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Helicopter Noise Measurement in Northern Ireland

GC McCullagh & JO Hetherington

UNIVERSITY OF ULSTER

Department of Building and Environmental Engineering

1. INTRODUCTION

Northern Ireland, with about 1.5 million inhabitants, has a relatively low population density and, as a consequence there are few noise problems which might be considered to be of major significance in comparison to those encountered in the UK mainland or in the United States. Road traffic noises would rate as the most significant source as far as its adverse affects on the population are concerned. It is interesting to note that, on the UK mainland since 1973, highway authorities are required, when certain qualifying conditions are met, to carry out works or to provide insulation grants to residents who are seriously affected by road traffic noise. This responsibility is inherent in the Land Compensation Act 1973 and is available under the Noise Insulation Regulations [1]. In Northern Ireland these Regulations would require an Order in Council for their introduction and, to the present, such an Order has not been made.

In about 1968 an increase in civil unrest in Northern Ireland led to a period of considerable violence which, to the present, is still ongoing, albeit at a reduced level. Much of this violence is concentrated in confined areas of Belfast, Londonderry and border areas such as South Armagh. As a consequence there is a strong military presence in these areas with troops based in Military Barracks and in Police Stations in various towns and manning numerous Look-out Posts. In order to facilitate the transfer of men and equipment to and from Look-out Posts and Barracks and to set down and pick up Mobile Patrols, the safest and most convenient mode of transport is the helicopter which is widely used in military operations throughout the Province.

To alleviate the worst effects of noise exposure in the vicinity of military airports and heliports, the MOD have operated an Insulation Grant Scheme [2] for some years in Great Britain. This scheme initially included Northern Ireland and specifically the village of Bessbrook in South Armagh, which has been recognised as one of the most heavily used Heliports in Europe. The Army Barracks at Bessbrook is the centre of helicopter operations and hence the number of daily movements is considerable.

In 1985, as a direct result of numerous complaints, it was decided to extend the Insulation Grant Scheme to additional helipads both on the mainland and in Northern Ireland [3]. Further, the 12 Hour $L_{A,eq}$ above which the Scheme came into operation was reduced from 75 dB(A) to 70 dB(A). Using a computer prediction method, a Grant Aid Contour was introduced in Forkhill and in Crossmaglen, two villages close to Bessbrook in the South Armagh area. Upon introduction of this Scheme there was an immediate reaction, particularly from those just outside the Insulation Grant Aid boundaries.

As a consequence the Grant Aid Authority decided to carry out noise surveys of the areas involved. This paper is an account of the noise surveys at Bessbrook, Forkhill and Crossmaglen and of the analytical methods employed in the validation of the respective Grant Aid Contours. These methods are relatively simple and could be used, for example, by a local Environmental Health Department, to generate noise contours around heliports.

2. GRANT SCHEME CONDITIONS

Aircraft noise has often, in the past, been measured using a variety of complex parameters such as Effective Perceived Noise Level [EPN(dB)] or Noise and Number Index (NNI). In recent years it has been considered more appropriate to use the Equivalent Continuous Sound Level (or $L_{A,eq}$), a more readily measured parameter, for assessment of nuisance from aircraft. This parameter is found to give good correlation between $L_{A,eq}$ and complaints.

A wide range of parameters can be used for assessment of nuisance and for this application the form adopted by the Grant Authority was the $L_{A,eq,12}$. This is the arithmetic average of 12 hourly measurements of $L_{A,eq}$ where the 12 hourly period chosen is that period between 6.00 hours and 18.00 hours. Any flights outside this measurement period are allowed for by lumping into the 12 hourly assessment on a pro-rata basis.

Grant Aid for the purpose of improving the sound insulation of domestic dwellings is available in circumstances where the $L_{A,eq,12}$ value, measured outside the dwellings in question, is equal to or greater than 70 dB(A). In addition, where there is an excessive amount of night flying, the sound insulation grant is payable when the maximum Sound Level or $L_{A,max}$ is equal to or in excess of 82 dB(A). Excessive night flying is defined as 20 or more landings or takeoffs regularly over the night-time period.

3. INSTRUMENTATION

C.E.L. Precision Computing Sound Level Meter type 393

C.E.L. Secondary Processor type 238

BRUEL & KJAER Sound Level Meter type 2231

BRUEL & KJAER Graphics Printer type 2318

BRUEL & KJAER Level Analysers type 4426 (2 No.)

BRUEL & KJAER Alphanumeric Printers type 2313 (2 No.)

BRUEL & KJAER Calibrators type 4230 (5 No.)

IBM PS2/70 Computer with Quattro Spreadsheet and associated Graphics

4. METHODS

(a) Measurement

Following inspections of the various areas and taking flight paths, terrain and local knowledge into consideration, sites were chosen both inside and outside the existing Helicopter Insulation Grant Aid Scheme boundary. In most cases the chosen sites were to the most sensitive side of the nearby dwellings. The Sound Level Meters were positioned with their microphones at a height of 1.2 metre above ground level. Measurements were made in dB(A) in the 'fast' response mode of the Sound Level Meters, as required by the Scheme. Where possible, to avoid serious reflection or shielding effects, the measurement locations were chosen at a distance from building facades. During measurements the microphones were protected by Wind Shields and, when the weather deteriorated, Rain Shields and De-humidifiers were also fitted.

Normally the measurement period commenced at 8.00 hours and finished at 18.00 hours but variations in this format occurred from time to time as the occasion demanded. Again, the hourly measurements were normally recorded both manually, a few minutes before the hour, and, on the hour, on the appropriate Printer. All Sound Level Meters were calibrated before and after each measurement session and for B&K Sound Level Meters, the calibration data was printed out. With the CEL 393 Sound Level Meter no calibration printouts were possible.

At each measurement position the member of the Survey Team responsible was required to keep both a record of the movements of helicopters and to identify helicopter types. Information collected on the data sheets included direction of arrival or of departure and direction, speed and height of approach to or of departure from the helipad. Where excessive noise from other sources was heard this information was recorded.

In all 8 University Laboratory Technicians were employed to record data, to ensure that the instrumentation was functional and that power supplies were maintained. The overall supervision of the Scheme was shared by Academic Staff. On-site measurements were made at either 2 sites per day or 4 sites per day with 1 supervisor per 2 sites. The supervisors were responsible for liaison with the local community, procuring measurement sites, calibrations and instrumentation status.

(b) Analysis

For each measurement period the hourly values of $L_{A,eq}$ (i.e $L_{A,eq,1}$) together with numbers of helicopter movements recorded over the hour were entered in Summary Sheets, for both the Manual readings and SLM Print-outs. When the numbers of Helicopter movements differed between measurement sites the data was later adjusted to give agreement with movements recorded at the site with the best view of the helipad and its approach. Data on weather conditions was also recorded on the Summary Sheets.

The information recorded in the Summary Sheets was analysed by Computer using the "Quattro" Spreadsheet program and the Spreadsheet data was then transposed into graphical form to show the variation of $L_{A,eq,1}$ with 10 Log N where N is the number of helicopter movements. Linear Regression Analysis was used to obtain the best fit straight line for each set of data (representing individual measurement sites). These straight lines were superimposed on the relevant graphs. In order to verify the contour which is already in use to delineate the Grant Aidable area, the Grant Authority provided, for this purpose, a value for the average number of helicopter movements to and from the Helipad per hour over an 8 month period. Using this average number of movements the $L_{A,eq,12}$ for each measurement site was then obtained from the appropriate graph of $L_{A,eq,1}$ - v - 10 log N.

The "Quattro" system was also used to plot a graph of $L_{A,eq,12}$ -V- 10 Log D (Where D is the distance of the measurement site from the Helipad) for each area. As before, Linear Regression Analysis was used to give the best fit straight line through the plotted points, hence showing the variation of the mean value of $L_{A,eq,12}$ with distance. To allow for the spread of sound levels due to variables such as differences in flight path and the probable higher levels resulting at first floor windows due to a reduction in barrier effect at some sites, an allowance of one standard deviation in the sound level constant was then applied to the mean values of the regression curve and a further straight line was plotted on the graph. The distance used for assessment of the 70 dB(A) contour was obtained from the graph by measuring the distance at which this straight line function had an $L_{A,eq}$ value of 70 dB(A) was plotted on the graph.

5. RESULTS AND ANALYSIS OF DATA

Measurements were recorded at, on average, 15 sites in each area. A sample of the data summary for one of the sites is given in Table 1. This table shows both value of $L_{A,eq,1}$ and of $L_{A,max,1}$ together with the hourly numbers of helicopter movements for each of the two measurement days at the site.

In Figure 1 examples of the Quattro generated graphs of $L_{A,eq,1}$ - V - 10 log N are given for typical sites. The graphs show the value of $L_{A,eq,12}$ as assessed from average numbers of helicopter movements for the area represented. For example, in Figure 1 (a) the average hourly number of helicopters for Site 3 was 8 (i.e. 10 log 8 = 9) and the resulting $L_{A,eq,12}$ was 65.7 dB(A).

The method of assessing the radius of the Grant Aid Boundary is demonstrated in Figure 2. The distance D used to calculate 10 log D was measured, for small Helipads such as Forkhill, from the centre of the Helipad or, in the case of Bessbrook, with a larger rectangular Helipad, from the closest point on an imaginary line, drawn down the centre of the Helipad. The radius of the Grant Aid Boundary was assess as shown, by using the best fit straight lines, generated by regression analysis and representing either the mean value or the mean value plus one standard deviation to locate the distance at which the

$L_{A,eq,12}$ was expected to be 70 dB(A). The resulting data is summarised in Table 2, where the corresponding radius values for each Helipad, assessed by the Grant Aid Authority, are given for comparison.

TIME	Day 1: 5.5.89 $L_{A,max}$	$L_{A,eq,1}$	N	Day 2: 14.5.89 $L_{A,max}$	$L_{A,eq,1}$	N
08.00-09.00	85.5	67.5	5	93.5	63.3	3
09.00-10.00	85.5	68.7	13	89.5	64.6	11
10.00-11.00	91.5	72.6	12	91.5	67.2	11
11.00-12.00	87.5	64.0	6	91.5	63.2	12
12.00-13.00	87.5	64.6	6	89.5	62.6	6
13.00-14.00	83.5	65.0	7	89.5	57.9	1
14.00-15.00	87.5	66.8	12	91.5	65.1	8
15.00-16.00	89.5	65.8	8	91.5	67.8	15
16.00-17.00	89.5	65.5	7	93.5	69.5	21
17.00-18.00	87.5	64.5	5	93.5	67.4	13

Table 1. $L_{A,max,1}$, $L_{A,eq,1}$ and Helicopter Movements (N) at Site 3.

Area	Radius of 70 dB(A) $L_{A,eq,12}$ Contour (a)	(b)	(c)
Bessbrook	150	52.5	112.5
Forkhill	117.5	2.0	5.0
Crossmaglen	147.5	41.5	64.5

Table 2. Comparison of $L_{A,eq,12}$ Radii:-
(a) Grant Aid Authority values with
(b) mean value, $\bar{x}$ and (c) $\bar{x}$ + s.d.
of on site measurements.

6. DISCUSSION

(a) Variation in $L_{A,eq,1}$ with hourly movements

It will be seen that there is good correlation between the values of $L_{A,eq,1}$ and hourly numbers of helicopters for the data given in Figure 1(a). This graph is representative of the results obtained for Bessbrook, where the number of helicopter movements was high, ranging from 49 to 147 movements per 10 hour day. At Forkhill and Crossmaglen there were less helicopter movements. The numbers of movements at Forkhill ranged from 15 to 33 per 10 hour day whilst at Crossmaglen, where there were no movements on one day, the maximum number observed was 45 movements per 10 hour day.

The reduction in movements is reflected in Figure 1(b) and Figure 1(c) which are typical graphs of $L_{A,eq,1}$ -v- 10 Log N for Forkhill and Crossmaglen. It will be seen that the spread in number of hourly movements is small and the range of sound levels is relatively large. In Figure 1(c) the slope of the regression analysis line is negative, ie. suggesting that noise levels decrease with increasing numbers of movements. This is clearly incorrect and can be attributed to the fact that, not only was there insufficient data, but that the movements which were recorded bunched into two groups at 2 movements per hour and 4 movements per hour. Apart from this one site, the slopes of the regression analysis lines were positive. At both Forkhill and Crossmaglen there was, however, considerable variation in slopes from site to site. Where slopes were extreme this indicated that sufficient data had ben collected to facilitate reliable estimates of $L_{A,eq,12}$.

(b) Variation in $L_{A,eq,12}$ with Distance

In order to assess the variation of sound level with distance, as described previously in the text, the values of $L_{A,eq,12}$ obtained from the graphs of $L_{A,eq,1}$ -v- 10 Log N were plotted against 10 Log D, where D is the distance from the centre of each of the three helipads. The graph for Bessbrook, on which regression analysis lines are also plotted, is shown in Figure 2. The slope of the regression analysis lines are almost -1, with a Standard Deviation of 0.3. Such a slope represents what would be expected for a line source of sound and this is not unreasonable for a long term average sound level from a number of moving sources. The slopes for Forkhill and Crossmaglen were -0.7 and -1.4 with Standard Deviations of 0.3 and 0.6 respectively.

(c) Determination of 70 dB(A) $L_{A,eq,12}$ Contour.

Figure 2 indicates the method used to assess the 70 dB(A) $L_{A,eq,12}$ Contour around each of the helipads. The distances derived from the graphs, both using the mean regression line and the regression line representing the mean plus 1 standard deviation, are given in Table 2, where they are compared with the existing Grant Aid Boundaries. At Forkhill and Crossmaglen these boundaries were circles centred on the helipad. At Bessbrook, where the helipad is a large rectangular area, the contour was elongated towards the North-East and

South-West extremities and was similar in shape to the existing Grant Aid boundary, as shown for Bessbrook in Figure 4. Some consideration was also given to the addition of a full standard deviation in both the y constant and the slope of the regression line. The effect of this addition for the Bessbrook data is shown in Figure 3. Inspection indicated that the radii of the 70 dB(A) $L_{A,eq,12}$ boundaries for Bessbrook and for Crossmaglen would be unrealistically large. In each instance the radius of the 70 dB(A) $L_{A,eq,12}$ contour assessed using $\bar{x}$ + 1 s.d. was less than the existing Grant Aid Contour radius. Since no values of $L_{A,eq,12}$ at any measurement site outside the radius assessed for each location were in excess of 70 dB(A), it was therefore recommended that the existing Grant Aid contours should be retained.

(d) Numbers of Qualifying Dwellings

The numbers of dwellings in South Armagh which are inside the Grant Aid boundaries and which are therefore entitled to Grant Aid are relatively small. When reviewing the Grant Aid arrangements in 1986, Boardman [4] indicated that at 70 dB(A) $L_{A,eq,12}$ 70 airfields and a total of 6710 houses would be expected to benefit from the Scheme, ie. on average about 100 houses per Airfield. Inspection of the respective plans suggests that, in Bessbrook, 17 dwellings (plus the Army Barracks) would qualify whilst in Forkhill and Crosmaglen the estimated numbers of qualifying dwellings are 18 dwellings and 50 dwelings respectively. Although some of the buildings in Crossmaglen may be used for commercial purposes only, it would have been expected that a greater number of dwellings in Bessbrook would have qualified than in Forkhill or in Crossmaglen.

(d) Night Flying

Although there was no requirement to measure values of $L_{A,max.}$ during this Survey, hourly values of this parameter were recorded together with other statistical data. Typical values of $L_{A,max.}$ measured are given in Table 1. Inspection of data showed that values of $L_{A,max.}$ in excess of 82 dB(A) were recorded at every measurement site at some time during measurement periods whilst, at some sites, an $L_{A,max.}$ of 82 dB(A) was exceeded over every hour.

The requirement for 20 or more nightly flights on a regular basis before the Grant Authority conditions for night flying apply is quite restrictive. Conditions in this area are quite different from those which would be encountered in the rest of Great Britain in that, for security reasons, there is a considerable amount of low flying. This exascerbates the noise nuisance which the residents experience and, at night, results in sleep interference and, in extreme cases, sleep deprivation. It may be that a relaxation in this Grant Aid condition would be advantageous to those most seriously affected but who are at present outside the existing Grant Aid Boundary.

(e) Roof Insulation

The Grant Aid provided under the Scheme is limited to the provision of double glazing and an alternative form of ventilation with, perhaps, installation of a second door where an outside door opens directly into an insulated room. Whilst this is possibly satisfactory to combat the problem of road traffic noise, in the case of helicopter noise there is the strong possibility of noise ingress via the roof which might limit the advantage gained by the installation of double glazing and/or of additional doors. It is recommended that some consideration should be given to extending the Scheme to provide some improvement in roof insulation. For example, Ford & Kerry [5] has shown that installation of fibreglass on joists in roof spaces can improve the sound insulation of roofs by about 6 dB(A).

On the other hand, care should be taken by householders not to degrade the existing sound insulation of roofing. During the Survey it was noted that roof ventilators were being installed to some dwellings owned by the Northern Ireland Housing Executive. It is expected that this measure, recommended by the Building Research Establishment to reduce humidity in roof spaces and hence to prevent rotting of roof timbers, may adversely affect the sound insulation of the roofs in which it is installed. Since some of these buildings are in close proximity to Helipads, some consideration should be given to fitting the ventilators installed with appropriate sound reduction.

CONCLUSIONS

The method used to derive the Grant Aid boundary from the results of this Survey has been reasonably effective. However, the accuracy of the resulting Grant Aid contour radius might have been improved by increasing the number of measurement sites in each area. This could possibly have been achieved, for example, at Bessbrook, by reducing measurement time at each site. At Forkhill and at Crossmaglen the numbers of helicopter movements was too small for accurate determination of the $L_{A,eq,12}$ for individual sites. An alternative might be to derive the appropriate values of $L_{A,eq,12}$ from measurements of SEL or $L_{A,eq,60s}$.

An addition of 1 standard deviation in the y constant to the regression line provided a means of allowing for such effects as screening of microphone position and of variability in helicopter flight paths. The line generated gave adequate allowance for the radius of the 70 dB(A) $L_{A,eq,12}$ contour in that measurements verified that no dwellings outside the assessed contour radius were exposed to an $L_{A,eq,12}$ in excess of 70 dB(A).

Some consideration might be given to relaxation of the qualifying condition regarding the numbers of night-time movements of helicopters at dwellings where the $L_{A,eq,12}$ exceeds 82 dB(A). Again, the extension of the Grant Aid Scheme to include sound insulation of roofs might be beneficial to residents.

In dwellings where roof space ventilators have been fitted it is probable that some reduction in the sound insulation of the roofing will have resulted. In such cases steps should be taken to remedy any deficiency in sound insulation which had been caused.

REFERENCES

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4. Boardman AM Review of the MOD's Compensation Arrangements near Military Airfields. Proc. IOA Vol 8 Part 4, 1986, pp 121-125.

5. Insulation against Aircraft Noise. Ford RD & Kerry G. University of Salford Acoustics Group. May 1973.

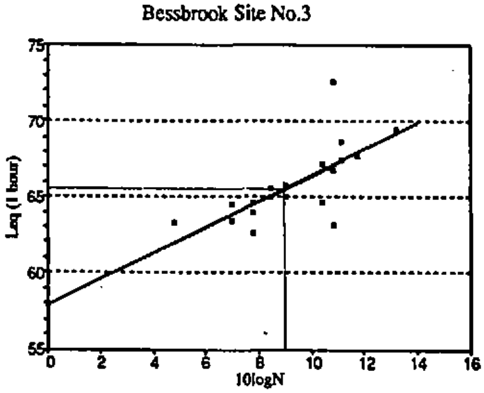

Figure 1(a)

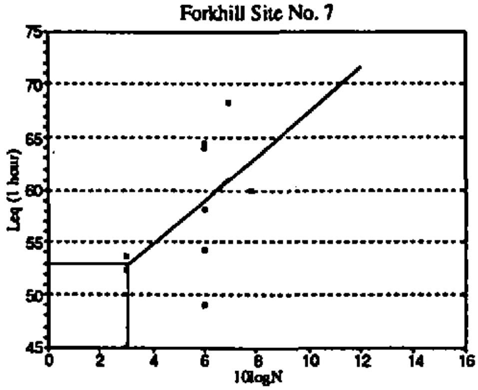

Figure 1(b)

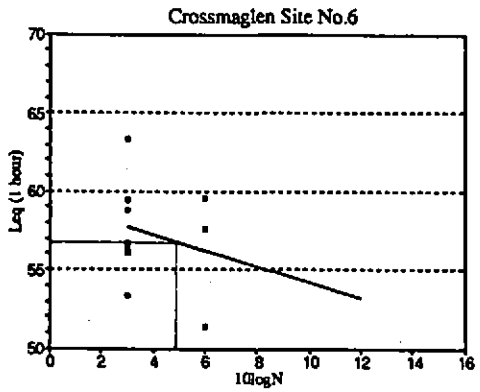

Figure 1(c)

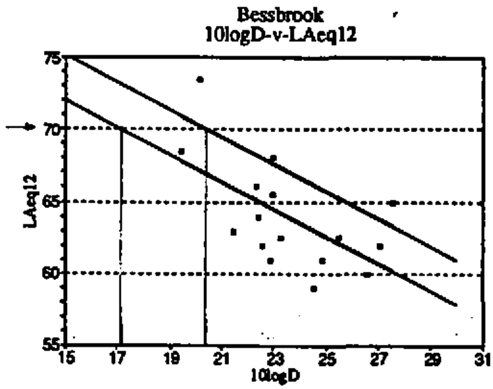

Figure 2

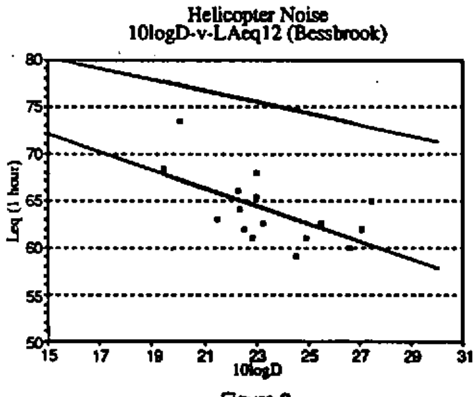

Figure 3.

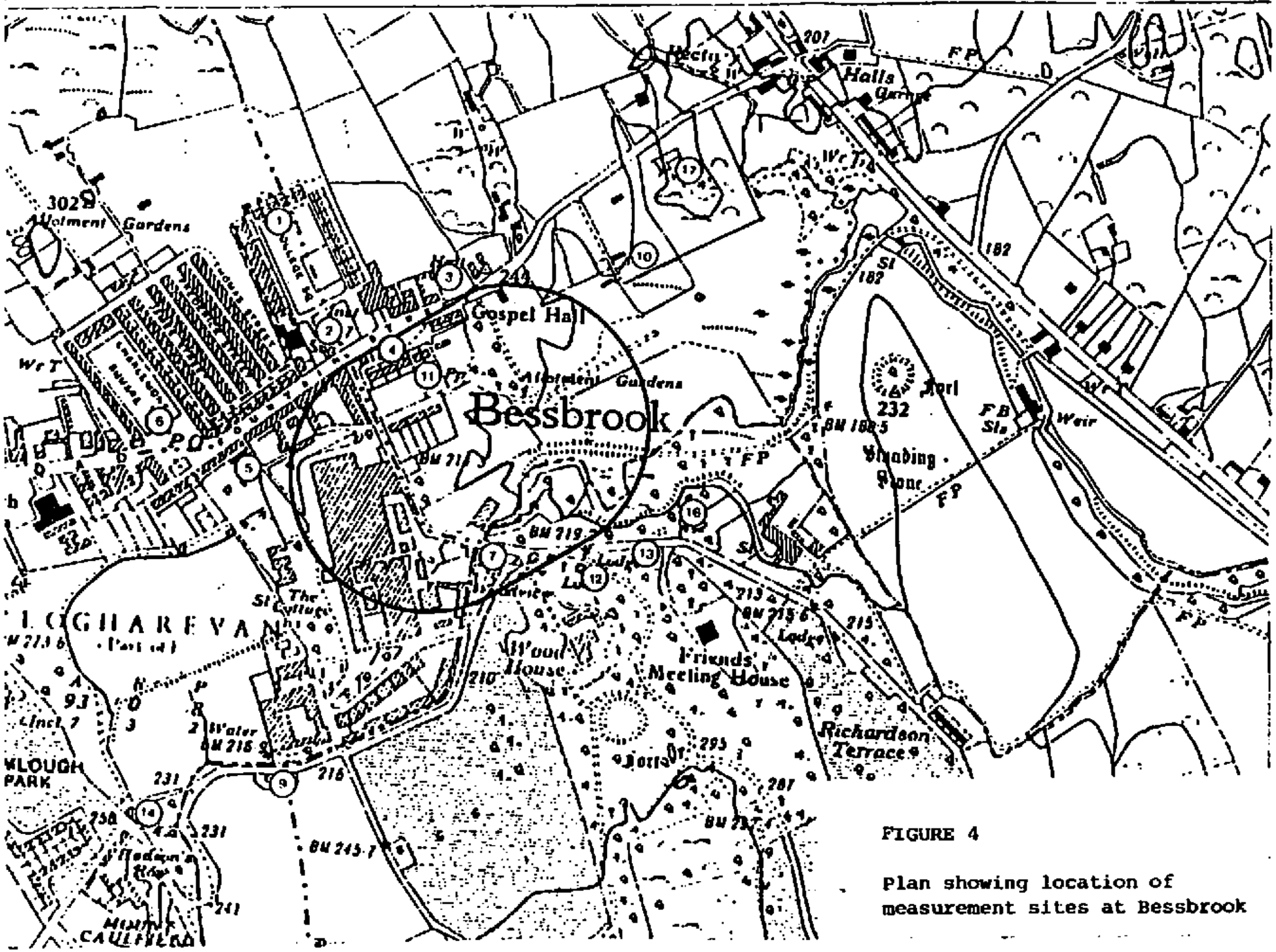

FIGURE 4

Plan showing location of measurement sites at Bessbrook

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