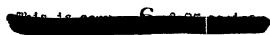




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# CIC-14 REPORT COLLECTION REPRODUCTION COPY



September 10, 1945

This document contains 29 pages

JULY 16th NUCLEAR EXPLOSION: METEOROLOGICAL REPORT

WORK DONE BY:

REPORT WRITTEN BY;

Forecaster

J. M. Hubbard

J. M. Hubbard

Pilot Balloons

Sgt. J. C. Alderson

Sgt. J. M. Lobel

Sgt. J. G. Taylor

PUBLICLY RELEASABLE
LANL Classification Group

Radiosonde

Sgt. L. D. Caskey

Sgt. I. E. Rosenthal

Sgt. P. A. Tudor

Classification changed to UNCLASSIFIED

by authority of the U. S. Atomic Energy Commission,

Records

Sgto Wo Blades

4 4 6

Radar

Lt. C. D. Curtis

By REPORT LIBRARY Such Declare By. O.R. 2-2-45

SCR-584

Pvt. L. K. France

T/5 T. Harlowe

Pvt. R. L. Heller

Pvt. G. F. Mason

Pvt. G. Meyers

Co45 Aircraft

Pfc. C. L. Hulford

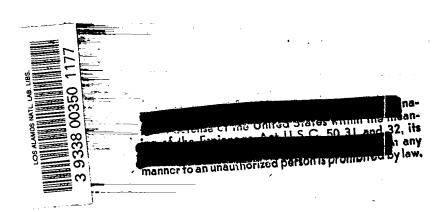
Lt. R. Stockton

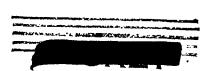
Smoke Studies

J. Mattingly

F. Oppenheimer







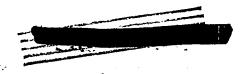


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#### TOARTEEL

A meteorological service was developed for the nuclear explosion in accordance with standard techniques of short and long range fore-casting developed by California Institute of Technology and the AAF Weather Division. Long range forecasts were used in operational planning and short range forecasts were used in the operation.

Weather records were made before, during and after the operation to be used by the different test groups.



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### I INTRODUCTION

Equipment
Information
Personnel

### II FORMULATION

The problem
Weather records
Least favorable conditions
Most favorable conditions

### III PROCEDURE

A. Types of operation B. Events

IV WEATHER AT THE TIME OF OPERATION

V WEATHER BEFORE AND AFTER THE OPERATION

### VI SPECIAL STUDIES

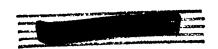
A. Smoke studies

B. Aircraft studies

C. Dilution studies

#### VII CONCLUSIONS

VIII ACKNOWLEDCHENT



JULY 16TH MUCLEAR EXPLOSION: METEOROLOGICAL REPORT

#### I. INTRODUCTION

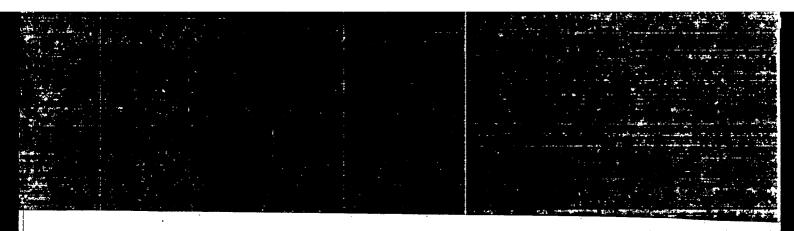
Equipment The weather equipment available for this operation consisted of the following. Two AAF portable weather stations, two radiosonde sets, four theodolites and pilot balloon sets, two field radar sets, two smoke generators, one hundred smoke pots, one weather teletype receiving the CAA hourly airway weather reports, one Hallierafter SX-28 receiving international weather and airway pilot reports, one automatic wind-recording instrument, one C-45 Beecheraft airplane equipped with a pressure, temperature and humidity-recording device, one 16-mm motion picture camera for documentation and smoke studies, twenty modified microbarographs, two regular microbarographs, one Army carryall, and one radio-equipped Army staff car.

Information Additional weather information was available from the Glass A Army Air Force Weather Station at Alamogordo Airbase, and from the Glass B Army Air Force Weather Station at Hirtland Field. Special forecasts were received from the Army Air Force Weather Division in Washington, D.C. A daily telephone conference with a special Weather Division forecaster was held each day for a week preceding the operation. The Weather Division's regular 10-day forecast with prognostic charts was received via air mail.

Hourly weather observations were kept at two locations, namely Base Camp and Outpost located about 100 yards east of the tower. Beginning June 25, the weather schedule included hourly observations at both locations, with winds aloft made 0330 and 1530 at the Outpost and 0930 and 2130 at Base Camp. Radiosonde observations were made from Base Camp at 0330 and 1530. Radar sets were located at point P, and in the Tularosa Valley, each making at least one high-altitude ascent per day. The Tularosa Valley location made a scheduled run at 0330.

The C-45 instrument-equipped aircraft made weather flights in the early morning hours, and was used to obtain information as to temperature, humidity, and wind structure near and around the Sierra Oscuro. In addition to the regular weather runs, the comparative altitude of the lower inversion in both the Jornada del Electo and the Tularosa valley was obtained. The height of the thermals as a function of time after sunrise was obtained roughly. Snoke studies from releases on the Oscuro were made and motion pictures taken during these operations. Balloons were released at short intervals, and the C-45 aircraft was able to fly compass courses which were checked from the ground which gave information as to movement in the upper air.

Iong-range forecasts were available for operational planning purposes. A double check was obtained by the use of the long-range forecasts of the AAF Weather Division, and those made by TR-4. Short-range forecasts were available for the operation and again a double check was possible. Observations and measurements before, during and after the operation served as a further weather guard over the operation.



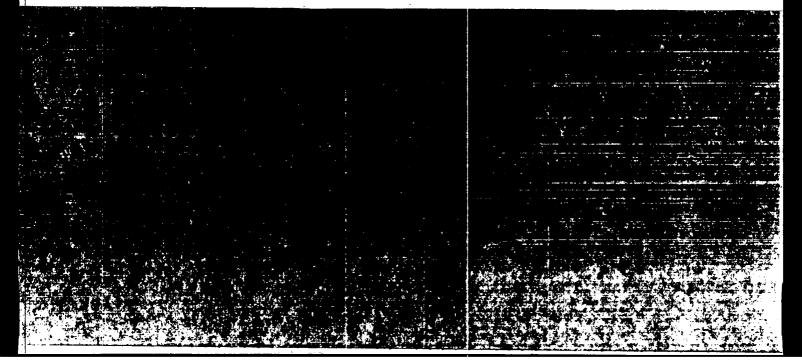
### II. FORMULATION

Although the weather program for the second Trinity operation was more extensive than the May 7th operation, the problems considered were similar:

- 1. What weather specifications are functional in the operation?
- 2. Could optimum specifications be met, and if so could a time of optimum condition be forecasted?

A circular was sent to all groups requesting that information be submitted listing the weather elements favorable and unfavorable to each. The replies were used in forming a composite picture of the weather needs of the operation, and are as follows:

- 1. Elements to be recorded before, during and after the operation.
  - A. Wind direction and velocity at all levels.
  - B. Temperature at all levels.
  - C. Humidity at all levels.
  - D. Visibility, both vertical and horizontal.
  - E. Pressure at the point of operation.
  - F. Air density at the point of operation (to be obtained from pressure, temperature and humidity).





- 2. Conditions least favorable to the operation.
  - A. Haze, dust, mirage effects, precipitation, restrictions of visibility below 45 miles.
  - B. Humidity greater than 85% at the surface or aloft which might result in condensation by the shock wave.
  - C. Thunderstorms within 35 miles at the time of operation or for 12 hours following.
  - D. Rain at the location within 12 hours of the operation.
  - E. Surface winds greater than 15 mph during and after the operation.
  - F. Winds aloft blowing toward Base Camp or any population center within 90 miles of the site.
- 3. Best conditions for the operation.
  - A. Visibility greater than 45 miles.
  - B. Rumidity below 85% at all levels.
  - C. Clear skies.
  - D. Temperature lapse rate aloft slightly stable to prevent dropping of the cloud.
  - E. Little or no inversion between 5000 and 25,000 feet to allow cloud to reach maximum altitude.
  - F. A thick surface inversion or none at all to prevent internal reflections and mirage effects.
  - G. Winds aloft fairly light, preferred direction from between south of west and 25° south of west. Steady movement desirable to anticipate track of cloud. Horizontal and vertical wind shears desirable for maximum dissipation of the cloud, although such a condition increases the tracking problem.
  - H. Low level winds light and preferred drift away from base camp and shelters.
  - I. No precipitation in the area (35 miles) within 12 hours of the operation.
  - J. Predawn operation desired by the photographic group, although 0930 operation considered best for thermals dissipating the lower levels of the cloud.

#### III. PROCEDURE

Types of Operation Two methods of using weather information were considered for the operation:

1. Assuming that reliable weather forecasts are available, an operation of this type may be set up to take advantage of the most favorable weather by coordinating the construction and development program to the forecast. Such doordination is economical in time and usually results in the most efficient operation. The favorable days as forecasted will usually meet the greatest number of weather specifications and the forecast will be most accurate.



2. The other type of operation occurs under conditions which require the forecast to be made for a date which is already fixed. Such a procedure usually results in a sacrifice of certain weather specifications and the urgency of the operation must be compared with the sacrifices to be made. Furthermore, dates which are arbitrarily fixed sometimes fall within weather periods which are extremely difficult to predict, such as periods of stagnation or poorly defined dynamic sequences. Provided a fairly accurate forecast can be made, the operation can then be tailored to the condition expected, or if the operation is too rigid, it can be delayed until enough specifications can be met.

Events The May 7th Trinity operation was conducted according to the forecast, and the second operation was originally planned in a similar fashion. During the first week in July, the date of July 16th became fixed. This changed the weather-operation relationship and introduced a consideration of the minimum specifications under which the operation could be conducted.

on June 21st, a request was received for an evaluation of July weather for the purpose of selecting days during which the operation could be successfully conducted. The forecast made on June 21st indicated that periods for favorable operation would be generated by the upper air trough passages expected on the days of July 13th and July 19th and 20th.

On June 30th, a second forecast was made substantiating the timing of the troughs to be July 13th and July 19th and 20th. The favorable day selection was predicated on the observations of previous upper air troughs and the conclusion that these influences produced proper wind structure for about one day before and one day after the central portion of the trough moved over New Mexico. This forecast indicated the dates of July 18, 19, 20, 21 as first choice, with the dates of July 12 and 14 as second choice. It was expected that the morning of July 13 would be unfavorable due to thunderstorms in the central portion of the trough. This would eliminate the 12th also, as rain the next day would be unfavorable.

on July 6th, a third forecast was made indicating the day of July 13th to be analogous to July 1st, each being the beginning date of a weather process during which Gulf air would move into the Trinity area. The 13th regime was expected to begin a period of thunderstorm activity, with an expected persistence of this condition for at least four days. The persistence actually lasted five days, which spoiled the 18th but left the morning of the 19th favorable as predicted. By July 6th it was expected that the morning of the 16th would be in a period of stagnation with the area dominated by slowly moving Gulf air. The wind structure was expected to be dominated by easterly winds in the lower levels, moisture layers, and afternoon thunderstorms. By fixing the date of operation for the morning of the 16th, weather permitting, it became necessary to tailor the operation and adjust certain aspects of the operation to the expected wind structure.

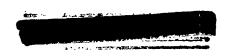


It was known that the morning of the 16th was to be in a very difficult period from the forecasters' standpoint. In order to safeguard the operation from the standpoint of weather, the additional services of the best forecasters available were desired. Col. B. Holzman, who had been one of the two AAF representatives in the European operation and D-Day operation was selected and he in turn requested Major J. Wallace of the AAF Long Range Unit be assigned to the New Mexico weather and be available for a daily telephone conference. In this way three judgments and all AAF information were available for the operation.

on July 12th, the AAF Weather Division forecast made by Major Wallace substantiated the original analysis indicating trough passages at Trinity late July 12th, and again on July 20th. This forecast indicated the period from July 14-19 to be in modified Gulf air with winds below 20,000 feet from the southeast with general thunderstorms. From the card punch file in Washington, Major Wallace selected the day of July 28, 1900 to be the most similar day in the past 40 years to the day of July 16, 1945. Hemisphere weather maps were obtained from the Alamogordo Air Base and the weather map of July 28, 1900 was studied closely from the short-range standpoint.

The July 13th forecast considered the trough passage and thunderstorm at 0200-0300 of the 13th to be an indication that the trough timing was correct. The forecast again indicated the most favorable days to be the 18, 19, 20 and 21. The days from July 15th through the 17th were expected to be characterized by light southerly and easterly winds in the levels below 15,000 feet and light winds above 15,000 feet. Light thunderstorms were expected during the afternoons of the 15th, 16th and 17th. The wind structure of the 16th was expected to include a deep layer of easterly winds.

The forecasts of July 12th and 13th compared favorably. The possibility of the stagnant condition producing a shallow, moderate, or deep layer of southeast winds was considered, and sample cases were studied from the winds aloft of July 5th, July 8th and July 10th. The case of July 8th turned out to be the most analogous case, although July 5th was considered to be the most likely on the July 13th analysis. The precautionary program was adjusted to consider the selected cases. It was believed that the track of the cloud would be a function of the depth of the easterly winds and the energy released into the atmosphere. It was decided that a low order test or deep easterly winds would move the main body of the cloud toward the northwest. For moderate energies, and moderately deep easterly winds, the cloud could be divided, with the lower portions moving toward the northwest, and the upper portion moving toward the northeast. For very high energy or shallow easterly winds. the main body of the cloud would move toward the northeast. The second consideration proved to be correct with the cloud moving toward the northwest in the lower levels, and toward the northeast above 18,000 feet.





The July 15th forecast held to the previous forecast in regard to wind structure. It departed from the previous forecasts by calling for no precipitation in the immediate area of the test. This turned out to be an incorrect analysis. Inversions were forecasted between 500 and 700 feet, at 17,000 feet, with the isothermal layer or lower stratosphere beginning at 52,000 feet. The wind structure held with easterly and southeasterly flow below 19,000 feet shifting to SM and WEW above 19,000 feet. Velocities light below 15 mph.

During the afternoon of July 15th, a conference was held. The Weather possibilities were discussed together with the possibility of sacrificing some of the measurements if the operation were to be conducted the next morning in the stagnant condition. The forecast at this time was optimistic and called for conditions under which an operation could occur during the early morning of the 16th. It was decided to set up the operation with the final decision to be made in a meeting at 0200 and 0330 of the 16th, at which time the operation could be called off in the event of unfavorable weather.

About 2000 of the 15th, thunderstorms of local nature moved into the Trinity area. These thunderstorms stagnated and reduced the 17,000-foot inversion. Thirty-mph winds were recorded until 2330. Rain which had been quite local reached the zero point about 0230 of the 16th, and a two o'clock conference at Base Camp was held with rain influencing Base Camp, West and South 10,000, and the 0 point.

At 0215, the forecast still held optimistic for an operation by 0600. No operation was expected at 0400 but rapid clearing was expected between dawn at 0500 and sunrise at 0600. On this basis the operation continued.

At 0400 the wind structure was prepared for K. T. Bainbridge and Col. Warren as follows:

7-16-45 0445

Winds aloft very light, variable to μ0,000 feet Surface Calm.

Skill ece	C	alm.
1200 ft.	2500	11 mph
4200	240	4
4800	160	ĺ
10,000	110	13
15,000	150	12
17,000	250	4
18,000	220	11
20,000	220	15
•		

Inversion about 17,000 feet, with humidity between 12,000 and 18,000 feet greater than 80%. Altitudes shown are above surface at Trinity, with conditions holding for the next two hours. Many now broken becoming scattered at 0515.



With this information K. T. Bainbridge returned to S 10,000 from 0, and set the time of operation at 0530.

The operation occurred at 0530, and the shock wave was observed to condense three moisture layers as it moved upward into the atmosphere.

### IV. WEATHER AT THE TIME OF OPERATION

Sky clear to the east and over 0 and S 10,000. Edge of solid overcast extended from base camp west of W 10,000 at 12,000 feet above the surface.

Visibility greater than 60 miles.

Surface wind from ESE 3-6 mph below 500 feet.

Temperature 68°F
Saturation temperature 61°F
Relative humidity 77%
Surface pressure 851.7 millibars
lat inversion at 100 feet, very slight
2nd inversion at 500 feet, very slight
3rd inversion at 17,000 feet, slight
Three layers of humidity greater than 95% existed between 12,000 and
20,000 feet
These layers condensed out in the shock wave

Thermal structure aloft 0555 7-16-45 Base Camp

Altitude Meters	Pressure	Temp. C	Rel. Humidity
Surface	860 mbs	19.4°C	81%
490 M	812	17.4	57
1190	748	12.3	<b>56</b> .
1560	716	12.0	50
1890	688	9.0	50
2560	633	6.2	51
3850	540	-2.5	85
4610	484	-9.2	99
4850	476	-8 <u>-</u> 9	95
6170	400	-18.1	78
7020	357	-24.0	36
7510	333	-30-5	43
8020	310	-34.5	63
8750	279	-39.7	58
11,890	170	-70.4	Too sold



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Winds Aloft: Composite of 0545 Base Camp pibel, 0400 Outpost pibal, and 0200 Point P rawin 7-16-45

Surface - 500 ft.	Wind from 1100	3-5 mph
720	160	7
1380	200	6
2040	230	7
2670	250	8
3300	250	10
3900	240	8
4500	230	7
5100	220	8
<i>5</i> <b>7</b> 00	220	12
6300	220	11
6900	200	8
7500	190	7
8100	170	9
8700	170	7 9 12 12
9300	160	12
9900	150	13
10,500	140	13 16
11,100	130	16
11,700	120	16
12,300	140	12
12,900	160	10
13,000	150	13
14,000	150 180	12
15,000	180	4
16,000	250	4
17,000	240	8
18,000	220	11
19,000	220	12
20,000	220	<b>1</b> 5
25,000	230	16
30,000	230	27
35,000	<b>24</b> 0	19
40,000	290	18
44 <b>,</b> 000	280	11



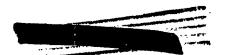
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V. WEATHER BEFORE AND AFTER THE OPERATION

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	·	•	•					The state of the s	
			HOURLY	OBSERVATIONS	}				
BASE	7-15-45					<u>~</u>	• 0	<b>500</b>	004
0030	040/	U		79	47	See	18	580	33%
0130	Ovo/	U		79	46	SSE	12	584	32
0230	OVG/	U		77	48	SSE	10	588	35
0330	sotd/	U		76	52	SSE	12	590	43 46
0430	So td/	บ		74	52	SSA	14	594	46
0530	80 Bkn	Ū		73	54	SSE	7	595	52
0630	80 Sota	Ū		73	54 56	SSE	8	594	52 56
0730	80 Bkn	Ū		73 76	56	SSW	8	606	51
0830	Bkn#	บ		81	56	3	10	604	44
0930	Sotd/	Ū		82	55	\$	7	603	38
1030	Olear	บี		86	56 55 54	Š	10	599	38 34
3300	Clear	Ū		87	54	R	-6	598	32
1130	Clear	ប		, 90	54	SE	10	590	29
1230	80 Sotd			92	74	SSW	10	587	25
1330		Ū			55 52	SSA		580	25
1430	80 Sotd	U		93	)E		4	576	19
1530	90 seta 80seta			96	47	SE	10	210	22
1630	80 Bkn/Bkn	U		94	49	SSW		571 562	25
1730	80 Bkn/Bkn	U		91	49	8	7	J02	24
1830	80 Ove/Bkn	U	TRW -	82	49	537	20	560	91 27
1930	85 Ovo/Bkn	U	TRW -	86	48	E	10	569	2/
2030	85 0vc	U	TRH-	84	53	E	18	574	35
2130	85 Ovo/Bkn	U	T.	80	52	R	8	583	38
2230	Ovo/85Scta	U		83	46	ESE	15	582	28
2330	Sctd/	U		82	48	ESK	15	585	31
					•				
OUTPOS	r 7-15-45								
0030	/1   "-L"							•	
0130									
0230	80 Bkn	υ		<b>7</b> 5	48	SE	15	505	39
0330	Bkn/80setd	บ		74	50	SE	20	507	113
0430	Bkn/	บ		72	52	SE	15	511	43 50 56 <b>61</b>
0530	Bkn/	บ		70	54	SE	13	515	56
0630	Bkn/	บ		69	54 55	303	20	515	<b>7</b> 3
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1030	Olear	Ū		82	20	SE	15	521	41
1130	Olear	บ		8 <b>3</b> 85	57	SE	15 11	517	28
1230	Clear	ប		87	21	33E	2 /2	513	33
1220	<b>~3</b> *			88	54		15	511 506	30
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1930	OO BET \ PKT	ប		88 82	46	SSW	17	402	24
7770	60 <b>Ove /B</b> kn 60 Bkn	ប	(Mores	02	51 58	E	13	493	34 60
2030		U	IRA-	73 78		ENE	12	503	
<b>2130</b> <b>223</b> 0	60 Bkn/ Bkn 60 Bkn/ Bkn	U	RW-	76 76	51	e ene	16 14	508 504	41
<b>44</b> 3U	OU BEEL RET	U		76	J.	MME	14	70//	/T E
2330	80 Bkn/Bkn	Ū		78	47	Cal		510	34



#### HOURLY OBSERVATIONS 7-16-45 Base 51 62 0030 606 617 39% 78 OV6/ NNW 20 U R-50 0vo 68 0130 RSE 9 U TH 59 61 4 616 68 0230 50 Ovc 3 U RWove/60 sota 68 611 0330 4 77 Binova SSE U 68 3 0430 Ove/60 Sota 61 2 610 77 U 0545 69 62 Ove/ U Calm 607 80 Bks to NE 5 2 0630 OVC/ 68 62 610 81 U MVM 0730 67 61 612 81 OVa/ U ENE Bkn/ 73 66 0830 69 60 2 616 U NE 0930 Bkn/ 71 2 59 55 57 55 54 52 620 U E 1030 So ta/ 79 2 614 U NW 43 1130 82 Clear 2 610 U N 40 1230 Sctd/ 85 U SW 606 38 1330 87 75 Seta U 51 4 596 34 1430 Sota/6550ta 90 6 589 27 U SSW 93 93 92 1530 Bkn/65Sota ESE 25 U 9 583 1630 Bkn/65 Scta 25 52 U 3 10 577 1730 52 52 Bkn/65 Sota 25 Π SE 12 570 <u>3</u>į 1830 Bkn/75 Sotd 86 6 U SH 570 51 1930 Ovo/75 Sotd 86 30 U 4 8 572 52 56 56 2030 Ove/75 Setd 83 U 577 34 S 10 2130 79 90 Bkn/Bkn 587 44 U 12 NVA 2230 90 Bkn U 77 594 NK 11 51 2330 80 Bkn 78 55 U 6 E 595 45 OUTPOST 7-16-45 80 Ove 50 58 60 0030 U 73 54 54 516 NIW 0130 80 Bkn 34 70 U 530 N 0230 80 Ove/Bkn IJ RW 0210-0245 70 3 0330 90 Ove/Bkn U 64 85 SSE 0430 Bkn/9030 td 6AB/290 IJ Observations suspended at 0430, 0530 observation extrapolated.

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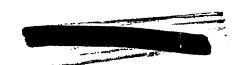
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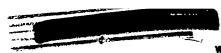


## TEMPERATURE, PRESSURE, HUMIDITY 7-16-45 station at 1440 M.

Base Press 860 794 676 662 526 444 400 365 310 242 201	7-16-45 Alt. M. 1440 2140 3510 3670 4210 5560 6860 7040 7650 8300 9500 11190 12410	0013 Temp 25.7 23.0 9.6 10.0 6.1 -3.5 -14.5 -14.3 -19.7 -23.8 -32.0 -43.8 -53.5	Hum- 42% 49 85 89 94 100 100	•	Base Press 861 827 729 588 560 505 482 400	7-16-45 Alt. M. 1440 1780 2830 4600 5000 5800 6180 7580	0335 Temp 20.0 18.9 10.3 -1.7 -4.0 -8.7 -10.3 -18.2	Hum. 77% 62 73 90 37 96 100 100
Base 860 812 748 716 688 633 540 484 476 400 357 333 310 279 170	7-16-45 1440 1930 2630 3000 3330 4000 5290 6150 6290 7610 8460 8950 9460 10190 13330	0555 19.4 17.4 12.3 12.0 9.0 6.2 -2.5 -9.2 -8.9 -18.1 -24.0 -30.5 -39.7 -70.4	8 81 <b>%</b> 57 56 50 551 8 99 58 43 43 58		860 812 763 678 653 614 602 562 524 512 400 326 218 140 70	7-16-45 1440 1940 2480 3490 3800 4310 4470 5030 5590 5780 6730 7250 7680 9200 12090 15000 16700 19200	1355 29.5 22.1 18.9 11.3 9.5 5.5 2.6 -2.5 -2.6 -10.5 -40.4 -57.2 -66.3 -68.7	34% 343 47 551 551 552 648 65 65 30

on 1355 Raob, isothermal layer begins at 16,700 meters or 54,700 ft. above sea level, or approximately 50,000 ft above the point of operation. This level may be the beginning of the stratosphere. Please note the temperature and humidity variation at the 400 millibar level.





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720	140°	35	160 <sup>0</sup>	19	1700		1000	180°	12
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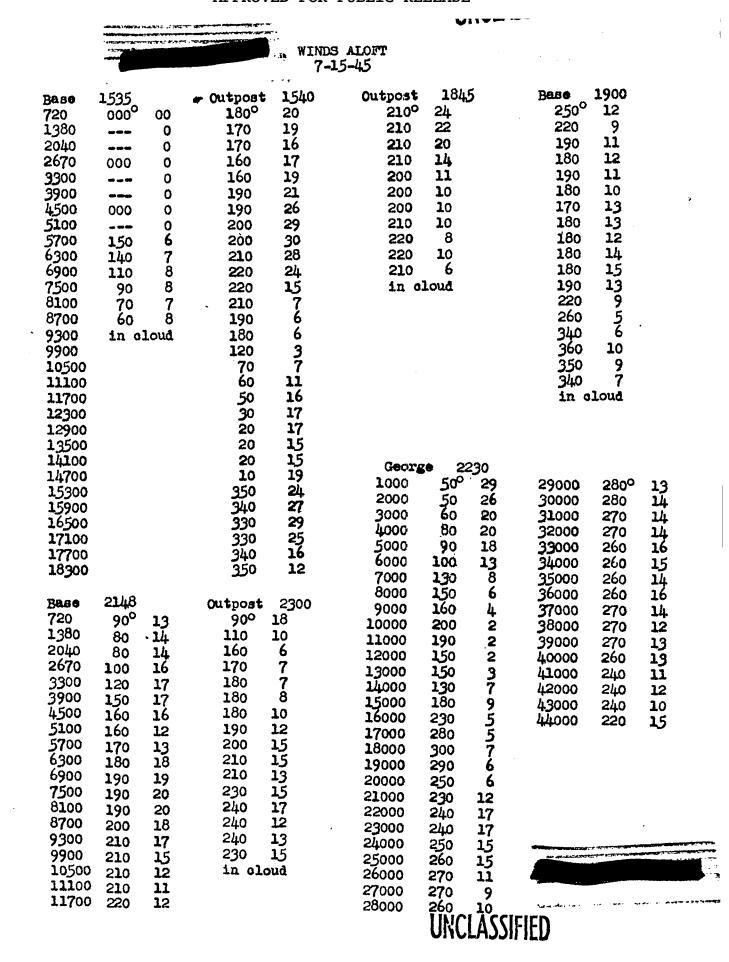
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3900	300	12	6000	320	8		270	10
4500	300	14	7000	350	5		260	10
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3300	250	7	28000	240	21		250	17
3900	260	9	29000	240	23		250	18
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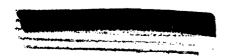


### VI. SPECIAL STUDIES

Smoke Operations Smoke studies were conducted from the top of the Oscuro by F. Oppenheimer and J. Mattingly. Aircraft observations were coordinated with the smoke operation and motion pictures were taken from the air.

July 7th Smoke Operation on the Oscuro Mountains

- \*In order to determine the path of a cloud passing over the Oscuro mountains, four smoke stations were set up between 5 A.M. and 7 A.M. on July 7th.
  - 1) One station on top of the ridge at an elevation of about 8000 ft.
  - 2) One station 50 ft. below the top of the ridge on the East slope.
  - 3) one in the valley to the East about 2400 ft. below the top.
  - 4) One station about 600 ft. below the top of the ridge on the East slope.
- "The stations were on an East-West line about 21 miles north of "O".
- \*Smoke pots were used for all stations except the one in the valley where an oil smoke generator was used.
- "Stations: At 5 A.M. smoke from stations 1 and 2 behaved identically. The smoke went due west pouring off the side of the escarpment and settling in the valley where, when observed from a plane, it appeared to lie on the valley floor. At about 6 A.M. the smoke stream changed direction and went ESE rising slightly from the crest. It continued to rise at about a 5° angle for 4 to 5 miles (as long as it could be followed).
- \*Station 3: The smoke in the valley streamed down the valley (SE) staying very close to the ground (75-100 ft.). This condition persisted from 5 A.M. until ? A.M. when the generator was turned off.
- "Station 4: At about the time that the wind began to change on top of the ridge (6:15) smoke was generated at a station about 600 ft. below the top. This smoke stayed close to the hillside until it was 800 to 1000 ft. above the floor of the valley at which point it left the ground and did not descend any further. The smoke in travelling down the hillside changed its direction from I to SE right after it had left the ground it travelled SE essentially parallel to the smoke generated in the valley.
- "The smoke was observed by Mr. J. M. Hubbard in a plane, by an observer on the east side of the ridge and by a photographer. T/5 Wallis, in the valley. As the films are not yet developed this report does not include any photographic information."





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\*CONCIDSION: The behavior of the smoke on the east and west sides of the ridge was found to be quite different. On the west it penetrated the inversion and dropped to the valley floor. On the east it did not penetrate the inversion and remained about 800 ft. above the valley floor. It is possible that on other occasions smoke on the east side would also descend to the floor. It would seem likely, however, that the steep escarpment on the west side as contrasted with the more gradual slope on the east is a sufficiently significant difference to account for the difference in the behavior of the smoke.\*

### F. Oppenheimer

July 14-15th Smoke Observations on Eastern Slopes of Oscuro Mountains

"Date: July 14, 1945

Site: 21 degrees north of 0 on Oscura eastern slopes

Station 1: 1900 feet above valley floor

Station 2: 2300 feet above valley floor

Time: 0535 to 0750

winds were light. Before sunrise the smoke from both points drifted downslope to the deep canyon that was directly to the north. The canyon filledup and the smoke spread down to the mountain base where it spread thinly and clung closely to the surface. There was no surface inversion present.

\*After sunrise the direction changed almost immediately from downslope to upslope flow. The smoke began to move up the canyon and that from the highest station appeared to apread over the crest on to the western slope.

\*pate: July 15, 1945

Site: Due east of 0 on the eastern slope of the Oscuras

Station 1: 1200 feet above the valley floor

Station 2: 1500 feet above the valley floor

Station 3: 1700 feet above the valley floor

Station 4: 200 feet below the mountain crest

Time: 0530 to 0715

Winds were light at all stations except the topmost which had a strong south wind blowing parallel to the ridge. At the other stations the smoke spilled downslope into the canyons and out on to the valley floor. There was no surface inversion present in the valley.

- \*After sunrise the three lower stations changed to upslope directions; the topmost station continued with strong southerly winds.
- \*At sunset the night previous and with a clear sky a shallow inversion began forming over the valley. At the same time the daytime upslope winds switched to a downslope flow and the smoke layered down the valley spreading the full width of the valley atop of the inversion. The path was SF heading directly over the bombing range and the range camp. After midnight the sky became clouded and the shallow inversion decayed.

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\*CONCLUSIONS: From sunset to sunrise with light winds the smoke will flow slowly downslope, filling up the canyons and then spreading on to the valley floor. This is true for all elevations along the eastern slopes except near the crest where there is a tendency for the smoke always to spill back over the western side. With a strong gradient wind that is parallel to the ridge, the higher elevations follow the gradient direction but with the lower elevations showing still a slow downslope flow. The smoke near the crest with the increased wind velocity dissipated to a large extent. If there is an diversion present the smoke will remain above the ground within the inversion layer, the height above the ground depending upon the depth of the inversion. But whether or not an inversion is present it is not important unless it extends from the surface up to 1500 or 2000 ft. (Very shallow inversions are normal now, July) because in either case the smoke is trapped in the valley for two or more hours after sunrise between the Oscuras and the first line of hills that parallel the Oscuras on the east a few miles. All passage to the east is blocked until at least two hours after sunrise. In the meentime the smoke drifts slowly southeastward, following the contours to the lowest levels and spreading as it moves. Then surface heating begins to increase the dilution. "

### J. F. Muttingly

A generalized conclusion from such little data is a bit dangerous. It might be said that the above conclusion is essentially correct under similar specialized conditions of stagnation. - JMH

### Aircraft Studies

#### July 7, 1945 Snoke Operation

A study was made of wind currents along the west face and east slope of the Sierra Oscuro at dawn of July 7th. A group under the direction of F. Oppenheimer ascended the east slope of the Oscuro by jeep with smoke pots and a smoke generator during the afternoon of July 6th. At dawn of July 7th, the operation was carried out as planned with the weather airplane arriving on the scene at approximately 0515. This report includes the aircraft study of this operation.

The weather airplane, a C-45 Beechcraft, left Rirtland Field at 0435. The pressure, temperature, humidity recorder was operating throughout the flight. The aircraft passed over the base camp at an altitude of 600 feet at 0511 and then proceeded to pass over the zero point and crossed the Oscuro at 9000 feet M.S.L. at 0519. The fire of the first smoke position, located at the crest of the Oscuro slightly north of the zero point, was seen at 0523. The airplane circled the origin of smoke until 0544. The smoke moved down the west slope of the escarpment and appeared as a white waterfall reaching the talus slide and moving along it until it reached a point in the valley about halfway between the escarpment and zero. The smoke apread out laterally along





the valley floor and appeared to be only about 100 feet thick. Motion pictures were taken of this smoke trail beginning about 0525. At 0535, two smoke origins were noticed along the east slopes of the Oscuro. One source appeared to be located about half way up the slope and the lower source well down in the valley. At 0544, the aircraft descended for a close view of the smoke flow. The direction of the two smoke streams appeared to follow the valley contours and the top appeared to be flat and about 100 feet above the terrain. The direction of flow was toward the southeast. Motion pictures were taken of this first descent. The aircraft then circled the south end of the Oscuro and returned along the west slope where the westward flow of the smoke from the creat was noted and photographed. A second descent was made along the east slope and the two sources were again photographed at 0558. The plane again circled the Oscuro and a third descent was made along the east slope into the valley at 0608 which netted a third complete motion picture record. At 0612 the aircraft returned to Kirtland Field and was landed at 0646. At 0612, the smoke from the top of the oscuro appeared to spread out along the top of the ridge and seemed to stop waterfalling over the west escarpment. There were actually two sources at the crest but they were so close together as to be considered as one source when viewed from aloft. The aircraft observation was abandoned at 0612 as fuel was running low.

The smoke operation of July 7 was successful from a meteorological standpoint and showed the normal downslope drainage on both slopes of the Oscuro. On the west slope the smoke appeared to descend below the slight inversion. Along the east slope smoke from the intermediate altitude rode aloft above the inversion and smoke from the valley floor remained below the inversion.

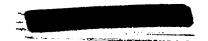
In addition to the daily flights made by the C-45 for the purpose of obtaining a record of the horizontal distribution of temperature, pressure, humidity and thermal activity, certain special flights were made:

7/11/45 Col. Warren, Capt. Lyon, Col. Holzman were flown in the C-45 over the Trinity area and the area to the northeast for the purpose of surveying the region over which the cloud was expected to travel.

### July 14, 1945 Smoke Operation

"The C-45 aircraft was over the Sierra Oscura at 0615 the morning of July 14, 1945. Smoke was observed coming from smoke pots on top of the ridge and the smoke train was blowing from east to west, falling down the escarpment and forming a layer in the bottom of the valley.

"Smoke from the smoke pots on the east slope drifted north to a canyon and then down the canyon in an easterly direction to the valley. Motion pictures were taken of the smoke trails."



Sgt. J. C. Alderson



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### July 15. 1945 Smoke Operation

The C-45 aircraft was over the Sierra Oscura for the smoke operation of July 15, 1945. Motion pictures were taken of the smoke trails.

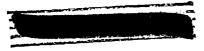
### July 15, 1945 Balloon Operation

The G-45 aircraft flew over the base camp before the smoke operation, and returned half an hour later. Meanwhile, balloons were released in clusters of two at intervals of two minutes. The ascent rate of the balloons was approximately 600 feet per minute. When the aircraft returned there was a trail of balloons separated by about 1200 feet extending to about 18,000 feet. The train of balloons was well defined, and it was possible to chart a compass course at the various levels and as the airplane was flown along the course, toward Base Camp. It was possible to determine by theodolite observation the course of the airplane and therefore the balloon to approximately one degree. Such a study would be of value in a homogeneous wind field, and it wasthought that this technique could be used to study the wind structure before the operation as a further check upon the rawin andpilot balloon observations.

- 7/18/45 The c-45 aircraft was flown over the Trinity area with Mr. J. E. Mack and Sgt. York for the purpose of making photographs and motion pictures of the crater. The ship was flown at altitudes of 2000 feet, 10,000 feet and 500 feet above the crater. On the return to Kirtland Field, the ship was flown over the track of the cloud on a compass course of 30 degrees and pictures taken of the terrain.
- 7/29/45 The 0-45 aircraft was tested for radiation by Mr. J. Magee, and it was found that there was little or no contamination on the fusilage, but the motors were positive with the greatest concentration in the air filters of the carburators. The ship was flown in the area 48 hours after the shot and was flown for a total of 20 hours between 7/18/45 and 7/29/45.

### Dilution Studies

The only data on dilution with respect to various meteorological conditions that I know have been taken at Hanford. But there all the work on dilution was done in the lowest 200 to 300 feet of the atmosphere. The three stability conditions of the atmosphere, stable, neutral, and unstable have been investigated quite thoroughly with regard to the dilution each condition produces. It is questionable whether or not the dilution rates found in the lower layers can be





\*applied to the great altitudes the smoke reached on May 7th. There is no question, however, that certain characteristics will be similar, for example, in stable air smoke of the same density as air will stratify, fan out laterally and widen slowly downwind. The average rate of dilution found under stable conditions varied somewhat with the degree of stability but is of the order of

$$\log Y_{\rm m} = \frac{\log x - 1}{0.7}$$

where Ym is the average dilution of the cloud

and X is the distance from the stack in ft.

In this case the smoke issuing from the top of the stack was considered to be of unit concentration and dilution started there. The above equation holds true for the average of the mean cloud dilutions out to 7000 ft from the stack.

\*The least dilution is that momentarily observed in the densest or least diluted part of a cloud segment. The least dilution followed rather closely, again out to 7000 ft.,

$$Y_a = 400 + 0.47 X$$

where Ya is the least dilution

and X is distance from the stack (ft) - 3000 (ft)

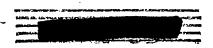
In tabular form the dilutions are as follows:

50001 7000 distance from stack 1000 20001 30001 4000 6000\* 3500 average dilution (times) 700 1900 5400 7500 9700 12600 least dilution 500 800 150 300 1300 1800 2300

From the above equations, if extrapolation may be used, the average dilution which should occur by the time a cloud has drifted in stable air from the point above Trinity where the cloud reaches equilibrium with the air density (assumed to be the smoke column after the shot) to over Carrizozo this dilution of the cloud should be 1.4 • 10° within which there will be less diluted portions which will have been subjected to a dilution of 1.0 • 105, using a distance of 200,000 ft, app. 40 miles. This further assumes that the concentration at the top of the smoke column where stratification of the smoke begins is 1. I hesitate to extrapolate to 40 miles when taken have been taken out from a smoke source only 1.5 miles.

In unstable air the rate of dilution is quite different because the air is composed of an infinite number of eddies of all dimensions. These eddies produce a high rate of dilution, a rate so great that we have been unable to obtain an appreciable number of readings as close as 2000 ft from the stack. We did not trust our instruments

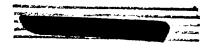
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beyond a dilution of 10,000 when working in the field though calibration in a laboratory showed the instruments would detect smoke diluted about 50,000 times from that in the stack. In unstable air the least and average dilutions at various distances from the stack are as follows:

distance from stack	1000'	2000
least dilution	900	2500
average dilution	4000	16000

- \*Again with free use of extrapolation at 10,000 ft the average dilution should be well over 1.0 105, perhaps 106 and the least diluted portions somewhat less, perhaps 104.
- "Assuming that the smoke column from the shot will stratify 10,000 ft above the surface, that it remains at that altitude until over Carrizozo and then unstable air brings it to the surface at that point, the cloud would then have been diluted 1.0 · 10<sup>5</sup> or perhaps 1.4 · 10<sup>6</sup> plus the dilution in the unstable air so necessary to bring it to the ground which would be 10<sup>5</sup> or 10<sup>6</sup>. On the other hand, if the shot was made under the unstable conditions of the day time, the dilution could reach perhaps 10<sup>100</sup> before reaching Carrizozo if extrapolation can be trusted.
- "In answer to the second question there are several meteorological conditions to be considered for the dress rehearsal.
- \*(1) Like the first shot, only a wind somewhere between northwest and southwest should be used. A due west wind carries air to Carrizozo and one slightly north of west carries it toward Roswell. In view of the fact that extrapolation is dangerous on so serious a problem probably a wind slightly south of west would be most desirable.
- "Normally there is a change of wind direction with increase of altitude. The greater this change per unit distance vertically, the greater the dilution, hence if a time can be picked when there is a change of direction at the altitude of anticipated "mushrooming" or stratification of smoke the hazard would be further reduced.
- \*(2) The vertical temperature structure for maximum dilution should be super-adiabatic in which active "thermals" or eddies are present. This situation exists from about 3 hrs after sunrise to about sunset, with a maximum activity and vertical penetration of eddies during early afternoon.





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### VII. CONCLUSION

The moteorological program prepared for the July 16th nuclear explosion at Trinity consisted of the procurement of excellent equipment, adaquate personnel, sufficient data, together with combined judgment in the evaluation of the weather problem and weather forecast.

A program was developed by which an economical and efficient use of weather could be obtained. The problem changed complexion and developed into a fixed date operation in which the operation was tailored to the weather.

It is suggested that future operations be conducted under a program which fits the weather to the operation, and that the operation be carried out on days of optimum conditions according to the weather forecast.

An operation such as the Trinity nuclear explosion requires a precision forecast about ten days in advance. Extended forecasts in this range have been carried out by a limited number of forecasters in the AAF Weather pivision and at Cal Tech. It is suggested that future operations be safeguarded with the best long range forecasters available, as the nature of the operation and the precision and range of the forecast makes the problem extremely difficult.

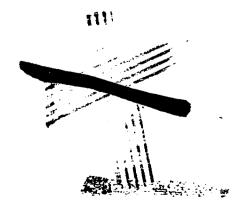
The author wishes to express his gratitude to the following men outside the project who contributed to the weather operation.

Col. D. N. Yates, AAF, Head of the Weather Division, who made available the entire facilities and files of his research and operating group.

Col. B. Holzman, AAF, Forecaster for the Normandy invasion, who aided in the weather evaluation at the site.

Major John Wallace, AAF, who was assigned to the New Mexico area and with whom telephone conversations were carried out between the site and the research center in Washington, D. C.

P. E. Church, Consultant on dilution.



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