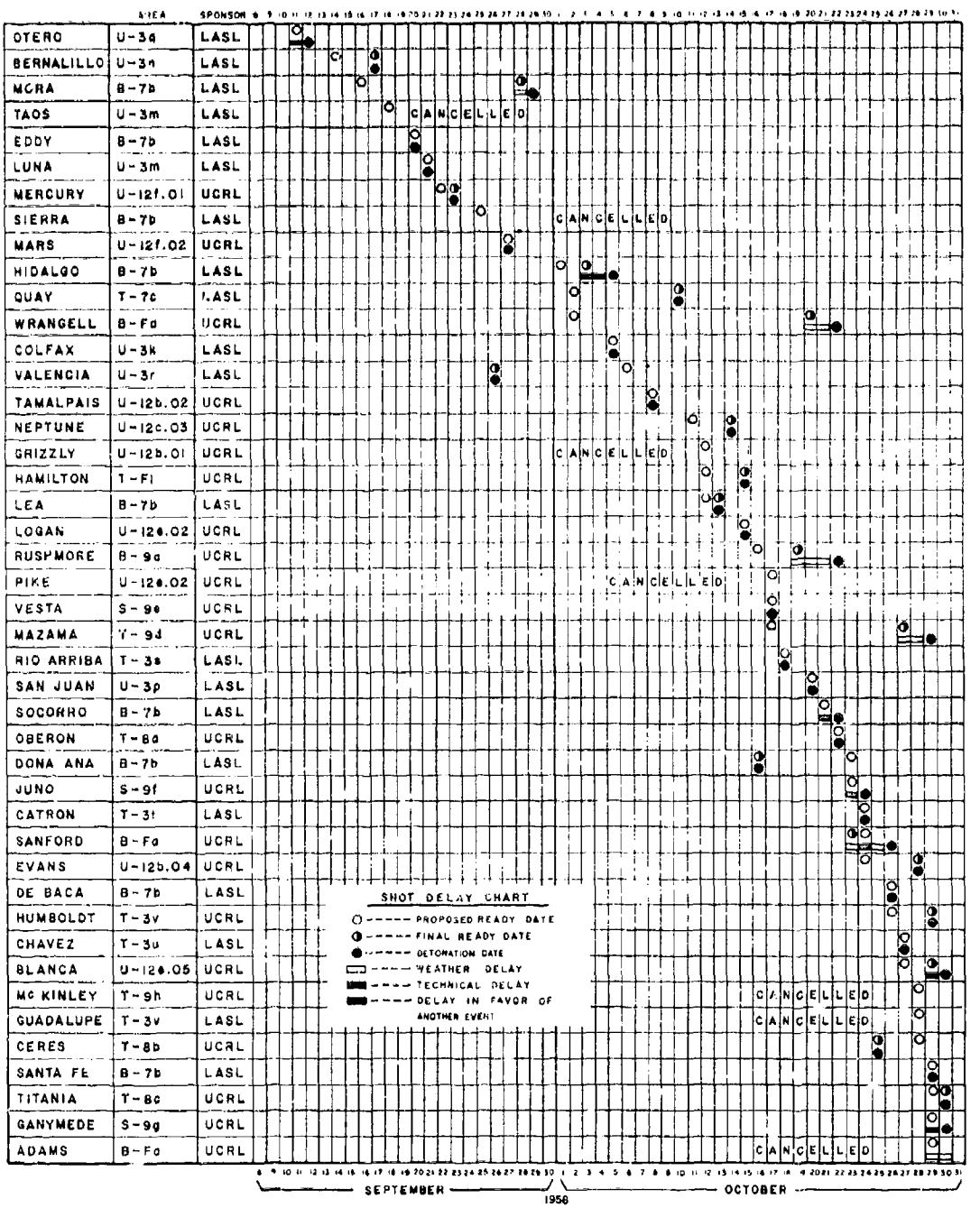


Chart No. 1. Schedule of Events - Operation HARDTACK, Phase II - Nevada Test Site

Due to the acceleration of design and construction of test facilities as a result of the new shot schedule, it became necessary to transfer to the Field Office all unfinished design work or work not yet under way. This required the assignment of 20 Los Angeles Office engineering personnel to the Field Office, including the Chief Project Engineer — Project Engineering, who coordinated all design criteria released by the participating agencies. Personnel with experience in previous operations were used to a great extent to provide a high level of engineering skill in the shortest possible time.

The first test of Operation HARDTACK, Phase II, was the Otero event, detonated on 12 September 1958 in Station U-3q. Six other events took place during September.

Throughout October, an accelerated testing program was placed in effect to complete the schedule of events by the end of month. For example, on 22 October four events were detonated, and on 29 and 30 October three shots were fired each day. The final shot of the series, the Titania event, was detonated on a 25-foot tower in Area 8 at 1235 hours, 30 October. Operation HARDTACK, Phase II, was officially concluded at 2359 hours PST, 15 November 1958.

HIGHLIGHTS

One of the salient features of Operation HARDTACK, Phase II, was the "crash" nature of the program. It embraced 37 events in a period of approximately one and one-half months. This required concentrated effort and close coordination among the participating Laboratories, Scientific Users, government agencies, the Architect-Engineer, and the Operating & Maintenance Contractor to complete testing by 30 October. Another significant feature of this Operation was the increased use of underground detonations. The feasibility of deep underground placement as a weapons testing technique was demonstrated by the Rainier event in Operation PLUMBBOB.

A geological engineer and mining engineer were added to the H&N staff to provide technical assistance during the scheduled events. These two engineers made valuable contributions in the design of tunnel workings and interpretation of geological conditions in the elaborate tunnel systems.

Throughout the Operation, H&N was engaged in an unusually large amount of surveying activities. Of the 160 peak number of H&N personnel at NTS, 104 were assigned to the Survey Section, and one-third of these were employed in the tunnel program.

The NTS Facilities Brochure, which was prepared at the completion of Operation PLUMBBOB, contained area maps, architectural drawings, data on scientific stations, indexes of as-built drawings, and data on utility installations. This document proved of immense value to participating groups in planning their operational programs.

LUMP SUM CONTRACTS

The significant decrease in lump sum contracts awarded during Operation HARDTACK, Phase II, as compared with previous operations at NTS, was due to the accelerated program. With time the prime factor, and faced with continuous criteria revisions, it became necessary to rely more heavily on the CPFF Operating & Maintenance Contractor for construction services.

Table 2 compares the total of Lump Sum and CPFF construction during Operations PLUMBBOB and HARDTACK, Phase II.

Contract	PLUMBBOB	HARDTACK Phase, II
Lump Sum	$ 4,814,979.72	$ 281,624.61
CPFF	11,506,352.19	6,578,499.89

Table 2. COMPARISON OF CONSTRUCTION, LUMP SUM VS. CPFF.

During Operation PLUMBBOB, about 70% of construction was accomplished by the CPFF Construction Contractor and approximately 30% by Lump Sum Contractors. However, during Operation HARDTACK, Phase II, the percentage of construction performed by CPFF Construction Contractor increased to approximately 95%.

COMMUNICATIONS

To achieve increased efficiency and improved operational results, H&N installed a Communications Engineering Group at NTS staffed with specialists in both radio and telephone.

In May 1958, H&N communications engineers initiated a cable testing program and converted cable records to as-built drawings. Although this program had not been completed at the start of the Operation, sufficient cable testing had been accomplished to aid the AEC, the Scientific Users, and the Construction Contractors in meeting the cable requirements of an accelerated test program. In addition to providing engineering design, the H&N Communications Group provided inspection of technical facilities and coordinated the communications requirements among all participating agencies.

A radio coverege survey of off-site RadSafe radio communications resulted in the installation of repeater stations at Angeles Peak, White Mountain, Highland Peak and Rib Hill. Generally, these sites provided satisfactory communications, however, second harmonic radiation

from one of the transmitters at Rib Hill interfered with another installation at this site and system lock-up between Rib Hill and Highland Peak occurred under certain conditions. The design of an automatic transfer and failure alarm system for use with stand-by equipment at the repeater sites was initiated to reduce maintenance and improve operation reliability. However, the time limitation of the program would not permit completion of the project in time for use during the Operation.

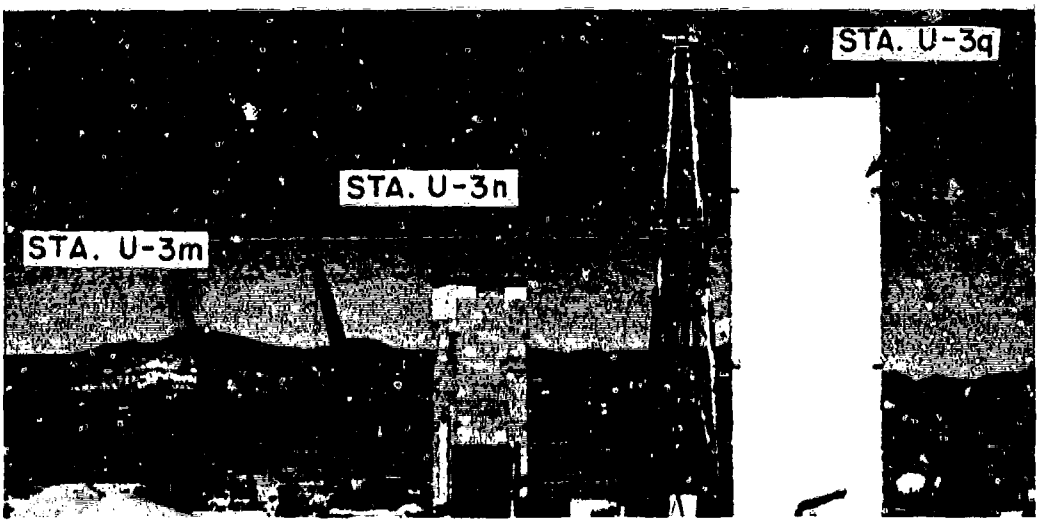
A feasibility study of the VHF radio system, including 1) the determination of a consolidated repeater site capable of serving all operational areas of NTS, 2) an analysis of the NTS frequency plan, 3) a proposed new frequency plan, 4) propagation calculations, and 5) field tests, resulted in the relocation of the consolidated repeater site from Smoky Jr. to Smoky Sr. Time limitations precluded the possibility of obtaining the crystals necessary to implement the new frequency plan; however, five of the eight VHF repeaters were relocated to Smoky Sr. and the signal strength to pertinent locations in Area 12 was materially improved. It is planned to relocate the three remaining VHF repeaters to Smoky Sr. upon completion of field tests, using the new frequency plan.

AREA 3 TEST FACILITIES

The Area 3 test facilities to be used during this Operation required extensive engineering and construction services. Five underground test facilities, similar to those used for the Pascal Event in Operation PLUMBBOB, were requested by LASL (Stations U-3k, U-3m, U-3n, U-3p, and U-3q). Three of these stations were to be completed facilities including a 500-foot deep hole cased with 36-inch diameter steel pipe, a middle and top concrete plug, a steel head tower, a winch system, and were to connect to existing diagnostic bunkers with signal and coaxial cables. The other two stations were to be only 500-foot cased holes.

An AEC contract was awarded to Casey & Montgomery, Inc., Bakersfield, California, for the drilling and casing of the holes. Drilling started 2 June 1958, and the first hole was cased and grouted by 13 June. The drilling of the second hole, Station U-3p, commenced on 14 June and was prepared for casing by 18 June. Six 32-foot joints (192 feet) of casing were welded and run into the hole when considerable material sloughed into the hole and the casing became immovable. During the next eight days, continuous efforts by the Contractor to free the casing were unsuccessful and the hole was abandoned on 26 June.

To provide the User with five completed 500-foot deep, 36-inch diameter holes, Station U-3r was added to the initial contract and between 27 June and 7 August, the four remaining holes were drilled and cased without incident. The Contractor again moved his drill rig over U-3p on 8 August to clean the hole below the 192-foot level and set 34-inch casings for the full depth of the hole. No serious problems were encountered in redrilling the hole to the 500-foot level, but after 310 feet of 34-inch casing



(58-16-2)

Figure No. 1. Head Towers at Stations U-3m, U-3n, and U-3q (Left to Right) Drill Rig Over Station U-3p

had been placed, the casing was again immovable. On 18 August the Contractor was given permission to abandon this hole and the contract was closed.

Later, it was determined that the U-3p hole would be required and the Operating & Maintenance Contractor provided through a subcontract, the services to bail the hole and place concrete in the annular void between the 34 and 36-inch casings. During bailing operations, the bucket became wedged between the 268 and 275-foot level and it was necessary to cut the lifting cable, with the bucket still in place, and fill the hole with concrete to the 251½-foot level.

Head towers for Stations U-3n, U-3p, and U-3q were to be provided by the Operating & Maintenance Contractor and required construction of two new head towers from sections of a Self-shot tower in stock and modification of the existing tower at Station U-3j. When the firm requirement was initiated for five 500-foot deep holes and one shallow hole for use in the Operation, it was necessary to construct four head towers from existing tower stock and move one tower from a previously utilized facility.

To provide additional testing facilities quickly for low yield detonations during the last 15 days of the Operation, two 70-foot high and one 50-foot high timber towers were constructed for LASL, using stock telephone poles and timber. In addition, a 25-foot high timber tower was constructed for LRL as a vehicle for a low yield event.

AREA 12 TEST FACILITIES

Plans by LRL for the development of existing Tunnel U-12b for use in Operation MILLRACE included 1) the modification of the diagnostic building, Station 12-300, 2) the construction of two trailer parking areas, and 3) the excavation of four side drifts off the main drift for shot locations, each drift with a buttonhook configuration leading to the shot chamber and with alcoves off the entrance for instruments and equipment.

Shortly after the start of Operation HARDTACK, Phase II, the requirement for the use of the U-12b.01 side drift was deleted.

The first test in the U-12b tunnel complex, the Tamalpais event, was held in Station U-12b.02 on 8 October. While recovering film after the test, the accidental igniting of gases resulted in an explosion that caused considerable damage to the main drift and to the other three side drifts. Therefore, the Rushmore event scheduled for U-12b.03 was rescheduled to a balloon in Area 9, and much of the diagnostic effort that was to be acquired from the Evans event in U-12b.04 was sacrificed.

Preliminary criteria furnished by LRL during September and October 1957 for the development of a new tunnel site south of Tunnel U-12b included 1) a straight 4000-foot long access tunnel with two tracks, 2) three branch tunnels leading to shot chambers, 3) a partially buried multi-plate arch-type diagnostic building, 4) a generator shelter, 5) a trailer parking area, 6) space for vehicle parking, 7) space for a future diagnostic shelter, and 8) a Contractor work and storage area.

In February 1958, the Users revised planning to include seven side drifts having two blast doors, two blast traps, drilling alcoves and a hooked-end configuration for each drift.

Construction of the portal by the Operating & Maintenance Contractor was started on 17 March, and excavation of the main drift commenced on 19 April 1958.

The Laboratory had originally planned on using Stations U-12e.02 and U-12e.05 for Operation MILLRACE. With the announcement of Operation HARDTACK, Phase II, construction of the main drift was terminated at the working face, station 20 + 34, in order to meet the established deadline.

During the first week in September, LRL was directed to perform a preliminary test involving a 6-foot diameter, 500-foot long vacuum pipeline and several underground alcoves. To meet this requirement the Logan event was substituted for the Pike event and it was necessary to scale the pipeline down to 24 inches in diameter by 165 feet long. The U-12e.02 drift was driven for approximately 650 feet with maximum effort and GZ was established on 27 September. The Users moved in their equipment on 4 October, and the Logan event was detonated at the end of this drift on 15 October.

The U-12e.05 drift for the Blanca event was driven to obtain the maximum overburden possible and still protect the main tunnel from collapse as a result of the Logan event. In addition, steel sets were installed on 4-foot centers for the first 500 feet of the drift.

Considerable damage occurred to the main tunnel as a result of the Logan event and it was necessary to excavate a new tunnel from station 17 + 94 to the portal of the U-12e.05 drift, and relocate GZ at station 5 + 97.

The construction of five safety test facilities off the existing main access Tunnel U-12f was requested by LRL in July 1958. Each facility was to consist of a short drift with a hook at the end, a blast door, and a small alcove for one instrument drill hole.

The requirement for U-12f.05 was deleted in August. The final configuration of the U-12f complex follows:

(58-1-18)

Figure No. 2. General View of Tunnel U-12e Portal Area

U-12f.01	155 feet at station	3 + 70
.02	155 feet at station	4 + 30
.03	311 feet at station	4 + 90
.04	155 feet at station	5 + 30

U-12f.03 and .04 side drifts were abandoned and relocated to surface test facilities in Area 9, due to radioactive contamination caused by the Mercury and Mars events.

Another safety test installation, Station U-12c.03, was excavated in the existing PLUMBBOB Tunnel U-12c and consisted of a 6-foot wide by 7-foot high by 165-foot long side drift at station 1 + 00.

To provide the Sandia Corp. and the Stanford Research Institute facilities for pre and postshot measurements, five 8¾-inch diameter vertical instrument holes were drilled from the top of the mesa in Area 12. The John S. Hagestad Drilling Co., Bakersfield, California, under an AEC lump sum contract, moved on the drilling site 4 August, and drilled and cased the first hole to a depth of 892 feet. Due to several program changes during the drilling operations, it was necessary to relocate the four remaining holes from the site originally planned to a point above the U-12b.04 GZ. During the interim period between drilling completion and instrumentation considerable sloughing action resulted from detonations in the immediate area, and it was necessary to ream one of the holes to 12¼ inches and redrill and clean the other three prior to lowering the instrumentation.

AREA 14 (LASL TUNNEL AREA)

In June 1958, LASL requested that AEC provide two horizontal tunnels and a diagnostic building, 20x30 feet, with coax lines to serve both tunnels. One of the tunnels was to have 1100 feet of vertical cover, and the other was to have 900 feet of vertical cover. As a result of a survey made by the United States Geological Survey, only one proposed site fulfilled the vertical cover requirements. Since this site did not provide for future expansion, LASL decided to abandon tunnel plans for Area 14 and undertook the consideration of other areas, including Skull Mountain, the east side of Shoshone Mountain, an area north of Area 14, and Forty Mile Canyon.

SECTION 3
CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. The reorganization of the Nevada Test Site Organization by the AEC and the inclusion of an Engineering & Construction Operations Office staffed by representatives of the AEC, LRL, and the A-E contributed materially to coordination and control throughout the Operation.

2. The availability at NTS of a considerable number of "Q"-cleared survey personnel surplused from EPG, substantially aided the A-E in keeping abreast of the frequent changes and additions to criteria.

3. During Operation HARDTACK, Phase II, the inspection staff was strengthened by the addition of qualified engineers enabling the A-E to effect and approve changes resulting from criteria modifications or nonavailability of materials, without the delays inherent in obtaining the concurrence of design engineers.

4. Additional information obtained on damage and response of AEC test structures close to the point of detonation will lead to improved design techniques and more accurate evaluations of shock damage to instruments and equipment. The data collected on radiation shielding provided by structures may result in more effective shielding measures, and the detailed studies of rock movements in response to nuclear explosions may provide better tunnel support design.

5. Completion of the main objectives demonstrated that by employing unusual flexibility with available manpower and by transferring design personnel to the site, an accelerated programming of events could be satisfactorily executed. However, this method is inevitably associated with some sacrifice in quality control and a corresponding increase in cost.

RECOMMENDATIONS

It is recommended that:

1. The Users advise and coordinate with the H&N Field Engineering staff all required design changes, and construction and support requirements. Compliance with this procedure would aid immeasurably in coping with the changing requirements and construction coordination necessary during a testing program.

2. All information, including design criteria and field changes, should be routed through authorized channels prior to construction to provide maximum coordination.

3. A fire-resistant structure be provided for the protection of critical engineering documents in possession of the A-E which relate to the test site.

4. A-E representatives be invited to attend planning meetings of the various Users to a greater extent than previously. This will result in an early understanding of the scope of operations, permitting intelligent planning of the total engineering and construction effort prior to the operational build-up period. Moreover, A-E representatives attending preliminary meetings as official observers will be in a position to transmit pertinent engineering and construction information to the AEC.

5. Periodic status reports, prepared by Project Officers of DOD, Sandia, CETG, and the Scientific Laboratories, be made available to the A-E. This will materially facilitate the planning activities of the A-E.

6. Additional office space and living quarters, in line with firm requirements, be furnished the A-E. This will result in a broader capability to absorb experienced Los Angeles Office Engineering personnel at Jobsite during a future program.

CHAPTER II
ENGINEERING AND CONSTRUCTION

SECTION 1
LOS ANGELES OFFICE ENGINEERING

ORGANIZATION AND RESPONSIBILITIES

Engineering functions in the Los Angeles Office were under the direction of the Engineering Manager who was responsible for the preparation, review, and issuance of engineering design for test structures and facilities developed from criteria received from the AEC and various Scientific Users. The supervisory staff of the Engineering Manager consisted primarily of the Chief Project Engineers for Project Engineering, Blast Study, Communications, and the Chief Production Engineer.

The Chief Project Engineer, Project Engineering was responsible for 1) the processing of AEC and User criteria, 2) scheduling of design completion to permit sufficient construction time to meet User occupancy dates, and 3) checking to ensure that design conformed to User criteria. Project Engineering maintained close liaison with the Scientific Users in order to incorporate the latest design changes on drawings prepared for test structures and facilities. This group also maintained liaison with the Resident Engineer on design responsibilities, and forwarded advance engineering drawings for procurement items requiring long lead times.

The Chief Project Engineer, Communication, was responsible for the design of all signal, communication, and radio requirements at NTS and for the maintenance of all records concerning telephone and signal cables installed in the forward area.

The Chief Project Engineer, Blast Study, assisted by design specialists, studied the effects of nuclear blasts on existing AEC structures, developed more reliable information on quantities and velocities of rock broken from tunnel walls, and recorded the deflection and damage of tunnel linings exposed to nuclear explosions.

The Chief Production Engineer was responsible for the production of all engineering design and drafting on a controlled schedule. He provided overall supervision for the Civil, Electrical, Mechanical, Structural, Checking, Specifications, and Coordination Sections; consisting of engineers, designers, and draftsmen functioning under the direct supervision of Section Chiefs.

An Assistant Project Engineer was assigned the position of Assistant Coordinator, Engineering & Construction Operations, on the Test Manager's staff. This component of the Test Organization reviewed and coordinated construction and support requirements of all participating Users, Agencies, and AEC.

DESIGN AND CRITERIA DEVELOPMENT

The following discussions concern only the stations involving major engineering design. The description of other scientific stations for which engineering was performed in the Los Angeles Office is contained in Chapter II, Section 5.

Stations U-3k, U-3m, U-3n, U-3p, and U-3q

LASL requested that design be accomplished to support several underground safety tests. A proposed layout was received for five zero points in Area 3 that were located 200 feet apart and 1000 feet from Station 3-300. Road, power, signal, and coax requirements were to remain basically the same as for the Area 3 stations constructed for the Pascal event during Operation PLUMBBOB and Project 58-NTS.

Each zero point was to consist of the following.

1. A 500-foot deep hole, cased with 36-inch nominal diameter steel casing, to the following specifications:
   a. Plugged at the bottom and watertight.
   b. Straight within a tolerance of $\pm 1°$.
   c. Vertical within $\pm 5°$.
   d. Clear ID of at least 34½ inches and tested with a mandrel 35 feet long with 32½-inch minimum OD.

e. Clear ID of at least 34½ inches for top 10 feet and tested with a mandrel 10 feet long with 34-inch minimum OD.

f. Replace drilling mud around the pipe with concrete for the entire 500-foot length.

2. A 5-foot steel-encased concrete plug placed near the 250-foot level with side slots for coaxial and hoist cables and a central collimation hole. Concrete would not be placed in the plug until the line-of-sight had been checked and the exact position of the collimation hole had been established.

3. A second concrete plug, consisting of a 28-foot long steel cylinder filled with four 5-foot long concrete cylinders, was to be placed at the top of the hole. A separate User-furnished canister connected underneath the provided compartment.

Jobsite Engineering was requested to accomplish the design for the stations, with the Los Angeles Office providing assistance as required. Prior to submitting drawings for User approval, Jobsite was requested to furnish copies to the Los Angeles Office for checking and approval.

The head tower, which was to have a vertical clearance of 62½ feet, was redesigned as a 75-foot tower with a sheave shelter. The system of winches and hoists went through four major revisions; however, the final design requirements specified two winches on the same side of the tower with two sets of sheaves, one above the other, and a monorail hoist.

Signal and coax requirements consisted of one 16-pair signal cable connected to Station 3-300, one 26-pair signal cable connected to Station 3-354, one 6-pair telephone cable connected to Station 3-24, nine runs of RG 18/U coaxial cable connected to Station 3-300, and two runs of RG 18/U connected to Station 3-300 from each of the six test sites through a common splice pit.

During the month of April specifications for the drilling and casing of the five 500-foot holes were prepared in the H&N Los Angeles Office. The Invitations to Bid on these holes were distributed on 25 April.

Seven bids were received and Casey & Montgomery, Inc., Bakersfield, California, was the low bidder with a total price of $128,850 for the required work. Contract AT(29-2)-706 was awarded to Casey & Montgomery, Inc., on 15 May 1958 and the Notice to Proceed was issued.

500-foot Steel Shot Towers

H&N was requested by LASL to develop design drawings and specifications for three 500-foot structures, utilizing five 300-foot towers stockpiled at NTS. It was requested that the following, plus any additional items required for modification, be authorized for procurement:

1. Elevator cabs and controls.
2. Elevator guide rails and connections.
3. Elevator sheaves and sheave components.
4. All standard tower electrical components.
5. New permanent guys at the 500-foot level.
6. New temporary guys at the 400-foot level.
7. New guy connector plates at the 300 and 400-foot levels.
8. Additional guy anchor beams (eight per tower).
9. New cable for existing elevator hoists.

Drawings were completed and forwarded to the User. Approval was received with the notation that the drawings were to be filed, since the use of 500-foot towers in the immediate future was improbable.

Tunnel Design

During late September 1957, H&N was requested to provide LRL survey support to establish the location of a portal and ground zeros for a proposed tunnel, and to determine the profiles of the ground surface directly over the tunnel centerline. The outline of the tunnel concept was as follows.

1. The main tunnel was to be approximately 3200 feet in length with three branch tunnels leading to shot chambers. From the portal to the last branch, the main tunnel was to be of sufficient width to permit two tracks, one for the User and one for the tunnel contractor. It was suggested that this could be accomplished by driving a tunnel 10½ feet wide and installing double tracks, or driving a tunnel seven feet wide and installing a single track with frequent turn-out sections for passing.
2. No special requirement was stipulated for a straight tunnel, other than ease of construction.

3. Ventilation, coax, power, signal, and blast doors were to be similar to those required for PLUMBBOB Station U-12b.

4. The requirements for the development of a portal area were to be similar to the U-12b portal and consisted of establishing a portal floor elevation of 6105 feet and developing an area at that point for:

   a. A partially buried 24x80-foot Armco multiplate arch-type diagnostic building.

   b. A shelter for one to six generators which were to be remote from the portal and diagnostics shelter because of the noise factor.

   c. A scientific trailer parking space for four van-type trailers with standard trailer outlets.

   d. Sufficient area for approximately four typical NTS Brockhouses.

5. In addition, the following items could be located on tailings or areas to be developed later than the required date for the preceeding portal area:

   a. Sufficient parking space for approximately 20 vehicles, exclusive of Contractor requirements.

   b. A future diagnostics shelter similar to the first one, but located on the opposite side of the portal.

   c. Sanitary facilities.

   d. Contractor work and storage areas.

The tentative date for User occupancy of the first side drift and shot chamber was set at 1 April 1958. The main tunnel was designated as Station U-12e.

The AEC disapproved construction of the new tunnel facility on 23 October 1957, and subsequently engineering design was discontinued. However, on 13 February 1958, H&N was informed that all work in connection with the design of the tunnel would be resumed and that LRL was developing revised criteria which would be available during the week of 17 February. Meanwhile, a LRL letter, dated 14 February, notified H&N that planning at the Laboratory indicated that Tunnel U-12e would be developed in accordance with the basic design prepared by the A-E, with certain modifications. Firm criteria for the side drifts were not developed at this time, but the general concept was to have two blast doors, two blast traps, drilling alcoves, and a hooked-end configuration for each drift.

A conference was held at NTS on 7 March with representatives of LRL to discuss the design of blast doors for the various tunnel experiments. Due to the special requirements for this type of experiment, the complete design was to be reviewed. Special consideration was to be given to the development of a gasket capable of containing gases at several hundred pounds per square inch for several hours.

Additional tunnel criteria were received from the User in March indicating that the main tunnel was to be 4000 feet in length with seven side drifts. Preliminary drawings were submitted for approval during March and April, and tunnel drawings prepared in the Los Angeles Office were transferred to the Field Office to enable the engineering designs to keep abreast of User's construction requirements.

Station 12-301

Design criteria were received for a LRL diagnostic building to be located at the portal of Tunnel U-12e. It was suggested that an Armco multiplate arch-type structure set into an embankment would economically fulfill the requirements. The instrument room was to be air conditioned and insulated to maintain a temperature range of 70 to 85°F necessary for the satisfactory operation of the electronic equipment inside the room.

Preliminary drawings were submitted to LRL for comments and approval in March 1958. During April and May, H&N received User-requested changes and in June the field staff was notified to proceed with site preparation and construction of the foundations.

Vertical Instrument Holes

Specifications and contract drawings were prepared in June 1958 for the drilling of five 8¾-inch diameter vertical instrument holes from the top of the mesa in Area 12. These holes were for pre and postshot measurements being made by the Sandia Corp. and the Stanford Research Institute. Holes No. 1 and 2 were to be uncased holes 1150 feet deep, and Holes No. 3 and 4 were to be uncased holes 800 and 600 feet deep, respectively. These four holes were to be located 90 degrees apart on a 25-foot radius around Station U-12e.05 GZ. Hole No. 5 was to be a cased hole, 865 feet deep, located 300 feet from Station U-12b.04 GZ.

AEC Contract AT(29-2)-738, in the amount of $68,785.25, was awarded to the John S. Hagestad Drilling Co., Bakersfield, California.

Extension of Power, Roads, and Signal Lines to Area 12

In view of the proposed activities in Area 12, AEC authorized H&N to proceed with the

development of engineering design, surveys, drawings, and specifications based upon the following criteria:

1. Extend the NTS power distribution lines into Area 12, investigating the advisability of burying the transmission line to avoid possible blast damage.
2. Extend the forward area primary road from Area 2 to the existing surfaced asphalt road at the base of the mesa. Since this was only a temporary access road into Area 12, it was suggested that a realignment might be necessary to accommodate the heavy traffic and to shorten the length of the road.
3. Provide the signal cables into Area 12 as required by the User Agencies.

The power line, as constructed, was for temporary service to operate electrical mining equipment in the proposed tunnel area (Area 14). H&N's PAC design had to be revised to take advantage of this line. Preliminary proposals and drawings were prepared for the extension of the primary road and power lines into Area 12; however, at the conclusion of the Operation, approval had not been received for construction.

Tables 3, 4, and 5 indicate the number of engineering documents prepared during the period from 1 November 1957 through 31 October 1958.

Engineering Orders Issued	1184
Shop Drawings Processed	338
Advance Notices Issued	3
Invitations to Bid	3

Table 3. ENGINEERING ACTIVITY STATISTICS, LOS ANGELES OFFICE

Type	Orig.	Rev.	Total
Civil	118	202	320
Electrical	123	144	267
Mechanical	60	71	131
Structural	244	360	604
Communications	4	3	7
Totals	549	780	1329

Table 4. FINAL DRAWINGS ISSUED BY FIELD OFFICE

SPECIAL STUDIES

High Pressure Vessels

H&N performed a comprehensive investigation and prepared cost studies for LRL to determine the means and feasibility of recovering special nuclear materials from safety detonations at NTS. Two types of facilities were considered; each included a steel containment sphere complete with ventilation, a recovery system, and refrigeration for maintaining ice within the sphere. The ice was intended to serve as an energy absorptive agent and as an aid in purging.

The first type, a surface facility, was designed to be located below an earth-covered, protective, concrete structure. The second type, a tunnel facility, was designed to be located at the end of an excavated hillside tunnel. Design drawings and cost estimates were prepared, and it was concluded that construction and operation of the facility were feasible. The estimated cost was $231,973 for the tunnel facility, and $277,102 for the surface facility.

1500-foot Lightweight Shot Tower

An investigation and study were made for LASL to determine the feasibility of constructing a lightweight 1500-foot, TV-type tower capable of supporting 5 to 10 tons at the top. The study was to include the determination of mass and individual composition of the proposed tower material by 100-foot sections. The most suitable materials and types of members were selected, and a framing and support scheme was determined to provide for an elevator facility. The mass and the composition of tower materials were itemized, and to establish the feasibility of the structure, the horizontal deflections of the tower cab were predicted.

Schematic drawings and cost estimates were prepared for the 1500-foot high lightweight tower. The cost for the facility, including foundations, tower, elevator, and control system, was estimated to be $1,441,215, and the determination was made that the tower construction was feasible.

LUMP SUM CONTRACTS

Plans and specifications were issued by H&N at the request of the AEC, based on criteria submitted by the AEC and prospective Users of the facilities to be constructed. The plans included location drawings and complete details of the work. Where necessary to amend the bid documents prior to bid opening date, addenda were issued to all interested parties. Amendments were not issued during the last

seven days of the bidding period. In all instances, standard Government forms were used, and invitations were distributed to all interested contractors to ensure competitive bidding. Final decision on awards was made by AEC after consulation and evaluation with H&N representatives.

Since the lump sum contracts were executed by the AEC, the entire program was conducted under specific authorization from the Chief, Las Vegas Branch. After approval of plans and specifications by Users and the Las Vegas Branch, invitation numbers, advertising dates, and bid opening dates were assigned by the Las Vegas Branch. Advance notices were issued by H&N to prospective bidders in selected categories, according to the type of construction work involved. These notices usually were mailed 10 days before the advertising date to 75 or more contractors and invited interested parties to request bid documents. All advance requests were honored on bid release dates, and subsequent requests were honored as soon as they were received.

	PRELIMINARY			FINAL		
Type	Orig.	Rev.	Total	Orig.	Rev.	Total
Civil	5	3	8	4	7	11
Electrical	53	4	57	14	10	24
Mechanical	25	6	31	13	8	21
Structural	83	14	97	36	18	54
Communications	141	56	197	16	7	23
Totals	307	83	390	83	50	133

Table 5. DRAWINGS ISSUED BY LOS ANGELES OFFICE

Contract Number	AT(29-2)-706	AT(29-2)-738
Contract Subject	500-foot Deep Holes	Vertical Instrument Holes
Date of Invitation for Bid	4-25-58	7-8-58
Bid Opening Date	5-9-58	7-18-58
Date Awarded	5-15-58	7-24-58
Date of Notice to Proceed	5-19-58	8-5-58
Actual Starting Date	6-2-58	8-5-58
Completion Date	8-19-58	10-23-58
Original Contract Amount	$128,850	$68,785.25
Cost of Change Orders and Modifications	$46,845.05	$44,385.31
Actual Cost	$171,087.05*	$109,669.42**
Contractor	Casey & Montgomery, Inc.	John S. Hagestad Drilling Co.

* The actual cost of Contract AT(29-2)-706 was $4,608 less than the total dollar value of the contract as modified, because the actual quantities of work performed on certain items were less than the estimated quantities as stated in the contract.

** The actual cost of Contract AT(29-2)-738 was $3,501.14 less than the total dollar value of the contract as modified, because the actual quantities of work performed on certain items were less than the estimated quantities as stated in the contract.

Table 6. SUMMARY OF LUMP SUM CONTRACTS AWARDED

Bids were opened publicly by the Las Vegas Branch with representation by H&N. Bid abstracts were prepared immediately with the H&N (Government) Estimates included. After consultation with H&N regarding the qualification of bidders and their bid proposals, LVB made recommendations to ALO for the contract awards and subsequent Notices to Proceed.

After awards were made, there were occasions when changes in criteria required plan and specification adjustments. Field Change Orders, prepared by H&N for AEC approval, consisted of work descriptions, justifications, drawings, H&N estimates, contractor quotations, and H&N recommendations. These were transmitted through LVB to ALO as supporting documents for formal contract modifications. After the Change Order had been approved by AEC, Notices to Proceed with the modified work were issued to the Contractor by LVB. Field Change Orders were incorporated into the contract by formal contract modification by AEC/ALO.

Enforcement of the provisions of the contracts was a function of H&N. The field force at NTS made inspections of work in progress to ensure compliance with plans and specifications and to make certifications necessary to support payments to contractors. Final acceptance by H&N and payment of contractors by AEC constituted the close-out of the individual contracts.

BLAST STUDY

H&N continued the program of developing improved design criteria for AEC test structures during Operation HARDTACK, Phase II, as a participant in test projects. In accordance with the decision of the Test Manager, this participation was included partly under the Civil Effects Test Organization (CETO) and partly under the LRL shock effects test program.

H&N participation with CETO was authorized by the Test Manager in a meeting with the Director, CETO, on 15 September, and formalized by EWO 61008, Revision 4, dated 17 September. Participation in nuclear tests conducted in tunnels was approved orally by the Assistant Manager for Test Operations, ALO, on 3 September and confirmed by TWX. As a major participant in CETO activity, H&N provided a director for Program 34, *Nuclear Effects on AEC Test Structures*, which was comprised of three related projects: Projects 34.1, 34.2, and 34.3. Instrumentation requirements were provided by EG&G and BRL through arrangements with CETO. Project 26.13, *Evaluation of Nuclear Effects on Tunnel Support Structures*, was included in LRL Program 26 due to its close relation to other effects projects in this program. Motion pictures and still photography to record transient response and resulting damage were provided by EG&G.

The design of close-in AEC test structures must usually provide adequate strength to withstand the blast-induced loads and sufficient shielding to protect against the extremely penetrating initial radiation resulting from nuclear detonations. Near GZ such structures are usually underground and massive in construction. Also, prediction of the total rigid body response is important because of possible effects of high accelerations on delicate instruments. Knowledge of the rigid-body response of structures of this type, resulting from air blast loading, is inadequate, and there is no sound theoretical basis for response prediction. For this reason, approximate methods and empirical correlation of experimental data are required to provide a basis for improved design of these structures and a more accurate evaluation of the probability of shock damage to instruments and equipment.

The primary cause for poor shielding in structures is frequently the streaming of radiation through the entrance-way where the thickness of material interposed is less than that of walls and roof. There is no known engineering method for satisfactorily calculating radiation intensities inside a structure, taking into account the shielding geometry.

The data gathered during the Operation should result in more realistic predictions of damage and better tunnel lining design.

Program 34

The projects summarized below were planned to provide much needed information on shielding and response and, in addition, to make observations and to collect data on blast and thermal damage to AEC test facilities. Two reports to be published by the AEC Technical Information Service Extension will cover the activities of this program's three projects: ITR 1701, *Physical Damage Survey of AEC Test Structures*, and ITR 1723, *Radiation Shielding and Response Studies of AEC Test Structures.*

PROJECT 34.1

The physical damage survey was conducted wholly by H&N personnel. The project personnel observed and recorded blast and thermal damage to a selected test site facility and to certain test structures to provide better criteria for use in the design of AEC facilities. This was a continuation of studies carried on in Operations PLUMBBOB and HARDTACK, Phase I.

Observations were made of Station 7-313, a massive concrete basehouse at GZ. This basehouse was exposed to extremely high pressures during the Quay event. Observations were also

made of seven wood-frame dwelling-type structures. They were studied for damage and total displacement in the Mora, Lea, and Socorro events.

PROJECT 34.2

The radiation instrumentation project had as its purpose the study of shielding against radiation provided by AEC test structures. The experiment supplied information concerning radiation intensity as a function of shielding geometry. Four close-in concrete underground structures were utilized for this purpose: Stations 7-24, 7-53, 7-302.01, and 9-22-6001. Participation in Area 9 was in two events, Vesta and Rushmore; in Area 7 it was in three events, Mora, Lea, and Socorro. Approximately 250 film detectors and 25 chemical detectors were exposed in obtaining data. Support of this project by EG&G consisted of providing the radiation detectors, reading them, and making a report of the readings obtained.

PROJECT 34.3

The blast instrumentation for this project was carried out entirely by BRL personnel. The purpose of the project was to study the total rigid body response of underground structures relative to free-field response in the earth. Measurements comprised 1) local blast overpressure measurements, 2) free-field accelerations of the adjacent ground, and 3) accelerations of the structure. The stations included were the tower basehouse (Station 7-313) in the Quay event and underground telephone and transformer vaults (Stations 7-24 and 7-53) in the Mora, Lea, and Sorcorro events.

Program 26

PROJECT 26.13

Project 26.13, *Evaluation of Nuclear Effects on Tunnel Support Structures* was under the direction of LRL. The purpose of this project was to obtain more comprehensive information on permanent displacements, changes in tunnel cross-sections, damage to tunnel linings, transient motions of rocks, velocities of fly rock, and transient deflections of linings; all leading to improved damage-distance criteria and better design of tunnel linings to resist nuclear explosive effects. Measurements consisted of:

1. Pre and post shot cross-sections—H&N
2. Phototheodolite surveys to show changes and damage — EG&G
3. Transient deflection measurements on selected sets in U-12b.02, U-12b.04, and U-12e.05 — H&N
4. High-speed motion picture photography of deflections of the same sets in U-12b.04 — EG&G
5. High-speed motion picture photography of unlined tunnel section in U-12b.04 to demonstrate motions of rock and fly rock velocities — EG&G

These measurements were made during the Tamalpais, Evans, Logan, and Blanca events. The report on the data collected and evaluations, ITR 1714, *Evaluation of Nuclear Effects on Tunnel Support Structures*, will be published by the Technical Information Service Extension, Oak Ridge, Tennessee.

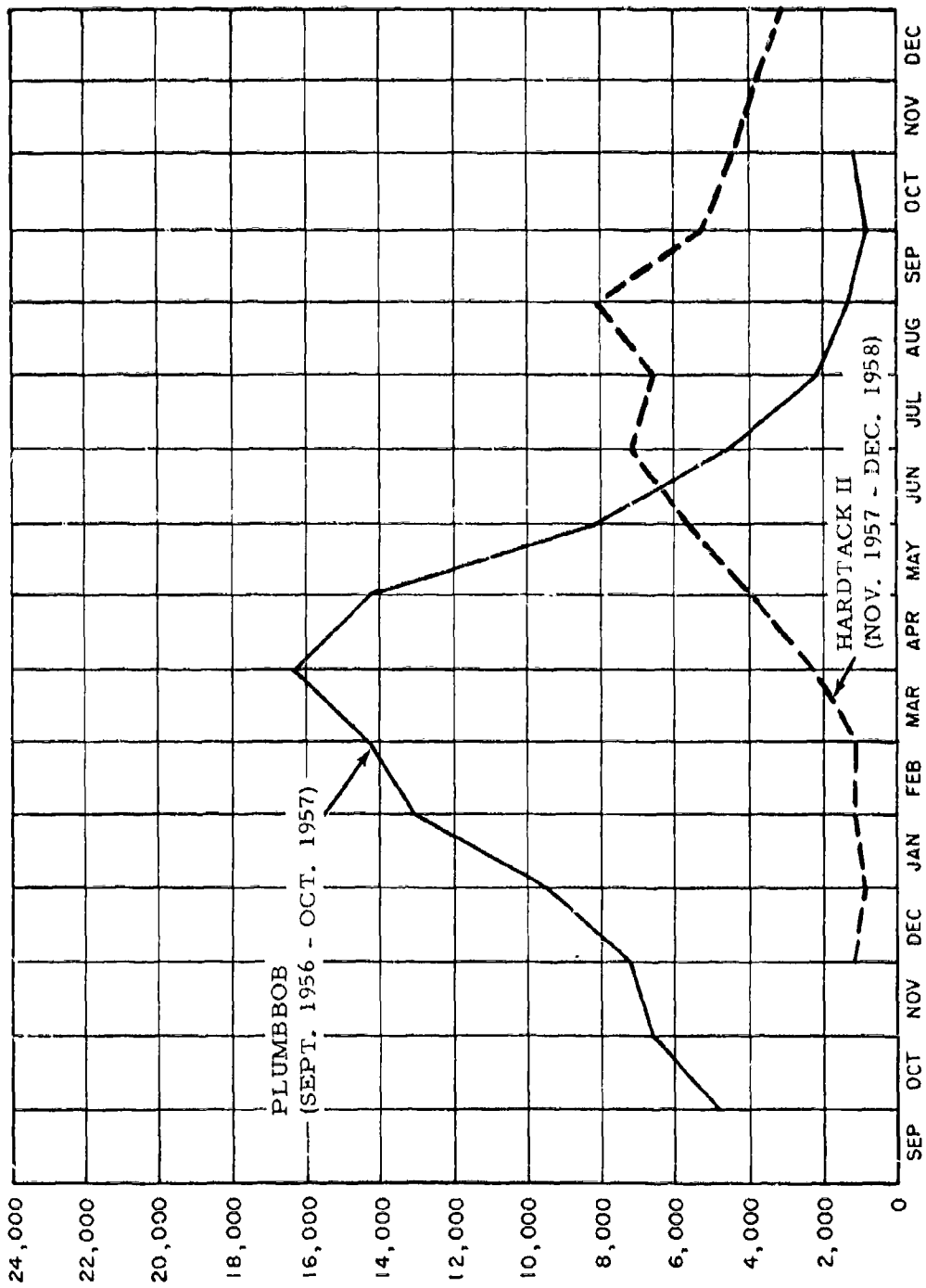


Chart No. 2. Los Angeles Office Man Hours - Engineering & Estimating
HARDTACK, Phase II vs. PLUMBBOB

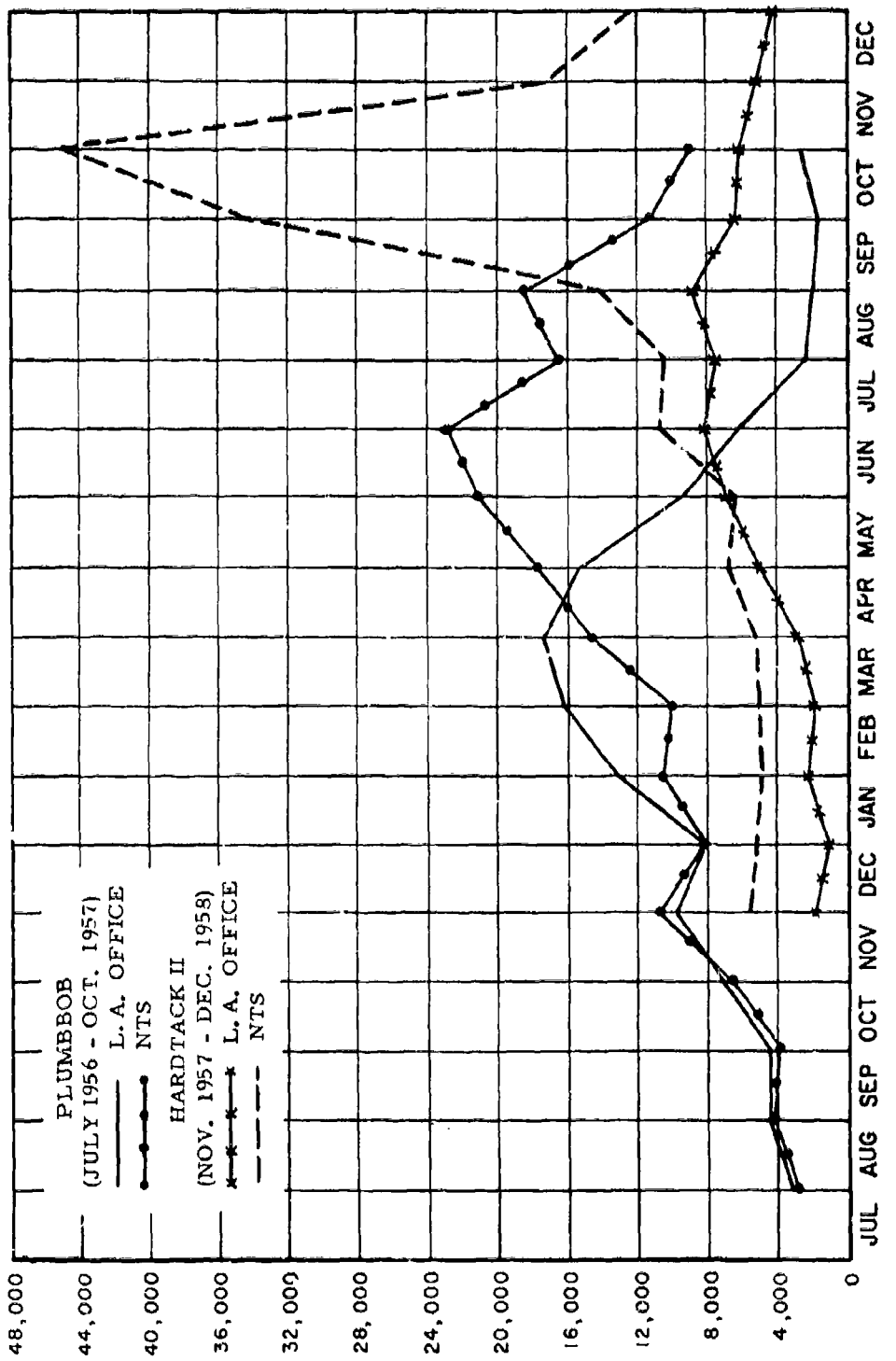


Chart No. 3. Total Man Hours - Nevada Test Site & Los Angeles Office
HARDTACK, Phase II vs. PLUMBBOB

SECTION 2
FIELD ENGINEERING

GENERAL

During the interim period following Operation PLUMBBOB, the Field Engineering organization was enhanced by the addition of a Communications Section. This increased the Field Engineering operating sections to four: Design, Surveys, Field Engineering (Inspection), and Communications. The supervisors of these various sections were under the direct supervision of the Resident Engineer.

The Field Engineering group was reduced to 33 persons immediately following Operation PLUMBBOB. This force initially was occupied with the development and recording of as-built data and the preparation of the basic drawings for a Facilities Brochure and an Orientation Brochure.

During the early part of 1958, plans for an elaborate tunnel complex for the MILLRACE-TRUMPET Operations began to take form. One of these tunnel complexes was planned around Tunnel Drift U-12b, remaining from Operation PLUMBBOB, and another tunnel complex, U-12e, was planned as a new facility. The Los Angeles Office Engineering group assumed responsibility for engineering design of Tunnel U-12e, and the Field Engineering Group accomplished the engineering design for Tunnel U-12b. Augmenting this work, design requirements were imposed by several small User projects for interim studies.

When Operation HARDTACK, Phase II, became a reality, the Field Engineering organization immediately expanded to handle the rapidly increasing work load. The four operating sections were strengthened both by new hires and by the transfer of Los Angeles Office personnel to NTS on a temporary basis. A rapid build-up to about 130 engineering personnel was achieved to handle the accelerated development of User requirements and to process the constantly changing criteria. This work force started to decline after the peak of the Operation was reached.

DESIGN

At the start of Operation HARDTACK, Phase II, the Field Engineering Design Section was comprised of eight persons. This number was increased to 21 with the transfer of several Los Angeles Office engineering personnel, including the Chief Project Engineer. The Field Engineering Section was delegated the task of processing original criteria into finished construction drawings. Criteria were received from the various agencies and covered the scientific structures required for User participation in the Operation. With the exception of the design for the U-12e tunnel complex, the U-12e diagnostic building, the fan house, scientific power station, and the LRL Calibration Building, all items, including the U-12b tunnel complex, were processed by the Field Engineering Design Section.

Design problems requiring specialized attention were referred to the Los Angeles Office for completion or review by the pertinent design section, e. g. heating or ventilating problems were not processed in the field. Revisions to Los Angeles Office drawings were made by the Field Engineering Design Section, as required, to conform to field changes. Such revisions received Los Angeles Office comments or approval.

During the interim period, data for field-engineered facilities were received in writing which, in most instances, were supplemented by User-prepared criteria drawings. However, as the tempo increased, particularly during the development of the U-12b tunnel complex, teletype and telephone instructions were received with greater frequency until the extremely rapid release of requirements and fluctuating criteria created severe problems in liaison and coordination.

The acceleration of all phases of the test program to meet the scheduled deadline made it mandatory for participating User agencies to establish resident offices at NTS. This began a period during which basic criteria were transmitted orally from User representatives to the A-E, to be followed by written confirmation. However, requirements fluctuated with such rapidity that a recording of all criteria changes became impossible, and construction proceeded on the basis of oral instructions. As a result, numerous design drawings were not completed until after the construction had been accomplished.

Approximately 700 construction drawings were completed by the Field Design Section and approved by on-site AEC and User representatives before issuance. Among these were drawings for the following major scientific features:

U-12e tunnel complex for LRL

U-12f tunnel complex for LRL

U-12b tunnel complex for LRL

One additional drift in Tunnel U-12e for LRL

Six underground stations in Area 3 for LASL

Balloon inflation pad at the BJ "Y" in Area 3 for Sandia Corp.

Three types of light, wood-frame, and transite paneled buildings for CETO

Ground zero stations comprising 50 and 70-foot high shot towers.

Foundation plans for a 50-foot steel shot tower in Area 9

"Gravel Gertie" surface shot stations

Tunnel U-12b

The constant changing of basic criteria for the U-12b tunnel complex had considerable impact on the design, field survey, construction inspection, and completion date for this facility.

Originally, the plans for this facility included 1) the modification of the existing diagnostic building (Station 12-300), 2) the construction of two trailer parking areas, and 3) the excavation of four side drifts off the main drift for shot locations. Each of these four drifts was to be constructed with a buttonhook configuration at the end leading to the shot chamber, and with alcoves off the entrance tunnel for scientific instruments and drilling equipment.

During the design and construction of the four side drifts, numerous changes were required. Side drift Station U-12b.04 is a typical example of development from transmittal of original criteria and preliminary sketches to a final as-built facility.

The first proposal for U-12b.04, as submitted by LRL in February 1958, stipulated the requirement for a single-track tunnel leading to a 12x12x12-foot high GZ room located 505 feet from the main U-12b drift, at an angle of 45 degrees. This tunnel had one blast door, a debris trap, and a 360 degree hook to the left at the GZ chamber end. A 6-foot wide by 30-foot long alcove was to be located diagonally across the drift at a point which provided a 40-foot long by 8-inch diameter line-of-sight hole to the GZ working point.

The second design criteria, received during the middle part of March, proposed a 690-foot side drift with 1) two blast doors, 2) one instrument alcove located near the branch point off the main drift, 3) three intermediate drilling alcoves between the instrument alcove and the zero room, and 4) a 180 degree hook entering the zero room. In this plan six holes would be drilled from the zero room, through the drilling alcoves, to the instrument alcove.

In late March, the distance from the side drift to the zero location was increased by 10 feet to a 700-foot total, and the size of the zero room was enlarged to 18x15x12 feet high.

Late in May, the dimensions of the ground zero room were increased to 20x15x12 feet high, the working point and six line-of-sight holes were relocated in the zero room, and a colemanite shield was required around the working point.

After construction had started, it was found that the location selected for the instrument alcove was in an area badly fractured by the Rainier event during Operation PLUMBBOB. Because re-entry into this alcove was absolutely essential, it became necessary to "mirror-image" the entire drift from the tunnel entrance. This placed the alcoves on the south side of the tunnel and a hook to the left in entering the zero room. As construction had advanced past the first two curves it was necessary to modify the entrance to the first intermediate alcove and to delete the blast trap.

During June and July, many details were added and revised, such as the addition of several short length drill holes between the zero room and the closure hook. In August, three of the major drill holes between the zero room and the instrument alcove were deleted to enable completion of the facility prior to the 31 October deadline.

SURVEYS

The H&N Survey Section at NTS was responsible for furnishing the H&N Design Sections, AEC, all User organizations, and the participating agencies with measured and calculated survey information essential to the Operation. The work involved many types of surveys, and was accomplished by utilizing various methods. The number of personnel in the Survey Section varied from 32 to 104. Approximately 35% of the 104 persons were employed in the tunnels on three shifts.

A strong framework of First and Second Order horizontal and vertical control was established and maintained throughout the test

site to provide precise points of known horizontal position and elevation. These points were marked with brass caps set in concrete monuments of sufficient size to insure stability. They were placed to aid surveys during this and all future operations, and were established by First and Second Order Triangulation and bench level procedures. Computations were based on accepted methods and adjustments were made according to USCGS procedures.

The Design Sections at Jobsite and in the Los Angeles Office frequently requested the Survey Section to furnish location surveys, topographic maps, cross-sections, and profiles of field terrain upon which to base engineering. These surveys were used to establish site selection, grade, orientation, drainage, and economical construction. During the peak activity of the Operation, the Survey Section was called on to provide as-built information relative to alignment and overbreak in the tunnels as construction progressed, so that late scientific requirements could be designed to fit existing field conditions. These as-built tunnel surveys were also used in the design of sandbag plugs to ensure tunnel closure. The Survey Section set survey stakes to locate, orient, and establish grade for the construction of all scientific facilities. After construction was completed on many structures, as-built locations were determined. During the Operation, the Users requested numerous computed positions, distances, angles, bearings, elevations, lines-of-sight, and special surveys.

Special Surveys

Surveys were required to establish alignment and grade for excavation of all main tunnels, side drifts, and alcoves in Tunnels U-12b, U-12c, U-12e, and U-12f. In addition, survey support was furnished for the exploratory tunnel into the Rainier event GZ. In Drifts U-12e.02 and U-12e.05 the final configuration was a result of continuing as-built surveys required when construction variances and shot schedules dictated changes from the original design layouts. For construction purposes, all surveys were of Third Order accuracy. At the peak of the Operation, six survey parties were assigned to the tunnel areas on a three-shift basis to furnish complete survey support.

H&N survey crews supported the drilling of the line-of-sight horizontal drill holes by establishing location and aligning drill rods in all drifts. Drill holes in Tunnel U-12b required a tolerance of ⅛ inch in 400 feet. To satisfy these requirements, Second Order bench marks were established and additional traverses were run employing First Order procedures. Permanent monuments were set throughout. Hole extremities and grades were located from these monuments by using precalculated distances, bearings, and vertical angles. Upon completion of each hole and after necessary reaming was completed, the extremities of each hole were again located horizontally and vertically, and the diameter measured to establish as-built data. Six survey crews were assigned to drill-hole activities, two crews to a shift, on a 24-hour basis. To verify the accuracy of work as drilling proceeded, daily logs were submitted by each crew which were checked by the Computing Section. Representing a continuing as-built record of drilling operations, these logs proved invaluable during the Operation.

Detailed as-built surveys were taken as construction proceeded, showing slab locations, finished floor elevations, and blast door locations. In addition, cross-sections were taken in all tunnels, drifts, alcoves, and GZ rooms. In Drift U-12b.05 both pre-blast and post-blast cross sections were completed.

Other activities included the location of canisters, vertical drill holes in the floor of Tunnel U-12b and vertical drill holes from the surface into the GZ chambers of U-12b.04, U-12c.03, U-12f.01, .02, .03, and .04. To determine the minimum overburden above the point of burst for each proposed underground event, profiles were taken on the top and slope of the mesa.

The Engineer Research and Development Laboratories required an extensive survey to determine permanent ground movement resulting from underground events. Precise surveys as set forth by the Project Officer for this program were started in early September 1958. Monuments were established for these movement studies as follows:

1. Monuments were set in outcroppings on the mesa slope to reflect movements resulting from the underground events in Tunnels U-12b and U-12e.

2. Ten brass cap monuments were set in concrete on top of the mesa to reflect the surface movement resulting from the Evans event. Horizontal positions were determined by Second Order triangulation, and traverse procedures and elevations were obtained by Second Order levels.

3. Forty-nine sets of 1¼-inch rebar monuments were driven in the walls, floor, and back of Tunnels U-12b and U-12e to reflect movements within the tunnels. Horizontal positions for these monuments were determined by Second Order traverse procedures and elevations by Second Order levels.

To provide stable horizontal control for the Second Order triangulation and traversing, a First Order triangulation net, consisting of 11 stations, was established from a known base line. In addition, the extremities of the base line were referenced to distant monuments in such a manner that they could be re-established by intersection, a procedure employing deflection angles. In conjunction with this triangulation a monument was established for re-entry into Tunnel U-12b with the capability of being accurately re-established by intersection.

In providing adequate vertical control for this survey, 11 miles of First Order levels were run, in which 27 bench marks were established. All Second Order level loops originated and terminated at one of these precise bench marks.

Tunnel surveys were slowed considerably by the operations of Contractors in the limited space. Postshot surveys of a particular event had to be fully completed before the next scheduled event took place, thus requiring a high degree of coordination between the field and office groups to ensure the accuracy of the surveys on a day-to-day basis. To meet the time requirements it was necessary to employ additional field survey parties and to schedule their work in such a manner as to encounter minimum interference.

The following pre and postshot surveys were completed:

1. Pre-Tamalpais
2. Post-Tamalpais (pre-Evans)
3. Pre-Blanca

Post-Evans and post-Blanca surveys were not initiated due to the limited access to Area 12 subsequent to these events.

Twelve balloons were positioned by the Survey Section during the Operation. In positioning the balloons, two control stations were established approximately 5000 feet from GZ and 90 degrees apart. Vertical angles were calculated from each control station to the point of burst

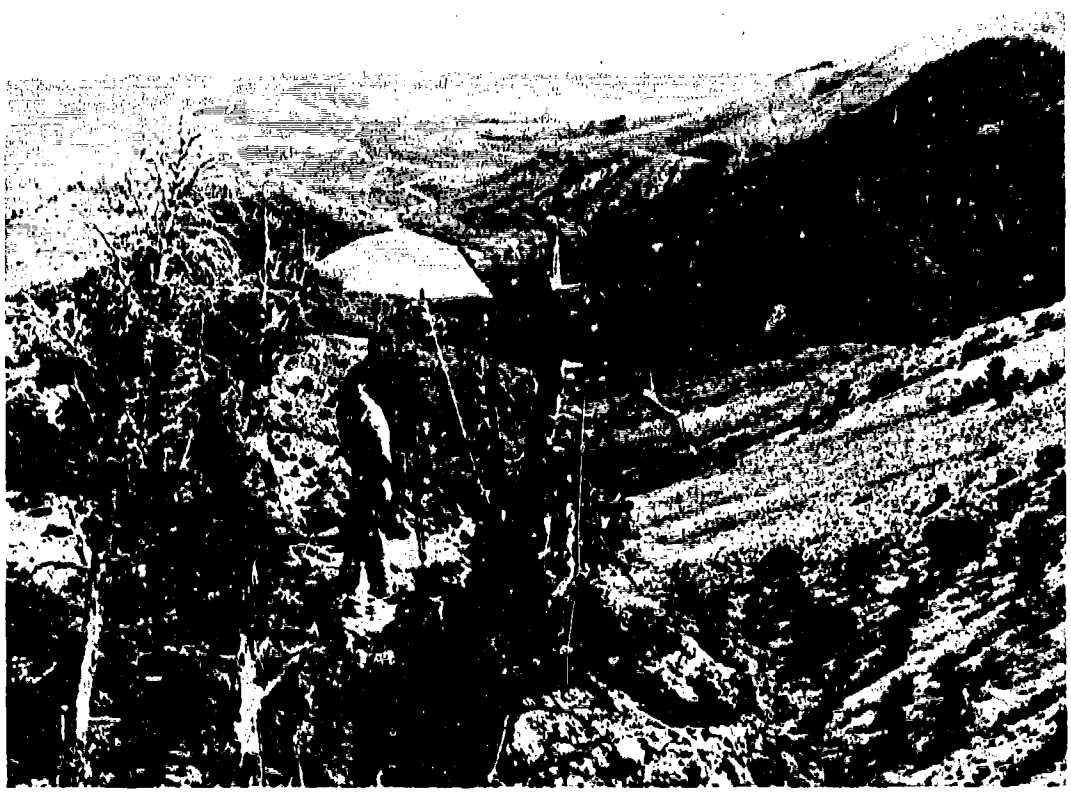


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Figure No. 3. H&N Triangulation Survey Party

in space. In positioning the balloon, the two control stations were occupied, GZ was sighted, the predetermined angles were set into the instruments, and the ascending balloon was moved laterally and vertically until an accurate location on the two lines-of-sight was obtained. This procedure was used throughout the Operation, with one exception: the positioning of the Adams event, in which the device was armed while the balloon was being positioned. Since existing control stations were too close to use while positioning an armed balloon, it was necessary to establish control elsewhere. Two stations were selected five to eight miles distant from GZ, and precise calculations were made to determine vertical angles.

Extensive surveys were completed in Area 12 and throughout the NTS in support of gravity surveys conducted by the USGS. Gravity stations on five lines radiating from Station U-12.04 GZ were located by Third Order traverse and levels on top of the mesa. Similarly, one line was run down the slope of the mesa to the U-12e tunnel portal. For this survey, a total of approximately 90 gravity stations and 106 seismic shot holes were located, involving 2 miles of traverse and levels.

Throughout the NTS, random traverse lines were run to establish gravity stations at intervals of approximately one-half mile. A total of 349 gravity stations were established, of which 296 were located both horizontally and vertically. Elevations only were determined on the remaining stations by Third Order procedures. Extensive calculations were involved, since the position of each station was required to be expressed in both Nevada State and geographic coordinates.

For fireball and documentary photography, EG&G used a total of 25 camera stations. Each of these stations was required to be located in elevation and position for bearing and slant range calculations on a true line-of-sight to the point of burst for each event. EG&G also had 19 illuminated photo towers requiring specific locations on top of the mesa for ground-motion studies in conjunction with the Evans event.

Miscellaneous Surveys

In conjunction with the underground shots in Area 3, it was necessary to stake out the location of air samplers as specified by the User in the field. Tower T-3v presented a time problem with the movement of the Humboldt event from Frenchman Flat to Area 3, complete with numerous DOD participating stations.

For the Hamilton event in Area 5, over 300 stations were staked, including biological pens, film badge stakes, shadow-shield detector poles, fox-holes, and thermal gauges. The existing collimator tubes at Station F-301 were uncovered, and alignment was determined before and after this event.

Seven light wood-frame structures were located in Area 7 for participation in three separate events. Subsequent to each event, the structures were located relative to established reference points to determine pre and postshot movements. In addition, 130 collimators were staked in this Area.

Topography by plane table was taken in Area 12 for the following projects:

1. Parking areas — 4 acres
2. Calibration range — 4 acres
3. Neptune crater — 4 acres
4. Blanca crater — 25 acres

In Area 14, existing control was not available and extensive triangulation was required for satisfactory control. Due to the time element a three-point fix was employed for control, and minimum profile lines were run at the proposed tunnel site.

INSPECTION

During the period preceeding Operation HARDTACK, Phase II, the Inspection Section consisted of two Field Engineers. Their principal activities were in the Area 12 tunnels, which were in the excavation stage, and in Area 3 during the drilling for the safety tests. The build-up of Inspection personnel began in July, with the addition of a Chief Field Inspector, and reached a maximum force of 13 in September, including some temporary transfers from the Los Angeles Office. The Mechanical and Electrical Field Engineers were not assigned to specific areas or stations, but were available to all areas, as directed by the Chief Field Inspector. Upon completion of the Operation, the Inspection Section was reduced to six personnel; consisting of three Civil Engineers, one Mining Engineer, one Electrical Engineer, and one Chief Clerk.

The Inspection Section was responsible for the following functions:

1. *Engineering Supervision of Construction*

   This section provided engineering inspection of work performed by all contractors involved in the construction of H&N-designed permanent facilities or scientific test facilities. Liaison service was furnished to all User agencies for both operational and construction activities.

2. *Contract and Subcontract Field Administration*

a. With regard to lump sum contracts, field administration involved a review and an approval of the Contractor's construction schedules and a periodic preparation of data required to substantiate payments to the Contractor. This function also included the coordination of Change Orders to existing contracts.

b. Field administration provided the Operating & Maintenance Contractor liason with H&N Work Order and Estimating Sections in drafting work orders and modifications, and in controlling "buck-slips." Buck-slips were used as field authorization for minor changes requested by a User representative, and were approved by H&N Field Engineers or the H&N Resident Engineer.

3. *Reports and Photography*

This function involved the preparation of various reports, including a Daily Field Engineering Report, a Weekly Narrative Report, and a Construction Progress Report. Documentary photographs were taken during various stages of construction at the test site for the benefit of the AEC, the Users, H&N, and other Contractors.

4. *Support Engineering Services*

a. The gathering of as-built information during construction was the responsibility of the Field Engineers. These data were presented to the Design Section to assist in the preparation of as-built drawings.

b. Inspection personnel assisted in promoting proper safety measures by making certain the Contractors' operations conformed to established safety rules and practices.

c. Field Engineers provided liaison among the H&N Jobsite Engineering Design Section, the User field personnel, and the Operating & Maintenance Contractor's supervisory personnel.

Material Tests

The majority of material tests consisted of concrete cylinder tests and in-place density tests for soils. All laboratory work was performed by the Nevada Testing Laboratories, Ltd., of Las Vegas, Nevada, under an H&N Purchase Order. This Purchase Order was periodically revised to authorize additional work and special tests. The concrete mix design developed during Operation PLUMBBOB was continued during Operation HARDTACK, Phase II, since aggregates used during both Operations were from the same stockpile.

1½-inch Maximum Aggregate Pit Run, Screened, and Stockpiled
(By Percentage Passing)

SIZE	FINE AGGREGATE	COARSE AGGREGATE	COMBINED
1½-inch	—	100.0	100.0
¾-inch	—	59.0	76.4
⅜-inch	—	11.6	49.2
No. 4	100.0	1.4	43.3
No. 8	78.8	—	33.5
No. 16	57.0	—	24.2
No. 30	32.9	—	14.0
No. 50	17.9	—	7.8
No. 100	4.3	—	1.8
Fineness Modulus	3.091	7.280	5.498
Specific Gravity	2.470	2.665	—

Table 7. SIEVE ANALYSIS OF AGGREGATE

Absolute volume of aggregate in one public yard of concrete	19.73 cu ft
Weight of aggregate in one cubic yard batch	3240 lb
Maximum slump	5 in.

Table 8. MIX DESIGN FOR 1 CUBIC YARD OF CONCRETE

	BATCH WEIGHT, POUNDS	ABSOLUTE VOLUME
Gravel	2,000	12.03 cu ft
Sand, dry (1188 lb)		7.70 cu ft
Free water in sand (52 lb)	1,240	0.84 cu ft
Water, added 28.5 gal	237	3.80 cu ft
Cement, 5.5 sacks	517	2.63 cu ft
		27.00 cu ft

Table 9. WEIGHT AND VOLUME OF CONCRETE MIX

	TOTAL CUBIC YARDS	AVERAGE 7 DAY BREAKS
Area 12 - Surface	422.0	2210 psi
Area 12 - Underground	932.2	2170 psi
Area 3	746.2	1930 psi
Area 5	49.5	2050 psi
Area 7	86.5	2195 psi
Area 9	140.5	2840 psi
	TOTAL 2376.9	AVERAGE ..... 2232 psi

Table 10. SUMMARY OF CONCRETE POURED

The mix design was occasionally varied to conform to:

a. The characteristics of the aggregates used at the location and time of the concrete pour.

b. Unusual strength requirements involving the use of "high-early" cement and changes to the water cement ratio.

c. The manner of placement and type of concrete pour.

In tunnel construction, extensive use of pumpcrete was necessary to pour walls and foundation for blast doors, and gas seal walls. Following experimentation with the pumpcrete method of placement, the exclusive use of ¾-inch maximum aggregate with seven bags of cement per cubic yard was found to be the most satisfactory specification and resulted in improved strengths, better workability, and a reduction in honeycombing.

During the Operational period, 84 concrete test cylinders were taken by H&N Field Engineers and shipped to the Nevada Testing Laboratory in Las Vegas for 7-day, 28-day, and shot-day break results. Cylinders were moulded in standard size fiber molds and, when possible, were stored in the field near the actual pour for a period of 5 days. During this 5-day period the cylinders experienced the same curing conditions as did the concrete from which they were taken.

Test cylinders were moulded from every batch used for a structural pour, and whenever the pour amounted to more than 50 cubic yards a second set of cylinders was taken for each 50-cubic-yard increment. Cylinders were not taken in non-structural pours (such as the underground zero chamber and the drilling alcove floor slabs) which were expended immediately after the pour.

Average 28-day breaks are not listed, since 1) many of the cylinders reserved to be broken at that period were used for special shot-day break results and 2) most stations during this Operation were utilized or actually expended prior to the 28-day concrete specification period.

A variety of soil tests were conducted by the Nevada Testing Laboratory under the direct supervision of H&N Field Engineers: in-place density tests for the backfill of structures; logs, gradations, and classifications of soil types in test pits and holes; California Bearing Ratio tests; aggregate analysis; and trial mixes for asphaltic concrete pavement.

Field Problems

In Station U-12b.02 the configuration of the tunnel and alcove sections in the Camera and Rack Room area was a composite of several revisions. This situation required an on-the-spot design of the supporting re-entry steel sets. Due to the time element for User occupancy in the drift, the steel work was left incomplete by the Prime Contractor. Using special safety precautions (such as the covering of electrical cope trays with transite sheets to prevent fire damage), the final welding and connections to complete this re-entry steel were ultimately completed within 24 hours of the event under the direct supervision of H&N Field Engineers.

In many instances approval of material substitutions or modifications to drawings, resulting from actual construction requirements, were made by Field Engineering personnel. Fracturing of the rock in the tunnel area caused modifications or substitutions such as the excavations in rock for blast door key-ways in excess of plan dimensions, and a 15-foot relocation of the blast door in Station U-12f.02.

During the Operational period a continual radiation hazard existed in all test areas. In several instances construction was delayed, or completely cancelled, as a result of radiation or unexpected fallout.

SECTION 3
COMMUNICATIONS

GENERAL

In accordance with NTO-SOP Chapter 0270, Communications, as revised 17 March 1958, H&N was delegated the following responsibilities for Communication facilities at NTS:

1. Engineering design.
2. Preparation of specifications and plans.
3. Collection of User criteria.
4. Translation of User criteria in terms of Communication facilities.
5. Preparation and issuance of work orders to the Operating & Maintenance Contractor.
6. Inspection of new facilities.
7. Communication engineering advisory services for planning the rehabilitation and improvement of the NTS cable plant and radio communication facilities.

TELEPHONE AND SIGNAL CABLE PLANT

Sets of record drawings accurately reflecting the existing cable facilities at the site were assembled to form a basis for planning rehabilitation and improvements. Field test teams were assigned to check cables in scheduled test areas and a system of cable identification, terminal designation, and information recording was devised and instituted.

Two sets of record drawings were available for reference; one set of 31 drawings for the telephone cable plant that primarily reflected installations of the Bell Telephone Company of Nevada, and one set of 32 drawings for the Government-owned signal cable system. These drawings were issued for information to all Users concerned, and were revised as additional field test data became available to show cable condition, routing, and designation.

Communication requirement forms covering signal and coax, telephone, radio, and frequency requirements were designed and submitted through the AEC to the User groups. Criteria and requirements were solicited, assembled, reviewed, and coordinated with the AEC and the Users. Cable plant construction proposals were based upon the installation of only that cable necessary to augment existing facilities.

In order to meet HARDTACK, Phase II, operational schedules, authority was issued to the Operating & Maintenance Contractor for the advance procurement of signal cable materials which required long lead-times for delivery. Specifications were provided for cable, terminals and terminations, splices, route markers, and installation methods.

Prior to this Operation the concept of complete separation of telephone, signal, and balloon control systems was adopted. This concept, coupled with the requirement for the multiple-operational capability of the signal cable system, materially increased the size of this system, particularly in the main feeders between CP-1 and the key distribution stations in Yucca Flat. Communication requirements of immediate interest to the Operation involved Areas 3, 5, 7, 9, and 12.

Negotiations with the Bell Telephone Company of Nevada for all telephone installation, including cable, were handled directly by AEC representatives. Information on these telephone installations was forwarded to the H&N Communications group for inclusion in record drawings.

The cable testing program was well underway when the AEC announced an accelerated series of tests at NTS. To assure adequate signal and telephone capability for this test series, a Communications construction program was initiated that required large-scale revisions to the previous signal facility planning. Due to the accelerated schedule, much of the engineering was assigned to Jobsite Communications personnel who were instructed to design to previously prescribed standards insofar as the program would permit.

Los Angeles Office engineers assisted Jobsite engineers during the cable tests and continued the cable plant design. The cable plant design was completed upon conclusion of the Operation and drawings issued prior to the test program were revised to show the actual installations made during the Operation.

Major factors for the successful accomplishment of telephone and signal cable installations for the Operation were the preliminary planning, the specifications, and the advance procurement of over 300,000 feet of signal cable and other associated major items. Having these items available in the Operating & Maintenance Contractor's stock enabled expeditious installation of required facilities on extremely short notice.

OFF-SITE RAD-SAFE RADIO COMMUNICATIONS

A radio coverage survey utilizing Highland Peak near Pioche, Nevada, as a repeater site indicated that this site equalled or exceeded coverage afforded by the former locations; one at Pioche, Nevada, and another at Iron Mountain, Utah.

A work order authorized the installation of repeater stations at Angel's Peak, adjacent to Mt. Charleston; White Mountain, near Bishop, California; Highland Peak; and Rib Hill, near Ely, Nevada.

Generally, communications were satisfactory, but the following difficulties were encountered.

1. Second harmonic radiation from one of the transmitters at Rib Hill interfered with another Government agency sharing the sit .
2. System lock-up between Rib Hill and Highland Peak occurred under certain conditions, presumably caused by malfunctioning of the coded keying system.

Time limitations did not permit a thorough analysis and correction of the troubles. As an expedient, the mode of operation was altered, resulting in some loss of system flexibility, without materially affecting communications capabilities.

A program was initiated to design an automatic transfer and failure alarm system for use with stand-by equipment at the repeater sites. Its purpose was to reduce maintenance requirements and improve operational reliability The exigencies of the accelerated program did not permit completion of the project in time for use in the Operation; however, the completed design could be employed in a future operation.

NTS VHF RADIO SYSTEM

Prior to Operation HARDTACK, Phase II, a study was undertaken to determine the feasibility of a consolidated repeater site capable of serving all operational areas of NTS. Signal coverage from the Smoky Jr. repeater was deficient in Area 12, Area 400, and Camp Mercury, due to terrain factors. Emphasis was placed on coverage in Area 12, since a major portion of HARDTACK, Phase II events were scheduled for this area. The study included an analysis of the NTS frequency plan and a proposed new plan, propagation calculations, and field tests.

The Smoky Sr. site was chosen as an interim consolidated repeater site because of its elevation and the availability of power and telephone cable facilities.

Drawings and specifications for the consolidated repeater station were prepared, and a work order authorizing installation was issued. Limited time, resulting from the accelerated program, precluded the possibility of obtaining the required frequency authorization and of procuring the crystals necessary to implement the new frequency plan and tests. Therefore, it was necessary to retain three of the eight repeaters in use at Smoky Jr. to avoid interference and system lock-up problems.

Upon completion of the Smoky Sr. installation, field tests were conducted in Area 12. The tests showed that the signal strength was materially improved in the pertinent locations of Area 12 as compared with signals from the Smoky Jr. site.

It is planned to move the three remaining VHF repeaters from Smoky Jr. to Smoky Sr. upon satisfactory completion of tests, using the new frequency plan. A corresponding improvement in signal strength can be expected in Area 12 for these repeatered nets.

A high-gain omnidirectional receiver antenna with multicouplers was introduced into the Smoky Sr. VHF Radio Repeater installation as a new design feature. This feature eliminated approximately 50% of the repeater antennas and associated transmission lines, while the receiving antenna gain essentially equalized the system performance of mobile-to-repeater versus repeater-to-mobile paths.

SECTION 4
CONSTRUCTION

Following Operation PLUMBBOB, construction activities consisted primarily of recovery, roll-up, and postshot drilling activities.

In January 1958, considerable construction activity took place in the existing U-12c and U-12d tunnel complexes. A new tunnel to Room B of Tunnel U-12c was excavated and the GZ room of U-12d was enlarged to facilitate Project 58A-NTS.

Major construction in Area 12 started in February with the U-12b tunnel drift, and in Area 3, in June, with the drilling of the 500-foot vertical holes. The construction activities within Areas 3 and 12 are discussed in detail, due to their prominence in Operation HARDTACK, Phase II. Construction activity in Areas 5, 7, 8, and 9 is discussed under the section titled "Other Areas."

AREA 3

Drilling of the five 500-foot deep holes started 2 June, and the first hole, Station U-3q, was drilled, cased and grouted without difficulty by 13 June.

On 14 June drilling of a 45-inch diameter hole for Station U-3p commenced, and it was considered adequately prepared for casing by 18 June when it reached the 508-foot level. Six 32-foot joints (192 feet) of casing were welded and run into the hole. The succeeding joint was welded and attempts were made to lower the casing further, but it was not possible to move the casing up or down. Unaccountably, considerable material had sloughed into the hole and the casing was immovable.

During the next eight days, continuous efforts were made by the Contractor to free the casing. Washing the sides of the drill hole, vibration of the casing, and lifting with the full capacity of the drill rig were all unsuccessful.

On 26 June the Contractor requested abandonment of the hole and was verbally authorized to move his rig to Station U-3n, with the understanding that a later determination would be made regarding the disposition of the U-3p hole.

Between 27 June and 7 August, four holes (including hole U-3r, added to the contract to provide the User with five completed 36-inch holes) were drilled and cased without further incident.

The collapse of the U-3p hole was considered to be no fault of the Contractor, and on 8 July the AEC officially concurred with the Contractor's request and gave permission to consider U-3p as a lost hole. H&N was requested by the AEC to make further attempts to recover the 192 feet of 36-inch casing and salvage the hole. High capacity jacks, having a total lifting force of 310 tons were utilized; however, the casing could not be freed.

At the request of the User, a second change order was issued to the Contractor on 31 July to grout in place the unsalvaged 36-inch casing and to clean the hole below the 192 feet of grouted casing to permit setting Government-furnished 34-inch casing for the full depth of the hole.

On 8 August the Contractor moved his drill rig over U-3p for the second time and began milling the driving point off the bottom of the 36-inch casing. Again trouble was encountered when a drill stem sheared and subsequent "fishing" was required. After the driving point was removed, a 34½-inch bit was used to reach the 500-foot level.

After 310 feet of 34-inch casing had been placed, the casing was again immovable. On 18 August, Casey & Montgomery, Inc., was given permission to abandon the U-3p hole and the contract was closed.

In preparation for Operation MILLRACE, REECo was authorized to construct two new head towers using sections of one of the 300-foot Self-shot towers in warehouse stock and to modify the existing tower at PLUMBBOB Station U-3j. The three towers were to be erected at Stations U-3n, U-3p, and U-3q after drilling was completed by the Lump Sum Contractor.

With the abandonment of the U-3p hole, the existing U-3j tower was modified and shifted to Station U-3m and a sixth 500-foot deep hole (Station U-3r) was added. At this time only the foundations and winch pads were to be constructed at Stations U-3k and U-3r. Coincidently, two runs of 51-pair signal cable were required between Stations 1-351 and 3-354.

With the announcement of Operation HARDTACK, Phase II, the Laboratory requested use of the five 500-foot holes and the salvage

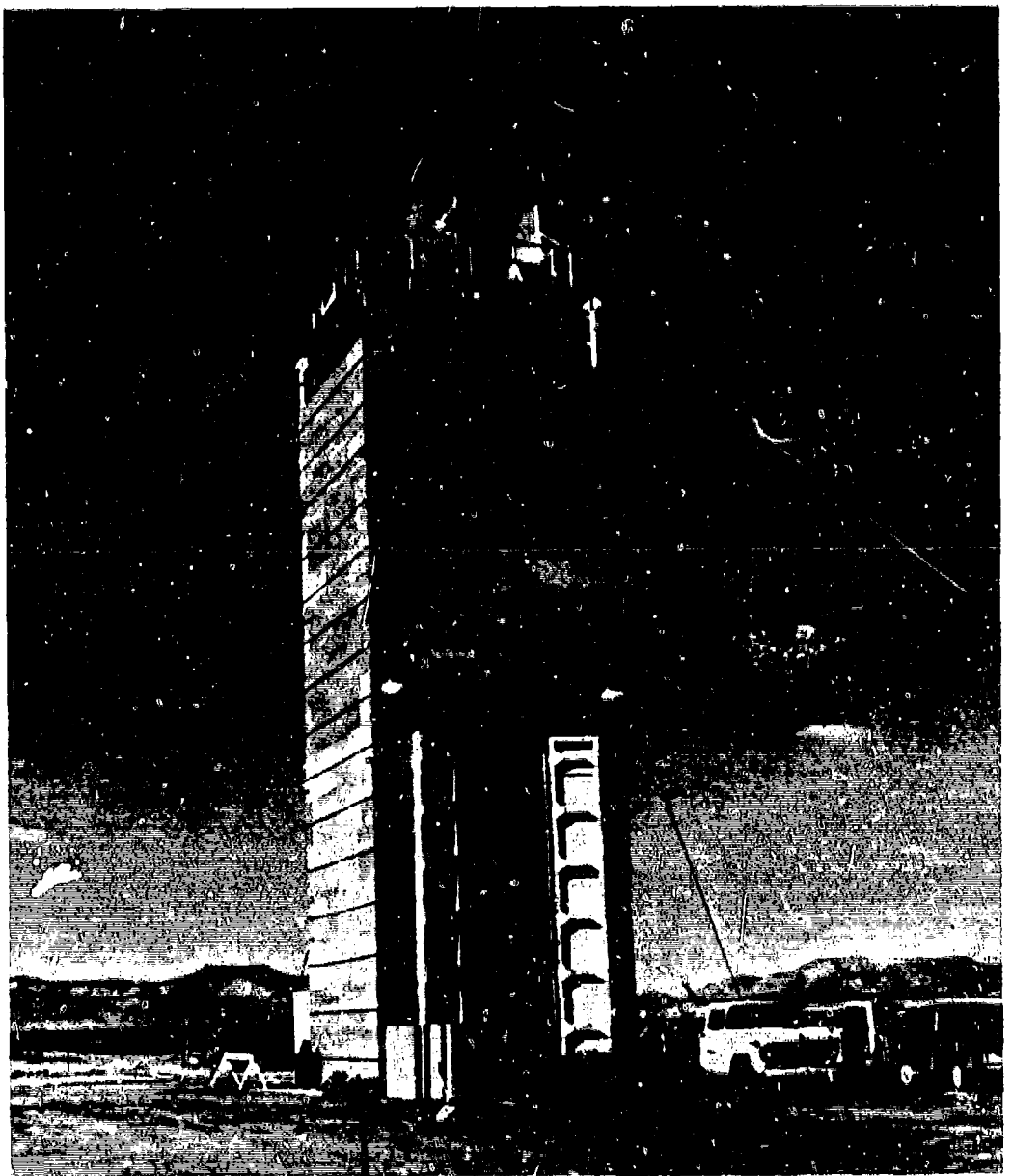

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Figure No. 4. Head Tower Station U-3p — 100% Complete

of the U-3p hole for a shallow test facility. To provide head towers for the six facilities it was necessary to construct two additional head towers from the existing tower stock and to plan on moving one tower from a previously used facility.

To salvage the U-3p hole, a work order was issued to grout the 34-inch pipe inside the 36-inch pipe and to remove all drilling mud from the casing. The Operating & Maintenance Contractor obtained the services of the Aller Water Well Company, Las Vegas, as a subcontractor to perform the above grouting and bailing.

The hole was bailed to the 310-foot level and concrete was placed in the annular void between the 34 and 36-inch casings. The grout would not hold in the void and fell to the bottom, raising the water level. Bailing was again required but the bucket became wedged between the 268 and 275-foot levels. Pulling would not free the bucket and after a close inspection it was deemed necessary to cut the lifting cable with the bucket still in place. The bottom was then filled with concrete to the 251½-foot level.

Grout was eventually placed between the casings, and the head tower was moved from expended Station U-3m to complete the facility as a 250-foot deep hole, 34 inches in diameter.

After expending the five 500-foot deep wells, it became apparent to LASL that additional test facilities for low yield and safety detonations would be required during the last 15 days of the Operation. To quickly provide these test facilities, construction of two 70-foot high timber towers and one 50-foot high timber tower was authorized using telephone poles and timber from warehouse stock.

LASL completed testing in Area 3 on 27 October and released the area to LRL for a low yield event on a 25-foot high timber tower. This event was originally planned for Frenchman Flat, but with the high alpha contamination and the scheduling of the Adams event in that area, the movement to Area 3 by LRL offered a great savings in time and effort.

AREA 12

Tunnel U-12b Complex

Tunnel U-12b was re-usable for a distance of 1940 feet, from Operation PLUMBBOB, and side drifts U-12b.01 through .04 subsequently were constructed using the original U-12b tunnel as a main drift. The final configuration of branch tunnels off U-12b was as follows:

U-12b.01	297 feet,	at station	4 + 84
U-12b.02	394 feet,	at station	6 + 67
U-12b.03	655 feet,	at station	9 + 66
U-12b.04	829 feet,	at station	14 + 00

Construction on drift U-12b.01 began on 10 June, and was excavated to include 1) a 19x15x-13-foot high GZ chamber lined with steel beams, timber posts and lagging, and 2) Alcove No.1 containing two large rooms and two small alcoves for drilling purposes, and lined with lagging over steel arches.

In August all excavation for drift U-12b.01 was finished, concrete floors were poured in Alcove No. 1 and the GZ room, the re-entry structural steel supports were installed, and the concrete for the blast door was poured. Also in August, line-of-sight holes were drilled from the GZ room to Alcove No. 1 and from the main drift to GZ room. The steel supports in the side drift and the alcove were completed in September. Due to a rescheduling of events, U-12b.01 was not used in the Operation.

Drift U-12b.02 was started on 19 May and completed on 8 October for use in the Tamalpais event. All excavation of this drift was completed in August, including the 19x19x12-foot high GZ chamber, the Alcove No. 1, the camera and rack room, and the two small drilling alcoves. Also in August, the concrete floors and re-entry arches were installed, the GZ room was lined and the camera and rack room was framed. In September a 32-inch diameter hole was grouted from the GZ room to the main drift, and the Users occupied the GZ and the alcoves.

On 4 May construction began on drift U-12b.03, which included a 19x19x14-foot GZ chamber and two large alcoves. In September this drift was 75% complete. When the drift was 97% complete in October, an accidental explosion in drift U-12b.02 damaged drift U-12b-.03, and it could not be used for a test during this Operation.

Drift U-12b.04 was started on 20 March, and was completed on 28 October for use in the Blanca event. The irregular-shaped GZ room, and the large rectangular Alcoves No. 1 and 2 were entirely excavated by late in August. Excavation of the large irregular shaped Alcove No. 3 and the small Alcoves 4 through 8 was completed late in September. The GZ room was lined with steel beams, timber posts and lagging, and Alcoves No. 1 and 2 were supported by steel arches. Alcove No. 3 was lined with steel beams and columns.

Tunnel Station U-12e

Construction of the portal by the Operating & Maintenance Contractor was started on 17 March 1958, and excavation of the main drift commenced on 19 April. The tunnel was driven without structural support, except at the portal area, to station 8 + 48 by 17 June, when a rockfall at station 5 + 48 injured one man and caused the death of another. To prevent further accidents of this type, timber sets to support the

roof were installed to station 8 + 95. From station 8 + 95 to Station 11 + 98, arch-type steel sets, 9 feet high by 13 feet wide, were installed. To allow ample clearance for heavy duty drilling and mucking equipment needed to increase tunnel progress, the 9-foot high steel sets were replaced by steel sets 14 feet high by 13 feet wide from station 11 + 98 to station 20 + 27.

A pocket of water was encountered in the vicinity of station 18 + 50. The flow from this pocket reached a peak of 560 gallons per minute considerably hampering construction activities at the face. To handle this flow of water it was necessary to install a 14-inch pipe from the face to outside the portal.

The Laboratory had originally planned on using two side drifts, Stations U-12e.02 and U-12e.05, for Operation MILLRACE. The shot points were selected to provide the required overburden and protect the main drift for use in Operation TRUMPET. With the announcement of Operation HARDTACK, Phase II, it became apparent that the desired shot points could not be reached in time. Therefore, construction of the main drift was terminated at the working face, station 20 + 34, in order to meet the established deadline.

During the first week in September, LRL was directed to perform a preliminary test for a large complex experiment involving a 6-foot diameter vacuum pipeline 600 feet long, and several underground alcoves. To meet this requirement, the Laboratory substituted the Logan event for the Pike event and requested construction of a vacuum pipeline, scaled down to 24-inches in diameter by 165 feet long, and one alcove in side drift U-12e.02. Criteria for this drift and the U-12e.05 drift were received at the test site immediately preceding the start of construction.

The U-12e.02 drift was driven for approximately 650 feet with maximum effort until 27

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Figure No. 5. Steel Supports in No. 1 Alcove — Side Drift U-12b.03

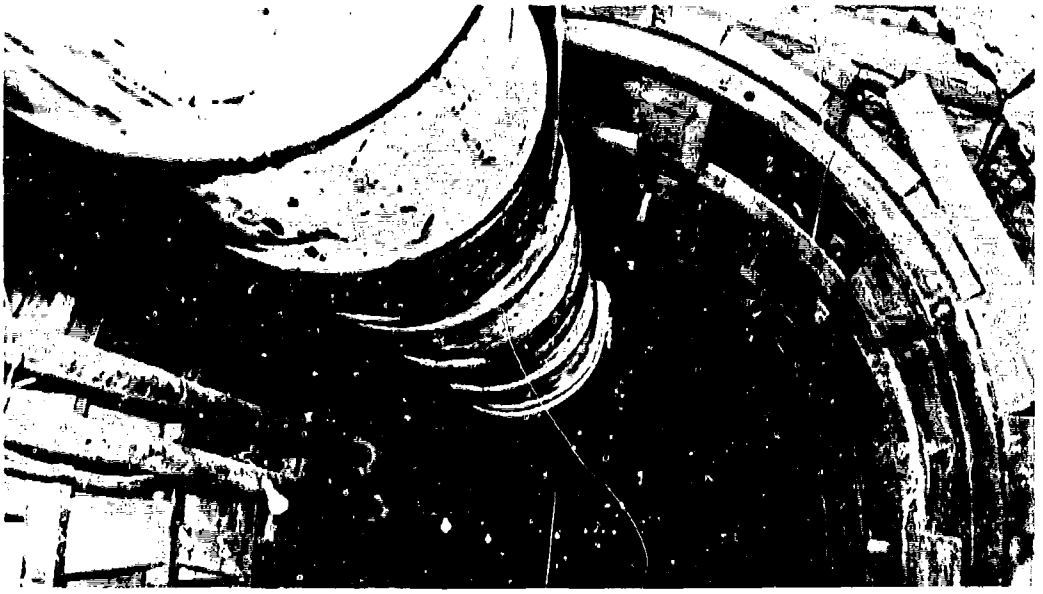

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Figure No. 6. Steel Supports in Side Drift U-12e.05

September at which time the heading was stopped and GZ was established. An additional week was allowed for construction of the blast door and completion of the coax cable installation. The Users moved in their equipment on 4 October and the Logan event was detonated at the end of this drift on 15 October.

The U-12e.05 drift for the Blanca event was driven to obtain the maximum overburden possible and still protect the main tunnel from collapse as a result of stresses created by the Logan event. As additional protection, steel sets 7 feet wide by 9 feet high were installed on 4-foot centers for the first 500 feet. This drift was terminated in a hooked-end configuration, at station 10 + 10 and the casement for the blast door was poured prior to the Logan event in Station U-12e.02.

Considerable damage occurred to the main tunnel as a result of the Logan event and a new tunnel was driven from station 17 + 94 to the portal of the U-12e.05 drift. Seven-foot wide steel sets were used through the twisted steel, timber and rock debris. The U-12e.05 side drift, beyond that portion reinforced with steel sets had collapsed, and it was necessary to relocate GZ at station 5 + 97.

Safety Tunnels

The construction of five safety test facilities (Stations U-12f.01 through .05) was requested by LRL in July 1958. Each facility was to consist of a short tunnel with a hook at the end, a blast door, and a small alcove for one instrument drill hole. These facilities were to be located off the main access tunnel, Station U-12f. The requirement for U-12f.05 side drift was deleted in August and the length of the U-12f.04 side drift was increased to 155 feet.

The final configuration of branch tunnels off U-12f was as follows:

U-12f.01 155 feet, at station 3 + 70

U-12f.02 155 feet, at station 4 + 30

U-12f.03 311 feet, at station 4 + 90

U-12f.04 155 feet, at station 5 + 30

As a result of radioactive contamination in the U-12f access tunnel, caused by the Mercury and Mars events, it was necessary to abandon the U-12f.03 and U-12f.04 side drifts and relocate the events scheduled for these locations to surface test facilities in Area 9.

In addition to the safety test installations in the U-12f tunnel complex, in September, side drift Station U-12c.03 was excavated in the existing Operation PLUMBBOB Tunnel U-12c. This facility consisted of a 6-foot wide by 7-foot high by 165-foot long side drift off the main tunnel at station 1 + 00.

Vertical Instrument Holes

The Lump Sum Contractor moved on the drilling site 5 August, and Hole No. 5 was drilled to a depth of 892 feet and cased with 4-inch light weight well casing.

The first of the four remaining holes was drilled to a depth of 101 feet when the Laboratory stipulated relocation of the U-12e.05 GZ and the four instrument holes.

The Contractor was then placed on standby for four days awaiting a firm location of the new GZ and the construction of an access road to the new site. The drill rig was moved to the new location and 169 feet of the first hole was drilled when the Users again relocated GZ. After three days of standby time, it was decided to move the cluster of four holes to a location above Station U-12b.04 GZ. The Contractor then moved the equipment to the third location and drilled and conditioned the four 8¾-inch diameter uncased holes as follows:

Hole No. 1 - 770 feet deep
Hole No. 2 - 471 feet deep
Hole No. 3 - 763 feet deep
Hole No. 4 - 360 feet deep

The instruments to be installed in the holes were not at the site when drilling was completed, and during the interim period the holes became plugged due to coagulation of the drilling mud and a sloughing action resulting from several test events in the area and nearby construction blasting. As a result of this plugging, instruments could not be installed and it was necessary to ream Hole No. 1 to 12¼ inches in diameter, and redrill and clean the other three holes just prior to the Users lowering and grouting their instruments.

OTHER AREAS

AREA 5

Construction of Station T-F1, a 50 foot wood tower for the Hamilton event, began on 15 September. The tower and its three platforms were completed by the end of September, with final completion of all related facilities on 13 October.

On 20 October construction began on Station T-Fb, a 50-foot aluminum tower originally scheduled for the Humboldt event. However, after the tower was erected and about 75% complete, plans were changed. The Humboldt event was rescheduled for Station T-3v, and the tower was dismantled and returned to the warehouse.

AREA 7

On 12 September construction started on the 100-foot tower, Station T-7c, for use in the Quay event. The station was erected from four 25-foot sections of a standard steel shot tower, and was completed on 9 October.

Construction for the balloon tests, Mora, Lea, and Socorro, began 23 June with all facilities completed 11 September. Paving and related construction on the colemanite pad was completed in July.

Seven light wood-frame structures (Stations 700.01 and .02, 701.01 and .02, 702.01 through .03) were constructed for the balloon events. Construction on these one and two-story structures began 7 September and was completed 26 September. Following the first two events, the structures were rehabilitated, with repair of fractured transite sheets and broken wood timbers, as required.

AREA 8

During the last week of the Operation, Stations 8a, 8b, and 8c were each constructed and turned over to the Users in one day. The stations were identical 25-foot wood towers prefabricated in the Area 12 sawmill for final erection at Area 8 sites and for use in the Oberon, Ceres and Titania events. Station T-8a was started and completed 23 October; T-8b, 24 October; T-8c, 26 October.

AREA 9

Construction for Area 9 events began 13 September and was completed 29 October.

An existing concrete balloon GZ pad, Station B-9a, required extensive rehabilitation for use in the Rushmore event. This construction was completed 22 September and included the pouring of a 4-foot thick reinforced pad over the existing pad and a 14x3x6-foot high reinforced concrete wall across one end.

Three heavy timber, 10 x 10 x 7-foot high "Gravel Gerties" with an entrance maze tunnel 26x4x7 feet high were constructed for the Vesta, Juno and Ganymede events. Construction activity on these zero stations was started and completed as follows: S-9e, 5 October-18 October; S-9f, 5 October-17 October; S-9g, 20 October-23 October.

A 50-foot steel tower erected on four 9x9x3-foot concrete footings was started on 30 September for use in the Mazama event. The tower and all related facilities, including the prefabricated shot cab, were completed 25 October.

GZ STA. NOS.	EVENT	AREA	DESCRIPTION
U-3k	COLFAX	3	500′ Deep Well
U-3m	TAOS	3	500′ Deep Well (Cancelled)
U-3n	BERNALILLO	3	500′ Deep Well
U-3n	LUNA	3	500′ Deep Well
U-3p	SAN JUAN	3	250′ Deep Well
U-3q	OTERO	3	500′ Deep Well
U-3r	VALENCIA	3	500′ Deep Well
T-3s	RIO ARRIBA	3	70′ Wooden Tower
T-3t	CATRON	3	70′ Wooden Tower
T-3u	CHAVEZ	3	52½′ Wooden Tower
T-3v	GUADALUPE	3	25′ Wooden Tower (Cancelled)
T-3v	HUMBOLDT	3	25′ Wooden Tower
T-F1	HAMILTON	5	50′ Wooden Tower
B-Fa	WRANGELL	5	1500′ Balloon
B-Fa	SANFORD	5	1500′ Balloon
B-Fa	ADAMS	5	1500′ Balloon (Cancelled)
B-7b	SIERRA	7	Balloon (Cancelled)
B-7b	MORA	7	1500′ Balloon
B-7b	HIDALGO	7	377′ Balloon
B-7b	LEA	7	1500′ Balloon
B-7b	SOCORRO	7	1450′ Balloon
B-7b	DOÑA ANA	7	450′ Balloon
B-7b	DE BACA	7	1500′ Balloon
B-7b	SANTA FE	7	1500′ Balloon
B-7b	EDDY	7	500′ Balloon
T-7c	QUAY	7	100′ Steel Tower
T-8a	OBERON	8	25′ Wooden Tower
T-8b	CERES	8	25′ Wooden Tower
T-8c	TITANIA	8	25′ Wooden Tower
B-9a	RUSHMORE	9	500′ Balloon
T-9d	MAZAMA	9	50′ Steel Tower
S-9e	VESTA	9	Gravel Gertie
S-9f	JUNO	9	Gravel Gertie
S-9g	GANYMEDE	9	Gravel Gertie
T-9h	McKINLEY	9	50′ Alum. Tower (Cancelled)
U-12b.01	GRIZZLY	12	Tunnel (Cancelled)
U-12b.02	TAMALPAIS	12	Tunnel
U-12b.04	EVANS	12	Tunnel
U-12c.03	NEPTUNE	12	Tunnel
U-12e.02	LOGAN	12	Tunnel
U-12e.02	PIKE	12	Tunnel (Cancelled)
U-12e.05	BLANCA	12	Tunnel
U-12f.01	MERCURY	12	Tunnel
U-12f.02	MARS	12	Tunnel

Figure No. 7. ZERO STATION INDEX

SECTION 5
TEST FACILITIES

STATION:	Balloon Cab Shelters
PURPOSE:	Balloon Cab Shelter at Zero Station
USER:	LASL
PARTICIPATION:	Mora, Eddy, Hidalgo, Wrangell, Lea, Rushmore, Socorro, Doña Ana, Sanford, De Baca, Santa Fe

Each cab shelter consisted of a skid-mounted, plywood-covered, wood-frame structure 16½x16¾x18½ feet high. Access was provided at one end by two sliding doors, each 8¼x18¼ feet high. The skids were 6x10-inch timbers. Each structure was equiped with electrical facilities and an air cooler.

STATION:	U-3k, U-3m, U-3n, U-3p, U-3q, and U-3r	
PURPOSE:	Zero Station	
USER:	LASL	
PARTICIPATION:	Colfax, Luna, Bernalillo, San Juan, Otero, Valencia	
CONSTRUCTION:	U-3k,	5/28/58 - 8/29/58
	U-3m,	5/28/58 - 9/10/58
	U-3q,	5/26/58 - 9/4/58
	U-3n,	5/26/58 - 9/10/58
	U-3r,	9/9/58 - 9/22/58
	U-3p,	9/3/58 - 10/8/58

With the exception of Station U-3p, which was a 32-inch, 250-foot deep cased hole, each station consisted of a 500-foot deep hole, cased with 36-inch ID well casing having 7/16-inch walls. The wells were capped with a 1-inch thick steel cover plate.

The casing contained two plugs. Plug No. 1 was located at the 250-foot level and consisted of a concrete-filled steel cylinder, 34 inches OD by 5 feet long. To accommodate coax and signal cables through the concrete plug, four pieces of 6-inch pipe were cut in half lengthwise and placed on the inside perimeter of the casing. A length of 8-inch pipe ran through the center of the plug and offset from this were two 2-inch diameter pipes located in opposite quadrants.

Plug No. 2 consisted of a 34-inch OD pipe, 28 feet in length, filled with concrete to within 4 feet of the top and bottom. The bottom 4 feet contained a detector and instrument housing.

A 30-foot-square concrete slab at the surface supported a 20x20x60-foot high head tower which was constructed from sections of a 300-foot shot tower. The exterior of the tower was covered with plywood and painted with aluminum paint. This tower was equipped with two sets of double sheaves, mounted one above the other, and a traveling 5-ton electric hoist for handling the upper plug.

A User-furnished canister, which rested at the bottom of the hole, and Plug No. 1 were raised and lowered by means of two 8-ton hoists located approximately 60 feet from the tower, with the hoist cables run over the sheaves in the head tower. Control of the hoists was from the tower.

The hole for Station U-3p was originally drilled to a depth of 500 feet; however, during the installation of the 36-inch casing, the casing became wedged at the 192-foot level and could not be pulled. Thirty-four-inch casing was then installed inside of the 36-inch casing to the 310-foot depth, where it collapsed due to the removal of the hydrostatic head. This hole was then bailed and filled with concrete to the 250-foot level.

STATION:	T-3s, T-3t, and T-3u	
PURPOSE:	Zero Station	
USER:	LASL	
PARTICIPATION:	Rio Arriba, Catron, Chavez	
CONSTRUCTION:	T-3s,	10/14/58 - 10/17/58
	T-3t,	10/20/58 - 10/22/58
	T-3u,	10/22/58 - 10/27/58

With the exception of T-3u, these tower stations provided 12x12-foot platforms, 70 feet above grade. The elevation of the tower platform on Station T-3u was 52½ feet above grade. Each tower was constructed of four poles, 80 feet in length, and extending below grade approximately 10 feet. The towers were braced with 2x2-inch cross-members.

(58-5-13)

Figure No. 8. Station T-3t — 90% Complete

The cabs were 12x12x8 feet high, were enclosed with plywood and had one pair of double-swing doors, 2½x7 feet each. Access to the tower cabs was by wood stairways encircling the towers, with landing platforms at approximately every 8 feet of tower height.

The towers were guyed with a ¾-inch steel cable from each of the four corners at the platform level. Guy cables terminated in 4x4x3-foot concrete anchor blocks, buried below grade.

STATION: T-3v
PURPOSE: Zero Station
USER: LRL
PARTICIPATION: Humbolt
CONSTRUCTION: 10/25/58 - 10/27/58

This station consisted of a wooden tower, 10x10x25 feet high, with 4x6-inch wood corner posts braced with 2x12-inch cross-members spaced at 8-foot intervals. A cab, 10x10x7½ feet high, was constructed on top of the tower and was completely enclosed with plywood, except for a door opening.

An intermediate platform was built at the 8-foot level, and all four sides of the tower were enclosed with plywood from the 8-foot to the 16-foot elevation. Wooden stairs encircling the tower provided access to the platforms at the 8-foot and 25-foot elevations.

The tower had no concrete base nor was it secured by guy wires.

STATION: T-F1
PURPOSE: Zero Station
USER: LRL
PARTICIPATION: Hamilton
CONSTRUCTION: 9/15/58 - 10/13/58

A 50-foot high wooden tower with three platforms was constructed by erecting four 60-foot wooden poles, approximately 18 inches in diameter, and encasing them in concrete footings which were 10 feet deep by 3½ feet square. The four poles were vertically stabilized with ¾-inch steel guy lines. Each platform was 11⅓x8⅓ feet, with 1-inch thick plywood flooring. The top platform was completely covered with weather-tight canvas, forming the device room. A wooden stairway encircling the tower provided access to each platform level.

STATION: T-Fb
PURPOSE: Zero Station
USER: LRL
PARTICIPATION: Cancelled

This station was originally planned to be a duplicate of Station T-F1. Before construction began, however, it was changed to a prefabricated, 50-foot high aluminum tower. Erection of the aluminum tower was approximately 75% complete when plans were again changed and the tower was dismantled and stored.

STATION: B-Fa
PURPOSE: Balloon Zero
USER: LRL
PARTICIPATION: Wrangell, Sanford
CONSTRUCTION: 10/10/58 - 10/22/58

Built for use during Operation PLUMBBOB, this facility was repaired and modified for use in Operation HARDTACK, Phase II.

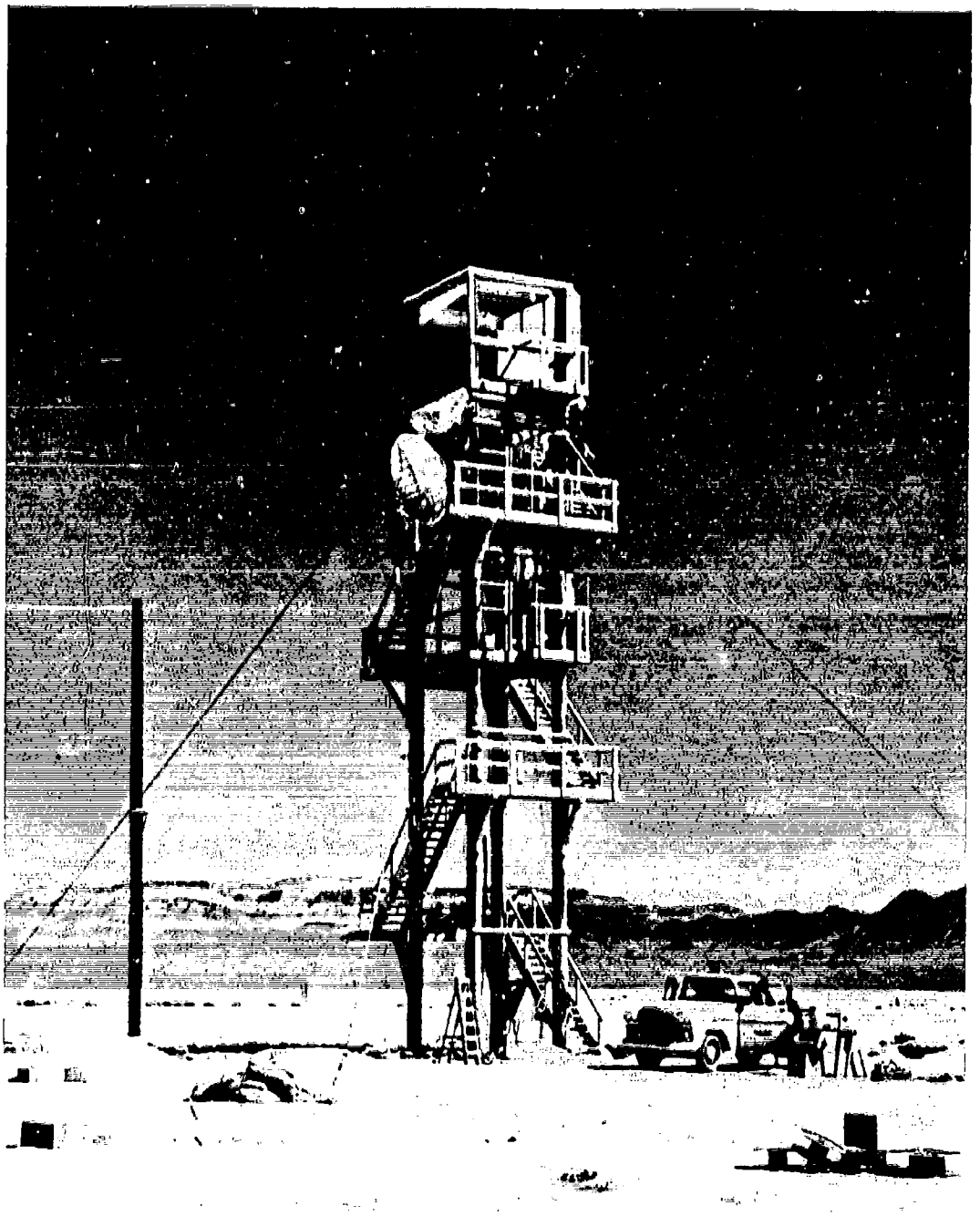
Repairs were made to the concrete pits, located directly below the balloon, which housed the transformer and EG&G and Sandia instruments. The area around GZ was cleared, new cable was installed or spliced as necessary to raise the balloon to 1500 feet, and the three existing winches were rehabilitated. Subsequent to the Wrangell event, new clean earth was hauled in and compacted around GZ to decontaminate the area for the Sanford event.

STATION: F-803
PURPOSE: To Transmit TV Signal from GZ to CP Station
USER: SC
PARTICIPATION: Wrangell, Sanford
CONSTRUCTION: 7/23/58 - 10/18/58

This station consisted of a wooden structure, 10x9x8 feet high, set on a 4-inch thick concrete floor slab. Mounted on top of this structure were two parabola antennas, one directed toward GZ and the other toward the Control Point. Various instruments, electrical outlets, work benches, and one air-conditioning unit were installed inside the structure.

STATION: 501.01 through 501.13
PURPOSE: Animal Pens
USER: DOD
PARTICIPATION: Hamilton
CONSTRUCTION: 9/15/58 - 9/23/58

Each of these stations consisted of four steel posts driven into the ground to within 2½ feet above grade. Using standard wire fence, an 18x24-inch rectangular enclosure was formed. A



(58-481-6)

Figure No. 9. Station T-F1 — 100% Complete

piece of fencing was wired over the top, totally enclosing each pen.

STATION:	502.01 through 502.96
PURPOSE:	Radiological Data Collectors
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/24/58 - 9/26/58

At each station a ½-inch diameter pipe, 5 feet 9 inches long, was driven into the ground, leaving 2 feet 9 inches extending above grade. On top of this pipe was attached a User-furnished film badge.

STATION:	503.01 through 503.04
PURPOSE:	To Collect Radiological Data
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/15/58 - 9/26/58

A hole, 8 feet deep and 19 inches in diameter, was drilled for each station. A 12-inch thick concrete ring with a 3-foot outside diameter and a 19-inch inside diameter was installed at the top of the hole with the top of the ring flush with grade. Each ring was cast with four ½-inch studs for use in mounting User-furnished instruments.

STATION:	504.01 through 504.30
PURPOSE:	Neutron Detectors and Soil Samplers
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/15/58 - 9/24/58

Each station consisted of one piece of ¾-inch diameter wire rope, anchored at GZ and then stretched for a distance of 3000 feet. User-furnished neutron detectors and soil samplers were attached to this rope at varying distances from GZ.

STATION:	505.01 through 505.100
PURPOSE:	Alpha Collectors
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/15/58 - 9/30/58

Each station consisted of a concrete slab, 10x10x2 inches thick. These slabs were placed on top of the ground at varying points from GZ.

STATION:	506.01 through 506.09
PURPOSE:	Thermal Detectors
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/29/58 - 9/29/58

A 6-inch diameter hole, 3 feet deep, was drilled at each station and a 6-inch diameter pipe extending about 2 feet above grade was placed in the hole to support a User-furnished thermal detector.

STATION:	508.01 through 508.26
PURPOSE:	Testing Biological Specimens for Blast Effects
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/29/58 - 9/30/58

These stations consisted of rectangular holes, 2x6x4½ feet deep, with a 6-inch high berm built up around the top. These holes were not covered during the test.

STATION:	509.01 through 509.26
PURPOSE:	Testing Biological Specimens for Blast Effects
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/15/58 - 9/23/58

Each of these stations consisted of a rectangular hole, 2x6x4½ feet deep. Two-thirds of each hole was covered with 6x6-inch timbers, 6 feet long, and 12 inches of earth fill, leaving a 2-foot-square opening.

STATION:	510.01 through 510.12
PURPOSE:	Testing Biological Specimens for Blast Effects
USER:	DOD
PARTICIPATION:	Hamilton
CONSTRUCTION:	9/15/58 - 9/23/58

A rectangular hole, 2x5x7 feet deep, with a 2-foot-square step, 4 feet from grade, was excavated for each of these stations. At the bottom of the hole, 90° to the wall, a 24-inch diameter, 4½-foot long corrugated metal pipe was placed, with a holding ring attached at one end. Sandbags were placed on top of this pipe to prevent its being filled with loose dirt. Roughly, half of the top of the excavated hole was covered

with 6x6-inch timbers and back-filled with 12 inches of earth, leaving an opening of approximately 2 feet square.

STATION: 517.01 through 517.08
PURPOSE: Pressure Recording
USER: DOD
PARTICIPATION: Hamilton
CONSTRUCTION: 9/26/58 - 9/30/58

A hole, 15 inches in diameter and 3 feet deep, was drilled for each station. A 15-inch diameter pipe was inserted into the hole and extended about 2 feet above grade. A User-furnished gauge was attached at the top of each pipe.

STATION: 518.01 through 518.27
PURPOSE: Pressure-Time Recording
USER: DOD
PARTICIPATION: Hamilton
CONSTRUCTION: 9/26/58 - 9/30/58

A 12-inch diameter hole, 18 inches deep, was drilled into the ground and 12-inch diameter pipe was inserted in each hole, extending about 2 feet above grade. A PT gauge, furnished by the User, was attached at the top of each pipe.

STATION: 522.01 through 522.10
PURPOSE: Shadow Shield Detection
USER: LRL
PARTICIPATION: Hamilton
CONSTRUCTION: 9/24/58 - 9/26/58

These stations consisted of 10 telephone poles extending 50 feet above grade and arranged in two parallel rows of five poles, each pole being opposite a pole in the other row. User-furnished detectors were attached to rope and chain catenaries suspended between each pair of opposite poles. Swivel blocks were used with the rope to raise and lower the detectors. At six locations, facing in various directions from GZ, a 6-inch pipe, 3 feet long, was placed in a V-shaped hole and held in position with sandbags.

STATION: 523.01 through 523.03
PURPOSE: Testing Valves for Closure
USER: OCDM
PARTICIPATION: Hamilton
CONSTRUCTION: 9/23/58 - 10/7/58

During Operation PLUMBBOB, three test cells were built of 7-foot, 7-inch diameter by 8-foot long concrete pipes, with 20-inch con-

(REECO 483-4)

Figure No. 10. General View of Station T-F1 and Stations 522.01 through 522.10

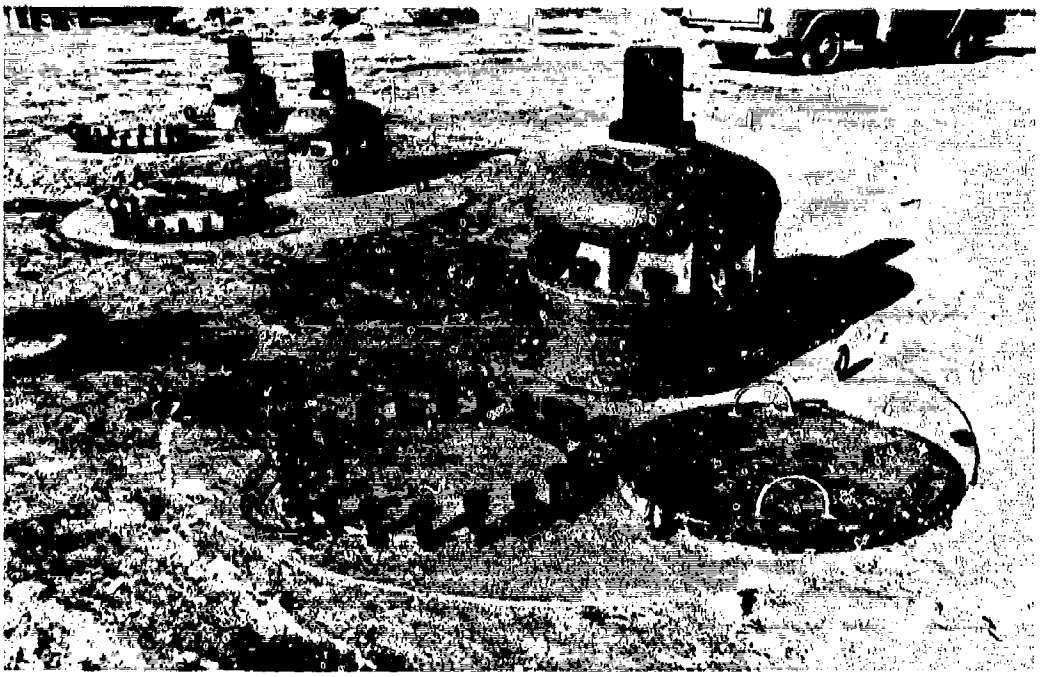


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Figure No. 11. Stations 523.01, .02 and .03 — 100% Complete

crete covers. These test cells were relocated on a new concrete base, 30 feet, 9 inches long by 10 feet, 2 inches wide, by 1 foot, 6 inches thick. One 12-inch, one 16-inch, and one 24-inch User-furnished valves were bolted in place on top of the cells. These valves were electrically wired and instruments were mounted inside to measure valve closure during the Hamilton event.

STATION:	T-7c
PURPOSE:	Zero Station
USER:	LASL
PARTICIPATION:	Quay
CONSTRUCTION:	9/12/58 - 10/9/58

This station was erected from four 25-foot sections of a standard steel shot tower. A 20x20x8-foot high wooden cab was built on top of the tower, the cab floor being 103 feet, 2¾ inches above grade. The cab floor was of ½-inch plywood decking and supported a paraffin shield, 2 feet thick and 10 feet in diameter. Access to the cab was by elevator.

A platform at the 49¾-foot level was built of 1-inch thick steel grating, and another platform of plywood decking was built at the 88-foot 1-inch level.

A pipe of varying diameters, as listed below, extended from the concrete plug in Station 7-313 to the cab floor.

Elevation	Diameter
Bottom of Concrete Plug to 24 feet above grade	6-inch OD
24 feet to 53 feet, 6 inches above grade	20-inch OD
53 feet, 6 inches to cab floor	34-inch OD

Each corner of the tower was guyed at the 100-foot level with 1-inch cables connected to existing concrete anchor blocks.

STATION:	7-313
PURPOSE:	Tower Base Structure
USER:	LASL
PARTICIPATION:	Quay
CONSTRUCTION:	9/22/58 - 10/7/58

(58-1-4)

Figure No. 12. Tower Station T-7c and Base Structure Station 7-313

Modifications to this existing structure involved adding a steel door at the entrance-tunnel opening and removing a boiler from the base-house structure.

The steel door was mounted on angle-iron tracks and so constructed that it could be opened from a remote location by pulling on an attached steel cable.

When the boiler, which included a previous tower footing, was removed from the base-house, the resultant void was filled with a concrete plug. A 6-inch pipe ran through the center of the plug, terminating at a ¾-inch steel plate mounted flush with the ceiling. Also, the existing tower footings were modified to accommodate a 103-foot steel shot tower.

A concrete wall was constructed across the top of the tunnel structure near the entrance to retain new fill over this station.

In conjunction with sample recovery, a sled was constructed of steel members with removable plywood sides. A steel tow cable was attached to the sled and ran to the exterior of the station.

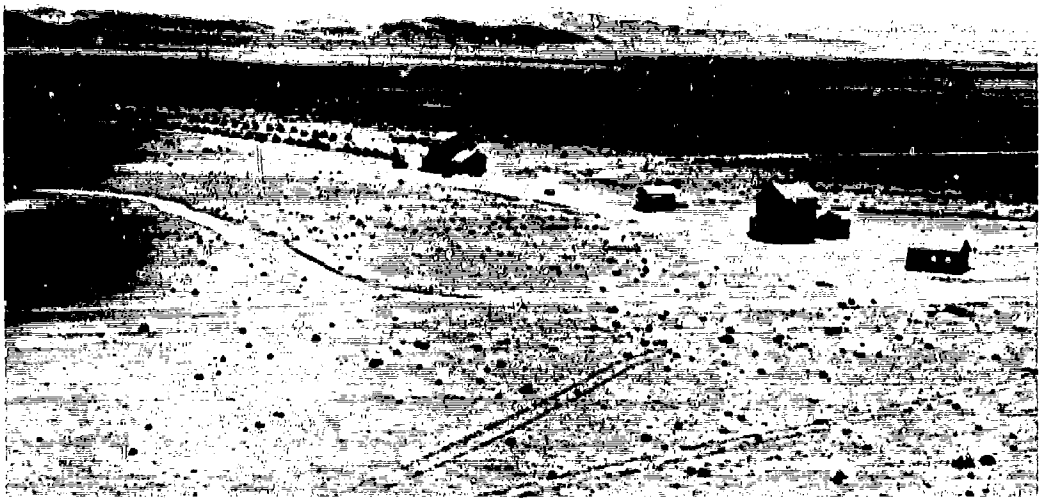
STATION:	700.01 through 700.02
PURPOSE:	Radiation Dosimetry for Human Exposure
USER:	CETO
PARTICIPATION:	Mora, Lea, Socorro
CONSTRUCTION:	9/7/58 - 9/26/58

These one-story structures were constructed of timber frame and specially fabricated transite panel. They were 28 feet, 4 inches long, 22 feet, 4 inches wide, and the eaves were 8 feet, 8 inches above grade. The plywood floor was nailed to floor joists which were mounted on four 12x12-inch skids. The roof slope was 5½ to 12. Door and window openings were framed into the outside walls; however, doors and windows were not installed. Interior partitions were erected to simulate a standard room arrangement. These two Type "A" structures were re-oriented or relocated at 3000 feet from GZ prior to each of three events.

STATION:	701.01 through .02
PURPOSE:	Radiation Dosimetry for Human Exposure

(58-23-9)

Figure No. 13. Stations 701.01 (Right) and 702.02 (Left)



(REECO 480-6)

Figure No. 14. Stations 700, 701 and 702 — Area 7

USER: CETO

PARTICIPATION: Mora, Lea, Socorro

CONSTRUCTION: 9/11/58 - 9/26/58

These two-story structures were of wood frame and specially fabricated transite panel construction. They were 37 feet, 6 inches long, 22 feet wide, and the eaves were 22 feet, 2 inches above grade. The roof slope was 5½ to 12. Both floors were plywood; the first floor rested on five 12x12-inch skids. Door and window openings were framed into the outside walls; however, doors and windows were not installed. Interior partitions were erected to simulate a standard room arrangement. Both structures were used in two events, and one structure was used in a third event. These stations were located 3000 feet from GZ during the three events.

STATION: 702.01 through 702.03

PURPOSE: Radiation Dosimetry for Human Exposure

USER: CETO

PARTICIPATION: Mora, Lea, Socorro

CONSTRUCTION: 9/7/58 - 9/26/58

These one-story structures were constructed of timber frame and specially fabricated transite panel and were 26 feet square with eaves 8 feet, 8 inches above grade. The roof slope was 5½ to 12. The floor was plywood nailed to floor joists which were mounted on three 12x12-inch skids. Door and window openings were framed into the outside walls, but doors and windows were not installed. Interior partitions were erected to simulate a standard room arrangement. The Type "C" structures were used in three separate events by locating them after each test.

STATION: T-8a, T-8b, T-8c

PURPOSE: Zero Tower

USER: LRL

PARTICIPATION: Oberon, Ceres, Titania

CONSTRUCTION: T-8a 10/22/58 - 10/23/58
T-8b 10/24/58 - 10/24/58
T-8c 10/26/58 - 10/26/58

Each station consisted of a 25-foot tower with a 10x10x7½-foot cab erected at the top. The towers were constructed of 4x6-inch posts and 2x6-inch cross-bracing. Three sides and the roof of the cabs were sheathed with plywood and one side was covered with paraffin. The cab floor was built of 2-inch plank on 2x8-inch joist. Access to the cab was through a 5-foot-square hatch and through a door opening at the head of a stairway.

(58-6-13)

Figure No. 15. Station T-8c Showing Power Cable Trench from Transformer to Tower

STATION: B-9a
PURPOSE: Balloon Zero Station
USER: LRL
PARTICIPATION: Rushmore
CONSTRUCTION: 9/13/58 - 9/22/58

This structure, an existing concrete GZ pad used for previous balloon launchings, had been damaged from past events and required extensive rehabilitation and construction. This was accomplished by pouring a 4-foot thick reinforced concrete pad over the existing pad and adding a 14x3x6-foot high reinforced concrete wall across one end. The wall contained two TV alcoves, one transformer alcove, and one terminal alcove. Steel doors were provided for all alcoves.

STATION: 902.01
PURPOSE: Camera Support
USER: LRL
PARTICIPATION: Rushmore
CONSTRUCTION: 10/13/58 - 10/17/58

This station was a phonex-camera-block-support consisting of a concrete foundation, 5 feet, 10 inches wide by 5 feet long, 18 inches deep, and tapered concrete walls on two sides, 8 inches wide at the top and 20 inches wide at the bottom, leaving a 2½x5-foot long space at the top. The open ends were enclosed with plywood.

On top of these walls a 6x6-inch angle-iron box section, 5 feet long, was filled with grout and supported the phonex block. Two feet of earth fill covered the phonex block and its support.

STATION: 904.01 through 904.03
PURPOSE: Personnel Safety Shelters
USER: OCDM
PARTICIPATION: Rushmore
CONSTRUCTION: 9/17/58 - 10/1/58

These stations were underground reinforced concrete shelters, 12x9⅓x7½ feet high, covered with 2¼ feet of earth fill.

To provide a passageway into the main room, a concrete partition, 8 inches thick, extended from one end wall of the structure to within 2 feet of the other end wall.

Access to the shelter was by a 2x3-foot hatch which entered into the passageway

(58-2-8)

Figure No. 16. Station B-9a Showing New Concrete Pad and Wall

(52-481-11)

Figure No. 17. Station 904 Prior to Backfill

through the top of the main structure. The hatch was covered with a ½-inch thick steel plate. Vent pipes were provided for the circulation of fresh air.

STATION:	S-9e, S-9f, and S-9g
PURPOSE:	Zero Station
USER:	LRL
PARTICIPATION:	Vesta, Juno, Ganymede
CONSTRUCTION:	S-9e, 10/ 5/58 - 10/18/58 S-9f, 10/ 5/58 - 10/17/58 S-9g, 10/20/58 - 10/23/58

These stations were heavy-timber structures, each comprising a room 10x10x7 feet high with an entrance-maze tunnel 26x4x7 feet high. The structures were built on 18-inch thick concrete foundations, and were covered with 20 feet of gravel. Timber wing walls extended 24½ feet out from the tunnel entrance at approximately 45° angles.

A 200-foot Rad-Chem line connected each structure to a pump that was protected by a concrete wall and sand bags.

STATION:	T-9d
PURPOSE:	Zero Tower
USER:	LRL
PARTICIPATION:	Mazama
CONSTRUCTION:	9/30/58 - 10/25/58

This structure consisted of 50-foot steel tower erected on four 9x9x3-foot concrete footings.

The tower was topped with a 20x20x10-foot high timber cab covered with plywood. The

(58-5-4)

Figure No. 18. Station S-9f -- 100% Complete

cab was provided with one 3x7-foot door, two 2½x7-foot, 10-inch doors, and a 5x5-foot access hatch in the roof. A steel stairway encircling the tower provided access to the cab.

Equipment was delivered to the cab by a 1-ton electric hoist traveling on a trolley beam cantilevered out 9 feet from the tower.

STATION: T-9h
PURPOSE: Zero Station
USER: LRL
PARTICIPATION: Cancelled

A tower 4 feet, 2¾ inches by 5 feet, 9⅝ inches by 50 feet high, consisting of aluminum scaffolding, was erected on a concrete foundation. With the exception of the cab, this structure was completed; however a program revision deleted the requirement for this station and it was dismantled and placed in storage at Mercury.

STATION: 9-30S
PURPOSE: Coax Connector Pit
USER: LRL
PARTICIPATION: Rushmore
CONSTRUCTION: 10/13/58 - 10/17/58

This was an existing reinforced concrete structure. Due to the proximity of the Rushmore event, it was necessary to install 6x6-inch cribbing on the inside for the full depth of the structure. To provide a protective roof over the pit, eight 12x12x3-inch wide-flange beams covered with plywood were installed, over which was placed a 6-foot fill covered with sandbags.

STATION: 9-30S
PURPOSE: Coax Connector Pit
USER: LRL
PARTICIPATION: Vista
CONSTRUCTION: 10/14/58 - 10/16/58

Two walls of this existing structure were cracked vertically, necessitating added reinforcement prior to a test event occurring in the immediate vicinity. The reinforcing included the

(58-5-8)

Figure No. 19. Station T-9d Prior to Installation of Prefabricated Cab

installation of 6x6-inch timber cribbing inside for the full depth of the station, 6x6-inch timbers across the top, sheathing the top timbers with plywood, and covering the structure with a 2-foot earth fill overlaid with sandbags.

STATION:	9-310
PURPOSE:	Coax Connector Pit
USER:	LRL
PARTICIPATION:	Ganymede
CONSTRUCTION:	10/29/58 - 10/29/58

This structure was reinforced and protected in the same manner as Station 9-308.

STATION:	U-12b.01, .02, .03, .04
PURPOSE:	Side Drifts into GZ Chambers
USER:	LRL
PARTICIPATION:	Tamalpais, Evans
CONSTRUCTION:	U-12b.01 - 297-foot branch tunnel off U-12b tunnel at station 4 + 84, 6/10/58 to 11/17/58
	U-12b.02 - 394-foot branch tunnel off U-12b tunnel at station 6 + 67, 5-19-58 to 10/8/58
	U-12b.03 - 655-foot branch tunnel off U-12b tunnel at station 9 + 66, 5/4/58 to 11/17/58
	U-12b.04 - 829-foot branch tunnel off U-12b tunnel at station 14 + 00, 3/20/58 to 10/28/58

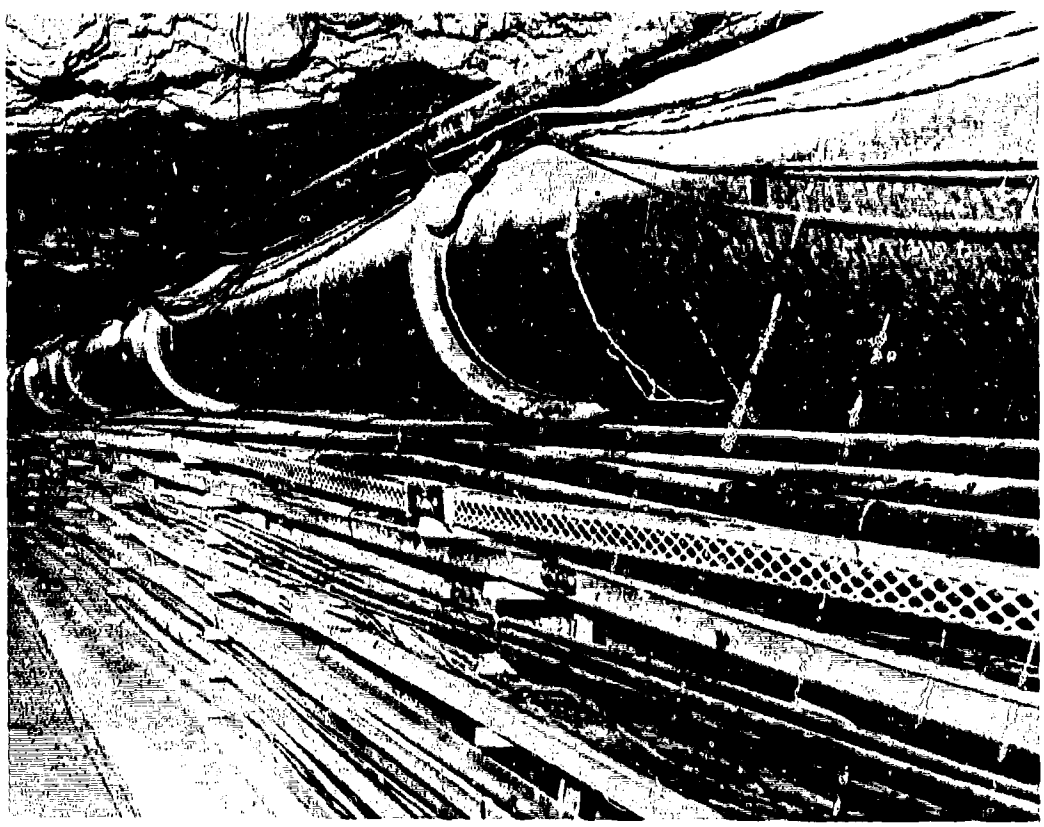


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Figure No. 20. Tunnel U-12b Showing Power, Signal, and Coaxial Cable Installation

(58-15-3)

Figure No. 21. Transition from Wire Mesh to Steel Supports in Side Drift U-12b.04

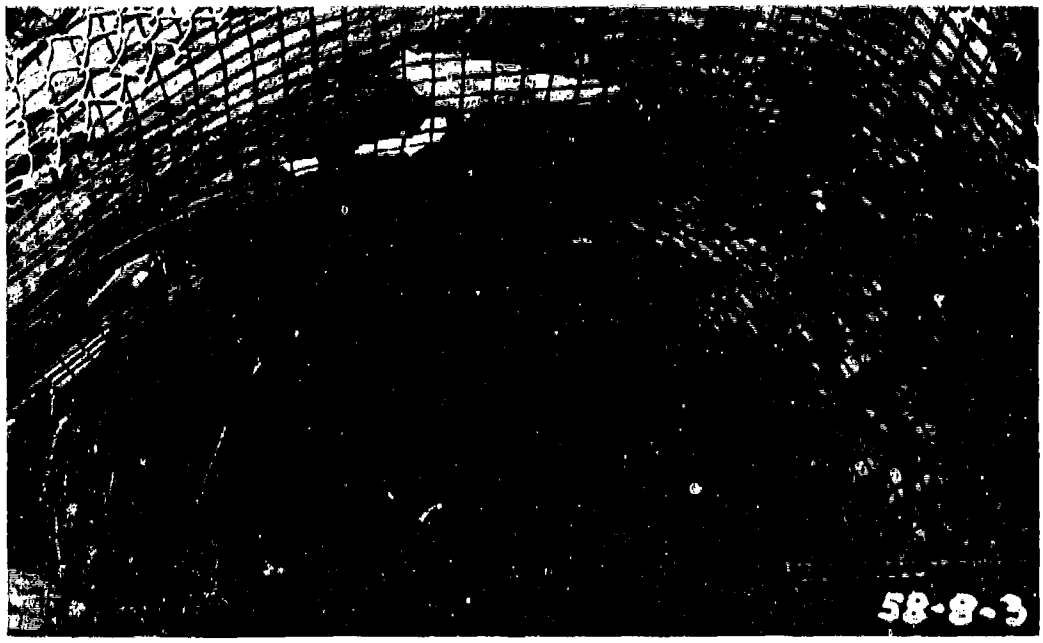

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Figure No. 22. Wire Mesh Used to Support Roof in Side Drift U-12b.04

The main drift of Tunnel U-12b was in existence prior to the activity described below. This tunnel was 1940 feet long with a 6x7-foot high cross-section.

Drift U-12b.01 was excavated to include a GZ chamber and an alcove (Alcove No. 1) containing two large rooms and two small alcoves for drilling purposes. A 19x15x13-foot high GZ chamber was lined with steel beams, timber posts, and timber lagging. For re-entry purposes, Alcove No. 1 was completely lined with lagging over steel arches. The entire drift was lined with steel arches, allowing a 8½-foot width and 8¼-foot clear height. A single track railroad was used in the tunneling operations. The drift was provided with compressed air, power, light, ventilation, and water. U-12b.01 was not used in this Operation due to a rescheduling of events.

Drift U-12b.02 was excavated to include a GZ chamber and an alcove (Alcove No. 1) containing two large rooms, a camera and rack room, and two small drilling alcoves. The GZ chamber was 19x19x12 feet high, and was lined with steel beams, timber posts, and timber lagging. The interior of the GZ chamber was lined with salt blocks which were held in place with plywood. Alcove No. 1 was lined with timber and steel arches. The camera and rack room was framed with steel beams and columns. The drift lining, equipment, and trackage were the same as described for drift U-12b.01. Drift U-12b.02 was used for the Tamalpais event.

Drift U-12b.03 was constructed to include a GZ chamber and two large alcoves (Alcoves No. 1 and No. 2). The GZ chamber was about 19x19x14 feet high, and was lined with steel beams, timber posts, and timber lagging. Alcove No. 1, rectangular in plan, was supported by steel arches with 7-foot horizontal beams, allowing a clear height of 9¼ feet and a width of 20 feet. Alcove No. 2 was completely lined with lagging over steel arches. An accidental explosion in drift U-12b.02 damaged drift U-12b.03 to the extent that it could not be used for a test event during this Operation.

Drift U-12b.04 was excavated to include an irregular-shaped GZ room, three large alcoves (Alcoves No. 1, No. 2, and No. 3), and several small drilling alcoves. The GZ room was lined with steel beams, timber posts, and timber lagging. Alcoves No. 1 and No. 2, rectangular in plan, were supported by steel arches as described in Alcove No. 1, drift U-12b.03. Alcove No. 3, irregular in plan, was lined with steel beams and columns. Utilities and trackage similar to those in drift U-12b.01, were installed. This drift was used for the Evans event.

(58-21-3)

Figure No. 23. Concrete Encasement for Blast Door in Side Drift U-12b.02

STATION: U-12c.03
PURPOSE: Side Drift into GZ Chambers
USER: LRL
PARTICIPATION: Neptune
CONSTRUCTION: 9/29/58 - 10/14/58

Tunnel U-12c was in existence prior to the activity described below. This tunnel was 200 feet long and had a 6x7-foot high cross-section.

The facility constructed for Operation HARDTACK, Phase II, consisted of a 165-foot side drift, 6 feet wide and 7 feet high, off the main tunnel at station 1 + 00. The drift included an unlined GZ room 15½x11⅔x8 feet high, and a drilling alcove for a line-of-sight hole. A 6-inch concrete floor was poured in the GZ room. A 12x18-inch cable trench was excavated in the tunnel floor for the major portion of the drift. Water, compressed air, ventilation, power, and lights were supplied.

STATION: U-12e
PURPOSE: Main Tunnel
USER: LRL
PARTICIPATION: Logan, Blanca
CONSTRUCTION: 3/21/58 - 8/30/58

The tunnel portal was located at N 887, 809.00; E 637, 719.00 at Elevation 6115 feet. A 14x14-foot drift was excavated in a straight line for approximately 2030 feet. From the portal to station 8 + 95, timber lining was installed. Steel supports were used from station 8 + 95 to station 11 + 98, providing a 13-foot, 2-inch width and a 11-foot, 7-inch clear height. From station 11 + 98 to station 20 + 27 steel supports were installed providing a clear cross-section 13 feet, 2 inches wide by 13 feet, 2 inches high. Steel tunnel supports were fabricated from 8-inch wide-flange steel beams, rested on 4-inch timber base plates and were braced with ¾-inch steel rods. Three by 12-inch timber lagging

(58-2-12)

Figure No. 24. Tunnel U-12c — Looking from Station 1 + 00 Towards Portal

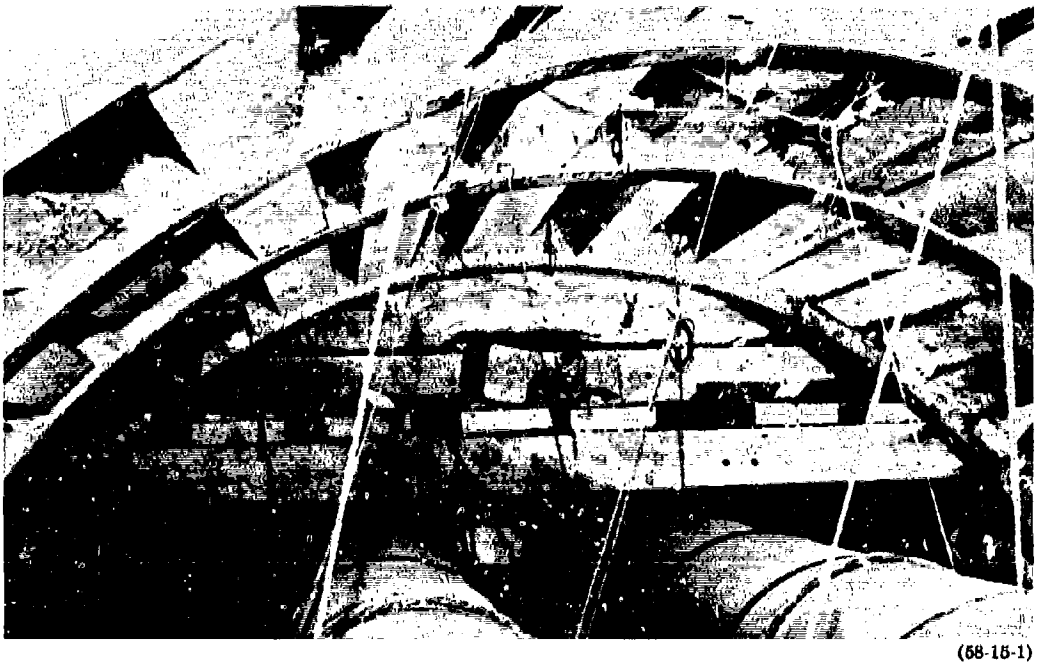

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Figure No. 25. Transition from Timber Sets to Steel Sets at Station 8 + 95 Tunnel U-12e

was placed between the steel supports. Ventilation was provided through two 20-inch round ducts suspended from supports at the center line. Power and signal cables were carried in five 13-inch suspended cope trays. Other utilities included a 4-inch water line and a 6-inch compressed air line. A double track railway extended for the full length of the tunnel.

STATION:	U-12e.02 and .05
PURPOSE:	Side Drifts into GZ Chambers
USER:	LRL
PARTICIPATION:	Logan, Blanca
CONSTRUCTION:	U-12e.02 - 8/29/58 to 10/15/58
	U-12e.05 - 8/29/58 to 10/30/58

U-12e.02

From the main drift of Tunnel U-12e, at station 20 + 31, a 665-foot side drift was excavated with one small diagnostic alcove and a GZ chamber. Steel lining sets, having a 3½-foot radius and a 5½-foot column section, provided a clear width of 7 feet. These were used from stations 0 + 25 to 0 + 43 and from 4 + 27 to 4 + 83. Between stations 0 + 96 and 1 + 14, 6x8-inch timber sets were used. The drift was widened by approximately 1 foot from station 4 + 34 to the end of the drift. The GZ chamber was located at the end of the drift and was of the same dimensions as the drift.

U-12e.05

This side drift was constructed off Tunnel U-12e at station 19 + 61. It extended 1010 feet and included a GZ room lined with 8x8-inch timbers to a height of 14 feet. A large loop reversed the direction of the drift to form an earth plug at shot time. Steel lining sets, having a 3½-foot radius and a 5½-foot column section, provided a clear width of 7 feet.

The Logan event in U-12e.02 damaged a considerable portion of the U-12e.05 drift, necessitating relocation of the GZ room to station 5 + 97. The new GZ room was 7 feet, 7 inches wide and was supported by 6x8-inch timber sets.

Both drifts were equipped with a single track railroad, water, compressed air, ventilation, power, and lights.

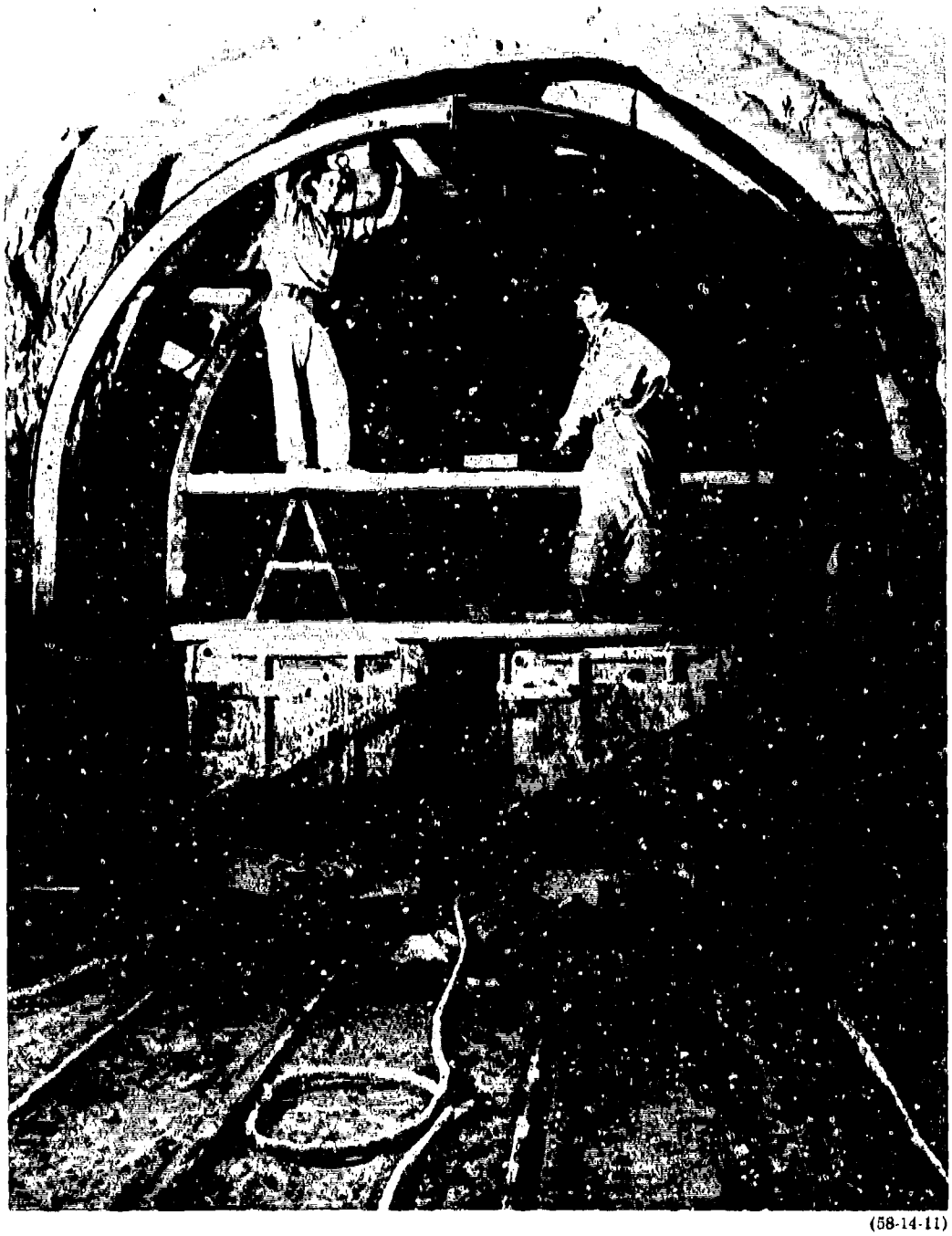

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Figure No. 26. Steel Sets at Station 12 + 17 — Tunnel U-12e

STATION: U-12f
PURPOSE: Main Tunnel
USER: LRL
PARTICIPATION: Mercury, Mars
CONSTRUCTION: 8/1/58 - 9/13/58

This was a 550-foot long tunnel with a cross-section of 6x7 feet, located at N 887, 666.50; E 636, 115.00 at Elevation 6712 feet. The tunnel terminated in a room 14x15x10 feet high and was provided with a blast door and a diagnostic alcove. Two steel supports were installed for personnel safety at the junction of the U-12f.03 side drift. Signal cable was housed in a 6x12-inch timber tray which was supported on 4x4-inch posts and beams spaced on 8-foot centers. These supports also carried a 20-inch round ventilation duct, a 2-inch water line and a 4-inch compressed air line. The power cable was supported on the tunnel wall by rock bolts spaced on 5-inch centers. A single track railway serviced this tunnel.

STATION: U-12f.01, .02, .03, .04
PURPOSE: Side Drifts into GZ Chambers
USER: LRL
PARTICIPATION: Mercury, Mars
CONSTRUCTION: U-12f.01 - 155-foot branch tunnel off U-12f at station 3 + 70, 8/28/58 - 9/22/58

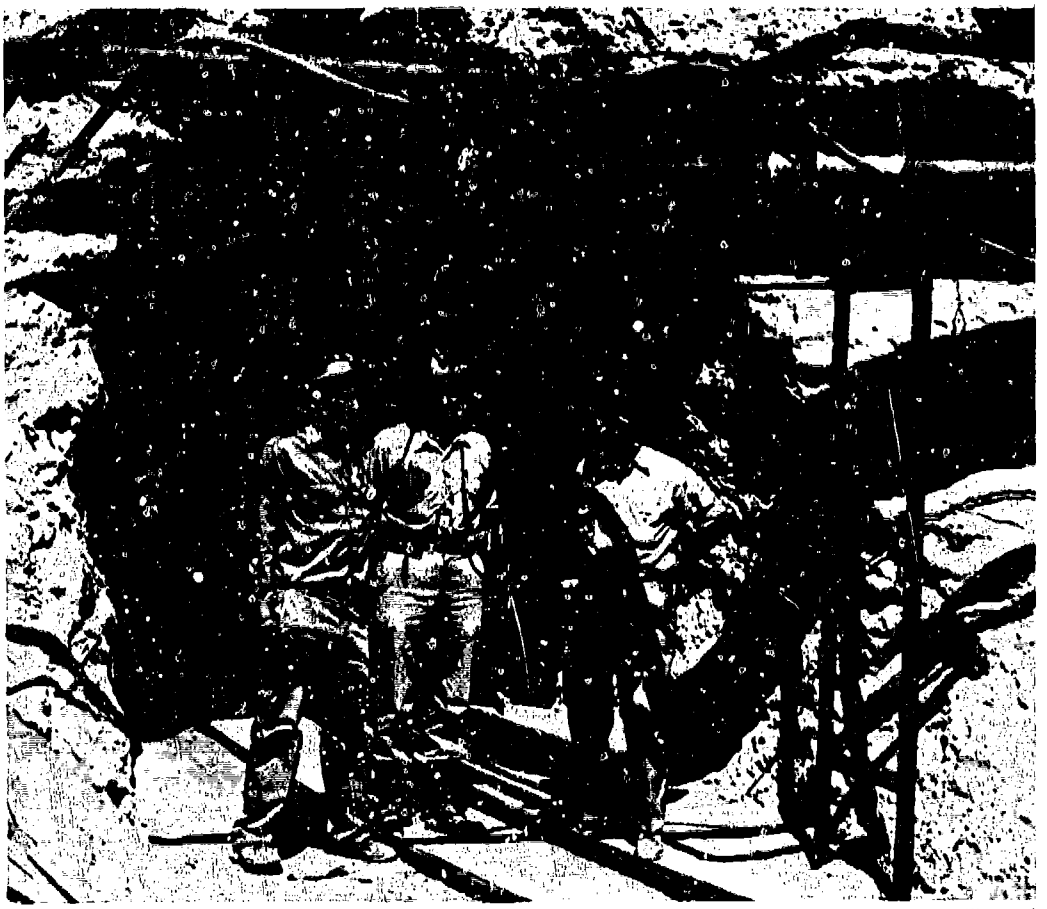

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Figure No. 27. Portal of Tunnel U-12f

U-12f.02 - 155-foot branch tunnel off U-12f at station 4 + 30, 8/31/58 - 9/27/58

U-12f.03 - 311-foot branch tunnel off U-12f at station 4 + 90, 9/7/58 - 10/15/58

U-12f.04 - 155-foot branch tunnel off U-12f at station 5 + 30, 9/10/58 - 10/15/58

Drifts U-12f.01 and .02 were constructed with a GZ room, an alcove for a line-of-sight hole, and a small alcove for a transformer and panel. Each GZ room was 15x14x8 feet high, and had a 6-inch concrete slab floor. The rooms were unsupported. Drift U-12f.03 was excavated to station 2 + 61 and was then deleted from the program. The excavation of U-12f.04 was concluded, but further work to complete the facility was discontinued.

Typical drift construction included excavation 6 feet wide by 7 feet high which was unsupported except for a few steel arch sets. Timber sets were erected on 8-foot centers to support an overhead cable trough. All drifts were supplied with water, compressed air, ventilation, power, and lights.

Only drifts U-12f.01 and U-12f.02 were used in this Operation.

STATION: 12-1

PURPOSE: Forward Observation and Control Point

USER: LRL

PARTICIPATION: Evans, Blanca

CONSTRUCTION: 10/23/58 - 10/27/58

This station included a trailer, various equipment, and parking areas. One parking area, 300x30 feet, was located on the south side of the Area 12 access road. The trailer, enclosed by a 40-foot-square, two-strand barbed wire fence, was located at the west end of the parking area. The trailer was equipped with a receiving antenna and TV monitor, and a hot line, with two telephones, to the Control Point. Another parking area, identical in size, was located across the road.

STATION: 12-63

PURPOSE: Generator Shelter

USER: LRL

PARTICIPATION: Logan, Blanca

CONSTRUCTION: 9/2/58 - 10/24/58

The building was constructed of steel arches with a clear height of 13 feet, 2 inches, a length of 23 feet, 6 inches, and a width of 17 feet, 6 inches. One end of the building was open with access limited by a chain link fence and gate. The opposite end was supported by two steel columns which framed into a horizontal beam. Two-by-twelve planking was secured to the outside flanges of the arches and 22-gauge corrugated metal siding was nailed over this. One 10-kw and one 35-kw generator set were vented by stacks through the roof. Two 550-gallon fuel oil tanks resting on concrete cradles were placed on one side of the building to supply fuel for the generators.

STATION: 12-300

PURPOSE: Alpha Recording Station

USER: LRL

PARTICIPATION: Tamalpais, Evans, Neptune, Mercury, Mars

CONSTRUCTION: 6/30/58 - 9/27/58

This existing rigid-frame, aluminum-covered building was lengthened by 20 feet. Construction of the new addition matched the existing structure. Partitions were relocated to enlarge Rooms 104 and 105. The 500-gallon water tank was relocated to a corner of the new extension. A 4-inch concrete slab, 10½x7⅓ feet, was added at the west side of the building for two dehumidifiers. A removable roof was erected over the front entrance, and the air conditioning ducts were extended into the new section.

STATION: 12-301

PURPOSE: Alpha Recording Station

USER: LRL

PARTICIPATION: Logan, Blanca

CONSTRUCTION: 8/4/58 - 10/15/58

This station was built on a 6-inch concrete slab and consisted of a standard corrugated metal arch building, 80x26x15¼ feet high. The multiplate arches had a radius of 12 feet, 8 inches and were supported by 6-inch reinforced concrete side walls which were 2 feet high above the finish floor. The outer surface of the multiplate arch was covered with 3 inches of insulation. A concrete vault, 21½x 13⅓x8 feet high, was constructed adjacent to the north side of the building. The east end wall of the building was constructed of 10-inch reinforced concrete and contained the main entrance doors. The west end wall was constructed of 12-inch reinforced concrete with an open slot through which conduit was run into the portal of Tunnel U-12e. After the conduit was in place, the slot was filled with grout.

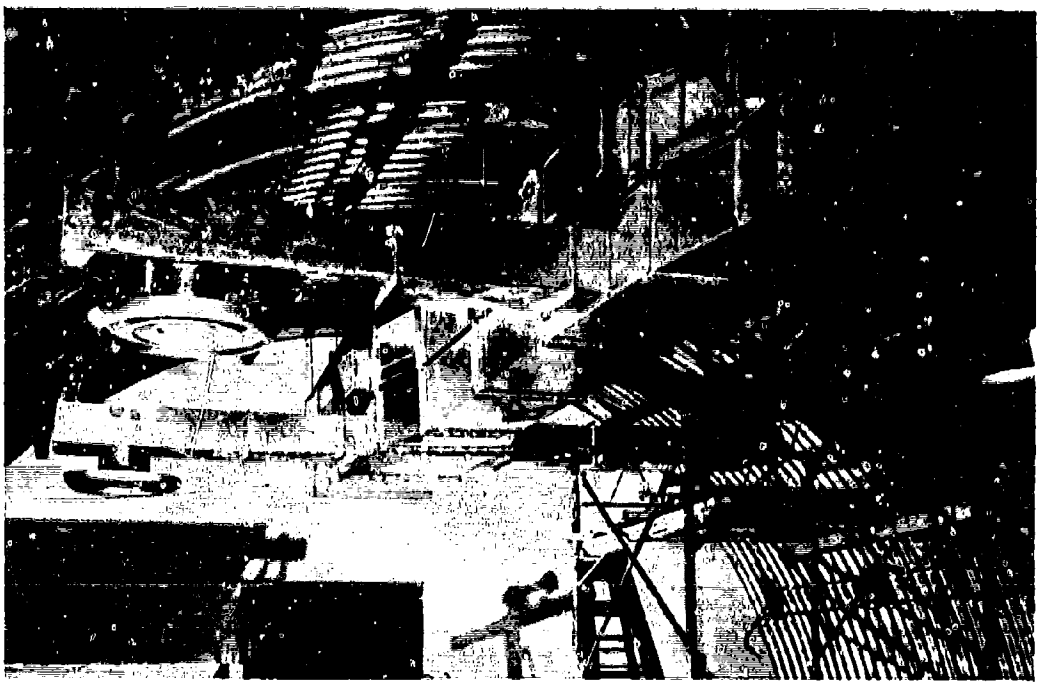

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Figure No. 28. Interior of Station 12-301 Showing Ductwork and Electrical Supports

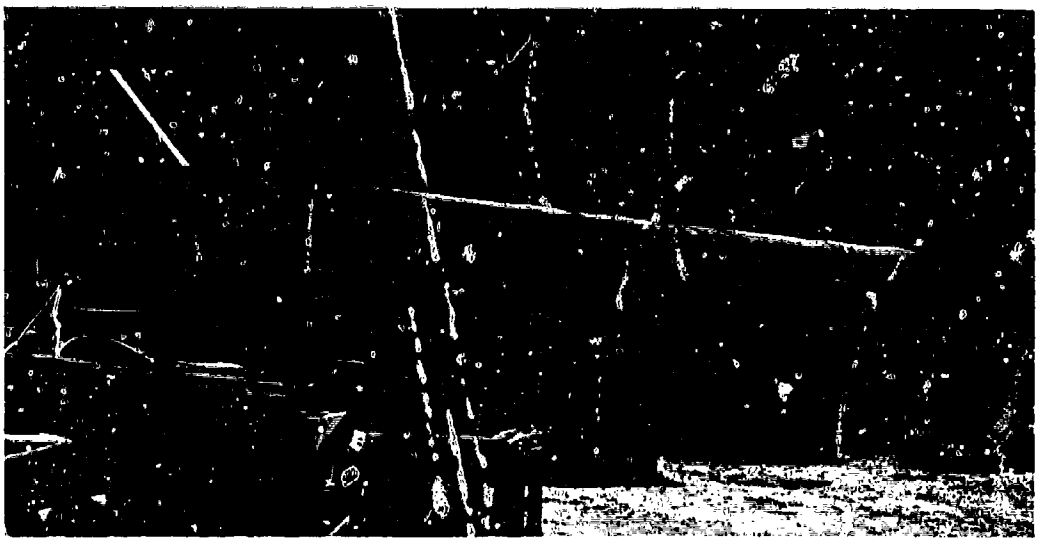

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Figure No. 29. Station 12-301 Prior to Backfill

The inside of the structure was partitioned into five rooms, as follows:

Instrument Room, 25'-4"x42'-2"
Work Room, 27'x14'-6'
Physics Diagnostics Space, 22'x10'
Dark Room, 8'x9'-2"
Mechanical Equipment Room, 10'x14'-2"

Air conditioning was supplied to all rooms through metal ducts located at the ceiling line. Power for utilities was supplied from the main transmission line through transformers housed in the concrete vault. Scientific power was supplied from two generators located in Building 12-63.

The south side of this structure abutted a vertical embankment. Earth fill covered the building with a minimum depth of 4 feet at the centerline, sloping off to the embankment on the south side and to a 4-foot high wood retaining wall erected 15 feet from the north side of the building. The fill partially covered the concrete vault. The east end wall extended beyond the building to retain the fill at this end. This wall was built to the embankment with a right angle wing; it extended to the wood retaining wall on the opposite side, and the height was designed to contain the fill along its contour.

STATION:	12-302
PURPOSE:	Warehouse
USER:	LRL
PARTICIPATION:	Not Applicable
CONSTRUCTION:	7/17/58 - 9/25/58

This building was a standard steel, rigid-frame structure, 49 feet, 10½ inches long, 40 feet, 2½ inches wide and 14 feet, 2½ inches to the eaves, constructed on a 4-inch concrete slab. The exterior was covered with aluminum panels. The front and rear of the building had double sliding doors and two fixed windows. Heat was supplied by two electric heaters, and for cooling an evaporative cooler was installed on a timber stand outside the building.

(58-18-1)

Figure No. 30. Station 12-302

(58-20-5)

Figure No. 31. Station 12-303

STATION: 12-303
PURPOSE: Ventilator Equipment Building for U-12e Tunnel
USER: LRL
PARTICIPATION: Logan, Blanca
CONSTRUCTION: 9/28/58 - 10/15/58

A structure, 29½x26½x13½ feet high, was built to shelter the existing blowers which provided the air supply for Tunnel U-12e. The floor was concrete, 6 inches thick, with 12-inch footings. Eight steel-arch sets, having a 3-foot, 7-inch radius, a 6-foot column section, and a horizontal beam section 11 feet, 4 inches long between the half-arches, comprised the framework of this building. Each end set was supported by two steel columns. Timber planking and 22-gauge corrugated metal siding covered the building except for one end which was left open. A chain-link fence and gate were erected at the open end.

STATION: 1200.03 through 1200.14
PURPOSE: Seismic Stations
USER: LRL, USC&GS
PARTICIPATION: Evans, Blanca, Tamalpais, Logan
CONSTRUCTION: 7/30/58 - 9/16/58

These stations were 9-foot-square wood-frame structures covered with plywood, and erected on 4-inch concrete slabs with thickened footings. Head room from 6 to 7 feet was provided under a sloping roof. Location of these stations was as designated by the User.

STATION: 1201
PURPOSE: Calibration Building
USER: LRL
PARTICIPATION: None
CONSTRUCTION: 8/20/58 - 11/6/58

This station was a standard rigid-frame metal building, 50x20x10 feet high to the eaves, constructed on a 6-inch thick concrete slab. Interior wall and roof surfaces were insulated with 1½-inch material. A 315-gallon fresh-water storage tank, mounted on a platform outside the building, was connected to a sink in the working area. Electricity was provided by the main distribution system. A 10-foot-square wood-frame building was added on the east side to house a 10-ton refrigerated air cooling unit. Parking areas were provided.

Radiation shielding was provided by a 6-inch concrete wall, 8 feet high, which was constructed 12½ feet from the south end of the building. This was a free-standing wall, ending 3 feet, 8 inches from each side of the structure. Two concrete baffle walls extended out 4 feet, 8 inches from each side wall on a line 3 feet north of the free-standing wall. This wall arrangement provided adequate shielding for the calibration room as well as access to the south end of the room.

A metal-covered cable trench in the floor extended from the north end of the building to a point 18 inches south of the cross-wall. A monorail, extending the entire length of the building at the roof ridge, supported a 2-ton electric hoist.

Access to the large open area was provided by 6x7-foot high double doors located in the side wall, and by 8x8-foot double doors in the end wall. A single door, 3x7 feet, was located in the work area behind the concrete cross-wall.

STATION: 1202
PURPOSE: Camera Shelter
USER: EG&G
PARTICIPATION: Tamalpais, Evans, Logan, Blanca
CONSTRUCTION: 9/26/58 - 10/17/58

A 12x12x8-foot high wood frame, plywood covered shelter, supported on a 10-inch concrete slab, comprised this Area 12 station. Access into the structure was through two 6x7-foot high doors.

STATION: 1205.01 through .19
PURPOSE: Photo Tower Marker Lights
USER: EG&G
PARTICIPATION: Evans
CONSTRUCTION: 10/12/58 - 10/27/58

Stations 1205.01 through .17 consisted of three-legged wooden towers, 17 feet high resting on 12-inch-cube concrete footings spaced 8 feet apart. Portable power was provided.

Stations 1205.18 and .19 were identical to the above towers, except they were 6 feet in height.

STATION: 1206; 1207.01 through 1207.04
PURPOSE: Pre and Postshot Measurements
USER: LRL, SRI, SC
PARTICIPATION: Evans
CONSTRUCTION: 8/5/58 - 10/23/58

All stations were vertical drift holes located on the mesa above Station U-12b.04. With the exception of Station 1206, all holes contained detection instruments lowered on cables. After instrumentation was completed, 1207.01 through 1207.04 were filled with a special light weight grout. Station 1206 was filled with water and drilling mud and had no instrumentation. Following is a brief description of the stations:

Station 1206	892 feet deep, 8¾-inch diameter, with 4-inch casing
Station 1207.01	770 feet deep, 12¼-inch diameter, uncased
Station 1207.02	471 feet deep, 8¾-inch diameter, uncased
Station 1207.03	763 feet deep, 8¾-inch diameter, uncased
Station 1207.04	360 feet deep, 8¾-inch diameter, uncased

STATION: 1208.01 and .02
PURPOSE: Vacuum Line
USER: LRL
PARTICIPATION: Mercury (1208.01) and Mars (1208.02)
CONSTRUCTION: 8/5/58 - 10/23/58

These stations consisted of 6-inch diameter, uncased holes vertically drilled from the ground surface into the GZ room of Stations U-12f.01 and U-12f.02. Each hole was capped with a concrete slab 6 feet square and 6 inches thick.

A 1-inch, schedule 40 pipe extended from 2 feet above the slab into the hole and was connected to a pipe muffler, 4 feet long and 4 inches in diameter, which ended 2 feet above the ceiling of the GZ room.

STATION: 1208.03
PURPOSE: Vacuum Line
USER: LRL
PARTICIPATION: None
CONSTRUCTION: Cancelled

The construction of this vacuum line was to be identical to Stations 1208.01 and .02; however, when the vertical drill hole had reached a depth of 82 feet it was abandoned as a result of damage to Tunnel U-12f sustained from the Mercury and Mars events.

FACILITY: Television Facility Area 12
PURPOSE: TV Camera and Antenna Mount
USER: LRL
PARTICIPATION: Blanca
CONSTRUCTION: 10/26/58 - 10/29/58

A 6-inch diameter steel pipe was installed adjacent to the LRL trailer park, near Station 12-300. The pipe was anchored in a 2-foot deep concrete footing and extended about 6 feet above grade. A TV camera was mounted on this pipe and oriented to cover the portal of Tunnel U-12e. Also mounted on the pipe was a parabola antenna pointing toward the Test Director's Trailer (Forward Control Point) located at Station 12-1. A receiving parabola antenna and a TV monitor were mounted at the Test Director's Trailer.

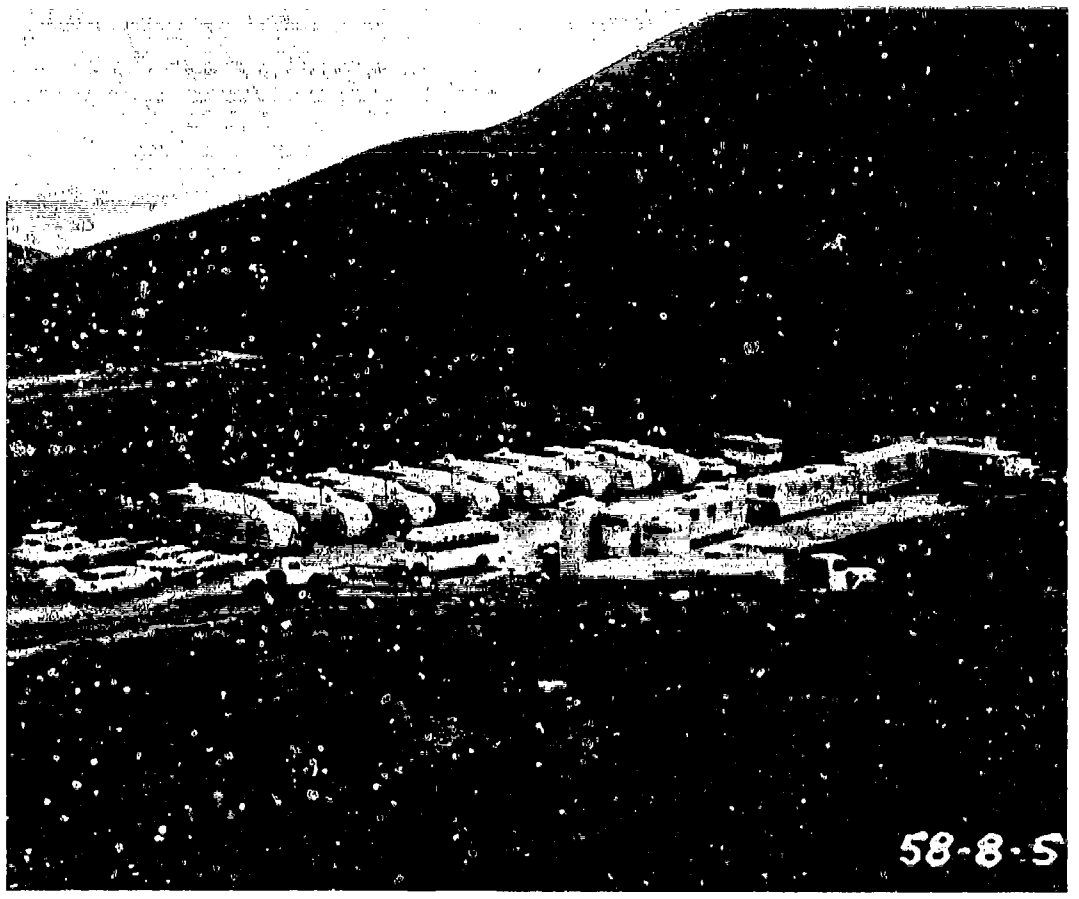

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Figure No. 32. General View of Area 12 Camp

CHAPTER III
ADMINISTRATION

SECTION 1
MANAGEMENT

The scope of work furnished by H&N at NTS under Contract AT(29-2)-460 provided for the following:

1. Engineering, design, and construction supervision of all structures and facilities required for weapons testing.
2. A Work Order Section to process, coordinate, control, and expedite work orders to the Operating & Maintenance Contractor for construction, equipment installation, and related work on weapons test structures and facilities.
3. Field surveys for AEC, various Government agencies, and others as approved by AEC.
4. Examinations and reports on the condition of test structures and facilities.
5. Studies, investigations, and feasibility designs pertaining to test structures and facilities.

The Vice President, Construction Division, was delegated broad authority for independent action and held primary responsibility for the entire AEC Facilities Project. Through redelegations of authority, the Manager, AEC Facilities Project, assisted by the Manager, Construction and Facilities, coordinated all activities affecting H&N operations at NTS.

The Project organization was autonomous with three exceptions: 1) Personnel & Security, 2) Wage & Salary Administration, and 3) Office Services. Purchasing, Estimating, Accounting, and Contract Administration, while established within the Project organization, were governed by corporate policies and procedures. To ensure a high level of professional quality, major engineering design was reviewed by the Vice President, Engineering, and the Chief Design Engineer (Corporate).

In the Los Angeles Office the Project organization was divided into three major divisions that performed functions in support of the NTS operations: 1) Engineering and Design, administered by the Engineering Manager; 2) Accounting, Contract Administration, and Budget, directed by the Project Controller; and 3) Estimating, Purchasing, Construction and Planning, and Field Operations, directed by the Manager, Construction & Facilities.

The Jobsite organization was under the direction of the Resident Manager, who reported to the Manager, Construction & Facilities. This organization consisted of seven sections reporting to:

Resident Manager	Resident Engineer
Estimating	Surveys
Cost Reports	Field Engineering and Design
Work Orders	Inspection
	Communications

Following the completion of Operation PLUMBBOB, preliminary planning was initiated by AEC and User agencies for a series of tests to be held at NTS during 1958 - 1960. By the end of February 1958, the test schedule had been defined as four operations with a total of 51 events during the 3-year period. By July 1958, the possibility of a moratorium on nuclear weapons testing had caused a major change in the schedule. Operation MILLRACE B, planned for Fall 1960, was eliminated, and the total number of shots to be fired during the three remaining operations was reduced to 39. All tower shots were deleted; two of the six tunnel shots planned for Operation TRUMPET in Spring of 1959 were moved up to Operation MILLRACE for Fall of 1958, and Area 14 was established as a new LASL tunnel area.

In August 1958, when the moratorium became a reality, a revised test program for NTS was announced by the AEC. The schedule included 6 vertical holes, 4 balloons, 9 tunnels,

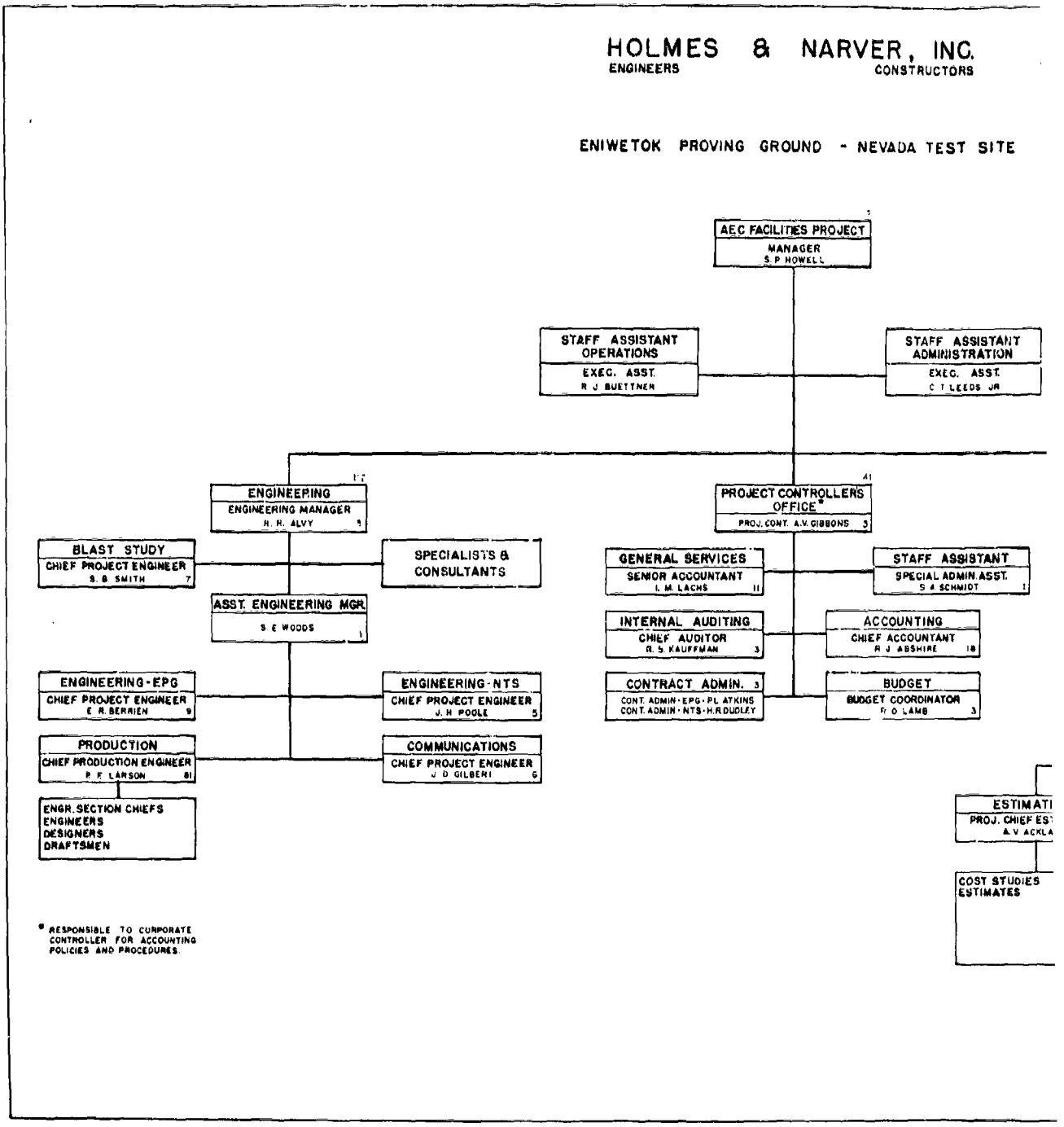


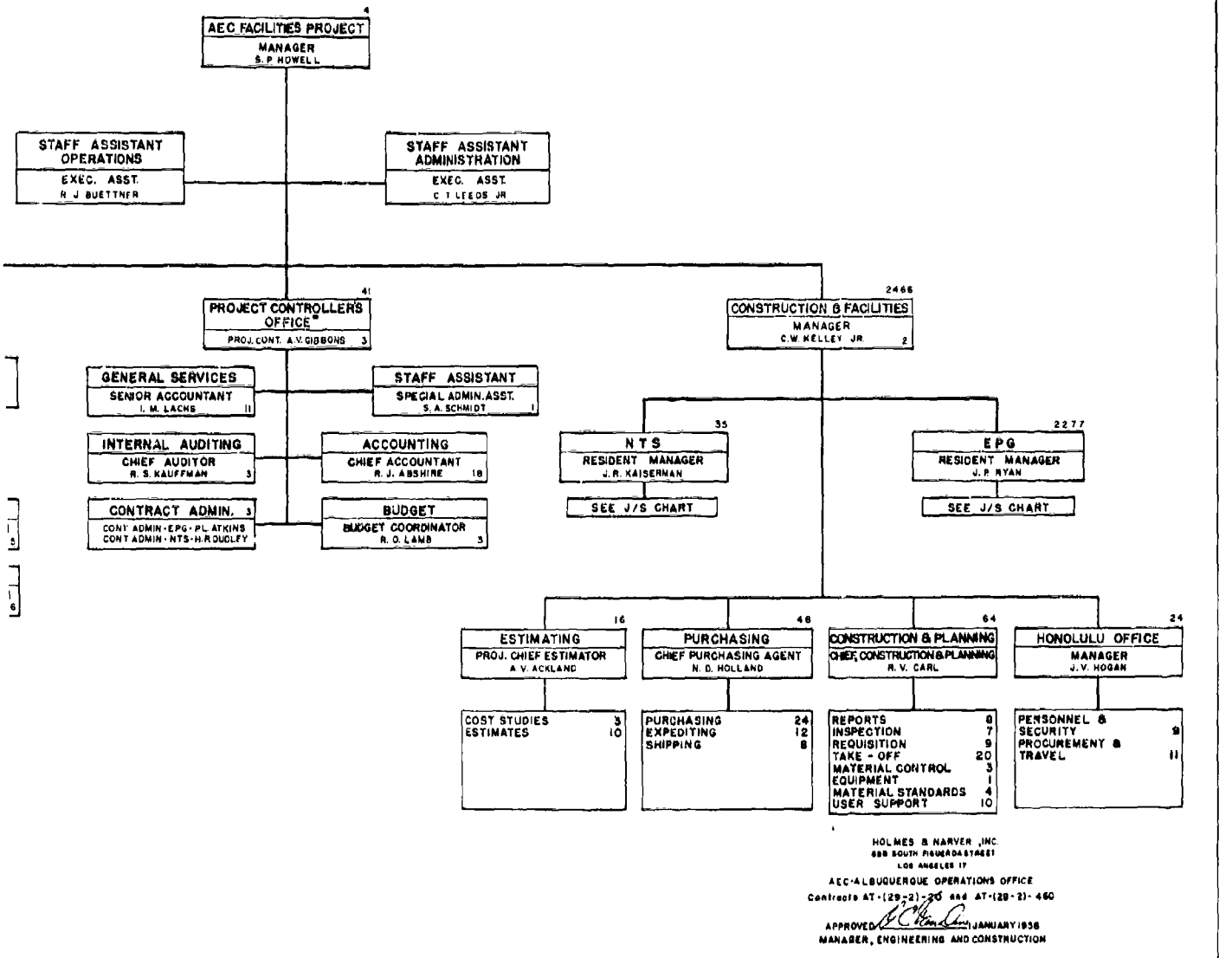
Chart No. 4. Organization Chart, Eniwetok Proving Ground & Nevada Test Site

HOLMES & NARVER, INC.

ENGINEERS CONSTRUCTORS

TOTAL 2623
SALARIED 289
HOURLY 2334

ENIWETOK PROVING GROUND – NEVADA TEST SITE



HOLMES & NARVER, INC.
888 SOUTH FIGUEROA STREET
LOS ANGELES 17

AEC-ALBUQUERQUE OPERATIONS OFFICE
Contracts AT-(29-2)-26 and AT-(28-2)-460

APPROVED [signature] JANUARY 1956
MANAGER, ENGINEERING AND CONSTRUCTION

ok Proving Ground &

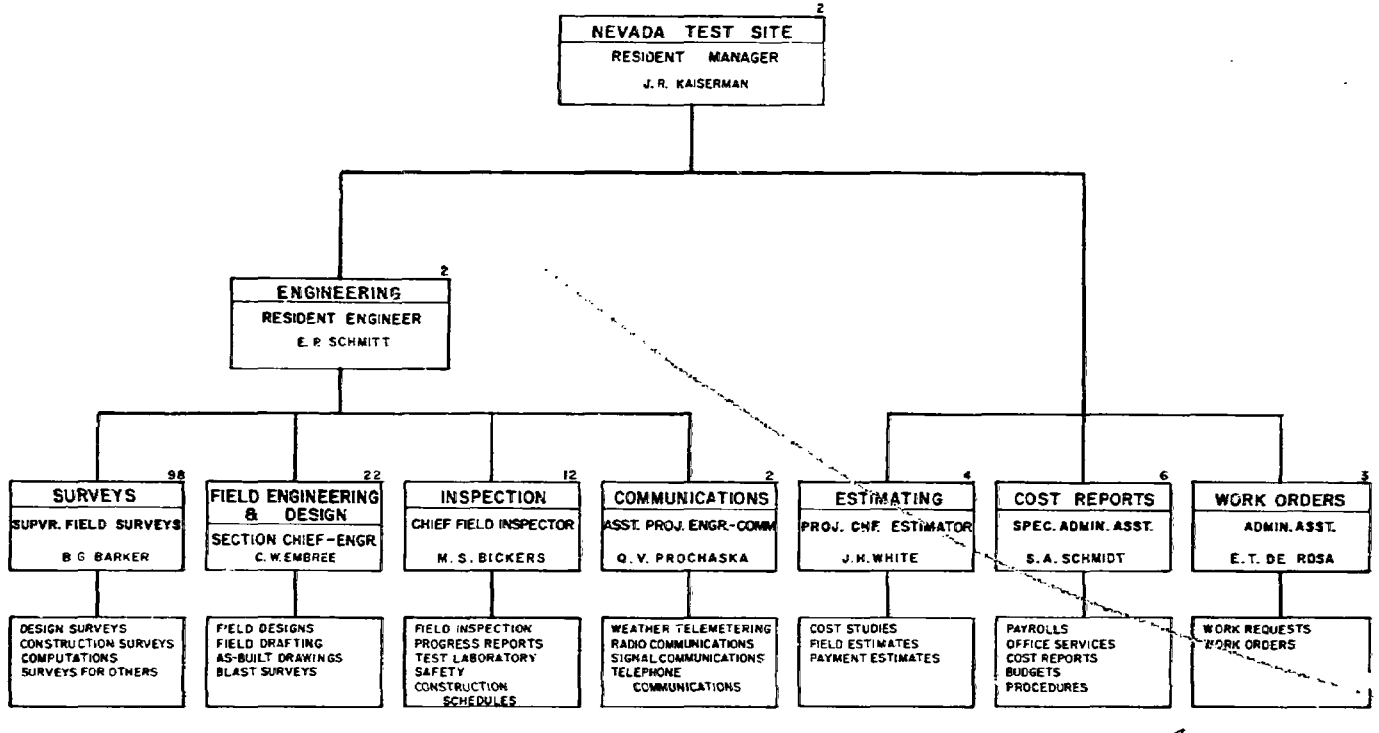
2

HOLMES & NARVER, INC.

ENGINEERS CONSTRUCTORS

TOTAL 151
SALARIED 23
HOURLY 128

JOBSITE ORGANIZATION CHART



APPROVED _____ 15 SEPT 1958
VICE PRESIDENT, CONSTRUCTION DIVISION

Chart No. 5. Jobsite Organization Chart — Nevada Test Site

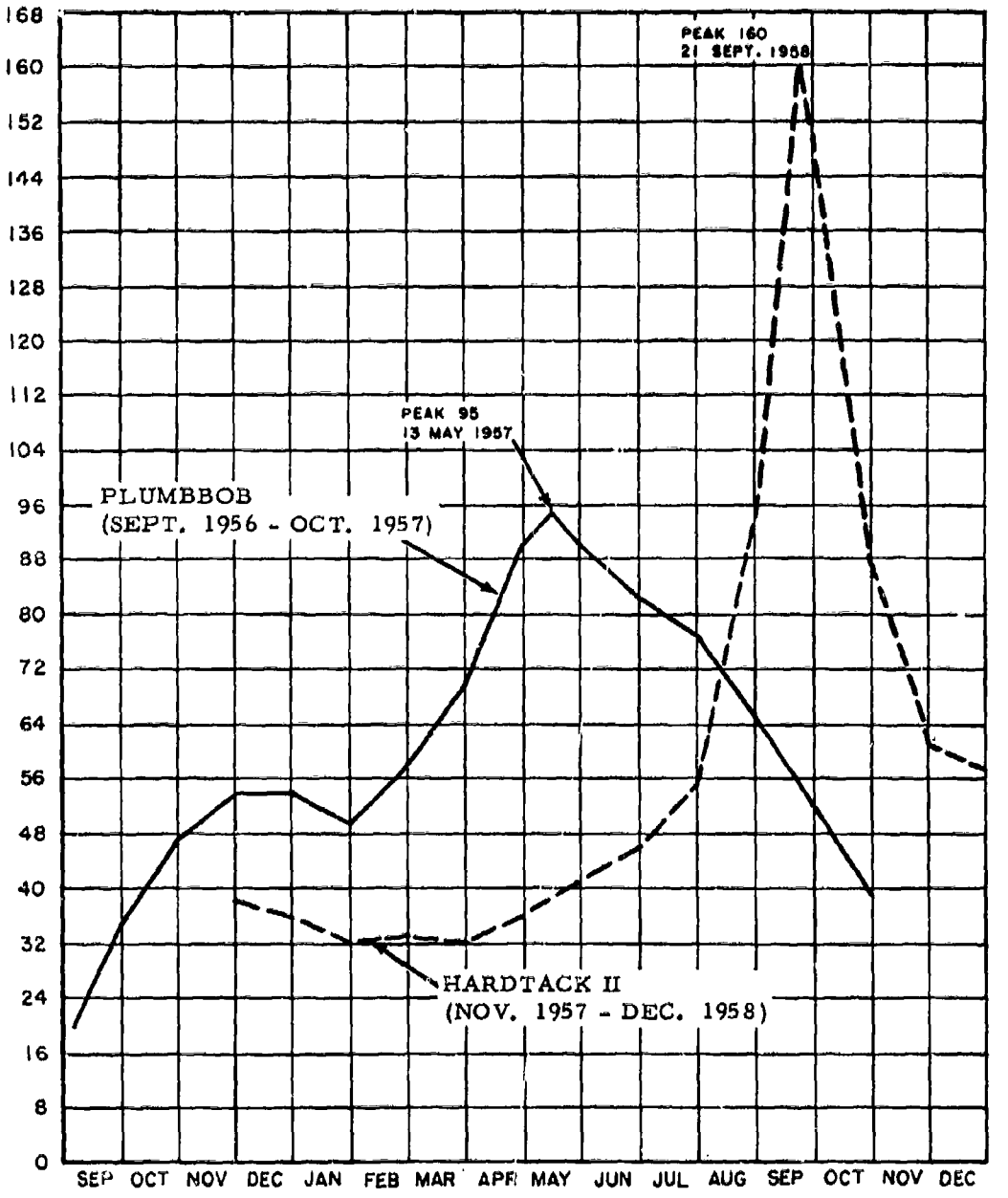


Chart No. 6. H&N Personnel at Nevada Test Site
HARDTACK, Phase II vs. PLUMBBOB

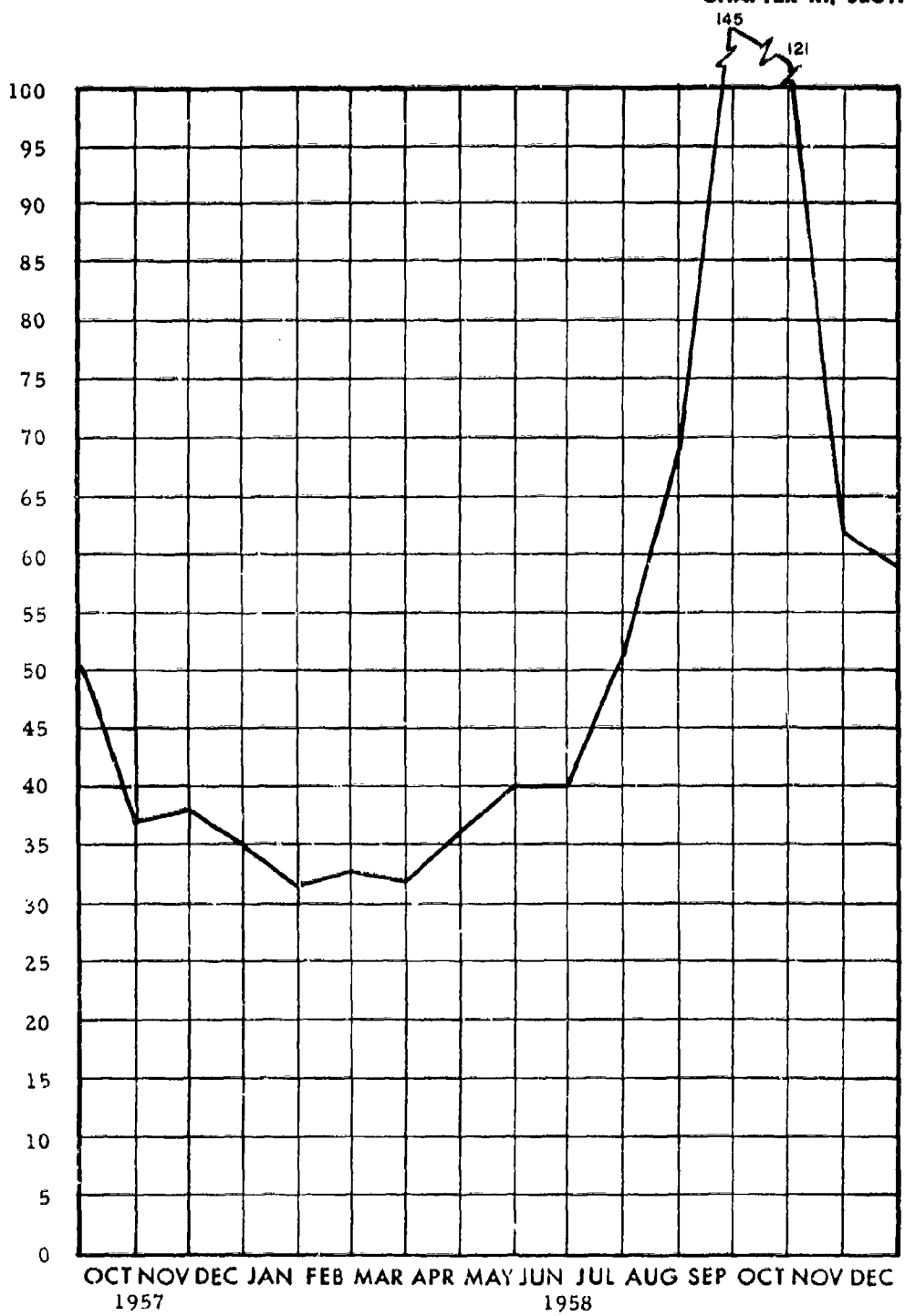


Chart No. 7. H&N Personnel at Nevada Test Site (Average per Month)

and 1 tower, for a total of 20 events. The program was further revised and expanded to ultimately include a total of 37 events (6 vertical holes, 11 balloons, 7 tunnels, 10 towers, and 3 surface).

Major changes in the concept of the Fall 1958 Operation and the rapid expansion of the program required maximum coordination among H&N, the Users, and AEC. In addition to the permanent liaison engineer maintained by H&N at LRL, Livermore, additional liaison personnel were assigned to temporary duty at LRL and LASL to obtain advance information of plans and criteria developed by the laboratories. As planning developed and changed, Project management personnel, and Project Engineers made frequent trips to the laboratories, NTS, and ALOO.

Close coordination was essential between the H&N field staff and the CPFF and Lump Sum construction contractors to ensure proper intrepretation of design and incorporation of changes.

A notable improvement in field inspection practices during the Operation was made by requiring the majority of inspectors to be qualified engineers. These inspectors were able to approve, at the construction site, minor changes required by modified criteria or nonavailability of materials, without the delays inherent in returning to the design engineers for concurrence.

On 4 July 1958, there were 45 H&N personnel at NTS, and a maximum of 160 was reached on 19 September 1958. The extremely rapid build-up of personnel to meet the Users' requirements, particularly in design and survey, created a difficult staffing problem. To overcome this problem many of the survey crew requirements were filled by EPG personnel surplused after Operation HARDTACK, Phase I. Los Angeles Office engineers on temporary duty at Mercury provided the required design assistance to the Field Engineering Group.

The rapid development of requirements and fluctuating criteria for the Operation, encompassing more events than any previous operation at EPG or NTS in an equal period of time, created problems in liaison, coordination, and control, making it difficult to schedule construction progress. Particularly in Tunnel U-12b the frequency and number of changes had considerable impact on design, survey, and inspection.

The many User agencies and the varied types of construction and support services required for the tests also created coordination and control problems. To meet schedules and to complete the Operation with appropriate records necessitated frequent conferences, adequate dissemination of data, and adherence of all User agencies to Standard Operating Procedures. However, the rapidity of design changes and the enlarged scope of the Operation resulted in some deviations from these essentials which added to the complexity of design and construction coordination and the compilation of as-built records.

SECTION 2
ACCOUNTING

GENERAL

The Los Angeles Office Accounting Department was responsible for the handling of all accounting records, the preparation of all financial reports pertaining to Contract AT(29-2)-460, the maintenance of a bank account, the preparation of payrolls, and the payment of all expenses other than petty cash items.

Jobsite general accounting functions comprised documentation and verification of labor and material costs and the submission of these documents, bearing approval signatures and cost-distribution codes, to the Los Angeles Office for payment. Petty cash disbursements for postage expense, miscellaneous minor expenses, and payment of final wages to terminated employees were effected at Jobsite. Travel expense vouchers covering employees transferred to NTS were prepared, documented, and approved at Jobsite and forwarded to the Los Angeles Office for payment. Budget and cost-code control were maintained on work orders issued to the Operating & Maintenance Contractor. H&N provided A-E cost information, by identification number, for inclusion in the Estimate and Cost Report which reflected total program costs and was consolidated by the Operating & Maintenance Contractor.

BUDGETING

H&N formulated two Budget Estimates for operations at NTS, one covering its own A-E activity and the other covering CPFF and Lump Sum construction performed by other contractors.

Initial Budget Estimates for Operation HARDTACK, Phase II, were an outgrowth of plans and estimates prepared about a year before the first of several scheduled operations. The original Budget Estimates were predicated on broad criteria supplied by the AEC, with major assumptions and cost estimates supplied by H&N based on experience at NTS and EPG.

As operational plans became defined, detailed estimates were prepared and incorporated into the total Budget Estimate. The Budget Section maintained constant surveillance of the situation, informing H&N management and ALO of all changes affecting total requirements. Upon arriving at a stable total, ALO issued a financial plan which became the framework within which operational costs had to be contained. The Budget Section periodically reported on the relative positions of budget allocations and expenditures. Several reviews were submitted, and about midway through the Operation ALO issued a revised financial plan that was satisfactorily maintained throughout the remainder of the tests.

CONTRACT ADMINISTRATION

Changes and modifications to Contract AT(29-2)-460 since the end of Operation PLUMBBOB were:

Modification No. 10, 25 November 1957, amended Part II of Appendix A, Fixed Fee Schedule, by increasing the total dollar coverage.

Modification No. 11, 26 December 1957, extended the Contract term for one month and provided terms to cover the use by the Contractor of Government-owned property.

Modification No. 12, 17 January 1958, increased the obligated funds.

Modification No. 13, 19 June 1958, amended Appendix A, Scope of Work, by describing the specific projects and the estimated construction costs agreed upon from 1 July 1956 through 31 December 1957.

Modification No. 14, 27 January 1958, revised the changes clause, extended the term through 30 September 1958, and modified Appendix A by increasing the obligated funds, revising the scope of work, and setting forth the fixed fee for the extended term.

Modification No. 15, 7 April 1958, increased the obligated funds.

Modification No. 16, 15 May 1958, increased the obligated funds.

Modification No. 17, 18 June 1958, increased the obligated funds.

Modification No. 18, 18 September 1958, increased the obligated funds.

Modification No. 19, 29 September 1958, extended the term through 31 December 1958, provided for additional fee covering the enlarged scope of work from 1 January 1958 through 30 September 1958, provided

for additional fee for the scope of work to be performed between 1 October 1958 and 31 December 1958, modified the fixed-fee payment clause, revised the scope of work from 1 January 1958 through 31 December 1958, and increased the obligated funds.

Modification No. 20, 13 October 1958, increased the obligated funds.

PAYROLLS

Daily time cards were prepared at Jobsite for each employee, indicating hours worked by work order or account number, with a brief description of the work performed. For certain administrative employees, whose time was charged consistently to a single cost account, a weekly time card was utilized. All time worked at the Los Angeles Office was reported on weekly time cards that indicated the identification or account number.

The time reported for each employee on daily or weekly time cards was transcribed to a weekly payroll card that indicated all pertinent information, including straight time or premium hours, vacation, sick leave, cost codes, and total hours for the work week. The cards were transmitted to the Los Angeles Office Payroll Section for preparation of payroll checks and for cost distribution. Controls were maintained to ensure that all time worked in excess of the established work week had the written approval of the Resident Manager and the AEC Contracting Officer.

COST ACCOUNTING

Jobsite cost accounting and reporting assigned and verified cost codes for all labor, materials, and other costs incurred at Jobsite, and forwarded related documents to the Los Angeles Office for the permanent cost records. Requests and authorizations for construction projects were referred to the Contract Administrator for the assignment of identification numbers which were affixed to the respective work orders. All direct A-E costs were accumulated in accordance with the assigned identification numbers.

A-E SERVICES, CONTRACT AT(29-2)-460

Permanent Construction	$ 49,022.07	
Expendable Construction	903,358.27	
Special Order Work	12,617.74	
Miscellaneous A-E Services	651,849.87	
TOTAL		$1,616,847.95
LESS: Reimbursable		
Transfers to AEC, ALO	$28,838.87	
Cash Reimbursable	6,109.17	
TOTAL		34,948.04
TOTAL NET COST		$1,581,899.91*

*Cost includes $360,473.10 not directly related to Operation HARDTACK, Phase II.

The above A-E services in the amount of $1,221,426.81 were performed in connection with HARDTACK, Phase II, construction and support as follows:

CPFF Contractor Construction (REECo)	$6,578,499.89
CPFF Contractor Support Services	2,211,608.35
Lump Sum Contract Construction	281,624.61
TOTAL	$9,071,732.85

Table 11. COST SUMMARY (12 MONTHS ENDING 31 OCTOBER 1958)

The Los Angeles Office Accounting Section maintained records of A-E costs under the major categories of Scientific Construction, Auxiliary Construction, Special Order Work, and Miscellaneous Services. These costs were further divided as direct engineering, indirect engineering, and general and administrative expense. Labor distribution was summarized by identification number or appropriate account number from the information shown on the weekly time cards. Procurement of materials and services were authorized by purchase orders issued by the Los Angeles Office and were charged to the proper accounts when received.

Fixed-price Contract costs, although determined by the A-E, were not carried under Contract AT(29-2)-460, but were paid by the AEC and transferred to the records of the Operating & Maintenance Contractor. Identification numbers assigned by the Contract Administrator, as reflected on the approved work orders, were also used by the Operating & Maintenance Contractor for cost accumulation and reporting. Reports of A-E costs and working estimates were submitted to the Operating & Maintenance Contractor for incorporation in the consolidated Cost and Estimate Report. Costs were identified and reported by area, type of work, and by scientific programs and projects. Due to the accelerated program, only two Cost and Estimate Reports were issued, the 30 September 1958 preliminary report, and the 2 November 1958 final report.

Table 11 presents a summary of costs for the 12 months ending 31 October 1958.

AUDITING

The major auditing functions at Jobsite included 1) the verification and review of documents pertaining to costs reported by lump sum contractors and the related contract pay estimates, 2) verification of invoices applicable to purchase orders, and 3) audit of petty cash expenditures. Final pay estimates in the total amount of $281,624.61, for two construction contracts executed by the AEC, were approved and submitted to AEC/ALO for payment.

TELETYPEWRITER SERVICE

Teletypewriter service was continuously available between the Los Angeles Office and Jobsite throughout Operation HARDTACK, Phase II. This system afforded a rapid means of exchanging correspondence, and improved operational efficiency.

SECTION 3
ESTIMATING

GENERAL

Estimating procedures and policies were formulated by the Corporate Chief Estimator. Direct supervision of the Estimating Section in the Los Angeles Office was provided by the Project Chief Estimator, functioning under the Manager, Construction & Facilities. The Jobsite Estimating Section was under the direction of the Resident Manager.

TYPES OF ESTIMATES

The five types of estimates prepared and a brief description of each type follows:

1. *Cost Studies* were made to compare various methods of construction, maintenance, and operation. (Although a total of only 15 cost studies is shown in Table 12 — Cost Estimates Prepared — many more cost studies were prepared to furnish the most economical design for AEC requirements.)
2. *Preliminary and Budget Estimates* were made at the request of AEC to determine the approximate cost of a proposed facility. Preliminary Estimates were usually incorporated in Preliminary Proposals.
3. *Official Estimates for Lump Sum Contracts* were prepared by the Los Angeles Office Estimating Department from approved drawings and the conditions of the Invitations to Bid. Changes after the award of a lump sum contract were covered by Field Change Orders, with the estimates prepared at NTS.
4. *Official Estimates for CPFF Work* were prepared to cover estimated construction costs incurred by the Operating & Maintenance Contractor in support of approved work orders.
5. *Estimates for A-E Services* covered various non-construction items, such as field surveys, feasibility studies, etc.

IMPROVED PROCEDURES

A meeting regarding methods to improve work coordination at NTS was attendted by representatives of the AEC, REECo, and H&N. To facilitate construction approvals it was agreed that estimates should be prepared by increments, as units of design were completed. The list of H&N subaccount numbers for construction categories was revised to meet the requirements of REECo.

To comply with the provisions of Chapter 6106.06 of the AEC Manual, preliminary proposals were submitted to AEC for all PAC work in excess of $20,000. These proposals were prepared in printed booklet form and included a general description of the work, justification of basic need, preliminary plans, outline specifications, preliminary estimates of cost, proposed starting and finishing dates, and proposed methods of accomplishment.

LUMP SUM CONTRACTS

Each of the AEC/LVB lump sum contract bid openings was attended by the Resident Manager, the Jobsite Project Chief Estimator, and the Los Angeles Office Project Chief Estimator. The two Project Chief Estimators checked the bids and prepared abstracts that were used to evaluate the bids.

Table 12 shows the number and type of estimates prepared during the period from November 1957 through October 1958, together with net estimated costs.

TYPE	NO.	NET ESTIMATED COST
Cost Studies	15	$ 5,334,711
Preliminary and Budget Estimates	30	3,167,993
Official Estimates for Lump Sum Contracts	2	287,090
Official Estimates for CPFF Work	411	7,735,694
Estimates for A-E Services	3	33,327
Totals	461	$16,558,815

Table 12. COST ESTIMATES PREPARED

SECTION 4
WORK ORDERS

H&N was responsible for the preparation and issuance of all work orders, except those applicable to Camp Mercury facilities. Work order requests contained the project cost symbol, date of request, date required, work to be performed, and site or station number. Requests were screened by the H&N Work Order Section for duplication and accuracy. The Jobsite Cost Reports Section assigned the proper job category ("C," "FS," or "O"), and when required the Estimating Section prepared cost estimates. All work orders were approved by AEC and were normally distributed with drawings and estimates.

The three types of work orders used are defined below.

"O" WORK ORDERS. The "O"-type Work Order was issued to REECo for services requested by participating test organizations, such as 1) advance procurement of material and equipment to be used in the test facilities program, 2) warehousing scientific equipment, 3) providing transportation and long distance communication services and 4) furnishing miscellaneous materials, supplies, and reproduction services. Cost estimates were not required for these work orders.

"FS" WORK ORDERS. The "FS"-type Work Order was issued for field support work requested by participating test organizations. This type of request did not require the preparation of formal drawings for its accomplishment. It

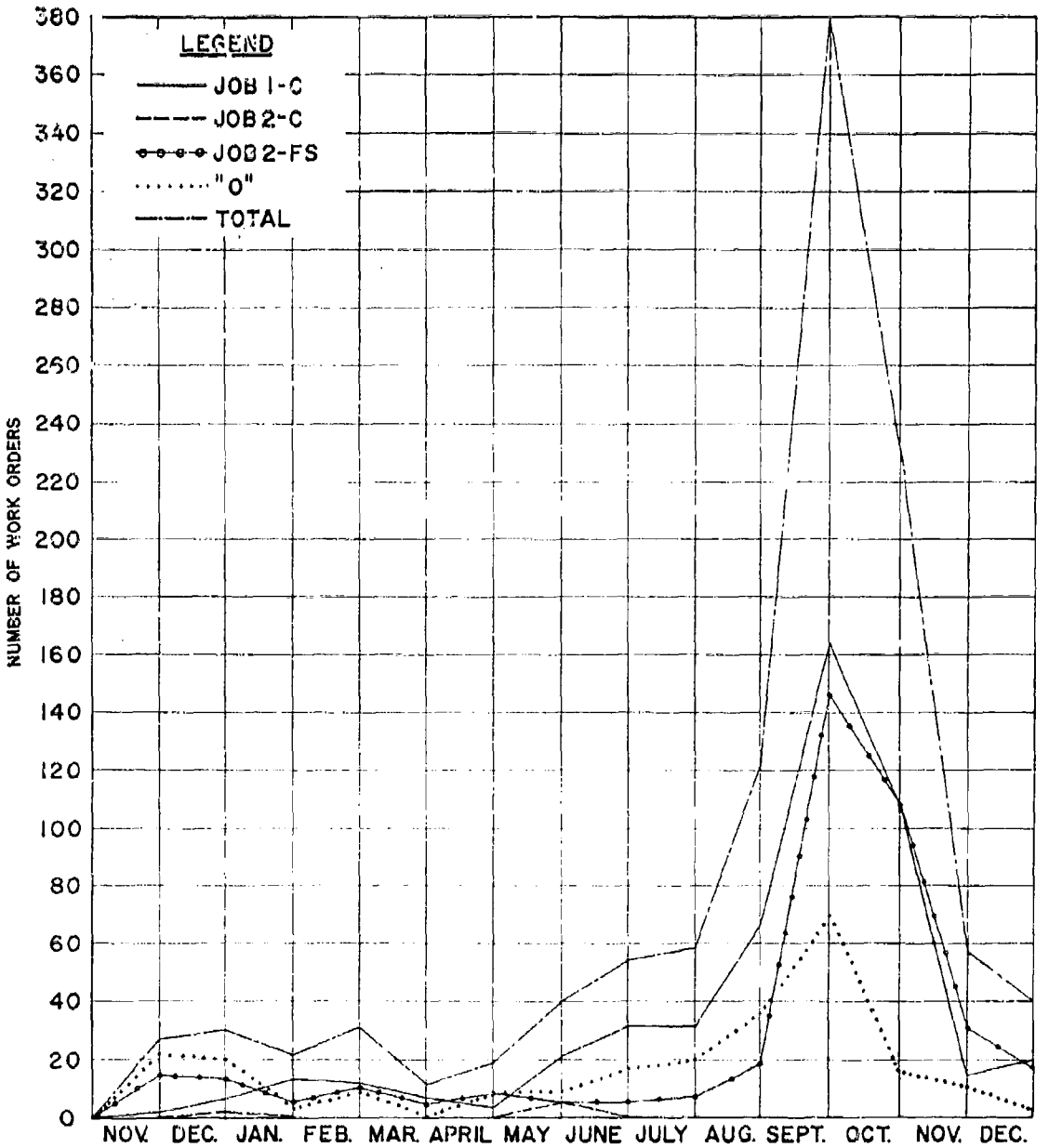


Chart No. 8. Number of Work Orders Per Month, Nov. 57 to Dec. 58

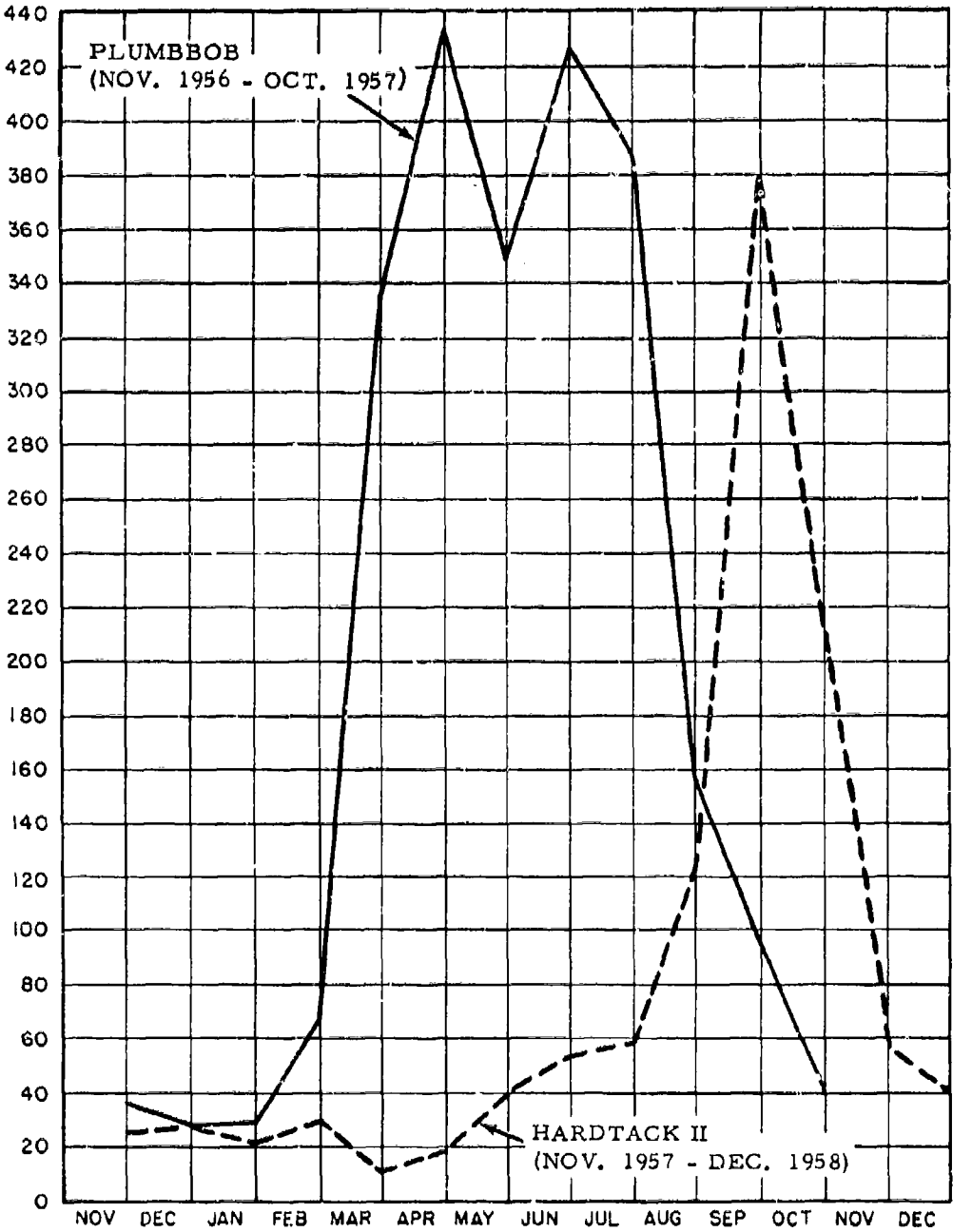


Chart No. 9. Number of Work Orders Per Month
HARDTACK, Phase II vs. PLUMBBOB

covered 1) labor and equipment support, 2) installation of scientific equipment and materials, 3) minor electrical, mechanical, and iron work, 4) decontamination, 5) recovery of scientific equipment, 6) minor rehabilitation of scientific facilities, and 7) preparation for test events. H&N prepared detailed estimates, assigned identification numbers, and reported progress on these work orders.

During the period of peak activity, the AEC, Scientific Users, H&N, and REECo agreed to the issuance of blanket-type work orders which were effective for a two-week period. The estimated costs were based upon an analysis of PLUMBBOB costs for "FS"-type services over a comparable two-week period. These blanket-type work orders were written to cover the individual Users' field requirements, as requested by "buck slips."

"C" WORK ORDERS. "C"-type Work Orders, issued to authorize construction for which engineering and design were performed by H&N under Job I of the contract, were assigned contractual identification numbers by the H&N Contract Administrator. The "C"-type, initiated by an authorized User or an H&N Jobsite Engineering representative, covered the construction of scientific stations, roads, technical support structures, scientific shop and trailer areas, and power, coax, signal, and communications systems.

SECTION 5
PERSONNEL AND SECURITY

GENERAL

The H&N Corporate Personnel & Security Department provided all industrial relations and security support for the AEC Facilities Project Group. Close coordination between these two offices in matters pertaining to policies, personnel standards, and manpower requirements resulted in fulfilling satisfactorily all AEC Facilities Project personnel and security requirements. Although there was no direct organizational relationship between the Corporate Personnel & Security Department and the AEC Facilities Project, the former group furnished certain services, including personnel recruitment and processing, insurance activities, monitoring of AEC security policies, personnel relations, and travel arrangements. The Corporate Personnel & Security Department was directed by the Manager, Personnel & Security, with the aid of Assistant Managers and Section Supervisors. These sections included Employment, Personnel Relations, Security, and Clerical & Travel. H&N Personnel & Security representatives were not assigned to NTS; therefore, the required personnel and security affairs were handled by the Special Administrative Assistant, Jobsite, under the technical direction of the Corporate Personnel & Security Department Section Supervisors.

EMPLOYMENT

Employment activities for NTS ended with the close of Operation PLUMBBOB in October 1957. H&N population at NTS steadily decreased throughout the balance of 1957, and by the end of the year a staff of only 35 persons was assigned. A number of the persons affected by this population decrease were absorbed by either the Los Angeles Office or EPG.

Early in Spring 1958, it became necessary to obtain the services of mining engineers and geologists with extensive tunnel experience. Shortly after 1 May 1958, a small number of inspectors and survey personnel were requisitioned. Simultaneously, the Employment Section was alerted that a build-up in personnel strength of H&N forces at NTS could be expected. Essentially this increase in personnel requirements involved surveyors, and initial requisitions were filled by former EPG employees; however, as the build-up demands accelerated, it was necessary to supplement the EPG rehires through the International Union of Operating Engineers in Las Vegas. By 19 September 1958, 104 survey personnel were assigned to NTS.

SECURITY

Applications for personnel security clearances were prepared at Jobsite and the Los Angeles Office. All requests for clearances were processed through the Los Angeles Office to ALOO. Whenever a cleared H&N employee was permanently transferred to NTS, extension of the employee's clearance to include NTS was accomplishd by a letter to the on-site AEC security representative, with a carbon copy to ALOO.

Permanent or temporary security badges, authorizing access to the various areas at NTS, were issued by the NTS Badge Office in reponse to a written request by the H&N Resident Manager. Temporary badges for uncleared personnel were issued only if security processing had begun.

Security representatives of H&N and AEC attended frequent conferences on classification and other security matters to deal with urgencies of the accelerated program.

APPENDIX

General Site Plan — Nevada Test Site
Area 3 — Layout
Area 5 — General Layout
Area 5 — Detail Layout - Sheet 1 of 2
Area 5 — Detail Layout - Sheet 2 of 2
Area 7 — Layout
Area 8 — Layout
Area 9 — Layout
Area 12 — Layout
U-12b Tunnel Complex
U-12c and U-12f Tunnel Complexes
U-12e Tunnel Complex

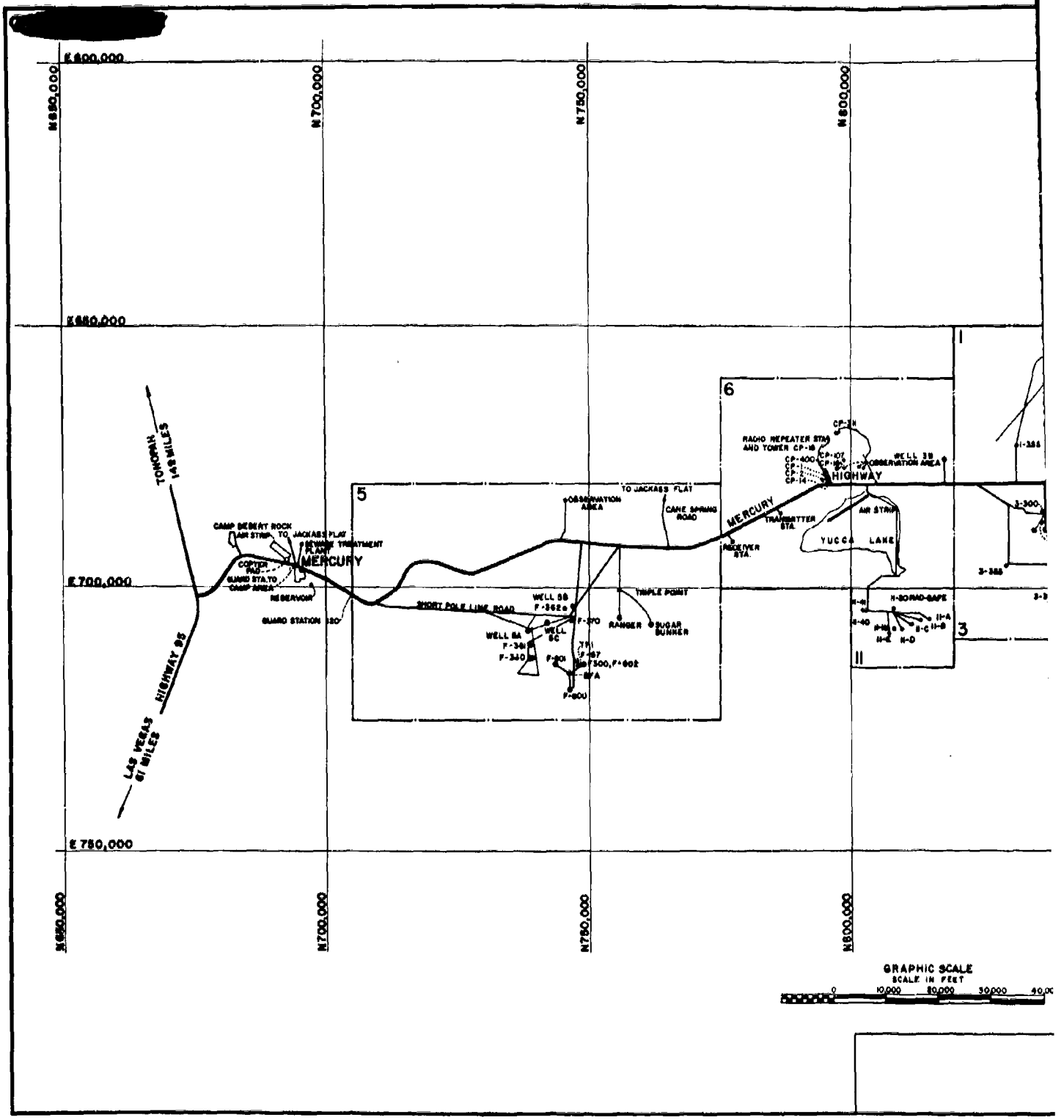
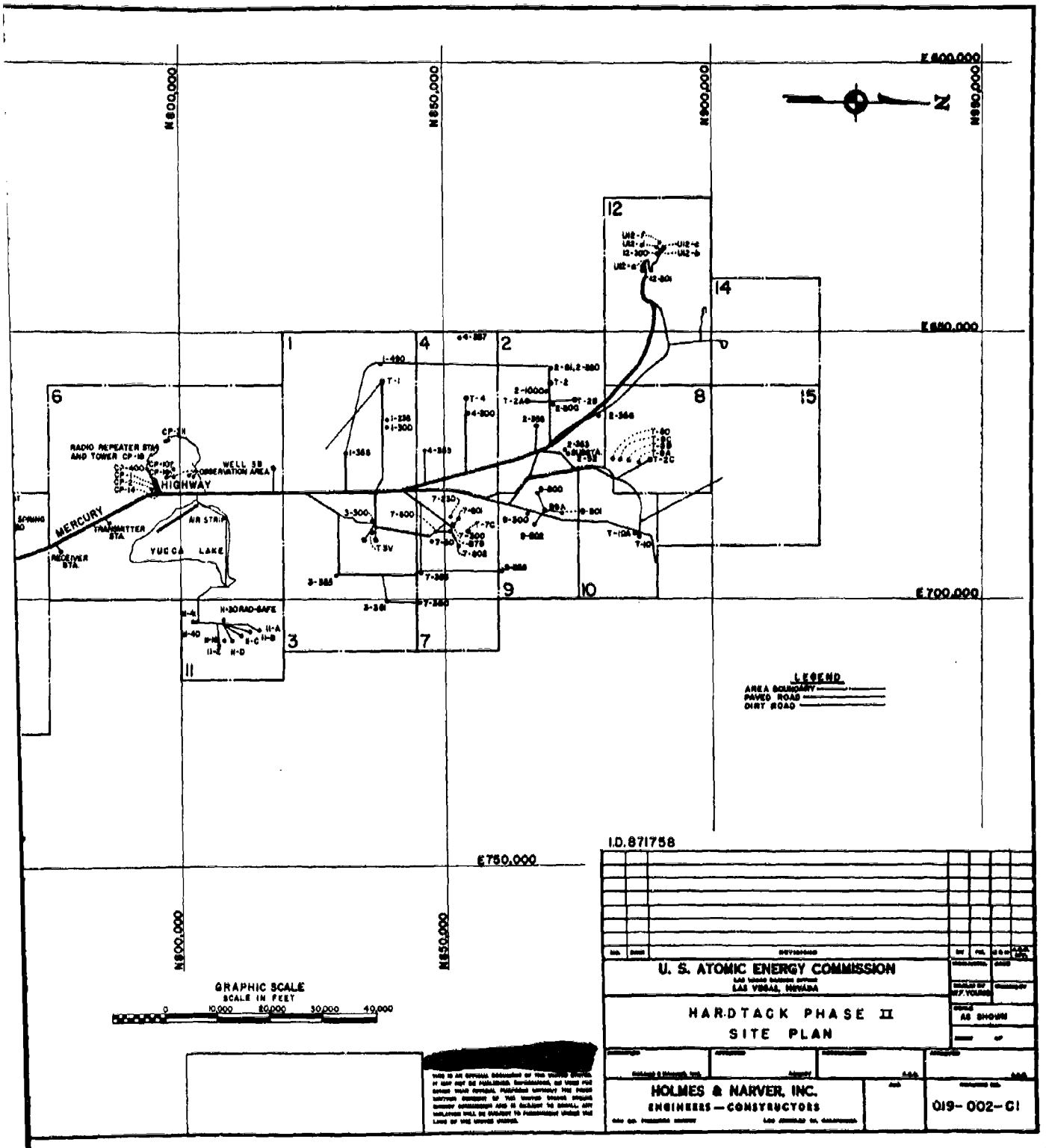


Figure No. 33. General Site Plan — Nevada Test Site

APPENDIX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YUCCA LAKE
RADIO REPEATER STN AND TOWER CP-18
WELL 5B
OBSERVATION AREA
TRANSMITTER STA.
RECEIVER STA.
H-30 RAD-SAFE
LEGEND
AREA BOUNDARY
PAVED ROAD
DIRT ROAD
GRAPHIC SCALE
SCALE IN FEET
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I.D. 871758
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
SITE PLAN
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
019-002-G1

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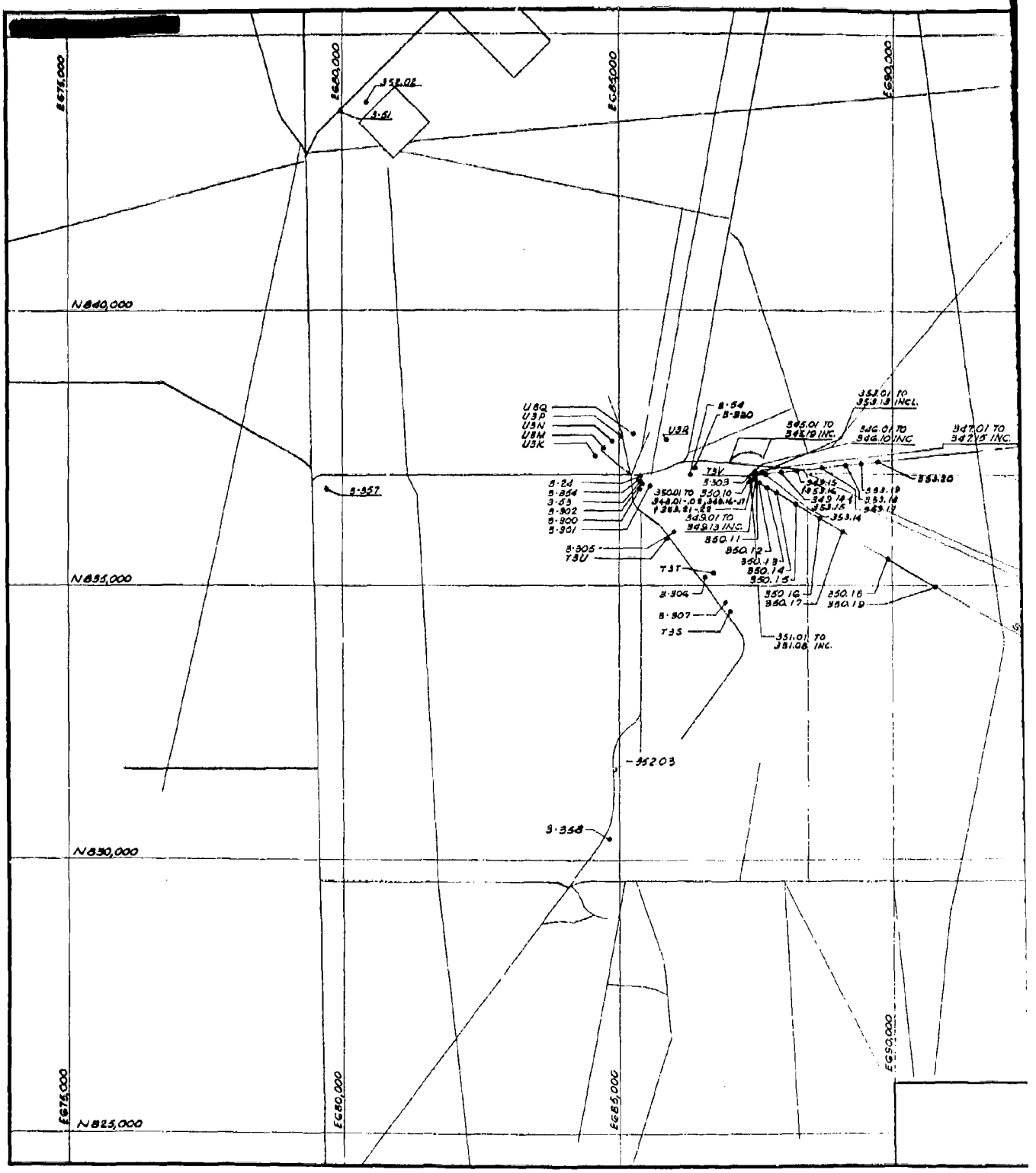
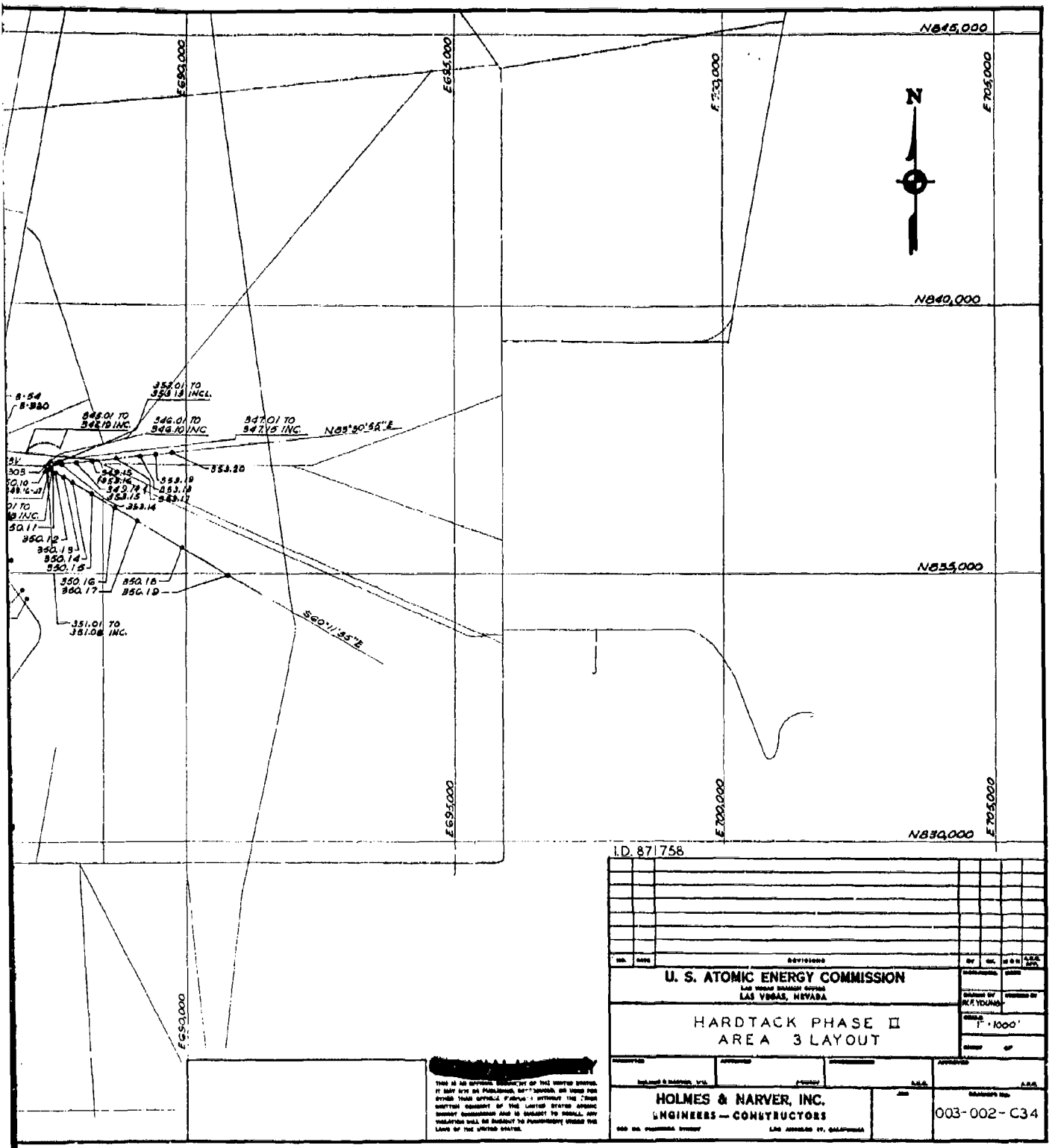


Figure No. 34. Area 3 Layout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346.01 TO 346.10 INCL.
347.01 TO 347.15 INCL.
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I.D. 871758
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 3 LAYOUT
1" = 1000'
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
003-002-C34

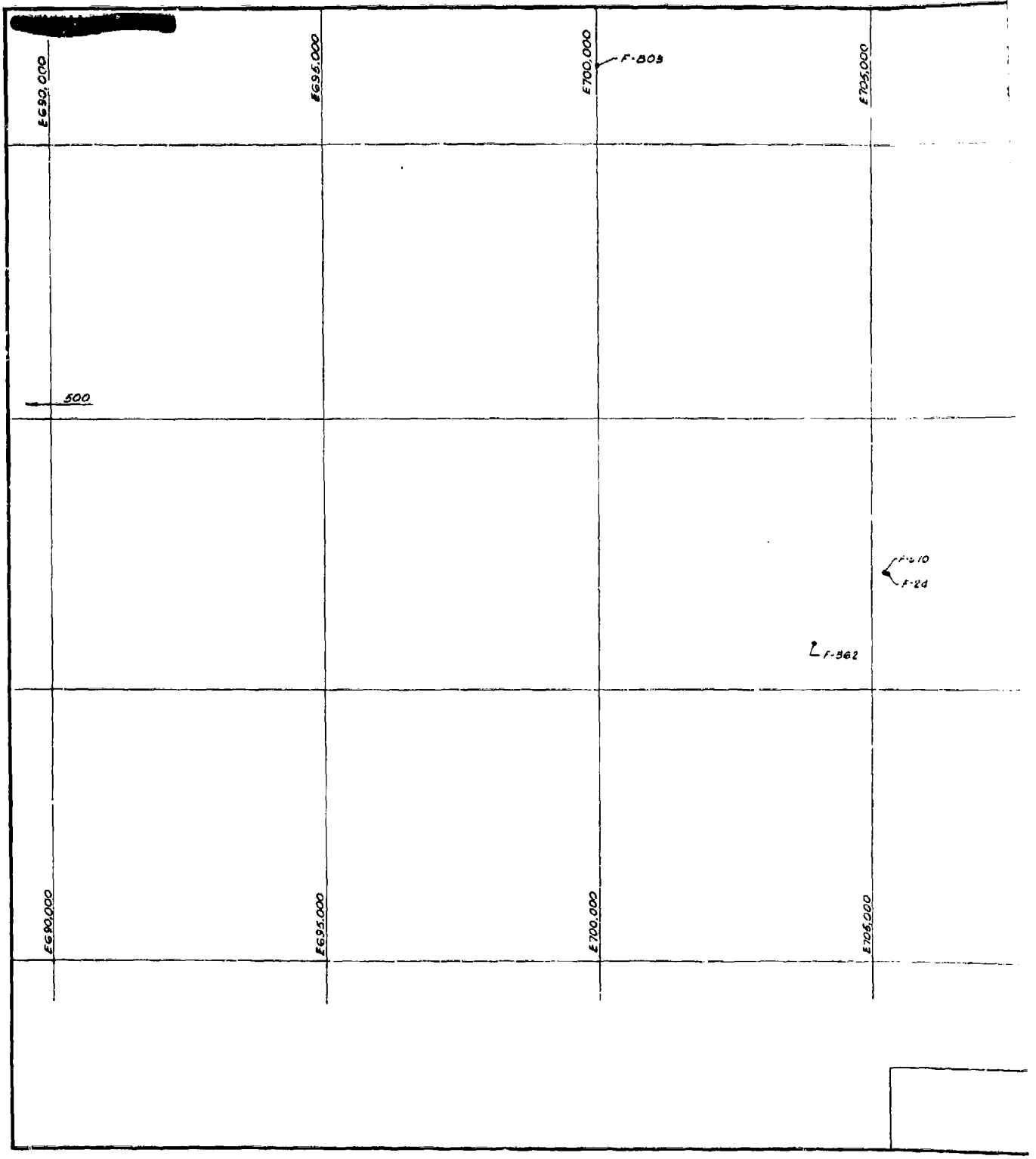
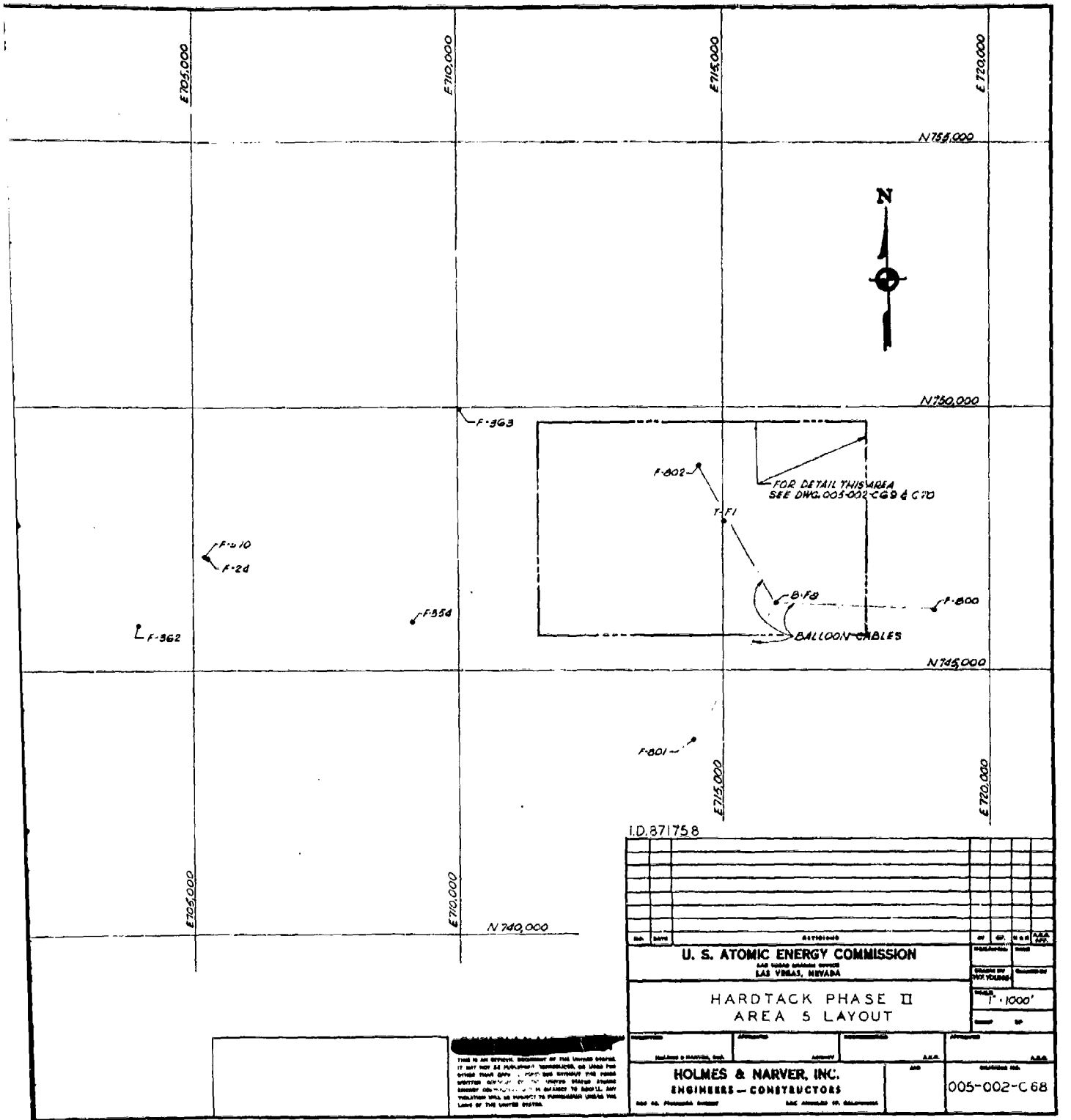


Figure No. 35. Area 5 — General Layout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F-802
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T-F1
F-410
F-24
B-F8
F-800
F-554
F-362
BALLOON CABLES
N 745,000
F-801
E 715,000
E 720,000
I.D. 871758
E 705,000
E 710,000
N 740,000
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 5 LAYOUT
1" = 1000'
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
005-002-C 68

2

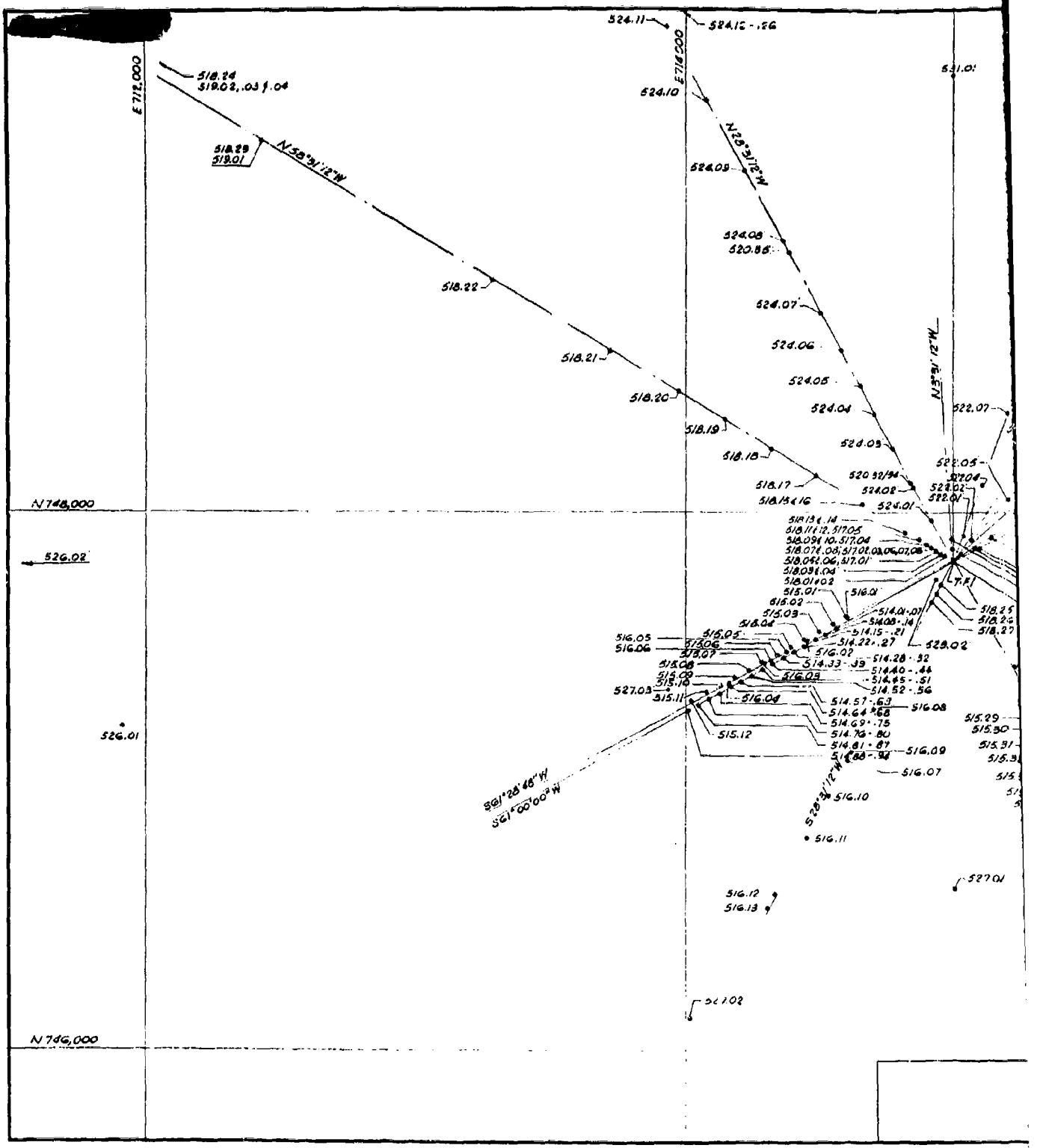
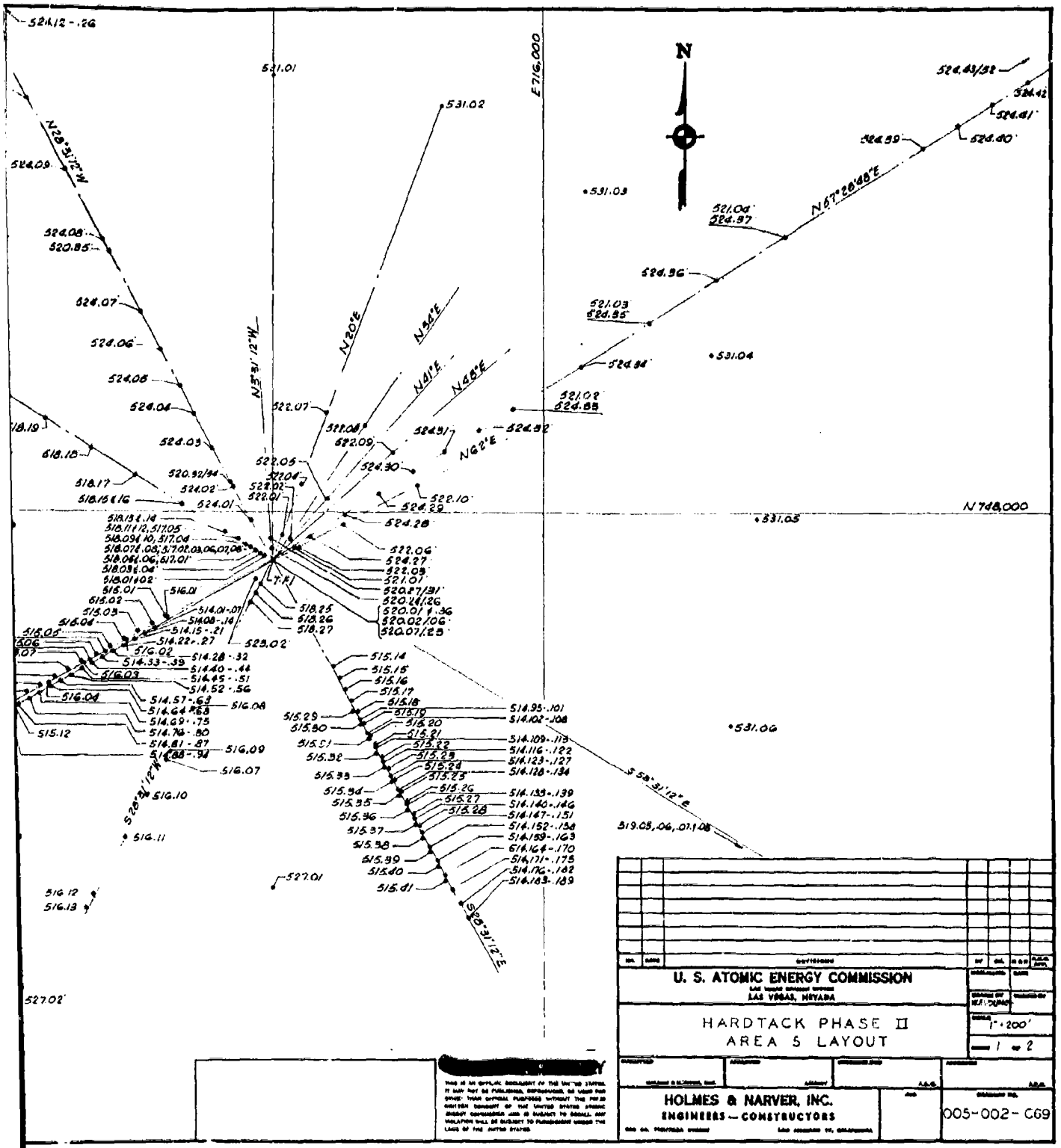


Figure No. 36. Area 5 — Detail Layout (Sheet 1 of 2)

APPENDIX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N 748,000
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N28°31'12"W
N3°31'12"W
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N36°E
N41°E
N48°E
N2°E
N67°26'48"E
S 58°31'12"E
S 28°31'12"E
S 28°31'12"W
T. 9 S.
R. 61 E.
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 5 LAYOUT
1" = 200'
1 of 2
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
005-002-C69

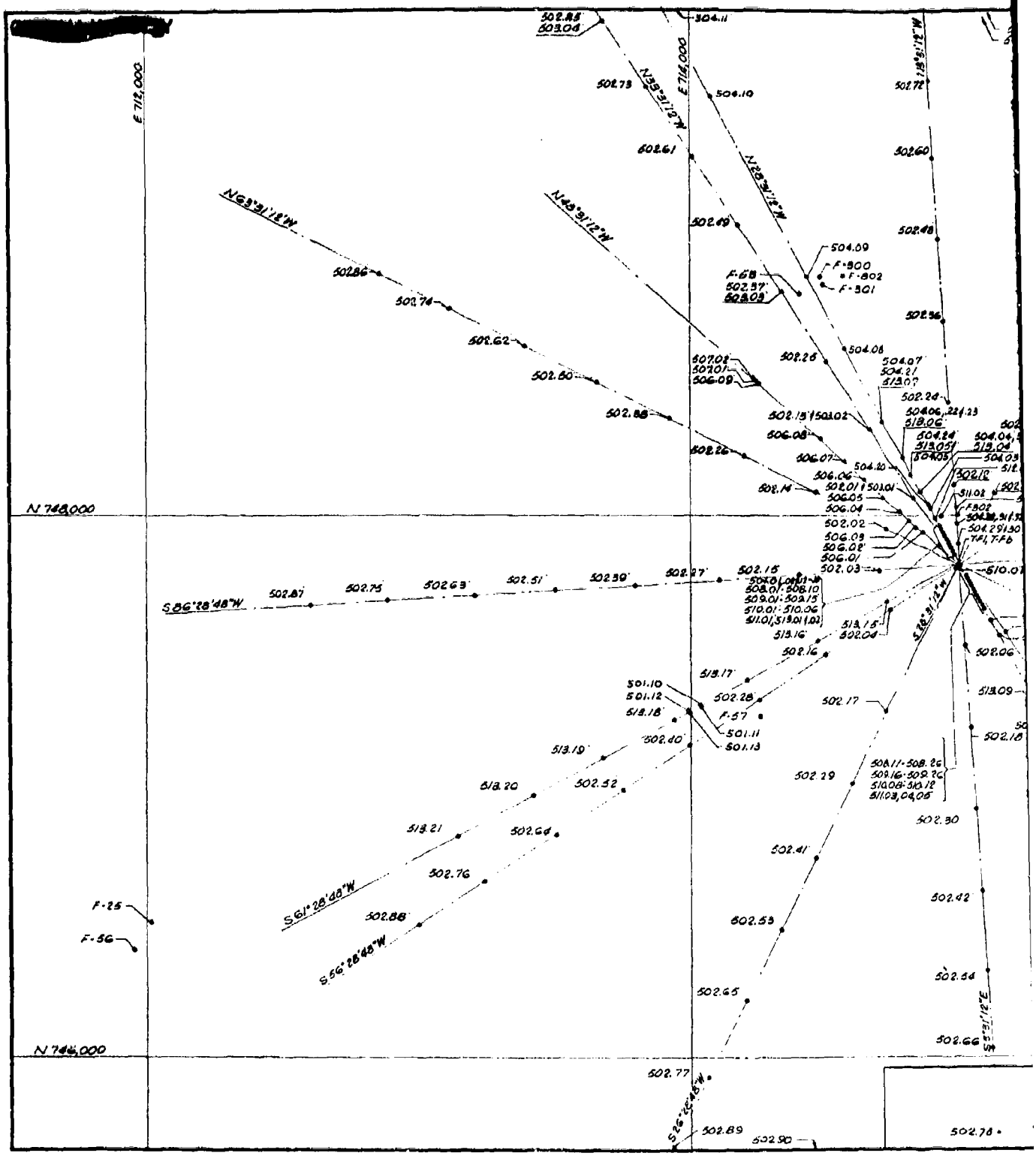
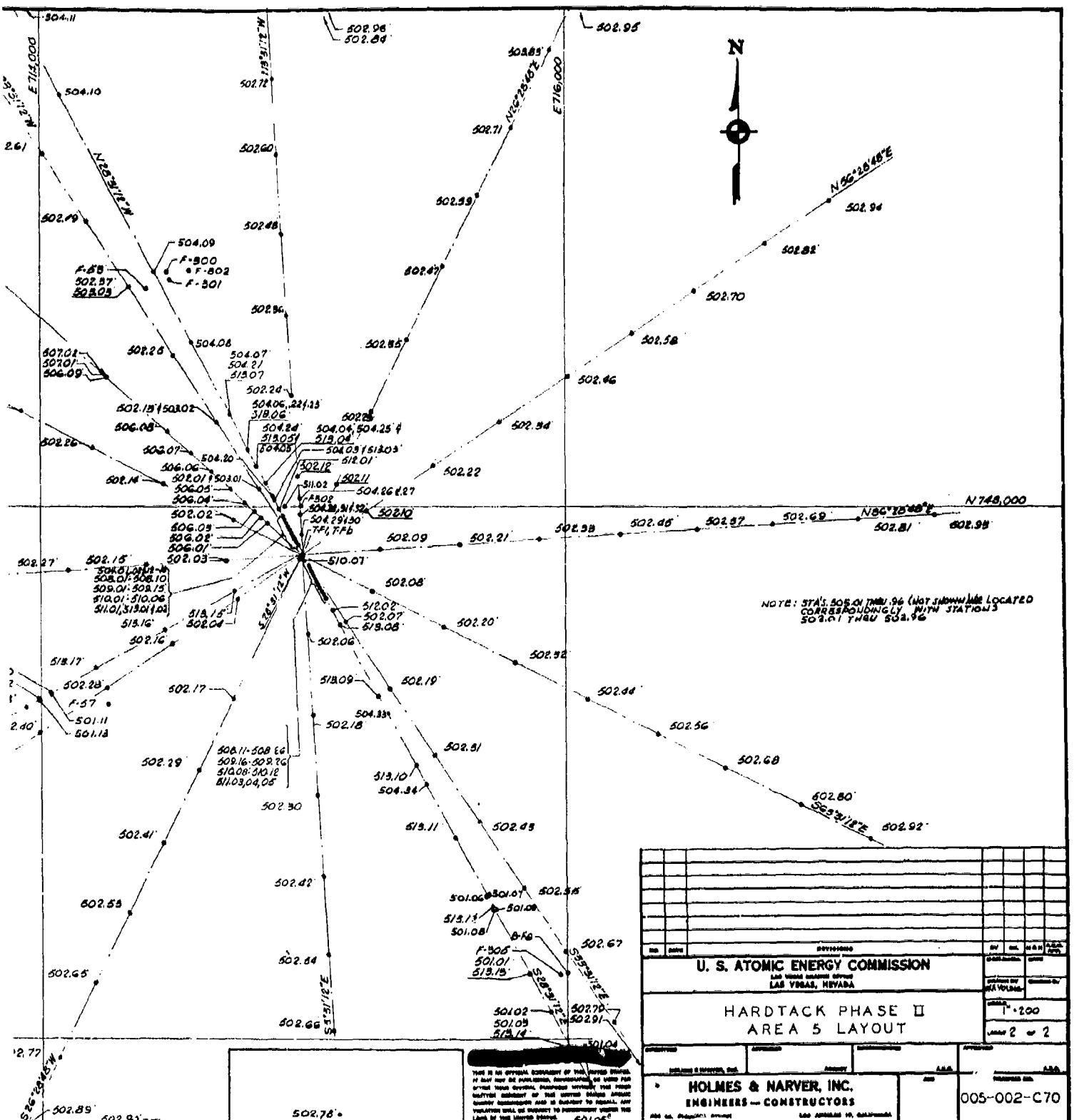


Figure No. 37. Area 5 — Detail Layout (Sheet 2 of 2)


N
E 716,000
N 748,000
NOTE: STA'S 508.01 THRU 96 (NOT SHOWN) ARE LOCATED CORRESPONDINGLY WITH STATIONS 503.01 THRU 502.96
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 5 LAYOUT
1" = 200
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
005-002-C70

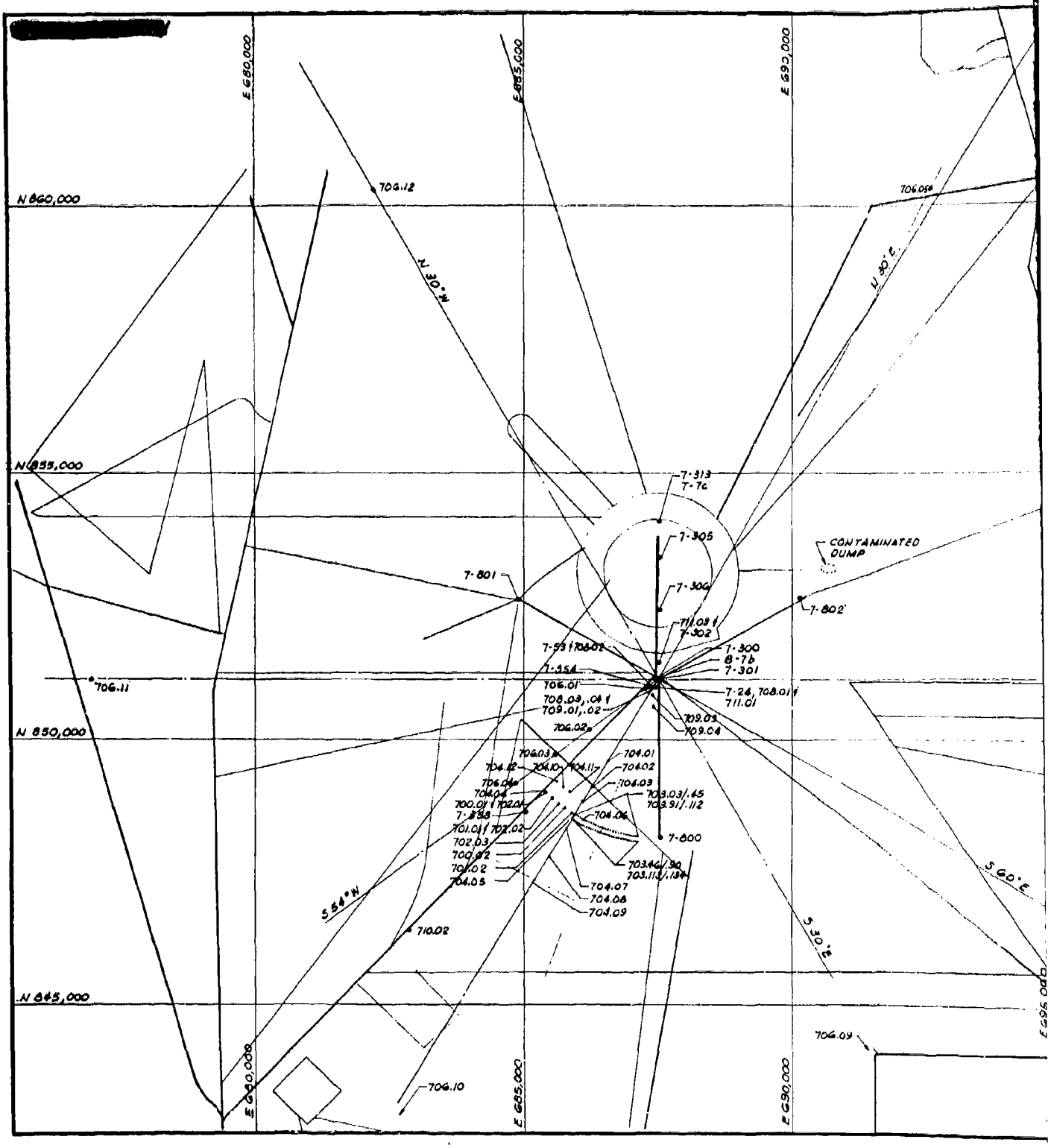
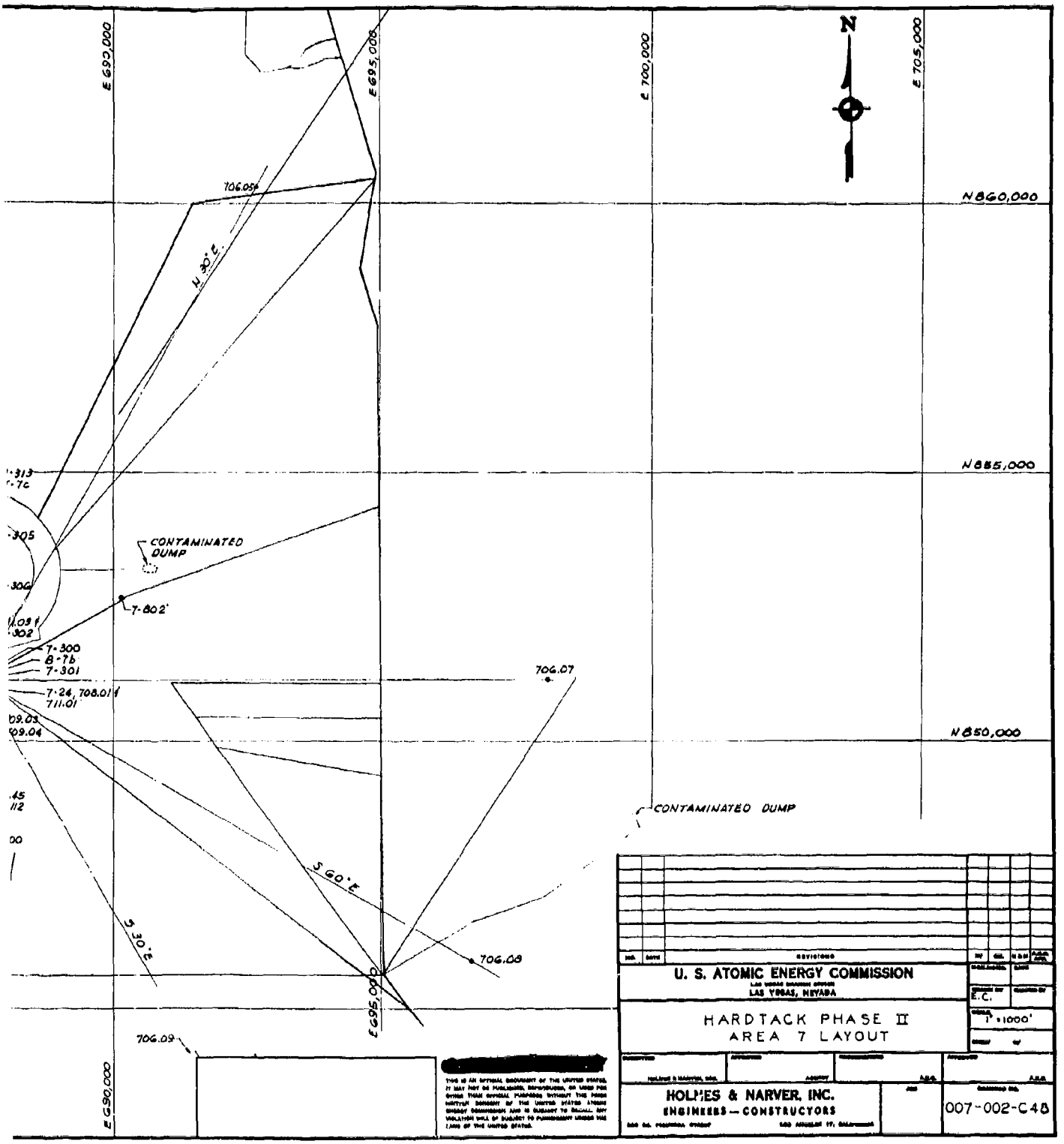


Figure No. 38. Area 7 Layout

APPENDIX


E 690,000
E 695,000
E 700,000
E 705,000
N
N860,000
N855,000
N850,000
E 690,000
E 695,000
706.05
N 30° E
CONTAMINATED DUMP
7-802'
7-300
B-7b
7-301
7-24, 708.01, 711.01
706.07
706.08
706.09
CONTAMINATED DUMP
S 60° E
S 30° E
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 7 LAYOUT
1" = 1000'
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
007-002-C48

2

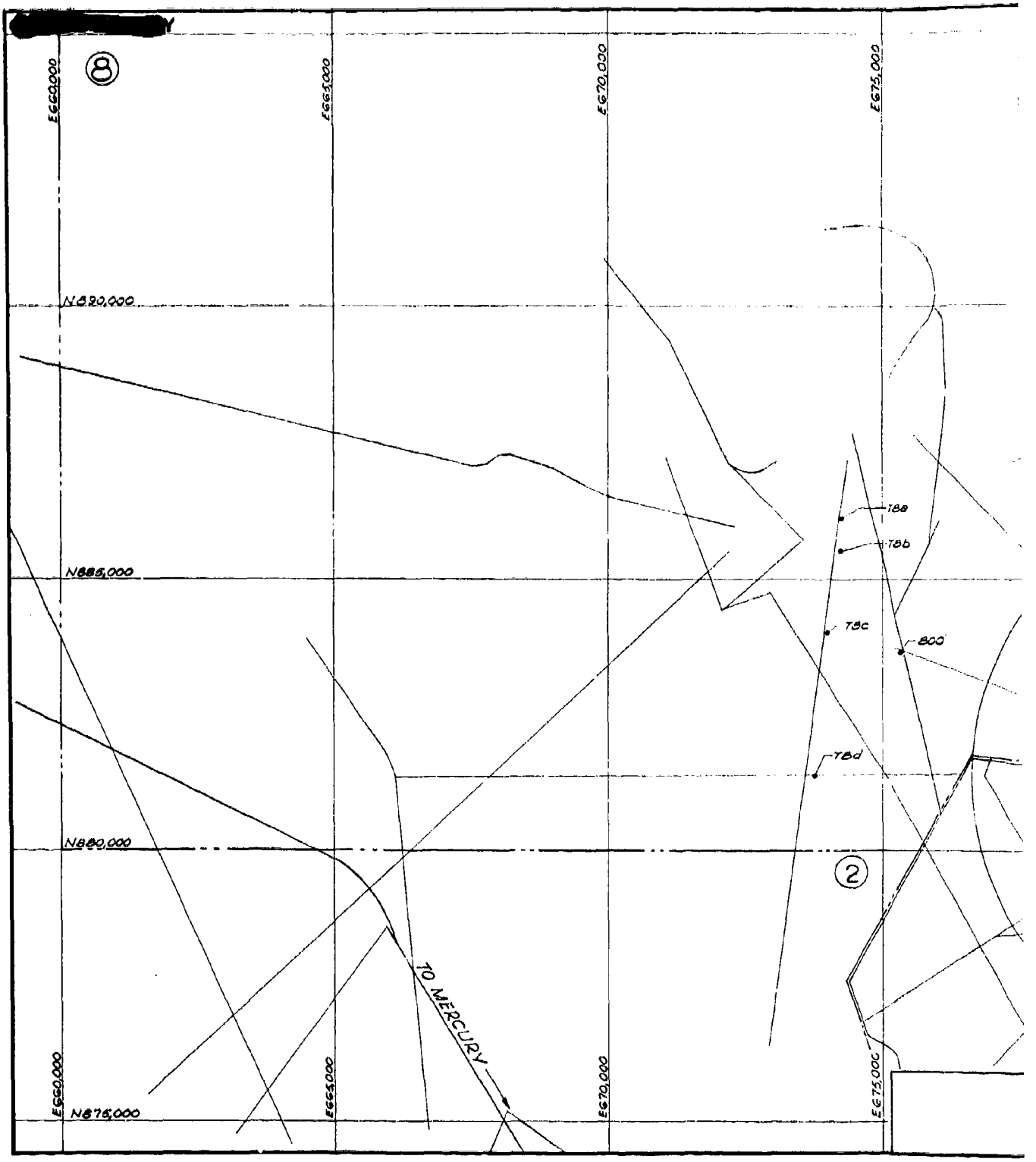
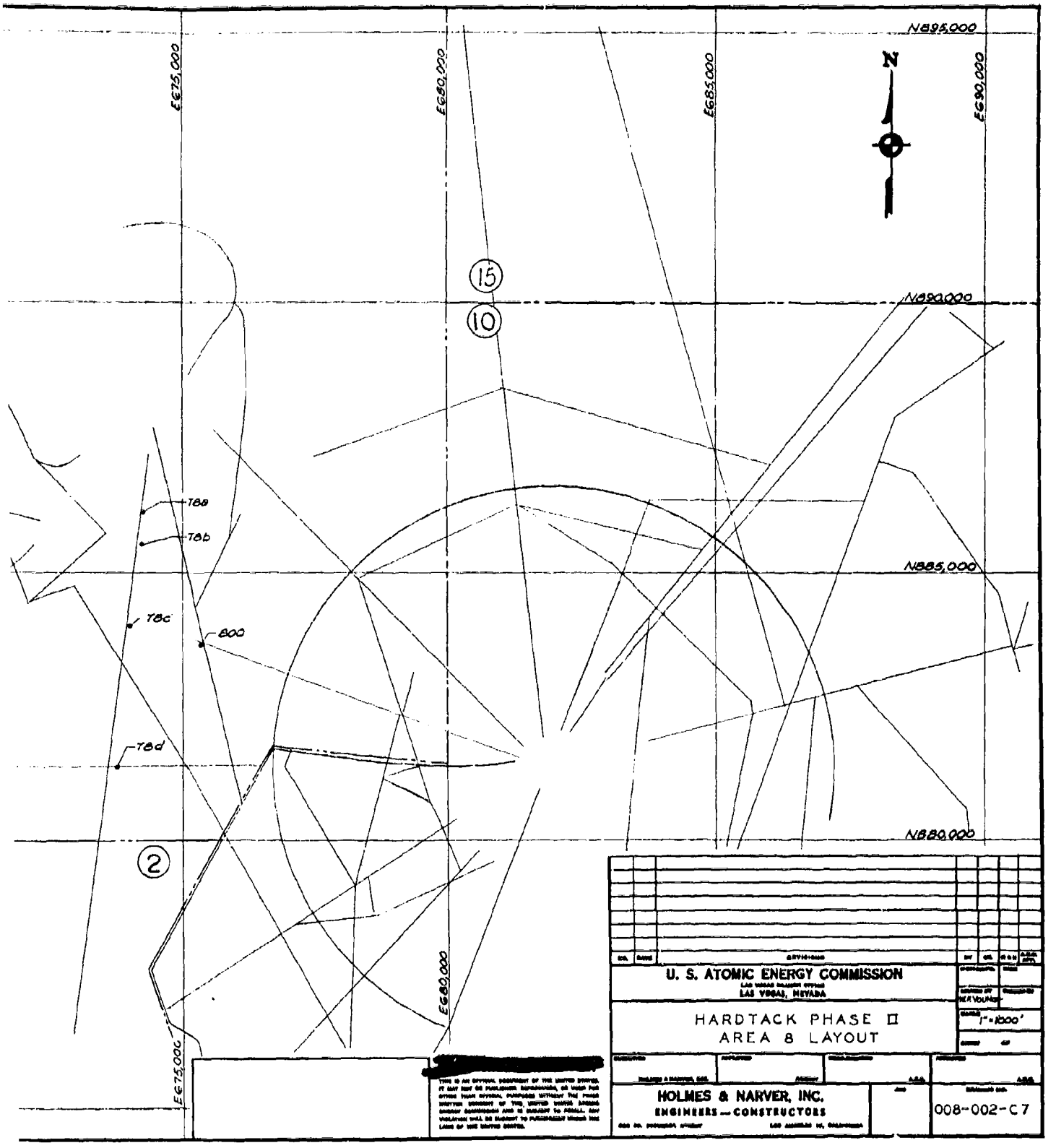


Figure No. 39. Area 8 Layout

APPENDIX


N895,000
N890,000
N885,000
N880,000
E675,000
E680,000
E685,000
E690,000
N
15
10
2
T8a
T8b
T8c
T8d
800
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 8 LAYOUT
1"=1000'
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
008-002-C 7

2

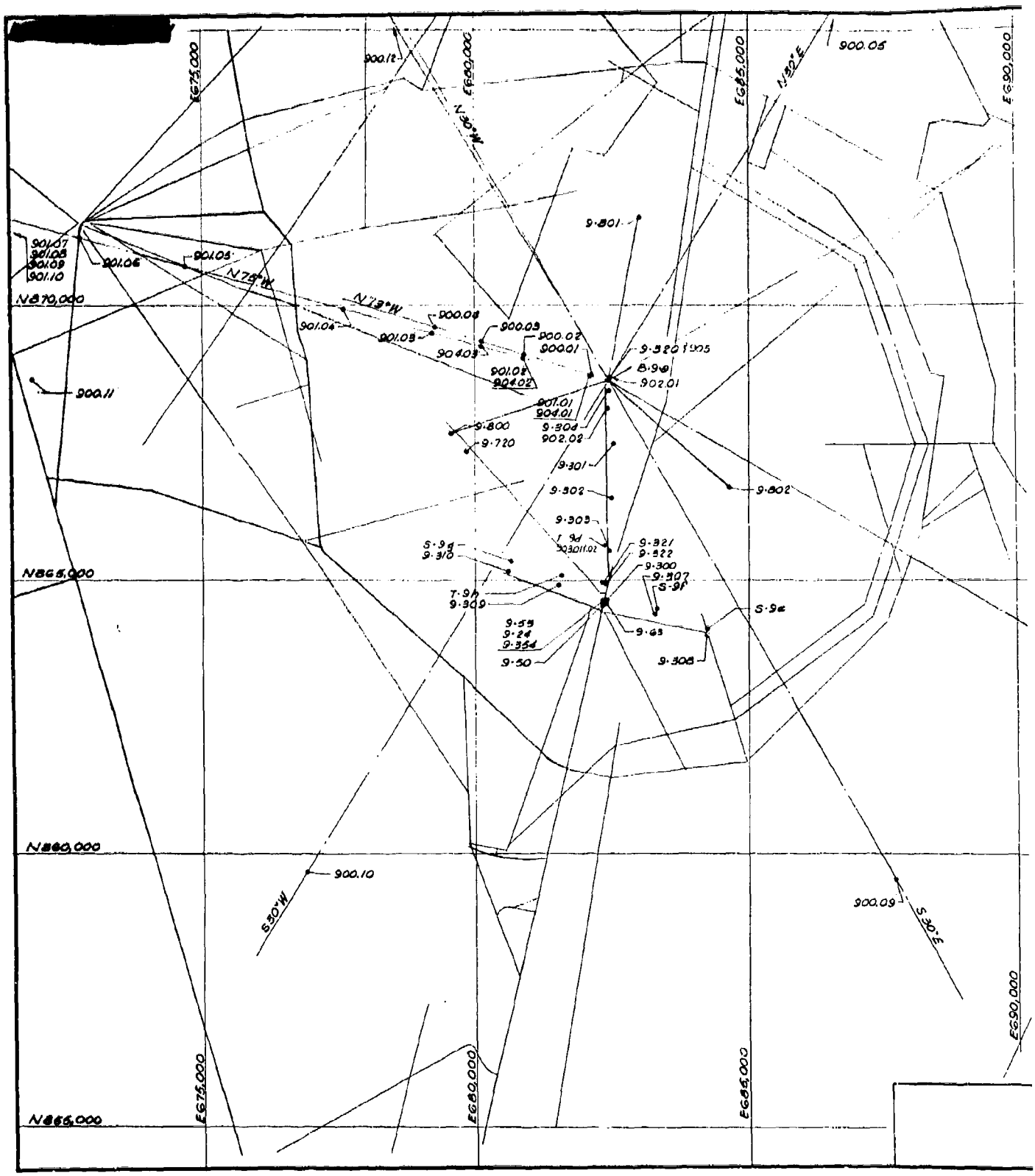
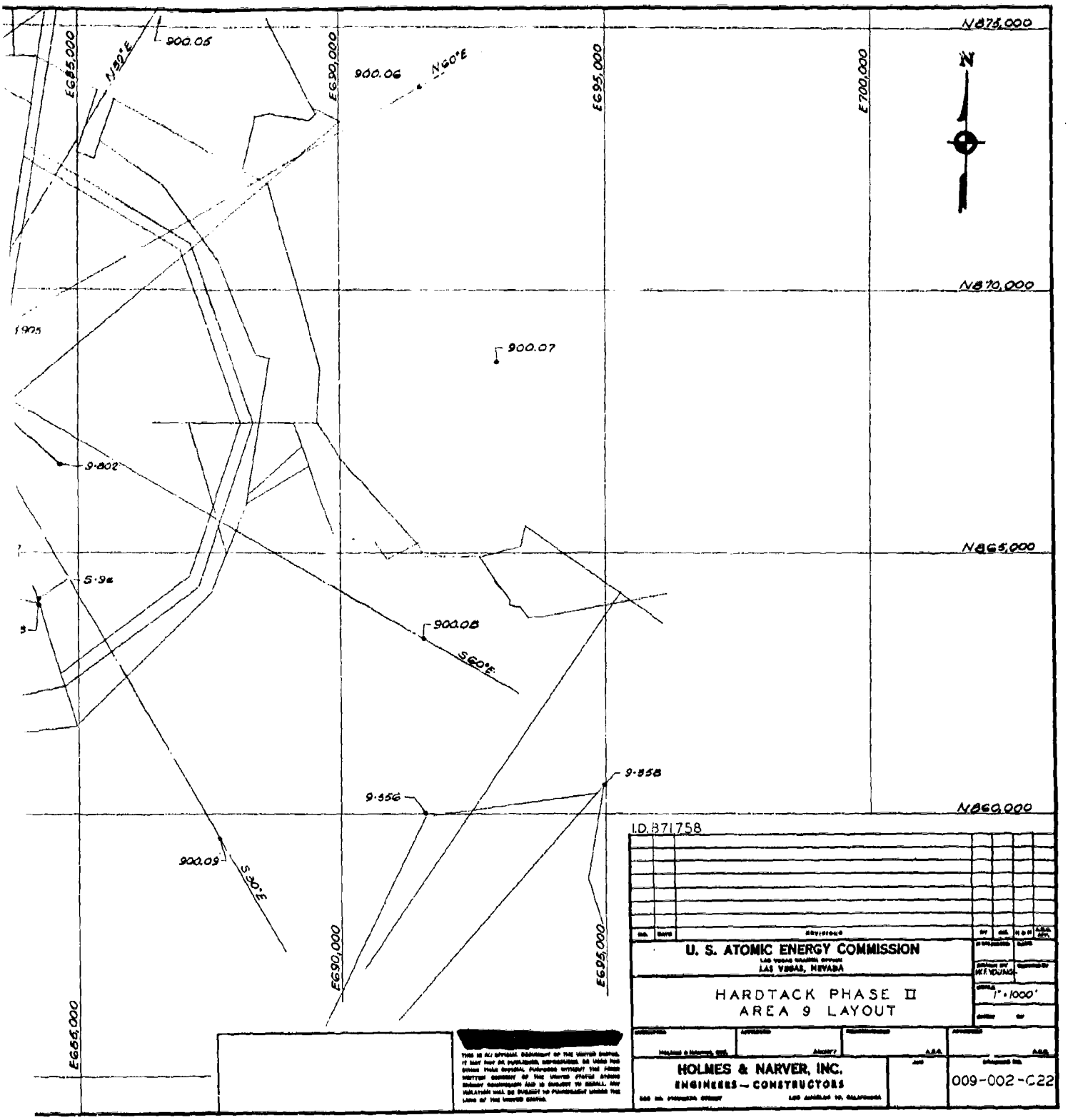


Figure No. 40. Area 9 Layout


N875,000
N870,000
N865,000
N860,000
E685,000
E690,000
E695,000
E700,000
N
900.05
N30°E
900.06
N60°E
900.07
900.08
S60°E
900.09
S30°E
9·802
5·9a
9·956
9·958
1905
ID.871758
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 9 LAYOUT
1"=1000'
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
009-002-C22

2

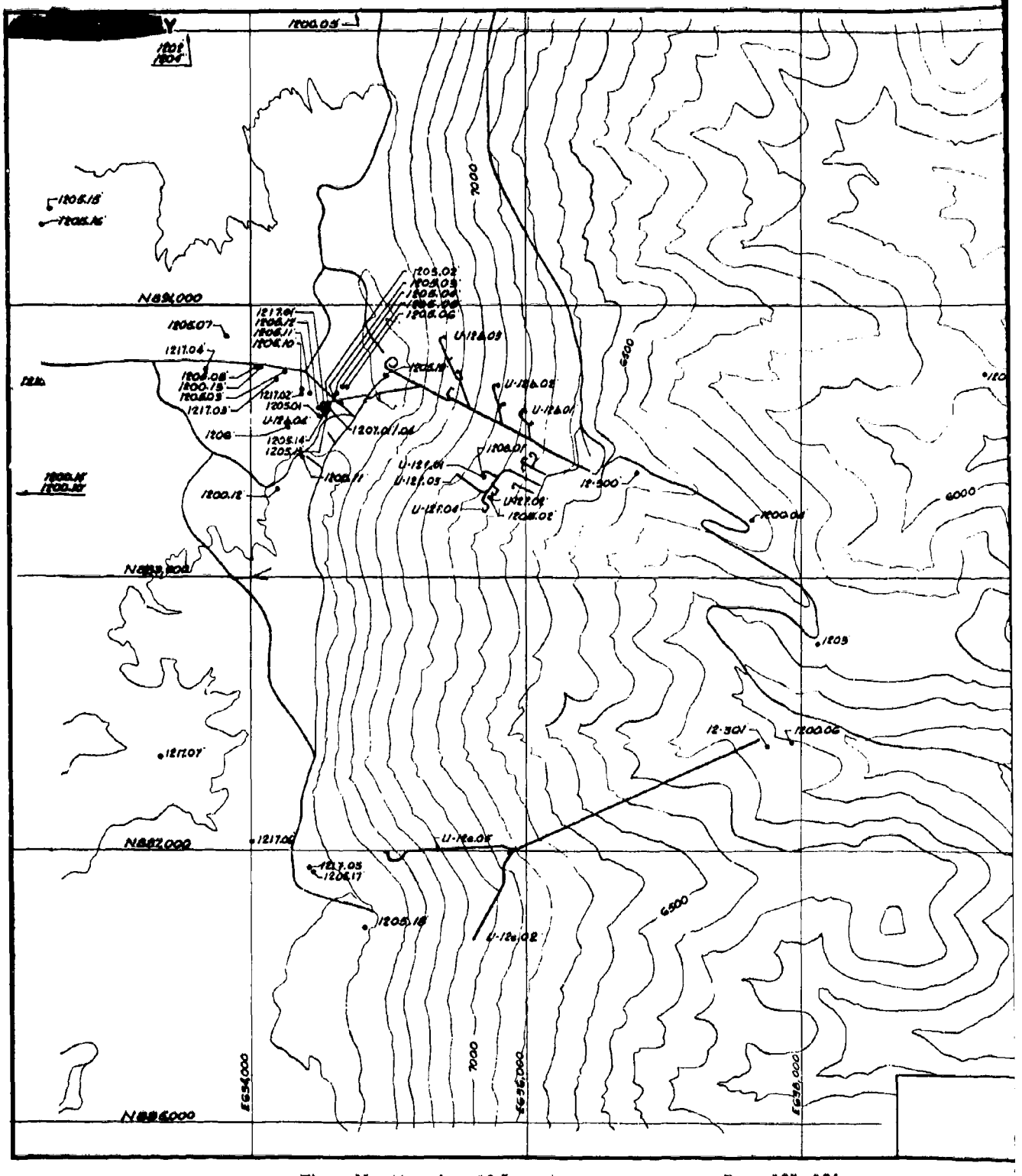
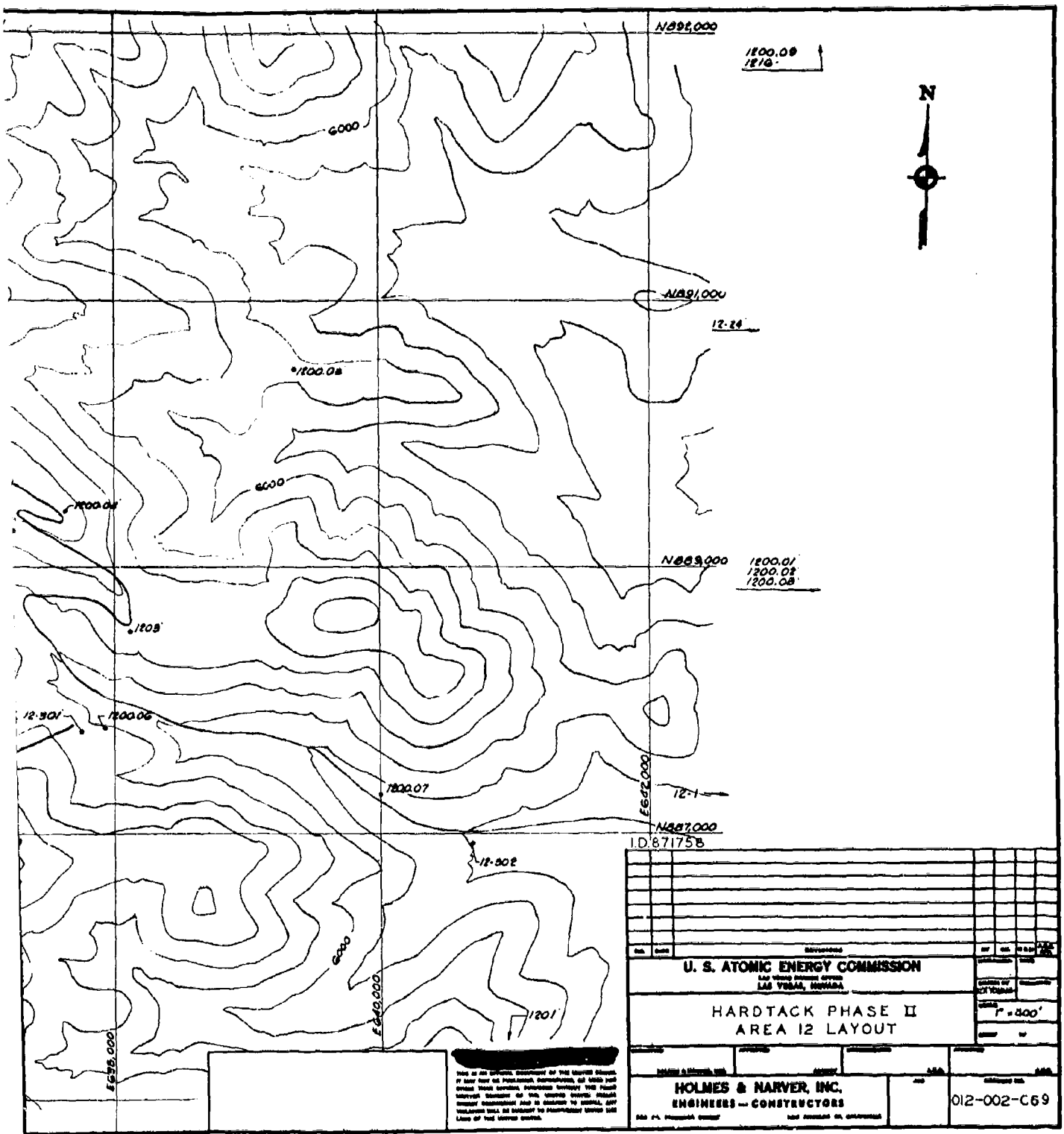


Figure No. 41. Area 12 Layout

APPENDIX


N892,000
1800.09
1810
N
6000
N889,000
12-24
1800.08
6000
1800.04
N888,000
1800.01
1800.02
1800.08
1809
12-301
1800.06
1800.07
E642,000
12-1
N887,000
I.D. 87175B
12-302
6000
E640,000
1201
E635,000
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
AREA 12 LAYOUT
1" = 500'
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
012-002-C69

2

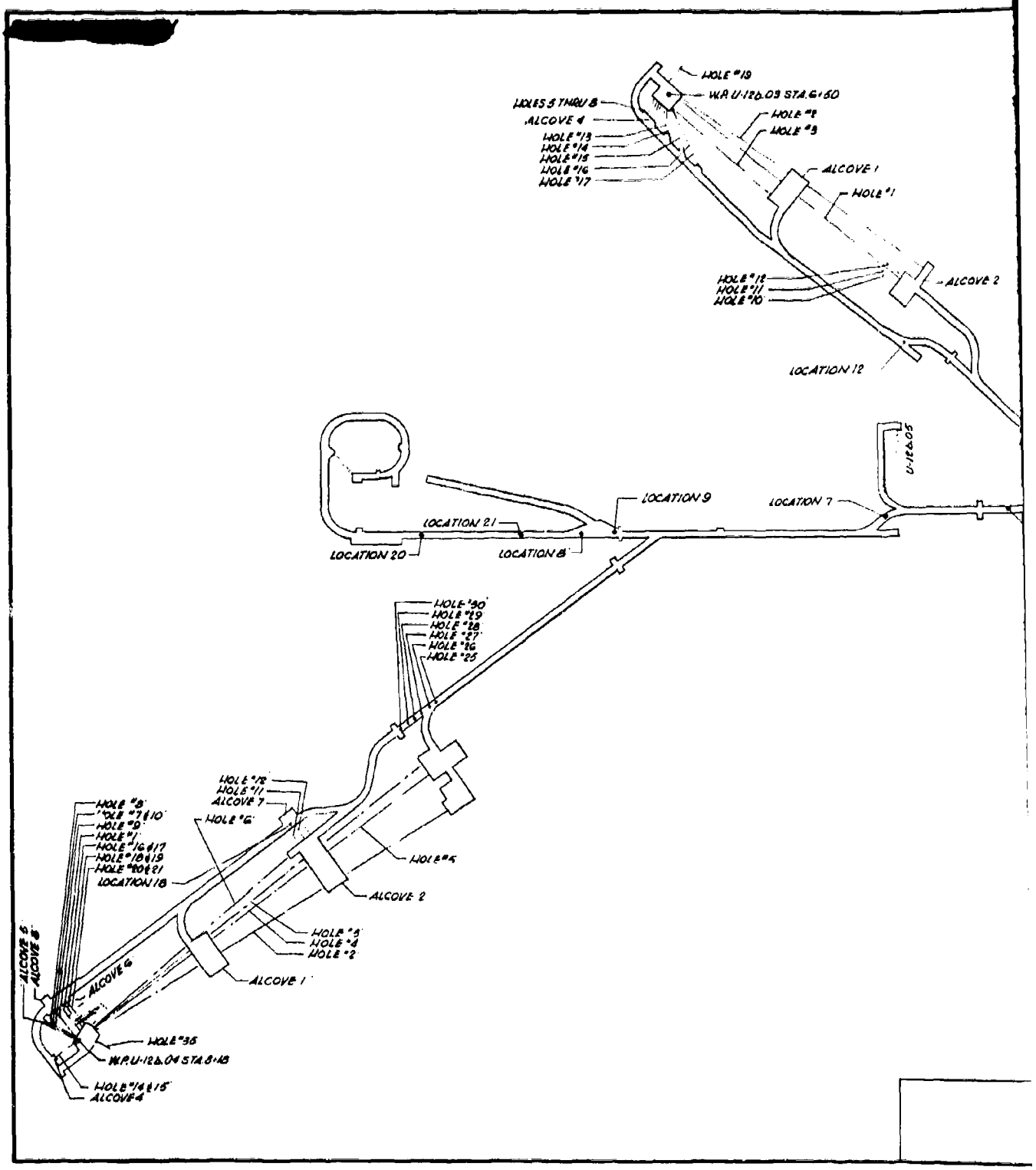
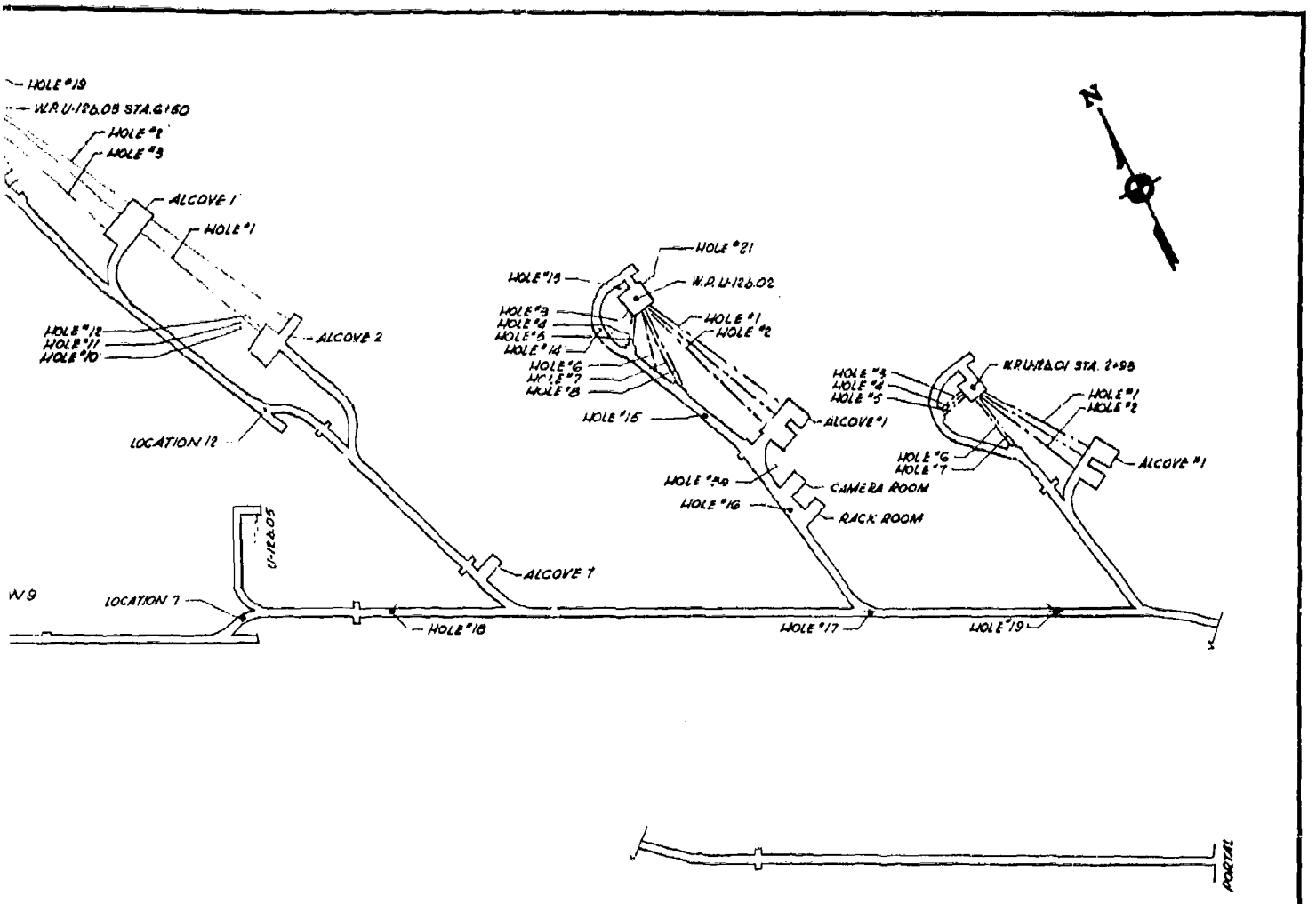


Figure No. 42. U-12b Tunnel Complex



I.D. 871758

NO.	DATE	REVISIONS	BY	NO.	A.E.C. APP.		

U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS BRANCH OFFICE
LAS VEGAS, NEVADA

HARDTACK PHASE II
TUNNEL PLAN
STA. U-12b AREA 12

DESIGNED BY: M.K. YOUNG
SCALE: 1" = 50'

HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
LAS VEGAS, NEVADA

012-U12b-C 8

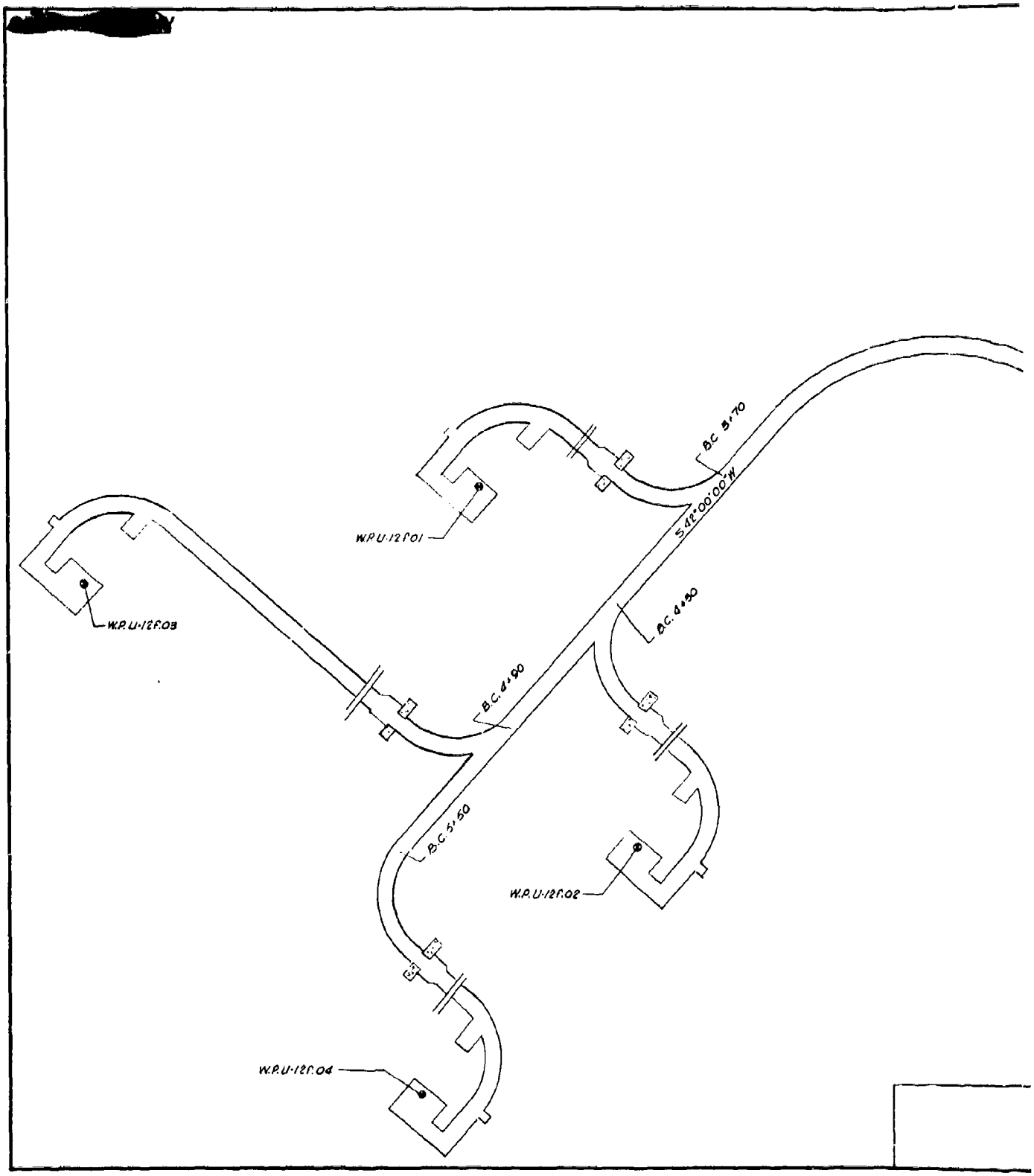
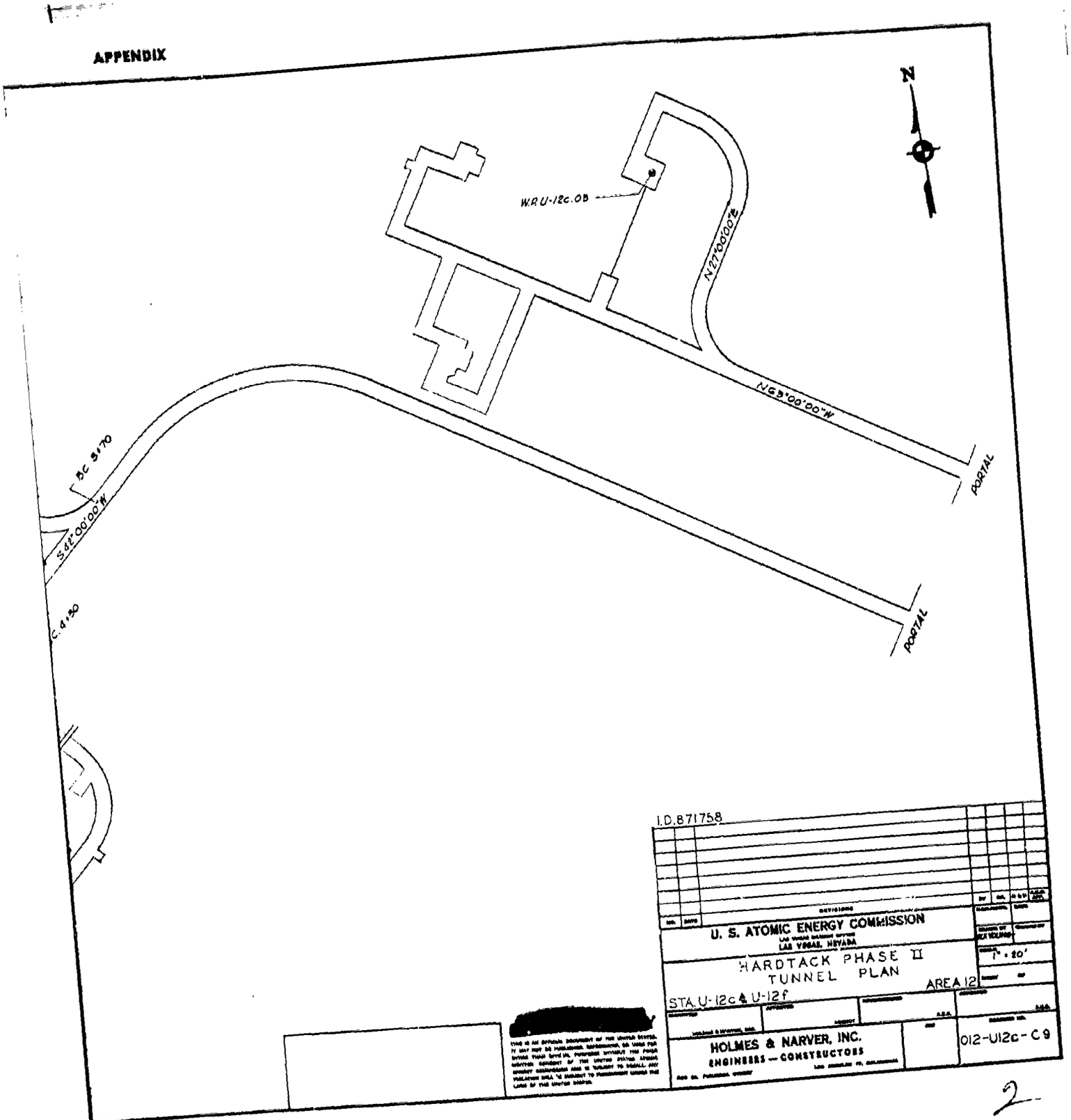


Figure No. 43. U-12c and U-12f Tunnel Complexes


N
W.R.U-12c.08
N27°00'00"E
N63°00'00"W
PORTAL
PORTAL
BC 3170
S 41°00'00"W
C. 4150
I.D.871758
U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA
HARDTACK PHASE II
TUNNEL PLAN
AREA 12
STA. U-12c & U-12f
1" = 20'
HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS
012-U12c-C9

2

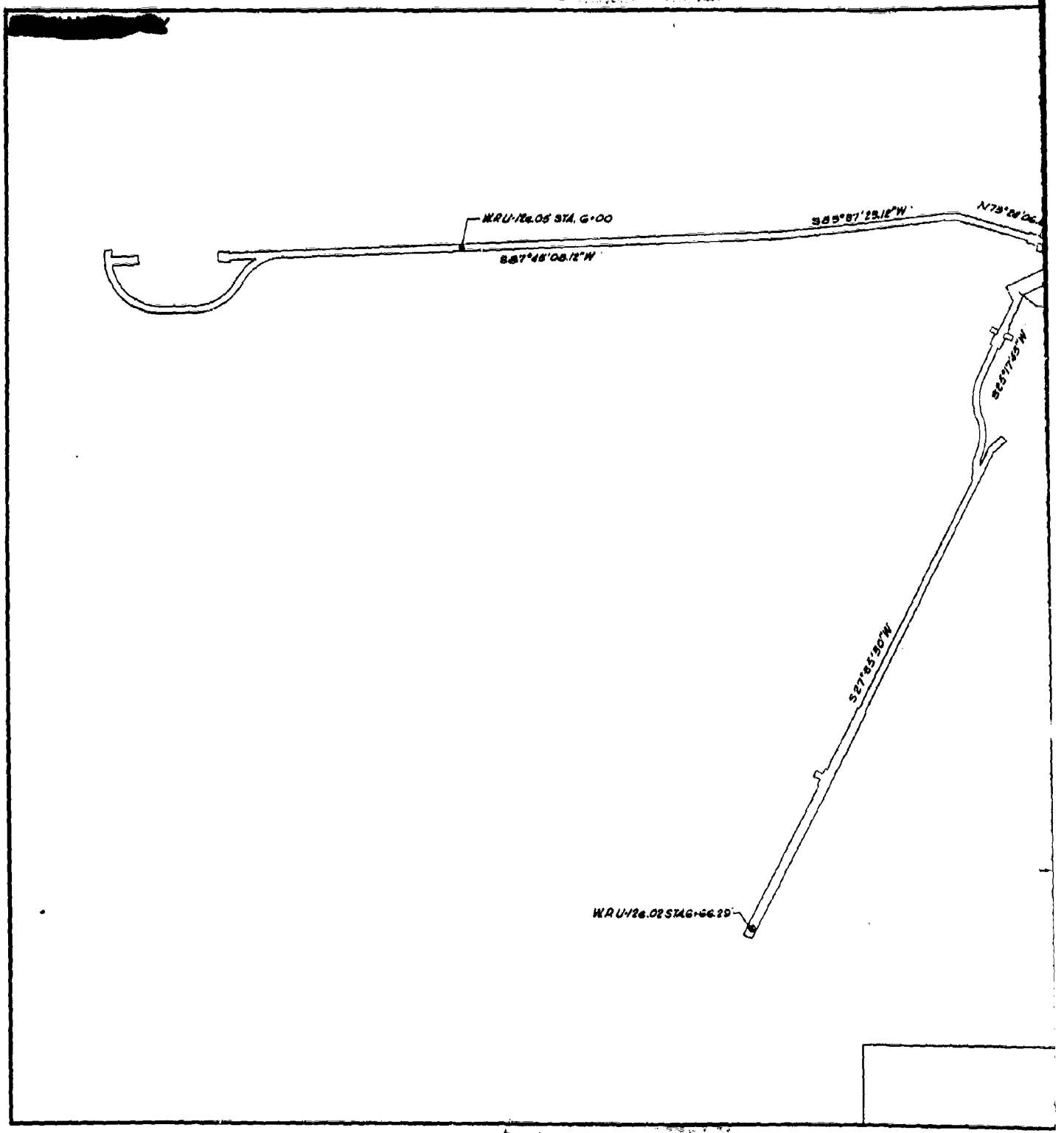
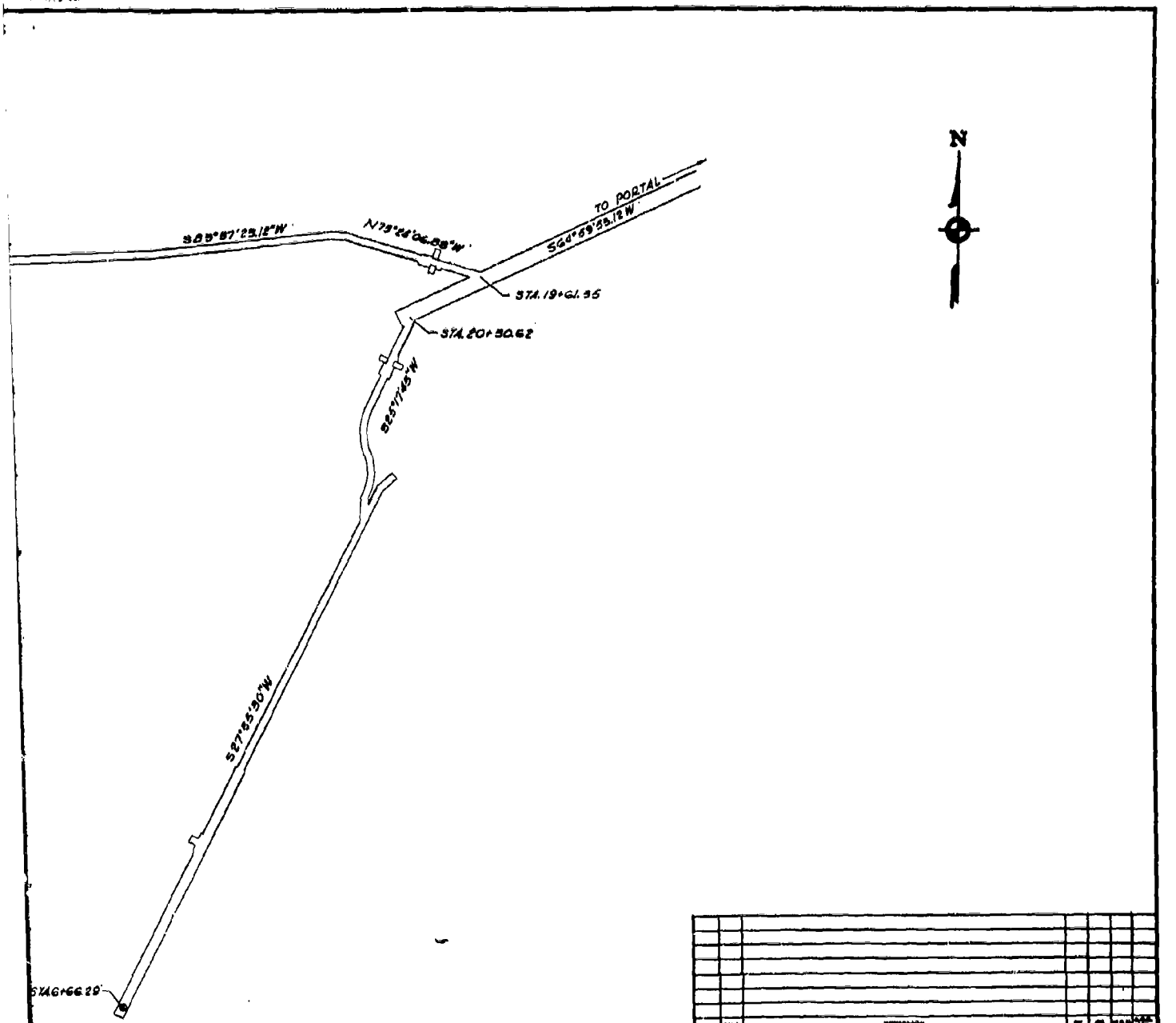


Figure No. 44. U-12e Tunnel Complex



U. S. ATOMIC ENERGY COMMISSION
LAS VEGAS, NEVADA

HARDTACK PHASE II
TUNNEL PLAN

STA. U-12e
AREA 12

1" = 50'

HOLMES & NARVER, INC.
ENGINEERS — CONSTRUCTORS

012-U12e-C12

2