Calculation of Road Traffic Noise (CoRTN)

Reference: Calculation of Road Traffic Noise, Department of Transport, Welsh Office, United Kingdom, 1988. ISBN 0 11 550847 3)

This method provides a standard calculation routine for calculating Road Traffic Noise (RTN). An outline of the procedure for making these calculations is shown in Chart 1. The **basic** procedure is summarized below. These notes are based on a summary made by Dr. N. Morris. For full details, refer to the CoRTN memorandum detailed above.

Note that calculations are based on an 18 hour period between times 0600 and 2400.

- **First, Divide the road into representative segments (i.e. segments with constant traffic flow, speed, gradient, etc...)**

Method - simple case. (See also the summary later.)

1. Count traffic.
2. Calculate L_{A10} (18 h) from traffic count data:
   $L_{A10}\,(18\text{ h}) = 29.1 + 10\log_{10}Q$ dB(A),
   where Q is the total traffic count for the road during the 18-hour period.
   This level is the predicted noise level 10m from the edge of the carriageway with all traffic travelling at 75 km/hr.
3. Add/deduct a correction for speed and percentage of heavy vehicles:
   Correction = $33\log_{10}(V + 40 + 500/V) + 10\log_{10}(1 + 5p/V) - 68.8$ dB(A),
   where V is the mean traffic speed in km/h and p is the percentage of heavy vehicles.
4. Add/deduct a correction for the gradient of the road :
   Correction = $0.3G$ dB(A),
   where G is the gradient of the road (in percent).
5. Add/deduct a correction for the road surface:
   (see CoRTN memorandum for full details.)
   For a mean traffic speed less than 75 km/h and impervious bituminous and concrete road surfaces, subtract 1 dB(A).
6. Deduct a distance correction:
   Correction = $-10\log_{10}(d'/13.5)$ dB(A),
   where d' is the shortest slant distance from the effective source position (3.5 m onto the road from kerb and 0.5 m above the ground). It can be calculated using
   $d' = [(d + 3.5)^2 + h^2]^{1/2}$,
   where d is the distance from the nearside carriageway and h is the height in metres of the reception point relative to the effective source height.
7. Deduct a screening correction (see chart 9).
8. Add a reflection correction for facades facing the reception point on the far side of the road (see Fig. 5).
9. Deduct an angle of view correction:
   Correction = $10\log_{10}(\theta/180)$ dB(A),
   where θ is the angle of view in degrees.
10. All of the above steps gives the contribution for a representative road segment.

- **Second, combine contributions from each segment and ADD.**

Notes:

(a) Barriers and mounds in road noise mitigation designs are usually done so for future traffic levels (10-15 yrs).
(b) Design includes corrections for topography, reflection from dwellings, and reflections from barriers (this last point is not covered in lectures).
(c) Design is complex, iterative and often political. (In other words, road traffic noise control is more than just setting barrier heights. It can involve community consultation and many unforseen arguments on the parts of road builders and residents.

Validation of CoRTN

It is always very good practice to validate any mathematical model you use when carrying out acoustical investigation. There may be $millions at stake if you get your model wrong. Measurements are the only really fail-safe way of validating or calibrating your model. (This applies for all models, not just CoRTN.)

1. Set up Sound Level Meter (SLM). (see Figure 1)

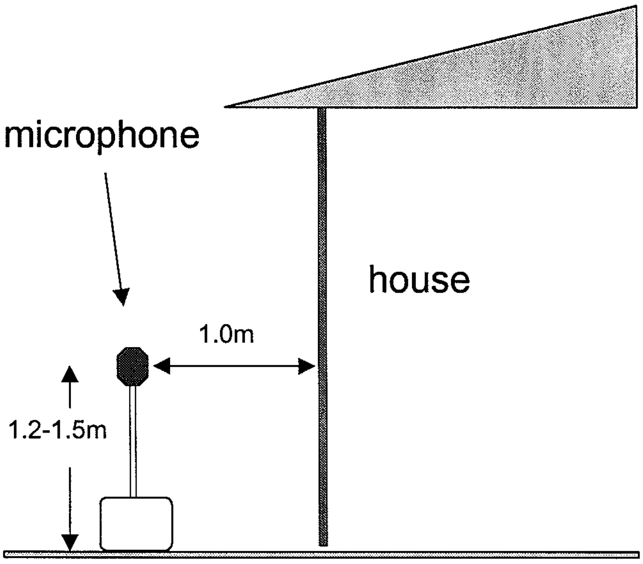


Figure 1 Microphone location for measurements near a house.

2. Measure traffic noise (0600-2400hrs) 6am to midnight, with $\Delta T = 1$ hr. (This is set on the SLM for the period over which the statistical measurement is taken.) Calculate the L_{A10} (18 hr) from these data.

3. Compare this measured data with the CoRTN prediction using the current traffic levels. Note: that in CoRTN, measurements taken 1m from the facade of a dwelling include a +2.5 dB(A) correction for facade reflection. (See annexe 8, stage 4.)

4. If the comparison between predicted and actual measurements is reasonable (within +/- 1 to 2 dB), then go on to use the model to do future barrier design. If the predicted levels are significantly different from the measured values, you **MUST CHECK** to see if your assumptions of traffic volumes, types, speed, road surface, etc. are correct and adjust if not the case.

5. Once you are confident the model can do the job it is meant to, go on to design barriers.

Summary of CoRTN Equations

Reference Level = basic noise level
+ speed correction
+ heavy vehicle adjustments
+ correction for gradients

Basic Noise Levels

L_{A10} (1h) - predicted for speed of 75 km/h

$$L_{A10}\,(1\text{ h}) = 42.2 + 10\log_{10}(q) \quad \text{dB(A)},$$

where q = number of vehicles per hour, assuming all cars, no trucks

L_{A10} (18h) - predicted for speed of 75 km/h

L_{A10} (18 h) = 29.1 + 10 $\log_{10}Q$ dB(A),

where Q = number of vehicles between 0600 and 2400 hours, assuming all cars, no trucks.

Note: Road departments usually give traffic figures in vehicles/day, ie in a 24hr period. An approximation for Q is

$Q = 0.95 \times$ vehicles/day.

Corrections

Speed/ Heavy Vehicle Correction

Correction = 33 $\log_{10}(V + 40 + 500/V)$ + 10 $\log_{10}(1 + 5p/V)$ - 68.8 dBA,

where V is velocity in km/hr, p is % heavy vehicles.

Gradient Correction

Correction = $0.3G$ dB(A),

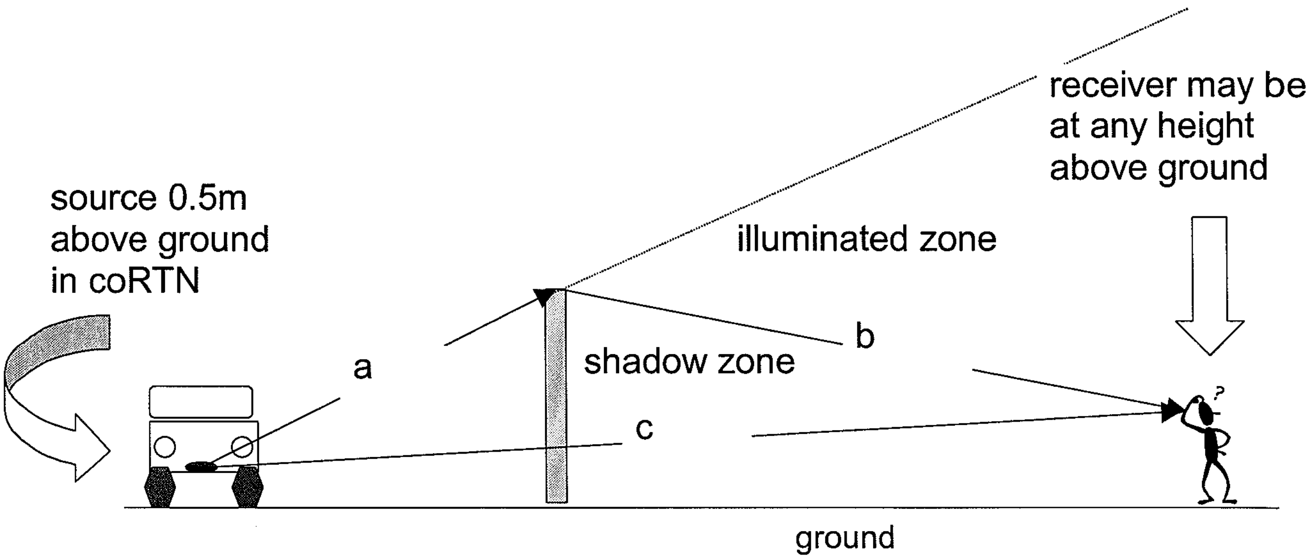
where G is the gradient of the road in percent.

Screening

Correction (seventh order Polynomial) = $A_0 + (A_1 X) + (A_2 X^2) + \ldots + (A_7 X^7)$

where $X = \log_{10}(\delta)$. The polynomial coefficients are given in Chart 9a. δ is the extra path length the sound has to travel above that of line of sight distance due to the existence of the barrier,

$\delta = a + b - c$.



Distance Correction

If d' is the straight-line distance from the source traffic line to the receiver point, then

$$\text{Correction} = -10 \log (d'/13.5) \quad \text{dB(A)}$$

$$d' = [(d + 3.5)^2 + h^2]^{1/2},$$

where d is the distance from the nearside carriageway and h is the height in metres of the reception point relative to the effective source height. The line source is assumed to be 3.5 m onto the road from the kerb and at a height of 0.5 m.

Note: The number 13.5 is a combination of the reference receiver distance of 10m to the edge of the carriageway (or road shoulder) plus an assumed distance of 3.5m from the edge of the road to the source line. ie the source traffic is always assumed to populate the line a distance 3.5m from the edge of the road. Therefore the reference noise level, which assumes a measurement point 10m from the road edge, in fact refers to a measurement point 13.5 from the noise source line.

Reflections

Where there are houses, other substantial buildings or a noise fence or wall on the far side of the road, a correction for reflections from the opposite façade can be applied. Refer to Fig. 5 for the correction:

$$\text{Correction} = 1.5(\theta'/\theta) \quad \text{dB(A)}$$

where $\theta' = \Sigma(\theta_i)$ is the sum of the angles subtended by all the reflecting facades and θ is the total angle subtended by the source line (road) at the reception point (Fig. 5).

Angle of View

$$\text{Correction} = 10 \log_{10}(\theta/180) \quad \text{dB(A)}$$

where θ is the angle of view of the road in degrees.

Computer Simulations

For large jobs, you can used proprietary software to calculate the CoRTN solution. You may need input such as the following:

- ground contours (typically in 3D DXF format)
- traffic numbers, road surface types, etc.
- dwelling positions, heights, number of stories, either from aerial photos or DXF data.
- a design criteria. E.g. L_{A10} (18hr) is not allowed to exceed 68 dB(A).

Your output may include optimal barrier design, noise contours, or individual noise levels at dwellings along the route.

CHART 1 FLOW CHART FOR PREDICTING NOISE FROM ROAD SCHEMES

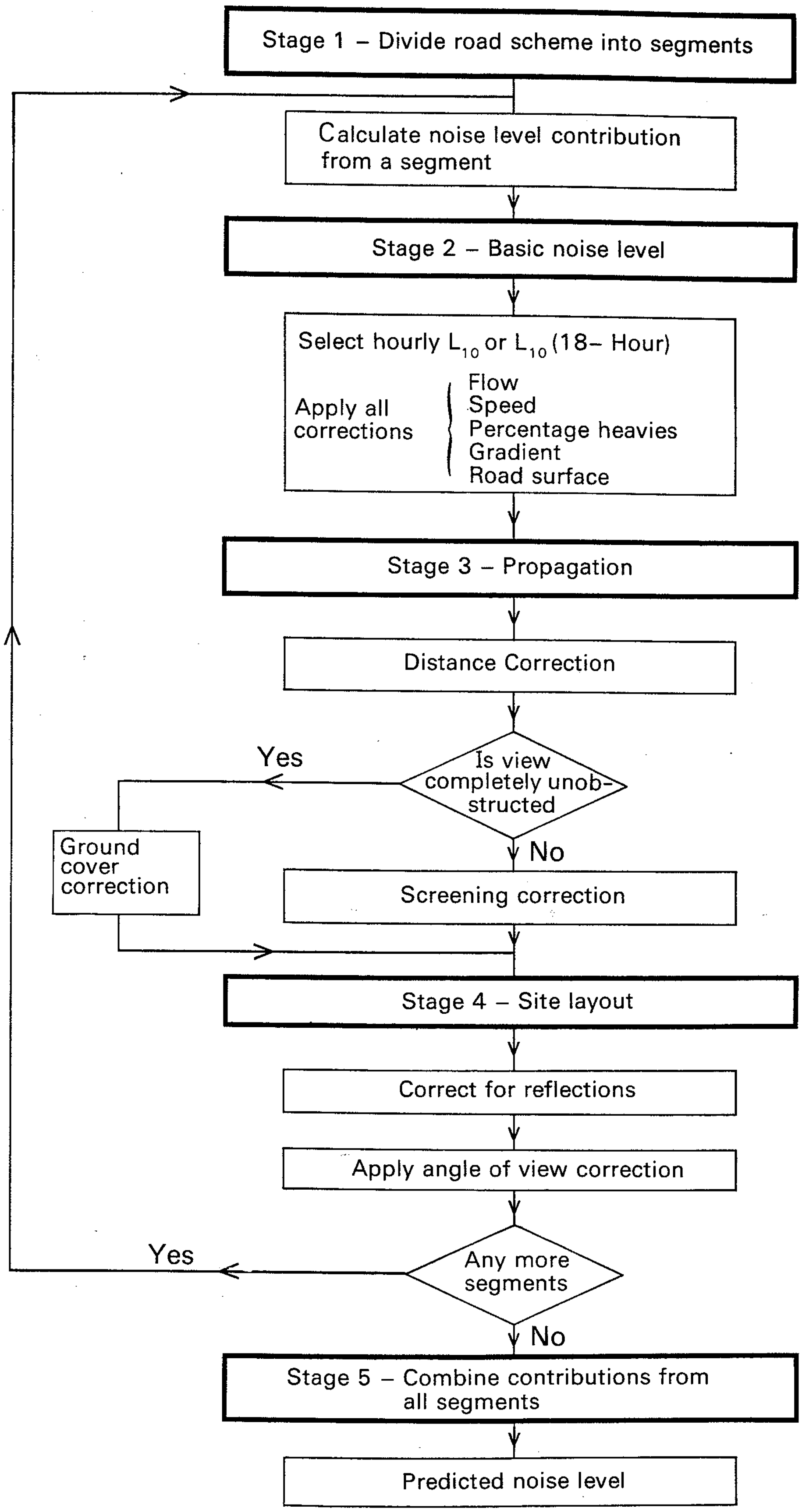
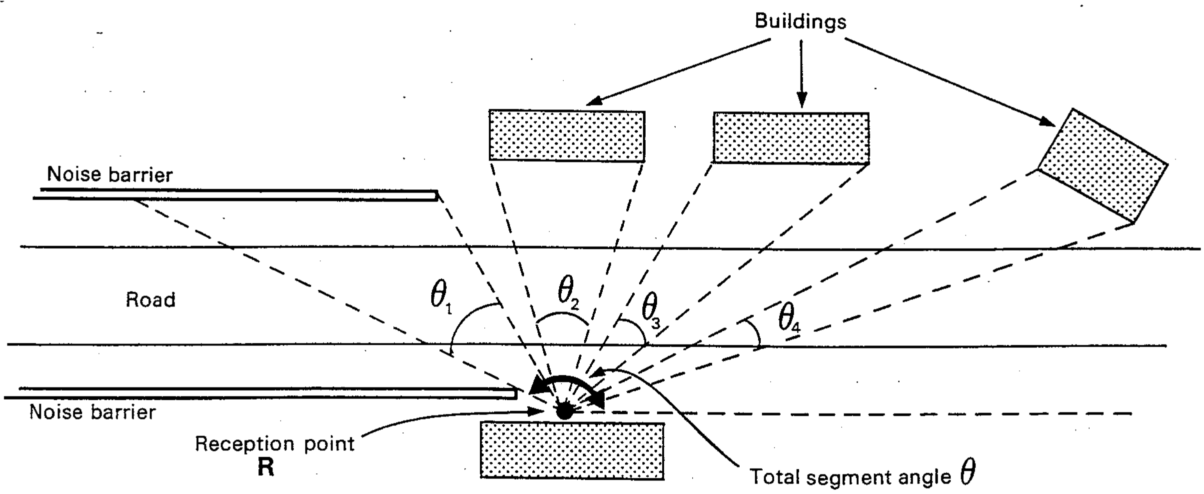


Figure 5. CALCULATING THE REFLECTION CORRECTION FOR FACADES FACING THE RECEPTION POINT ON THE FAR-SIDE OF THE TRAFFIC STREAM

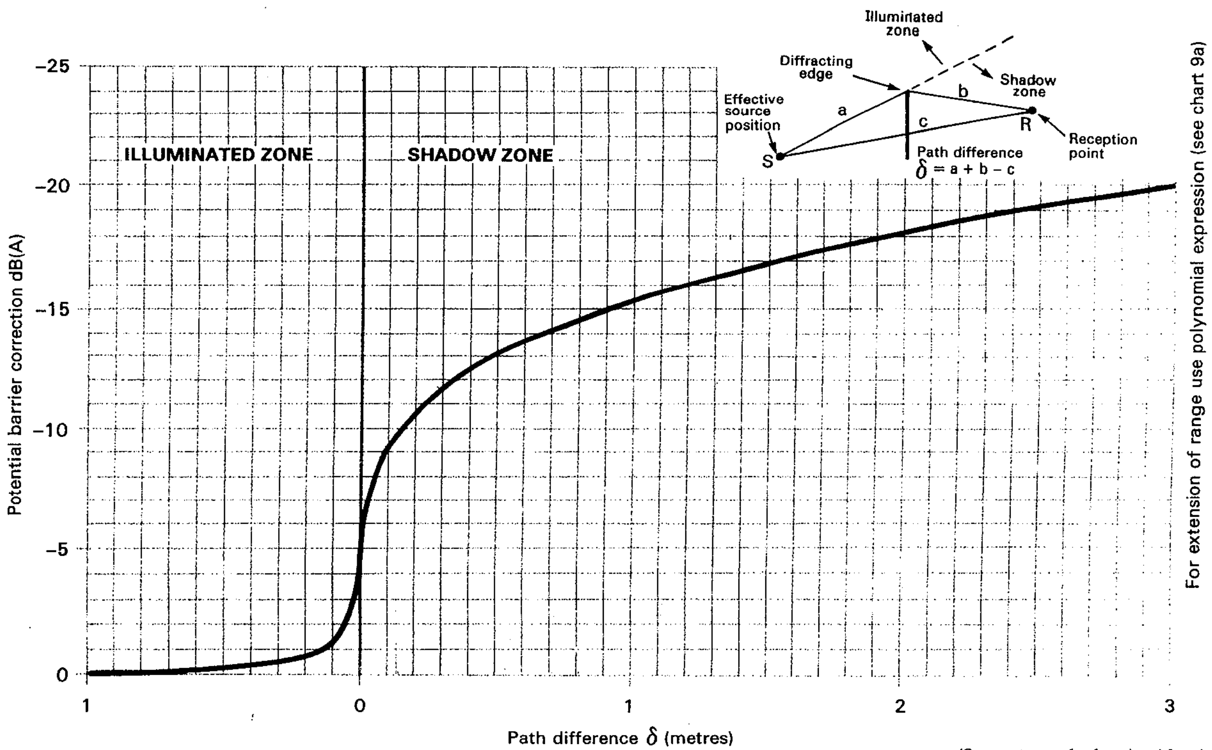


$$\text{REFLECTION CORRECTION} = +\,1.5\left(\frac{\theta'}{\theta}\right)\ \text{dB(A)}$$

where $\theta' = \theta_1 + \theta_2 + \theta_3 + \theta_4$

and θ = TOTAL SEGMENT ANGLE

Chart 9 POTENTIAL BARRIER CORRECTION AS A FUNCTION OF PATH DIFFERENCE δ



(See next page for functional form)

Chart 9a

Polynomial expressions for potential barrier correction

Potential barrier correction $A = A_0 + A_1x + A_2x^2 + \ldots + A_nx^n$ where $x = \text{Log}_{10}\,\delta$ (δ being the path difference in metres between the direct and diffracted rays), the coefficients A_n being given in the table below.

	Shadow zone	*Illuminated zone*
A_0	−15.4	0
A_1	−8.26	+0.109
A_2	−2.787	−0.815
A_3	−0.831	+0.479
A_4	−0.198	+0.3284
A_5	+0.1539	+0.04385
A_6	+0.12248	
A_7	+0.02175	
Range of validity	$-3 \leq x \leq +1.2$	$-4 \leq x \leq 0$

Outside the above ranges of validity the potential barrier correction is defined as follows:

Shadow zone	*Illuminated zone*
For $x < -3$ $A = -5.0$	For $x < -4$ $A = -5.0$
For $x > 1.2$ $A = -30$	For $x > 0$ $A = 0$

Chart 9b Potential barrier correction A* dB(A) for path differences (δ = i + j) calculated to the nearest 0.01 metres.**

i \ j	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
	SHADOW ZONE									
0.0	5.0	6.4	7.1	7.6	7.9	8.2	8.5	8.7	9.0	9.2
0.1	9.3	9.5	9.7	9.8	10.0	10.1	10.3	10.4	10.5	10.6
0.2	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7
0.3	11.7	11.8	11.9	12.0	12.1	12.1	12.2	12.3	12.4	12.4
0.4	12.5	12.6	12.6	12.7	12.8	12.8	12.9	13.0	13.0	13.1
0.5	13.1	13.2	13.3	13.3	13.4	13.4	13.5	13.5	13.6	13.6
0.6	13.7	13.7	13.8	13.8	13.9	13.9	14.0	14.0	14.1	14.1
0.7	14.2	14.2	14.3	14.3	14.4	14.4	14.5	14.5	14.5	14.6
0.8	14.6	14.7	14.7	14.7	14.8	14.8	14.9	14.9	14.9	15.0
0.9	15.0	15.1	15.1	15.1	15.2	15.2	15.3	15.3	15.3	15.4
1.0	15.4	15.4	15.5	15.5	15.5	15.6	15.6	15.6	15.7	15.7
1.1	15.7	15.8	15.8	15.8	15.9	15.9	15.9	16.0	16.0	16.0
1.2	16.1	16.1	16.1	16.2	16.2	16.2	16.3	16.3	16.3	16.3
1.3	16.4	16.4	16.4	16.5	16.5	16.5	16.6	16.6	16.6	16.6
1.4	16.7	16.7	16.7	16.8	16.8	16.8	16.8	16.9	16.9	16.9
1.5	16.9	17.0	17.0	17.0	17.1	17.1	17.1	17.1	17.2	17.2
1.6	17.2	17.2	17.3	17.3	17.3	17.3	17.4	17.4	17.4	17.4
1.7	17.5	17.5	17.5	17.5	17.6	17.6	17.6	17.6	17.7	17.7
1.8	17.7	17.7	17.8	17.8	17.8	17.8	17.8	17.9	17.9	17.9
1.9	17.9	18.0	18.0	18.0	18.0	18.1	18.1	18.1	18.1	18.1
2.0	18.2	18.2	18.2	18.2	18.3	18.3	18.3	18.3	18.3	18.4
	ILLUMINATED ZONE									
0.0	5.0	3.5	2.8	2.3	2.0	1.8	1.6	1.5	1.3	1.2
0.1	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6
0.2	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0

* Values of A are negative

** e.g. where the reception point is in the shadow zone and δ = 1.45 metres:
then i = 1.4 and j = 0.05
from the table the value of A is − 16.8 dB(A).