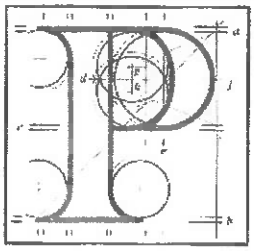
Appendix 1

Appendix 1

An Bord Pleanála



Mr. Martin Collins,
Derrybrien Development Society Limited,
Derrybrien,
Loughrea,
County Galway.

16th October 2008.

Dear Mr. Collins,

The Board has asked me to reply to your letters.

The Board is not in a position to advise you in relation to the implications of the judgement for the case in question. The more appropriate body to which you might address queries is the Department of the Environment, Heritage and Local Government.

I enclose for your information a copy of the circular letters issued by the Department of the Environment, Heritage and Local Government which set out the Department's advice to planning authorities to date, in relation to the implications of the judgement. Hopefully, these will be of assistance to you in terms of understanding the position.

Yours sincerely,

Chris Clarke,
Secretary.

64 Sráid Maoilbhríde,
Baile Átha Cliath 1.

Tel: (01) 858 8100
LoCall: 1890 275 175
Fax: (01) 872 2684
Web:http//www.pleanala.ie
email:bord@pleanala.ie

64 Marlborough Street,
Dublin 1.

An Bord Pleanála

Mr. Martin Collins,
Derrybrien Development Society Limited,
Derrybrien,
Loughrea,
County Galway.

16th October 2008.

Dear Mr. Collins,

The Board has asked me to reply to your letters.

The Board is not in a position to advise you in relation to the implications of the judgement for the case in question. The more appropriate body to which you might address queries is the Department of the Environment, Heritage and Local Government.

I enclose for your information a copy of the circular letters issued by the Department of the Environment, Heritage and Local Government which set out the Department's advice to planning authorities to date, in relation to the implications of the judgement. Hopefully, these will be of assistance to you in terms of understanding the position.

Yours sincerely

Chris Clarke,
Secretary.

64 Sráid Maoilbhríde
Baile Átha Cliath 1

Tel (01) 858 8100
LoCall 1890 275 175
Fax (01) 872 2684
Website www.pleanala.ie
email bord@pleanala.ie

64 Marlborough Street
Dublin 1

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

Circular PD 6/08

8 October 2008

Subject: Implications of European Court of Justice ruling on retention planning permission for development requiring environmental impact assessment (Case C-215/06).

The purpose of this circular is to extend the advice provided to planning authorities in Circular PD 5/08 of 15 August 2008 (enclosing a copy of the above judgement) and the e-mail communication of 4 September 2008 issued to relevant Directors of Service in the main planning authorities.

The judgment

In its judgment of 3 July 2008, the Court ruled that the retention permission system as it applies in Irish law with regard to projects that require or may require an environmental impact assessment (EIA) under the EIA Directives does not comply with the Directives and needs to be amended. Irish legislation fails to ensure that EIAs will be conducted prior to the construction of a project and permits post development EIAs contrary to the intent of the Directives

As of 3 July 2008 any permission granted on applications/appeals for retention planning permission in respect of EIA development is in breach of Community law having been granted under a legislative system that the Court has found is inconsistent with the EIA Directives.

Ireland is obliged under the Treaty of the European Community to comply with the judgment or else face the consequence that the Commission will issue Article 228 proceedings and seek the imposition of penalties/fines. Ireland is therefore obliged to respond to the judgment by introducing legislation that will amend the existing

An Roinn Comhshaoil, Oidhreachta agus Rialtais Áitiúil, Teach an Chustaim, Baile Átha Cliath 1
Department of the Environment, Heritage and Local Government, Custom House, Dublin 1
Tel: 353 1 888 2000 LoCall: 1890 20 20 21 Fax: 353 1 888 2888 Web: www.environ.ie

planning legislation insofar as it permits retention permissions on projects requiring EIAs.

Proposed legislation

The Minister has received approval of Government to the drafting of the General Scheme of a Planning and Development (Amendment) Bill, which will, among other things –

- remove the possibility of retention for unauthorised development which would otherwise have been subject to environmental impact assessment, other than in exceptional circumstances, and
- revoke the current 7 year time limit within which enforcement action may be taken in respect of unauthorised development (section 157(4) of the Planning and Development Act 2000).

In the interim, more immediate legislative measures with respect to retention planning applications for projects that fall under the EIA Directive are under consideration. The intention to make such legislation was notified to the European Commission on 3 September 2008, in Ireland's initial formal response to the ECJ judgement.

More immediately however, there is the issue of necessary action in relation to relevant planning applications (i.e. applications for retention permission for development which required an EIA), falling into two categories –

- applications currently awaiting determination by planning authorities; and
- applications which have been determined favourably since 3 July 2008.

Applications awaiting determination

It is understood that some planning authorities may have incorrectly taken the view that they must comply with and operate the relevant planning legislation as it currently stands, and therefore have to continue to make decisions on EIA/retention applications. The case law of the European Court of Justice makes it clear that administrative bodies such as planning authorities and An Bord Pleanála, being emanations of the State, are bound to comply with Community law and if necessary to disapply national law.

planning legislation insofar as it permits retention permissions on projects requiring EIAs.

Proposed legislation

The Minister has received approval of Government to the drafting of the General Scheme of a Planning and Development (Amendment) Bill, which will, among other things –

- remove the possibility of retention for unauthorised development which would otherwise have been subject to environmental impact assessment, other than in exceptional circumstances, and
- revoke the current 7 year time limit within which enforcement action may be taken in respect of unauthorised development (section 157(4) of the Planning and Development Act 2000).

In the interim, more immediate legislative measures with respect to retention planning applications for projects that fall under the EIA Directive are under consideration. The intention to make such legislation was notified to the European Commission on 3 September 2008, in Ireland's initial formal response to the ECJ judgement.

More immediately however, there is the issue of necessary action in relation to relevant planning applications (i.e. applications for retention permission for development which required an EIA), falling into two categories –

- applications currently awaiting determination by planning authorities, and
- applications which have been determined favourably since 3 July 2008.

Applications awaiting determination

It is understood that some planning authorities may have incorrectly taken the view that they must comply with and operate the relevant planning legislation as it currently stands, and therefore have to continue to make decisions on EIA/retention applications. The case law of the European Court of Justice makes it clear that administrative bodies such as planning authorities and An Bord Pleanála, being emanations of the State, are bound to comply with Community law and if necessary to disapply national law.

Accordingly, in respect of applications for permission for the retention of unauthorised development where such development should have been subject to prior EIA and where such development comes within Annex I of the Directive, planning authorities should return the application as invalid, on the basis that there is no jurisdiction to grant retention planning permission in those circumstances. That step should be taken upon receipt of the application. Applications that have been received and are currently being processed should be returned in the same way. The relevant body should refer to the judgment of the court in Case C-215/06 when communicating with applicants for retention permission.

In respect of applications for permission for the retention of unauthorised development where such development comes within Annex II of the Directive, planning authorities should proceed to decide whether an EIA is necessary or not ("screening decision"). If an EIA is not considered necessary, then the planning authority should proceed to deal with the application in the normal course. If, conversely, the planning authority decides that an EIA is necessary it should take the steps referred to in the previous paragraph.

The screening decision as to whether an EIA is necessary or not should be made as it would be made in the normal course of events, *i.e.* on the basis of the criteria set out at Schedule 7 of the Planning and Development Regulations, 2001.

Relevant retention planning permissions granted since 3 July 2008

It would appear that some relevant permissions have been granted since 3 July 2008 and that the planning authorities concerned may not have brought to the attention of the applicants the judgment of the ECJ and its potential implications for the permissions being granted.

Subject to the final paragraph, a recipient of such any retention permission issued since 3 July 2008 in respect of developments requiring an EIA must be informed as follows.

- The ECJ delivered a judgment in Case C-215/06 Commission v Ireland on 3 July 2008. The effect of the judgment should be briefly outlined.

Accordingly, in respect of applications for permission for the retention of unauthorised development where such development should have been subject to prior EIA and where such development comes within Annex I of the Directive, planning authorities should return the application as invalid, on the basis that there is no jurisdiction to grant retention planning permission in those circumstances. That step should be taken upon receipt of the application. Applications that have been received and are currently being processed should be returned in the same way. The relevant body should refer to the judgment of the court in Case C-215/06 when communicating with applicants for retention permission.

In respect of applications for permission for the retention of unauthorised development where such development comes within Annex II of the Directive, planning authorities should proceed to decide whether an EIA is necessary or not ("screening decision"). If an EIA is not considered necessary, then the planning authority should proceed to deal with the application in the normal course. If, conversely, the planning authority decides that an EIA is necessary it should take the steps referred to in the previous paragraph.

The screening decision as to whether an EIA is necessary or not should be made as it would be made in the normal course of events, *i.e.* on the basis of the criteria set out at Schedule 7 of the Planning and Development Regulations, 2001.

Relevant retention planning permissions granted since 3 July 2008

It would appear that some relevant permissions have been granted since 3 July 2008 and that the planning authorities concerned may not have brought to the attention of the applicants the judgment of the ECJ and its potential implications for the permissions being granted.

Subject to the final paragraph, a recipient of such any retention permission issued since 3 July 2008 in respect of developments requiring an EIA must be informed as follows

- The ECJ delivered a judgment in Case C-215/06 Commission v Ireland on 3 July 2008. The effect of the judgment should be briefly outlined.

- As a result of the judgment the permission granted is in breach of Community law having been granted under a legislative system that the Court has found is inconsistent with the EIA Directives.
- The applicant is advised not to act upon the permission.

Such notification should be sent by registered post to the applicant for the permission and copied to any person required by the Planning Acts to be notified of a decision on the application.

It is the Department's understanding that a notification need not be made in respect of a permission granted since 3 July for the continued operation of a quarry in respect of which an application for planning permission was made under and in strict accordance with section 261(7) of the 2000 Act, i.e. an application, with an environmental impact statement, made within such period as was specified by or agreed with the planning authority for the purposes of the subsection in respect of a quarry that commenced operation before 1 October 1964. (By extension, any such application currently being processed may proceed to determination).

Liam Whelan
Principal Officer
Planning System

To all planning authorities.

c.c. An Bord Pleanála

- As a result of the judgment the permission granted is in breach of Community law having been granted under a legislative system that the Court has found is inconsistent with the EIA Directives.
- The applicant is advised not to act upon the permission.

Such notification should be sent by registered post to the applicant for the permission and copied to any person required by the Planning Acts to be notified of a decision on the application.

It is the Department's understanding that a notification need not be made in respect of a permission granted since 3 July for the continued operation of a quarry in respect of which an application for planning permission was made under and in strict accordance with section 261(7) of the 2000 Act, i.e. an application, with an environmental impact statement, made within such period as was specified by or agreed with the planning authority for the purposes of the subsection in respect of a quarry that commenced operation before 1 October 1964. (By extension, any such application currently being processed may proceed to determination).

Liam Whelan
Principal Officer
Planning System

To all planning authorities.
c.c. An Bord Pleanála

Circular PD 5/08

15 August 2008

European Court of Justice ruling on retention planning permission for development requiring environment impact assessment, and the specific case of a windfarm development at Derrybrien in Galway.

The purpose of this circular is to draw the attention of planning authorities to a recent European Court of Justice (ECJ) judgement (Case-215/06 – see Appendix 1). The judgement in this case, that Ireland had failed to fulfil its obligations under Articles 2, 4, 5 and 10 of Directive 85/337/EEC, as amended by Directives 97/11/EC and 2003/35/EC - the "EIA Directive" - should be carefully considered by planning authorities for the purpose of dealing with planning applications involving projects that fall under the scope of the Directive, as amended.

This circular is advisory, and not a legal interpretation of the judgement, which should be referred to the authority's law agent for detailed consideration.

Overview of the Court Findings

There were two matters addressed in the ECJ judgement – the availability under Irish planning legislation of retention planning permission for development requiring environmental impact assessment, and the specific case of a windfarm development at Derrybrien, County Galway.

1. Retention Planning and Enforcement

In this regard, the ECJ ruling was twofold - firstly that Ireland had failed to adopt all measures necessary to ensure that projects which are within the scope of the EIA Directive are, before they are executed in whole or in part, first, considered with regard to the need for an EIA, and, secondly, where those projects are likely to have a

Circular PD 5/08

15 August 2008

European Court of Justice ruling on retention planning permission for development requiring environment impact assessment, and the specific case of a windfarm development at Derrybrien in Galway.

The purpose of this circular is to draw the attention of planning authorities to a recent European Court of Justice (ECJ) judgement (Case-215/06 – see Appendix 1). The judgement in this case, that Ireland had failed to fulfil its obligations under Articles 2, 4, 5 and 10 of Directive 85/337/EEC, as amended by Directives 97/11/EC and 2003/35/EC - the "EIA Directive" - should be carefully considered by planning authorities for the purpose of dealing with planning applications involving projects that fall under the scope of the Directive, as amended.

This circular is advisory, and not a legal interpretation of the judgement, which should be referred to the authority's law agent for detailed consideration.

Overview of the Court Findings

There were two matters addressed in the ECJ judgement – the availability under Irish planning legislation of retention planning permission for development requiring environmental impact assessment, and the specific case of a windfarm development at Derrybrien, County Galway.

1. Retention Planning and Enforcement

In this regard, the ECJ ruling was twofold - firstly that Ireland had failed to adopt all measures necessary to ensure that projects which are within the scope of the EIA Directive are, before they are executed in whole or in part, first, considered with regard to the need for an EIA, and, secondly, where those projects are likely to have a

significant impact on the environment by virtue, inter alia, of their nature, size or location, that they are assessed in accordance with Articles 5 to 10 of the EIA Directive.

The ECJ concluded that in Ireland retention planning permission could be granted for unauthorised projects which are covered by the EIA Directive, after those projects were completed. The ECJ found that while Community law cannot preclude the use of retention planning in certain cases, retention planning should not offer developers the opportunity to circumvent the EIA Directive, and that retention should remain the exception.

The ECJ stated that Member States are required to take appropriate action to counteract the unlawful consequences of a breach of Community law and that Irish planning authorities are obliged to take measures to remedy situations where an EIA should have been carried out prior to the granting of planning permission.

2. Derrybrien Wind Farm

The ECJ ruled that Ireland had failed to adopt all measures necessary to ensure that the planning permissions granted, and the execution of, wind farm developments and associated works at Derrybrien were preceded by an assessment with regard to their environmental effects in accordance with Articles 5 to 10 of the EIA Directive as amended. While wind-farms were not listed under Annex's I or II of the Directive at the time of this development, the initial works at Derrybrien included the extraction of peat/minerals of a non metalliferous or energy producing nature, and road construction, both of which were listed in Annex II of the Directive.

The ECJ found that despite the fact that the peat extraction and road construction may have been of secondary importance vis-à-vis the wind farm construction, as a whole, this did not mean, by virtue of that fact alone, that those projects were not likely to have significant effects on the environment. In this specific case, the ECJ found that the peat extraction and road construction should have been regarded as likely to have significant impacts on the environment and should have been subject to an assessment.

significant impact on the environment by virtue, inter alia, of their nature, size or location, that they are assessed in accordance with Articles 5 to 10 of the EIA Directive.

The ECJ concluded that in Ireland retention planning permission could be granted for unauthorised projects which are covered by the EIA Directive, after those projects were completed. The ECJ found that while Community law cannot preclude the use of retention planning in certain cases, retention planning should not offer developers the opportunity to circumvent the EIA Directive, and that retention should remain the exception.

The ECJ stated that Member States are required to take appropriate action to counteract the unlawful consequences of a breach of Community law and that Irish planning authorities are obliged to take measures to remedy situations where an EIA should have been carried out prior to the granting of planning permission.

2. Derrybrien Wind Farm

The ECJ ruled that Ireland had failed to adopt all measures necessary to ensure that the planning permissions granted, and the execution of, wind farm developments and associated works at Derrybrien were preceded by an assessment with regard to their environmental effects in accordance with Articles 5 to 10 of the EIA Directive as amended. While wind-farms were not listed under Annex I or II of the Directive at the time of this development, the initial works at Derrybrien included the extraction of peat/minerals of a non metalliferous or energy producing nature, and road construction, both of which were listed in Annex II of the Directive.

The ECJ found that despite the fact that the peat extraction and road construction may have been of secondary importance vis-à-vis the wind farm construction, as a whole, this did not mean, by virtue of that fact alone, that those projects were not likely to have significant effects on the environment. In this specific case, the ECJ found that the peat extraction and road construction should have been regarded as likely to have significant impacts on the environment and should have been subject to an assessment.

The ECJ also found that the environmental impact statements that were provided by the developer in this case were deficient. In particular, they did not examine soil stability when excavation was involved. The Court also noted that, contrary to Irish law, deforestation at Derrybrien authorised in May 2003 was not preceded by an assessment. Annex III of the EIA Directive refers to the risks inherent in projects that should be considered when examining the requirement for an assessment. One such risk is the environmental sensitivity of the geographical area, which must be considered having regard, inter alia, to the absorption capacity of the natural environment paying particular attention to mountain and forest areas.

The ECJ further ruled that applications for planning permission for the wind farm submitted after the EIA Directive was amended in April 1998 should have been subject to EIA as wind farms were specifically listed in Annex II 3(i) of the amended Directive and Annex II 13 refers to the requirement to screen for EIA any extension or change to a project that is covered by the Directive, but has already been authorised.

Action on foot of the ECJ Judgement

Ireland is obliged, before 3 September, to notify the European Commission of the measures that the relevant authorities here have taken in order to comply with the terms of the ECJ judgement.

The Minister has received approval of Government to the drafting of the General Scheme of a Planning and Development (Amendment) Bill, which will, among other things –

- remove the possibility of retention for unauthorised development which would otherwise have been subject to environmental impact assessment, other than in exceptional circumstances, and
- revoke the current 7 year time limit within which enforcement action may be taken in respect of unauthorised development (section 157(4) of the 2000 Act).

In the interim, more immediate legislative measures with respect to retention planning applications for projects that fall under the EIA Directive are under consideration.

The ECJ also found that the environmental impact statements that were provided by the developer in this case were deficient. In particular, they did not examine soil stability when excavation was involved. The Court also noted that, contrary to Irish law, deforestation at Derrybrien authorised in May 2003 was not preceded by an assessment. Annex III of the EIA Directive refers to the risks inherent in projects that should be considered when examining the requirement for an assessment. One such risk is the environmental sensitivity of the geographical area, which must be considered having regard, inter alia, to the absorption capacity of the natural environment paying particular attention to mountain and forest areas.

The ECJ further ruled that applications for planning permission for the wind farm submitted after the EIA Directive was amended in April 1998 should have been subject to EIA as wind farms were specifically listed in Annex II 3(i) of the amended Directive and Annex II 13 refers to the requirement to screen for EIA any extension or change to a project that is covered by the Directive, but has already been authorised.

Action on foot of the ECJ Judgement

Ireland is obliged, before 3 September, to notify the European Commission of the measures that the relevant authorities here have taken in order to comply with the terms of the ECJ judgement.

The Minister has received approval of Government to the drafting of the General Scheme of a Planning and Development (Amendment) Bill, which will, among other things –

- remove the possibility of retention for unauthorised development which would otherwise have been subject to environmental impact assessment, other than in exceptional circumstances, and
- revoke the current 7 year time limit within which enforcement action may be taken in respect of unauthorised development (section 157(4) of the 2000 Act).

In the interim, more immediate legislative measures with respect to retention planning applications for projects that fall under the EIA Directive are under consideration.

For their part, planning authorities are requested to analyse the findings of the ECJ in this case, and reflect them in their approach to applications for planning permission for projects that require, or may require, EIA. The Development Management Guidelines (June 2007) address EIA in Chapter 4, while Chapter 10 deals with enforcement of planning control.

For their part, planning authorities are requested to analyse the findings of the ECI in this case, and reflect them in their approach to applications for planning permission for projects that require, or may require, EIA. The Development Management Guidelines (June 2007) address EIA in Chapter 4, while Chapter 10 deals with enforcement of planning control.

Appendix 2

Appendix 2

Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Windfarms

Recommendations on the Siting of Windfarms in the Vicinity of Eskdalemuir, Scotland

Professor Peter Styles, Dr Ian Stimpson, Mr S Toon, Mr R England, Mr M Wright

Applied and Environmental Geophysics Research Group
Earth Sciences and Geography
School of Physical and Geographical Sciences
Keele University
Keele
Staffs ST5 5BG

18 July 2005

Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Windfarms

Recommendations on the Siting of Windfarms in the Vicinity of Eskdalemuir, Scotland

Professor Peter Styles, Dr Ian Stimpson, Mr S Toon, Mr R England, Mr M Wright

Applied and Environmental Geophysics Research Group
Earth Sciences and Geography
School of Physical and Geographical Sciences
Keele University
Keele
Staffs ST5 5BG

18 July 2005

Abstract

In order to meet, and in fact exceed, Kyoto targets, the UK government has set a challenging target of reducing the UK's carbon dioxide emissions by 60% by 2050. The development of renewable energy, especially wind power, will be an important contributor to the success of that policy.

Some 40% (in excess of 1 Gigawatt), of this wind generation capacity, was planned for the southern uplands of Scotland. However, the United Kingdom seismic monitoring site which constitutes our component of the Comprehensive Test Ban Treaty compliance for nuclear testing is situated at Eskdalemuir near Langholm in the Scottish Borders. The Ministry of Defence therefore placed a precautionary blanket objection to any wind farm developments within 80 km of Eskdalemuir in case this compromised UK capability to detect distant nuclear test and breached our agreement under the CTBT. This effectively removed at least 40% of the UK renewable wind resource identified by the DTI.

Because of our previous, unique experience in monitoring seismic vibrations from wind turbines in the UK, the Applied and Environmental Geophysics Group of the School of Physical and Geographical Sciences at Keele University, were asked by the MOD, the DTI and the British Wind Energy Association to investigate whether there was a solution to this impasse. By carrying out a detailed programme of seismic and infrasound measurements in the vicinity of several wind farms in Scotland we have been able to identify the characteristic frequencies and mode of propagation of seismic vibrations from wind turbines and develop a model for the integrated seismic vibration at the Eskdalemuir site which will be created by any distribution of wind farms. By carefully considering the present ambient background experienced at the monitoring site it has been possible to set a noise budget which is permissible at Eskdalemuir without compromising its detection capabilities, and we have demonstrated that at least 1.6 GW of planned capacity can be installed and have developed software tools which allow the MOD and planners to assess what further capacity can be developed against criteria established by this study.

Abstract

In order to meet, and in fact exceed, Kyoto targets, the UK government has set a challenging target of reducing the UK's carbon dioxide emissions by 60% by 2050. The development of renewable energy, especially wind power, will be an important contributor to the success of that policy.

Some 40% (in excess of 1 Gigawatt), of this wind generation capacity, was planned for the southern uplands of Scotland. However, the United Kingdom seismic monitoring site which constitutes our component of the Comprehensive Test Ban Treaty compliance for nuclear testing is situated at Eskdalemuir near Langholm in the Scottish Borders. The Ministry of Defence therefore placed a precautionary blanket objection to any wind farm developments within 80 km of Eskdalemuir in case this compromised UK capability to detect distant nuclear test and breached our agreement under the CTBT. This effectively removed at least 40% of the UK renewable wind resource identified by the DTI.

Because of our previous, unique experience in monitoring seismic vibrations from wind turbines in the UK, the Applied and Environmental Geophysics Group of the School of Physical and Geographical Sciences at Keele University, were asked by the MOD, the DTI and the British Wind Energy Association to investigate whether there was a solution to this impasse. By carrying out a detailed programme of seismic and infrasound measurements in the vicinity of several wind farms in Scotland we have been able to identify the characteristic frequencies and mode of propagation of seismic vibrations from wind turbines and develop a model for the integrated seismic vibration at the Eskdalemuir site which will be created by any distribution of wind farms. By carefully considering the present ambient background experienced at the monitoring site it has been possible to set a noise budget which is permissible at Eskdalemuir without compromising its detection capabilities, and we have demonstrated that at least 1.6 GW of planned capacity can be installed and have developed software tools which allow the MOD and planners to assess what further capacity can be developed against criteria established by this study.

Introduction

The Eskdalemuir Seismic Array (EKA)

Eskdalemuir in the Scottish Borders is the location of a monitoring facility operated by the British Geological Survey where seismological, magnetic and other environmental parameters are monitored because the site is located in a very quiet magnetic and seismic environment. Measurements include horizontal and vertical magnetic field components and declination, total field intensity, and absolute values of the geomagnetic field. Three-component seismological measurements are made at the sites. An environmental monitoring facility operates at Eskdalemuir, monitoring soil and air temperature, wind speed and direction; UV and nuclear radiation; sunshine; concentrations of ozone, SO2 and NOx gases; rainfall; humidity and surface wetness.

In addition the UK seismological array **(EKA)** operated by AWE Blacknest is also sited at Eskdalemuir. The facility at Eskdalemuir is part of the auxiliary seismic network of the International Monitoring System (IMS) being set up to help verify compliance with the Comprehensive Test Ban Treaty (CTBT) which bans nuclear-test explosions. So far the CTBT has been signed by 175 states, and ratified by 121. The UK and France were the first nuclear-weapons states to ratify the treaty. The facility at Eskdalemuir is to be upgraded to be an alternate primary IMS seismic station. The treaty requires that States Parties shall not interfere with the verification system, of which Eskdalemuir is an element.

The seismometer array at Eskdalemuir (EKA) (Figure 1) became operational on the 19 May 1962. The recording station comprises a recording laboratory, a seismological vault and an array of seismometers installed in pits spaced over an area 10 km square. The laboratory is situated on the eastern side of the Langholm-Innerleithen road (B709) about 30 km north of Langholm and 3 km north of the Eskdalemuir meteorological observatory. The seismological vault is about 400 m east south east of the laboratory, and the array lies to the east in the form of a cross with its centre, about 2.5 km from the laboratory. The latitude of the point of intersection of the two lines of the array is 55° 20' north and the longitude is 03° 09½' west. The array is situated across the watershed between tributary headstreams of the Teviot and Tweed flowing to the north-east, and headstreams of the Esk which generally flow to the south-west. The ground surface is largely open rolling moorland and forest plantations, which in is in many places peat covered. The altitude of the seismic pits varies from c 210 m to c 430 m. The isolated location ensures that microseismic interference is kept to a minimum. While there is very little light vehicular traffic on the Langholm-Innerleithen road logging trucks and heavy forestry machinery do use this road albeit intermittently.

The Array

The array consists of two straight lines of instrument pits intersecting at right angles. Each line has eleven pits (of which only ten on each line are used) approximately 1000 yards apart. Each line intersects the other off centre, forming a cross whose four arms are unequal. The lines run roughly from SSW to NNE and from WNW to ESE. The overall length of each line is approximately 9 km. The seismic pits have been excavated through an overburden of superficial soil (peat in some instances) or thickness from 0 to 1 m into shales of the Llandovery Series (Silurian age). These were folded during late Silurian times, and as a result of the lateral pressures exerted are highly cleaved. Buried recording cables connect each instrument pit to the recording laboratory.

Each pit on the array contains one vertical Willmore MK2 short period seismometer. The signals from the seismometers are transmitted via buried cables back to the recording laboratory where it is then digitised using 3 separate CMG-DM16-R8 digitisers. A central acquisition system then records this data. In addition the seismic vault at Eskdalemuir contains four seismometer plinths. Currently a broadband 120s to 50Hz GURALPCMG-3TD is installed in the vault. The data is transmitted from the vault to the recording station using a leased line modem. Data from this acquisition computer is then transmitted on two separate networks via TCP/IP to a VSAT system link to CTBTO in Vienna and to a local network. From the local network the data is transmitted via VSAT to AWE Blacknest and a second computer records the data locally onto a tape backup system. A study of the background noise at Eskdalemuir was undertaken in 1997/8 as an AWE report (Trodd 1998). The winter and summer RMS averages of the unfiltered summed channels of the array were found to be 8.96 and 1.65 nanometres respectively.

EKA has two arms, each of ten seismometers. The array comprises sensitive seismometers that have recorded signals associated with about 400 nuclear explosions (up to 15,000 km away from EKA). Why is Eskdalemuir so good at this? The main reason is that it occupies a seismically very quiet site (one of only three ever considered in the UK, (Bache et al., 1986)), approaching the low noise model of Petersen (1993), and its history of operation. EKA is the longest operating steerable array in the world has long experience of detecting events over 42 years, is well calibrated, and has detected signals from areas of low seismicity. It has detected signals generated from the detonation of c 100 tonnes of conventional explosive in Kazakhstan. The seismometers are deployed in shallow pits which means that the constructive interference between the up-going and reflected P-waves (compressional-dilatational first arrivals) from the free surface , effectively doubles the amplitude for vertically arriving (teleseismic) phases from distant events in addition to the increase in signal to noise ratio obtained by stacking the 20 seismometer records.

EKA(AS104) was offered by the UK during negotiations with the Comprehensive Test Ban Treaty Organisation (CTBTO) as an auxiliary station and EKA was designated a substitute for a primary seismic station (CTBT/WGB-10/1,1999). EKA data is widely used by the international research community in the pre-Entry into Force (EIF) phase

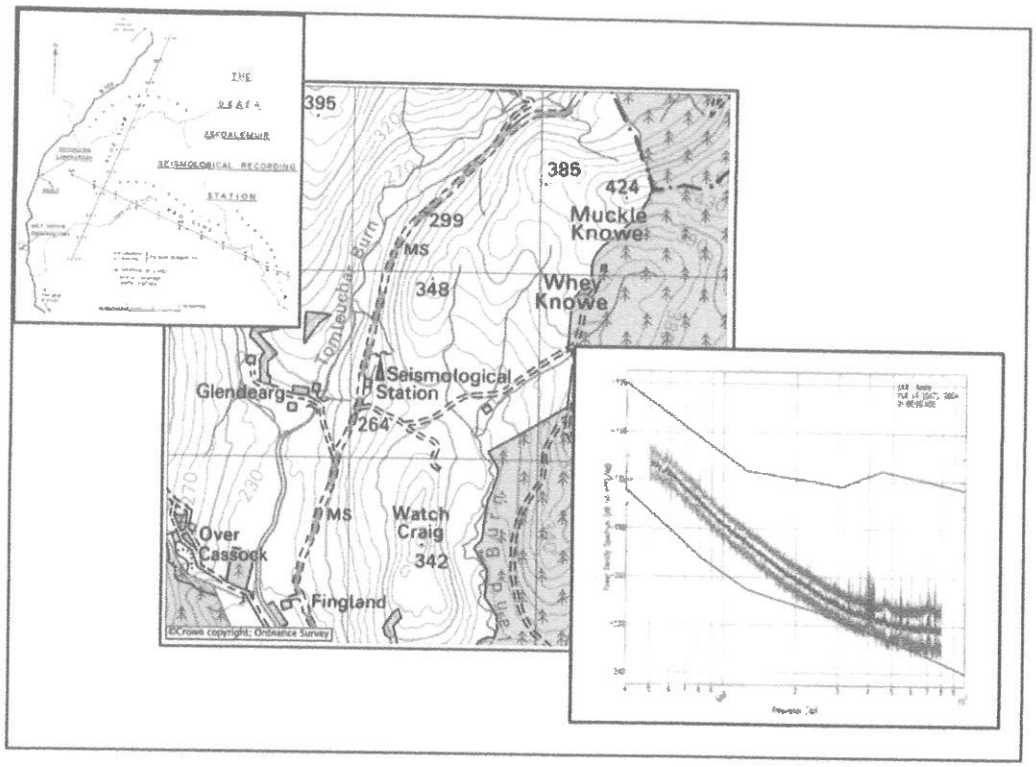
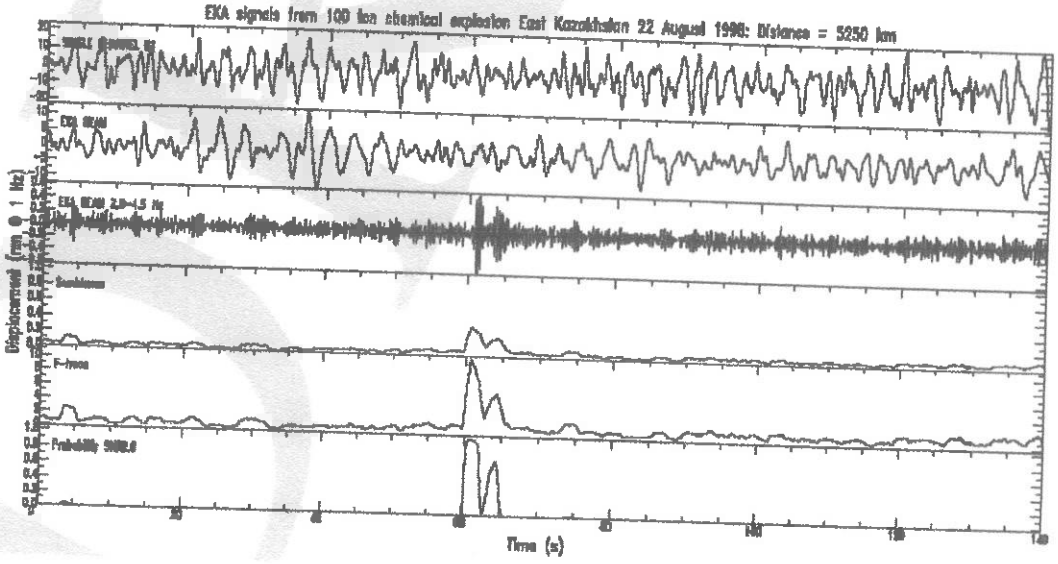


Figure 1 The Location of the EKA seismological array, the detailed layout of the arms of the array and the noise spectrum at the array which closely approaches the Low Noise Model of Petersen (1993).

Figure 2 indicates the detection sensitivity of the Eskdalemuir array as it clearly show the discrimination of the detonation of 100 T of conventional explosive in Kazakhstan a distance of some 5250 km away! The subsequent table which shows the statistics of ambient background is a partial explanation of this exceptional sensitivity as the median noise during a windy period was only 0.25 nm. This, together with years of historical data, makes EKA an unparalleled resource for forensic seismology, i.e. the discrimination of distant nuclear detonations.

EKA signals from a 100 t chemical explosion, Kazakhstan



Passband (Hz)	Quiet rms (nm)			Windy rms (nm)		
	Mean	SD	Median	Mean	SD	Median
1.0-2.0	1.425	0.144	1.454	1.900	0.331	1.857
2.0-3.0	0.245	0.116	0.202	0.497	0.292	0.454
3.0-4.0	0.147	0.097	0.111	0.341	0.220	0.317
4.0-5.0	0.116	0.079	0.088	0.271	0.178	0.253

Quiet times: 2003/12/08 02:00 (1), 2003/12/08 10:00 (1) , 2003/12/08 22:00 (2), 2003/12/09 02:00 (1), 2003/12/09 10:00 (1), 2003/12/09 22:00 (1).

Windy times: 2003/12/01 22:00 (16). 2003/12/02 02:00 (19), 2003/12/02 03:00 (20), 2003/12/02 10:00 (11), 2003/12/02 11:00 (9), 2003/12/06 10:00 (7).

Figures in parenthesis are mean wind speed in knots (1 knot = 0.51 m s^{-1}) at Eskdalemuir weather station (source: Met. Office website).

Figure 2 Statistics of ambient microseismic noise at Eskdalemuir during quiet and noisy wind periods and an example of the detection capability of the array in the 2 to 4.5 Hz band (from Bowers (2004) , Elliot and Bowers 2004).

The International Monitoring System (IMS) network will eventually comprise:

1. 50 primary seismic stations,
2. 120 auxiliary seismic stations,
3. 60 infrasound stations,
4. 11 hydroacoustic stations,
5. 80 radionuclide stations

The IMS station at Eskdalemuir is part of the verification system. Article IV, Paragraph 6 of the CTBT means that as a state signatory the UK is not allowed to interfere with (degrade) the performance of the verification system.

The International Monitoring System (IMS) network will eventually comprise:

1. 50 primary seismic stations,
2. 120 auxiliary seismic stations,
3. 60 infrasound stations,
4. 11 hydroacoustic stations,
5. 80 radionuclide stations

The IMS station at Eskdalemuir is part of the verification system. Article IV, Paragraph 6 of the CTBT means that as a state signatory the UK is not allowed to interfere with (degrade) the performance of the verification system.

Renewable Energy in the Southern Uplands of Scotland and its implications for Seismic Verification.

The hills of the Lake District and Scottish Borders constitute a major wind resource and some existing wind farms have been operating for many years and many new facilities are planned. As part of the UK renewable energy targets set in order to meet the Kyoto protocol, in excess of 1 GigaW of wind energy capacity are planned for the Southern Uplands of Scotland, a valuable wind resource area. In late December 2003 AWE/MoD recognised that many wind farm developments are planned in the vicinity of the Eskdalemuir International Monitoring Site which constitutes part of the CTBTO monitoring network and that the discrimination capabilities of it might be affected by possible vibration intrusion by wind turbines erected in proximity to the array and that this might have implication for its performance in discriminating nuclear weapons tests.

Wind turbines are large vibrating cylindrical towers, strongly coupled to the ground with massive concrete foundation, through which vibrations are transmitted to the surroundings and with rotating turbine blades generating low-frequency acoustic signals which may couple acoustically into the ground. This may occur in several ways:

1. As a cantilever carrying the nacelle/blade mass, with frequencies typically less than 1Hz, depending on height of tower.
2. As a torsional oscillator at low frequencies.
3. As a complex distributed system at higher frequencies

Additionally, the blade tower interaction is a source of pulses at a low repetition rate, which contain components in the infrasound region. The local and surrounding geology especially layering may play an important part in determining vibration transmission. Energy may propagate via complex paths including directly through the ground or principally through the air and then coupling locally into the ground and it is hope that this study will be able to clarify this.

The site is of national and international significance and requires protection. Because of uncertainty at that time as to the actual levels of seismic vibration generated by large UK wind farms, the Ministry of Defence implemented interim proposals for 30km and 80km cautionary distances. Holding objections were placed on wind farm development within a radius of 30 km from the seismic detection facility near Eskdalemuir and developments up to 80 km radius would be re-examined.

Potential Scottish Wind farm developments which might be affected by this objection are:

Within a 30 km. radius:

Minch Moor, Over Dalgleish (Mast), Craik Forest (Mast) Corbie Shank, Carlesgill , Ewe Hill/Haggy Hill Allfornought Hill, and Ae Forest

Between 30 km and an 80 km. radius:

Auchencorth Moss , Bowbeat, Broadmeadows, Carcant, Soutra, Fallagore Ridge, Black Hill. Clints Hill, Lauder Common/Sell Moor, Long Park (mast), Crystal Rig, Monashee , Dalswinton and Kyle Forest.

In addition, many Cumbrian and Northumbrian windfarm sites or planned developments lie within or close to the 80 km re-examination zone.

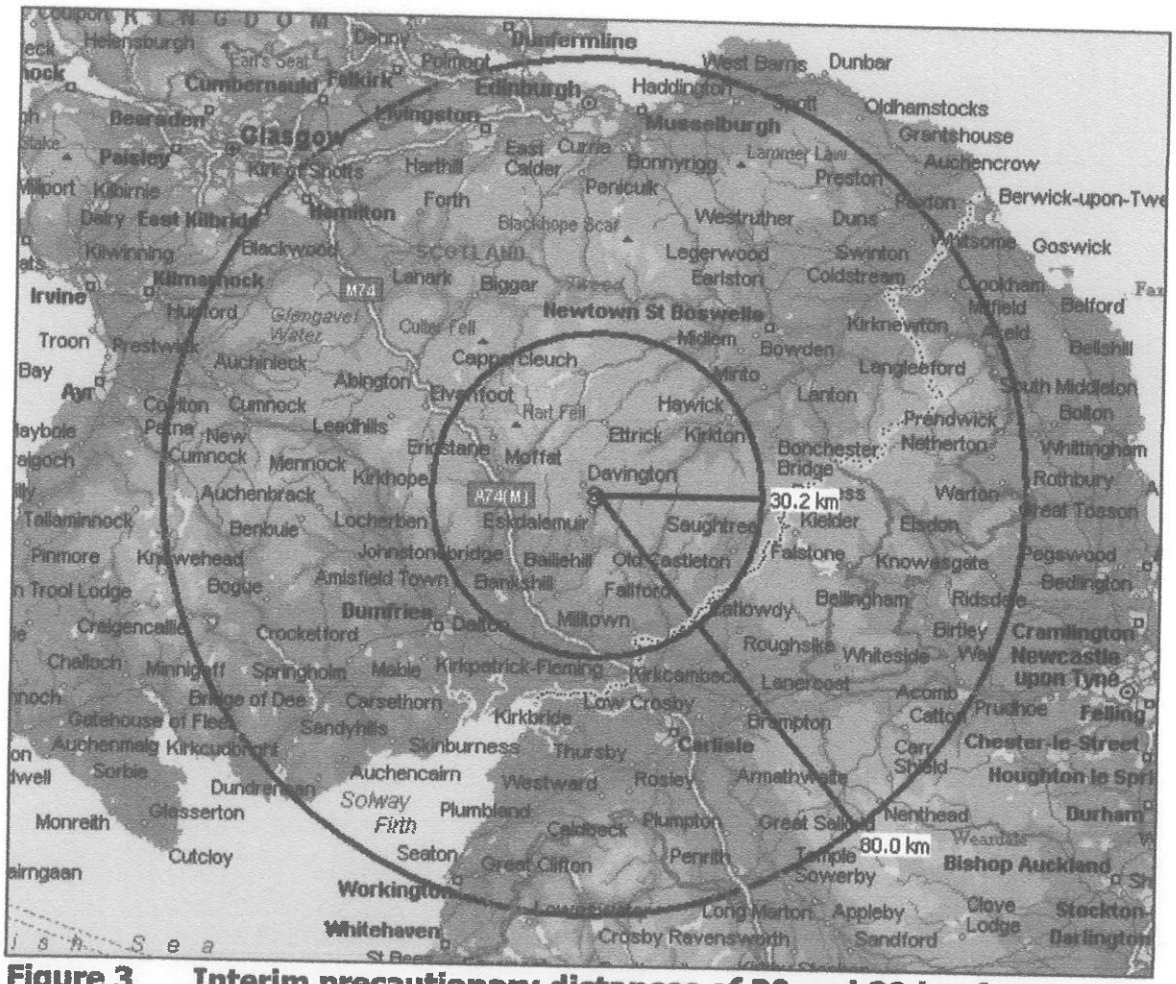


Figure 3 Interim precautionary distances of 30 and 80 km from Eskdalemuir indicating the large areas (2800 km^2 and 20000 km^2) which would be excluded from windfarm development.

This preliminary assessment was based on results from literature and web searches presented to BWEA/MoD meeting on 10 February2004 by Dr David Bowers of AWE Blacknest.

It was recognised that further research was urgently required in order to establish guidelines for future wind-farm development in the vicinity of EKA. The Eskdalemuir Working Group was established to ensure the guidelines had a sound scientific basis and to investigate whether these are the appropriate distances and if necessary develop guidelines for this protection.

Very few studies of the microseismic vibrations from wind farms have been carried out anywhere. The only UK studies prior to this were carried out by the Microseismology Research Group at the University of Liverpool (led by Dr Peter Styles)

The Department of Earth Sciences at the University of Liverpool operated a single three-component seismic station at the Powys Observatory, Knighton, Powys for several years to monitor the seismicity of the Welsh Borders after the large (5.1) Bishop's Castle earthquake of 2 April 1990 and when plans were submitted for a windfarm development a few kilometres away on an adjacent farm it raised concerns that this might produce vibrations which would interfere with the detection of seismic events. Preliminary experiments were carried out near existing Mid-Wales windfarms followed by a significant study at St Breock Down, Cornwall funded by POWERGEN and ETSU (Styles P. (1996), Low-Frequency Wind Turbine Noise and Vibration: ETSU/POWERGEN, Contract Number 503922) and reported by SNOW, (ETSU W/13/00392/REP Low frequency noise and vibration measurements at a modern wind farm, D.J. Snow (1997)) and also reported by Manley and Styles (1995) and Legerton et al. (1996).

In addition a NERC funded studentship was awarded for Microseismic Investigation of Infrasonic Environmental Noise and Vibration (Rushforth, I, PhD Liverpool (2002), While vibrations were found to be well below the BS standards for disturbance to populations they were not interpreted in the light of possible disturbance to ultra-sensitive monitoring facilities.

Details of the various experiments which constitute these studies follow.

Previous Microseismic Monitoring of Wind farms in the UK

1 St. Breock Downs, Cornwall, SW 970 683, 50° 28′ 33″, 04° 51′ 40″

Rated Power: 4.95MW
Wind Turbines: 11 Bonus 450kW
Rotor Diameter: 36 metres
Hub Height: 35m
Connection Voltage: 33 kV
Site Design and Environmental Impact Assessment: EcoGen
Planning Consent: August 1993
Developer: EcoGen SeaWest Tomen Joint Venture
Commissioning: June - July 1994
Owner: PowerGen

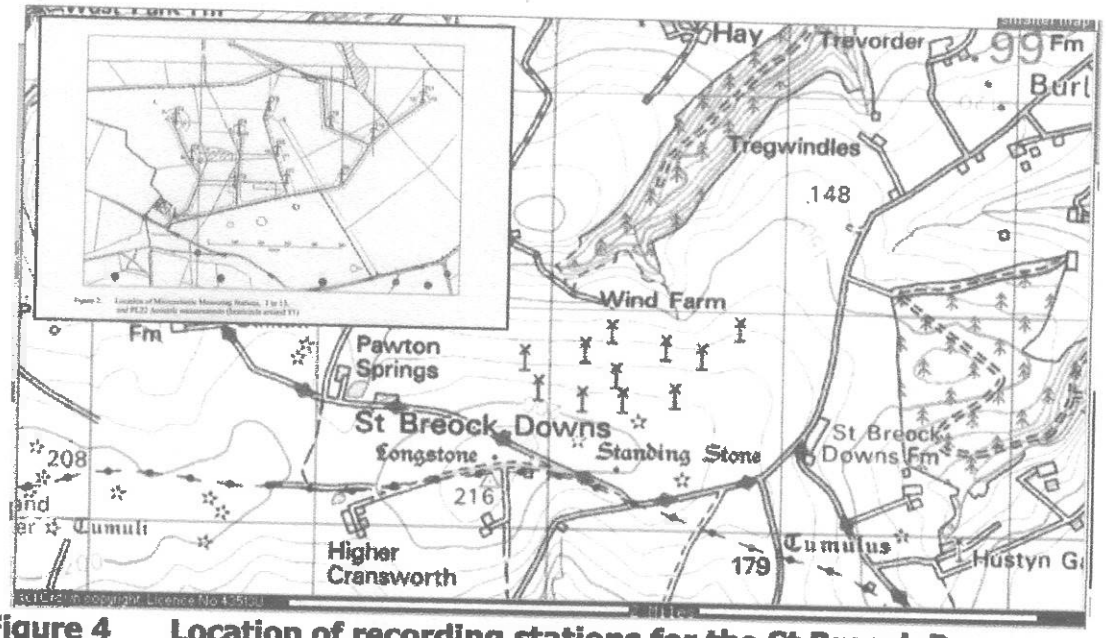


Figure 4 Location of recording stations for the St Breock Downs experiments

A sequence of three experiments were carried out

1 Deployment of VIBROSOUND SP1 24-bit Digital Recorder with LENNARTZ LE-3D/1 Seismometers in buried pits. Two sets of three-component seismometers were used with specifications and calibrations given in Appendix 1. These were deployed from 18 March until 30 March in order to record data from a wide range of wind speed and directions and were the principal instruments on which this investigation was based. Measurements were made at distances of 100 metres, 50 metres and 25 metres for Turbine 1 (positions 1, 2 and 3 on Figure 3).

Figure 4 Location of recording stations for the St Breock Downs experiments

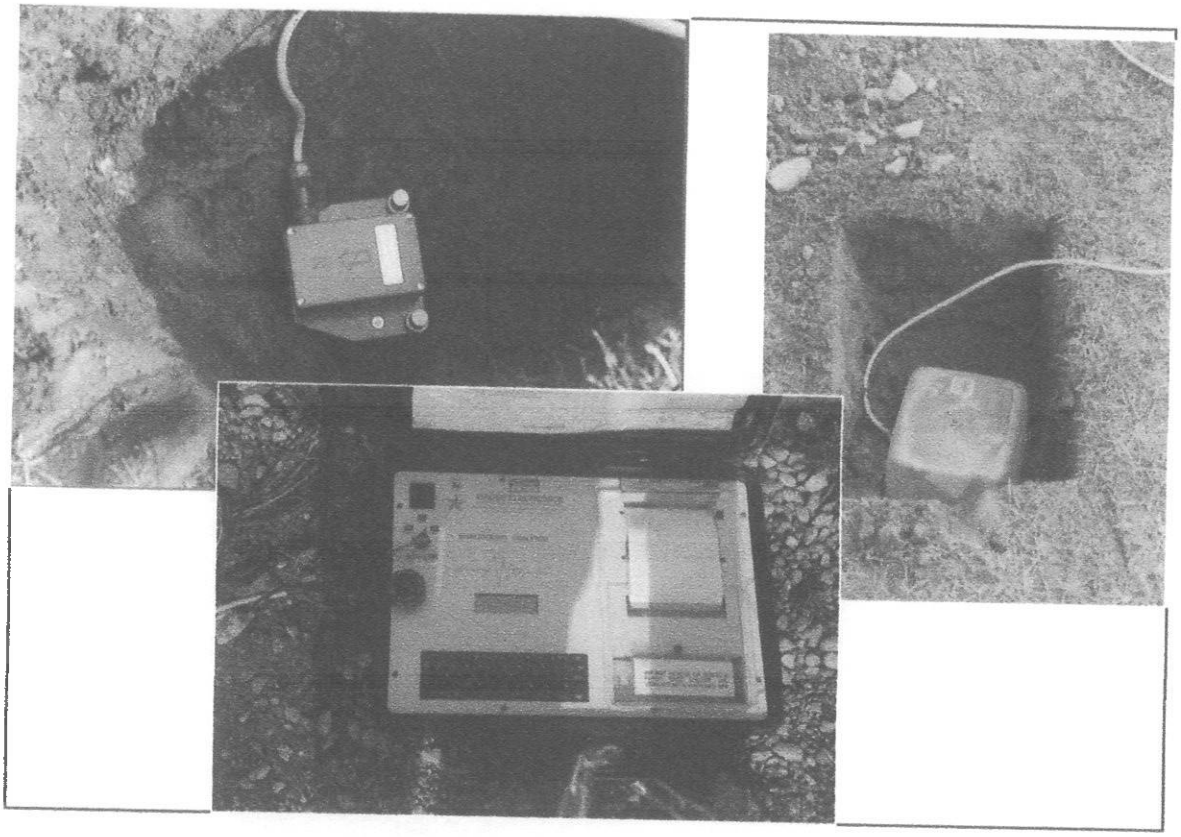


Figure 5 Recording Equipment for experiment 1

2 Deployment of GEOSENSE DV1 three component digital seismographs with direct PC interface. This was a portable, compact three-component instrument with a bandwidth from 0.2 Hz to 64 Hz which could be quickly and easily moved from site to site. This was ideal for measuring the variation in the low-frequency signal form different turbines and at a range of distances. This experiment took place during the period 18 to 20 March 1996 and measurements were made at positions 4 through 13 on Figure 4 and also at a distance of c 1 kilometre at Pawton Springs Farm (Figure 4).

3 Measurement of Acoustic Noise Level Variation with azimuth around a wind-turbine using Diagnostic Instruments PL22 FFT Frequency Analyzer and a Cirrus Research Ltd ZE901-40F with MK 182LF Microphone Capsule. This was supplied directly from the manufacturers with a dedicated calibrator. This instrument was also used to measure the actual machinery vibration using B&K Type 5318 accelerometers mounted on the base of Turbine 1. (Figure 6).

Figure 5 Recording Equipment for experiment 1

2 Deployment of GEOSENSE DV1 three component digital seismographs with direct PC interface. This was a portable, compact three-component instrument with a bandwidth from 0.2 Hz to 64 Hz which could be quickly and easily moved from site to site. This was ideal for measuring the variation in the low-frequency signal form different turbines and at a range of distances. This experiment took place during the period 18 to 20 March 1996 and measurements were made at positions 4 through 13 on Figure 4 and also at a distance of c 1 kilometre at Pawton Springs Farm (Figure 4).

3 Measurement of Acoustic Noise Level Variation with azimuth around a wind-turbine using Diagnostic Instruments PL22 FFT Frequency Analyzer and a Cirrus Research Ltd ZE901-40F with MK 182LF Microphone Capsule. This was supplied directly from the manufacturers with a dedicated calibrator. This instrument was also used to measure the actual machinery vibration using B&K Type 5318 accelerometers mounted on the base of Turbine 1. (Figure 6).

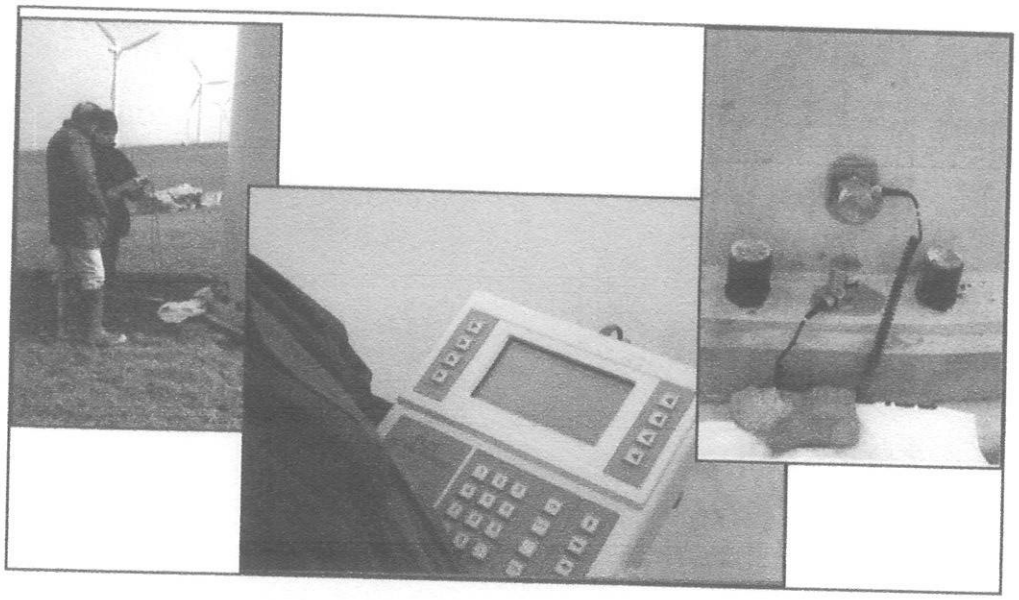


Figure 6 Recording equipment for the on-tower experiment 3

The following objectives were addressed: and the following main conclusions were reached:

1 **To determine whether low frequency vibrations (down to 0.1 Hz) are transmitted through the ground from a modern wind farm and if so to measure their amplitude and frequency content.**

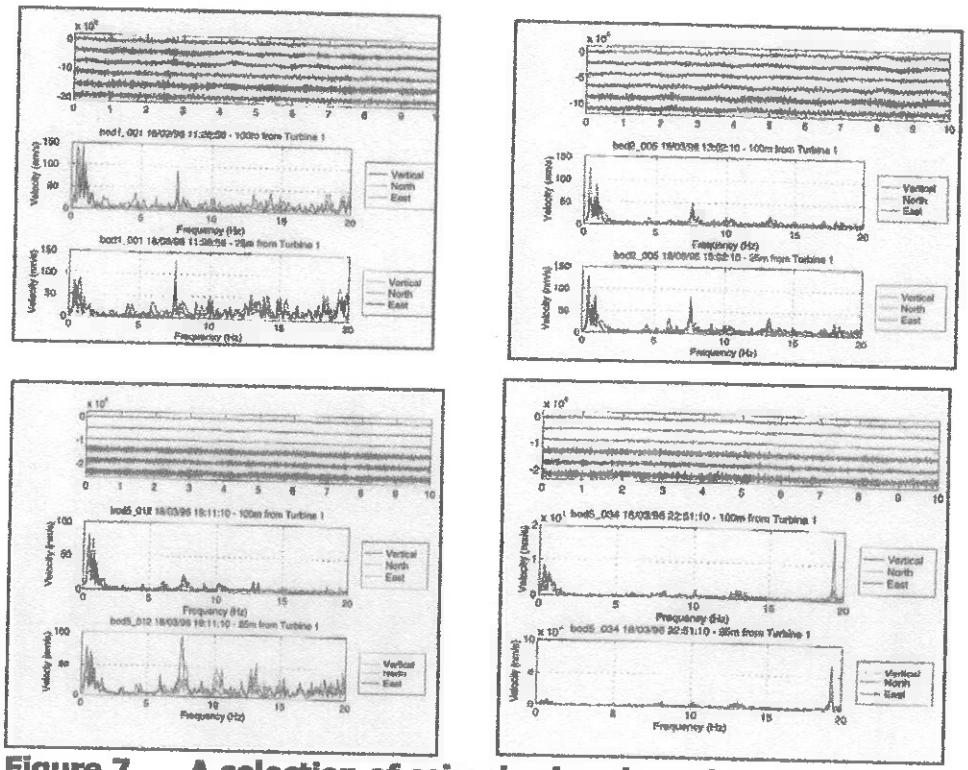


Figure 7 A selection of seismic signals and their spectra measured at St Breock Downs

Clear harmonic components at multiples of 0.5 Hz were observed on the majority of the spectra with particular peaks at 0.5, 3.0, 4.5, 6.0, 7.5 Hz and higher frequencies at levels of up to 250 nanometres s^{-1} (0.25 microns s^{-1}) and general levels of 50 to 80 nanometres s^{-1} (Figure 6) . The presence of so many harmonics which are multiples of the blade passing frequency and the clear attenuation of signal amplitude with distance especially for the 7.5 Hz component is a prima facie argument that the signals are being generated from the wind turbines and although the levels are small they can easily be detected on appropriate sensors. The 1.5 Hz component is not the strongest harmonic as might have been suspected.

2 To make measurements at a range of distances to determine the variation in frequency and amplitude of low-frequency vibrations

Measurements were made at distances of 25, 50 and 100 metres from Turbine 1 and the frequencies above 3.0 Hz were seen to attenuate with distance with higher frequencies decaying faster as expected. During the sequential shutdown frequencies were observed over a distance of some 500 to 700 metres and significant attenuations noted with the exception of the very lowest frequencies which in fact increased in frequency. This may be a due to interference effects which were less with fewer turbines in operation or the harmonic may be sourced from elsewhere. The 0.5 Hz signals were detected at a distance of c 1 kilometre from St Breocks Down at Pawtonsprings Farm.

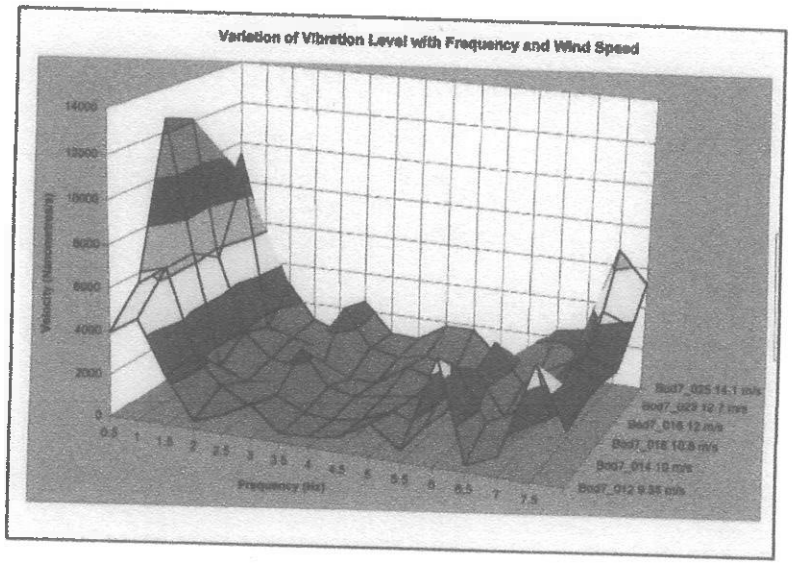
3 To make measurements for a range of wind speeds to determine the variation in frequency and amplitude of low-frequency vibrations

Measurements were made over a range of wind speeds from c 7 ms^{-1} to 14 ms^{-1} at a constant direction (Figure 8). The amplitude of the harmonics generally increase with increasing windspeed. This is particularly evident for the 0.5 Hz harmonic, the 3 Hz harmonic and the 7.5 Hz harmonic. However and rather surprisingly the amplitude of the 6 Hz harmonic shows an inverse relationship: as the wind speed rises the amplitude of this harmonic falls. It seems that the partition of energy between the 6 and 7.5 Hz harmonics in particular is strongly dependent on wind-speed. Notwithstanding the reservations expressed concerning the nature of the ultra-low vibrations, the increase in amplitude of the 0.5 Hz component with wind speed suggests that it does have a source which is related in some way to the wind turbine farm.

4 To make measurements for a range of wind directions to determine the variation in frequency and amplitude of low-frequency vibrations

Measurements were made over a range of wind directions from c 120^0 to c 310^0 at a constant wind speed of 10 ms^{-1}. Clear variations in amplitude were

observed with levels varying by about a factor two. The variation had the same spatial pattern for most frequencies and this pattern correlated with acoustic measurements made at closer angular increments within the limitations of the data



Event Number	Wind Speed	Wind Direction
Bod7_012	9.35	119.5
Bod7_014	10.0	113
Bod7_016	12	123
Bod7_018	10.8	110
Bod7_023	12.7	118.5
Bod7_025	14.1	120

Figure 8 Variation of Amplitude and frequency with windspeed

5 To investigate the variation of amplitude and frequency as a sequence of wind turbines were sequentially switched off

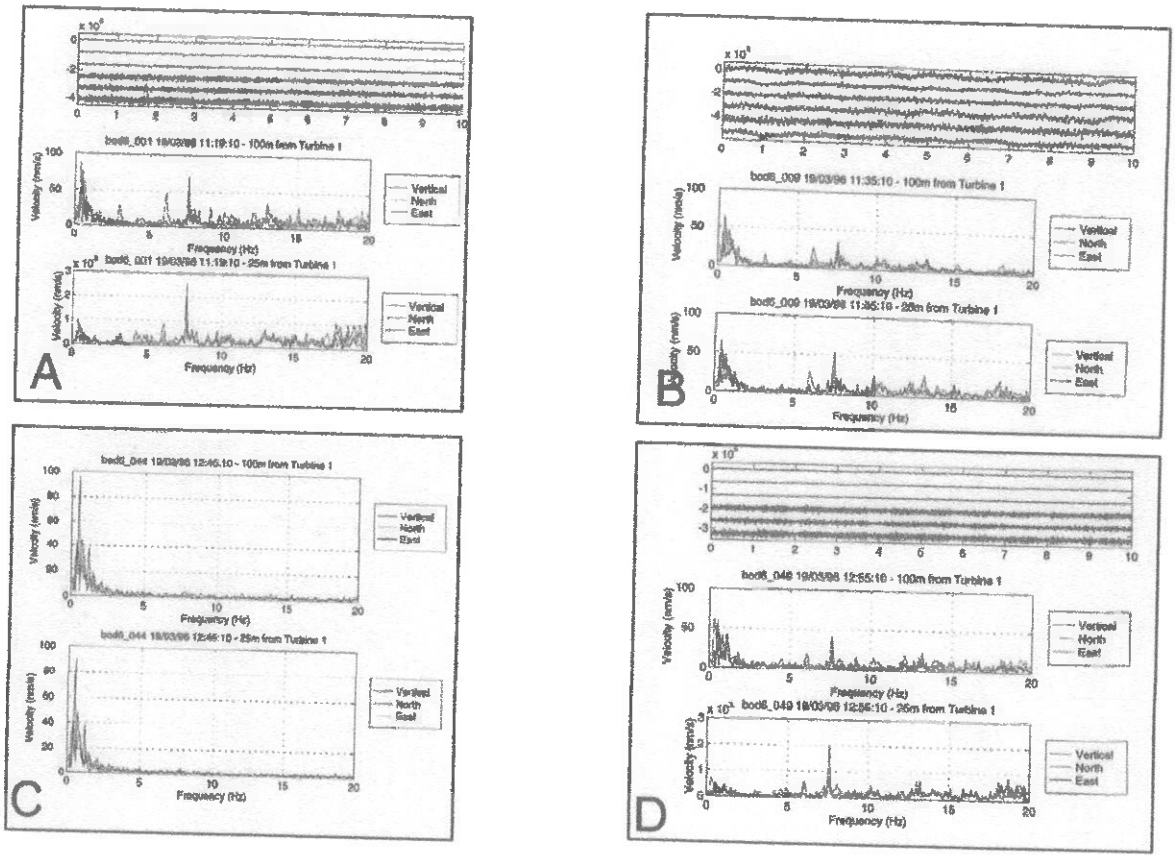


Figure 9 Sequential Shutdown

A) All On, B) T1 Off, C) All Off, D) Only T1 On

Time Interval	Turbines On	Turbines Off	Event Numbers
11:19 to 11:28	All 1 to 11	None	Bod6_001 to Bod6_005
11:29 to 11:48	2 to 11	1	Bod6_007 to Bod6_016
11:49 to 12:08	3 to 11	1,2	Bod6_017 to Bod6_025
12:09 to 12:10	4,5,6,7,8,9,10,11	1,2,3	Bod6_026
12:11 to 12 :12	5,6,7,8,9,10,11	1,2,3,4	Bod6_027
12:12 to 12:23	3,5,6,7,8,9,10,1	1,2,4	Bod6_028 to Bod6_3
12:24 to 12:41	5,6,7,8,9,10,11	1,2,3,4	Bod6_034 to Bod6_041
12:42 to 12:49	None	1,2,3,4,5,6,7,8,9,10,11	Bod6_042 to Bod6_046
12:50 to 12:56	1	2,3,4,5,6,7,8,9,10,11	Bod6_047 to Bod6_050
12:57 to 13:13	None	1,2,3,4,5,6,7,8,9,10,11	Bod6_053 to Bod6_058
13:14 to 13:15	3	1,2,4,5,6,7,8,9,10,11	Bod6_059

A
B
C
D

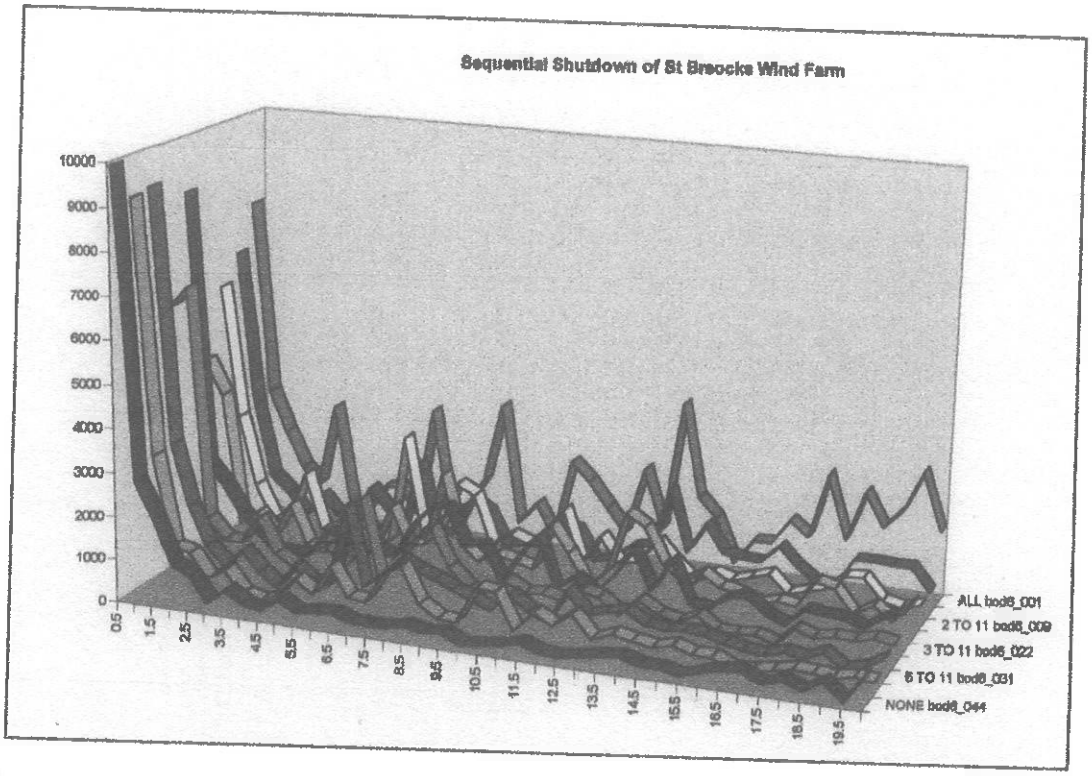


Figure 10 Shutdown Summary

The levels of vibration fell in a manner which was consistent with their origin being from the wind turbine farm. The lowest frequencies persisted even when the whole turbine field was shut-down which indicates that their source may be external to the site or that some complex interference is happening between the multiple vibration sources such as the resonance of the tower structure itself under wind loading.

6 To investigate the variation of amplitude and frequency between individual wind turbines

The presence of large wind components on the shallowly buried instrument masked some of the subtler variation but the levels of vibration (c 50 to 100 nms^{-1}) were consistent between machines although individual frequencies showed considerable variation over the whole St Breocks site.

7 To investigate the frequencies present in the vibrational spectrum of the turbine tower itself for comparison with the microseismic measurements

Figure 11, recorded using accelerometers mounted on the base of Turbine 1, clearly show tonal components which correspond with the frequencies observed out as far as 1 km away from the windfarm. The 4.5 and 7.5 Hz components seen on the microseismic records are particularly pronounced within the infrasonic band (sub 20 Hz) as are other harmonics of 1.5 Hz.

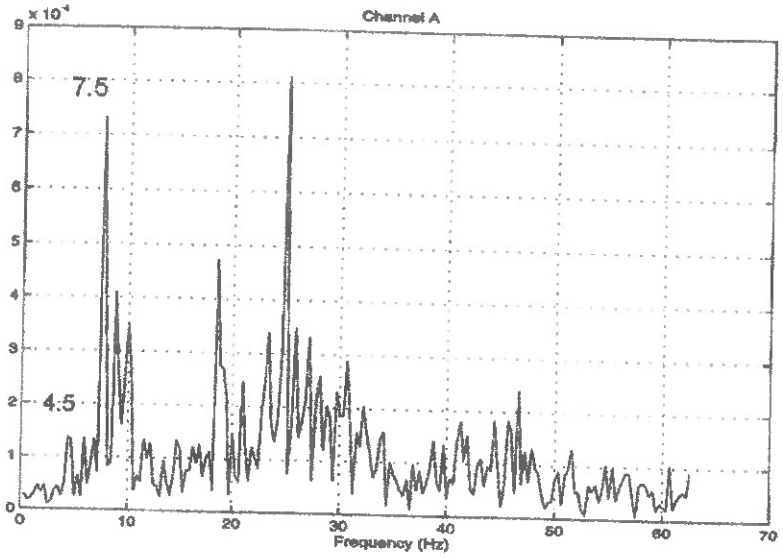


Figure 11 **On-tower accelerometer spectrum at Turbine 1 recorded while all other turbines were switched off.**

Figure 11 On-tower accelerometer spectrum at Turbine 1 recorded while all other turbines were switched off.

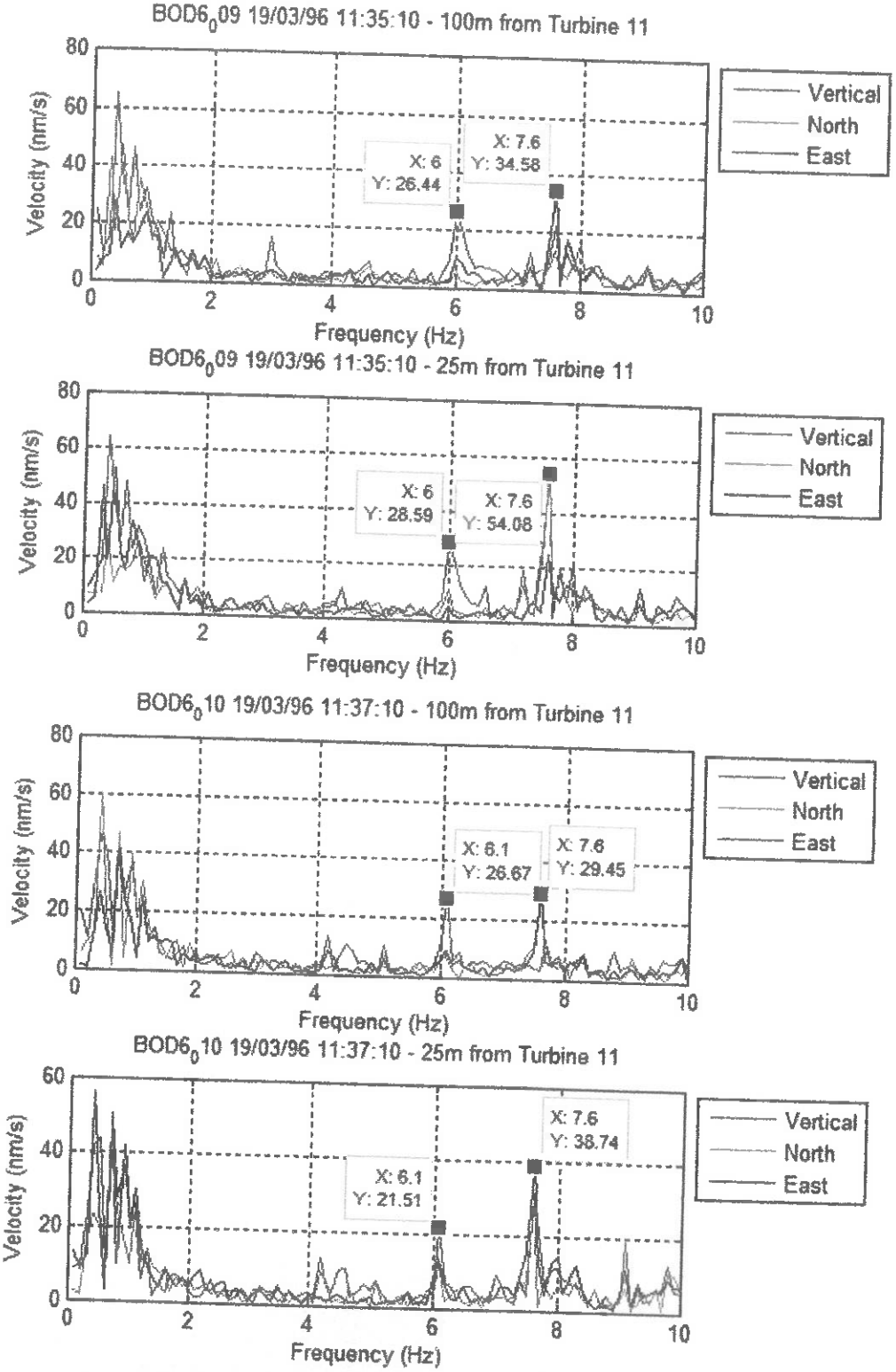


Figure 12 Selected spectra during the sequential shut-down at St Breock Downs

Figure 12 Selected spectra during the sequential shut-down at St Breock Downs

8 To investigate the mode of propagation of the seismic vibrations

The spectra above and the following figure show the variation in amplitude of the best detected 6 and 7.5 Hz harmonics, against distance from the turbine during the switch-off experiment. These and their averages have then been compared with different models for the attenuation of the amplitude with distance. There is considerable variation but the data fit a $r^{-(1/2)}$ model much better than a r^{-1} model.

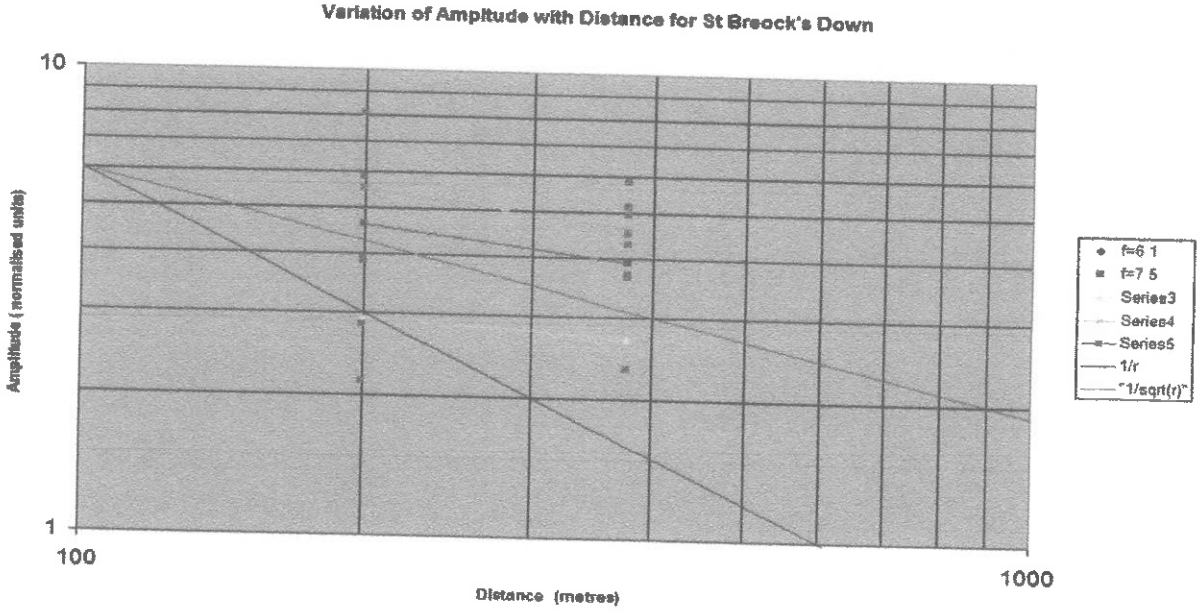


Figure 13 Variation of amplitude of well-detected frequencies with distance and a comparison with various attenuation models.

Figure 13 Variation of amplitude of well-detected frequencies with distance and a comparison with various attenuation models.

Extremely Low wind speed, no production:

Date:	01.10.2004
Time:	04:00 to 05:00
Average wind speed:	3.46ms^{-1}
Average wind direction:	206.67°
Average production:	-4.5 kW

It is clear that when wind speeds are close to zero and there is no production then no infrasound signals can be seen on any of the detectors as would be predicted.

Low wind speed, low production:

Date:	01.10.2004
Time:	06:00 to 07:00
Average wind speed:	4.58ms^{-1}
Average wind direction:	221.33°
Average production:	1826.8 kW

When the windfarm starts to generate at low wind speeds, considerable infrasound signals can be detected at all stations out to c 10 km. Clear harmonic components which are the second multiple and up of 1.4 Hz (the blade-passing frequency) can be seen although interestingly and somewhat enigmatically the blade-passing frequency itself is not so strongly detected

Moderate wind speed, moderate production:

Date:	02.10.2004
Time:	00:00 to 01:00
Average wind speed:	7.29ms^{-1}
Average wind direction:	245.67°
Average production:	9100.9 kW

When the windspeed and production rise clear signals can be seen on Kelphope 1 at c 2 km but the signals are not so well detected at the more distant array.

High wind speed, full production:

Date:	02.10.2004
Time:	11:00 to 12:00
Average wind speed:	11.189ms^{-1}
Average wind direction:	254.67°
Average production:	16920.8 kW

Extremely low wind speed, no production:

Date:	01.10.2004
Time:	04:00 to 05:00
Average wind speed:	3.46ms^{-1}
Average wind direction:	206.67°
Average production:	-4.5 kW

It is clear that when wind speeds are close to zero and there is no production then no infrasound signals can be seen on any of the detectors as would be predicted.

Low wind speed, low production:

Date:	01.10.2004
Time:	06:00 to 07:00
Average wind speed:	4.58ms^{-1}
Average wind direction:	221.33°
Average production:	1826.6 kW

When the windfarm starts to generate at low wind speeds, considerable infrasound signals can be detected at all stations out to c. 10 km. Clear harmonic components which are the second multiple and up of 1.4 Hz (the blade-passing frequency) can be seen although interestingly and somewhat enigmatically the blade-passing frequency itself is not so strongly detected

Moderate wind speed, moderate production:

Date:	02.10.2004
Time:	00:00 to 01:00
Average wind speed:	7.29ms^{-1}
Average wind direction:	245.67°
Average production:	9100.9 kW

When the windspeed and production rise clear signals can be seen on Kelphope 1 at c 2 km but the signals are not so well detected at the more distant array.

High wind speed, full production:

Date:	02.10.2004
Time:	11:00 to 12:00
Average wind speed:	11.19ms^{-1}
Average wind direction:	264.67°
Average production:	16920.8 kW

When the windspeed and production rise then while it is possible to see the harmonics at Kelphope they are not detectable at all on the more distant array at 10 km.

This is a very significant observation and indicates that infrasound signals from windfarms only appear to propagate efficiently to the more distant parts of the array during relatively calm conditions when turbulence associated with high wind velocities is not present.

This is in marked contrast to the microseismic signals observed during exactly the same period which grow in amplitude and power as the wind speed and energy production increase. While it is apparent that infrasound signals can clearly be detected at considerable distances away from a windfarm in the right conditions and may have an importance in this regards, they CANNOT be the primary source for the ground vibrations we measure on buried seismometers as there is an inverse relationship with windspeed and weather conditions for the two phenomena and they cannot therefore be causally related.

This confirms what was suggested earlier, that the vibrations experienced on seismometers situated at considerable distances from farms propagate through the ground as high frequency Rayleigh waves and not through the air, and as such must obey the propagation modes and attenuation and absorption laws for geological materials and not air.

When the windspeed and production rise then while it is possible to see the harmonics at Kelphope they are not detectable at all on the more distant array at 10 km.

This is a very significant observation and indicates that infrasound signals from windfarms only appear to propagate efficiently to the more distant parts of the array during relatively calm conditions when turbulence associated with high wind velocities is not present.

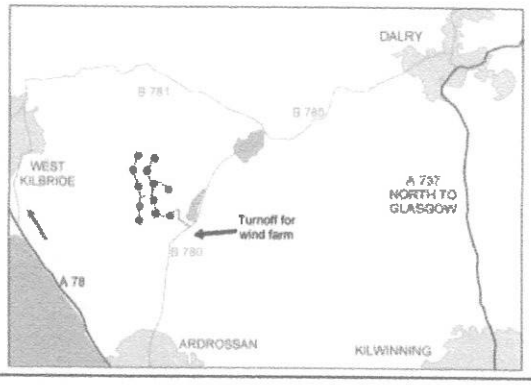
This is in marked contrast to the microseismic signals observed during exactly the same period which grow in amplitude and power as the wind speed and energy production increase. While it is apparent that infrasound signals can clearly be detected at considerable distances away from a windfarm in the right conditions and may have an importance in this regards, they CANNOT be the primary source for the ground vibrations we measure on buried seismometers as there is an inverse relationship with windspeed and weather conditions for the two phenomena and they cannot therefore be causally related.

This confirms what was suggested earlier, that the vibrations experienced on seismometers situated at considerable distances from farms propagate through the ground as high frequency Rayleigh waves and not through the air, and as such must obey the propagation modes and attenuation and absorption laws for geological materials and not air.

ON-Tower monitoring of a variable speed wind farm

A variable speed site was made available at Ardrossan, a 12 turbine 24 MW windfarm operated by Airtricity in order for us to carry out on-tower monitoring there and we are grateful for their very helpful cooperation.

12 Vestas V80
24 MW
Airtricity
Latitude 55 41 09
Longitude 04 48 26



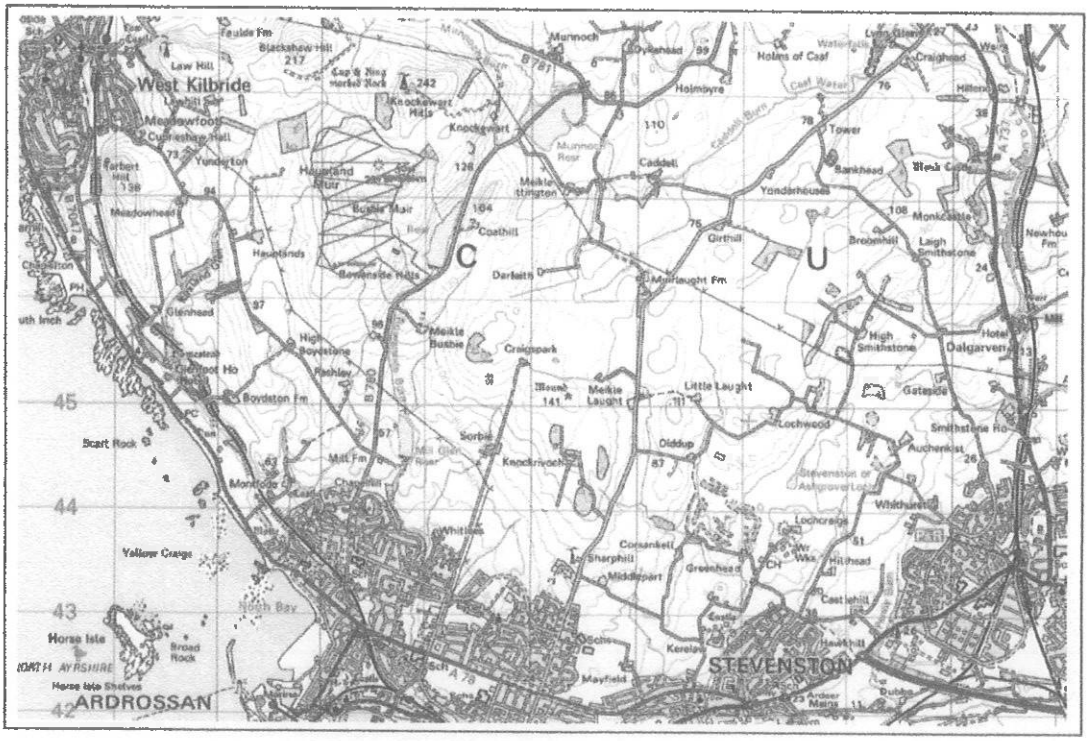


Figure 56 Location of Ardrosssan variable speed windfarm

Figure 56 Location of Ardrossan variable speed windfarm

The Güralp CMG-DM24S12AMS acquisition and monitoring system with 6 CMG-5U accelerometers was deployed on wind turbine 1 on 2/11/2004 and on Turbine 7 on 9/12/2004 , in each case a 1 CMG-5TD digital output strong motion accelerometer buried at a distance between from each turbine. Locations of the site and the turbines are shown in figures 56 and 57. Details of the deployment and sequence of shutdown of these experiments are given in Appendix C.

Accelerometers were attached to the tower along North South East and West azimuths and also mounted vertically as described in Appendix 3. A rapid shut down and sequential switch on was carried out and the spectrograms for both phases are shown in Figures 58 and 59.

As these are variable speed turbines we should not expect to obtain quite such distinct harmonics as we might measure at a fixed speed windfarm as has already been shown from Crystal Rig. However, it is very clear that we do have remarkably persistent spectral peaks which do not appear to change much during the 90 minutes of this experiment. They form bands which are very pronounced between 3 to 5 Hz and between 6 to 9 Hz but there are distinct spectral peaks even within these bands. They disappear as soon as the farm is switched off, re-appear for the short time that turbine 7 and then 6 are on individually and then reappear gradually as the sequential switch-on occurs as described in the tables beneath the spectrograms.

Measurements close to the turbines allow us to clearly see the fall and subsequent rise in power but because there is a considerable disparity in distance to the individual turbines does not allow us to assess quantitatively how the signal sums as extra turbines are included.

In order to address this we have selected the 4.5 Hz band on the Kelphope1 station (2.4 km) during the Dun Law switch-off experiment and have calculated the power change during the switch off and on. The signals from this station were filtered to remove all other components and the rms power was calculated through the duration of the switch off. These are shown in Figure 60 (lower figure).

It is clear that as the number of turbines increases the power increases but it does not scale linearly with power (i.e. the final signal is not 26 times as large as the l with a single turbine.

Schofield (2001) suggested that the power should scale as /N and this seems to be the case as in fact it is approximately 4 to 5 times as much, which is close to what we would anticipate for 26 turbine (/26=5.1).

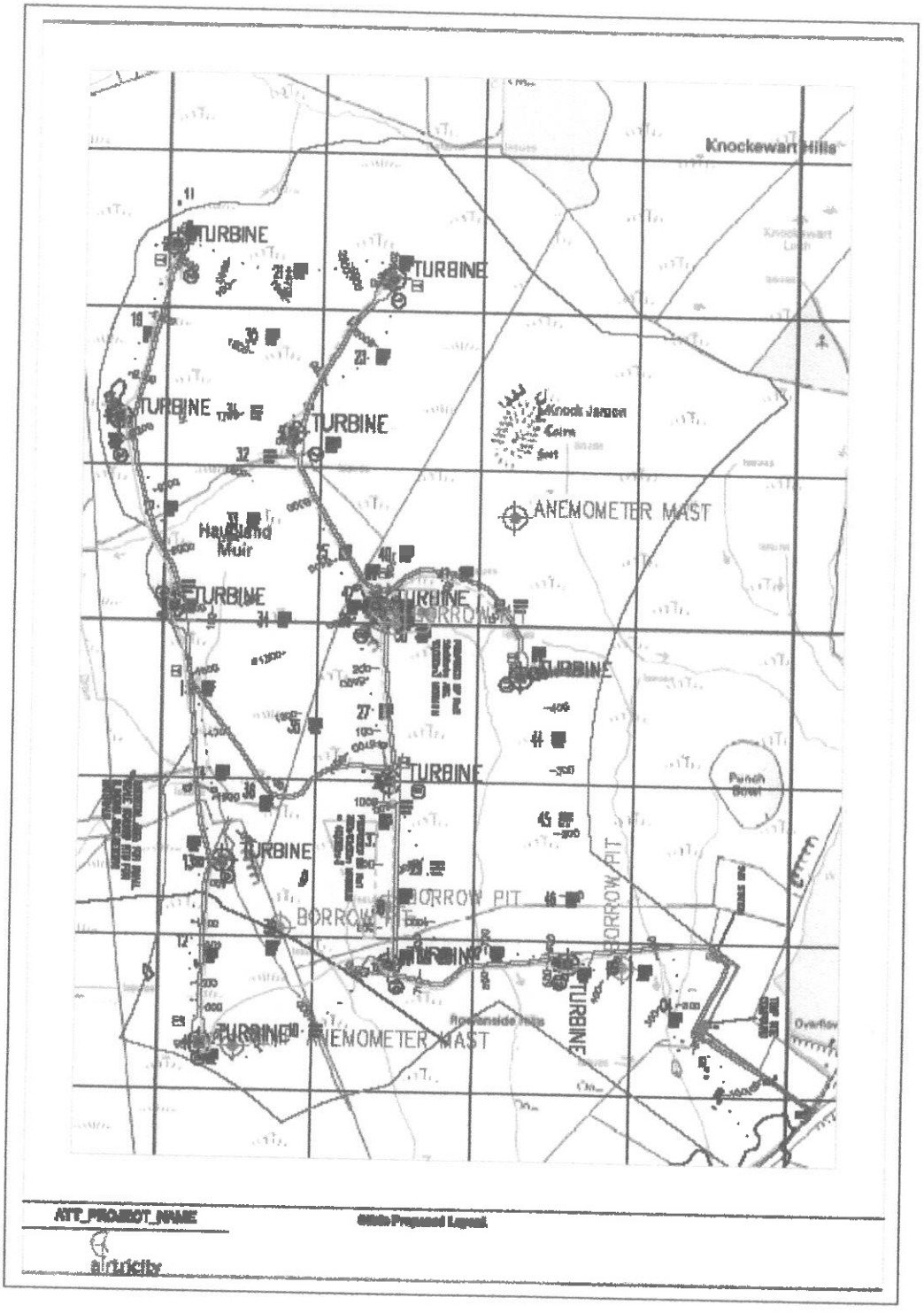
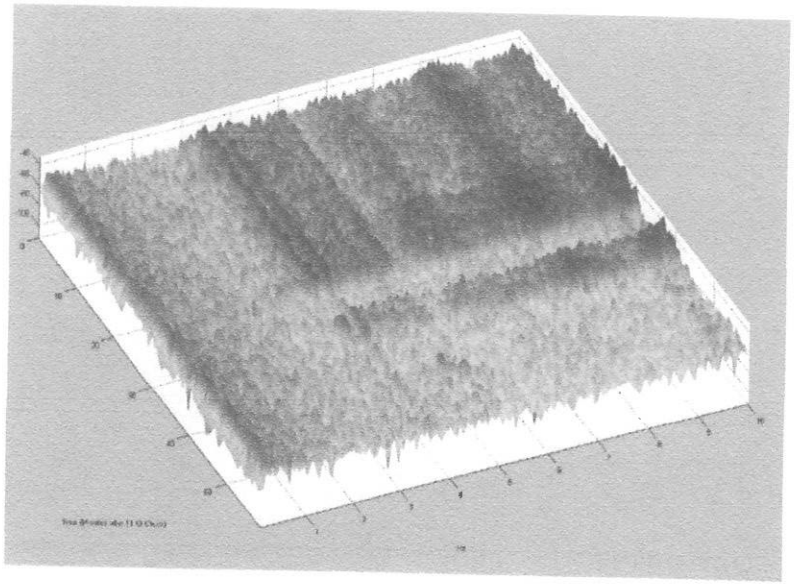


Figure 57 Map of the Turbine Locations at Ardrossan

Figure 57 Map of the Turbine Locations at Ardrossan



11.25	All
11.30	All Off
11.35	7
11.40	All Off
11.45	6
11.50	6,10
11.55	6,10,12

12.00	6,10,12,5
12.05	6,10,12,5,9
12.10	6,10,12,5,9,11
12.15	6,10,12,5,9,11,8
12.20	6,10,12,5,9,11,8,4
12.25	6,10,12,5,9,11,8,4,3
12.30	6,10,12,5,9,11,8,4,3,2
12.35	6,10,12,5,9,11,8,4,3,2,7

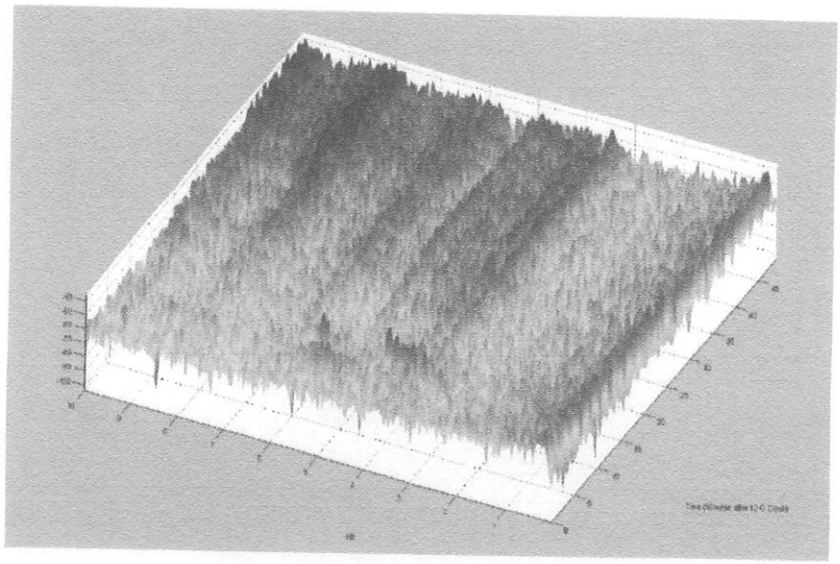


Figure 58 Spectrograms of the switch of and switch on at Ardrossan on 9/12/2004

11.25	All
11.30	All Off
11.35	7
11.40	All Off
11.45	6
11.50	6,10
11.55	6,10,12

12.00	6,10,12,5
12.05	6,10,12,5,9
12.10	6,10,12,5,9,11
12.15	6,10,12,5,9,11,8
12.20	6,10,12,5,9,11,8,4
12.25	6,10,12,5,9,11,8,4,3
12.30	6,10,12,5,9,11,8,4,3,2
12.35	6,10,12,5,9,11,8,4,3,2,7

Figure 58 Spectrograms of the switch of and switch on at Ardrossan on 9/12/2004

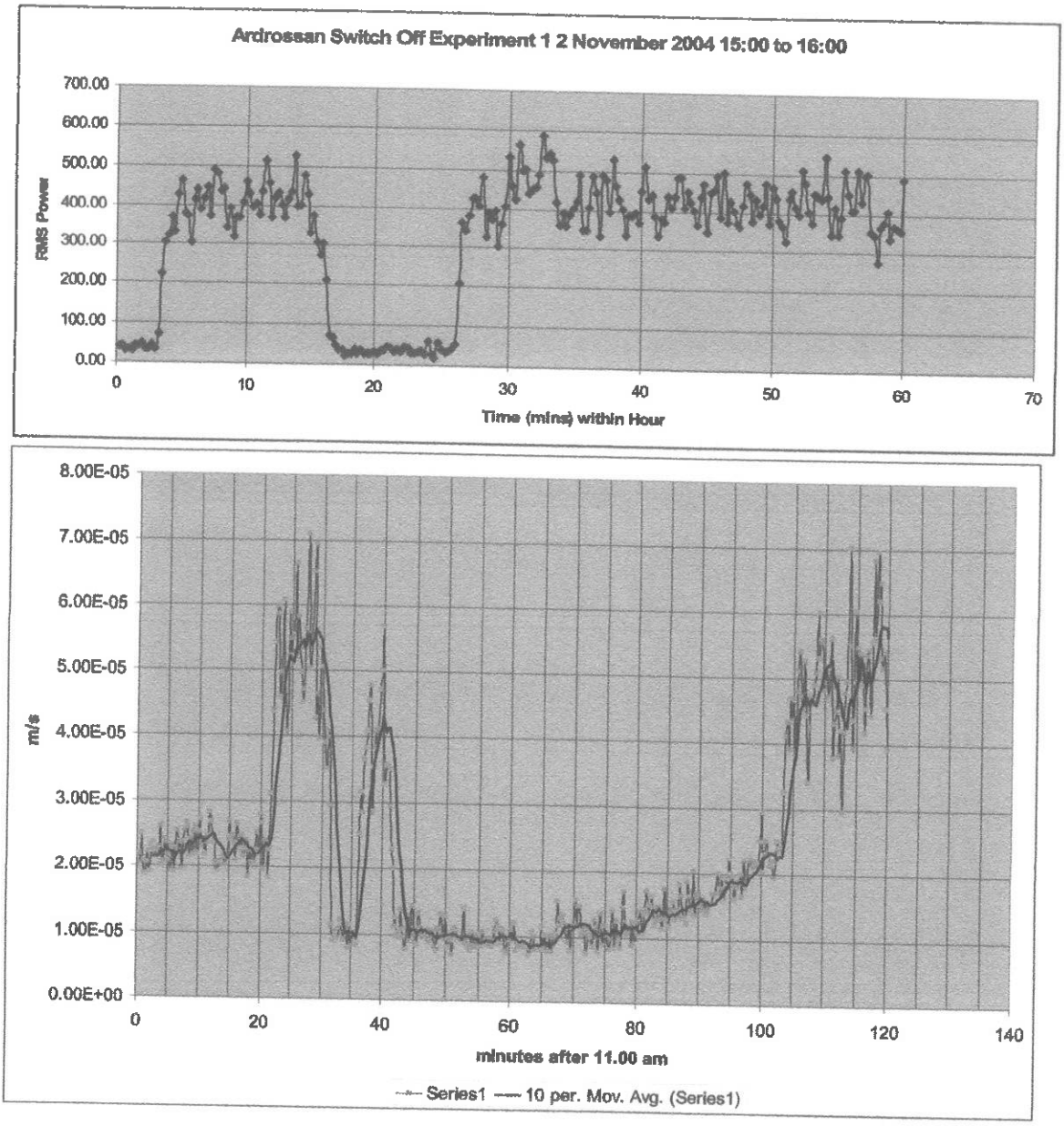


Figure 59 Ardrossan Switch Off and On, 2 /11/2004 15:00 to 16:00 (top) and 9/12/2004, 11:00 to 13:00 (bottom)

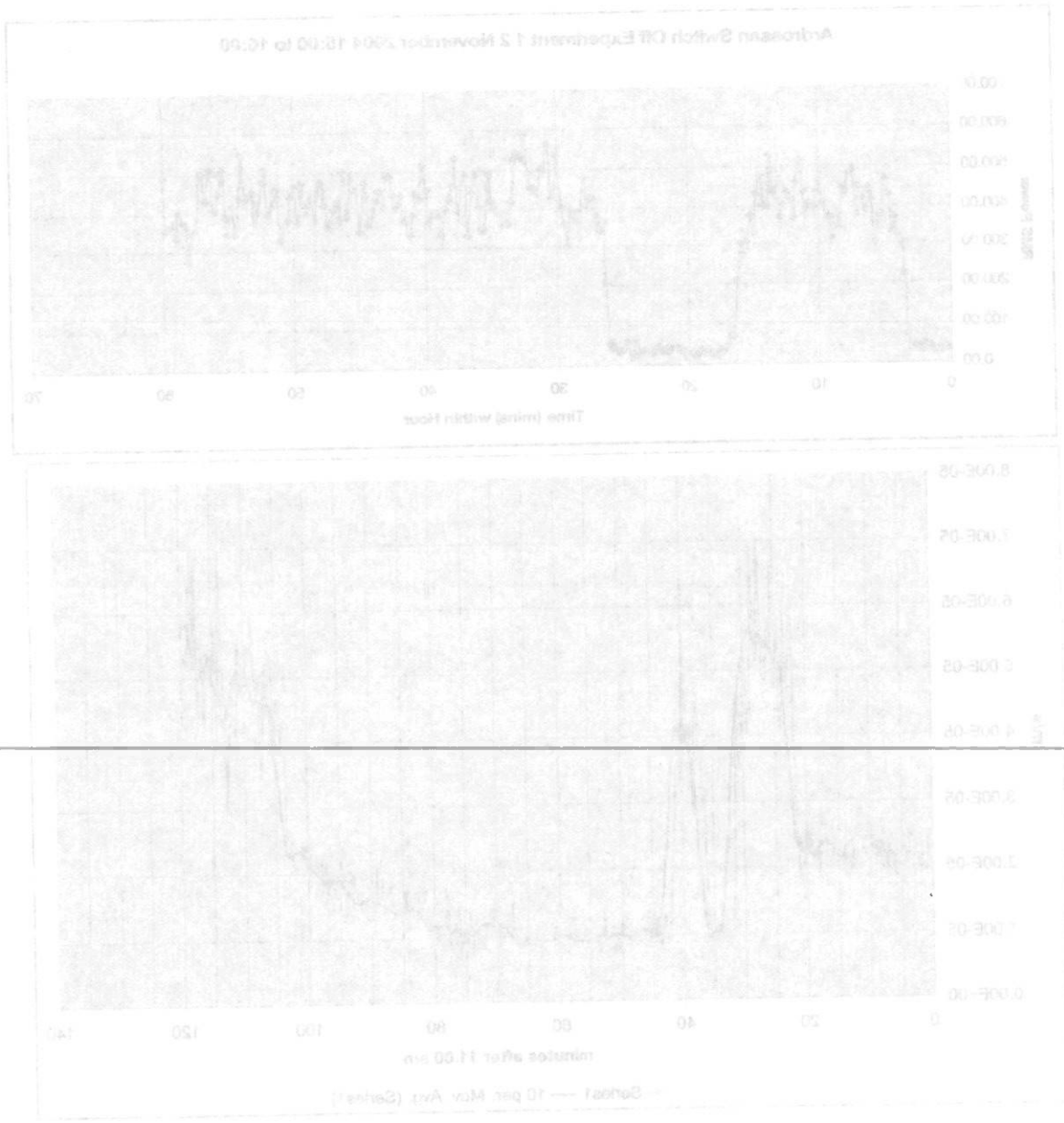
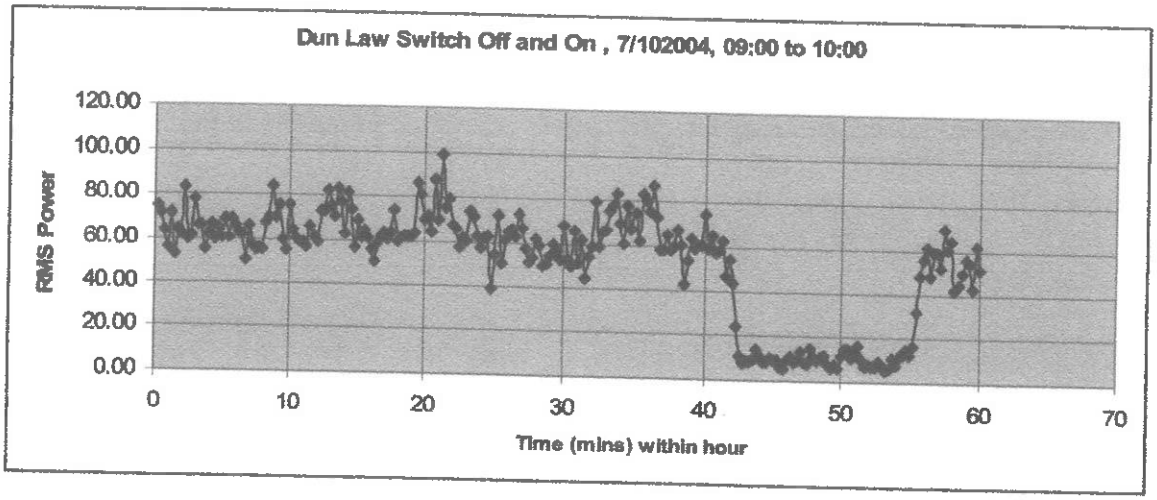
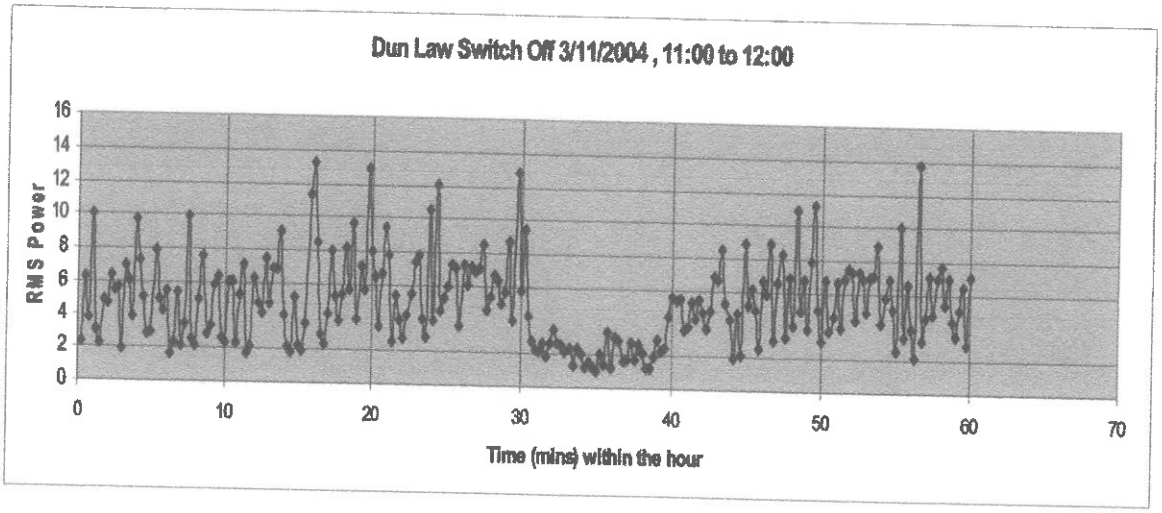


Figure 59 Ardrossan Switch Off and On, 2/11/2004 15:00 to 16:00 (top) and 9/12/2004, 11:00 to 13:00 (bottom)





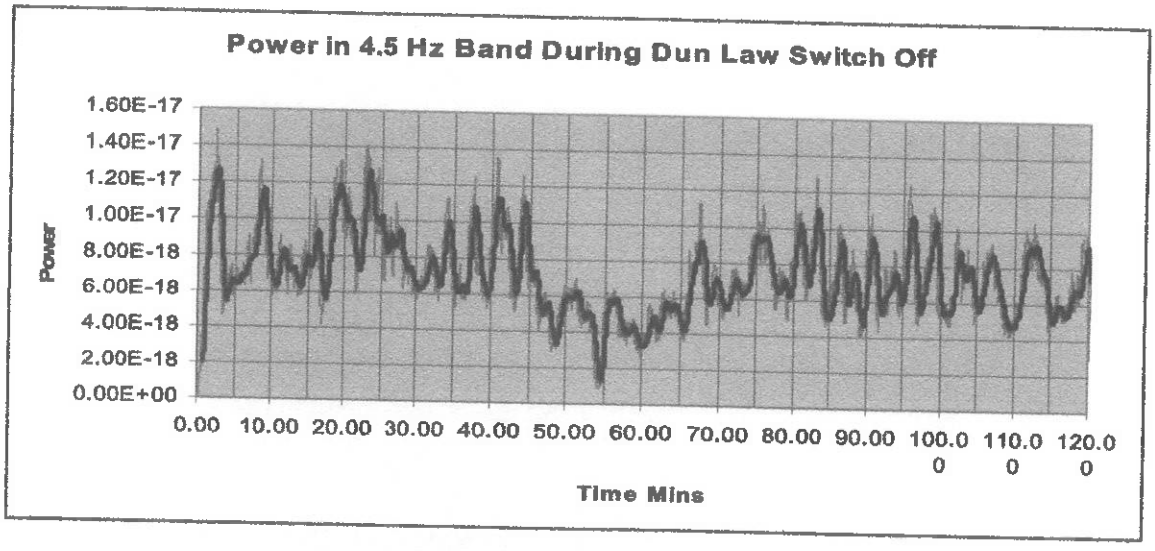


Fig 60 **Switch Off at Dun Law on 7/8/2003 Top and Bottom and 3/11/2004 (middle)**

We now have sufficient information from the monitoring and analysis of microseismic, infrasound and on-tower monitoring to develop a solution to the problem of what level of vibration is permissible at Eskdalemuir, how does wind farm vibration propagate and attenuate and what is the permissible number and distribution of wind farms and turbines in the Southern Uplands. We first propose a mathematical model for the system following Bowers (2004) and then address the points of interest as a series of important questions with the answers derived from this study.

Mathematical Model of Wind Farm Noise Propagation

In order to evaluate the nature and properties of noise propagation from windfarms we postulate the following mathematical model

The seismic displacement amplitude spectrum, U(ω, r) at angular frequency ω, of a single wind turbine operating at distance r, from the recording station is given by the following convolutional mathematical model:

$$U(\omega,r) = S(\omega)G(r)B(\omega,r)P(r)$$

where,

S(ω) represents the source spectrum,
P(r) is a frequency-dependent receiver-site effect,
G(r) represents geometrical spreading, $G(r) = r^{\eta}$
***B*(ω, r)** is the attenuation
v=seismic velocity

$$B(\omega,r) = \left(\exp\left(\frac{-\omega r}{2Q(\omega)v} \right) \right)$$

For Cylindrical Spreading (seismic surface waves)

$$\eta = -0.5$$

Therefore the amplitude of the signal from a single turbine at a distant location, A_{far}, is related to the amplitude at a location closer to the turbine, A_{near}, by the following equation (the 1/sqrt(r) with linear attenuation model), where:

$$A_{far} = A_{near}\sqrt{R_{near}/R_{far}}\, e^{\frac{\pi f (R_{near} - R_{far})}{Qv}}$$

R_{near} and R_{far} are the distances from the source to the near and far locations, respectively,

Q is a factor giving the non-geometrical attenuation of the wave with distance travelled i.e. absorption of energy within the rock as the seismic wave does work to vibrate the particles of the material.

f is the frequency of the signal (ω=2πf)

This formula is applicable to surface waves radiating out from the source uniformly. Localised inhomogeneties may cause some focussing of the energy but this is not predictable in a generalised model and is unlikely to significantly affect the conclusions.

Mathematical Model of Wind Farm Noise Propagation

In order to evaluate the nature and properties of noise propagation from windfarms we postulate the following mathematical model

The seismic displacement amplitude spectrum, $U(\omega, r)$ at angular frequency ω, of a single wind turbine operating at distance r, from the recording station is given by the following convolutional mathematical model:

$$U(\omega,r) = S(\omega)G(r)\beta(\omega,r)P(r)$$

where,

$S(\omega)$ represents the source spectrum,
$P(r)$ is a frequency-dependent receiver-site effect,
$G(r)$ represents geometrical spreading, $G(r) = r^{\gamma}$
$\beta(\omega, r)$ is the attenuation
v=seismic velocity

$$\beta(\omega,r) = \left(\exp\left(\frac{-\omega r}{2Q(\omega)v}\right)\right)$$

For Cylindrical Spreading (seismic surface waves)

$$\gamma = -0.5$$

Therefore the amplitude of the signal from a single turbine at a distant location, A_{far}, is related to the amplitude at a location closer to the turbine, A_{near}, by the following equation (the 1/sqrt(r) with linear attenuation model), where:

$$A_{far} = A_{near}\sqrt{\frac{R_{near}}{R_{far}}}\, e^{\frac{-\pi f (R_{far} - R_{near})}{Qv}}$$

R_{near} and R_{far} are the distances from the source to the near and far locations, respectively,

Q is a factor giving the non-geometrical attenuation of the wave with distance travelled i.e. absorption of energy within the rock as the seismic wave does work to vibrate the particles of the material,

f is the frequency of the signal ($\omega = 2\pi f$)

This formula is applicable to surface waves radiating out from the source uniformly. Localised inhomogeneties may cause some focussing of the energy but this is not predictable in a generalised model and is unlikely to significantly affect the conclusions.

Question 1: **Do Fixed and Variable speed wind turbines generate detectable vibrations**

Answer: **Yes**

- We have clearly shown that both fixed speed and variable speed wind turbines generate low frequency vibrations which are multiples of blade passing frequencies and which can be detected on seismometers buried in the ground at significant distances away from wind farms even in the presence of significant levels of background seismic noise (many kilometres).

- Some of these are non-stationary at very low wind speeds where we clearly see variation in frequency over long and short timescales and we postulate that these are generated by the interaction between the blades and the towers. There are other frequencies which are stationary and we postulate that these are caused by normal modes of vibration of the towers

- We have clearly shown that wind turbines generate low frequency sound (infrasound) and acoustic signals which can be detected at considerable distances (many kilometres) from wind farms on infrasound detectors and on low-frequency microphones (Hayes pers. comm.)

Question 2: **How does energy propagate from the Wind Turbine to a receiving SEISMIC Station?**

- as Infrasound travelling through the air for the near zone where

$$G=r^{-1}?$$

or

- as Seismic Surface Waves travelling through the ground (cylindrical spreading), where

$$G=r^{-1/2}?$$

Note: At greater distances where the atmosphere acts as a waveguide infrasound may also have a cylindrical dependency on r

Answer

- It travels to the seismometer as seismic surface waves, because, we can examine co-located seismic records and infrasound records at the same times and show that it is clear that infrasound energy propagation is optimal in quiet wind conditions where stable atmospheric conditions prevail and that the amplitude DECREASES as the wind speed (and turbulence) increase.

- Conversely, Seismic Amplitude INCREASES with wind speed as the energy of the turbines increases

- Clearly there CANNOT be a casual relationship between the seismic amplitude and the infrasound if they have different behaviours with wind speed.

- N.B. However, it is also clear that low-frequency sound waves can be detected at considerable distances away from a wind farm under the right atmospheric conditions.

Question 3: **If we have a wind farm of N turbines, how does the seismic amplitude increase as compared to 1 turbine?**

Answer

- We have shown it varies as the square root of N and this is to be expected because the turbines are not all in phase and neither are they operating at exactly the same frequency because of the slight possible variations in rotation speed and also wind conditions across the farm. There is also a possible 10% variation in speed (Optislip) which will cause broadening of the spectral peaks. They are quasi-random sources and therefore add as $\sqrt{N}$

- Therefore 100 turbines are 10 times as noisy as 1, not 100 times

Question 4: If we have N wind farms, how does the seismic amplitude increase as compared to 1 windfarm?

Answer:

- For similar reasoning as given previously for individual wind turbines, individual wind farms will not be in phase with each other and so they will add in QUADRATURE

- $vtot=\sqrt{(v1^2+v2^2+ v3^2...+ vn^2)}$

Question 5: **How will wind speed and direction affect the vibrations?**

Answer: The following graph (Figure 2) shows the variation of seismic power with windspeed and direction. Although there is some variation with wind direction there is a clear increase with windspeed within the operational region (up to c 15m/s)

Appendix 3

Appendix 3

Who will monitor the hundreds of thousands of tonnes of excavated peat and rock, which will be disturbed during construction?

Is there a suitably qualified archaeologist at all times on the site?

Has the roads and bridges in this area been assessed and upgraded where necessary in light of the fact that construction has started?

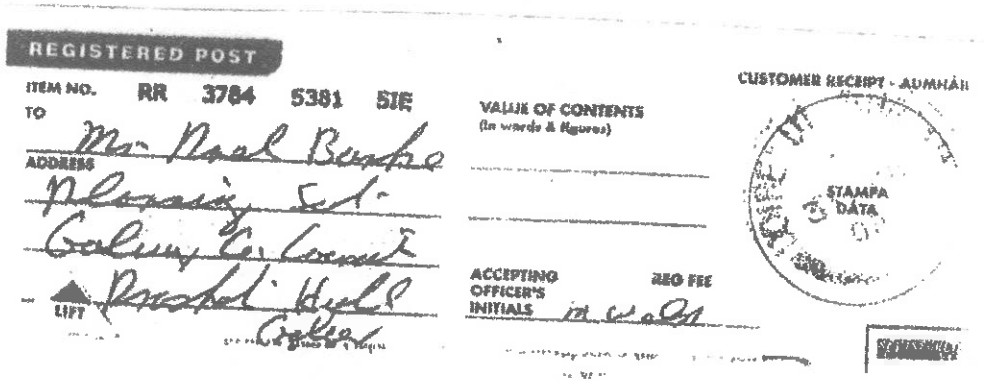
All of the above questions are in the interest of proper planning and development of the community in which I live.

The integrity of both the planning and democratic processes are at stake here so therefore it is of critical importance that openness, transparency and accountability principals are rigidly adhered to.

I may be contacted at the above address or by phone at 091 632291 or E- mail: migcollins@eircom.net

Yours sincerely,

Martin Collins



Who will monitor the hundreds of thousands of tonnes of excess peat and rock which will be disturbed during construction?

Is there a suitably qualified archaeologist at all times on the site?

Has the roads and bridges in this area been assessed and upgraded where necessary in light of the fact that construction has started?

All of the above questions are in the interest of proper planning and development of the community in which I live.

The integrity of both the planning and democratic processes are at stake here so therefore it is of critical importance that openness, transparency and accountability principals are rigidly adhered to.

I may be contacted at the above address or by phone at 091 632291 or E. mail mjpcollins@eircom.net

Yours sincerely,

Martin Collins

Derrybrien
Loughrea
Co Galway

29/7/2003

Mr Noel Burke
Enforcement Officer
Planning Section
Galway Co Council
Prospect Hill
Galway

Dear Mr Burke

I have made a number of unsuccessful attempts to contact you since our conversation by phone on 24/7/2003.

As you are aware from my initial contact with you on 16/7/2003 I am requesting information from the planning section of Galway Co Council as to whether or not development work adjacent to windfarm sites at Derrybrien North, Toormacnevin and Bohaboy are authorised or unauthorised.

The planning reference numbers for the developments referred to are 97/3470, 97/3652 and 00/4581.

It is my understanding that Galway County Council and An Board Pleanala decided to "grant permission for the said development in accordance with the said plans and particulars, subject to the conditions specified in the second schedule".

I would be grateful to you if you could clarify and make the following information available to me as soon as possible.

Is the entry exit roadway currently under construction approximately 2 km north of the original access roadway authorised or unauthorised?

Is the quarry, which is in operation authorised or unauthorised?

Is the site compound authorised or unauthorised?

What is the status of the 5-year grant of permission given on 12/10/1998 as the construction is likely to take approximately 18 months to complete?

What steps have been taken to monitor water quality before and since construction started?

Has the developers requested changes to roadways, control house or turbine locations since the grant of permission?

Has the survey of the Hen Harrier population been properly undertaken?

Appendix 4

Appendix 4

Mr John Morgan,
Director of Services,
Roads and Transport Unit,
PO Box 27,
Aras and Chontae,
Prospect Hill,
Galway.

Your Ref: JM/MH RT1072

Re: Landslide at Derrybrien, County Galway.

Dear Mr Morgan,

I refer to your letter dated the 27th January 2004 in connection with the above matter.

The Department welcomes the assurances given by Galway County Council in relation to habitat protection generally and the Derrybrien situation in particular. We further welcome the commitment at Point 1 of your letter to make all relevant reports available to this Department for comment.

We note also that the County Council is satisfied that the development thus far complies with the planning permission granted. The question of whether any future works would require planning permission is, of course, a matter for the local authority. The reference in paragraph 8 of our previous letter to submission of new planning applications, as appropriate, was not intended to suggest otherwise. We also accept, as stated at points 5 and 6 of your letter, that the issues referred to at those points are matters for the developer.

We note your position at point 4 of your letter regarding the EIS. Overall, our letter of the 22nd December was concerned with impacts of the landslide and assessments of future works. The reference to the EIS was mainly in the context of advising on sensitive peatland areas to be avoided in any future works.

The Department does not dispute that Galway County Council is operating to appropriate professional standards in relation to its planning and other key services and notes your affirmation to this effect.

Yours sincerely,

Amanda Maguire
Site Protection Section
NPWS

6th February 2004

Mr John Morgan,
Director of Services,
Roads and Transport Unit,
PO Box 27,
Áras an Chontae,
Prospect Hill,
Galway.

Your Ref: JM/MH RT1077

Re: Landslide at Derrybrien, County Galway.

Dear Mr Morgan,

I refer to your letter dated the 27th January 2006 in connection with the above matter.

The Department welcomes the assurance given by Galway County Council in relation to habitat protection generally and the Derrybrien situation in particular. We further welcome the communication at Point 1 of your letter to make all relevant reports available to this Department for comment.

We note also that the County Council is satisfied that the development thus far complies with the planning permission granted. The question of whether any future works would require planning permission is, of course, a matter for the local authority. The reference in paragraph 6 of our previous letter to submission of new planning applications, as appropriate, was not intended to suggest otherwise. We also accept, as stated at points 5 and 6 of your letter, that the issues referred to at those points are matters for the developer.

We note your position at point 4 of your letter regarding the EIS. Overall, our letter of the 22nd December was concerned with impacts of the landslide and assessments of future works. The reference to the EIS was mainly in the context of advising on sensitive peatland areas to be avoided in any future works.

The Department does not dispute that Galway County Council is operating to appropriate professional standards in relation to its planning and other key services and notes your affirmation to this effect.

Yours sincerely,

Amanda Magrane
Bog Protection Section
NPWS

6th February 2006

3. With regard to any new works proposed to be carried out on the site, all such works, unless exempted development, will constitute development for which Planning Permission will be required.

4. Whilst noting your view of the E.I.S. lodged with the Planning Authority, you should note that the contents of the E.I.S. was considered by both the County Council as Planning Authority and by An Bord Pleanala, both of whom granted Planning Permission.

5. The provision of an Ecological Assessment and the carrying out of works as described by you as well as the consideration of the regeneration and future management of the area damaged by the landslide are all matters for the developers.

6. The assessment of indirect impact on any designated sites is also a matter for the developer as, indeed, you have pointed out in your letter.

The dissemination of information within the County Council whether by formal circulation of minutes or by other direct means is a matter for the Council itself. Indeed the inference that Galway County Council is failing in some way to conduct its affairs to a sufficiently high standard is resented and I would wish to place on record the fact that grave exception is taken by the County Council to that inference.

Mise, le meas,

John Morgan
Director of Services
Roads and Transportation Unit

C.C. Mr. Tom O'Mahony,
Assistant Secretary,
Department of the Environment, Heritage & Local Government,
Custom House,
Dublin 1.

Post Office Box No. 27,
Áras an Chontae,
Prospect Hill,
Galway.

35

JM/MH RT1072

Bosca Poist Uimhir 27,
Áras an Chontae,
Cnoc na Radharc,
Gaillimh.

Telephone: (091) 509000
Fax: (091) 509010
E-Mail: @galwaycoco.ie
Web: www.gaillimh.ie
www. galway.ie

Mo Thag:

Do Thag.

COMHAIRLE CHONTAE NA GAILLIMHE
GALWAY COUNTY COUNCIL

Mm —
This was copied to me,
I presume for main reply
to Fri. Ire will go back DE
DNT route.

Housing Loans/Grants
(091) 509 301

Housing Applications
(091) 509 300

Environment
(091) 509 302

Personnel
(091) 509 303

Motor Taxation
(091) 509 099

Driving Licences
(091) 509 305

Water Services
(091) 509 306

Community & Ent.
(091) 509 066

Planning
(091) 509 308

Engineering
(091) 509 309

Register of Electors
(091) 509 310

Higher Ed. Grants
(091) 509 310

27th January, 2004.

The Secretary General,
Department of the Environment, Heritage & Local Gov
Custom House,
Dublin 1.

RE: Landslide at Derrybrien, County Galway

A Chara,

I wish to refer to your letter dated the 22nd December last dealing with the purpose and content of a number of meetings attended by representatives from your Department, the Shannon Regional Fisheries Board, E.S.B. Fisheries, E.S.B. International and the Environment Section of the County Council.

In general terms, the County Council would agree with your view of the purpose of these meetings, namely, to review environmental issues, exchange information and highlight various concerns. From this perspective the meetings have been extremely productive.

The Council is keenly aware of its obligations and duties under Environmental Legislation and accords a high priority to the protection of all habitats. In that context, it has always facilitated full disclosure of all information to interested parties including your Department. Please be assured that the County Council will continue to provide full co-operation to your Department and its officials are available to discuss any environmental aspect of the Derrybrien situation of concern to you.

With regard to the specific points raised in your letter, I reply as follows:-

1. The County Council will make available all relevant reports to your Department and will consider your comments thereon.

2. The County Council has inspected the site and assessed it for compliance with the Planning Permissions granted. The Planning Authority is satisfied that the development, thus far, is in compliance with the Planning Permissions granted

It is our opinion that all Sections of the Galway County Council dealing with the proposed development and the resulting landslide should be informed of the above concerns and requirements regarding same. Accordingly this letter should be forwarded to all relevant personnel.

Yours faithfully,

Amanda Maguire
Site Protection Section
NPWS

2. There should be ecological assessment of any areas outside the limits of the windfarm footprint and works area that will be impacted in the course of emergency and stabilisation works. This assessment should include any areas that may be used for the removal and disposal of peat from the landslide area, the dams or the river.

3. There should be detailed consideration of the regeneration and future management of the damaged areas within the limits of the landslide. The revegetation of these areas will be a key element in their stabilisation and in the control of ongoing erosion and siltation.

4. In the course of site works and any new site drainage, areas of intact wet bog, (some with extensive pool systems) and the infilling lake, should be avoided. One such sensitive peatland area occurs near the summit, in the area bounded by turbines 60, 61, 62, 11, 66 and 67. There should be no negative impacts on these areas in the course of stabilisation works or any other works associated with the completion of this development.

5. It is our opinion that the original EIS for this development, including the extensions, was deficient in that it failed to identify many sensitive ecological areas and hydrological issues within the site. This was pointed out at the meetings and accepted by ESBI.

6. There should be a detailed report on how the current development deviates from the original EIS and planning conditions, including in terms of:
    - site layout (locations of site access roads and turbines);
    - construction methodology;
    - on-site quarrying and blasting;
    - siltation and pollution control measures (silt traps, settlement ponds, cement wash out facilities);
    - site drainage.

7. There should be a detailed report on the environmental impacts associated with the landslide and the emergency and stabilisation works. It should be noted that, under Article 6 of the Habitats Directive, the onus is on the developer to assess the indirect impacts on any designated sites (candidate Special Areas of Conservation - SACs or Special Protection Areas -SPAs) as a result of a plan or project. This is therefore required in relation to the impacts on sites downstream of the Owendalulleegh River: Lough Cutra cSAC (No. 299), Lough Cutra SPA (No. 4096), Coole-Garryland Complex cSAC (No. 252) and Coole-Garryland SPA (No. 4107).

8. There should be a detailed report and ecological assessment of any proposed new works at the site, including any changes to the site layout, site drainage or construction methodology. New planning applications should be submitted to Galway County Council for these changes, as appropriate.

72

Copy

Our Ref: SP278/AM

County Secretary
Galway County Council
County Hall,
Prospect Hill
Galway

Issued.
22nd December 2003

Re: Planning Application Reg. Ref. No. 02/3560 by Saorgus Energy Limited for permission for alterations to previously approved wind farm development at Toormacnevin, Bohaboy & Derrybrien North, Co. Galway.
- Co-ordinating meetings of ad hoc group re landslide at Derrybrien in October 2003.

Dear Sir/Madam,

We refer to the above proposed development and the meetings between representatives of Galway County Council (Environment Section), the windfarm developer (ESBI), ESB Fisheries, the Shannon Regional Fisheries Board, and the National Parks & Wildlife Service (NPWS) of this Department which were arranged following the landslide in October 2003.

It is our understanding that the meetings of this ad hoc group were intended as a means of distributing and reviewing information on the landslide, particularly in relation to the impacts on surface waters, and as a means of keeping all parties informed of progress on the emergency works being carried out. It has now emerged that this ad hoc group does not report back formally to other sections of Galway County Council. As a result, many of the issues and concerns that were raised by NPWS and recorded in minutes of the meetings, may not have been passed on to other relevant sections of the Council, such as the Planning and Development Section.

It should be noted that, in addition to the landslide, the emergency works being carried out, and the likely impacts on designated conservation areas downstream, there are other serious concerns about the project, including possible future ecological impacts. In addition to proposals for monitoring from NPWS (see copy attached), other issues that were raised by NPWS in these meetings are outlined below.

1. NPWS should be provided with copies of all reports, including technical assessments, pertaining to the landslide and the development in general, and should be given an opportunity to comment.