IoA Wind Turbine Noise 6

Prediction & Assessment of Wind Turbine Noise

Agreement Published in the IoA Bulletin

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What is this agreement and why was it published in the IoA Bulletin?

- The results of discussions between an ad-hoc group, members of which had worked together many times at Public Inquiry covering...
  - Vibration and Low Frequency Noise
  - Noise Prediction Methodology
  - Wind Shear
- Acoustics Bulletin has wide target audience for expressing views.
- Is not official IoA Guidance and should not be regarded as such.

Who were these people?

Dick Bowdler, **Andrew Bullmore**, **Bob Davis**, **Malcolm Hayes**, **Mark Jiggins**, **Geoff Leventhall** (Section 4), **Andy McKenzie**

The authors were the independent noise consultants who sat on the DTI/BERR Noise Working Group on wind farm noise in 2006/2007

Geoff Leventhall PhD HonFIOA is a noise and vibration consultant.

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Malcolm Hayes BSc MIOA is with Hayes McKenzie, Machynlleth

Andy McKenzie PhD BSc MIOA is with Hayes McKenzie, Salisbury

Dick Bowdler BSc FIOA is with New Acoustics, Clydebank

Bob Davis BSc(Eng) MIOA is with Robert Davis Associates, Hampshire

Vibration and low frequency noise …….

- Hayes McKenzie Low Frequency Noise Study for DTi 2006
- Reports on Vibro-Acoustic Disease
- Keele University Vibration Studies

‘*From examination of reports of the studies referred to above, and other reports widely available on internet sites, we conclude that there is no robust evidence that low frequency noise (including ‘infrasound’) or ground-borne vibration from wind farms, generally has adverse effects on wind farm neighbours*’.

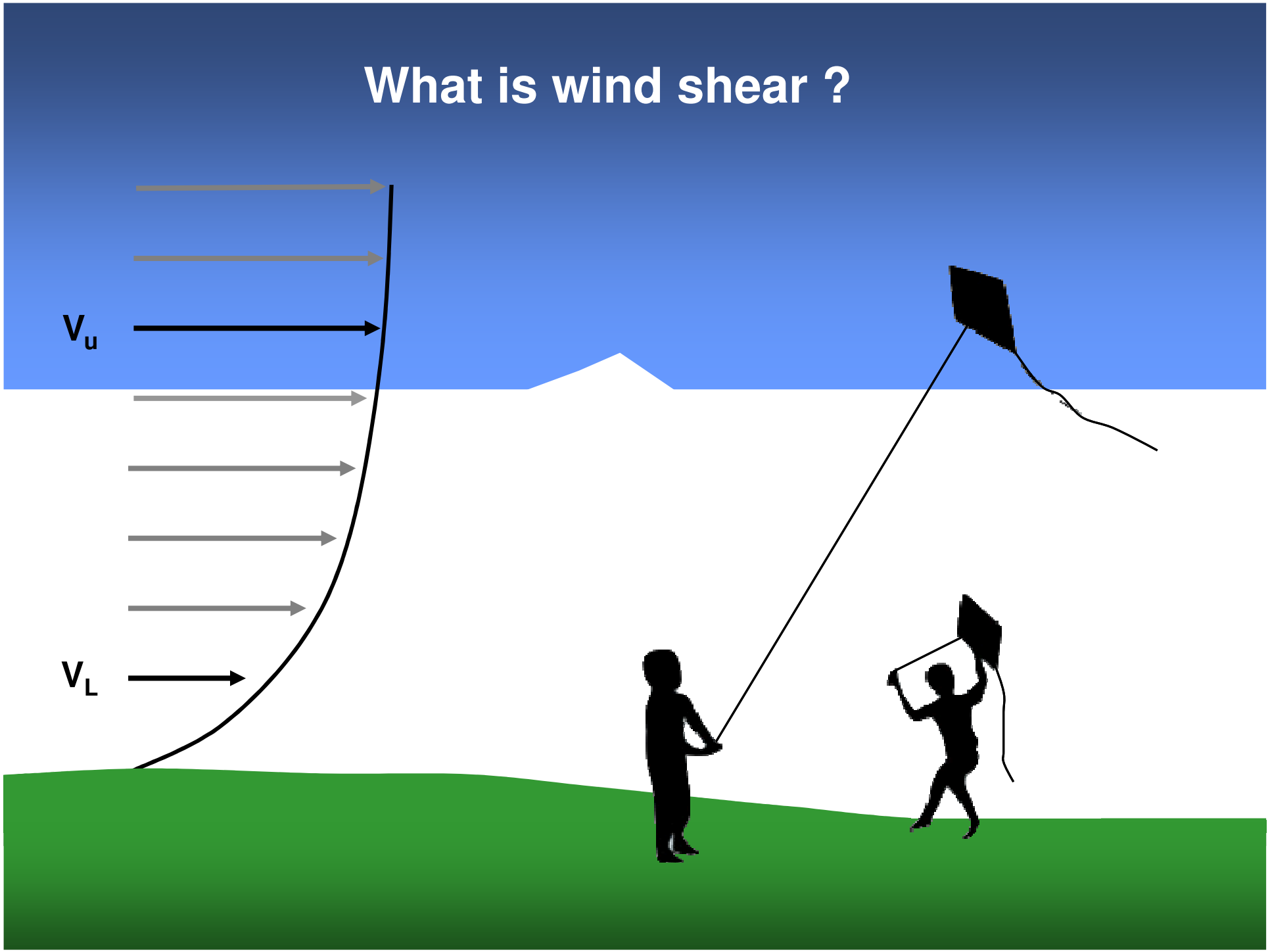
Noise prediction methodology …….

- Use of ISO9613-2 (Octave Bands)
- Turbine Sound Power Levels
- Temperature and Humidity Assumptions
- Ground Factor Assumptions
- Effects of Barriers

Wind shear …….

- What is wind shear ?
- What causes wind shear ?
- Can a single value of site specific wind shear be defined ?
- Why is wind shear an issue for wind farm noise assessment ?
- How can wind shear be dealt with ?
- How does the IoA Bulletin Agreement deal with it?

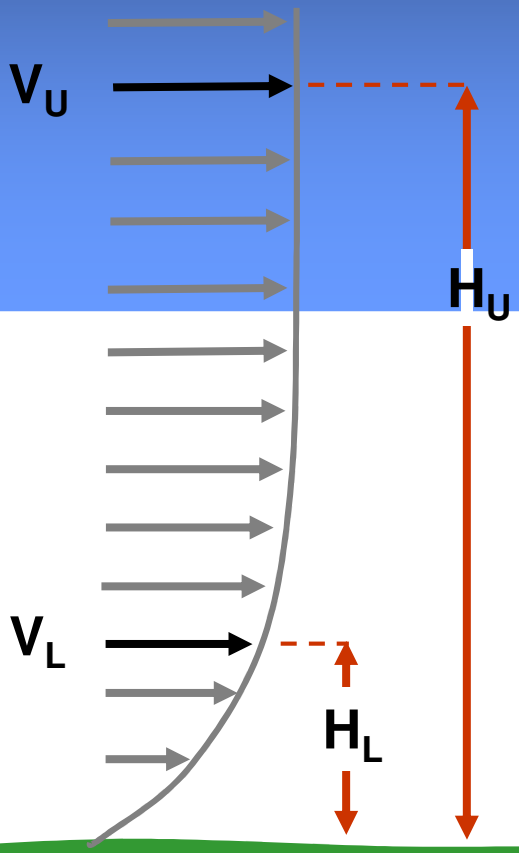
What is wind shear ?



What causes wind shear ?

- Ground Roughness
- Atmospheric Factors
  - In practice a combination of both occur

Modelling wind shear due to ground roughness



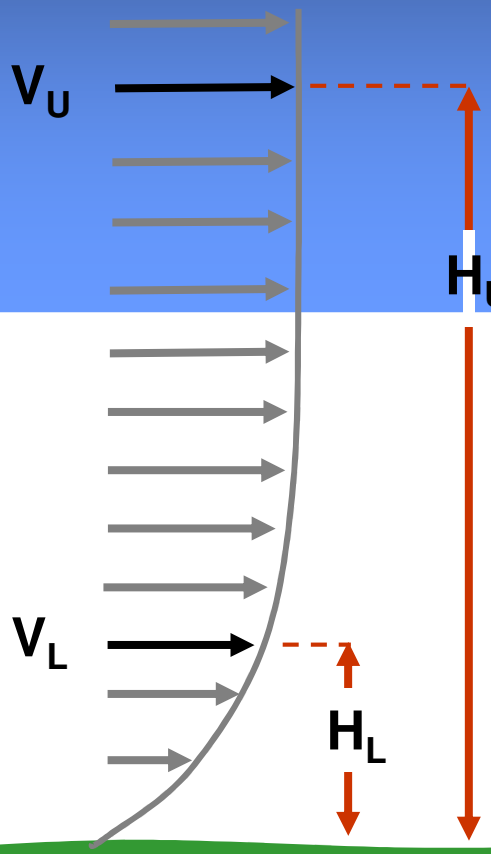
$$V_U = V_L \times \frac{\log(H_U/z_0)}{\log(H_L/z_0)}$$

z_0 = ground roughness length

Type of Terrain	Roughness length z_0
Water areas, snow or sand surfaces	0.001m
Open, flat land, mown grass, bare soil	0.01m
Farmland with some vegetation	0.05m
Suburbs, towns, forests, many trees and bushes	0.30m

Ground roughness is fixed for a given site

Modelling wind shear due to atmospheric effects



$$V_U = V_L \times \left\{ \frac{H_U}{H_L} \right\}^m$$

m = shear exponent

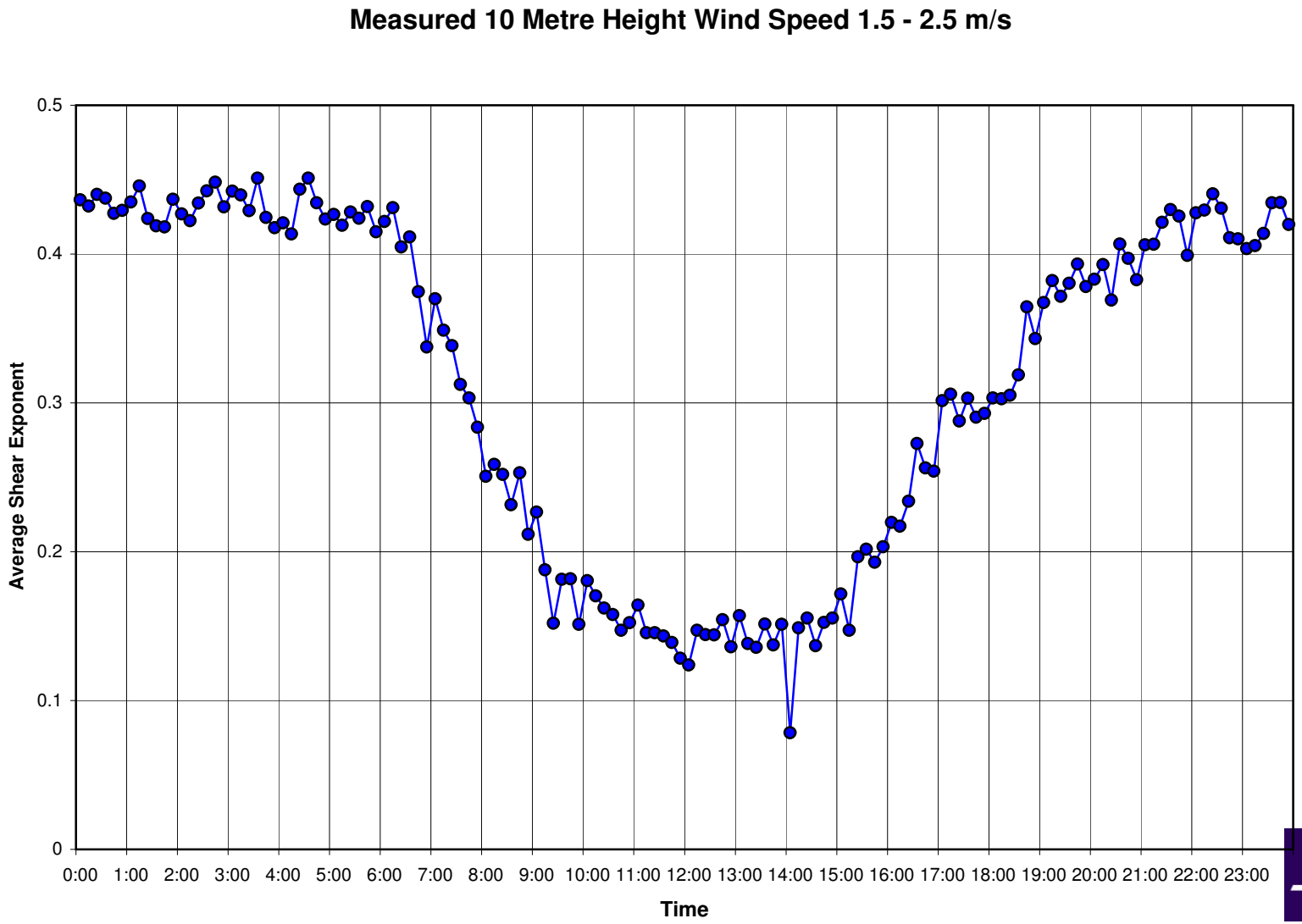
Pasquill class	name	shear exponent
A – B	(very – moderately) unstable	$m \leq 0.21$
C	near neutral	$0.21 < m \leq 0.25$
D – E	(slightly – moderately) stable	$0.25 < m \leq 0.4$
F	very stable	$0.4 < m$

Atmospheric effects are not fixed for a given site and vary, particularly by time of day

Can a single value of site specific wind shear be defined ?

- No, because…
- No fixed value of 'z_0' or 'm' can be used to define the speed up from one height to another.
- Varies with atmospheric conditions which means it varies with:
  - Weather (including wind)
  - Time of day

Wind shear as a function of time of day for increasing wind speed



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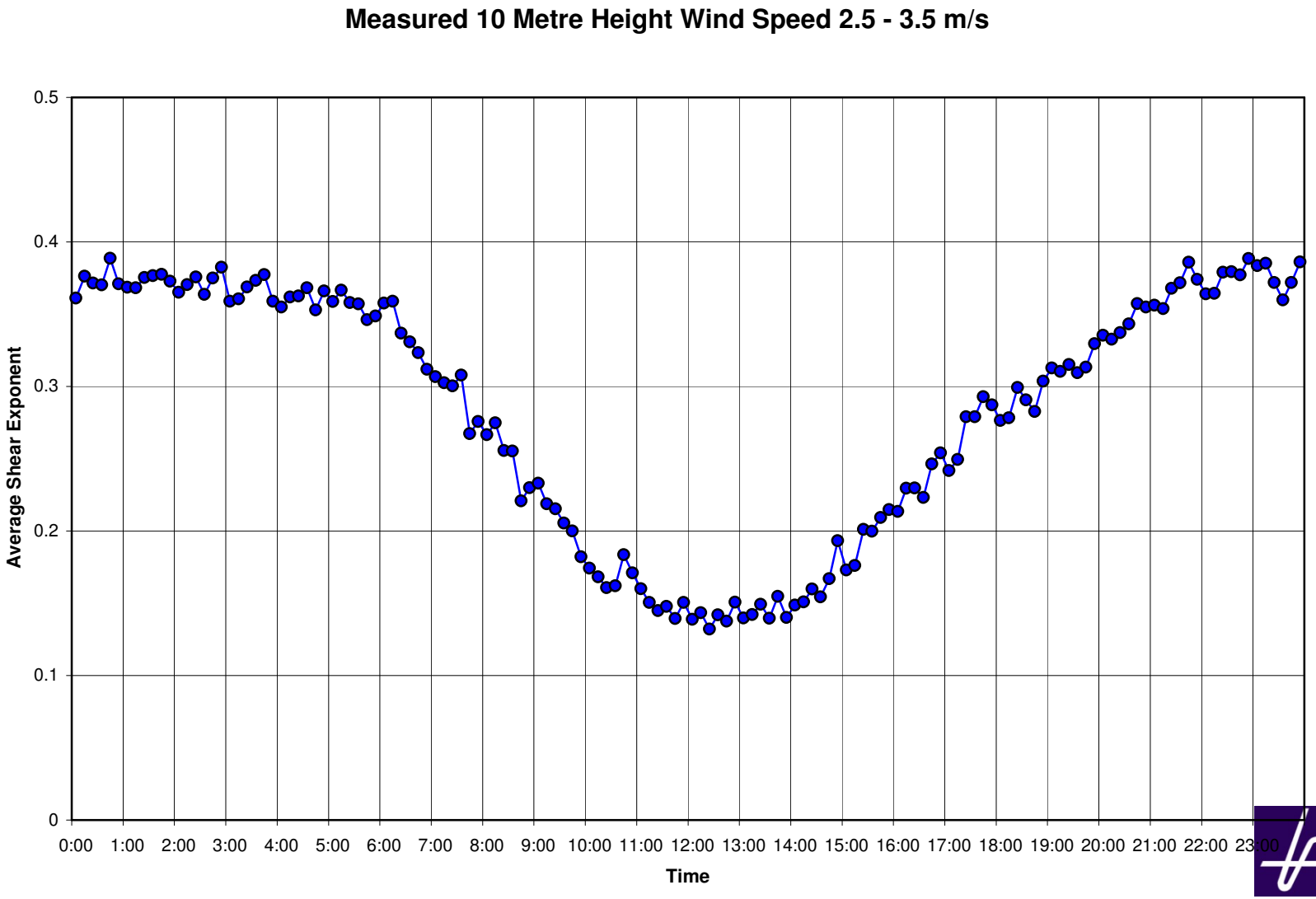

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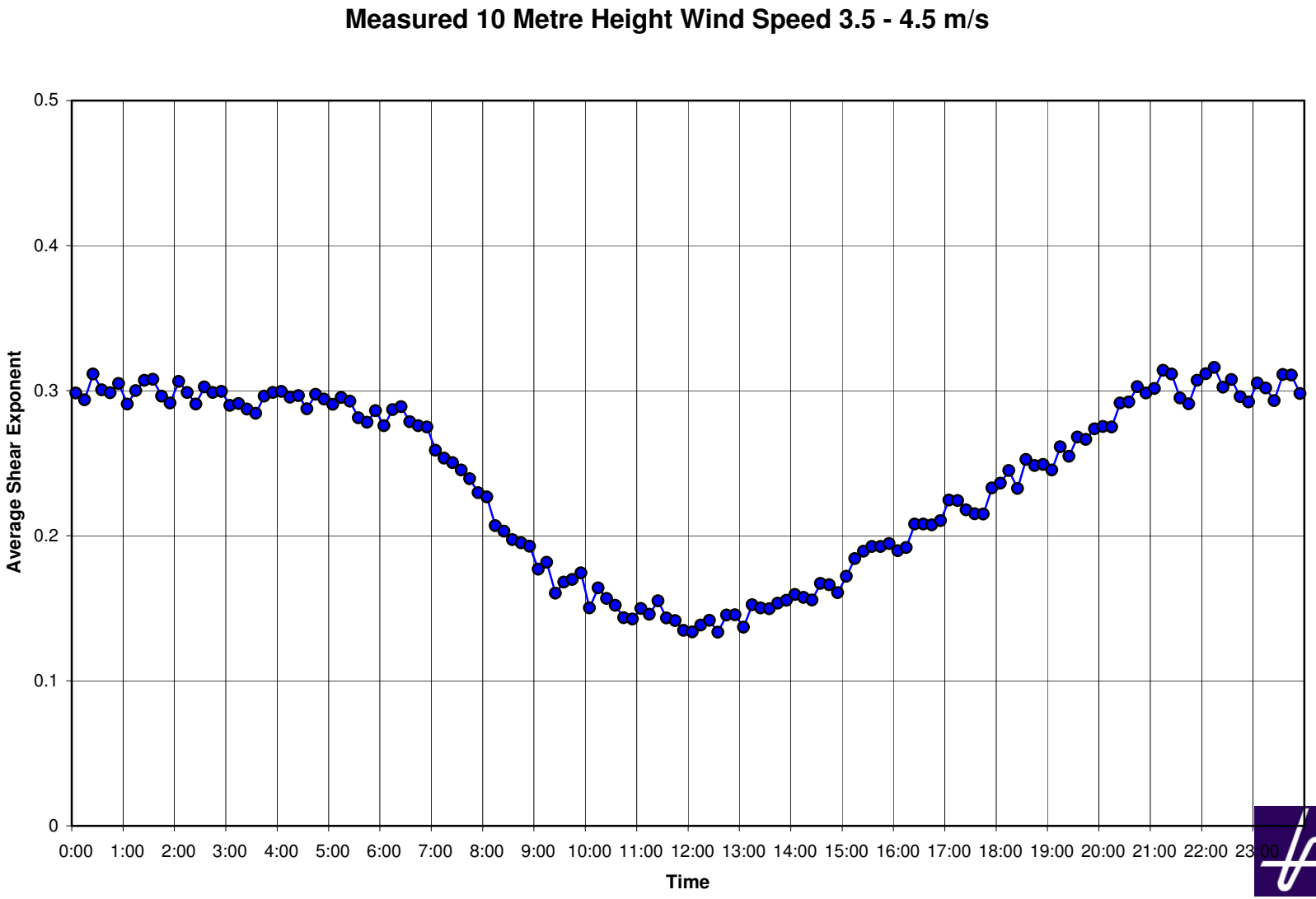

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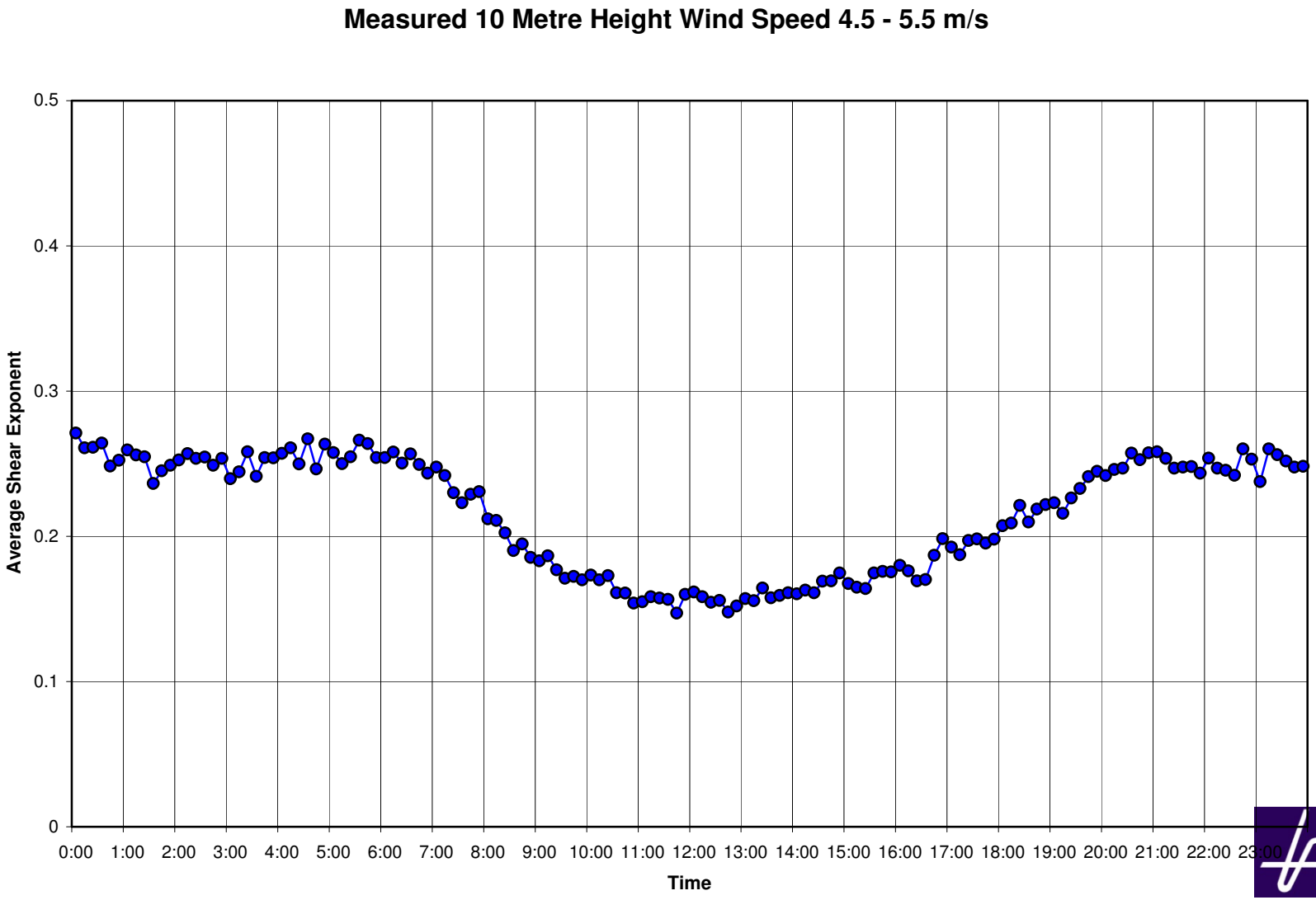

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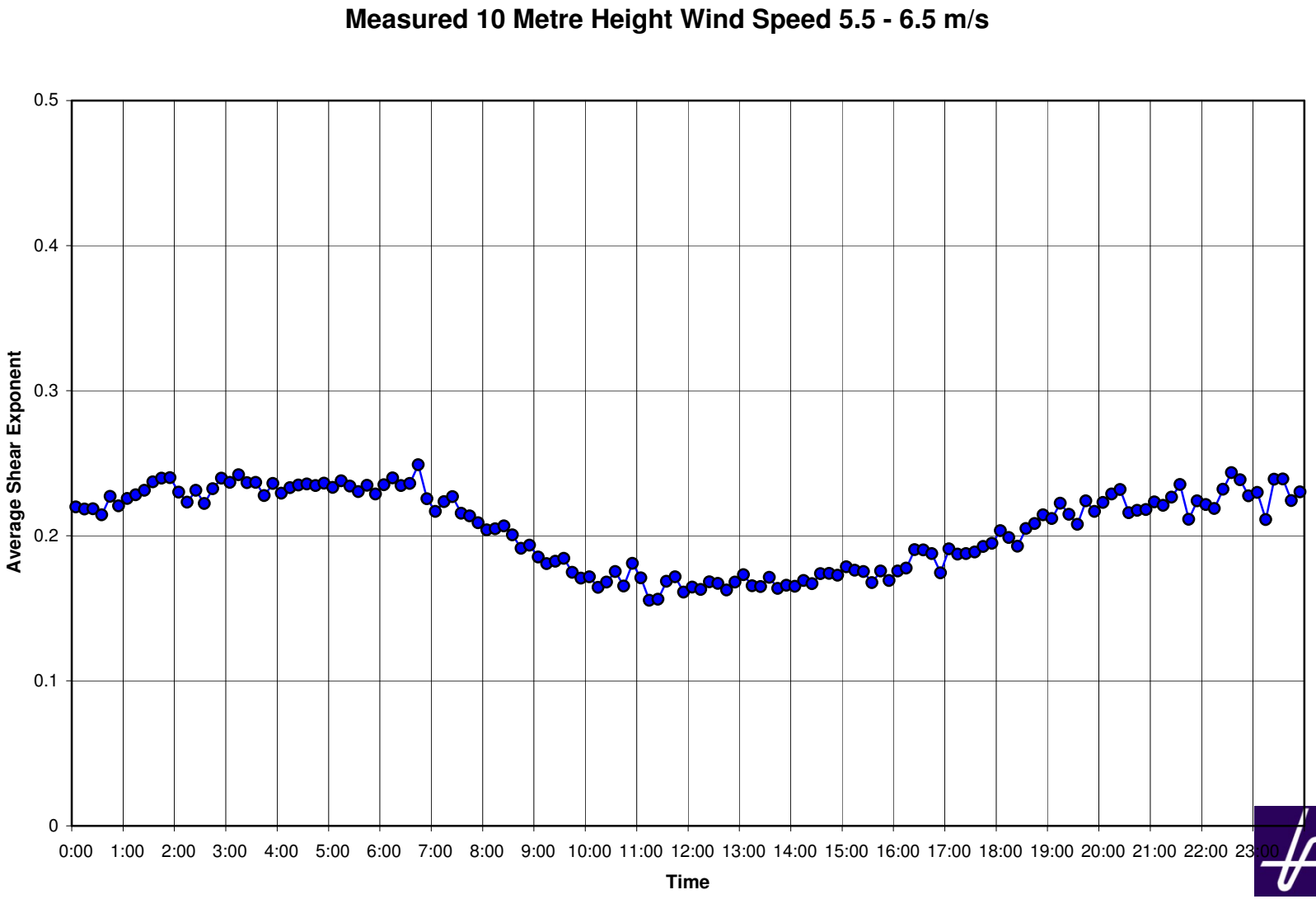

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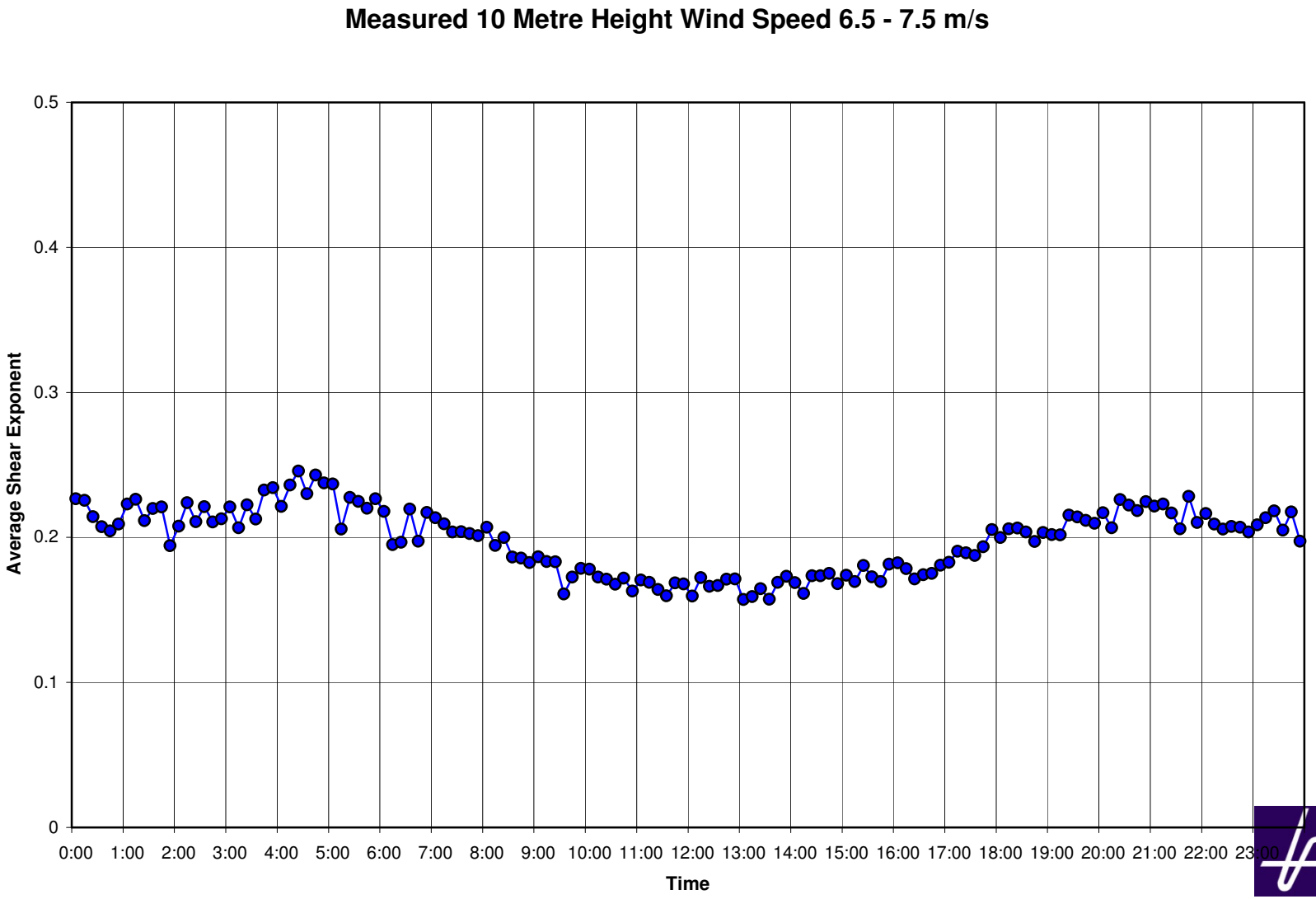

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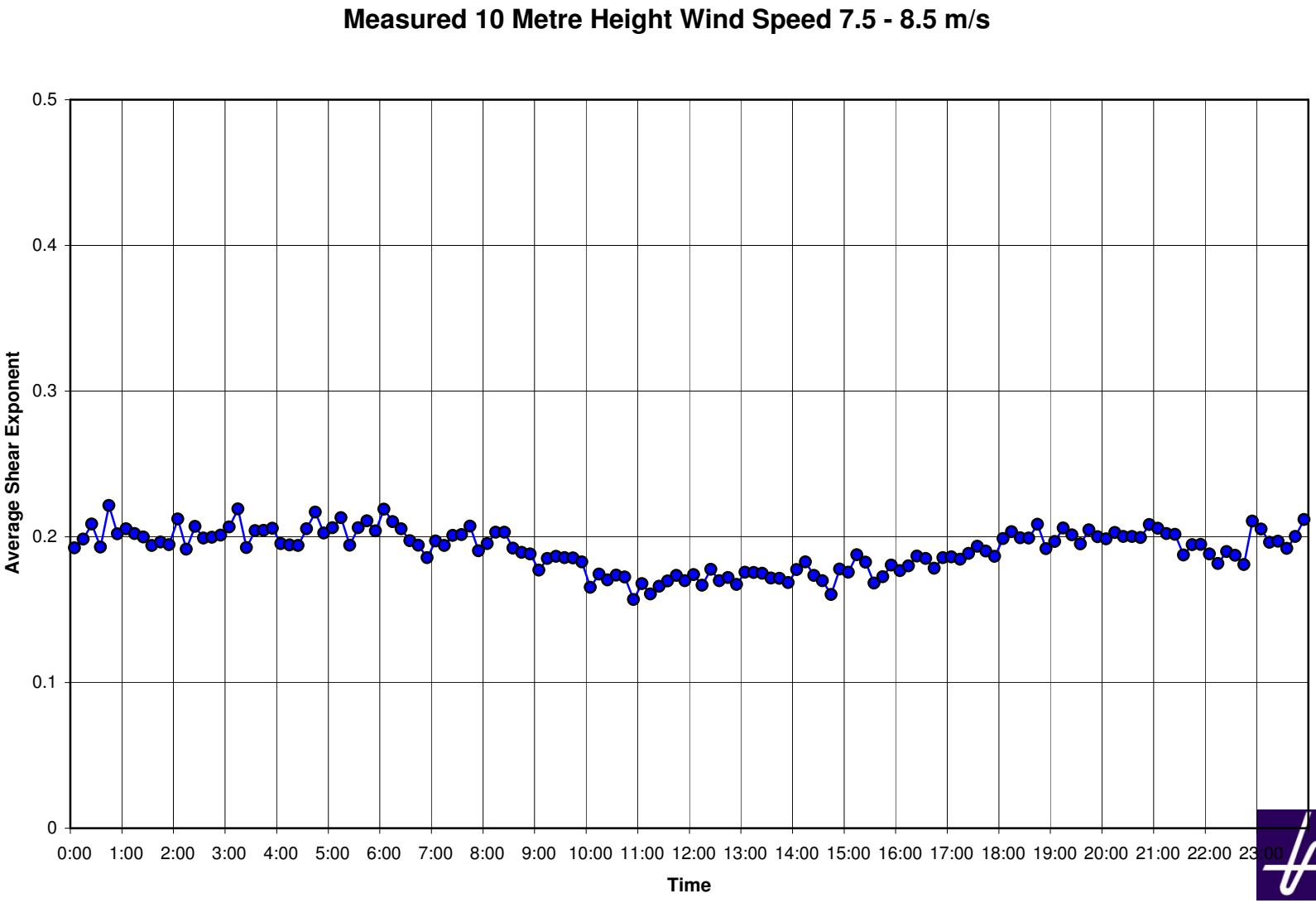


Two fundamental standards for wind farm noise assessment…

- ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*

- IEC61400-11, *Wind Turbine Generator Systems Part 11: Acoustic noise measurement techniques*

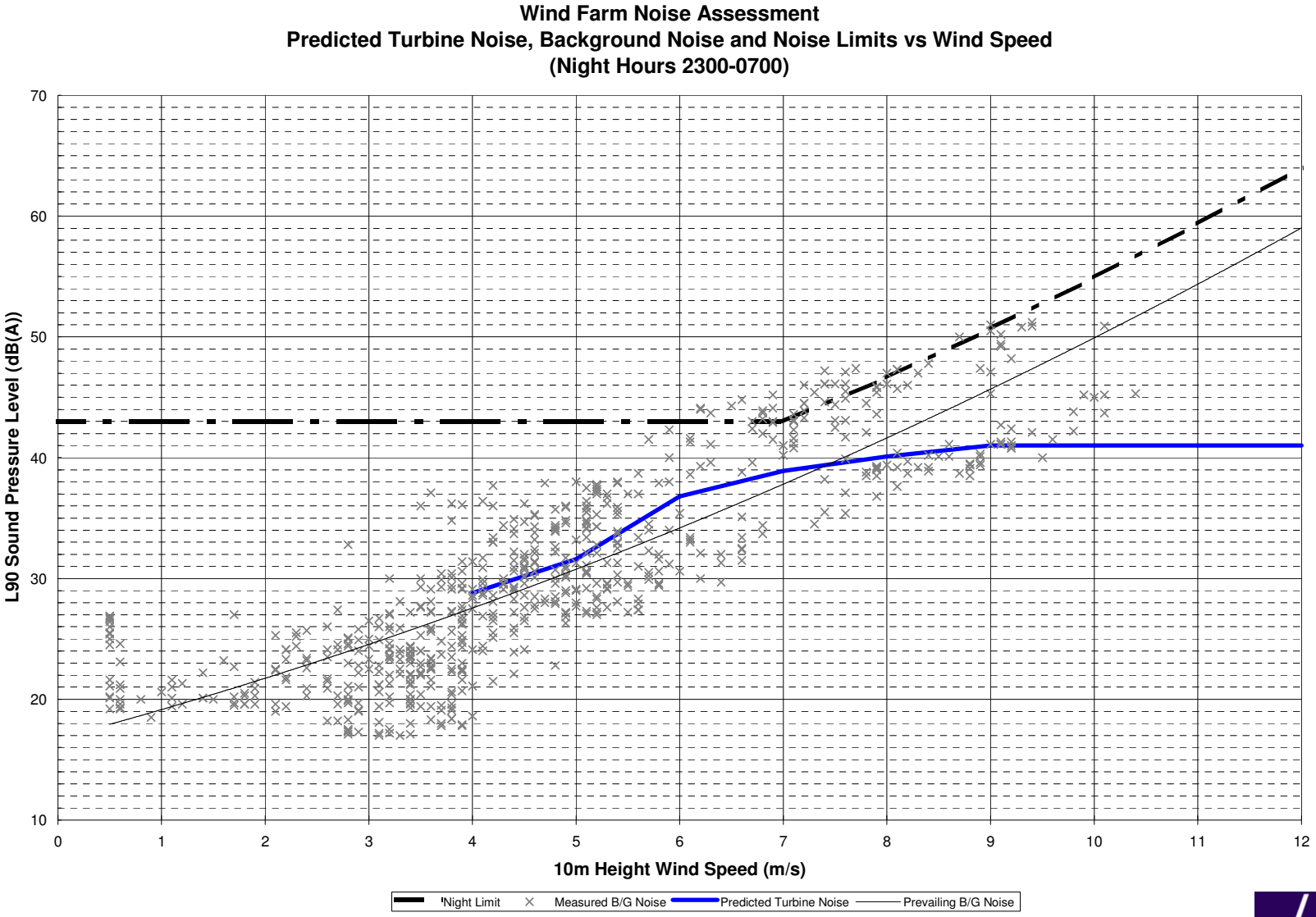
Why is wind shear an issue for wind farm noise assessment ?

- Because…
- ETSU-R-97 appears to require correlation of noise measurements with measurements of wind speed at 10m height to quantify baseline.
- IEC61400-11 requires correlation of noise measurements with hub height wind speed ‘standardised’ to 10m height for quantification of turbine noise (ie. based on ground roughness of 0.05 – equivalent to unstable conditions / low wind shear).

Why is wind shear an issue for wind farm noise assessment

- And…
- The inherent assumption in ETSU-R-97 that referencing everything to 10m height in this manner provides a comparison between predicted turbine and background noise under the same wind conditions (at the turbine hub).
- Or is there?

Effects of Wind Shear with 10m Height Measurements



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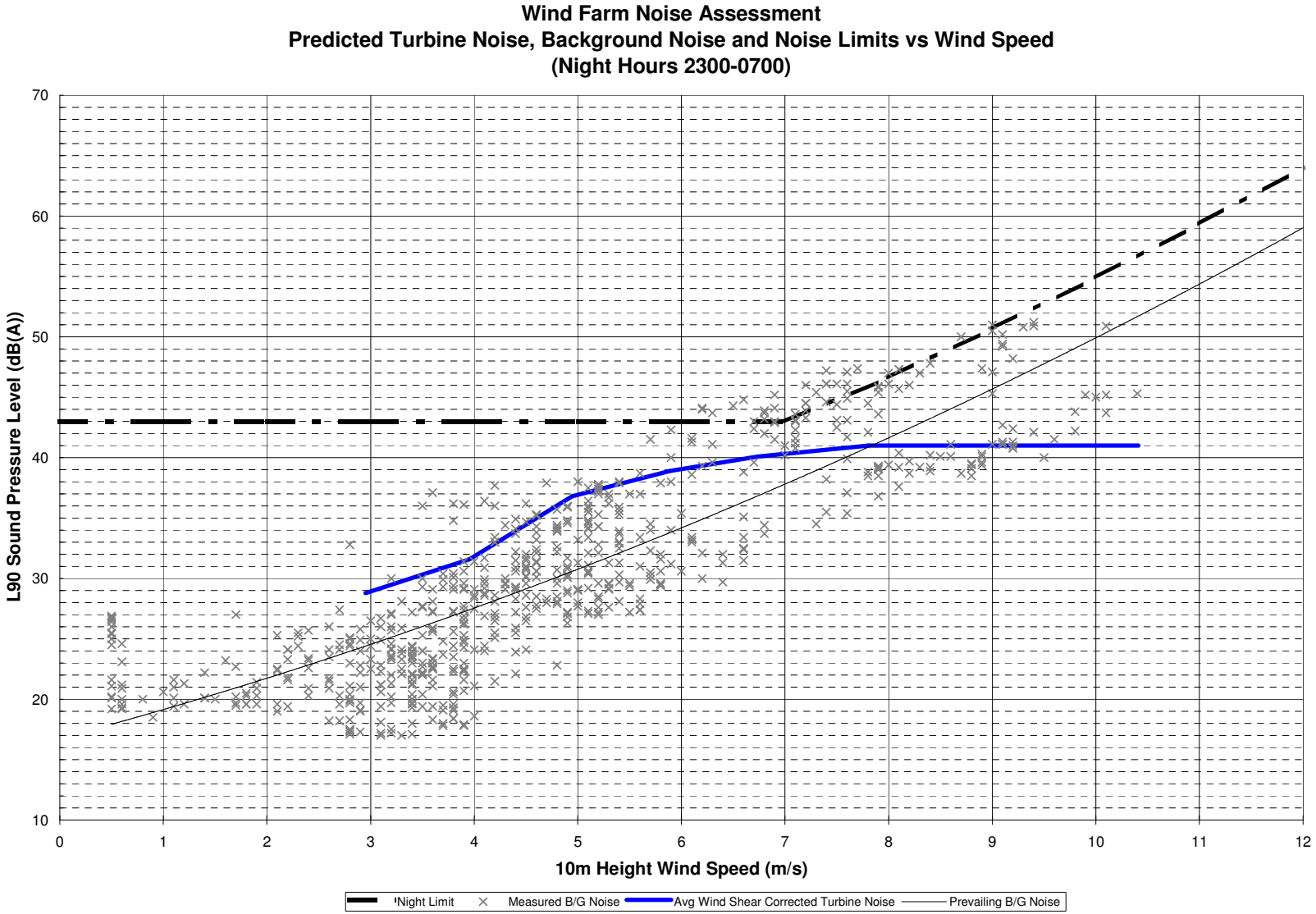

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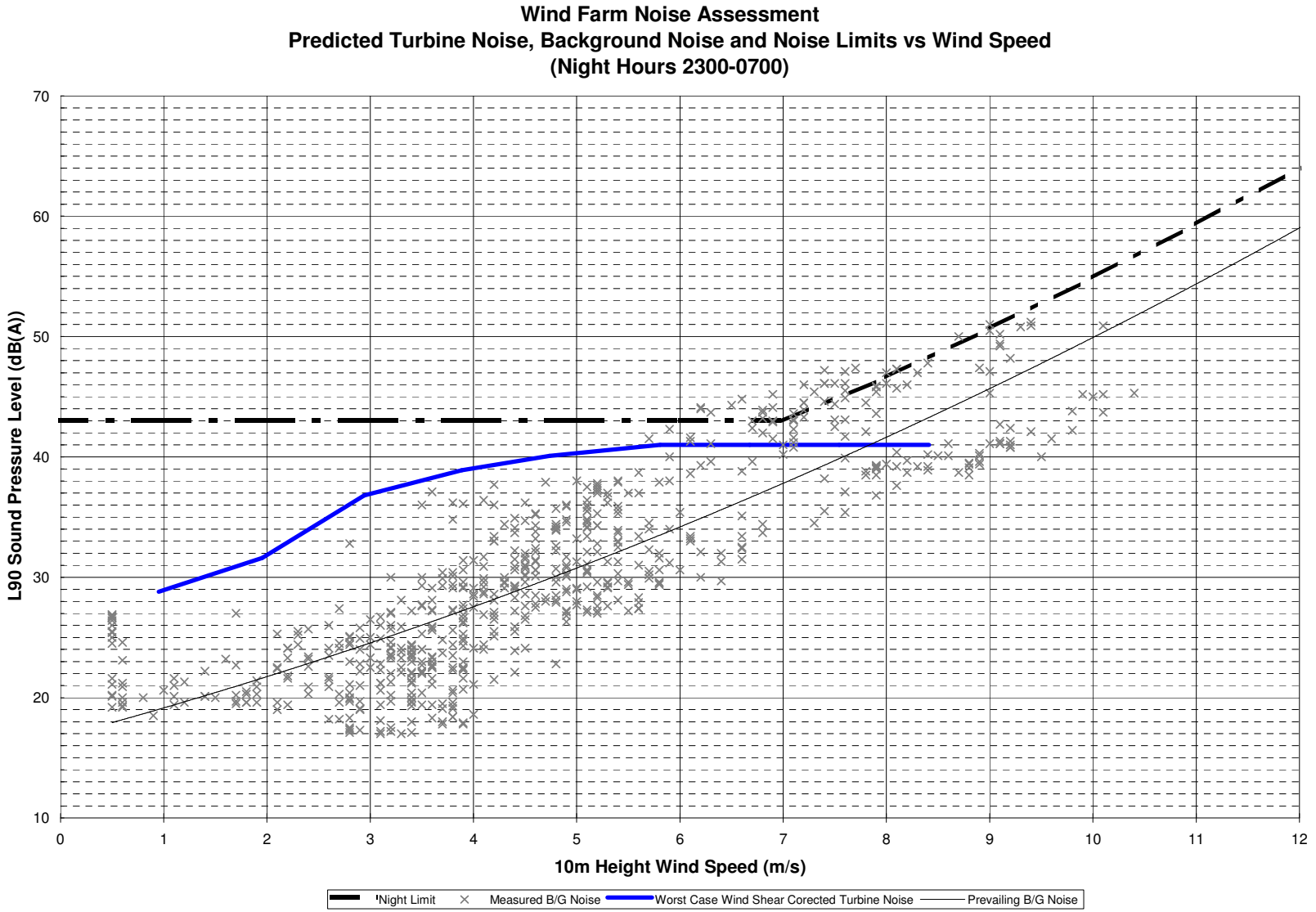

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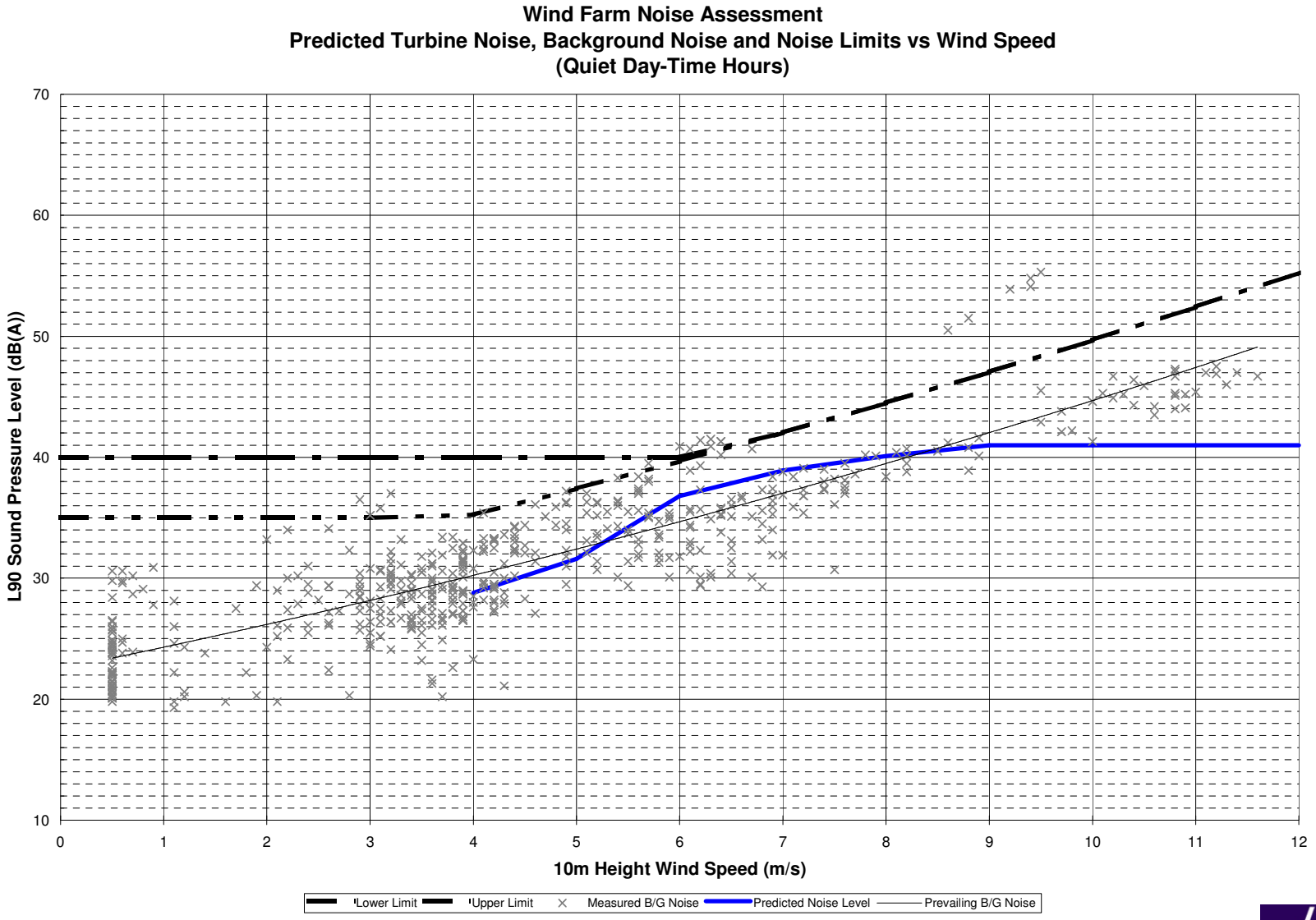

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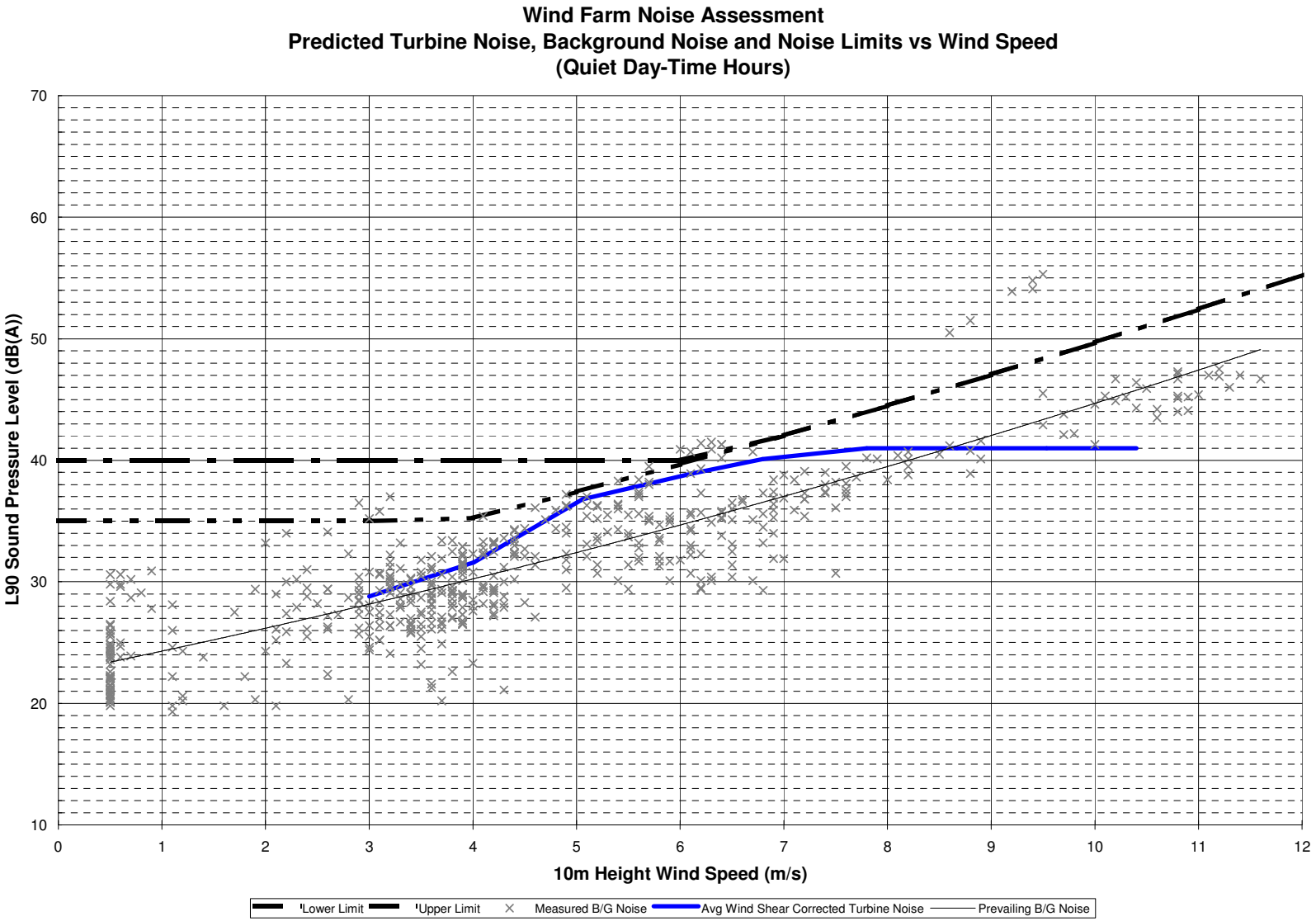

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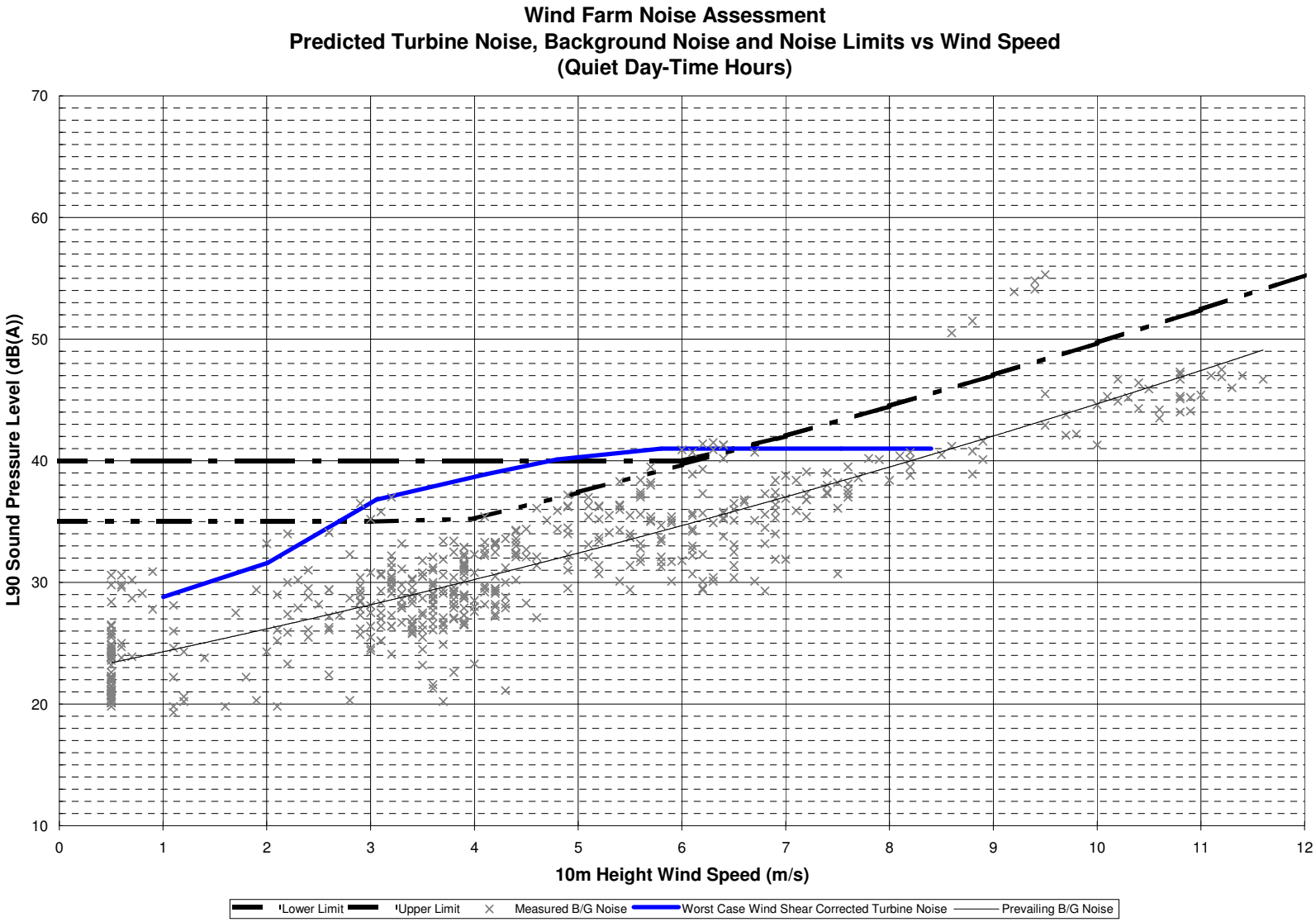

The ‘agreed’ approach…

- Background noise measurements correlated with hub height wind speed ‘standardised’ to 10 m height.
- If HH WS not measured directly then derive shear exponent ‘m’ from measurements at heights H1 and H2 for each 10 minute period.
  - H1 >=60% of HH
  - H2 = 40–50% of HH
- Derive HH WS from measurements at H1 and derived values of ‘m’ for each 10 minute period.

What are positive implications of this approach for planning purposes ?

+ Background noise evaluated under (wind) conditions corresponding to the level of noise generated. Consistent with approach in BS4142

  [7.1.3 Make measurements during periods when the background noise level is typical of the background noise when the specific noise source is or will be operating…].

  ie.Compares like with like

+ Clear methodology for taking wind shear into account without possibility of unknowns.

+ Allows meaningful evaluation of whether limits in planning conditions can be met.

What are negative implications of this approach for planning purposes ?

- Creates more ‘scatter’ around trend line through baseline data. ETSU-R-97 already criticised for ‘average’ approach to baseline data.
- Different noise limits apply for different hub heights!
- Problems for small schemes where costs of deriving hub height wind speeds may be prohibitive. Will need alternative approach.

Conclusions…

- Removes uncertainty
- Provides a meaningful comparison between turbine noise and existing noise under the same wind conditions.
- Adds to the complexity of deriving the ‘prevailing’ background noise level.
- Adds to question mark over meaningfulness of background noise measurements in rural areas.