At the October 12 LASL Weapons Working Group meeting, Ogle summarized the projected LASL testing schedule and budget (including the next fiscal year) which had been submitted to DMA. [redacted]

Ex.(b)(3)

Consideration of the Christmas Tree concept included a study by the corporation run by Roland Beers, known as RFB, Inc., which was evaluating the concept as requested by Jim Reeves early in October. On October 16, after studying the concept to some degree and looking at some of the data from the early underground shots, RFB people were in the midst of evaluating the separation of shot points and the various laws to be followed in setting out the configuration for safety, containment, lack of contamination, access, and other considerations. Generally, they felt that the 600 $W^{1/3}$ scaling law for the separation of shot points from the access shaft and the 50 $W^{1/3}$ law for the spacing of the shots around the ring were possibly inadequate. While noting that there would soon be a better understanding of this from current data, they suggested providing a second access shaft, extending the working radius further out from the shaft and providing greater spacing between each shot around the ring. Two days later, Mr. Collins of Holmes & Narver submitted his company's preliminary drawings illustrating the Christmas Tree configuration as well as views of the camp and tunnel facilities.

By the middle of October, with four underground tests behind them, the Laboratories had changed very little their feelings about the suitability of the underground regime for effective weapons testing. At a lengthy Commission meeting on October 17, with the Laboratory Directors and Managers of the Albuquerque and San Francisco Operations Offices present, Bradbury expressed his view that it was extremely difficult to acquire reliable data in the underground medium, which some at LASL had always held to be the case. He noted that in one test the measurements had been impaired by the underground location and the close proximity of material interfering with the alpha measurements; also, the radiochemical results had been marginal since the samples were badly fractionated. In response to a question from Commissioner Wilson, he observed that, as yet, seismic measurements were not satisfactory for determining the yield and that there was insufficient experience in seismology of weapons detonations in heterogeneous media. Foster briefly summarized the results of the two Livermore tests: only an approximate yield determination had been possible for the Ex.(b)(3) since no alpha measurement was obtained and only limited radiochemical samples had been acquired after the test. [redacted]

Ex.(b)(3)

Foster expressed his general feeling that, although some smaller weapons could be more effectively tested underground, he preferred above ground testing for the most part since it resulted in better diagnostics. Bradbury agreed that in almost all cases it was desirable to test above ground. The subject of tunnel contamination was then raised by the Chairman, and Foster said that the Chena tunnel contained radioactive material immediately following the explosion. Blowers turned on the day after the test forced the contamination out of the tunnel, and only several days later was the tunnel reentered to find that it had been blocked by debris at the juncture with the connecting tunnel. Foster emphasized, as he had quite recently, that adequate tunnel space was not as critical a pacing factor for Livermore at this time as the

lack of sufficient test devices. The latter shortage was primarily a result of the concern that an acceleration of activities during the moratorium might have touched off adverse public reaction. He also reported that during the moratorium, the psychological reaction to not being able to test had permeated the Laboratory and adversely affected its productivity. Furthermore, even if the U.S. decided to resume atmospheric testing, Foster stated that tunnel construction should be accelerated. Bradbury continued, still very uncertain of the underground method, that he would prefer to retest in the atmosphere, if the U.S. decided to resume such testing, those devices which had been tested only underground. After Commissioner Graham recalled the 1958 attitudes of Livermore and LASL about underground testing as being pro and con, respectively, Bradbury said he still believed that the merits of underground testing were overestimated, although such testing was better than none at all. Foster emphasized that if the U.S. continued underground testing exclusively, it would require a considerably greater level of effort over a longer period of time to acquire optimum diagnostics. Thus, he felt the U.S. should resume atmospheric testing, but at the same time underground test preparations should be accelerated in order to acquire the technical capability to test in that regime and to best allow for the possibility that political developments would again require testing underground exclusively. He suggested that the AEC spend an additional $50-$100 million to advance tunnel construction. Bradbury said that while he did not disagree with arguments favoring increasing development of underground testing, he was hesitant to support a $50-$100 million increase. Edwin McMillan, Director of Lawrence Radiation Laboratory at Berkeley, who entered into the discussion at this point, endorsed vigorous underground testing and tunnel construction, but said that the U.S. should resume atmospheric testing since he believed underground testing would never be an adequate substitute. Schwartz of Sandia endorsed the others' feelings that underground testing was better than none at all, but that atmospheric testing was more desirable since efficient techniques in that regime were already developed. In response to a question from the Chairman about where underground capabilities should be developed, Foster felt that NTS would be adequate for a period of a couple of years, but suggested that other sites should be ready after that. He estimated that Livermore would have developed their technology in about five or six months to the stage where they could test two devices per month, and, including LASL testing at a similar rate, this would mean about one test per week. Foster said he would prefer to continue that rate even if the U.S. decided to resume atmospheric testing. A discussion of accelerating the underground program then included Hertford of ALOO, who commented on the adequacy of current tunnel construction, noting that he had the crews now working continuously (24-hour days, 7-day weeks) on i, j, and k tunnels. With additional funds, ALOO could have more tunnels constructed. The Chairman agreed that acceleration of the underground program was necessary, but that this must be balanced against funding required and examined in the light of other national needs. Commissioner Wilson expressed his opinions about underground testing techniques in a continuation of the meeting with the Laboratories and Operations Offices later the same day, based on information from Hertford that because of repeated weapons tests, fissures had developed in the ground above the tunnels. Consequently, Wilson suggested that testing in vertical shafts, as LASL had done, might be more useful than tunnel testing. Hertford then argued (incorrectly, in retrospect) that vertical-hole-testing presented many of the problems common to tunnel testing, such as steam venting and possible contamination of groundwater. In lengthy discussions of the various Laboratory weapons development programs that had either been accelerated or deemphasized due to the press of getting devices ready for testing, Foster and the others in the afternoon discussions addressed just what the underground program objectives were at the moment. Ex.(b)(3)

Ex.(b)(3) [redacted] and Foster stated that the significance of any results from the current series for the Hardtack weapons development program would not be fully realized for some eight months after the tests. Chairman Seaborg asked that a study be prepared on what the scope of underground testing should be in the event the U.S. resumed atmospheric testing. Wilson noted Foster's earlier recommendation for an additional $50-$100 million to advance tunnel construction and said that he rather agreed with LASL's approach to testing in vertical shafts, "noting that several of the tunnels had been seriously damaged by detonations and existing tunnel space will permit only limited testing." Commissioner Haworth then argued that when the tunnels were built, the pressing time schedule had limited the quality of the tunnels. The AEC General Manager, Alvin Luedecke, went even further in recommending that if it could be demonstrated that 2,000-foot shafts could be properly instrumented, he would recommend abandoning the tunnel approach. To him it was evident that there was no full containment except at extreme depths and that even the slightest degree of venting would both arouse public concern and in fact raise the radioactivity level. Thus, weather conditions at the time of underground tests must be taken into consideration. Commissioner Haworth then suggested that tunnels could best be used for small-yield tests where only slight fracturing would occur. Luedecke, however, pointed out that even in the smaller tests, serious fracturing had taken place. The Commission concluded its meeting by requesting recommendations on the scope of the underground capability, taking into consideration the comparative advantages of tunnel and vertical hole shots.

On October 19 Bob Campbell, Assistant LASL J-Division Leader, sent Jim Reeves a letter responding to Reeves' September 21 request for cost estimates from the Laboratories and others. Campbell set out several LASL projections for the general scope of testing over the next 20 months (through the end of FY 1963). [redacted]

Ex.(b)(3) [redacted] The heavily instrumented tests would be done in shafts* with short, heavily instrumented drifts at the bottom, rather than in holes, and would require personnel access to the zero point, collimated lines of sight for instrumentation, and complex sampling equipment, among other things. [redacted]

Ex.(b)(3) [redacted] It should be stressed that LASL's attitude at this point was that if atmospheric testing as desired were possible, the underground test method would be abandoned during that period. Based on these numbers of projected tests, Campbell set out specific requirements to support the scenarios as follows:

1. Alpha Systems: Three systems of 60 oscilloscopes each were required in addition to what was then on hand: these were to be obtained, installed, and operated by EG&G under LASL technical direction.
2. Detectors: EG&G was to furnish alpha detectors as needed to support the test scenarios.
3. Portable Alpha Station: H&N and REECo were currently designing and constructing such a station for use at NTS and this should be completed.
4. Coaxial Cable: These requirements for underground tests might be scaled directly from the Nougat requirements.
5. Update Balloon Area: LASL wanted an alpha station of sufficient size to hold a modern alpha recording system and, if possible, a winch and detector arrangement to permit using more than one ground-zero.

*A shaft is a mined vertical hole with drifts at the bottom. Holes are drilled.

6. Timing and Firing: Independent timing and firing systems for Areas 3 and 7 at the NTS were desired.
7. Zero Racks: A zero rack for each shot would be furnished by EG&G.
8. Zippers: Zippers would be required from Sandia for most shots.
9. HRT (High-Resolution Telemetry): Sandia's assistance with this system would be required on all above ground shots.
10. Underground Hydrodynamic Yield:* Sandia, in conjunction with J-15 at LASL, would continue their attempts at obtaining underground yields by hydrodynamic methods.
11. Assembly Facilities: A weapons assembly facility physically separated from the existing complex was strongly desired to preclude the unnecessary safety and scheduling problems due to the present arrangement of sharing assembly and storage facilities at the NTS with other organizations.
12. USGS: The USGS effort at NTS should continue as necessary to support underground testing.
13. Weather: LASL recommended that the present facilities be augmented by upper wind stations at Shoshone, Alamo, Tonopah, Beatty, and Indian Springs for any atmospheric NTS tests.
14. Aircraft: Sampling aircraft requirements as detailed elsewhere.
15. Shop Facilities: Present NTS facilities were adequate for this.
16. Radchem Lab: A Radchem Lab would be required at the NTS for early yield determinations should conditions of firing such as in Hardtack Phase II prevail again.
17. ECM: In the event of atmospheric testing, ECM or comparable equipment would be required to locate sources of electronic interference.
18. Housing, Transportation, and Communication Requirements: As on previous operations where required, it was hoped, because of the continuing nature of these programs, that single occupancy quarters would be made available.

In its meeting of October 19-21 the AEC's General Advisory Committee heard detailed briefings and had lengthy discussions on the test resumption, the various techniques, and the possibilities for weapons testing in the immediate future. One of the briefings presented showed a chart giving the relative advantages of the different types of testing, such as what sort of diagnostic data could be gathered. This chart is shown in Table XXI. In light of the poor results thus far in radiochemistry work and the efforts being put into this area, Commissioner Wilson noted that such work had fallen about six months behind schedule and that the Commissioners were desirous of employing additional good radiochemists. Willard Libby, a former Commissioner, asked if the Commission had canvassed Argonne and Brookhaven to see if some of their radiochemists who might not be willing to leave their laboratories permanently would be willing to receive some of the samples for analysis there and thus alleviate the work load. Libby generally advised that since underground testing was in the development stage, improvements in technique and diagnostics could be expected, to which General Betts agreed. In a discussion of the overall status of the Test Site activities, Captain Craig of the DMA test office explained that Livermore was expanding its tunnel complexes at Nevada and there were 12 to 16 drill rigs drilling holes for LASL devices. (See Figure 10.) He briefly described the Livermore

*A September 7 entry from the author's diary describes a concept for making hydrodynamic yield measurements on underground shots. The proposal was to drill a small-diameter (perhaps 8-inch) hole alongside the main hole but about 10 feet away, and another smaller (perhaps three-inch diameter) hole within the next 30 feet (Ed. note: along the same radius). Time-of-arrival and pressure-versus-time measurements made at the bottoms of these holes would allow J-15 to make yield estimates, it was felt. Potential problems were largely in the capability to determine the distances from the emplaced device to the bottoms of these holes and in the time and effort to drill the holes. The first shot for which these could be performed would be in the middle part of November, but unless accurate position measurements could be made it was not clear that there was any point in this technique. The decision was made to have J-6 investigate these problems and have J-15 think a little more about yield determination from measurements made within the canister itself or in the main hole.

TABLE XXI
COMPARISON OF DIAGNOSTIC QUALITY

Diagnostics	Underground	vs Atmospheric Testing
A. Prenuclear		
1. Detonator signal	good results	good results
2. HE burn signal	good results	good results
B. Nuclear		
1. Fission (n, gamma)	good results	good results
2. Fusion (n, 2n)	good results	good results
C. Postnuclear		
1. Fireball growth	no results[a]	good results
2. Bhangmeter	no results	good results
3. Shocks	poor results[a]	good results
4. Radiochemistry	poor results[b]	good results

[a]Clearly not possible in underground tests because of limitations arising from fireball and nuclear shock interactions with the cavity. Shocks and blast waves in the surrounding earth can easily be detected, but inferences about the details of the nuclear source are highly uncertain.

[b]In 1968, ff, these technologies were completely in hand and underground testing had demonstrated its flexibility and superiority for all but atmospheric effects purposes.

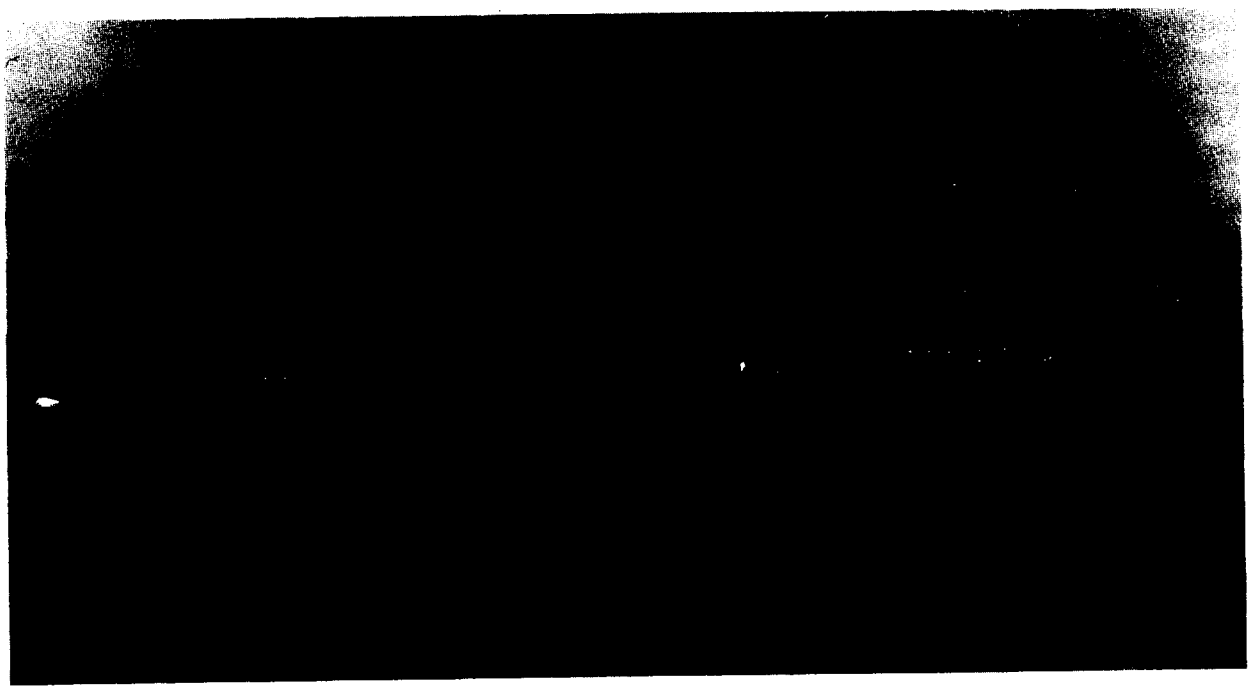


Figure 10.
A twilight photograph showing some of the drill rigs.

Christmas Tree tunnel concept as having about 15 shot locations, the deepest at about 4,000 feet, which could accommodate yields as large as 200 kt. After a couple of days of discussions, which included detailed looks at the possible testing scenarios for the future, Libby recommended that, since the U.S. might not be able to test in the atmosphere, the underground techniques should be emphasized, and he mentioned the possible establishment of an additional test site in a salt dome such as the Mississippi-Louisiana area, where exploratory drilling operations were currently under way in preparation for site-selection for the salt-medium decoupling experiments in the Vela Uniform program. Abelson, another GAC member, while noting that there were some aspects of underground testing that actually presented very considerable advantages, also pointed out that radiochemical samples could be collected about as easily underground as in the atmosphere. Since the committee seemed to agree on these points, the Chairman, Ken Pitzer, asked Libby to draft the General Advisory Committee's view on weapons matters for their recommendations. Thus, the October 21 letter to Chairman Seaborg with the recommendations of the General Advisory Committee contained the following under the heading "Underground Testing":

> The committee believes strongly that the Commission should continue urgent development of the underground testing technique, even if atmospheric testing is resumed. In particular, the possible use of the salt domes in Mississippi and elsewhere for underground testing of devices of larger yield than can be handled in Nevada should be thoroughly explored. The forthcoming Gnome Plowshare shot should give valuable information about the usefulness of the salt medium. Other underground formations as well as outer space should remain under consideration as sites for testing.

Nougat Continues with Revisions

Jim Reeves sent a message to the Labs on October 20 discussing the DOD Marshmallow event, citing the Planning Board's investigation of possible sites, and identifying U-16a in the Shoshone Mountains as a possible location. While this Ex.(b)(3) underground test was to be emplaced, stemmed, armed, fired, and instrumented by the AEC, the majority of the information to be obtained was for the DOD. Reeves asked for the addressees' comments on a construction start date of about November 1.

The same day, Bob Miller remarked to Jim Reeves on a number of items, including the DOD Nevada tests. At the DOD's request Sandia was to handle all of the AEC technical participation on the Hardhat event, including Vela Uniform (Lollipop) and Plowshare measurements by Livermore, as well as arming, timing, and firing. The DOD had requested the same relationship for the Marshmallow event, for which, Miller said, the Labs agree with the DOD's choice of a Tippipah Springs site. (See Figure 11.)

LASL's concern over the lack of good diagnostic data in underground testing was emphasized in an October 24 message from Bob Newman to Joe Sanders stressing the necessity for LASL to get radiochemical samples within two weeks after a shot in order that they be relatively unfractionated. Any greater time for recovery resulted in great uncertainties, and Newman said, "It is doubtful we can continue to operate underground unless we can get samples within two weeks after the shot." Thus, more pressure was put on the field test organization to improve their drilling capabilities. The future work load in that particular area would certainly be heavy, based on an October 25 message from Betts to the Labs. Betts' list, which had been submitted to the President for approval, Ex.(b)(3) [redacted] Ex.(b)(3) [redacted] extending from March through September 1962.

On October 23 Ogle reported to DMA on some problems in preparing for the Mink event. Mink was originally scheduled for October 1 in an 800-foot hole, which was to

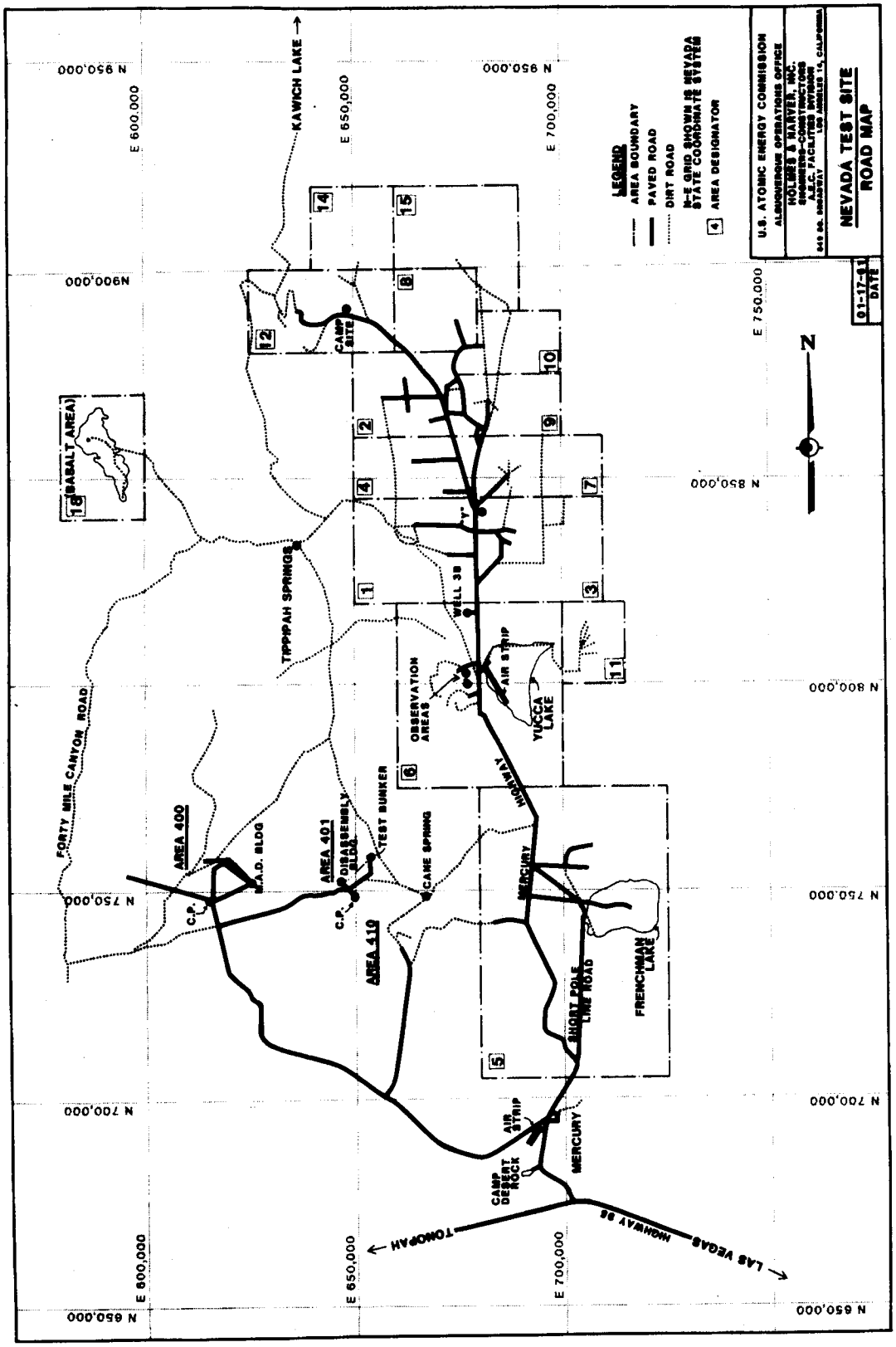


Figure 11.
Early 1961 map of NTS.

be obtained by deepening the existing U-3ae 500-foot hole, but difficulties with lost tools and other problems resulted in delaying it and putting Boomer in that hole. "It was a bad guess on my part to try to deepen the 500-foot hole. U-3ae is now completed at 640 feet, and preparations for use are moving rapidly, i.e., putting in coax, sampling system, etc." Although it was hoped to fire on October 28, this could easily slip to October 29. Dormouse, Ex.(b)(3) [redacted] Ex.(b)(3) was originally scheduled to be fired in U-3ah at 1,200 feet on November 1. Due to the addition of small holes drilled for attempted hydrodynamic yield measurement, which would not be finished until October 29, LASL was now hoping to lower the device on November 3 or 4 for a firing date of November 5 or 6. The main hole was now at 1,200 feet and casing was under way. Packrat, the next event scheduled, was originally to be November 15 in U-3ai at 1,200 feet. That hole was now at that depth awaiting casing, which could not be done until after casing U-3ah was completed because of lack of tools. After that, LASL expected to be able to do the shot one week after Dormouse, or about November 12. Thus, Ogle felt that, overall, LASL hoped to pick up a little time on the original schedule.

On October 25 the status of DASA funding needs for the various testing possibilities was forwarded to the Secretary of Defense. Of the total $40.5 million increment required for various projected test possibilities, $2 million was for underground test participation in FY 1962 and an additional $4 million would be needed to complete the Marshmallow test.

At LASL, the radiochemistry group (J-11) reported on October 25 that drilling for the core samples of the Boomer debris had not yet begun since the appropriate equipment was still engaged in trying to obtain core samples from Shrew, tested on September 16.

J-6 of LASL also reported on the status of the construction work at the Test Site on October 25. During the month, drilling and casing to extend U-3ae from 500 feet to 640 feet deep had been completed and casing had begun on U-3ah and U-3ai, indicating that drilling of these 1,200-foot holes had been completed. One other hole (U-3ak) had been dug to 1,215 feet and another (U-3am) was in progress, along with a number of smaller-diameter holes for diagnostics, dump holes, and exploration. Two new postshot drill setups had been ordered and were due for delivery by about November 24. A 100-ton crane was also ordered. H&N and REECo had been asked to propose a dry drilling method that would work in Area 3 for postshot and instrumentation holes. Coaxial cable for Area 7 balloons and J-15/Sandia time-of-arrival measurements had been ordered. J-6 had also spent some time with Sandia and DASA discussing stemming, radiochemical sampling, and operational problems with the Hardhat event, and had participated in discussions between Livermore, H&N, and the AEC on the Christmas Tree concept. J-8 of LASL, also reporting on October 25, had supported the Boomer event with pressure measurements and now had sufficient equipment for three pressure channels on Mink and on future events. They also had worked on planning for supporting timing and firing for 1962, in coordination with Sandia and EG&G.

An October 25 message from Hickey of ALOO noted that coaxial cable delivery schedules for the Nougat events had been worked out up through the end of 1961. It had been confirmed with Phelps-Dodge, the coax supplier, that additional cable could not be delivered earlier than certain specified dates in January, February, and, in some cases, April of 1962. Since the requirements for Nougat events after January 1, as well as the two DOD events in 1962, had not been provided to the cable supplier and answered with appropriate delivery schedules, there was a possibility of not being able to meet some of the shot requirements. Hickey also noted that the users had not yet supplied their requirements for the mid-term program (after February 1962). The next day Jim Reeves asked the Test Group Directors of LASL, Livermore,

DASA, and Sandia to review their scheduled Nougat event requirements based on the 1962 delivery dates for cable provided by Hickey. He further asked what relief would be gained if atmospheric testing were authorized and whether there were acceptable substitutes for any of the coaxial cable, "thus allowing program to continue after January 1."

An October 27 meeting of the LASL Weapons Working Group discussed the interesting fact that the Dormouse site was being delayed by difficulties in casing, possibly for several weeks. At the same meeting it was stated that balloon shots, if authorized for the NTS, would begin after the Mink shot, with a repeat of the Shrew device to verify the yield, followed by Dormouse and, tentatively, the rest of the Nougat schedule as approved. As a contingency, a pit for a repeat of the Shrew event had been ordered and was scheduled to be available at the Test Site on November 6.

General Betts wrote to the Laboratories on October 27, asking for several detailed comparisons. He wished to know the advantages, if there were any, of underground testing, a comparison in cost and time and instrumentation limitations for the vertical hole and tunnel techniques, and what should be pursued in the way of underground facility preparations in the event that atmospheric testing was authorized. He wished the Labs to answer by November 3.

On the same day, the Commission's General Manager, Alvin Luedecke, wrote to the Joint Committee on Atomic Energy summarizing the underground tests to date and including a lot of detail on current planning for future testing, underground and in other environments as well. Among other things he stated that approval for balloon testing at the NTS would permit acceleration of certain underground tests scheduled in 1962 by as much as four or five months.

On October 28 Norris Bradbury gave Betts a list of the accelerated execution dates of various planned Nougat tests if balloon testing at the NTS were permitted. He stressed that not only would the tests be accelerated, but that more accurate and more easily executed diagnostics would be possible. Kenner Hertford replied for ALOO on the same day, noting that ALOO could reduce the response time for the balloon program by two weeks if given the authority to fly practice balloons for training purposes. John Foster of Livermore replied the next day with several complete test series possibilities, giving the various options. His schedules all showed underground testing continuing even if atmospheric testing were authorized.

In an October 30 letter from Chairman Seaborg to President Kennedy, Seaborg stated that whether we did atmospheric testing or not, it was mandatory that the underground program be continued, very much in line with the Livermore opinion and not in line with Bradbury's approach to move completely above ground for the time being if that were possible. In a meeting three days later the National Security Council recommended that underground testing continue in parallel with preparations for atmospheric testing.

After delays in the emplacement process caused slippage of one day, Mink was detonated on October 29, and the initial report said that there was a small flash and some small gas seepage. Several hours later significant radiation levels were confined to areas within a 25-foot radius around each sample pot and the dump hole, and there was no radiation off site. There was one unusual incident: the Air Force B-57 sampling aircraft carrying Paul Guthals, the sampling controller for the tests, struck a weather tower on its second pass over ground zero, lost a sampling tank, and sustained some damage to one wing, requiring it to land nearby at Indian Springs Air Force Base. The tower crumpled and was a complete loss.

Communication between DMA and LASL at the end of October indicated the status of diagnostics on underground tests and the dearth of information from the underground techniques. General Betts noted that they had not yet received a firm yield figure for the Boomer event conducted at the beginning of October. Bill Ogle answered that

the only figure LASL could give at the moment would come from the prompt radiochemical samples. Ex.(b)(3) [redacted] The alpha measurements were about as predicted, but these did not give a precise yield figure. The various hydrodynamic measurements as yet had not provided yield figures. Thus, a good yield measurement was expected to come only from the core radchem samples after drillback, but that had not yet been completed and might take some time.

A message from Batzel to Betts on October 31 concerned the planned underground shot in dolomite. The fact that it was to be performed in a medium not yet used made it very important to Livermore that the device detonated be one whose yield was already well known. In addition, Livermore urged that radiochemistry not be the method relied on for yield determination due to the uncertainties of fractionation behavior in dolomite. Batzel also pointed out that because of the press of other underground construction for more immediate test requirements, Livermore was delaying the conduct of this shot.

These and other changes were the beginning of a shift in Livermore underground testing philosophy, no doubt based on their negative experiences with containment and contamination on their first two tunnel events. Milton Rex of the AEC wrote to Betts on October 26 about what had been discovered on reentry into both of the main Livermore tunnels, U-12b and U-12e. He described the areas that were free of radioactivity and the amount of debris blocking various areas, and stated that:

> The Laboratory (Livermore) plans to continue the current operations plan until the conditions beyond the 12e.03 intersection are known. At that time, a determination will be made as to the practicality or possibility of further operations in the 12e complex. It should be noted that reclamation activity is proceeding at a faster rate than would be possible for excavation of a new tunnel. It is hoped that radiation levels beyond the intersection will decrease and that reclamation progress will improve. We cannot predict at this time the impact of the reentry schedule on the present event schedule.

Livermore once again explicitly made known their feelings about development of the underground testing technique in a message from Batzel to Betts on October 31. Batzel began by noting that, to Livermore, the underground shot program was essentially independent of a decision to return to atmospheric testing, particularly with respect to preparing sites. He then presented a revised schedule, prefacing this with "Based on the LASL experience in Area 3 and the improved situation in e tunnel, we have developed a new site plan to match the present schedule." This schedule is shown as Table XXII.

TABLE XXII
LIVERMORE NOUGAT SCHEDULE
October 31, 1961

Event	Date	Shot Site	Ex.(b)(3) [redacted]
Mad	11/30/61	U-9a	
Feather	12/15/61	U-12b.08	
Platte	01/15/62	U-12k.01	
Brazos	01/20/62	U-12e.04	
Rogue	02/01/62	U-9b	
Kuskokwim	02/05/62	U-9c	
Cheyenne	02/10/62	U-9d	
Jordan	02/15/62	U-12i.01	
Columbia	02/20/62	U-12e.01	
Eel	02/28/62	U-12b.07	

The new schedule was a substantial departure from the most recently revised Livermore schedule. One significant change was Livermore's use of Area 9 for vertical hole shots such as those LASL had been performing in Area 3.

Darol Froman, LASL Technical Associate Director, responded on November 2 to queries by General Betts, getting LASL on the bandwagon by stating that even if atmospheric testing started, LASL urged that a stockpile of underground holes be accumulated in case atmospheric tests were again stopped. He said that any particular number of sites would just be a guess, but perhaps four sites for a megaton, four for 50-100 kt, four for 20 kt, and four for 10 kt. In spite of current casing difficulties, LASL still preferred holes to tunnel sites. Based on recent experience, LASL endorsed the 475 $W^{1/3}$ containment rule for the present time.

Jim Reeves further endorsed some of LASL's position in the November 2 ALOO reply by pushing to obtain a large inventory of both tunnel and vertical hole sites, much greater than existed before the moratorium ended. After Reeves had emphasized what kind of a stockpile of underground sites should be built up, he made an interesting recommendation to Betts, namely "that atmospheric testing be held to a minimum even at the expense of increased costs and acceptable delay in order to decrease to a minimum the probability of public opinion forcing an early termination of atmospheric testing."

The Livermore reply from John Foster on November 2 was slightly more elaborate than the others, still going very clearly down the road of developing extensive tunnel complexes. Livermore estimated that 12 portals would be required to provide a capability for about 50 tunnel site detonations per year, and Foster also pushed consideration of the Christmas Tree concept for higher-yield detonations. Foster did note several diagnostics problem areas requiring development for the tunnel sites, specifying these as:

> (A) There is need for a technique to give prompt yield data; (B) experiments such as Pinex and Phonex which involve recovery of data relatively close to the detonation point involve high risk of losing data due to rockfalls; (C) large-yield shots (50-100 kilotons) involve very long cable runs and consequent high cost to bring out diagnostic information. LRL is conducting research and development work in each of these areas and this must be continued until acceptable solutions are found.

He also stated that Livermore preferred tunnels because of the size and the large number of drifts per tunnel portal. He made an interesting and admittedly very gross comparison of the costs and time of preparation for tunnel sites and vertical hole sites, which is shown in Table XXIII.

TABLE XXIII
LIVERMORE COMPARISON OF COSTS AND TIMES FOR UNDERGROUND SITES
November 2, 1961

Yield Range (kt)	Cost (thousand dollars) Tunnel	Cost (thousand dollars) Hole	Preparation Time (days) Tunnel	Preparation Time (days) Hole
Less than 1	295	75	30	25
1-5	425	130	45	40
5-10	525	170	55	60
10-25	675	280	70	80
25-30	870	400	85	110

The poor results in collecting useful prompt radiochemical samples on LASL events continued with the Mink event, as reported by Charles Browne at the November 6 LASL Weapons Working Group meeting. The sample that had been obtained, in addition to being highly fractionated, was small in size and Browne concluded that the yield could not be estimated from the sample. Drilling had been started to obtain better samples from the core.

Of interest in comparing the Laboratories' diagnostic techniques was a November 9 message from C. Godfrey of Livermore to DMA on the radiochemical yield for Chena, Ex.(b)(3) [redacted] Thus, Livermore, by a tunnel technique, claimed to be able to measure yield with 10 percent uncertainty from radiochemical sampling within a month of their shots.

In Betts' November 4 message to the Laboratories on the results of the National Security Council meeting, he noted a change in the quantitative character of the projected Nougat program derived from the Laboratory directors' messages on October 28 and 29. He told the Labs that he now would require detailed revisions to this program before asking for Presidential approval for increased expenditure of nuclear materials, which would be substantially different from that authorized in September. Thus, he asked that Reeves convene the NTS Planning Board to provide a revised detailed listing of diagnostics, cabling, device availability, and other considerations needed for the Nougat schedule through the end of February 1962, requesting these revised Nougat plans by November 9. He noted that Seaborg had indicated that the underground program should be vigorously continued. Curiously, there was absolutely no mention made of atmospheric testing by balloons or other methods at the NTS.

In response to Betts' November 4 request, Bradbury sent a new LASL Nougat list of 13 tests, of which less than half had previously been approved. The list is shown in Table XXIV. Noting that LASL wished to test the Fisher device next because of the behavior of the Mink device, Bradbury requested DMA approval for that shot to occur on November 16 in hole U-3ah. No dates or exact locations were given for the other tests, since they depended upon the availability of holes and the results of related current tests. The November 11 NTS Planning Board would consider such detailed scheduling.

DMA responded to Bradbury's request on November 10, following some telephone conversations, notifying LASL that the AEC was trying to obtain Presidential approval for the addition of the Fisher event with a proposed date of November 19.

The NTS Planning Board met on November 11 in Albuquerque and Reeves immediately thereafter provided DMA with an up-to-date modified Nougat test list. Some of the details of the new list, which contained 27 devices to be tested before the end of February 1962, are shown in Table XXV. Of the 12 Livermore shots planned through the end of February, six were now planned for vertical holes in Area 9. The other six were planned to be done in the i and k tunnels, on which construction had begun since test resumption, and in the b and e tunnel complexes, which still required some recovery work. In addition to the effort required to prepare these underground sites, the Planning Board addressed the Ivanhoe series (Table XXVI), which was to commence underground on March 1 and continue through the end of the fiscal year (June 30, 1962). The Laboratories presented preliminary programs requiring a great deal of additional construction. This was set forth by Reeves to the AEC and to contractors required to prepare the underground sites.

The Livermore program for Ivanhoe resulted in the following projected construction program: 18 separate tunnel sites (some double tunnels) to contain tests up to 100 kt; and more sites in either tunnels or Area 9 holes to contain up to 50 kt. Noting that the Planning Board supported all of this long lead time construction for

TABLE XXIV
LASL NOUGAT TEST LIST
November 4, 1961

Device	Yield (kt)	Nickname	Previously Approved for Nougat
Ex.(b)(3) [redacted]		Fisher	No
		Packrat	Yes
		Ferret	Yes
		Coney	No
		Dormouse	Yes
		Woodchuck	Yes
			No
			No
			No
			No
			Yes
			No
			No

Ivanhoe, Reeves asked his assistant, Milton Rex, to develop cost and time estimates for the overall program since he expected that there would be funding problems and wanted to make DMA aware of these as soon as possible. By the end of November, LASL reported that there were five underground sites complete, with about 20 additional drilling jobs in progress.

On November 14 ALOO published one of their periodic listings of the projects in which they were involved or had done planning. Under the Vela Uniform program they showed the Dribble and Shoal programs as needing lots of work and the Shade program as in progress, including support of DOD measurements-- primarily seismic--at the NTS. The Plowshare program included three active projects; Gnome, discussed elsewhere, and Wagon and Chariot still being addressed. (It is not at all clear what the status of Wagon and Chariot was.) Under DOD support, the Marshmallow effects test involved installation of 800 feet of vacuum pipe in a new tunnel facility, which was being prepared in the Oak Springs tuff of Area 16 at the NTS. Hardhat, which included structural response experiments as well as Vela Uniform experiments, required a tunnel and hole in Area 15.

Reeves continued specifying NTS authorizations on November 14, directing Rex to proceed with construction of U-3ah and with emplacement for the Fisher test (excluding stemming) to meet the November 19 date provided to DMA, though that test did not have final approval. (That approval came only on November 17.) Furthermore, Reeves directed that construction proceed on U-3ao and U-3ad for LASL events Dormouse and Coney on Janary 5 and December 12, respectively, and on Area 9 Holes a, b, c, and d for four new Livermore events. For the longer term, he reiterated the request for the best available time and cost estimates for the overall Ivanhoe effort, charging Rex to coordinate thoroughly preparations for that program at the field level in real time to assure there was continuing need for the facilities.

TABLE XXV
MODIFIED NOUGAT, NTS PLANNING BOARD
November 11, 1961

Device	Sponsor/ Nickname	Yield (kt)	Location	"R" Date	DMA Approved Date
Ex.(b)(3)	LASL/Fisher	Ex.(b)(3)	U-3ah	11/19/61	New
	LASL/Packrat		U-3ak	11/29/61	Early Nov. 61
	LRL/Mad		U-9a	11/30/61	New
	LASL/Ferret		U-3ai	12/08/61	Mid-Dec. 61
	LRL/Feather		U-12b.08	12/08/61	Mid-Dec. 61
	LRL/Gnome (Plowshare)		Carlsbad	12/10/61	12/10/61
	LASL/Coney		U-3ad	12/12/61	New
	LASL/Ringtail		U-3ap	12/19/61	Mid-Feb. 62
	LASL/Dormouse		U-3ao	01/05/62	Mid-Nov. 62
	LASL/Woodchuck		U-3am or U-4b	01/15/62	Mid-Jan. 62
	LASL/Lemming		Area 3 (700 ft)	01/25/62	New
	LASL/Talpa		Area 3 (700 ft)	01/25/62	New
	LRL/Platte		U-12k.01	01/15/62	New
	DOD/Hardhat		U-15a	01/15/62	Early Jan. 62
	LASL/Aardvark		U-4b or U-3am	01/15/62	New
	LRL/Cimarron		U-12e.04	01/20/62	New
	LRL/Skagit		U-9e	01/62	New
	LRL/Umptua		U-9f	02/62	New
	LRL/Rogue		U-9b	02/01/62	New
	LRL/Kuskokwim		U-9c	02/05/62	New
	LASL/Platypus		Area 3 (250 ft)	02/07/62	New
	LRL/Cheyenne		U-9d	02/10/62	New
	LASL/Pangolin		Area 3 (1200 ft)	02/15/62	New
	LRL/Jordan		U-12i.01	02/15/62	Mid-Jan. 62
	LRL/Brazos		U-12b.07	02/20/62	New
	LASL/Sorillo		Area 3 (1200 ft)	02/27/62	New
	LRL/Eel		U-12e.01	02/28/62	Early Feb. 62

TABLE XXVI
LASL UNDERGROUND SITE PROPOSAL THROUGH FY62
(IVANHOE)
November 1961

Quantity	Depth (ft)[a]	Area	Date Required
2	1,000	3	March 1962
2	2,500	New Site	April 1962
2	1,600	3	April 1962[b]
2	1,000	3	May 1962
2	1,200	3	May 1962[b]
1	2,200	3	June 1962
3	200	3	March 1962
1	6,000	U-15d	June 1962

[a]All holes were to be 3 feet in diameter.

[b]These may be heavily instrumented, involving shaft construction and room or drift at bottom of shaft and several auxiliary holes.

These proposed expanded schedules for Nougat were discussed by the Commission on November 16. In discussing the feasibility of supporting such an expanded schedule, Betts said that ALOO "has unqualifiedly indicated the necessary increase can be achieved if vertical shafts can be utilized; it is less certain if tunnels are required." Betts also noted that as a result of the Chena event in U-12b.09 there was danger of excessive radiation exposure to the miners now attempting to clean out that tunnel for further testing. The then current dose limits recommended by the Federal Radiation Council (FRC) were 3 rem per quarter and 5 rem per year; 3.9 rem quarterly and no yearly limitation had been used on the most recent EPG test series. The General Manager noted that few of the miners working in the tunnel had exceeded the quarterly limit of the FRC, but in view of the danger of a large exposure at some point in the tunnel, it was uncertain at what pace the tunnel could be cleared. Discussion of funding for testing in the same meeting included concern expressed by Commissioner Wilson about Betts' remark that funds might have to be diverted from the underground program to initiate preparations for atmospheric testing. Betts explained that funds taken from the underground program would be redirected only with assurance that they could be replaced later, thus allowing the underground program to continue as scheduled while expediting the atmospheric test program.

The frank opinion of one of the experts in the testing community, Bill Ogle, on the greatly expanded underground programs being readied in parallel with the atmospheric test preparations, was expressed in an internal LASL memorandum of November 17, "Outlook for Nougat/Ivanhoe." In the transmittal letter attached to a listing of some 14 LASL devices considered for testing before the end of February 1962 was the following:

> In all the wild dreaming going on recently in the weapon test business, a set of devices, holes, etc., have been associated with Operation Nougat in order to obtain authority to do field construction, expend active material, etc. . . . I am unaware of anyone who believes there is any serious relationship between this listing and what will actually happen. However, for what it is worth, the appended table is presented. (Ed. note: table not included here.)

Livermore's overall projections were even more grandiose, in addition to their relying most heavily on a tunnel testing technique which had had very poor success to date.

By November 10 one possible method of alleviating the cable shortage problem had been tried and found not to work. The United Kingdom, which had a large amount of surplus cable, had offered this--through Headquarters, AEC--to the test community. However, after an exchange of information and correspondence Reeves informed Betts that none of the Laboratories had a practical use for the British cable, which had originally been offered about a month earlier.

Adding to the problems of achieving the ever-growing program at the NTS was the fact, discussed at a Commission meeting on November 21, that the pipe fitters and operating engineers at the Site had had a disagreement and the pipe fitters had gone on strike, establishing a picket line which certain of the other unions had refused to cross. Luedecke noted that the Rover project was being delayed on a day-by-day basis and the weapons test program would be seriously affected.

The expanded Nougat test program was sent by Betts to Chairman Seaborg on November 28 along with a proposed letter to the President requesting authorization.

Radioactive Contamination of Tunnels

A brief description of the tunnel contamination problems was included in a letter from General Manager Luedecke to the Chairman of the JCAE, Chet Holifield, on November 29. Luedecke pointed out that the Antler test:

> . . . resulted in loss of entry into the U-12e tunnel complex because of the contamination and spread of debris through the side drift and the main tunnel. . . . Following the Antler shot, a program was commenced to decontaminate and rehabilitate the U-12e tunnel complex so as to attempt to salvage four shot locations which had been previously constructed. . . . U-12e tunnel rehabilitation has been accomplished to a point about 1,800 feet from the portal. At this point, the tunnel is plugged by a mass of debris from the side drift where the Antler device was placed. It has been determined that rather than attempt to remove the debris plug, it should be bypassed and work is proceeding. Until we are able to complete the bypass, we will not know whether the remaining shot sites of the U-12e tunnel can be used. . . . In addition to the difficult situation in regard to the U-12e tunnel complex, we have a troublesome problem with regard to tritium in a portion of the U-12b tunnel complex. This problem arose after the Chena event and was complicated by the tritium residue remaining from the Evans event of Hardtack II. The combination of the external radiation whole body exposures in the U-12e tunnel and the additional internal exposure in the U-12b tunnel has resulted in 108 miners and supporting personnel receiving, as of November 24, 1961, a combined whole body exposure in excess of 3 rem in one quarter and of these, 38 in excess of 5 rem in one year. No individual was exposed to more than 8.045 rem. . . . Because of our inability to continue full-scale tunnel operations within the established normal peacetime radiation criteria, the U-12b and U-12e tunnel operations were curtailed on November 27, 1961. Underground workers who were approaching 3 rem per quarter were removed from the tunnels, as well as any individuals who may have received a dosage of more than 3 rem per quarter.

What would this do to the expanded Livermore plans for building up a large stockpile of tunnel sites? Part of the answer was included in a message the same day from Cliff Bacigalupi of Livermore to Jim Reeves which stated, "Reentry into the E tunnel complex indicates that the U-12e.01 and U-12e.04 locations cannot be used for the Cimarron and Brazos events in the near future. In order to maintain the Nougat schedule, it will be necessary to develop new emplacement locations for these events." Thus, he requested approval for construction of new sites in Area 9.

In light of these problems, it seems that the death knell for the Christmas Tree concept could already be heard. The Christmas Tree working group had continued to

meet through November, and on November 9 H&N had submitted preliminary cost estimates for various sites which were being evaluated for this complex. The estimates for seven possible locations in Utah, California, and New Mexico ranged from about $5 million to $8 million. By the end of November a final draft of the Christmas Tree report was being reviewed by the committee and other concerned people. LASL had made it clear that while they were not interested in developing the concept, they would continue to evaluate it and keep informed in order to be ready to utilize it if it proved feasible.

More Nougat

LASL finally got a chance to see if the radiochemical samples obtained by drilling back would give better results than the prompt samples and other techniques. On November 17, drillback of the first LASL shot, Shrew, brought some samples to the surface. Charles Browne reported the observations and analysis results to the LASL Weapons Working Group on November 27:

> The general activity level remained constant in the hole from a depth of 310 feet down to a 3-foot void encountered at 335 feet. The activity then jumped by a factor of 10 or more at the void, returned to the initial level from 338 feet to 343 feet, then fell off to zero at about 350 feet. Data was taken from samples obtained around 325 feet, at the level of peak activity, and at 343 feet. The fractionation pattern appeared reasonable, with very little fractionation at the 330-foot level, an excess of volatiles at the upper levels, and an excess of refractories at the lower levels. . . . Ex.(b)(3) [redacted] The drillback on the Mink hole is now down to 425 feet. Complete samples are expected sometime this week.

The value of these more accurate results was immediately evident from a discussion opened by Harold Agnew on corrections which might be made to the Ex.(b)(3) on the basis of the Shrew yield results. Ex.(b)(3) [redacted] Ex.(b)(3) [redacted]

At the same meeting, the upcoming schedule presented by Ogle listed Fisher to be shot sometime in the next week, followed by the next two or three shots at about one-week intervals.

> Holes exist for Packrat, Ferret, and Coney, with only surface work remaining to be done. The hole for Ringtail is not yet available. Subsequent to the discussion of the Ex.(b)(3) [redacted] . . . it was noted that, in order to fire Ringtail in December, it might be necessary to skip one of the preceding shots. Ferret could be delayed if necessary. The present order of events then is Fisher, Packrat, Ringtail, then Ferret and Coney, all hopefully before the first of the year.

When the time to perform Fisher finally did arrive in late November, following delays because of strikes at the Test Site, the event was postponed due to a mechanical problem discovered during insertion. The shot was first slipped to December 1, then December 2, and then postponed 24 more hours because of flooding and danger of shorting a transformer at the alpha station. Although electrical problems were still present on the morning of the test, it was detonated on December 3. It Ex.(b)(3) [redacted] Ex.(b)(3) [redacted] involved new diagnostic techniques, and was detonated about 1,200 feet deep with essentially 100 percent containment. It resulted in the largest subsidence crater yet. The crater, which formed 27 minutes after the event, was 50 feet deep and 585 feet in diameter. Furthermore, as Charles Browne reported at the

WWG meeting on December 13, prompt sampling yielded the best sample yet recovered by that technique, the sample pipe data showing between Ex.(b)(3) fissions. Al Graves, the Scientific Advisor to the Test Manager, reported immediately after Fisher that the crater "now contains rubble from one red shack, one white shack, one red and white shack, one blue shack, one silver shack, and one Chic Sale." One of the lessons learned from the extensive cratering following the Fisher event, as can be seen in Figure 12 (a, b, and c) was the possibility of damage and loss of equipment. Three amplifiers and a power supply were completely destroyed and a zero rack and other things suffered lesser damages.

The Nougat schedule as recently revised had not yet been fully approved, and it was still loosely defined. LASL was reconsidering the Nougat schedule in order to conduct those experiments relevant to Blue Straw (the Pacific Operation) as soon as possible, and reached the conclusion that those tests leading to a Ex.(b)(3) Ex.(b)(3) were to have first priority. The devices considered important as candidates for this role were Ex.(b)(3) The first of these was to be tested in the Ringtail event and that shot was moved ahead to utilize the existing Packrat hole, which was 200 feet deeper than the 1,000-foot depth planned for Ringtail. This switch necessitated several days delay in Ringtail, which was scheduled as the next LASL event on December 20. That change left Livermore's initial vertical hole test, Mad, as the next event. The AEC Chairman approved Mad on December 8 and it was performed on December 13. It was the first Livermore event of this series to be completely contained.

Toward Normalcy in Nevada

On December 12 General Betts formally requested from the Laboratories a reassessment of their underground programs in the light of two main assumptions: (1) that the underground program would not be terminated in the near future so that efficiency of operations might become a primary factor, and (2) that the atmospheric test program would begin about April 1 and consist of a program approximately as presented to the President on November 30 (see Chapter IV). Betts requested that the Laboratories provide detailed event plans, including firing location, device readiness date, etc., for their programs through the end of March, and he wished these to be sent to him by April 1. Moreover, he requested a tentative list of additional tests (with less detail) covering the April 1 to June 30 period. Concurrently, Betts asked Reeves to have the NTS Planning Board consider the feasibility of providing suitable locations for each of the suggested Laboratory tests. As a guideline, with no clarifying elaboration, Betts said this should be based on "resuming a normal, noncrash set of operating conditions at the NTS." Following receipt of the desired information from the Laboratories and Planning Board, Betts would request approval for the revised schedule through April 1, 1962. In another message from Betts to Kenner Hertford on the same day, the budget problems arising from the enlarged underground program projections were evident. Betts reported that because more money was needed for the larger underground program, the AEC had, for the time being, deleted a substantial number of the items in the Ivanhoe program.

Some clarification of DMA guidelines was provided by Reeves prior to a December 20 NTS Planning Board meeting. Specifically, the definition of "normal, noncrash set of operating conditions" was to be construed as a 40-hour workweek for all crafts where possible, but providing for three-shift operation for those functions which normally work on that basis. For the Test Site technical and management staff, a 54-hour workweek was considered normal during a test series. In addition, the radiation exposure standards to be utilized in NTS operation would be to limit whole body

Figure 12.
(a) Part of teletype from Al Graves, Scientific Advisor for the Fisher event, to the Test Manager, referring to above photograph of the Fisher event.

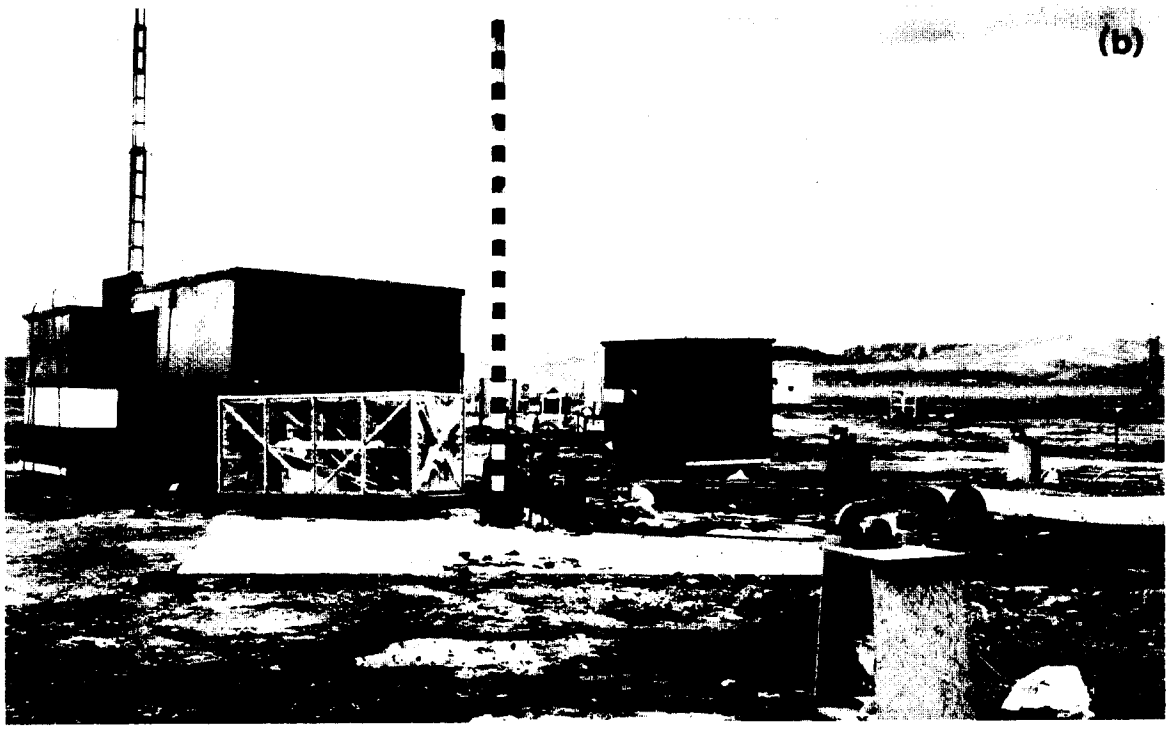
P 031822Z DEC 61

FM GRAVES SCIENTIFIC ADVISOR

TO REEVES, AEC TEST MANAGER

THE CRATER NOW CONTAINS RUBBLE FROM ONE RED SHACK, ONE WHITE SHACK, ONE RED AND WHITE SHACK, ONE BLUE SHACK, ONE SILVER SHACK, AND ONE CHIC SALE.

Figure 12. (cont)



(b) Close-up view of Fisher buildings before detonation.

(c) Close-up view of some of the same Fisher buildings after collapse.

radiation to 3 rem per quarter and 12 rem per year, provided the quantity 5 times (N minus 18) rem, where N is the individual's age, was not exceeded. (Ed. note: Obviously, it was assumed that there were no workers younger than age 19.)

Improvement in LASL's ability to obtain delayed radiochemical samples for yield determination was reported by Charles Browne at the WWG on December 13. Drillback samples on Shrew, Boomer, and Mink had been obtained and second drillback holes were being started. Drillback on the Fisher event was already at 600 feet, and the average drilling rate was about 100 feet per day. Thus, techniques using the newly acquired rigs had been successful in greatly accelerating the acquisition of postshot radiochemical samples. Two days later, on December 15, the drillback went 190 feet in one day, the highest rate per day yet attained.

The W-, J-, and T-Divisions within LASL got together on December 14 to modify the underground test schedules in light of the atmospheric test considerations and the test results to date. Norris Bradbury communicated this revised list to General Betts late that day. It was based on roughly ten days between shots (with the exception of one-point safety tests) Ex.(b)(1) [redacted] Ex.(b)(1) [redacted] Bradbury said that if the United Kingdom shot were delayed until after April 1, LASL would be more confident of performing Aardvark, which was slightly squeezed because of the British test. [redacted] Ex.(b)(3) [redacted] A follow-on tentative list for April through June showed 10 tests. Ex.(b)(3) [redacted]

On the same day, December 14, Foster sent Livermore's revised list to Betts. [redacted] Ex.(b)(3) [redacted] Substantial use of the tunnel areas was still planned as shown in the attached Table XXVII. This table shows the pertinent information for both the LASL and Livermore shots as presented to Betts. As noted several days later by Reeves, the urgent need for integrated answers made it impractical to assemble the Planning Board in time to meet DMA needs. Consequently, a later Planning Board session would include review and refinement of these schedules, but that session would not be held until general concurrence and approval of the schedule had been received from Washington.

On December 5, in discussion between Hans Bethe and Bradbury, Bethe indicated his preference for tunnel testing over vertical holes. These comments led to a December 15 memorandum from George Cowan, the LASL radiochemistry group leader, to Bradbury, summarizing the status of radiochemical sampling from vertical hole tests. The memorandum notes that experience on prompt samples had been very poor, but that the Fisher event had finally yielded the first useful prompt sample from a shot of multi-kiloton yield. Delayed sampling to that date had had one- to two-months delay, but with the latest equipment this delay was coming down to a matter of weeks. This shorter delay permitted reasonably accurate determination of yield Ex.(b)(3) [redacted] Ex.(b)(3) [redacted] LASL had had greater drillback problems than Livermore because it was more difficult to drill in uncompacted alluvium than in compacted tuff. Overall, however, Cowan felt that Bethe's conclusions were based on overly-optimistic statements about tunnel containment, statements not in accord with experience to date, and that the only significant advantage of tunnels over holes was the ease of some line-of-sight experiments, rather than in sample recovery. Bradbury utilized Cowan's summary in his December 20 reply to Hans Bethe comparing tunnels and holes for underground testing in which the desired results were primarily yield, alpha, and some timing information. Bradbury noted that so far the tunnel shots had all given trouble to a greater or lesser

TABLE XXVII
LASL AND LIVERMORE PROPOSED NOUGAT SCHEDULES
December 14, 1961

Nickname	Sponsor	Ex.(b)(3)	Location	Possible Firing Date
Ringtail	LASL	[redacted]	U-3ak	12/17/61
Feather	LRL	[redacted]	U-12b.08	12/20/61
Stoat	LASL	[redacted]	U-3ap	01/09/62
Umptua	LRL	[redacted]	U-9e	01/10/62
Packrat	LASL	[redacted]	U-3aq	01/19/62
Anteater	LASL	[redacted]	U-3ao	01/09/62
Platte	LRL	[redacted]	U-12k.01	01/31/62
Cimarron	LRL	[redacted]	U-9d	02/01/62
Dormouse	LASL	[redacted]	U-3ai	02/08/62
Coney	LASL	[redacted]	U-3ad	02/13/62
Agouti	LASL	[redacted]	U-3at	02/18/62
Rogue	LRL	[redacted]	U-9g	02/21/62
Pampas	U.K./LASL	[redacted]	U-3al	02/28/62(?)
Brazos	LRL	[redacted]	U-9h	02/28/62
Jordan	LRL	[redacted]	U-12i.01	03/01/62
Aardvark	LASL	[redacted]	U-4b	03/03/62
Kuskokwim	LRL	[redacted]	U-9c	03/07/62
Armadillo	LASL	[redacted]	U-3ar	03/10/62
Des Moines	LRL	[redacted]	U-12j.01	03/14/62
Ermine	LASL	[redacted]	U-3az	03/15/62
Cheyenne	LRL	[redacted]	U-9b	03/15/62
Lemming	LASL	[redacted]	U-3ax	03/20/62
Chipmunk	LASL	[redacted]	U-3ay	03/25/62
Columbia	LRL	[redacted]	U-9i	03/28/62
Chinchilla	LASL	[redacted]	U-3az	03/30/62

degree with their lack of containment, whereas the vertical holes had given no such trouble. This was particularly significant from a personnel exposure point of view. LASL had also been able to fire about twice as many shots as Livermore and all of LASL's shots had and would have prompt diagnostics. Bradbury did agree that for heavily diagnosed, heavily collimated experiments, tunnels were probably preferable to vertical holes. Further, he observed that Bethe's point was probably not that tunnels were so much better than vertical holes, but that LASL should believe "more fervently in the virtues of underground testing." While acknowledging the place of underground testing, Bradbury expounded on his strong feelings about preparing and carrying out atmospheric tests, feelings based on his perception of the realities of the international situation.

Since there could be no Planning Board meeting in the time required to submit the revised schedule (noted earlier), Reeves felt that the separately determined and submitted Laboratory schedules should be reviewed with those who had to support them. This occurred in a meeting on December 16 and 17 with the best qualified personnel of his office, H&N, and REECo. The result was concurrence that the proposed Lab schedules were practical and could be done efficiently at a cost of $121 million in FY 1962 and $28 million in FY 1963. Although they clearly felt themselves under some pressure to reduce the overtime costs and cut down the number of people working many

extra hours per week, the contractors made a case for continuing the drilling program through the summer using three crews, each crew working seven days per week, eight hours per day. Part of the justification, other than that it was required to meet the Lab schedules, was the cost of the rented drill rigs (they were approximately 40 in number) and the impracticality of shutting down rigs on weekends (because of problems such as mud circulation). Moreover, adding another shift to decrease the hours per man would have greatly increased the numbers that would have to be supported with living facilities, thus causing other indirect costs and problems at the Test Site. The same sorts of arguments applied for the crews involved in tunneling, where an average workweek of 54 hours for the present crews would still require hiring additional men to meet the Laboratories' programs.

LASL detonated its fifth Nougat event, Ringtail, on December 17, and the good record for containment continued: containment was essentially complete, with the highest radiation levels being near the prompt sampling pots and no radiation outside the immediate test area. Diagnostics results were discussed in a WWG meeting three days later. Westervelt reported that the J-10 alpha station had gotten results which had been analyzed partially. Charles Browne reported that, in contrast to Fisher, there was no indication of a good prompt rad-chem sample. Drillback had begun some distance from the well head and a new (to the NTS) technique known as Whipstock drilling was being used, in which the direction of drilling may be altered during the operation to intersect the original hole at the appropriate depth. A brief summary of LASL progress in radiochemical sampling techniques for underground shots was provided at the last WWG meeting of 1961 on December 27. George Cowan summarized the results from the five Nougat shots as follows:

> Analysis of drillback samples gave a radiochemical yield of Ex.(b)(3) [redacted] Boomer samples were not yet analyzed. Mink drillback samples gave a radiochemical yield of Ex.(b)(3) [redacted] Ex.(b)(3) [redacted] Fisher had the first useful prompt sample, which showed the yield to be greater than [redacted] Ringtail had brought no results as yet.

Livermore's containment problems continued on the Feather event on December 22. Immediately after firing, a small cloud came out of the tunnel portal (U-12b) and the vent pipes on top of the mesa also expelled a cloud. Activity half an hour after the shot was about 3 R per hour at the portal and the vents, and off-site activity was not anticipated. In spite of the venting it appeared that early recoveries of film could be accomplished. Six hours after the test it was reported that diagnostic data had been recovered from all stations outside the portal, but reentry would not start until about January 3, 1962.

J-15, the LASL hydrodynamic group, reported just before the end of the year that the Fisher event had been the first one instrumented for time-of-arrival measurements. These measurements, together with data on the media and the equations of state, would, with time, lead to improvements in this yield technique. As of December 22, about three weeks after the shot, J-15 analysis of these measurements gave an estimated yield of 13 plus or minus 4 kt.

Livermore Rethinks Tunnels vs. Holes

Livermore, in a message from Roger Batzel to General Betts on December 19, took stock of their present experience in stemming tunnel detonations and outlinged some new ground rules they felt were valid. From their point of view, looking back over not just Nougat but all the tunnel experience, there had now been four detonations

with yield greater than 1 kiloton, three of which (Rainier, Blanca, and Logan) had been successfully contained. The fourth (Antler) vented. Ex.(b)(3) there had been three events, all of which had released significant radioactivity into the tunnel (Tamalpais, Evans, and Chena). As for Chena, since they were able to reenter the b tunnel within a few days after the event, Livermore considered it acceptably contained. Thus, their experience had led them to conclude Ex.(b)(3) Ex.(b)(3) , and they felt the underground program should utilize a combination of tunnels and holes in an appropriate combination. In what was certainly a new approach for Livermore, Batzel said:

> We believe that the optimum manner to use tunnels is one in which a single shot site is constructed for each separate tunnel entrance, and then, depending on the subsequent situation on radioactivity, we would either reuse the individual tunnel for a following event or, if excessive radiation levels exist, we would abandon that tunnel for the time being and let the radiation decay to an acceptable level before reuse. . . . Based on our past experience, we would expect that 60 to 70 percent of the time, a given tunnel could be reentered without delay. We are convinced that given another six months to one year of (Ed. note: "of" inserted) experience, we can significantly improve the probability of successful stemming.

In a statement somewhat in conflict with the Livermore Director's recent statements about being device limited, Batzel added: "It should be remembered that as of the present time and probably at least through the first of May, we are still site limited and some important experiments which are ready for execution cannot be done because of the lack of sites and tunnels." Batzel then turned to the vertical holes which he called an important complement to tunnels, especially for those shots which required a minimum of diagnostics. Livermore was not only expanding the Area 9 hole operation, but also was doing preliminary planning for another area along the west side of Rainier mesa where the water table problems for deep holes might be more simply solved. Moreover, Livermore was discussing vertical hole drilling with a limited number of outside contractors, such as Kerr-McGee. Finally, in answer to a recent query from General Betts about the expensive high-yield test methods of the Christmas Tree concept, Batzel stated:

> In light of our existing experience, LRL also has reservations about the feasibility and desirability of starting construction of a Christmas Tree facility at this time. As we gain more experience about the problems of stemming, radii of damage, and the effects of geology, we will be in a position to make a firm recommendation.

Finally, he expressed the Livermore position that developing a space testing capability was very important, adding that they were concentrating on plans to develop diagnostic techniques and instrumentation for that regime, and it was urgent that the techniques be checked out during the forthcoming atmospheric tests.

Other Nevada Topics

Vela Uniform

Further information on the status of the Vela Uniform program was provided to DMA by Jim Reeves on December 21. The off-NTS program (Dribble) was being maintained in a "bare standby condition for a period of 6 to 12 months." The Shoal event was being treated in a special manner aiming for preparations for a shot, perhaps in

1964. Note was made of the Whirlaway devices prepared for the moratorium Vela program, which were being stored and maintained by Sandia. Reeves asked DMA for further guidance or concurrence with the present status.

Intentional Venting Study

At about this same time, on December 22, Betts raised a question on the utility and effectiveness of intentional venting as a means of alleviating the contamination problems encountered to date, especially in tunnels. Specifically, he asked for comments and recommendations concerning detonation of underground shots so as to form high chimneys which would produce slight intentional venting, thus reducing tunnel contamination.

For a brief period Graves endorsed this as a method of decreasing the time spent in drilling holes for emplacement and sample recovery, feeling that it might be worth investigating in order to establish some assurance that intentional venting could be accomplished without undue risk of off-site radiation. Don Shuster of Sandia said he was not optimistic about using controlled chimneying to lessen tunnel contamination. For one thing, it was hard to plan for chimneying soon enough to relieve pressures on the stemming, thus controlling the venting in the desired method. Batzel answered a little more elaborately, including in his remarks some discussion of the major mechanisms of containment failure in tunnels. In the Antler failure, where water in the hot cavity resulted in a steam explosion, controlled venting probably would have prevented the contamination of e tunnel. Ex.(b)(3) [redacted] Ex.(b)(3) [redacted] All of these items, including the debates about the depth of burial scaling constant and the exponent on the yield, illustrated the fact that containment design principles and the mechanisms of venting were not fully understood and were complicated by the various media and site locations. Underground testing was very much in the learning stages.

Simultaneous Detonations

Ex.(b)(1) [redacted] The replies from the Laboratories indicated that it would be feasible, but it was not desirable operationally since there were not sufficient alpha stations to allow one Laboratory to do more than one detonation at a time. To schedule simultaneous shots from the two separate Laboratories would raise operational and planning problems that nobody desired. Reeves, in the ensuing discussions, made some related points about the interpretations of overt actions such as the arrival of specific types of people on or near shot day. He noted that people in the local area (Las Vegas) came to be aware of such things, could guess the occurrence of shots, and might deduce what was going on should both Labs fire at the same time. Reeves formally transmitted his opinions to Betts on January 10, 1962, noting that it was technically and operationally possible to fire a LASL and Livermore shot almost simultaneously, but that the delays to achieve such an objective were not warranted for three reasons. First, in order to meet the proposed overseas device schedule, the Labs could not stand delays in their planned NTS programs. Second, delays were cumulative for each Lab, i.e., a delay in an Area 3 shot would delay all of the shots in that area. Finally, the fact that there were to be two devices prepared and fired on the same day could not be protected since "the necessary use of Red Badge (Ed.note: uncleared) personnel to meet construction requirements, the buildup in communications traffic, the mere

arrival of key personnel in Las Vegas all disclose shot intentions and cannot be eliminated without serious schedule delays." The Labs at this point seemed to have the attitude that if it happened that they both arrived at shot readiness at the same time, it might be worth trying but not otherwise.

Nougat in 1962

As an aside, it is interesting to note that by the beginning of 1962, the numbers of personnel involved in NTS activities had increased significantly. Employment by the 25 or more contractors had grown from a total figure of 5,326 on November 11 to 6,454 on December 9, 1961. The growth was almost entirely accounted for by REECo, which grew from 3,865 to 4,910 in this period. Not all of these were in residence at the NTS, but that segment had grown from 2,997 on November 11 to 3,840 on December 9. As of December 11, there were only 150 unassigned housing spaces at the Test Site, and on that date REECo was processing 153 new hires. Thus, all available housing was committed. Another example of confusion resulting from the very busy work schedule involved changes in the construction work scheduling which arose from discussion among the NTS AEC staff and the construction contractors, but not including Laboratory representatives. This type of confusion led to strong objections being voiced by the Laboratory representatives at the January 3, 1962, meeting of the NTS Planning Board. The result, of course, was agreement among all participants that, subsequently, any changes in construction activities would be coordinated with the Laboratories. A further result of the meeting was a new schedule, extending through the end of March 1962; see Table XXVIII.

Also early in the year, Livermore summarized their diagnostics results to date:

> On the Antler event, radiochemistry gave a yield of 2.45 plus or minus .3 kt. The other diagnostics were to be done by equipment installed in the tunnel, in the interest of minimizing the time to get ready, and due to the postshot steam explosion this fast electronic data was not recovered.
>
> The Chena event resulted in radiochemistry indicating a total yield [redacted]
>
> Ex.(b)(3) [redacted]
>
> The Gnome event in the Plowshare program had as one of its objectives gathering diagnostic information on a Ditchdigger configuration. Diagnostic data was by and large not yet available since the radiochemical sample obtained was still being analyzed and gaseous fission products released from the main shaft fogged some of the fast electronic film, making it then appear that data on the primary had been lost. Some data on the secondary had been salvaged and was being analyzed.
>
> On the Mad event a radiochemical sample was obtained and it was then being analyzed [redacted]
>
> Ex.(b)(3) [redacted]
>
> The Feather event had a yield in the 100-300-ton range based on external effects and peak gamma data. [redacted]
>
> Ex.(b)(3) [redacted]

On January 10 General Betts informed the test organization that the newly revised Nougat schedule through the end of March had been approved by the President, who also had approved the required expenditure of special material. The only event omitted was Pampas, the detonation for the United Kingdom, which would be handled separately.

TABLE XXVIII
UNDERGROUND SCHEDULE, NTS PLANNING BOARD
January 3, 1962

Nickname	Sponsor	Location	Ready Date
Stoat	LASL	U-3ap	01/09/62
Agouti	LASL	U-3at	01/19/62
Anteater	LASL	U-3ao	01/29/62
Codsaw	LRL	U-9e	01/31/62
Platte	LRL	U-12k.01	02/07/62
Rogue	LRL	U-9g	02/07/62
Dormouse	LASL	U-3ai	02/08/62
Coney	LASL	U-3ad	02/13/62
Cimarron	LRL	U-9d	02/14/62
Brazos	LRL	U-9h	02/28/62
Hardhat	DOD	U-15a	01/15/62
Packrat	LASL	U-3aq	?
Pampas	LASL/U.K.	U-3al	02/28/62
Aardvark	LASL	U-4b	03/03/62
Jordan	LRL	U-12i.01	03/07/62
Kuskokwim	LRL	U-9r	03/07/62
Armadillo	LASL	U-3ar	03/10/62
Cheyenne	LRL	U-9b	03/15/62
Ermine	LASL	U-3av	03/15/62
Lemming	LASL	U-3ax	03/20/62
Chipmunk	LASL	U-3ay	03/25/62
Columbia	LRL	U-9i	03/28/62
Des Moines	LRL	U-12j.01	03/28/62
Chinchilla	LASL	U-3az	03/30/62

The January 10 Nougat schedule as approved through the end of March was to prove just as changeable as earlier schedules. Of the ten shots authorized through the end of February, only three of the nine shots that were actually performed in that time period were from the DMA authorization list.

LASL reported on January 12 that no drillback sample from Fisher had yet been obtained (about 40 days after the test). Production and release of steam in the drillback operations had caused the delay in obtaining core samples. No prompt samples were obtained in Ringtail, Ex.(b)(3) [redacted] The latest test, Stoat, on January 9, also failed to give prompt samples, Ex.(b)(3) [redacted] indicated a yield of about 3 kt. Both Stoat and Ringtail had been detonated in holes deeper than required in the interest of doing the tests as early as possible and using the results in designs to be tested in the atmospheric test program.

It could be seen at this time that the Livermore testing, which had started out the postmoratorium period with more potential shot sites, now was behind because of the unanticipated loss of sites arising from contamination and containment problems. LRL thus was now using a hybrid of holes and tunnels. LASL, which was pursuing its program with essentially the same diagnostics they had used during September 1961, was beginning to improve techniques of gathering samples and obtaining data (e.g., a

portable alpha station had been prepared and was in use by the beginning of February), and was preparing for future events. Livermore, which had the more elaborate early plans for diagnostics, were not yet getting much data from their instruments because of containment problems.

The Danny Boy cratering test was taking some shape by mid-January, as indicated by a January 16 message from Reeves to Betts discussing the dosage predictions for this test. Of particular interest is that the worst case prediction for some of the Danny Boy experiments showed that the project would get such a heavy dose that postshot work would be seriously delayed for many weeks. Reeves asked DMA to let him know immediately if Washington planned to specifically direct execution of this event, so that he could call the NTS Planning Board into session to evaluate potential problems.

Some of the improved sample drillback techniques evidently paid off because the first drillback sample of the Stoat event (fired at 1000-ft depth) was received only nine days after the event. Two other indicators of the improving test situation are noteworthy; namely, by late January a supply of vertical holes had been built up, with six holes available ranging in depth from 200 to 1,200 feet; and EG&G was preparing two "universal zero racks" which would be delivered to Los Alamos and Livermore the week of February 5.

In early 1962 planning for the DOD effects test Small Boy began, and this was followed not long after by inclusion of other planned atmospheric tests for the DOD at the NTS. Much of the DOD test program that evolved into, among others, the Little Feller and Johnnie Boy events, came from a program Gerry Johnson (Assistant to the Secretary of Defense for Atomic Energy) discussed with DASA in January 1962. Johnson suggested tests at the NTS to obtain data on which to base an improved theory of cratering produced by nuclear explosives. He wanted an estimate of the program's scope no later than February 26. The tentative program suggested to DASA noted that the shots might include a 100- to 120-foot-deep test in basalt, a 20-foot-deep test to address scaling laws, a series of three tests (1 foot above the surface, on the surface, and 1 foot below the surface) to assess the dependence of ground shock and cratering effects on height at the surface, and a 50- to 100-foot-deep test in dolomite. He proposed to begin as early as March 1.

On March 7 Don Schueler of the Livermore NTS organization, in a letter to Fred Hohner of the AEC reviewing the drilling operations, noted, as background, that the REECo drilling division had been born after the dissolution of the relationship between Livermore and the E. J. Longyear Company (who had done the Livermore drilling) in 1958, with most of the equipment and pertinent supplies being retained by Livermore or the AEC. Schueler recalled a number of problems with REECo's capability since the Nougat program began, noted the Livermore opinion that REECo was not staffed or equipped to accept the increased load resulting from the beginning of Nougat, made recommendations for improving the REECo capability, and suggested letting other contracts for drilling work. After Livermore began its massive vertical hole effort in Area 9 in mid-October of 1961, problems with REECo led Livermore to recommend that a single agency be made responsible for the drill work and that that agency be H&N. Subsequent discussions led to the decision that vertical emplacement holes would be drilled by a new contractor, and REECo would retain responsibility for all other drilling, e.g., sampling drillback and satellite holes for hydrodynamic yield measurements.

On March 13, Vay Shelton and R. Preston of Livermore distributed a paper entitled "Technical concept for a program of measurements of phenomenon [sic] involved in nuclear explosions in tunnels." Based on their experience in tunnel shots, as pointed out in the paper, LRL planned additional measures to improve stemming and to control venting, incorporating these in future tests beginning with Platte. The

paper described in some detail a modest program of measurements to evaluate the effectiveness of the modifications. It was noted that for shots which go below the predicted yield, lack of containment was not unexpected when the stemming had been designed to operate properly for the predicted yield. Consequently, "to obtain more assurance that frizzles do not occur, LRL is now 'pretesting' nuclear devices with vertically emplaced test detonations in the Yucca Flat alluvium." The authors note two ways in which destructive shock waves can be generated in tunnels: for shots, such as Antler, that give the predicted yield, the collapse of the cavity formed by the nuclear explosion can generate a shock wave; and in other shots, collapse of a portion of a tunnel can generate a shock. In both instances the shock can dislodge sandbags and other types of plugs, leading to venting. The Laboratory planned to institute a series of measurements, in conjunction with SRI, (a) to study the phenomena involved in venting and other aspects of containment, (b) to evaluate containment effectiveness, and (c) to ensure the safety of postshot operations.

On March 21, Al Embry of LASL J-Division reported on some interesting cable EMP experiments conducted on the LASL Mink, Fisher, Ringtail, and Stoat events. The overall purpose of Embry's experiments was to characterize the EMP signals induced in cables positioned in various ways around the nuclear explosion and to investigate the potential diagnostic applications of such signals, especially for measuring time intervals in multistage devices. On the first test, Mink, three methods were tried, namely, wrapping cabling around the sampling pipe, putting cabling around the zero point on the surface, and utilizing cables run down the hole to the device canister. Only the last method showed promise and there were further experiments on the next three events. Embry summarized his results as follows:

> Very large clean signals are induced in coaxial cables near the device. These signals are short, the main signal usually being about one-tenth microsecond wide, and with no signals after about one microsecond. Time intervals of one microsecond or more should be very easily measured from these signals, and much shorter ones with reasonable care and proper equipment.

In an independent effort, other LASL scientists (especially L. K. Neher) had by now found that signals that followed the temporal behavior of the gamma radiation output were induced in cables due to the Compton effect. Thus, Neher had been able to make alpha measurements using so-called "Compton diodes," which then rapidly replaced conventional fluor-photodiode detectors in reaction-history (alpha) measurements. LASL pursued the refinement of solid Compton diodes, which in every respect (linear response, appropriate sensitivity, wide dynamic range), were superior to their predecessors, making the reaction-history measurement, even on boosted devices, a precise "table top" experiment. (Later it was learned that a Brazilian patent existed, based on the same principle.) Some time later, as they too moved toward vertical holes, LRL introduced a "vacuum Compton diode" into their program. Neither laboratory accepted the other's approach to alpha detector technology, though each vastly improved the quality of close-in reaction-history measurement. Later developments were to expand the utility of underground testing in vertical emplacement holes beyond any 1962 expectations, rendering the early tunnel versus hole debate most unimportant.

Overview of Nougat

The resumption of testing in Nevada should be reviewed in order to emphasize the enormous effort made in achieving the testing rates and quality of technical experimentation in such a short time.

The LASL review of underground testing in 1962 showed that while the techniques had not been thoroughly developed at the beginning of the series, a capabilility for obtaining good data existed by the summer of 1962.

> The observation of the yield enhancement effect, which is caused by neutrons reflected from the walls of the test hole causing extraneous fissions in the explosion process, caused some initial concern about the accuracy of the radiochemical yields. Although the effect has been reduced by the use of appropriate shielding materials, we are not yet able to make very satisfactory yield determination, particularly of all-oralloy devices where the accuracy is no better than plus or minus 20 percent. The data on alpha and time intervals are, of course, fully satisfactory.

Balloon Shots at NTS, Early 1962

On January 5, General Betts notified the Laboratories and Operations Offices of a slightly new twist on atmospheric test possibilities, which arose from certain political aspects of resuming testing. It had been suggested that it might now be desirable to open the U.S. atmospheric testing program with one balloon shot executed at the NTS on March 1. Therefore, Betts requested that each Lab submit one or more candidates for this single shot and provide assurance that each candidate could be readied and executed by March 1. Candidates might come from either the current underground test program or atmospheric plans, and it was desirable, although not necessary, that the yield should not exceed 10 kt. The contingencies were to be coordinated with Reeves to assure that the NTS could support the candidates. Betts added that, assuming the March 1 date for the NTS balloon shot, it might then be desirable to execute one of the Pacific shots as soon as possible thereafter, but not before March 15. Although he did not know whether JTF-8 could support a shot on that time scale, he assumed it to be no problem and wanted one or more candidates from each Lab for that shot.

On January 7, Batzel presented two Livermore candidates of less than 10-kt yield, both of which could be ready for a March 1 shot. The LRL facilities in Area 9 would require only minor rehabilitation, and Livermore's examination of drilling schedules indicated that an atmospheric detonation in Area 9 would lead to only minor adjustments in the schedules. Thus, Livermore could meet the March 1 date with a high degree of assurance for either device in their Area 9 balloon facility.

On January 8, Bradbury presented four LASL possibilities in the proper yield range for a balloon test by March 1. Moreover, LASL had four devices that could be ready for overseas airdrop by March 15. For a single balloon test at the NTS, LASL would not propose to set up even minimum diagnostics stations, but Bradbury also pointed out that if any balloon test was to be done in Nevada it would seem logical to continue such balloon testing. If that became the case, LASL would need to know at the earliest possible date so as to prepare for such testing in Area 7.

Betts told the Commission that approval by February 9 was necessary so that the site and diagnostics could be ready by March 1. The Chairman said that he would advise the White House a decision by February 9 was needed. On the next day Betts informed the test organization that he had recommended beginning preparations immediately using a LASL device. He did not think the Commission would approve this recommendation soon enough to allow for a March 1 shot even on a rush basis, but, pending Commission action, he personally requested that the necessary preparations be made, except for practice balloon flights.

Of peripheral interest in these arguments were discussions of the public relations approach to test resumption announcements. The information officers of various agencies met with the President's Press Secretary, Pierre Salinger, in early February

and generally agreed on some of the recommendations of the Foster Committee. The Foster Committee had recommended to the President that he should consider resuming atmospheric testing with a shot in Nevada since that would help reduce the concern about putting fallout only in other countries and it would make atmospheric test resumption possible before the opening of an upcoming Disarmament Conference. McGeorge Bundy, the President's national security advisor, who had also attended the information officers meeting, stressed that a Nevada atmospheric test should not be used as the first test merely for the purpose of shortening the time between announcement of test resumption and the first test, but he was not opposed to a first shot in Nevada if done for legitimate military and scientific purposes. When General Manager Luedecke forwarded some of these thoughts and AEC positions to Seaborg on February 10, he referred to a conversation between Seaborg and Bundy on February 8 when Bundy had given his opinion that a March 1 date for a balloon shot was not indicated and the AEC was not to proceed with the plans to meet this date. This conversation had served as a basis for the AEC's stopping preparations for an early atmospheric detonation in Nevada. Moreover, the AEC notified General Starbird that he should not speed up the opening date for Pacific tests before the previously agreed plan of April 1 (see Chapter IV). Luedecke now saw Bundy's statements in the information officers' meeting as somewhat conflicting with the conversation with Seaborg that had led to the AEC decision. Thus, in these few days, the opinion, certainly within AEC Headquarters, was that a March 1 balloon shot was not an option to be pursued, but there is no indication that this was conveyed to the field organization.

Apparently acting on the earlier information from Betts, Reeves, on February 13, authorized the Laboratory, contractor, and AEC personnel at the NTS to begin preparing immediately for an NTS balloon shot to be ready March 1. He noted the assumption that Area 7 would be utilized for this event, specified the two candidates, and told REECo to assess all problems related to meeting this date, including helium availability. Sandia was asked if they could meet the date, allowing sufficient time for practice flights which were not yet authorized. On the same day, Betts asked LASL to be ready for a possible balloon event on March 1. Two days later, Al Graves, head of the LASL Test Division, in messages to Jim Reeves and General Betts, noted that the balloon event was now called Musquash and would use the Ex.(b)(3) Ex.(b)(3) Because of the desire for vulnerability measurements, LASL would consider moving the zero point and firing the shot at 500 feet altitude. Graves interpreted Betts' guidance to mean doing everything short of inflating the balloons. The next day, Paul Guthals, LASL Project Director for Air Sampling, expressed his feelings that there must be at least one day set aside for dry runs on the B-57 sampling aircraft operations since this was to be the first time sampling of this magnitude had been done for some time.

The uncertainty as to the possibility of opening with a balloon shot was further confused by a message from General Betts on February 17 which noted that the starting date for atmospheric testing was uncertain and might be any time during March or on April 1. He also expressed doubt that the low-yield device selected for the balloon event would satisfy the "nontechnical goals of the opening event." Thus, in a significant shift, Betts now planned to argue for a larger-yield balloon test at the NTS as the opening event and wanted the Labs to suggest candidates with yields larger than 10 kt that could be available on the necessary time scale. LASL dutifully answered two days later with four candidates. The first Ex.(b)(3) Ex.(b)(3) and the second was the device tested as Fisher, which would be of interest in possible later studies of the effects of close tamping of earth on device performance in underground tests. LASL expressed dismay over the problems with the changing scenarios for the balloon test and the uncertainties in yield, date, device,

etc., asked for any kind of definition possible, and noted that if the test were to be much later than March 15, certain diagnostics would necessarily be minimal because equipment and people would have departed for the Pacific. The point was made also that meeting the March 1 date was already a problem for the low-yield balloon shot since two weeks was the stated balloon practice flying time required before the detonation could be carried out, and practice flying was still prohibited.

On February 19, Milton Rex at NTS pointed out that a shot of yield more than 10 kt in Area 7 would necessitate lowering a considerable number of drill rigs in Areas 3 and 9, and this would obviously impact test preparations and recovery in those areas. He also posed the question of damage to the BREN tower in Area 4 if the yield went up and noted it appeared that the highest yield that would not be a hazard to the Linen high explosive stored in Area 2 was about 30 kt. Moving the balloon shot to Frenchman Flat (Area 5) would eliminate problems in Areas 3, 4, and 9, but would in itself have some other problems.

A message from Betts later that same day, February 19, did nothing to alleviate the uncertainty, stressing again the need to prepare for a low-yield balloon event, simultaneously plan for a higher-yield event, and also to be prepared to respond to a Presidential request, should it come, for an event sometime after early March. Foster gave a brisk Livermore reply to all this "what-iffing" on February 19, stating that this confused situation should be satisfied by the following: "Unless the situation can be better defined, I suggest a standard bomb of the appropriate political yield be taken from stockpile and dropped to take care of the political situation."

Schwartz informed Betts on February 21 that Sandia would continue preparations and would schedule a flight of the primary balloon for the low-yield event on February 26. Sandia would then be prepared for the detonation within 48 hours after the flight, or to meet a March 1 date. Any delays after February 26 would result in about a five-day lead time for detonation of the low-yield planned device and a longer lead time if a different device were selected.

Finally, on February 23, Betts canceled preparations for the small-yield balloon event and requested that LASL immediately prepare for a test of the device used in Fisher. His understanding was that the test might be executed within ten days after authorization, which would be requested from the President, and he reiterated that practice balloon flights were not authorized.

The situation was resolved on March 6 when General Betts told the Laboratories and the test organization to terminate all preparations for the Musquash event, expressing his thanks to all the staff for the work done in preparing this event. On March 7, Reeves, in a message to Betts, advised that preparations for Musquash readiness had been canceled.

Steady State vs. Breather

Testing had been proceeding long enough on the emergency, high-pressure, crash basis by early February 1962 that General Betts asked the Planning Board to consider the possibility of modifications to the underground testing program. He noted in a February 7 message that although planning for underground tests after April 1 would go on, Chairman Seaborg had indicated to President Kennedy that the AEC was considering permitting the Labs and test organizations to have a reasonable "breather" after about April 1. An alternative approach mentioned, if practicable, would be based on a technical program plan and test organization which could safely and efficiently test on an extended "steady state basis." Betts suggested that perhaps the organizations were already approaching the latter course. Early in March he

intended to submit to the Commission a program for the April 1 through June 30 period, and he wished to be in a position then to assure the Commissioners that "fatigue or overwork" would not create a hazardous testing situation. Thus, he asked for Planning Board comments and recommendations on the "breather and steady state alternatives" prior to March 1. Specifically, he wanted the Planning Board to compare operational efficiency, morale, safety, funding, atmospheric testing, etc. for each alternative. If the Planning Board recommended a breather as the preferable approach, Betts wanted their recommendations on the length of the breather and an estimate of the extent to which NTS operations would be curtailed during the non-testing period. The Planning Board addressed these questions, among others, in a meeting in Las Vegas on February 26.

The first Laboratory response giving thoughts on these alternative methods seems to be in a message from Jane Hall of LASL to Betts on February 16 proposing that the six LASL shots during the period April through June be performed in pairs spaced five days apart with each pair separated by about three weeks. LASL suggested that this method, which would allow test personnel to have breathers on a steady basis, was preferred to a long vacation followed by another intensive series.

The NTS Planning Board summary of their discussion on these alternatives was brief:

> It was agreed that the shot schedule . . . is feasible and necessary and serves the needs of the Laboratories from a technical standpoint. Any breather or further slowdown would complicate their problems. The "hot beds" vs. high paychecks problem still exists, but it was determined that this matter should be subject to separate study by OFO (Ed. note: ALOO Office of Field Operations) at the same time the drilling program is scrutinized. LASL and LRL proposed redundancy in crafts to reduce overtime.

Kenner Hertford of ALOO did not feel that continuing the present situation was at all acceptable. In a message to Betts three days later he made it very clear that in the light of discussions with testing organization personnel, observations of the operations in Nougat to date, and ten years of experience in the business, he was firmly convinced that:

> We collectively cannot continue the present pace for the next six months for many reasons. Excessive wages, in my opinion, are totally unjustified and can be the subject of not only extreme adverse national publicity, but also the subject of investigations either by the Congress or other government agencies. Both technical as well as supervisory personnel are gravely overworked with long hours and, in my opinion, cannot perform efficiently at this pace for another three to six months.

In addition, the support organization, including the contractors, was strained and while he was not too concerned about the probability of a nuclear accident, he was worried about industrial or high-explosive accidents. Finally he stated that:

> After discussing this matter here and carefully considering it myself, I strongly recommend that you recommend to the Commission and the President that we be instructed to go to a so-called steady state, effective not later than April 1 this year. This steady state would mean the following nuclear detonations: two each for LRL and LASL; one for either DOD, Plowshare, or the United Kingdom. This would mean a total of 5 nuclear detonations per month.

Clearly, this position impressed General Betts, who then asked the Laboratories to comment on Hertford's suggestions and his formula for the number of shots per year. Moreover, he asked them to submit revised schedules beginning in April in accordance with Hertford's proposed formula. Finally, and most importantly, he stated his opinion that "I believe that our underground program has reached the point

where a steady state type of operations is appropriate. This has been my goal for a long time, and budget preparations for FY 1963 are geared to only one shot per week."

Bradbury replied on March 8 that the rate of two shots per month for LASL sounded reasonable if it could be assumed that testing would go on indefinitely. However, his main point was that there should be no restraints on NTS testing until the atmospheric testing was completed and that, in effect, the steady state testing at NTS should be postponed until after Dominic and become a policy for FY 1963 unless the political situation had changed. Bradbury said that, "In spite of the fact that people are working hard, we do not think that they are strained beyond ordinary physical endurance and that nothing should be allowed to interfere with any support that Dominic may require."

Taking into account the spirit of Bradbury's intent, General Betts provided modified guidance on the steady-state future in a message on March 13. He set forth a program showing more than five events per month for the period April through June and said that he saw that period as a transition time in going to a steady state situation. His guidelines included materially reduced overtime except in areas such as those directly related to supporting the Dominic program. He made a rather general point that in the future the Planning Board should assume responsibility for integrating budgets and budgetary limitations for weapons testing into the Planning Board's recommendations and proposed programs.

The details of these arguments are less important than the fact that the atmospheric testing program didn't end within the fiscal year, as had been expected. Moreover, the discussions of a reduced-level steady state and a reduced budget for the next fiscal year went on well into the summer.

In a message to Betts on June 8, Jim Reeves, newly appointed Manager of the newly-formed NVOO (Nevada Operations Office), summarized the status and actions related to a steady state for weapons testing at the Test Site. He began by reviewing the DMA guidelines (which had been discussed within the test organization in the spring) toward reaching standard workweeks of 40 hours, with exceptional cases requiring 48-hour workweeks. The consensus seemed to be that "The most logical approach to the steady state could be facilitated by establishing a basic workweek for support personnel at NTS of 45 hours (five 9-hour days) as soon as possible." The principal supporting contractors--REECo, H&N, and EG&G--had been asked to recommend an NTS standard workweek policy for a steady state. The recommendations indicated workweeks between 40 and 48 hours depending on the type of work, such as drilling, tunneling, personnel support activities, etc. After discussing the individual cases, Reeves directed establishment of: "an interim workweek for the Nevada Test Site of 45 hours, subject to the exceptions as indicated above as applying to EG&G, H&N, and REECo. Prior to January 1, 1963, the work load and workweek will be reviewed with the objective of reducing the approved workweek to 40 hours on or before that date. Any acceleration of the testing program beyond the eight events per month or 24 events per quarter which was used as a basis for the steady state study, or the introduction of unique or excessively complex experiments, will result in a general overall increase in the workweeks cited above or will require an increase in the personnel levels of the contractors work forces." His message ended with the suggestion that the employment level related to NTS weapons test work would remain relatively constant at about 6,200 employees in the period following a reduction in the basic workweek.