SECTION 5

Ref. 8065/0548/02

19th July 2014

ACOUSTIC
CONSULTANTS

PROPOSED WIND TURBINE
BALHALL LODGE, MENMUIR
BRECHIN

NOISE IMPACT ASSESSMENT

architectural

environmental

occupational

industrial

noise control at source

project management

planning

legal services

expert witness

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Document Control

Project: Noise Impact Assessment for the proposed wind turbine at Balhall Lodge, Menmuir, Brechin

Reference: 8065/0548

Date: 19th July 2014

Issue	**1**	**2**	**3**	**4**
Remark	First Issue	Report updated following comments made by the EHO		
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CONTENTS

1.0 SUMMARY

At the request of Harmony Energy, PDA has undertaken an assessment of the noise generation of the proposed wind turbine approximately 460m northwest of Balhall Lodge, Menmuir, Brechin.

Worst case downwind turbine noise levels have been predicted at the nearest noise sensitive locations to the proposed turbine location. This has been based on the measured sound power for a Northern Power NPS 100-24 wind turbine and prediction methodology in accordance with the Institute of Acoustics (IoA) *"Good Practice Guide the Application of ETSU-R-97 for The Assessment and Rating of Wind Turbine Noise".*

The assessment has shown that the calculated noise levels generated by the proposed wind turbine will not exceed the noise criteria specified within ETSU-R-97.

In addition it is noted that there is a second existing turbine already on the site. The noise predictions have been compared with the consent levels for the existing turbine. The results have indicated that the proposed turbine is more than 10dB below the consent level therefore there will be no cumulative impact for the proposed second turbine.

2.0 INTRODUCTION

The proposals are for a single wind turbine at Balhall Lodge, Menmuir, Brechin.

The proposal consists of a single Northern Power NPS 100-24 turbine. This model of turbine is a 100kW three bladed, upwind turbine. The turbine will be installed on a tower such that the hub height will be 37m above the ground. Please refer to Appendix A attached to this report, which details the location of the wind turbine. The co-ordinates of the turbine are E350832, N764324.

In addition it should be noted that there is an existing Northern Power 100kW turbine 245m to the east of the proposed development planning application reference 10/01133/FULL.

3.0 TERMS OF REFERENCE

3.1 Scottish Government Planning Advice

Scottish Government planning advice on renewable energy is available in the form of online planning guidance documents. The document "Onshore Wind Turbines", last updated December 12th 2013 [1], provides guidance for the assessment of noise from wind turbines.

With respect to the noise assessment for wind turbines this document states the following:

"The Report, "The Assessment and Rating of Noise from Wind Farms" (Final Report, Sept 1996, DTI), (ETSU-R-97) describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available. This gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions."

3.2 ETSU–R–97

ETSU–R–97 *"The Assessment and Rating of Noise from Wind Farms"* [2] is a report detailing the finding of the Working Group on Wind Turbine Noise issued in 1997.

The document provides indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours. Separate limits are set for daytime and night time periods. The noise limits are derived from background noise data measured during the relevant period of the day or night.

Daytime limits are based on background noise data measured during the 'quiet daytime' periods that are defined as all evenings from 6pm to 11pm, Saturday afternoon from 1pm to 6pm, all day Sunday, 7am to 6pm.

The measured background noise data in each time period is plotted against the wind speed data measured on the wind farm site itself. Using this data the background noise level is calculated as a function of wind speed. The ETSU–R–97 noise limit is then based on a level 5 dB(A) above this curve over the wind speed range of the operation of the wind turbine.

Noise from the wind farm should be limited to 5 dB(A) above background for both day and night-time. In addition ETSU–R–97 indicates that where the background noise falls below a certain level a fixed limit would also be applicable.

For night-time this limit is fixed at 43dB(A) to account for the 35dB(A) sleep criteria detailed within Planning Policy Guidance 24 and an allowance for attenuation through an open window. For the daytime this limit is fixed within the range of 35 – 40 dB(A). These daytime limits are chosen to protect external amenity.

In addition it is noted that ETSU–R–97 recommends that both day and night-time lower fixed limits can be increased to 45dB(A) where the occupier of the property has some financial involvement in the wind farm.

It is also detailed within ETSU–R–97 for single turbines or when the separation distances are large, if the noise is limited to 35 dB $L_{A90,10min}$ up to wind speeds of 10m/s at 10m height, then this condition alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary.

ETSU–R–97 indicates that the $L_{A90,10min}$ descriptor should be used for both the background noise and the wind farm noise, and that when setting limits it should be borne in mind that the $L_{A90,10min}$ of the wind farm noise is 1.5 – 2.5dB(A) less than the L_{Aeq} measured over the same period.

In regard to cumulative assessments ETSU-R-97 states the following:
"The noise working group is of the opinion that absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in questions"

3.3 Prediction of Wind Turbine Noise

The methods for the calculation of wind turbine noise propagation are not covered within ETSU-R-97. Guidance on the prediction of wind turbine noise levels have been based upon the guidance contained within Institute of Acoustics (IoA) *"Good Practice Guide the Application of ETSU-R-97 for The Assessment and Rating of Wind Turbine Noise"* [3]

The preferred method of calculating wind turbine noise emission levels (i.e. noise levels to be experienced at receptor locations in the surrounding area) is the octave band prediction method of International Standard ISO9613-2. The output from an ISO9613-2 prediction model depends on the model input parameters. These parameters have been defined within the IOA good practice document and provide realistic predictions of turbine noise level:

- The IOA guidance indicates that there are number of methods of declaring the sound power level of the Turbine. However regardless of the method or presenting noise data it needs to be ensured that the sound power level incorporates a suitable margin of uncertainty, be this specified by the Turbine manufacturers or derived from test reports.

- It is recommended within the document that the ground absorption factor G = 0.5 (with a 4 meter receptor height) result in realistic estimates of noise emission.

- The preferred atmospheric conditions (temperature and RH) assumed are 10°C and 70% RH.

- Topographical screening should normally be limited to a reduction of no greater than 2dB and only if there is no direct line of site from the highest point of the turbine rotor to the receiver. If significant screening from a landform barrier is present in close proximity to the receiver higher barrier attenuation of up to 10dB(A) may be appropriate.

- A correction of +3dB should be added where the noise propagates over a valley where the average propagation height is greater than 1.5 times that over flat ground.

- The ETSU-R-97 procedures adopt the $L_{A90,10m}$ noise index. The relationship between L_{A90} and L_{Aeq} for wind turbines stated in ETSU-R-97 ($L_{A90,10m}$ = $L_{Aeq,10m}$ – 2 dB) remains valid.

3.4 Low Frequency Noise

A study, published in 2006 by acoustic consultants Hayes McKenzie on behalf of the DTI investigated low frequency noise from wind farms [4]. This study concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines, but that complaints attributed to low frequency noise were in fact possibly owing to a phenomenon known as Amplitude Modulation (AM).

3.5 Amplitude Modulation

A study was carried out on behalf of the Department for Business, Enterprise and Regulatory Reform (BERR) by the University of Salford [5], which investigated the incidence of noise complaints associated with wind farms and whether these were associated with AM. This report defined AM as aerodynamic noise from wind turbines with a greater degree of fluctuation than normal at blade passing frequency. Its aims were to ascertain the prevalence of AM on UK wind farm sites, to try to gain a better understanding of the likely causes, and to establish whether further research into AM is required.

The study concluded that AM has occurred at only a small number (4 of 133) of wind farms in the UK, and only for between 7% and 15% of the time. It also states that, at present, the causes of AM are not well understood and that prediction of the effect is not currently possible. BERR has decided against conducting further research into the phenomenon at this stage, and no revision to the current guidelines (ETSU-R-97) on wind farm noise assessment has been recommended.

4.0 NOISE LEVEL ASSESSMENT

4.1 Noise Limits

It is noted in the absence of background noise data, the simplified assessment methodology has been adopted here. Based upon the guidance the turbine noise emissions will be limited to 35dB L_{A90} up to wind speeds of 10m/s at 10m height for non-financially involved properties and 45dB L_{A90} up to wind speeds of 12m/s at 10m height for financially involved properties.

4.2 Identification of Noise Sensitive Receivers

Based upon Ordnance Survey maps and utilising online tools such as aerial photographs the nearest noise sensitive locations have been identified. The table below details these locations.

Table 1. Noise Assessment Locations

Receiver Location	Eastings	Northings	Distance to Turbine (m)
P1 Balhall Lodge	351273	764199	458
P2 Balhall Lodge Cottage / Balhall Crescent	351524	763807	864

The above locations have been measured to the nearest part of the properties curtilage from the proposed turbine.

4.3 Source Sound Power Levels

We have been provided with the sound power level and spectrum of the turbine at different operating speeds ranging from 6m/s to 10m/s (at 10m height above ground). Please refer to the Arcus Consulting noise information document dated December 2013.

In addition the document details the measured uncertainty at each wind speed. In order to account for uncertainty our assessment is based upon the uncertainty value multiplied by 1.645 as defined within the IOA Good practice guidelines.

Details of the sound power level and the uncertainties are included within the table below:

Table 2. NPS 100-24 Sound Power Level and uncertainties

Wind Speed at 10m Height (m/s)	Measured Sound Power Level (L_{WA})	Uncertainty (dB)	Uncertainty x 1.645 (dB)	Resultant Sound Power Level (L_{WA})
6	87.9	0.6	1.0	88.9
7	89.4	0.6	1.0	90.4
8	90.3	0.6	1.0	91.3
9	90.9	0.6	1.0	91.9
10	91.3	0.5	0.8	92.1

The octave band spectrum detailed within the documentation has been normalised to correspond to the A-Weighted sound power level inclusive of uncertainty.

Details of sound power levels and octave spectra used within our noise model are included within the table below:

Table 3. NPS 100-24 Sound Power Level

Wind Speed at 10m Height (m/s)	A-Weighted SWL Octave Band Centre Frequencies								A-weighted SWL
	63	125	250	500	1000	2000	4000	8000	
6	67.1	75.4	81.0	83.9	83.6	80.0	74.9	68.6	88.9
7	68.6	76.9	82.5	85.4	85.1	81.5	76.4	70.1	90.4
8	69.5	77.8	83.4	86.3	86.0	82.4	77.3	71.0	91.3
9	70.1	78.4	84.0	86.9	86.6	83.0	77.9	71.6	91.9
10	70.3	78.6	84.2	87.1	86.8	83.2	78.1	71.8	92.1

4.4 Noise Prediction Methodology

We have undertaken calculations of the noise prediction from the proposed wind turbine. The method of calculation is in accordance with ISO 9613-2:1996 *"Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation"*.[6]

The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level and reducing the noise level by a number of attenuation factors according to the following:

Predicted Octave Band Noise Level = $L_w - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$

Details of each attenuation measure are highlighted as follows:

A_{geo} – Geometrical Divergence
The noise level of the turbine will be attenuated by spherical spreading into space. The degree of attenuation will be dependent upon the distance from the source.

A_{atm} – Atmospheric Absorption
Atmospheric absorption is where the sound energy is absorbed by the atmosphere and converted into heat. Our calculations have utilised the attenuation factors at 10°C and 70% humidity.

A_{gr} – Ground Absorption
When sound is propagating, attenuation will occur due to interference of reflected sound off the ground with the sound directly from source to receiver. These losses are dependent upon the type of ground the sound is propagating over. The ISO standard defines the ground absorption with a variable G which varies between 0 for 'hard' ground (includes paving, water, ice, concrete & any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). Our calculations have assumed that the ground would have a G=0.5 and a receiver height of 4m.

A_{bar} – Barrier Attenuation
Noise propagation will be reduced due to the presence of a solid barrier between source and receiver. Due to the turbine heights we have not included any shielding within our noise propagation calculations for the other receiver locations.

A_{misc} – Miscellaneous
The ISO standard provides an allowance for the attenuation through trees, foliage, and other effects. These attenuation measures have not been applied within our calculations.

It should be noted that the ISO 9613 method predicts noise levels likely to occur under conditions favourable to noise propagation i.e. downwind or under a moderate ground-based temperature inversion that may occur at night. Therefore the reported wind turbine noise level assumes a worst case prevailing wind direction.

In addition all calculations have been based a 2dB correction to adjust the calculated L_{Aeq} to L_{A90} as required by ETSU – R – 97.

4.5 Feature Correction

ETSU–R–97 provides a method for adding penalties should the noise level from the turbine be deemed to be tonal. It should be noted that the ETSU-R-97 method can only be applied to installed turbines at the proposed site location and can not be inferred from other installed turbines where site specific factors, such as background masking noise, will be different. However we have inspected manufacturer's data to determine if the turbines exhibit tonality.

Noise literature for the Northern Power turbines have identified tonal noise levels at varying wind speeds which may require the inclusion of a feature correction as specified within ETSU-R-97. Details of the identified tonal audibility levels and the required feature correction summarised as follows:

Table 4. NPS 100-24 Tonal Penalties

Wind Speed at 10m Height (m/s)	Sound Power Level (L_{WA})	Tonal Audibility $\Delta_{a,k}$ (dB)	Tonal Penalty (dB)	Effective Sound Power Level (L_{WA})
6	88.9	6.0	4.6	93.5
7	90.4	5.4	4.1	94.5
8	91.3	4.1	3.1	94.4
9	91.9	3.0	2.3	94.2
10	92.1	1.1	0	92.1

All our calculations will be based upon the sound power level inclusive of tonal penalties at 7m/s as a worst case.

4.6 Calculation Results

The table below details the results of the noise modeling.

Table 5. Noise level prediction upto 10m/s

Assessment location	Predicted noise level (dB L_{A90})
P1 Balhall Lodge	27.9
P2 Balhall Lodge Cottage / Balhall Crescent	21.4

The results above indicate that the proposed turbine does not exceed the simplified noise criteria detailed within ETSU-R-97

5.0 CUMULATIVE NOISE IMPACT

The noise limits detailed within ETSU – R – 97 are for all wind energy developments that residential properties are exposed to; therefore we have undertaken additional calculations on these turbines to determine the cumulative noise level.

Calculations have been undertaken on the existing Northern Power 100kW turbine 245m to the east of the proposed development. We have been informed that the grid co-ordinates of this turbine are E351072, N764272. Please refer to Angus Council planning reference 10/01133/FULL.

As part of the Planning Consent, noise conditions have been specified for the turbine. These are detailed as follows:

3 *At any property lawfully existing at the date of this planning permission the rating level of noise emissions, including any tonal correction, from the wind turbine, when measured in accordance with the guidance in "The assessment and Rating of noise from wind farms, ETSU-R-97", shall not exceed the LA90 noise limits shown in table A below.*

Table A
Location LA90 (10 min) Noise limit at a standardised wind speed of up to10m/s at 10m height
Balhall Lodge 39dBA
Any other location 35dBA

It should also be noted that the IOA good practice guidelines provide an indication of when cumulative noise impacts need to be considered. Where it states the following within Section 5.1.4:

"During scoping of a new wind farm development consideration should be given to

wind farm produces noise levels within 10 dB of any existing wind farms at the same receptor location, then a cumulative noise impact assessment is necessary."

The implications of this is that should the prediction of the proposed wind turbine be 10 dB(A) or more below the existing wind farm noise level then it will have an negligible impact on the noise level at the receiver locations.

Reviewing the predicted turbine levels detailed within Table 5 it can be seen that the prediction of noise emissions from the proposed turbine will be more than 10dB below the consent level of the existing turbine at all noise sensitive properties surrounding the proposed development. The proposed turbine will therefore have a negligible impact on the existing consented noise level.

6.0 DISCUSSION OF RESULTS

The results detailed within Table 5 indicate that the predicted noise levels have not exceeded the simplified noise criteria of 35dB L_{A90} at all noise sensitive properties surrounding the proposed turbine.

In addition the noise predictions of the turbine will more than 10dB below the consent noise levels of the existing turbine at the site. The proposed turbine will therefore have a negligible impact on the existing noise climate.

References

[1] Scottish Government online planning guidance documents. Onshore Wind Turbines dated December 2013
http://www.scotland.gov.uk/Topics/Built-Environment/planning/National-Planning-Policy/themes/renewables/Onshore

[2] ETSU-R-97, The Assessment and Rating of Noise from Wind Farms
ETSU for the Department of Trade Industry, 1996

[3] Institute of Acoustics, A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise, Issue 1, May 2013

[4] W/45/00656/00/00, The measurement of Low Frequency Noise at Three UK Windfarms. Department of Trade and Industry, 2006

[5] DEFRA NANR233, Research into amplitude modulation of wind turbine noise, University of Salford, 2007

[6] ISO 9613-2, Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation
International Organization for Standardization, 1996

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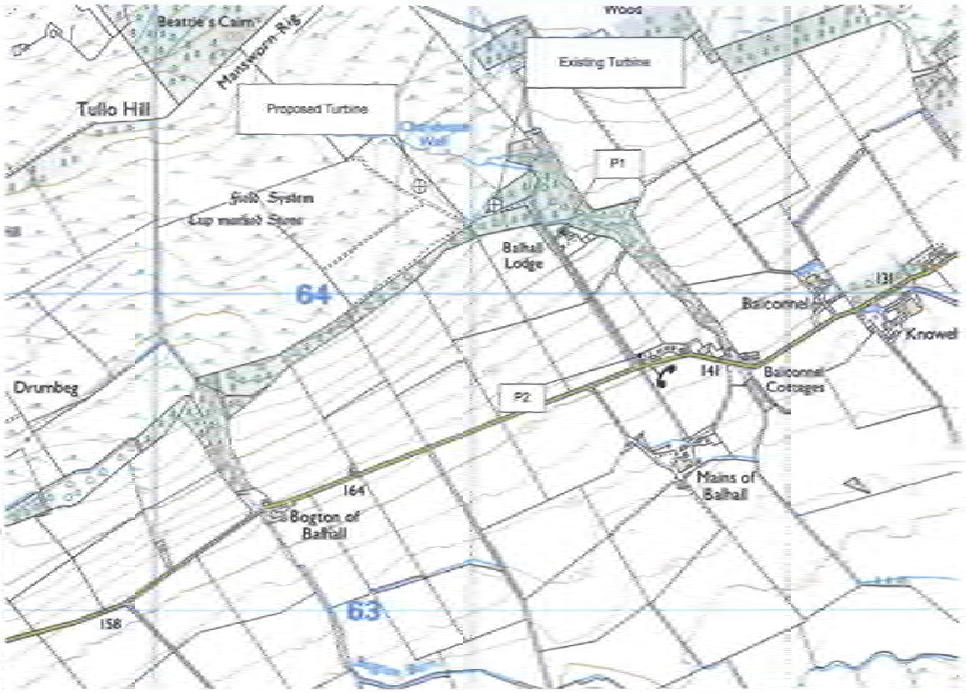
Appendix A – Site Layout



Proposed Turbine at Balhall Lodge

Site Layout

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Appendix B – Definition of Acoustic Terms

The decibel
This is the basic unit of noise, denoted dB.

A Weighting
This is a weighting process which simulates the human ear's different sensitivity at different frequencies. A weighting can be shown two typical ways, 50 dB(A) L_{eq} or 50 dB L_{Aeq}. Both mean the same thing. (See below for a definition of L_{eq}). The dB(A) level can be regarded as the overall level perceived by human beings.

L_{eq} and $L_{eq(s)}$
This is the equivalent continuous noise level which contains the same acoustic energy as the actual time-varying sound. In other words it is a kind of average noise level. It is denoted dB L_{eq} or, for A-weighted figures dB(A) L_{eq} or dB L_{Aeq}. It can also be expressed in terms of frequency analysis (see later). $L_{eq(s)}$ is the sample L_{eq} level.

L_n
This is the level exceeded for n% of the time. It is denoted dB L_n or, for A-weighted figures dB(A) L_n or dB $_{LAn}$. It can be expressed in terms of frequency analysis (see later). L_{90} is the level exceeded for 90% of the time and is a measure of the lowest level typically reached. L_{10} is the level exceeded for 10% of the time and is the highest level typically reached. L_{50} is the level exceeded for 50% of the time and, mathematically, it is the median.

L_{max}
This is the maximum level reached during a measurement period. The "time constant", or the ability of the equipment to respond to impulses is usually expressed along with it, e.g. "Fast", "Slow", etc. It is denoted dB L_{max} or, for A-weighted figures dB(A) L_{max}, dB L_{Amax}, etc. It can also be expressed in terms of frequency analysis.

Frequency Analysis
Whereas dB(A) gives a very useful overall figure, it has its limitations in that it cannot be used to model or predict the effect of noise control and mitigation as this nearly always has radically different performance at different frequencies.

Frequency analysis expresses an overall noise level at each frequency or band of frequencies in the audible range. Octave band analysis divides the audible range into 10 bands from 31.5 Hz to 16 kHz and the noise level in each band can be expressed in any form e.g. L_{eq}, L_{90}, L_{max} etc. One third octave band analysis uses 30 bands.

Narrow band analysis takes the process to resolutions of less than 1 Hz. This is useful for identifying the existence of tones (whines, hums, etc.) and in pin-pointing the sources.

Appendix C – Calculation Tables

Job Number:	**8065**
Client:	**Harmony Energy**
Project:	**Balhall Lodge Wind Turbine**
Calculation:	**Proposed Turbine noise propagation at 10m/s at 10m wind speed**

Frequency (Hz)	31	63	125	250	500	1000	2000	4000	8000
Source Data									
Measured Spectrum (A-Weighted)	55.2	69.5	77.8	83.4	86.3	86.0	82.4	77.3	71.0
Calculated Broadband (dBA)	91.3								
Measured Broadband (dBA)	89.4								
Reported Uncertainty (dB)	0.6								
Uncertainty Correction (dB)	1.0								
Tonality Correction (dB)	4.1								
Resultant Sound Power Level (dBA)	94.5								
Normalised Turbine SWL (dBA)	58.4	72.7	81.0	86.6	89.5	89.2	85.6	80.5	74.2
Balhall Lodge									
Source - Reciever Horizontal Distance	458 m								
Source Height	37 m								
Reciever Height	4 m								
Source - Reciever Distance	460 m								
Attenuation / dB:									
Divergence: A_{div}	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2
Atmospheric Absorption: A_{atm}	0.0	0.0	0.2	0.5	0.9	1.7	4.5	15.1	53.8
Ground Effects: A_{gr}	-3.0	-3.0	0.1	-0.5	-1.5	-1.5	-1.5	-1.5	-1.5
Total: A_{total}	61.2	61.3	64.6	64.2	63.6	64.4	67.2	77.8	116.5
Resultant Noise Level	-2.9	11.4	16.4	22.4	25.9	24.7	18.4	2.7	-42.3
dB (A) L_{Aeq}	30								
dB (A) L_{A90}	27.9								
Balhall Lodge Cottage									
Source - Reciever Horizontal Distance	864 m								
Source Height	37 m								
Reciever Height	4 m								
Source - Reciever Distance	864 m								
Attenuation / dB:									
Divergence: A_{div}	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7
Atmospheric Absorption: A_{atm}	0.0	0.1	0.3	0.9	1.6	3.2	8.4	28.4	101.1
Ground Effects: A_{gr}	-3.0	-3.0	0.4	-0.5	-1.5	-1.5	-1.5	-1.5	-1.5
Total: A_{total}	66.7	66.8	70.5	70.1	69.9	71.4	76.6	96.6	169.4
Resultant Noise Level	-8.4	5.9	10.5	16.5	19.6	17.7	9.0	-16.1	-95.2
dB (A) L_{Aeq}	23								
dB (A) L_{A90}	21.4								

Appendix D – Source Noise Data

ARCUS

NORTHERN POWER SYSTEMS 100-24

NOISE INFORMATION

December 2013

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Table of Contents

1 INTRODUCTION

This document has been prepared by Arcus Consultancy Services Ltd (Arcus) on behalf of Northern Power Systems (NPS). It presents a summary of current (December 2013) noise emission data[1] for the Northwind NPS 100-24 wind turbine with a hub height of 36.8 m, and an interpretation of this information for the purposes of supporting UK planning applications.

2 NOISE MEASUREMENT TEST RESULTS

Measurements of the noise emissions of the NPS 100-24 wind turbine located at Ft. Yates, North Dakota were carried out in December 2013 by The Cadmus Group Ltd (Cadmus) in accordance with IEC 61400-11. The results of these measurements are summarised in Tables 1 and 2.

Table 1: Summary of Noise Measurement Test Results, NPS 100-24, 36.8 m hub height

Standardised 10 m Integer Wind Speed, ms^{-1}	**6**	**7**	**8**	**9**	**10**
Apparent Sound Power Level, L_{WA}, dB	87.9	89.4	90.3	90.9	91.3
Total Uncertainty of Apparent Sound Power Level, dB	0.6	0.6	0.6	0.6	0.5
Tonal Audibility for Tone with Highest Audibility[2], $\Delta L_{a,k}$, dB	6.0	5.4	4.1	3.0	1.1
Frequency of Tone, Hz	5024	5024	5024	5024	4976

Table 2: Worst Case Octave Band Sound Power Spectrum for Wind Speed of 12.5 ms^{-1}, 36.8 m hub height

Octave Band Centre Frequency, Hz	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Sound Power Level, L_{WA}, dB	55.2	69.5	77.8	83.4	86.3	86.0	82.4	77.3	71.0

3 UK PLANNING ASPECTS OF WIND TURBINE NOISE

The de facto standard for assessing the effects of noise from wind turbines in the UK is ETSU-R-97[3], as recommended by EN-3 in England and Wales, the Scottish Government's web-based planning information on onshore wind turbines (last updated July, 2013) and PPS18 in Northern Ireland. In addition, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*[4] ('the GPG') was published by the Institute of Acoustics in May 2013 and has been formally endorsed by DCLG in its *Planning Practice Guidance for Renewable and Low Carbon Energy*[5] as current good practice.

ETSU-R-97 recommends the application of external noise limits at the nearest noise-sensitive properties. These are set in relation to wind speed[6] and are based on a combination of fixed lower limits and a margin of 5 dB above the prevailing background noise level. Both background noise and wind turbine noise levels are expressed as $L_{A90,10min}$, with the turbine noise $L_{A90,10min}$ assumed to be 2 dB lower than its $L_{Aeq,10min}$. All noise levels in this document are therefore expressed in this form, unless stated otherwise.

[1] Wind turbine Acoustic Noise Test Report, Northwind NPS-100-24 at Ft. Yates, North Dakota, Cadmus Group Report, Issue Date December 17, 2013

[2] Other tones are present, but are not considered to be significant for planning purposes.

[3] ETSU-R-97: The Assessment and Rating of Noise from Wind Farms, ETSU for the DTI, 1996.

[4] A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind turbine Noise, IOA, 2013.

[5] [illegible]

[6] Measured at 10m height at the location of the turbine(s)

During the day (0700 to 2300) the noise limits are defined as the higher of a fixed lower limit of 35 to 40 dB(A) and 5 dB above prevailing background noise levels measured during defined quiet daytime periods (Monday to Friday 1800 to 2300, Saturdays 1300 to 2300 and Sundays 0700 to 2300).

At night (2300 to 0700), the noise limits are defined as the higher of 43 dB(A) and 5 dB above prevailing background noise levels measured during the same time period.

Where the occupier of a property has a financial interest in the development, the fixed lower noise limit for both daytime and night-time may be increased to 45 dB(A) and consideration may be given to increasing the margin above background noise.

A simplified noise criterion is also defined, where, if turbine noise is limited to no more than 35 dB(A) at wind speeds (at 10 m above ground level) of up to 10 ms^{-1}, consideration of background noise levels is unnecessary. This also implies a simplified criterion of 45 dB(A) for properties where the occupier has a financial interest.

ETSU-R-97 recommends the addition of penalties, where tonal noise of audibility 2 dB or more are present, ranging from 1.5 dB at a tonal audibility of 2 dB to 5 dB at audibility of 6.5 dB or more. Table 3 details the tonal penalties applicable to the NPS 100-24 and resulting effective sound power levels.

With regards to uncertainty, the GPG states that '*the results of a test made in accordance with the IEC 61400-11 standard, including a reported test uncertainty σ...with the addition of a margin equal to 1.645 σ can be used.*' Therefore, in accordance with the GPG, the uncertainties specified in Table 1 have been multiplied by 1.645.

Table 3: Tonal Penalties and Effective Sound Power Levels

Standardised 10 m Integer Wind Speed, ms^{-1}	**6**	**7**	**8**	**9**	**10**
Apparent Sound Power Level, L_{WA}, dB	87.9	89.4	90.3	90.9	91.3
Total Uncertainty , dB, (1.645 σ)	1.0	1.0	1.0	1.0	0.8
Tonal Audibility[7] for Tone with Highest Audibility[i], $\Delta L_{a,k}$, dB	6.0	5.4	4.1	3.0	1.1
Applicable Tonal Penalty, dB	4.6	4.1	3.1	2.3	0
Effective Sound Power Level, L_{WA}, dB	93.5	94.5	94.4	94.2	92.1

4 CALCULATED NOISE IMMISSION LEVELS

Noise immission[8] levels for a range of distances have been calculated from the test results presented above, using the method specified in ISO 9613-2:1996[9], with model input parameters in accordance with the GPG as follows:

- Acoustically mixed ground (G=0.5);
- 70% relative humidity;
- Temperature of 10°C
- No barrier attenuations; and
- Subtraction of 2 dB from the L_{Aeq} level to provide the required $L_{A90,10min}$.

The results are shown in Chart 1 and Table 4.

[9] ISO (1996). ISO 9613-2:1996 Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation

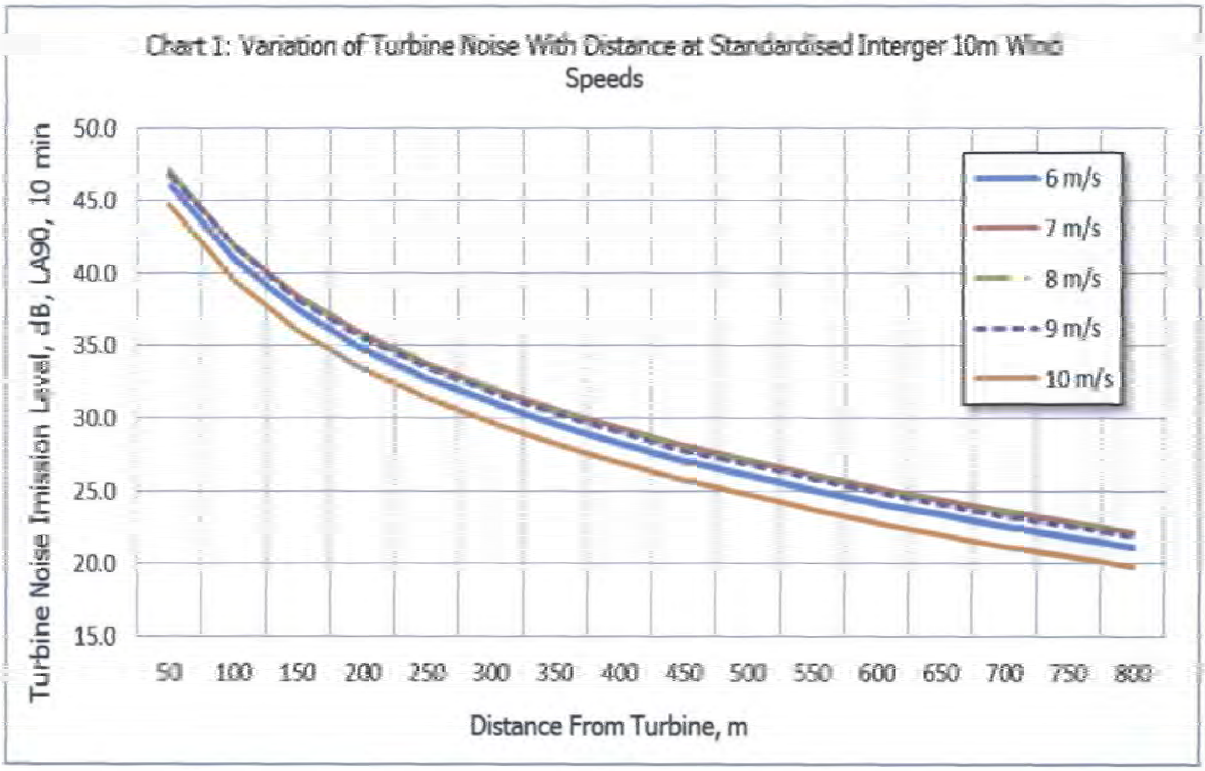


Table 4: Variation of Turbine Noise with Distance at Standardised Integer 10 m Wind Speeds

Standardised 10 m Wind Speed, ms^{-1}	Distance from Turbine, m															
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
	Noise Immission Level, dB, $L_{A90,10min}$															
6	46.1	40.9	37.4	34.8	32.8	31.1	29.6	28.3	27.1	26.1	25.1	24.2	23.4	22.6	21.9	21.2
7	47.1	41.9	38.4	35.8	33.8	32.1	30.6	29.3	28.1	27.1	26.1	25.2	24.4	23.6	22.9	22.2
8	47.0	41.8	38.3	35.7	33.7	32.0	30.5	29.2	28.0	27.0	26.0	25.1	24.3	23.5	22.8	22.1
9	46.8	41.9	38.1	35.5	33.5	31.8	30.3	29.0	27.8	26.8	25.8	24.9	24.1	23.3	22.6	21.9
10	44.7	39.5	36.0	33.4	31.4	29.7	28.2	26.9	25.7	24.7	23.7	22.8	22.0	21.2	20.5	19.8

5 INDICATIVE NOISE ASSESSMENT FOR SINGLE TURBINE

Table 5 presents indicative typical background noise levels for a typical rural location with minimal sources of background noise, which are equally applicable to day or night, along with derived ETSU-R-97 noise limits.

Table 5: Indicative Prevailing Background Noise Levels and Derived Noise Limits for Quiet Rural Location

Wind Speed at 10 m, ms^{-1}	6	7	8	9	10
Indicative Background Noise Level, dB, $L_{A90,10min}$	30	32	35	37	39
Quiet Daytime Noise Limit, dB, $L_{A90,10min}$	35	37	40	42	44
Night-time Noise Limit, dB, $L_{A90,10min}$	43	43	43	43	44

Based upon Table 5 and the results presented in Chart 1 and Table 4:

- The simplified 35 dB(A) criterion would be met at distances of 220 m and greater;
- A simplified criterion of 45 dB(A) for financially involved properties would be met at distances of 67 m and greater; and
- It is likely that the full ETSU-R-97 noise limits would be met in typical rural locations at distances of 196 m and greater.

In locations with additional sources of background noise, smaller distances may be acceptable; in these circumstances a site-specific background noise survey, carried out in accordance with ETSU-R-97 and the GPG, is recommended.

Proposed developments of more than one turbine and/or those requiring the consideration of cumulative wind turbine noise effects are likely to require greater separation distance to nearest properties, and should therefore be subject to individual, site-specific assessment.

6 DISCLAIMER

The above information has been prepared based on noise emission measurements undertaken by The Cadmus Group Ltd. Arcus accept no responsibility for the accuracy of the test measurements and subsequent results. This report has been developed for guidance only, based upon current best-practice methods. Arcus accept no responsibility for its use by third parties or its applicability to any particular situation.

SECTION 6

AC30

Northern
POWER SYSTEMS

NPS 100-24 Class III/S Wind Turbine General Specifications

A05450
July 2012

Revision History

Revision	Description of Change
A	Release for Internal Use
B	Release for Customer Use
C	Reformatting for clarity regarding Class III/S
D	Added 23m tower

Northern
POWER SYSTEMS

Contents

Northern
POWER SYSTEMS

1 Introduction

This document presents key specifications for the Northern Power Systems NPS 100-24 Class III/S wind turbine with a 24 meter rotor, either 37 or 30 meter tower, and 50 Hz or 60 Hz operation. Specifications for the NPS 100-24 are provided in Table 1, with certain details deferred to the appropriate section(s) of this document.

Table 1 NPS 100-24 Class III/S General Information

General Configuration	
Model	NPS 100-24
Design Class	IEC WTGS[1] III/S(see Table 3 for details)
Power Regulation	Variable speed; stall control
Orientation	Upwind
Yaw Control	Active
Number of Blades	3
Rotor Diameter	23.6 meters
Performance	
Rated Electrical Power at standard conditions	95 kW
Rated Shaft Speed (Standard Turbine)	51.4 RPM
Cut-in Wind Speed	3.0 meters/second (7 miles per hour)
Rated Wind Speed	14.0 meters/second (31 miles per hour)
Cut-out Wind Speed	25.0 meters/second (56 miles per hour)
Noise	55 dBA at 40 meters from nacelle (55 dBA at 131')

[1] International Electrotechnical Commission Wind Turbine Generating System, 61400-1 ed2

Northern
POWER SYSTEMS

Control System			
Controller Type	DSP-based multi-processor embedded platform		
Monitoring System	SmartView® Monitoring System		
Safety System	Designed to IEC 61400-1ed2, redundant braking		
Communications Protocol	Modbus TCP		
Tower System	**37 Meter option**	**30 Meter Option**	**23 Meter Option**
Tower Height	35.7 meters (117')	29.0 meters (95.1')	21.5 meters (71')
Hub Height	36.8 meters (120.7')	30.1 meters (98.8')	22.6 meters (74')
Tower Configuration	3 section tubular monopole, nested for shipping		2 section tubular monopole, nested for shipping
Unit Mass			
Nacelle and Rotor Mass	8,000 kilograms (17,600 pounds)		
Tower Mass (37 meter option)	14,000 kilograms (30,800 pounds)		
Tower Mass (30 meter option)	14,000 kilograms (30,800 pounds)		
Tower Mass (23 meter option)	8,400 kilograms (18,500 pounds)		
Standard Conditions			
Elevation	Sea Level		
Air Temperature	15 degrees Celsius (59 degrees Fahrenheit)		
Air Density	1.225 kilograms per cubic meter (13.08 ft^3/lb)		

2 Environmental Specifications

This section provides the environment specifications for the NPS 100-24 turbine.

Table 2 Ambient Turbine Conditions

	Standard Turbine
Operational	-20°C to 50°C (-4 °F to 122°F)
Storage	-40°C to 55°C (-40 °F to 131°F)
Maximum Elevation	1,000 meters above sea level

Table 3 IEC WTGS Conditions

Parameter	**Class III/S**
Annual Average Wind Speed at hub height, V_{avg} (maximum annual average)	7.0 meters/second (16 miles/hour)
Reference Wind Speed at hub height, V_{ref} (10 minute average)	37.5 meters/second (84 miles/hour)
Extreme Wind Speed at hub height (3 second gust, 50 year recurrence period) V_{e50}	52.5 meters/second (117 miles/hour)
Characteristic turbulence intensity at 15 m/s, I_{15}	0.18 (defined by IEC 61400-1ed3)
Design lifetime	20 years

Northern POWER SYSTEMS

3 Power Curve and Energy Production

The following power curve is intended for use in estimating annual energy production. This curve is based on performance using a 37m tower in air at standard density. Annual energy calculations assume a Rayleigh wind speed distribution and 100% turbine availability.

Power Curve Data	
Vm	Power
(m/s)	(kWe)
1	-0.6
2	-0.6
3	0.9
4	5.0
5	11.7
6	22.2
7	35.5
8	49.9
9	63.4
10	74.7
11	83.5
12	89.7
13	93.7
14	95.5
15	95.2
16	92.5
17	87.7
18	81.1
19	73.8
20	67.3
21	62.4
22	57.7
23	54.0
24	50.6
25	47.4

Annual Energy Production (AEP)	
Annual Average Wind Speed	Annual Output
(m/s)	(MWh)
5.0	170
5.5	210
6.0	250
6.5	290
7.0	330

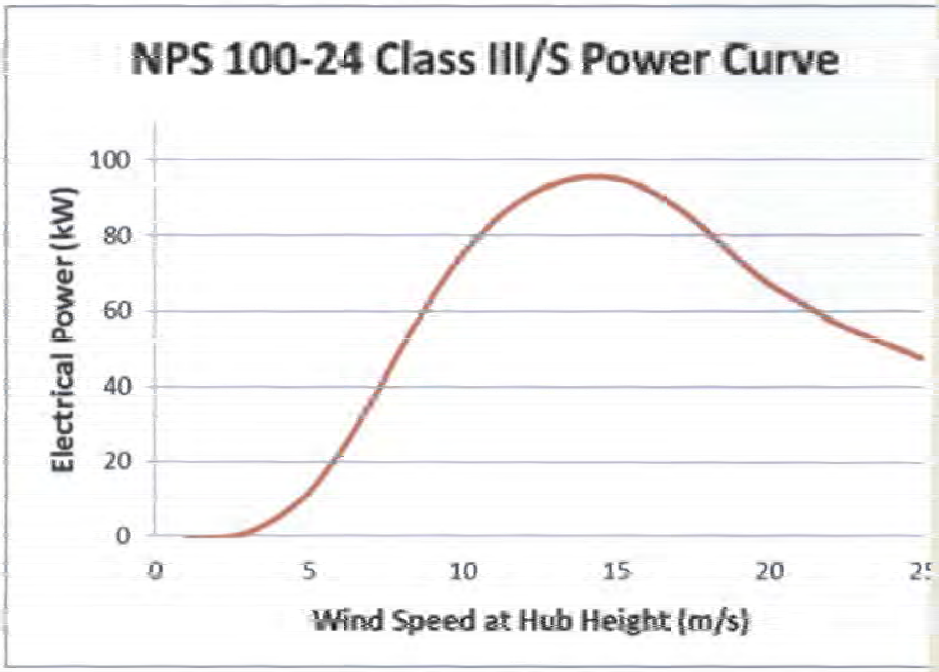


Figure 1: NPS 100-24 Power Curve

4 Electrical Specifications

4.1 Section Overview

This section defines the electrical specifications for the NPS 100-24 wind turbine. NPS 100-24 wind turbine scope of supply includes turbine equipment up to and including the fused disconnect and junction box located at the bottom of the tower. Specifications herein refer to turbine output at the base of the tower.

4.2 Turbine Output Specifications

These specifications refer to the base of the tower and the fused disconnect

Table 4 NPS 100-24 Output Specifications

3-Phase Output Voltage	480 VAC (+/-10%)
Frequency	50 Hz (+/- 5 Hz) or 60 Hz (+/- 5 Hz)
Nominal Active Power Output	95 kW
Maximum Reactive Power	+/-45 kVAR

Northern
POWER SYSTEMS

5 Disclaimers and Reservations

Weather and altitude beyond standard conditions may affect system performance. High turbulence can reduce system performance.

The turbine controls may safely stop operation or delay startup when ambient conditions appear to be within specification. Various safety, environmental and situational variables will cause the turbine's control system to behave this way.

Following periods of grid outage and/or extended low temperatures, a time allowance for warm-up must be expected; the time will vary based on ambient conditions and the duration of the conditions.

A variety of conditions can affect turbine performance, including but not limited to maintenance, site conditions, climatic conditions and electrical grid conditions. These general specifications do not guarantee performance or operability at a particular site.

Turbines may be installed in coastal environments, but should not be subjected to sea spray. The lifetime maintenance costs of a turbine will vary based on site conditions, including wind, precipitation, temperature, and corrosivity of the air. Corrosivity of the air varies based on the local atmospheric conditions at the site including time of wetness, acidity, and salinity.

The values stated in metric (SI) units shall be regarded as the standard. The inch-pound (IP) units shown in parenthesis shall be for reference only. Northern Power Systems is continually developing product upgrades, modifications and improvements, and as a result reserves the right to change or alter these specifications at any time.

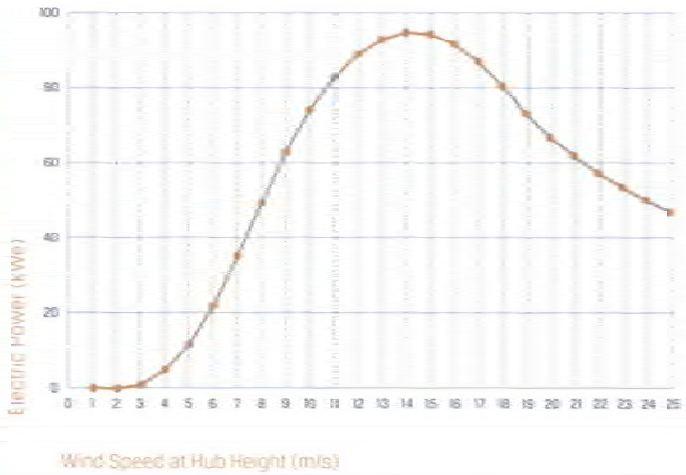
SECTION 7

AC30

Specifications

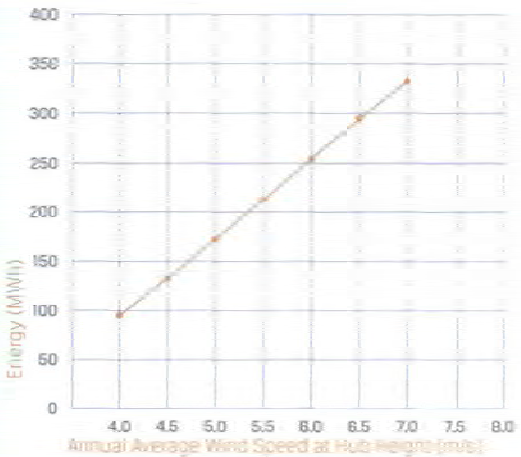
Northern Power® 100-24
IEC Class IIIS

Power Curve: 24-Meter Rotor Standard Air Density (1.225 kg/m³)



Wind Speed (m/s)	Power (kWe)	Wind Speed (m/s)	Power (kWe)
1	0	14	95.5
2	0	15	95.2
3	0.9	16	92.5
4	5.0	17	87.7
5	11.7	18	81.1
6	22.2	19	73.8
7	36.5	20	67.3
8	49.9	21	62.4
9	63.4	22	57.7
10	74.7	23	54.8
11	83.5	24	50.6
12	89.7	25	47.4
13	93.7		

Annual Energy Production*: 24-Meter Rotor Standard Air Density, Rayleigh Wind Speed Distribution



Average Annual Wind Speed (mph)	Average Annual Wind Speed (m/s)	Annual Energy Output (MWh/yr)
11	5.0	170
12	5.5	210
13	6.0	250
15	6.5	290
16	7.0	330

*Annual energy production estimates assume standard conditions, 100% availability and no losses.

Northern POWER SYSTEMS

Specifications

GENERAL CONFIGURATION	DESCRIPTION
Model	Northern Power® 100-24
Design Class	IEC WTGS III/S air density 1.225 kg/m³ average annual wind below 7 m/s (16 mps), 50-yr peak gust below 52.5 m/s (117 mph)
Design Life	20 years
Hub Height Options	37 m (121 ft) / 30 m (98 ft)
Tower Type	Tubular steel monopole
Orientation	Upwind
Rotor Diameter	24 m (78 ft)
Power Regulation	Variable speed, stall control
Certifications	CE compliant

PERFORMANCE	DESCRIPTION (standard conditions: air density of 1.225 kg/m³, equivalent to 15°C (59°F) at sea level)
Rated Electrical Power	95 kW, 3 Phase, 480 VAC, 60/50 Hz
Rated Wind Speed	14 m/s (31 mph)
Maximum Rotation Speed	51.4 rpm
Cut-In Wind Speed	3.0 m/s (7 mph)
Cut-Out Wind Speed	25 m/s (56 mph)
Extreme Wind Speed	52.5 m/s (117 mph)

WEIGHT	DESCRIPTION
Rotor (24-meter) & Nacelle (standard)	8,000 kg (17,600 lbs)
Tower (37-meter)	14,000 kg (30,800 lbs)

DRIVE TRAIN	DESCRIPTION
Gearbox Type	No gearbox (direct drive)
Generator Type	Permanent magnet, passively cooled

BRAKING SYSTEM	DESCRIPTION
Service Brake Type	Two motor-controlled calipers
Normal Shutdown Brake	Generator dynamic brake and two motor-controlled calipers
Emergency Shutdown Brake	Generator dynamic brake and two spring-applied calipers

YAW SYSTEM	DESCRIPTION
Controls	Active, electromechanically driven with wind direction/speed sensors and automatic cable unwind

CONTROL/ELECTRICAL SYSTEM	DESCRIPTION
Controller Type	DSP-based multiprocessor embedded platform
Converter Type	Pulse-width modulated IGBT frequency converter
Monitoring System	SmartView remote monitoring system; ModBus TCP over ethernet
Power Factor	Set point adjustable between 0.9 lagging and 0.9 leading
Reactive Power	+/- 45 kVAR

NOISE	DESCRIPTION
Apparent Noise Level	55 dBa at 40 meters (131 ft)

ENVIRONMENTAL SPECIFICATIONS	DESCRIPTION
Temperature Range: Operational	-20°C to 50°C (-4°F to 122°F)
Temperature Range: Storage	-40°C to 55°C (-40°F to 131°F)
Lightning Protection	Receptors in blades, nacelle lightning rod and electrical surge protection
Icing Protection	Turbine designed in accordance with Germanischer Lloyd Wind Guidelines Edition 2003

All Specifications subject to change without notice.

SECTION 8

AC31

Northern
POWER SYSTEMS

January 23, 2013

Re: Northern Power® 100-24 wind turbine acoustic performance

To Whom It May Concern:

The NPS™ 100-24 wind turbine is the same equipment as the NPS 100-21, with blade extenders added to increase the rotor diameter. To keep structural, electrical, and acoustic performance within the design constraints of the original design, rotor speed is reduced to a maximum of 52 rpm, keeping the maximum blade-tip speed to the same 142 mph as the NPS 100-21. As the acoustic effects from blades are related to blade-tip speed and as all other acoustical characteristics of the NPS 100-24 are the same as those of the NPS 100-21, we expect the acoustic performance of the NPS 100-24 to match that of the NPS 100-21.

We encourage end users and developers to continue to use the existing NPS 100-21 acoustic data for their planning applications, confident that the acoustic performance of the NPS 100-24 will not exceed those values.

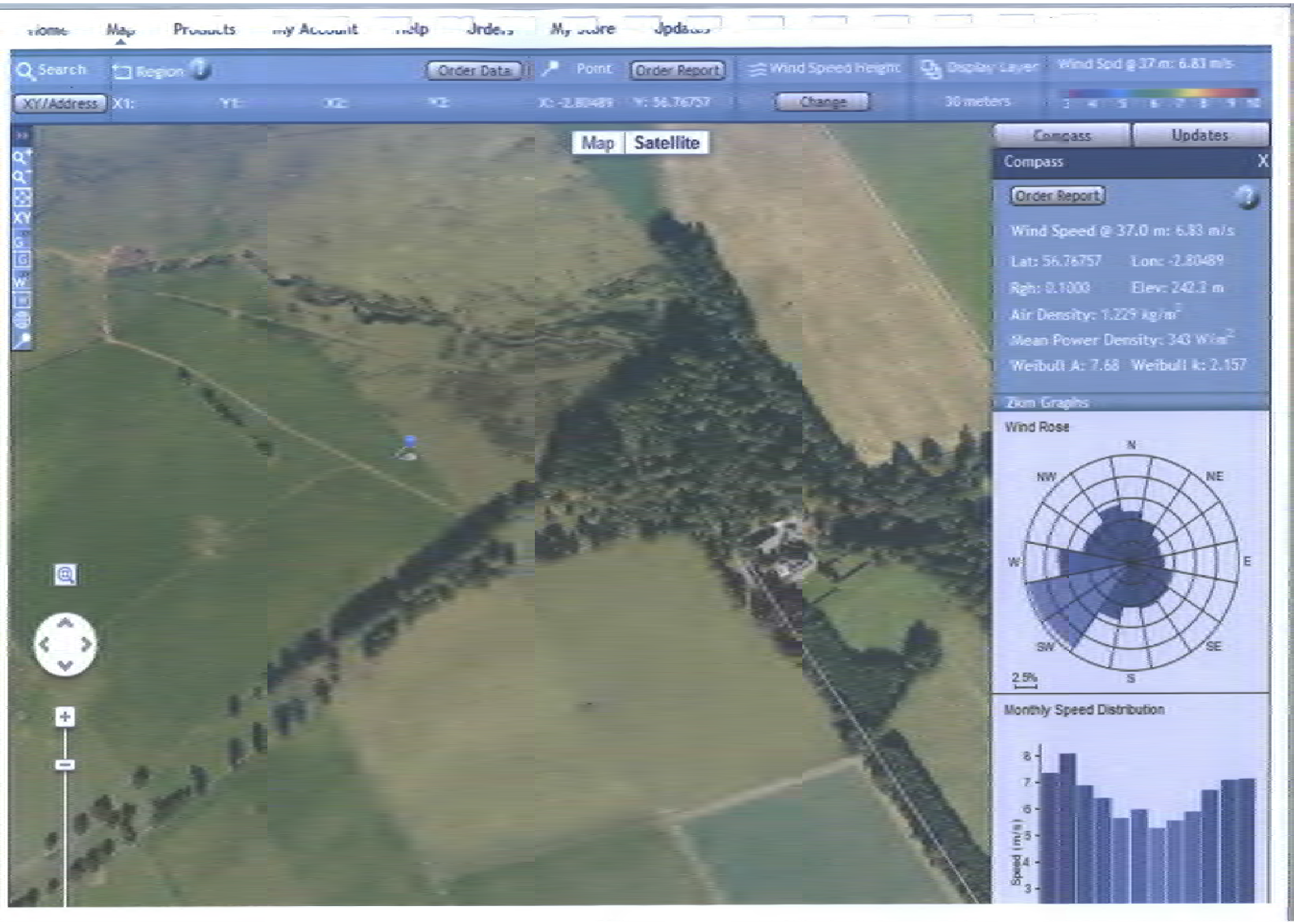
Northern Power continues efforts to optimize performance of the NPS 100-24, including reducing sound output. Modifications with the potential to reduce sound output will be followed by testing to substantiate such reductions.

Respectfully submitted,

[redacted]

Chris McKay
Director, Engineering
Northern Power Systems

SECTION 9

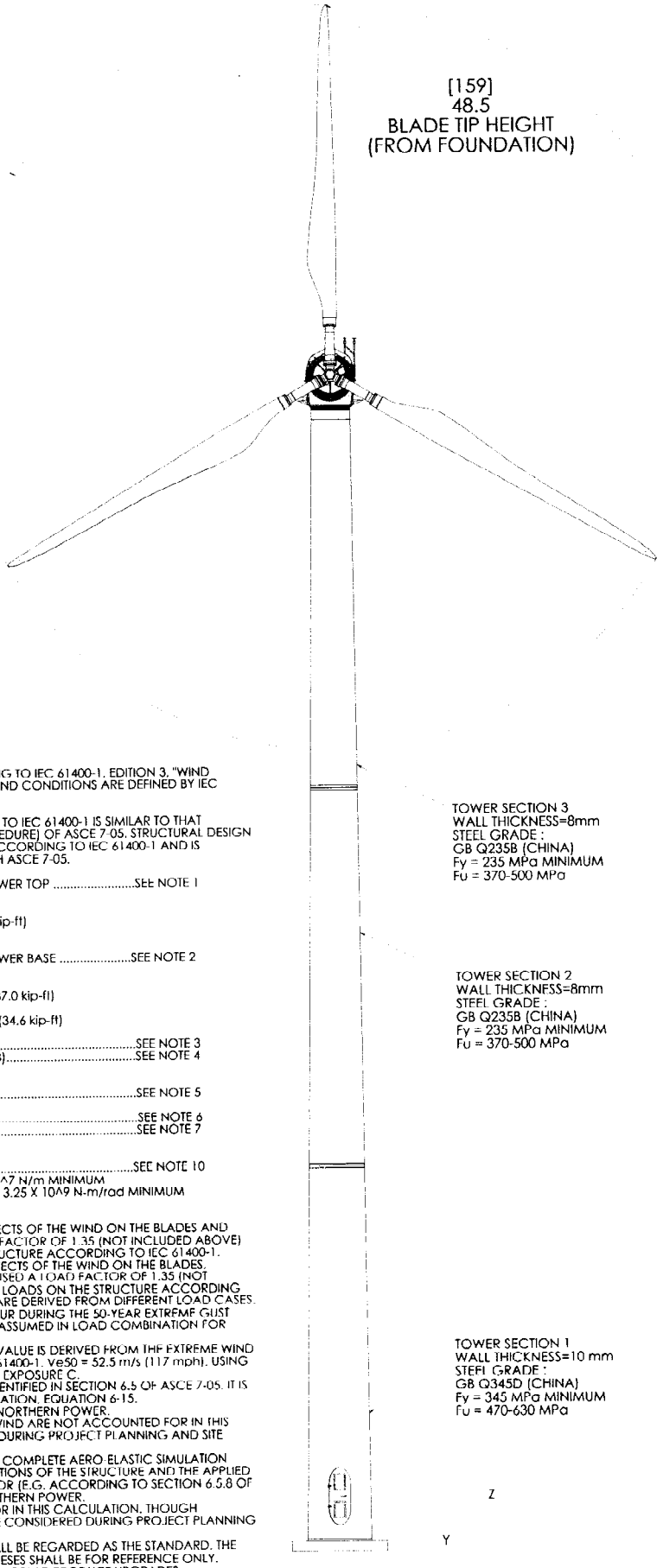

Map
Products
Search
Region
Order Data
Point
Order Report
Wind Speed Height
Display Layer
Wind Spd @ 37 m: 6.83 m/s
XY / Address
Change
30 meters
Map
Satellite
Compass
Updates
Compass
Order Report
Wind Speed @ 37.0 m: 6.83 m/s
Lat: 56.76757
Lon: -2.80489
Elev: 242.2 m
Air Density: 1.229 kg/m³
Mean Power Density: 343 W/m²
Weibull A: 7.68
Weibull k: 2.157
Zkm Graphs
Wind Rose
N
NE
E
SE
S
SW
W
NW
2.5%
Monthly Speed Distribution
Speed (m/s)

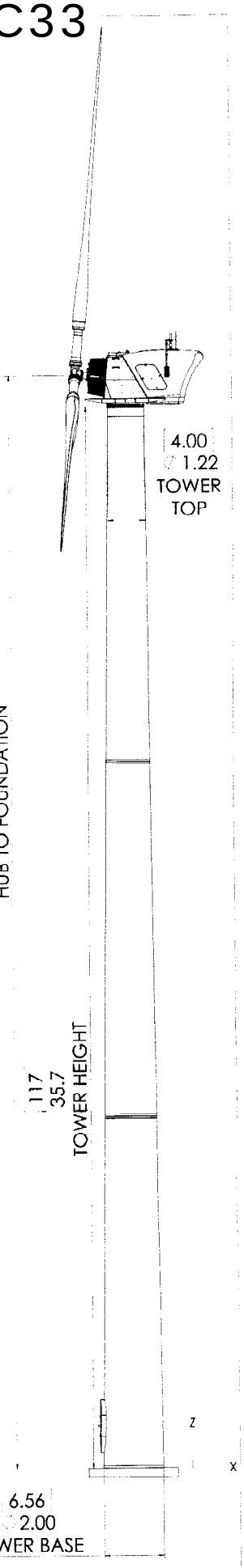
SECTION 10

AC33

77
23.6
ROTOR DIAMETER

[159]
48.5
BLADE TIP HEIGHT
(FROM FOUNDATION)





TOWER SECTION 3
WALL THICKNESS=8mm
STEEL GRADE :
GB Q235B (CHINA)
Fy = 235 MPa MINIMUM
Fu = 370-500 MPa

TOWER SECTION 2
WALL THICKNESS=8mm
STEEL GRADE :
GB Q235B (CHINA)
Fy = 235 MPa MINIMUM
Fu = 370-500 MPa

TOWER SECTION 1
WALL THICKNESS=10 mm
STEEL GRADE :
GB Q345D (CHINA)
Fy = 345 MPa MINIMUM
Fu = 470-630 MPa

STRUCTURAL DESIGN IS PERFORMED ACCORDING TO IEC 61400-1, EDITION 3, "WIND TURBINES - DESIGN REQUIREMENTS". EXTREME WIND CONDITIONS ARE DEFINED BY IEC WTGS CLASS IIIA.

TOWER TOP LOAD CALCULATION ACCORDING TO IEC 61400-1 IS SIMILAR TO THAT DESCRIBED BY SECTION 6.5 (ANALYTICAL PROCEDURE) OF ASCE 7-05. STRUCTURAL DESIGN INFORMATION USED BY NORTHERN POWER IS ACCORDING TO IEC 61400-1 AND IS PRESENTED BELOW IN A FORM CONSISTENT WITH ASCE 7-05.

CHARACTERISTIC (UNFACTORED) LOADS AT TOWER TOP .....SEE NOTE 1
- Fxy (Shear): 58.3 kN (13.1 kip)
- Fz (Weight): -78.5 kN (-17.6 kip)
- Mxy (Overturning Moment): 45.8 kN-m (33.8 kip-ft)
- Mz (Torsional Moment): 14.1 kN-m (10.4 kip-ft)

CHARACTERISTIC (UNFACTORED) LOADS AT TOWER BASE .....SEE NOTE 2
- Fxy (Shear): 112.0 kN (25.2 kip)
- Fz (Weight): 200.3 kN (-45.0 kip)
- Mxy (Overturning Moment): 3100.7 kN-m (2287.0 kip-ft)
- Mz (Torsional Moment): 14.1 kN-m (10.4 kip-ft)
- Mz Maximum (Torsional Moment): 46.9 kN-m (34.6 kip-ft)

BASIC WIND SPEED, V = 45.5 m/s (102 mph).....SEE NOTE 3
AIR DENSITY, ρ = 1.225 kg/m^3 (0.0765 lbm/ft^3).....SEE NOTE 4
IMPORTANCE FACTOR, I = 1.0
EXPOSURE CATEGORY = C
WIND DIRECTIONALITY FACTOR, Kd = 1.0.....SEE NOTE 5
TOWER HEIGHT, h = 35.7 m (117 ft)
TOPOGRAPHIC FACTOR, Kzt = 1.0.....SEE NOTE 6
GUST EFFECT FACTOR, G = 1.0.....SEE NOTE 7
TOWER FORCE COEFFICIENT, Cf = 0.6

FOUNDATION STIFFNESS REQUIREMENTS .....SEE NOTE 10
- LATERAL FOUNDATION STIFFNESS, Kxy = 5 X 10^7 N/m MINIMUM
- ROTATIONAL FOUNDATION STIFFNESS, Kθ,xy = 3.25 X 10^9 N-m/rad MINIMUM

NOTES
1. TOWER TOP LOADS PROVIDED INCLUDE EFFECTS OF THE WIND ON THE BLADES AND NACELLE. NORTHERN POWER USED A LOAD FACTOR OF 1.35 (NOT INCLUDED ABOVE) FOR ALL AERODYNAMIC LOADS ON THE STRUCTURE ACCORDING TO IEC 61400-1.
2. TOWER BASE LOADS PROVIDED INCLUDE EFFECTS OF THE WIND ON THE BLADES, NACELLE, AND TOWER. NORTHERN POWER USED A LOAD FACTOR OF 1.35 (NOT INCLUDED ABOVE) FOR ALL AERODYNAMIC LOADS ON THE STRUCTURE ACCORDING TO IEC 61400-1. "Mz" AND "Mz MAXIMUM" ARE DERIVED FROM DIFFERENT LOAD CASES. NOTE THAT "Mz MAXIMUM" DOES NOT OCCUR DURING THE 50-YEAR EXTREME GUST LOAD CASE, BUT MAY BE CONSERVATIVELY ASSUMED IN LOAD COMBINATION FOR PURPOSES OF FOUNDATION DESIGN.
3. BASIC WIND SPEED IS AT h=10m (33 ft). THIS VALUE IS DERIVED FROM THE EXTREME WIND SPEED AT HUB HEIGHT ACCORDING TO IEC 61400-1, Ve50 = 52.5 m/s (117 mph), USING A POWER LAW EXPONENT CONSISTENT WITH EXPOSURE C.
4. STANDARD AIR DENSITY IS NOT EXPLICITLY IDENTIFIED IN SECTION 6.5 OF ASCE 7-05. IT IS IMPLICIT IN THE VELOCITY PRESSURE CALCULATION, EQUATION 6-15.
5. A DIRECTIONALITY FACTOR IS NOT USED BY NORTHERN POWER.
6. EFFECTS OF LOCAL TOPOGRAPHY ON THE WIND ARE NOT ACCOUNTED FOR IN THIS CALCULATION. THEY MUST BE CONSIDERED DURING PROJECT PLANNING AND SITE REVIEW.
7. THE TOWER LOADS ARE PREDICTED USING A COMPLETE AERO-ELASTIC SIMULATION WHICH ACCOUNTS FOR DYNAMIC INTERACTIONS OF THE STRUCTURE AND THE APPLIED LOADS. AN ADDITIONAL GUST EFFECT FACTOR (E.G. ACCORDING TO SECTION 6.5.8 OF ASCE 7-05) IS THEREFORE NOT USED BY NORTHERN POWER.
8. SEISMIC ACTIONS ARE NOT ACCOUNTED FOR IN THIS CALCULATION, THOUGH TYPICALLY NON-GOVERNING, THEY MUST BE CONSIDERED DURING PROJECT PLANNING AND SITE REVIEW.
9. THE VALUES STATED IN METRIC (SI) UNITS SHALL BE REGARDED AS THE STANDARD. THE INCH-POUND (IP) UNITS SHOWN IN PARENTHESES SHALL BE FOR REFERENCE ONLY.
10. NORTHERN POWER IS CONTINUALLY DEVELOPING PRODUCT UPGRADES, MODIFICATIONS, AND IMPROVEMENTS, AND AS A RESULT RESERVES THE RIGHT TO CHANGE OR ALTER THESE SPECIFICATIONS AT ANY TIME. REFER TO DOCUMENT A05450 "NPS 100-24 GENERAL SPECIFICATION" AND DOCUMENT A00298 "NPS 100 APPLICATION REQUIREMENTS" FOR FURTHER INFORMATION.

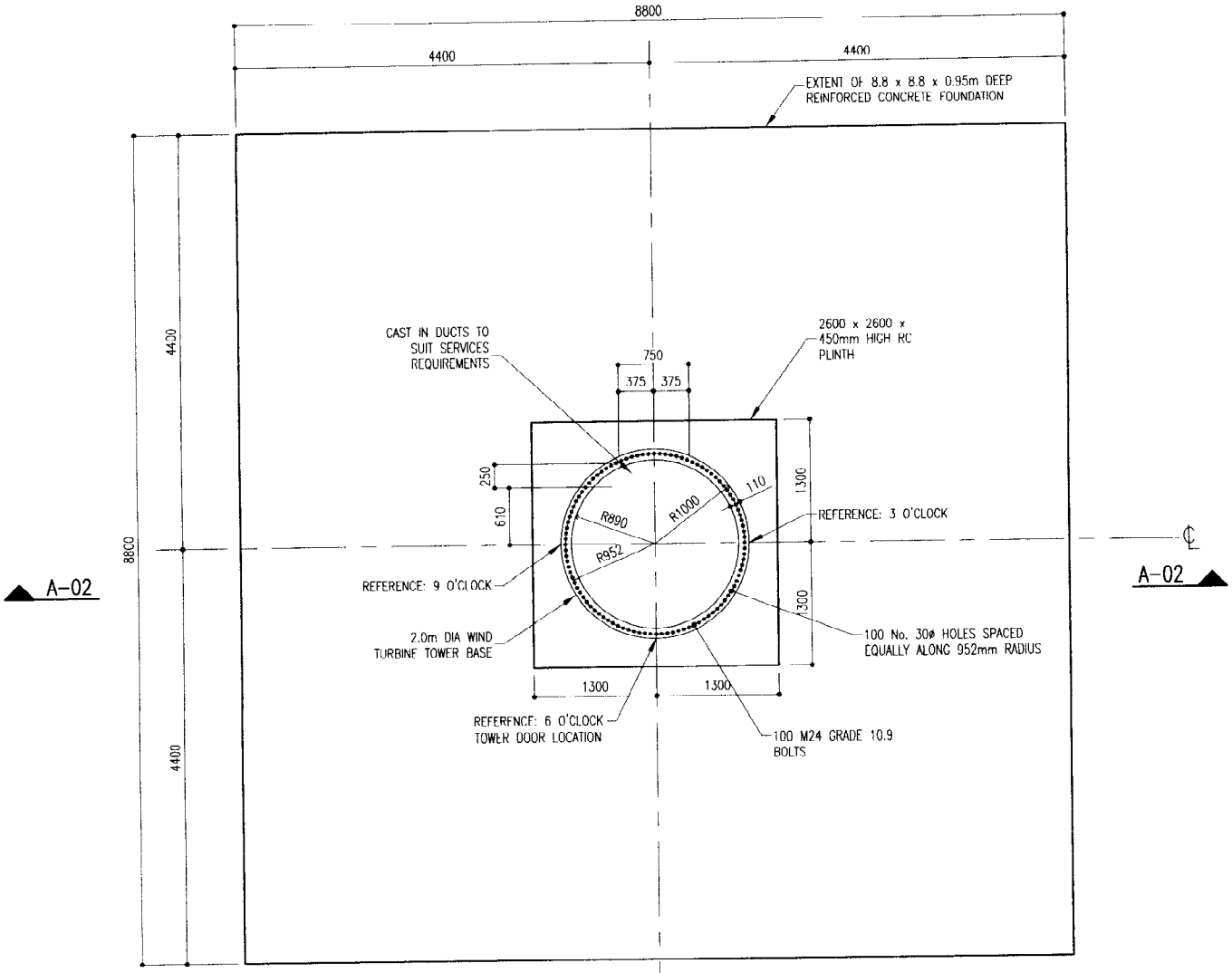
NPS100-24/30
ROTOR DIAMETER: 24m
HUB HEIGHT: 37m
SCALE 1:50
WHEN PRINTED ON ISO A0
ALL DIMENSIONS IN METERS AND [FEET]

REV	DESCRIPTION	DATE	ENG	CHK	APR
C	RELEASE FOR CUSTOMER USE. ADDED NPS100-24/30. UPDATED LOADS NOTES AND FORMATTING	7/25/2012	NMS	CBC	DPC
B	RELEASE FOR BID/QUOTE	4/9/2012	NMS	CBC	DPC
A	RELEASE FOR BID/QUOTE	12MAR12	CBC	NMS	CAM

DRAWING NUMBER: 101347 REVISION: C SHEET 1 OF 2

Northern POWER SYSTEMS
Barre, VT 05641 USA
www.northernpower.com

AC33



A-01

PLAN ON FOUNDATION BASE
SCALE 1:50

Notes:

1. FOR GENERAL NOTES SEE BELOW.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH HYDROCK STRUCTURES 1 DRAWINGS 2194/A-02 TO A-05, AND NORTHERN POWER SYSTEMS NORTHWIND 100 TURBINE APPLICATION & INSTALLATION DOCUMENTS A00298 & W00308.
3. THE FOUNDATION DETAILS GIVEN ARE FOR A NORTHWIND 100, 3/m HUB HEIGHT WITH 21m ROTOR AND AN UNFACTORED OVERTURNING MOMENT AT THE BASE OF 3353 kNm. THE DETAILS SHOWN MUST NOT BE USED FOR ANY OTHER WIND TURBINES.
4. THE DRAWINGS ARE BASED ON A FOUNDATION DEPTH OF 1.4m BELOW GROUND LEVEL, WITH A COMPETENT NATURAL BEARING STRATA AT THIS DEPTH ACHIEVING A MINIMUM ALLOWABLE BEARING PRESSURE OF 100 kN/m². PRIOR TO PROCEEDING WITH THE WORKS AN APPROPRIATE SITE INVESTIGATION MUST BE UNDERTAKEN AND THE GROUND CONDITIONS CONFIRMED SUITABLE BY A GEOTECHNICAL ENGINEER. SHOULD A COMPETENT BEARING STRATA BE FOUND AT A DEEPER DEPTH THEN REFER TO DRAWINGS 2194/B-01 TO B-05 OR 2194/C-01 TO C-05. NOTE THAT THE FOUNDATION MUST BE BACKFILLED OVER THE TOP OF THE BASE AS SHOWN ON THE DRAWINGS AS THIS WEIGHT CONTRIBUTES TO ITS STABILITY.
5. ON EXCAVATING THE FOUNDATION, THE FORMATION SHOULD BE CHECKED BY A COMPETENT ENGINEER/GEOLOGIST, IN PARTICULAR ANY SMALL INCONSISTENCIES & SOFT SPOTS MUST BE REMOVED AND REPLACED WITH MASS CONCRETE SO THAT THE FORMATION IS ALL IN ONE STRATA/MATERIAL. SHOULD THE FORMATION NOT MATCH THE DESCRIPTION OF THE NATURAL BEARING STRATA GIVEN IN THE SITE INVESTIGATION REPORT THEN SEEK FURTHER INSTRUCTION FROM THE GEOLOGIST/STRUCTURAL ENGINEER PRIOR TO PROCEEDING. THE EXCAVATION MUST BE KEPT DRY AND THE FORMATION PROTECTED WITH BLINDING CONCRETE AT THE EARLIEST OPPORTUNITY (I.E. TRIM THE LAST 150mm, & POUR BLINDING CONCRETE ON THE SAME DAY).
6. CONCRETE TO BE DESIGNATED GRADE RC35/45 TO BS 8500-1 (FOR DESIGN CHEMICAL CLASS DC-1 & DC-2 ONLY) AS PART OF THE SITE INVESTIGATION TEST SOIL FOR DESIGN SULPHATE AND CHEMICAL CLASS TO ENSURE COMPLIANCE WITH BS 8500. ONLY READY MIXED CONCRETE FROM A PLANT WITH UKAS ACCREDITATION TO BS EN 45011 SHOULD BE USED. NO CHANGES SHOULD BE MADE TO THE MIX (E.G. THE ADDITION OF WATER) AFTER LEAVING THE PLANT. THE FOUNDATION SHOULD BE CAST IN ONE CONTINUOUS POUR WITHOUT JOINTS. IN COLD WEATHER (WHERE OVERNIGHT FROST MAY OCCUR) OR HOT WEATHER (>30°C) SEEK SPECIALIST ADVICE PRIOR TO POURING. PLACE CONCRETE TO ENSURE NO SEGREGATION OF INGREDIENTS AND USE POKER VIBRATORS TO ENSURE FULL COMPACTION. ON COMPLETION APPLY AN APPROPRIATE CURING COMPOUND TO THE TOP SURFACE. SHOULD THE TOP "PLINTH" BE CAST SEPARATELY, BRUSH LAITANCE FROM SURFACE OF FIRST POUR TO ENSURE A GOOD CONSTRUCTION JOINT. DURING CASTING TAKE ALL NECESSARY PRECAUTIONS TO SUPPORT HOLDING DOWN BOLTS. ENSURE THAT HOLDING DOWN BOLTS ARE APPROPRIATELY SLEEVED. COMPLY WITH THE REQUIREMENTS OF THE LATEST EDITION OF THE NATIONAL STRUCTURAL CONCRETE SPECIFICATION.
7. ON COMPLETION OF THE POUR PREPARE BOLTS, SLEEVES, LEVELING NUTS, TOWER BASE & GROUT STRICTLY IN ACCORDANCE WITH WITH NORTHERN POWER DOCUMENTS W00308 SECTION 5.6 & A00298 SECTION 6. USE NON-SHRINK GROUT WITH MIN 1 DAY STRENGTH OF 50 N/mm² (E.G. FOSROC CONBEXTRA EPR). HAUNCH GROUT AS SHOWN ON DRAWING 2194/A-02 (LEAVE CAPS TO ENABLE LEVELING NUTS TO BE LOOSENED BEFORE GROUTING THESE AREAS). INSTALL GROUT TO MANUFACTURERS INSTRUCTIONS.
8. HOLDING DOWN BOLTS/THREADED BAR TO BE 1500mm LONG M24 GRADE 10.9 TO BS 4190 & CORRESPONDING GRADE 10 NUTS TO BS 4190. BOLTS TO BE PRE-LOADED TO 185 kN USING DIRECT TENSION INDICATORS. PRIOR TO TENSIONING BOLTS ENSURE THAT CONCRETE STRENGTH IS AT LEAST 35 N/mm². (TEST CUBES SHOULD BE UNDERTAKEN TO CONFIRM THIS SHOULD BOLTS NEED TO BE PRE-LOADED PRIOR TO 28 DAYS ELAPSING AFTER POURING FOUNDATION. HIGHER STRENGTH / RAPID HARDENING CONCRETES MAY BE REQUIRED TO ENABLE EARLY PRE-LOADING OF BOLTS). THE GROUT MUST CURE FOR AT LEAST 24 HOURS PRIOR TO PRE-LOADING BOLTS.

General Notes

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH HYDROCK STRUCTURES 1 SECTION/DETAIL DRAWINGS 2194/A-02 & A-03, AND REINFORCEMENT DRAWINGS 2194/A-04 & A-05.
2. THIS DRAWING PROVIDES INFORMATION FOR A GRAVITY BASE FOUNDATION FOR THE NORTHERN POWER SYSTEMS NORTHWIND 100 TURBINE (21m ROTOR, 37m TOWER) ONLY.
3. THE DETAILS SHOWN ON THIS DRAWING ARE A GENERIC DESIGN FOR A SHALLOW FOUNDATION WHERE COMPETENT BEARING STRATA IS ENCOUNTERED AT A DEPTH OF 1.4m BELOW GROUND LEVEL. THE CONTRACTOR MUST UNDERTAKE A GROUND INVESTIGATION FOR EACH SITE WHICH IS INTERPRETED TO VERIFY THAT A SHALLOW
4. THE STRUCTURAL DESIGN OF THIS FOUNDATION IS BASED ON THE INFORMATION SUPPLIED IN THE FOLLOWING NORTHERN POWER SYSTEMS DOCUMENTS: DRAWING 1006225 (rev D) SHEET 1, DRAWING 1001441 (rev D) SHEET 1, DRAWING 1000152 (rev C), NORTHWIND 100 APPLICATION REQUIREMENTS DOCUMENT A00298 (rev C), NW100 INSTALLATION INSTRUCTIONS DOCUMENT W00308. SHOULD THESE DOCUMENTS BE REVISED OR OTHERWISE ADAPTED THEN THESE DRAWINGS BECOME OBSOLETE AND THE FOUNDATION REQUIREMENTS MUST BE RE-ASSESSED BY A STRUCTURAL ENGINEER.
5. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.

Rev.	Date	Details	By	Chk.
P2	16.05.11	NOTES UPDATED	MR	DB
P1	10.05.11	PRELIMINARY	MR	DB

Client: MYRIAD CEG LTD SEGEN

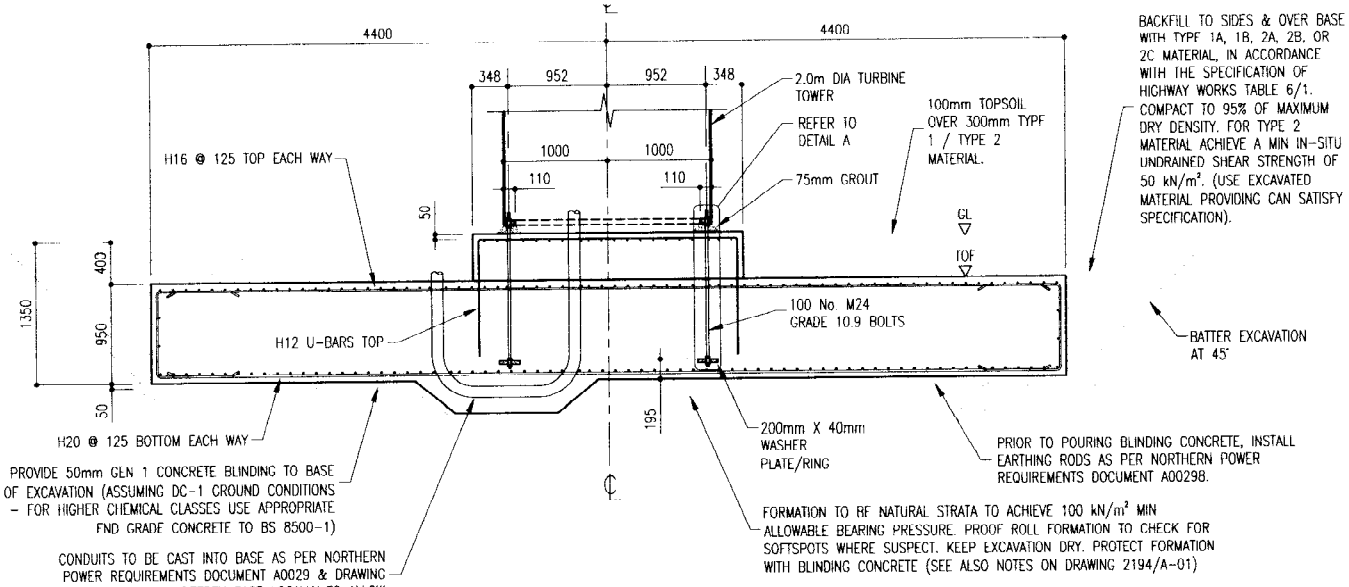
Project: NORTHWIND 100

Title: GRAVITY BASE FOR NORTHWIND 100 WIND TURBINE (21m ROTOR, 37m TOWER) PLAN ON FOUNDATION

Hydrock structures
1 Westgate House, The Island, Gloucester, GL1 2RU
Tel: +44 (0)845 128 0070. Fax: +44 (0)117 930 0692

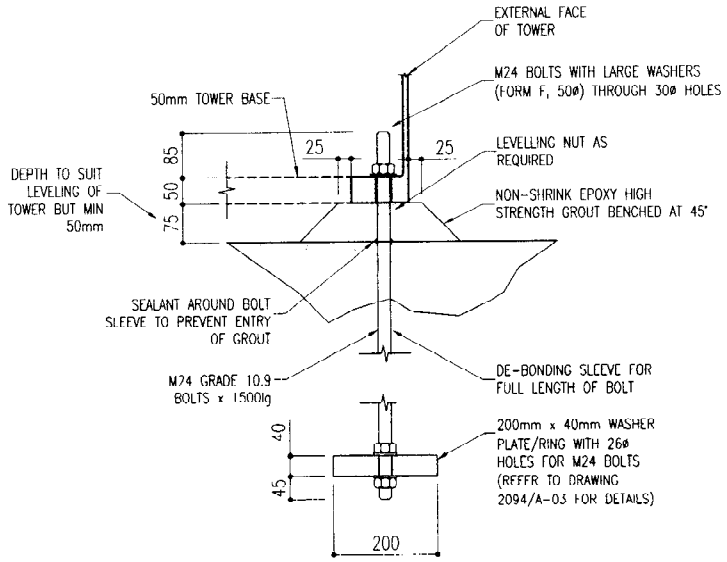
Not to be used for fabrication/construction unless marked construction status

Job No.				
2194				
Drawn: MR	Checked: DB	Scales: 1:50 @ A3	Date: MAY 2011	Issue Date: 16.05.11
Drawing No.: 2194/A-01				Revision: P2



A-02

FOUNDATION BASE SECTION @ ℄ X-AXIS
SCALE 1:50



DETAIL A

SCALE 1:10

General Notes

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH HYDROCK STRUCTURES 1 PLAN/DETAIL DRAWINGS 2194/A-01 & A-03, AND REINFORCEMENT DRAWINGS 2194/A-04 & A-05.
2. THIS DRAWING PROVIDES INFORMATION FOR A GRAVITY BASE FOUNDATION FOR THE NORTHERN POWER SYSTEMS NORTHWIND 100 TURBINE (21m ROTOR, 37m TOWER) ONLY.
3. THE DETAILS SHOWN ON THIS DRAWING ARE A GENERIC DESIGN FOR A SHALLOW FOUNDATION WHERE COMPETENT BEARING STRATA IS ENCOUNTERED AT A DEPTH OF 1.4m BELOW GROUND LEVEL. THE CONTRACTOR MUST UNDERTAKE A GROUND INVESTIGATION FOR EACH SITE WHICH IS INTERPRETED TO VERIFY THAT A SHALLOW FOUNDATION IS SUITABLE FOR THAT SITE.
4. THE STRUCTURAL DESIGN OF THIS FOUNDATION IS BASED ON THE INFORMATION SUPPLIED IN THE FOLLOWING NORTHERN POWER SYSTEMS DOCUMENTS: DRAWING 1006225 (rev D) SHEET 1, DRAWING 1001441 (rev D) SHEET 1, DRAWING 1000152 (rev C), NORTHWIND 100 APPLICATION REQUIREMENTS DOCUMENT A00298 (rev C), NW100 INSTALLATION INSTRUCTIONS DOCUMENT W00308. SHOULD THESE DOCUMENTS BE REVISED OR OTHERWISE ADAPTED THEN THESE DRAWINGS BECOME OBSOLETE AND THE FOUNDATION REQUIREMENTS MUST BE RE-ASSESSED BY A STRUCTURAL ENGINEER.
5. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.

Rev.		Details	By	Chk
P2	16.05.11	NOTES UPDATED	MR	DB
P1	10.05.11	PRELIMINARY	MR	DB

Client: MYRIAD CEG LTD SEGEN

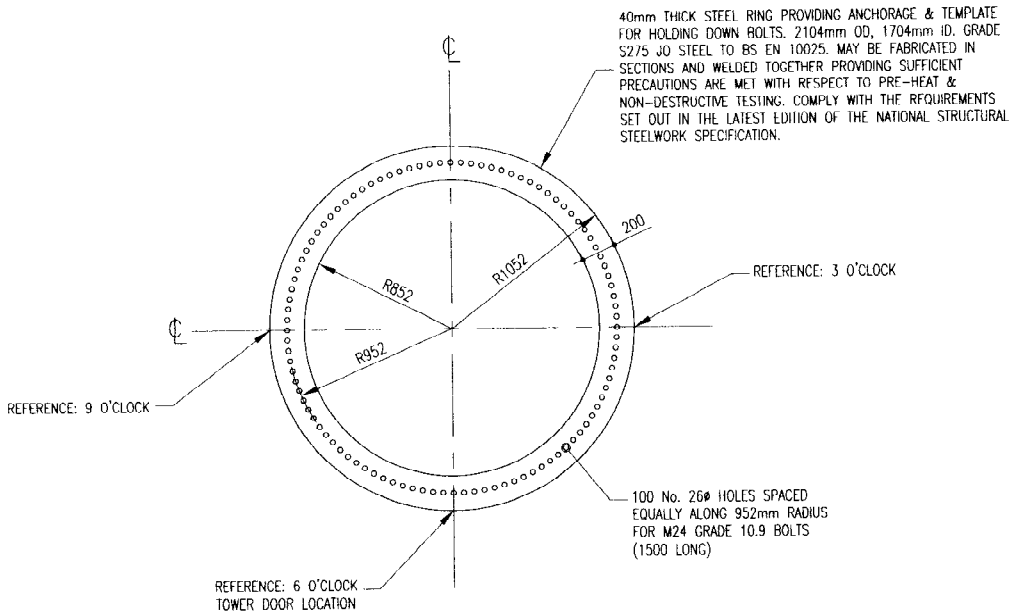
Project: NORTHWIND 100

Title: GRAVITY BASE FOR NORTHWIND 100 WIND TURBINE (21m ROTOR, 37m TOWER) SECTION ON FOUNDATION

Hydrock structures
1 Westgate House, The Island, Gloucester, GL1 2RU
Tel: +44 (0)845 128 0070. Fax: +44 (0)117 930 0692

Not to be used for fabrication/construction unless marked construction status

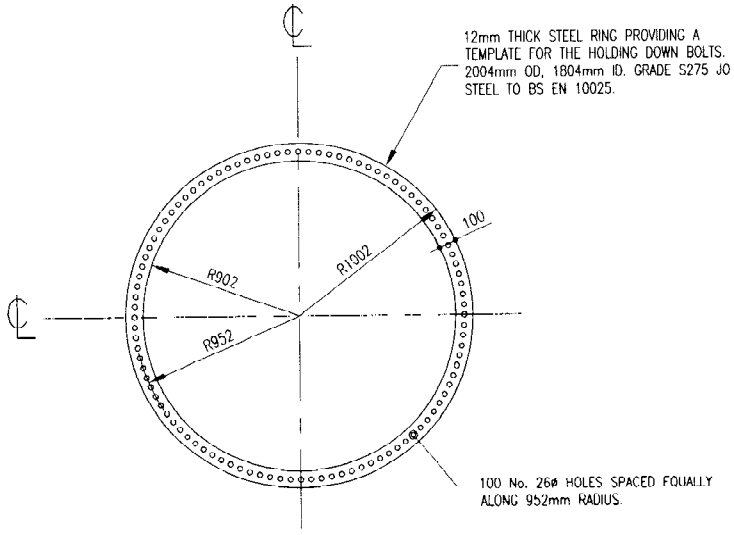
Job No.			
2194			
Drawn: MR	Checked: DB	Scales: 1:50 @ A3	Date: MAY 2011
Drawing No: 2194/A-02			Issue Date: 16.05.11 Revision: P2



LOWER RING / WASHER PLATE

THIS RING PROVIDES ANCHORAGE OF THE HOLDING DOWN BOLTS AND MUST BE CAST INTO THE CONCRETE BASE AT LOW LEVEL AS INDICATED ON DRAWING 2094/A-02

SCALE 1:30



UPPER RING

THIS RING PROVIDES A TEMPLATE TO SUPPORT THE HOLDING DOWN BOLTS AT HIGH LEVEL AND MUST NOT BE CAST INTO THE CONCRETE BASE, AS INDICATED ON DRAWING 2094/A-05. THE TEMPLATE CAN BE RE-USED.

SCALE 1:30

General Notes

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH HYDROCK STRUCTURES 1 PLAN/SECTION DRAWINGS 2194/A 01 & A-02, AND REINFORCEMENT DRAWINGS 2194/A-04 & A-05.
2. THIS DRAWING PROVIDES INFORMATION FOR A GRAVITY BASE FOUNDATION FOR THE NORTHERN POWER SYSTEMS NORTHWIND 100 TURBINE (21m ROTOR, 37m TOWER) ONLY.
3. THE DETAILS SHOWN ON THIS DRAWING ARE A GENERIC DESIGN FOR A SHALLOW FOUNDATION WHERE COMPETENT BEARING STRATA IS ENCOUNTERED AT A DEPTH OF 1.4m BELOW GROUND LEVEL. THE CONTRACTOR MUST UNDERTAKE A GROUND INVESTIGATION FOR EACH SITE WHICH IS INTERPRETED TO VERIFY THAT A SHALLOW
4. THE STRUCTURAL DESIGN OF THIS FOUNDATION IS BASED ON THE INFORMATION SUPPLIED IN THE FOLLOWING NORTHERN POWER SYSTEMS DOCUMENTS: DRAWING 1006225 (rev D) SHEET 1, DRAWING 1001441 (rev D) SHEET 1, DRAWING 1000152 (rev C), NORTHWIND 100 APPLICATION REQUIREMENTS DOCUMENT A00298 (rev C), NW100 INSTALLATION INSTRUCTIONS DOCUMENT W00308. SHOULD THESE DOCUMENTS BE REVISED OR OTHERWISE ADAPTED THEN THESE DRAWINGS BECOME OBSOLETE AND THE FOUNDATION REQUIREMENTS MUST BE RE-ASSESSED BY A STRUCTURAL ENGINEER.
5. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.

Rev	Date	Details	By	Chk
P2	16.05.11	NOTES UPDATED	MR	DB
P1	10.05.11	PRELIMINARY	MR	DB

Client: MYRIAD CEG LTD SEGEN

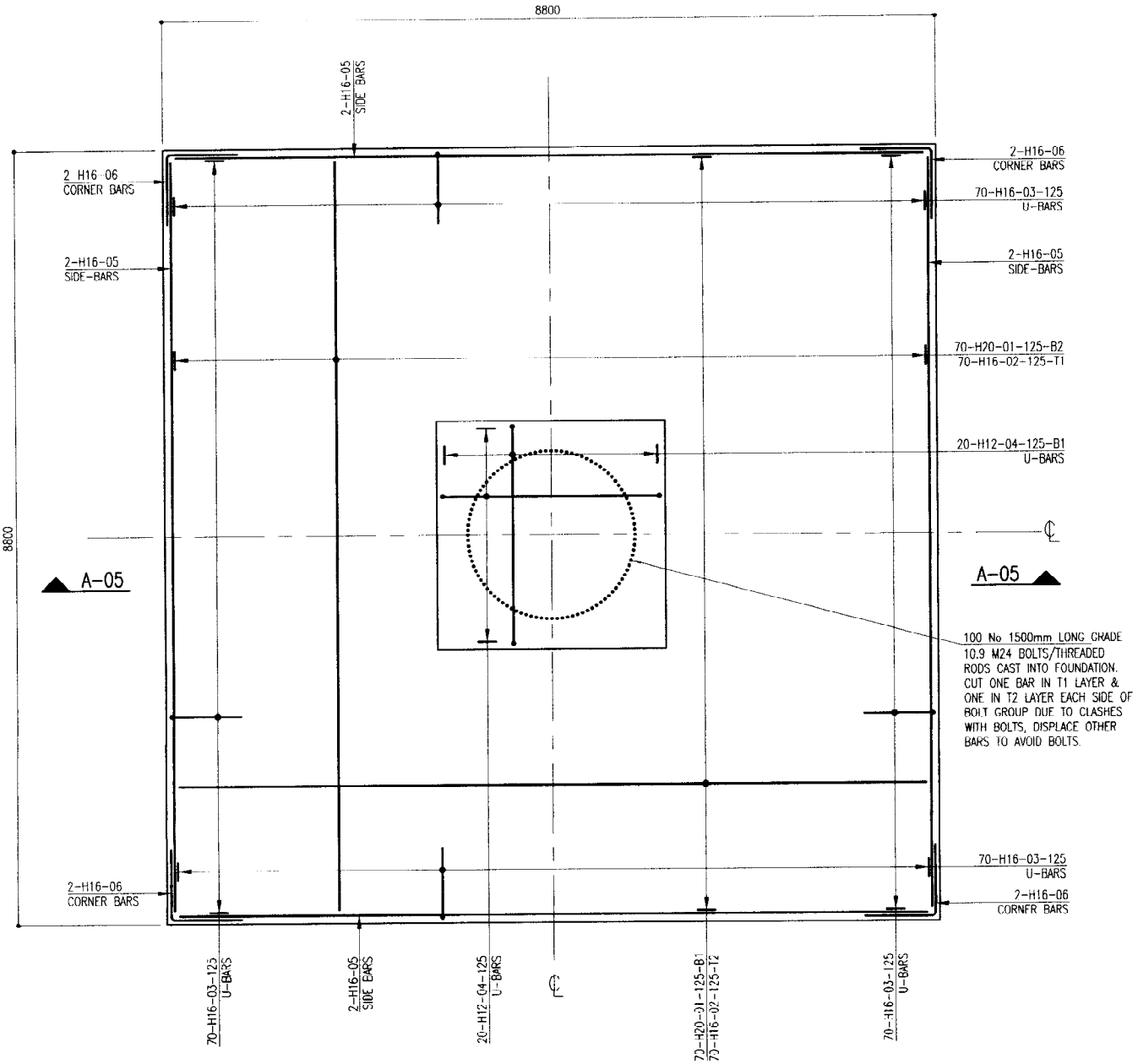
Project: NORTHWIND 100

Title: GRAVITY BASE FOR NORTHWIND 100 WIND TURBINE (21m ROTOR, 37m TOWER) DETAILS

Hydrock structures
1 Westgate House, The Island, Gloucester GL1 2RU
Tel: +44 (0)845 128 0070, Fax: +44 (0)117 930 0692

Not to be used for fabrication/construction unless marked construction status

Job No.				
2194				
Drawn	Checked	Scales	Date	Issue Date
MR	DB	1:50 @ A3	MAY 2011	16.05.11
Drawing No.				Revision
2194/A-03				P2



A-04

PLAN SHOWING REINFORCEMENT DETAILS
SCALE 1:50

Notes:

1. MIN CONCRETE TO BE GRADE RC35/45 TO BS 8500-1 (FOR DESIGN CHEMICAL CLASSES DC-1 & DC-2 ONLY).
2. COVER TO REINFORCEMENT TO BE 50mm TOP, BOTTOM & SIDES.
3. REINFORCEMENT ON THIS DRAWING IS LISTED IN THE BAR BENDING SCHEDULE ON DRAWING 2094/A-05.
4. ALL REINFORCEMENT TO BE GRADE B500B TO BS 4449.
5. REFER TO ADDITIONAL NOTES ON DRAWING 2094/A-01.

General Notes

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH HYDROCK STRUCTURES 1 REINFORCEMENT DRAWING A-05, AND PLAN/SECTION/DETAIL DRAWINGS 2194/A-01 TO A-03.
2. THIS DRAWING PROVIDES INFORMATION FOR A GRAVITY BASE FOUNDATION FOR THE NORTHERN POWER SYSTEMS NORTHWIND 100 TURBINE (21m ROTOR, 37m TOWER) ONLY.
3. THE DETAILS SHOWN ON THIS DRAWING ARE A GENERIC DESIGN FOR A SHALLOW FOUNDATION WHERE COMPETENT BEARING STRATA IS ENCOUNTERED AT A DEPTH OF 1.4m BELOW GROUND LEVEL. THE CONTRACTOR MUST UNDERTAKE A GROUND INVESTIGATION FOR EACH SITE WHICH IS INTERPRETED TO VERIFY THAT A SHALLOW FOUNDATION IS APPROPRIATE.
4. THE STRUCTURAL DESIGN OF THIS FOUNDATION IS BASED ON THE INFORMATION SUPPLIED IN THE FOLLOWING NORTHERN POWER SYSTEMS DOCUMENTS: DRAWING 1006225 (rev D) SHEET 1, DRAWING 1001441 (rev B) SHEET 1, DRAWING 1000152 (rev C), NORTHWIND 100 APPLICATION REQUIREMENTS DOCUMENT A00298 (rev C), NW100 INSTALLATION INSTRUCTIONS DOCUMENT W00308. SHOULD THESE DOCUMENTS BE REVISED OR OTHERWISE ADAPTED THEN THESE DRAWINGS BECOME OBSOLETE AND THE FOUNDATION REQUIREMENTS MUST BE RE-ASSESSED BY A STRUCTURAL ENGINEER.
5. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.

Rev	Date	Details	By	Chk
P1	16.05.11	PRELIMINARY	MR	DB

Client: MYRIAD CEG LTD SEGEN

Project: NORTHWIND 100

Title: GRAVITY BASE FOR NORTHWIND 100 WIND TURBINE (21m ROTOR, 37m TOWER) REINFORCEMENT PLAN

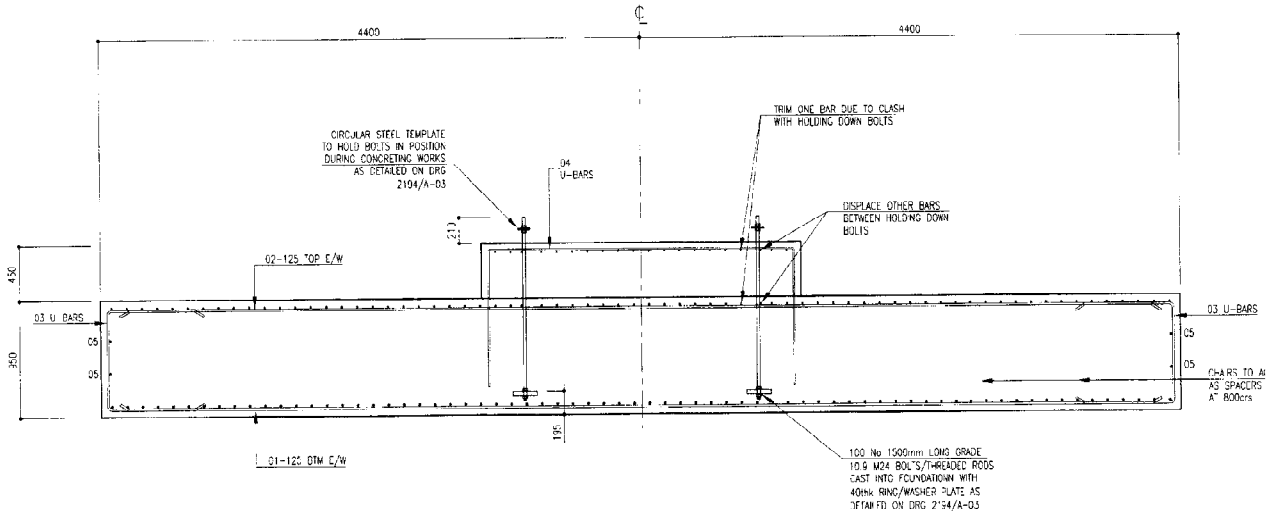
Hydrock structures
1 Westgate House, The Island, Gloucester, GL1 2RU
Tel: +44 (0)845 128 0070. Fax: +44 (0)117 930 0692

Not to be used for fabrication/construction unless marked construction status

Job No. 2194

Drawn	Checked	Scales	Date	Issue Date
MR	DB	1:50 @ A3	MAY 2011	16.05.11

Drawing No. 2194/A-04 Revision P1



A-05

SECTION SHOWING REINFORCEMENT DETAILS
SCALE 1:30

REINFORCEMENT SCHEDULE TO BS 8666:2005 (REFER TO DRAWING A-04):

BAR MARK	TYPE SIZE	No OFF	No IN EACH	TOTAL No	LENGTH mm	SHAPE CODE	A mm	B mm	C mm	D mm
01	H20	1	140	140	8500	00	8500			
02	H16	1	140	140	8500	00	8500			
03	H16	1	280	280	2375	21	800	825		
04	H12	1	40	40	4760	21	1120	2490		
05	H16	1	8	8	8500	00	8500			
06	H16	1	8	8	1575	11	800			

TOTAL WEIGHT OF REINFORCEMENT = 6·50kg

General Notes

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH HYDROCK STRUCTURES REINFORCEMENT DRAWING A-04, AND PLAN/SECTION/DETAIL DRAWINGS 2194/A-01 TO A-03.
2. THIS DRAWING PROVIDES INFORMATION FOR A GRAVITY BASE FOUNDATION FOR THE NORTHERN POWER SYSTEMS NORTHWIND 100 TURBINE (21m ROTOR, 37m TOWER) ONLY.
3. THE DETAILS SHOWN ON THIS DRAWING ARE A GENERIC DESIGN FOR A SHALLOW FOUNDATION WHERE COMPETENT BEARING STRATA IS ENCOUNTERED AT A DEPTH OF 1·4m BELOW GROUND LEVEL. THE CONTRACTOR MUST UNDERTAKE A GROUND INVESTIGATION FOR EACH SITE WHICH IS INTENDED TO VERIFY THAT A SHALLOW FOUNDATION IS SUITABLE. THE GROUND CONDITIONS ARE UNIFORM ACROSS THE BASE PLAN AREA/ZONE OF INFLUENCE, THERE ARE NO STABILITY CONCERNS (E.G. LAND SLIP, MINE WORKINGS, SOLUTION FEATURES), AN ALLOWABLE BEARING PRESSURE OF AT LEAST 100 kN/m² CAN BE ACHIEVED AND THAT UNDER THIS PRESSURE TOTAL SETTLEMENTS ARE LESS THAN 25mm.
4. THE STRUCTURAL DESIGN OF THE FOUNDATION IS BASED ON THE INFORMATION SUPPLIED IN THE FOLLOWING NORTHERN POWER SYSTEMS DOCUMENTS: DRAWING 1606225 (rev D) SHEET 1, DRAWING 1201441 (rev D) SHEET 1, DRAWING 1600152 (rev C), NORTHWIND 100 APPLICATION REQUIREMENTS DOCUMENT 402308 (rev 0), NW100 INSTALLATION INSTRUCTIONS DOCUMENT 402308. SHOULD THESE DOCUMENTS BE REVISED OR OTHERWISE ADAPTED THEN THESE DRAWINGS BECOME OBSOLETE AND THE FOUNDATION REQUIREMENTS MUST BE RE-ASSESSED BY A STRUCTURAL ENGINEER.
5. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.

Rev	Date	Details	By	Chk
P1	16.05.11	PRELIMINARY	MB	BS

Client: MYRIAD CEG LTD SEGEN

Project: NORTHWIND 100 FOUNDATION

Title: GRAVITY BASE FOR NORTHWIND 100 WIND TURBINE (21m ROTOR, 37m TOWER) REINFORCEMENT SECTION/SCHEDULE

Hyckstru

1 Westgate House, Towcester, Gt. Brit.
Tel: +44 (0)845 128 9444 (0)117 930 0692

Birmingham Towcester

Drawing Status: PRELIMINARY

Not to be used for tendering/commercial construction status

Job No.

Drawn	Checked	Scales	Issue Date
MB	BS	1:30	16.05.11

Drawing No.: 2195 Revision: P1

SECTION 11

AC34

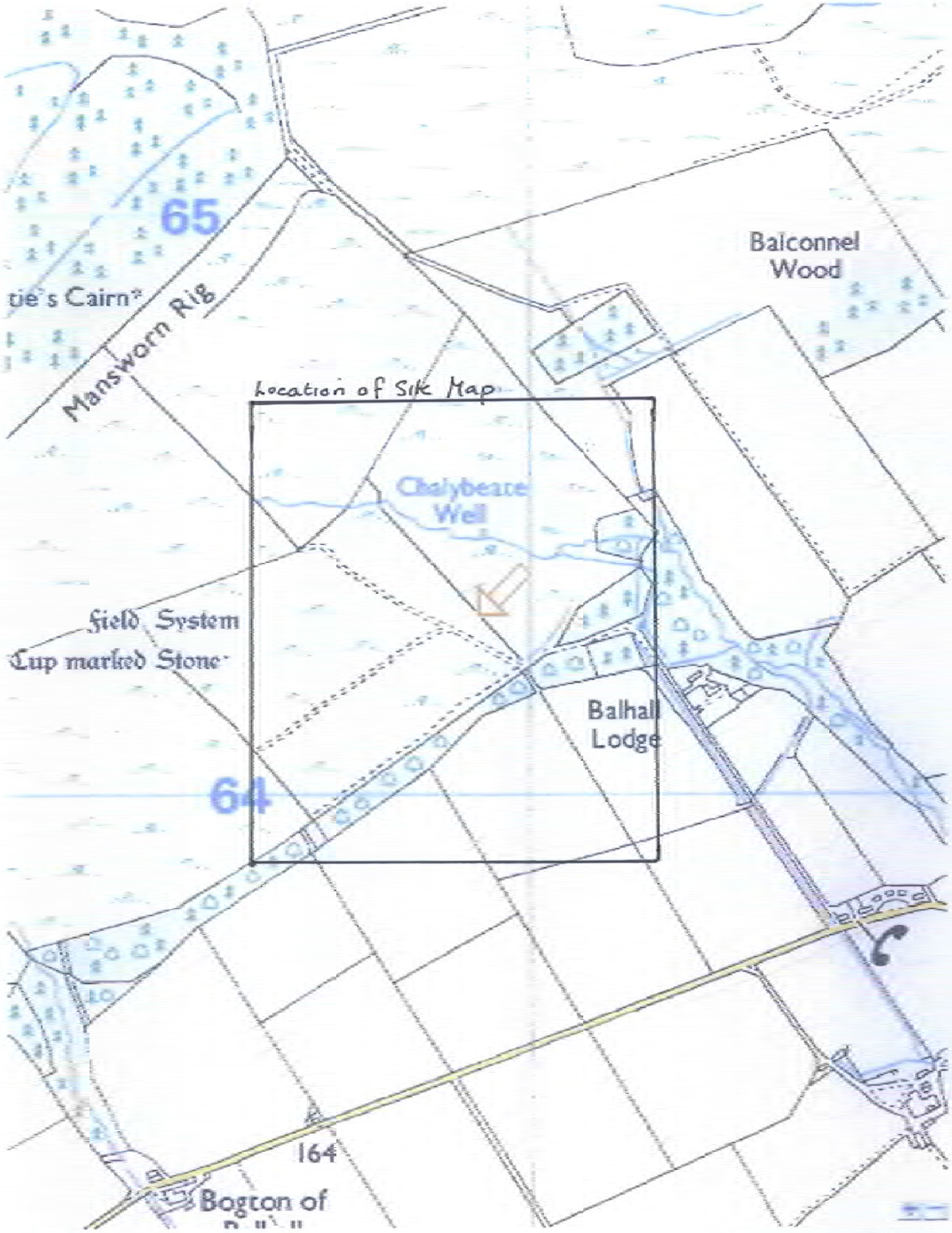
Mains of Balhall
Menmuir, by Brechin

Survey Report

by

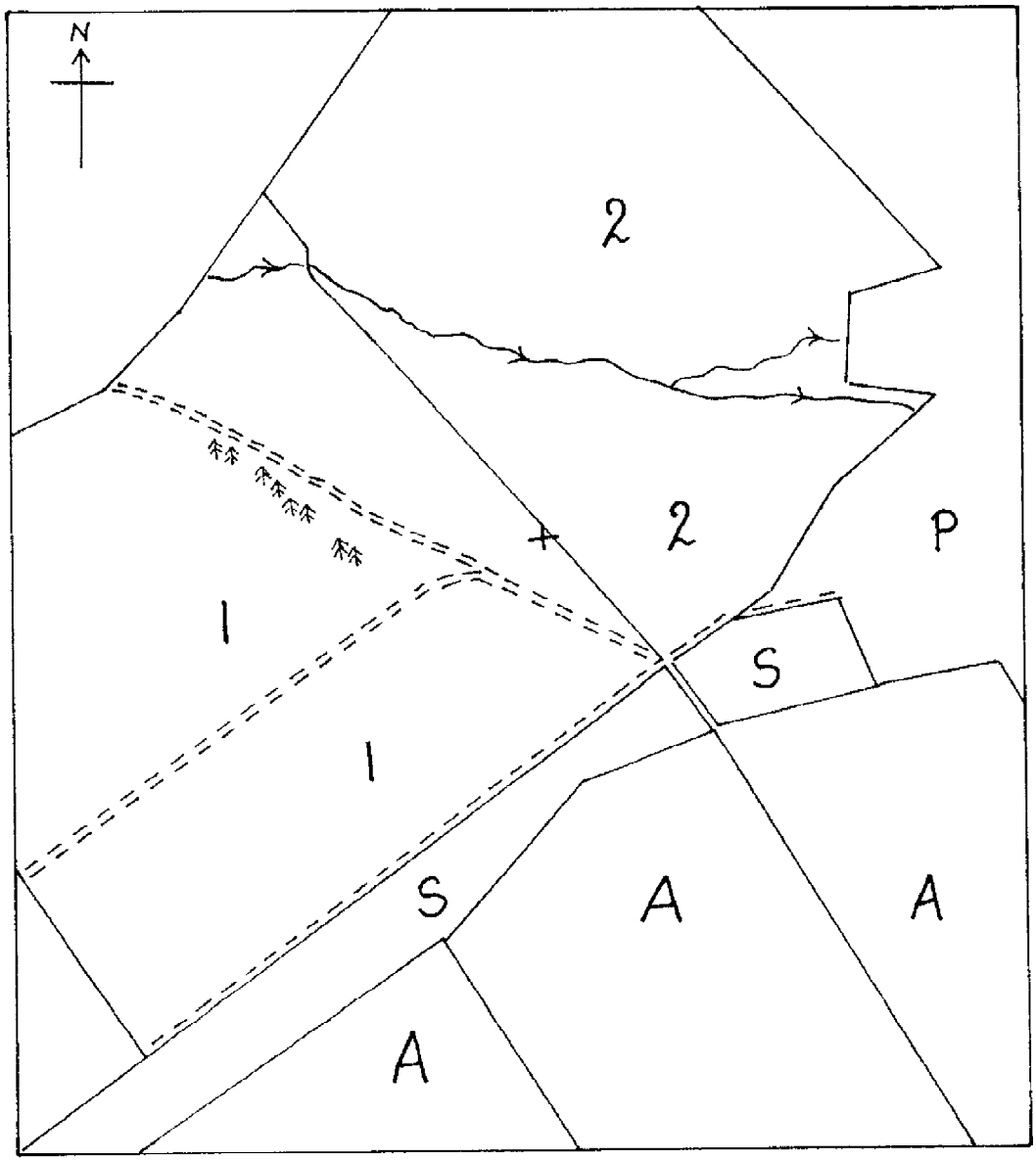
Barbara Hogarth

15 June 2013


65
Balconnel Wood
Mansworn Rig
location of Silk Map
Chalybeate Well
Field System
Cup marked Stone
Balhall Lodge
64
164
Bogton of

Mains of Balhall

Site Map



Areas 1 and 2 see report

↟ Scattered larch trees

~ Stream

A Arable

P̂ Policy

\+ Site of proposed wind turbine

Mains of Balhall, Menmuir, by Brechin

In relation to proposals to erect a single wind turbine at NO 50907 64304 a habitat survey and environmental assessment were carried out at the request of Alex Craig, Architectural Consultant.

The survey was undertaken on 14 June 2013 by Barbara Hogarth.

Site map

The map shows land use in the immediate surroundings of the proposed site for the wind turbine. The numbers relate to those in the description of the site.

Description of site

The area surrounding the proposed site for the wind turbine is mostly improved pasture.

1 Improved pasture

Grassland with short turf and scattered Larch trees close to the line of a track. Running along the southeastern boundary of the pasture is a shelterbelt with mature Beech trees.

This area is of insignificant nature conservation value.

2 Improved pasture

In this area the grassland has extensive areas of heavily trampled ground. Rushes have encroached across the disturbed ground. Gorse is present in the valley of a small stream.

This area does not have any vegetation of nature conservation value but has the potential to attract ground nesting, wading birds.

Observations

A brown hare was seen during the survey but these animals are not likely to be adversely affected by the presence of a wind turbine.

Conclusion

There are no habitats of significant nature conservation value in close proximity to the *proposed site*.

Barbara Hogarth BSc (Hons) Botany
Botanist/Habitat Surveyor