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OPERATION CASTLE

A PRELIMINARY REPORT [redacted] SHOT

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OPERATION CASTLE

A VERY PRELIMINARY REPORT OF THE RESULTS OF THE DELETED [redacted] SHOT

Submitted by

Task Group 7.1

W. E. Ogle,
CTG 7.1

R. L. Aamodt,
CTU-1

H. K. Gilbert,
CTU-13

[redacted]

JO-43

July 1954
(Date)

[redacted]

[redacted]

INTRODUCTION

The [redacted] device was fired May 14, 1954 as a barge shot in the crater of the Ivy "Mike" device at Eniwetok Atoll.

It represented the Los Alamos Scientific Laboratory's attempt at

DELETED

At the beginning of the Castle operation the device was to be fired just south of Yurochi on Bikini Atoll at the same zero position DELETED Early weather delays in the Castle operation led to the suggestion of making ready to fire [redacted] at Eniwetok in order to be able to accept some weather that would not be acceptable for firing at Bikini. However, by the time the plan was carried out, weather conditions had changed, and the [redacted] device sat in place just two days less than a month before satisfactory weather conditions allowed firing.

DELETED

The total energy release was measured by ball-of-fire methods to be [redacted] where the uncertainty is due to having satisfactory pictures from only one position. The energy release due to fission appears to have

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DELETED

The following project reports, though somewhat late, are still to be considered preliminary. The reader is referred to the final reports of the separate projects for more complete and difinitive information.

Since this is the last of the Task Group 7.1 summary reports for Operation Castle, the Commander takes this opportunity to thank the project and program leaders who have contributed to these volumes; the task unit commanders, especially Lee Aamodt, Col H. K. Gilbert, and Art Hudgins; and the secretaries who actually put the reports together, James Carryl, Jerry Purdum and Frank Boss.

[redacted]

[redacted]

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* Reports not received by publication time.

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PART I

TASK UNIT 13

DOD PROGRAMS

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Program 2 - NUCLEAR EFFECTS

Program Director - E. A. Martell, LtCol, USA

Project 2.1 - GAMMA RADIATION DOSIMETRY

Project Officer - R. H. Dempsey

Objective

To measure the gamma radiation exposure at various locations following a nuclear detonation.

Instrumentation

Film and chemical dosimeters were placed in $\frac{1}{4}$" aluminum cannisters mounted on 2" aluminum stakes. The detectors were placed at a height of 3 feet above ground. Both detecting systems were calibrated against an 11 Mev betatron.

Results

Shown in Table 2.1-1.

Discussion

Analysis of the data was made assuming a fall-out time of $\frac{1}{4}$ hr. Stations 76, 77, 78, and 79, show evidence of having been exposed to considerable initial radiation in addition to the residual radiation which must have been present. Unfortunately, the films from stations 76, 77, and 78 were partially destroyed, the data from 78 being based on the single piece of film found. It is hoped to be able to plot an HD^2 vs D curve for the initial radiation when the chemical detectors are analyzed.

The decay exponent was calculated for the remaining stations and has an average value of 1.13.

[redacted]

[redacted]

TABLE 2.1-1
RESULTS - GAMMA EXPOSURES

Station	Type	Location	Total Exp. (r)	Rec. Rate* (r/hr)	X**
210.74	land	Bogallua	126	0.210	1.07
210.75	land	Bogombogo	123	0.150	1.18
210.76[1]	land	Ruchi	chem.	0.210	
210.77[1]	land	Cochiti	chem.	0.250	
210.78[2]	land	Sanildefonso	1450	4.20	
210.79	land	Bogon	640	0.055	
210.80	land	Engebi	20.5	0.030	1.12
210.81	land	Engebi	20.5	0.030	1.12
210.82	land	Engebi	19.5	0.022	1.20
210.83	land	Muzin	15	0.021	1.14
210.84	land	Kirinian	13	0.015	1.19
210.85	land	Yeiri	5.9	0.008	1.15
210.86	land	Yeiri	6.0	0.012	1.00

* Rate at recovery time plus 80 hours.

** Decay exponent in the expression $A = A_0 T^{-x}$

1 Stations 76 and 77 had film destroyed. Total exposures will be determined from final analysis of chemical detectors.

2 Station 78 film recovered lying on ground.

[redacted]

[redacted]

Project 2.5b - FALL-OUT DISTRIBUTION STUDIES

Project Officer - E. F. Wilsey

Objectives

The objectives of this project include the collection of fall-out samples for the documentation of physical characteristics as a function of time and distance and to provide samples for radiochemical analysis by Project 2.6b.

Instrumentation

One intermittent fall-out collector was placed on the Project 6.5 barge anchored near the reef southwest of Bogallua and on each of the following islands: Bogallua, Bogombogo, Ruchi, Bogon, Engebi, Kirinian, Bokonoaarappu, Aitsu, Biijiri, and Rigili. These instruments were set to sample at 30 minute intervals for a total time of 12 hours. A second instrument, set for 5 minute intervals for a total time of 2 hours was located on Ruchi and Bogon. All instruments were set to begin sampling after the first water wave, assumed to be traveling at 40 mph, had passed the stations; the delay ranged from 5 minutes at Ruchi and Bogon to 26 minutes at Rigili.

Recovery

Recovery was carried out on the afternoon of 15 May 1954.

Results

The collectors operated at Bogallua, Bogombogo, Engebi, Bokonaarappu, and Aitsu. The battery compartments of the stations on Ruchi and Bogon were damaged by the shock wave. The instrument on Kirinian was overturned by a water wave. The blueboxes did not trigger at the Biijiri and Rigili stations.

Only fall-out of very low activity was collected by the stations which operated. All samples were shipped to ACC for analysis.

[redacted]

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[redacted]

Project 2.6b - RADIOCHEMICAL ANALYSIS OF SURFACE CONTAMINATION

Project Officer - R. C. Tompkins

Objectives

The objectives of this work were to study the distribution of certain nuclides within fall-out particles and to determine some of the differences in radiochemical properties between liquid and solid fall-out.

Instrumentation

Total fall-out collectors were set up on the lagoon phototower (Mack), the Project 6.5 barge, Engebi, and Bokonaarappu. Only the collector on Engebi and the phototower were fully instrumented with collecting solutions. The phototower station failed to operate because of a circuit failure. Of the other stations, only Engebi gave a sufficient sample to work with. In addition, a soil sample was obtained from Bogallua.

Results

Data have not been received from the test site.

[redacted]

Program 6 - TEST OF SERVICE EQUIPMENT AND OPERATION

Program Director - D. I. Prickett, LtCol, USAF

Project 6.1 - TEST OF INTERIM IBDA PROCEDURES FOR HIGH YIELD WEAPONS

Project Officer - R. Triantafellu, LtCol, USAF

Objectives

To test under field conditions current IBDA procedures for high yield weapons.

Instrumentation

Three B-50 aircraft equipped with standard APQ-24 radar and O-15 radar scope cameras were positioned relative to ground zero as shown in Table 6.1-1. The APQ-24 radar is X-band navigational and bombing radar equipment. The camera records one scope picture every 1.25 sec on Sector Scan and one every 3 sec on 360° Scan.

TABLE 6.1-1
B-50 POSITIONS

Aircraft Code Name	Indicated Altitude (ft)	Bearing from Ground Zero (degrees)	Horizontal Range (Nautical Miles)	Orientation T_o	Orientation T_s
Hardtime 1	32,000	225	12	Tail to GZ	Tail to GZ
Hardtime 2	31,000	225	20	Side to GZ	Tail to GZ
Hardtime 3	30,000	225	27	Side to GZ	Side to GZ

Results

The SAC participation in [redacted] was successful. Good Scope photos of the detonation were obtained by all three radar sets. The duration and magnitude of the phenomena, in keeping with the yield, is smaller than any of the previous shots, [redacted] excepted.

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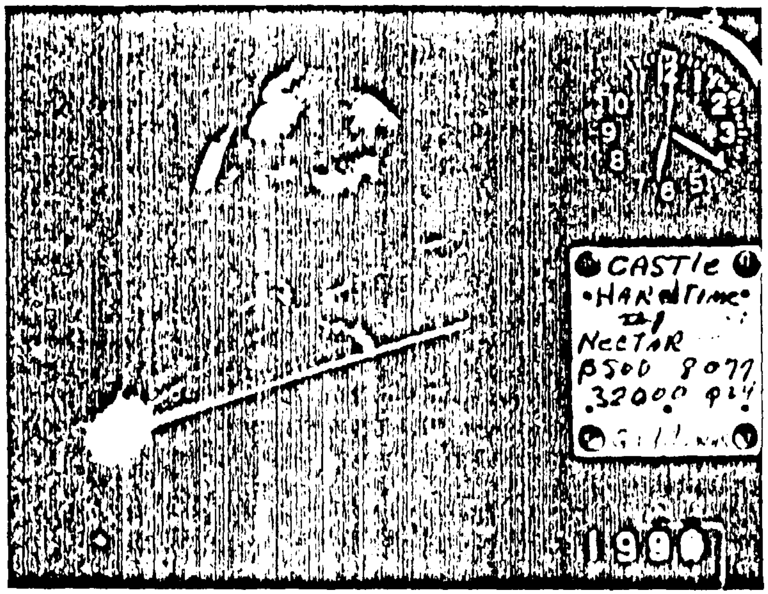

Fig. 6.1-1 Early Return at About H + 1 sec.

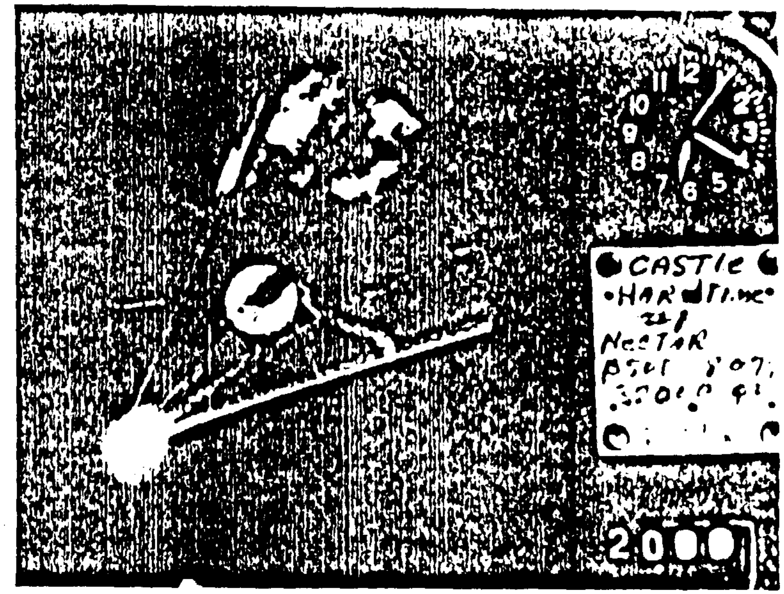

Fig. 6.1-2 Phenomena at About H + 6 sec.

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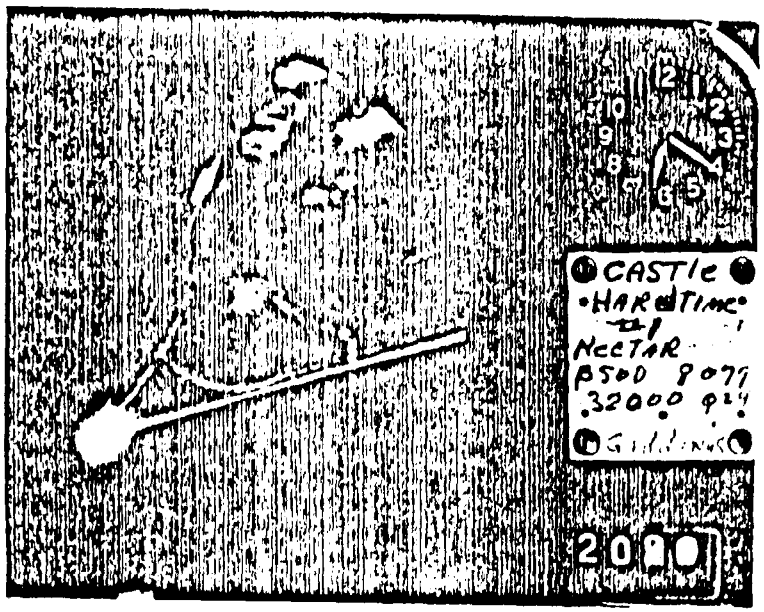

Fig. 6.1-3 Progress of Shock Front at About H+29 sec.

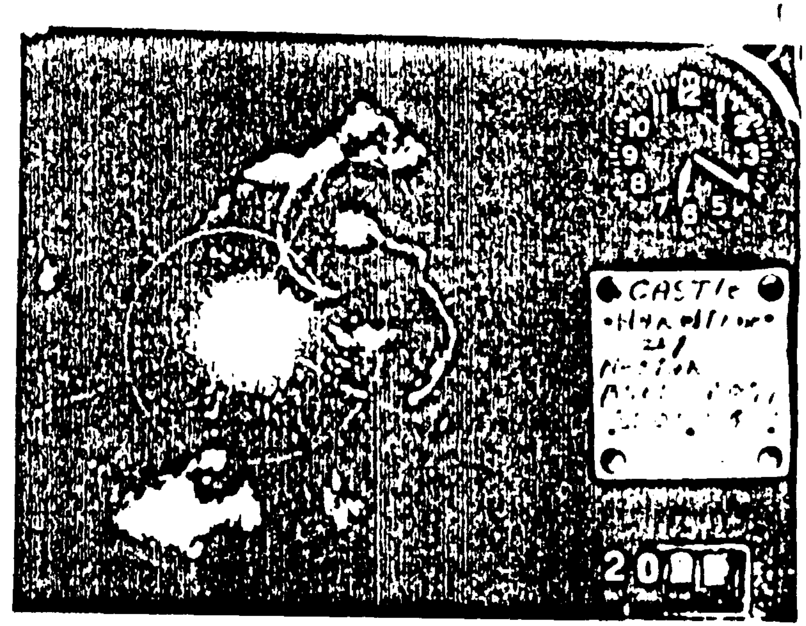

Fig. 6.1-4 A 360^0 Scan at About H+32 sec.

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Project 6.5 - DECONTAMINATION AND PROTECTION

Project Officer - J. C. Maloney

Objectives

The objectives of this project were to determine relative contamination and decontaminability of outside construction surfaces exposed to fall-out

DELETED

Instrumentation

A set of fourteen 4 ft sq panels of widely used exterior construction surfaces was mounted at normal orientations on the barge anchored at Station 650 (approximately 7 miles SW of Ground Zero). It was expected that this station would be in the fall-out area following the shot.

Procedure

The barge was towed to Parry Island eighteen hours after the detonation. The panels were unloaded and transported to the decontamination area where they were mounted on racks at normal pitch and spaced far enough apart to minimize background effects. Then the panels were subjected to high pressure hosing and water scrubbing techniques. Gamma and beta intensity readings were taken at 16 points on each surface initially and after each decontamination procedure. For comparison, these readings were corrected to a common basis of H + 28½ hours (time of initial survey) by the use of the -1.2 law.

Residual intensity levels in percent were calculated for each decontamination procedure used.

Results

The average initial gamma intensity and residual intensity percentages are summarized in Table 6.5-1 for each surface.

[redacted]

[redacted]

The initial intensity levels of the panels were very low as the fall-out apparently followed a different path than that indicated by pre-test planning. Fall-out samples taken on the barge by other projects were also very low in activity.

The contamination remaining after decontamination by vigorous methods was very high and varied from 41% to 98% depending on the nature of the construction surface.

The two most useful methods of decontamination, hosing and scrubbing, were applied to the panels. No further effort was practical, because the residual contamination after application of these methods was very low, due mainly to the combined effects of low initial contamination and decay.

Conclusions

The contamination resulting from this detonation is of a very tenacious nature and is more difficult to remove than the contamination encountered after the DELETED

A difference exists among the construction surfaces in regard to initial contamination levels and ease of removal. However, the marked difference in contamination levels between vertical and horizontal or sloped surfaces [redacted]

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TABLE 6.5-1
DATA SUMMARY

Material	Coating	Panel Orientation	Initial Gamma Reading (mr/hr)	Residual Fields in Percent Corrected for Decay and Background: Before Decontamination	High Pressure Hosing (30 sec)	Scrub with Low Pressure Rinse, 1 min
Asphalt Road	None	Horizontal	6.3	100	100	98
Concrete Road	None	Horizontal	6.9	100	86	71
Concrete Road	Sealcoat	Horizontal	8.9	100	92	82
Asbestos Shingle	Sealed Joints	Vertical	12.1	100	99	84
Asbestos Shingle	Plain Joints	Vertical	12.9	100	99	89
Wood Siding	None	Vertical	8.5	100	87	78
Wood Siding	Alkyd	Vertical	7.3	100	73	41
Wood Siding	Lead & Oil Paint	Vertical	6.9	100	84	68
Wood Siding	Phenolic	Vertical	5.3	100	89	70
Geometry Effects	Alkyd	Vertical	5.8	100	69	41
Sheet Metal	Alkyd	Vertical	4.1	100	93	46
Sheet Metal	Phenolic	Vertical	3.4	100	97	68
Brick	None	Vertical	7.1	100	90	85
Brick	Luminall	Vertical	8.2	100	72	57
Concrete Block	None	Vertical	7.9	100	89	70
Concrete Block	Luminall	Vertical	8.4	100	89	51
Cinder Block	None	Vertical	8.3	100	92	92
Cinder Block	Luminall	Vertical	8.3	100	92	75
Strip Shingles	Sealed Joints	Sloped	8.3	100	89	86
Strip Shingles	Plain Joints	Sloped	8.4	100	94	92
Roll Roofing	PVA	Sloped	6.8	100	71	54
Roll Roofing	None	Sloped	5.4	100	74	56
Corrugated Metal Roofing	Asphalt (galbestos)	Sloped	6.5	100	86	54
Tar & Gravel Roofing	PVA	Horizontal	6.5	100	82	75
Tar & Gravel Roofing	None	Horizontal	6.9	100	81	75

NOTE: Initial gamma reading is expressed in mr/hr and is corrected to H + 28½ hours with an AN/PDR/T1B held 1 inch from panel surface.

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Project 11.2 - CLOUD SAMPLING

(H. Plank)

Aircraft Sampling

As discussed in preliminary reports for previous Castle shots, the probability of collecting satisfactory cloud samples by means of manned aircraft is, to a very large extent, dependent upon how well the director and sampling aircraft can maintain visual contact with the bomb cloud. It is, perhaps, fortunate that weather difficulties forseen as early as [redacted] did not actually arise until the last shot of the Castle series. Late in the afternoon on N-1 day an acceptable wind shear situation between 30,000 and 45,000 feet and acceptable cloud cover were predicted for shot day. Although an 8/8 cirrus layer was also predicted, no trouble was anticipated because this layer was predicted to lie between 39,000 and 41,000 feet, and it was probable that the director and sampling aircraft could climb above the cirrus cover and maintain visual contact with at least the upper portion of the cloud if not with the portions at the actual sampling altitudes. With such a visual reference, sampling can be carried out in a satisfactory manner.

The weather conditions, however, worsened considerably during the night and at shot time were characterized by an 8/8 cumulus cover from 1,000 to approximately 15,000 feet (absolute), an alto-stratus layer of unknown extent above the cumulus, and, still higher, a total cirrus cover extending from approximately 37,000 feet (absolute) to what later was established to be 52,000 feet (absolute). From its zero time altitude of 40,000 feet (absolute), the director aircraft had no view of the bomb

[redacted]

cloud during early times after burst except for a brief period when the bomb light shown diffusely through the cloud cover.

A graphic view of the weather formations from an altitude of about 15,000 feet (absolute) between H+1 and H+5 minutes can be obtained from Figs. 11.2-1 thru 11.2-4 (pictures and data were furnished by Project 9.1). As is shown in Fig. 11.2-4, contrast between the bomb cloud and the natural clouds is becoming extremely poor. Consolidation of the space between cloud layers from growth of the moisture rings and the rise of the cumulus layer, together with the high moisture content of the bomb cloud, made it extremely difficult to distinguish bomb cloud from natural weather cloud at later times. The situation was also complicated by rapid dispersion of the bomb cloud because of a very unfavorable wind-shear structure. DELETED mission is reported in some detail below as illustrative of the difficulties of successfully conducting a sampling mission under "all-weather" conditions.

As daylight illumination increased, the extent and opaqueness of the cirrus layer within which the director aircraft was flying became apparent. An attempt was made by interrogation of other aircraft in the vicinity to find a location from which visual contact with the cloud could be made. This attempt was in some degree successful in that at about H+60 minutes, the director aircraft (now at 45,000 feet (absolute)) found a hazy hole in the cirrus cover to the east of zero point. By looking down and to the north through this hole, heavy white clouds could be seen which cast a shadow of brown transmitted light on lower cumulus heads. Because of the heavy weight of the director aircraft which required a long orbit

[redacted]

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path in order not to lose altitude, the desire to avoid serious contamination of this aircraft, and the production of contrails by the aircraft itself which filled the hasy hole in the cirrus, it was not possible to hold what was probably the bomb cloud in view for longer than about twenty minutes.

At about this time the two reconnaissance F84G aircraft reported "solid instrument conditions up to 30,000 feet (pressure) with cumulonimbus heads protruding well above this altitude and a cirrus layer beginning at 36,000 feet (pressure) and extending up to an estimated 55,000 feet". These aircraft were able to see only an extremely small edge of the cloud on the north side at 38,000 feet altitude that was in a small break in the cirrus and another portion of the cloud on the south side which was in another small break. This portion was reported to be not over 1/8 mile long and 1/2 mile wide. They were not able to remain under visual flying conditions while skirting the cloud at 40,000 feet, and furthermore, found that the space between 30,000 and 36,000 feet (pressure) was approximately 4/8 to 5/8 obscured by cumulus and stratoform clouds which afforded very little visibility between layers. For this reason it was decided not to have the director aircraft descend. It therefore remained at an altitude of 45,000 feet and made blind orbits in the soup, generally east and west and more or less parallel with the expected path of the cloud. The west end of this orbit brought it into a gamma radiation field which, from the projected shear pattern of the cloud, probably originated from an upper layer of cloud. The east end of this orbit showed no traces of radiation.

[redacted]

With the help of three F84G aircraft from the first flight, another hazy hole was later located and these aircraft were directed to sample in a random manner in likely clouds in its vicinity. They were able to find only very diffuse, low-intensity material and were unable to collect very large samples. The middle flight of aircraft experienced a number of mechanical and limited-fuel aborts so that no samples were collected between H+3 and H+5 hours.

During this period, however, the director aircraft received a series of Eniwetok wind observations and was able to predict with reliability the position of a section of the cloud lying between 36,000 and 43,000 feet. It, therefore, descended to approximately 38,000 feet, crossed below a heavy portion of higher cloud which lay along the line of flight of the predicted layer, and found a hazy hole on one side of which a bank of heavy white clouds could be seen. Since these clouds gave evidence of gamma radiation when approached by the director aircraft, the last flight of F84G aircraft were brought from zero point to this position, one pair flying a systematic search mission enroute, the second pair being brought directly to the director and vectored into the target clouds.

Both pairs of F84G aircraft were successful in finding diffuse cloud material of low concentration. Had their flight time been longer or this position achieved earlier, it is possible that the samples collected by them might have been larger.

The presence of high altitude cirrus, as well as a marked velocity and directional wind shear between 50,000 and 60,000 feet, also adversely

[redacted]

[redacted]

affected the B-36 samplers. The upper cloud lay far to the west, while the cloud below 50,000 feet lay within the cirrus to the south-east of zero point. These aircraft had to sample below their maximum altitude capability at positions where the presence of the bomb cloud could only be inferred by the detection of gamma radiation in flying above the cirrus. While sampling in the cirrus, they were unable to distinguish whether they were flying in radiation shine from cloud at yet lower altitudes or whether they were flying through primary cloud. Their collection results appear to indicate that much of the radiation intensity seen could be attributed to cloud shine.

Although it reported that the bomb cloud was completely obscured by alto-cumulus and alto-stratus clouds at altitudes in the neighborhood of 25,000 feet, the "fractionation sampler" (WB-29, Wilson 1) was the most successful of the sampling aircraft on this "all-weather" mission. Blessed by almost light and variable winds between 20,000 and 30,000 feet, it very systematically searched on instruments for areas of gamma radiation to the north of zero point and was able to collect a normal sample.

The sample collection results for the [redacted]ission are shown in Table 11.2-1. The samples collected on the [redacted]ot are given for comparison. Inspection of this table immediately reveals that with the exception of Wilson 1, the samples collected for [redacted]ere between [redacted] It may be possible, theoretically, to conduct a successful "all-weather" sampling mission if favorable wind shear conditions exist and are accurately known.

[redacted]

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[redacted]

The results of the [redacted] mission indicate, however, that, if "all-weather" conditions are complicated by unfavorable and inaccurately known wind-shear conditions, the probability of collecting satisfactory samples is low. As it was, the collection of at least some cloud material by the majority of the sampling aircraft should be considered an achievement of the first magnitude. In view of the weather conditions and the aircraft malfunctions which occured, the execution of the [redacted] sampling mission without fatality should be considered a tribute to the skill and courage of the F84G pilots who flew it.

Under circumstances in which a high probability of a complete failure of the aircraft sampling effort existed it is fortunate that two surface samples, one from a blower unit on Engebi and the other from a funnel unit on Bogallua, provided useful sample material and would have been invaluable in the absence of any other samples.

[redacted]

EXTRANEOUS MATERIAL DELETED

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PART III

TASK UNIT 7

TASK UNIT 7 - J. D. Servis, Maj, USA

RADIOLOGICAL SAFETY

(J. D. Servis)

A damage and radiation survey was conducted at approximately H+4 hours DELETED This survey covered the islands of the atoll and was conclusive enough to limit reentry to the southern and eastern islands of the atoll. This survey indicated that radioactive contamination extended north of a line from Bogallua to Piraai. Secondary fall-out amounting to 2 mr/hr was experienced at Parry on the evening of [redacted] day.

Lagoon water was moderately contaminated in the vicinity of the chain Bogallua - Teiteiripucchi and cleared within two days.

TABLE TU-7-1
[redacted] RADIATION SUMMARY (r/hr)

Island	Extrapolated H+4 hrs	D + 1 day*	D + 2 days
Eniwetok	0	0	0
Parry	0	0	0
Japtan	0	0	0
Chinimi	0	0	0
Aniyaanii	0	0	0
Chinieero	0	0	0
Runit	0	0	0
Piraai	0.05	0.006	0.006
Aaraanbiru	0.06	0.01	0.01
Rojoa	0.10	0.01	0.01
Bijiri	0.12	0.014	0.01

DELETED TABLE TU-7-1 (Continued)
[redacted] SUMMARY (r/hr)

Island	Extrapolated H + 4 hrs	D + 1 day*	D + 2 days
Aomon	0.17	0.02	0.02
Eberiru	0.17	0.02	0.02
Rujoru	0.10	0.012	0.02
Aitsu	0.14	0.016	0.02
Yairi	0.17	0.02	0.02
Bokonaarappu	0.17	0.02	0.02
Kirinian	0.35	0.04	0.04
Muzin	0.42	0.05	0.06
Engebi	0.70	0.08	0.08
Bogon	0.98	0.12	0.14
Bogairikk	?	0.22	0.60
Teiteiripucchi	60.0	6.8	7.0
Cochiti	70.0	8.0	12.
San Ildefonso	75.0	8.4	1.0
Ruchi	8.0	0.80	0.36
Bogombogo	3.9	0.44	0.36
Bogallua	2.2	0.26	0.28
Rigili	0	0	- -
Giriinien	0	0	- -
Ribaioni	0	0	- -
Pokon	0	0	- -
Mui	0	0	---
Igurin	0	0	- -

* Period preceded by heavy rainfall.

[redacted]

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EXTR[illegible]

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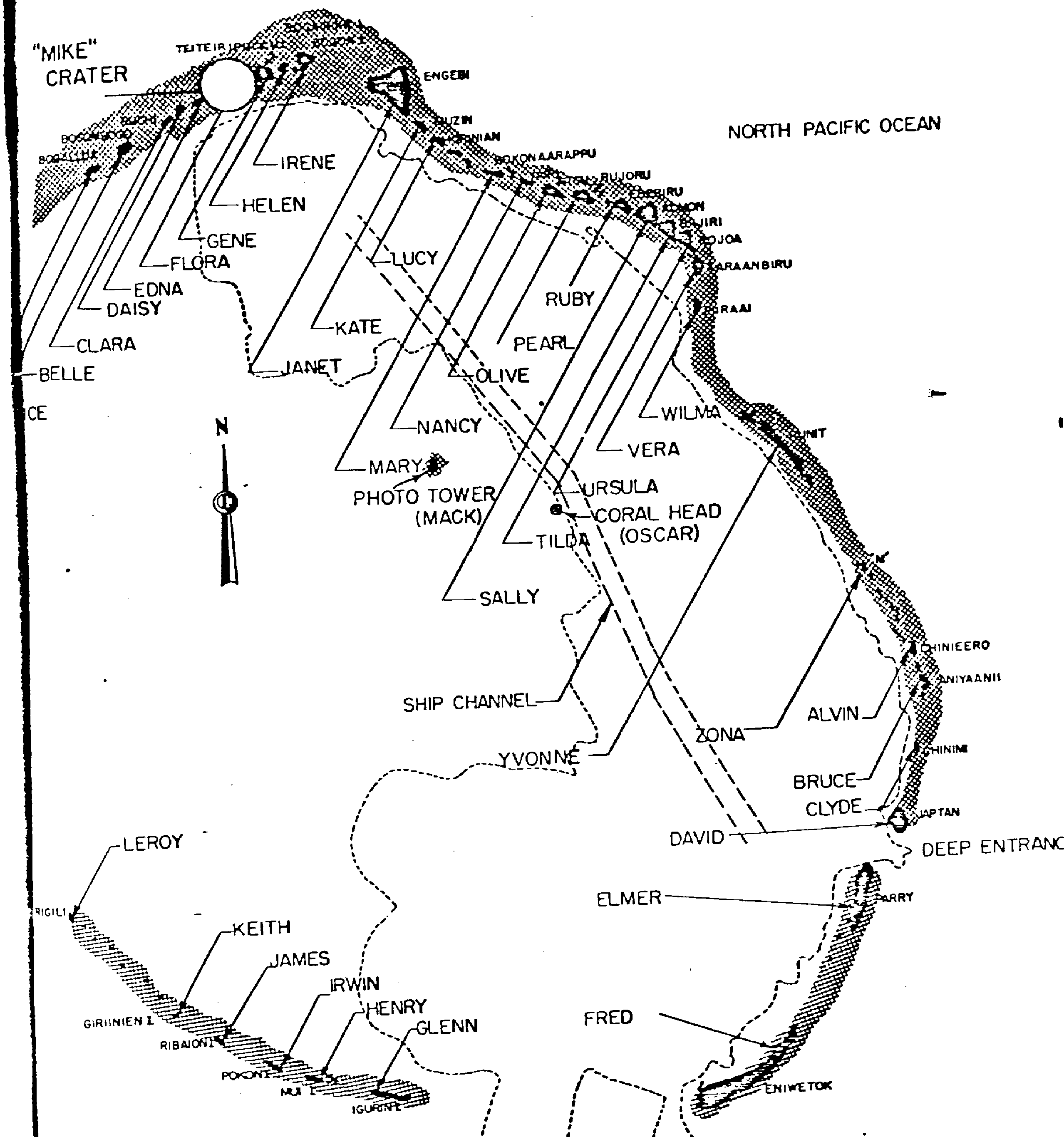
[redacted]

TABLE A-1
WEATHER (ENIWETOK ATOLL) AT 0558M, 14 MAY 1954

Surface Pressure	1006.4 mb
Surface Temperature	80° F
Surface Humidity	85%

Altitude (ft)	Wind Direction (degrees)	Velocity (knots)	Pressure (mb)	Temp. (°C)	Dew Point (°C)	Relative Humidity
Surface	090	19	1006	25.9	24.7	93
1,000	090	21	968	24.5	22.7	90
1,500	100	20	953	23.6	22.0	91
2,000	100	17	937	22.7	21.1	91
3,000	110	19	905	21.0	19.6	92
4,000	110	19	874	19.3	17.9	92
5,000	110	15	843	17.3	16.2	93
6,000	110	14	813	16.6	15.5	93
7,000	100	12	785	13.8	12.8	94
8,000	100	10	757	10.6	08.3	85
9,000	110	11	730	10.5	06.3	75
10,000	110	14	704	9.3	05.5	77
12,000	120	17	653	5.4	02.6	82
14,000	110	18	606	3.1	00.5	83
16,000	130	12	562	-0.5	-2.8	84
18,000	140	12	522	-4.1	-12.9	50
20,000	130	08	488	-5.8	-18.8	35
25,000	190	06	395	-15.0	MB	MB
30,000	230	17				
35,000	210	09				
40,000	210	24				
45,000	230	32				
50,000	280	35				
51,000	290	38				

[redacted]



[redacted]

Fig. A-1

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