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COLLECTION OF CLOSE-IN FALLOUT AND UPPER WIND DATA FOR THE GREENHOUSE, IVY, AND CASTLE TESTS

By

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April 9, 1956

INTRODUCTION

A number of organizations have made observations of radioactive fallout from the bursts in the Pacific Proving Ground. As there has apparently been no previous collection of this information, this report attempts to gather together the fallout data from and near Bikini and Eniwetok atolls. The upper wind data appropriate for the study of the close-in fallout from each of the bursts is also given.

There are uncertainties in interpreting some of the fallout measurements and in the choice of the appropriate wind data, but it is felt that this summary might be useful in the forthcoming Redwing series.

Joint Task Force 7 provided the financial support for this work.

FALLOUT DATA

Tables 1 and 2 describe the bursts considered in this report. Figures 1 and 2 show the location of the islands in Eniwetok and Bikini atolls, respectively, as well as the barge station numbers and locations for the CASTLE series.

For each of the bursts, a map is shown (Figures 3-14) which gives the following information: (1) the dose rate measurements converted to H + 12 hours in milliroentgens per hour, from the various sources as identified below; (2) the approximate time of the measurement in hours or days after the explosion, in parenthesis, as (H + 3) or (D + 2); (3) a set of numbers indicating approximate average arrival time (in hours after the explosion) of the fallout - in circles where the time was estimated from the fallout plot and in squares where it was based on actual measurements; (4) an analysis of the total dose from time of fall to infinity, in roentgens; and (5) a weighted hodograph for a particle which takes one hour to fall from 35,000 to 5,000 feet, (a particle 291 microns in diameter if spherical and of specific gravity 2.5).

GREENHOUSE Data

Figures 3-6 are for the GREENHOUSE series. The reports used in preparing these maps are as follows:

a. WT-89 - Scientific Director's Report, Annex 9.3, Radiological Safety. All four shots were monitored from helicopters. Although the readings may have

been made from an altitude of from 10 to 20 feet, the observations were considered representative of readings three feet above ground. Therefore, the dose rates shown may be about 15 percent too low.

b. WT-4 - Scientific Director's Report, Annex 6.4, Fallout Phenomenology. Fallout samples collected on a greased aluminum plate were counted by a beta-gamma survey meter and/or a gamma survey meter. Some helicopter measurements from a height of 10-20 feet are given. They were accordingly increased by about 15 percent to make them comparable with other readings.

The subscripts after the dose rates on Figures 3-6 denote the sources of data as follows:

From WT-89

R - Rad. Safe. helicopter readings.

From WT-4

a - Rad. Safe. helicopter readings.
b - Beta-gamma survey meter readings.
c - Gamma survey meter readings.

IVY Data

Figures 7 and 8 contain the data for the IVY series from the following sources:

a. WT-615 (Project 5.4a) Nature, Intensity, and Distribution of Fallout from MIKE Shot. Various types of collectors (total, incremental, and differential) were used in this operation but the report (Figure 4.1, page 34) did not describe how the various gamma dose rates were derived.

b. WT-614 - Operation IVY, Radiological Safety. Rad. Safe. helicopter readings from about 50 feet for MIKE and about 25 feet for KING are given and have all been converted to ground readings by multiplying by a factor of 3, as suggested in the report. Also a few Rad. Safe. ground readings are given.

The subscripts on data in Figures 7 and 8 denote the following sources of data:

From WT-615

C - Readings from various collectors.

From WT-614

R - Rad. Safe. helicopter readings.
G - Rad. Safe. ground readings.

CASTLE Data

Figures 9-14 include CASTLE fallout information from the following sources:

a. Project 2.5a; USNRDL. Operation CASTLE Final Report (draft copy). For shots 1, 3, 4, and 6, the report contains: (1) Rad. Safe., (2) Project 2.5, (3) total collector, and (4) gummed paper data.

b. WT-917 - Project 2.6a; USNRDL. Chemical, Physical and Radiochemical Characteristics of the Contamination. For the four bursts covered by this report the following information is given:

Shot 1. Average of Rad. Safe. and/or Project 2.5a surveys.

Shot 2. Total collector and gummed paper measurements as evaluated by Project 2.6a.

Shot 3. Project 2.6a analysis of Project 2.5a data (Dose rates are inconsistent with others for this burst and are believed to be too large).

Shot 4. Preliminary estimates from Project 6.4 data.

c. Project 2.5b; CRL. Fallout Studies, Special Report. (draft). For all six CASTLE bursts this report lists: (1) Rad. Safe. gamma survey readings, and (2) Project 2.5b readings. This report also contains analyses (and data) prepared after activity from previous explosions was subtracted as background.

d. ITR-934 - Operation CASTLE, Summary Report of the Commander, Task Unit 13. For shot 1, an analysis is given of the gamma radiation field in the vicinity of Bikini, as well as for more distant areas, apparently based on preliminary analysis of the data which appears in the above CASTLE reports (a, b, c).

e. Rad. Safe. Intensity File (Original data from JTF-7.3). These original data were used to augment and correct the Rad. Safe. gamma survey readings from the Project 2.5b report.

f. ITR-912 - Project 2.1, Evans Signal Laboratory. Gamma Radiation Dosimetry. Film badge and dosimeter readings are tabulated. The integrated doses computed from "infinite field" dose rates (measured on the islands) were found to average roughly 2-1/2 times the integrated doses determined from nearby film badges and dosimeters. Accordingly, the dose rates and infinite doses derived from film badges and dosimeters on free floating buoys for shot 1 were multiplied by this factor to get some concept of the fallout intensity in the area of the buoys.

g. ITR-915 - Project 2.5a; USNRDL. Distribution and Intensity of Fallout. An estimate of 500 R/hr at H + 2 is given for shot 2 at a downwind distance of 45 miles. This would be about 50,000 mr/hr at H+ 12. The specific measurements (if any) on which this estimate is based are not given.

The subscripts used to identify the sources of data on Figures 9-14 are as follows:

From Project 2.5a report

R - Rad. Safe. data.
A - Project 2.5a data.
TC - Total collector data.
G - Gummed paper data.

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From WT-917

a (Shot 1) - Average of Rad. Safe. and/or Project 2.5a data.

a (Shot 3) - Project 2.5a data - dose rates believed to be too large.

a (Shot 4) - Project 6.4 data.

a_{TC} (Shot 2) - Total collector data.

a_G (Shot 2) - Gummed paper data.

From Project 2.5b report

b - Rad. Safe. gamma survey and Project 2.5b data.

B - Rad. Safe. readings with background subtracted.

From ITR-934

E - Preliminary estimates of gamma radiation, shot 1.

From ITR-912

F - dose rates estimated from film badge and dosimeter data.

From ITR-915

C - estimated dose rate.

Additional Information

GREENHOUSE. The many Rad. Safe. measurements listed in Figures 3-6 near each of the burst sites show a large range of activity. They were not taken at the same spot, however, but show the gradient of activity within the first half mile or so of the burst site.

IVY. The fallout from IVY-2 (KING) on the northern islands of the atoll was not distinguishable from the high residual activity from MIKE, so no measurements were available there.

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CASTLE. The CASTLE Rad. Safe. surveys were generally made between 0800 and 1100 local time except on shot days, when they were generally made between 1200 and 1400. For the helicopter measurements the data were converted to ground readings by use of the correlation curve for air to ground readings from the report on Radiological Safety Operations for the Upshot-Knothole series.

According to the Project 2.5a Final Report, fallout after Shot 1 (BRAVO) began on the southern and eastern islands of the atoll and at the lagoon stations approximately 1/2 to 1-1/2 hours after the detonation. The mean diameter of the particles observed for several of these stations was about 90 microns. These times of arrival and this particle size are inconsistent with the normal fallout process, and some mechanism other than transport by the wind of individual falling particles is suggested. A possible mechanism may be descent in rain drops from the column of water which constituted the bulk of the visible nuclear cloud. It is believed that part of the column drifted to the south and east. Also, in WT-917 the character of some of the lagoon samples in question was described as a slurry defined in one section of the report as "the appearance of sea water plus slaked lime suspension" and in another described merely as being wet. The chemical analysis of some of the pertinent samples reported as wet when collected showed no evidence of sea water, so that whatever moisture was present probably came from rain water.

For Shot 6 (NECTAR) the Rad. Safe. readings were made approximately one day after the detonation, but to avoid further cluttering the D + 1 has been omitted from Figure 14.

WIND DATA

For each of the bursts considered in this report an attempt was made to estimate the mean winds at shot time through various layers in the atmosphere to the 5,000 foot level nearest to the top of the cloud. These were generally obtained by plotting the balloon position as a function of height, based on the original readings of azimuth and elevation angles, and the ship's course and speed in the case of shipboard soundings. Then the selected altitudes between which mean winds were desired were interpolated on the curve and the vector displacements between successive heights were measured and the mean speeds and directions obtained. In a few cases where the original data were unavailable, the published coded wind messages were used to estimate the mean winds. Usually, the mean winds were obtained for a sounding before and a sounding

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after shot time, and an interpolation was made for the shot time winds. Where those soundings nearby in time and space did not reach the altitude of the cloud top, soundings more remote in time and space were used to estimate the mean winds. No attempt was made to consider time and space variability in the wind.

Table 3 gives the selected mean winds for the various bursts, along with the identification of the soundings used in the estimations.

The times of fall through 5,000-foot layers of selected sizes of a spherical particle of specific gravity 2.5, for a tropical atmosphere as computed by H-Division of the Los Alamos Scientific Laboratory, are given in Table 4.

The times for the 291 micron line were used along with the assumed mean winds in determining the positions of the 291 micron line in Figures 3-14.

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Table 1. Description of GREENHOUSE and IVY (MIKE) Bursts

GREENHOUSE

Burst Number	Code Name	Location	Ground Zero	Date (1951)	Time (GMT)	Type	Yield (KT)	Estimated Mushroom Heights (1000's of feet) Base	Top
1	DOG	Eniwetok	Yvonne (Runit)	7 Apr.	1934	300-foot Tower	82.0[a]	--	55[b]
2	EASY	Eniwetok	Janet (Engebi)	20 Apr.	1927	300-foot Tower	47.2[a]	30[b]	40[b]
3	GEORGE	Eniwetok	Ruby (Eberiru)	8 May	2230	300-foot Tower	257.2[a]	42[b]	57[b]
4	ITEM	Eniwetok	Janet (Engebi)	24 May	1917	300-foot Tower	47.1[a]	--	40[b]

IVY

				(1952)					
1	MIKE	Eniwetok	Elugelab Is.	31 Oct.	2015	Surface	10,500	60[c]	98[c]
2	KING	Eniwetok	Runit Is.	16 Nov.	0030	1480-foot Air Burst	570	55[b]	76[b]

a. Progress Report No. 2, "Weather Bureau Study of Physical Characteristics of Atomic Clouds", (SECRET), Special Projects Section, Scientific Services Division, U. S. Weather Bureau, May 26, 1955.

b. RM-1378-AEC.

c. ITR-933 Project 9.1

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Table 2. Description of CASTLE Bursts

Burst Number	Code Name	Location	Ground Zero	Date (1954)	Time (GMT)	Type	Estimated Mushroom Heights (1000's of feet) Base	Top
1	BRAVO	Bikini	West of Charlie (Namu) on Reef	28 Feb.	1845	Surface	62_b	114_b
2	ROMEO	Bikini	Shot 1 Crater	26 Mar.	1830	Barge	62_b	110_b
3	KOON	Bikini	Tare (Eninman)	6 Apr.	1820	Surface	—	53_a
4	UNION	Bikini	On Barge at Intersection of Arcs with Radii of 6900 ft. from Dog (Yurochi) and 3 Statue Miles from Fox (Aomoen)	25 Apr.	1810	Barge	53_b	94_b
5	YANKEE	Bikini		4 May	1810	Barge	75_b	110_b
6	NECTAR	Eniwetok	IVY MIKE Crater Flora (Klugelab)	13 May	1820	Barge	46_b	71_b

a. NYO-4645

b. ITR-933 Project 9.1

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Table 3. Estimated Mean Shot Time Winds
for the GREENHOUSE, IVY and CASTLE Series.

GREENHOUSE-1 (DOG), 1934 GCT, 7 April 1951

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	064	33.8	1,2
5-10	081	21.6	1,2
10-15	082	17.0	1,2
15-20	061	23.4	1,2
20-25	356	13.0	1,2
25-30	304	15.9	1,2
30-40	236	24.2	1,2
40-50	254	23.0	1,2
50-55	355	24.0	1

1 - Eniwetok, 1500 GCT, 7 April 1951
2 - Eniwetok, 2100 GCT, 7 April 1951

GREENHOUSE-2 (EASY), 1927 GCT, 20 April 1951

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	073	17.3	1,2
5-10	129	5.7	1,2
10-15	114	2.6	1,2
15-20	298	3.3	1,2
20-25	305	4.8	1,2
25-30	285	12.2	1,2
30-40	278	25.1	1,2

1 - Eniwetok, 1500 GCT, 20 April 1951
2 - Eniwetok, 2100 GCT, 20 April 1951

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Table 3. (Continued)

GREENHOUSE-3 (GEORGE), 2230 GCT, 8 May 1951

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	253	24.3	2,3
5-10	261	26.6	2,3
10-15	263	29.3	2,3
15-20	243	25.6	2,3
20-25	221	26.4	2,3
25-30	207	21.9	2,3
30-40	221	19.2	2,3
40-50	221	8.4	2,3
50-60	131	13.3	1,4

1 - Majuro, 2046 GCT, 8 May 1951
2 - Eniwetok, 2053 GCT, 8 May 1951
3 - Eniwetok, 0245 GCT, 9 May 1951
4 - Majuro, 0245 GCT, 9 May 1951

GREENHOUSE-4 (ITEM), 1917 GCT, 24 May 1951

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	075	20.7	1,2
5-10	092	9.5	1,2
10-15	264	6.4	1,2
15-20	287	7.9	1,2
20-25	329	7.6	1,2
25-30	035	12.0	1,3
30-40	280	8.0	1

1 - Eniwetok, 1500 GCT, 24 May 1951
2 - Eniwetok, 2100 GCT, 24 May 1951
3 - Kusaie, 2100 GCT, 24 May 1951

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Table 3. (Continued)

IVY-1 (MIKE), 2015 GCT, 31 October ~~1951~~ 1952

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	090	14	2,3
5-10	095	15	2,3
10-15	115	15	2,3
15-20	125	12	2,3
20-25	170	13	2,3
25-30	220	17	2,3
30-40	230	15	2,3
40-50	220	12	2,3
50-60	040	08	2,3
60-70	100	20	2,3
70-80	085	08	2,4
80-90	280	10	2,4
90-100	250	20	1,2,4
100-110	300	20	5
110-120	040	05	6
120-130	000	00	6
130-135	000	00	6

1 - Kwajelein, 2100 GCT, 30 October 1952
2 - Eniwetok, 1500 GCT, 31 October 1952
3 - Bikini, 2100 GCT, 31 October 1952
4 - Kusaie, 2100 GCT, 31 October 1952
5 - Majuro, 0300 GCT, 1 November 1952
6 - Eniwetok, 0300 GCT, 4 November 1952

IVY-2 (KING), 0030 GCT, 16 November 1952

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	105	20.2	1,2
5-10	085	22.3	1,2
10-15	069	16.3	1,2
15-20	059	17.6	1,2
20-25	056	21.3	1,2
25-30	018	11.5	1,2
30-40	325	24.4	1,2
40-50	320	26.0	1,2
50-60	083	12.0	1,2
60-70	076	18.2	1,2
70-75	288	6.0	1,2

1 - Eniwetok, 2100 GCT, 15 November 1952
2 - Eniwetok, 0300 GCT, 16 November 1952

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Table 3 (Continued)

CASTLE-1 (BRAVO), 1845 GCT, 28 February 1954

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	075	14.5	2,4
5-10	355	3.4	2,4
10-15	306	9.5	2,4
15-20	285	14.6	2,4
20-25	282	18.4	2,4
25-30	220	25.8	2,4
30-40	228	38.0	2
40-50	261	38.7	2
50-60	316	23.2	2
60-70	051	6.0	3,5
70-80	083	20.0	3,5
80-90	078	40.0	3,5
90-100	080	50.0	1,6
100-110	090	45.0	8,7
110-115	110	40.0	8

1 - Rongerik, 1500 GCT, 28 February 1954
2 - USS Curtiss, 1707 GCT, 28 February 1954
3 - Eniwetok, 1800 GCT, 28 February 1954
4 - USS Curtiss, 2000 GCT, 28 February 1954
5 - Rongerik, 2100 GCT, 28 February 1954
6 - Majuro, 2100 GCT, 28 February 1954
7 - Eniwetok, 0900 GCT, 1 March 1954
8 - Eniwetok, 0300 GCT, 2 March 1954

CASTLE-2 (ROMEO), 1830 GCT, 26 March 1954

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	067	13.9	2,3
5-10	133	5.3	2,3
10-15	123	10.4	2,3
15-20	093	19.1	2,3
20-25	121	12.6	2,3
25-30	188	10.5	2,3
30-40	189	16.7	2,3
40-50	206	10.2	2,3
50-60	195	6.5	2
60-70	291	8.3	2
70-80	110	22	4,1
80-90	080	60	5,1
90-100	080	65	6,1
100-110	100	75	6

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1 - Majuro, 1800 GCT, 26 March 1954.
2 - USS Curtiss, 1700 GCT, 26 March 1954.
3 - USS Curtiss, 2003 GCT, 26 March 1954.
4 - Eniwetok, 2100 GCT, 26 March 1954.
5 - Majuro, 2035 GCT, 26 March 1954.
6 - Ponape, 2200 GCT, 26 March 1954.

Table 3. (Continued)

CASTLE-3 (KOON), 1830 GCT, 6 April 1954

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	082	13.8	1,2
5-10	162	12.5	1,2
10-15	173	11.7	1,2
15-20	182	12.0	1,2
20-25	206	16.8	1,2
25-30	206	16.1	1,2
30-40	231	24.4	1,2
40-50	248	36.0	1,2
50-55	254	30.0	2

1 - USS Curtiss, 1534 GCT, 6 April 1954
2 - USS Curtiss, 2000 GCT, 6 April 1954

CASTLE-4 (UNION), 1810 GCT, 25 April 1954

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	077	17.3	2,3
5-10	081	11.7	2,3
10-15	050	6.9	2,3
15-20	281	8.8	2,3
20-25	213	21.9	2,3
25-30	240	30.8	2,3
30-40	250	37.3	2,3
40-50	259	34.2	2,3
50-60	191	10.2	2,3
60-70	070	7.0	1,3
70-80	095	39.0	1,3
80-90	083	54.0	1,3
90-95	085	69.0	4

1 - Eniwetok, 1500 GCT, 25 April 1954
2 - USS Curtiss, 1610 GCT, 25 April 1954
3 - USS Curtiss, 2030 GCT, 25 April 1954
4 - Eniwetok, 2100 GCT, 25 April 1954

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Table 3. (Continued)

CASTLE-5 (YANKEE), 1810 GCT, 4 May 1954

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Soundings Used in Estimate
0-5	082	23.4	2
5-10	060	13.3	2
10-15	328	3.4	2
15-20	298	11.2	2
20-25	285	17.5	2
25-30	220	30.4	2
30-40	264	40.2	2
40-50	271	51.8	2
50-60	260	20	1,3
60-70	045	15	1,3
70-80	080	40	1,3
80-90	090	45	1,3
90-100	090	35	3
100-110	100	30	4

1 - Rongerik, 1800 GCT, 4 May 1954
2 - USS Curtis, 1550 GCT, 4 May 1954
3 - Eniwetok, 2100 GCT, 4 May 1954
4 - Majuro, 2100 GCT, 4 May 1954

CASTLE-6 (NECTAR), 1820 GCT, 13 May 1954

Layer (1000's of feet)	Direction (degrees)	Speed (knots)	Sounding Used in Estimate
0-5	104	18.5	1,2
5-10	107	11.4	1,2
10-15	133	11.4	1,2
15-20	125	10.2	1,2
20-25	192	8.8	1,2
25-30	257	6.1	1,2
30-40	206	15.0	1,2
40-50	236	18.0	1,2
50-60	264	10.8	2
60-70	071	14.7	2

1 - USS Curtiss, 1542 GCT, 13 May 1954
2 - USS Curtiss, 1917 GCT, 13 May 1954

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Table 4. The Times of Fall Through 5,000-foot Layers (hours).

Layers (1000's of feet)	Particle Size (microns) 1025	555	375	291	162	120	100
120-115	.008	.027	.043	.070	.19	.33	.45
115-110	.009	.028	.044	.071	.19	.33	.45
110-105	.010	.029	.045	.072	.19	.33	.45
105-100	.011	.030	.047	.073	.19	.33	.45
100-95	.012	.031	.049	.075	.19	.33	.45
95-90	.013	.032	.050	.077	.19	.33	.46
90-85	.014	.033	.052	.079	.19	.33	.46
85-80	.014	.034	.054	.082	.20	.33	.46
80-75	.015	.036	.057	.085	.20	.33	.46
75-70	.016	.038	.060	.089	.20	.34	.46
70-65	.019	.041	.064	.093	.21	.34	.47
65-60	.022	.044	.069	.097	.21	.34	.47
60-55	.024	.047	.074	.102	.22	.35	.48
55-50	.025	.051	.080	.108	.23	.36	.49
50-45	.027	.056	.086	.114	.25	.37	.51
45-40	.030	.060	.092	.121	.26	.39	.53
40-35	.032	.065	.099	.129	.27	.41	.56
35-30	.035	.069	.104	.138	.29	.43	.58
30-25	.037	.074	.111	.147	.31	.46	.61
25-20	.040	.079	.119	.159	.32	.49	.65
20-15	.043	.085	.127	.171	.34	.51	.68
15-10	.046	.092	.138	.184	.36	.54	.72
10-5	.049	.101	.151	.201	.38	.57	.76
5-0	.052	.111	.166	.219	.40	.60	.80
Time to fall from 35,000 to 5,000 feet (hours)	.25	.50	.75	1.00	2.00	3.00	4.00

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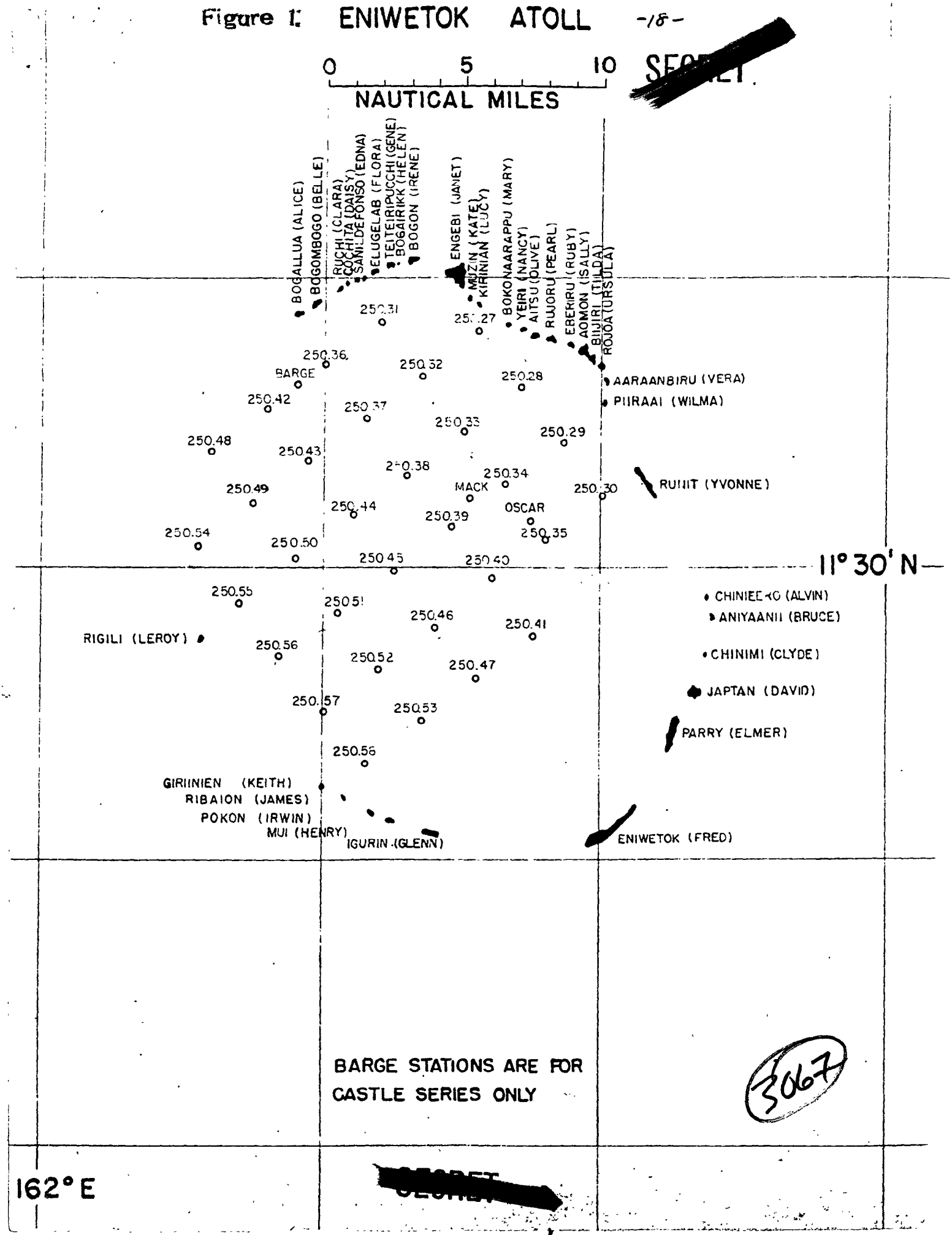
Figure 1. ENIWETOK ATOLL



~~Figure 2 BIKINI ATOLL~~

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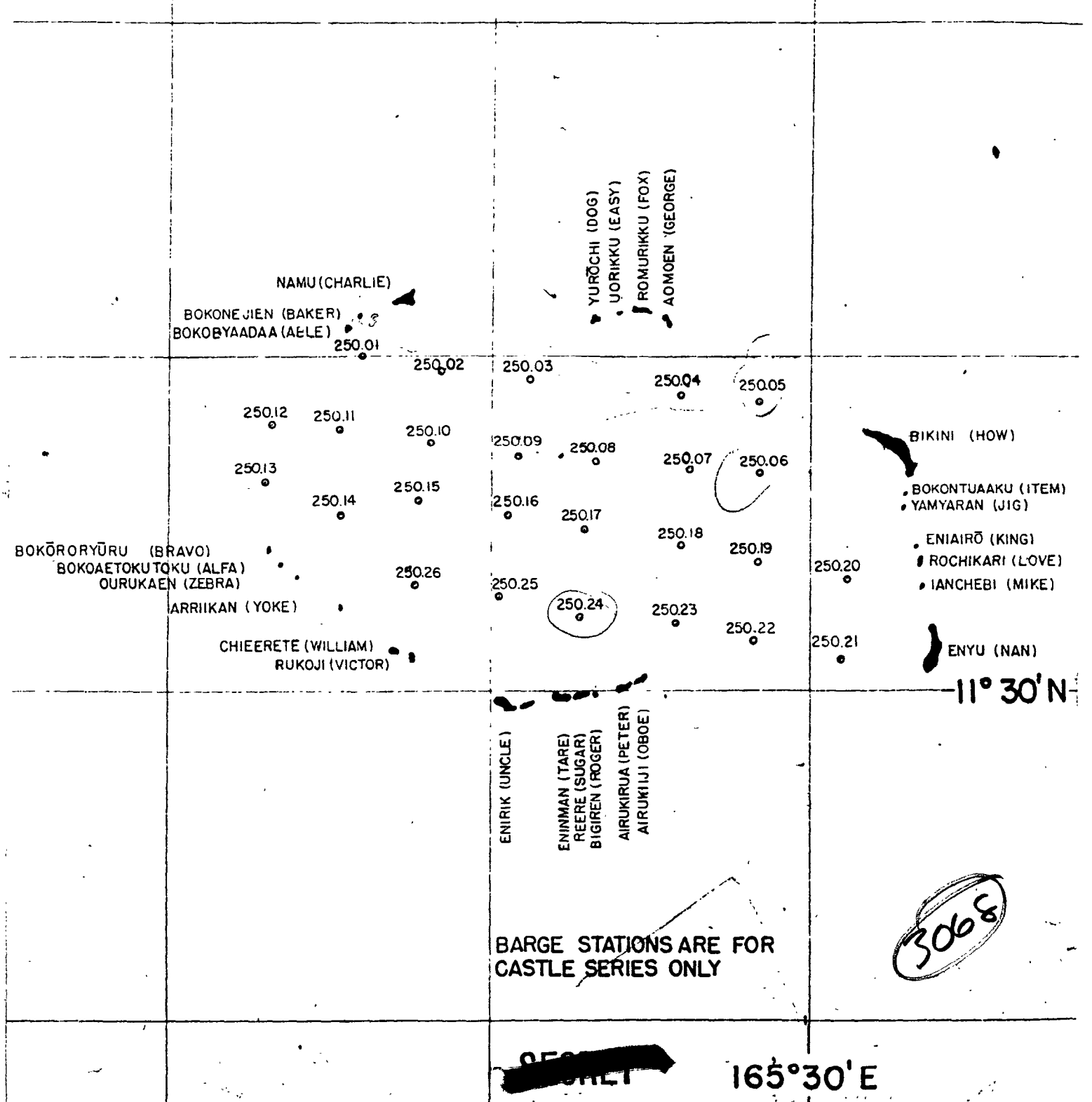
NAUTICAL MILES

Figure-2 BIKINI ATOLL



BARGE STATIONS ARE FOR CASTLE SERIES ONLY

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[redacted]

Figure 3. GREENHOUSE " DOG " NO. 1

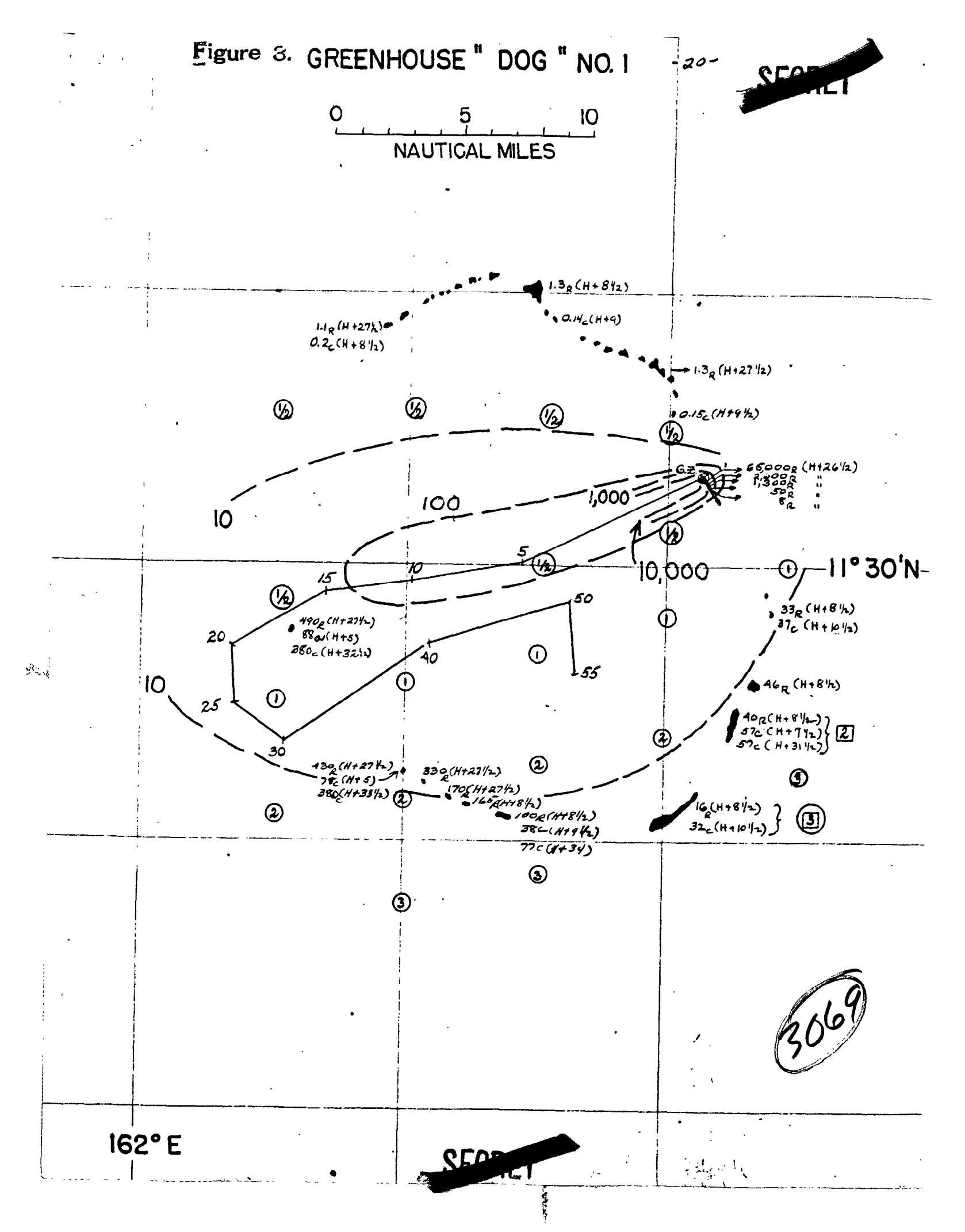
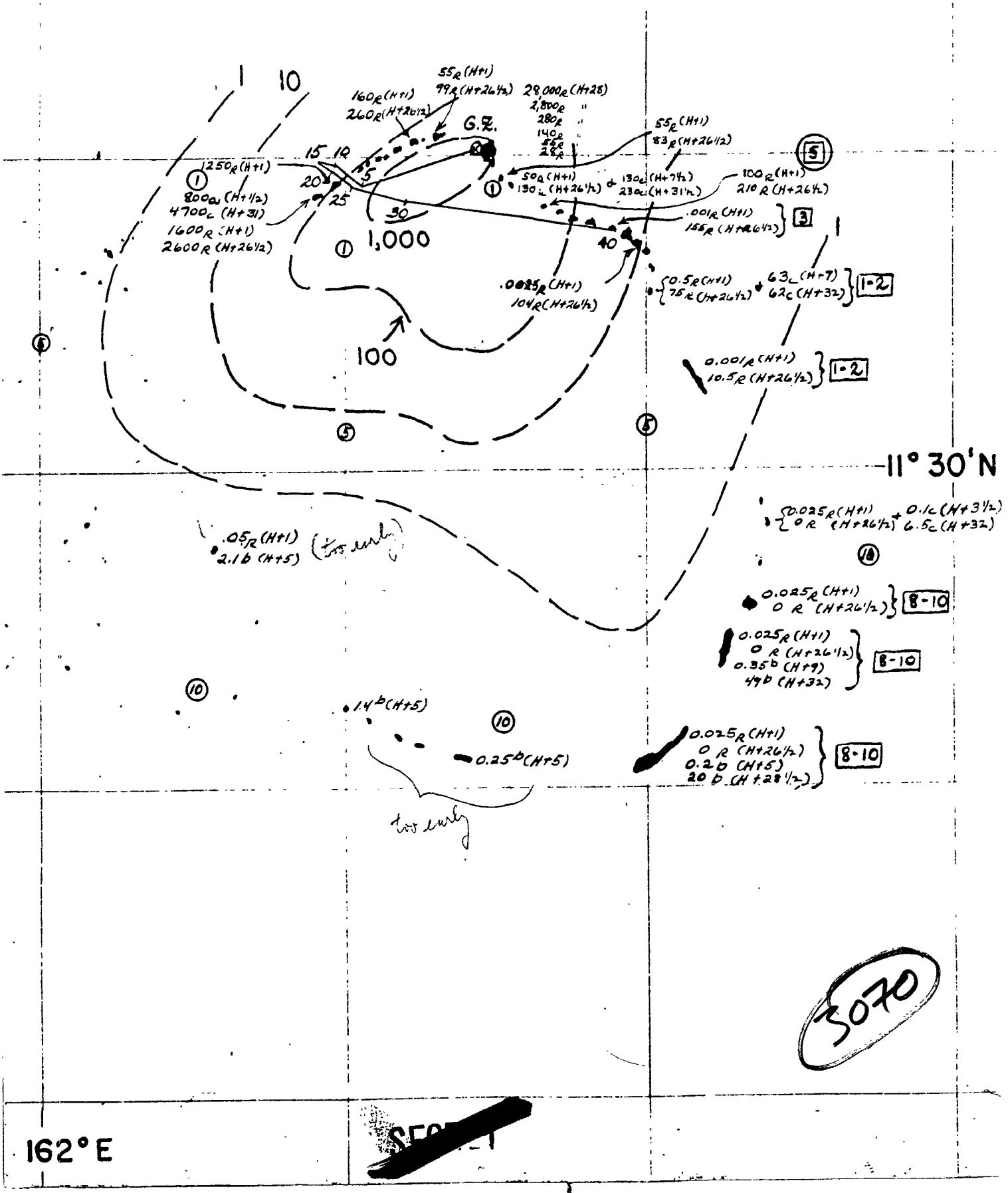


Figure 4. ~~GREENHOUSE "EASY" NO. 2~~

Figure 4

0 5 10
NAUTICAL MILES

~~SECRET~~



~~SECRET~~

Figure 5. GREENHOUSE "GEORGE" NO. 3

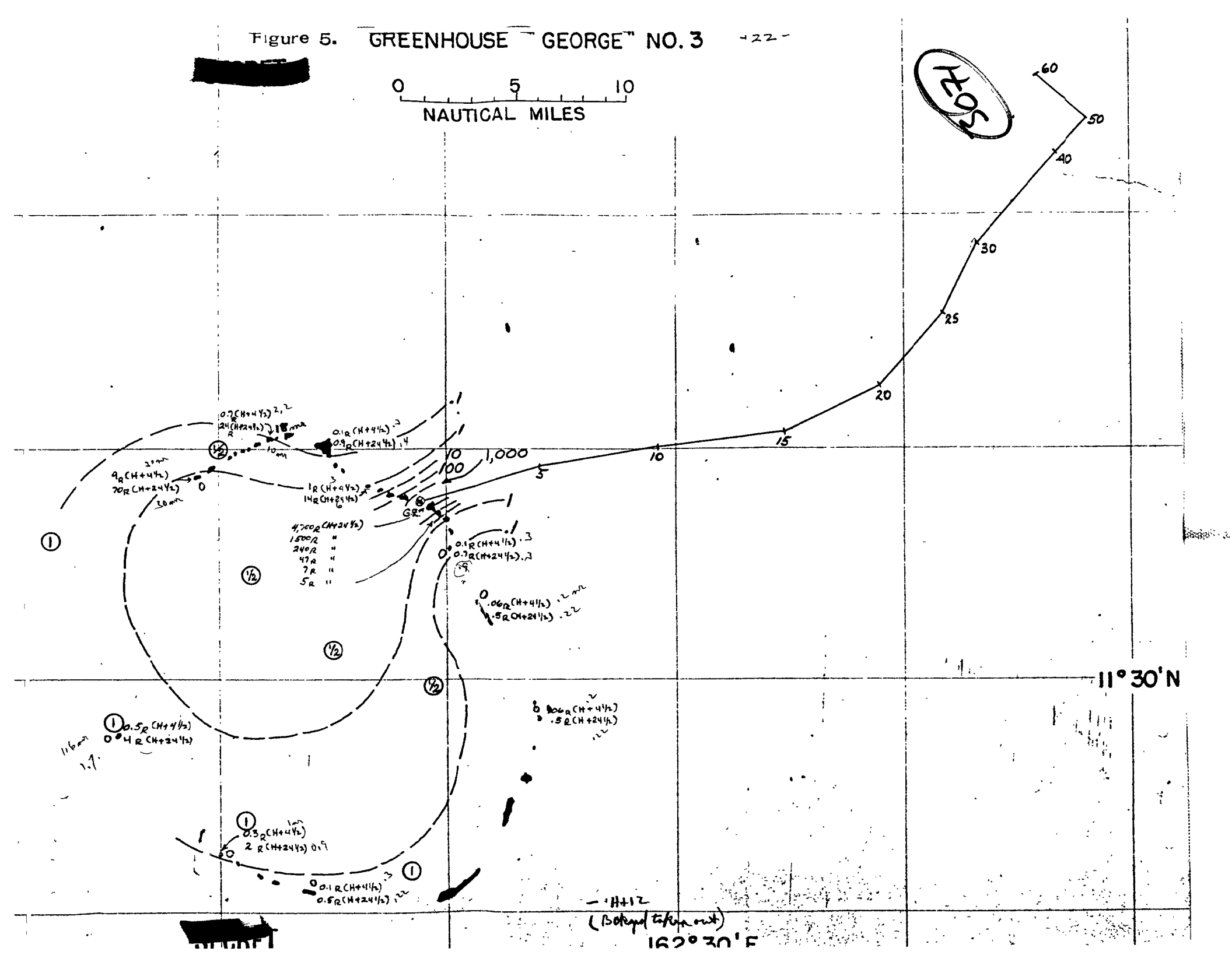


Figure 6. GREENHOUSE ITEM NO. 4

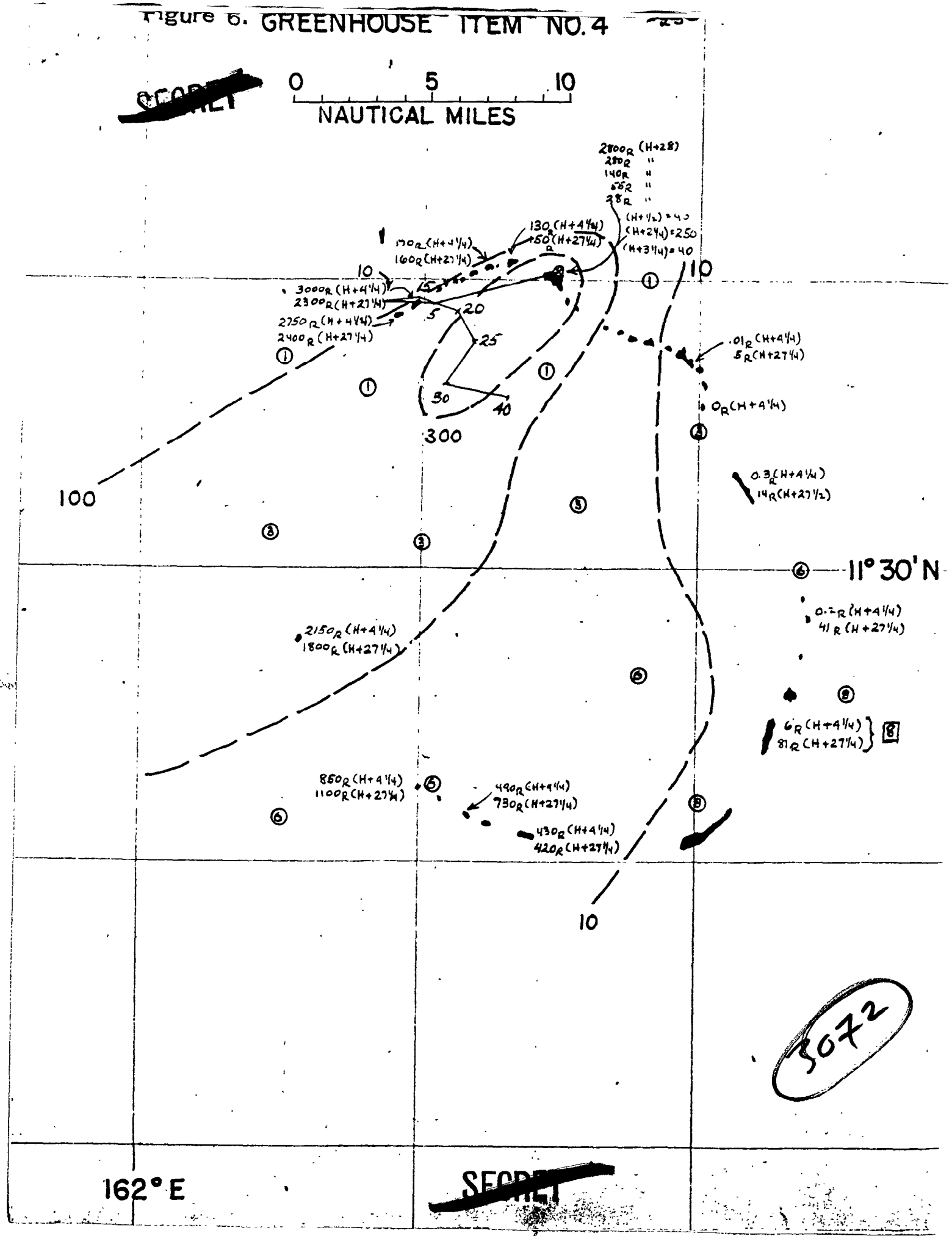
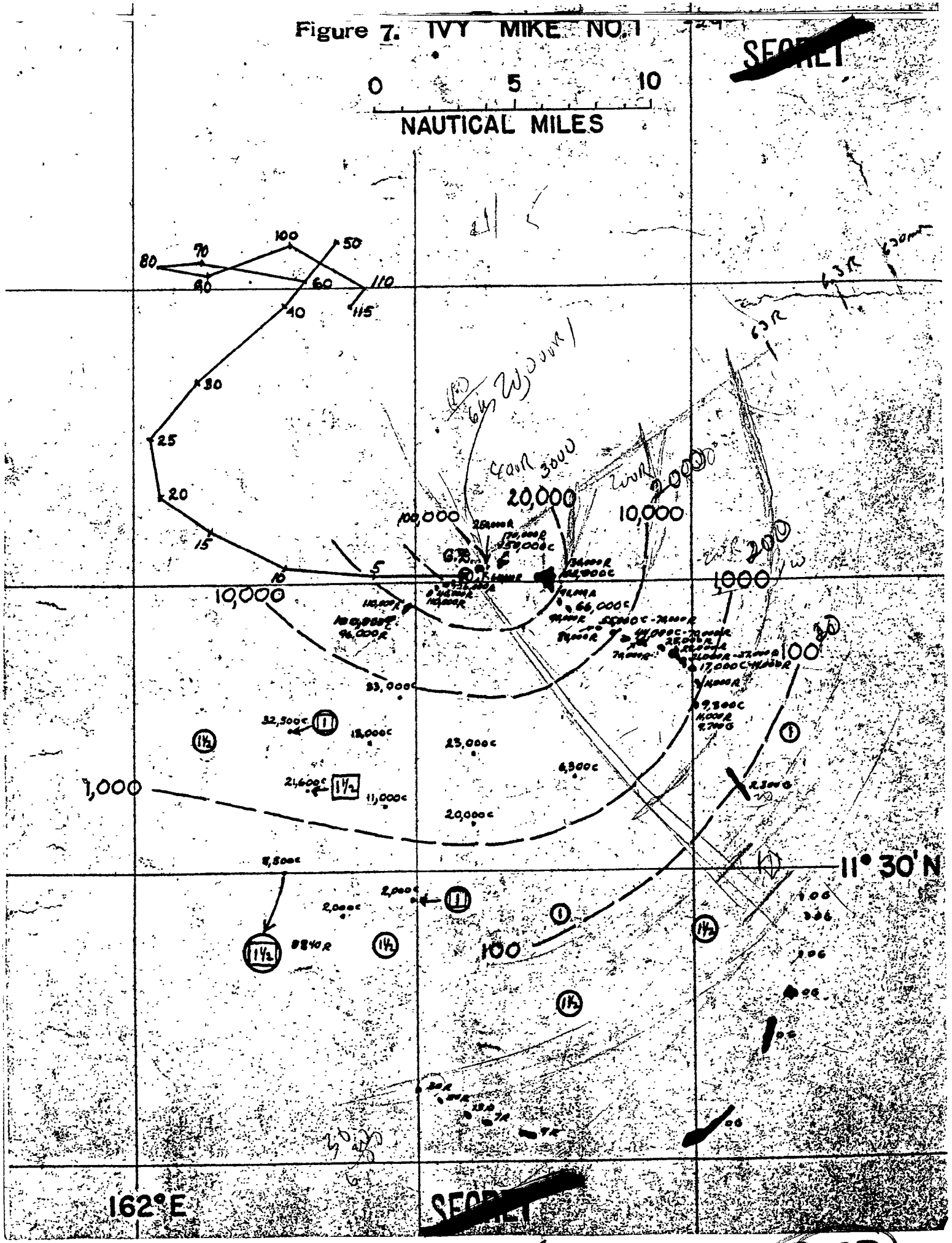


Figure 7. IVY MIKE NO. 1



3073

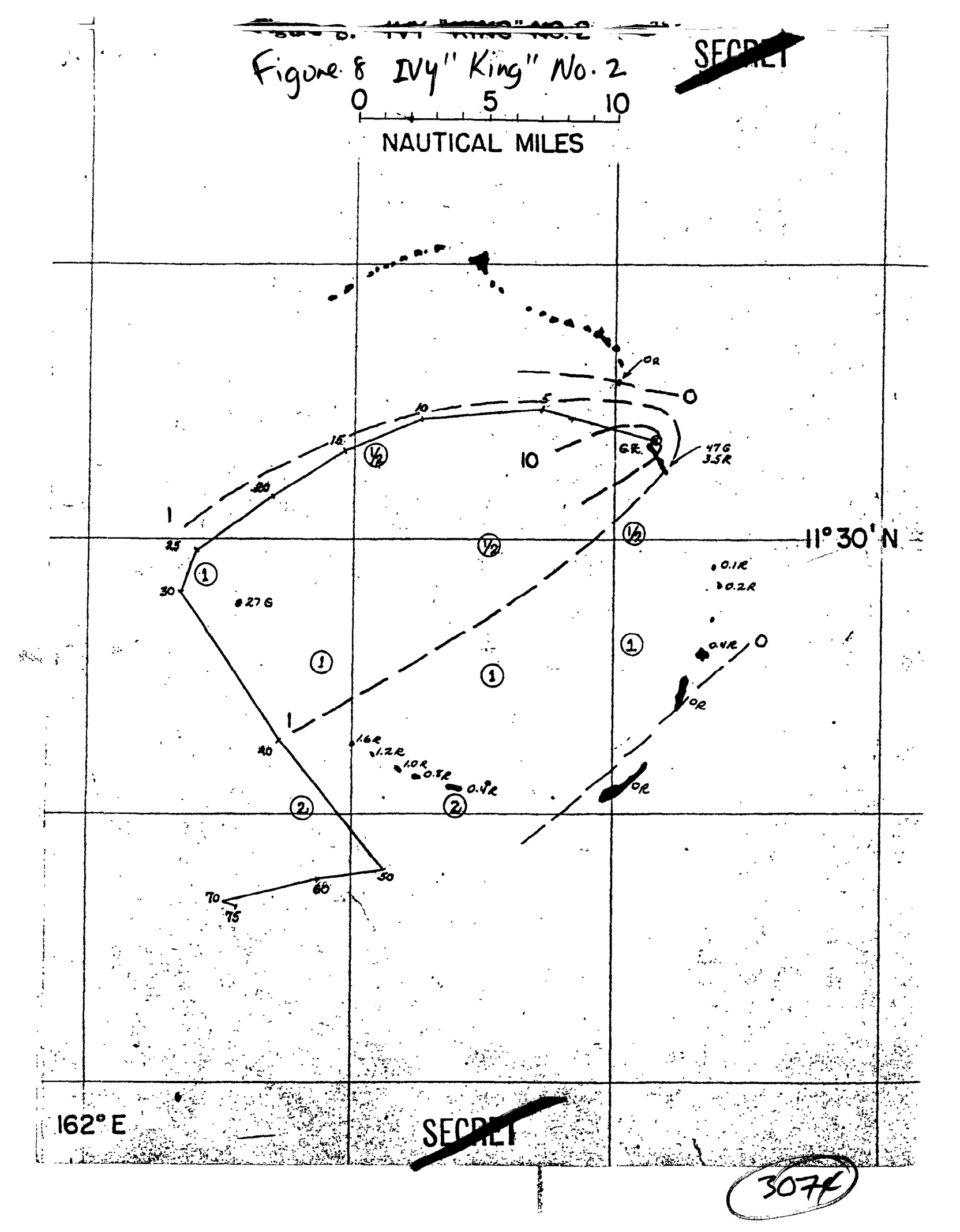
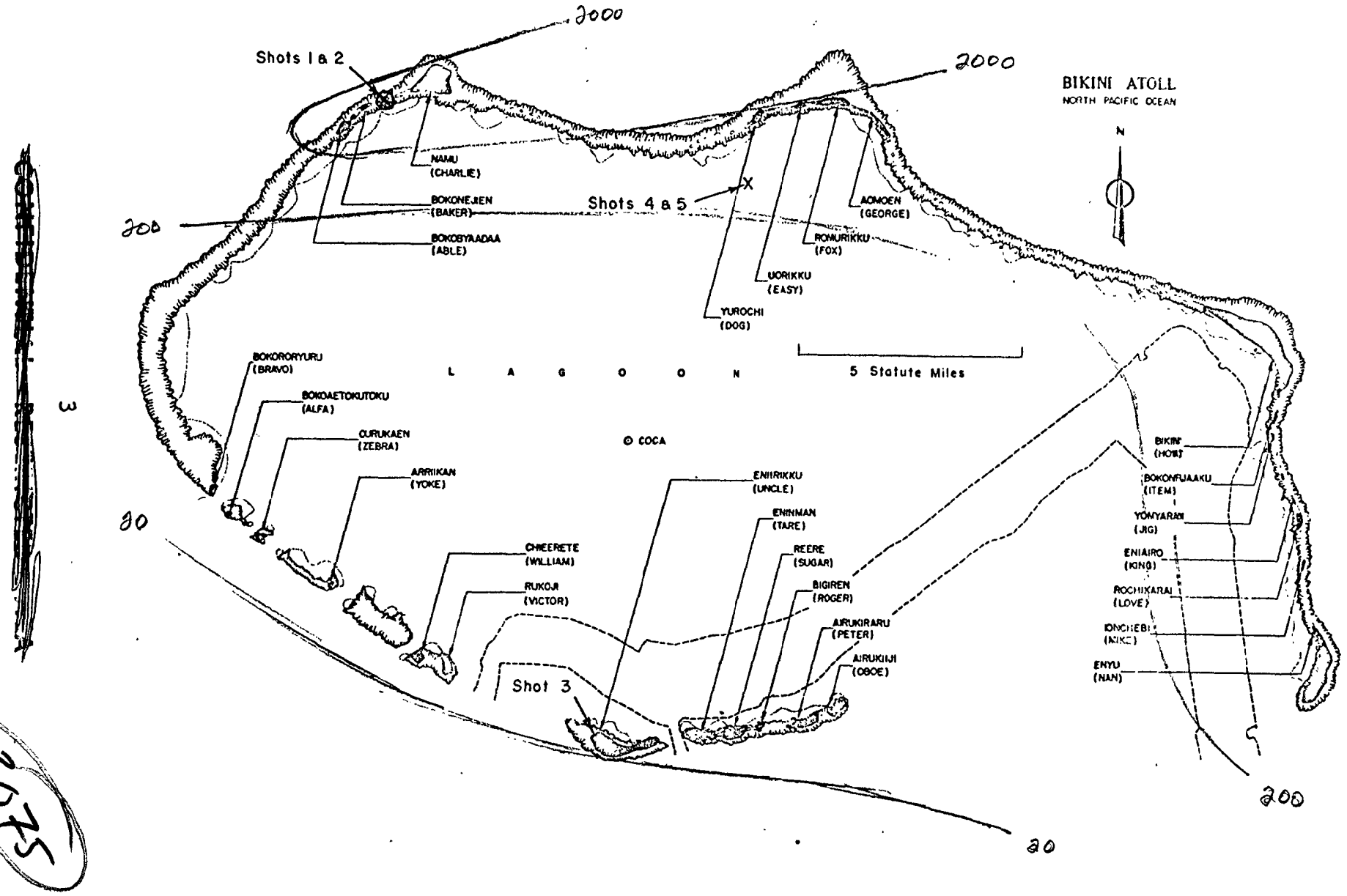


Figure 8 IVY "King" No. 2
SECRET
0 5 10
NAUTICAL MILES
11° 30' N
162° E
SECRET
307

BRAVO r/hr at H+1 (wx Bx Report)

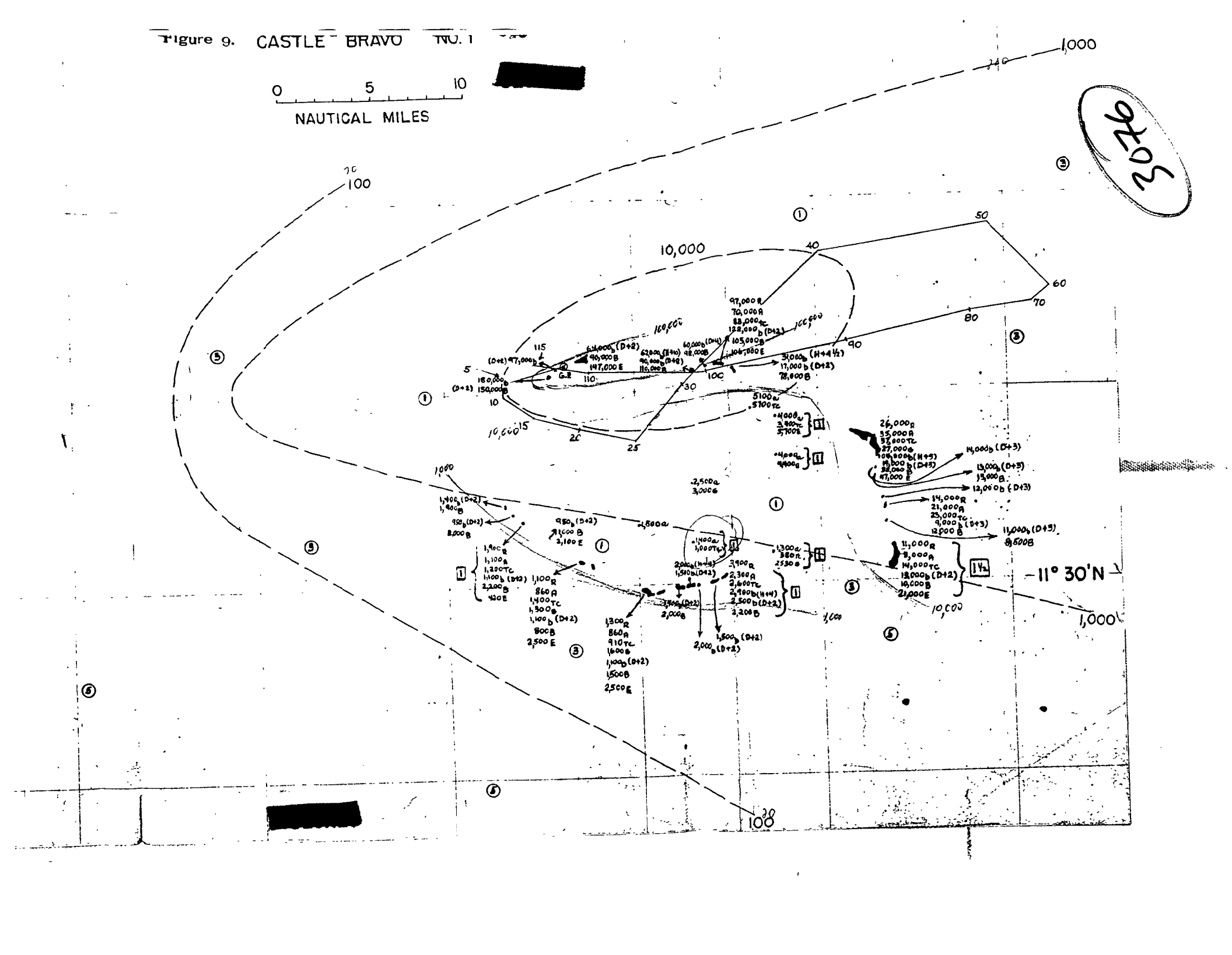
28 Feb 1954, 1845Z

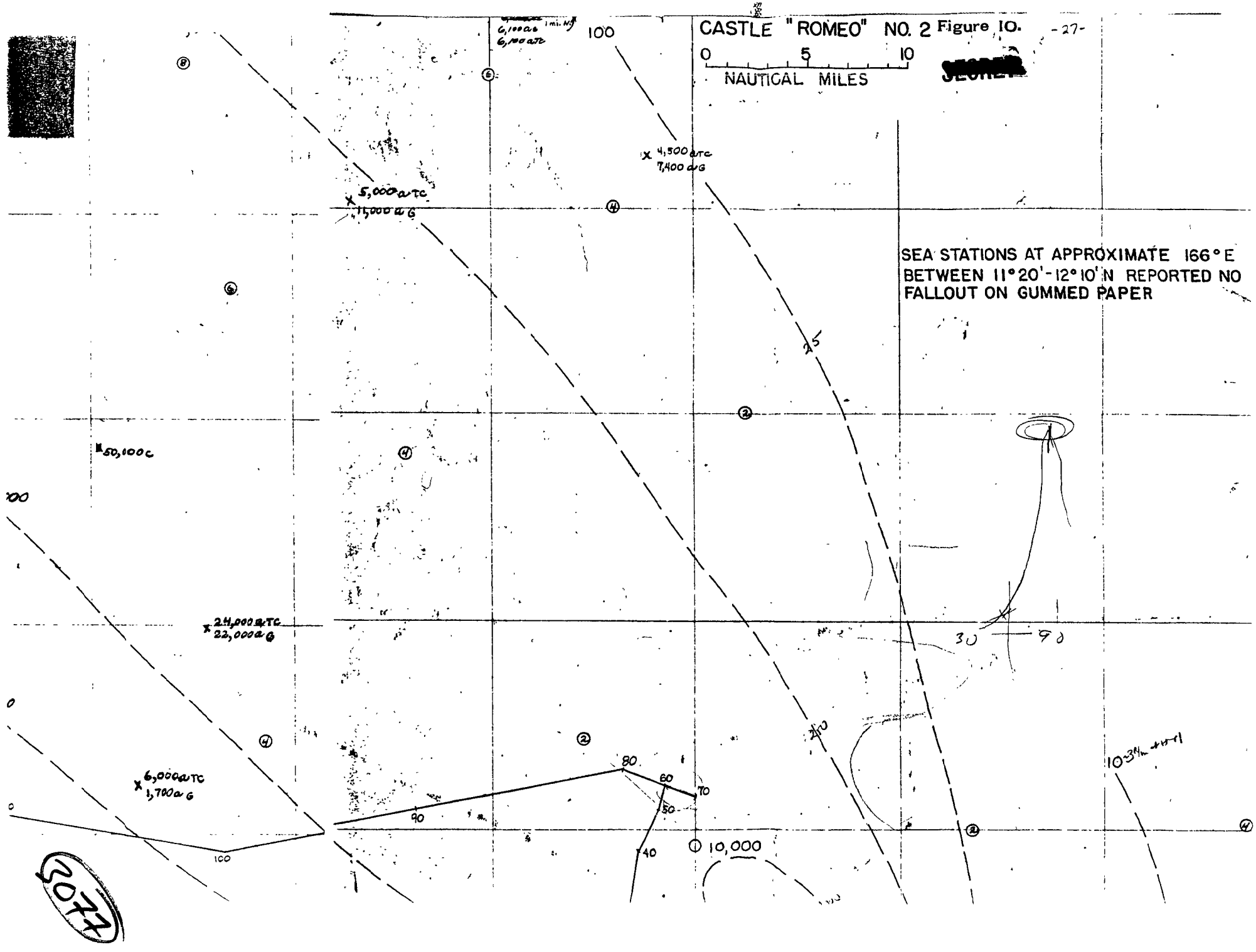


3

5075

Figure 9. CASTLE BRAVO NO. 1




CASTLE "ROMEO" NO. 2 Figure 10.
0 5 10
NAUTICAL MILES
SECRET
SEA STATIONS AT APPROXIMATE 166° E BETWEEN 11°20'-12°10' N REPORTED NO FALLOUT ON GUMMED PAPER
5,000 a TC
11,000 a G
4,500 a TC
7,400 a G
50,100 c
24,000 a TC
22,000 a G
6,000 a TC
1,700 a G
100
90
80
70
60
50
40
30
25
10,000

5077

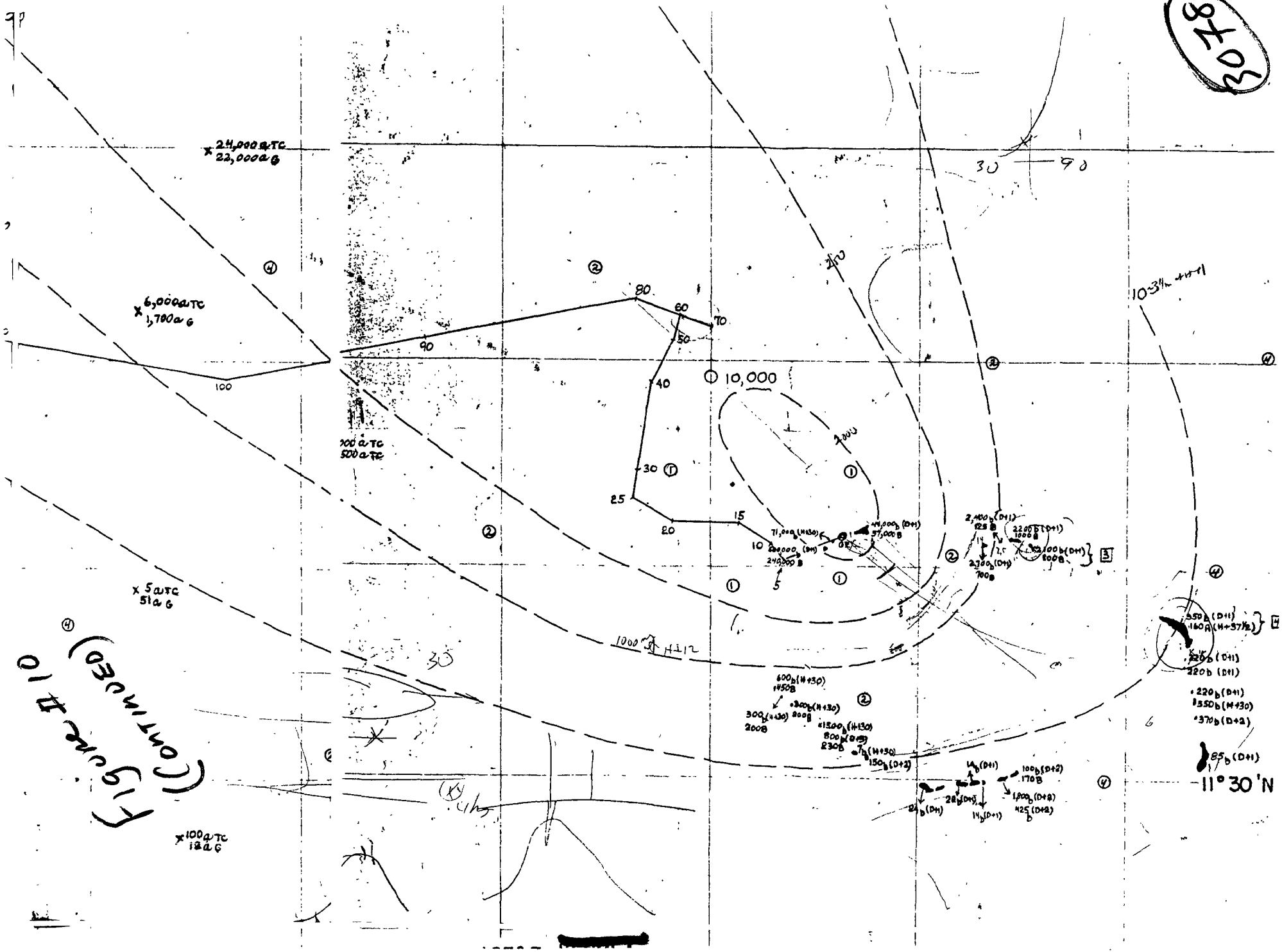
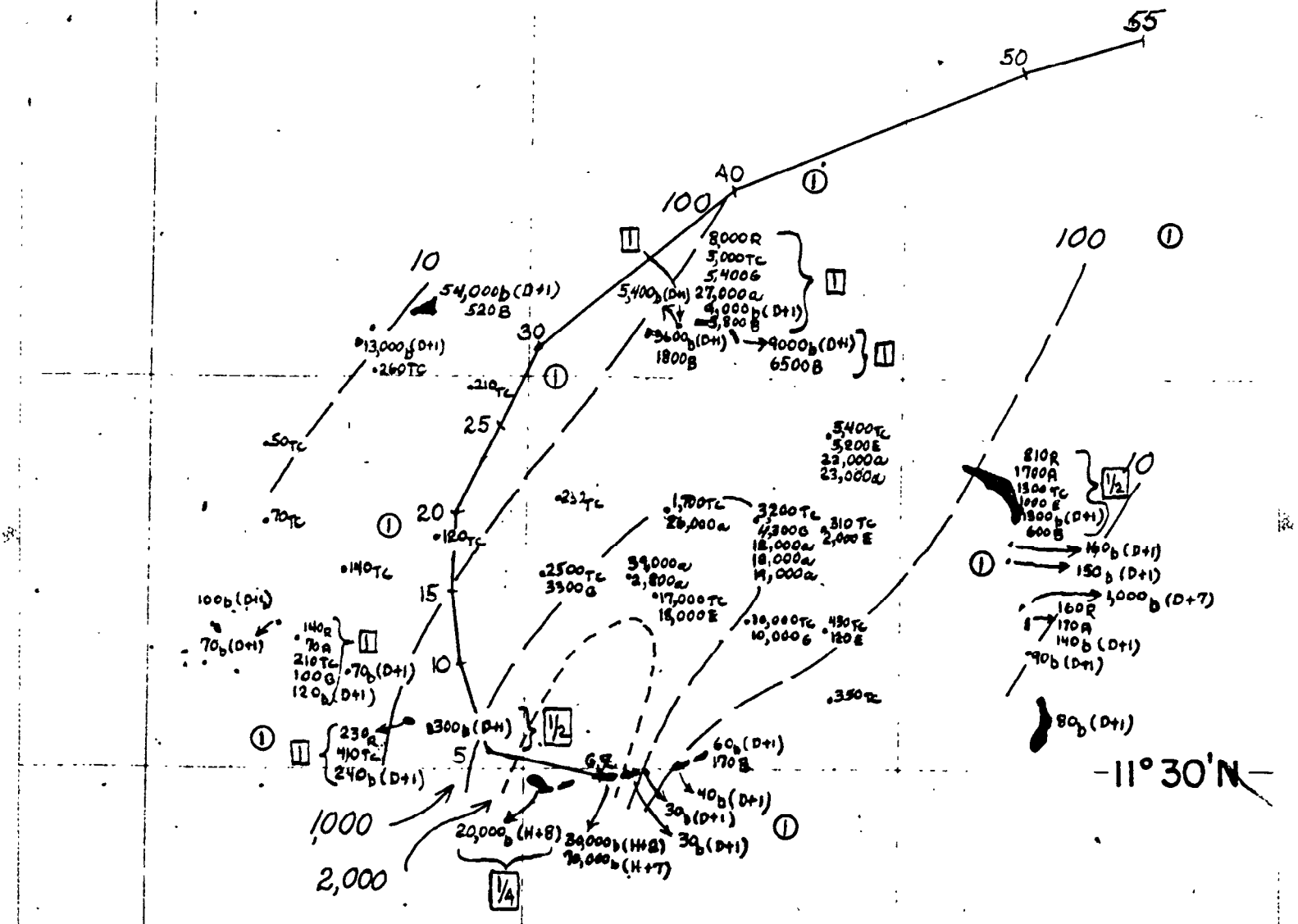


Figure 10
(CONTINUED)

Figure 11: CASTLE "KOON" NO. 3

SECRET

0 5 10
NAUTICAL MILES

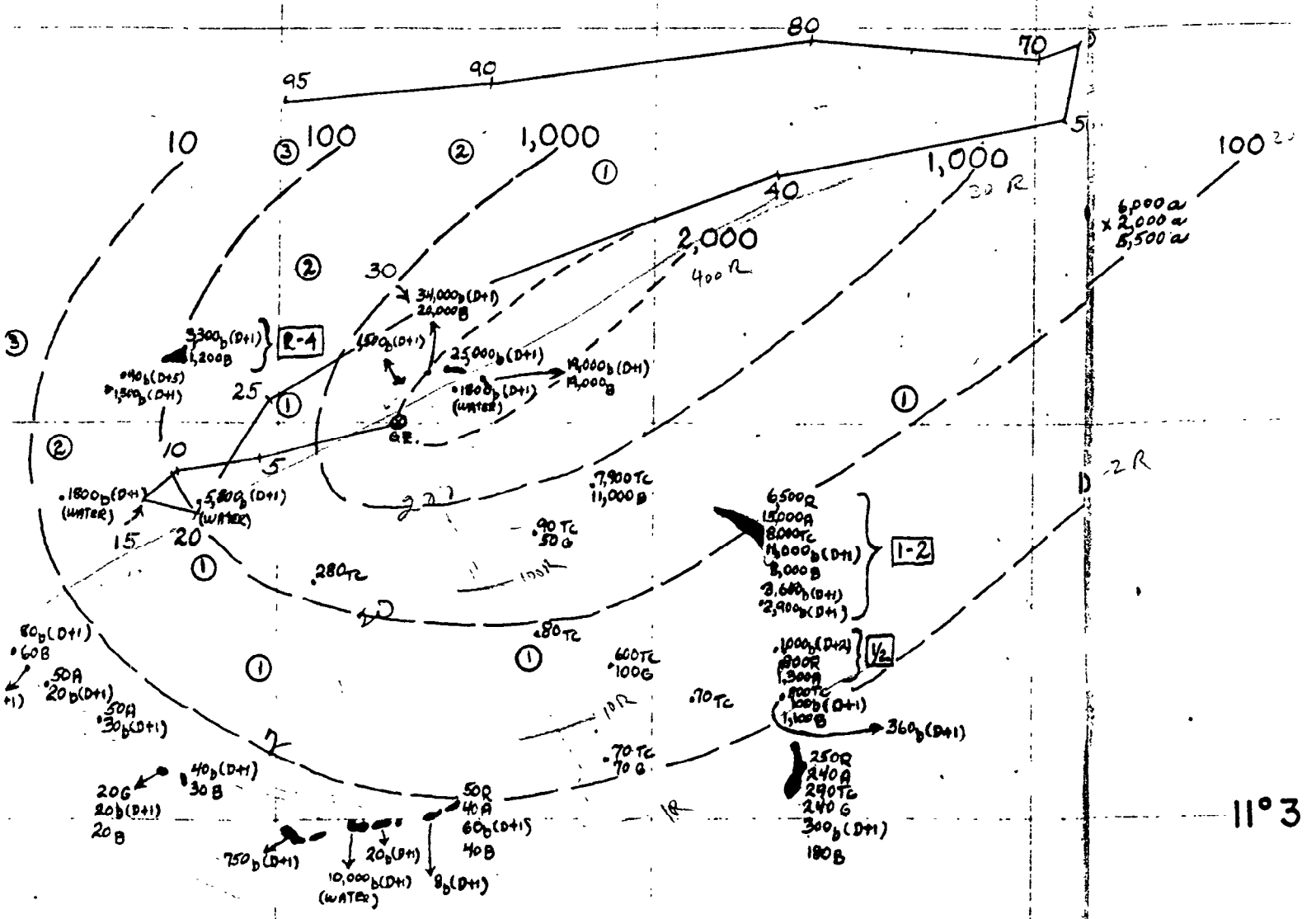


SECRET

Figure 12. CASTLE UNION NO. 4

SECRET

0 5 10
NAUTICAL MILES



SECRET

165°30'E

[redacted]

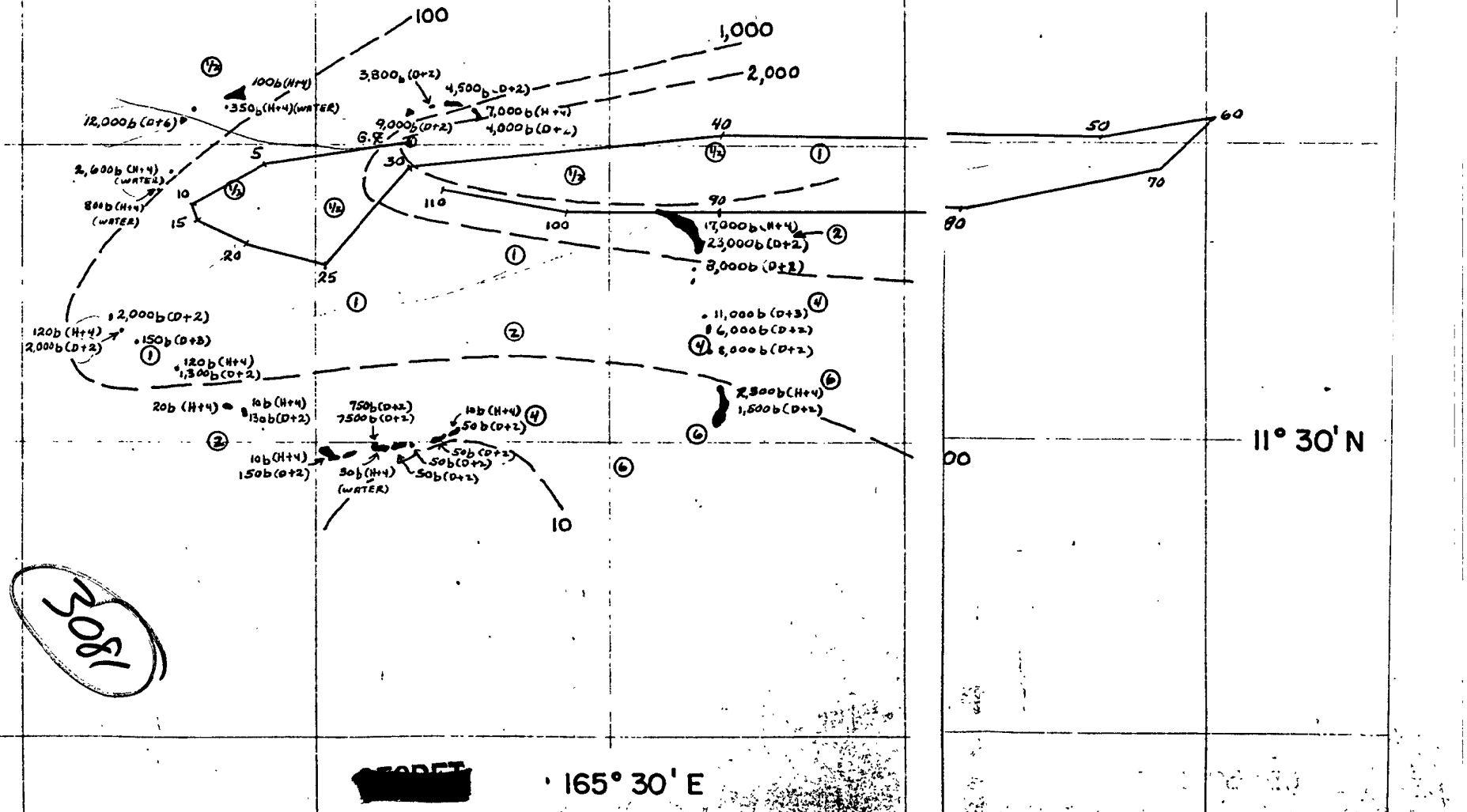
Figure 13. CASTLE YANKEE NO. 5

Figure 13:

[redacted]

0 5 10

NAUTICAL MILES



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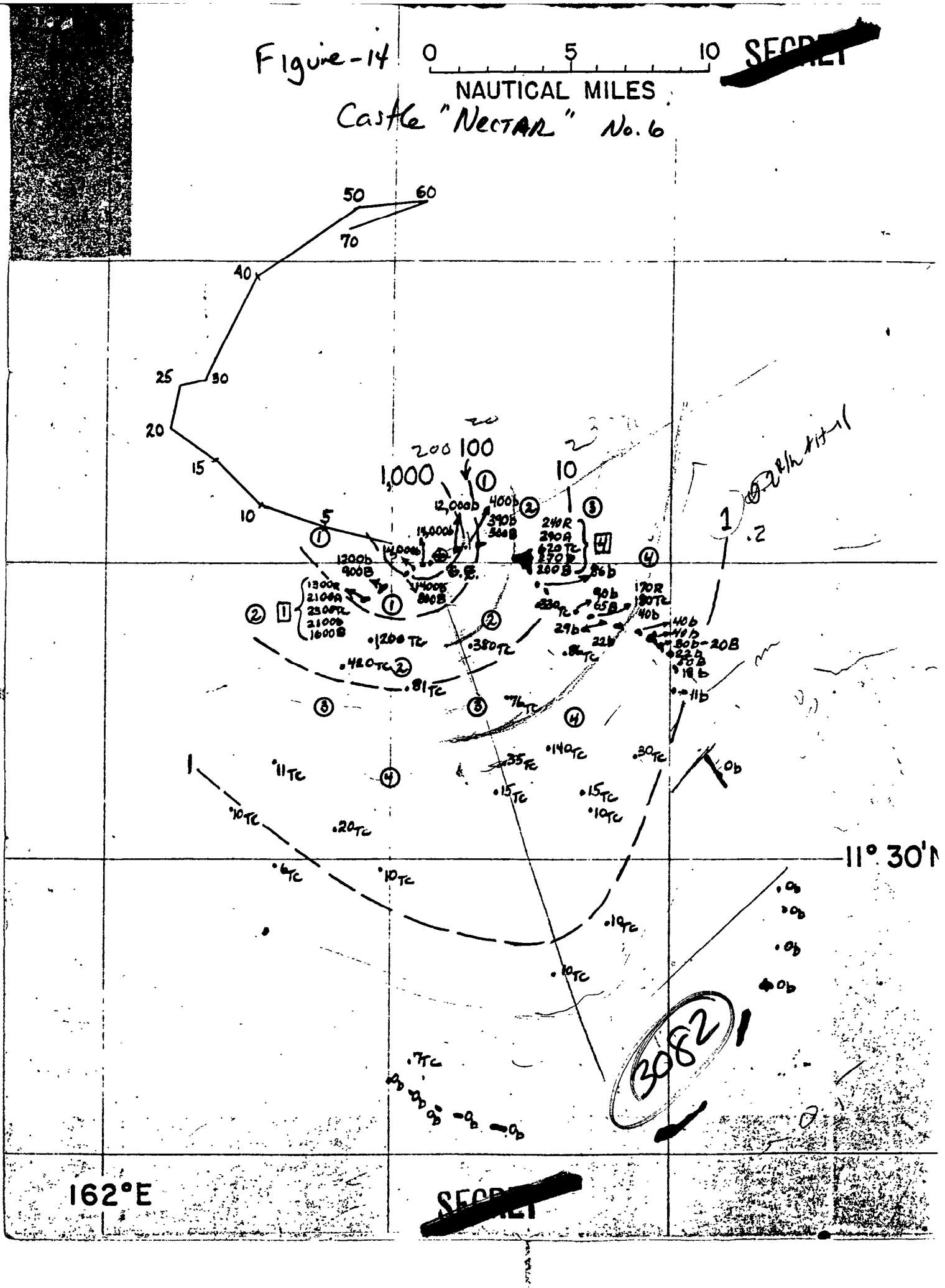
Figure-14
0 5 10
NAUTICAL MILES
SECRET
Castle "NECTAR" No. 6
50
60
70
40
25
30
20
15
10
5
200
100
1,000
10
1
2
3
4
5
12,000b
400b
390b
360B
14,000b
1200b
900B
1400b
880B
240R
240A
220 TC
170b
160B
86b
1300R
2100A
2300TC
2100b
1600B
90b
65B
170R
180TC
40b
29b
22b
80b-20B
18b
11b
.1200 TC
.380TC
.420TC
.81TC
.76TC
.140TC
.30TC
.11TC
.35TC
.15TC
.10TC
.20TC
.6TC
.7TC
11° 30'N
162°E
SECRET