WORLD-WIDE FALLOUT FROM OPERATION CASTLE

Weather Bureau
Washington, D. C.

May 17, 1955

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# Report Title

**WORLD-WIDE Fallout FROM OPERATION CASTLE**

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## Abstract

A world-wide network of gummied film stations was established to monitor fallout following Operation Castle. Although meteorological data were poor, a general connection of tropospheric flow patterns with observed fallout was evident. There was a tendency for debris to remain in tropical latitudes, with incursions into the temperate regions associated with meteorological disturbances of the predominantly zonal flow. As the season advanced, such incursions became more evident. Outside of the tropics, the southwestern United States received the greatest total fallout, about five times that received in Japan.

## Key Words

- Operation CASTLE
- World-Wide Fallout

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FOREWORD

This report has had classified material removed in order to make the information available on an unclassified, open publication basis, to any interested parties. This effort to declassify this report has been accomplished specifically to support the Department of Defense Nuclear Test Personnel Review (NTPR) Program. The objective is to facilitate studies of the low levels of radiation received by some individuals during the atmospheric nuclear test program by making as much information as possible available to all interested parties.

The material which has been deleted is all currently classified as Restricted Data or Formerly Restricted Data under the provision of the Atomic Energy Act of 1954, (as amended) or is National Security Information.

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It is the belief of the individuals who have participated in preparing this report by deleting the classified material and of the Defense Nuclear Agency that the report accurately portrays the contents of the original and that the deleted material is of little or no significance to studies into the amounts or types of radiation received by any individuals during the atmospheric nuclear test program.
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# Illustrations

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ABSTRACT

A world-wide network of gummed film stations was established to monitor fallout following Operation Castle. Although meteorological data were poor, a general connection of tropospheric flow patterns with observed fallout was evident. There was a tendency for debris to remain in tropical latitudes, with incursions into the temperate regions associated with meteorological disturbances of the predominantly zonal flow. As the season advanced, such incursions became more evident. Outside of the tropics, the southwestern United States received the greatest total fallout, about five times that received in Japan. The total world-wide fallout up to July 1, 1952, from the Castle series outside of the immediate test area, is estimated to be about of the total fission activity produced.

The maximum fallout on any day at an individual station in the United States, corrected to sampling day, was 200,000 d/m/ft².

It is concluded that the probability of early fallout in inhabited regions would be reduced by holding Pacific test series in the winter months.
CHAPTER 1

INTRODUCTION

In the spring of 1952, Operation Castle, a series of atomic tests, was conducted at the Atomic Energy Commission's Pacific Proving Grounds in the Marshall Islands. Again, as in other recent test series (1, 2, 3), an extensive network of gummed cellulose acetate film sampling stations was established by the New York Operations Office Health and Safety Laboratory to monitor the deposition of radioactive dust resulting from the detonations. For the Castle tests, the gummed film network was expanded considerably to include a representative world-wide network of 122 stations (Figures 1.1 and 1.2). The U. S. Weather Bureau operated 39 stations in the continental United States and 13 at overseas locations; the Air Weather Service operated 22 overseas stations, the State Department 31, three were operated by the Navy and Coast Guard, and two by the Atomic Bomb Casualty Commission. The Canadian Meteorological Service cooperated by operating nine stations and the Canadian Atomic Energy Commission one. All stations were scheduled to make two simultaneous 24-hour collections starting at 1230 G.C.T. each day.

In addition, single gummed film stands were installed on most ships of the Military Sea Transport Service scheduled to be on routes in the Pacific Ocean. The ship collections were also made daily.

The mechanism of transport of atomic debris and the representativeness of gummed film samples have been discussed in previous reports. The only changes in technique involved in the present series of observations concern the decay correction and the installation of snow melting devices at certain northern stations.

The modified gummed film stand for use in snowy climates consisted of a 0.5 ft² plate warmed by a thermostatically-controlled electric heating element. The melt water was allowed to run off the surface, making the observations comparable to those of rainfall on a conventional gummed film stand.

To simplify the procedures used in correcting for decay and assigning measured activity to particular bursts, a somewhat arbitrary system of burst assignment was used in those cases where the burst responsible for the radioactive debris was uncertain. All radioactivity collected from Pacific Islands and from ships was assumed to have come from the latest burst, activity elsewhere in the world, from the burst prior to the latest. Where there were definite
FIGURE 12  FALLOUT MONITORING NETWORK, ATLANTIC HEMISPHERE
indications that the arbitrary system was in error, the activity was reassigned to the appropriate burst. In the case of observations in the Pacific and adjoining regions, it was usually possible to determine the burst responsible for the activity from an examination of the trajectories of the debris in conjunction with observed increases in radioactivity. Elsewhere in the world, it was ordinarily necessary to use the arbitrarily assigned burst. All maps of daily fallout values indicate the burst assignment used in computing the decay correction. Unless otherwise indicated, all radioactivity is reported in units of disintegrations per minute per square foot of gummed film, decayed to 100 days after the day of the burst. The t^-1.2 law for the decay of fission product activity has been used throughout.

The maps of daily fallout include only the data from the land stations, since there is considerable uncertainty in the ship data. The locations of the ships were imperfectly known and the procedures for avoiding cross-contamination of samples in handling and mailing, particularly on ships exposed to heavy fallout at some time during their voyage, were not adequate. The ship data were utilized in the drawing of isolines of activity on the fallout maps and in the interpretation of the land station data.
The bursts of the Castle series are given in Table 2.1.

Table 2.1. Castle Test Series

<table>
<thead>
<tr>
<th>Burst No.</th>
<th>Code</th>
<th>Date</th>
<th>Time</th>
<th>Yield (MT)</th>
<th>Estimated vertical mushroom dimension (1000's of ft.)</th>
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<tbody>
<tr>
<td>1</td>
<td>Bravo</td>
<td>Feb. 28</td>
<td>1845</td>
<td>15</td>
<td>62</td>
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<tr>
<td>2</td>
<td>Romeo</td>
<td>Mar. 26</td>
<td>1830</td>
<td>11</td>
<td>62</td>
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<tr>
<td>3</td>
<td>Koon</td>
<td>Apr. 6</td>
<td>1820</td>
<td>0.11</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Union</td>
<td>Apr. 25</td>
<td>1810</td>
<td>7</td>
<td>53</td>
</tr>
<tr>
<td>5</td>
<td>Yankee</td>
<td>May 4</td>
<td>1810</td>
<td>13.5</td>
<td>7h</td>
</tr>
<tr>
<td>6</td>
<td>Nectar</td>
<td>May 13</td>
<td>1820</td>
<td>1.7</td>
<td>45</td>
</tr>
</tbody>
</table>

With the exception of the third burst, the Castle series consisted of high-yield detonations. The first burst was detonated on Bikini Atoll, the succeeding four from barges in the Bikini lagoon and the last on Eniwetok Atoll.

As shown in Table 2.1, most of the radioactive clouds created in the Castle series extended to very great heights, with the mushroom of the cloud well in the stratosphere, and the greater part of the cloud in levels beyond the reach of routine meteorological observations. For this reason, it has been impossible to prepare adequate meteorological trajectories to determine the path of the debris at various levels. The network of upper air observing stations in the tropics is extremely sparse at best, and wind reports at levels above 40,000 feet are virtually nonexistent, with the exception of a few from stations in the Marshall Islands and adjacent areas established especially for this test series. Even at these stations, the highest observations rarely extend above 100,000 ft.
The meteorological trajectories for the various bursts cannot, therefore, be computed at levels above 40,000 ft. and are doubtful even at lower levels. All trajectories given in this report were computed by personnel of the Air Weather Service (SUPA Branch) and are prepared for the 850-mb. (5,000-ft.), 700-mb. (10,000-ft.), 500-mb. (18,000-ft.), 300-mb. (30,000-ft.), and 200-mb. (40,000-ft.), levels only.

The temperature soundings for all of the Castle bursts were very similar in their major features. There were no pronounced inversions in the lower layers (except for an inversion at about 7,000 feet during Romeo). The air was quite moist up to about 5,000 feet, and somewhat drier above, with fairly steep lapse rates in the upper troposphere. The tropopause was between 48,000 and 54,000 feet with very stable lapse rates in the lower stratosphere above. The winds obtained from observations made at or near each of the shots are shown in Figure 2.1.

2.1 BRAVO

The first burst of the Castle series, Bravo, was detonated from a coral reef in Bikini Atoll on 18h5 GCT, February 28, 1954. The resulting cloud of radioactive debris reached to 114,000 feet with the base of the mushroom at about 60,000 feet. The tropopause at this time was at about 54,000 feet, so that the mushroom of the cloud was entirely in the stratosphere. The low-level easterly trades extended to about 6,000 feet, with light westerly winds increasing with altitude to a maximum of about 40 knots at 35-40,000 feet, extending to the base of the stratosphere. Easterly winds prevailed throughout the stratosphere to the highest altitude reached by the meteorological observations, about 100,000 feet. Winds at this level were easterly at about 50 knots.

Trajectories of the lower parts of the cloud are shown in Figure 2.2, but unfortunately, no trajectories can be constructed for the higher levels. Available evidence to about 100,000 feet (observations in the Marshall Islands and at Guam) indicates general easterly winds in the lower stratosphere, so that this portion of the cloud moved toward the Philippines. No observations to indicate the movement of the cloud above 100,000 feet are available. However, it is likely that easterly winds prevailed at these levels.

The daily fallout maps for the period following the Bravo test are particularly interesting in that the background of fission product activity from previous tests was negligible and the succeeding burst did not occur until 26 days later, so that the progression of areas of fallout from day to day is more easily seen.
FIGURE 2.1 WINDS ALOFT FOR CASTLE EVENTS
FIGURE 2.2 METEOROLOGICAL TRAJECTORIES FOR BURST NO. 1, BRAVO
The eastward moving debris reached the Americas on March 7 and 8, indicating an average west wind of about 40 knots, in good agreement with the few wind observations available in the upper troposphere. Although the progression of debris to the west appears to be in good agreement with the 5,000-foot trajectory, indicating that the transport occurred in the trade wind layers, it is entirely possible that stratospheric debris moving with the upper level easterlies contributed to this fallout also.

The most striking fact which emerges from a study of the fallout in the period following the Bravo test is the tendency for the debris to remain in the tropical latitudes. By far the largest amounts of fallout occurred in the latitude band from 10°S to 20°N, with occasional excursions into the more temperate latitudes of each hemisphere, particularly in the Americas. An example of this can be seen in the southwestern United States in the period beginning March 15. At this time, a deep low pressure system extending through most of the troposphere was located just off the west coast, with strong southwesterly winds over the southwestern states. This depression moved slowly eastward so that by March 18th, the southwesterly winds were over the Mississippi Valley. An examination of the fallout maps reveals that fallout during this period was associated with the southwesterly winds, which carried debris from the tropical regions. It is significant that this fallout was independent of precipitation. The highest fallout values occurred during the first three days of the period when there was no precipitation, and even on the 18th, when there were several stations reporting precipitation, the fallout occurred in the region dominated by the southwesterly winds and was not closely associated with the existence of precipitation. A somewhat similar series of events occurred in the period March 21-25, although precipitation was more widespread in this case and may have had more influence on the observed fallout patterns.

2.2 ROMEO

The second burst of the Castle series, Romeo, also a high-yield burst of the same order of magnitude as the Bravo test, was detonated from a barge at 1830 GCT, March 26, 1954. The resulting cloud of debris reached to 110,000 feet, with the base of the mushroom top at 62,000 feet. The wind observations associated with this burst showed light easterly winds at virtually all levels increasing in speed above 80,000 feet to a maximum of 92 knots from the SE at the top of the highest observation, 95,000 feet. Although the trajectories (Figure 2.3) at all levels in the troposphere moved westward initially, the 30,000- and 40,000-foot trajectories curved northward
and then eastward within a very short time. The lowest levels con-
tinued westward and the 18,000-foot trajectory appeared to curve
back towards the United States on the 26th, although the meteor-
ological data is uncertain. Winds in the stratosphere up to the
level of the top of the cloud were probably from the east, carrying
most of the mushroom westward.

Although almost a month elapsed between the first and second
bursts of the Castle series, enough debris from the first burst was
present to seriously interfere with attempts to trace the progress
of the second cloud by an examination of fallout data. For example,
an increase in deposited activity occurred at some stations in
Central and South America on March 31 and April 1, several days
before the meteorological trajectories would indicate the arrival
of debris. It is not certain if this is due to the complete lack
of meteorological observations in the Eastern Pacific and the winds
were really stronger than assumed, or that the debris was actually
from the Bravo burst. (Note: Since all fallout data is extrapolated
to 100 days after the assigned burst, values assigned to different
bursts cannot be compared directly. The extrapolation factor depends:
both on the day of the burst and on the day the sample was counted.
For the areas mentioned in this paragraph, values assigned to burst
2 would have to be increased by about a factor of three if the debris
were assigned to burst 1).

By April 2nd and 3rd increases in activity are evident along the
Gulf Coast of the United States and certainly by the 4th and 5th there
is good evidence that debris from this burst has arrived over the
United States. Again, as when fresh Bravo debris was present, fallout
seemed to occur irrespective of the occurrence of precipitation.

The progression of debris westward from the test site appears to
have been more rapid than indicated by the low-level trajectories
at 5,000 and 10,000 feet, at least for the first few days following
the burst. Whether the arrival of debris at Yap and Koror on March 29
is a result of transport of material westward in the stratospheric
easterlies or in faster-than-observed low-level trades is not certain.
Again, as with Bravo debris, there was a marked tendency for the
fallout to occur in the tropical areas, with occasional incursions into
the United States.

2.3 Koon

Koon, the third burst of the series, was, by far, the least
powerful device tested, with a yield of 110 KT. It was detonated at
Bikini at 1820 GCT, April 6, 1954, but cloudy conditions prevented
accurate observations of the character of the cloud. Presumably, the top of the mushroom was at, or slightly above, the tropopause, which was at 53,000 feet. The winds were easterly to 5,000 feet, light southerly above to about 30,000 feet, becoming westerly about 30-40 knots to the tropopause. Because of large amounts of fallout from the second burst, which occurred eleven days earlier, it was impossible to trace the history of the debris from Koon. According to the meteorological trajectories (Figure 2.4), the lowest layers moved westward, the mid-tropospheric portion milled about to the north of the Marshall's for many days and the upper portion moved eastward, remaining south of the Hawaiian Islands, reaching the southwestern states on April 13. No fallout station reported debris which can be definitely assigned to this burst, although it is likely that some of the activity assigned to Romeo is a mixture of debris from the two bursts. No fallout has been assigned to Koon in this report.

2.4 UNION

The fourth test of the series, Union, detonated at Bikini at 1810 GCT, April 25, 1954, was also a high-yield burst, which reached well into the stratosphere to 91,000 ft. The wind pattern was typical, easterly trades in the lower levels, light winds above, becoming westerly near the tropopause, and strong easterlies above 70,000 feet. Trajectories of this burst are shown in Figure 2.5. If the 30,000- and 40,000-foot trajectories are correct, very little fallout was evident from these levels, since no debris was detected in Mexico or along the Gulf coast until May 5 or later. Fallout at Medford, Ore., on May 2 and in the western states on the following days is in good agreement with the 18,000-foot meteorological trajectory. It is very possible that the lack of meteorological data resulted in erroneous trajectories at 30,000 and 40,000 feet, since debris arriving in Central and South America on May 5 was most likely transported at these levels. Fallout to the west of Bikini seemed to be in good agreement with the trajectories. It should be noted that even though a month had elapsed since the last high-yield burst, considerable fallout is occurring throughout the tropics and it is by no means certain that the debris assigned to Union is not from an earlier burst, or that some of the activity assumed to be from Romeo is not actually from Union.

2.5 YANKEE

Yankee, the fifth burst of the series, was detonated from Bikini at 1810 GCT, May 4, 1954. It was a high-yield device
FIGURE 2.4 METEOROLOGICAL TRAJECTORIES FOR BURST NO. 3, KOON
the cloud reached 110,000 feet. Although the winds, in general, were similar to those of the previous bursts, the westerly winds just below the tropopause attained higher speeds than had occurred during the previous tests, 55 to 65 knots at 40,000 feet. Trajectories are shown in Figure 2.6. Debris reached Mexico City on May 8, and fallout was widespread over the western plains states and the Rockies by May 9. Fallout from this burst continued over the western half of the United States (with the exception of the Pacific Coast) in significant amounts for a period of more than a week. The fallout from Yankee in this region exceeded, by almost an order of magnitude, the fallout from any of the other tests of the series. The westward moving debris appeared to proceed faster than indicated by the low-level trades, reaching Koror by May 6 and Singapore by May 9. Again, it is very possible that high-level easterlies carried the debris, since the 25-30 knot winds required are somewhat faster than expected in the trades of the Western Pacific.

2.6 NECTAR

The last test of the series, Nectar, was the only burst detonated from Emiwo. It occurred at 1820 GMT, May 13, 1951, and was of a somewhat lower yield than the other high-yield tests of the series. The resulting cloud reached 72,000 feet. The easterly winds extended to 20,000 feet, with light westerlies above to the base of the stratosphere. The trajectories from this burst (Figure 2.7) began with a slightly greater component towards the north than for the previous bursts.

Since Yankee and Nectar were separated by only nine days, it is virtually impossible to distinguish between debris from the two bursts. An attempt to separate the two sources of debris was made for the first week following Nectar, but was not attempted beyond this time. Daily fallout maps for the remainder of the month, May 22-31, are given with all data extrapolated to 100 days after Nectar because of the arbitrary system of burst assignment used. However, it is likely that the major portion of the fallout reported on these days originated from Yankee. To convert the reported activity to 100 days after Yankee, assuming the debris originating from Yankee, the values given on the maps should be increased by about 30-40%.
FIGURE 2.7 METEOROLOGICAL TRAJECTORIES FOR BURST NO.6, NECTAR
To conserve space, daily fallout maps for the month of June are not shown. Rather, a map showing the average daily fallout for the month is given, together with the number of days for which data was available at each station. Again, the extrapolation is based on Nectar, and activity is shown at 100 days after burst. It is also likely that the major portion of the fallout in June originated from Yankee and all values should be increased by about 25% to give values at 100 days after Yankee.

Although the discussion of the transport of debris in the atmosphere has been confined to essentially horizontal trajectories, the actual paths of individual radioactive particles are complex, three-dimensional phenomena, influenced by the fall velocities of the particles, atmospheric turbulence, rain scavenging and orographic effects.
CHAPTER 3

TOTAL WORLD-WIDE FALLOUT

3.1 CASTLE TOTAL

The total world-wide fallout from each of the Castle tests (except Koon) and from the whole series has been computed on the basis of results from the monitoring network. Since none of the stations were located immediately downwind of the test area so as to experience fallout in the first day or two following a detonation, it is apparent that by far the largest fraction of the fallout, the "close-in" fallout, has not been measured.

A composite map for the complete series, showing the total of all fallout occurring through June 30, 1954, and decayed to July 1, 1954, is shown in Figures 3.1 and 3.2. These maps contain the cumulative total of all debris deposited on the network from February 28 through June 30, 1954. The debris was extrapolated to July 1 on the basis of the burst assignments indicated in Appendix A (except for fallout occurring after May 21, which was reextrapolated to Yankee, see Section 2.6).

Isolines of activity were interpolated between stations and the average fallout for the world was computed, by numerical integration, to be 9194 d/m/ft² for a total of 22.73 megacuries.

3.2 TOTALS FOR INDIVIDUAL TESTS

To obtain the total fallout due to each of the individual tests, the following procedure, was used. At each station, all fallout assigned to the given burst, as indicated on the maps of Appendix A, was summed, and the total fallout values, in d/m/ft² at 100 days after burst, were entered on a map. (For these computations, fallout occurring after May 21 was not considered, since there was some doubt as to burst assignment.) In the event that data were missing for an occasional day at a given station, the missing values were estimated by interpolation. If data were missing for a number of days, the sum was entered in parentheses and indicated as a lower limit of activity. Isolines of activity were drawn and the total fallout computed by numerical integration.
It is not appropriate to compare the results from the various tests without first considering the time periods between tests. For example, fallout from Bravo was not masked by later debris for about a month in the region of tests, and could be identified for an even longer period in regions remote from the test site. On the other hand, Union debris was quickly overshadowed by fallout from Yankee, which occurred nine days later.

The world-wide distribution of fallout from Bravo is shown in Figures 3.3 and 3.4. Assigned to the burst was all fallout from the period from February 28 to April 5, 1954, with the exception of debris in a limited area which was determined to be from Romeo (See Appendix A). The average activity of this fallout, corrected to 100 days after burst, was 1937 d/m/ft², for a total fallout of megacuries, or megacuries as of July 1, 1954.

Figures 3.5 and 3.6 show the total Romeo fallout from the time of the bursts through May 3, 1954. The world-wide average activity at 100 days after burst was 1145 d/m/ft² for a total of megacuries, or megacuries on July 1. No debris was assigned to the third burst, Koon.

Fallout from Union (Figures 3.7 and 3.8) covers the period through May 12, a somewhat shorter period than the first two bursts, since Yankee was detonated only nine days after Union. The world-wide average fallout was 282 d/m/ft² at 100 days after burst for a total of megacuries, or megacuries on July 1.

Yankee cumulative results are given in Figures 3.9 and 3.10. Debris was specifically attributed to this burst through May 21. However, much of the fallout which occurred beyond this period also originated from Yankee so that the total fallout is undoubtedly much greater than the values given. Through May 21, Yankee fallout averaged 1219 d/m/ft², for a total of megacuries at 100 days after burst. Corrected to July 1, 1954, this value becomes megacuries.

Nectar fallout is shown in Figure 3.11. Since this burst followed the powerful Yankee burst by only nine days, debris from Nectar is identifiable as such only for a few days and in the region near the test area. This fallout from Nectar amounts to a world-wide average of 81 d/m/ft², or megacuries, at 100 days after burst, megacuries on July 1, 1954.
3.3 COMPARISON WITH TOTAL BETA YIELD

It is possible to compare the total fallout observed during the Castle series with the amount of beta activity produced. Assuming the relationships between fission yield and total beta activity given in The Effects of Atomic Weapons (4, p. 251) is valid, the beta activity in the fission products from a nominal bomb (20 kt) is approximately 266 megacuries after one day. Using the fission yields given in Table 2.1, and the $t^{-1.2}$ law, the total beta activity produced in the Castle is shown in Table 3.1.

### TABLE 3.1

Total Beta Activity Products in Castle Series

<table>
<thead>
<tr>
<th>Burst</th>
<th>Total Activity Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bravo</td>
<td></td>
</tr>
<tr>
<td>2. Romeo</td>
<td></td>
</tr>
<tr>
<td>3. Koon</td>
<td></td>
</tr>
<tr>
<td>4. Union</td>
<td></td>
</tr>
<tr>
<td>5. Yankee</td>
<td></td>
</tr>
<tr>
<td>6. Nectar</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

A comparison of the observed fallout from the first two events and from the series as a whole with the total produced is shown in Table 3.2. The remaining events are not shown individually since the intervals between bursts were too short to adequately differentiate the debris for this purpose.

### TABLE 3.2

Comparison of Observed Fallout with Total Produced

<table>
<thead>
<tr>
<th>Burst</th>
<th>Total Fallout</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 days after burst (megacuries)</td>
</tr>
<tr>
<td>Bravo</td>
<td></td>
</tr>
<tr>
<td>Romeo</td>
<td></td>
</tr>
<tr>
<td>Castle Series</td>
<td>- 23 -</td>
</tr>
</tbody>
</table>
The small percentage of total debris accounted for by the observing network is somewhat puzzling. Although it must be assumed that a large fraction of the active debris was deposited in the vicinity of the test site, it is also true that the shortcomings of the gummed film technique, which have been discussed in previous reports, may be responsible for the effect noted.

A suggestion that increased "stratospheric storage" may be important is indicated by the fact that approximately 1% of the debris from the Castle series was detected, as compared to over 4% from the Ivy series.*

Since the three most powerful bursts of the Castle series were considerably larger than the Ivy Mike test, it is possible that a larger fraction of the debris was transported initially into the lower stratosphere.

3.4 METEOROLOGICAL INTERPRETATION

The total fallout from the Bravo test (Figures 3.3 and 3.4) clearly show the tendency for the major activity to remain near the source latitude. In marked contrast with the fallout from the Ivy series, there seems to be no evidence that debris was carried northward around the western side of the Pacific high-pressure cell. Almost no fallout occurred in Japan, and very little on Iwo Jima from the Bravo test, while Ivy Mike resulted in more fallout on Iwo Jima than on any of the other Pacific Islands. The difference between the two tests is a result of the seasonal difference in the location and intensity of the western cell of the Pacific high. This cell is almost non-existent, in the mean, during the winter and

---

*The figures given in Table 6.2 of reference (2) have been revised following a recalibration of the counting equipment. The revised figures are:

<table>
<thead>
<tr>
<th></th>
<th>Observed World-wide Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(megacuries as of 1/1/53)</td>
</tr>
<tr>
<td>Mike</td>
<td></td>
</tr>
<tr>
<td>King</td>
<td></td>
</tr>
<tr>
<td>Ivy total</td>
<td></td>
</tr>
</tbody>
</table>

---

- 33 -
early spring, when the Aleutian lows are farther south. As the western cell of the Pacific high intensifies, more debris can be carried toward the north, so that by the time of the Yankee test (Figures 3.9 and 3.10), in early May, a larger fraction of the fallout occurred in Japan. Presumably, tests in the summer and early fall would result in the greatest contamination of the Japanese Islands, while winter tests would result in the least. Also during the winter months, precipitation in Japan is at a minimum except for a narrow zone on the western slopes. For most of Japan, maximum rainfall occurs during the warm season, with the heaviest rains in June and September.

Similarly, in other inhabited regions likely to be most affected by relatively early fallout, Mexico and Central America to the east and the Phillipines to the west of the test area, the dry season occurs in the winter and the rainiest in the warmer months, so that here too, fallout would be at a minimum for winter tests as compared to other seasons.

3.5 MAXIMUM ACTIVITY AT INDIVIDUAL STATIONS

The highest fallout reported on sampling day on an individual gummed film at each of the stations of the network is shown in Figures 3.12 and 3.13, together with the burst responsible (figure in parentheses), the number of days after burst that the fallout occurred and the precipitation observed. All activity values are in d/m/ft² corrected to sampling day. As can be seen, the fifth burst, Yankee, was responsible for the highest activity at most of the stations.

The high tropospheric westerlies were faster, resulting in a more rapid transport of debris towards the Americas. In addition, the winds in the eastern Pacific were from the west southwest, resulting in the passage of fresh debris over the southwestern and southern states.

On the western side of the Pacific, the normal seasonal increase in intensity of the western portion of the Pacific high-pressure cell and the retreat of the Aleutian low resulted in the transport of Yankee debris towards the Japanese Islands in the lower levels, although the direct trajectories at these levels moved generally eastward.
Activity in excess of 200,000 d/m/ft² on sampling day occurred at two stations in the United States following the Yankee burst (Billings, Mont., and Salt Lake City, Utah) and was a result of dry fallout at Salt Lake City and with rain at Billings. These values exceed by an order of magnitude the maximum fallout reported at any of the Japanese stations and are larger than the maximum values reported at many of the Pacific Islands much closer to the Pacific Proving Ground. (It should be noted that it is likely that Kusaie, Ponape and Kwajalein received their maximum activity following the Bravo burst, however, these stations did not start gummed film observations until about two weeks after this burst and the values given probably do not represent the maximum fallout for the Castle series.)
A series of special gummed film collections were made on Ponape, in the Caroline Islands. In addition to the regular gummed film observations, which were made at 0030 GCT daily at Ponape, a gummed film stand was placed near the windward shore of the island to attempt to sample air unaffected by local dust sources. No significant differences were found. Another gummed film stand was placed near the regular stands, but the film was changed at 12-hour intervals, in the morning and evening. On 11 days with heavy fallout, the film exposed during the daytime hours collected about 50% more activity than did the film exposed during the night hours, despite the fact that precipitation was about equally distributed in the two periods. This may be a result of the nocturnal stabilization of the very lowest layers of the atmosphere which inhibited the deposition of debris from turbulent eddies, although diurnal variations in the vertical temperature lapse rate are small on a 1.5-square-mile island in the trade wind belt.

To investigate the deposition of debris due to rainfall, rainwater samples were collected by a 30-inch diameter funnel (4.9 ft²) coincident with the exposure of the 24-hour films. The collected water was filtered at the end of each observation period and the filter sent to New York, for analysis. On the nine days with the heaviest fallout at Ponape, the total collection on the rain filters averaged 56% as much activity as on the one-square-foot gummed film. During the month of June, when fallout was relatively light, the rain filters collected twice as much activity as the gummed film. This is again indicative of the importance of the rainout process in bringing old debris (and presumably smaller particles) to the ground.
Maps showing the daily fallout on the monitoring network from February 28 to May 31, 1954, and the average daily fallout during the month of June, 1954, are appended. All values of radioactivity are in d/m collected on a square foot of gummed film in a day, extrapolated to 100 days after the burst. In most cases, two films were exposed simultaneously and the values for each are shown. The burst to which the debris was assigned for extrapolation purposes is indicated on each map. (See sec. 2.6 with reference to burst assignments after May 21.)

Lines delineating the areas of significant fallout (over 100 d/m/ft$^2$/day extrapolated to 100 days after burst), labelled with the event believed responsible for the fallout, are shown. The lines are dashed in areas of greatest uncertainty.

The precipitation which fell during each sampling period is shown in accordance with the code given on the maps. Snow has been reduced to its water equivalent.
FIGURE A.5  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1250 GCT, MARCH 2, 1954

ACTIVITIES
(SUMMARY)
PRELIMINARIES
ACTIVITY IN COUNTS/SEC AT SIX HOURS AFTER BURST
ALL ACTIVITY IS REFERRED TO BURST NO. 1, BORON, UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES
FIGURE A.9
RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 6, 1954

KEY
NERVIS
PRECAUTION

ACTIVITY IN Bq/m² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSUMED TO BURST NO. 1, UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARANETHESIS
FIGURE A 23
RADIOACTIVE FALLOUT IN THE
24-HOUR PERIOD BEGINNING
1230 GCT, MARCH 11, 1954

REV. ACTIVITY
(Data on)

PARTRITION

ACTIVITY IN Bq/m² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, BRAVO
UNLESS OTHERWISE INDICATED BY BURST NUMBER
IN PARENTHESES.
FIGURE A.26  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1250 G.C.T., MARCH 12, 1954

KEY

ACTIVITY

PRESENTATION

ACTIVITY IN S/KT* AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSUMED TO BURNOUT 1, BURST UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES
FIGURE A 29  RADIOACTIVE FALLOUT IN THE
24-HOUR PERIOD BEGINNING
1230 G.C.T., MARCH 14, 1954

KEY:
ACTIVITY
BURST
PRECIPITATION
ACTIVITY IN D/MT² IT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, BIKINI
UNLESS OTHERWISE INDICATED BY BURST NUMBER
IN PARENTHESES
FIGURE A 31  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 15, 1954

ACHT: ACTIVITY (Bq/m²)  PRECIPITATION

ACTIVITY IN Bq/m² AT 60 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, BANG
UNLESS OTHERWISE INDICATED BY BURST NUMBER
IN PARENTHESES.
FIGURE A.35
RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 17, 1954

KEY:

ACTIVITY (BURST #)

PRECIPITATION

ACTIVITY IN Ci/MPY AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, BRAWL
UNLESS OTHERWISE INDICATED BY BURST NUMBER
IN PARENTHESES.
FIGURE A.37  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 18, 1954

KEY
ACTIVITY
BURST NO.
PRECIPITATION
ACTIVITY IN 1/87"² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, BURST UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PRECEDING DEGREES.
FIGURE A.39  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 19, 1954

ACTIVITY (BURST)
PRECIPITATION

ACTIVITY IN Bq/m² as 100 days after burst
ALL ACTIVITY IS ASSIGNED TO BURST No. 1, BRAVO
UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES
FIGURE A.41
RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING
1230 G.C.T., MARCH 20, 1954

KEY
- ACTIVITY
- PRECIPITATION

ACTIVITY IN B/M/FT$^2$ AT 30 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, BIKINI
UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES
FIGURE A.43

RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 21, 1954

ACTIVITY

BUST (BURST)

PRECIPITATION

ACTIVITY IN MILIFIS AT THE DAY AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, BRAVO
UNLIT EXPLOSIONS INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.44  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 21, 1954

ACTIVITY

ACTIVITY IN Bq/17^2 AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSUMED TO BURST NO. 1, BRAVO
UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.

PRECIPITATION CODE:
N NO PRECIPITATION
Y YACOS
L LIGHT (0.01-0.05)
M MODERATE (0.06-0.10)
H HEAVY RAIN (0.10+)

FIGURE A.44  RADIOACTIVE FALLOUT IN THE
24-HOUR PERIOD BEGINNING
1230 G.C.T., MARCH 21, 1954

ACTIVITY

ACTIVITY IN Bq/17^2 AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSUMED TO BURST NO. 1, BRAVO
UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.

PRECIPITATION CODE:
N NO PRECIPITATION
Y YACOS
L LIGHT (0.01-0.05)
M MODERATE (0.06-0.10)
H HEAVY RAIN (0.10+)
FIGURE A.51 RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 25, 1954

KEY:

ACTIVITY

BLOOMS

PRECIPITATION

ACTIVITY IN B/S/FT² AT 90 DAYS AFTER BURN
ALL ACTIVITY IS ASSIGNED TO BURN NO. 1, 1949
UNLESS OTHERWISE INDICATED BY BURN NUMBER IN PARENTHESES.
FIGURE A.55  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 27, 1954

ACTIVITY @ PRECIPITATION
ACTIVITY IN Q/MA/Ft. AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.60 RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 29, 1954

KEY:
- ACTIVITY (LOW) - PRECIPITATION
- ACTIVITY IN Bq/m² AT NO DAYS AFTER BURST
- ALL ACTIVITY IS ASSUMED TO BE #1, #201
- BURST SOURCES INDICATED BY BURST NUMBER IN SUPERΘDES.
FIGURE A.03  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MARCH 31, 1954

KEY:

ACTIVITY (BURST)
PRECIPITATION

ACTIVITY IN B/C/T 1-2 AT 100 DAYS AFTER BURST
ALL ACTIVITY IS REFERENCED TO BURST NO. 1, BROAD UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.64  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 GCT, MARCH 31, 1954

KEY:
- ACTIVITY (ACTIVITY)
- TRAFFIC (TRAFFIC)

ACTIVITY IS 0.5 C/S/FT² AT 100 DAYS AFTER BURST.
ALL ACTIVITY IS ADDED TO BURNT 50.1 UNITS UNLESS OTHERWISE INDICATED BY SMALL NUMBER IN PARENTHESES.
FIGURE A.77 RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., APRIL 7, 1954

ACTIVITY (RMB) PRECIPITATION

ACTIVITY IN RMB/FT² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, JAMO, UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.79
RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING
1230 G.C.T., APRIL 8, 1954

KEY:
ACTIVITY (SI)
PRECIPITATION
ACTIVITY IN C/MT² AT 300 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, 1954,
UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.88

RADIOACTIVE Fallout in the 24-Hour Period Beginning
1230 G.O.T., APRIL 12, 1954

KEY

ACTIVITY (in Bq/m²)

PREDICTION

ACTIVITY in Bq/m² AT 100 DAYS AFTER DETONATION

ALL ACTIVITY IS ASSUMED TO BE IN AIR. UNITS SHOWN INDICATED BY BOLD NUMBER IN PARENTHESES.
FIGURE A.89

RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING
1230 GCT, APRIL 13, 1954

ACTIVITY (Bq/m²)

PROGNOSIS

ACTIVITY IS Bq/m² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSUMED TO BURST NO. 1, UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHSEES.
FIGURE A.96  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., APRIL 16, 1954

LEGEND:
1. INFANTRY 24 HOURS AFTER BURST
2. TRACER
3. LIGHT (100-299 T.S.)
4. MEDIUM (300-1199 T.S.)
5. HEAVY OVER 1200 T.S.

ACTIVITY IN B.C.R.² BY 100 HOURS AFTER BURST
ALL ACTIVITY IS ADDED TO BURST NO. 1 ACTIVITY UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARANTHESES.

LEGEND

ACTIVITY (BURTS) [RM]

PRECIPITATION

ACTIVITY IN B/FT^2 AT 100 DAYS AFTER BURST

ALL ACTIVITY IS ASSUMED TO BURST NO. 1 JACOBO UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.115
RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 GCT, APRIL 25, 1954

KEY:
- ACTIVITY
- PRECIPITATION

ACTIVITY IN 5 KIARY² AT 100 DAYS AFTER BUST
ALL ACTIVITY IS ASSUMED TO BURN 1000 OBSERVED
UNLESS OTHERWISE INDICATED BY BURNT RANKED IN PARENTHESES.
FIGURE A.119  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.T. APRIL 28, 1954

KEY:
- Activity bursts
- Precipitation

ACTIVITY IN B.I.U. 1/2 AT 20 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 2, JUPITER
UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A 122  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.0.T., APRIL 29, 1954

KEY

ACTIVITY

(VALUES)

PREFERENCE

ACTIVITY IN B.C./SF. AT 180 DAYS AFTER BURST

ALL ACTIVITY IS ASSUMED TO BURST NO. 2, JOHNSON

INDICATED BY SHADY SHADY

IN PARENTHESES.
FIGURE A.126 RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1250 G.H.T., MAY 1, 1954

KEY

1. ACTIVITY
2. ISOTOPES
3. PRECIPITATION

ACTIVITY IN COUNTS/CM² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 2, HIBOU
UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES
FIGURE A.127  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MAY 2, 1954

KEY:
- ACTIVITY
- PRECURSOR
- ACTIVITY IN S/FT^2 AT 900 DAYS AFTER BURST
- ALL ACTIVITY IS ASSIGNED TO BURST NO. 2, EXCEPT UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.133  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MAY 5, 1954

KEY:

ACTIVITY (SIEVERTS)

PRECIPITATION

ACTIVITY IS DIS/FT² AT 100 DAYS AFTER BOMB

ALL ACTIVITY IS ADDED TO BOMB NO. 5 UNLESS OTHERWISE INDICATED BY BOMB NUMBER IN FRAMEWORK.
FIGURE A 139  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MAY 6, 1954

KEY:

ACTIVITY (BURST)  PREDICATION
ACTIVITY IN DM/ft² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 4, UNLESS OTHERWISE INDICATED BY BURST NUMBERS IN PARENTHESES.
FIGURE A150  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MAY 13, 1954

KEY

ACTIVITY (BURSTS)

PREDEPOSITION
I  NO PREDEPOSITION
T  TRACK
L  LIMIT (0-0-0-0)
M  MODERATE (0-1-0-0)
H  HEAVY OVER 100 MG

ACTIVITY IN Bq/m² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 1, UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.152  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T. MAY 14, 1954

KEY

- KEY ACTIVITY (UNITS) 1 PRECIPITATION
- ACTIVITY IN 0.1/FT² AT 600 DAYS AFTER BURNT
- ALL ACTIVITY IS ASSUMED TO BURNT NO. 1, UNLESS OTHERWISE INDICATED BY BURNT NUMBER IN PARENTHESES
FIGURE A.155 RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.G.T., MAY 16, 1954

KEY
ACTIVITY
BURST
PRECIPITATION

ACTIVITY IN Ci/Kg/Ft\(^2\) AT 30 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 8, UNLESS
UNLESS OTHERWISE INDICATED BY BURST NUMBER
IN PARENTHESES.
FIGURE A.163 RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MAY 20, 1954

ACTIVITY

UNIT: Bq/m^2

PRECIPITATION

ACTIVITY IN Bq/m^2 AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSOCIATED TO BURST NO. 8 NUMBER UNLESS OTHERWISE INDICATED BY BURST NUMBER IN HAWKEYES
FIGURE A.199  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MAY 23, 1954

KEY:
- ACTIVITY (BUtS/ft²)
- PRECIPITATION

ACTIVITY IN 0.1/ft² at 30 days after burst
ALL ACTIVITY IS ASSUMED TO BURST IN A JUXTA UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESIZED.
FIGURE A.171  RADIOACTIVE FALL-OUT IN THE 24-HOUR PERIOD BEGINNING 1230 G.C.T., MAY 24, 1954
KEY:
ACTIVITY (Bq/m²)
PRESIPITATION
ACTIVITY IN Bq/m² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 2; NORTHERN UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIGURE A.177  RADIOACTIVE FALLOUT IN THE 24-HOUR PERIOD BEGINNING 1230 GCT, MAY 27, 1954

KEY:  
ACTIVITY  (BECM)  
PRECIPITATION

ACTIVITY IN D/W/FT² AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 6. VECTORS UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.

KEY:
- 0 ACTIVITY
- ACTIVITY IN 0.1/FT² AT 100 DAYS AFTER BURN
- ALL ACTIVITY IS ASSUMED TO BURN AT 0.1 METER UNLESS OTHERWISE INDICATED BY BURN NUMBER IN PARENTHESES.

PRECIPITATION CODE:
- 0 NO PRECIPITATION
- TRACE
- LIGHT (0.1-0.5)
- MODERATE (0.6-1.0)
- HEAVY (OVER 1.0)

KEY:
- ACTIVITY (GAMMA) + PRECIPITATION

ACTIVITY IN $Bq/m^2$ AT 100 DAYS AFTER BURST
ALL ACTIVITY IS ASSIGNED TO BURST NO. 2, UNLESS OTHERWISE INDICATED BY BURST NUMBER IN PARENTHESES.
FIG. 187 AVERAGE DAILY FALLOUT DURING JUNE, 1954

UPPER FIGURE: DM/FT$^2$ AT 100 DAYS AFTER BURST NO. 6, NECTAR
LOWER FIGURE: NUMBER OF DAYS FOR WHICH DATA WERE AVAILABLE
REFERENCES


