Wind Farms

Noise Impact Assessment for Environmental Statements

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Wind Turbines & Noise

- Sources of Noise
  - Aerodynamic, mechanical
- Location
  - Elevated, usually rural, usually ‘quiet’
- Variation of Noise with Wind Speed
  - Rotor speeds – fixed, twin and variable
- Acoustic Features
  - Spectral, temporal

General Noise Assessment

- Compare predicted noise levels with:
  - Pre-existing level of specific noise (not valid for new development).
  - Absolute limit (used for noise from transport, construction, minerals).
  - Pre-existing background (used for noise from industrial sources).
- Noise from wind turbine sites
  - Guidance for industrial sources suggests comparison with ‘background’.
  - Lack of guidance for low noise environments (eg. Scope of BS4142)
  - Specific requirements for wind farms led to hybrid proposal (ETSU-R-97).
  - Takes into account variation in source noise and background with wind.
  - Relates to ‘worst case’ wind direction.

ETSU-R-97 Noise Limits

- X dB L_{A90} or 5 dB above 'prevailing' background, whichever is the greater.
  - X varies with time of day and other factors
    - Day-time: X=35-40
    - Night-time: X=43
    - Financially Involved: X=45
  - B/G quantified as a function of wind speed
  - B/G averaged over relevant period
    - night 2300-0700
    - 'sensitive' day-time hours (1800-2300, Sat pm and all day Sun)
- Simplified Limit 35 dB L_{A90} for V_{10} < 10m/s

Status of ETSU-R-97

- PAN45 → ETSU-R-97
- TAN8 → ETSU-R-97
- PPS22 → ETSU-R-97
- PPS22 Companion Guide → ETSU-R-97

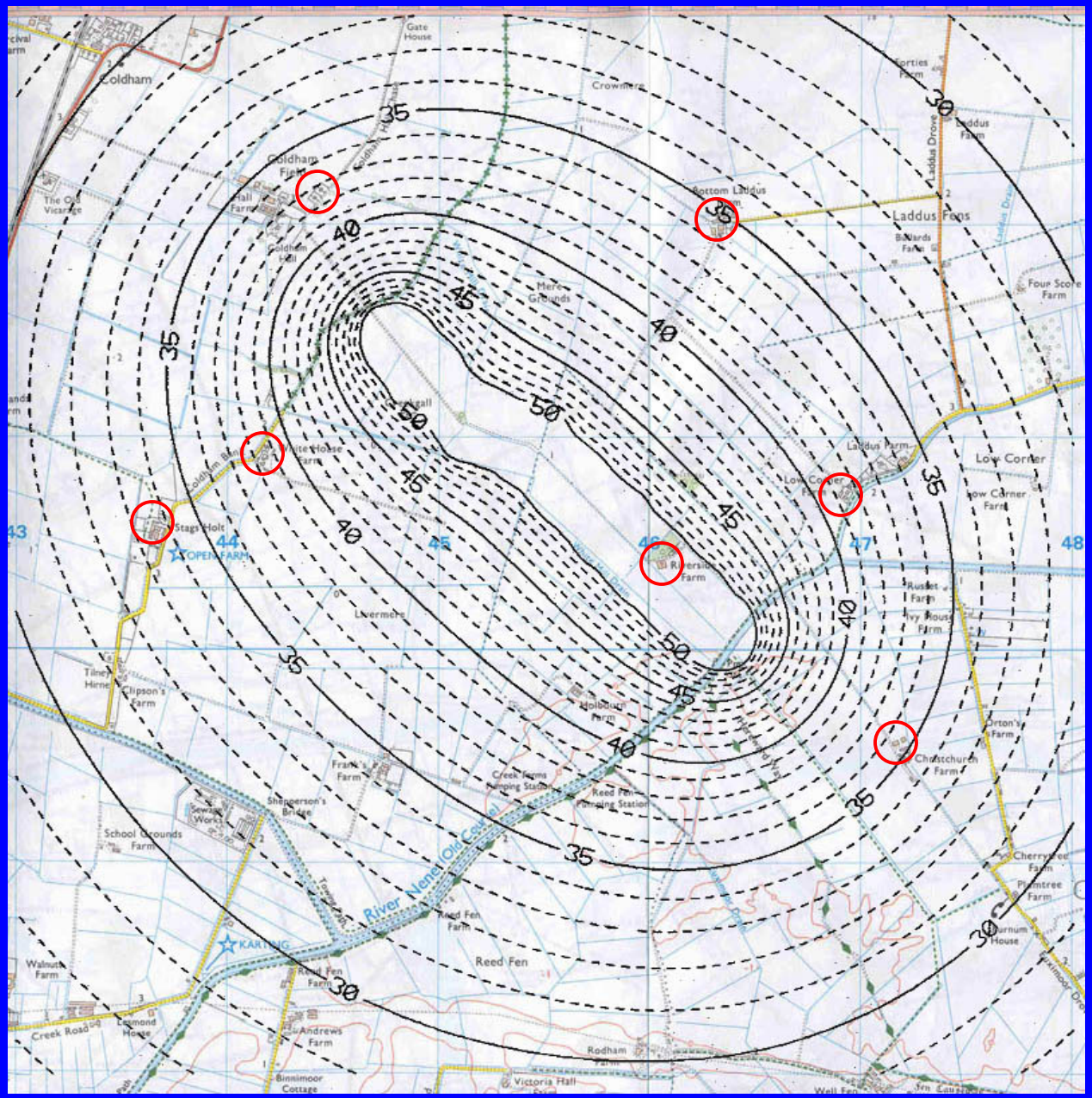
> *"The 1997 report by ETSU for the Department of Trade and Industry should be used to assess and rate noise from wind energy development."*

Planning guidance un-likely to suggest levels leading to un-acceptable impact.

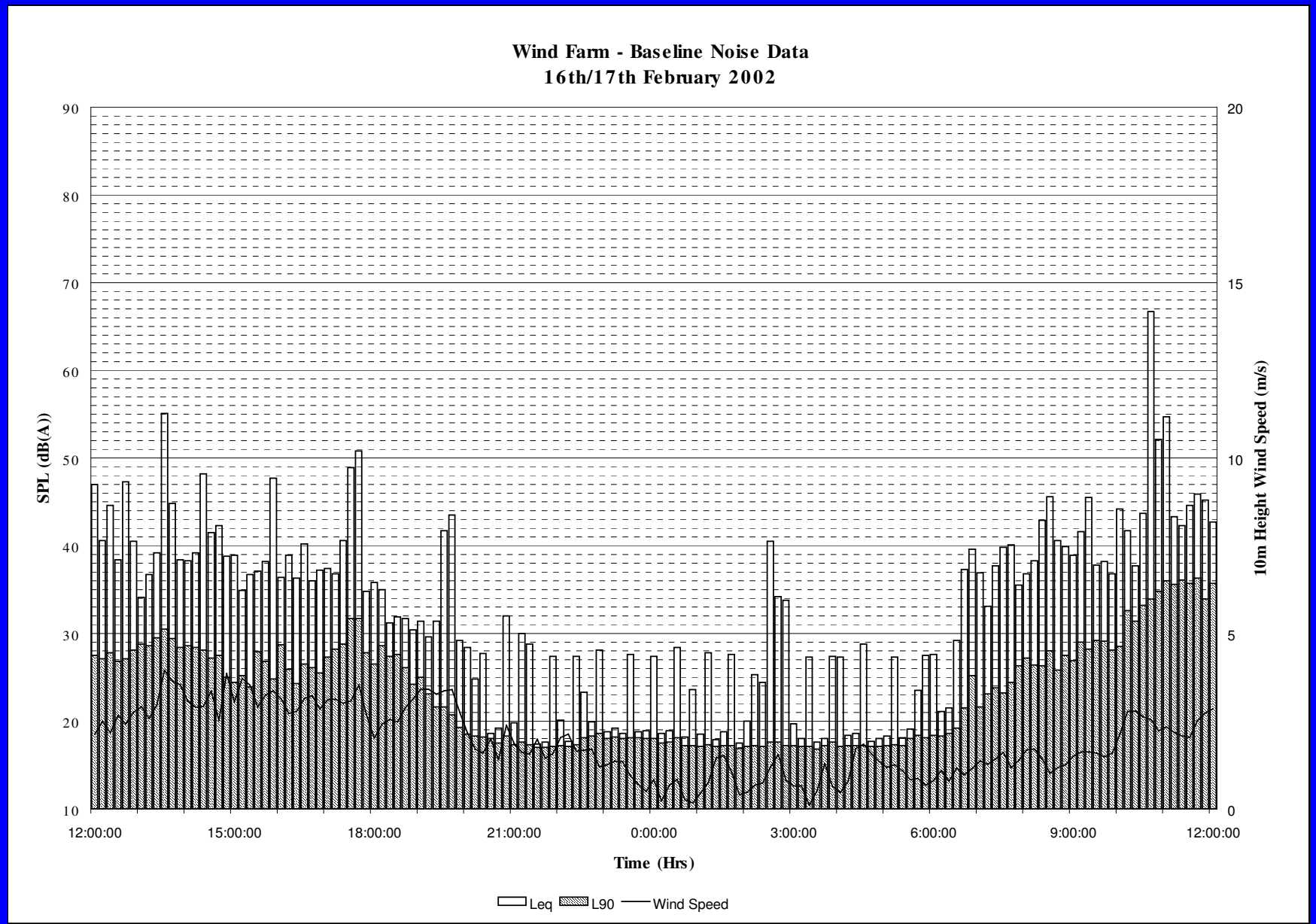
Establish Prevailing Background

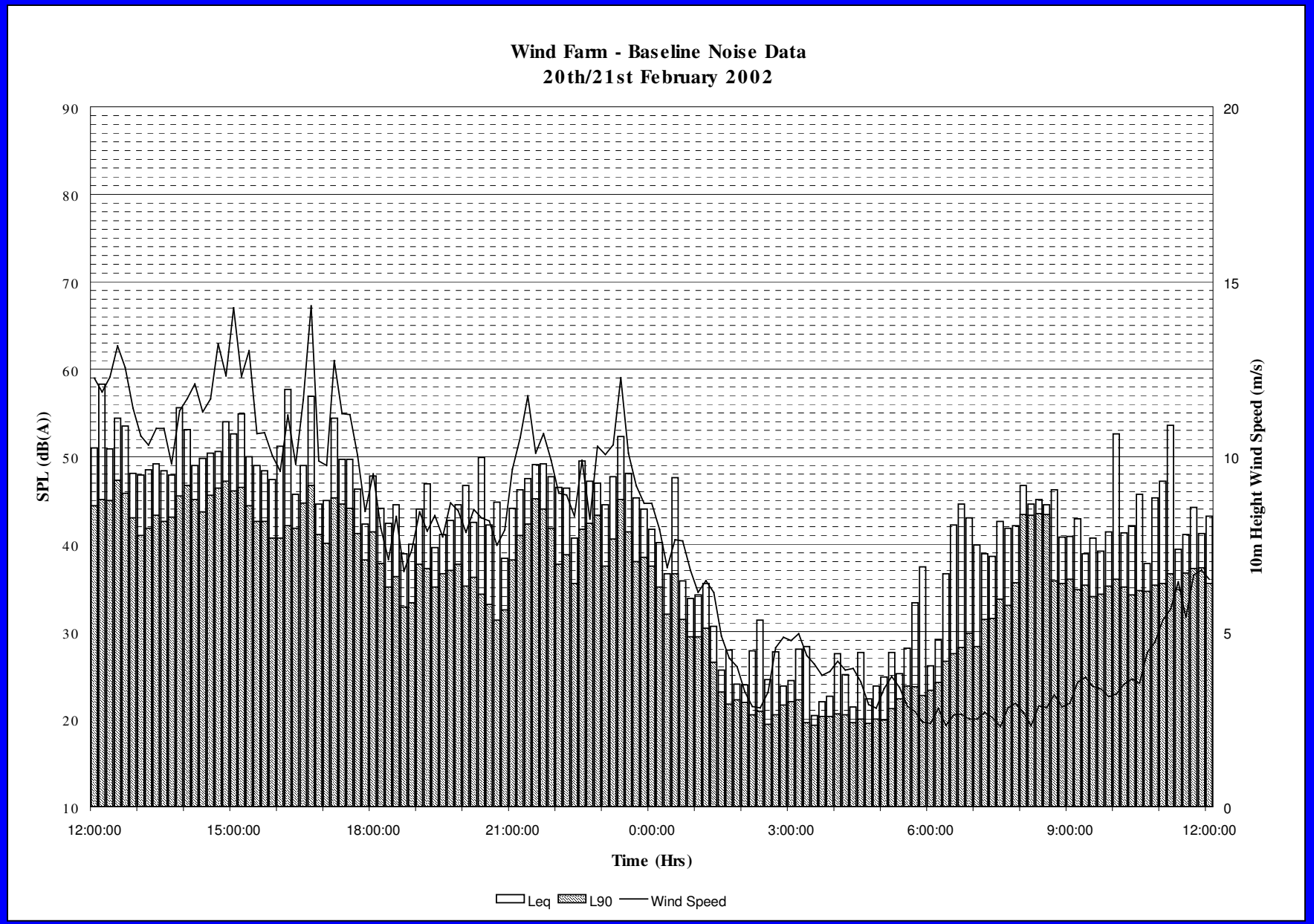
- Successive 10 min. L_{A90} noise levels
- Successive 10 min. *synchronised* w/s & w/dir
- Leave for two weeks
- Plot variation of noise & wind with time

Measurement Locations



Siting

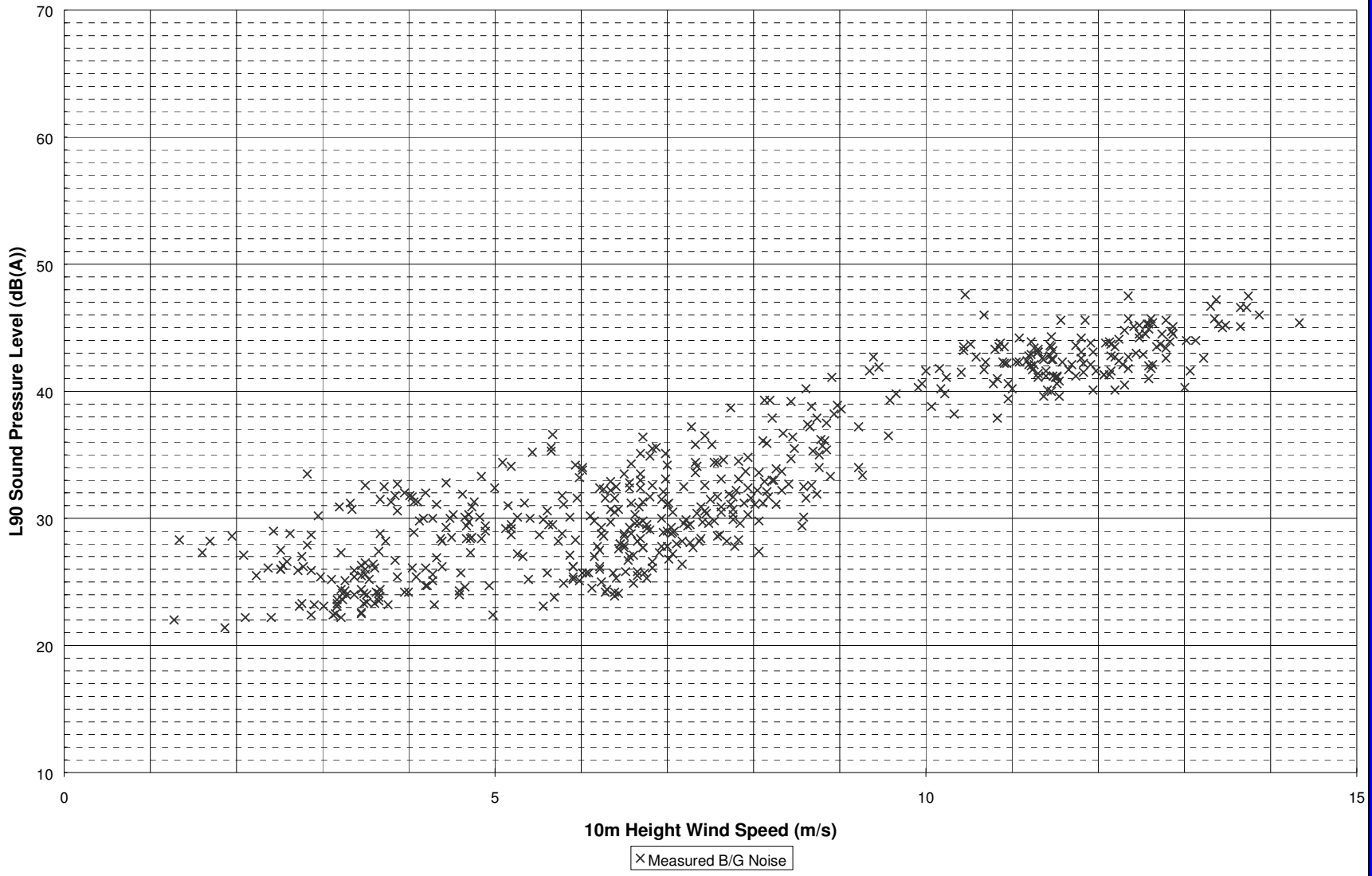

Wind Farm - Baseline Noise Data
16th/17th February 2002
SPL (dB(A))
10m Height Wind Speed (m/s)
Time (Hrs)
90
80
70
60
50
40
30
20
10
20
15
10
5
0
12:00:00
15:00:00
18:00:00
21:00:00
0:00:00
3:00:00
6:00:00
9:00:00
12:00:00
Leq
L90
Wind Speed


Wind Farm - Baseline Noise Data
20th/21st February 2002
SPL (dB(A))
10m Height Wind Speed (m/s)
Time (Hrs)
90
80
70
60
50
40
30
20
10
20
15
10
5
0
12:00:00
15:00:00
18:00:00
21:00:00
0:00:00
3:00:00
6:00:00
9:00:00
12:00:00
Leq
L90
Wind Speed

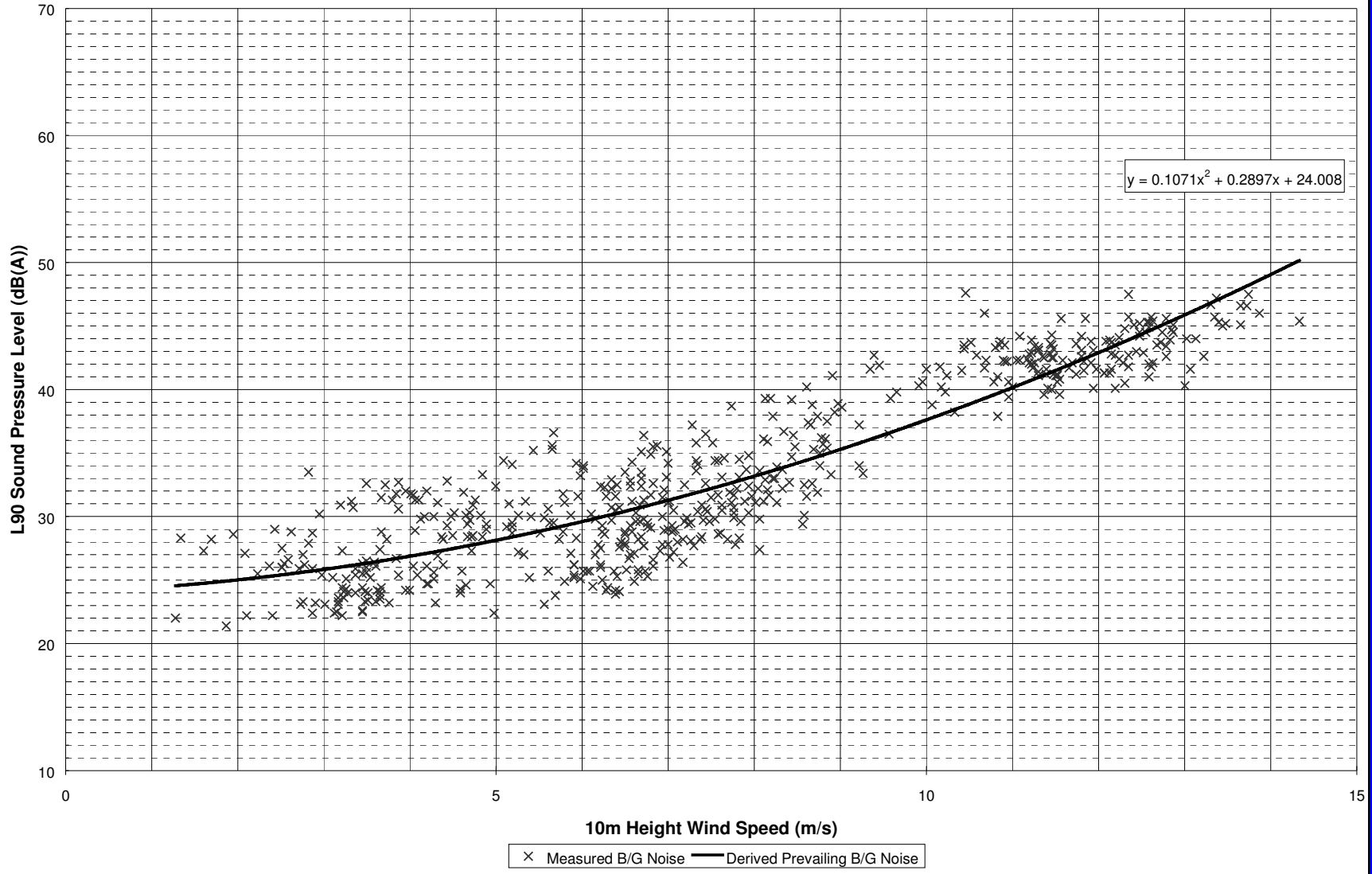
Derivation of Noise Limits

- For ‘sensitive’ day-time and night time hours:
- For each measurement location:
  - Plot noise against wind speed
  - Derive ‘prevailing’ b/g
  - Derive noise limits

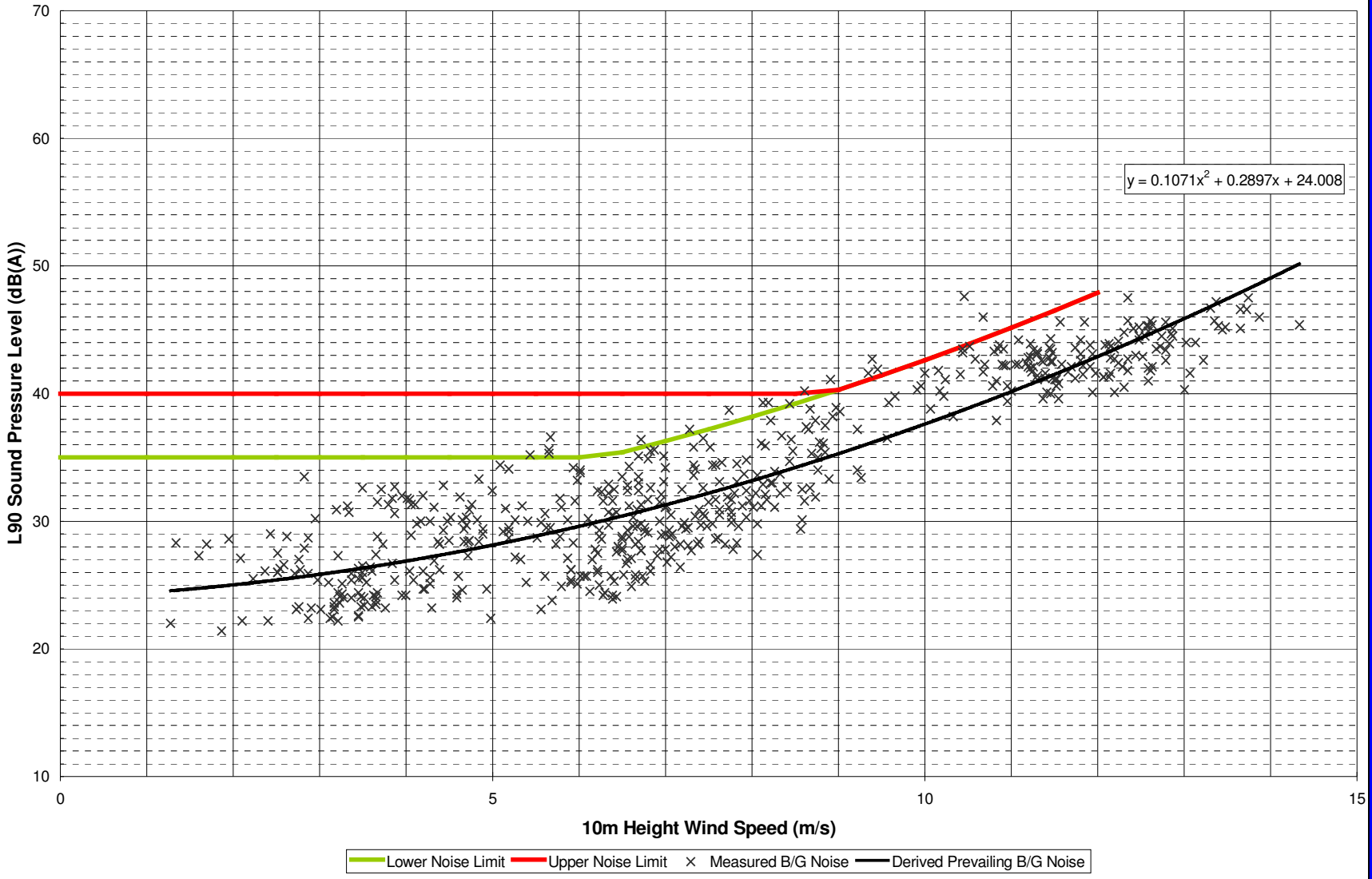
Wind Farm Noise Assessment
Background Noise vs Wind Speed



Wind Farm Noise Assessment
Background Noise vs Wind Speed
(Amenity Hours)



Wind Farm Noise Assessment
Predicted Turbine Noise and Background Noise vs Wind Speed
(Amenity Hours)



Prediction

- Predicted noise level =

  Source sound power level - Propagation Factors

Source Sound Level

- Measurement standard - IEC 61400-11
- Sound *power* level at integer V_{10} wind speeds
- Ideally cut-in to 12 m/s
- Octave or 1/3 octave band spectra
- Analysis of tonal noise

Prediction

20 log d + 11

✓

Hard Ground – Worst Case

- $L_P = L_W + D - A_{geo} - A_{atm} - A_{gr} - A_{scr} - A_{misc}$

Downwind – worst case

15 deg C 70% RH

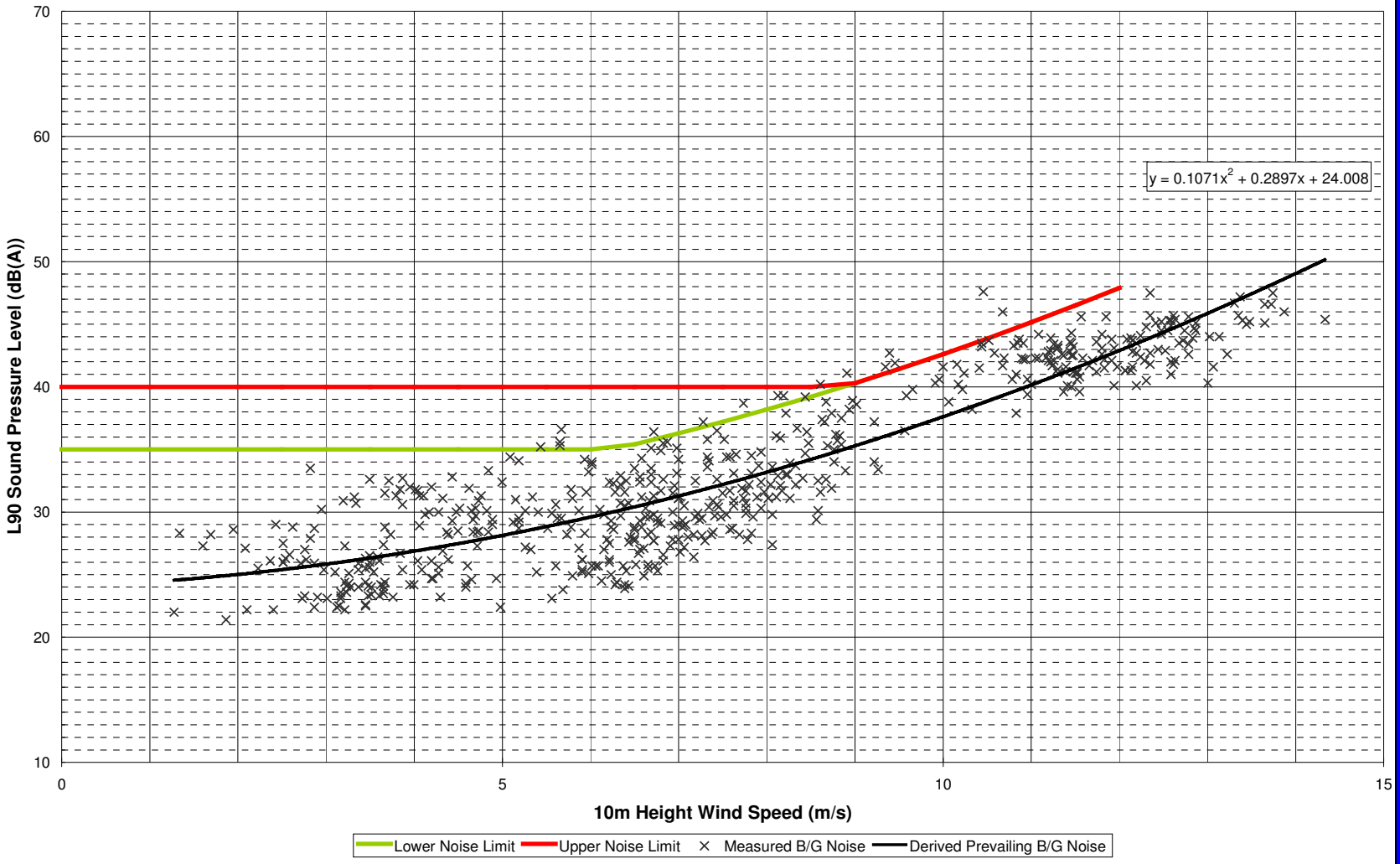
- 2 dB / 10 dB

Downwind Bending

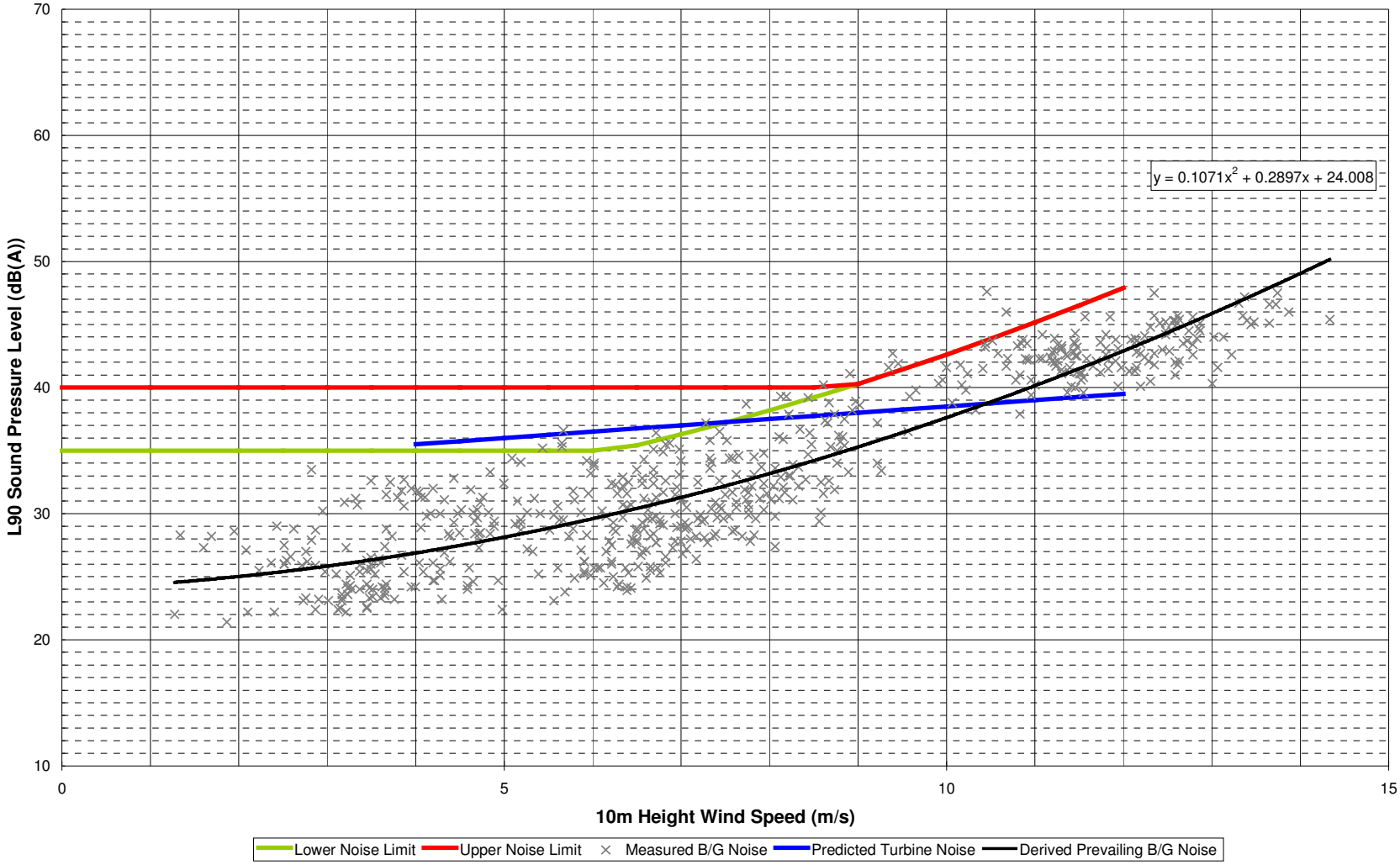
Impact Assessment

- Comparison of predicted level, over range of wind speeds, with:
  - ETSU-R-97 noise limits
  - Baseline
- For worst case wind direction

Wind Farm Noise Assessment
Predicted Turbine Noise and Background Noise vs Wind Speed
(Amenity Hours)



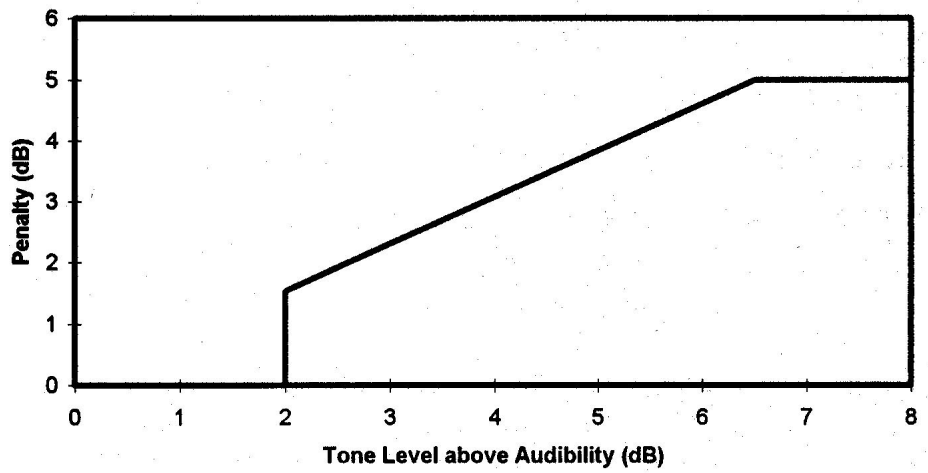
Wind Farm Noise Assessment
Predicted Turbine Noise and Background Noise vs Wind Speed
(Amenity Hours)



Other Issues

- Tonality
- Modulation
- Infrasound (<20 Hz)
- Low Frequency (20Hz – 200Hz)
- Wind Shear (variation of wind speed with height)

ETSU-R-97 Tone Penalty

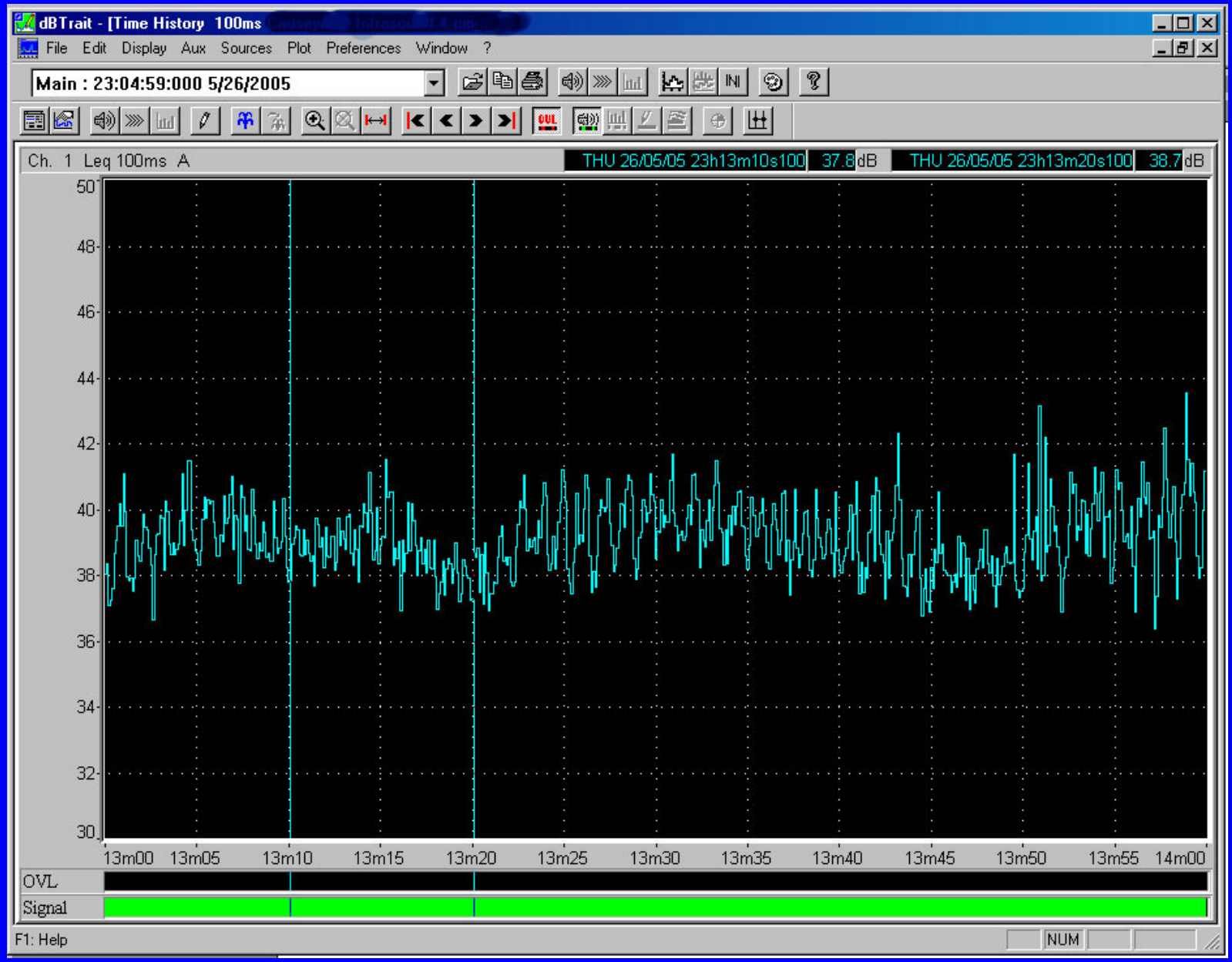


Penalties for tonal noise

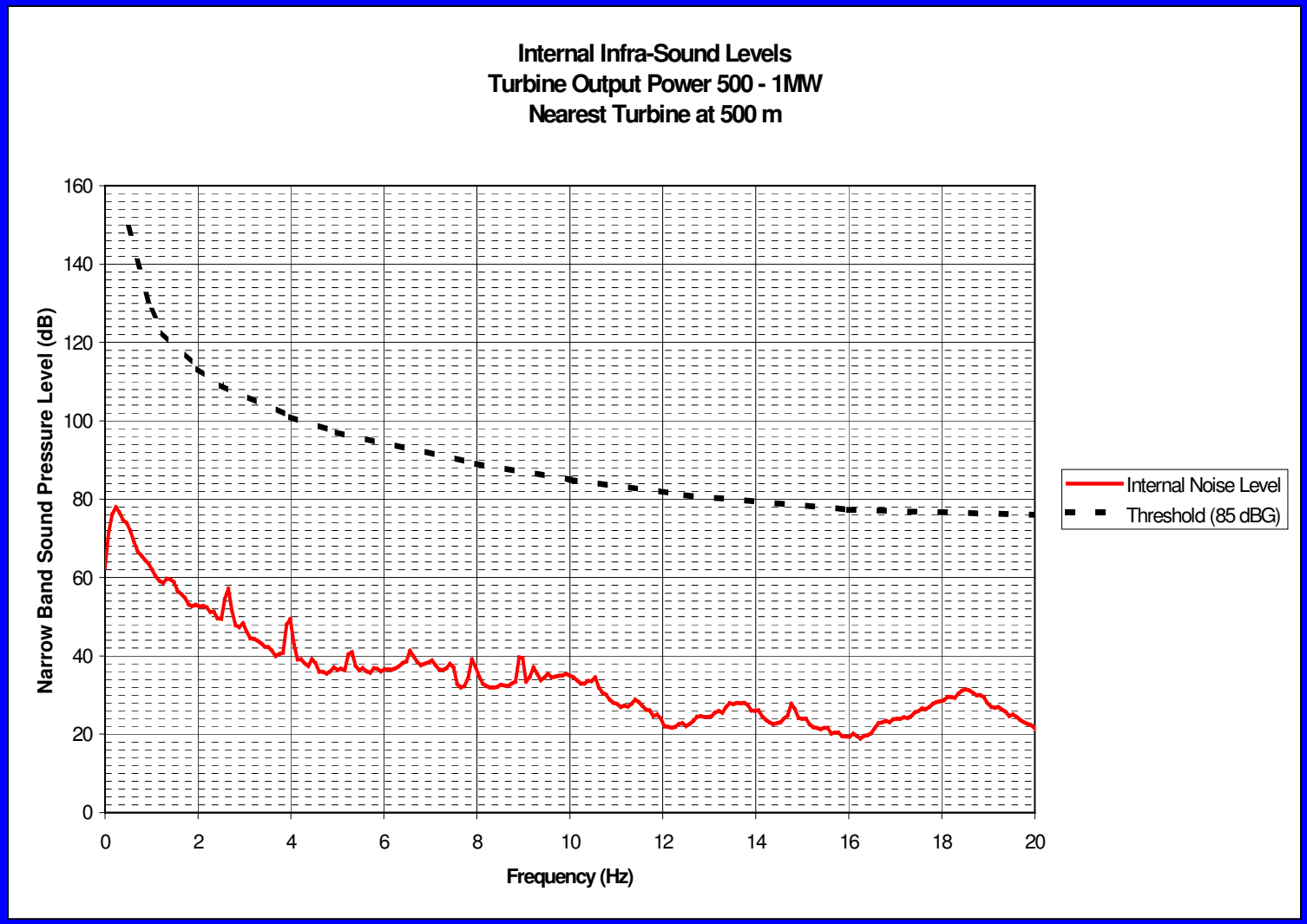
Wind Turbine
Tonal Noise Analysis
Power Output 199.3 kW

Modulation

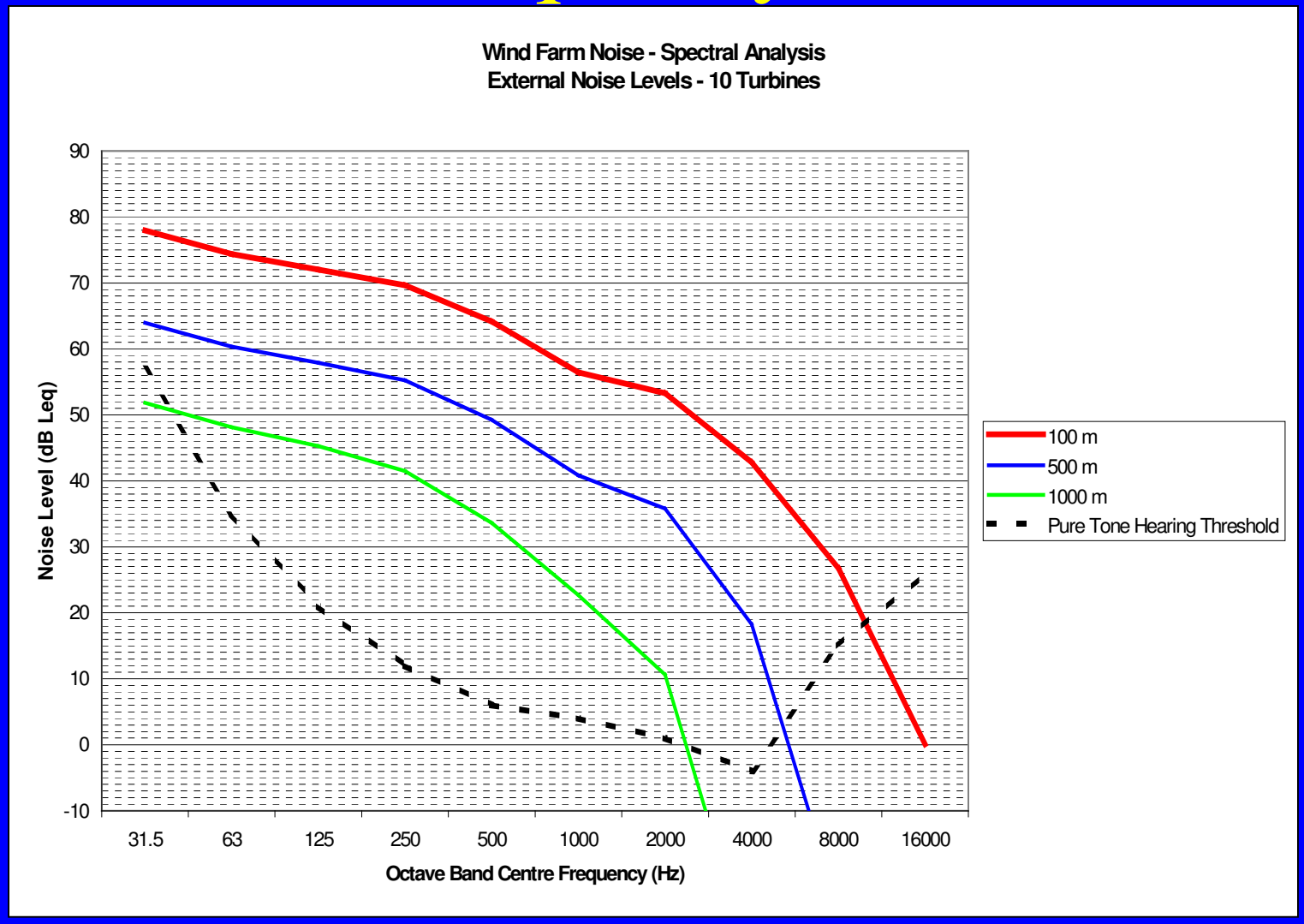
- ETSU-R-97 noise limits allow for the fact that there may be a degree of fluctuation at times.
- Occurs at turbines but diminishes with distance.


dBTrait - [Time History 100ms
File Edit Display Aux Sources Plot Preferences Window ?
Main : 23:04:59:000 5/26/2005
Ch. 1 Leq 100ms A
THU 26/05/05 23h13m10s100 37.8 dB
THU 26/05/05 23h13m20s100 38.7 dB
50
48
46
44
42
40
38
36
34
32
30
13m00 13m05 13m10 13m15 13m20 13m25 13m30 13m35 13m40 13m45 13m50 13m55 14m00
OVL
Signal
F1: Help
NUM

Infrasound


Internal Infra-Sound Levels
Turbine Output Power 500 - 1MW
Nearest Turbine at 500 m
Narrow Band Sound Pressure Level (dB)
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
18
20
Frequency (Hz)
Internal Noise Level
Threshold (85 dBG)

Low Frequency Sound



Wind Shear

- Speed up from reference height (10m) to hub height may be greater than predicted from ground conditions alone.
- A modification to the ETSU-R-97 methodology is suggested such that baseline measurements are referenced to derived hub height wind speeds.
- Wind speed for baseline noise and source noise are then corrected to ‘standardised’ 10m height.

Conclusion

- Noise from wind farms is assessed using methodology described in ETSU-R-97, *Assessment and Rating of Noise from Wind Farms*, as required by PS22, *Renewable Energy*.
- This methodology remains as valid today as when it was introduced in 1996 subject to baseline noise measurements being referenced to derived or measured hub height wind speed prior to being 'standardised' to 10m height.