Site survey of Daniel's Head, Bermuda

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https://doi.org/10.4224/21273530

Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB); no. ERB-502, 1959-01-15

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R & EE Divison ERB 502

Site Survey of Daniels Head, Bermuda

N. Burtnyk and C.W. McLeish

Jan. 15, 1959 Copy #1 of 5

TECHNICAL MEMORANDUM COPY NO. 1

TO: DIRECTOR,
Supplementary Radio Activities,
Room #3717, "A" Building,
Cartier Square,
OTTAWA, Ontario.

SUBJECT: SITE SURVEY OF DANIEL'S HEAD, BERMUDA

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January 15, 1959

APPROVED BY:

SITE SURVEY OF DANIEL'S HEAD, BERMUDA (CONFIDENTIAL)

I Calibrations of the Site with Spaced Loop Direction Finder

Obstructions: 3 - 150' radio towers are on the site see map "Sketch A"

1 - Adcock DF installation with four 30' elements

1 screened hut 10' high x 8' x 8'

Numerous buried cables, extending from ops. building to DF hut, exact positions unknown.

Overhead wires extending from ops. building (600 feet away) back to living quarters.

It was estimated that the nearest radio towers at primary resonance (which is near 1.5 mc, assuming they are grounded at the base) would each cause about 10° peak error at the site centre near the old DF. Measurements down to 1.75 mc, the lowest usable with the test gear, showed errors of up to 17½° from true bearings of the transmitter. The error (curves A) is, of course, possibly due to the summation of a number of errors caused by the three towers, and by buried cables up to the old DF 100 feet away from the test DF. In the band above 3 mc, where the towers may be considered as scattering sources, the total errors are smaller, having maxima of about 5°. The rate of change of the largest error component in this band with frequency is low, indicating a nearby reradiator, possibly the DF hut and buried cables from it. An error component with a more rapid change, having a cyclic interval of about 1.5 mc, is also apparent in the band. Its peak amplitude seems to decay from about 3° at 3 mc to about 1° at 12 mc. This component is likely due to scattering from the towers. The random contribution from site errors other than the metallic reradiators discussed above

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is difficult to estimate. Further tests (curves B and C) from three positions of the transmitter about 1200 feet away on the water, produced similar results. From position (1), in the direction of the old DF installation, large errors were obtained below 10 mc, but above this frequency the errors were generally less than 3^{o}. From positions (2) and (3), (see Sketch A), the errors are about the same above 10 mc, but smaller than for position (1) below this frequency.

One conclusion to be drawn from these tests is that extremely large errors are caused by the radio towers below 3 mc. From 3 mc to 10 mc there are errors attributable to the old DF installation in the centre of the proposed site. Finally over the whole frequency range, there are site errors which are 2-4 times the amplitude to be expected from a good DF site. To confirm this general statement about the site errors, an attempt was made to locate a similar site, from the point of view of roughness, which was clear of metallic reradiators. On such a site an estimate of site error could be made which would be an indication of the site error at Daniel's Head. No such site was found, but a much rougher piece of ground at Spanish Rock on the south shore, which was clear of all overhead wires (except for one fence line), was measured as a matter of interest. The errors shown in curves D were obtained over the paths shown in the sketch on the same sheet. Large errors are caused by the irregular terrain and also to some extent by the proximity of tidal water on both sides of the test position. An indication of the effect of the sea, which had waves about 3 feet high, was the fluctuation of the null indicated on the spaced loop direction finder when the transmitter was at T_2.

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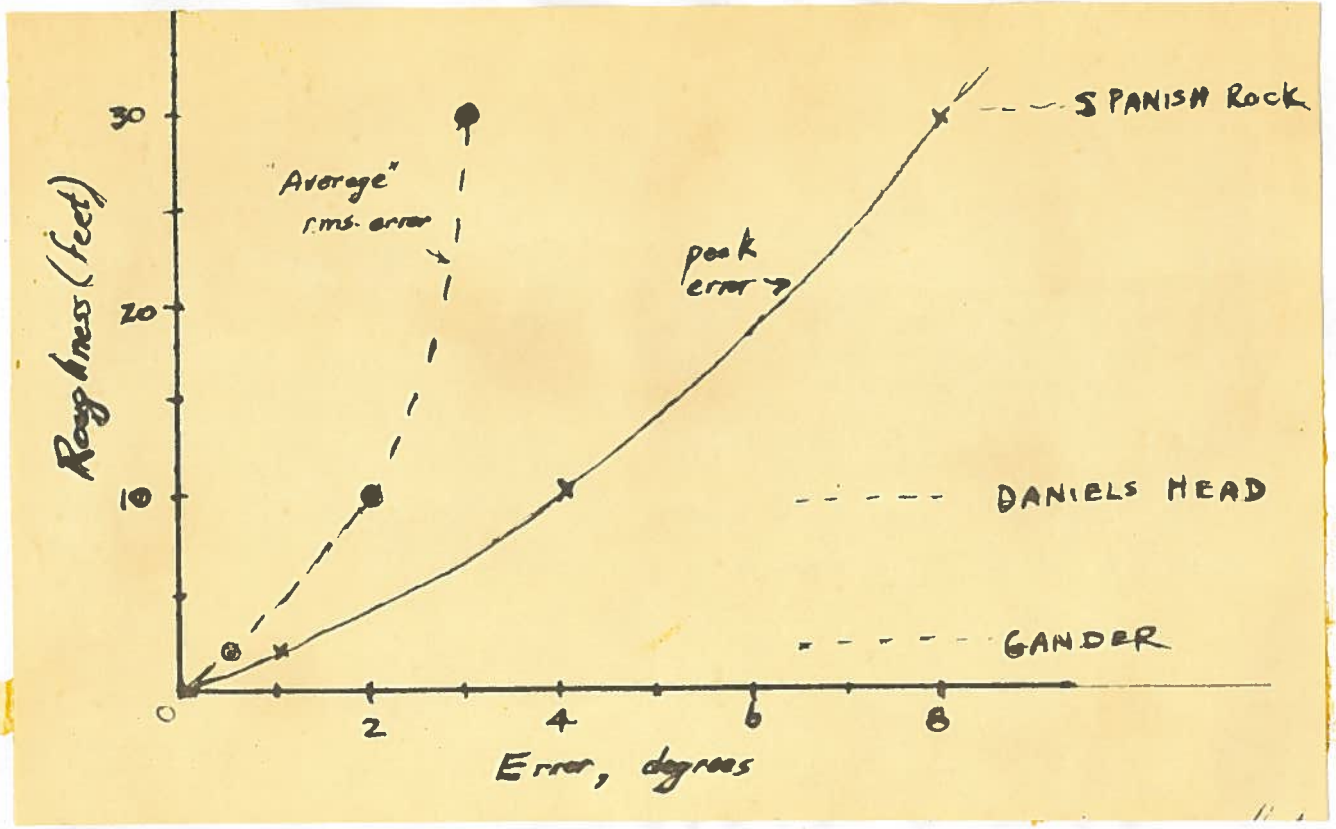
At 16 mc the null was about 22 db below maximum signal indication and it was fluctuating about ±2½ db. At 18.5 mc the fluctuation was ±5 db in a 30 db average null, while at 20 mc the fluctuation was ± 7 db in a 30 db null. In terms of bearing deviation the effective spread of very deep nulls was about ±1° at 20 mc. The effect was just noticeable on the path to T1.

The conclusion to be drawn from this test is that although the site at DANIEL'S HEAD is far less irregular than SPANISH ROCK, the large site errors measured at the latter site would confirm the need to improve the proposed site by levelling. An estimate of the degree of flatness needed to reduce site error to a reasonable figure may be arrived at by comparing roughness with error measured by local calibration at these and other sites. The plot below shows an approximate relation between roughness of the near site and errors.



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Roughness is expressed in terms of the difference between the limits and the mean elevation of the site. It can be seen that in order to achieve site errors of less than 1° peak, the site should be flat to within about ±2 feet. It should be mentioned that the total site error in operational use may be larger than this, due to distant irregularities, as was explained in a previous report[1].

II Ground Constant Measurements (K = dielectric constant, σ = conductivity)

Ref: ERA-245 Measurement of Earth Conductivity by the Wavetilt Method - W. Searle

1. At 3 mc $\frac{E_H}{E_V} = \frac{121}{300}$ $Q = 0°$ $K = 1 + \left(\frac{E_V}{E_H}\right)^2 = 7.83$ (no σ value)

2. At 2 mc $\frac{E_H}{E_V} = \frac{136}{300}$ $\phi = 8.5°$ $2\phi = 17°$ $K = 5.65$ $\sigma = 1.65 \times 10^{-15}$ emu

3. At 1.5 mc $\frac{E_H}{E_V} = \frac{105}{300}$ $\phi = 21.7°$ $2\phi = 43.5°$ $K = 6.9$ $\sigma = 4.66 \times 10^{-15}$ emu

The above values, derived from measurements made at the top of the knoll on DANIEL'S HEAD, lie in the range of low values of conductivity and dielectric constant measured at WHITEHORSE, UPLANDS, and CHURCHILL (in winter). It may therefore be considered a very low conductivity site. Geologically it consists of coral rock, with a thin 6" - 12" overburden of coral sand and humus. If levelling of the site is contemplated, the average level will be some 10-15 feet lower than the knoll where the measurements were made. This

1. ERB-496 - The Derivation of HF DF Corrections from Local Calibrations, p. 12

would probably result in a higher effective conductivity but it would still be relatively low compared with the average RCN site.

III RECEIVED SIGNAL STRENGTHS IN THE HF BAND (3-25 mc) AT BERMUDA

TIME → (1400-1500 AST)			(2200-2300 AST)	
Freq. band (mc)	No. of signals over 1 mv/m	No. of signals over 300 μv/m	No. of signals over 1 mv/m	No. of signals over 300 μv/m
3 - 4	0	1	0	7
4 - 5	0	4	3	20
5 - 6	0	1	2	21
6 - 7	0	0	7	25
7 - 8	0	1	8	43
8 - 9	0	3	0	31
9 - 10	4	13	14	43
10 - 11	3	12	3	42
11 - 12	4	10	11	45
12 - 13	1	7	2	18
13 - 14	2	19	3	12
14 - 15	3	11	5	18
15 - 16	0	23	8	17
16 - 17	1	11	1	4
17 - 18	0	16	2	4
18 - 19	2	13	3	8
19 - 20	1	10	1	1
20 - 21	0	6	0	3
21 - 22	2	10	1	2
22 - 23	1	2	0	1
23 - 24	1	1	1	5
24 - 25	0	0	0	0

NOTE: About three "local" signals are included in each of the three columns above.

COMMENTS: The signal density at Bermuda measured in these tests is about three of four times that measured in Ottawa in the summer of 1955. The implication is that this is probably a very good site for general reception by comparison with Ottawa.

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IV NOISE MEASUREMENTS

Measurements of background atmospheric and man-made noise, ignoring large peaks, were made with the Stoddard field strength meter. A low noise amplifier and 15' whip were added at the input for all measurements above 1.0 mc. Where it was significant, allowance was made for receiver noise. The results in the table below are all expressed in terms of microvolts per metre for a 1 Kc bandwidth. Experimental readings are compared with expected values of atmospheric and galactic noise from the NBS circular #557, "Worldwide Radio Noise Levels Expected on the Frequency Band 10 Kc to 100 mc". Where man-made noise to be expected in quiet locations remote from urban areas exceeds atmospheric and galactic noise, the total expected value is included, in

Frequency (mc)	Day-time (1500-1600 AST) Observed	Expected	Night-time (2100-2200 AST) Observed	Expected
0.15	- μv/m	2.4 μv/m	3.3 μv/m	27 μv/m
0.20	-	1.1	3.5	20
0.30	-	0.50	3.5	13.5
0.50	-	0.22 (.55)	3.0	8.9
1.5	2.0	0.02 (.25)	-	3.8
3.0	0.50	0.03 (.19)	1.2	1.9
6.0	0.4	0.13 (.15)	1.7	1.1
10.0	0.65	0.30	1.25	0.50
20.0	0.70	0.20	1.00	0.14
25.0	0.77	0.18	0.38	0.14

brackets.

Unfortunately, a single set of readings is not sufficient to describe conditions of noise level to very great accuracy.

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The expected values given by NBS have a normal spread of about ±9 db due to unpredictable slow time variations and to local conditions. Therefore it is reasonable to say that the observed levels are not exceptionally high. There is a possibility that the higher levels observed both day and night above 10 mc may be due to man-made noise sources from local installations, many of which are well within ground wave range. This is not too likely however, because such sources usually radiate heavily in the L.F. range and this is not apparent in the night-time results.

In conclusion, it may be generally stated that noise levels although above expected levels on the day of measurement, were not sufficiently high or generally spread over the band to cause concern over reception conditions.

V RECOMMENDATIONS

As a receiving site, DANIEL'S HEAD appears to be adequate if the usual precautions toward restricting the generation of noise in any new installations are taken. General signal levels in the HF band are high, and the existing noise levels are within the normal range of expected values.

For direction finding purposes, site errors due to the irregular terrain are likely to be large, even with such reradiators as the three 150' radio masts, the old R.N. DF installation, and existing buried cables removed. To reduce the error to the order of 1°, the area within the ground mat radius (100') should be levelled to within ±6", and that over the rest of the site out to a radius of 300 feet, approximately to within ±3 feet. This

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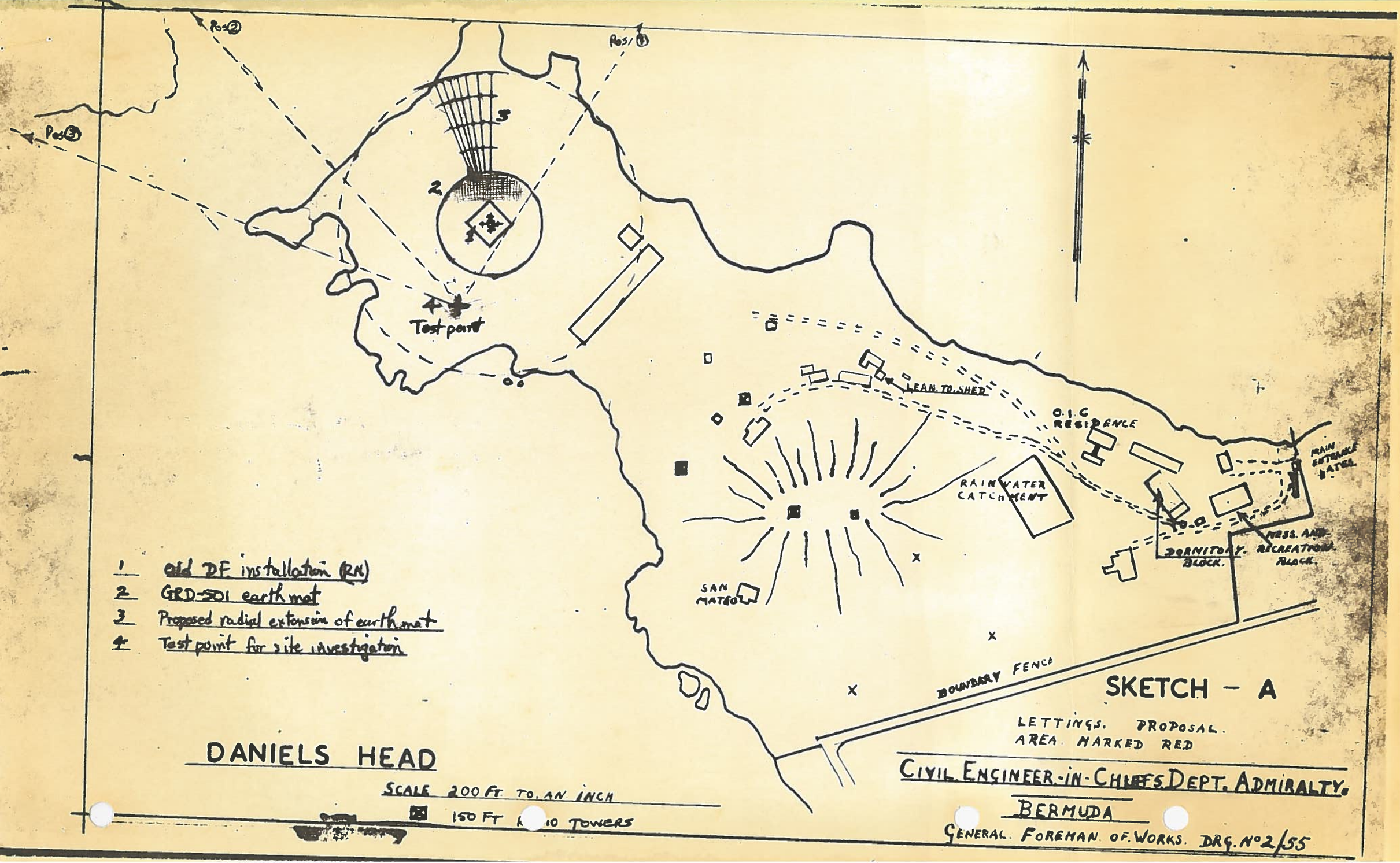
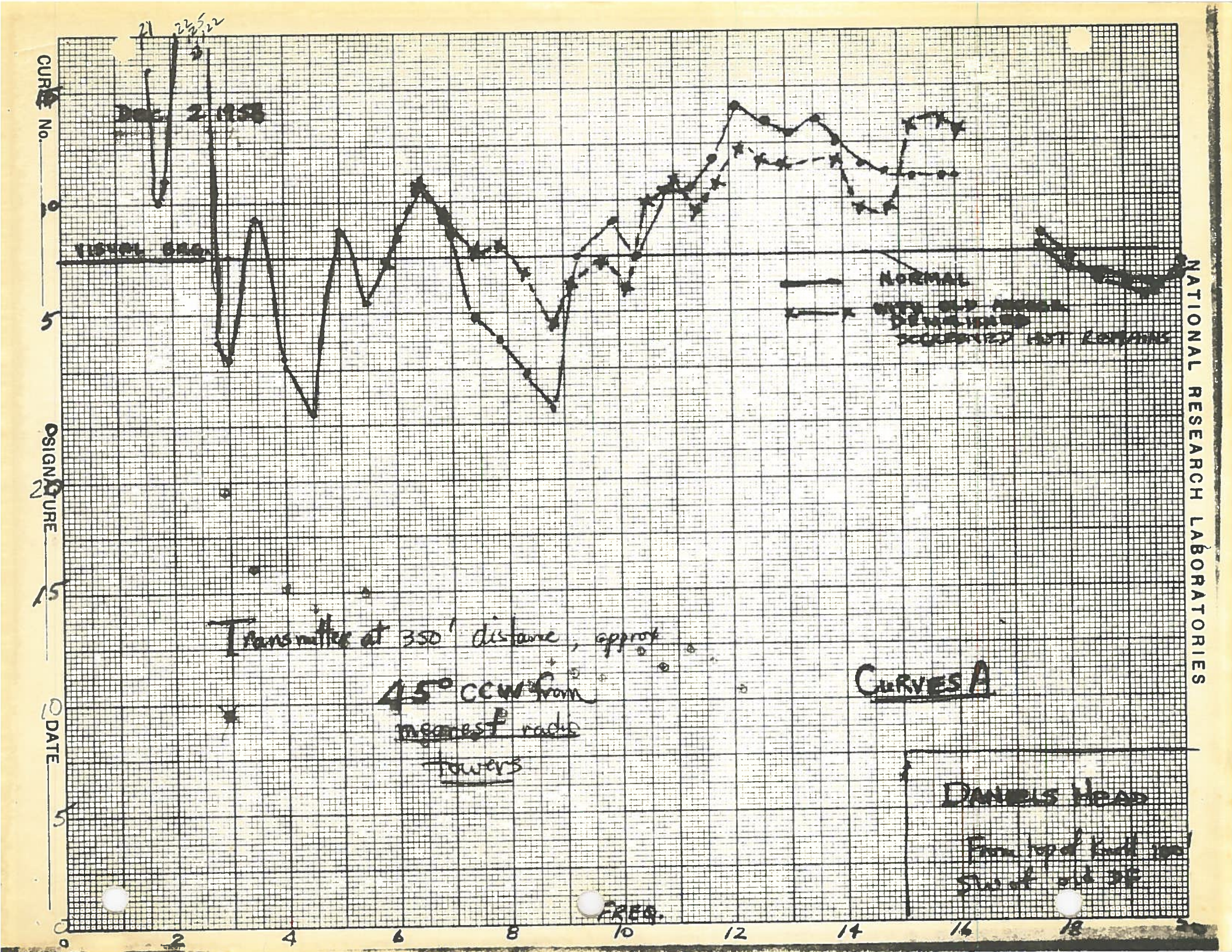
will necessitate the shifting of a large amount of coral rock from the southwest side of the site to the north and east sides. The exact amount may be estimated from the contour maps of the area.

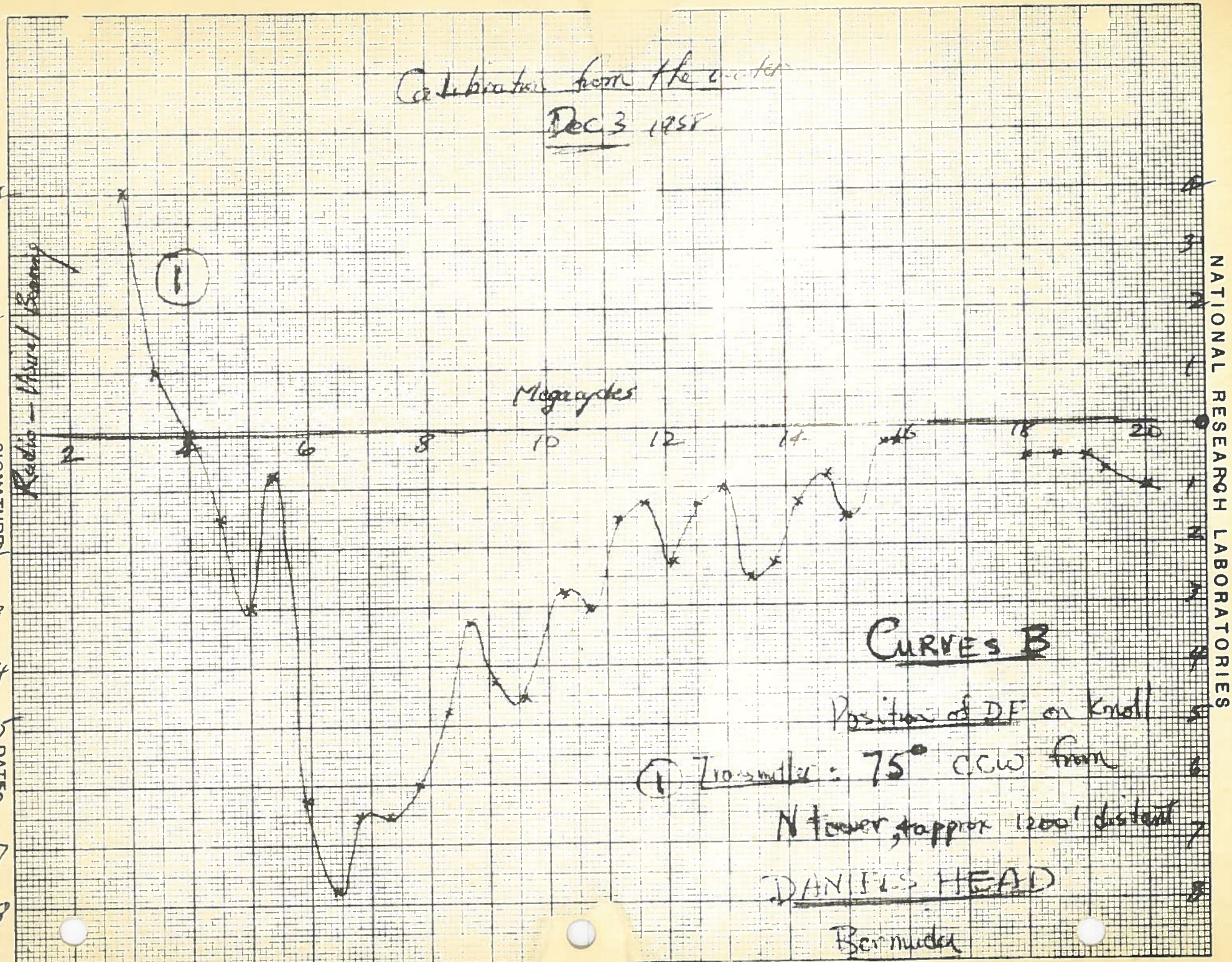
Because of the low conductivity of the rock, an extension to the ground mat of 120 radial wires, each 200 feet long, bonded by at least four concentric rings, is recommended. This extension will in some arcs reach down to the high-water mark. The extension will reduce the reradiation from cables between the DF hut and the operations building, which would otherwise have to be buried at an unreasonable depth. It will also tend to smooth out inhomogeneities in the site due to refraction at the irregular shoreline.

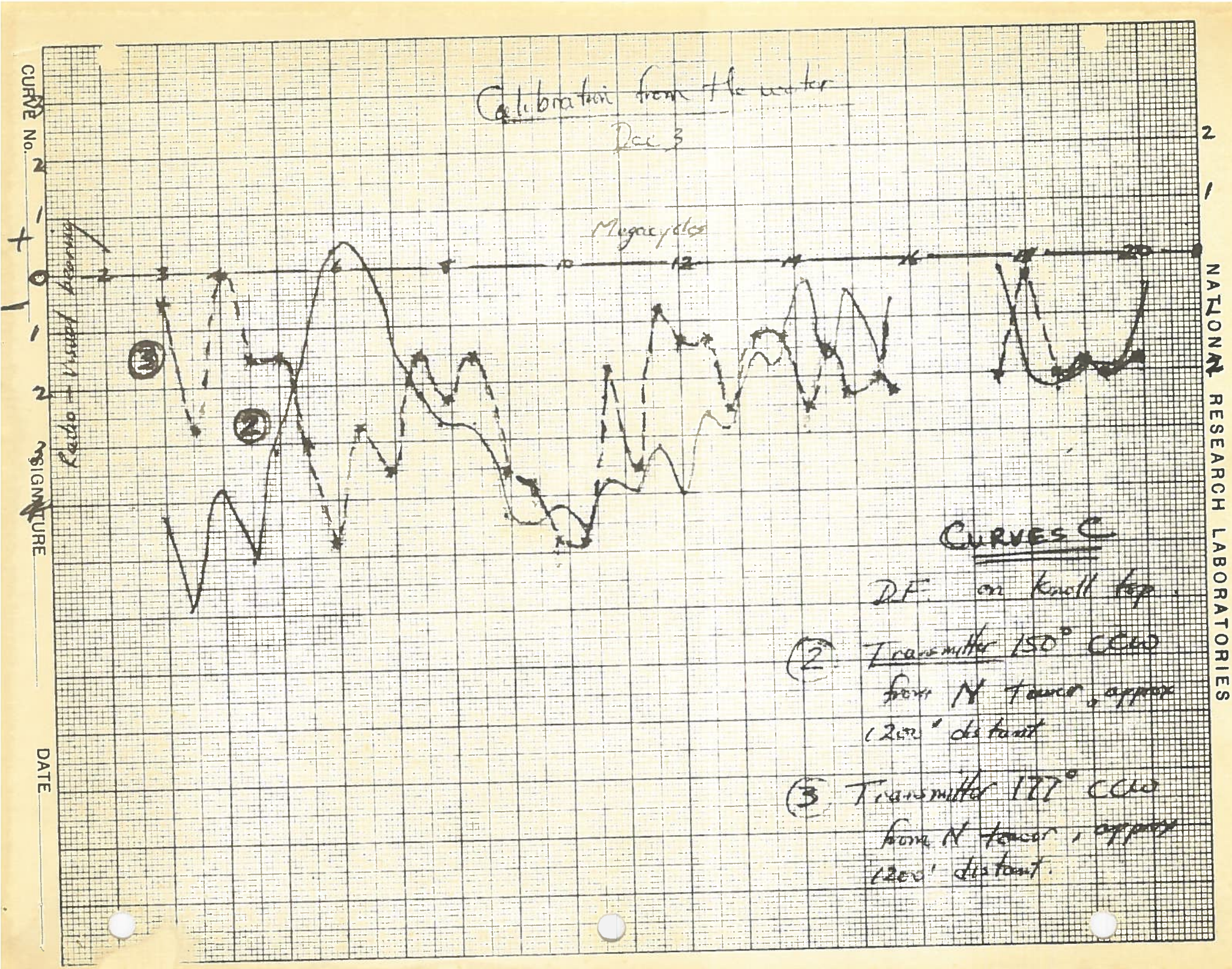
It is probable that on rough days, reflections from sea waves may be detected in the form of a slight fluctuation of the DF display. But it is anticipated that these will be negligibly small (less than $\frac{1}{2}^{o}$) at the distance and height of the proposed site centre from the shoreline.

CWMcL/gcf


Pos②
Pos①
Pos③
3
2
1
Test point
LEAN TO SHED
O.I.C RESIDENCE
RAIN WATER CATCHMENT
MAIN ENTRANCE GATES
MESS AND RECREATIONAL BLOCK.
DORMITORY BLOCK.
SAN MATEO
BOUNDARY FENCE
1 old DF installation (RN)
2 GRD-501 earth mat
3 Proposed radial extension of earth mat
4 Test point for site investigation
DANIELS HEAD
SCALE 200 FT TO AN INCH
150 FT [illegible] 10 TOWERS
SKETCH – A
LETTINGS. PROPOSAL.
AREA MARKED RED
CIVIL ENGINEER-IN-CHIEFS DEPT. ADMIRALTY.
BERMUDA
GENERAL FOREMAN OF WORKS. DRG. N°2/55


CURVE No.
SIGNATURE
DATE
NATIONAL RESEARCH LABORATORIES
FREQ.
0
2
4
6
8
10
12
14
16
18
NORMAL
Transmitter at 350' distance, approx
45° ccw from
nearest radio
towers
CURVES A
DANIELS HEAD


Calibration from the center
Dec 3 1958
Megacycles
2
4
6
8
10
12
14
16
18
20
1
2
3
4
5
6
7
8
CURVES B
Position of DF on Knoll
① Transmitter: 75° CCW from
N tower, approx 1200' distant
DANIELS HEAD
Bermuda
CURVE No.
SIGNATURE
DATE
NATIONAL RESEARCH LABORATORIES


Calibration from the meter
Dec 3
Magnetics
Amplitude in arbitrary units
CURVE No.
SIGNATURE
DATE
NATIONAL RESEARCH LABORATORIES
CURVES C
(1) DF on knoll top.
(2) Transmitter 150° CCW from N tower, approx 12cm' distant
(3) Transmitter 177° CCW from N tower, approx 12cm' distant.

CURVE No. 4

SIGNATURE

DATE 58

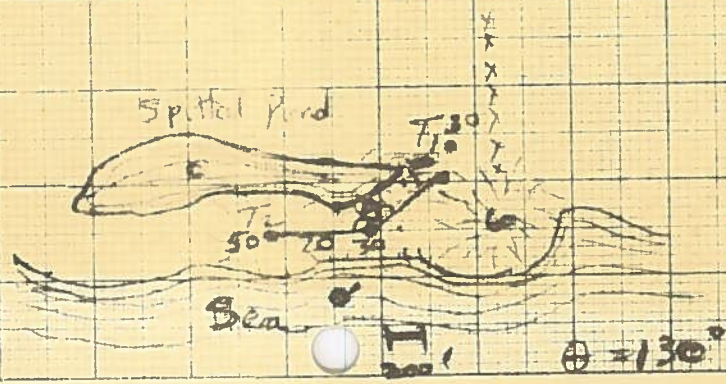
NATIONAL RESEARCH LABORATORIES

T_2

T_1

FREQUENCY MC

2 4 6 8 10 12 14 16 18 20



CURVES D

SPANISH ROCK Dec 5/58

From top of shoulder (3' above sea)