AUSTRALIAN BROADCASTING CONTROL BOARD

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ENGINEERING SERVICES DIVISION

REPORT NO. 42

TITLE: MEASUREMENTS OF MF SKY WAVE SEA GAIN

Issued By:

The Chairman,
Australian Broadcasting Control Board,
562-574 Bourke Street,
MELBOURNE, VIC., 3000

Engineering Report No. 42

Title

Measurements of MF Sky Wave Sea Gain

Authors

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and Development Section - 5th March, 1976.

Summary

This work is part of continuing investigations for the development of MF sky-wave field strength prediction methods. It deals mainly with the increase in field strength observed when MF sky-wave signals are received with sea water in the foreground instead of land.

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Director
Engineering Services Division

1. Introduction

For some considerable time, it has been known that LF, MF and HF sky-wave field strengths are higher at coastal receiving sites than at sites well inland. Knight (1969, 1975) has described many of the associated effects and has proposed a predication method whereby the increase in sky-wave field strength can be calculated approximately when sea water replaces land at either end of the propagation path. Subsequent measurements of sea gain in Australia (Sandham 1975) were found to conflict with the predictions by Knight, and as a consequence further measurements were made in Australia. Some of these measurements are the subject of this report.

2. Path and Station Details

For convenience of measurement, the reception site in Melbourne used in previous MF sky-wave measurement campaigns served as the inland site. It is located in the suburb of Surrey Hills, indicated in Figure 1. Blairgowrie on a peninsula 65 km south of Melbourne was selected as the coastal site, providing sea paths to the north. The most distant stations to the north which had previously been recorded on a regular basis in Melbourne were selected for these tests - Akita, Japan, and 4QD Emerald, Australia. Relevant details are given in Table 1.

Table 1

Station Call Sign and Location	Freq. kHz	Power kW	Path Length to Blair-gowrie km	Path Bearing from Blair-gowrie	Sea Water Path Length from Blairgowrie km	Nightly Recording Period
4QD Emerald, Australia.	1550	50	1686	11.92° True	56	2000-2300 EST.
Akita, Japan.	770	500	8697	356.21° True	47	2300-0100 EST.

3. Measurement Procedure and Results

Simultaneous field strength recordings were made of each station on 21 consecutive nights during February, 1976. The ratio of median field strengths during any hour is taken as the sea gain. The median of these ratios is the median sea gain. Results of the measurements are shown in Table 2.

Table 2

	Field Strength Surrey Hills $(E50)_{50}$*	$(E_{50})_{50}$* 300 mV/m at 1 km.	$\left[\frac{(E_{50})_B}{(E_{50})_{SH}}\right]_{50}$ ** dB	σ dB	Corrections to $\frac{(E_{50})_B}{(E_{50})_{SH}}$ dB	Median Sea Gain dB
4QD	50.6 dBu (0.34mV/m)	32.5 dBu	9.5	1.8	Site correction Surrey Hills +1.0 Site correction Blairgowrie -0.3 Distance +0.7 Total correction +1.4	10.9

Table cont.

	Field Strength Surrey Hills $(E_{50})_{50}$ *	$(E_{50})_{50}$* 300mV/m at 1 km.	$\left[\frac{(E_{50})_B}{(E_{50})_{SH}}\right]_{50}$ ** dB	σ dB	Corrections to $\frac{(E_{50})_B}{(E_{50})_{SH}}$ dB	Median Sea Gain dB
Akita	35.3dBu (58uV/m)	6.8dBu	5.3	1.5	Site correction +0.5 Surrey Hills Site correction -0.4 Blairgowrie Distance +0.2 Total Correction+0.3	5.6

* 4QD 2200-2300 hrs, AKITA 2400 hrs, site correction included.
** Median of hourly median ratios, 4QD 2000-2300 hrs, Akita 2300-0100 hrs.

Measured sea gains of 10.9 dB and 5.6 dB for reception of 4QD and Akita transmissions at Blairgowrie exceed predicted values according to reference 2 by 4.2 dB and 1.2dB respectively. In the case of 4QD these results are consistent with theoretical calculations for the 1 hop E mode. There was sufficient sea path to achieve maximum sea gain for 4QD, but insufficient (about half) to achieve maximum sea gain for Akita.

Hourly median field strengths measured at Blairgowrie and Surrey Hills are fairly well correlated. This can be seen from Figures 2 and 3 where all the results are plotted. Sea gain varies from hour to hour and from night to night, but these results show no significant variation with time of night. In the case of 4QD, Figure 2 indicates that maximum and minimum sea gains occur when field strengths are depressed. Maximum sea gain for the period (15.7dB) occurred because of depressed signals at Surrey Hills. The minimum sea gain measured (3.8dB) occurred because signals were depressed at Blairgowrie. The situation for Akita transmissions is rather different, with sea gain maxima and minima not necessarily being restricted to periods of depressed signal.

4. Fading Characteristics

Three separate fading characteristics are evident in the recordings of signals from 4QD. The dominant signal component has a slow fading rate and is assumed to be the 1 hop E mode. This is the only mode present during the early stage of signal build up at sunset. A second mode soon becomes evident producing more rapid fading but of lower amplitude. This is assumed to be the 2 hop E mode. On some nights a third mode may be present producing much more rapid fading. This mode is assumed to be 1 hop F. Its amplitude is the same at Blairgowrie and Surrey Hills, which is consistent with the higher angle of arrival for F mode signals.

Reduction of the 1 hop E component at Surrey Hills compared with that at Blairgowrie produces greatly different fading patterns at the two sites when the F mode is present. On some nights the two components may be of equal amplitude at Surrey Hills whereas there will be a 3:1 amplitude ratio at Blairgowrie. Figure 4 shows these differing fading patterns.

5. Site Correction Factors

Measurements were made away from the two base sites, in a manner described previously (Reference 5), to correct for peculiarities of the base sites. Details of these measurements are given in Appendix 1. Only those sites

at or near the Port Phillip Bay coastline were used in determining the site correction factors for Blairgowrie.

In regard to measurements made at Blairgowrie inland sites, sea gain was still effective for reception of Akita transmissions at the most distant site S_3 (9 λ from the coast), but had diminished completely for reception of 4QD at this same site (18 λ from the coast). Ground conductivity in this area is assumed to be low because of the sandy nature of the peninsula.

6. Accuracy of Sea Gain Measurements

The probability that the errors of median sea gains presented here exceed ±1dB is 32%. The error is mainly due to measurements of site correction factors for which there are substantially fewer results than for sea gain. Both quantities have approximately the same deviation from the median, as a proportion of the median. Standard deviations of these measurements vary from 1.3dB to 2dB for site correction factors, and 1.5dB to 1.8dB for sea gain.

7. Conclusion

Sea gain measurements presented in this report are consistent with predictions determined in accordance with reference 2 in regard to sites at or near the coast, but there is contradictory evidence for sites extending beyond 13 wavelengths from the coast. No sea gain was evident at 18 wavelengths from the coast. It is assumed that this discrepancy is due to low ground conductivity typical for sandy coastal areas. The prediction method would be improved if it provided for a range of ground conductivities at the inland site.

References

1. Knight P. and Thoday RDC (1969) Influence of the ground near transmitting and receiving aerials on the strength of medium-frequency sky waves. Proc. IEE Vol. 116 No. 6 911-919.

2. Knight P (1975) LF and MF Propagation - an approximate formula for estimating sea gain. BBC Research Department Report 1975/32.

3. CCIR Report 575. Methods for predicting sky-wave field strengths at frequencies between 150 kHz and 1600 kHz. (Annex)

4. Sandham J.K. (1975) The estimation of the sea gain factor for medium frequency sky wave propagation into Australia. Australian Broadcasting Control Board, Engineering Services Division Report.

5. CCIR (1966-1969) Document 6/171, Australia. The influence of reception site environment on medium frequency sky wave field strength.

Appendix 1

Site Correction Factors

Site at Blairgowrie	Distance to the Coast km	Distance from Base km	$\left\{\frac{E_s}{E_B}\right\}_{50}$ Akita	4QD
Base	0.48	0	1	1
N_I	0	0.56	0.91	1.17
N_2	0	1.85	1.13	1.16
N_3	0	1.14	1.18	0.96
N_4	0	2.71	0.83	0.91
N_5	0	2.33	1.12	0.98
N_6	0.13	1.49	0.85	0.90
N_7	0.08	1.53	0.86	0.98
M_1	0.60	0.68	1.07	0.72
M_2	0.48	0.66	0.50	0.71
Median			0.95	0.97
S1	2.2	1.77	1.36	0.77
S_2	2.5	2.5	0.58	0.40
S_3	3.5	5.0	0.79	0.28

Site at Surrey Hills	Distance from Base km	$\left(\frac{E_s}{E_B}\right)_{50}$	
		Akita	4QD
Base	0	1	1
N_1	0.7	1.00	0.89
N_2	1.3	1.21	1.04
S_1	0.7	0.67	0.60
S_2	1.3	0.76	0.85
E_1	0.8	1.27	1.44
E_2	1.4	0.70	0.81
W_1	0.7	0.92	0.77
W_2	1.4	0.94	0.94
NW_1	0.7		0.85
NE_1	0.6		1.20
Median		0.94	0.89

Appendix 2

The sea gain agreed to by Interim Working Party 6/4 of the CCIR is given by the following expression for the MF band -

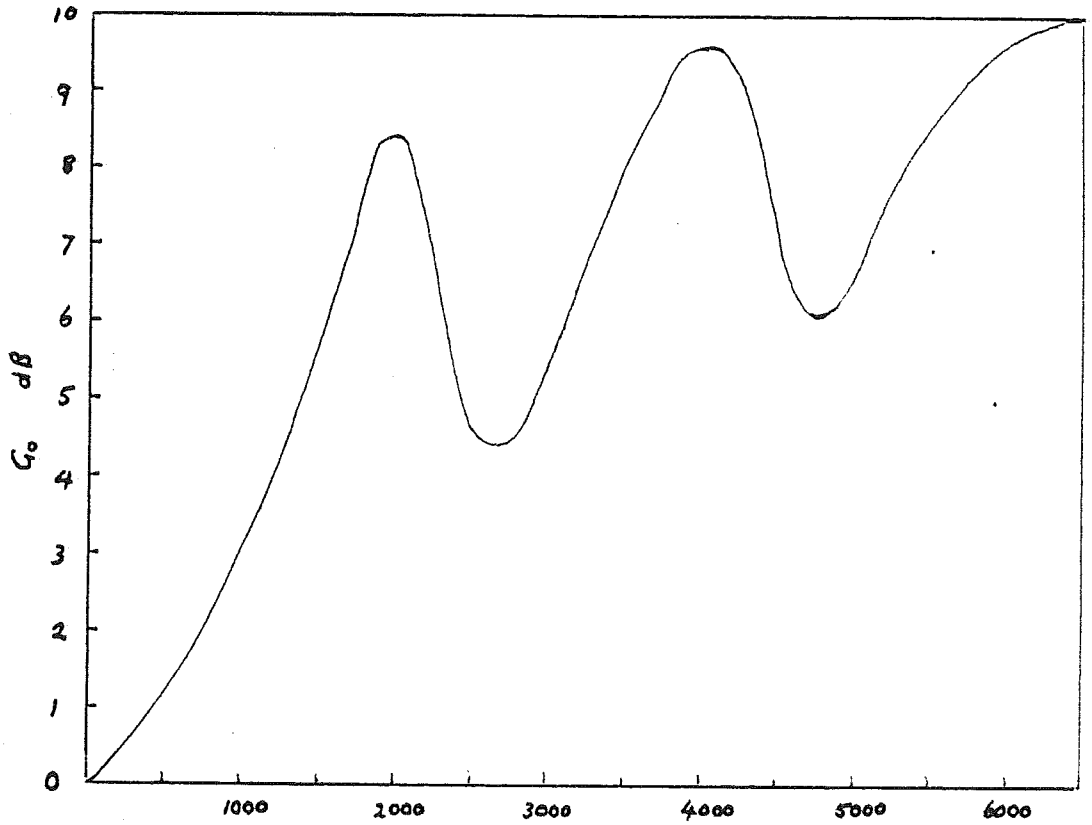
$$G_s = G_o - 10^{-3} \left(\frac{1.75\ s\ f}{G_o}\right)$$

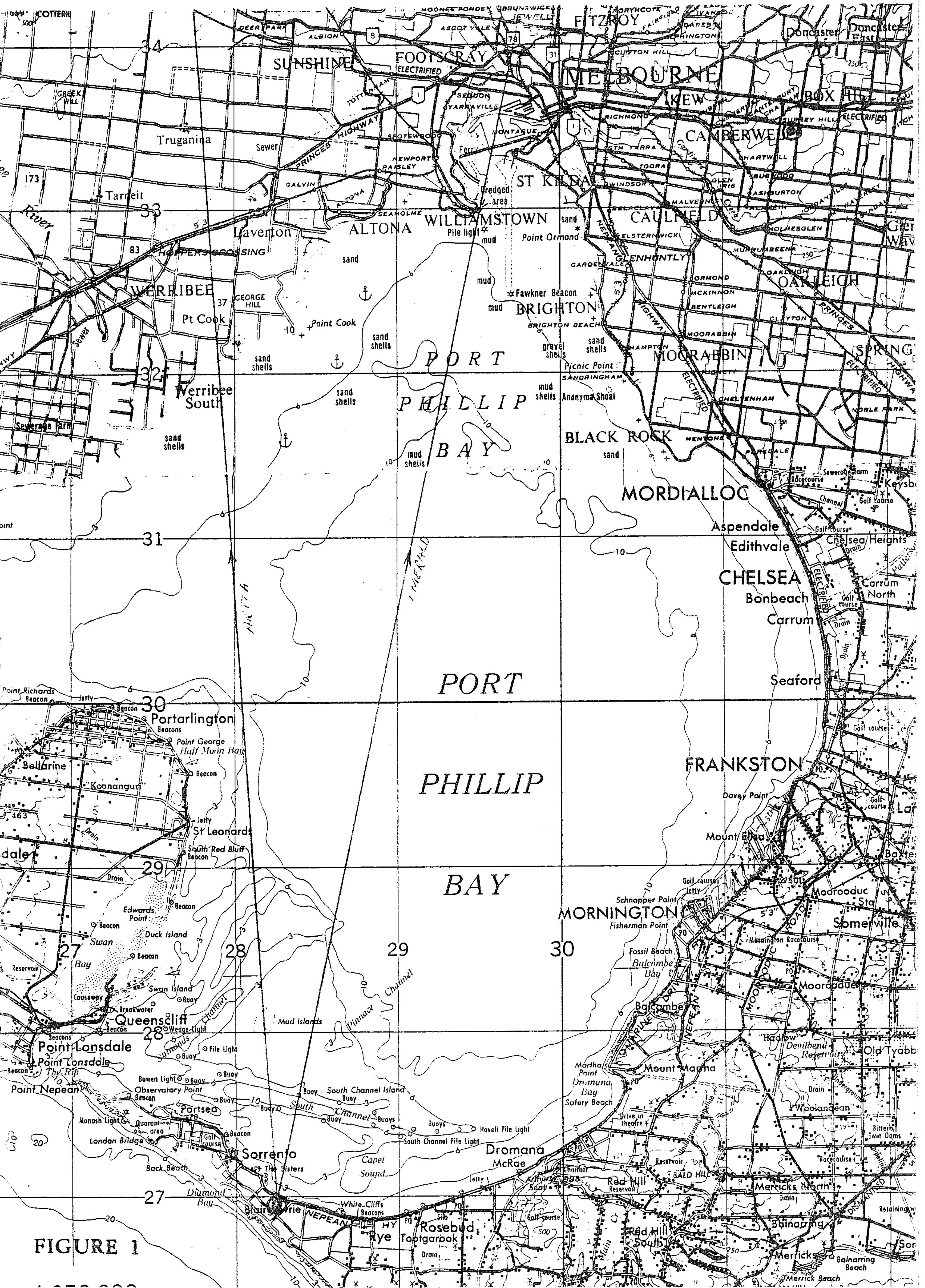
where G_s is the gain in dB for a single terminal

G_o is the gain in dB when the terminal is on the coast, and is shown below.

f is the frequency in kHz

s is the distance of the terminal from the sea in km.





MELBOURNE
FITZROY
FOOTSCRAY
SUNSHINE
ELECTRIFIED
KEW
BOX HILL
CAMBERWELL
RICHMOND
Doncaster
Truganina
Sewer
PRINCES HIGHWAY
SPOTSWOOD
NEWPORT
PAISLEY
GALVIN
ALTONA
SEAHOLME
ST KILDA
Tarneit
River
Laverton
HOPPERS CROSSING
WERRIBEE
GEORGE HILL
Pt Cook
Point Cook
Dredged area
WILLIAMSTOWN
Pile light
Point Ormond
CAULFIELD
ELSTERNWICK
GARDENVALE
ELSTERNWICK
Fawkner Beacon
BRIGHTON
BRIGHTON BEACH
ORMOND
MCKINNON
BENTLEIGH
OAKLEIGH
MOORABBIN
HAMPTON
SANDRINGHAM
Picnic Point
Anonyma Shoal
CHELTENHAM
BLACK ROCK
MENTONE
PARKDALE
Werribee South
Sewerage Farm
sand
shells
mud
PORT PHILLIP BAY
MORDIALLOC
Aspendale
Edithvale
CHELSEA
Bonbeach
Carrum
Chelsea Heights
Carrum North
Seaford
FRANKSTON
Davey Point
Mount Eliza
Point Richards Beacon
Jetty
Portarlington
Point George
Half Moon Bay
Bellarine
Koonangurt
St Leonards
South Red Bluff Beacon
Drain
Edwards Point
Duck Island
Swan Bay
Swan Island
Reservoir
Causeway
Breakwater
Queenscliff
Point Lonsdale
The Rip
Point Nepean
Observatory Point
Portsea
Monash Light
Quarantine area
London Bridge
Sorrento
The Sisters
Back Beach
Diamond Bay
Blairgowrie
NEPEAN HY
Rye
Tootgarook
Rosebud
White Cliffs
Mud Islands
Pinnace Channel
Symonds Channel
Pile Light
Bowen Light
Buoy
South Channel Island
South Channel
South Channel Pile Light
Hovell Pile Light
Capel Sound
Dromana
McRae
Arthurs Seat
Red Hill
Red Hill South
Schnapper Point
MORNINGTON
Fisherman Point
Fossil Beach
Balcombe Bay
Balcombe
Martha Point
Dromana Bay
Safety Beach
Mount Martha
Mooroodue
Somerville
Devilbend Reservoir
Old Tyabb
Woolangean
Merricks North
Balnarring
Merricks
Balnarring Beach
Bittern
27
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FIGURE 1

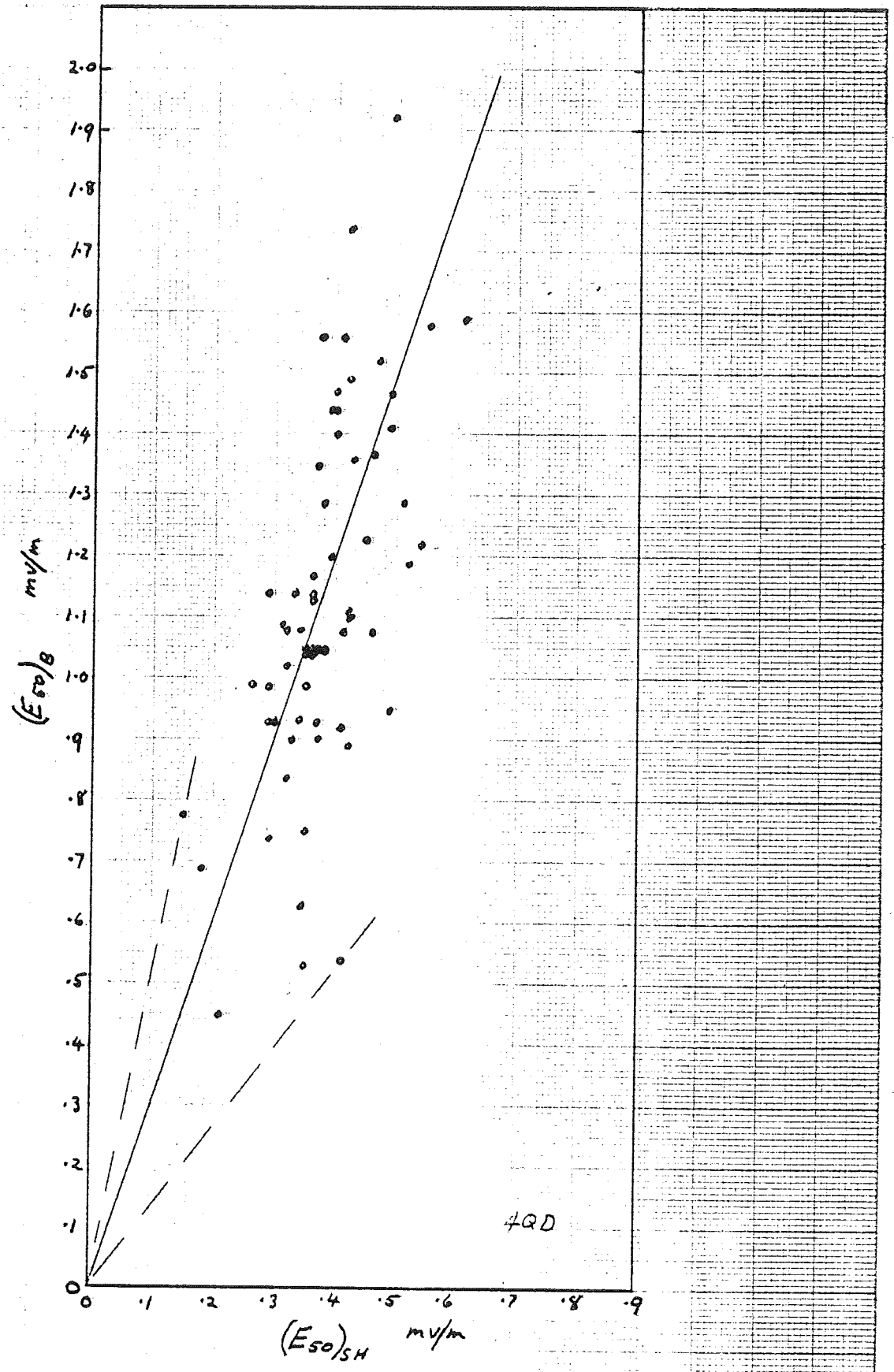

FIGURE 2

Hourly median field strengths of 4QD measured simultaneously at Blairgowrie and Surrey Hills

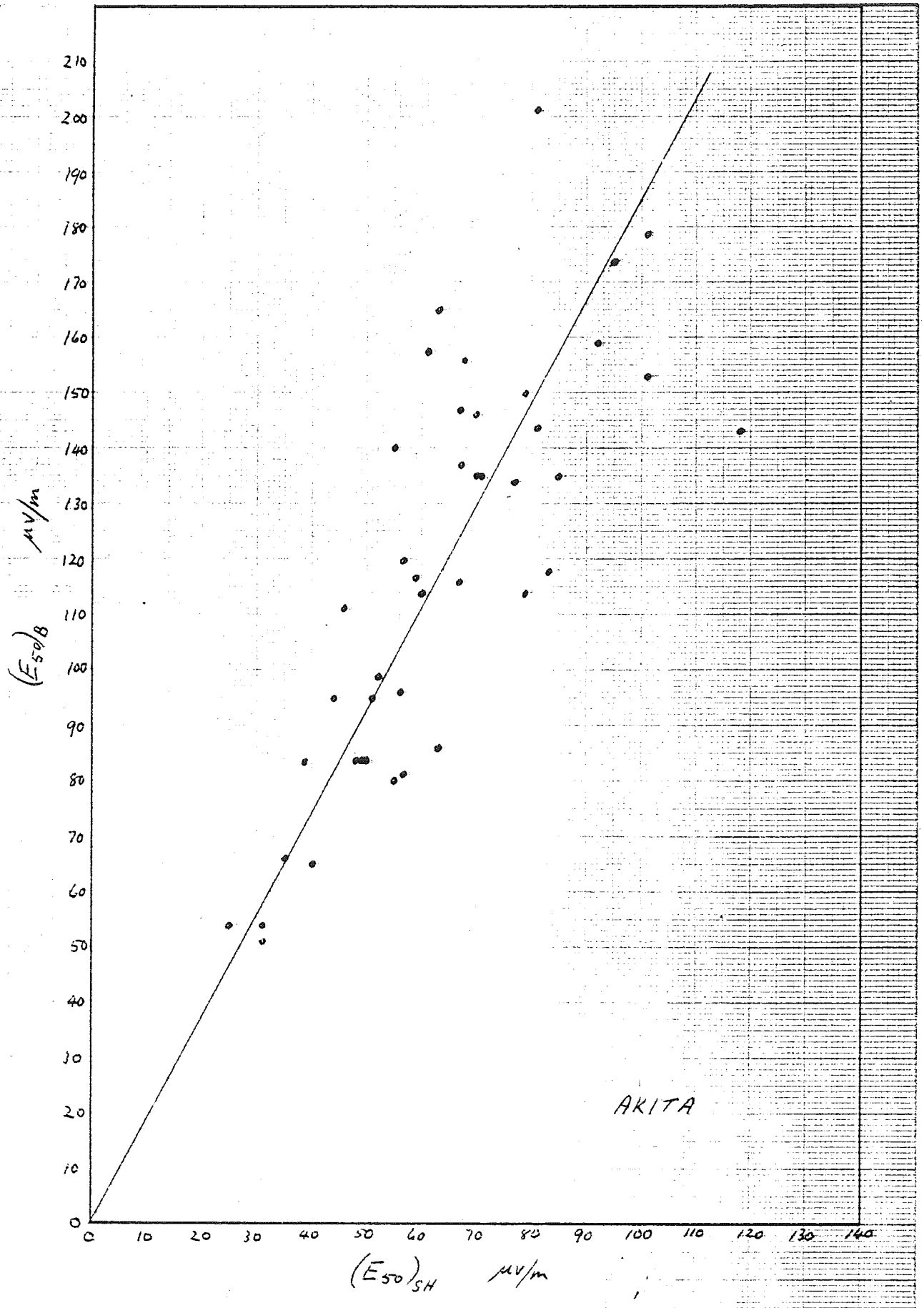

FIGURE 3

Hourly median field strengths of Akita transmissions measured simultaneously at Blairgowrie and Surrey Hills.

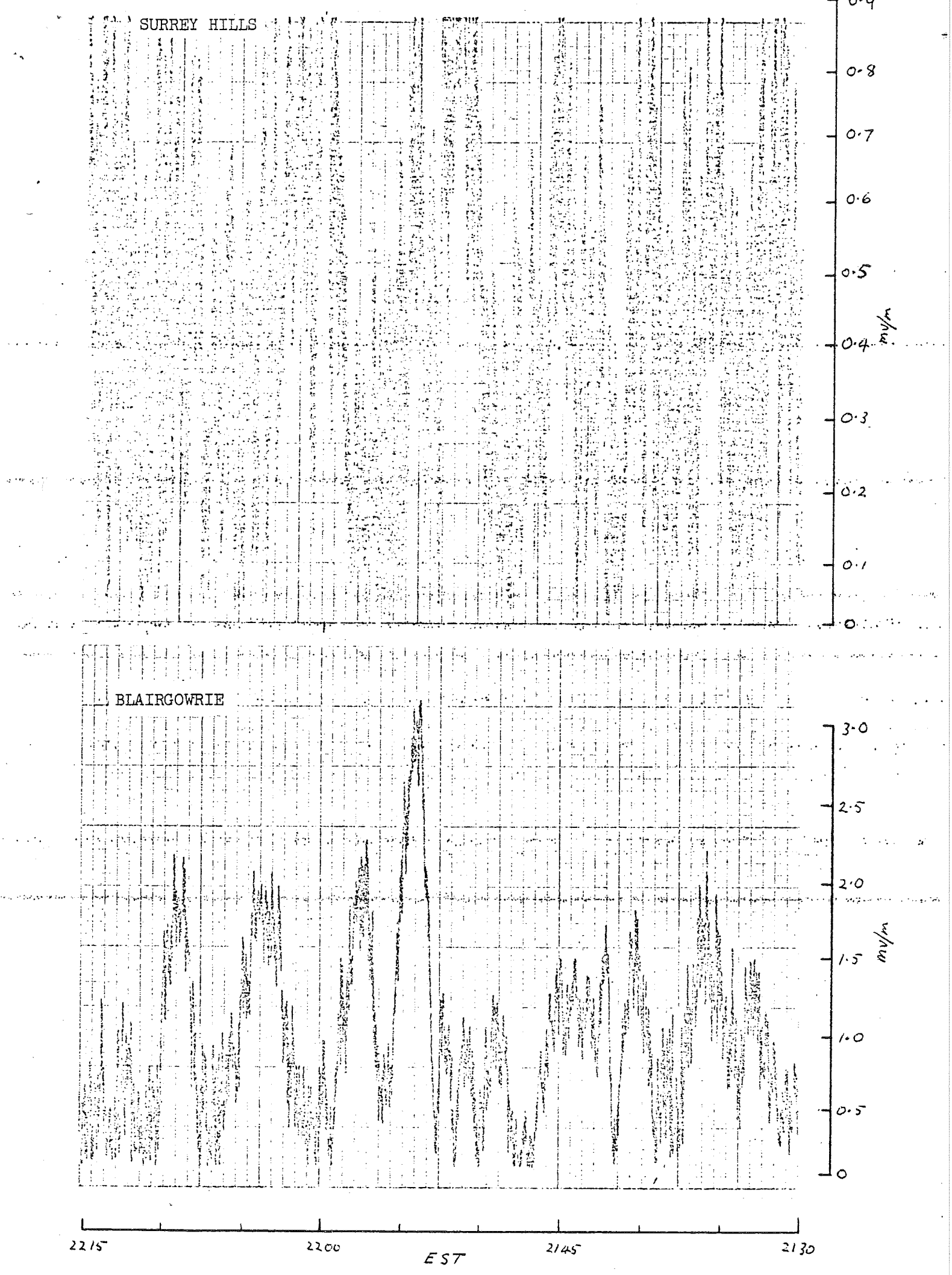

FIGURE 4

4QD fading patterns at Blairgowrie and Surrey Hills on a night when rapid fading was prevalent.

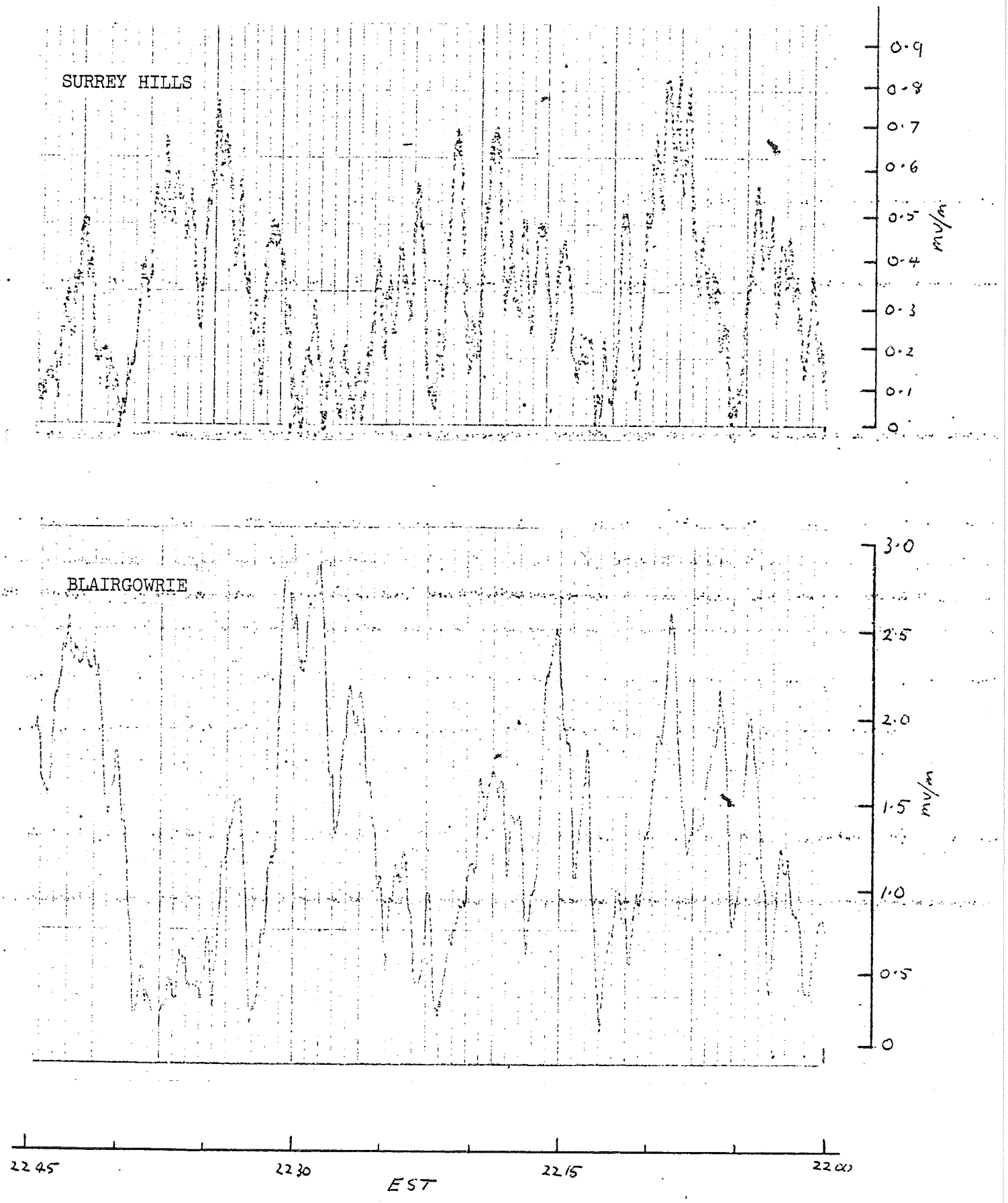

FIGURE 5

Normal fading patterns of 4QD at Blairgowrie and Surrey Hills.