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RURAL TRAFFIC NOISE PREDICTION – AN APPROXIMATION

by

D G Harland

Environment Division
Transport Systems Department
Transport and Road Research Laboratory
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ABSTRACT

A broad brush method of predicting the noise of traffic on a rural road network is described. An example prediction is given as an Appendix.

1. THE PREDICTION METHOD

Rural transport studies involve large areas of land, low densities of roads and homes, and low background noise. The detailed calculation of the noise effects of the transport network in this situation could be very tedious and expensive. The noise prediction described in this paper is an approximation designed to assess in broad terms the changes of noise level following changes in a transport network. It gives a fairly accurate prediction of the fractional change of land area exposed to a given noise level but is less reliable as a prediction of the absolute change. The method is developed by combining Charts 2–5 of the *Calculation of Road Traffic Noise*[1] with sound attenuation characteristics derived from a study of the noise from roads in the Lake District[2].

Charts 2–5 of *Calculation of Road Traffic Noise* predict the L_{10} level at 10m from a road[1]. The formulae are:

$$L_{10}\,(18\text{ hour}) = -40.7 + 10\log_{10} Q + 33\log_{10}(V + 40 + 500/V) + 10\log_{10}(1 + 5p/V) + 0.2G \quad \ldots \quad (1)$$

and

$$L_{10}\,(1\text{ hour}) = -27.6 + 10\log_{10} q + 33\log_{10}(V + 40 + 500/V) + 10\log_{10}(1 + 5p/V) + 0.2G \quad \ldots \quad (2)$$

where

L_{10} (18 hour) is the average L_{10} for the hours between 0600 and 2400 hrs.

Q is the total traffic flow between 0600 and 2400 hrs.

L_{10} (1 hour) is the L_{10} level for any one hour.

q is the total traffic flow in the hour considered.

V is the mean traffic speed (see below Tables 1 and 2) in km/h.

p is the percentage vehicles, other than motorcars, whose unladen weight exceeds 1525 kg.

G is the gradient of the road expressed as a percentage.

The mean traffic speed will usually be derived from estimates of mean journey time. A standard set of speeds, estimated for 1990, as given in the calculation method[1], are reproduced in Table 1. Forecasts for other years and taking account of the hilliness or bendiness of particular links in the network may be derived from TRRL data[3,4]. Duncan[3] has described and discussed the standard formulae for predicting journey speeds which are reproduced as Table 2. Forsgate and Hammond[4] indicate that the presence of recreational traffic may lead to journey speeds about 10 per cent below the standard speed.

Figure 1 shows the sound attenuation characteristics derived from the Lake District study[2]. The differences between this figure and the figure given in the Lake District study arise because the figure in the reference shows the attenuation for a single vehicle and the reference distance is 7.5m from the vehicle centre while Figure 1 shows the attenuation for a road source with the reference distance 10m from the edge of the carriageway. The attenuation characteristics can be represented by the following equations:–

$$\text{Correction (Open ground)} = -13.7 \log_{10}((d + 3.5)/13.5) \quad \ldots \quad (3)$$

$$\text{Correction (Farmland)} = -16.5 \log_{10}((d + 3.5)/13.5) \quad \ldots \quad (4)$$

$$\text{Correction (Woodland)} = -20.0 \log_{10}((d + 3.5)/13.5) \quad \ldots \quad (5)$$

where d is the distance from the near edge of the carriageway.

The ground classification was developed to describe the measurement sites in the Lake District study[2]. Open sites were those where the road was either viewed across a reflecting surface, such as a lake, or where the propagation path was well above the intervening ground. Farmland included sites on rough grazing and moorland where there were no dense plantations of trees between the measurement point and the road, while woodland included sites in forests and other dense plantations of trees.

2. NOTES ON THE APPLICATION OF THE METHOD

In an assessment of rural noise the first problem is to try to decide what constitutes a noise. Because there has been little research into the noise nuisance experienced by people visiting the countryside it is difficult to give more than very general guide lines. If the assessment is part of a 'before' and 'after' study for an existing road on which traffic conditions will change but the land use will be invariant, the areas enclosed by all high noise contours will change by the same fixed ratio, r. In this case it may be sufficient to state as a conclusion that in going from the 'before' to the 'after' state the area of land adversely affected by noise will increase by the factor r. Although r may have been derived by calculating the change in area of a particular contour the level chosen need not be stated and the question of what is a threshold level need not be discussed. Where the comparison is to be made between different links or where changes in the area of woodland are being considered the ratio of areas affected is dependent on the particular contour level considered. The ratio presentation can still be adopted but requires some supplementary information on the sensitivity of the ratios to contour level. In the example given in the appendix, the ratios for levels of 55, 60 and 65 dB(A), along a particular link in a road network are calculated and compared.

For assessments of the consumption of the resource of quiet land the ratio presentation will be inadequate. It will be necessary to specify the noise level at the quiet to unquiet boundary and to calculate the area enclosed. It may be possible to establish this boundary experimentally. Alternatively one may develop some feel for this boundary by considering reported measurements of rural noise. For example, in the Lake District survey[2] the five quietest L_{10} levels lay in the range 37.8 to 44.4 dB(A). The introduction of an L_{10} level of 45 dB(A) from a road would be clearly intrusive in these situations and so could well be considered as consuming the resource of quiet land. As an example of this sort of analysis, in the appendix, the area of land enclosed by the 45dB(A) contour has been calculated. It must be understood that this is done only as an example and is not to be taken as a recommendation that the 45 dB(A) contour invariably provides the boundary between quiet and unquiet regions.

There are certain assumptions implicit in the application of the prediction method that are not generally supported by the actuality of the road network. The calculation rests on the assumption that each link in the network is an element of an infinitely long straight road, that traffic conditions do not vary along this road, that there are no other noise sources affecting the land within the contours and that the ground type does not change with distance from the road within the range of the predicted contours. It would be possible to take account of most of the errors arising from these assumptions by making a point by point prediction of the noise contours using a more exact prediction procedure such as that given in *Calculation of Road Traffic Noise*[1]. However this would require considerable effort and even with computer assistance could be very costly for all but the smallest networks. It is fortunate that the errors in the simple prediction described in this paper can be of either sign and over a large network will tend to cancel each other out.

As outlined, the prediction procedure has taken no account of the effect geographical features may have on the predicted levels. However it is unlikely that noise from a road will penetrate beyond the tops of adjoining hills. If no allowance is made for this the area of land exposed to low levels of noise will be over-estimated. Over an extensive network this systematic error would lead to a serious underestimate of the area of quiet. One method for eliminating this error is demonstrated in the appendix.

Finally it must be stressed again that the prediction method is an approximation designed for application to a road network. As such it can assist in analysing the noise implications of rural regional transport plans when an aggregate assessment is required. The assumptions underlying the method make it quite unsuitable for calculating traffic noise at specific points, such as buildings where there may be a statutory entitlement for insulation, and for these the prediction procedure is specified in reference 1.

3. ACKNOWLEDGEMENTS

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TABLE 1

Mean traffic speeds

*Roads not subject to a speed limit of less than 60 mph**	
Special roads (rural)	108 km/h
Special roads (urban)	97 km/h
All purpose dual carriageways excluding slip roads	97 km/h
Single carriageways, more than 9 m wide	88 km/h
Single carriageways, 9 m wide or less	81 km/h
Roads subject to a speed limit of 50 mph	
Dual carriageways	80 km/h
Single carriageways	70 km/h
Roads subject to a speed limit of less than 50 mph but more than 30 mph	
Dual carriageways	60 km/h
Single carriageways	50 km/h
Roads subject to a speed limit of 30 mph or less	
All carriageways	50 km/h

* The schedule in *Calculation of Road Traffic Noise*[1] shows slip roads as a special case but they are omitted from this table because they are a detail consideration not relevant to the broad brush consideration of a network.

TABLE 2

Speed/flow formulae for rural roads, 1973 (Reproduced from LR 651)

Type of Carriageway	Free speed, V_o	Speed/flow slope, S, in observed flow range	Values for the average road: In observed flow range V (Q)	S	V (Q)	Suggested extensions: S	V_c	Qc (Capacity)
2-lane Single	$82.5^* - \frac{(P-15)}{10} - \frac{H}{7.5}\left(\frac{185+P}{200}\right) - \frac{B}{7.5}\left(\frac{215-P}{200}\right)$	$-½(V_o-62.5^*) - \left(\frac{P}{5}\right)\left(\frac{H}{7.5}\right)$	70.5* (300)	– 10	63.5* (1000)	– 10	62.5*	1100
3-lane Single	$85.5^* - \frac{(P-15)}{8} - \frac{H}{7.5}\left(\frac{185+P}{200}\right) - \frac{B}{7.5}\left(\frac{215-P}{200}\right)$	$-½(V_o-62.5^*) - \left(\frac{P}{7.5}\right)\left(\frac{H}{7.5}\right)$	77.5* (300)	– 11½	69.5* (1000)	– 11½	64.5*	1400
Dual, 2- or 3-lane	$92.5^* - \frac{(P-15)}{5} - \frac{H}{2.5}$	Zero	86.5* (300)	Zero	86.5* (1200)	– 15	77.5*	1800
Motorway 2-lane	$97.5^* - \frac{(P-15)}{5}$	Zero (up to Q = 1400)	97.5* (300)	Zero	97.5* (1400)	–	–	–
		– 24 (when Q is greater than 1400)	97.5* (1400)	– 24	78.5* (2200)	(–24)	83.5*	2000
Motorway 3-lane	$98.5^* - \frac{(P-15)}{5}$	Zero	98.5* (300)	Zero	98.5* (1400)	– 24	84.5*	2000

Definitions

- V = average journey speed, all vehicles (km/h)
- Q = total flow, all vehicles, per standard lane of 3.65 m width (vehicle/h)
- V_o = free speed: value of V when Q = 300 (km/h)
- S = speed/flow slope: change in speed when Q increases by 1000 vehicles/h (km/h)
  Basic speed/flow relation: $V = V_o + S\frac{(Q-300)}{1000}$
- Q_c = suggested typical absolute capacity per standard lane (vehicle/h)
- V_c = value of V when $Q = Q_c$ (km/h)
- P = percentage of heavy vehicles (those with more than 4 tyres). The average value for rural main roads is P = 15 per cent.
- H = hilliness: total rise-and-fall per unit distance (m/km). Values of 0, 15, and 30, may be used for roads judged to be flat, average, and hilly, respectively, if no measurements are available.
- B = bendiness: total change of direction per unit distance (degree/km). Values of 0, 75 and 150, (on 2-lane single carriageways), and 0, 45 and 90, (on 3-lane single carriageways), may be used for roads judged to be straight, average, and bendy, respectively, if no measurements are available.

All values marked* must be adjusted to allow for the tendency for speeds to increase over the years
(LR 651 suggests that up to 1973 the trend has been for speeds to increase at 1½ km/h per year)

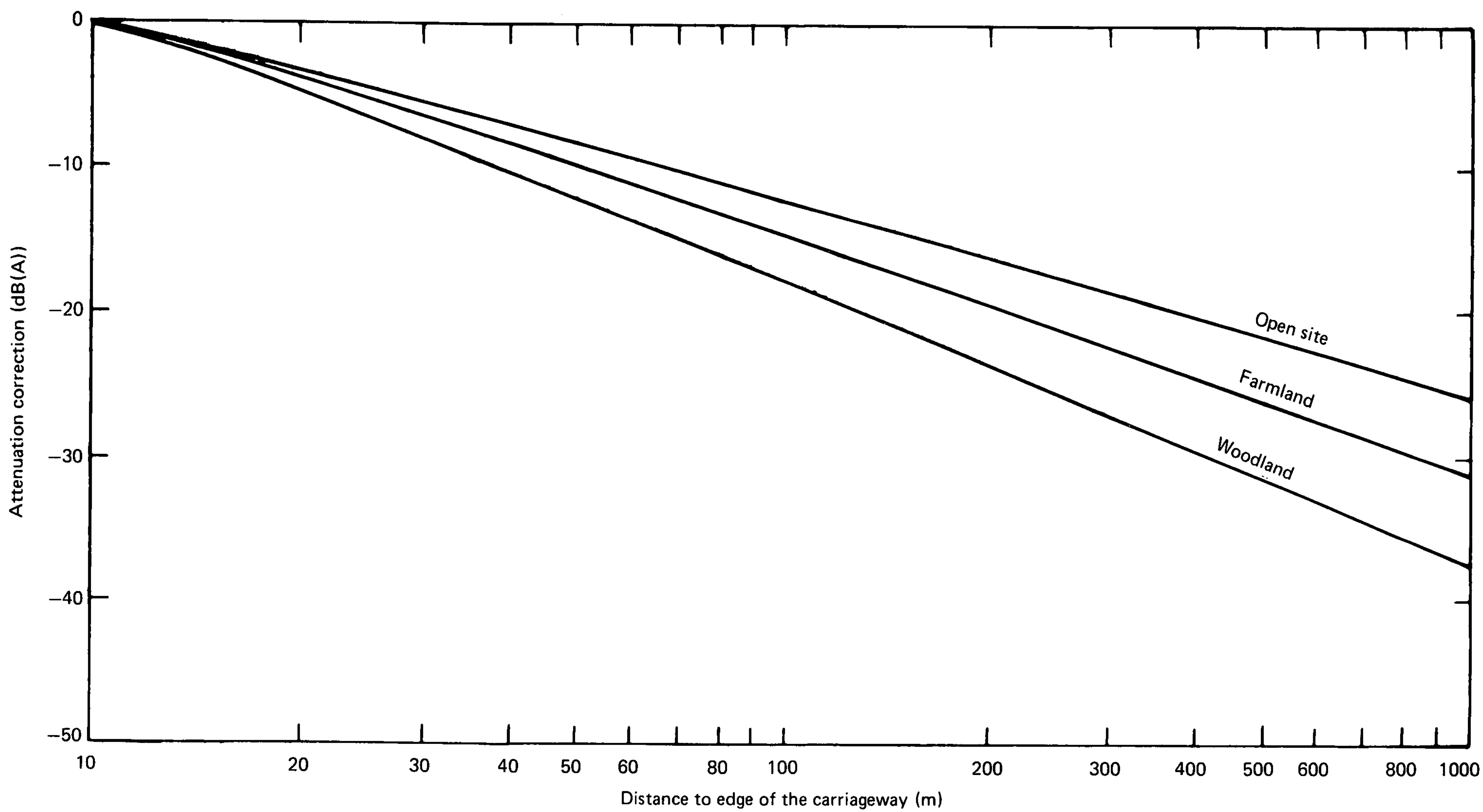

Fig. 1 ATTENUATION CORRECTIONS FOR L_{10}

5. APPENDIX

An example calculation

As an example of the prediction method an assessment of the noise around one particular link in the trunk road network is given in this Appendix. The link considered in the example is the A6013, shown in the sketch map on Figure 2. The A6013 runs from the A625 near Bamford Station (Grid Reference SK208825) to a junction with the A57 (Grid Reference SK202864) near the East end of the Ladybower Reservoir. From Bamford Station to Bamford the road travels across the valley of the River Noe. North of Bamford the road passes along the east side of the valley between Win Hill and Bamford Moor, and climbs about 77m in a length of 4400m to give an average gradient of 1.8 per cent. Classified counts of traffic suggest that in 1974 the average peak hour flow was 500 vehicles with 20 per cent of heavy vehicles. The predicted journey speed[3], assuming average bendiness and hilliness and ignoring any recreational traffic effect, is 67.8 km/h. Equation 2 gives a reference L_{10} level of 71.7 dB(A) for these traffic conditions. Table 3 shows the range from this road of four L_{10} contours, 45, 55, 60 and 65 dB(A). As an example of a 'before' and 'after' situation the contour ranges have also been calculated for a hypothetical increase of traffic and speed that might give a reference level of 79.6 dB(A), an increase of almost 8 dB(A).

Table 4 lists the ground types along each side of the A6013, which were derived from the 1/50 000 Ordnance Survey map. North of Bamford the road is on the lower slopes of the rise to Bamford Edge and consequently is in open view from the slopes of Win Hill. This is shown in the sketch cross-section on Figure 3. As a consequence on the West side of the road all the ground North of Bamford has been classed as open site. On the East side apart from the 210m of viaduct across the Ladybower Reservoir, the ground contours do not suggest the use of the open-site classification. On both sides the lengths not included in the assessment are lengths where the road passes through built up areas.

The simplest assessment procedure at this stage is to multiply the appropriate contour ranges (Table 3) by the ground type extents (Table 4) to obtain an estimate of the areas enclosed by the various contours. These estimates are shown in Table 5. The ratio row in Table 5 shows that increasing the traffic flow and speeds on the A6013 to the hypothetical levels increases the areas enclosed by all the noise contours considered by about 3½ times. Thus it could be reported that an increase in traffic, such as that hypothesised, would lead to an increase of 3½ times in the area adversely affected by traffic noise. This statement carefully avoids specifying where the limit of adverse noise actually lies. However if it is desired to report the consumption of a resource, such as land not previously exposed to more than a particular level of L_{10}, then the change must be reported as the difference between the base conditions and the future. These differences are shown as the fourth row of Table 5 and clearly their magnitude is a function of the L_{10} level considered.

It is unlikely that noise from the A6013 will penetrate beyond the top of Win Hill, 1480m to the West, or beyond Bamford Edge, from 440 to 860m to the East. Examination of Tables 3 and 4 suggest that these features will limit the spread of the 45 dB(A) contour if traffic ever does rise to the conditions of the hypothetical future. Table 6 shows the calculated corrections to the area of the 45 dB(A) contour and the corrected areas and ratios are shown in parentheses in Table 5 below the uncorrected values. It can be seen that there is a wide divergence between the uncorrected and corrected areas. Over an extensive network failure to make this correction would lead to a serious underestimate of the area of quiet.

TABLE 3

Calculated noise contour ranges

Traffic conditions and reference level of L_{10}	L_{10} dB(A)	Contour range over		
		Open sites (m)	Farmland (m)	Woodland (m)
1974 Peak				
500 vph	65	38	31	26
20% heavy	60	93	66	48
67.8 km/h	55	220	135	89
Ref L_{10} = 71.7 dB(A)	45	1197	557	288
Hypothetical future				
2000 vph	65	154	100	69
25% heavy	60	360	205	125
85 km/h	55	840	415	226
Ref L_{10} = 79.6 dB(A)	45	4524	1684	721

TABLE 4

Ground classification for A6013

Ground type	Extent of ground type along		
	West side (m)	East side (m)	Both sides (m)
Open site	2580	210	2790
Farmland	880	2190	3070
Woodland	0	1270	1270
Not included in rural assessment (Built etc)	940	730	1670
Totals	4400	4400	8800

TABLE 5

Areas enclosed by contours of L_{10}

Road and traffic	Area enclosed by contour			
	65 dB(A) $m^2 \times 10^6$	60 dB(A) $m^2 \times 10^6$	55 dB(A) $m^2 \times 10^6$	45 dB(A) $m^2 \times 10^6$
A6013 – 1974 Peak	0.234	0.523	1.14	5.42
A6013 – Hypothetical future	0.824	1.79	3.90	18.7 (9.5)*
Ratio A6013 $\frac{\text{Hypothetical}}{\text{1974 Peak}}$	3.5	3.4	3.4	3.5 (1.8)*
Difference A6013 Hypothetical – 1974 Peak	0.590	1.27	2.76	13.3 (4.1)*

* Area of contours adjusted to exclude ground beyond Win Hill and Bamford Edge.

TABLE 6

Corrections to hypothetical future area enclosed by the 45 dB(A) contour

Ground type	Length of road m	Range of 45 dB(A) contour m	Range of Geog. feature m	Correction to contour area $m^2 \times 10^6$
West side of A6013 (Win Hill)				
Open site	2580	4524	1480	– 7.85
East side of A6013 (Bamford Edge)				
Farmland	1250	1684	710	– 1.22
Woodland	710	721	500	– 0.157
Total Correction				– 9.23

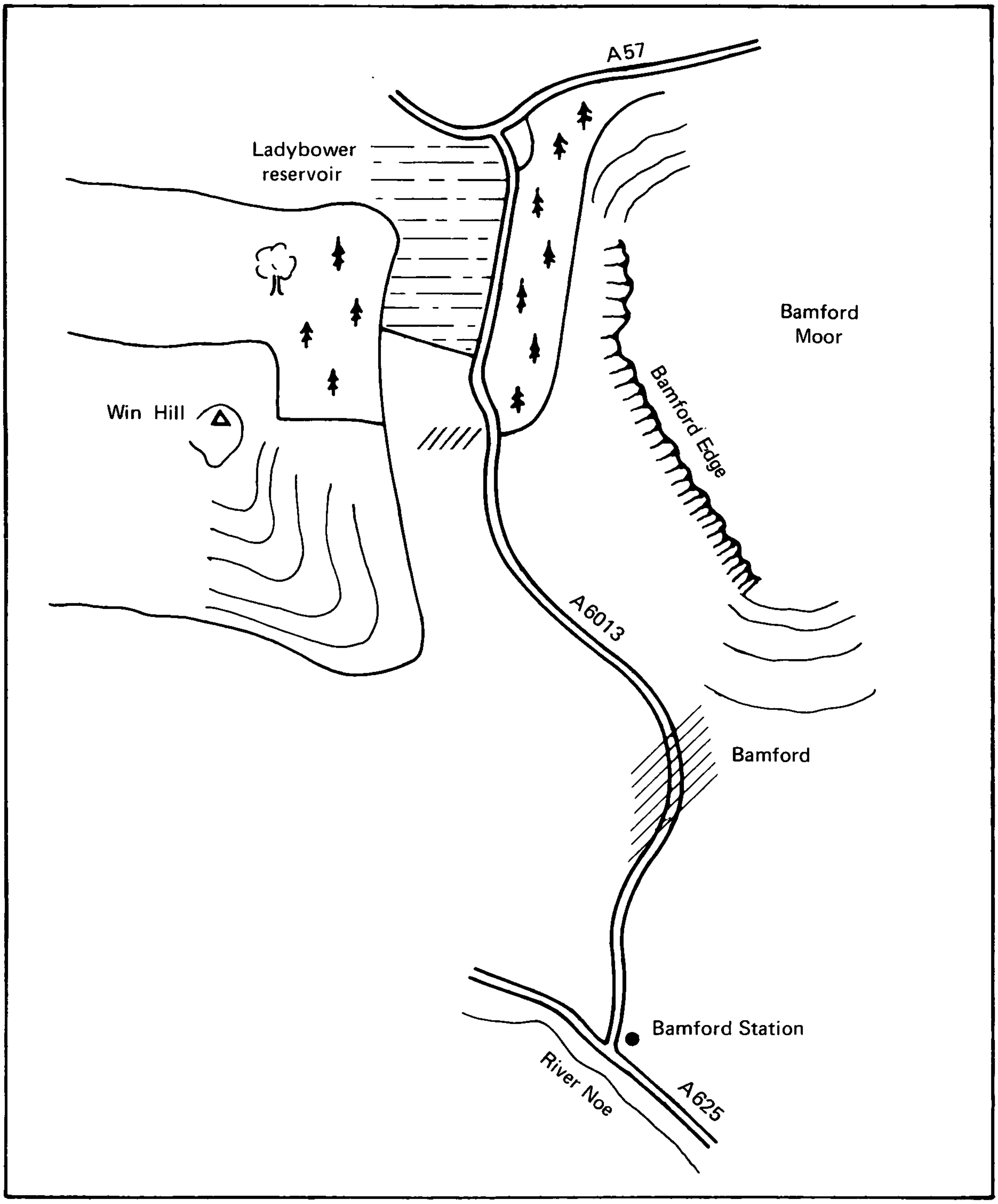

Fig. 2 SKETCH PLAN OF THE A6013 LINK

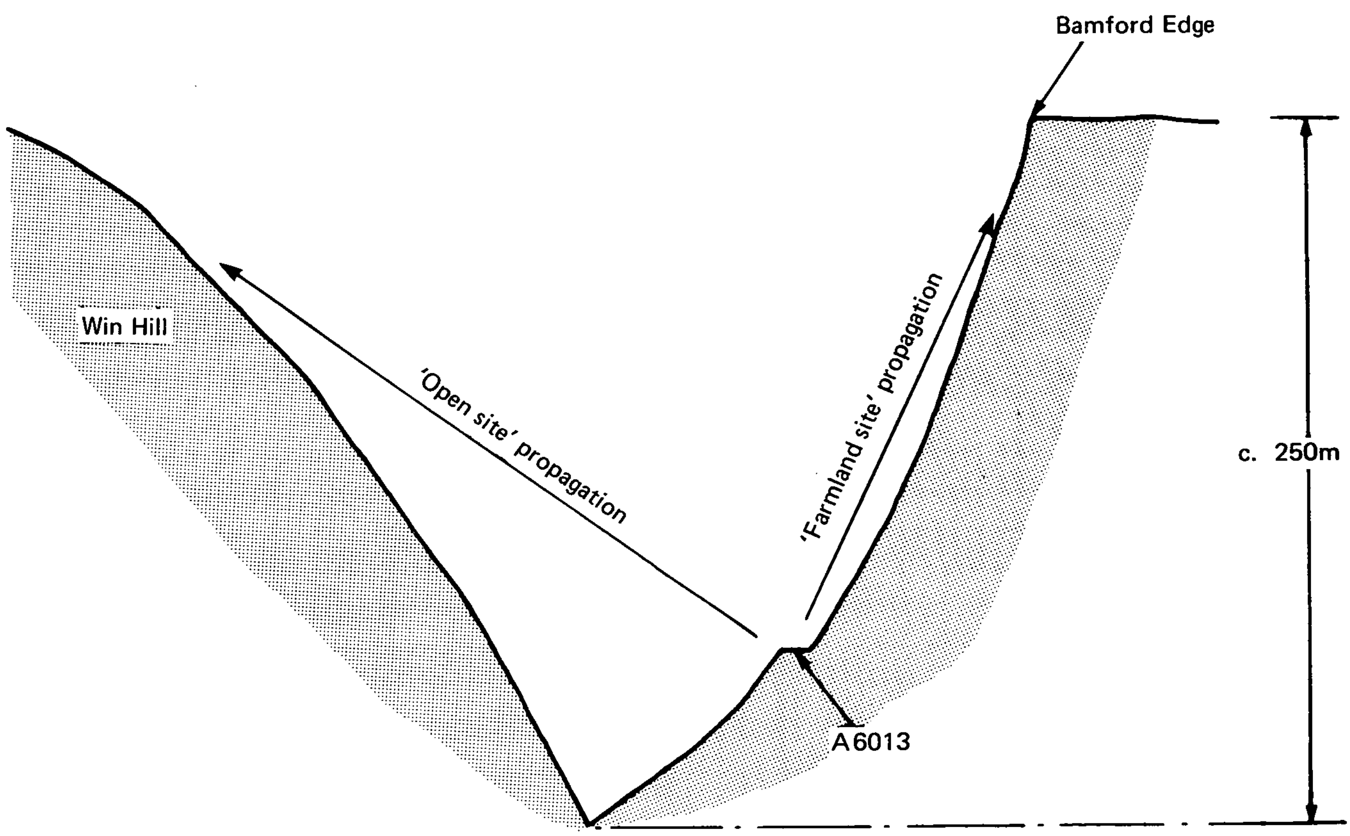

Fig. 3 SKETCH CROSS–SECTION OF THE VALLEY NORTH OF BAMFORD

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