LLANBRYNMAIR WIND FARM

Supplementary Environmental Information

August 2013

Volume II – B - Supporting Appendices

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APPENDIX 5.1 - NVC QUADRAT DATA

Table 1: 293542, 303198 - Peat depth 55cm

Species	Common Name	Percentage Cover
Juncus effusus	Soft Rush	70
Agrostis canina	Brown Bent	40
Juncus acutiflorus	Sharp-flowered Rush	<4 (several)
Cirsium palustre	Marsh Thistle	<4 (few)
Stellaria media	Chickweed	5
Rumex acetosa	Common Sorrel	5
Galium saxatile	Heath Bedstraw	<4 (few)
Rhytidiadelphus squarrosus	Springy Turf-moss	40
Scleropodium purum	Neat Feather-moss	20
Holcus lanatus	Yorkshire-fog	20

Table 2: 293413, 303264 - Peat depth 150cm.

Species	Common Name	Percentage Cover
Sphagnum fallax	Flat-topped Bog-moss	80
Carex rostrata	Bottle Sedge	10
Juncus effusus	Soft Rush	<4 (many)
Rumex acetosa	Common Sorrel	<4 (several)
Polytrichum commune	Common Haircap	10
Molinia caerulea	Purple Moor-grass	15
Stellaria uliginosa	Bog Stitchwort	5

Table 3: 293263, 303449 - Peat depth 2cm

Species	Common Name	Percentage Cover
Hylocomium splendens	Glittering Wood-moss	70
Carex hostiana	Tawny Sedge	10
Carex pilulifera	Pill Sedge	20
Vaccinium myrtillus	Bilberry	<4 (several)
Festuca ovina	Sheep's Fescue	10
Agrostis canina	Velvet Bent	20
Galium saxatile	Heath Bedstraw	<4 (few)
Polytrichum commune	Common Haircap	5

Table 4: 292994, 303544 - Peat depth 50cm

Species	Common Name	Percentage Cover
Agrostis capillaris	Common Bent	5
Carex echinata	Star Sedge	<4 (several)
Festuca ovina	Sheep's Fescue	5
Juncus effusus	Soft rush	<4 (several)
Juncus squarrosus	Heath Rush	5
Molinia caerulea	Purple Moor-grass	5
Aulacomnium palustre	Bog Groove-moss	<4 (several)
Pleurozium schreberi	Red-stemmed Feather-moss	5
Polytrichum commune	Common Haircap	50
Rhytidiadelphus loreus	Little Shaggy-moss	<4 (several)
Sphagnum fallax	Flat-topped Bog-moss	60

Table 5: 292685, 303873 - Peat depth 60cm

Species	Common Name	Percentage Cover
Sphagnum capillifolium	Red Bog-moss	50
Sphagnum palustre	Blunt-leaved Bog-moss	5
Juncus squarrosus	Heath Rush	30
Polytrichum commune	Common Haircap	10
Festuca ovina	Sheep’s Fescue	5
Molina caerulea	Purple Moor-grass	5
Rhytidiadelphus squarrosus	Springy Turf-moss	15
Aulacomnium palustre	Bog Groove-moss	10
Hylocomium splendens	Glittering Wood-moss	5

Table 6: 293778, 304035 - Peat depth 30cm

Species	Common Name	Percentage Cover
Agrostis capillaris	Common Bent	20
Festuca ovina	Sheep’s Fescue	5
Galium saxatile	Heath Bedstraw	<4 (few)
Juncus squarrosus	Heath Rush	5
Molinia caerulea	Purple Moor-grass	20
Nardus stricta	Mat Grass	20
Vaccinium myrtillus	Bilberry	<4 (many)
Polytrichum commune	Common Haircap	60
Rhytidiadelphus loreus	Shaggy Turf-moss	20

Table 7: 293836, 304240 - Peat depth 70cm

Species	Common Name	Percentage Cover
Juncus effusus	Soft Rush	70
Molinia caerulea	Purple Moor-grass	40
Galium saxatile	Heath Bedstraw	<4 (few)

Species	Common Name	Percentage Cover
Polytrichum commune	Common Haircap	50
Sphagnum capillifolium	Red Bog-moss	10
Sphagnum palustre	Blunt-leaved Bog-moss	10

Table 8: 292960, 304910 - Peat depth over 150cm

Species	Common Name	Percentage Cover
Eriophorum vaginatum	Hare's-tail Cotton-grass	40
Sphagnum papillosum	Papillose Bog-moss	40
Sphagnum capillifolium	Red Bog-moss	40
Polytrichum juniperinum	Juniper Haircap	30
Vaccinium myrtillus	Bilberry	5
Empetrum nigrum	Crowberry	<4 (several)
Vaccinium oxycoccos	Cranberry	<4 (few)
Juncus squarrosus	Heath Rush	<4 (sev)

Table 9: 295701, 306284 - Peat depth 50cm

Species	Common Name	Percentage Cover
Sphagnum capillifolium	Red Bog-moss	60
Calluna vulgaris	Heather	20
Erica tetralix	Cross—leaved Heath	10
Molinia caerulea	Purple Moor-grass	10
Eriophorum vaginatum	Hair's-tail Cotton-grass	10
Vaccinium oxycoccos	Cranberry	5
Pleurozium schreberi	Red-stemmed Feather-moss	10
Juncus squarrosus	Heath Rush	<4 (several)
Carex echinata	Star Sedge	<4 (several)

Table 10: 295014, 307341 - Peat depth 70cm

Species	Common Name	Percentage Cover
Eriophorum vaginatum	Hare's-tail Cotton-grass	40
Sphagnum fallax	Flat-topped Bog-moss	70
Molinia caerulea	Purple Moor-grass	20
Calluna vulgaris	Heather	5
Empetrum nigrum	Crowberry	<4 (several)
Vaccinium myrtillus	Bilberry	<4 (few)
Potentilla erecta	Tormentil	<4 (sev)
Hylocomium splendens	Glittering Wood-moss	<4 (several)
Polytrichum commune	Common Haircap	5

Table 11: 294352, 305245 - Peat depth30cm (peaty soil)

Species	Common Name	Percentage Cover
Juncus effusus	Soft Rush	70
Agrostis canina	Velvet Bent	15
Festuca ovina	Sheep's Fescue	5
Deschampsia cespitosa	Tufted Hair-grass	5
Galium saxatile	Heath Bedstraw	2
Rhytidiadelphus squarrosus	Springy Turf-moss	30
Polytrichum commune	Common Haircap	30

Table 12: 294315, 305264

Species	Common Name	Percentage Cover
Juncus effusus	Soft Rush	70
Cirsium palustre	Marsh Thistle	5
Agrostis canina	Velvet Bent	30
Deschampsia cespitosa	Tufted Hair-grass	5
Wahlenbergia hederacea	Ivy-leaved Bellflower	<4 (few)

Species	Common Name	Percentage Cover
Rumex acetosa	Common Sorrel	<4 (several)
Galium saxatile	Heath Bedstraw	5

Table 13: 294288, 305267 - Peat depth 30cm (peaty soil)

Species	Common Name	Percentage Cover
Juncus effusus	Soft Rush	60
Rumex acetosa	Common Sorrel	5
Ranunculus repens	Creeping Buttercup	5
Rhytidiadelphus squarrosus	Springy Turf-moss	5
Polytrichum commune	Common Haircap	15
Sphagnum fallax	Flat-topped Bog-moss	10
Sphagnum palustre	Blunt-leaved Bog-moss	5

Table 14: 295029, 308951 - Peat depth: 70cm

Species	Common Name	Percentage Cover
Calluna vulgaris	Heather	20
Eriophorum vaginatum	Hare's-tail Cotton-grass	20
Molinia caerulea	Purple Moor-grass	10
Deschampsia flexuosa	Wavy Hair-grass	20
Vaccinium oxycoccos	Cranberry	10
Vaccinium myrtillus	Bilberry	2
Sphagnum capillifolium	Red Bog-moss	10
Sphagnum palustre	Blunt-leaved Bog-moss	5
Polytrichum commune	Common Haircap	5
Aulacomnium palustre	Bog Groove-moss	5
Hylocomium splendens	Glittering Wood-moss	10

Table 15: 295233, 308987 - Peat depth 10cm

Species	Common Name	Percentage Cover
Molinia caerulea	Purple Moor-grass	80
Pleurozium schreberi	Red-stemmed Feather-moss	20
Vaccinium myrtillus	Bilberry	10
Galium saxatile	Heath Bedstraw	2

Table 16: 295534, 308992 - Peat depth 65cm

Species	Common Name	Percentage Cover
Molina caerulea	Purple Moor-grass	75
Deschampsia flexuosa	Wavy Hair-grass	10
Vaccinium myrtillus	Bilberry	5
Vaccinium oxycoccos	Cranberry	5
Polytrichum commune	Common Haircap	15
Sphagnum capillifolium	Red Bog-moss	5
Sphagnum fallax	Flat-topped bog-moss	10

Table 17: 295546, 309137 - Peat depth 105cm

Species	Common Name	Percentage Cover
Molinia caerulea	Purple Moor-grass	50
Vaccinium myrtillus	Bilberry	25
Calluna vulgaris	Heather	5
Erica tetralix	Cross-leaved Heath	5
Vaccinium oxycoccos	Cranberry	2
Deschampsia flexuosa	Wavy Hair-grass	30
Empetrum nigrum	Crowberry	2
Pleurozium schreberi	Red-stemmed Feather-moss	20
Sphagnum capillifolium	Red Bog-moss	10

Table 18: 295286, 309279 - Peat depth over 150cm

Species	Common Name	Percentage Cover
Empetrum nigrum	Crowberry	15
Vaccinium myrtillus	Bilberry	20
Erica tetralix	Cross-leaved Heath	5
Calluna vulgaris	Heather	60
Eriophorum vaginatum	Hare's-tail Cottongrass	40
Deschampsia flexuosa	Wavy Hair-grass	20
Vaccinium oxycoccos	Cranberry	2
Sphagnum capillifolium	Red Bog-moss	10
Pleurozium schreberi	Red-stemmed Feather-moss	10

Table 19: 295383, 309462 - Peat depth 55cm

Species	Common Name	Percentage Cover
Calluna vulgaris	Heather	30
Molinia caerulea	Purple Moor-grass	10
Deschampsia flexuosa	Wavy Hair-grass	50
Vaccinium myrtillus	Bilberry	10
Sphagnum capillifolium	Red Bog-moss	10
Polytrichum commune	Common Haircap	10
Pleurozium schreberi	Red-stemmed Feather-moss	20
Eriophorum vaginatum	Hare's-tail Cotton-grass	20
Vaccinium oxycoccos	Cranberry	2

Table 20: 295168, 309240 - Peat depth over 150cm

Species	Common Name	Percentage Cover
Calluna vulgaris	Heather	60
Empetrum nigrum	Crowberry	10
Deschampsia flexuosa	Wavy Hair-grass	20

Species	Common Name	Percentage Cover
Eriophorum vaginatum	Hare's-tail Cotton-grass	20
Vaccinium myrtillus	Bilberry	15
Sphagnum capillifolium	Red Bog-moss	20
Pleurozium schreberi	Red-stemmed Feather-moss	60
Erica tetralix	Cross-leaved Heath	10

Table 21: 294075, 305282 - Peat depth 70 cm

Scientific Name	Common Name	Percentage cover
Agrostis stolonifera	Creeping Bent	15
Anthoxanthum odoratum	Sweet Vernal-grass	10
Carex binervis	Green-ribbed Sedge	5
Carex nigra	Common Sedge	10
Carex panicea	Carnation Sedge	5
Cirsium palustre	Marsh Thistle	5
Holcus lanatus	Yorkshire-fog	30
Nardus stricta	Mat-grass	10
Ranunculus repens	Creeping Buttercup	2
Calliergonella cuspidata	Pointed Spear-moss	20
Rhytidiadelphus squarrosus	Springy Turf-moss	10
Sphagnum palustre	Blunt-leaved Bog-moss	2
Sphagnum subnitens	Lustrous Bog-moss	10
Thuidium tamariscinum	Common Tamarisk-moss	2

Table 22: 294058, 305436 - Peat depth 110cm

Scientific Name	Common Name	Percentage cover
Carex nigra	Common Sedge	2
Deschampsia flexuosa	Wavy Hair-grass	20
Juncus squarrosus	Heath Rush	2

Scientific Name	Common Name	Percentage cover
Nardus stricta	Mat-grass	30
Vaccinium myrtillus	Bilberry	5
Aulacomnium palustre	Bog Groove-moss	5
Polytrichum commune	Common Haircap	10
Rhytidiadelphus loreus	Little Shaggy-moss	10
Rhytidiadelphus squarrosus	Springy Turf-moss	10
Sphagnum capillifolium	Red Bog-moss	40
Sphagnum fallax	Flat-topped Bog-moss	10

Table 23: 294146, 305481 - Peat depth 90cm

Scientific Name	Common Name	Percentage cover
Carex nigra	Common Sedge	2
Deschampsia cespitosa	Tufted Hair-grass	30
Galium palustre	Common Marsh-bedstraw	2
Juncus effusus	Soft Rush	40
Polytrichum commune	Common Haircap	10
Sphagnum fallax	Flat-topped Bog-moss	80

Table 24: 294232, 305584 - Peat depth 60cm.

Scientific Name	Common Name	Percentage cover
Carex echinata	Star Sedge	2
Deschampsia cespitosa	Tufted Hair-grass	2
Galium palustre	Common Marsh-bedstraw	2
Juncus effusus	Soft Rush	40
Polytrichum commune	Common Haircap	25
Sphagnum fallax	Flat-topped Bog-moss	50
Sphagnum palustre	Blunt-leaved Bog-moss	10

Table 25: 294243, 305693 - Peat depth 110cm

Scientific Name	Common Name	Percentage cover
Anthoxanthum odoratum	Sweet Vernal-grass	2
Carex canescens	White Sedge	1
Carex echinata	Star Sedge	2
Deschampsia cespitosa	Tufted Hair-grass	2
Equisetum fluviatile	Water Horsetail	2
Eriophorum angustifolium	Common Cotton-grass	20
Holcus lanatus	Yorkshire-fog	2
Juncus bulbosus	Bulbous Rush	2
Juncus effusus	Soft Rush	2
Nardus stricta	Mat-grass	2
Potentilla erecta	Tormentil	1
Vaccinium oxycoccos	Cranberry	2
Polytrichum commune	Common Haircap	5
Sphagnum subnitens	Lustrous Bog-moss	90

APPENDIX 5.2 – OUTLINE HABITAT MANAGEMENT PLAN

1.1 Introduction

Background

1.1.1 Habitat restoration and management proposals form a fundamental part of the proposed Llanbrynmair Wind Farm scheme. The Environmental Statement (ES), submitted as part of the Llanbrynmair Wind Farm Planning Application in 2008, detailed Heads of Terms for a Habitat Management Plan (HMP). The ES confirmed that an HMP would be prepared to address any opportunities to reduce potential ecological effects during the construction, operation and decommissioning phases. The ES and subsequent SEI documents provide full details of the Site, the Proposal and the development as referred to in the text below.

1.1.2 This outline Habitat Management Plan (oHMP) presents the proposed habitat mitigation, restoration and compensation, habitat management and monitoring at Llanbrynmair during the 25 year project lifespan of the wind farm. The oHMP includes prescriptions that will deliver a net conservation gain to the area's ecological interests. The measures included provide mitigation that is relevant and proportionate to the nature and scale of the likely adverse impacts, as well as providing site enhancements for biodiversity.

1.1.3 In addition, a separate Peat Management Plan has been produced. This addresses the management of peat during construction and immediate restoration. The HMP then looks at habitat restoration and management post construction. The two plans together are to provide evidence of the mitigation measures that have been put in place to minimise any impacts and the long term habitat restoration and management plans for key areas of the site that are designed to enhance the site for the life of the windfarm.

1.1.4 The proposed HMP will be implemented over 820ha lying within the proposed development site boundary (Figure 6.1 of the 2011 SEI). The areas have been chosen for habitat management owing to their existing conservation importance and potential to provide additional conservation benefits.

1.1.5 It should be noted that this is a working document in progress. It outlines the first stage in the development of the HMP, to draft outline proposals. These will then be refined through discussions with the stakeholders and a final plan agreed. It should also be noted that the proposed habitats to be restored or created may vary with experience and are included here as broad aims not prescriptive habitats.

1.1.6 The detailed HMP would be developed following approval of the planning application for the proposed development, following consultation and input from consultees including Natural Resources Wales (NRW), Powys County Council Ecologist, Royal Society for the Protection of Birds (RSPB), Montgomeryshire Wildlife Trust (MWT) and the landowners.

1.1.7 Prior to any finalisation of the plan a full site survey would be undertaken to identify and finalise the specific management prescriptions within the site. The aim would be to secure the HMP via a formal planning agreement.

Existing Environment

1.1.8 The site predominantly consists of species-poor acid, marshy or improved pasture and conifer plantations. There are also large areas with a mosaic of mire (some rather modified), marshy and acid grassland, and heath. It is currently used primarily for grazing sheep and cattle. Grazing densities vary over the Site. Much of the blanket bog has some drainage but there are still large areas that are wet and boggy, and that support good quality blanket bog vegetation. There are numerous small streams that run through the area.

1.1.9 There have been extensive baseline surveys undertaken during 2006-2008. These have included an Extended Phase 1/National Vegetation Classification habitat survey, bat surveys, breeding bird surveys, wintering bird surveys and vantage point surveys to quantify bird flight activity over the site. Further work on peat, wintering birds, breeding birds and vegetation has been carried out in 2011 and presented as Supplementary Environmental Information (SEI).

1.1.10 The current ecological character and ornithological interests of the site are well documented in the ES (Chapter 6 – Non-Avian Ecological Assessment & Chapter 7 – Ornithological Assessment) and the 2010 SEI (Chapter 3 – Ecology & Chapter 6 – Ornithology) which should be read in conjunction with this document. The ornithology assessment has also been updated following additional survey work; this is also included within the 2011 SEI.

Habitats

EU Habitat Directive Priority Habitat

1.1.11 The main habitat of importance within the area is active blanket bog. The extent of this habitat is shown on Figure 6.1 of Volume 3 of the ES. Blanket bog has been identified by the European Union in the Habitats Directive (EU 1992), where it is still actively accumulating peat, as a priority habitat requiring special conservation measures. Its take by the developmenthas been minimised but there will still be a small residual loss.

1.1.12 The peat habitats across parts of the site were much modified and damaged by afforestation in the 1980's. Much of the blanket bog within the study area is currently grazed by sheep, and the species composition is affected consequently. It has also been extensively drained.

1.1.13 Within the Environmental Statement (ES) the predicted effects have been quantified as a loss of 3.147ha of blanket bog habitat, which is considered to be a Certain significant negative impact. However, the development will also involve Certain positive impacts including the clearance of forestry from 64ha of peatland. In addition, the existing area of blanket bog (137ha) will be subject to favourable habitat management.

UK BAP Priority Habitats

1.1.14 Two additional habitats identified on the Site are of importance as UK BAP priority habitats: acid flush and blanket bog (all types). These are marked as mire on Figure 6.1 of Volume 3 of the ES.

Birds

1.1.15 The main ornithological interests found during the baseline surveys comprised hen harrier, black grouse and curlew so the ornithological aspects of the HMP would be largely targeted at these species.

Black Grouse

1.1.16 Black grouse is a species of the moorland/forest fringe, using both moorland and woodland habitats through the annual cycle. Though young forestry plantations can provide important habitats, closed canopy conifer forest is less attractive to them. Wet grassland and marsh areas are important as an invertebrate food source for young birds, and more heavily grazed habitats are generally less-used.

1.1.17 The ES reported that there was only a very low level of flight activity of this species recorded through the collision risk zone and no flights were observed at rotor height. There is a likelihood of a low level of collision with the turbine towers though this should be at most a low magnitude effect and not significant (particularly as the wind farm has been located outside the main area used by this species).

1.1.18 There is only one recently used lek site within 500m of the proposed turbine locations (200m from the nearest proposed wind turbine). This lek was only recorded used by a single male on a single date and not all during the main 2005-2006 baseline surveys. If it were displaced therefore such displacement would not be significant.

Hen harrier

1.1.19 Hen harriers prefer to nest in rank heather (30-60cm), below an altitude of 500m and often close to burns. Grassland/heathland mosaics and young (pre-thicket) conifer plantations are preferred foraging habitats, supporting abundant meadow pipit and field vole populations..

1.1.20 There were no recorded hen harrier nest sites within 500m of the proposed ES wind farm layout. There were three recorded nest sites within 2km of the wind farm, at distances of 502m, 621m and 785m from the nearest proposed wind turbine location. The updated layout (particularly the deletion of turbines 20, 22 and 23) has reduced the number of turbines within the main hen harrier area (the moorland/moorland edge in the north of the site) such that these separation distances are now 1.2km, 670m and 740m.

1.1.21 The precautionary predicted collision risk identified in the ES was small, at 0.1 birds per year. This would only constitute only a 0.15% increase over the existing baseline mortality, an effect of negligible magnitude that would not be significant.

Curlew

1.1.22 Curlews were recorded breeding in grazed pastures, where they need a combination of areas suitable for nesting and feeding. Access to damp foraging areas for chicks is important, as ground nesting birds curlew are very susceptible to predation.

1.1.23 However, the 2011survey results indicated that there has been a considerable decline in curlew activity within the survey area in comparison with the 2005 and 2006 surveys that were used as the baseline for the ES. Up to 4 individual curlews were observed using the survey area in 2011. These birds' behaviour indicated that neither of these pairs were actually breeding within the survey area.

1.1.24 The ES reported that risk to curlew would be of negligible magnitude both in the number of collisions predicted (0.03 per year) and in the context of the population baseline mortality (0.04%), even applying a precautionary 99% avoidance rate.

1.1.25 It was concluded in the ES and the previous SEI that on the balance of evidence from currently available studies, and given the availability of alternative habitat in the vicinity to which displaced birds could move, as well as the benefits that would accrue from the proposed Habitat Management Plan, that if such displacement did occur it would be only small-scale relocation and not significant. The reduced baseline population reinforces this conclusion.

Mammals

Bats

1.1.26 Several species of bat were detected across the site: common and soprano pipistrelles, brown long-eared, whiskered, Natterer's and Noctule bats. Pipistrelles were the predominant species detected. The majority of bats were found feeding along forest edges and following sheltered streams, although pipistrelles and noctules were occasionally detected feeding across the open moorland.

1.1.27 The ES describes the impact of the felling of woodlands proposed as part of the Proposal. Felling will reduce the foraging habitat for bats on this site. Although forest edge will be lost these areas will berestored to a bog and heathhabitat with scattered trees which will continue to provide bats with sheltered foraging areas and a variety of insects to feed on.

Otters

1.1.28 Otters are known to be present in the area but were not found to be using the Site itself. They may commute across the Site or forage occasionally.

1.1.29 The ES stated that no signs of otters were seen at sites of proposed new crossings, but some potential otter habitat was identified. This will be retained during the development and therefore it is Extremely Unlikely that construction will have any effect on the integrity of the local otter population.

Current Management

1.1.30 The Site is owned and managed by eleven different families or bodies, many carrying out different activities on the land: it can mainly be divided into forestry, intensive sheep grazing, and low level cattle and sheep grazing.

Forests

1.1.31 Several areas of commercial forest are included within the Site. 65ha of this forestry has been planted on peaty habitat (HMA 1 on Figure 6.1), the other 88ha has been planted on land that is also considered to be quite wet and boggy (HMA 2and HMA 7). Neither forest type is considered to be growing very well. Discussions with the owners of these forests indicates that without the proposed wind farm they wouldbe allowed to mature and will then be felled for timber value. Management of these areas after felling of the current crop is not known at this time.

Low Level Grazing

1.1.32 To the north of the site sheep and cattle graze at low densities, partly owing to the poor quality of grazing material available and also for conservation reasons. This area includes an existing black grouse management area, coinciding with HMA 3, which is managed jointly by the landowner and the RSPB. It is considered likely that the black grouse management area will continue to be managed appropriately if the Proposal were not to proceed to construction. The remaining low-intensity grazing could theoretically in future become more intensively grazed to increase productivity; depending on future needs of the landowners.

Intensive Grazing

1.1.33 The remainder of the rest of the site is grazed intensively on improved grassland, modified bog and flush. It is considered unlikely that the management of this part of the Site would change in the future if the Proposal were not to proceed.

Proposed Development

1.1.34 Development proposals are described in detail in the ES (Chapter 4) and are not repeated here. The ES also contains specific sections relating to Hydrology and Hydrogeology (Chapter 9) which is also relevant to the habitat management proposals and should be read in conjunction with this document.

1.1.35 This outline HMP has been designed to be compatible with the proposals of an HMP that is proposed by a neighbouring wind farm developer to the north of the Llanbrynmair Wind Farm. The two HMPs are not dependent on one another and will work independently, but if both projects progress the two HMPs will complement one another. This will include mutual support of respective proposed HMP measures by each developer to ensure synergy and co-ordination between the two schemes, if both were to be consented, to ensure the objectives of both plans are fulfilled.

1.2 Scope and Implementation

1.1.36 The HMP considers the key features of the site, the local area, and the proposed development in making its recommendations. It is based on the best and most current information available. The HMP is intended to cover the establishment, management, and monitoring of habitats (and associated species) across the site during the operation of the wind farm (25 years).

Management Objectives: Key Features

1.1.37 The HMP's main objective is to mitigate any adverse impacts predicted for habitats and species during the construction and operation of the proposed wind farm. Further to this the HMP aims to result in a net biodiversity gain over the life time of the wind farm. In order to achieve these objectives, the key features that the HMP has focussed on as a result of the scheme are provided below.

1.1.38 The HMP would be targeted at the key nature conservation interests in the area: the blanket bog habitat; black grouse; and curlew.The measures implemented for these features would benefit other species including hen harrier (which have not been included as a key conservation interest due to the lack of evidence of this species using the site). Measures to enhance the habitat for bats and otters are also included.

1.1.39 The proposals discussed within this document can be considered as firm commitments on the part of RES UK & Ireland Ltd both to implement appropriate habitat management and to monitor the success of the relevant management actions over a 25 year period.

1.1.40 The overall aims of this plan are to:

- improve the overall quality of the blanket bog habitat;
- enhance moorland bird habitats, particularly for the species listed above;
- provide preferred nesting habitat that will encourage bird species potentially sensitive to collision to use areas away from the proposed turbine locations;
- offset any loss or degradation of habitats due to the development;
- provide enhanced predator control across the area to benefit ground-nesting birds.

1.1.1. The aims relevant to each habitat of interest and animal species are listed below.

Blanket bog

- Reduction of the effects of past drainage through drain blocking;
- Reduction of the current levels of grazing to improve heather and other dwarf shrub cover;
- Restoration of currently afforested areas to blanket bog.

Black grouse

- Removal of closed canopy plantation forestry;
- Planting of native broad-leaved species such as birch where appropriate;
- Improvement of wetter habitats for chick-rearing;
- Enhancement of heather moorland mosaic suitable for foraging and nesting;
- Enhanced predator control to improve adult survival rate and increase productivity.

Curlew

- Maintain current land management practice to maintain curlew population
- Encourage areas of damp vegetation as cover and feeding areas for chicks.
- Enhanced predator control to improve adult survival rate and increase productivity.

Bats

- Plant trees (willow and alder) along stream sides in the southern half of the site to provide sheltered foraging areas and to increase connectivity across the landscape.
- Protect existing broadleaved woodland.

Otters

- Provide improved facilities for breeding and foraging.

Funding and Delivery

1.1.2. It is anticipated that the commitments to the HMP methods outlined within this document will be conditioned on the planning application. RES will guarantee to fund these via a ring fenced sum committed for the 25 years of the wind farm development. The enforcement of the HMP will be through planning conditions.

1.1.3. The applicant is prepared to enter into a planning agreement to secure the management of habitat management areas via the formation of a habitat management group throughout the working life of the wind farm. Clause 1 of this agreement would set the parameters of the HMP detailing the means by which the proposals contained within this outline HMP report shall be implemented. Clause 2 would pertain to the formation of a habitat management group to be set up within six months of the date of any permission granted. Its function would be to review and inform the implementation of the HMP approved in accordance with Clause 1 and approved in writing by the Local Planning Authority.

Implementation of the HMP

1.1.4. The implementation of the plan would be guided by thehabitat management group, who would agree the detail of the plan and oversee its implementation, meeting as necessary to review survey results and alter management prescriptions as necessary. Members of this group would comprise representatives of the developer, the landowners, NRW, Powys County Council Ecologist MWT and RSPB.

1.1.5. A Method Statement will be prepared for each of the management techniques described within this document. Each Method Statement will be cross-referenced with the Construction Environmental Management Plan (CEMP) and Construction Method Statement (CMS). Method Statements will include:

- reference to the time of year operations will take place
- machinery or techniques to be used
- any reason why the management may be stopped, e.g. very wet conditions
- reference to any ecological or conservation issue, e.g. protected species
- who is responsible for the management
- detailed reinstatement methods for disturbed ground, which include methods to minimise disruption to vegetation types to be affected (including storage areas)
- detailed methods for the maintenance and support of all areas where applicable.

1.1.6. Each Method Statement would be signed off following approval from the relevant consultees as defined by the habitat management group.

1.1.7. All of the management plans will be thoroughly monitored throughout the lifetime of the wind farm, or until the management is considered successful and stable. The primary objective of the monitoring and subsequent consultation with the habitat management group will be to rapidly inform on-going management, such that prescriptions can be altered at the appropriate timescales and prevent the possibly damaging impacts that may result if changes in management are delayed.

Timing of the HMP

1.1.8. A number of the management techniques specified in the HMP would commence during the construction period with some commencing either prior to construction or after the completion of the construction of the wind farm. The actions of the HMP would be overseen by a Project Environmental Manager throughout the duration of the development.

An Ecological Clerk of Works (ECoW) will be available when required throughout the works and will be directed by the Method Statements for each management prescription, and by the direction of the Project Environmental Manager.

1.1.9. Specific start and end dates will be agreed with the habitat management group and detailed within the Method Statements and construction programme.

1.1.10. The key activities of the ECoW would include:

- Marking of key peat habitats to ensure avoidance, and advise on micrositing.
- To relocate any individual amphibians, reptiles and mammals found within the zone of clearance to an adjacent safe area. Such advice may include a 'destructive search' of the area to be cleared immediately prior to its clearance and the potential use of fencing to ensure that any translocated individuals cannot move back into the construction areas.

1.1.11. The Project Environmental Manager's responsibilities would include the following:

- Overseeing the management of environmental issues before/during/after the construction period and advising on the resolution of environmental issues as they arise, - to protect the on site features, habitats and species;
- Providing on-site guidance to contractors - to ensure legal compliance with respect to protected species;
- Ensuring that any landscaping and ecological works, including habitat creation projects and mitigation for protected species, are agreed with the Local Planning Authority; and
- Maintaining liaison with officers of the Local Planning Authority and other relevant bodies with respect to the above.

On-site Construction Management

1.1.12. The mitigation and enhancement opportunities that are written into this HMP will not commence until the HMP has been agreed between the relevant stakeholders and conditioned or a planning agreement has been made as part of any planning permission. For on-site environmental management, there are two documents which would support the HMP and will reference proposals and associated methodologies contained within the HMP; Construction Environmental Management Plan (CEMP) and Construction Method Statement (CMS).

1.1.13. A CEMP would be prepared and implemented for the construction, operation, maintenance, and decommissioning phases of the development, to ensure that any planning conditions associated with the consent are adhered to.

1.1.14. A CMS will also be prepared which seeks to provide detailed information regarding the construction method and measures taken to reduce the environmental impact of the development in accordance with the consented Environmental Statement. The processes and methods detailed in this CMS adopt construction best practice and would take full account of relevant health, safety and environmental legislation and guidance.

Monitoring Implementation

1.1.15. A separate ecological monitoring plan will be prepared to cover all the aspects of the monitoring within the HMP. The ecological monitoring plan will set out the purpose of each monitoring proposal and include a time line as to when monitoring will be carried out. Monitoring is however detailed within this HMP.

1.1.16. The implementation of any monitoring and the submission of monitoring reports will be conditioned as part of the planning application. The condition should allow for the updating of the monitoring plan as required.

1.1.17. As discussed above a habitat management groupwith statutory and non-statutory bodies will be set up prior to the construction of the wind farm. The groupwill be consulted during the HMP implementation and will receive regular reports from a conservation officer (appointed by RES)on monitoring of habitats and species throughout the proposed monitoring (as discussed above). This will enable any changes or remedial actions tothe management prescriptionsto be identified so that the relevant objectives of the management prescriptions are achieved. The monitoring reports will be compared to a baseline of existing habitats within the site and/or a control/model habitat for which the management plan is aiming to achieve.

1.1.18. The structure, members and governance of the habitat management group will be discussed and agreed with the members prior to the construction of the wind farm. The frequency of meetings will also be discussed. However, it would be expected to meet at least once a year during the implementation of the management plans. The frequency is likely to be increased (potentially quarterly) within the first few years of implementation when decisions on any changes of the management prescriptions are more likely. A terms-of-reference will also be drawn up that outlines the processes proposed to deal with arbitration and timely resolution of matters.

2. MANAGEMENT PRESCRIPTIONS

2.1.1. Suitable areas for habitat management have been selected through a combination of areas suitable for management and areas where land owner agreement was possible. Areas were first identified as potentially suitable (mainly conifers on peat that could be restored or areas of existing bog habitat that could be improved), then landowner agreements explored.

2.1.2. Further areas which are identified through the habitat management group as being worthwhile to include within the HMP will be considered as appropriate, and will be subject to land owner negotiation.

2.1.3. Four main management measures were identified in the ES as fundamental for the HMP:

- Blocking of grip drains to encourage re-wetting in areas that have been drained in the past. A detailed ditch blocking method statement will be agreed with NRW prior to the commencement of construction. The most appropriate methods would be used, chosen on a site by site basis as described below. Such measures would benefit the area’s general ecological interest at the same time;
- Planting of native woodland along river edges and improving general connectivity of habitats, especially bat foraging areas, across the site;
- Felling and thinning of forest coupes and/or forest edges to create more open areas. All standing timber and brash will be removed from site. Brash will probably be baled. Exact felling methods are to be agreed on a site by site basis in order to minimise impacts on peat and create conditions for restoration;
- A programme of licensed predator control through the lifetime of the wind farm, details of this are provided in the Confidential Addendum which accompanies the ES.

2.1.4. Grazing levels will be managed within each HMA to ensure appropriate levels of grazing which will allow the restoration and maintentance of blanket bog, heath and upland grassland. The Glastir guidance will be used where appropriate to guide the detailed method statements for blanket bog and heath management, which includes recommended levels for grazing.

2.1.5. In order to achieve the objectives of the management plan, the following prescriptions will be developed in detail, in conultation with NRW and the habitat management group, specific to each of the current management units where appropriate:

Habitat Management Area (HMA) 1 - (62 hectares): forestry felling for black grouse habitat and blanket bog restoration

2.1.6. Clear fell majority of conifers either leaving some small stands of young trees, or planting stands of conifers using species such as scots or lodgepole pine where conditions allow, to provideshelter for black grouse. Following felling all standing timber and brash will be removed from site. Brash will most likely be baled. Exact felling methods are to be agreed with the habitat management group on a site by site basis, in order to minimse impacts on peat and create conditions for restoration.

2.1.7. All drains will be blocked. This will be done using the most appropriate method once the extent and size of the drains is revealed following felling. A survey of the drains will be undertaken and the area mapped in detail from LIDAR data. Drains will be blocked by filling with peat removed as part of construction elsewhere on site (depending on amount of peat available), blocked with peat dams or where necessary (such as on steep ground or areas where peat may be unstable) blocked with plastic piling dams.

2.1.8. The aim will be to restore the areas to pre-planting blanket bog habitat – the habitats present in the existing rides indicate that this will be successful. From the evidence of the rides it is thought that there will be sufficient seed available within the existing peat to allow re-growth of heather and other species across the site post felling. There is also already sphagnum present in many of the ditches. If this does not occur the area will be sprayed with heather brash, collected from elsewhere on site and other methods such as inoculation of wet areas with sphagnum will be considered, based on methods used successfully elsewhere (See peat management plan – SEI Chapter 7).

2.1.9. The area will then be managed and monitored as described in Section 4, with any remedial actions which may be needed to be agreed by the habitat management group and implemented by the developer.Cattle grazing will be implemented where necessary.

2.1.10. If monitoring shows that black grouse are not present within this area the remaining trees will be removed.

Habitat Management Area (HMA) 2 - (46 hectares): forestry felling to revert to bog and mire habitat

2.1.11. Fell forest and allow to revert to bog, mire, heath and scrub habitat.Following felling all standing timber and brash will be removed from site. Brash will most likely be baled. Exact felling methods are to be agreed with the habitat management group on a site by site basis, in order to minimse impacts on peat and create conditions for restoration.

2.1.12. Drains put in during afforestation will be blocked using the most appropriate method, either filled or dammed with peat or dammed with plastic piling. The most appropriate method will be chosen once the extent and size of the drains is revealed following felling. A survey of the drains will be undertaken and the area mapped in detail from LIDAR data.

2.1.13. Existing willow and other scrub will be retained and will be allowed to develop along streamsides and damp areas. This will provide feeding areas for bats and nesting sites for birds. Additional planting of hedges to maintain and increase connectivity of potential bat foraging areas will be undertaken adjacent to these areas.

2.1.14. The naturally occurring vegetation growth will be monitored. Any areas that remain bare will be sprayed with heather brash or another appropriate seed source to ensure successful re-vegetation of the site.

2.1.15. Drier areas will be allowed to revert to heath – a priority habitat – as there is some remnant heath vegetation in the plantations. The habitat will be monitored and grazing introduced as considered necessary.

Habitat Management Area (HMA) 3 - (147 hectares): black grouse refuge

2.1.16. Area not to have wind turbines constructed in it to allow for a precautionary approach to wind turbines and black grouse.

2.1.17. Current management for black grouse area to be continued and extended out to whole of HMA.The principle of the plan is to add value and secure for the longer term (the lifetime of the wind farm) the management instigated under the RSPB Welsh Black Grouse Recovery Project (WBGRP), though continuation and extension of the previous management. The plan would also deliver an increased level of predator control (focussing particularly on crows and foxes) through the employment of a conservation officer.

2.1.18. Further ditch blocking will be undertaken by filling them with peat removed as part of construction elsewhere on site (favoured method - depending on amount of peat available). Peat will be placed in the drains and compacted to ensure full blocking. Drains may also be blocked with peat dams or where necessary (such as on steep ground or areas where peat may be unstable) blocked with plastic piling dams.

2.1.19. The RES black grouse refuge has been designed to be compatible with a black grouse refuge that is proposed by a neighbouring wind farm developer to the north of the Llanbrynmair Wind Farm. The two refuge areas are not dependent on one another and will work individually, but if both projects progress the two refuge areas will complement one another.

Habitat Management Area (HMA) 4 – (150 hectares): blanket bog restoration.(Overlaps with and complimentary to, HMA 4 and 7)

2.1.20. The actual area to be restored will be slightly less that the total figure for HMA 4 as this section includes proposed infrastructure. The main habitat aimed at restoring is blanket bog, but there are some other habitats likely to be included as the plan develops. The figure of 150 ha covers areas not including HMA7.

2.1.21. The site is currently crossed by a series of narrow drains which are flowing with water most of the time. Although the bog is fairly wet it is clear that a considerable amount of water is being drained off the site. These drainage ditches will be blocked to increase wetness of the area and to increase activity of bog areas. This will also provide an improved source of invertebrate food for breeding waders and nearby black grouse. As the peat habitats (including blanket bog, mire and heath) were identified as the most important and sensitive a detailed construction method for work across peatlands and a peat management plan has been developed (see Appendix 8.9).

2.1.22. All drains will be blocked.This will be done using the most appropriate method once the extent and size of the drains is revealed following felling. A survey of the drains will be undertaken and the area mapped in detail from LIDAR data. Drains will be blocked by filling with peat removed as part of construction elsewhere on site (depending on amount of peat available), blocked with peat dams or where necessary (such as on steep ground or areas where peat may be unstable) blocked with plastic piling dams.

2.1.23. Immediately following construction some turves will be replaced along the road edges to allow quicker re-vegetation and soften the road edges. Peat will be replaced around the turbine base excavations, and re-turfed. Peat will be spread over the parts of the crane pads, rotor assembly pads and other areas used in the construction and re-turfed to prevent erosion.

2.1.24. Remaining peat will be kept in damp storage and used for drain blocking. A detailed work programme for this activity will be developed to ensure that the peat does not dry out and become unsuitable for this purpose. Any surplus peat will spread in areas identified by the Ecological Clerk of Works as suitable, and only on areas of existing peat with poorer quality vegetationor within forest clearance areas. These areas will be stripped of turves beforehand, and vegetation replaced on the bare peat, or if surplus turves are available, these will be used if of appropriate vegetation.

2.1.25. Any edges of cut peat that may remain exposed, or areas of peat excavation on steep slopes, will be covered with hessian textile to stabilise the peat. This will be held in place with biodegradable pegs. This will allow re-turfing and re-vegetation without erosion risks.

2.1.26. The construction areas will be fenced and stock excluded for up to two years to allow full and proper recovery of vegetation.

2.1.27. The re-vegetated areas will be monitored. Any areas of bare peat, where vegetation is not re-growing, will be seeded with a seed mixture obtained from the existing habitat.

2.1.28. Sheep or cattle grazing will be monitored and adjusted to allow initial recovery of vegetation, and then development of a diverse bog habitat or other habitats where appropriate. Grazing levels will be based on Glastir guidance or as directed by the HMP group.

Habitat Management Area (HMA) 5 - (350 hectares): curlew area

2.1.29. Area not to have wind turbines constructed in it to allow for the precautionary approach to wind turbines and curlew.

2.1.30. Existing land management to be continued to maintain preferred habitat for curlew. The current agricultural management appears to have supported high numbers of curlew within the study area up until recently, though there has clearly been a major decline since the main ES baseline surveys.

2.1.31. The management plan for curlew would seek to maintain (and where possible enhance) the mosaic of habitats available to the curlew, including rushy patches for nesting and providing cover for chicks, and agriculturally-improved grassland for foraging, together with reducing mortality through predator control.

2.1.32. Management proposals with regard to curlew would be to adopt management prescriptions for this species developed through the Glastir scheme and as recommended by RSPB[1]. This would involve:

- Unimproved pastures:
  - Unimproved pastures would be managed with no, or very limited, use of fertiliser.
  - No grazing or field operations in fields identified as having breeding curlew during the possible nest period – 1st April – end May. Light grazing from end May to mid – July.
  - Grazing by cattle from late summer onwards would provide a suitable sward for nesting and feeding in the following spring.
- Silage Fields:
  - If curlews are nesting within silage fields, these fields would be cut from the middle of the field outwards and no cutting would take place after dark. No cutting would take place in the 12 weeks from 1st April where curlew are identified as breeding.
- Wet Areas:
  - Wet flushes, boggy areas and damp, rough grassland would be retained by avoiding new drainage and by blocking drains where feasible. These are important invertebrate-rich feeding areas, particularly for chicks.
- Hay Meadows:
  - Some unimproved hay meadows would be retained/restored, rather than harvesting all grass as silage
- Rush Control
  - Rushes will be controlled to prevent areas becoming too dense for breeding curlew, but with some patches retained to give cover.
- Predator Control:
  - Control of potential curlew predators would be enhanced through the employment of a ranger. These measures would include control of crows, foxes, weasels and stoats.

[1] RSPB Advice Note on Farming for Wildlife in Wales: Curlew.

2.1.33. Removal of sheep grazing from key curlew breeding fields during main incubation period (Mid April to early June) to reduce nest loss to trampling / sheep predation on an experimental basis with monitoring.

2.1.34. Potentially damaging operations such as re-seeding or any agricultural intensification or drainage to be agreed beforehand with habitat management group.

2.1.35. Further general management, provision of damp areas and predator control across the whole site (see below) will also benefit curlew.

2.1.36. Monitoring of curlew to be carried out to inform management and record any possible impacts of turbine operation as part of monitoring programme – see Section 4 below.

2.1.37. Further biodiversity gains can be made within this area by appropriate management of the area of broadleaved trees and scrub, and some planting of hedges in the south west corner to improve habitat connectivity for bats.

Habitat Management Area (HMA) 6 - (34 hectares): black grouse refuge extension area

2.1.38. Area not to have wind turbines constructed in it to allow for the precautionary approach to wind turbines and black grouse.

2.1.39. As this area is coincident with HMA 4 the habitat management of HMA 4 would apply to HMA 6.

2.1.40. It is considered that this area would act as a further buffer zone between HMA 4 and the proposed wind turbines.

Habitat Management Area (HMA) 7 - (41 ha) forestry felling to revert to bog and mire habitat

2.1.41. This forestry area is adjacent to HMA 4 and the existing bog would have been, pre-planting, a contiguous part of this bog area. The aim is to restore the areas to pre-planting blanket bog habitat – the habitats present in the existing rides indicate that this will be successful. From the evidence of the rides it is thought that there will be sufficient seed available within the existing peat to allow re-growth of heather and other species across the site post felling. There is also already sphagnum present in many of the ditches. If this does not occur the area will be sprayed with heather brash, collected from elsewhere on site and other methods such as inoculation of wet areas with sphagnum will be considered, based on methods used successfully elsewhere.

2.1.42. There are three turbines and associated infrastructure proposed within the forest area. The trees will be felled and removed from the site prior to construction. After the construction of all the infrastructure all drains will be blocked. This will be done using the most appropriate method once the extent and size of the drains is revealed following felling. A survey of the drains will be undertaken and the area mapped in detail from LIDAR data. Drains will be blocked by filling with peat removed as part of construction elsewhere on site (depending on amount of peat available), blocked with peat dams or where necessary (such as on steep ground or areas where peat may be unstable) blocked with plastic piling dams.

2.1.43. There are also five turbines sited either on this blanket bog habitat or on adjacent semi-boggy areas, along with track, crane pad and other infrastructure - a total of 3.147 ha within this area. A further 0.32 ha will be temporarily used for rotor assembly and other uses. Some other areas of marshy grassland and flush habitat also include peat.

2.1.44. Prior to construction, the top layer of vegetation on areas subject to construction activities within HMA 7 will be stripped off as turf by an experienced specialist contractor.

These turves will be stored adjacent to the construction area in a way to ensure that they remain moist and viable. Peat will then be removed and stored separately and kept damp nearby. Extra care will be taken when working within peat areas to keep all activities within the narrow construction envelope.

Habitat Management Area (HMA) 8 -(35 ha). Blanket bog protection and improvement.

2.1.45. This is an area of existing blanket bog previously mapped as M19 Calluna vulgaris - Eriophorum vaginatum blanket mire NVC community and H12 Calluna vugaris – Vaccinium myrtilis heath mosaic with U5 Nardus stricta – Galium saxatile grassland. The aim of the management is to protect this habitat and improve it if possible. Key management will be:

- Full survey of area to identify any drains of other threats to the site.
- Blocking of drains if found (no obvious drainage noted to date)
- Grazing at Glastir prescription for blanket bog
- No new improvement, drainage, fertiliser of other works to be carried out.

Habitat Management Area (HMA) 9 - (20 ha) Mire protection and improvement.

2.1.46. This is an area of M6 / M25 mire (Carex echinata – sphagnum fallax/denticulum / Molinia caerulea – Potentilla erecta mires). Adjacent areas have been drained and improved. The aim of the management is to protect this habitat and improve it if possible. It overlaps with HMA 2 and it will be made sure that management work is mutually beneficial to the aims of both areas. Key management will be:

- Full survey of area to identify any drains or other threats to the site.
- Blocking of drains if found (no obvious drainage noted to date)
- Grazing at Glastir prescription for this habitat
- No new improvement, drainage, fertiliser of other works to be carried out.

HMA 10 - (46 ha). Potential additional curlew area.

As curlew have been seen in the vicinity of this land it will be available for additional curlew management, under similar prescriptions as HMA 5, depending on results of curlew surveys and with the discretion of the HMP group.

Summary of HMP Areas

HMP	*Area(Ha)*	*Aim*
1	62	Forestry felling and habitat restoration
2	46	Forestry felling and habitat restoration
3	147	Black grouse refuge
4	150	Blanket bog restoration
5	350	Curlew management area
6	34	Black grouse extension
7	41	Forest felling and habitat restoration
8	35	Blanket bog protection and improvement
9	20	Mire protection and improvement
10	46	Potential addition curlew area

Habitat Management across Whole Site (1,713 hectares)

2.1.47. No further agricultural intensification will be undertaken - this will be agreed by lease terms and HMP agreements between RES and individual landowners. The agreements will be negotiated post consent and the HMP enacted after commissioning. Stocking levels will be controlled and reduced on areas currently considered overgrazed by the Management Group. Stocking levels will be based on Glastir guidance, or as recommended by the HMP Group.

2.1.48. A programme of licensed predator control as described in the confidential addendum to benefit ground nesting bird species.

2.1.49. Maintenance of current low stocking level on heather moorland habitats (such as H12, for example the areas adjacent to Llyn Gwyddior) to sustain and enhance heather cover (to provide hen harriers with enhanced foraging and nesting habitat).

2.1.50. Where topping of rushes is carried out this should be done outside of nesting season (i.e. no topping between March – July). Pastures should be kept generally open to benefit curlew and other ground nesting birds, although some small patches of rushes should be retained to provide cover.

2.1.51. This cover can be provided by leaving patches of rushes long in wet corners. As well as providing cover this will to encourage invertebrates and feeding areas for wader chicks as well as newts and bats.

2.1.52. Small scrapes will also be provided and drains in wet flushes and remnant bog areas blocked or reduced to ensure damp areas are retained. Some small bog areas may also benefit from stock exclusion.

2.1.53. Carry out streamside planting of alder and willow. This will provide sheltered foraging areas and flightline corridors to encourage bats away from wind turbines.

2.1.54. Streamsides will be fenced from stock where tree planting has taken place as this will protect the trees and provide undisturbed cover for otters.

2.1.55. Bird nest and bat boxes will be erected in areas where tree planting has taken place. Bat boxes will also be installed in areas of existing conifer forest and in semi-open areas designated as black grouse habitat/refuge. All locations of boxes will be plotted using GPS. All bat boxes installed will be constructed of woodcrete as this is very long lasting e.g. Schwegler boxes. The exact type (different boxes are used for different bat species) and number of boxes will be agreed by the Habitat Management Group.

2.1.56. Install otter holts by stream at bottom of valley. Artificial otter holts, generally of log pile construction, have been shown to increase otter usage of streams where natural cover is lacking.

3. MONITORING PROGRAMME

3.1.1. An appropriate monitoring programme will be designed and implemented following the development of the detailed HMP and the implementation of management prescriptions. The monitoring programme will be developed with two specific aims: Fistly to monitor the effect of windfarm construction on surrounding habitats – there is still doubt as to the exact impact of infrastructure such as tracks on adjacent peat habitats. Monitoring will be designed to measure any change and allow remedial action if change is considered unacceptable. Secondly the monitoring will measure the success of the HMP and inform changes in management during the lifetime of the windfarm.

3.1.2. Details of the monitoring programmes and protocols would be drawn up prior to their commencement and following consultation with NRW, PCC, RSPB and MWT. However, monitoring may include the following:

- Monitoring of habitats and vegetation: Monitoring of vegetation may include fixed point quadrats, more extensive NVC surveys or other methods as decided by the management group. The frequency of the monitoring will vary by site and by management prescription, but will be frequent enough to allow changes in prescriptions to be implemented if considered necessary.
- In all areas where management includes drain blocking the water levels will be monitored using a series of dip wells with automatic data loggers. Dip wells will be installed in a line at right angles across the blocked drain to monitor the extent of influence on the water table across the previously drained area. The water level monitoring method statement will be agreed with NRW prior to installation of any monitoring.
- Breeding bird surveys to assess the effect of the proposed development and the HMP on their populations: a breeding bird survey for key species following standard methods. This monitoring would be undertaken in the year immediately prior to construction and then at years 1,2,3,5,10 and 15 following construction or as decided by the consultees.
- Carcass searches are an important part of bird monitoring, especially for species for which collision is highlighted as a critical issue in the preliminary environmental statement. There are, however, a number of serious methodological constraints that make obtaining reliable estimates of collision victims very difficult. In particular:
    - Birds may fall outside the search area. This is especially likely if a moving turbine blade injures the bird, so that while the victim may be crippled it may be able to fly (or move) away from the turbine, (possibly into cover) thus taking it out of the turbine search area. These two sources of error: search area bias and crippling bias are clearly linked, but can be very difficult to correct for.
    - For those birds falling within the search area around turbines, the efficiency of finding will vary considerably because not all birds will be found by observers. Different species, in different habitats, will have different detectabilities. Search efficiency can be corrected for, but for good reasons, search efficiency must be calculated for each wind farm site, as there is currently no reliable means of extrapolating data from other wind farms to any particular site. Furthermore, there is likely to be variation in observer efficiency which cannot be evaluated a priori, but must be tested in the field.
    - Finally, there is scavenger removal. Predators which also scavenge may be attracted to wind farms and will therefore remove a proportion of carcasses, away from the wind farm and hence, out of the search area. Search frequency needs to be determined on the basis of prior assessment of scavenger activity and such activity must be corrected for.

   - These biases will cause the estimate of collision mortality based simply on numbers of birds found to be too low, and must be corrected for. Methods for estimating these correction factors are discussed within the SNH**Error! Bookmark not defined.** guidance and will be used for the collision mortality calculations. Carcass searches will occur during each site visit during the vantage point surveys, which will aim to cover each month of the year within the year of survey as described above, and will follow SNH guidance. The ground under each turbine to a distance to 100m radius will be searched for carcasses and injured birds. Any signs of carrion foragers feeding on carcasses will be investigated to determine whether they are likely collision victims. Any victims found may need to be further investigated to determine cause of death. This may involve the opinion of a professional, such as a vet.

- Bat surveys will also be undertaken which will include monitoring of bats at height using the met masts. This monitoring will be undertaken in the year immediately prior to construction and then at years 1,2,3,5,10 and 15 following construction or as decided by the consultees. Survey methodology will be comparable to that undertaken pre-construction (baseline survey). All bat boxes installed will be checked every three years to determine their use and ensure they remain as installed and in useable condition. In addition carcass searches for bats will be undertaken during the same time as the bird searches (as described above), in terms of searches being conducted in years 1, 2, 3, 5, 10 and 15, as suggested by SNH. Methods are rapidly developing and current best practice at the time of survey will be employed.
- Results of the monitoring programme would be reported annually to the habitat management group and be made publicly available to inform understanding of the effects of windfarms on wildlife.

3.1.3. The management prescriptions detailed above will be an adaptive process according to existing site conditions and developments over time. Details of the prescriptions will be modified as the HMP develops to adjust to any changes in environmental conditions as highlighted by the monitoring programme.

4. CONCLUSIONS

4.1.1. The HMP’s main objective is to mitigate any adverse impacts predicted for habitats and species during the construction and operation of the proposed wind farm. Further to this the HMP aims to result in a net biodiversity gain over the life time of the wind farm which will result in enhancement of the site.

4.1.2. Table 1 provides a summary of the potential adverse environmental effects on habitats and species of the wind farm without any mitigation measures and the residual effects based on the all of the mitigation and enhancement measure documented within this HMP. Key aspects are also described below.

4.1.3. Over the life time of the wind farm it is expected that there will be a net gain in the amount and quality of the blanket bog habitat at Llanbrynmair. This conclusion is based on:

- 14.8 ha of peatland habitat will be directly lost to tracks, turbines and other infrastructure;
- There will be an area of a around 200 ha of blanket bog and mire habitat restored and maintained;
- 149 ha of forestry on previous peat habitat will be removed;
- Habitat of conservation importance restored.

4.1.4. The creation of wetter areasand wader scrapes within the site boundary but away from turbines is considered here to provide enhancement for waders, particularly the curlew.

4.1.5. It is considered that the restoration of habitats, and wider habitat management measures across the Site, represents a net gain on the conservation value of the Site to species including curlew, hen harrier and black grouse.

4.1.6. Restoration of bogs and planting of streamside vegetation may improve some feeding habitats for bats.

Table 1 - Review of predicted environmental effects before any mitigation or enhancement measures, mitigation and enhancement measures and subsequent residual effects

Receptor	Environmental Effect	Mitigation and Enhancement Measures	Residual Effect
Construction			
Blanket bog	14.8 ha of peatland habitat will be directly lost to tracks, turbines and other infrastructure. *Certain negative significant impact*	There will be an area of a total of 200 ha bog and mire habitat restored and maintained along with149 ha of forestry on previous peat habitat removed and habitat of conservation importance restored.	*Net gain*
Operation			
Bats	Reduction of bat populations resulting from collision with blades or barotraumas. *Unlikely to have a significant impact*	Avoiding locating turbines close to linear features (Design Mitigation) Enhancement measures – bat boxes, planting up hedgerows, increasing invertebrate abundance, monitoring.	*Net gain*
Otters	Loss of habitat at proposed water crossings. *Extremely Unlikely to have a significant impact*	Enhancement measures – artificial otter holts and otter habitat.	*Net gain*
Black grouse	There may be a small loss of habitat around the wind turbines if this species were to be displaced. *Negligible magnitude and not significant*	Current management for black grouse area to be continued and extended out to whole of HMA.	*Net gain*

Receptor	Environmental Effect	Mitigation and Enhancement Measures	Residual Effect
Hen harrier	There may be a small loss of foraging habitat around the wind turbines if this species were to be displaced. *Negligible magnitude and not significant*	This species would receive a net benefit from scheme through the habitat management plan, particularly through increased foraging habitat provided by forest felling.	*Net gain*
Curlew	On the basis of the new 2011 baseline data, there would be only a small potential loss of a small part of the feeding range of two pairs of curlew. *Negligible magnitude effect, which would not be significant*	The management plan for curlew would seek to maintain (and where possible enhance) the mosaic of habitats available to the curlew, including rushy patches for nesting and providing cover for chicks, and agriculturally-improved grassland for foraging, together with reducing mortality through predator control.	*Net gain*

APPENDIX 5.3: ACCESS ROUTE ECOLOGY IMPACT ASSESSMENT AND MITIGATION

1.1.1 This appendix gives details of any ecological impacts assessed along each section of the proposed off-site access works and gives details of proposed mitigation. It is based on the multi-disciplinary appraisal carried out in Spring 2013 and on the results of a series of previous surveys.

General principles:

1.1.2 No habitat clearance will take place within the bird breeding season of March to August.

1.1.3 Re-planting will take place using stock of local provenance (where that is available – provenance should be sourced within Wales if immediately local plants are not available).

1.1.4 Where hedge translocation has been suggested this is where the hedge is growing on an existing earth bank. This can be pushed back using suitable equipment (bulldozer blade or similar) where there is sufficient room for manoeuvre. The whole bank with hedgerow bushes is pushed back to its new location. The hedge is then monitored and if some bushes do not take in their new location they will be replaced with new plants.

1.1 Section 1

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
Llanerfyl Access.	Some of the current roadside hedge will be removed then replanted. It is currently relatively newly planted Hawthorn. Any replanted hedge will be improved by the addition of other species such as blackthorn and hazel to match other hedges in the vicinity.
OVER-RUN AREA AND BRIDGE PARAPET WORKS CH 460 - 590	70m of hedgerow will be removed and replaced with 73 m of new hedging. This will be a mix of hawthorn, blackthorn, hazel and cherry to match the existing species mix. In addition the soil from the existing hedge base will be used to form a small mound into which the new hedge is planted to maintain existing ground flora.
1.2 - OVER-RUN AREA CH 720 - 740	35m of the existing hedgerow will be removed and a new hedge of 32m planted 1.5 m to the South. The species mix will reflect the existing mix of sycamore, hawthorn and blackthorn.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.3 - OVER-RUN AREA CH 875 - 950	50m of the existing hedge will be removed and replaced with 50m of replanted hedge. Species mix will reflect the existing hedge of sycamore, blackthorn, hawthorn, holly ash and hazel.
1.4 - OVER-RUN AREA WITH STRUCTURE CH 970 - 990	No ecological issues for this section.
1.5 - OVER-RUN AREA CH 1045 - 1080	The existing hedge will not be impacted by proposals for this section. It may need to be trimmed and any such work will be carried out outside the bird breeding season.
1.6 - OVER-RUN AREA CH 1130 - 1175	The existing hedge will not be impacted by proposals for this section. It may need to be trimmed and any such work will be carried out outside the bird breeding season. An existing tree at CH1150 may need to be felled and will be replaced by a standard oak.
1.7 - EXISTING ACCESS CH 1175 - 1210	No ecological issues for this section.
1.8 - OVER-RUN AREA CH 1380 - 1450	The existing small trees are not affected but for landscape purposes it it proposed to lay them. Currently this is a tall, unmanaged hedge of very spindly hazel and hawthorn that would lend itself to laying.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.9 - OVER-RUN AREA CH 1950 - 2000	The existing hedge will be cut back (any works outside of the bird breeding season) and if any loss is needed it will be replaced with a similar mix of species tied in to the existing hedge
1.10 - EXISTING ACCESS CH 2055 - 2090	No ecological issues for this section.
1.11 - EXISTING ACCESS CH 2300 - 2340	No ecological issues for this section.
1.12 - OVER-RUN AREA CH 2400 - 2575	The hedge will be coppiced back to allow ail vehicles to pass. If loss is unavoidable, a new hedge to match and tie in with the existing hedge will be planted. Potential impact on existing tree roots to the south at chainage 2515 adjacent to two electricity poles. If trees are lost standard ash trees will be re-planted in their place.
1.13 - EXISTING ACCESS CH 2580 - 2630	No ecological issues for this section.
1.14 - OVER-RUN AREA CH 2970 - 3050	Part of the existing coppice (45m in length) will be lost to enable earthworks. Soil to be excavated and reused and additional hazel coppice planted on new bank. This is currently a solid row of mainly hazel which has been previously coppiced along with occasional elder and hawthorn. The loss of this row will leave the more scattered coppice behind exposed. The row should be replanted on the new bank once earthworks are complete. It may be possible to leave the existing rootstock of the row whilst undertaking earthworks, and allowing this to re-grow through the new bank, with planting up to fill any gaps. This area was surveyed for dormouse previously and no signs were found.
1.15 - OVER-RUN AREA CH 3340 - 3450	Part of the existing coppice (107m in length) will be lost to enable earthworks. Soil to be excavated and reused and additional hazel coppice planted on new bank. As 1.14. Also, possibility of extending area of coppice in the field behind to increase habitat subject to landowner agreement.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.16 - EXISTING ACCESS CH 3870 - 3930	No ecological issues for this section.
1.17 - OVER-RUN AREA CH 3875 - 4090	One large Ash tree to be felled. Another ash on the southern side, an oak and a sycamore on the northern side to be retained. New trees to be planted outside of the impacted work at locations to be agreed post planning. Existing hedgerow along the southern edge from ch 3950 - 4080 impacted and relocated to top of proposed earthworks at rear of over-run. any vegetation loss is to be replaced. hedgerow removed = 110m and hedgerow replaced = 110m. Southern hedge is hazel hedge to be replaced. This hedge has previously been surveyed for dormouse and no signs found. Northern section of hedge to be trimmed is mainly hawthorn with some hazel and blackthorn.
1.18 - OVER-RUN AREA CH 4120 - 4200	108m of existing hedgerow will need to be moved/removed and will be replaced by 100m of species rich mixed hedge to tie into the continuous hedgelines on either side of the works. Earthworks to be blended into the existing landform to look at natural as possible and seeded to match adjacent areas. This is a hawthorn and hazel hedge on a low bank that should be able to be translocated.
1.19 - OVER-RUN AREA CH 4235 - 4315	70m of hedgerow will need to be moved/removed and will be replaced by 73m of species rich mixed hedge to tie into existing hedges. Fencelines to replace existing fences. Earthworks to be blended into the existing landform to look at natural as possible and seeded to match adjacent areas. Re-plant to reflect existing mix of dominant hazel with occasional hawthorn and blackthorn.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.20 - OVER-RUN AND PASSING PLACE **CH 4335 - 4430**	58m of hedgerow will need to be removed. This will be replaced by 83m of new mixed hedge to follow the curve of the road and tie into the existing hedgerows. Fences will be replaced like with like and existing field access to be relocated back into the field. The aim is to improve the condition and character of this section of the road. Replacement hedge will reflect existing mix of sycamore, hawthorn and hazel. Further enhancement can include hedging around the construction compound.
1.21 - OVER-RUN AREA CH 4390 - 4450	70m of hedgerow will need to be removed. This will be replaced by 78m of new mixed hedge to follow the curve of the road and tie into the existing hedgerows. . Replacement hedge will reflect the existing species mix of sycamore, hawthorn and blackthorn.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.22 - GOSEN BRIDGE: ROAD WIDENING, ROAD RETENTION AND NEW SECTION OF BRIDGE CH 4440 - 4540	All of the options for this section will necessitate the removal of a numbers of trees on the embankment. These are currently a number of rather spindly trees and a mix of hazel, birch and ash. There is little ground flora under the trees. Recent winds have caused several trees to fall opening up the bank and de-stabilising the soil at some points. All of the trees on this bank will need to be cleared to enable the proposed works. In addition a small section of hedge, comprising blackthorn, hawthorn, ash and hazel, will be removed to allow access to the works. None of the mature trees adjacent to the existing property will be felled. An otter survey was carried out within the river and no signs of otter were found. This will be repeated immediately prior to construction. No felling or hedge clearance will be carried out during the bird breeding season (March – August). Following the works a selection of trees will be replanted at the top of the new retaining wall. These will be of a similar species mix to those lost. The trees will be planted fairly close together, and managed by coppicing to keep a dense cover and to prevent them getting too spindly causing future windblow problems. The hedge will be replanted at the top of the new retaining wall and will use the same species previously in the hedge, sourced from local provenance.
1.23 - ROAD WIDENING FOR OVER-RUN CH 4540 - 4560	No ecological issues for this section.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.24 - ROAD WIDENING FOR OVER-RUN CH 4550 - 4640	Construction will result in loss of some scrub vegetation and 3 small trees (birch and hawthorn). A new mixed hedge with hedgerow oak and birch trees will be provided to replace vegetation lost. Additional shrubs such as hawthorn and blackthorn and trees including birch and cherry will be planted running east/west to the south-west of chapel on raised ground to screen views of crawler lane from the road.
GOSEN TO SYCHTYN OFF-ROAD TRACK CH 4620 TO 4970	A new hedgerow will be planted along the edge of the existing road to enhance the character of the road and minimise visibility of the proposed off-road track. The hedge will reflect the general species mix of hedges in the area and comprise hawthorn, blackthorn, ash and hazel.
1.25 - ROAD WIDENING CH 4970 - 5040	No ecological issues for this section.
1.26 - ROAD WIDENING CH 5050 - 5110	No ecological issues for this section.
1.27 - OVER-RUN AREA AND WALL REMOVAL CH 5130 - 5180	No ecological issues for this section.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.28 - OVER-RUN AREA CH 5175 - 5315	73M of hedgerow will be affected. the hedgerow, comprising hazel with a few hawthorn and blackthorn bushes, is on a low bank and will be translocated at the rear of the verge line before the earthworks profile.
1.29 - OVER-RUN AREA CH 5330 - 5430	30M of hedge, 0.5m above road level, will be impacted. this is currently a hedge of old previously layered hazel and hawthorn. it is considered to woody to translocated and therefore a new mixed species rich hedge, mainly of hazel and hawthorn, will be planted at the rear of the verge at the foot of new cut earthworks.
1.30 - OVER-RUN AREA AND IMPROVED PASSING PLACE CH 5430 - 5700	Over-run to be constructed from reinforced grass laid along verge with new mixed hedges planted to rear of verge to enhance the character of the road in the long term. Existing hawthorn bushes, which are covered with several species of lichen, to be retained.
1.31 - OVER-RUN AREA CH 5770 - 5880	No ecological issues for this section.
1.32 - OVER-RUN AREA CH 6060 - 6115	No ecological issues for this section.
1.33 - OVER-RUN AREA CH 6090 - 6325	There will be unavoidable loss if five trees(one sycamore and 4 beech) and these will be replaced by 5 root balled extra heavy standard beech trees. A new mixed species hedge will be planted along the new over-run to enhance the character of the this section of road in the long-term.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.34 - OVER-RUN AREA CH 6350 - 6480	No ecological issues for this section.
1.35 - OVER-RUN AREA CH 6450 - 6575	There are some impacts on the existing hedgerow due to proposed fill earthworks and in all cases, new hedgerow will be planted to match the existing length of hedgerow at the back of the proposed works.
1.36 - OVER-RUN AND PASSING PLACES CH 6530 - 6770	A new hedge bank will be planted at the rear of the works, with a new hedgerow located on top of the embankment. this will allow hedgerow to span between the two passing places, tying into the two small areas of existing hedgerow.
1.37 - OVER-RUN AREA CH 6730 - 6950	There are some impacts on the existing hedgerow due to proposed fill earthworks and in all cases new hedgerow will be planted to match the existing length of hedgerow of hazel and hawthorn at the back of the proposed works. this is currently a thin hedge and the new hedgerow will be an improvement and will be planted prior to the earthwork profile into the field to the south. existing field access at chainage 6625 used for access into field to the south for construction works.
1.38 - OVER-RUN AND PASSING PLACE CH 6950 - 7130	Hedgerow impact to the north. this will be cut back or replanted within the existing field as shown. Maximum expected impacted length to be 15m of hedgerow comprising blackthorn, hazel and hawthorn. Any vegetation loss is to be replaced and current hedgbank soil to be used in construction of new hedge.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.39 - OVER-RUN AREA CH 7100 - 7170	Embankment can be planted with a variety of shrubs such as hawthorn, birch and hazel to enhance the section.
1.40 - OVER-RUN AREA CH 7170 - 7290	No ecological issues for this section.
DOLWEN ISAF - OPTION 1 and 2: BRIDGE WIDENING WITH OVER-RUN CH 7270 - 7530	The works at the bridge will involve the loss of a mature Ash tree and a small amount of scrub. The bank works into the conifer plantation will involve the loss of some hazel bushes, although these have recently been trimmed back extensively by highway works. The bushes currently screen the conifers and should be replanted at the top of the new embankment. There was a small amount of badger activity noted in the conifer plantation, but there is no sett in the wood. A re-survey for badgers will take place immediately before any works commencing. Planting on new embankments to the bridge will be of ash, hazel, birch and hawthorn to replicate the species currently present. An otter survey was carried out under the bridge and immediately up and down stream and no signs were found. This will be repeated immediately prior to construction.
1.41 - OVER-RUN AREA CH 7500 - 7670	Approximately 15m of hedgerow and 105m of fencing removed which is to be replaced with 140m of new hedgerow around the over-run area.
1.42 - OVER-RUN AREA CH 7660 - 7720	No ecological issues for this section.

LOCATION TITLE AND CHAINAGE	Ecological Impacts and mitigation.
1.43 - OVER-RUN AREA CH 7700 - 7780	The current hedge is of hazel and hawthorn on a small bank and can be translocated.
1.44 - OVER-RUN AREA CH 7950 - 8040	No ecological issues for this section.
1.45 - OVER-RUN AREA CH 8150 - 8240	No ecological issues for this section.
SITE ACCESS 1 CH 8250	No ecological issues for this section.

1.2 Section 2

LOCATION TITLE AND CHAINAGE	Location Description
2.1 - OVER-RUN AREA CH 8280 - 8320	No ecological issues for this section.
2.2 - OVER-RUN AND PASSING PLACE CH 8330 - 8580	3 existing trees are impacted and will need to be removed and replanted/replaced outside of the works These are 2 small ash trees and a small hawthorn. An additional hawthorn in the centre of this section will also be lost, along with a small patch of gorse. These will be replaced in similar positions outside the new works. A larger area of gorse will be planted adjacent to the current bushes on the inside of the bend.
2.3A - OVER-RUN AREA CH 8500 - 8850	No ecological issues for this section.
2.3B - NEINTHIRION BYPASS ACCESS AND OVER-RUN AREA CH 8850 - 8950	No ecological issues for this section.
NEINTHIRION BYPASS - DRAWING 60283248-D-045. 900m OF NEW ROAD	The by-pass involves the loss of a small area of scrub where it leaves the existing road and crosses the stream. This will be replanted on the embankment of the new by-pass using a mix of ash and hawthorn. An otter survey was undertaken and no signs were found. This will be repeated immediately prior to construction. The by-pass then crosses a series of improved fields. Where the track is raised on an embankment scrub should be allowed to develop along the banks to provide habitat and screen the track. However, the scrub should be kept trimmed to ensure the open nature of the area is maintained and to ensure it does not provide nesting habitat for crows. Towards the Western end the route crosses an area of marshy grassland over peat. This section is approx 150 metre and peat depths vary between 20 cm in the south, 85cm in the centre and 65 cm at the North. This has been extensively drained but still retains marshy habitat, mainly *Molinia*. The area between the marshy grassland and where the by-pass rejoins the road is damp but is on mineral soil. This section is subject to further route change that will reduce this impact.
2.4 - NEINTHIRION BYPASS EGRESS AND OVER-RUN CH 9550 - 9680	No ecological issues for this section.
2.5 - OVER-RUN AND PASSING PLACE CH 9680 - 9840	Planting of gorse bushes along road boundaries will enhance this section.

LOCATION TITLE AND CHAINAGE	Location Description
2.6 - OVER-RUN AND PASSING PLACE, ADJACENT TO CATTLE GRID CH 9770 - 9980	No ecological issues for this section.
SITE ACCESS 2 CH 10140	No ecological issues for this section.
2.7A - OVER-RUN AND PASSING PLACE TO SOUTH OF ACCESS 2 **CH 9980 - 10100**	No ecological issues for this section.
2.7B - OVER-RUN AND PASSING PLACE TO EAST FROM ACCESS 2 TO RIVER **CH 10100 - 10440**	No ecological issues for this section.
2.8 - OVER-RUN AND PASSING PLACE **CH 10410 - 10500**	No ecological issues for this section.
2.9 - OVER-RUN AND PASSING PLACE ADJACENT TO RIVER BED **CH 10480 - 10530**	No ecological issues for this section.
2.10 - OVER-RUN AREA TO NORTH CH 10530 - 10610	No ecological issues for this section.
2.11 - OVER-RUN AREA TO NORTH WEST OF CATTLE GRID CH 10620 - 10730	No ecological issues for this section.
2.12 - CULVERT WIDENING AND PASSING PLACE CH 10750 - 10800	No ecological issues for this section.
2.13 - OVER-RUN AND PASSING PLACE CH 10675 - 10950	No ecological issues for this section.
2.14 - OVER-RUN AREA CH 10920 - 11120	No ecological issues for this section.

LOCATION TITLE AND CHAINAGE	Location Description
2.15 - OVER-RUN AND PASSING PLACE **CH 11100 - 11390**	No ecological issues for this section.
2.16A - OVER-RUN AND PASSING PLACE **CH 11390 - 11430**	No ecological issues for this section.
2.16B - OVER-RUN AND PASSING PLACE CH 11430 - 11640	No ecological issues for this section.
2.16C - OVER-RUN AND PASSING PLACE CH 11640 - 11700	No ecological issues for this section.
2.16D - OVER-RUN AND EXISTING PASSING PLACE IMPROVED **CH 11700 - 12000**	No ecological issues for this section.
2.17 - OVER-RUN AND PASSING PLACE **CH 12000 - 12390**	No ecological issues for this section.
SITE ACCESS 4 CH 12390	No ecological issues for this section.

1.3 Section 3

LOCATION TITLE AND CHAINAGE	LOCATION DESCRIPTION
3.1A - EXISTING PASSING PLACE CH 12700	No ecological issues for this section.
3.1B - EXISTING PASSING PLACE, IMPROVED CH 12950	No ecological issues for this section.
3.1C - EXISTING PASSING PLACE, IMPROVED CH 13160	No ecological issues for this section.
3.1D - EXISTING PASSING PLACE CH 13330	No ecological issues for this section.
3.2A - EXISTING PASSING PLACE, IMPROVED CH 13460	No ecological issues for this section.
3.2B - EXISTING PASSING PLACE CH 13550	No ecological issues for this section.
3.3 - EXISTING PASSING PLACE, IMPROVED CH 13700	No ecological issues for this section.
3.4 - NEW PASSING PLACE AT ACCESS CH 13840	No ecological issues for this section.
3.4A - NEW PASSING PLACE CH 13950	Earthworks profile to blend into existing levels and verge to be seeded with local seed mix.
3.5 - EXISTING PASSING PLACE, IMPROVED CH 14075	No ecological issues for this section.
3.6 - EXISTING PASSING PLACE CH 14250	No ecological issues for this section.

LOCATION TITLE AND CHAINAGE	LOCATION DESCRIPTION
3.7 - EXISTING PASSING PLACE AT CATTLE GRID CH 14300	No ecological issues for this section.
3.8A - EXISTING PASSING PLACE, IMPROVED CH 14520	No ecological issues for this section.
3.8B - NEW PASSING PLACE CH 14620	No ecological issues for this section.
3.9 - EXISTING PASSING PLACE AT ACCESS, IMPROVED CH 14695	No ecological issues for this section.
3.10 - EXISTING PASSING PLACE AT ACCESS CH 14850	No ecological issues for this section.
3.11 - EXISTING PASSING PLACE CH 15000	No ecological issues for this section.
3.12 - EXISTING PASSING PLACE CH 15150	No ecological issues for this section.
3.13 - EXISTING PASSING PLACE AT ACCESSES CH 15350	No ecological issues for this section.
3.14 - NEW PASSING PLACE CH 15570	No ecological issues for this section.
3.15 - EXISTING PASSING PLACE, IMPROVED CH 15780	Works will impact on an area of willow scrub which will replaced with newly planted willow
3.16 - EXISTING PASSING PLACE, IMPROVED CH 15950	A new mixed hedgerow will be planted along back of the works – this will be an improvement over the exisiting very thin hazel hedge which is very sparse and was not suitable for dormouse.

LOCATION TITLE AND CHAINAGE	LOCATION DESCRIPTION
3.17A - NEW PASSING PLACE CH 16275	No ecological issues for this section.
3.17B -EXISTING PASSING PLACE, IMPROVED CH 16370	No ecological issues for this section.
3.18 - EXISTING PASSING PLACE AT PANTGLAS FARM CH 16480	No ecological issues for this section.
3.19 - NEW PASSING PLACE CH 16550	No ecological issues for this section.
3.20 - EXISTING PASSING PLACE, IMPROVED CH 16715	No ecological issues for this section.
3.21 - EXISTING PASSING PLACE, IMPROVED CH 16855	.If these trees and the fenceline are impacted, new trees oak trees will be re-planted along the relocated fenceline.
3.22A - EXISTING PASSING PLACE, IMPROVED AT EXISTING CATTLE GRID. CH 17080	No ecological issues for this section.
3.22B - EXISTING PASSING PLACE, IMPROVED CH 17200	No ecological issues for this section.
3.22C - NEW PASSING PLACE CH 17290	No ecological issues for this section.
3.23 - NEW PASSING PLACE CH 17450	No ecological issues for this section.
Tallerddig Junction works	Cut slopes to be profiled out to look at natural as possible and scrub allowed to generate on banks to blend into surroundings. A Mixed hedgerow – hazel, hawthorn, ash to match other hedges nearby - to be planted along the top of the bank (alongside road) to tie in with existing hedgerows.

APPENDIX 6.1: COLLISION RISK MODELLING

Please note: raw data on which these calculations are based is available on request from RES UK & Ireland Ltd.

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA [SNH BAND MODEL]

Red kite												
K: [1D or [3D	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:			Downwind:		
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution	check area
Pitch (degree	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	total
BirdLength	0.63	m	0.025	0.575	7.63	29.59	1.00	0.00125	29.17	1.00	0.00125	0.00125
Wingspan	1.85	m	0.075	0.575	2.54	10.00	0.54	0.00404	9.58	0.52	0.00387	0.0075
F: Flapping (	0		0.125	0.702	1.53	6.80	0.37	0.00458	6.29	0.34	0.00423	0.0125
			0.175	0.860	1.09	5.59	0.30	0.00527	4.96	0.27	0.00468	0.0175
Bird speed	13	m/sec	0.225	0.994	0.85	4.87	0.26	0.00589	4.14	0.22	0.00501	0.0225
RotorDiam	93	m	0.275	0.947	0.69	3.91	0.21	0.00580	3.22	0.17	0.00477	0.0275
RotationPeric	4.29	sec	0.325	0.899	0.59	3.25	0.18	0.00569	2.59	0.14	0.00454	0.0325
			0.375	0.851	0.51	2.76	0.15	0.00557	2.14	0.12	0.00431	0.0375
			0.425	0.804	0.45	2.38	0.13	0.00544	1.79	0.10	0.00410	0.0425
			0.475	0.756	0.40	2.08	0.11	0.00531	1.52	0.08	0.00389	0.0475
Bird aspect r	0.34		0.525	0.708	0.36	1.83	0.10	0.00516	1.31	0.07	0.00370	0.0525
			0.575	0.660	0.33	1.63	0.09	0.00506	1.15	0.06	0.00356	0.0575
			0.625	0.613	0.31	1.50	0.08	0.00506	1.06	0.06	0.00356	0.0625
			0.675	0.565	0.28	1.39	0.07	0.00506	0.98	0.05	0.00356	0.0675
			0.725	0.517	0.26	1.29	0.07	0.00505	0.91	0.05	0.00357	0.0725
			0.775	0.470	0.25	1.20	0.06	0.00502	0.86	0.05	0.00359	0.0775
			0.825	0.422	0.23	1.12	0.06	0.00499	0.82	0.04	0.00362	0.0825
			0.875	0.374	0.22	1.05	0.06	0.00495	0.78	0.04	0.00366	0.0875
			0.925	0.327	0.21	0.98	0.05	0.00490	0.74	0.04	0.00371	0.0925
			0.975	0.279	0.20	0.92	0.05	0.00484	0.72	0.04	0.00377	0.0975
				Overall p(collision) =			**Upwind**	**9.9%**		**Downwind**	**7.7%**	1.00
								Average	**8.8%**			

Goshawk											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.55	m	0.025	0.575	7.63	26.92	1.00	0.00125	26.50	1.00	0.00125
Wingspan	1.5	m	0.075	0.575	2.54	9.11	0.49	0.00368	8.69	0.47	0.00351
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.53	6.27	0.34	0.00422	5.76	0.31	0.00387
			0.175	0.860	1.09	5.21	0.28	0.00491	4.58	0.25	0.00432
Bird speed	13	m/sec	0.225	0.994	0.85	4.57	0.25	0.00553	3.84	0.21	0.00465
RotorDiam	93	m	0.275	0.947	0.69	3.67	0.20	0.00544	2.98	0.16	0.00441
RotationPeriod	4.29	sec	0.325	0.899	0.59	3.04	0.16	0.00533	2.39	0.13	0.00418
			0.375	0.851	0.51	2.58	0.14	0.00521	1.96	0.11	0.00395
			0.425	0.804	0.45	2.22	0.12	0.00508	1.63	0.09	0.00374
			0.475	0.756	0.40	1.93	0.10	0.00495	1.38	0.07	0.00353
Bird aspect ratioo: β	0.37		0.525	0.708	0.36	1.70	0.09	0.00482	1.19	0.06	0.00335
			0.575	0.660	0.33	1.55	0.08	0.00481	1.07	0.06	0.00332
			0.625	0.613	0.31	1.42	0.08	0.00480	0.98	0.05	0.00329
			0.675	0.565	0.28	1.31	0.07	0.00477	0.90	0.05	0.00327
			0.725	0.517	0.26	1.21	0.07	0.00474	0.83	0.04	0.00326
			0.775	0.470	0.25	1.12	0.06	0.00469	0.78	0.04	0.00326
			0.825	0.422	0.23	1.04	0.06	0.00464	0.74	0.04	0.00327
			0.875	0.374	0.22	0.97	0.05	0.00457	0.70	0.04	0.00328
			0.925	0.327	0.21	0.90	0.05	0.00450	0.66	0.04	0.00331
			0.975	0.279	0.20	0.84	0.05	0.00442	0.64	0.03	0.00335
				Overall p(collision) =			**Upwind**	**9.2%**		**Downwind**	**7.0%**
								Average	**8.1%**		

Hen harrier											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.52	m	0.025	0.575	7.63	24.63	1.00	0.00125	24.21	1.00	0.00125
Wingspan	1.2	m	0.075	0.575	2.54	8.35	0.45	0.00337	7.93	0.43	0.00320
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.53	5.81	0.31	0.00391	5.30	0.29	0.00357
			0.175	0.860	1.09	4.88	0.26	0.00460	4.26	0.23	0.00401
Bird speed	13	m/sec	0.225	0.994	0.85	4.31	0.23	0.00523	3.59	0.19	0.00435
RotorDiam	93	m	0.275	0.947	0.69	3.46	0.19	0.00513	2.77	0.15	0.00410
RotationPeriod	4.29	sec	0.325	0.899	0.59	2.87	0.15	0.00502	2.21	0.12	0.00387
			0.375	0.851	0.51	2.43	0.13	0.00490	1.81	0.10	0.00365
			0.425	0.804	0.45	2.09	0.11	0.00478	1.50	0.08	0.00343
			0.475	0.756	0.40	1.85	0.10	0.00474	1.30	0.07	0.00332
Bird aspect ratioo: β	0.43		0.525	0.708	0.36	1.67	0.09	0.00473	1.16	0.06	0.00327
			0.575	0.660	0.33	1.52	0.08	0.00472	1.04	0.06	0.00322
			0.625	0.613	0.31	1.39	0.08	0.00469	0.95	0.05	0.00319
			0.675	0.565	0.28	1.28	0.07	0.00466	0.87	0.05	0.00316
			0.725	0.517	0.26	1.18	0.06	0.00462	0.80	0.04	0.00314
			0.775	0.470	0.25	1.09	0.06	0.00457	0.75	0.04	0.00313
			0.825	0.422	0.23	1.01	0.05	0.00450	0.71	0.04	0.00313
			0.875	0.374	0.22	0.94	0.05	0.00443	0.67	0.04	0.00314
			0.925	0.327	0.21	0.87	0.05	0.00435	0.63	0.03	0.00316
			0.975	0.279	0.20	0.81	0.04	0.00426	0.61	0.03	0.00319
				Overall p(collision) =			**Upwind**	**8.8%**		**Downwind**	**6.6%**
								Average	**7.7%**		

Merlin											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.28	m	0.025	0.575	7.63	19.75	1.00	0.00125	19.33	1.00	0.00125
Wingspan	0.56	m	0.075	0.575	2.54	6.72	0.36	0.00272	6.30	0.34	0.00255
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.53	4.84	0.26	0.00326	4.32	0.23	0.00291
			0.175	0.860	1.09	4.19	0.23	0.00395	3.56	0.19	0.00335
Bird speed	13	m/sec	0.225	0.994	0.85	3.77	0.20	0.00457	3.04	0.16	0.00369
RotorDiam	93	m	0.275	0.947	0.69	3.02	0.16	0.00447	2.33	0.13	0.00345
RotationPeriod	4.29	sec	0.325	0.899	0.59	2.49	0.13	0.00436	1.84	0.10	0.00321
			0.375	0.851	0.51	2.10	0.11	0.00425	1.48	0.08	0.00299
			0.425	0.804	0.45	1.83	0.10	0.00419	1.24	0.07	0.00284
			0.475	0.756	0.40	1.61	0.09	0.00412	1.06	0.06	0.00271
Bird aspect ratioo: β	0.50		0.525	0.708	0.36	1.43	0.08	0.00405	0.92	0.05	0.00259
			0.575	0.660	0.33	1.28	0.07	0.00398	0.80	0.04	0.00248
			0.625	0.613	0.31	1.15	0.06	0.00389	0.71	0.04	0.00238
			0.675	0.565	0.28	1.04	0.06	0.00379	0.63	0.03	0.00229
			0.725	0.517	0.26	0.94	0.05	0.00368	0.56	0.03	0.00220
			0.775	0.470	0.25	0.85	0.05	0.00356	0.51	0.03	0.00213
			0.825	0.422	0.23	0.77	0.04	0.00344	0.47	0.03	0.00207
			0.875	0.374	0.22	0.70	0.04	0.00330	0.43	0.02	0.00201
			0.925	0.327	0.21	0.63	0.03	0.00316	0.39	0.02	0.00197
			0.975	0.279	0.20	0.57	0.03	0.00300	0.37	0.02	0.00193
				Overall p(collision) =			**Upwind**	**7.3%**		**Downwind**	**5.1%**
								Average	**6.2%**		

Peregrine											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.42	m	0.025	0.575	7.63	23.26	1.00	0.00125	22.84	1.00	0.00125
Wingspan	1.02	m	0.075	0.575	2.54	7.89	0.42	0.00319	7.47	0.40	0.00302
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.53	5.54	0.30	0.00373	5.02	0.27	0.00338
			0.175	0.860	1.09	4.69	0.25	0.00442	4.06	0.22	0.00382
Bird speed	13	m/sec	0.225	0.994	0.85	4.16	0.22	0.00504	3.43	0.18	0.00416
RotorDiam	93	m	0.275	0.947	0.69	3.34	0.18	0.00494	2.65	0.14	0.00392
RotationPeriod	4.29	sec	0.325	0.899	0.59	2.76	0.15	0.00484	2.11	0.11	0.00368
			0.375	0.851	0.51	2.34	0.13	0.00472	1.71	0.09	0.00346
			0.425	0.804	0.45	2.01	0.11	0.00459	1.42	0.08	0.00325
			0.475	0.756	0.40	1.75	0.09	0.00448	1.20	0.06	0.00307
Bird aspect ratioo: β	0.41		0.525	0.708	0.36	1.57	0.08	0.00445	1.06	0.06	0.00299
			0.575	0.660	0.33	1.42	0.08	0.00441	0.94	0.05	0.00291
			0.625	0.613	0.31	1.29	0.07	0.00436	0.85	0.05	0.00285
			0.675	0.565	0.28	1.18	0.06	0.00430	0.77	0.04	0.00279
			0.725	0.517	0.26	1.08	0.06	0.00423	0.70	0.04	0.00275
			0.775	0.470	0.25	0.99	0.05	0.00415	0.65	0.04	0.00271
			0.825	0.422	0.23	0.91	0.05	0.00406	0.61	0.03	0.00269
			0.875	0.374	0.22	0.84	0.05	0.00396	0.57	0.03	0.00267
			0.925	0.327	0.21	0.77	0.04	0.00385	0.53	0.03	0.00266
			0.975	0.279	0.20	0.71	0.04	0.00374	0.51	0.03	0.00267
				Overall p(collision) =			**Upwind**	**8.3%**		**Downwind**	**6.1%**
								Average	**7.2%**		

Black grouse											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.48	m	0.025	0.575	8.80	24.25	1.00	0.00125	23.83	1.00	0.00125
Wingspan	0.73	m	0.075	0.575	2.93	8.22	0.38	0.00288	7.80	0.36	0.00273
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.76	5.84	0.27	0.00341	5.33	0.25	0.00311
			0.175	0.860	1.26	5.00	0.23	0.00408	4.37	0.20	0.00357
Bird speed	15	m/sec	0.225	0.994	0.98	4.46	0.21	0.00469	3.73	0.17	0.00392
RotorDiam	93	m	0.275	0.947	0.80	3.57	0.17	0.00458	2.87	0.13	0.00369
RotationPeriod	4.29	sec	0.325	0.899	0.68	2.94	0.14	0.00446	2.28	0.11	0.00346
			0.375	0.851	0.59	2.53	0.12	0.00443	1.91	0.09	0.00334
			0.425	0.804	0.52	2.22	0.10	0.00441	1.63	0.08	0.00324
			0.475	0.756	0.46	1.98	0.09	0.00438	1.42	0.07	0.00315
Bird aspect ratioo: β	0.66		0.525	0.708	0.42	1.77	0.08	0.00434	1.25	0.06	0.00307
			0.575	0.660	0.38	1.60	0.07	0.00430	1.12	0.05	0.00300
			0.625	0.613	0.35	1.46	0.07	0.00424	1.01	0.05	0.00294
			0.675	0.565	0.33	1.33	0.06	0.00418	0.91	0.04	0.00288
			0.725	0.517	0.30	1.22	0.06	0.00411	0.84	0.04	0.00283
			0.775	0.470	0.28	1.12	0.05	0.00404	0.77	0.04	0.00279
			0.825	0.422	0.27	1.03	0.05	0.00395	0.72	0.03	0.00276
			0.875	0.374	0.25	0.94	0.04	0.00386	0.67	0.03	0.00274
			0.925	0.327	0.24	0.87	0.04	0.00375	0.63	0.03	0.00272
			0.975	0.279	0.23	0.80	0.04	0.00364	0.60	0.03	0.00272
				Overall p(collision) =			**Upwind**	**7.9%**		**Downwind**	**6.0%**
								Average	**6.9%**		

Golden plover											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.28	m	0.025	0.575	7.63	20.97	1.00	0.00125	20.55	1.00	0.00125
Wingspan	0.72	m	0.075	0.575	2.54	7.13	0.38	0.00288	6.71	0.36	0.00271
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.53	5.08	0.27	0.00342	4.57	0.25	0.00307
			0.175	0.860	1.09	4.36	0.23	0.00411	3.73	0.20	0.00352
Bird speed	13	m/sec	0.225	0.994	0.85	3.91	0.21	0.00473	3.18	0.17	0.00385
RotorDiam	93	m	0.275	0.947	0.69	3.13	0.17	0.00464	2.44	0.13	0.00361
RotationPeriod	4.29	sec	0.325	0.899	0.59	2.59	0.14	0.00453	1.93	0.10	0.00338
			0.375	0.851	0.51	2.18	0.12	0.00441	1.56	0.08	0.00315
			0.425	0.804	0.45	1.87	0.10	0.00428	1.28	0.07	0.00294
			0.475	0.756	0.40	1.62	0.09	0.00415	1.07	0.06	0.00273
Bird aspect ratioo: β	0.39		0.525	0.708	0.36	1.43	0.08	0.00405	0.92	0.05	0.00259
			0.575	0.660	0.33	1.28	0.07	0.00398	0.80	0.04	0.00248
			0.625	0.613	0.31	1.15	0.06	0.00389	0.71	0.04	0.00238
			0.675	0.565	0.28	1.04	0.06	0.00379	0.63	0.03	0.00229
			0.725	0.517	0.26	0.94	0.05	0.00368	0.56	0.03	0.00220
			0.775	0.470	0.25	0.85	0.05	0.00356	0.51	0.03	0.00213
			0.825	0.422	0.23	0.77	0.04	0.00344	0.47	0.03	0.00207
			0.875	0.374	0.22	0.70	0.04	0.00330	0.43	0.02	0.00201
			0.925	0.327	0.21	0.63	0.03	0.00316	0.39	0.02	0.00197
			0.975	0.279	0.20	0.57	0.03	0.00300	0.37	0.02	0.00193
				Overall p(collision) =			**Upwind**	**7.4%**		**Downwind**	**5.2%**
								Average	**6.3%**		

Curlew											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.55	m	0.025	0.575	8.80	25.75	1.00	0.00125	25.33	1.00	0.00125
Wingspan	0.9	m	0.075	0.575	2.93	8.72	0.41	0.00305	8.30	0.39	0.00291
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.76	6.14	0.29	0.00358	5.63	0.26	0.00328
			0.175	0.860	1.26	5.21	0.24	0.00426	4.58	0.21	0.00374
Bird speed	15	m/sec	0.225	0.994	0.98	4.63	0.22	0.00486	3.90	0.18	0.00410
RotorDiam	93	m	0.275	0.947	0.80	3.70	0.17	0.00475	3.01	0.14	0.00386
RotationPeriod	4.29	sec	0.325	0.899	0.68	3.06	0.14	0.00464	2.40	0.11	0.00364
			0.375	0.851	0.59	2.60	0.12	0.00455	1.98	0.09	0.00346
			0.425	0.804	0.52	2.29	0.11	0.00455	1.70	0.08	0.00338
			0.475	0.756	0.46	2.05	0.10	0.00453	1.49	0.07	0.00331
Bird aspect ratioo: β	0.61		0.525	0.708	0.42	1.84	0.09	0.00451	1.32	0.06	0.00324
			0.575	0.660	0.38	1.67	0.08	0.00448	1.19	0.06	0.00319
			0.625	0.613	0.35	1.53	0.07	0.00445	1.08	0.05	0.00314
			0.675	0.565	0.33	1.40	0.07	0.00440	0.98	0.05	0.00310
			0.725	0.517	0.30	1.29	0.06	0.00435	0.91	0.04	0.00307
			0.775	0.470	0.28	1.19	0.06	0.00429	0.84	0.04	0.00305
			0.825	0.422	0.27	1.10	0.05	0.00422	0.79	0.04	0.00303
			0.875	0.374	0.25	1.01	0.05	0.00414	0.74	0.03	0.00302
			0.925	0.327	0.24	0.94	0.04	0.00406	0.70	0.03	0.00303
			0.975	0.279	0.23	0.87	0.04	0.00396	0.67	0.03	0.00303
				Overall p(collision) =		**Upwind**		**8.3%**		**Downwind**	**6.4%**
								Average	**7.3%**		

COLLISION RISK PREDICTIONS FOR THE LLANBRYNMAIR WIND FARM (30-turbine layout):

	RED KITE				GOLDEN PLOVER		PEREGRINE				MERLIN				HEN HARRIER			
	Breeding		*Non-breeding*		*Non-breeding*		*Breeding*		*Non-breeding*		*Breeding*		*Non-breeding*		*Breeding*		*Non-breeding*	
Collision Zone area	819	*ha*	819	*ha*	819	*ha*	819	*ha*	819	*ha*	819	*ha*	819	*ha*	819	*ha*	819	ha
Upper rotor ht	126.5		126.5		126.5		126.5		126.5		126.5		126.5		126.5		126.5	
Lower rotor ht	33.5		33.5		33.5		33.5		33.5		33.5		33.5		33.5		33.5	
Proportion of observation time seen flying	1.22%		0.82%		26.1%		0.02%		0.08%		0.01%		0.02%		0.86%		1.09%	
Proportion at rotor ht	90%		41%		65%		73%		89%		0%		0%		35%		3%	
Proportion of observation time seen flying at rotor height	1.0980%		0.3362%		16.9650%		0.0146%		0.0712%		0.0000%		0.0000%		0.3010%		0.0349%	
Flight activity at rotor height per ha.	1.341E-05		4.105E-06		2.071E-04		1.783E-07		8.694E-07		0.000E+00		0.000E+00		3.675E-06		4.259E-07	
Season length	153	*days*	212	*days*	212	*days*	153	*days*	212	*days*	153	*days*	212	*days*	153	*days*	212	*days*
Activity per day	14	*hours*	10	*hours*	10	*hours*	14	*hours*	10	*hours*	14	*hours*	10	*hours*	14	*hours*	10	*hours*
Total flight activity in collision zone at rotor ht	23.519	*hours*	7.127	*hours*	359.658	*hours*	0.313	*hours*	1.509	*hours*	0.000	*hours*	0.000	*hours*	6.447	*hours*	0.739	*hours*
Flight risk volume	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*
No Turbines	30		30		30		30		30		30		30		30		30	
Rotor radius	46.5	*m*	46.5	*m*	46.5	*m*	46.5	*m*	46.5	*m*	46.5	*m*	46.5	*m*	46.5	*m*	46.5	*m*
Rotor depth	3.5	*m*	3.5	*m*	3.5	*m*	3.5	*m*	3.5	*m*	3.5	*m*	3.5	*m*	3.5	*m*	3.5	*m*
Bird length	0.63	*m*	0.63	*m*	0.28	*m*	0.42	*m*	0.42	*m*	0.28	*m*	0.28	*m*	0.52	*m*	0.52	*m*
Swept volume	841641	*m3*	841641	*m3*	770316	*m3*	798846	*m3*	798846	*m3*	770316	*m3*	770316	*m3*	819225	*m3*	819225	*m3*
Bird occupancy of swept volume	93.56	*secs*	28.35	*secs*	1309.47	*secs*	1.18	*secs*	5.70	*secs*	0.00	*secs*	0.00	*secs*	24.96	*secs*	2.86	*secs*
Bird speed	13	*m/s*	13	*m/s*	13	*m/s*	13	*m/s*	13	*m/s*	13	*m/s*	13	*m/s*	13	*m/s*	13	*m/s*
Rotor transit time	0.318	*secs*	0.318	*secs*	0.291	*secs*	0.302	*secs*	0.302	*secs*	0.291	*secs*	0.291	*secs*	0.309	*secs*	0.309	*secs*
No of rotor transits	294		89		4503		4		19		0		0		81		9	
Total rotor transits	**384**				**4503**		**22.8**				**0.0**				**90**			
Band collision rate	0.088		0.088		0.063		0.072		0.072		0.062		0.062		0.077		0.077	
Non-avoid collisions	25.9	*/yr*	7.9	*/yr*	283.7	*/yr*	0.3	*/yr*	1.4	*/yr*	0.0	*/yr*	0.0	*/yr*	6.2	*/yr*	0.7	*/yr*
Avoidance rate	99%		99%		99%		99%		99%		98%		98%		99%		99%	
Collision prediction	0.26	*/yr*	0.08	*/yr*	2.837	*/yr*	0.003	*/yr*	0.014	*/yr*	0.0000	*/yr*	0.0000	*/yr*	0.062	*/yr*	0.007	*/yr*
Total predicted collisions/yr	**0.34**				**2.84**		**0.02**				**0**				**0.069**			

	BLACK GROUSE		GOSHAWK				CURLEW	
	Non-breeding		*Breeding*		*Non-breeding*		*Breeding*	
Collision Zone area	819	*ha*	819	*ha*	819	ha	819	*ha*
Upper rotor ht	126.5		126.5		126.5		126.5	
Lower rotor ht	33.5		33.5		33.5		33.5	
Proportion of observation time seen flying	0.004%		0.67%		0.19%		0.22%	
Proportion at rotor ht	100%		91%		90%		46%	
Proportion of observation time seen flying at rotor height	0.0040%		0.6097%		0.1710%		0.1012%	
Flight activity at rotor height per ha.	4.884E-08		7.444E-06		2.088E-06		1.236E-06	
Season length	212	*days*	153	*days*	212	*days*	153	*days*
Activity per day	10	*hours*	14	*hours*	10	*hours*	14	*hours*
Total flight activity in collision zone at rotor ht	0.085	*hours*	13.060	*hours*	3.625	*hours*	2.168	*hours*
Flight risk volume	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*	7.617E+08	*m3*
No Turbines	30		30		30		30	
Rotor radius	46.5	*m*	46.5	*m*	46.5	*m*	46.5	*m*
Rotor depth	3.5	*m*	3.5	*m*	3.5	*m*	3.5	*m*
Bird length	0.48	*m*	0.55	*m*	0.55	*m*	0.55	*m*
Swept volume	811073	*m3*	825338	*m3*	825338	*m3*	825338	*m3*
Bird occupancy of swept volume	0.33	*secs*	50.95	*secs*	14.14	*secs*	8.46	*secs*
Bird speed	15	*m/s*	13	*m/s*	13	*m/s*	15	*m/s*
Rotor transit time	0.265	*secs*	0.312	*secs*	0.312	*secs*	0.270	*secs*
No of rotor transits	1		164		45		31	
Total rotor transits	**1**		**209**				**31**	
Band collision rate	0.069		0.081		0.081		0.073	
Non-avoid collisions	0.1	*/yr*	13.2	*/yr*	3.7	*/yr*	2.3	*/yr*
Avoidance rate	95%		99%		99%		99%	
Collision prediction	0.0042	*/yr*	0.132	*/yr*	0.037	*/yr*	0.023	*/yr*
Total predicted collisions/yr	**0.004**		**0.17**				**0.02**	

APPENDIX 6.2: REPORT TO INFORM A HABITATS REGULATIONS ASSESSMENT FOR THE PROPOSED LLANBRYNMAIR WINDFARM

1.1 Introduction

1.1.1 This document updates the previous report to inform an Appropriate Assessment for the Llanbrynmair wind farm that was produced in March 2010 at the request of DECC. It has been updated to reflect the reduced size of the proposed development (from 43 to 30 turbines) and subsequent advice provided by Natural Resources Wales (NRW).

1.1.2 Renewable Energy Systems UK and Ireland Ltd is proposing to construct a 30-turbine wind farm at Llanbrynmair, in Powys. The proposed development site is located approximately 13km west from Welshpool in mid-Wales. The assessment presented here has, as in the Environmental Statement, been based on a development of 30 x 2-3 MW turbines, using a worst-case approach in relation to turbine specifications. The wind turbines would be up to 93m rotor diameter and up to 127m to tip height. There would be a minimum distance of 30m between the lowest point of the rotor blades and ground level. Blade rotational speeds would be up to 14 revolutions per minute. The area in which the turbines will be sited covers about 4.7km2. The development will include concrete bases for the 30 wind turbine foundations, the wind turbines themselves and associated electrical transformers, electrical sub-station compounds and control buildings, a permanent (80m high) freestanding lattice wind monitoring mast and on-site infrastructure (underground cabling, access tracks, off-site road improvements, water crossings and crane hardstandings), for a period of 25 years. Construction would take place over approximately 24 months.

1.1.3 All of the on-site cabling and cabling to connect to the grid will be under-grounded, so there will not be any new overhead lines associated with the development. As a result this would not be expected to result in any additional ornithological effects resulting from the grid connection that could be potentially significant.

1.1.4 Operation and minor maintenance of the wind farm will take place throughout the year, with additional annual servicing.

1.1.5 Decommissioning is assumed will take place at the end of the lifetime of the wind farm (approximately 25 years). All of the wind turbines, meteorological masts and substations will be removed.

1.1.6 NRW has advised in its Opening Statement to the Mid-Wales Conjoined Wind Farm Public Inquiry that it does not consider than an Appropriate Assessment for the project would be required under the Habitats Regulations, but notwithstanding this, this report has been produced to assist such an assessment should a different view be taken.

1.1.7 The only SPA that could possibly be affected by the Llanbrynmair wind farm is the Berwyn SPA (there are no others located within 20km of the wind farm). This report addresses the avian nature conservation issues raised by the proposal for the Llanbrynmair wind farm in relation to the Habitats Regulations. The report seeks to provide information on the existing baseline populations for the species for which the Berwyn SPA has been designated (and that could be affected by the proposed development), and an assessment of the effects of the proposed development on those populations alone and in combination with other wind farm applications in the area.

1.1.8 The field studies, evaluation and assessment of effects of the proposed wind farm on the area's bird populations have been reported fully in the Environmental Statement [ES] and Supplementary Environmental Information [SEI]. The information presented in this report draws on that work but focuses on the key species that are qualifying features of the SPA sites that could possibly be significantly affected by the wind farm, in order to summarise the key information to inform the Appropriate Assessment.

1.1.9 Potential effects of the proposed Llanbrynmair wind farm on the Berwyn SPA site were considered in the ES and SEI. This SPA lies 5.3km north from the nearest proposed turbine, and is an extensive area of blanket mire and heath, with acid grassland and bracken. The main ornithological interests of the SPA are its breeding populations of hen harrier, red kite, merlin and peregrine. These qualifying features are detailed in Table 1.

Table 1. Qualifying features of the Berwyn SPA.

Species	Citation Population[1]	Protection status	Time of year	Population importance
Hen Harrier	14 pairs	Annex 1	Breeding	2.2% GB
Red Kite	2 pairs	Annex 1	Breeding	1.2% GB
Merlin	14 pairs	Annex 1	Breeding	1.1% GB
Peregrine	18 pairs	Annex 1	Breeding	1.5% GB

1.2 Legislative Framework

1.1.10 Under Regulation 61 of the Conservation of Habitats and Species Regulations 2010 ("the Habitats Regulations") a development that could potentially have an adverse effect on an SPA needs to be assessed for its implications for the nature conservation interests of that SPA.

1.1.11 Consideration of development proposals under the Habitats Regulations involves a series of steps, as detailed in Figure 1 of Annex 3 of Planning Policy Wales Technical Advice Note 5: Nature Conservation and Planning (Welsh Assembly Government 2009). The first step under the Habitats Regulations is to determine whether the proposal is directly connected with or necessary to site management for nature conservation. With regard to the Llanbrynmair wind farm it is clear that this is not the case.

1.1.12 The second step is then to determine whether the development may have a Likely Significant Effect on the interests of importance for which the site has been designated.

1.1.13 If it would, then (the third step) an Appropriate Assessment needs to be carried out by the Competent Authority (here the Secretary of State) to assess the implications of the proposal for the site in view of the site's conservation objectives.

1.1.14 If it cannot be determined beyond reasonable scientific doubt that there would be no adverse effect on the integrity of a European site, then the Regulations require consideration of whether there are alternative solutions that would have a lesser effect, or avoid an adverse effect, on the integrity of the site, in which case consent would not be granted. If there are no alternative solutions that could achieve this, then consent could only be granted in cases of imperative reasons of over-riding public interest.

1.1.15 In the ES and SEI it was concluded that the development would not be likely to result in any adverse effects that would be deemed significant under the Environmental Impact Assessment [EIA] Regulations. That finding has been further examined in the context of the Habitats Regulations and it was concluded that there is no Likely Significant Effect under these regulations. NRW has also advised this same conclusion in its Opening Statement to the public inquiry. Nonetheless, this report has gone on, without prejudice to that conclusion, to look at the question of adverse effect on the integrity of the sites. Thus, notwithstanding that conclusion (i.e. absence of a likely significant effect), this report also provides the information that would be required should an Appropriate Assessment be deemed to be necessary.

1.1.16 The Nature Conservation Objectives of the Berwyn SPA, against which the possible impacts of the scheme should be assessed, are as set out by CCW in Thomas (2008), though this is currently under review. Details of the Objectives are given in Appendix 1.

[1] As listed in the Natura 2000 standard data form – www.jncc.gov.uk - see Appendix 1.

1.3 Scope of this Report

1.1.17 The scope of this report to inform an Appropriate Assessment is as follows:

- To review the relevant data to determine the current status of the qualifying SPA species that could be potentially affected by the proposed Llanbrynmair wind farm;
- To interpret baseline data collected for the development's ES and SEI, in order to determine the baseline conditions for these species at the development site;
- To review data from existing wind farm sites relevant to this proposal in relation to these species;
- To carry out an assessment of the possible collision mortality and disturbance effects for cited SPA species that could be potentially affected by the proposed Llanbrynmair wind farm.

1.1.18 The possibility of cumulative and 'in combination' effects have been considered in relation to other proposed developments that could affect these SPA species. Potential cumulative effects were considered in the ES and the SEI, and no likely significant cumulative/in-combination effects were identified. Notwithstanding this, additional consideration of possible cumulative effects is included within this report in relation whether any SPA species might be significantly affected by the Llanbrynmair development in combination with any other developments in the region.

1.1.19 A key consideration in the assessment is the existence of any ecological link between the wind farm site and the SPA. Given the distance between the two (5.3km at their nearest point to each other), such a link is unlikely in relation to all of the qualifying bird populations breeding on the SPA. That distance is greater than the usual foraging distances, so birds breeding on the SPA are unlikely to make use of the wind farm site. The birds of those species that have been observed using the site are rather more likely to have been birds breeding more local to the wind farm site. As a result the potential for any adverse effect on the integrity of the SPA is very low.

1.4 Key Ornithological Interests: Baseline Conditions

1.1.20 The data available for this assessment include field data obtained from detailed year-round baseline studies carried out for the project EIA. Full details are given in the Environmental Statement and SEI. These included breeding bird surveys, wintering bird surveys and year-round vantage point surveys.

1.1.21 In relation to the Berwyn SPA, all of its four SPA qualifying species were recorded during the baseline surveys at Llanbrynmair; hen harrier, red kite, merlin and peregrine. All are cited for their breeding populations.

1.1.22 All are Schedule 1 species, specially protected from disturbance during the breeding season under the 1981 Wildlife and Countryside Act (as amended). In order to avoid possible persecution/infringement of the Act, the details of breeding site locations were given in a separate Confidential Appendices to the ES and the SEI. In this report the key information relevant to the assessment is presented without revealing the locations of nest sites.

Hen harrier

1.1.23 The desk study indicated that there were no known hen harrier breeding sites within 500m of any of the proposed wind turbine locations. There were three recorded nest sites within 2km of the wind farm, at distances of 1.2km, 670m and 730m from the nearest proposed wind turbine locations. This species was recorded over-flying the study area but the numbers flying through the site at rotor height were low.

1.1.24 During the 2005 baseline surveys 1-2 males and two females were seen in the study area, and at least one pair probably bred there (but outside the wind farm site itself). All were seen regularly and the male bird was observed displaying. Despite an increased survey effort in 2006, no clear evidence of hen harrier breeding was recorded. The study area was used by foraging birds in that year but no behaviour was observed that would suggest that the birds were breeding within the study area. Overall flight activity within the potential impact zone of the wind farm was very low.

Red Kite

1.1.25 No red kite behaviour indicative of breeding was observed within the main study area, but there were two breeding sites in the wider survey area, one 1.9km from the nearest proposed turbine location and another 2.5km away. This species was regularly observed flying within the study area. Its main area of flight activity was the steep valley slopes in the south-eastern part of the study area, associated particularly with the broad-leaved woodland in that area. Most flights were observed in the Nant yr Eira valley on the south-eastern edge of the study area, and less in the central part of the study area in which the wind farm would be located.

Merlin

1.1.26 The desk study indicated that a single bird had been seen irregularly about 900m west from the nearest proposed wind turbine but with no evidence of breeding there. This species was not seen during the 2005 surveys and there were only two sightings in the 2006 breeding season (again with no evidence of breeding behaviour observed).

Peregrine

1.1.27 This species was not seen during the 2005 surveys and there were only four of records obtained during the 2006 breeding season vantage point surveys. There was no indication that it was breeding within the study area in either year. No breeding sites were reported within 2km from the desk study.

Key Species Use of the Collision Risk Zone

1.1.28 The over-flying rates of the four key species within the potential collision risk zone is summarised in Table 2. The flight occupancy rate is expressed as the proportion of the total survey time in which the birds were in the collision zone. Movement rates across this zone were generally low, with no regular flight lines or important foraging activity observed.

Table 2. Over-flying rates of SPA species within the potential collision risk zone (wind farm plus 200 m buffer).

Species	Non-breeding season Flight occupancy rate (% observation time seen)	Total bird-time observed (bird-mins)	Breeding season: Flight rate (% observation time seen)	Total bird-time observed (bird-mins)
Red kite	0.82%	38.2	1.22%	58.8
Hen harrier	1.09%	51.0	0.86%	41.7
Merlin	0.02%	0.7	0.01%	0.3
Peregrine	0.08%	3.6	0.02%	1.1

1.5 Habitats Regulation Tests

1.1.29 This section provides an overview of the tests that need to be applied under the Habitats Regulations, drawing on Annex 3 of Planning Policy Wales Technical Advice Note 5: Nature Conservation and Planning (TAN5; Welsh Assembly Government 2009). After an initial discussion of the tests to be applied, the information relevant to each species is presented. The process for applying these tests, as summarised in Figure 1 of Annex 3 of TAN5, is included in Appendix 2.

Test 1: Likely Significant Effect

1.1.30 The initial test that has to be considered is whether the development may result in a likely significant effect. This "significance" differs from its definition under the EIA Regulations. In the context of the Habitats Regulations, it is usually used as a coarse filter to identify projects that require further assessment. TAN5 defines Likely Significant Effect as follows:

> *"The development project should be considered '**likely**' to have such an effect if the planning authority is unable, on the basis of objective information, to exclude the possibility that the project could have significant effects on any "European site", either alone or in combination with other plans or projects.*
>
> *An effect will be '**significant**' in this context if it could undermine the site's conservation objectives. The assessment of that risk must be made in the light of factors such as the characteristics and specific environmental conditions of the "European site" in question."*

1.1.31 The potential effects need to be judged in relation to the features for which the European sites (SPAs) have been designated, and their nature conservation objectives.

1.1.32 A significant effect can result from off-site projects as well as those within the European site, so could potentially occur at Llanbrynmair even though the proposed wind farm is not located within any SPA. No part of the proposed development would directly affect an SPA.

1.1.33 These effects could potentially occur through the lifetime of the wind farm (25 years), after which it would be decommissioned and removed from the site (and hence would not be a permanent feature of the site).

Test 2: Threat to Ecological Integrity

1.1.34 The Competent Authority will be required to decide whether the plan or project would adversely affect the integrity of the site(s), in the light of the relevant conservation objectives. In this context ecological integrity is defined in TAN5 (Welsh Assembly Government 2009) as follows:

> *"The integrity of a site is the coherence of its ecological structure and function, across its whole area, which enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified or listed."*

1.1.35 An adverse effect on integrity is one that is likely to prevent the site from making the same contribution to favourable conservation status for the relevant feature as it did at the time of its designation.

1.6 Assessment of Ornithological Effects

1.1.36 There are three ways in which the proposed wind farm might have an adverse effect on these species: direct loss of habitat, increased mortality rate through collision with the turbines and loss of habitat through disturbance. Each is considered in turn in relation to each of the SPA species that has been recorded using the study area.

1.1.37 Design mitigation has ensured that none of the proposed Llanbrynmair turbines have been located within potentially suitable hen harrier, merlin, peregrine or red kite breeding habitat and there are no known hen harrier, red kite, merlin, peregrine or red kite nest sites within 500m of any proposed turbine.

Direct Loss of Habitat

1.1.38 The wind turbines would be located outside any protected nature conservation area, so direct loss of habitat as a result of the construction of these is not an issue that requires detailed consideration in the Appropriate Assessment. No component of the proposed development would directly affect any SPA.

Collision Risk

1.1.39 There have been a number of wind farms that have caused bird mortalities through collision but their characteristics are very different to those at the proposed Llanbrynmair site. Most notably, at Altamont Pass in California and Tarifa in southern Spain, large numbers of raptors have been killed (Orloff and Flannery 1992, Janss 1998, Thelander et al. 2003). Such problems have occurred where large numbers of sensitive species occur in close proximity to very large numbers (hundreds/thousands) of turbines, and usually also where the wind farm area provides a particularly attractive feeding resource. In wind farm sites in the UK, with similar bird densities to Llanbrynmair, collision rates have generally been very low and are not considered to be significant (Meek et al. 1993, Tyler 1995, Dulas 1995, EAS 1997, Bioscan 2001, Percival et al. 2008, Percival et al. 2009). The risk is from operational turbines so would only apply to the construction phase of the development.

Disturbance

1.1.40 Disturbance could potentially affect a rather greater area than direct habitat loss. The maximum distance that wind turbines have been shown to affect breeding birds is 800m (Percival 2005; Pearce-Higgins et al. 2009), though most reliable studies have not reported effects further than 600m from turbines (Drewitt and Langston 2006) and displacement is usually partial rather than complete (i.e. a reduction in use not complete exclusion). Displacement has generally been more widely reported and over a greater distance outside the breeding season.

Construction Phase

1.1.41 Disturbance is likely to be highest during construction owing to the activities being carried out. Pearce-Higgins et al. (2012) found that red grouse, snipe and curlew densities all declined on wind farms during construction, though also that densities of skylark and stonechat increased. Construction also involves the presence of work personnel on site which itself can be an important source of potential disturbance. Even at this time displacement from a zone around the wind turbines is likely to only be partial. Pearce-Higgins et al. (2012) for example reported decreases in curlew density during construction of 40% and snipe by 53%. A worst-case approach has been adopted in this assessment for the construction disturbance assessment, that all breeding birds within 500m of the wind turbines could potentially be at risk of displacement, and a slightly wider zone (600m) for wintering birds (Percival 2005; Drewitt and Langston 2006).

Operational Phase

1.1.42 Experience from existing UK wind farms have shown that many species are tolerant of the presence of operational wind turbines and not unduly disturbed by them. A recent study of wintering golden plover, lapwing and pink-footed geese, found no evidence of displacement of any of these species (Percival et al. 2008). All three species were observed feeding within 300m of wind turbines in years when their preferred crop was present in that zone.

1.1.43 Some short-term displacement during wind farm operation of species such as curlew may occur following construction but populations have subsequently re-established themselves (Bullen Consultants 2002). Most species that have been studied have not been significantly affected (Meek et al. 1993, Phillips 1994, Dulas 1995, Thomas 1999, Gill 2004, Percival 2005, Percival et al. 2008, Devereux et al. 2009). Scarcer species such as hen harrier have been less studied, however, so a cautious approach has been taken with these. However there are an increasing number of records of such species breeding successfully in close proximity to operational wind turbines, e.g. hen harriers in Scotland 400m from a turbine (M. Madders, pers, comm.) and only 200 m from a turbine in Northern Ireland (Steele 2005). A recent RSPB study has reported partial displacement of breeding upland birds around wind turbines up to 800m (Pearce-Higgins et al. 2009). This scale and pattern of displacement is similar to that reported for breeding waders in general by Hotker et al (2004), with most studies reporting only small scale (0-200m) displacement distances and a smaller number over a greater distance. For the purposes of this assessment it has been assumed that all breeding birds within 300m of the wind turbines could be at risk of disturbance during operation, with consideration also given to the breeding populations within a 500m buffer as well, and a 600m buffer outside the breeding season.

Effects on Hen Harrier

1.1.44 Hen harrier this species was recorded over-flying the Llanbrynmair study area but the numbers flying through the wind farm site at rotor height were low. It is also a species considered to be at relatively low risk of collision (Whitfield and Madders 2006a). As a result the precautionary predicted collision risk was small, at 0.07 birds per year, equivalent to a 0.09% increase over the existing baseline mortality. This would be an effect of negligible magnitude that would not be significant. The birds are not likely to originate from the Berwyn SPA but rather would be likely to be more local breeders. No collision effect on the SPA population would be likely for this species.

1.1.45 In terms of potential disturbance effects on hen harrier, the wind farm has been designed to avoid areas of potentially suitable habitat and historic nesting sites. Mitigation would also be put in place to ensure that there is not any disturbance to nesting birds during construction. There may be a small loss of foraging habitat around the wind turbines if this species were to be displaced, but any such adverse effects would be of negligible magnitude and not significant (and again this would not be likely to affect any SPA birds given the distance of the wind farm from the SPA). Rather this species would receive a net benefit from scheme through the habitat enhancement plan (see ES and SEI), particularly through increased foraging habitat provided by forest felling.

Effects on Red Kite

1.1.46 Red Kites were recorded over-flying the study area but their activity within the proposed wind farm site was rather less than in other parts of the study area. There is some information on red kites at existing wind farms that suggests that they are not particularly vulnerable to collision and that they will forage in proximity to wind turbines (Green 1995, Tyler 1995, Whitfield and Madders 2006b). There have been at least three records of kite deaths by collision at one mid Wales wind farm (Welsh Kite Trust pers. comm.), and four collisions documented in Scotland (Natural Research 2010). Although formal monitoring has not taken place at many wind farms, it would be expected that more deaths would have been recorded if it was a widespread problem. In general, it is considered that kite are not particularly vulnerable and with the relatively low amount of time spent by kites feeding over the proposal site it is considered unlikely that collision risk is significant or would affect the conservation status of the local kite population. The results of the collision risk modelling supported this conclusion, with a precautionary prediction of 0.34 collisions per year, for a population that is increasing steadily year on year (Welsh Kite Trust 2011). This would be an effect of negligible magnitude (equivalent to only a 0.07% increase over the existing baseline mortality) and not significant. The birds are not likely to originate from the Berwyn SPA but rather would be likely to be more local breeders. No collision effect on the SPA population would be likely for this species.

1.1.47 Disturbance could potentially displace foraging kites from a zone around the wind turbines, though the evidence from existing wind farms suggests that kites do use wind farm sites. They may still be discouraged to a degree, and it is uncertain as to the precise extent of any potential disturbance zone. In terms of quantifying the magnitude of any potential impact, the key issue is the ecological consequence of any disturbance that may occur. That magnitude will be primarily dependent on the availability of alternative feeding areas to which birds may move should they be displaced from the wind farm site. At Llanbrynmair, there are two points that demonstrate that the magnitude should be of at most low magnitude, (i) the birds currently make only limited use of the proposed wind farm site, and (ii) there is ample alternative foraging habitat available in the vicinity, as the wind farm site does not support any particularly important or scarce kite habitat. In addition, precautionary mitigation measures described below would be implemented to ensure compliance with the 1981 Wildlife and Countryside Act in that no active nest would be disturbed. Again the birds using the proposed wind farm site are not likely to originate from the Berwyn SPA but rather would be likely to be more local breeders. No disturbance effect on the SPA would be likely for this species.

Effects on Peregrine

1.1.48 There was only a very low level of flight activity of this species recorded, and consequently there would be a negligible collision risk (0.02 collisions per year, equivalent to an increase of only 0.01% over the existing baseline mortality). This would be an effect of negligible magnitude and not significant. The birds are not likely to originate from the Berwyn SPA but rather would be likely to be more local breeders. No collision effect on the SPA population would be likely for this species.

1.1.49 Disturbance to peregrine would be of negligible magnitude and not significant. There are not any known nesting sites within 2km of the proposed turbine locations and the Llanbrynmair study area was not important to this species. No disturbance effects would be likely on any SPA birds.

Effects on Merlin

1.1.50 There was only a very low level of flight activity of this species recorded through the collision risk zone and no flights at all observed at rotor height (all were below). As a result the collision risk would be of negligible magnitude and not significant. The birds are also unlikely to originate from the Berwyn SPA but rather would be likely to be more local breeders. No collision effect on the SPA population would be likely for this species.

1.1.51 In terms of potential disturbance effects to merlins, the wind farm has been designed to avoid areas of potentially suitable habitat and historic nesting sites. Mitigation would also be put in place to ensure that there is not any disturbance to nesting birds during construction. There may be a small loss of foraging habitat around the wind turbines if this species were to be displaced, but any such adverse effects would be of negligible magnitude and not significant. Rather this species would receive a net benefit from scheme through the habitat enhancement plan, particularly through increased foraging habitat provided by forest felling. No disturbance effects would be likely on any SPA birds.

1.7 Cumulative Assessment

Cumulative Effects on Hen Harrier

1.1.52 There are no records of hen harriers breeding within 500m of any of the proposed Llanbrynmair turbines and preferred hen harrier habitat was avoided in the site design process. As a result, only negligible magnitude effects on this species are predicted for the scheme, including a collision risk of only 0.07 birds per year.

1.1.53 The Carnedd Wen site supported a breeding hen harrier population of 0-4 pairs during 2005-08, with a mean of 2.4 pairs over that period. Their breeding productivity over those years was zero, with at least some of those losses attributable to fox predation. No hen harriers were recorded at all at this site during a 2012 survey (Owen 2012).

1.1.54 The Carnedd Wen scheme would result in a positive effect on harriers. There would be a large increase in habitat availability for this and other open ground species through forest felling. The Habitat Management Plan will also encourage harriers to nest away from the immediate vicinity of the turbines in order to reduce the potential collision risk, and will implement measures to increase breeding productivity.

1.1.55 The Llanbrynmair wind farm is located sufficiently distant from the SPA such that it would not contribute to any likely significant effect on the SPA hen harrier population. It was also concluded in the Carnedd Wen ES that there would be no likely significant effect on any SPA in terms of the Habitats Regulations from that scheme either. The two schemes in combination would not result in any likely significant effect on the SPA in terms of the Habitats Regulations.

1.1.56 Hen harriers have been shown to have a low sensitivity to disturbance and will nest within 200-300m of turbines, with a displacement distance of only 100m (Carnedd Wen ES). Therefore, only a very small disturbance effect would be likely to occur.

1.1.57 The Carnedd Wen site design followed the same principle as that of the Llanbrynmair wind farm, implementing a minimum 500m separation between hen harrier breeding areas and wind turbines.

1.1.58 On the basis of the current baseline (and applying a precautionary 99% avoidance rate), it was predicted that there would be 0.26 hen harrier collisions per year from the Carnedd Wen scheme[2]. The planned deforestation would lead to a reduction in flight height and a consequent reduction in collision risk. Taking this into account, a revised value of 0.02 collisions per year was predicted in the Carnedd Wen ES. This very small effect would be "*comfortably offset by enhanced breeding success due to deforestation and habitat management at Carnedd Wen*"[3]. When looked at from a population perspective using population modelling, the population trajectory would hardly change even if the hen harrier collision mortality were 10 times higher than predicted. It is clear that the cumulative collision risk would also be well below a level that could be considered to be significant. The Llanbrynmair scheme would add only a small amount to this cumulative risk (which would still, in combination, not be significant), and, being further from the SPA, would be less likely to involve SPA birds.

1.1.59 In conclusion there would not be likely to be any cumulative effects on hen harrier that could possibly result in any adverse effect on the integrity of the Berwyn SPA population.

Cumulative Effects on Red Kite

1.1.60 There was no evidence found of any red kites breeding within either the Llanbrynmair or the Carnedd Wen wind farm site, although there were 1-5 pairs in the surrounding wider survey area. Both sites were regularly over-flown by this species, giving a precautionary predicted red kite collision risk at Llanbrynmair of 0.34 and at Carnedd Wen of 0.26 collisions/year (applying a 99% avoidance rate for both sites). This would be equivalent to only a 0.1% increase over the existing baseline mortality in the context of the Welsh population. The collision risk to this species would not be significant for either Llanbrynmair alone, or in combination with Carnedd Wen.

1.1.61 As noted in the Llanbrynmair ES, disturbance could potentially displace foraging kites from a zone around the wind turbines. Although the evidence from existing wind farms suggests that kites do use wind farm sites, they may still be discouraged to a degree, and it is uncertain as to the precise extent of any potential disturbance zone. In terms of quantifying the magnitude of any potential impact, the key issue is the ecological consequence of any disturbance that may occur. This magnitude will be primarily dependent on the availability of alternative feeding areas to which birds may move should they be displaced from the wind farm site. At both the Proposal and Carnedd Wen, there are two points that demonstrate that the magnitude of disturbance would be low at most, even at the two sites in combination: (i) the birds currently make only limited use of the proposed wind farm site; (ii) there is ample alternative foraging habitat available in the vicinity, and the wind farm

[2] Carnedd Wen wind farm SEI Dec 2011 Appendix 8.2

[3] Carnedd Wen wind farm ES, RWE Npower Renewables.

site does not support any particularly important or scarce kite habitat. The cumulative disturbance effect is therefore considered to be of low significance. In addition, precautionary mitigation measures described below would be implemented to ensure that no active nest would be disturbed and compliance with the 1981 Wildlife and Countryside Act.

1.1.62 In conclusion there would not be likely to be any cumulative effects on red kite that could possibly result in any adverse effect on the integrity of the Berwyn SPA population.

Cumulative Effects on Peregrine

1.1.63 There was only a very low level of flight activity of this species recorded at Llanbrynmair, and consequently there would be a negligible collision risk (0.02 collisions per year) from this scheme. This would be an effect of negligible magnitude and not significant. The collision risk at Carnedd Wen was found to be of a similar negligible magnitude (0.04 collisions per year), such that the cumulative collision risk would also not be significant.

1.1.64 Disturbance to peregrine from the Llanbrynmair wind farm would be of negligible magnitude and not significant. There are no known nesting sites within 2km of the proposed turbine locations and no important foraging areas were identified. There was a peregrine nest site within the Carnedd Wen site and another 2 in its buffer. Effects on this species were not considered significant in the Carnedd Wen ES and the Llanbrynmair wind farm would not contribute to any cumulative impact. The two schemes in combination would not result in any likely significant effect on the SPA in terms of the Habitats Regulations.

1.1.65 In conclusion there would not be likely to be any cumulative effects on peregrine that could possibly result in any adverse effect on the integrity of the Berwyn SPA population.

Cumulative Effects on Merlin

1.1.66 There was only a very low level of flight activity of this species recorded through the Llanbrynmair wind farm collision risk zone and no flights at all observed at rotor height (all were below). As a result the collision risk for that site would be of negligible magnitude and not significant. A similar conclusion was reached in the Carnedd Wen ES. The collision risk from each scheme would be so small that the cumulative risk would be negligible and not significant.

1.1.67 In terms of potential disturbance effects to merlins, both the Proposal and Carnedd Wen wind farms have avoided areas of importance for this species. Mitigation would also be put in place to ensure that there is not any disturbance to nesting birds during construction. There may be a small loss of foraging habitat around the wind turbines if this species were to be displaced, but any such adverse effects would be of negligible magnitude and not significant for both of the schemes together in combination. Rather, this species would receive a net benefit from schemes through the two habitat enhancement plans, particularly through increased foraging habitat provided by forest felling. The two schemes in combination would not result in any likely significant effect on the SPA in terms of the Habitats Regulations.

1.1.68 In conclusion there would not be likely to be any cumulative effects on peregrine that could possibly result in any adverse effect on the integrity of the Berwyn SPA population.

Barrier Effects

1.1.69 A further potential disturbance effect is disruption to important flight paths. Birds may see the wind farm and change their route to fly around (rather than through) it. This would reduce the risk of collision but could possibly have other effects, for example, it may potentially make important feeding areas less attractive (by acting as a barrier to the birds reaching them) and (if diversions were of a sufficient scale) result in increased energy consumption.

1.1.70 In fact neither the Llanbrynmair nor the Carnedd Wen wind farm lie on any important bird flight routes to which the wind farms could be a potential barrier. Hence, any barrier effect resulting from the Proposal either alone or in combination with Carnedd Wen would be of negligible magnitude and not significant.

Cumulative Benefits – Habitat Enhancement

1.1.71 As well as potential negative cumulative effects, the two projects would be beneficial to nature conservation (including ornithology). These benefits, in particular the felling of extensive conifer plantation and restoration of open moorland, far outweigh any risks that the proposed wind farms would bring. The overall consequences of both schemes, alone or in combination, would therefore be positive.

1.8 Conclusions

1.1.72 This report has provided baseline data and analysis to inform the assessment process should the Competent Authority determine that an Appropriate Assessment is required.

1.1.73 Possible effects on the Berwyn SPA qualifying species (hen harrier, red kite, merlin and peregrine) constitute the only possible likely significant effect of the proposed Llanbrynmair wind farm (either alone or in-combination) in the context of the Habitats Regulations.

1.1.74 Though some very minor (negligible magnitude) effects may occur on these SPA populations, none of these effects would have an adverse effect on the ecological integrity of the SPAs. There would also be considerable benefits to these species resulting from the habitat enhancement plans that will be implemented at both Llanbrynmair and Carnedd Wen, which will mean that both schemes would deliver a net benefit to these species, both alone and in combination.

1.1.75 In summarising the likely effects on the qualifying bird populations for the SPAs, the assessment process illustrated in the flow diagram in Figure 1 of Annex 3 of TAN5 [see Appendix 2] is undertaken as follows:

- "Is the proposal directly connected with or necessary to site management for nature conservation?" No.
- "Is the proposal likely to have a significant effect on the internationally important interest features of the site, alone or in combination with other plans and projects?" It has been concluded that the proposed development would not result in a likely significant effect on any international site, the result of which would therefore be that "permission may be granted". However, this report still progresses along this route notwithstanding that assessment of likely significant effect as if the answer here were 'yes'.
- "Assess the implications of the effects of the proposal for the site's conservation objectives. Can it be ascertained that the proposal will not affect integrity of the site?" The Nature Conservation Objections are to maintain, subject to natural change, the favourable condition the habitats of the internationally important populations of regularly occurring Annex 1 species for which it has been designated.
- No species has been identified as potentially being significantly affected by the Llanbrynmair wind farm (either alone or in combination). In terms of the relevant tests under the Habitat Regulations, it can be safely concluded that the proposed development would not threaten the ecological integrity of the SPA. Hence the end result again is that "permission may be granted."

1.1.76 Whichever route is followed the outcome is the same, i.e. that there would not be a threat to the ecological integrity of the Berwyn SPA, either alone or in combination with any other plan or project.

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APPENDIX 7.1: UNDESIGNATED HISTORIC ASSETS WITHIN 0.5KM OF THE OFFSITE HIGHWAY WORKS

1.1.1 The table below lists all records of undesignated historic assets within 0.5km of the proposed offsite highway works on minor roads between Talerddig, Llanerfyl and the windfarm site. It comprises records held by Clwyd Powys Archaeological Trust in the regional historic environment record and additional records held in the National Monument Record.

1.1.2 The assets are listed in numerical order, based on their primary record number (PRN). The location of all of these assets is shown in Figures 7.7a and 7.7b.

1.1.3 A sub-set of undesignated assets, located immediately adjacent to the minor roads along which the works would take place, are also listed in Table 7.9 of Chapter 7. Designated historic assets within 1km of the offsite highway works are listed in Table 7.10 of Chapter 7.

prn	Site Name	Site Type	Period
1239	Afon Banwy Find II	Find	Roman
1320	Talerddig Chapel Site	Chapel	Medieval
1321	Talerddig find	Find	Bronze Age
1323	Llyssun Castle, well	Medicinal well	Medieval
1326	Bryn Tanat find	Find	Iron Age
1328	Llanerfyl 'fort' earthworks	Non-antiquity	unknown
1737	Dol Capel placename	Chapel	Post-Medieval
1741	Llanerfyl Church (St Erfyl), stone	Inscribed Stone	Early Medieval
1744	Llanerfyl cockpit	Cockpit	Post-Medieval
1747	Werglodd Maen Llwyd placename	Standing stone	Bronze Age
3873	Dol y Garreg Wen	placename	unknown
3881	Castell y Gwynt	placename	unknown
4289	Ffynnon Erfyl Well	Holy well	Medieval
4819	Llysun Mound	Round barrow	Bronze Age
4833	Ty Mawr ridge and furrow	Ridge and furrow	Medieval
4841	Talerdigg Mound	Spoil heap	Modern
7574	Llanerfyl Church (St Erfyl), yard	Churchyard	Medieval
7575	Llanerfyl village earthworks	Earthwork	Post-Medieval
7642	Llanerfyl, Caer Fynnon	House	Post-Medieval
8519	Caban y Nos House Site	House	Post-Medieval
8521	Ty Helyg House Site	House	Post-Medieval

prn	Site Name	Site Type	Period
8523	Nant yr Cyra House Site	House	Post-Medieval
8524	Pant y Gareg house site	House	Post-Medieval
8525	Sychnant House Site	House	Post-Medieval
8529	Ty Newydd House Site	House	Post-Medieval
8536	Hafod Mill	Corn Mill	Post-Medieval
8537	Glan y Nant House Site	House	Post-Medieval
8541	Ty Isaf House Site	House	Post-Medieval
8786	Prys Gwyn Gyll Building	Barn	Post-Medieval
8788	Ty'n y Waen House Site	House	Post-Medieval
8789	Cwm y Ffridd House Site	House	Post-Medieval
8790	Ty'n y Gors House Site	House	Post-Medieval
8791	Prys Gwyn Gyll House Site	House	Post-Medieval
11303	Aber Independent Chapel	Chapel	Post Medieval
11309	Talerddig Independent And Congregational Chapel, Talerddig	Chapel	Post Medieval
11326	Beulah Welsh Independent Chapel, Cwm Nant-Yr-Eira	Chapel	Post Medieval
11327	Bethel Welsh Independent Chapel, Llanerfyl	Chapel	Modern
11328	Gosen Chapel (Welsh Calvinistic Methodist;Llanerful), Llanerfyl	Chapel	Post Medieval
11329	Llanerfyl Methodist Chapel (Wesleyan;Capel-Y-Llan;Philadelphia), Llanerfyl	Chapel	Post Medieval
12251	Bethel I, Diosg, Llanerfyl	Chapel	Post Medieval
14413	Caersws-Carno-Pennal	Road	Post-Medieval
15714	Llanerfyl	Settlement	Multiperiod
15755	Talerddig	Settlement	Multiperiod
16409	llanerfyl church	Church	Medieval
17678	Llanerfyl Church (St Erfyl), bells	Church bell	Post-Medieval
17923	Tirymynach Manor (Strata Marcella)	Manor	Medieval
17924	Capel Dolwen (Strata Marcella)	Chapel	Medieval

prn	Site Name	Site Type	Period
20217	Pant-Glas house	House	Post-Medieval
26544	Moel Gloria hafod	Hafod	Post-Medieval
26678	Fron Mill; Talerddig Mill	Corn Mill	Post-Medieval
26680	Talerdig, Dolgoch Sawmill	Saw mill	Post-Medieval
26768	Ty-Newydd Woollen Mill	Woollen mill	Post-Medieval
29841	Pont Talerddig	Dwelling	Post Medieval?
33654	Dolgoch Machine Shop; possible former mill, Talerddig	Water wheel	Post Medieval
36356	Llanerfyl, Pont Llanerfyl	Bridge	Post-Medieval
36357	Llanerfyl, Water standpoint/fire hydrant	Fire hydrant	Post-Medieval
37401	Llanerfyl, Felin Fach mill	Corn Mill	Medieval
40151	Fron Mill, Talerddig	Corn Mill	Post Medieval
42507	Caerfynnon, railings and gates	Gateway	Post-Medieval
43034	Talerddig railway cutting, Talerddig	Railway cutting	Post Medieval
47124	Long Mountain to Mallwyd	Road	Post-Medieval
48251	Ffridd Fawr, farmstead	Farmstead	Post-Medieval
48252	Ffridd Fawr, stone I	Boundary stone	Post-Medieval
48255	Pen-y-ffridd, farmstead	Farmstead	Medieval
48256	Pen-y-ffridd, quarry	Quarry	Post-Medieval
48257	Castell-y-gwynt, well	Well	Post-Medieval
48258	Castell-y-gwynt, farmstead	Farmstead	Post-Medieval
48259	Dolau, footbridge I	Bridge	Post-Medieval
48260	Dolau, ford	Ford	Post-Medieval
48261	Dolau, farmstead	Farmstead	Post-Medieval
48262	Dolau, footbridge II	Bridge	Post-Medieval
57519	Pont Diosg Brickworks	Brickworks	Post-Medieval
65503	Dolwen bridge	Bridge	Post-Medieval
65504	Hafod quarry I	Quarry	Post-Medieval
65505	Hafod footbridge	Footbridge	Post-Medieval
65506	Hafod ford	Ford	Post-Medieval

prn	Site Name	Site Type	Period
65507	Hafod building	Building	Post-Medieval
65604	Ffridd Fawr cow shed	Cow house	Post-Medieval
65606	Dolau cartshed	Cart shed	Post-Medieval
65607	Dolau stable	Stable	Post-Medieval
65608	Dolau cow shed II	Cow house	Post-Medieval
65609	Dolau cow shed I	Cow house	Post-Medieval
65697	Hafod farmstead	Farmstead	Post-Medieval
65698	Hafod stable II	Stable	Post-Medieval
65699	Hafod stable I	Stable	Post-Medieval
65700	Hafod cow shed I	Cow house	Post-Medieval
65701	Hafod cow shed II	Cow house	Post-Medieval
65702	Hafod farmhouse	House	Post-Medieval
65703	Hafod pigsty	Pigsty	Post-Medieval
65704	Hafod building platform I	Building platform	Medieval
65705	Hafod building platform II	Building platform	Post-Medieval
65706	Hafod quarry I	Quarry	Post-Medieval
65708	Hafod mill leat	Mill race	Post-Medieval
65710	Hafod outbuilding	Outbuilding	Post-Medieval
66430	Ty mawr sheepfold	Sheep fold	Post-Medieval
66527	Pandy-bach	Woollen factory	Post-Medieval
66528	Pandy-bach footbridge	Footbridge	Post-Medieval
67176	Bryn-coch-uchaf well	Well	Post-Medieval
67177	Bryn-coch-uchaf quarry	Quarry	Post-Medieval
67178	Bryn-coch-isaf	Farmstead	Post-Medieval
67179	Bryn-coch-isaf quarry	Quarry	Post-Medieval
67180	Glyn	Farmstead	Post-Medieval
67181	Glyn well	Well	Post-Medieval
67895	Tyn-y-ddol, farmstead	Farmstead	Post-Medieval
67896	Pont Pant-glas, bridge	Bridge	Post-Medieval

prn	Site Name	Site Type	Period
67897	Tyn-y-ddol, well	Well	Post-Medieval
67898	Pandy-bach	Woollen factory	Post-Medieval
67899	Pant-glas, trackway	Trackway	Post-Medieval
67900	Capel-yr-aber trackway	Trackway	Post-Medieval
67902	Pant-glas, ford	Ford	Post-Medieval
67903	Coed Esgair, farmstead	Farmstead	Post-Medieval
67905	Machynlleth-Newtown railway (section)	Railway	Post-Medieval
71338	Craen Cottage and forge	Building	Post-Medieval
71339	Craen Trackway	Trackway	Medieval
71340	Craen Cottage well	Well	Post-Medieval
71341	Craen Trackway well	Well	Post-Medieval
71342	Craen Farm Well II	Well	Post-Medieval
71343	Craen Farm Well I	Well	Post-Medieval
71344	Craen Trackway	Trackway	Medieval
80083	Aber-ucha house	Farmstead	Post-Medieval
80092	Moel Gloria Fach earthworks	Peat cutting	Post-Medieval
85854	Llanerfyl Church (St Erfyl), stone, former location	Inscribed Stone	Early Medieval
93531	Pant-y-pwsi house	Long-hut	Post-Medieval
96100	Llanerfyl, Tyntwll	Barn	Post-Medieval
97163	Ty Newydd Methodist Chapel (Wesleyan;Gosen), Ty-Newydd	Chapel	Post Medieval
125992	Nant yr Cyra, enclosure	Enclosure	Post-Medieval
126016	Haulfron, building IV	Building	Post-Medieval
126017	Haulfron, building V	Building	Post-Medieval
126018	Haulfron, building III	Building	Post-Medieval
128013	Maes-gwyn potato store	Root store	Modern
286279	Toll House Talerddig, Llanbrynmair	Workers housing	Post Medieval
400025	Traws Nant, ruined structures SE of	Earthwork	Medieval;Post Medieval
410074	Llanerfyl Vicarage; Llanerfyl Rectory;	Rectory; Vicarage	Post Medieval

prn	Site Name	Site Type	Period
	Garth Erfyl		
417600	Talerddig	Village	Multiperiod
418340	Meliden Station Quarry	Limestone Quarry	19th Century

APPENDIX 7.2: ASIDOHL

1.1 Introduction

1.1.1 This appendix reproduces the Assessment of the Significance of the Impact of Development on the Historic Landscape (ASIDOHL) prepared by the Dyfed Archaeological Trust and originally included as Chapter 4 of SEI Package 1 (2010).

1.2 Summary

1.1.2 In response to a consultation on the proposed Llanbrynmair Windfarm Development, the archaeological advisors to Powys County Council recommended that an Assessment of the Significance of the Impact of Development on the Historic Landscape (ASIDOHL) be undertaken to assess the potential effects of the Proposal upon the historic landscape of the development area and its surroundings. The proposed development area lies within the refined TAN 8 Strategic Search Area (SSA) B (Carno North) (see figure 1). Although the area is not included within the Register of Landscapes of Special Historic Interest in Wales, landscape characterisation of TAN 8 areas has been undertaken in order to enable assessment of the effects of such developments upon the historic landscape (CPAT 2006).

1.1.3 This ASIDOHL concluded that the proposed windfarm development would have:

- A slight direct physical impact on the historic landscape;
- Very slight (if any) indirect physical impact on the historic landscape; and,
- Moderate indirect (non-physical) visual impact on the historic landscape.

1.1.4 The assessment also concluded that the relative importance of the affected Historic Landscape Character Areas (HLCAs) varies from **Low** to **High**. The overall impact of the development is rated as **Moderate**.

1.1.5 Mitigation of the potential effects of the Proposal upon the historic environment will include the avoidance of physical impact upon known archaeology through design, with a watching brief during construction to undertake appropriate measures should unexpected archaeologically significant features be encountered during construction. Where possible, visual effects on the historic landscape will be mitigated through design, but a certain degree of visual effect is inevitable with this form of development.

1.3 STAGE 1 - Contextual Information

Background

1.1.6 Clwyd-Powys Archaeological Trust (CPAT), in their role as archaeological advisors to Powys County Council, requested that, in order to inform the planning process, an ASIDOHL be provided to supplement the EIA for the Llanbrynmair Wind Farm Proposal from RES UK & Ireland Ltd. This ASIDOHL has been undertaken by Dyfed Archaeological Trust Field Services.

1.1.7 The ASIDOHL specifically assesses the potential effects of the Proposal upon the historic landscape of the development area and the surrounding landscape. The ASIDOHL process is based upon characterisation of defined historic landscape areas. Elsewhere in Wales, historic landscape characterisation has only been undertaken in areas identified in the Register of Landscapes of Historic Interest in Wales. The process of historic landscape characterisation does not in itself suggest, or give extra weight to, the significance of the landscape studied. The study does not therefore evaluate the relative importance of these components, nor the historic landscape importance of the total area that they represent.

1.1.8 The landscape characterisation process does, however, enable the potential effects of windfarm developments upon the historic landscape within the TAN 8 areas to be assessed using ASIDOHL 2 methodology (Cadw 2007).

1.1.9 An Historic Landscape Characterisation study (Britnell 2006) was jointly commissioned by Powys County Council and Cadw in July 2006 with the principal objective of identifying the visible historic components of the landscapes (and a broad overview of their significance) within the refined TAN 8 SSAs B (Carno North) and C (Newtown South) (Arup 2006; Powys County Council 2006) within Powys (see figures 1, 2 and 3).

1.1.10 It should be noted that the currently defined HLCAs extend beyond the Development area and the TAN 8 area (see figures 4 and 5). In assessing the impact of the proposed development upon HLCAs, their entire area is considered, rather than only that proportion that falls within the development area. Only those HLCAs that contain, or adjoin the proposal area are considered in this ASIDOHL process.

The Proposal

1.1.11 The Proposal consists of:

- 43 wind turbines, which will have a maximum overall tip height of up to 126.5m;
- Access works and site tracks;
- Electricity transformers;
- Borrow pits;
- Water crossings;
- Underground cabling;
- Crane hardstandings;
- Control buildings and substation compounds;
- Permanent free-standing wind monitoring mast;
- Temporary works including construction compounds, batching plant, welfare facilities and 10 guyed meteorological masts up to 80m high.

1.1.12 The following National and Local Policy Frameworks have been identified as being of relevance to the proposed development:

- In Wales, the protection of ancient monuments and archaeological areas remains of national importance and is statutorily governed under the provisions of the Ancient Monuments and Archaeological Areas Act 1979;
- For certain types of development, formal EIA may be necessary. Where EIA is required, the developer must provide an Environmental Statement setting out the information specified in Schedule 3 of the Regulations about the site and the likely significant effects of the development on the environment;
- Planning Policy Wales 2002 provides the overarching context for sustainable land use planning policy in Wales;
- Planning and the Historic Environment – Archaeology. Welsh Office Circular 60/96 is the key policy document of Welsh Assembly Government providing detailed guidance on the handling of archaeology in the legal land-use planning system in Wales.

1.1.13 The following policies within the **Powys County Council UDP 2001-2016** are noted as being of particular relevance to cultural heritage and archaeological issues:

- Policy UDPSP3 – Natural, Historic & Built Heritage;
- Policy ENV2 - Safeguarding the Landscape;
- Policy ENV14 - Listed Buildings;
- Policy ENV16 - Landscapes, Parks and Gardens of Special Historic Interest;
- Policy ENV17 - Ancient Monuments and Archaeological Sites;
- Policy ENV18 - Development Proposals Affecting Archaeological Sites.

Methodology

1.1.14 This ASIDOHL was undertaken with reference to and in accordance with the revised second edition of the Guide to Good Practice on Using the Register of Landscapes of Historic Interest in Wales in the Planning and Development Process (Cadw 2007). This document (ASIDOHL 2) should be consulted in conjunction with this assessment and is available as a pdf at: www.cpat.org.uk/projects/longer/histland/**asidohl**/**asidohl**2.pdf

1.1.15 Throughout this chapter table numbers relate to the paragraph number with which they are associated.

Historic Landscape Characterisation

1.1.16 The development site lies within an area of enclosed and unenclosed upland and enclosed farmland in fringing valley slopes. The core of the area is now unpopulated and only limited evidence of former settlement is present on the periphery of the core area, although farms and other settlements are present at lower levels on the fringes of the site. The core area in which most of the turbines will be located can be considered in two parts- the northern and southern zones. Much of the pasture in the southern zone is now, or has previously been, improved pasture, but with significant areas of marshy ground and rough, unimproved pasture. The northern zone consists of large areas of unimproved heath/moor, with smaller areas of improved grassland pasture. A significant proportion of both areas is forested.

1.1.17 There are numerous forestry and farm access tracks providing access to much of the area and the Glyndwr's Way national trail traverses the proposed windfarm site. Although the peripheral slopes were already enclosed, the Llanbrynmair Parish Tithe Map and apportionment of 1839 and the 1st edition Ordnance Survey map of the area indicate that the core was still largely open common in 1891.

1.1.18 Field boundaries in the core of the northern zone consist mainly of post and wire (generally stockproof) fencing. On the eastern periphery of this zone, on hill slopes and valley sides where agricultural enclosure has been established for longer, denuded hedgebanks and drystone walling are present, now topped with post and wire fencing. The field boundaries are similar in the southern zone, but also present here are substantial denuded banks and dry-stone walls.

1.1.19 Although not a Registered Landscape of Historic Interest, in sum, the landscape does have a distinct character and appearance resulting from and reflecting the combination of its topography and land-use history. This character extends beyond, and is shared with, landscapes beyond the landscape area that has been characterised.

1.1.20 Within the characterised area, the individual historic landscape elements tend to compete against each other, so that no single element can be considered to be a unifying theme in the landscape, providing a character that can be considered different from other areas in the region.

1.1.21 Details on the definition of landscape character areas and historic landscape themes are presented in Britnell 2006, but edited extracts are included in the following section.

Landscape Designations

Nant Carfan HLCA 3

1.1.22 Key landscape characteristics for HLCA 3 include stream valleys with predominantly large and small irregular fieldscapes and dispersed farmsteads of possible medieval and later origin, between a height of generally 150-300 metres OD. Present-day settlement is represented by several dispersed farms. Post-medieval industry is represented by the Nant Carfan stone quarry and by two former woollen mills on the Clegyrnant stream. Some rural depopulation in the late 19th to 20th centuries is suggested by a derelict and abandoned house site at Ffridd Fach.

Mynydd Lluest Fach HLCA 5

1.1.23 Key landscape characteristics for HLCA 5 include enclosed moorland on upland plateau and on more steeply-sloping hill-sides, between a height of 230-480 metres OD, including an area of registered Common Land. There are no extant settlements in the area. Prehistoric land use and settlement in the area is indicated by a cluster of Bronze Age funerary and ritual monuments on Mynydd Lluest Fach, including a ring cairn, three possible burial mounds and a hut circle. Medieval to post-medieval settlement and land use, possibly of a seasonal nature and associated with the exploitation of upland grazing, is suggested by a number of abandoned settlements including: two building platforms on the hill crest towards the southern end of the area on Mynydd Rhiw-Saeson; the remains of a long hut at the head of the Nant Carfan stream; shelters on Mynydd Lluest Fach and Mynydd Nantcarfan; and the element *lluest* in the name Mynydd Lluest Fach suggests the location of a former shepherd's hut. Upland improvement, possibly of post-medieval date, is suggested by a number of clearance cairns on Mynydd Lluest Fach. Peat cutting, possibly in the post-medieval period is indicated by a peat-drying platform on Mynydd Nantcarfan. Some bog areas may survive which are of significance to the environmental and land use history of the area.

Carnedd Wen HLCA 6

1.1.24 This HLCA area comprises extensive 20th-century conifer plantation on undulating upland plateau and more steeply-sloping hill edge, between a height of 200-520 metres OD, superimposed upon an area of largely unenclosed moorland with areas of residual ancient broadleaved woodland and scrub on some of the hillslopes. The area includes the large natural lake of Llyn Coch-hwyad and the smaller lake known as Llyn Twrchyn. There are no extant settlements in the area. Some indication of historic land use and settlement in the area is provided by placename evidence. Former rough grazing enclosed from the mountain is indicated by the element *ffridd* in the names Fridd Uchaf and Ffridd Ganol on the slopes above the Afon Cwm in the southern part of the area. Likewise, upland pasture is indicated by the element *gwaun* in the name Waun Pwll-budr. A former clearing is indicated by the element *llannerch* in Llannerch Wen on the southeast side and A small former habitation on the northern edge of the area is suggested by the name Hendy ('old house'). The possible former significance of wildfowl resources is hinted at in the element *hwyad* ('duck') in the Nant Llyn Cochhwyad and *ysguthan* ('wood pigeon') in Nant Ysguthan. Prehistoric land use and settlement in the area is indicated by the hoard of middle Bronze Age bronze axes found in peat near Llidiart y Barwin towards the northern side of the HLCA area, and hill-top burial mounds on Ffridd Goch, Carnedd y Cylch and Nant y Bwlch. Former settlement of possibly post-medieval origin, pre-dating afforestion, is represented by the former house sites on the Nant Llyn Coch-hwyad stream, at Ty Coch Hwyad and just above enclosed land towards the northern side of the area at Hendy. Several small disused stone quarries on Ffridd Uchaf and Carnedd y Cylch were probably opened for extracting building stone in the post-medieval period. A number of former sheepfolds of probably post-medieval date are recorded in the area. There are a number of waterlogged deposits in the HLCA area which are of potential significance to its environmental and land use history including those associated with Llyn Coch-hwyad and Llyn Twrchyn and within a number of stream valleys.

Llyn Gwyddior HLCA 8

1.1.25 The HLCA area comprises predominantly enclosed moorland on the upland plateau and hill edge, with some areas of 20th-century conifer plantation between a height of about 290-490 metres OD, and the small natural upland lake of Llyn Gwyddior. Many of the existing boundaries appear to date from the period between the late 19th century and the 20th century. There are no extant settlements in the area. Some evidence of historic land use is suggested by placename evidence. The element *gwaun (*'mountain grazing') in the name Waun Lwyd indicates a traditional association with upland grazing. The element mawn ('peat') in Esgair Mawn indicates waterlogged conditions. The area includes an abandoned farmstead and barn of probable post-medieval date at Rhaiadr Du as well as several sheepfolds which also belong to this period. Some small bog areas and deposits associated with Llyn Gwyddior are of potential significance to the environmental and land use history of the HLCA area.

Cerrig y Tan HLCA 9

1.1.26 Cerrig y Tan HLCA area predominantly comprises improved pasture forming a patchwork of large irregular fields, mostly on west-facing hillslopes on the upland edge associated with more low-lying farms of medieval and later origin in the valley of the Afon Rhiwsaeson. There are no extant settlements in the area. The presence of the late 18th to early 19th-century farmhouse of estate character at Cwm Pen Llydan on the north-west boundary of the area, suggests the influence of estate management on the enclosure of hill land during this period. Prehistoric land use is suggested by the ridge-top Bronze Age burial mound on Ffridd Cwm y Ffynnon and the top-of-slope burial mound on Ffridd Pwll y Warthol which may indicate the early exploitation of upland grazing by a number of different communities. The historic use of the area for upland grazing by communities to the west, possibly even before enclosure in the medieval and early post-medieval periods, is emphasised by the frequency of *ffridd* placenames in the character area, including Ffridd Caeaugleision, Ffridd Esgairgelynen, Ffridd Cwmffynnon, Ffridd Pwllmelyn, and Hen Ffridd ('old ffridd'). The possible presence of seasonal habitations associated with upland grazing is suggested by the nearby placename Hafodowen containing the element *hafod* ('summerhouse') which is first recorded in a late 12th-century charter of Strata Marcella abbey.

Penylan Gwynion HLCA 10

1.1.27 HLCA 10 is represented by 20th-century conifer plantation occupying upland plateau and some more steeply sloping hill edge, between a height of about 310-440 metres OD, superimposed upon a former area of unenclosed moorland crossed by several trackways. There are no extant settlements in the area. Rocky outcrops in the area are indicated by the placename element *carreg* ('stone', 'rock') in the names Post Carreg and Carreg y Fran ('crow's rock'). Former upland grazing is suggested by the element *gwaun* ('mountain pasture') in the name Waun y Sarn, in which the element *sarn* ('road, causeway') probably refers to an earlier trackway. Some small ponds and bog areas which existed prior to afforestation are likely to survive within the area, which may be of significance to its environmental and land use history. Little of archaeological significance has so far been recorded in the area. Several small quarries appear to be associated with the construction of relatively recent access roads built in the forestry plantation.

Bryn Gwyn HLCA 11

1.1.28 HLCA 11 comprises a compact area of post-medieval enclosed moorland and small, modern conifer plantations around the headwaters of Afon Gam stream, between a height of about 300-420 metres OD, with some areas of small fields suggesting medieval to early post-medieval upland encroachment. There are no extant settlements in the area. Prehistoric land use is suggested by the burial mound sited at the top of a hill slope on Esgair Priciau. A seasonal settlement in the medieval to early post-medieval pattern is suggested by the *hafod* ('summerhouse') placename element in Mynydd Hafod-y-Foel in the southern part of the area. A pattern of small fields at Pentre-lludw suggests an encroachment on the former upland common in the medieval or early post-medieval period. Rural depopulation in possibly the late 19th to 20th centuries is suggested by abandoned farmsteads and relict field systems, such as the abandoned buildings at Prys Gwyn Gyll and Pentre Lludw Uchaf, and including a number superimposed by modern conifer plantations, as at Ty'n y Gors and Bryn Gwyn. The Glyndwr's Way National Trail runs along the southern edge of this area.

Pen Coed HLCA 12

1.1.29 This HLCA area comprises an extensive area of enclosed moorland between a height of generally 290-360 metres OD, substantial parts of which are registered Common Land. The area is subdivided into large, straight-sided polygonal enclosures that were probably created during the course of the 19th century. Several discrete encroachments are represented by small, curvilinear field patterns surrounding the now abandoned settlements at Bwlch-y-ffrith, Lluest and elsewhere which are probably of medieval or post-medieval origin. There are no extant settlements in the area. Some indication of historic land use and settlement is provided by placename evidence. The significance of former rough grazing enclosed from the mountain is probably indicated by the many placenames including the element *ffridd*: Fridd Goch; Nant y Ffridd; Nant Ffriddycastell; Bwlch-y-ffridd; and Blaen y Ffridd. The placename Lluest attached to an upland encroachment probably signifies a former shepherd's or crofter's hut. Prehistoric land use is suggested by the Bronze Age hilltop burial mound on a spur of Pen y Coed hill. Seasonal settlement associated with the exploitation of upland pasture in the medieval to early post-medieval period is suggesed by former building platforms at Cenuant Du, sited near the crest of steep south-east facing valley slope of Nant y Esgair, by house platforms and drystone footings on the bank of the Nant Ffridd Goch and Nant Graig y Fran streams. Former cultivation is possibly indicated by clearance cairns on Ffridd Goch and by relict field banks on eastern side of Pen y Coed suggesting some earlier enclosure of the upland common in the medieval to early post-medieval period. Some bog areas may survive which are of significance to the environmental and land use history of the area. The HLCA area is crossed by the Glyndwr's Way National Trail.

Ffrith Fawr HLCA 13

1.1.30 This area comprises a pattern of dispersed farms, small and large irregular fieldscapes on lower hillslopes and tributary valleys of the Afon Laen and Afon Cam, generally between a height of 250-420 metres OD. Present-day settlement is represented by several dispersed farms. Placename evidence provides some indication of the historic land use and vegetation of the area. Rough grazing enclosed from the mountain is indicated by the element *ffridd* in the names Ffridd Fawr, Ffridd Cwmderwen, and Peny- ffridd and by the element *rhos* in Rhosydd 'moorland'. Gorse is indicated by the element *eithin* in Eithin Gleision and Eithin-llwyn. Trees are indicated by the element *llwyn* ('grove, bush') in Eithin-llwyn and by *derwen* ('oak') in Cwmderwen. Traditional meadow land is suggested by the element *dol* in Dol-y-garreg-wen-isaf and Dolau-ceimion. There is widespread evidence of rural depopulation in the area, probably during the late 19th and 20th centuries, represented by abandoned farms and cottages and farm amalgamations. Derelict or abandoned farms, cottages and field barns (some possibly representing earlier house sites) including those at Traws Nant, Pant y Gareg, Nant yr Cyra, Troed yr Ffordd, Castell-y-gwynt, Aber-ucha, Mynydd yr Aber, Troed-yr-esgair-wen, Pen-y-ffridd, Dol-y-gareg-wenuchaf, and Nant-yr-eira. A number of these may have originated as seasonally occupied settlements associated with upland grazing in the late medieval and early post-medieval periods, including those, for example, at Moel Gloria and Caban and a shelter at Mynydd yr Aber. Abandoned and relict field systems have also been recorded in parts of area, as for example near Fawnog-fawr farm and alongside the Afon Canon stream, with boundaries of banks and ditches or collapsing drystone walls. There are possible traces of former peat cutting in the area. Some boggy areas survive which may be of significance to the environmental and land use history of the area. The area is crossed by the Caersws to Abbey Cwmhir section of the unofficial Cistercian Way long-distance footpath.

Fridd Rhyd HLCA 14

1.1.31 This HLCA area comprises 20th-century conifer woodland overlying former unenclosed moorland and marginal farmsteads in stream valleys between a height of about 270-420 metres OD. Prior to afforestation the area formed unenclosed moorland with relict abandoned field systems associated with abandoned farms and house sites in stream valleys, including former farmsteads of Sychnant and Rhyd-ddu of possibly medieval or later origin. There are no extant settlements in the area. Some indication of historic land use patterns is provided by placename evidence. Mountain pasture is indicated by the element *gwaun* in the names Waun Ffridd-fawr and Waun Rhyd-ddu. The existence of former rough grazing enclosed from the mountain is probably indicated by the element *ffridd* in the names Waun Ffridd-fawr, Ffridd- Rhyd-Ddu. An association with animal and horse husbandry is suggested by the element *lloi* ('calves') in Bryn y Lloi, the element *ceirch* ('horse') in the name Cwm Blawd-ceirch ('horse-fodder cwm') and *ebolion* ('colt') in Cors yr Ebolion ('Colt's Bog'). A number of sheepfolds are recorded which are probably of post-medieval date. Some bog areas may survive which are of significance to the environmental and land use history of the area.

Defining Features of the Historic Landscape Character Areas

1.1.32 The primary defining features of the HLCAs relate to the former and present day agricultural landscape. Not all landscape elements are present in all character areas.

Vegetation history

1.1.33 Pollen studies undertaken at Carneddau near Carno in the late 1980s have produced a record of the sequence of vegetation change since about 10000 BC, which may be relevant to the region as a whole. During the early Mesolithic period the area was first colonized by birch trees. Between about 9,500-8,500 BC hazel scrub and woodland expanded into the region. Mixed forest with pine, oak, birch, elm, hazel and later alder developed from about 8500 BC. From about 7000 BC, other woodland types (notably pine) were gradually replaced by alder. From about 6000-5800 BC, during the late Mesolithic period, as the climate became wetter, blanket peats began to develop across the hillsides.

1.1.34 From about 3800 BC, at the transition from the Mesolithic to the Neolithic period, the rate of woodland decline increased, perhaps due partly to natural climate and environmental change, but possibly also due to human activity. Open woodland and heathland developed. At about 1400-1300 BC clearance of woodland cover on the upland plateau and the development of pastoral and arable farming had a major effect on the landscape. This continued into the Roman period, to about AD 250. Subsequent episodes of woodland regeneration are possibly associated with reduced human activity, before the modern grassland and open heathland vegetation became established, probably during the medieval period.

1.1.35 Peat deposits, other waterlogged sediments and ancient buried soils which may survive within the area can provide important reservoirs of information relating to climate and vegetation history and to the history of land use, and therefore have significant archaeological potential.

Administrative boundaries

1.1.36 The characterized areas lie within the present-day county of Powys but formerly lay within the historic county of Montgomeryshire and the ecclesiastical tithe parishes of Cemmais, Garthbeibio, Llanbrynmair, Llanerfyl, and Llangadfan. The tithe parishes were first consistently mapped in the 19th-century, though most of them originated in the medieval period.

1.1.37 These administrative boundaries and other influences such as the grange of the medieval Cistercian abbey of Strata Marcella and the large land-owning estates which became prominent during the 18th and 19th centuries, have effected the subdivision of upland commons and the development of settlement and field patterns within the region.

Settlement history

1.1.38 Within most of the LCAs there is little or no modern settlement. Many of these areas (including areas of conifer plantation and upland moorland), however, contain evidence of settlement in earlier times. The presence of prehistoric burial and ritual monuments suggests that settlement was much more widespread during this period. The upland settlement appears to relate to a warmer, dryer climate during the early Prehistoric period, ending in the late Bronze Age. Settlement and exploitation of the study area during the late Prehistoric period and the Roman period is less apparent, based on existing evidence. Evidence of settlement during the early medieval, medieval and post-medieval periods, is more apparent, including standing buildings, place names and historical map evidence. Many existing dispersed farms and cottages with medieval or early post-medieval buildings may have earlier origins. Upland settlement appears to relate to transhumance of possible early origin. In the post medieval period, new farms and smallholdings developed during the 19th century as a result of the enclosure of moorland and marginal areas. Rural depopulation in the 19th and 20th centuries is represented by the abandonment of many of these outlying farms and cottages, giving rise to distinctive landscapes of demolished or derelict farmhouses and isolated barns. In some instances abandoned and derelict farm complexes now lie within modern conifer woodlands. Some apparently later settlement sites may occupy sites which were first inhabited many centuries ago.

Land use patterns

1.1.39 Evidence of the extent and nature of former land use patterns is provided by various sources including present-day land use, field patterns, settlement and place name evidence. Field boundaries are a significant landscape feature regardless of their condition. They contribute to the character of the landscape and reflect changes in land management, property divisions and other aspects of human impact upon the landscape. In their current state the field boundaries are a key indicator of the antiquity of the agricultural landscape. They relate to documentary evidence for the ownership of land holdings. They help to define the change in land-use between settlement and enclosed farmland.

1.1.40 Most of the field systems appear to be of post-medieval origin and character, although place-name evidence suggests the area was probably exploited as seasonal rough grazing land, probably since medieval times. Lower-lying land below or on the mountain edge often takes the form of large and small irregular fields which generally appear to represent a gradual process of woodland clearance and enclosure from at least the medieval period or as a result of the process of encroachment upon former common pasture, probably mostly during the late medieval and early post-medieval periods.

1.1.41 Some surviving areas of enclosed moorland and rough pasture survive as registered Common Land. Other areas are too steep or marginal to have made agricultural or other exploitation possible, other than as rough grazing.

1.1.42 The dominant land use in the study area at the present day is associated with various aspects of sheep rearing. Structures probably to be associated with sheep grazing in the post-medieval period such as drystone sheepfolds, sheep shelters and temporary human shelters are numerous. Placename evidence however, suggests that cattle rearing and dairying may historically have been just as important.

Forestry

1.1.43 The LCAs include some areas entirely consisting of extensive forestry plantation, while other areas contain smaller parcels of forestry plantation. These forested areas, established in the 20th century, were generally formerly unenclosed moorland or earlier fieldscapes. Place name evidence suggests the land has probably been used for seasonal grazing since medieval times.

Prehistoric burial and ritual activity

1.1.44 Although there is evidence of prehistoric activity in the landscape character areas (mostly in the form of funerary and ritual monuments), these are generally isolated and widely spaced, occurring either as single monuments or small clusters.

1.1.45 Most of these monument types probably belong to the period between the late Neolithic period and the middle to late Bronze Age, but monuments of these kinds continued to be observed and respected long after they had ceased to be used, sometimes as important land markers. The monuments provide important evidence of past human activity and interaction with the landscape. Few of the sites appear to be associated with evidence of settlement but they represent the best evidence we have for the general extent of early settlement and land use in the area.

1.1.46 The landscape setting of prehistoric burial and ritual monuments is also of significance. They are often located on or near hilltops or ridges, presumably to visually dominate territory.

Roads and tracks

1.1.47 Some roads and tracks are of relatively recent origin, whereas others are probably of much greater antiquity - connecting farms, providing access to upland grazing and linking communities across moorland. Some of the tracks are associated with sheepfolds on the upland edge - gathering points for sheep being taken up or down the hill at certain times of the year.

1.4 STAGE 2 - Assessment of Direct, Physical Impact of Development

1.1.48 In Stage 2, direct physical effects are assessed in relation to a range of considerations described in the ASIDOHL methodology (absolute, relative and landscape value).

Intrinsic Importance of Landscape Features (Site Category)

1.1.49 Based upon HLCA descriptions, information gathered during fieldwork, research undertaken for the Archaeology and Cultural Heritage baseline study and EIA, and other sources of landscape evaluation such as Landmap, the relative importance of the various landscape elements considered in defining landscape character have been used to attribute the following extrinsic landscape values to each HLCA under consideration.

1.1.50 Because feature types have been grouped together for consideration, individual sites that might be afforded SAM status (being of national importance) do not necessarily raise the overall value of that landscape element.

1.1.51 The scores for each landscape element are based on the following criteria, and as presented in the ASIDOHL methodology:

Table 4.7.3

Site Category	Definition of Site Category	Score
High (A)	Features of national importance - Scheduled Ancient Monuments, Listed buildings Grade I and II*, well preserved historic landscapes, registered parks and gardens and historic battlefields	4
Medium (B)	Non-scheduled sites of regional or county importance. Listed Buildings Grade II, reasonably preserved historic landscapes	3
Low (C)	Features of district or local importance but generally common features at a national or regional level	2
Negligible (D)	Minor sites or sites so badly damaged that too little now remains to justify their inclusion in a higher grade	1
Unknown (U)	Features about which insufficient is known to attribute them to a higher rank, or which cannot be sufficiently accurately located to justify their consideration	1

Settlement

1.1.52 Settlement features are of local importance to landscape character, but their general ubiquity in the wider region and absence of special features unique to the character area prevents the attribution of higher landscape importance value.

Enclosed and unenclosed moorland/rough pasture

1.1.53 Land use and associated features are of local importance to landscape character. Although not unique within the wider region, areas of unenclosed upland common land are becoming increasingly rare and are considered to be valuable landscapes with important historical features and associations. Areas of moorland and rough pasture in these HLCAs have therefore been given a regionally important ranking but their lack of special status attribution prevents their inclusion in a higher landscape importance rank.

Forestry

1.1.54 Areas of modern plantation forestry are here considered to be of negligible value to historic landscape character.

Field systems

1.1.55 Field systems are of local importance to landscape character, but their general ubiquity in the wider region and absence of special or unique features prevents the attribution of higher landscape importance value.

Prehistoric funerary and ritual monuments

1.1.56 As discussed previously in this assessment, prehistoric funerary and ritual monuments are of local importance to landscape character. Although some individual examples (and groups) have been afforded SAM status, the generally low numbers and sparse distribution of these features considered in the HLCAs, and the presence of similar features in other areas, do not warrant their inclusion in the highest landscape value rank. In some HLCAs, there is potential for as yet unidentified prehistoric funerary monuments to exist, warranting their 'U' (unknown) ranking.

Summary of intrinsic landscape value/sensitivity

1.1.57 In light of the above discussion, the following intrinsic values have been attributed to the landscape elements considered (based on scores within table 4.7.3):

Table 4.7.9

Landscape feature	Value of Landscape element to HLCA	Score
Field Systems	C	2
Settlement	C	2
Enclosed and unenclosed moorland	B	3
Forestry	D	1
Prehistoric funerary and ritual monuments	B	3

Physical Impact in Absolute Terms

1.1.58 It should be noted that the HLCAs extend beyond the limits of the proposal. The area of proposed windfarm development lies to varying extent within parts of HLCAs 6 (total area approx. 2199ha), 8 (total area approx. 470ha), 9 (total area approx. 479ha), 11 (total area approx. 473ha), 12 (total area approx. 772ha) and 13 (total area approx. 906ha).

1.1.59 Although the development envelope can occupy a relatively large percentage of an HLCA, the actual area of direct physical impact to the surface area of the HLCA is much less, due to the dispersed nature of windfarm development. To provide an area for use in calculating the magnitudes of direct physical impact, 'over-generous' polygons (in terms of the area they cover) were drawn around the proposed tracks and turbine locations. In reality the physical impact will be less.

1.1.60 The absolute impact of the development proposal upon the HLCAs considered has been calculated using the following grading system:

Table 4.8.3

Magnitude of absolute physical impact		Grading	Score
75-100%	Permanently lost or removed	Very Severe	6
50-74%	Permanently lost or removed	Severe	5
30-49%	Permanently lost or removed	Considerable	4
15-29%	Permanently lost or removed	Moderate	3
5-14%	Permanently lost or removed	Slight	2
0-4%	Permanently lost or removed	Very Slight	1

1.1.61 Based on the above table (4.8.3), the following absolute physical impacts are estimated for all the HLCAs considered in this ASIDOHL:

Table 4.8.4

HLCA	Magnitude of absolute impact	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	1% Very Slight	1
Llyn Gwyddior HLCA 8	6% Slight	2
Cerrig y Tan HLCA 9	8% Slight	2
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	7% Slight	2
Pen Coed HLCA 12	3% Very Slight	1
Ffrith Fawr HLCA 13	6% Slight	2
Fridd Rhyd HLCA 14	None	0

Physical Impact In Relative Terms

1.1.62 The proposed development will only have direct physical impact in HLCAs (or parts of them) that lie within the proposal area. Only a very small percentage of the landscape elements of the HLCAs will be affected at all.

1.1.63 Relative physical impact is graded according to the following criteria, which is then used in to calculate the results for Tables 4.9.3 to 4.9.7:

Table 4.9.2

Magnitude of relative physical impact		Grading	Score
75-100%	Permanently lost or removed	Very Severe	6
50-74%	Permanently lost or removed	Severe	5
30-49%	Permanently lost or removed	Considerable	4
15-29%	Permanently lost or removed	Moderate	3
5-14%	Permanently lost or removed	Slight	2
0-4%	Permanently lost or removed	Very Slight	1

Field systems

1.1.64 Only parts of five of the ten HLCAs will be physically impacted upon. In those that are, only a very small proportion of the total area will be affected. Very few (if any at all) landscape elements relating to field systems will be affected. The 'very slight' magnitude of impact assigned to the relevant HLCAs is effectively precautionary and does not necessarily imply there will be any impact.

Table 4.9.3

HLCA	Magnitude of relative impact	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	Very slight	1
Cerrig y Tan HLCA 9	Very slight	1
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	Very slight	1
Pen Coed HLCA 12	Very slight	1
Ffrith Fawr HLCA 13	Very slight	1

HLCA	Magnitude of relative impact	Score
Fridd Rhyd HLCA 14	None	0

Settlement

1.1.65 The design of the proposed development has avoided any direct impact upon any known settlement features.

Table 4.9.4

HLCA	Magnitude of relative impact	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	None	0
Cerrig y Tan HLCA 9	None	0
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	None	0
Pen Coed HLCA 12	None	0
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Enclosed and unenclosed moorland/rough pasture

1.1.66 Of those HLCAs (or parts of them) for which any direct impact will occur, the proportions of the total area of each HLCA and the characteristic land use elements they contain which will be affected will be very slight.

Table 4.9.5

HLCA	Magnitude of relative impact	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	Very slight	1
Cerrig y Tan HLCA 9	Very slight	1

HLCA	Magnitude of relative impact	Score
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	None	0
Pen Coed HLCA 12	Very slight	1
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Forestry

1.1.67 Only very small areas of forestry will be affected by the proposal.

Table 4.9.6

HLCA	Magnitude of relative impact	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	Very slight	1
Llyn Gwyddior HLCA 8	Very slight	1
Cerrig y Tan HLCA 9	None	0
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	Very slight	1
Pen Coed HLCA 12	None	0
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Prehistoric funerary and ritual monuments

1.1.68 All known prehistoric funerary and ritual sites and appropriate buffer zones around them have been avoided at the design stage to minimise the likelihood of any possible impact upon these landscape elements.

Table 4.9.7

HLCA	Magnitude of relative impact	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	None	0
Cerrig y Tan HLCA 9	None	0
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	None	0
Pen Coed HLCA 12	None	0
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Landscape Value

1.1.69 The extrinsic value for each landscape element to each of the HLCAs considered is then judged according to Table 4.10.1 below as presented in the ASIDOHL, and then used to assign the scores within Tables 4.10.2 – 4.10.6:

Table 4.10.1

Value of landscape element to HLCA	Score
Very High	6
High	5
Considerable	4
Medium	3
Low	2
Very Low	1

Field systems

1.1.70 The extrinsic landscape value of field systems is greater in areas of enclosed agricultural land than in unenclosed moorland or forestry.

Table 4.10.2

HLCA	Value of Landscape element to HLCA	Score
Nant Carfan HLCA 3	Very High	6
Mynydd Lluest Fach HLCA 5	Very Low	1
Carnedd Wen HLCA 6	Very Low	1
Llyn Gwyddior HLCA 8	Very Low	1
Cerrig y Tan HLCA 9	Medium	3
Penylan Gwynion HLCA 10	Very Low	1
Bryn Gwyn HLCA 11	Medium	3
Pen Coed HLCA 12	Very Low	1
Ffrith Fawr HLCA 13	Very High	6
Fridd Rhyd HLCA 14	Very Low	1

Settlement

1.1.71 The extrinsic landscape value of settlement is greater in areas of enclosed agricultural land than in unenclosed moorland or forestry, but is generally low due to low settlement density.

Table 4.10.3

HLCA	Value of Landscape element to HLCA	Score
Nant Carfan HLCA 3	Medium	3
Mynydd Lluest Fach HLCA 5	Very Low	1
Carnedd Wen HLCA 6	Very Low	1
Llyn Gwyddior HLCA 8	Very Low	1
Cerrig y Tan HLCA 9	Very Low	1
Penylan Gwynion HLCA 10	Very Low	1
Bryn Gwyn HLCA 11	Very Low	1
Pen Coed HLCA 12	Very Low	1
Ffrith Fawr HLCA 13	Medium	3
Fridd Rhyd HLCA 14	Very Low	1

Enclosed and unenclosed moorland/rough pasture

1.1.72 The extrinsic landscape value of enclosed and unenclosed moorland/rough pasture is greater in areas of unenclosed moorland than in enclosed agricultural land or forestry.

Table 4.10.4

HLCA	Value of Landscape element to HLCA	Score
Nant Carfan HLCA 3	Low	2
Mynydd Lluest Fach HLCA 5	Very High	6
Carnedd Wen HLCA 6	Very Low	1
Llyn Gwyddior HLCA 8	Very High	6
Cerrig y Tan HLCA 9	Medium	3
Penylan Gwynion HLCA 10	Very Low	1
Bryn Gwyn HLCA 11	Medium	3
Pen Coed HLCA 12	Very High	6
Ffrith Fawr HLCA 13	Low	2
Fridd Rhyd HLCA 14	Very Low	1

Forestry

1.1.73 The extrinsic landscape value of forestry is greater in areas of enclosed agricultural land and forestry than in unenclosed moorland, but is generally low.

Table 4.10.5

HLCA	Value of Landscape element to HLCA	Score
Nant Carfan HLCA 3	Low	2
Mynydd Lluest Fach HLCA 5	Very Low	1
Carnedd Wen HLCA 6	Very High	6
Llyn Gwyddior HLCA 8	Low	2
Cerrig y Tan HLCA 9	Very Low	1
Penylan Gwynion HLCA 10	Very High	6
Bryn Gwyn HLCA 11	Low	2
Pen Coed HLCA 12	Very Low	1
Ffrith Fawr HLCA 13	Very Low	1

HLCA	Value of Landscape element to HLCA	Score
Fridd Rhyd HLCA 14	Very High	6

Prehistoric funerary and ritual monuments

1.1.74 The extrinsic landscape value of Prehistoric funerary and ritual monuments is generally greater in areas of unenclosed moorland than in enclosed agricultural land or forestry, but is generally low due to low density of such features.

Table 4.10.6

HLCA	Value of Landscape element to HLCA	Score
Nant Carfan HLCA 3	Very Low	1
Mynydd Lluest Fach HLCA 5	Very High	6
Carnedd Wen HLCA 6	Very Low	1
Llyn Gwyddior HLCA 8	Considerable	4
Cerrig y Tan HLCA 9	High	5
Penylan Gwynion HLCA 10	Very Low	1
Bryn Gwyn HLCA 11	Considerable	4
Pen Coed HLCA 12	Very High	6
Ffrith Fawr HLCA 13	Very Low	1
Fridd Rhyd HLCA 14	Very Low	1

Summary of extrinsic landscape value/sensitivity

1.1.75 The following table presents the sum of the extrinsic landscape values and the overall extrinsic landscape value for each HLCA as defined in Table 4.10.1 and laid out in tables 4.10.2 – 4.10.6

Table 4.10.7

HLCA	Sum value of landscape elements	Average Score and Rounding to Nearest Integer	Overall landscape value	Score
Nant Carfan HLCA 3	6+3+2+2+1= 14	14÷5= 2.8 ➔ 3	Medium	3
Mynydd Lluest Fach HLCA 5	1+1+6+1+6= 15	15÷5= 3 ➔ 3	Medium	3
Carnedd Wen HLCA 6	1+1+1+6+1= 10	10÷5= 2➔ 2	Low	2
Llyn Gwyddior HLCA 8	1+1+6+2+4= 14	14÷5= 2.8 ➔ 3	Medium	3
Cerrig y Tan HLCA 9	3+1+3+1+5= 13	13÷5= 2.6 ➔ 3	Medium	3

HLCA	Sum value of landscape elements	Average Score and Rounding to Nearest Integer	Overall landscape value	Score
Penylan Gwynion HLCA 10	1+1+1+6+1= 10	10÷5= 2 ➔ 2	Low	2
Bryn Gwyn HLCA 11	3+1+3+2+4= 13	13÷5= 2.6 ➔ 3	Medium	3
Pen Coed HLCA 12	1+1+6+1+6= 15	15÷5= 3 ➔ 3	Medium	3
Ffrith Fawr HLCA 13	6+3+2+1+1= 13	13÷5= 2.6 ➔ 3	Medium	3
Fridd Rhyd HLCA 14	1+1+1+6+1= 10	10÷5=2 ➔ 2	Low	2

Landscape Value Effects

1.1.76 Only in those HLCAs within which part of the proposal area lies, will there be any direct physical impact on landscape value at all. The proportion of area directly impacted is very small in relation to the total area, therefore landscape value effects will be very slight. The loss of these small portions of the HLCAs and their landscape components will not materially affect the physical landscape character of the HLCAs. This section does not consider visual or perceptual effects.

1.1.77 The following criteria (table 4.11.2) are used in evaluating the magnitude of effect of the development upon landscape value, and these are then assigned to the landscape elements in tables 4.11.3 to 4.11.7:

Table 4.11.2

Magnitude of physical effect on landscape value	Score
Lost	6
Substantially reduced	5
Considerably reduced	4
Moderately reduced	3
Slightly reduced	2
Very slightly reduced	1
None	0

Field systems

1.1.78 The landscape value of field systems will only be very slightly affected in the following HLCAs:

Table 4.11.3

HLCA	Magnitude of physical impact on Landscape value	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	Very Slight	1
Cerrig y Tan HLCA 9	Very Slight	1
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	Very Slight	1
Pen Coed HLCA 12	Very Slight	1
Ffrith Fawr HLCA 13	Very Slight	1
Fridd Rhyd HLCA 14	None	0

Settlement

1.1.79 There will be no physical impact upon the landscape value of settlement features in the HLCAs considered.

Table 4.11.4

HLCA	Magnitude of physical impact on Landscape value	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	None	0
Cerrig y Tan HLCA 9	None	0
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	None	0
Pen Coed HLCA 12	None	0
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Enclosed and unenclosed moorland/rough pasture

1.1.80 The total area of land impacted upon in relation to the total areas of the HLCAs means direct physical impact upon these landscape value elements will be very slight. Visual effects on this landscape element are considered in Stage 3 B.

Table 4.11.5

HLCA	Magnitude of physical impact on Landscape value	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	Very Slight	1
Cerrig y Tan HLCA 9	Very Slight	1
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	None	0
Pen Coed HLCA 12	Very Slight	1
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Forestry

1.1.81 Where it occurs at all, the magnitude of the physical impact of the development upon the landscape value of parts of the HLCAs which contain forestry is very slight.

Table 4.11.6

HLCA	Magnitude of physical impact on Landscape value	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	Very Slight	1
Llyn Gwyddior HLCA 8	Very Slight	1
Cerrig y Tan HLCA 9	None	0
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	Very Slight	1

HLCA	Magnitude of physical impact on Landscape value	Score
Pen Coed HLCA 12	None	0
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Prehistoric funerary and ritual monuments

1.1.82 There will be no direct physical impact upon this aspect of HLCA landscape value. Visual effects on this landscape element are considered in Stage 3 B.

Table 4.11.7

HLCA	Magnitude of physical impact on Landscape value	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	None	0
Cerrig y Tan HLCA 9	None	0
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	None	0
Pen Coed HLCA 12	None	0
Ffrith Fawr HLCA 13	None	0
Fridd Rhyd HLCA 14	None	0

Calculation Of Overall Direct Physical Impact

1.1.83 The overall magnitude of direct physical impact is calculated using the following scale (table 4.12.1). In calculating averages, decimal values have been rounded up or down to the nearest whole number unless this is considered to unduly distort the degree of significance of any effect.

Table 4.12.1

Overall Magnitude of Direct Physical Impact	
Score	Grading
24-28	Very Severe
19-23	Severe
14-18	Considerable

Overall Magnitude of Direct Physical Impact	
Score	**Grading**
9-13	Moderate
4-8	Slight
0-3	Very Slight

***Nant Carfan* HLCA 3**

1.1.84 The following table and calculations present the overall direct physical impact of the Proposal upon Nant Carfan HLCA.

Table 4.12.2

Absolute Impact (Loss Of Area)			Magnitude & Score	
0 %			**None - 0**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0 %	C - 2	None - 0	Very High - 6	Unaffected: 0
Settlement 0 %	C - 2	None - 0	Medium - 3	Unaffected: 0
Moorland/rough pasture 0 %	B - 3	None - 0	Low - 2	Unaffected: 0
Forestry 0 %	D - 1	None - 0	Low - 2	Unaffected: 0
Prehistoric monuments 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0

The average score for the direct, physical impact on **Nant Carfan HLCA**

= 7 + 5 + 5 + 3 + 4 ÷ 5 = 4.8 → 5

The average score is then added to the score for the magnitude of absolute impact:

5 + 0 = 5 = **Slight (Actually no direct physical impact at all)**

Mynydd Lluest Fach HLCA 5

1.1.85 The following table and calculations present the overall direct physical impact of the Proposal upon Mynydd Lluest Fach HLCA.

Table 4.12.3

Absolute Impact (Loss Of Area)			Magnitude & Score	
0 %			**None - 0**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Moorland/rough pasture 0 %	B - 3	None - 0	Very High - 6	Unaffected: 0
Forestry 0 %	D - 1	None - 0	Very Low - 1	Unaffected: 0
Prehistoric monuments 0 %	B - 3	None - 0	Very High - 6	Unaffected: 0

The average score for the direct, physical impact on **Mynydd Lluest Fach HLCA**

= 3 + 3 + 9 + 2 + 9 ÷ 5 = 5.2 ➔ 5

The average score is then added to the score for the magnitude of absolute impact:

5 + 0 = 5 = **Slight (Actually no direct physical impact at all)**

Carnedd Wen HLCA 6

1.1.86 The following table and calculations present the overall direct physical impact of the Proposal upon Carnedd Wen HLCA.

Table 4.12.4

Absolute Impact (Loss Of Area)			Magnitude & Score	
Approx 1.0%			**Very Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Moorland/rough pasture 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0
Forestry 0 - 4%	D - 1	V. Slight - 1	Very High - 6	Slightly reduced: 1

Absolute Impact (Loss Of Area)			Magnitude & Score	
Approx 1.0%			**Very Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Prehistoric monuments 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0

The average score for the direct, physical impact **Carnedd Wen HLCA**

= 3 + 3 + 4 + 9 + 4 ÷ 5 = 4.6 ➔ 5

The average score is then added to the score for the magnitude of absolute impact:

5 + 1 = 6 = **Slight overall magnitude of direct physical impact**

Llyn Gwyddior HLCA 8

1.1.87 The following table and calculations present the overall direct physical impact of the Proposal upon Llyn Gwyddior HLCA.

Table 4.12.5

Absolute Impact (Loss Of Area)			Magnitude & Score	
Approx 6.0%			**Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0 - 4%	C - 2	V. Slight - 1	Very Low - 1	Slightly reduced: 1
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Moorland/rough pasture 6.0%	B - 3	Slight - 1	Very High - 6	Slightly reduced: 1
Forestry 0 - 4%	D - 1	V. Slight - 1	Low - 2	Slightly reduced: 1
Prehistoric monuments 0 %	B - 3	None - 0	Considerable - 4	Unaffected: 0

The average score for the direct, physical impact on **Llyn Gwyddior HLCA**

5 + 3 + 11 + 5 + 7 ÷ 5 = 6.2 ➔ 6

The average score is then added to the score for the magnitude of absolute impact:

6 + 1 = 7 = **Slight overall magnitude of direct physical impact**

Cerrig y Tan HLCA 9

1.1.88 The following table and calculations present the overall direct physical impact of the Proposal upon Cerrig y Tan HLCA.

Table 4.12.6

Absolute Impact (Loss Of Area) **Approx 8.0%**			Magnitude & Score **Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0 - 4%	C - 2	V. Slight - 1	Medium - 3	Slightly reduced: 1
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Moorland/rough pasture 8.0%	B - 3	Slight - 1	Medium - 3	Slightly reduced: 1
Forestry 0 %	D - 1	None - 0	Very Low - 1	Unaffected: 0
Prehistoric monuments	B - 3	None - 0	High - 5	Unaffected: 0

The average score for the direct, physical impact on **Cerrig y Tan HLCA**

= 6 + 3 + 8 + 2 + 8 ÷ 5 = 5.4 → 5

The average score is then added to the score for the magnitude of absolute

impact: 5 + 1 = 6 = **Slight overall magnitude of direct physical impact**

Penylan Gwynion HLCA 10

1.1.89 The following table and calculations present the overall direct physical impact of the Proposal upon Penylan Gwynion HLCA.

Table 4.12.7

Absolute Impact (Loss Of Area) **0%**			Magnitude & Score **None - 0**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0

Absolute Impact (Loss Of Area)			Magnitude & Score	
0%			**None - 0**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Moorland/rough pasture 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0
Forestry 0 %	D - 1	None - 0	Very High - 6	Unaffected: 0
Prehistoric monuments 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0

The average score for the direct, physical impact on **Penylan Gwynion HLCA**

= 3 + 3 + 4 + 7 + 4 ÷ 5 = 4.2 → 4

The average score is then added to the score for the magnitude of absolute impact:

4 + 0 = 4 = **Slight (Actually no direct physical impact at all)**

Bryn Gwyn HLCA 11

1.1.90 The following table and calculations present the overall direct physical impact of the Proposal upon Bryn Gwyn HLCA.

Table 4.12.8

Absolute Impact (Loss Of Area)			Magnitude & Score	
Approx 7.0%			**Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0-4%	C - 2	V. Slight - 1	Medium - 3	Slightly reduced: 1
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Moorland/rough pasture 7.0%	B - 3	Slight - 1	Medium - 3	Slightly reduced: 1
Forestry 0 %	D - 1	None - 0	Low - 2	Unaffected: 0
Prehistoric monuments 0 %	B - 3	None - 0	Considerable - 4	Unaffected: 0

The average score for the direct, physical impact on **Bryn Gwyn HLCA**

= 6 + 3 + 8 + 3 + 7 ÷ 5 = 5.4 → 5

The average score is then added to the score for the magnitude of absolute impact:

5 + 1 = 6 = **Slight overall magnitude of direct physical impact**

Pen Coed HLCA 12

1.1.91 The following table and calculations present the overall direct physical impact of the Proposal upon Pen Coed HLCA.

Table 4.12.9

Absolute Impact (Loss Of Area) **Approx 3.0%**			Magnitude & Score **Very Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0-4%	C - 2	V. Slight - 1	Very Low - 1	Slightly reduced: 1
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Moorland/rough pasture 3.0%	B - 3	V. Slight - 1	Very High - 6	Slightly reduced: 1
Forestry 0 %	D - 1	None -0	Very Low - 1	Unaffected: 0
Prehistoric monuments 0 %	B - 3	None - 0	Very High - 6	Unaffected: 0

The average score for the direct, physical impact on **Pen Coed HLCA**

5 + 3 + 11 + 2 + 9 ÷ 5 = 6

The average score is then added to the score for the magnitude of absolute impact:

6 + 1 = 7 = **Slight overall magnitude of direct physical impact**

Ffrith Fawr HLCA 13

1.1.92 The following table and calculations present the overall direct physical impact of the Proposal upon Ffrith Fawr HLCA.

Table 4.12.10

Absolute Impact (Loss Of Area) **Approx 6.0%**			Magnitude & Score **Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field system 0-4%	C - 2	V. Slight - 1	Very High - 6	Slightly reduced: 1
Settlement 0 %	C - 2	None - 0	Medium - 3	Unaffected: 0
Moorland/rough pasture 6 %	B - 3	Slight - 1	Low - 2	Slightly reduced: 1

Absolute Impact (Loss Of Area)			Magnitude & Score	
Approx 6.0%			**Slight - 1**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Forestry 0 %	D - 1	None - 0	Very Low - 1	Unaffected: 0
Prehistoric monuments 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0

The average score for the direct, physical impact on **Ffrith Fawr HLCA**

= 10 + 5 + 7 + 2 + 4 ÷ 5 = 5.6 ➔ 6

The average score is then added to the score for the magnitude of absolute impact:

6 + 1 = 7 = **Slight overall magnitude of direct physical impact**

Fridd Rhyd HLCA 14

1.1.93 The following table and calculations present the overall direct physical impact of the Proposal upon Fridd Rhyd HLCA.

Table 4.11.11

Absolute Impact (Loss Of Area)			Magnitude & Score	
0%			**None - 0**	
Relative & Landscape Impact (Loss Of Known Elements Or Characteristics) & Scores				
Element/% Loss	Category	Magnitude	Landscape	Landscape Value Effect
Field System 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Settlement 0 %	C - 2	None - 0	Very Low - 1	Unaffected: 0
Moorland/Rough Pasture 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0
Forestry 0 %	D - 1	None - 0	Very High - 6	Unaffected: 0
Prehistoric Monuments 0 %	B - 3	None - 0	Very Low - 1	Unaffected: 0

The average score for the direct, physical impact on **Fridd Rhyd HLCA**

= 3 + 3 + 4 + 7 + 4 ÷ 5 = 4.2 ➔ 4

The average score is then added to the score for the magnitude of absolute impact:

4 + 0 = 4 = **Slight (Actually no direct physical impact at all)**

Summary of overall direct physical effects upon Historic Landscape

1.1.94 With reference to Table 4.11.1, the following summarises the overall direct physical effects:

Table 4.11.12

HLCA	Score	Magnitude of impact on Historic Landscape
Nant Carfan HLCA 3	5	None
Mynydd Lluest Fach HLCA 5	5	None
Carnedd Wen HLCA 6	6	Slight
Llyn Gwyddior HLCA 8	7	Slight
Cerrig y Tan HLCA 9	6	Slight
Penylan Gwynion HLCA 10	4	None
Bryn Gwyn HLCA 11	6	Slight
Pen Coed HLCA 12	7	Slight
Ffrith Fawr HLCA 13	7	Slight
Fridd Rhyd HLCA 14	4	None

1.5 STAGE 3A - Assessment of Indirect Physical Effects of Development

1.1.95 The extent and potential severity of any indirect physical impact to HLCAs that might result from the proposed development are at present unknown and are difficult to predict. In general, however, unforeseen effects are likely to be small scale in relation to the total areas of the development and the HLCAs, and are probably avoidable or transformable into positive outcomes through appropriate management and mitigation.

1.1.96 **Increased access resulting in damage to cultural heritage features in development area.** Within the development area, indirect physical effects upon the historic landscape might conceivably arise from improved access to the area, possibly resulting in negative effects upon (ie. damage to) features such as prehistoric funerary and ritual monuments and ruined settlement sites.

1.1.97 **Change of traditional land use in development area.** Although the proposed development would result in a change of land use, this would not necessarily result in the cessation of previous agricultural management within the development area, and would not prevent it continuing elsewhere. Changes such as reduced stocking levels for grazing, could have both positive and/or negative effects upon the condition of cultural heritage features.

Table 4.13.3

Impact	Category & Score	Magnitude & Score
Increased access resulting in damage to cultural heritage features in development area	U - 1	V. Slight 1
Change of traditional land use in development area resulting in damage to cultural heritage features in development area	U - 1	V. Slight 1

1.1.98 Applying the same methodology as previously (adding the scores for each element and dividing by the number of elements to obtain an average), the following indirect physical impacts are predicted:

Table 4.13.4

HLCA	Magnitude of indirect physical impact on Historic Landscape	Score
Nant Carfan HLCA 3	None	0
Mynydd Lluest Fach HLCA 5	None	0
Carnedd Wen HLCA 6	None	0
Llyn Gwyddior HLCA 8	V. Slight	1
Cerrig y Tan HLCA 9	V. Slight	1
Penylan Gwynion HLCA 10	None	0
Bryn Gwyn HLCA 11	V. Slight	1
Pen Coed HLCA 12	V. Slight	1
Ffrith Fawr HLCA 13	V. Slight	1
Fridd Rhyd HLCA 14	None	0

1.6 STAGE 3 B - Assessment of Indirect (Non-Physical) Visual Effects

1.1.99 Field visits to the area during the data gathering stages of the baseline study and EIA, gave a general impression of the potential visual effects of the Proposal upon the historic landscape, and likely views and vistas that might be affected. ZTV mapping produced for the EIA provides a useful means of evaluating to what extent, and over what proportion of the total area of the HLCAs, the proposed windfarm development will be visible. The colour zones can be equated with ASIDOHL grading of impact from very severe to very slight. This does not however, account for the effects of tree cover nor the effects of topography on the proportion of individual turbines visible. Wireframe images produced for the EIA provide useful information demonstrating the diminishing scale of turbines in the landscape with distance. This information, coupled with experience obtained during the fieldwork aspects of the assessment have been used to make a judgement of the magnitude of visual effects of the Proposal upon the historic landscape. Only HLCAs within or immediately adjacent to the Proposal area are considered. Other areas are either considered too distant to warrant assessment, or were not included in the initial HLC assessment process.

1.1.100 The proposed development area will be visible at various distances to varying degrees from all directions. Existing forestry plantation will have a considerable influence on the extent to which the proposed development will be visually intrusive in close proximity to the development. At greater distances, the primary visual effect of the proposals would be cumulative, in association with other existing and proposed windfarms in the region.

Cumulative visual effects

1.1.101 Cumulative effects are considered to be an expected outcome of TAN 8 which states in Annex D that 'within (and immediately adjacent to) the SSAs, the implicit objective is to accept landscape change i.e. a significant change in landscape character from wind turbine development'.

1.1.102 An attempt to evaluate the likely cumulative effect of the proposed windfarm development upon the broader landscape and the setting of individual SAMs, in relation to other existing and proposed windfarms in the area was made in the EIA. This methodology was based upon ZVI mapping and wireframe images. ASIDOHL methodology will not be used to evaluate cumulative effects as part of this assessment because of the large number of sites and the large area that would need to be considered.

1.1.103 Decisions as to when the number of turbines visible within the surrounding landscape might be considered to have had an unacceptable effect upon landscape character and appreciation of historic landscape character, and how this might best be quantified and assessed, lie beyond the remit of this assessment.

1.1.104 The following potential indirect (non-physical) visual impacts from the proposed development have been identified. In the absence of their being any views recognised as being of national or regional importance in the vicinity of the proposed development none of the visual impacts identified have been assessed as being of more than local significance. The complexity and variety of some views makes it difficult to assign them to less than locally significant importance. The issues considered in evaluating the magnitude of visual effect are presented below:

Views towards the development

1.1.105 In general, a greater number of wind turbines, and a greater proportion of each turbine will be apparent from elevated viewpoints. From some locations, turbines will appear clustered together, from others, they will appear more spread out. The scale of the turbines in relation to the landscape is reduced as the distance from the development area increases.

1.1.106 For several of the HLCAs, only a small proportion of their total area actually lies within the development area. The irregular shapes of several of the HLCAs also means that visibility of turbines will vary greatly in different parts of each area.

1.1.107 Except for views of SAM MG 314 from HLCAs 3 and 5, there are few if any Cultural Heritage features that are specifically and clearly visible in views towards the development area from surrounding HLCAs. Views from the HLCAs facing away from the proposed development area will not be affected.

1.1.108 While appreciation of the historic landscape may be altered by the presence of turbines and infrastructure, the main historic landscape elements will remain visible and 'readable' in the landscape.

Views within the development area

1.1.109 The number, scale and density of turbines visible in views from within the development area will vary depending upon the degree of elevation of the viewpoint and the direction faced. The visual presence, noise and movement of turbines will all be of a high magnitude in the immediate vicinity, and will inevitably also have a significant effect upon landscape character.

1.1.110 The identification of TAN 8 areas as appropriate locations for windfarm development implies an acceptance of the effects that such developments will inevitably have on the visual and sensory landscape (and sense of place) during their operational life. Only a certain amount of mitigation of these effects by varying the number and location of turbines can be achieved before the viability of the proposed scheme is compromised.

1.1.111 The proximity of turbines and associated infrastructure features to specific locations and historic landscape features (and their resulting effect upon the setting and sensory context of these features) has already been addressed according to accepted degrees in the design and layout of the proposal, and through mitigation measures as presented in the EIA. Physical effects upon the HLCAs have likewise been minimised (as is demonstrated elsewhere in this assessment).

Views from the development area

1.1.112 The extent to which the proposal will affect views from the development area towards the surrounding landscape and the extent to which they detract from appreciation of the defined HLCAs will to a large extent depend upon the location of the viewspot and the direction of the view. For many HLCAs, there will be relatively small areas from which it is possible to see a significant proportion of the neighbouring HLCAs.

1.1.113 Views from the development area will also include views of other windfarms in the area. Perception of the quantity, scale and intrusiveness of windfarms in the surrounding landscape will vary depending upon the location of the viewspot, direction, distance to neighbouring windfarms and visibility conditions.

Nant Carfan **HLCA 3**

1.1.114 Taking into account the proportion of the HLCA that has a considerable or above view of the turbines, a **Moderate** rating seems appropriate. No part of the development lies within the HLCA. Appreciable views of the HLCA are only possible from parts of the southern half of the Proposal area.

Table 4.14.16

Impact	Category & Score	Magnitude & Score
Views towards the development	C - 3	Moderate 3
Views within the development area	C - 3	0
Views From the development area	C - 3	Slight - 2
Development Form	3*	Slight - 2
Development Appearance	3*	Moderate -3

***Average value of element sensitivity =** (3+3+3) ÷ 3 = 3

Average score for indirect visual impact = (3+3) + (3+0) + (3+2) + (3+2) + (3+3) ÷ 5 = **5**

Mynydd Lluest Fach HLCA 5

1.1.115 Although at high elevations, visibility of the development will be very severe, considering the proportion of the HLCA that has moderate or less visibility, a **Considerable** ranking seems reasonable. No part of the development lies within this HLCA. Views of elevated parts of the HLCA are primarily appreciable from parts of the southern half of the development area. Wireframe images suggest the development is not visible from SAM MG 313.

Table 4.14.17

Impact	Category & Score	Magnitude & Score
Views towards the development area	C - 3	Considerable - 4
Views within the development area	C - 3	0
Views From the development area	C - 3	Moderate -3
Development Form	3*	Moderate -3
Development Appearance	3*	Considerable - 4

***Average value of element sensitivity =** (3+3+3) ÷ 3 = 3

Average score for indirect visual impact = (3+4) + (3+0) + (3+3) + (3+3) + (3+4) ÷ 5 = **5.8**

***Carnedd Wen* HLCA 6**

1.1.116 For most of this HLCA, views of the development will be prevented or reduced by tree cover. Only a very small part of the development is within the HLCA, this is also tree covered. Views towards the HLCA are partially limited by the effects of elevation and tree cover.

Table 4.14.18

Impact	Category & Score	Magnitude & Score
Views towards the development area	D - 2	Slight - 2
Views within the development area	D - 2	0
Views From the development area	D - 2	Slight - 2
Development Form	2*	Slight - 2
Development Appearance	2*	Slight - 2

***Average value of element sensitivity** = (2 + 2 + 2) ÷ 3 = 2

Average score for indirect visual impact = (2+2) + (2+0) + (2+2) + (2+2) + (2+2) ÷ 5 = **3.6**

Llyn Gwyddior HLCA 8

1.1.117 ZVI mapping suggests the majority of this area will see parts of 15-43 turbines. The shape and location of this HLCA means that there are varying degrees of turbine visibility in different locations within the HLCA. While some locations will be severely affected, forestry, relative distance and effects of topography will reduce the magnitude of visual intrusion.

Table 4.14.19

Impact	Category & Score	Magnitude & Score
Views towards the development area	C - 3	Moderate - 3
Views within the development area	C - 3	Considerable - 4
Views From the development area	C - 3	Considerable - 4
Development Form	3*	Considerable - 4
Development Appearance	3*	Severe - 5

***Average value of element sensitivity** = (3+3+3) ÷ 3 = 3

Average score for indirect visual impact = (3+3) + (3+4) + (3+4) + (3+4) + (3+5) ÷ 5 = **7**

Cerrig y Tan HLCA 9

1.1.118 ZVI mapping suggests the majority of this area will see parts of 15-43 turbines. The location of this HLCA in relation to the development means that the turbines will appear distributed over much of the area, with turbines in the immediate vicinity and at greater distance. Wireframe images from SAM MG 314 (Ffrydd cwmyfynnon) and PRNs 720 and 4288 (Esgair Priciau and Ffridd Pwll-y-warthol) give some impression of the extent to which the proposal will be visible from the worst affected locations.

Table 4.14.20

Impact	Category & Score	Magnitude & Score
Views towards the development	C - 3	Considerable - 4
Views within the development area	C - 3	Considerable - 4
Views From the development area	C - 3	Considerable - 4
Development Form	3*	Severe - 5
Development Appearance	3*	Severe - 5

***Average value of element sensitivity** = (3+3+3) ÷ 3 = 3

Average score for indirect visual impact = (3+4) + (3+4) + (3+4) + (3+5) + (3+5) ÷ 5 = **7.4**

Penylan Gwynion HLCA 10

1.1.119 ZVI mapping suggests the majority of this area will see parts of 15-43 turbines. The shape and location of this HLCA means that there are varying degrees of turbine visibility in different locations within the HLCA. Forestry, relative distance from much of the development, and effects of topography will reduce the magnitude of visual intrusion.

Table 4.14.21

Impact	Category & Score	Magnitude & Score
Views towards the development	D - 2	Moderate - 3
Views within the development area	D - 2	0
Views From the development area	D - 2	Moderate - 3
Development Form	2*	Slight - 2
Development Appearance	2*	Slight - 2

***Average value of element sensitivity =** (2 + 2 + 2) ÷ 3 = 2

Average score for indirect visual impact = (2+3) + (2+0) + (2+3) + (2+2) + (2+2) ÷ 5 = **4**

Bryn Gwyn HLCA 11

1.1.120 ZVI mapping suggests that some portion of 15-43 turbines will be visible from much of the HLCA. The location of this HLCA in relation to the development means that the turbines will appear distributed over much of the area, with turbines in the immediate vicinity and at greater distance. Wireframe images from PRNs 720 and 4288 (Esgair Priciau and Ffridd Pwll-y-warthol) give some impression of the extent to which the proposal will be visible.

Table 4.14.22

Impact	Category & Score	Magnitude & Score
Views towards the development	C - 3	Considerable - 4
Views within the development area	C - 3	Considerable - 4
Views From the development area	C - 3	Considerable - 4
Development Form	3*	Severe - 5
Development Appearance	3*	Severe - 5

***Average value of element sensitivity** = (3 + 3 + 3) ÷ 3 = 3

Average score for indirect visual impact = (3+4) + (3+4) + (3+4) + (3+5) + (3+5) ÷ 5 = **7.4**

Pen Coed HLCA 12

1.1.121 ZVI mapping suggests that some portion of 15-43 turbines will be visible from much of the HLCA. The location of this HLCA in relation to the development means that most turbines will appear relatively distant and concentrated. A wireframe image from SAM MG 149 (Moel Ddolwen) gives some impression of the extent to which the proposal will be visible.

Table 4.14.23

Impact	Category & Score	Magnitude & Score
Views towards the development	C - 3	Considerable - 4
Views within the development area	C - 3	Considerable - 4
Views From the development area	C - 3	Moderate - 3
Development Form	3*	Moderate - 3
Development Appearance	3*	Slight - 2

***Average value of element sensitivity** = (3 + 3 + 3) ÷ 3 = 3

Average score for indirect visual impact = (3+4) + (3+4) + (3+3) + (3+3) + (3+2) ÷ 5 = **6.2**

Ffrith Fawr HLCA 13

1.1.122 ZVI mapping suggests the majority of this area will see that some portion of 15-43 turbines will be visible from much of the HLCA. The shape and location of this HLCA means that there are varying degrees of turbine visibility in different locations within the HLCA. Forestry, relative distance from much of the development, and effects of topography will reduce the magnitude of visual intrusion. Wireframe imaging from Abercannon (SH9628906930) suggests that visual intrusion will be moderate.

Table 4.14.24

Impact	Category & Score	Magnitude & Score
Views towards the development	C - 3	Considerable - 4
Views within the development area	C - 3	Considerable - 4
Views From the development area	C - 3	Moderate - 3
Development Form	3*	Slight - 2
Development Appearance	3*	Moderate - 3

***Average value of element sensitivity** = (3 + 3 + 3) ÷ 3 = 3

Average score for indirect visual impact = (3+4) + (3+4) + (3+3) + (3+2) + (3+3) ÷ 5 = **6.2**

Ridd Rhyd HLCA 14

1.1.123 ZTV mapping suggests that at least part of 33-34 turbines will be visible from the majority of locations within this HLCA, but since most of the area is at present forested, views towards the proposal area will be substantially restricted by trees. Any potential detrimental effects on the view of historic landscape elements resulting from the development are likely to be occluded by the presence of the forestry. Where possible at all, views of the HLC area from the development area are not likely to be significantly compromised.

Table 4.14.25

Impact	Category & Score	Magnitude & Score
Views towards the development	D - 2	Slight - 2
Views within the development area	D - 2	0
Views From the development area	D - 2	Slight - 2
Development Form	2*	Slight - 2
Development Appearance	2*	Slight - 2

***Average value of element sensitivity** = (2 + 2 + 2) ÷ 3 = 2

Average score for indirect visual impact = (2+2) + (2+0) + (2+2) + (2+2) + (2+2) ÷ 5 = **3.6**

The overall magnitude of indirect impact

1.1.124 To calculate the score for the overall magnitude of indirect impact for each HLCA, the average score for the indirect visual impact on each HLCA is added to the score for the indirect physical impact. This figure is on a scale of 1 – 20. This score range cannot be divided into the six whole number ranges, as is the case with the 28-point scale used in Stage 2. Therefore the average score is multiplied by 28 then divided by 20 to convert it to the 28-point scale.

Table 4.14.26

Overall Magnitude of Indirect Impact	
Score	**Grading**
24-28	Very Severe
19-23	Severe
14-18	Considerable
9-13	Moderate
4-8	Slight
0-3	Very Slight

Summary of indirect physical and visual impact

1.1.125 With reference to table 4.14.26, the following table presents the summary of indirect physical and visual effects:

Table 4.14.27

HLCA	Score	Magnitude of indirect impact on Historic Landscape
Nant Carfan HLCA 3	0 + 5.0 x 28 ÷ 20 = 7 ➔ 7	Slight
Mynydd Lluest Fach HLCA 5	0 + 5.8 x 28 ÷ 20 = 8.12 ➔ 8	Slight
Carnedd Wen HLCA 6	0 + 3.6 x 28 ÷ 20 = 5.04 ➔ 5	Slight
Llyn Gwyddior HLCA 8	1 + 7.0 x 28 ÷ 20 = 11.2 ➔ 11	Moderate
Cerrig y Tan HLCA 9	1 + 7.4 x 28 ÷ 20 = 11.76 ➔ 12	Moderate
Penylan Gwynion HLCA 10	0 + 4.0 x 28 ÷ 20 = 5.6 ➔ 6	Slight
Bryn Gwyn HLCA 11	1 + 7.4 x 28 ÷ 20 = 11.76 ➔ 12	Moderate
Pen Coed HLCA 12	1 + 6.2 x 28 ÷ 20 = 10.08 ➔ 10	Moderate
Ffrith Fawr HLCA 13	1 + 6.2 x 28 ÷ 20 = 10.80 ➔ 10	Moderate
Fridd Rhyd HLCA 14	0 + 3.6 x 28 ÷ 20 = 5.04 ➔ 5	Slight

1.7 STAGE 4 - Evaluation of Relative Importance

1.1.126 In this stage the relative importance of HLCAs that are directly and/or indirectly affected are assessed. Although the area has undergone a process of landscape characterisation, the character areas do not form parts of a larger registered landscape. For the purposes of this stage of the ASIDOHL process therefore, the character areas that are assessed are considered in isolation (in relation to each) rather than in relation to the entirety of the TAN 8 areas that have undergone characterisation.

1.1.127 In Step 1, the character areas are compared in terms of their contribution to the character of the entire landscape area represented by the character areas assessed.

1.1.128 In Step 2, the character areas are considered in a broader context, but since this broader context has no defined extent (other than the entirety of the TAN 8 areas), comparison of relative importance is difficult and of limited value.

1.1.129 In comparison to each other, and the broader landscape, the character areas assessed are not uncommon or unusual and are generally representative of the majority of the defined HLCAs beyond the development area. Land use mapping from the landscape characterisation suggests that the characterised landscape areas are a mixed and complex mosaic of land-use patterns. Because the TAN 8 areas are primarily located in upland areas, enclosed and unenclosed moorland and forestry dominate the land use, with enclosed agricultural land on valley slopes and bottoms. Agricultural landscapes are more widespread in the broader landscape. The moorland environments are, however, increasingly rare in the broader landscape. As a consequence the rarity and overall importance of the moorland environments have a tendency to be understated within the ASIDOHL methodology when applied to TAN 8 areas.

1.1.130 The character areas are not usually well documented and have no particularly significant associations.

1.1.131 The character areas have no specific or unusual potential or amenity value in comparison to each other or other similar areas elsewhere.

1.1.132 The group value, survival, condition, coherence and integrity of the character areas in relation to each other and in the broader context are not significantly different and are generally representative of similar landscapes beyond the development area that are not in TAN 8 areas. The group value of moorland areas is considered to be higher than for forestry or enclosed agricultural land.

1.1.133 Forested character areas are generally considered to be of less importance, because they are less well preserved and 'readable' in comparison to similar landscapes that remain un-forested, where landscape elements are better preserved and coherent.

1.1.134 Areas of enclosed and unenclosed moorland are considered to be of greater importance due to their relative rarity, and the cultural heritage features they contain. Areas of traditional enclosed improved agricultural land, are widespread, but are more dynamic, and illustrate the historical changes in land-use and settlement etc. Both landscapes are closely associated in terms of cultural heritage, land use and settlement patterns.

1.1.135 In Steps 1 and 2 below, the criteria are scored according to the following table:

Table 4.15.10

Overall Magnitude of Indirect Impact	
Score	**Criterion value**
5	Very High/good
4	High/good
3	Moderate/medium
2	Low
1	Very low/poor

STEP 1 - Evaluation of the relative importance of the historic character areas directly and/or indirectly affected by the development to the landscape area

1.1.136 With reference to the above considerations, the following table presents the scores and sum of the relative importance of the HLCAs (based on the listed criteria) to the landscape area that is directly and/or indirectly affected by the development proposal.

Table 4.15.11

HLCA	Rarity	Representativeness	Documentation	Group Value	Survival	Condition	Coherence	Integrity	Potential	Amenity	Associations	Sum & relative importance score
Nant Carfan HLCA 3	2	2	1	2	2	3	2	3	2	1	0	20
Mynydd Lluest Fach HLCA 5	3	4	1	4	3	3	4	4	3	1	0	30
Carnedd Wen HLCA 6	1	2	0	1	1	1	0	0	1	2	0	9
Llyn Gwyddior HLCA 8	3	4	1	4	3	3	4	4	3	1	0	30
Cerrig y Tan HLCA 9	2	2	1	2	2	3	3	3	2	1	0	21
Penylan Gwynion HLCA 10	1	2	0	1	1	1	0	0	1	1	0	8
Bryn Gwyn HLCA 11	2	2	1	2	2	3	2	3	2	1	0	20
Pen Coed HLCA 12	3	4	1	4	3	3	4	4	3	1	0	30
Ffrith Fawr HLCA 13	2	2	1	2	2	3	2	3	2	1	0	20
Fridd Rhyd HLCA 14	1	2	0	1	1	1	0	0	1	1	0	8

STEP 2 - An evaluation of the relative importance of the historic character areas concerned in the wider context

1.1.137 The table below presents the scores and sums of an evaluation of the relative importance of the historic character areas concerned, in the wider landscape context.

Table 4.15.12

HLCA	Rarity	Representativeness	Documentation	Group Value	Survival	Condition	Coherence	Integrity	Potential	Amenity	Associations	Sum & relative importance score
Nant Carfan HLCA 3	3	2	1	2	3	2	2	3	1	1	0	20
Mynydd Lluest Fach HLCA 5	4	4	1	4	3	2	4	4	1	1	0	28
Carnedd Wen HLCA 6	2	1	0	1	1	1	0	0	1	1	0	8
Llyn Gwyddior HLCA 8	4	4	1	4	3	2	4	4	1	1	0	28
Cerrig y Tan HLCA 9	3	2	1	2	3	2	2	3	1	1	0	20
Penylan Gwynion HLCA 10	2	1	0	1	1	1	0	0	1	1	0	8
Bryn Gwyn HLCA 11	3	2	1	2	3	2	2	3	1	1	0	20
Pen Coed HLCA 12	4	4	1	4	3	2	4	4	1	1	0	28
Ffrith Fawr HLCA 13	3	2	1	2	3	2	2	3	1	1	0	20
Fridd Rhyd HLCA 14	2	1	0	1	1	1	0	0	1	1	0	8

The average overall value of all the Historic Character Areas affected by the development

1.1.138 By dividing the sum of the above as shown in the last column of tables 4.15.11 and 4.15.12 by the maximum possible score (55) and multiplying by 100, the averages for steps 1 and 2 are reached:

Table 4.15.13

HLCA	Sum and rating at Step 1	Sum and rating at Step 2
Nant Carfan **HLCA 3**	(20÷55) x 100 = 36.36 = 36	(20÷55) x 100 = 36.36 ➔ 36
Mynydd Lluest Fach **HLCA 5**	(30÷55) x 100 = 54.54= 55	(28÷55) x 100 = 50.90➔ 51
Carnedd Wen **HLCA 6**	(9÷55) x 100 = 16.36 = 16	(8÷55) x 100 = 14.54 ➔ 15
Llyn Gwyddior **HLCA 8**	(30÷55) x 100 = 54.54 = 55 Considerable	(28÷55) x 100 = 50.90 ➔ 51
Cerrig y Tan **HLCA 9**	(21÷55) x 100 = 38.18 = 38	(20÷55) x 100 = 36.36 ➔ 36
Penylan Gwynion **HLCA 10**	(8÷55) x 100 = 14.54 = 15	(8÷55) x 100 = 14.54 ➔ 15
Bryn Gwyn **HLCA 11**	(20÷55) x 100 = 36.36 = 36	(20÷55) x 100 = 36.36 ➔ 36
Pen Coed **HLCA 12**	(30÷55) x 100 = 54.54= 55	(28÷55) x 100 = 50.90 ➔ 51
Ffrith Fawr **HLCA 13**	(20÷55) x 100 = 36.36 = 36	(20÷55) x 100 = 36.36 ➔ 36
Fridd Rhyd **HLCA 14**	(8÷55) x 100 = 14.54 = 15	(8÷55) x 100 = 14.54 ➔ 15

1.1.139 The scores above are graded according to the values presented in Table 4.15.14 below:

Table 4.15.14

Grades of overall value	
80 –100	Very High
60 –79	High
40-59	Considerable
20-39	Moderate
5-19	Low
0-4	Very Low

1.1.140 With reference to the table above, Table 4.15.15 presents the grade of value of the HLCAs:

Table 4.15.15

HLCA	Sum and rating at Step 1	Sum and rating at Step 2
Nant Carfan **HLCA 3**	Moderate	Moderate
Mynydd Lluest Fach **HLCA 5**	Considerable	Considerable
Carnedd Wen **HLCA 6**	Low	Low
Llyn Gwyddior **HLCA 8**	Considerable	Considerable
Cerrig y Tan **HLCA 9**	Moderate	Moderate
Penylan Gwynion **HLCA 10**	Low	Low
Bryn Gwyn **HLCA 11**	Moderate	Moderate
Pen Coed **HLCA 12**	Considerable	Considerable
Ffrith Fawr	Moderate	Moderate

HLCA	Sum and rating at Step 1	Sum and rating at Step 2
HLCA 13		
Fridd Rhyd **HLCA 14**	Low	Low

1.1.141 The average overall value of all the Historic Character Areas affected by the development is:

(36+36) + (55+51) + (16+15) + (55+51) + (38+36) + (15+15) + (36+36) + (55+51) + (36+36) + (15+15) ÷ 20 = **34.85 = Moderate overall value**

1.8 STAGE 5 - Assessment of Overall Significance of Impact

1.1.142 This final stage combines the results of Stages 2-4 to produce an assessment of the overall significance of the impact of the development and the effect that altering the HCLAs in question has on the whole of the Historic Landscape Area. The overall impact of the development is assessed using Table 13 in the Guide to Good Practice on Using the Register of Landscapes of Historic Interest in Wales in the Planning and Development Process (Cadw 2007), and is calculated using the following scale:

Table 4.16.1

Overall Significance Of Impact	
Score	**Grading**
26-30	Very Severe
21-25	Severe
16-20	Fairly Severe
10-15	Moderate
4-9	Slight
1-3	Very Slight

Table 4.16.2

HCLA	VALUE OF HCLA (based on STAGE 4) (Score based on ASIDOHL guidance table 13)		IMPACT OF DEVELOPMENT (based on STAGES 2 & 3 results) (Score based on ASIDOHL guidance table 13)		REDUCTION OF VALUE OF THE HLCA (Score based on ASIDOHL guidance table 13)		TOTAL SCORE FOR HCLA	OVERALL SIGNIFICANCE OF IMPACT FOR HCLA
Nant Carfan HLCA 3	Moderate	3	No direct physical impact Slight indirect physical impact	1	Very low	1	5	Slight
Mynydd Lluest Fach HLCA 5	Considerable	7	No direct physical impact Slight indirect physical impact	2	Very low	3	12	Moderate
Carnedd Wen HLCA 6	Low	2	Slight direct physical impact Slight indirect physical impact	3	Very low	1	6	Slight
Llyn Gwyddior HLCA 8	Considerable	7	Slight direct physical impact Moderate indirect physical impact	4	Medium	4	15	Moderate
Cerrig y Tan HLCA 9	Moderate	5	Slight direct physical impact Moderate indirect physical impact	5	Medium	4	14	Moderate
Penylan Gwynion HLCA 10	Low	2	No direct physical impact. Slight indirect impact	1	Very low	1	4	Slight

HCLA	VALUE OF HCLA (based on STAGE 4) (Score based on ASIDOHL guidance table 13)		IMPACT OF DEVELOPMENT (based on STAGES 2 & 3 results) (Score based on ASIDOHL guidance table 13)		REDUCTION OF VALUE OF THE HLCA (Score based on ASIDOHL guidance table 13)		TOTAL SCORE FOR HCLA	OVERALL SIGNIFICANCE OF IMPACT FOR HCLA
Bryn Gwyn HLCA 11	Moderate	6	Slight direct physical impact. Moderate indirect impact	5	Medium	4	15	Moderate
Pen Coed HLCA 12	Considerable	7	Slight direct physical impact. Moderate indirect impact	3	Slight	2	12	Moderate
Ffrith Fawr HLCA 13	Moderate	6	Slight direct physical impact. Moderate indirect impact	4	Medium	5	15	Moderate
Fridd Rhyd HLCA 14	Low	2	No direct physical impact. Slight indirect impact	1	Very low	1	4	Slight

1.9 Summary Statements and Conclusions

Background

1.1.143 Clwyd-Powys Archaeological Trust (CPAT), in their role as archaeological advisors to Powys County Council, recommended that a specific Assessment of the Potential Impact of Development upon the Historic Landscape (ASIDOHL) be undertaken to supplement an Environmental Impact Assessment (EIA) presented by RES UK & Ireland Ltd in order to inform the planning process in support of a proposal for the Llanbrynmair Wind Farm. The site (centred at SH 945 065) lies approximately 6km north-east of the village of Llanbrynmair, Powys within the TAN 8 Strategic Search Area B (Carno North).

1.1.144 An Historic Landscape Characterisation (HLC) study was commissioned by Powys County Council and Cadw in July 2006 with the principal objective of identifying the visible historic components of the landscapes of the TAN 8 areas within Powys, so that ASIDOHL methodology could be applied.

1.1.145 Only those HLCAs that contain or adjoin the Proposal area have been considered in this ASIDOHL process. The HLCA assessed are:

1.1.146 Carfan (HLCA 3); Mynydd Lluest Fach (HLCA 5); Carnedd Wen (HLCA 6); Llyn Gwyddior (HLCA 8); Cerrig y Tan (HLCA 9); Penylan Gwynion (HLCA 10); Bryn Gwyn (HLCA 11); Pen Coed (HLCA 12); Ffrith Fawr (HLCA 13); Fridd Rhyd (HLCA 14).

Summary of assessment of impact

1.1.147 The assessment of impact of the development is based upon professional and objective judgements as to the archaeological and landscape value of the various elements identified and objective judgement of the degree of severity of impact upon those elements from the development.

Direct physical impact

1.1.148 The Proposal area lies within TAN 8 Strategic Search Area B (Carno North). The proposal 'envelope' covers an area of approximately 1,890 ha. This area contains all, or some part of, 6 HLCAs that will be physically affected. In reality only a small proportion of this 'envelope' will be physically affected. Some HLCAs will have only a small part of their total area within the proposal 'envelope'; however, since the physical impact is limited to the footprint of the turbines and associated infrastructure, in any instance, only a small percentage (not formally calculated) of the HLCAs will be affected. The proportion of landscape elements within each HLCA that will be affected are even smaller. The approximate percentage of each landscape element that will be impacted upon by the development is weighed against the archaeological importance of the features and their landscape significance to calculate the impact of the development upon landscape value. The ASIDOHL methodology identified only a **Slight** direct physical impact for the six HLCAs. In reality many of these could be reduced to **Very Slight**.

Indirect physical and non-physical impact

1.1.149 The proposed development would result in **Very Slight** (if any) or **no** indirect physical impact on the historic landscape.

Evaluation of relative importance

1.1.150 Evaluation of the relative importance of the HLCAs affected by the development produced a value of **Low Importance** for forested areas, **Moderate Importance** for agricultural areas and **Considerable Importance** for areas of moorland.

Assessment of overall significance of impact

1.1.151 The overall significance of impact rating of **Moderate Significance of Impact** is a consequence of the relatively slight physical impact on the historic landscape from windfarm developments, balanced against the relatively high visual effects of such developments.

Considerations of development impact on the Historic Landscape

1.1.152 The shapes of the HLCAs and the proportion of each that occurrs within the proposed development area has the effect of reducing the impact of development upon each individual HLCA.

1.1.153 The development area is spread across a mosaic of different landscape characteristics and topographical variation which to some extent breaks up and diffuses the visual impact of the development, depending on the viewing location. No single landscape characteristic is significantly detrimentally affected more than another within the Proposal area. Areas of forestry effectively break up the landscape, and to some extent bind turbine locations into localised clusters. Areas of moorland (e.g. HLCA 8) are fragmented or isolated by blocks of forestry, or are a small part of a larger area beyond the development area (e.g. HLCA 12).

1.1.154 Some landscape character areas (e.g. HLCA 11) are degraded, or are not of particular landscape value, while others (e.g. HLCAs 3 and 13) are relatively common. Consequently, the significance of the impact of the development is lessened.

1.1.155 While there will be visual intrusion from the development, it will not inhibit the 'readability' of the historic elements that make up the landscape. It will still be possible to trace field systems, differentiate between different land use areas, and to identify deserted settlements and prehistoric funerary and ritual monuments.

1.1.156 There is only one historic landscape feature within the development area that is considered to be of national significance (SAM Mg 314). Although there are some other prehistoric funerary monuments in the development area, these are not considered to have significant relationships of intervisibility with SAM Mg 314 which would be compromised by the Proposal.

1.1.157 The proposed layout aims ro minimise the intrusive effects of the development on the setting of the SAM by locating turbines and infrastructure at an appropriate distance from the feature.

Mitigating aspects of the development

1.1.158 The Proposal is located in an area of mixed landscape character, and does not have an unacceptable impact upon any one landscape characteristic. Areas of forestry break up the proposed layout into smaller clusters of turbines, and will to some extent reduce the degree to which the development is visible from different locations within and around the development area.

1.1.159 Mitigation of the potential physical effects of the Proposal upon the historic environment will include the avoidance of physical impact upon known archaeological sites through design, with a watching brief during construction to undertake appropriate measures if unexpected archaeologically significant features are encountered during construction.

1.10 References

1.1.160 Cadw 2001, *Register of Landscapes of Special Historic Interest in Wales*. Cardiff

1.1.161 Cadw 2007, *Guide to Good Practice on Using the Register of Landscapes of Historic Interest in Wales in the Planning and Development Process.(ASIDOHL 2)* Cardiff

1.1.162 CPAT 2006, TAN 8 Strategic Search Areas In Powys: Historic Landscape Characterisation. Report No 821

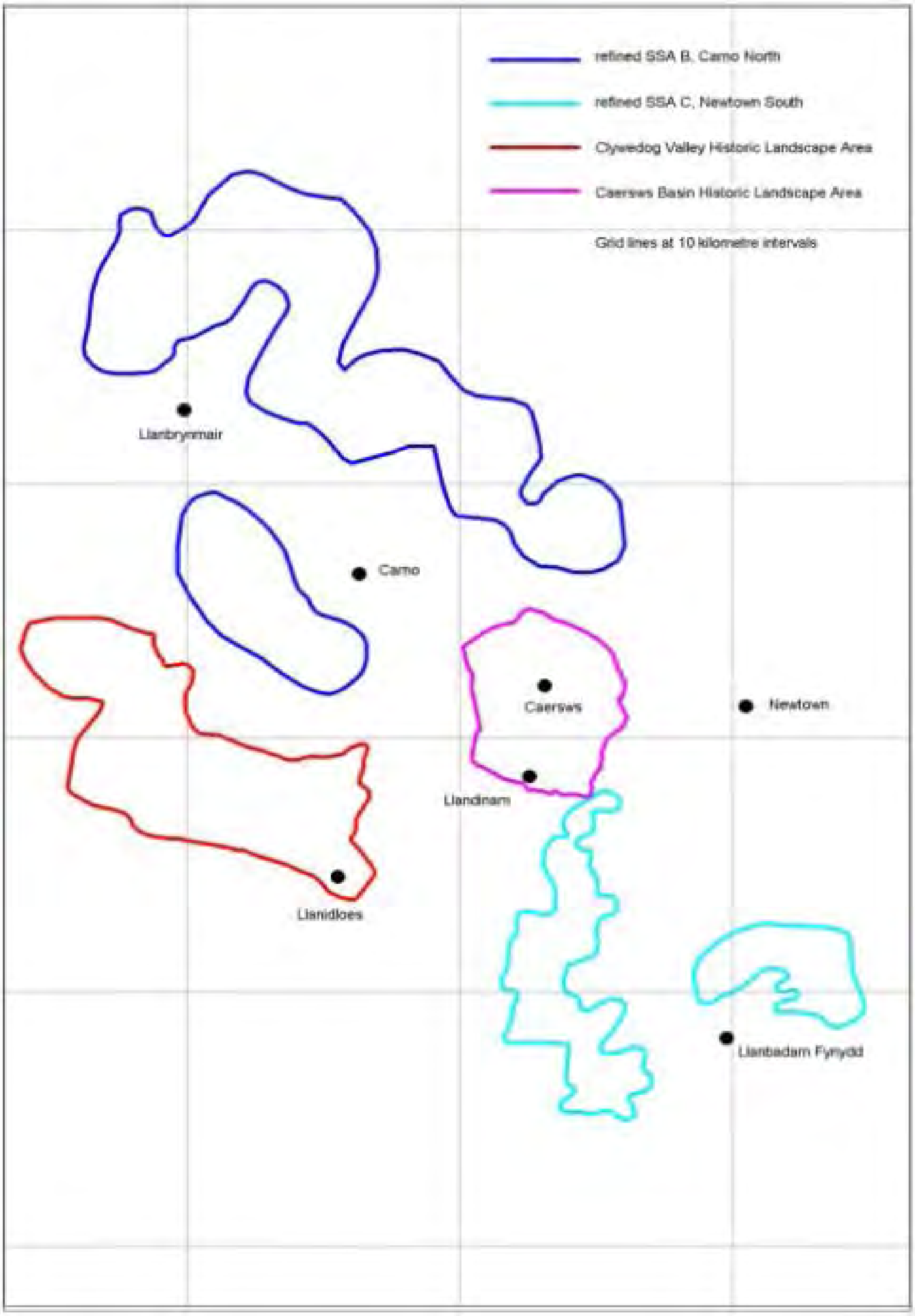


Figure 1: Plan showing TAN8 SSAs (reproduced from CPAT 2006, TAN 8 Strategic Search Areas In Powys: Historic Landscape Characterisation. Report No 821)

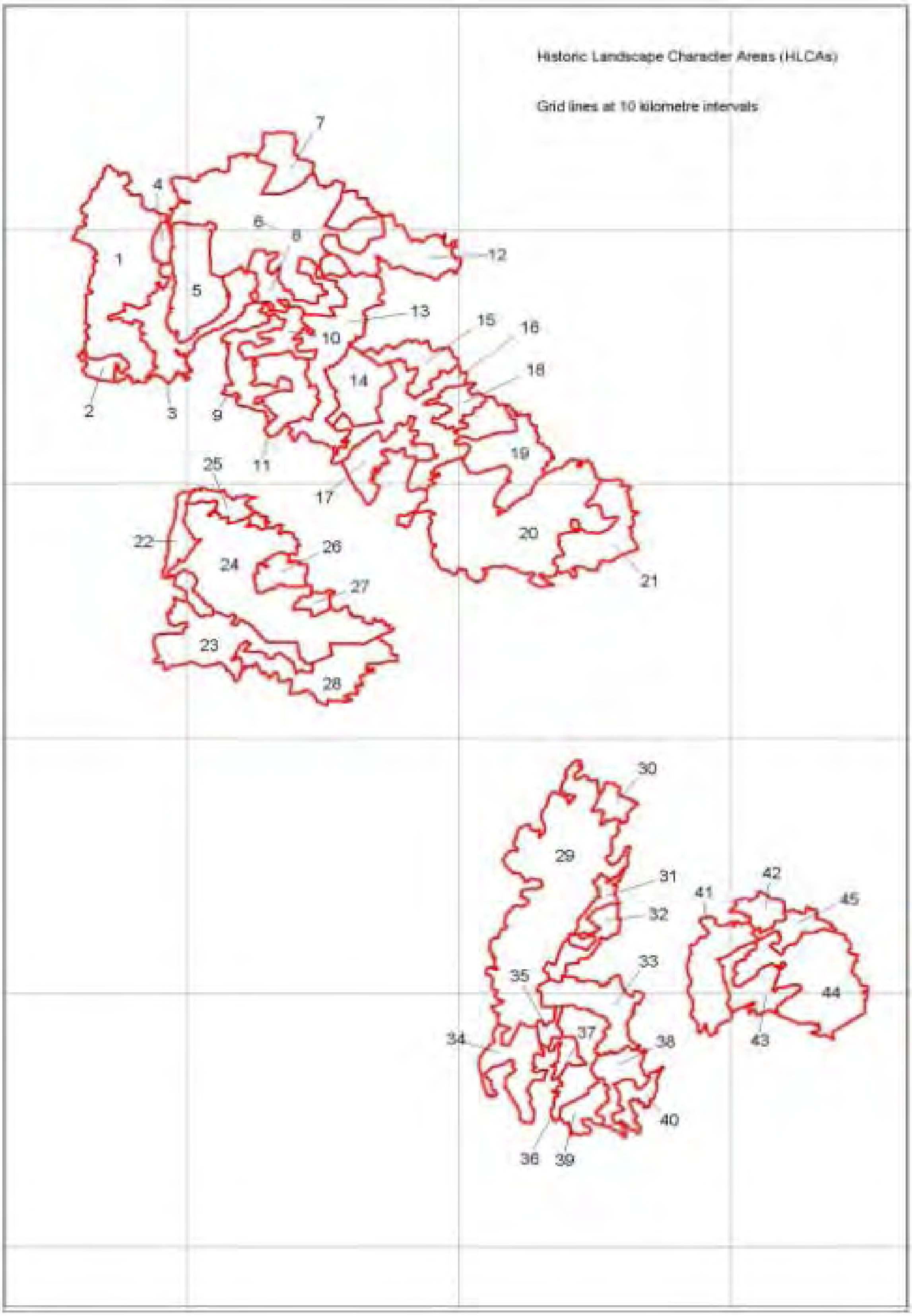


Figure 2: Plan showing Hisoric Landscape Character Areas within Carno North SSA (reproduced from CPAT 2006, TAN 8 Strategic Search Areas In Powys: Historic Landscape Characterisation. Report No 821)

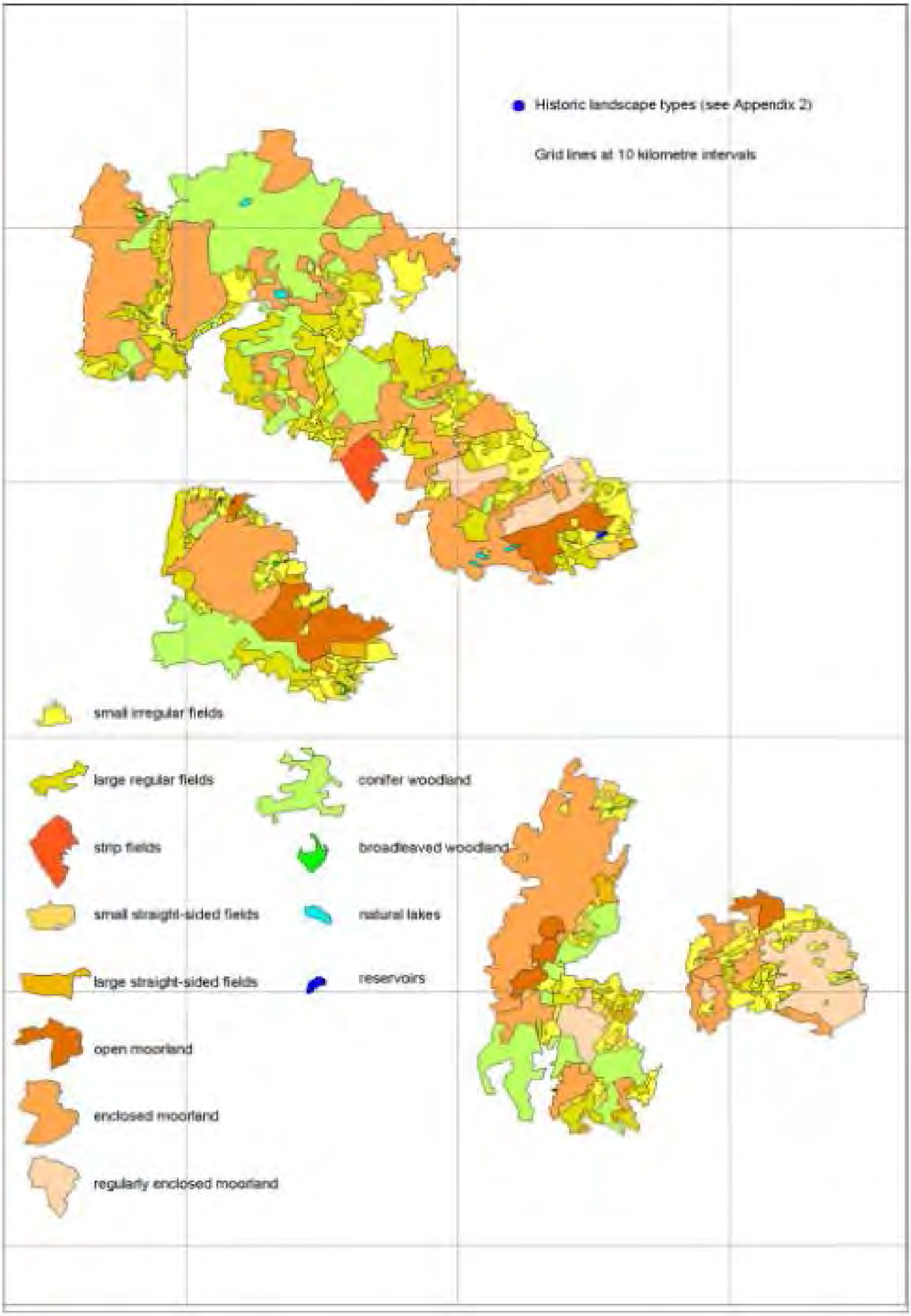


Figure 3: Plan Showing Historic Landscape types within Carno North SSA (reproduced from CPAT 2006, TAN 8 Strategic Search Areas In Powys: Historic Landscape Characterisation. Report No 821)

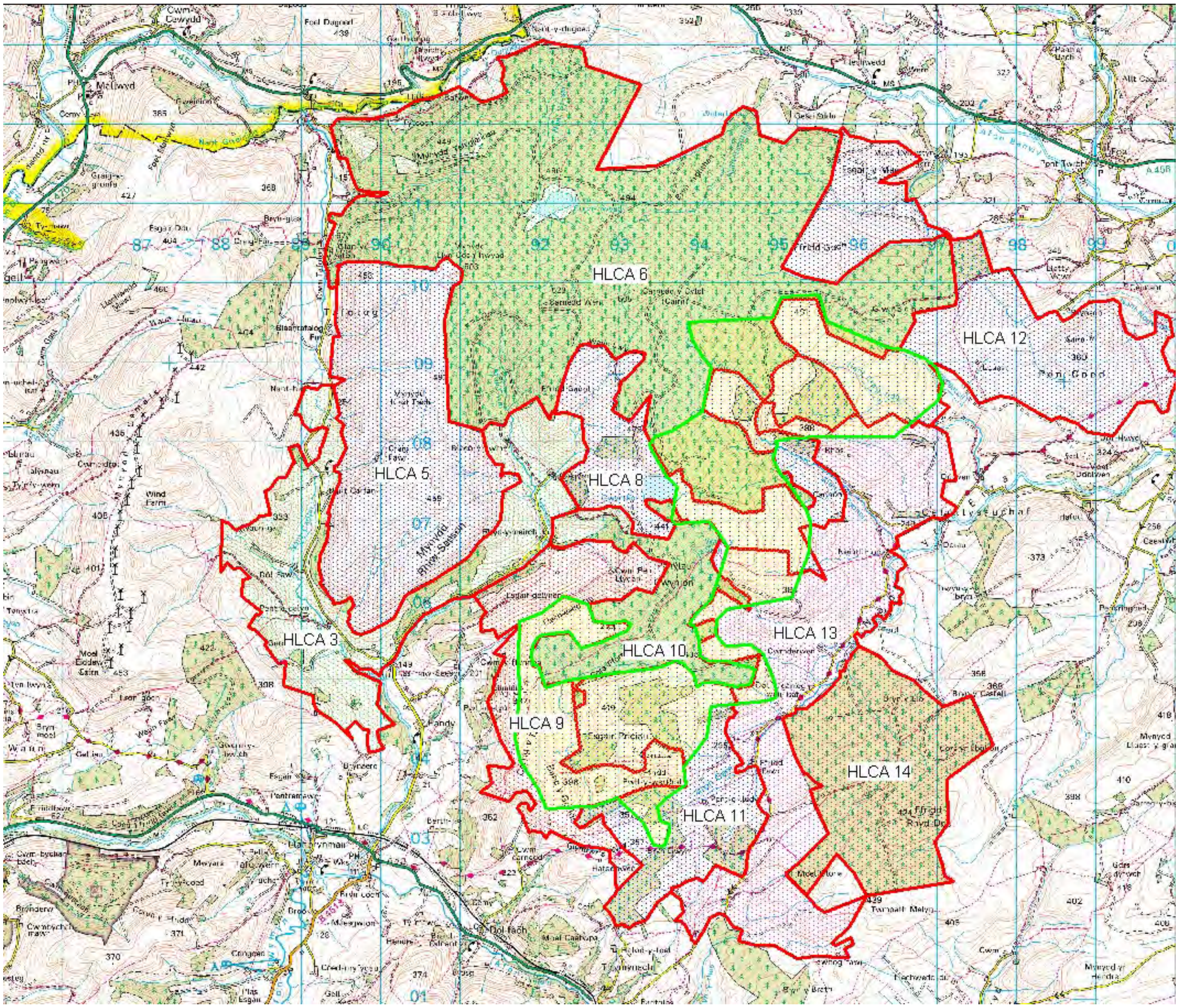


Figure 4: Map showing HLCAs considered for the Llanbrynmair Windfarm ASIDOHL

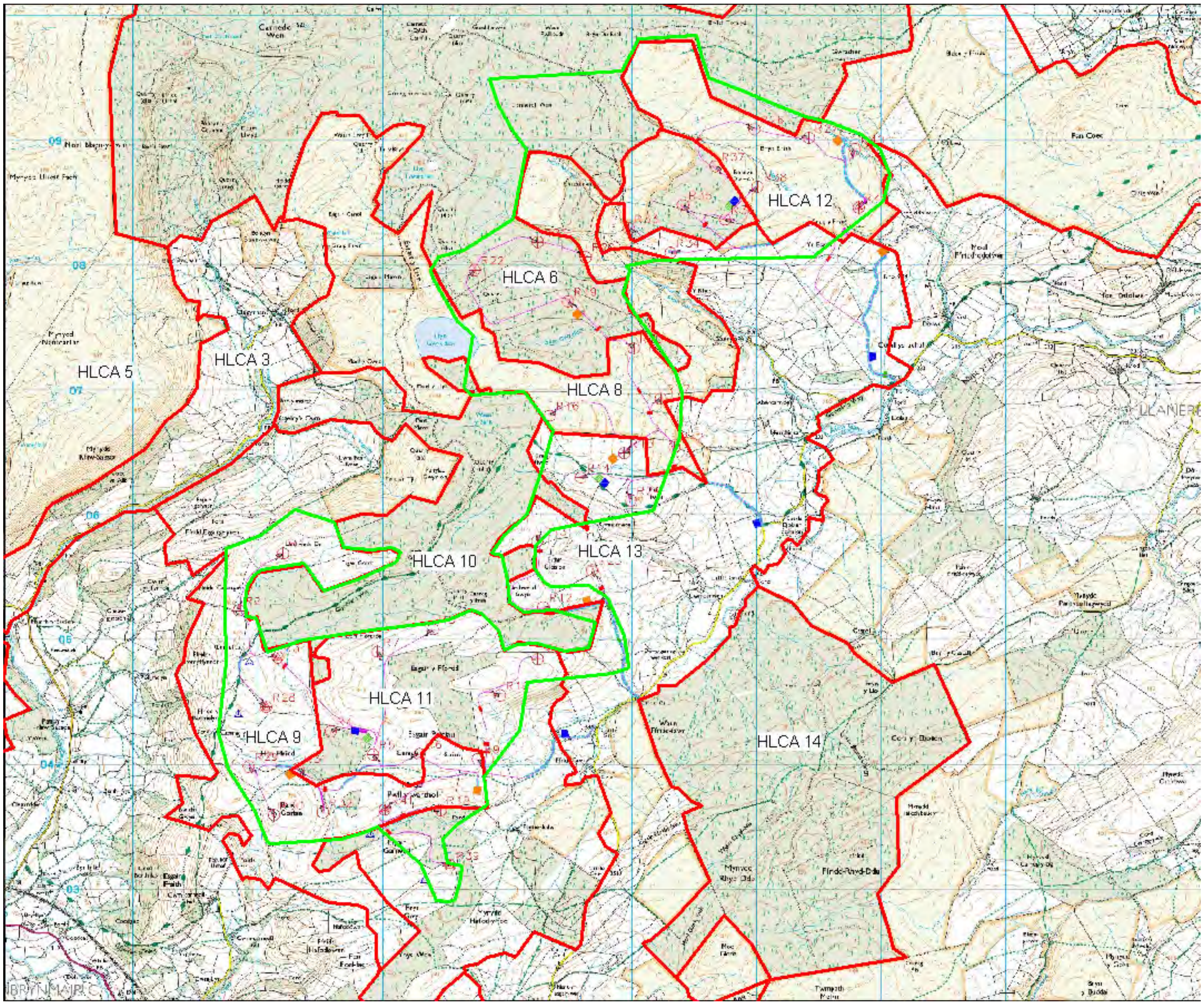


Figure 5: Map showing Proposed turbine locations in relation to HLCAs

APPENDIX 8.1 – PEAT EXCAVATION VOLUMES

1.1.1 The peat excavation volumes associated with the project have been calculated using the GIS package ArcGIS based on the following data and assumptions:

- A contour map of assumed peat depth based on interpolation of values from probing across the site;
- Dimensions of the proposed areas for excavation for site infrastructure;
- An estimated acrotelm depth of 0.2m across the site based on observations from cores (Appendix 8.3); and
- An assumption that the probe depth is representative of the actual depth of the peat.

1.1.2 The peat depth map has been created based on almost 5,000 locations where a probe has been used to ascertain the depth of penetration to 0.1m accuracy. The frequency of the probing is:

- Tracks – at the centre line of the track and 10m either side at 25m intervals;
- Turbines – at the centre of each turbine base and then at each of the cardinal points at 25m and 50m distance from the centre (9 probes per turbine base);
- Other infrastructure – probing as deemed necessary to characterize the footprint; and
- Areas away from proposed infrastructure with no other overriding constraints – these include steep gradients, noise constraints, ornithological constraints, watercourse buffers, landscape constraints etc. Probing was conducted on a 100m grid.

1.1.3 This data has allowed a contoured plot of the peat surface to be constructed in the areas where probing has been completed (Volume III - Figure 8.2a, 8.2b and 8.2c).

1.1.4 Coring has also been undertaken at a 117 locations to compare the probe penetration depth with the actual depth of the peat. The coring has demonstrated that soft clay is present in many areas of the site and is not distinguishable from the peat when using the probe. This has likely led to a substantial over estimate in peat depths and therefore a subsequent substantial overestimate in excavated peat volumes (Appendix 8.3).

1.1.5 The excavation footprint of all proposed infrastructure are presented in Table 1.

Table 1 Infrastructure dimensions

Infrastructure	Excavated Dimensions (m)	Number or length in the case of tracks	Total Area (m2)
Tracks	Width of 7.5m which includes 5.5m running width and 1m of drainage on either side of track	21,190 m of new track and 4,050m of existing track to be upgraded	158,925 m2 of new track and 30,375 m2 of existing track
Borrow pits	60m x 60m	6	21,600 m2
Site construction compounds	50m x 60m	5	15,000 m2
Batching Plant	80m x 80m	1	6,400 m2
Welfare Buildings	5m x 7.5m	2	75 m2

Infrastructure	Excavated Dimensions (m)	Number or length in the case of tracks	Total Area (m2)
Turbine base and crane pad	4,700m^2 (area as irregular dimensions)	30	141,000 m^2
Substation	65 x 62	1	4,030 m^2
Met mast base and associated crane pad	6 x 6 and 20 x 20	1	436 m^2
Total			377,841 m^2

1.1.6 It is assumed that any peat excavated for cable trenches is stored adjacent to the trench while the track is laid and then replaced, therefore this volume is not applicable to the excavated volume.

1.1.7 The contoured surface of the peat created has then been used to determine the average depth of peat under the excavation footprint of all proposed infrastructure and therefore the total volume of peat to be excavated as well as the volume of acrotelm and catotelm. These data are presented in Table 2.

Table 2 Excavated volumes for all infrastructure

Name	Peat Depth Average (m)	Area (m^2)	Acrotelm volume (m^3)	Catotelm volume (m^3)	Total Volume (m^3)
Met Mast and associated crane pad	0.18	436	78	0	78
Substation	0.16	4,028	640	0	640
Welfare Building (south)	0.17	38	7	0	7
Welfare Building (north)	0.13	38	5	0	5
Construction Compound 1	0.07	3,000	224	0	224
Construction Compound 2	0.54	3,000	600	963	1,563
Construction Compound 3	0.06	3,000	95	0	95
Construction Compound 4	0.41	3,000	600	619	1,219
Construction Compound 5	0.00	3,000	0	0	0
Borrow Pit 1	0.00	3,600	5	0	5
Borrow Pit 2	0.08	3,600	328	0	328
Borrow Pit 3	0.13	3,600	462	0	462
Borrow Pit 4	0.55	3,600	720	1,236	1,956

Name	Peat Depth Average (m)	Area (m^2)	Acrotelm volume (m^3)	Catotelm volume (m^3)	Total Volume (m^3)
Borrow Pit 5	0.07	3,614	221	0	221
Borrow Pit 6	0.05	3,600	184	0	184
Batching Plant	0.05	6,400	324	0	324
Turbine R4 including crane pad	0.46	4,768	954	1,448	2,402
Turbine R5 including crane pad	0.46	4,768	954	1,037	1,991
Turbine R6 including crane pad	0.56	4,768	954	1,721	2,674
Turbine R7 including crane pad	0.28	4,768	954	376	1,330
Turbine R8 including crane pad	0.55	4,768	954	1,616	2,570
Turbine R9 including crane pad	0.46	4,768	954	1,272	2,226
Turbine R12 including crane pad	0.60	4,768	954	1,904	2,858
Turbine R13 including crane pad	0.28	4,768	954	309	1,262
Turbine R14 including crane pad	0.24	4,768	954	249	1,202
Turbine R15 including crane pad	0.55	4,768	954	1,699	2,653
Turbine R16 including crane pad	0.31	4,768	954	593	1,546
Turbine R17 including crane pad	0.56	4,768	954	1,752	2,706
Turbine R18 including crane pad	1.27	4,768	954	4,978	5,932
Turbine R19 including crane pad	0.42	4,768	954	1,078	2,032
Turbine R23 including crane pad	0.04	4,768	186	0	186
Turbine R24 including crane pad	0.10	4,768	470	0	470
Turbine R25 including crane pad	0.72	4,768	954	2,496	3,450
Turbine R26 including crane pad	0.63	4,768	954	2,026	2,980
Turbine R27 including crane pad	0.30	4,768	954	439	1,393
Turbine R31 including crane pad	0.59	4,768	954	1,928	2,881
Turbine R32 including crane pad	0.12	4,768	563	0	563
Turbine R35 including crane pad	1.52	4,768	954	6,333	7,287
Turbine R36 including crane pad	0.88	4,768	954	3,256	4,209

Name	Peat Depth Average (m)	Area (m^2)	Acrotelm volume (m^3)	Catotelm volume (m^3)	Total Volume (m^3)
Turbine R37 including crane pad	0.54	4,768	954	1,632	2,585
Turbine R38 including crane pad	0.72	4,768	954	2,466	3,419
Turbine R39 including crane pad	0.80	4,768	954	2,729	3,682
Turbine R40 including crane pad	0.39	4,768	954	844	1,797
Turbine R41 including crane pad	0.30	4,768	954	459	1,412
Turbine R42 including crane pad	0.36	4,768	954	756	1,709
Turbine R43 including crane pad	0.07	4,768	345	0	345
Total			30,861	48,214	79,075
Track			19,511	22,275	41,786
Total Volume infrastructure + Tracks			50,372	70,489	120,861

1.1.8 The total calculated excavation volumes are:

- Total volume of peat excavated = 120,900m3
- Total volume of acrotelm excavated = 50,400 m3
- Total volume of catotelm excavated = 70,500 m3

1.1.9 These values are estimates based on the available data and the above assumptions. As coring has verified, actual peat depths particularly those related to the probe penetration depths of 0.5m to 1m are significantly less.

APPENDIX 8.2: DEWATERING ASSESSMENT

1.1 Background

1.1.1 Excavations in peatlands can lead to a change in peat hydrology including temporary and permanent dewatering of the peat. There has been substantial research on the effects of drainage on peatland however the results are wide ranging and demonstrate the broad range of values that could be applied to the various parameters that are input to any assessment.

1.1.2 The peat on site is a generally saturated and relatively thin and discontinuous layer overlying bedrock and also usually clay of glacial origin. Where sections of peat and underlying material are removed for the installation of turbine bases or tracks there is the potential for the groundwater within the adjacent peat to drain to these excavations potentially resulting in a drying out of some of that adjacent peat and deterioration in its quality. To estimate the potential impact on the peat a dewatering assessment has been conducted using appropriate guidance. Based on relevant guidance for appropriate methodologies to complete dewatering assessments an assessment has been undertaken to determine how much peat will be dewatered at the proposed Llanbrynmair windfarm.

1.1.3 The impact of the wind farm infrastructure on peat will be in part dependent on the extent of the excavations required for the construction of this infrastructure and whether these excavations will be backfilled or permanently drained.

Table 1 Proposed Llanbrynmair windfarm infrastructure dimensions

Infrastructure	Excavated Dimensions (m)	Number or length in the case of tracks	Effect on drainage (permanent or temporary)
Tracks	width of 7.5m which includes 5.5m running width and 1m of drainage on either side of track	21,190 m of new track and 4,050m of existing track to be upgraded	Permanent
Borrow pits	60m x 60m	6	Temporary
Site construction compound	50m x 60m	5	Temporary
Batching Plant	80m x 80m	1	Temporary
Welfare Building	5m x 7.5m	1	Temporary
Turbine base and crane pad	4700m^2 (area as irregular dimensions)	30	Temporary
Substation	65 x 62	1	Temporary
Met mast base and associated crane pad	6 x 6 + 20 x 20	1	Temporary

1.2 Assessment Methodology

1.1.4 The location of the current proposed layout has been part of an iterative process to examine all constraints and reduce the impact on them including avoidance of peat. The following methodology was used to estimate the potential volume of peat that could be impacted from dewatering from the revised layout of the development, both during the construction period on a temporary basis and post construction long term. The approach was slightly different depending on the type of infrastructure assessed:

1.1.5 An assessment of this potential impact was undertaken using the following methodology:

- The site was assessed to determine which level of analysis is required based on the Environment Agency guidance: Hydrogeological Impact Appraisal for Dewatering Abstractions April 2007;
- Based on the level of analysis required the appropriate analytical equations were then used along with a range of parameters to determine the extent of the hydrogeological impact due to the construction and operation of the site infrastructure both during development and operation;
- The peat depths at the location of all proposed infrastructure were established using probes to determine the depth of penetration possible. This depth is assumed to be equal to the peat depth, however a substantial number of cores (117, Appendix 8.3) have been completed on site to determine the actual peat depth and establish the nature of the underlying superficial deposits. This exercise has demonstrated that in many occasions the peat depth is an over estimation as the probe easily penetrates the underlying clay with no increase in resistance until a more gravelly clay layer or bedrock is reached. Although this has been demonstrated to be common across the site NRW have indicated that they expect a worst case scenario to be adopted and therefore the peat depths used are the probe depths, except in cases where sufficient coring has been completed;
- The peat depths at each infrastructure were then input into the GIS package ArcGIS so that a contour plot of the peat surface could be established and the average peat depth at the infrastructure could be determined for dewatering analysis;
- The peat depths used for dewatering calculations along the track are those of the adjacent probes and calculations are undertaken on each of these individual probe depths to obtain a distance that dewatering is active away from the track and is associated with each 50m length of track between probe locations; and
- The relevant input parameters were established such as peat permeability, acrotelm thickness, groundwater level and recharge rate.

1.3 Peat Depth

Turbine Bases and crane pads

1.1.6 Each turbine base was probed a total of 9 times, once at the centre, four times at each of the cardinal points at 25 m from the centre and then again four times at the cardinal points at 75 m from the centre. Probes were also completed across the crane pad in the centre and at 10 m either side. This data was then input to a GIS package to allow the average peat depth to be established (Table 3 and from Table 2 in Appendix 8.1).

Tracks

1.1.7 Peat depth probes were undertaken along the track at approximately 25 m intervals and additionally at 10 m from either side of the track (also at approximately 25 m spacing). Given that the running width of the track will be about 5.5 m and a drain will be located outside of this track the depths recorded from adjacent probes will likely be about 5 m outside of the track edge and therefore will be representative of the depth of the peat in which groundwater drawdown functions (Figure 2).

Other infrastructure

1.1.8 All other infrastructure was assessed using the same methodology as the turbine bases taking into the contoured peat generated from the GIS package to obtain the average peat depth across the area of each infrastructure. These are presented in Table 5.

1.4 Tier Level Assessment

1.1.9 Subsequent to grouping the sections of the site the potential impact of the development was undertaken using the Environment Agency Guidance: Hydrogeological Impact Appraisal for Dewatering Abstractions April 2007.

1.1.10 The impact of an excavation, whether water is pumped out of a pit or the water is directed away in a channel, is that a seepage face will develop which will result in a lowering of the water table in the surrounding formation above the base level of the excavation (in this case a turbine base, track, borrow pit or other wind farm infrastructure requiring some level of excavation). This water level lowering will extend outwards in all directions from the exaction or dewatering operation in a convex arc to the normal water table level. This effect will continue extending until equilibrium is reached with the recharge being equal to the discharge and is defined by the maximum distance where any drawdown occurs. This effect may be temporary and the actual maximum possible extent may not be reached in the time the excavation is open or could be permanent if the excavation is not backfilled.

1.1.11 To predict the extent of the drawdown the guidance was used to first determine what level of assessment should be undertaken. Based on the scoring criteria, classes and weights as given in Table 3.1 of Hydrogeological Impact Appraisal for Dewatering Abstractions, the site is assigned a score of 16. This is based on the site being potentially over a minor aquifer (score 2), near a SSSI but not directly connected (score 2), an assumption that water is available (score 1) and the potential dewatering quantity being low (score 1).

1.1.12 Therefore the site is assessed using Tier 1 (Basic) analysis. This involves using simple analytical equations to arrive at a ‘best basic’ conceptual model of the hydrogeological relationships between the point of abstraction and the surrounding environment.

1.5 Analytical Equations

1.1.13 Basic analytical assessment has therefore been used to predict the extent of drawdown from the point of abstraction or effective abstraction given the drainage of the tracks. These use conservative aquifer parameters and assumptions, but must be regarded with caution as the parameters used are estimates and no site specific data, with the exception of the depth of peat, is currently available.

1.1.14 The method selected estimates the radius of influence in an unconfined aquifer from an open pit by Niccoli et al. (1998) as provided by the Tier 1 Groundwater Analytical Equation Tool (EA, 2007). It consists of the following equation:

$$H = \sqrt{h_s^2 + \frac{P}{K_{h1}}\left[R_o^2 ln\left(\frac{R_o}{r_w}\right) - \frac{R_o^2 - r_w^2}{2}\right]}$$

Where:

H = drawdown in centre of pit or track (m) – (depth of peat)

hs = saturated thickness of seepage face (m) – (worst case is 0m)

P = recharge (m/day)

Kh1 = layer 1 horizontal hydraulic conductivity (m/day)
rw = radius of quarry (m) – (estimated at 23 m for turbine base and crane pad, 3.75 m for track, 30 m for site compound, 30 m for the borrow pits, 40 m for the batching plant, 32.5 m for substation, 3.75 m for the welfare building and 3 m for the met mast)
Ro = effective radius (m)

This equation has been applied to both the acrotelm and catotelm and their results summed together to produce the overall effect.

1.6 Input Parameters

Acrotelm thickness

1.1.15 It is assumed that the acrotelm has a thickness of 0.2m which is a conservative value and is based on site observations as detailed in Appendix 8.3. NRW have commented (letter addressed to RES on 25 April 2013 no ref number) that they consider the acrotelm to be less than 0.2m at Llanbrynmair although no site specific data has been presented.

Recharge

1.1.16 The rainfall data over a 30 year period has been used. The data was obtained from the met office website for the Trawscoed meteorological station for the period 1971-2000, which provides an average annual precipitation of 1213.9 mm/yr. Given the high permeability of the acrotelm, the type of vegetation promoting infiltration and general limited slope on those areas with peat it is assumed that the effective rainfall will be 50%, equivalent to 607mm/yr.

1.1.17 When the peat is saturated it is assumed that the recharge to the acrotelm is 50% of actual precipitation due to the high permeability of the acrotelm, the high amount of vegetation and the generally low slope angle reducing runoff. In this instance the recharge to the underlying catotelm is not restricted and is therefore equal to the permeability of the catotelm.

1.1.18 When the peat is not saturated the water level is assumed to be at the base of the acrotelm (0.2m) and the recharge to the underlying catotelm is 50% of the actual precipitation.

Peat Permeability

1.1.19 There have been numerous studies and papers written on peat permeability and its properties and there is a large variety and very wide spread of results indicating the difficulty of providing definitive data for use in analytical equations. It is widely recognised that peat permeability can vary over short distances based on a variety of factors. A wind farm is essentially a linear project crossing different habitats, slopes, hydrological conditions and peat depths along with having proximity to other factors such as watercourses, forestry, etc. In order to obtain data for all of the different areas on site a very spatially extensive and long duration (to cover extreme events) monitoring network would be necessary and is not justified (as determined by the Tier Level Assessment).

1.1.20 The following review has been undertaken to examine the range and extent of peat permeability:

1.1.21 Velocity of flow of water though peat is determined by its hydraulic conductivity, which is typically in the range of mm or cm per day but can vary widely depending on the physical properties of the peat (including vegetation composition, compaction, decomposition and presence of macropores (pipes) and entrapped gas bubbles) (Labadz 2010). Generally, these physical properties enable the peat to be divided into two distinct layers: an upper active layer of roots and recently decomposing plant material termed the “acrotelm”, and a lower layer of denser and more decomposed (humified) peat called the “catotelm”. The actrotelm which is typically 0.5 m thick (Lindsay and Bragg 2005) tends to have a higher hydraulic conductivity than the catotelm as a result of its less dense nature formed by the large spaces between the decaying plant material and roots. Whilst the diplotelmic nature of peat is useful to consider when investigating its hydraulic conductivity, in reality water movement within peat is more complex and has also been found to vary significantly between sampling sites.

1.1.22 To date, efforts at estimating hydraulic conductivity in peatlands using different field and laboratory methods have resulted in a wide range of hydraulic conductivity values as low as 10^{-8} ms^{-1} to as high as 10^{-2} ms^{-1} (Lewis et al 2011) Holden and Burt (2003) found hillslope and catchment scale variability may be more important than plot scale variability and that depth and individual peat layers were not always significant controls on hydraulic conductivity.

1.1.23 A review of the literature on the hydraulic conductivity of peat found significant variability in testing results (Table 2). For the purposes of a robust estimation of dewatering volumes it was decided to reflect the differences in the hydraulic conductivity between the acrotelm and the catotelm. This system for analysing peat became widely accepted from the 1970s and is regularly used in the conceptual modeling of peat (Holden and Burt 2003). However, given the findings of Holden and Burt (2003) and the large area of the site, it was not felt it was practical to base the hydraulic conductivity on site specific data as a very large volume of samples would have been required. Instead, the figures used have been based on an extensive literature review.

Table 2 Peat Hydraulic Conductivity

Study	Hydraulic conductivity (k)	Methodology	Area of Study
Holden and Burt 2003	Single peat layers cannot be characterised by a typical conductivity value	Rigid and compressible soil theory. Head recovery tests (slug withdrawal) performed on piezometers at depths ranging from 10 – 80cms.	North Pennine blanket peat, U.K
Clymo 2004	*1×10^{-6} - *1.2×10^{-5} $m\ s^{-1}$	Piezometer for depths of 0.1m – 7.0m	Raised peatlands in Scotland.
Sturridge et al 2005	*1.1×10^{-4} - 1.6×10^{-3} $m\ s^{-1}$	Piezometer and MCM at depths up to 1m	English fens
Gnatowski et al 2010	5.5×10^{-8} - 5×10^{-5} $m\ s^{-1}$	Porous plate	Polish fens
Beckwith et al 2003	1×10^{-5}- 1.2×10^{-3} $m\ s^{-1}$	MCM for depths of up to 0.15m	Raised peatlands in England
Ronkannan and Klove 2005	*In situ* – 5.2×10^{-7} – 2.9×10^{-3} $m\ s^{-1}$ *Horizontal* – 6.1×10^{-6} – 3.8×10^{-2} ms^{-1} *Vertical* – 4.2×10^{-6} – 2.6×10^{-2} $m\ s^{-1}$ Acrotelm 3×10^{-3} – 10^{-4} $m\ s^{-1}$ Catotelm 5×10^{-7} – 10^{-4} $m\ s^{-1}$	Falling head piezometers in situ and soil cores in horizontal and vertical directions.	Northern Finland, natural peatlands receiving different wastewater quality and loading.

Study	Hydraulic conductivity (k)	Methodology	Area of Study
Boelter, D.H. 1964	Well decomposed peat (50 – 60cm depth) – 4.6×10^{-5} m s^{-1}		
Wong, Hashim and Ali 2009	10^{-5} – 10^{-8} m sec^{-1}		
Hanrahan, E.T., 1954.	Fibrous Peat 4×10^{-6} m sec^{-1}		
Weber, W.G., 1969.	Peat 10^{-6} m sec^{-1}		
Samson, L. and P. La Rochelle, 1972	Fibrous peat 10^{-6} - 10^{-5}m sec^{-1}		
Lefebvre, G., P. Langlois, C. Lupien and J.G. Lavallee, 1984.	Fibrous peat 5×10^{-7} – 5×10^{-5}m sec^{-1}		
Mesri, G., T.D. Stark, M.A. Ajlouni and C.S. Chen, 1997.	Fibrous peat 6×10^{-8} – 10^{-7}m sec^{-1}		
Rycroft et al, 1975	Blanket peats at 30cm 1.1×10^{-7} m s^{-1} Blanket peats at 1m 6×10^{-10} m s^{-1}	Rigid soil theory	
Bragg 1991	Peat at 1 m depth 8.5×10^{-8} m s^{-1}		Large raised bog at Wedholme flow in Cumbria
Van Wirdum at al 1997	Surface fen peat 2.5×10^{-5} m s^{-1}		Sutton Fen Norfolk
Van Wirdum at al 1997	Humified brushwood peats 4.6×10^{-8} m s^{-1}		Broadland sites Berry Hall Fen, Norfolk
Van Wirdum at al 1997	Firm brushwood peat 5.8×10^{-8} m s^{-1}		Catfield Fen Norfolk
Van Wirdum at al 1997	Humified peat with monocot and brushwood remains 1.1×10^{-6} m s^{-1}		Reedham Marshes, Norfolk

* - Figures used in the dewatering calculations sensitivity analysis

1.1.24 Based on these findings it is assumed that the following permeability values are reasonable for use at the site:

- acrotelm permeability of 3 m/day (3.5 x 10^{-5} ms^{-1}); and
- catotelm permeability of 0.003 m/day (3.5 x 10^{-8} ms^{-1}).

1.1.25 To calculate the overall distance to zero drawdown the values generated for each of the layers is summed. The volume of dewatered peat is calculated by applying the peat depth by the distance to zero drawdown divided by 2 and then multiplied by the perimeter of the infrastructure or the length of track over which the reading applies.

1.1.26 It is assumed that the groundwater level is reduced to the base of the peat due to the low permeability of the underlying layers.

Sensitivity Analysis

1.1.27 To examine the effect of changing the input parameters for the equation a sensitivity analysis was conducted using:

- Recharge variation of:
  - 50% (assumed case);
  - 30% (low recharge case); and
  - 10% (very low recharge case)

1.1.28 All of these scenarios are calculated for groundwater at the ground surface and at the base of the acrotelm;

- Permeability variation of:
  - Acrotelm 3 m/day, Catotelm 0.003 m/day (assumed case);
  - Acrotelm 9.5 m/day, Catotelm 0.09 m/day (high permeability case);
  - Acrotelm 1 m/day, Catotelm 0.00005 m/day (low permeability case);

1.1.29 All of these scenarios are calculated for groundwater at the ground surface and at the base of the acrotelm;

- Acrotelm depth of 0.3 m (occasionally observed at Llanbrynmair);
- Acrotelme depth of 0.2 m (assumed case); and
- Acrotelm depth of 0.1 m (thinner acrotelm as suggested by NRW).

All of these scenarios are calculated for groundwater at the ground surface and at the base of the acrotelm;

1.1.30 These results are presented in Tables 3 to 5.

Peat Sensitivity Analysis

Effective peat radius of 3.75m used for all calculations i.e. assumes calculations are for tracks

Table 3 Sensitivity to recharge

Peat depth (m)	Acrotelm saturation state based on habitat classification	Groundwater level (m below ground surface)	50% precipitation recharge: Distance to zero drawdown (m)			30% precipitation recharge: Distance to zero drawdown (m)			10% precipitation recharge: Distance to zero drawdown (m)		
			Acrotelm	Catotelm	Total distance to zero drawdown (m)	Acrotelm	Catotelm	Total distance to zero drawdown (m)	Acrotelm	Catotelm	Total distance to zero drawdown (m)
0.5	Wet	0	7.1	0.3	7.4	8.88	0.3	9.18	18.2	0.3	18.5
0.5	Dry	0.2	-	0.4	0.4	-	0.51	0.51	-	0.87	0.87
1	Wet	0	7.1	0.77	7.87	8.88	0.77	9.65	18.2	0.77	18.97
1	Dry	0.2	-	1.03	1.03	-	1.32	1.32	-	2.22	2.22
1.5	Wet	0	7.1	1.24	8.34	8.88	1.24	10.12	18.2	1.24	19.44
1.5	Dry	0.2	-	1.65	1.65	-	2.09	2.09	-	3.49	3.49
2	Wet	0	7.1	1.69	8.79	8.788	1.69	10.48	18.2	1.69	19.89
2	Dry	0.2	-	2.24	2.24	-	2.84	2.84	-	4.7	4.7

Table 4 Sensitivity to permeability

			Acrotelm- 3m/day, Catotelm- 0.003m/day			Acrotelm - 9.5m/day Catotelm 0.09m/day			Acrotelm 1m/day Catotelm 0.0000518m/day		
Peat depth (m)	Acrotelm saturation state based on habitat classification	Ground water level (m below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)
			Acrotelm	Catotelm		Acrotelm	Catotelm		Acrotelm	Catotelm	
0.5	Wet	0	7.1	0.3	7.4	11.75	0.3	12.05	4.37	0.3	4.67
0.5	Dry	0.2	-	0.4	0.4	-	0.7	0.7	-	0.3	0.3
1	Wet	0	7.1	0.78	7.88	11.75	0.78	12.53	4.37	0.78	5.15
1	Dry	0.2	-	1.03	1.03	-	1.74	1.74	-	0.78	0.78
1.5	Wet	0	7.1	1.24	8.34	11.75	1.24	12.99	4.37	1.24	5.61
1.5	Dry	0.2	-	1.65	1.65	-	2.75	2.75	-	1.24	1.24
2	Wet	0	7.1	1.69	8.79	11.75	1.69	13.44	4.37	1.69	6.06
2	Dry	0.2	-	2.24	2.24	-	3.71	3.71	-	1.69	1.69

Table 5 Sensitivity to acrotelm depth

Peat depth (m)	Acrotelm saturation state based on habitat classification	Ground water level (m below ground surface)	Acrotelm depth 0.2m: Distance to zero drawdown (m) Acrotelm	Acrotelm depth 0.2m: Distance to zero drawdown (m) Catotelm	Acrotelm depth 0.2m: Total distance to zero drawdown (m)	Acrotelm depth 0.3m: Distance to zero drawdown (m) Acrotelm	Acrotelm depth 0.3m: Distance to zero drawdown (m) Catotelm	Acrotelm depth 0.3m: Total distance to zero drawdown (m)	Acrotelm depth 0.1m: Distance to zero drawdown (m) Acrotelm	Acrotelm depth 0.1m: Distance to zero drawdown (m) Catotelm	Acrotelm depth 0.1m: Total distance to zero drawdown (m)
0.5	Wet	0	7.1	0.3	7.4	10.1	0.2	10.3	3.8	0.39	4.19
0.5	Dry	0.2	-	0.4	0.4	-	0.27	0.27		0.53	0.53
1	Wet	0	7.1	0.77	7.87	10.1	0.68	10.78	3.8	0.87	4.67
1	Dry	0.2	-	1.03	1.03	-	0.91	0.91		1.16	1.16
1.5	Wet	0	7.1	1.24	8.34	10.1	1.15	11.25	3.8	1.33	5.13
1.5	Dry	0.2	-	1.65	1.65	-	1.52	1.52		1.76	1.76
2	Wet	0	7.1	1.69	8.79	10.1	1.6	11.7	3.8	1.78	5.58
2	Dry	0.2	-	2.24	2.24	-	2.11	2.11		2.35	2.35

Recharge Variation

1.1.31 Distance to zero drawdown for a peat depth of 2m and water table at surface is 8.8m for 50% recharge, 10.5m for 30% recharge (a 19% increase) and 19.9m for 10% recharge (a 126% increase). These percentage increases are very similar for shallower peat depths with the water table at the surface as the majority (>80%) of the drawdown occurs in the acrotelm.

1.1.32 Distance to zero drawdown for a peat depth of 2m and water table at the base of the acrotelm is 2.2m for 50% recharge, 2.8m for 30% recharge (27% increase) and increasing to 4.7m for 10% recharge(113% increase). Again these percentage increases are similar for shallower peat depths with the water table at the base of the acrotelm.

1.1.33 It therefore appears that the recharge rate does have a significant effect if rates are as low as 10% but if a rate of 30% is assumed there is limited change from the assumed 50% base case.

Permeability Variation

1.1.34 Altering the permeability of the acrotelm and the catotelm alters the shape of the dewatered cone of depression as the water will drain to the depression at a faster or slower rate depending on the permeability. The range of permeability values used in the analysis were based on the literature review with some of the more extreme values discarded.

1.1.35 Increasing the permeability from 3 m/day to 9.5 m/day (approximately 3 times) increases the distance to zero drawdown in the 0.2m thick acrotelm layer from about 7 m to nearly 12 m (65% increase), whereas decreasing it by 3 times (to 1 m/day) decreased the distance to zero drawdown to about 4.5 m (62% decrease). It was not deemed reasonable to increase the permeability to higher than 9.5 m/day (1 x 10-4 m/s) which is about the same as the permeability of fine sand.

1.1.36 The variability in the permeability of the catotelm from the literature review is wide and although a value of 0.003 m/day is assessed as being appropriate for use in the assessment a wider range of permeability values has been used to assess the effect within the catotelm.

1.1.37 For saturated peat of 0.5m depth the catotelm is 0.3m deep and is recharged from the saturated acrotelm at the same permeability of the catotelm (the recharge is equal to the permeability of the catotelm as it is not possible to force more water into the formation). This results in a distance to zero drawdown of 0.3 m at a permeability of 0.003 m/day and the same distance for all permeabilities due to the recharge term being equal to the permeability.

1.1.38 For unsaturated peat the recharge to the catotelm is equal to the rainfall recharge, 50%, unless the permeability of the catotelm is lower than the recharge rate which would therefore limit recharge. The variation in the permeability of the catotelm results in limited variation in the distance to zero drawdown and it is only in peat >1.5m deep at the higher permeability rates for the catotelm where the drawdown effects may extend to 2-3m.

Acrotelm Thickness Variation

1.1.39 A fairly uniform increase in distance to zero drawdown is observed with an increase in thickness of the acrotelm. At 0.1m thick the distance to zero drawdown is 3.8m. This increases to 7.1m (87% increase) at 0.2m thick and 10.1m (78% increase per 0.1m depth increase). This is expected as this is the permeable upper layer where the majority of drawdown occurs.

1.7 Limitations and Assumptions

1.1.40 The predicted distance to zero drawdown from the excavated area is dependent on various influencing factors. In this assessment the best estimate has been used. A sensitivity analysis has also been completed to assess the potential variation these extreme estimates may have.

Influencing Factors

1.1.41 The equations used to evaluate the impact on groundwater levels are simplifications of the actual environment as they do not include the wide number of variables that can alter the lateral extent of water table lowering. These variables include:

- the specific geology of each excavation. The actual depth of the peat across the site is likely to be an overestimate based on the data from coring which indicates a soft clay underlies the peat and is often recorded as the probe depth along with the peat.
- The underlying geology is comprised of low permeability clay of glacial origin or on occasion the bedrock that will yield little water. These factors will control the rate of flow into the excavation. The low permeability underlying geology will also have some impact on the hydrology of the peat above as an underlying higher permeability layer such as sands and gravels could act as a drain for the water within the overlying peat;
- the slope of the ground surface and the layering of the different geological formations;
- the connectivity between the geological layers. The presence of the low permeability clay layer that appears to be present across the majority of the site will limit the extent of the impact of peat dewatering solely on the peat;
- the depth of the excavation;
- the state of degradation of the peat as this influences the permeability; and
- the recharge rate, which will vary across the site depending on the slope, vegetation, rainfall intensity, storm duration and variations in the state of degradation of the peat.

Assumptions

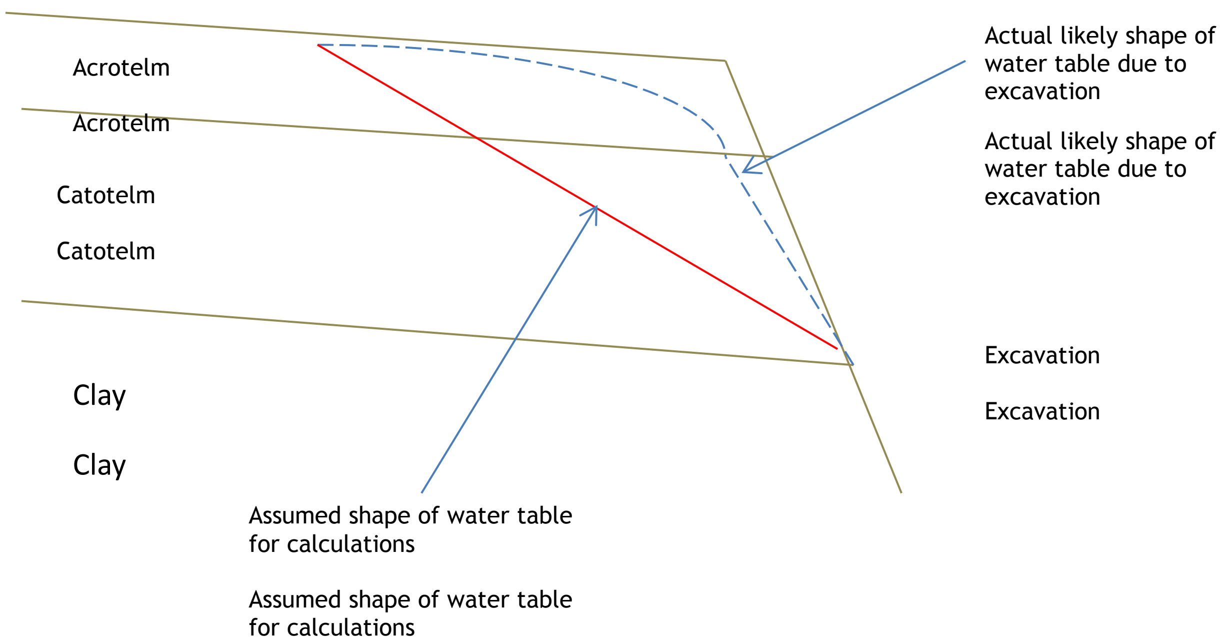
1.1.42 It is not feasible or assessed to be appropriate to obtain all the information necessary to calculate the actual predicted impact across the whole site. Therefore the following assumptions have been made:

- The peat depth for each infrastructure is an average of those recorded by the depth probe. This is likely an overestimate in most cases however it is a conservative approach;
- The peat depth for each 25m section of track is that recorded by the probe adjacent to the track;
- The peat depth is used as the depth of the seepage face;
- The acrotelm is assumed to be 0.2m deep based on site observations (Appendix 8.3);
- The peat saturation state is dependent on the surface habitats as mapped by the ecologists. A saturated habitat indicates that groundwater level is at surface. A non saturated habitat indicates that the groundwater level is at the base of the acrotelm i.e. 0.2m below ground surface;
- Based on the literature review the permeability of the acrotelm peat is estimated to be 3m/day and the catotelm peat 0.003m/day;

- A recharge rate of 0.0017m/day (607mm/yr) has been used which assumes that 50% of rainfall is effective. (From met office website, Trawscoed 1971-2000 average 1213.9 mm/yr);
- It is assumed that all tracks will be excavated to below the base of the peat and therefore will always drain. This is the worst case scenario; and
- The distance to zero drawdown is the maximum extent of the peat that could be impacted either permanently by the tracks, or temporarily by the turbine bases or other infrastructure.

Volume Calculation

1.1.43 The calculation of the volume of peat dewatered is conservative as it assumes a triangular wedge of peat is dewatered with a depth corresponding to the depth of peat (based on probing) within the excavation and a length of distance to zero drawdown. However, only minor dewatering occurs in the catotelm with most in the acrotelm. The following figure demonstrates the likely shape of the water table due to the excavation compared to that assumed by the calculation.



1.8 Results

1.1.44 The calculated distances to zero drawdown associated with the different infrastructure and based on the above assumptions are presented in Tables 4.

Turbine bases

1.1.45 All 30 turbine bases were assessed. The deepest average depth of peat across the turbine base and crane pad was at turbine R35 with a depth of 1.52m, however as this is within a dry habitat the distance to zero drawdown is limited by the low permeability of the catotelm. This limits the distance to zero drawdown to only 1.76 m and results in a total volume of peat dewatered, assuming a perimeter of 434m, of about 500m^3.

1.1.46 The greatest distance to zero drawdown is estimated to be 8.7m at turbine R39 which has an average peat depth of 0.8m in a wet habitat. Assuming a perimeter of 434m the associated volume of peat dewatered is about 1,500m^3.

1.1.47 The total volume of peat that would be dewatered in association with the 30 turbine bases is estimated to be 18,300m^3. This would be on a temporary basis during construction (Figure 4) and would not be impacted during operation (Figure 5). This volume does not include the peat that would be removed directly from the excavated area.

Tracks

1.1.48 The total length of track of 25,240 m was evaluated to assess all sections where peat was encountered. A dewatering assessment was undertaken on the contoured peat depths every 50m on either side of the track to build up a complete profile of the total amount of peat that is estimated to be dewatered. This comprises a total of 753 locations where probe depths greater than 0.1m were measured. This corresponds to 18,825m of track if it is assumed that peat was generally located on both sides of the track. Of these locations 539 had probe depths of 0.5m or less (equivalent to 13,475m of track). There is approximately 5,350m of track located on areas where the probe penetrated greater than 0.5m depth. As indicated previously, this is likely to be a substantial overestimate based on coring results.

1.1.49 The distance to zero drawdown was a maximum for a saturated habitat with 2m depth of peat. This produced a drawdown distance of 8.8m and therefore a volume of 440m^3 from the associated 50m length of track.

1.1.50 The total volume of peat potentially permanently drained by the access tracks is estimated at 34,700m^3. This volume does not include the peat that would be removed directly from the excavated area.

Other infrastructure

1.1.51 All other infrastructure have also been assessed to examine the potential impact on peat through dewatering. The majority of other infrastructure is located on dry habitats and therefore unless the probe depth was greater than 0.2m there is no associated dewatering impact. Those infrastructure that have no dewatering impact on peat are:

- Met Mast and associated crane pad;
- Welfare building (south);
- Welfare building (north);
- Construction compound 3;
- Construction compound 5;
- Borrow Pit 1;
- Borrow Pit 2;
- Borrow Pit 3;
- Borrow Pit 5;
- Borrow Pit 6; and
- Batching Plant.

1.1.52 Those infrastructure having an impact on peat through dewatering are therefore:

- Substation;

- Construction compound 1;
- Construction compound 2;
- Construction compound 4; and
- Borrow Pit 4.

1.1.53 The impact from these infrastructures will be of short duration, only during their construction and it is assumed that the extent of the drawdown is uniform on all sides of these infrastructure. The worst case distance to zero drawdown for these infrastructure is 8.6m from construction compound 4 which results in a total volume of dewatered peat of 390 m^3. The total estimated peat volume dewatered during the excavation of these structures in approximately 600 m^3.

Total effect

1.1.54 The total volume of peat calculated to be impacted by all wind farm infrastructure is predicted to be about 53,600 m^3. Of this 18,900 m^3 will be temporary and 34,700 m^3 will be permanent.

1.1.55 These values are likely to be maximum values as peat coring has demonstrated that the actual peat depth is generally substantially less than the probe depths and the method of calculated the volume as shown in section 3.3 is an overestimate.

1.1.56 If the linear drawdown assumption is used for the two separate layers of peat rather than directly across them both the volume of peat calculated to be impacted by all wind farm infrastructure is predicted to be substantially reduced to about 24,600 m^3. Of this 8,900 m^3 will be temporary and 15,700 m^3 will be permanent.

1.1.57 In addition, mitigation methods will likely reduce the effect of dewatering.

Table 3 Volume of peat dewatered due to Turbine base and Crane pad excavations

Turbine Number	Average Peat Depth (m)	Acrotelm saturation state	Groundwater level (metres below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Volume of peat dewatered (m^3)
				Acrotelm	Catotelm		
R4	0.46	Dry	0.2	-	0.35	0.35	20
R5	0.46	Wet	0	8.1	0.26	8.36	844
R6	0.56	Wet	0	8.1	0.36	8.46	1021
R7	0.28	Wet	0	8.1	0.08	8.18	490
R8	0.55	Wet	0	8.1	0.35	8.45	1006
R9	0.46	Wet	0	8.1	0.26	8.36	842
R12	0.60	Wet	0	8.1	0.40	8.50	1103
R13	0.28	Wet	0	8.1	0.08	8.18	491
R14	0.24	Wet	0	8.1	0.04	8.14	417
R15	0.55	Wet	0	8.1	0.35	8.45	1003
R16	0.31	Wet	0	8.1	0.11	8.21	549
R17	0.56	Wet	0	8.1	0.36	8.46	1035
R18	1.27	Dry	0.2	-	1.43	1.43	332
R19	0.42	Dry	0.2	-	0.3	0.30	14
R23	0.04	Dry	0.2	-	-	0.00	0
R24	0.10	Dry	0.2	-	-	0.00	0
R25	0.72	Wet	0	8.1	0.52	8.62	1342
R26	0.63	Wet	0	8.1	0.43	8.53	1164
R27	0.30	Wet	0	8.1	0.10	8.20	537
R31	0.59	Wet	0	8.1	0.39	8.49	1079
R32	0.12	Dry	0.2	-	-	0.00	0
R35	1.52	Dry	0.2	-	1.76	1.76	506
R36	0.88	Dry	0.2	-	0.91	0.91	135
R37	0.54	Dry	0.2	-	0.46	0.46	34
R38	0.72	Wet	0	8.1	0.52	8.62	1341
R39	0.80	Wet	0	8.1	0.60	8.70	1506
R40	0.39	Wet	0	8.1	0.19	8.29	704

Turbine Number	Average Peat Depth (m)	Acrotelm saturation state	Groundwater level (metres below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Volume of peat dewatered (m^3)
				Acrotelm	Catotelm		
R41	0.30	Wet	0	8.1	0.10	8.20	530
R42	0.36	Wet	0	8.1	0.16	8.26	280
R43	0.07	Dry	0.2	-	-	0.00	0
						Total volume	**18,324 m3**

Table 4 Volume of peat dewatered due to track excavations

Peat depth (m)	Acrotelm saturation state based on habitat classification	Groundwater level (metres below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Volume of peat dewatered (m^3)	Number of occurrences	Total volume of peat dewatered (m^3)
			Acrotelm	Catotelm				
0.05	Wet	0	2	-	2	2.50	20	50
0.05	Dry	0.2	-	-	0	0.00	41	0
0.1	Wet	0	3.75	-	3.75	9.38	24	225
0.1	Dry	0.2	-	-	0	0.00	65	0
0.15	Wet	0	5.5	-	5.5	20.63	12	248
0.15	Dry	0.2	-	-	0	0.00	30	0
0.2	Wet	0	7.1	0	7.1	35.50	36	1278
0.2	Dry	0.2	-	-	0	0.00	38	0
0.25	Wet	0	7.1	0.05	7.15	44.69	32	1430
0.25	Dry	0.2	-	0.07	0	0.00	27	2
0.3	Wet	0	7.1	0.1	7.2	54.00	23	1242
0.3	Dry	0.2	-	0.13	0.13	0.98	18	6
0.35	Wet	0	7.1	0.15	7.25	63.44	23	1459
0.35	Dry	0.2	-	0.2	0.2	1.75	21	16
0.4	Wet	0	7.1	0.2	7.3	73.00	41	2993
0.4	Dry	0.2	-	0.27	0.27	2.70	15	20

Peat depth (m)	Acrotelm saturation state based on habitat classification	Groundwater level (metres below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Volume of peat dewatered (m^3)	Number of occurrences	Total volume of peat dewatered (m^3)
			Acrotelm	Catotelm				
0.45	Wet	0	7.1	0.25	7.35	82.69	24	1985
0.45	Dry	0.2	-	0.33	0.33	3.71	16	33
0.5	Wet	0	7.1	0.3	7.4	92.50	25	2313
0.5	Dry	0.2	-	0.4	0.4	5.00	8	24
0.55	Wet	0	7.1	0.34	7.44	102.30	19	1944
0.55	Dry	0.2	-	0.46	0.46	6.33	7	28
0.6	Wet	0	7.1	0.39	7.49	112.35	9	1011
0.6	Dry	0.2	-	0.53	0.53	7.95	12	64
0.65	Wet	0	7.1	0.44	7.54	122.53	28	3431
0.65	Dry	0.2	-	0.59	0.59	9.59	15	100
0.7	Wet	0	7.1	0.49	7.59	132.83	18	2391
0.7	Dry	0.2	-	0.66	0.66	11.55	3	25
0.75	Wet	0	7.1	0.54	7.64	143.25	10	1433
0.75	Dry	0.2	-	0.72	0.72	13.50	4	40
0.8	Wet	0	7.1	0.59	7.69	153.80	11	1692
0.8	Dry	0.2	-	0.78	0.78	15.60	3	35
0.85	Wet	0	7.1	0.63	7.73	164.26	6	986
0.85	Dry	0.2	-	0.85	0.85	18.06	5	69
0.9	Wet	0	7.1	0.68	7.78	175.05	11	1926
0.9	Dry	0.2	-	0.91	0.91	20.48	1	16
0.95	Wet	0	7.1	0.73	7.83	185.96	4	744
0.95	Dry	0.2	-	0.97	0.97	23.04	3	55
1	Wet	0	7.1	0.77	7.87	196.75	0	0
1	Dry	0.2	-	1.03	1.03	25.75	1	21
1.05	Wet	0	7.1	0.82	7.92	207.90	4	832
1.05	Dry	0.2	-	1.1	1.1	28.88	1	23

Peat depth (m)	Acrotelm saturation state based on habitat classification	Groundwater level (metres below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Volume of peat dewatered (m^3)	Number of occurrences	Total volume of peat dewatered (m^3)
			Acrotelm	Catotelm				
1.1	Wet	0	7.1	0.87	7.97	219.18	2	438
1.1	Dry	0.2	-	1.16	1.16	31.90	2	52
1.15	Wet	0	7.1	0.92	8.02	230.58	5	1153
1.15	Dry	0.2	-	1.22	1.22	35.08	4	116
1.2	Wet	0	7.1	0.96	8.06	241.80	1	242
1.2	Dry	0.2	-	1.28	1.28	38.40	6	192
1.25	Wet	0	7.1	1.01	8.11	253.44	0	0
1.25	Dry	0.2	-	1.34	1.34	41.88	1	35
1.3	Wet	0	7.1	1.05	8.15	264.88	3	795
1.3	Dry	0.2	-	1.4	1.4	45.50	0	0
1.35	Wet	0	7.1	1.1	8.2	276.75	1	277
1.35	Dry	0.2	-	1.46	1.46	49.28	2	84
1.4	Wet	0	7.1	1.15	8.25	288.75	0	0
1.4	Dry	0.2	-	1.52	1.52	53.20	0	0
1.45	Wet	0	7.1	1.19	8.29	300.51	1	301
1.45	Dry	0.2	-	1.59	1.59	57.64	2	99
1.5	Wet	0	7.1	1.24	8.34	312.75	0	0
1.5	Dry	0.2	-	1.65	1.65	61.88	1	54
1.55	Wet	0	7.1	1.28	8.38	324.73	0	0
1.55	Dry	0.2	-	1.71	1.71	66.26	0	0
1.6	Wet	0	7.1	1.33	8.43	337.20	0	0
1.6	Dry	0.2	-	1.76	1.76	70.40	0	0
1.65	Wet	0	7.1	1.37	8.47	349.39	0	0
1.65	Dry	0.2	-	1.82	1.82	75.08	0	0
1.7	Wet	0	7.1	1.42	8.52	362.10	0	0
1.7	Dry	0.2	-	1.88	1.88	79.90	2	141

Peat depth (m)	Acrotelm saturation state based on habitat classification	Groundwater level (metres below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Volume of peat dewatered (m^3)	Number of occurrences	Total volume of peat dewatered (m^3)
			Acrotelm	Catotelm				
1.75	Wet	0	7.1	1.47	8.57	374.94	0	0
1.75	Dry	0.2	-	1.94	1.94	84.88	1	75
1.8	Wet	0	7.1	1.51	8.61	387.45	0	0
1.8	Dry	0.2	-	2	2	90.00	2	160
1.85	Wet	0	7.1	1.56	8.66	400.53	0	0
1.85	Dry	0.2	-	2.06	2.06	95.28	0	0
1.9	Wet	0	7.1	1.6	8.7	413.25	0	0
1.9	Dry	0.2	-	2.12	2.12	100.70	1	90
1.95	Wet	0	7.1	1.64	8.74	426.08	0	0
1.95	Dry	0.2	-	2.18	2.18	106.28	1	95
2	Wet	0	7.1	1.69	8.79	439.50	0	0
2	Dry	0.2	-	2.24	2.24	112.00	0	0
2.15	Dry	0.2	-	2.41	2.41	129.54	1	117
							Total	**34,700 m3**

Table 5 Volume of peat dewatered due to other infrastructure excavations

Infrastructure	Average Peat Depth (m)	Acrotelm saturation state	Groundwater level (metres below ground surface)	Distance to zero drawdown (m)		Total distance to zero drawdown (m)	Volume of peat dewatered (m^3)
				Acrotelm	Catotelm		
Met Mast and crane pad	0.18	Dry	0.2	0	0	0	0
Substation	0.16	Wet	0	6.6	0	6.6	131
Welfare Building (south)	0.17	Dry	0.2	0	0	0	0
Welfare Building (north)	0.13	Dry	0.2	0	0	0	0
Construction Compound 1	0.07	Wet	0	2.93	0	2.93	24
Construction Compound 2	0.54	Dry	0.2	0	0.46	0.46	17
Construction Compound 3	0.06	Dry	0.2	0	0	0	0
Construction Compound 4	0.41	Wet	0	8.21	0.41	8.62	391
Construction Compound 5	0.00	Dry	0.2	0	0	0	0
Borrow Pit 1	0.00	Dry	0.2	0	0	0	0
Borrow Pit 2	0.08	Dry	0.2	0	0	0	0
Borrow Pit 3	0.13	Dry	0.2	0	0	0	0
Borrow Pit 4	0.55	Dry	0.2	0	0.47	0.47	20
Borrow Pit 5	0.07	Dry	0.2	0	0	0	0
Borrow Pit 6	0.05	Dry	0.2	0	0	0	0
Batching Plant	0.05	Dry	0.2	0	0	0	0
						Total	**584 m3**

1.9 Mitigation options

1.1.58 In order to reduce the impact on peat hydrology the following mitigation measures should be taken into account in the construction and operational period of the wind farm:

Tracks

- On slopes above tracks the cut off ditch should be positioned close to the track so that as much water as possible has the opportunity to infiltrate into the upgradient peat;
- Regular discharge of water from the track and from the upgradient diversion channel to the down gradient land is required. This process will allow the water to infiltrate a short distance from the track and can help counter potential down gradient dewatering effects (Figure 3); and
- Dressing the cut slopes alongside the tracks with low permeability material can potentially help reduce flow rates from more permeable sections as it will act as a barrier to groundwater flow.

Turbine bases and other infrastructure

- Dewatering of the turbine bases may be required depending on the permeability of the surrounding geology, however current understanding suggests this is low. This will be limited to as short duration as possible to keep the excavation dry until the concrete is poured, cured and the void space backfilled;
- Any water from dewatering excavations should be discharged to peat areas surrounding the turbine base excavation during this period to promote recharge and reduce the impact of dewatering. This is a recognised method of mitigating the environmental impact of an abstraction (EA, 2007). If there are no peat areas immediately surrounding the infrastructure but they are close by then the water should be discharged between the excavation and the peat to reduce the extent of drawdown in the other formations that may extend to the peat;
- Cut off ditches on upgradient slopes should also be close to the excavated areas as it practical to allow water to recharge the surrounding peat; and
- Excavations should be left open for as short duration as practical to reduce the impact of dewatering on the surrounding peat.

1.10 References

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FIGURE 1 POTENTIAL GROUNDWATER LEVEL CHANGE DUE TO TRACK DEVELOPMENT

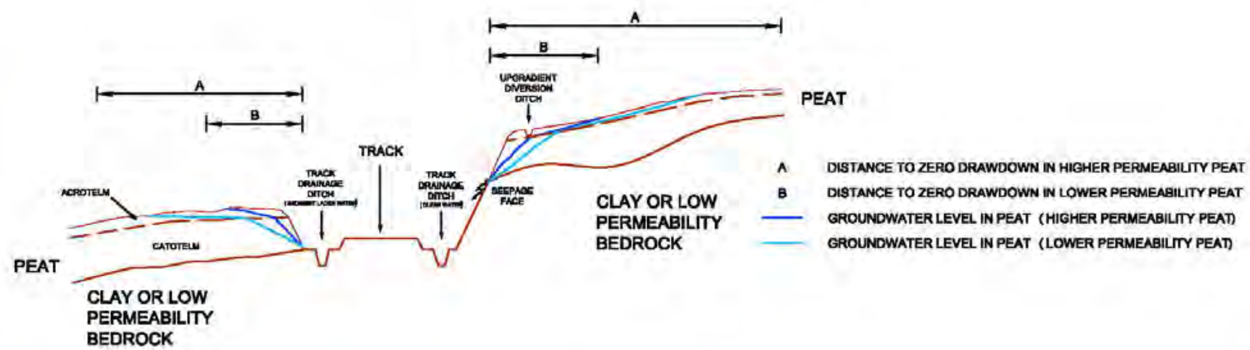


FIGURE 2 SCHEMATIC DRAINAGE ARRANGEMENT FOR ACCESS TRACK

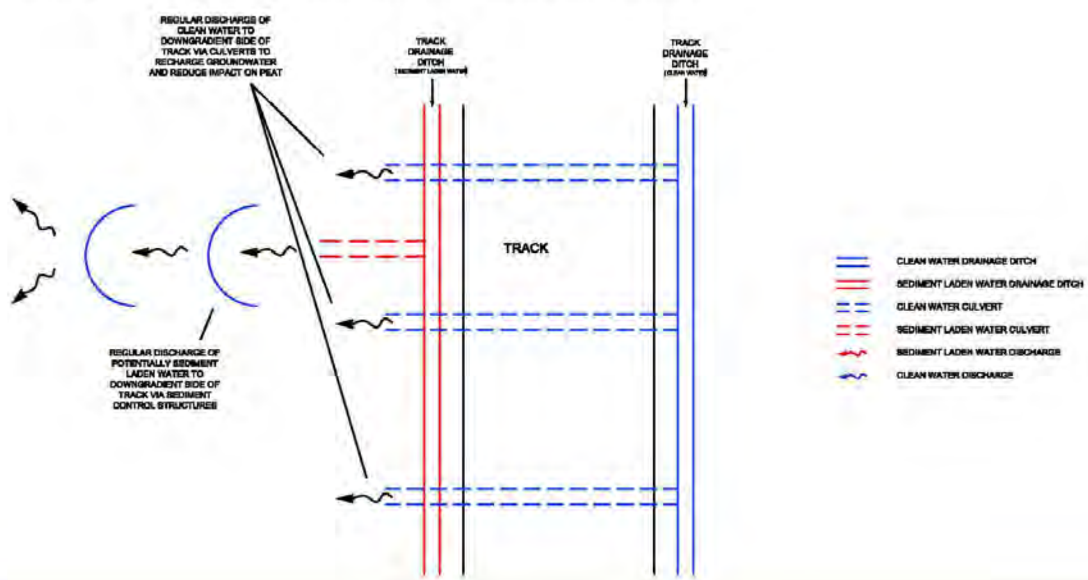


FIGURE 3 POTENTIAL GROUNDWATER LEVEL CHANGE DUE TO TURBINE BASE EXCAVATION DURING CONSTRUCTION

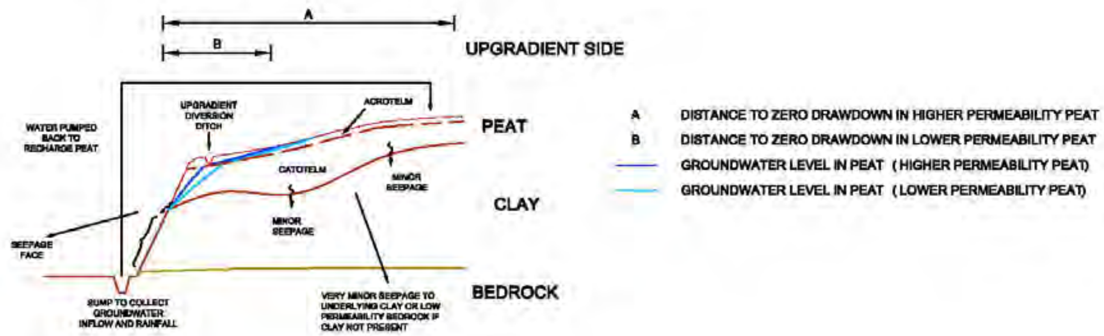
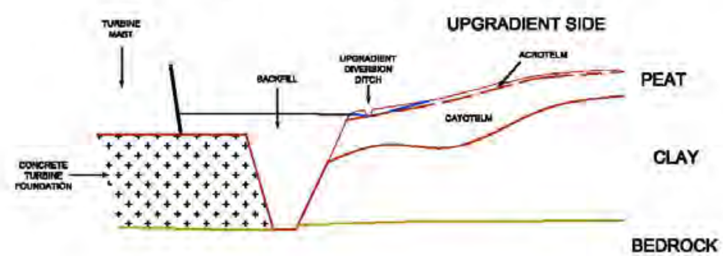


FIGURE 4 SCHEMATIC HYDROGEOLOGICAL CROSS SECTION AFTER TURBINE BASE CONSTRUCTION



APPENDIX 8.3: PEAT CORING AND PROBING COMPARISON

1.1.1 Probing has been completed at the Llanbrynmair project site at and around infrastructure locations at a specific configuration and also in other areas where there are no other constraints on a 100m grid basis. The probing has used narrow diameter probes that do not allow a sample to be obtained that are pushed into the ground until there is sufficient resistance to prevent further penetration. This depth is then recorded as the peat depth.

1.1.2 This probe is usually accurate for peat depth estimation when the formation underlying the peat is sands and gravels or bedrock, however can over estimate depths when soft clay is present. The probes used at Llanbrynmair were of the type show in Photo 1 (orange narrow diameter probe).

Photo 1 Probe (orange) alongside corer

1.1.3 To assess the underlying formation a series of cores have been obtained using a corer or auger (see photos 2 and 3) to determine the actual depth of the peat and obtain a sample of the underlying formation.

Photo 2 Peat corer

Photo 3 Peat Auger

1.1.4 These corers have demonstrated the widespread occurrence of clay across the site, directly underlying the peat. The acrotelm and the catotelm layers within the peat can often be distinguished as shown below.

Photo 4 Fibrous acrotelm layer

Photo 5 Catotelm layer

Photo 6 Clay underlying peat across much of the site

Photo 7 Thin acrotelm and catotelm layer over clay

1.1.5 Table 1 presents the data collected at various locations across a series of 5 separate visits. A comparison is made of the peat depth estimate from the probe and the actual cored sample taken from the corer/auger. In some cases the acrotelm depth was not examined as the focus was on the peat/clay (or other formation) interface.

1.1.6 A total of 117 locations around the site have been cored with a focus on areas that have been indicated as being on deep peat based on probe results.

1.1.7 Of the 117 locations a total of 34 actually encountered peat greater than 0.5m depth based on the coring. This is compared to 95 probes which were greater than 0.5m depth (probing was not taken at the time of the other 22 cores or was less than 0.5m depth). It should be noted that the large majority of these cores were focused on areas determined to be deep peat by probing and in particular 13 of the 34 cored locations encountering peat greater than 0.5m depth were at the watercourse crossing between R26 and R37.

1.1.8 There is significant variability in the probe penetration depth and the peat depth obtained from coring.

- A total of 72 probe penetration depths between >0.5m and up to 1.0m were compared with coring. Only 14 cores (19%) encountered peat >0.5m, whereas 58 cores identified peat <0.5m;
- Of the 117 locations cored 104 (89%) encountered clay beneath the peat, 5 encountered bedrock and 8 did not encounter the base of the peat; and
- Of the 26 probe penetration locations that were >1.0m a total of 20 were confirmed with the corer to have peat depths >1.0m.

Table 1 Peat Coring and Probe Data

Probe/Core Location Coordinates		Location Description	Peat Probe Penetration Depth (m)	Peat Core depth to base of peat (m)	Acrotelm Interval (m)	Catotelm Interval (m)	Mineral soil type and depth (m)
Northing	Easting						
294670	305730	Track to north of R23	0.3	0.1	0.0 - 0.1	-	Clay 0.1m
294660	305690	Track to north of R23	1.3	0.05	0.0 - 0.05	-	Clay 0.05m
295980	309120	Near Turbine R26	0.9	0.3	-	-	Clay 0.3m
295850	309150	Between R26 and R37	0.8	0.35	0.0 - 0.2	0.2 - 0.35	Clay 0.35m
295770	309160	Between R26 and R37	0.8	0.5	0.0 - 0.2	0.2 - 0.5	Clay 0.5m
295610	309130	Between R26 and R37	1.8	0.0 - 1.8	0.0 - 0.4	0.4 - 1.8 (assumed as no recovery)	Rock 1.8m
296560	309100	Between R26 and R37	0.5	0.5	0.0 - 0.2	0.2 - 0.5	Rock 0.5m
295360	308480	Near Turbine R35	2.5	1.8	0.0 - ?	? - 1.8	Clay 1.8m
295630	308410	Near Turbine R36	1.0	0.25	0.0 - 0.25	-	Clay 0.25m
295740	308380	Near Turbine R36	0.9	0.5	0.0 - 0.15	0.15 - 0.5	Clay 0.5m
295870	308590	Track between R36 and R38	0.6	0.35	-	-	Clay 0.35m
295990	308630	Turbine R38	1.0	0.8	-	-	Clay 0.8m
294970	306470	Near Turbine 15	0.9	0.4	-	-	Clay 0.4m
294970	306490	Near Turbine 15	1.0	0.4	-	-	Clay 0.4m
293470	303690	Near Turbine R18	>2.0	2.0	-	-	Clay 2.0m
293450	303660	Near Turbine R18	>2.0	1.7	-	-	Clay 1.7m
293730	304020	Near Turbine R9	0.7	0.4	-	-	Clay 0.4m
293720	304010	Near Turbine R9	0.8	0.25	-	-	Clay 0.2m
293022	304977	Near Turbine R7	0.25	0.15	0.05	0.05 - 0.15	Clay 0.15m
292954	304922	Near Turbine R7	0.25	0.2	0.1	0.1 - 0.2	Clay 0.20m
292905	304806	Near Turbine R7	0.2	0.15	0.05	0.05 - 0.15	Clay 0.15m
292960	304596	Between Turbine R7 and Turbine R5	0.15	0.1	0 - 0.1	None	Clay 0.1m
292476	304300	Near Turbine R4	0.85	0	None	None	All clay
292491	304218	Near Turbine R31	0.6	0.2	-	-	Clay 0.2m
292280	303995	Near Turbine R31	0.2	0.2	-	-	Clay 0.2m
293355	303350	Near Turbine R39	0.2	0	None	None	Soil from surface
293400	303650	Near Turbine R18	1.1	0.2	-	-	Clay 0.2m
		Near Turbine R18		0.0	-	-	Clay 0.1m
		Near Turbine R18		0.4	-	-	Clay 0.4m
		Near Turbine R18		0.5	-	-	Clay 0.5m
293760	304060	Near Turbine R9	0.75	0.45	0.0 - 0.35	0.35 - 0.45	Clay 0.45m
293275	304120	Near Turbine R6	Between 0.3 and 0.9	None	None	None	Clay 0.2m

Probe/Core Location Coordinates		Location Description	Peat Probe Penetration Depth (m)	Peat Core depth to base of peat (m)	Acrotelm Interval (m)	Catotelm Interval (m)	Mineral soil type and depth (m)
Northing	Easting						
293080	304200	Track between R5 and R6	Between 0.0 and 0.4	0.35	0.0 - 0.15	0.15 - 0.35	Clay 0.35m
292900	304100	Near Turbine R5	Between 0.4 and 0.65	0.1	0.0 - 0.1	None	Clay 0.10m
292640	303800	Track to water crossing to Turbine R31 and R32	?	0.2	0.0 - 0.15	0.15 - 0.2	Clay 0.2m
292615	303770	Between Turbine R5 and Turbine R6 on track	Between 0.5 and 0.7	>0.5	0.0 - 0.15	0.15 - >0.5	Base of peat not reached
292860	303670	Between Turbine R41 and Turbine R32	?	>0.9	0.0 - 0.25	0.25 - >0.9	Base of peat not reached
292760	303630	Between Turbine R41 and Turbine R32	0.70	0.4	0.0 - 0.4	-	Clay 0.40m
293027	304795	Soligenous fen	>3	>3	-	>3	Base of peat not reached. No recovery
295325	306515	Near Turbine R42	0.6 0.9	0.5 0.5	- -	- -	Clay 0.50m Clay 0.50m
		Quarry near Turbine R24	?	None	-	-	Bedrock under thin soil
295240	306930		1.0	0.50	-	-	Clay 0.50m
294938	306501	R15	1.2	1.0	-	-	Blue clay 1.0m
294963	306501	R15 25R	1.3	0.6	-	-	Clay 0.6m
294988	306501	R15 50R	1.10-1.20	1.1	-	-	Gravelly clay 1.1m
294913	306501	R15 25L	0.5 - 1.1	0.4	0.0 - 0.2	0.2 - 0.4	Clay 0.4m
294888	306501	R15 50L	0.3	0	-	-	Soil and clay only
294938	306526	R15 25N	1.8	1.3	-	-	Clay 1.3m
294938	306476	R15 25S	0.6	0.25	-	-	Grey clay 0.25m
294366	306803	R16 25R	0.4	0.35	0.0 - 0.15	0.15 - 0.35	Stiff brown clay 0.35m
294341	306828	R16 25N	0.8	0.4	0.0 - 0.2	0.2 - 0.4	Soft brown clay 0.4m
294341	306853	R16 50N	1.1	0.85	-	-	Clay 0.85m
294341	306778	R16 25S	0.5 to 0.55	0.3	0.0 - 0.15	0.15 - 0.3	Stiff brown clay 0.3m
294341	306753	R16 50S	0.35	0.25	0.0 - 0.2	0.2 - 0.25	Stiff brown clay 0.25m
295064	307341	R25 50R	up to 1.0	0.8	0.0 - 0.4	0.4 - 0.8	Clay 0.8m

Probe/Core Location Coordinates		Location Description	Peat Probe Penetration Depth (m)	Peat Core depth to base of peat (m)	Acrotelm Interval (m)	Catotelm Interval (m)	Mineral soil type and depth (m)
Northing	Easting						
294989	307341	R25 25L	0.6	0.5	-	-	Clay 0.5m
294964	307341	R25 50L	up to 1.2	0.6	0.0 - 0.4	0.4 - 0.6	Clay 0.6m
295014	307366	R25 25N	0.5 to 0.7	0.35	0.0 - 0.15	0.15 - 0.35	Stiff brown clay 0.35m
295014	307391	R25 50N	0.5 - 1.0	0.3	-	-	Clay 0.3m
295014	307316	R25 25S	up to 0.9	0.4	0.0 - 0.25	0.25 - 0.4	Clay 0.4m
295014	307291	R25 50S	up to 1.0	0.4	0.0 - 0.2	0.2 - 0.4	Clay 0.4m
294288	305267	R12	up to 0.7	0.25	0.0 - 0.1	0.1 - 0.25	Clay 0.25m
294288	305292	R12 25n	up to 0.8	0.15	0.0 - 0.2	0.15 - 0.2	Clay 0.9m
294288	305317	R12 50N	up to 1.0	0.3	0.0 - 0.3	0.3 - 0.9	Clay 0.9m
294263	305267	R12 25W	up to 0.9	0.2	0.0 - 0.1	0.1 - 0.2	Grey clay 0.2m
294238	305267	R12 50W	0.7	0.2	0.0 - 0.1	0.1 - 0.2	Clay 0.2m
293323	304091	R6 25E	up to 1.0	0.15	0.0 - 0.1	0.1 - 0.15	Clay 0.15m
293348	304091	R6 50E	0.3 to 0.7	0.2	0.0 - 0.1	0.1 - 0.2	Clay 0.2m
293763	304052	R9	up to 0.9	0.3	0.0 - 0.15	0.15 - 0.3	Clay 0.3m
293763	304077	R9 25N	0.6 - 0.75	0.5	0.0 - 0.2	0.2 - 0.5	Clay 0.5m
293713	304052	R9 50W	0.3 - 0.6	0.15	0.0 - 0.1	0.1 - 0.15	Clay 0.15m
293738	304052	R9 25W	0.5	0.25	0.0 - 0.15	0.15 - 0.25	Clay 0.25m
293763	304102	R9 50N	up to 0.8	0.2	0.0 - 0.1	0.1 - 0.2	Clay 0.2m
293763	304027	R9 25S	0.3 to 0.6	0.25	0.0 - 0.1	0.1 - 0.25	Clay 0.25m
293763	304002	R9 50S	0.9 - 1.0	0.6	0.0 - 0.2	0.2 - 0.6	Clay 0.6m
293788	304052	R9 25E	0.3 - 0.9	0.2	0.0 - 0.15	0.15 - 0.2	Clay 0.2m
293813	304052	R9 50E	up to 0.6	0.2	0.0 - 0.1	0.1 - 0.2	stiff brown clay 0.2m
292313	303990	R31	up to 1.0	1.0	-	-	Clay 1.0m
292325	304001	R31 25N	>1.0	0	-	-	Clay 0m
292325	304026	R31 50N	>1.0	0	-	-	silty soil getting clayier with depth
292325	303951	R31 25S	0.5	0	-	-	topsoil to 10cm then clay
292350	303976	R31 25E	1.0 to 1.1	0.35	0.0 - 0.05		Clay 0.35m

Probe/Core Location Coordinates		Location Description	Peat Probe Penetration Depth (m)	Peat Core depth to base of peat (m)	Acrotelm Interval (m)	Catotelm Interval (m)	Mineral soil type and depth (m)
Northing	Easting						
292375	303976	R31 50E	up to 0.9	0.1	-	-	Clay 0.1m
293542	303198	R39	0.7 - 0.9	0.25	-	-	Clay 0.25m
293542	303173	R39 25S	up to 0.9	0.3	-	-	Yellow stiff clay 0.3m
293492	303198	R39 50W	up to 0.9	0.3	-	-	Clay 0.3m
293517	303198	R39 25W	up to 0.9	0.1	-	-	Clay 0.1m
295982	309095	R26	up to 0.7	0.3	0.0 - 0.1	0.1 - 0.3	Clay 0.3m
296032	309095	R26 50E	0.4 - 0.6	0.1	0.0 - 0.1	-	Clay 0.1m
296007	309095	R26 25E	up to 0.8	0.3	0.0 - 0.15	0.15 - 0.3	soft brown clay 0.3m
295982	309070	R26 25S	up to 0.5	0.25	0.0 - 0.15	0.15 - 0.25	Clay 0.25m
295982	309045	R26 50S	up to 0.7	0.4	0.0 - 0.2	0.2 - 0.4	Clay 0.4m
295982	309120	R26 25N	up to 0.7	0.15	0.0 - 0	0 - 0.15	Clay 0.15m
295982	309145	R26 50N	up to 1.0	0.4	0.0 - 0.2	0.2 - 0.4	Clay 0.4m
295957	309095	R26 25W	up to 0.9	0.6	0.0 - 0.4	0.4 - 0.6	Clay 0.6m
295659	309090	Near watercourse crossing R26 - R37	>1.3	>1.3	-	-	Base of peat not reached
295666	309084	Near watercourse crossing R26 - R37	>1.3	1.3	-	-	Clay 1.3m
295672	309078	Near watercourse crossing R26 - R37	>1.3	1.1	-	-	Clay 1.1m
295681	309074	Near watercourse crossing R26 - R37	>1.3	>1.3	-	-	Base of peat not reached
295689	309067	Near watercourse crossing R26 - R37	>1.3	>1.0	-	-	Base of peat not reached
295696	309059	Near watercourse crossing R26 - R37	1.1	1.0	-	-	Clay 1.0m
295706	309055	Near watercourse crossing R26 - R37	1.1	1.0	-	-	Clay 1.0m
295717	309049	Near watercourse crossing R26 - R37	>1.3	>1.0	-	-	Base of peat not reached
295724	309046	Near watercourse crossing R26 - R37	>1.3	>1.0	-	-	Base of peat not reached
295736	309040	Near watercourse crossing R26 - R37	0.6	0.6	-	-	Rock 0.6m
295746	309035	Near watercourse crossing R26 - R37	0.7	0.6	-	-	Clay 0.6m
295754	309029	Near watercourse crossing R26 - R37	0.7	0.6	-	-	Clay 0.6m
295763	309022	Near watercourse crossing R26 - R37	0.5	0.25	-	-	Clay 0.25m
295773	309032	Near watercourse crossing R26 - R37	1.0	1.0	-	-	Rock 1.0m

Probe/Core Location Coordinates		Location Description	Peat Probe Penetration Depth (m)	Peat Core depth to base of peat (m)	Acrotelm Interval (m)	Catotelm Interval (m)	Mineral soil type and depth (m)
Northing	Easting						
296007	308635	R38	0.7 - 0.8	0.35	0.0 - 0.15	0.15 - 0.35	Clay 0.35m
295982	308635	R38 25W	0.85	0.85	0.0 - 0.2	0.2 - 0.85	Clay 0.85m
295957	308635	R38 50W	up to 0.8	0.2	-	-	Clay 0.2m
296007	308610	R38 25S	0.6	0.5	-	-	Clay 0.5m
296007	308585	R38 50S	0.9	0.55	-	-	Clay 0.55m
296032	308635	R38 25E	0.6	0.35	0.0 - 0.2	0.2 - 0.35	Clay 0.35m
296057	308635	R38 50E	0.8	0.8	0.0 - 0.4	0.4 - 0.8	Clay 0.8m

1.1 Peat Depth at Turbine Bases

1.1.9 Coring undertaken at a number of turbine bases has demonstrated that a number of these bases are not actually located on peat >0.5m. The following table indicates the depth of penetration around the turbine base and also some data from cores (shaded cells). The comment alongside indicates where micrositing will avoid peat >0.5m (values in red).

Table 2 Peat Coring and Probe Data for Turbine Bases

Turbine Number	Depth (m)					Comments
	Turbine centre	25m to North	25m to South	25m to East	25m to West	
R 4	0.25	0.35	0.75	0.20	0.50	Assume micrositing of turbine to north - probe depth 50m north of centre 0m
R 5	0.10	0.10	0.10	0.10	0.30	
R 6	0.10	0.45	0.30	0.15	0	
R 7	0.15	0.35	0.70	0.45	0.15	Assume micrositing of turbine to north - probe depth 50m north of centre 0.35m
R 8	0.35	0.40	0.35	0.30	0.50	
R 9	0.30	0.50	0.25	0.20	0.25	
R 12	0.25	0.30	0.40	0.30	0.20	
R 13	0	0	0	0	0.20	
R 14	0	0.20	0	0	0	
R 15	1.0	1.30	0.25	0.60	0.40	Assume micrositing of turbine to south west - probe depth 50m south of centre 0.35m and 50m west of centre 0m
R 16	0.30	0.40	0.30	0.35	0.15	
R 17	0.50	0.90	0.40	0.30	0.35	Assume micrositing of turbine to south - probe depth 50m south of centre 0.50m
R 18	>2.0	0.85	>2.00	1.50	0.30	Peat depths to be reviewed post felling for micrositing
R 19	0.40	0.25	0.60	0.35	0.35	Assume micrositing of turbine to north - probe depth 50m north of centre 0.50m
R 23	0.20	0	0	0	0.20	
R 24	0	0	0	0	0	

Turbine Number	Depth (m)					Comments
	Turbine centre	25m to North	25m to South	25m to East	25m to West	
R 25	0.35	0.35	0.40	0.20	0.50	
R 26	0.30	0.15	0.25	0.30	**0.60**	Assume micrositing of turbine to east - probe depth 50m east of centre 0.10m
R 27	0.15	0.10	0.50	0.20	**0.90**	Assume micrositing of turbine to east - probe depth 50m east of centre 0.15m
R 31	**1.0**	0	0	**1.25**	0.30	Peat depths to be reviewed post felling. Assume micrositing of turbine to west
R 32	0.10	0.10	0.10	0.10	0.10	
R 35	**1.3**	**1.90**	**1.80**	**1.20**	**1.5**	Peat depths to be reviewed post felling for micrositing
R 36	**1.1**	**1.00**	0.50	**0.90**	**0.90**	Peat depths to be reviewed post felling for micrositing
R 37	0.50	0.30	0.30	0.50	0.50	
R 38	0.35	0.40	0.50	0.35	**0.85**	Assume micrositing of turbine to north - probe depth 50m north of centre 0.40m
R 39	0.25	0.50	0.30	0.50	0.10	
R 40	0.50	0.10	0.50	0.30	**0.70**	Assume micrositing of turbine to east - probe depth 50m east of centre 0.50m
R 41	0	0.10	0.20	0.25	0.10	
R 42	0.40	0.50	0.40	0.20	**0.75**	Assume micrositing of turbine to east - probe depth 50m east of centre 0.30m
R 43	0	0	0	0	0	

1.1.10 The data presented indicates that minor micrositing can avoid the possible peat >0.5m at turbines R4, R7, R17, R19, R27, R40 and R42 – however these locations have not been cored and it is likely that the depth of peat in these locations are <0.5m.

1.1.11 Additional micrositing can avoid the peat that has been verified to be >0.5m through coring at R15, R26 and R38.

1.1.12 The only turbines that will therefore be located on areas of peat of depth >0.5m and will require additional probing and refinement of micrositing post felling are those at R18, R31, R35 and R36. All of these are located on degraded peat that has been afforested and which will be felled and the peatland habitat restored.

APPENDIX 8.4: DRAINAGE ASPECTS OF FORESTRY RESTORATION

1.1.1 Blanket bog is a priority habitat under Annex 1 of the Habitat Directive, and a priority habitat for biodiversity in the United Kingdom (UK). Blanket bog areas have been under rapid decline over the last 100-150 years and the European Union (EU) scientific community has recognised at an international level that this decline must be halted and reversed where feasible.

1.1.2 The Habitat Management Plan has identified five forestry areas on site where peatland restoration will be undertaken. These areas are presented on Figure 5.3 (the Habitat Management Plan) and comprise a total area of 149 hectares (Area 1: 35ha and 27ha; Area 2: 16ha and 30ha and Area 7: 41ha). The methodology for peat restoration in these areas and the assessment of the potential volume of peat that can be reused are presented below.

1.1 Methodology for Peat Restoration

1.1.3 The formation of peatland is reliant on a high water table, whether temporary or permanent, therefore the current drainage in these areas must be controlled to allow restoration to take place. In these five forested areas it is assumed that once the forestry has been felled the drains can be blocked to raise the water levels in the drains and therefore the groundwater level across these areas.

1.1.4 As the project site presents both extensive natural and anthropogenic drainage systems along with the impact from forestry, which have led to a severely altered blanket bog, the first step and main activity to restore the natural habitat will include a comprehensive effort to block most of the ditches on the site. These blockings will benefit the characteristic vegetation and species of the peatland, as well as decrease the risk of soil erosion and flash flooding.

1.1.5 It is generally recommended that drain blocking is undertaken used either highly decomposed peat or plastic piling. Peat turves do have the highest dam failure rate if not installed correctly but if they are installed correctly they tend to be the most cost effective solution. There are however a number of considerations that must be taken into account when selecting the dam material which include slope, drain size and exposure of mineral substrate.

1.1.6 Peat dams can be built by hand and have proven to be very effective (Armstrong et al., 2009) on bare peat sites, if correctly installed. For larger ditches, other techniques can be used i.e. machinery to push down the sides of the drain using an excavator bucket or using an excavator bucket to scoop material out and place it in the drain. It is important to get a complete, firm contact between wet peat to create a seal. Then, a piece of turf should be laid on top of the bare peat to prevent it drying out, increase stability and improve aesthetics.

1.1.7 The ideal dam spacing depends on slope angle and volume of water: drains on steeper slopes and with greater supply area draining into them should be blocked at shorter intervals as stream powers will be higher. However, they should not be more than 12 m apart.

1.1.8 For any larger drains (greater than 2 m wide and/or more than 1 m deep) plastic piling will be used as they are both stronger (to prevent erosion) and easy to transport (they come in small, light weighted sections).

1.1.9 Once the drains have been blocked with a combination of plastic sheeting and peat it is recommended that catotelm peat that has been excavated on site is deposited into the existing furrows between the trees which will become saturated as the drains will no longer maintain groundwater levels at depth.

1.2 Peat Volume Reuse Estimation

1.1.10 To determine how much peat may be used within these areas an examination was completed insofar as possible given the extent of tree cover and the limited options for examining all drains and furrows. The following photos and associated measurements provide an indication of the dimensions of the furrows in these areas and their spacing.


Waterlogged furrow in 17.5 ha area


Wide furrow in 17.5 ha area


Dry furrow approximately 0.5m wide by 0.2m deep.


Drain intercepting upgradient groundwater at upgradient edge of forestry


Drain connecting to furrows


Wider drainage within forestry

Sphagnum upgradient of forestry

Furrows and drainage channels

Rows of trees with alternate deep and shallow furrows

1.1.11 Site observations indicate a variety of conditions in forested areas ranging from areas between rows of trees that were essentially flat to broad furrows of about 1m or more wide and up to 0.3m deep. In places the furrows alternate between rows of trees with a deep furrow adjacent to a shallow one. These tend to be about 2m apart. In other locations the deeper furrows are located every 2m or 3m.

1.1.12 In addition drainage ditches cross the forested areas however these have no specific frequency although they do not tend to be wide (~0.5m) and vary in depth between about 0.3m and 0.6m although there are deeper sections in places. Furthermore a number of natural drainage channels cross the forested areas and the drains and furrows are all linked to these.

1.1.13 Based on observations at all of the five areas, the presence of some areas where there are limited trees and the land is already saturated and the presence of numerous deeper drainage ditches an approximation of furrow dimensions and density is therefore estimated. If the average dimension of a furrow is 0.5m wide by 0.2m deep and they are spaced at approximately 3m then the potential volume of peat that could be placed in these furrows is about 330 m3 per hectare or about 50,000 m3 for the whole 149 hectares.

1.3 References

1.1.14 Armstrong, A., Holden, J., Kay, P., Foulger, M., Gledhill, S., McDonald, A.T. and Walker, A. 2009. Drain-blocking techniques on blanket peat: A framework for best practice. Journal of Environmental Management. 90 (2009): 3512–3519.

APPENDIX 8.5: GROUNDWATER LEVELS BASED ON NVC AND GWDTE ASSESSMENT

1.1.1 Groundwater levels across the Llanbrynmair site have been estimated based on the occurrence of peat across the site and the habitat present at surface. It is assumed that for wet habitats (A) (Table 1) the groundwater level is at surface as these habitats are saturated. For other habitats (B) it is assumed that the groundwater level is at either the base of the acrotelm or the soil base where it overlies the low permeability clay or bedrock surface.

1.1.2 Table 1 presents the NVC communities found on the site, a description of the community and whether they fall into a wet or dry habitat. In addition a note on whether the community is a Groundwater Dependent Terrestrial Ecosystem based on the SEPA LUPS guidance is included.

Table 1 Groundwater levels across the site based on National Vegetation Classification Survey Results for Site

A - Groundwater levels at the surface
B - Groundwater levels at the base of the acrotelm

NVC code	Community name	Details	Habitat Type (A or B)	GWDTE dependency (SEPA LUPS)	Waterlogged
H12	Calluna vulgaris-Vaccinium myrtillus heath	Heath This community is the typical sub-shrub community of acidic to circumneutral, free-draining mineral soils throughout the cold and wet sub-montane zone generally between 200m and 600 m. The soils on which it occurs are widespread throughout this zone, developing from a variety of siliceous parent materials, intrusive igneous rock or coarse glaciofluvial gravels. Despite being free-draining the soils are normally moist for the majority of the year because of the climate and the superficial pH is usually between 3.5 and 4.5.	B	No	N
H12/M19		Heath /Mire	B	No/no	Y
H12/M25		Heath /Mire	A	No/mod	Y
H12 /U5		Heath / Calcifugous grasslands and montane communities	B	No	
H8	Calluna vulgaris-Ulex gallii heath	Heath A dry heath community found on free-draining, generally acid to circumneutral soils, in the warm oceanic regions of lowland Britain. It can be found over a wide range of arenaceous sedimentaries and acid igneous and metamorphic rocks as well as on silty and sandy superficials like loess and Aeolian sands. The superficial pH underneath this community is usually from 3.5 to 4.5.	B	No	

NVC code	Community name	Details	Habitat Type (A or B)	GWDTE dependency (SEPA LUPS)	Waterlogged
M15	Scirpus cespitosus-Erica tetralix wet heath	Heath This wet heath community is characteristic of moist and generally acid and oligotrophic peats and peaty mineral soils in the wetter western and northern parts of Britain.It is a community of shallow, wet or intermittently waterlogged, acid peat or peaty mineral soils on hillsides, over moraines, and within tracts of blanket mire. It also extends on to deep peat where the original bog vegetation has been damaged or modified by burning, grazing, drainage and peat cutting.	A	mod	Y
M15 /M23		Mire	A	Mod/high	Y
M19	Calluna vulgaris-Eriophorum vaginatum blanket mire	Mire This mire is the typical blanket bog vegetation of high-altitude ombrogenous peats present in the wet and cold climate of the uplands of northern Britain. In particular, it occurs on high-level plateaux and broad watersheds, usually above 300 m, and is confined to deeper peats, usually more than 2m thick, on flat or gently-sloping ground. The peats are not consistently waterlogged and may become surface oxidised in summer.	A	No	Y
M19 / H12			A	No	
M19/M20		Mire / Heath	A	No	Y
M19/M6		Mire	A	No/high	Y
M20	Eriophorum vaginatum blanket and raised mire	Mire This community is characteristic of ombrogenous peats on bogs where certain treatments have greatly affected the vegetation; grazing and burning have been of greatest significance, but draining and aerial pollution have also played a part. It is commonest on blanket mires, where these factors have contributed both to floristic impoverishment and to gross erosion of the peats, but is also found locally on run-down raised bogs. The *Eriophorum* mire is present mainly between 500 m and 700m where the climate is cold and wet. The peats are generally dry, often showing surface oxidation and with a pH frequently as low as 3.	A	No	Y

NVC code	Community name	Details	Habitat Type (A or B)	GWDTE dependency (SEPA LUPS)	Waterlogged
M23	Juncus effusus/acutiflorus-Galium palustre rush-pasture	Mire This rush-pasture occurs over a variety of moist, moderately acid to neutral, peaty and mineral soils in the cool and rainy lowlands of western Britain. It is a community of gently-sloping ground around the margins of soligenous flushes, as a zone around topogenous mires and wet heaths, and especially widespread in ill-drained, comparatively unimproved or reverted pasture. It can be found on a variety of moderately acid to neutral soils that are kept moist to wet for most of the year with a pH in the range of 4-6.	A	High	N
M23 /M25		Mire	A	High/mod	Y
M25	Molinia caerulea-Potentilla erecta mire	Mire This mire is a community of shallow, wet peats found in the wet and cool western lowlands of Britain. It occurs over gently-sloping ground, marking out seepage zones and flushed margins of sluggish streams, water-tracks and topogenous mires, but also extends onto the fringes of ombrogenous mires.	A	mod	Y
M25 / M6		Mire	A	Mod/high	Y
M25/ U5		Mire	A	Mod/no	Y
M6	Carex echinata-Sphagnum recurvum/auriculatum mire	Mire These mires occur in wet hollows, seepage lines, flushes, shallow gullies cutting down hillsides, and along the margins of streams within expanses of blanket mire, dwarf-shrub heath or acid grassland. They also occur around slow-flowing springs at the heads of rivers. The soils beneath *Carex echinata-Sphagnum* flushes are deep, wet and usually peaty.	A	High	N
M6 / M23		Mire	A	High/mod	Y
M6 / M25		Mire	A	High/mod	Y
M6 / U5		Mire / Calcifugous grasslands and montane communities	A	Hhigh/no	Y
MG6	Lolium perenne-Cynosurus cristatus grassland	Mesotrophic grassland Associated with well drained permanent pastures and meadows.	B	no	N
MG6 / M23		Mesotrophic grassland / mire	A	No/high	
MG6 / MG7		Mesotrophic grassland	B	No/no	

NVC code	Community name	Details	Habitat Type (A or B)	GWDTE dependency (SEPA LUPS)	Waterlogged
MG7	Lolium perenne leys and related grasslands	Mesotrophic grassland	B	No	N
MG7 / M23		Mire	A	No/high	Y
MG7 / MG6		Mesotrophic grassland	B	No/mod	N
P	Plantation		B	No	N
U20	Pteridium aquilinum-Galium saxatile community	Calcifugous grasslands and montane communities The community covers fairly deep, well-drained but moist, base-poor and infertile soils. It is absent from wet ground and strongly flushed slopes.	B	No	N
U20 / M6		Calcifugous grasslands and montane communities / mire	A	No/high	
U20 / U4		Calcifugous grasslands and montane communities	B	No/No	
U20 / scrub		Calcifugous grasslands and montane communities / scrub	B	No/no	
U4	Festuca ovina-Agrostis capillaris-Galium saxatile grassland	Calcifugous grasslands and montane communities This is a grassland of acid brown earths and brown podsolic soils that drain freely but can be moist.	B	No	N
U4 / M25		Calcifugous grasslands and montane communities / mire	A	No/high	N
U4 / U20		Calcifugous grasslands and montane communities	B	No/no	N
U5	Nardus stricta-Galium saxatile grassland	Calcifugous grasslands and montane communities Typically found on damp acid mineral soils with peaty upper horizons. It typically occupies slopes where the depth and wetness of the soil are intermediate between the drier podsols under and the wet shallow peats.	B	No	N

1.1.3 Table 2 presents the various NVC categories present across the site and their total area along with their GWDTE dependency status. In comparison to the 1695 ha there are a total of 399 ha of High dependency GWDTE and 234.4 ha of Moderate dependency GWDTE.

Table 2 GWDTE dependency status

NVC Category	Total Area (ha)	GWDTE
M20	8.6ha	No
M19	93.9ha	No
M15	3.9 ha	**Moderate**
M6	329.4 ha	**High**
M25	230.5 ha	**Moderate**

NVC Category	Total Area (ha)	GWDTE
M23	69.6 ha	**High**
H12	34.6 ha	No
H8	1.5 ha	No
Other grasslands (U4, U5, MG6, MG7)	631.0 ha	No
U20	42.8 ha	No
S27	0.2 ha	No
Plantation	249.0 ha	No
Total	**1695 ha**	

1.1.4 The actual area of loss of each habitat is presented in Table 3 and the associated loss of GWDTE. This indicates a total loss of 5 ha (1.2%) of High dependency GWDTE and 4.6 ha (2%) of Moderate dependency GWDTE.

Table 3 GWDTE percentage loss

NVC Category	Area of loss (ha)	GWDTE
M20	<0.1 ha	No
M19	0.6 ha	No
M15	0.3 ha	8% loss of Moderate GWDTE
M6	4.5 ha	1.3% loss of High GWDTE
M25	4.3 ha	2% loss of Moderate GWDTE
M23	0.5 ha	0.7% loss of High GWDTE
Plantation	4.6 ha	No
Total	**14.8 ha**	**1.2% of High GWDTE** **2% of Moderate GWDTE**

1.1.5 These data show a total loss of approximately 15 ha of peat mire habitat of which 9.6 ha are GWDTE compared to peatland habitat enhancement of about 350 ha.

1.1 References

1.1.6 Averis, A., Averis, B., Birks, J., Horsfield, D., Thomson, D. and Yeo, M. 2004. An Illustrated Guide to British Upland Vegetation. Peterborough, Joint Nature Conservation Committee.

1.1.7 Elkington, T., Dayton, N., Jackson, D.L., & Strachan, I.M. (2002) National Vegetaion Classification field guide to mires and heaths. ISBN 1 86107 526.

1.1.8 Rodwell, J.S. (ed.) 1991. British Plant Communities. Volume 2. Mires and heath. Cambridge University Press.

1.1.9 Scottish Environmental Protection Agency, Land Use Planning System SEPA Guidance Note 4. March 2012.

APPENDIX 8.6: PRIVATE WATER SUPPLY QUESTIONNAIRE

Water Supply Questionnaire

Name: Date:

Address: Tel No:

Please answer questions 1 to 4 within Section1.

Section 1: Water Supply

1. Is your house on mains water supply? Yes/No

2. Do you receive any water for your house from a private water supply (PWS)? Yes/No

3. Do you receive any water from a PWS for any other use e.g. livestock, irrigation, garden? Yes/No

4. Do you have an old PWS that used to supply water either to your house or for any other use? Yes/No

If you answered yes to question 1 and no to questions 2, 3 and 4 then there is no need to answer any more questions.
If you answered yes to either questions 2, 3 or 4 then please continue with Section 2.

Section 2: PWS Information

Please answer the following questions with respect to the PWS identified in questions 2, 3 and 4.

5. Is the location of this PWS on land owned or occupied by you? Yes/No

   If you are a tenant please give name and address of the owner:

6. What are the locations of the PWS abstraction point, associated storage or settlement tanks and supply lines? (if possible, please supply grid references or annotate the attached map)

7. What type of supply is it? (eg., borehole/well, collection facility)

8. Is the source of the supply:
   - groundwater
   - surface water
   - a spring (please tick one)

9. If there is a borehole/well:
   - How deep is it and what is its diameter?
   - When was it installed?

10. If there is a collection facility please give details of any drains feeding the collection tank.

11. Please provide details of any pumps used.

12. Please provide any other information about the source of the water or nature of the collection facility not covered above.

13. Do you have facilities for storing water and to what capacity?

14. Does the supply have seasonal variation in flow and has it been known to dry up? Please provide details.

15. Does the water undergo any form of treatment? (eg., filter, UV, ozone, cholorination)

16. Please provide details of any maintenance or inspection routines carried out on the supply?

17. Do you maintain any water quality records and have there ever been any problems with the quality or clarity of the water?

18. What is the water used for (eg drinking water, house supply, livestock, irrigation), and how much water is required for each different usage?

19. Please list any other properties, if any, which also use this PWS.

20. Please give any details you know of other PWS in the area.

21. Please give any further information not covered in this questionnaire that might help in this investigation (continue on a separate sheet if necessary).

The information provided in this questionnaire will be used solely for the purposes of this water supply survey and will be treated with confidentiality.

APPENDIX 8.7: HYDROLOGY PHOTOGRAPHS

1.1 Private Water Supplies

 **Photo 1.** Private water supply for Dolwen (PWS 1)	 **Photo 2.** Private water supply for Cannon Farms (PWS 2a and PWS 2b))
 **Photo 3.** Settlement tank for Cannon Farms private water supply (PWS 2)	 **Photo 4.** Private water supply for Abercannon (PWS 3)
 **Photo 5.** Borehole private water supply for Neinthirion (PWS 4a)	 **Photo 6.** Well private water supply for Neinthirion (PWS 4b)

 **Photo 7**. Private water supply for Cwmderwen (PWS 6a and 6b)	 **Photo 8.** Private water supply for Cwm Pen Llydan (PWS 7).
 **Photo 9.** Private water supply for Ffridd Fawr (PWS 9	 **Photo 10**. Borehole private water supply for Ffridd Fawr (PWS 9)
 **Photo 11**. Private water supply for Cwmcarnedd Uchaf (PWS 13)	

1.2 Watercourse Crossings

 **Photo 12.** Water crossing 1: East access track over existing drain (SH 97030 07130)	 **Photo 13.** Water crossing 13: East access track over existing drain (SH 97030 07130)
 **Photo 14.** Proposed water crossing 2 on Nant Craigyfrân tributary (SH 96580 08070).	 **Photo 15.** Proposed water crossing 2 on Nant Craigyfrân tributary (SH 96580 08070).
 **Photo 16.** Proposed water crossing 3 on Nant Craigfrân (SH 95530 09000)	 **Photo 17.** Proposed water crossing 3 on Nant Craigfrân (SH 95530 09000)

Photo 18. Just downstream of the proposed water crossing 4 on a tributary of the Nant Craigfrân (SH 95750 08340)

Photo 19. Proposed water crossing 5 on Nant Gwyddior (SH 94725 07500)

Photo 20. Proposed water crossing 6 on Afon Cannon tributary (SH95075 07005)

Photo 21. Proposed water crossing 6 on Afon Cannon tributary (SH 95130 06820)

Photo 22. Proposed water crossing 7 on Afon Cannon tributary (SH 95240 06900)

Photo 23. Proposed water crossing 7 on Afon Cannon tributary (SH 95240 06900)

Photo 24. Proposed water crossing 8 on Afon Cannon tributary (SH 9508 0700)

Photo 25. Proposed water crossing 8 on Afon Cannon tributary (SH 9508 0700)

Photo 26. Proposed water crossing 9 on Afon Cannon tributary (SH 9515 0683)

Photo 27. Proposed water crossing 9 on Afon Cannon tributary (SH 9515 0683)

Photo 28. Proposed water crossing 10 on Afon Gam tributary (SH 9533 0640)

Photo 29. Proposed water crossing 10 on Afon Gam tributary (SH 9533 0640)

 **Photo 30.** Proposed water crossing 11 on Afon Gam tributary (SH 94800 06490	 **Photo 31.** Proposed water crossing 11 on Nany y Graig tributary (SH 94814 05270)
 **Photo 32.** Proposed water crossing 12 on Afon Gam tributary (SH 94410 06590)	 **Photo 33.** Proposed water crossing 12 on Afon Gam tributary (SH 94410 06590)
 **Photo 34.** Existing water crossing 13 on Nant y Graig Lwyd tributary (SH 94700 05700)	 **Photo 35.** Existing water crossing 13 on Nant y Graig Lwyd tributary (SH 94700 05700)

 **Photo 36.** Existing culvert at water crossing 13 on Nant y Graig Lwyd tributary (SH 94700 05700)	 **Photo 37.** Proposed water crossing 14 on Nant y Graig Lwyd tributary (SH 94600 05600
 **Photo 38.** Proposed water crossing 14 on Nant y Graig Lwyd tributary	 **Photo 39.** Bed of proposed water crossing 15 on Nant y Graig Lwyd tributary
 **Photo 40.** Proposed water crossing 15 on Nant y Graig Lwyd tributary (SH 94630 05500)	 **Photo 41.** Existing drains on Afon Gam tributary at water crossing 16

Photo 42. Existing drains at water crossing 17 on Afon Gam tributary (SH 94380 05580).

Photo 43. Existing drains at water crossing 17 on Afon Gam tributary (SH 94380 05580).

Photo 44. Proposed water crossing 18 on Afon Gam tributary (SH 94360 05600)

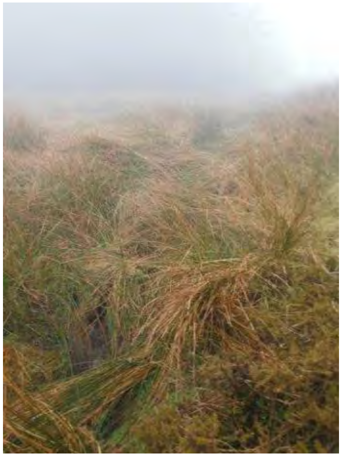


Photo 45. Proposed water crossing 19. Narrow channel flowing from woods at SH 94270 05750.

Photo 46. Proposed water crossing 20 on a tributary of the Afon Gam (SH 93150 03750)

Photo 47. Proposed water crossing 21 on the Afon Gam (SH 93100 03440)

 **Photo 48.** Proposed water crossing 21 on the Afon Gam (SH 93100 03440)	 **Photo 49.** Proposed water crossing 22 on the Afon Gam (SH 92550 03830)
 **Photo 50.** Proposed water crossing 22 on the Afon Gam (SH 92550 03830)	

1.3 Temporary Construction Compound Locations

Photo 51. Location of temporary construction compound 2 (SH 9290 0425)

Photo 52. Location of temporary construction compound 3 (SH 9600 0593)

Photo 53. Looking downgradient of temporary construction compound 3 (SH 9600 0593)

Photo 54. Location of temporary construction compound 4 (SH 9470 0630)

Photo 55. Location of temporary construction compound 5 (SH 9688 0734)

1.4 Photographs of Borrow Pit Locations

Photo 56. Borrow pit 1 within 125m of Afon Gam uppermost tributaries (SH 9377 0380)

Photo 57. Borrow pit 2 within 75m of tributary of Afon Gam (SH 9225 0393)

Photo 58. Borrow pit 2 within 75m of tributary of Afon Gam (SH 9225 0393)

Photo 59. Borrow pit 3 within 25m of Afon Gam tributary (SH 9485 0645)

Photo 60. Drainage in area of borrow pit 5 (SH 9700 0810)

Photo 61. Drainage in area of borrow pit 5 (SH 9700 0810)

 **Photo 62.** Drainage in area of borrow pit 5 (SH 9700 0810)	 **Photo 63.** Borrow pit 6 (SH 9665 0900)
 **Photo 64.** Borrow pit 6 (SH 9665 0900)	

APPENDIX 8.8: FLOOD CONSEQUENCES ASSESSMENT

Memo

SKM ENVIROS

To	Mike Whitbread (RES)	Date	12 June 2013
From	Daniel Watson	Project No	JL30671
Copy	John Ferry (SKM), Duncan Saunders (Fluidec)		
Subject	**Llanbrynmair wind farm - flood consequence assessment**		

Development Advice Map

The Welsh Assembly has published the development advice map (DAM) for the entirety of Wales. This map classifies areas into flood zones A, B and C according to the assessed risk of flooding from tidal and major fluvial sources[1].

Within flood zone A it is considered that there is little or no risk of flooding, flood zone B relates to areas where drift deposits indicate flooding has historically occurred and flood zone C represents areas where there is believed to be a current risk in excess of 0.1% annually. Flood zone C is then broken down into C1 and C2 representing defended and undefended area respectively.

The section of the DAM covering the Llanbrynmair wind farm site is included as Figure A1. This shows that virtually the entire site is in flood zone A with very small areas of flood zone C2 following the course of the larger watercourses.

The only element of the development that extends into flood zone C2 is one crossing of the watercourse called Afon Gam.

Technical Advice Note 15

Technical Advice Note 15 (TAN15) states that there is no requirement to consider the risk of flooding within flood zone A, but in flood zone C2 only less vulnerable development should be considered subject to the application of the justification test.

TAN15 defines transport and utilities infrastructure as less vulnerable development. Given this it is clear that elements of the wind farm development could, if necessary, be sited in flood zone C2 if the justification test can be fulfilled.

This note is intended to fulfil point four (iv) of the justification test. This is to demonstrate that the potential consequences of a flooding event for a particular type of development have been considered.

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1 It should be noted that small features and other types of flood sources will not be covered.

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Elements of the development at risk of flooding

Full descriptions of the site area and the watercourses that flow through and past the site are contained within the main report Chapter 8 Hydrology, Hydrogeology and Geology. In general the area is hilly and characterised by steep and incised valleys formed by the watercourses that flow through them.

Development on the site includes the construction of wind turbines, crane hardstanding areas, borrow pits and a track network. For pollution control purposes no development will occur within 20m of any of the watercourses as shown on the 1:25,000 ordnance survey map. Given the nature of the local topography this is considered sufficient to ensure that the development will not be impacted by any normal flood event along these features.

The only exception to this will be the locations where the track network crosses watercourses, however it is noted that the track network has been designed to minimise the number of these crossing points. Given this there are only 22 crossings proposed, of which 4 are upgrades to existing crossings, and the majority of these relate to crossing very minor drainage features (Figure 8.1).

A review of the crossing locations has identified just four water crossings that cross channels with a catchment area of greater than 1km^2 in size, one of which is an existing feature. These locations are detailed in Table 1A below.

Table 1A – Significant watercourse crossings

Crossing Number	Watercourse	Location	Grid Ref	Catchment area
5	Nant Gwyddior	Between R19 – R25	SH 94725 07500	1.03 km^2
13	Nant y Graig Lwyd	Between R23 and second access point	SH 94700 05700	1.97 km^2
21	Afon Gam	Between R41 – R39	SH 93100 03440	3.27 km^2
22	Afon Gam	Between R5 – R31	SH 92550 03830	2.83 km^2

As noted previously only one element of the development actually falls with flood zone C2. This is crossing 21. We are however aware that the flood extent shown on the DAM was generated as part of the Environment Agency's national flood mapping programme which only covers watercourses with catchment area of greater than 3km^2. As such whilst flooding may occur along smaller features this would not be represented on the DAM.

In order to remain conservative this assessment will therefore consider the potential probability and significance of flooding associated with the development at each of the four crossing locations detailed in Table 1A.

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Flood Probability

For general infrastructure TAN 15 states that the annual probability of fluvial inundation should not exceed 1%. In addition, potential increases in flood severity due to climate change must be considered. Current DEFRA guidance recommends that to account for this, systems should be tested for a possible 20% increase in peak fluvial flows.

In the light of this, hydrological modelling of these 4 catchments has been undertaken to estimate the appropriate design flows. Statistical method analysis has however at this stage been avoided due to a lack of suitable gauged donor catchments of a comparable size.

The standard alternative technique for estimating flood flows in UK un-gauged catchments is the re-vitalised FEH rainfall runoff method (ReFH). This methodology has been calibrated such that results typically correlate well to the statistical method. An additional estimate of flood flow has therefore also been undertaken using the original FEH / FSR rainfall runoff method. For small rural catchments (<2km^2) the methodology set out in Institute of hydrology technical report 124 (IH124) can alternatively be used with the results for the mean annual flood scaled using the flood growth curves from the Flood Studies Report. For crossings 5 and 13 the results for this are also presented for comparison.

The results of this modelling are shown below (Table A2) and calculation sheets are appended (Annex 1).

Table A2 – Summary of hydrological modelling

Crossing number	Watercourse	Flood flow estimates (m^3/s)					
		IoH 124		FEH rainfall runoff		ReFH	
		Current	Climate Change	Current	Climate Change	Current	Climate Change
5*	Nant Gwyddior	2.7	3.3	4.2	5.1	6.1	7.3
13	Nant y Graig Lwyd	4.9	5.9	6.2	7.4	10.5	12.6
21	Afon Gam	-	-	10.8	13.0	12.0	14.4
22	Afon Gam	-	–	6.8	8.1	11.4	13.7

* we would note that this crossing is downstream of a large lake (Llyn Gwyddior) that would act to attenuate catchment flows and that such features are often not well represented in the simplistic types of modelling used in this study. As such actual flood flows are likely to be significantly lower.

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In the absence of additional data it is recommended that the highest set of results (i.e. those from the ReFH method) should be adopted as the design flows for these crossings[2].

At the detailed planning application stage, designs will be prepared for each of the four crossings. These designs will ensure that the following objectives are achieved;

- The conveyance capacity of the structures will be in excess of the 1% annual probability fluvial flow including the 20% climate change allowance.
- Checks will be undertaken to ensure that the proposed structures do not significantly alter flood flows rates upstream or downstream of the crossing locations for a range of flood flow events.
- The crossing soffit levels will be set a minimum of 600mm above the design flood level at the crossing location to reduce the risk of blockage.

Additional design objectives for minimising long term ecological and geomorphological impact are detailed in the main report.

If the design objectives detailed above are implemented at each of the four crossing locations the probability of the crossing locations being impacted by flooding, or the crossings adversely impacting flooding elsewhere will be low.

Flood Significance

Whilst the flood probability at the crossing locations has (subject to detailed design) been assessed to be low, flooding during extreme but very rare events is still possible. In addition to this, blockage of the crossings through siltation, accumulation of debris or partial collapse (whilst unlikely) could also result in the tracks becoming impassable.

The hazard posed by such unlikely flood events is a factor of the risk posed to;

- human health;

The potential for impact to human health is very small as the site will be unmanned except for occasional maintenance. This has therefore not been considered further.

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2 We would note that there is a significant discrepancy between the results from the ReFH and the FEH / FSR rainfall runoff analysis. Whilst we have conservatively recommended that the higher set of results are used for design purposes, it is possible that additional analysis may indicate that the lower results are more realistic. If therefore at the detailed design stage it becomes apparent that there is significant advantage in adopting a lower set of design flows, further analysis should be undertaken and results agreed with the NRW. Indicatively such analysis might make use of NRFA gauging data from an adjacent catchment (Afon Cwm. Station no.64008). The details of analysis techniques would however depend on the length and nature of the data record available from this location.

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- infrastructure; and

Impact to infrastructure will be confined to the crossings themselves as all other infrastructure will be set back from the watercourses. The crossings themselves will be designed to withstand design flow conditions and the risk associated with failure and damage during larger events is considered to be minimal.

- site operation.

Should flooding of the crossings occur, access to specific areas of the site will not be possible for a period of time. Table A3 details the predicted maximum likely duration of flooding (based on rainfall runoff modelling) and the number of turbines which could not be accessed during periods of flooding.

Table A3 – summary of impact of flooding on site operation

Crossing number	Watercourse	Number of turbines	Maximum flood duration*
5	Nant Gwyddior	1	1.6 hours
13	Nant y Graig Lwyd	3	1.4 hours
21	Afon Gam	1	2.4 hours
22	Afon Gam	2	2.1 hours

* Taken as the period for which flows exceeds 50% of the design flow on ReFH output hydrograph

A loss of access to very limited parts of the development (max 7 turbines assuming all watercourses are in flood simultaneously) for short periods (max 2.4 hours) on very rare occasions (annual probability less than 1%) is not considered to be a significant problem. The significance of such flooding is therefore assessed to be low.

Conclusion

This assessment concludes that, given the design standards set out, the infrastructure proposed will not be subject to undue flood risk and is unlikely to alter the rate or timing of flood flows proceeding downstream. This is therefore considered to be a very low flood consequence and should not pose a barrier to the wider development proposals.

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ANNEX 1: Hydrological modelling calculation sheets

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Calculation Sheet (Institute of Hydrology technical report 124)
Crossing 5: Nant Gwyddior

Catchment Area (A) =	103	ha
Standard Annual Average Rainfall (SAAR) =	1722	mm
Soil Index (SOIL, from FSR) =	0.46	

Institute of Hydrology Report 124 (not advised for catchments < 50ha)

Peak Site Flow =	$Q_s = 0.0108 AREA^{0.89} SAAR^{1.17} SOIL^{2.17}$	1256.6	l/s
Peak Flow =	$Q = Q_s / A$	**12.2**	**l/s/ha**

Where the catchment area is less than 50ha, the area (AREA) is set at 50ha then the resultant runoff is scaled by the ratio of the actual site area and 50ha.

The value calculated above is considered to be equivalent to the 1 in 1 year peak flow. CIRIA guidance recmmends that if required, estimates for larger events can be obtained by scaling this value using the regional growth churve from the flood studies report.

1 in 10 year Storm Event Peak Site Flow =	Q_s x	1.42 =	1784.4	l/s
1 in 10 year Storm Event Peak Flow =	Q x	1.42 =	17.3	l/s/ha
1 in 50 year Storm Event Peak Site Flow =	Q_s x	1.94 =	2437.8	l/s
1 in 50 year Storm Event Peak Flow =	Q x	1.94 =	23.7	l/s/ha
1 in 100 year Storm Event Peak Site Flow =	Q_s x	2.18 =	2739.4	l/s
1 in 100 year Storm Event Peak Flow =	Q x	2.18 =	26.6	l/s/ha
1 in 200 year Storm Event Peak Site Flow =	Q_s x	2.45 =	3078.6	l/s
1 in 200 year Storm Event Peak Flow =	Q x	2.45 =	29.9	l/s/ha

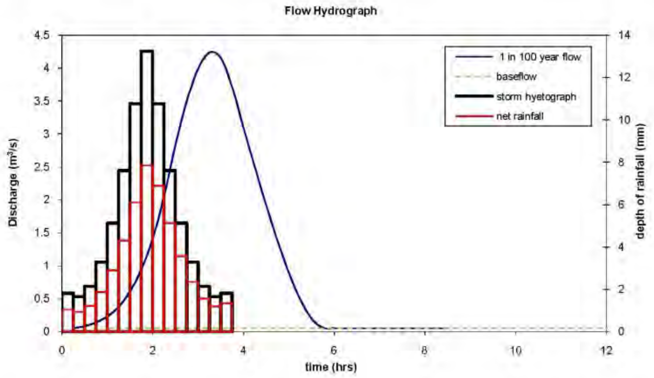
FEH rainfall runoff method (calculation sheet)

Crossing 5: Nant Gwyddior

Results

Series	Unit												
Time	hours	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75
Design Rainfall	mm	0.00	1.82	1.65	2.14	3.30	5.12	7.61	10.75	13.23	10.75	7.61	5.12
Net rainfall	mm	0.00	1.03	0.94	1.22	1.88	2.91	4.32	6.11	7.85	6.90	5.14	3.58
Direct runoff	m^3/s	0.00	0.03	0.09	0.18	0.33	0.56	0.90	1.36	2.01	2.78	3.44	3.94
Baseflow	m^3/s	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total flow	m^3/s	0.05	0.08	0.14	0.23	0.38	0.61	0.95	1.42	2.06	2.84	3.50	3.99

Series	Unit												
Time	hours	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75
Design Rainfall	mm	3.30	2.14	1.65	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net rainfall	mm	2.36	1.55	1.21	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct runoff	m^3/s	4.19	4.10	3.66	3.04	2.44	1.87	1.33	0.84	0.44	0.15	0.01	0.00
Baseflow	m^3/s	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total flow	m^3/s	4.24	4.16	3.71	3.10	2.50	1.92	1.38	0.89	0.49	0.20	0.06	0.05



Key model parameters:

AREA	1.03 km^2	
URBEXT	0	A RURAL CATCHMENT
SAAR	1722 mm	
DPSBAR	87.9 m/Km	
PROPWET	0.66	
DPLBAR	1.04 Km	
BFIHOST	0.227	
Tp	1.269 hours	
Up	1.625 m^3/s	
TB	3.514 hours	
c	-0.03	
d1	0.49442	
d2	0.39934	
d3	0.36577	
e	0.29903	
f	2.43969	

design storm 140 year 225 minute
rainfall depth 77.4 mm

Results summary

Peak flow = 4.24 m^3/s for the 100 year event

Series	Unit											
Time	hours	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	**Total (mm)**
Design Rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**78.01**
Net rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**48.33**
Direct runoff	m^3/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**32.93**
Baseflow	m^3/s	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	**1.58**
Total flow	m^3/s	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	**34.51**

Revitalised FSR/FEH rainfall runoff method

Stand-alone application report

User name	Daniel Watson	**Catchment name**	Crossing 5: Nant Gwyddior	**Date/time modelled**	23-May-2013 17:02
Company name	SKM	**Catchment easting**	294700	**Version**	1.4
Project name	Llanbrynmair FCA	**Catchment northing**	307450		
		Catchment area	1.03		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	100	**C_{max} (mm)**	161	**T_p (hr)**	0.72	**BL (hr)**	15.9
Duration (hr)	2.1	**C_{ini} (mm)**	109	**U_p**	0.65	**BR**	0.65
Timestep (hr)	0.1	**α factor**	0.83	**U_k**	0.8	**BF_0 (m^3/s)**	0.1
Season	Winter						

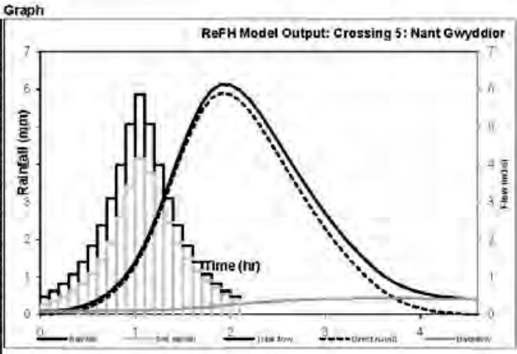
Summary of results

FEH DDF rainfall (mm)	59.1	**Peak rainfall (mm)**	5.9
Design rainfall (mm)	47.3	**Peak flow (m^3/s)**	6.1

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	mm	mm	m^3/s	m^3/s	m^3/s
0.0	0.5	0.3	0.0	0.1	0.1
0.1	0.6	0.4	0.0	0.1	0.1
0.2	0.8	0.5	0.0	0.1	0.1
0.3	1.1	0.6	0.1	0.1	0.1
0.4	1.4	0.8	0.1	0.1	0.2
0.5	1.8	1.1	0.2	0.1	0.3
0.6	2.4	1.4	0.3	0.1	0.4
0.7	3.1	1.9	0.4	0.1	0.5
0.8	4.0	2.6	0.7	0.1	0.8
0.9	5.1	3.4	0.9	0.1	1.0
1.0	5.9	4.2	1.3	0.1	1.4
1.1	5.1	3.8	1.8	0.1	1.9
1.2	4.0	3.1	2.3	0.1	2.5
1.3	3.1	2.4	3.0	0.1	3.1
1.4	2.4	1.9	3.7	0.1	3.8
1.5	1.8	1.5	4.3	0.2	4.5
1.6	1.4	1.2	4.9	0.2	5.1
1.7	1.1	0.9	5.4	0.2	5.6
1.8	0.8	0.7	5.8	0.2	6.0
1.9	0.6	0.5	5.9	0.2	6.1
2.0	0.5	0.4	5.9	0.3	6.1
2.1	0.0	0.0	5.7	0.3	6.0
2.2	0.0	0.0	5.4	0.3	5.7
2.3	0.0	0.0	5.1	0.3	5.4
2.4	0.0	0.0	4.7	0.3	5.0
2.5	0.0	0.0	4.3	0.4	4.6
2.6	0.0	0.0	3.8	0.4	4.2
2.7	0.0	0.0	3.4	0.4	3.8
2.8	0.0	0.0	3.0	0.4	3.4
2.9	0.0	0.0	2.6	0.4	3.0
3.0	0.0	0.0	2.3	0.4	2.7
3.1	0.0	0.0	1.9	0.4	2.4
3.2	0.0	0.0	1.6	0.4	2.0
3.3	0.0	0.0	1.3	0.4	1.8
3.4	0.0	0.0	1.1	0.4	1.5
3.5	0.0	0.0	0.8	0.4	1.3
3.6	0.0	0.0	0.6	0.4	1.1
3.7	0.0	0.0	0.5	0.4	0.9
3.8	0.0	0.0	0.3	0.4	0.8
3.9	0.0	0.0	0.2	0.4	0.7
4.0	0.0	0.0	0.2	0.4	0.6
4.1	0.0	0.0	0.1	0.4	0.5
4.2	0.0	0.0	0.1	0.4	0.5
4.3	0.0	0.0	0.0	0.4	0.4
4.4	0.0	0.0	0.0	0.4	0.4
4.5	0.0	0.0	0.0	0.4	0.4
4.6	0.0	0.0	0.0	0.4	0.4
Total (mm)	47.3	33.6	33.6	4.5	38.1

Graph



Audit comments

Model run with ReFH dll version 1.4.0005

Catchment
Catchment descriptors imported from file
Catchment descriptor file = 'Crossing 5.csv'
Catchment descriptor file exported from CD-ROM version 3
Catchment descriptor file exported on 23-May-2013 15:26
BFIHOST value of 0.227 used
PROPWET value of 0.66 used
SAAR value of 1722 used
DPLBAR value of 1.04 used
DPSBAR value of 87.9 used
URBEXT value of 0 used
C value of -0.03 used
D1 value of 0.49442 used
D2 value of 0.34934 used
D3 value of 0.36577 used
E value of 0.29903 used
F value of 2.43969 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.82 applied
ReFH design standard Areal Reduction Factor of 0.97 applied

Loss Model

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Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

C_{MAX} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

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Calculation Sheet (Institute of Hydrology technical report 124)

Crossing 13: Nant y Graig Lwyd

Catchment Area (A) =	197	ha
Standard Annual Average Rainfall (SAAR) =	1722	mm
Soil Index (SOIL, from FSR) =	0.46	

Institute of Hydrology Report 124 (not advised for catchments < 50ha)

Peak Site Flow =	$Q_s = 0.0108 AREA^{0.89} SAAR^{1.17} SOIL^{2.17}$	2237.9	l/s
Peak Flow =	$Q = Q_s / A$	**11.4**	**l/s/ha**

Where the catchment area is less than 50ha, the area (AREA) is set at 50ha then the resultant runoff is scaled by the ratio of the actual site area and 50ha.

The value calculated above is considered to be equivalent to the 1 in 1 year peak flow. CIRIA guidance recmmends that if required, estimates for larger events can be obtained by scaling this value using the regional growth churve from the flood studies report.

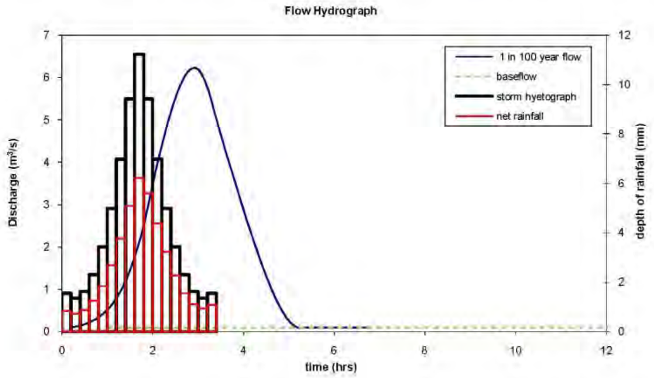
1 in 10 year Storm Event Peak Site Flow =	Q_s x 1.42 =	3177.8	l/s
1 in 10 year Storm Event Peak Flow =	Q x 1.42 =	16.1	l/s/ha
1 in 50 year Storm Event Peak Site Flow =	Q_s x 1.94 =	4341.5	l/s
1 in 50 year Storm Event Peak Flow =	Q x 1.94 =	22.0	l/s/ha
1 in 100 year Storm Event Peak Site Flow =	Q_s x 2.18 =	4878.6	l/s
1 in 100 year Storm Event Peak Flow =	Q x 2.18 =	24.8	l/s/ha
1 in 200 year Storm Event Peak Site Flow =	Q_s x 2.45 =	5482.9	l/s
1 in 200 year Storm Event Peak Flow =	Q x 2.45 =	27.8	l/s/ha

FEH rainfall runoff method (calculation sheet)

Crossing 13: Nant y Graig Lwyd

Results

Series	Unit																								
Time	hours	0.00	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60
Design Rainfall	mm	0.00	1.55	1.37	1.62	2.31	3.43	4.99	6.98	9.41	11.23	9.41	6.98	4.99	3.43	2.31	1.62	1.37	1.55	0.00	0.00	0.00	0.00	0.00	0.00
Net rainfall	mm	0.00	0.84	0.74	0.88	1.25	1.86	2.70	3.78	5.09	6.22	5.61	4.38	3.24	2.28	1.56	1.11	0.94	1.08	0.00	0.00	0.00	0.00	0.00	0.00
Direct runoff	m^3/s	0.00	0.04	0.12	0.24	0.42	0.69	1.09	1.65	2.40	3.39	4.29	5.08	5.70	6.07	6.10	5.69	4.94	4.20	3.48	2.79	2.13	1.51	0.96	0.50
Baseflow	m^3/s	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total flow	m^3/s	0.10	0.14	0.22	0.34	0.52	0.79	1.19	1.75	2.50	3.48	4.39	5.18	5.79	6.16	6.20	5.79	5.04	4.30	3.58	2.89	2.23	1.61	1.06	0.59



Key model parameters:

AREA	1.97 km^2
URBEXT	0 A RURAL CATCHMENT
SAAR	1668 mm
DPSBAR	129.4 m/Km
PROPWET	0.66
DPLBAR	1.27 Km
BFIHOST	0.267
Tp	1.235 hours
Up	3.246 m^3/s
TB	3.364 hours
c	-0.03
d1	0.49127
d2	0.3979
d3	0.36968
e	0.29885
f	2.44079

design storm 140 year 204 minute
rainfall depth 74.0 mm

Results summary

Peak flow = 6.20 m^3/s for the 100 year event

Series	Unit										
Time	hours	4.80	5.00	5.20	5.40	5.60	5.80	6.00	6.20	6.40	6.60	**Total (mm)**
Design Rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**74.56**
Net rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**43.58**
Direct runoff	m^3/s	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**23.25**
Baseflow	m^3/s	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	**1.22**
Total flow	m^3/s	0.26	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	**24.48**

Revitalised FSR/FEH rainfall runoff method

Stream/fleet application report

User name	Daniel Watson	**Catchment name**	Crossing 13: Nant y Graig Lwyd	**Date/time modelled**	23-May-2013 17:06
Company name	SKM	**Catchment easting**	294800	**Version**	1.4
Project name	Llanbrynmair FCA	**Catchment northing**	305750		
		Catchment area	1.97		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	100	**C_{max} (mm)**	188	**T_p (hr)**	0.73	**BL (hr)**	17.9
Duration (hr)	1.9	**C_{ini} (mm)**	121	**U_p**	0.65	**BR**	0.78
Timestep (hr)	0.1	**α factor**	0.83	**U_k**	0.8	**BF_0 (m^3/s)**	0.2
Season	Winter						

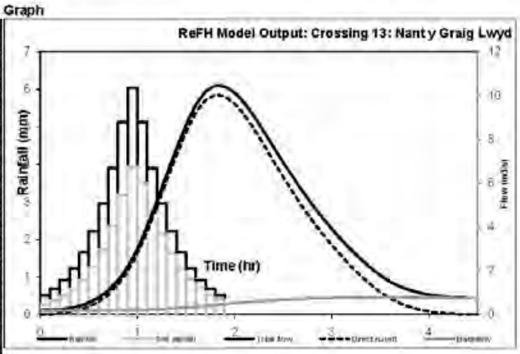
Summary of results

FEH DDF rainfall (mm)	57	**Peak rainfall (mm)**	6
Design rainfall (mm)	44.3	**Peak flow (m^3/s)**	10.5

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	mm	mm	m^3/s	m^3/s	m^3/s
0.0	0.5	0.3	0.0	0.2	0.2
0.1	0.7	0.4	0.0	0.2	0.2
0.2	0.9	0.5	0.0	0.2	0.2
0.3	1.2	0.7	0.1	0.2	0.3
0.4	1.6	0.9	0.2	0.2	0.4
0.5	2.2	1.3	0.4	0.2	0.5
0.6	2.9	1.7	0.6	0.2	0.8
0.7	3.9	2.3	0.9	0.2	1.1
0.8	5.1	3.2	1.4	0.2	1.5
0.9	6.0	3.9	2.0	0.2	2.2
1.0	5.1	3.5	2.8	0.2	3.0
1.1	3.9	2.8	3.8	0.2	4.0
1.2	2.9	2.1	4.9	0.2	5.1
1.3	2.2	1.6	6.1	0.3	6.4
1.4	1.6	1.2	7.3	0.3	7.5
1.5	1.2	0.9	8.3	0.3	8.7
1.6	0.9	0.7	9.2	0.4	9.6
1.7	0.7	0.5	9.8	0.4	10.2
1.8	0.5	0.4	10.0	0.4	10.5
1.9	0.0	0.0	9.9	0.5	10.4
2.0	0.0	0.0	9.6	0.5	10.1
2.1	0.0	0.0	9.1	0.5	9.6
2.2	0.0	0.0	8.5	0.6	9.0
2.3	0.0	0.0	7.7	0.6	8.4
2.4	0.0	0.0	7.0	0.6	7.6
2.5	0.0	0.0	6.2	0.7	6.9
2.6	0.0	0.0	5.6	0.7	6.3
2.7	0.0	0.0	4.9	0.7	5.6
2.8	0.0	0.0	4.3	0.7	5.0
2.9	0.0	0.0	3.7	0.7	4.4
3.0	0.0	0.0	3.2	0.7	3.9
3.1	0.0	0.0	2.7	0.8	3.4
3.2	0.0	0.0	2.2	0.8	2.9
3.3	0.0	0.0	1.7	0.8	2.5
3.4	0.0	0.0	1.4	0.8	2.1
3.5	0.0	0.0	1.0	0.8	1.9
3.6	0.0	0.0	0.7	0.8	1.5
3.7	0.0	0.0	0.5	0.8	1.3
3.8	0.0	0.0	0.3	0.8	1.1
3.9	0.0	0.0	0.2	0.8	1.0
4.0	0.0	0.0	0.1	0.8	0.9
4.1	0.0	0.0	0.1	0.8	0.8
4.2	0.0	0.0	0.0	0.8	0.8
4.3	0.0	0.0	0.0	0.7	0.8
4.4	0.0	0.0	0.0	0.7	0.7
4.5	0.0	0.0	0.0	0.7	0.7
Total (mm)	**44.3**	**29.0**	**29.0**	**4.3**	**33.2**

Graph



Audit comments

Model run with ReFH dll version 1.4.0005

Catchment
Catchment descriptors imported from file
Catchment descriptor file = 'Crossing 13.csv'
Catchment decriptor file exported from CD ROM version 3
Catchment descriptor file exported on 23-May-2013 15:59
BFIHOST value of 0.267 used
PROPWET value of 0.66 used
SAAR value of 1868 used
DPLBAR value of 1.27 used
DPSBAR value of 129.4 used
URBEXT value of 0 used
C value of -0.03 used
D1 value of 0.48127 used
D2 value of 0.3979 used
D3 value of 0.36968 used
E value of 0.29885 used
F value of 2.44079 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.81 applied
ReFH design standard Areal Reduction Factor of 0.96 applied

Loss Model
C_{max} derived from catchment descriptors

Page 1 of 3

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

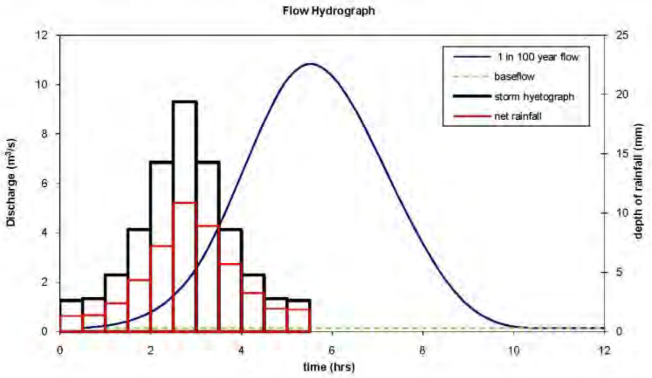
FEH rainfall runoff method (calculation sheet)

Crossing 21: Afon Gam

Results

Series	Unit												
Time	hours	0.00	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50
Design Rainfall	mm	0.00	2.63	2.78	4.78	8.61	14.30	19.39	14.30	8.61	4.78	2.78	2.63
Net rainfall	mm	0.00	1.33	1.40	2.41	4.34	7.21	10.87	8.93	5.72	3.27	1.94	1.87
Direct runoff	m^3/s	0.00	0.09	0.28	0.64	1.31	2.41	4.11	6.22	8.34	10.04	10.69	10.19
Baseflow	m^3/s	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Total flow	m^3/s	0.15	0.24	0.43	0.79	1.46	2.56	4.26	6.37	8.49	10.18	10.84	10.34

Series	Unit											
Time	hours	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50
Design Rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct runoff	m^3/s	8.86	7.06	5.16	3.41	1.95	0.91	0.32	0.06	0.00	0.00	0.00	0.00
Baseflow	m^3/s	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Total flow	m^3/s	9.01	7.21	5.31	3.56	2.10	1.06	0.47	0.21	0.15	0.15	0.15	0.15



Key model parameters:

AREA	3.27	km^2
URBEXT	0	A RURAL CATCHMENT
SAAR	1523	mm
DPSBAR	89.1	m/Km
PROPWET	0.66	
DPLBAR	2.47	Km
BFIHOST	0.321	
Tp	2.016	hours
Up	3.175	m^3/s
TB	5.709	hours
c	-0.03	
d1	0.48343	
d2	0.4016	
d3	0.36672	
e	0.298	
f	2.43158	

design storm 140 year 330 minute
rainfall depth 84.9 mm

Results summary

Peak flow = 10.84 m^3/s for the 100 year event

Series	Unit										
Time	hours	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	**Total (mm)**
Design Rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**85.59**
Net rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**49.30**
Direct runoff	m^3/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**45.18**
Baseflow	m^3/s	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	**2.78**
Total flow	m^3/s	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	**47.96**

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Daniel Watson	**Catchment name**	Crossing 21: Afon Gam	**Date/time modelled**	23-May-2013 17:09
Company name	SKM	**Catchment easting**	293050	**Version**	1.4
Project name	Llanbrnmair FCA	**Catchment northing**	303400		
		Catchment area	3.27		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	100	**C_{max} (mm)**	224	**T_p (hr)**	1.2	**BL (hr)**	22.5
Duration (hr)	3.15	**C_{ini} (mm)**	134	**U_p**	0.65	**BR**	0.95
Timestep (hr)	0.15	**α factor**	0.83	**U_k**	0.8	**BF_0 (m^3/s)**	0.3
Season	Winter						

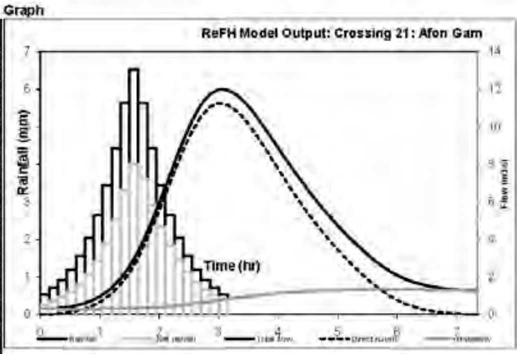
Summary of results

FEH DDF rainfall (mm)	66.6	**Peak rainfall (mm)**	6.5
Design rainfall (mm)	52.6	**Peak flow (m^3/s)**	12

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	mm	mm	m^3/s	m^3/s	m^3/s
0.00	0.5	0.3	0.0	0.3	0.3
0.15	0.7	0.3	0.0	0.3	0.3
0.30	0.9	0.5	0.0	0.3	0.3
0.45	1.2	0.6	0.1	0.3	0.4
0.60	1.6	0.8	0.2	0.3	0.5
0.75	2.0	1.1	0.3	0.3	0.6
0.90	2.6	1.4	0.5	0.3	0.8
1.05	3.4	1.9	0.7	0.3	1.0
1.20	4.4	2.5	1.1	0.3	1.4
1.35	5.6	3.3	1.6	0.3	1.9
1.50	6.5	4.0	2.2	0.3	2.5
1.65	5.6	3.6	3.0	0.3	3.4
1.80	4.4	2.9	4.0	0.4	4.4
1.95	3.4	2.3	5.2	0.4	5.5
2.10	2.6	1.8	6.4	0.4	6.8
2.25	2.0	1.4	7.6	0.5	8.0
2.40	1.6	1.1	8.7	0.5	9.2
2.55	1.2	0.9	9.7	0.6	10.3
2.70	0.9	0.7	10.6	0.6	11.2
2.85	0.7	0.5	11.1	0.7	11.7
3.00	0.5	0.4	11.2	0.7	12.0
3.15	0.0	0.0	11.1	0.8	12.0
3.30	0.0	0.0	10.8	0.9	11.7
3.45	0.0	0.0	10.3	0.9	11.3
3.60	0.0	0.0	9.7	1.0	10.7
3.75	0.0	0.0	9.0	1.0	10.0
3.90	0.0	0.0	8.2	1.1	9.3
4.05	0.0	0.0	7.5	1.1	8.6
4.20	0.0	0.0	6.8	1.2	7.9
4.35	0.0	0.0	6.1	1.2	7.3
4.50	0.0	0.0	5.4	1.2	6.6
4.65	0.0	0.0	4.8	1.3	6.0
4.80	0.0	0.0	4.2	1.3	5.4
4.95	0.0	0.0	3.6	1.3	4.9
5.10	0.0	0.0	3.1	1.3	4.4
5.25	0.0	0.0	2.6	1.3	3.9
5.40	0.0	0.0	2.2	1.3	3.5
5.55	0.0	0.0	1.7	1.3	3.1
5.70	0.0	0.0	1.4	1.3	2.7
5.85	0.0	0.0	1.0	1.3	2.3
6.00	0.0	0.0	0.8	1.3	2.1
6.15	0.0	0.0	0.5	1.3	1.9
6.30	0.0	0.0	0.4	1.3	1.7
6.45	0.0	0.0	0.3	1.3	1.6
6.60	0.0	0.0	0.2	1.3	1.5
6.75	0.0	0.0	0.1	1.3	1.4
6.90	0.0	0.0	0.1	1.3	1.3
7.05	0.0	0.0	0.0	1.3	1.3
7.20	0.0	0.0	0.0	1.3	1.3
7.35	0.0	0.0	0.0	1.3	1.3
Total (mm)	**52.6**	**32.4**	**32.4**	**7.2**	**39.5**

Graph



Audit comments

Model run with ReFH dll version 1.4.0005

Catchment
Catchment descriptors imported from file
Catchment descriptor file = 'Crossing 21.csv'
Catchment decriptor file exported from CD ROM version 3
Catchment descriptor file exported on 23-May-2013 15:39
BFIHOST value of 0.371 used
PROPWET value of 0.66 used
SAAR value of 1523 used
DPLBAR value of 2.47 used
DPSBAR value of 89.1 used
URBEXT value of 0 used
C value of -0.03 used
D1 value of 0.48343 used
D2 value of 0.4016 used
D3 value of 0.36672 used
E value of 0.298 used
F value of 2.43158 used

Rainfall
Recommended season is Winter, as URBEXT <0.125
ReFH design standard Seasonal Correction Factor of 0.83 applied

Page 1 of 7

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

ReFH design standard Areal Reduction Factor of 0.96 applied

Loss Model

C_{Max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model

T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model

BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

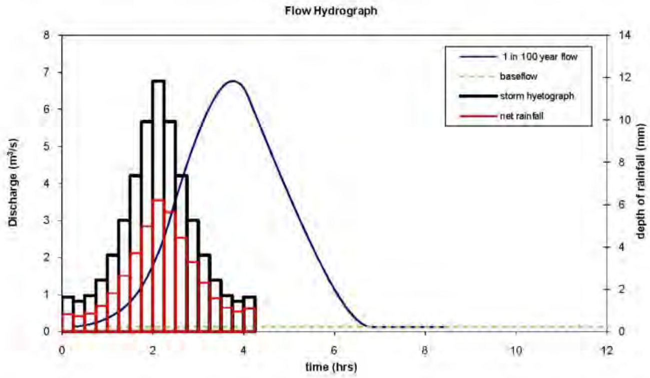
FEH rainfall runoff method (calculation sheet)

Crossing 22: Afon Gam

Results

Series	Unit												
Time	hours	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75
Design Rainfall	mm	0.00	1.64	1.44	1.71	2.43	3.62	5.26	7.36	9.92	11.83	9.92	7.36
Net rainfall	mm	0.00	0.82	0.72	0.86	1.22	1.81	2.64	3.69	4.98	6.21	5.65	4.44
Direct runoff	m^3/s	0.00	0.04	0.12	0.23	0.41	0.68	1.08	1.66	2.42	3.43	4.38	5.22
Baseflow	m^3/s	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total flow	m^3/s	0.13	0.17	0.25	0.36	0.54	0.81	1.21	1.79	2.55	3.56	4.51	5.35

Series	Unit												
Time	hours	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75
Design Rainfall	mm	5.26	3.62	2.43	1.71	1.44	1.64	0.00	0.00	0.00	0.00	0.00	0.00
Net rainfall	mm	3.30	2.33	1.59	1.13	0.96	1.11	0.00	0.00	0.00	0.00	0.00	0.00
Direct runoff	m^3/s	5.93	6.42	6.62	6.43	5.75	5.00	4.26	3.55	2.86	2.19	1.57	1.01
Baseflow	m^3/s	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total flow	m^3/s	6.05	6.55	6.75	6.56	5.88	5.13	4.39	3.68	2.98	2.32	1.70	1.14



Key model parameters:

AREA	2.83 km^2	
URBEXT	0	A RURAL CATCHMENT
SAAR	1531 mm	
DPSBAR	88.2 m/Km	
PROPWET	0.66	
DPLBAR	1.7 Km	
BFIHOST	0.325	
Tp	1.653 hours	
Up	3.501 m^3/s	
TB	4.481 hours	
c	-0.03	
d1	0.48396	
d2	0.40211	
d3	0.36719	
e	0.298	
f	2.43327	

design storm 140 year 255 minute
rainfall depth 78.0 mm

Results summary

Peak flow = 6.75 m^3/s for the 100 year event

Series	Unit											
Time	hours	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	**Total (mm)**
Design Rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**78.59**
Net rainfall	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**43.47**
Direct runoff	m^3/s	0.54	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**22.89**
Baseflow	m^3/s	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	**1.40**
Total flow	m^3/s	0.67	0.32	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	**24.29**

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Daniel Watson	**Catchment name**	Crossing 22: Afon Gam	**Date/time modelled**	23-May-2013 17:16
Company name	SKM	**Catchment easting**	292550	**Version**	1.4
Project name	Llanbrynmair FCA	**Catchment northing**	303800		
		Catchment area	2.83		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	100	**C_{max} (mm)**	227	**T_p (hr)**	0.96	**BL (hr)**	20.9
Duration (hr)	2.38	**C_{ini} (mm)**	135	**U_p**	0.65	**BR**	0.96
Timestep (hr)	0.14	**α factor**	0.83	**U_k**	0.8	**BF_0 (m^3/s)**	0.3
Season	Winter						

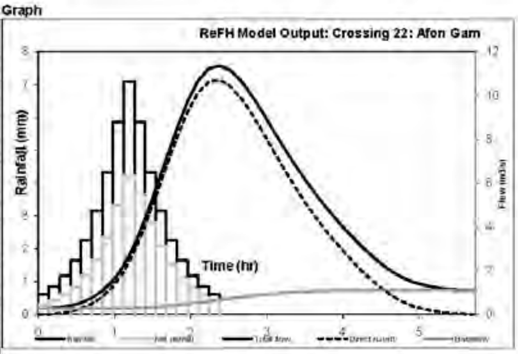
Summary of results

FEH DDF rainfall (mm)	60.6	**Peak rainfall (mm)**	7.1
Design rainfall (mm)	46.8	**Peak flow (m^3/s)**	11.4

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	mm	mm	m^3/s	m^3/s	m^3/s
0.00	0.6	0.3	0.0	0.3	0.3
0.14	0.8	0.4	0.0	0.3	0.3
0.28	1.2	0.6	0.1	0.3	0.3
0.42	1.6	0.8	0.1	0.3	0.4
0.56	2.3	1.2	0.3	0.3	0.5
0.70	3.1	1.7	0.5	0.3	0.7
0.84	4.3	2.4	0.8	0.3	1.1
0.98	5.9	3.3	1.3	0.3	1.5
1.12	7.1	4.2	1.9	0.3	2.2
1.26	5.9	3.7	2.9	0.3	3.1
1.40	4.3	2.8	4.0	0.3	4.3
1.54	3.1	2.1	5.3	0.3	5.7
1.68	2.3	1.5	6.7	0.4	7.1
1.82	1.6	1.1	8.0	0.4	8.5
1.96	1.2	0.8	9.2	0.5	9.7
2.10	0.8	0.6	10.1	0.5	10.7
2.24	0.6	0.4	10.6	0.6	11.2
2.38	0.0	0.0	10.7	0.7	11.4
2.52	0.0	0.0	10.4	0.7	11.1
2.66	0.0	0.0	9.9	0.8	10.7
2.80	0.0	0.0	9.2	0.8	10.0
2.94	0.0	0.0	8.4	0.9	9.2
3.08	0.0	0.0	7.5	0.9	8.4
3.22	0.0	0.0	6.7	1.0	7.6
3.36	0.0	0.0	5.9	1.0	6.9
3.50	0.0	0.0	5.1	1.0	6.2
3.64	0.0	0.0	4.4	1.1	5.5
3.78	0.0	0.0	3.8	1.1	4.9
3.92	0.0	0.0	3.2	1.1	4.3
4.06	0.0	0.0	2.7	1.1	3.8
4.20	0.0	0.0	2.1	1.1	3.3
4.34	0.0	0.0	1.7	1.1	2.8
4.48	0.0	0.0	1.3	1.1	2.4
4.62	0.0	0.0	0.9	1.1	2.0
4.76	0.0	0.0	0.6	1.1	1.7
4.90	0.0	0.0	0.4	1.1	1.5
5.04	0.0	0.0	0.3	1.1	1.4
5.18	0.0	0.0	0.1	1.1	1.2
5.32	0.0	0.0	0.1	1.1	1.2
5.46	0.0	0.0	0.0	1.1	1.1
5.60	0.0	0.0	0.0	1.1	1.1
5.74	0.0	0.0	0.0	1.1	1.1
Total (mm)	**46.8**	**28.0**	**28.0**	**5.5**	**33.5**

Graph



Audit comments

Model run with ReFH dll version 1.4.0005

Catchment
Catchment descriptors imported from file
Catchment descriptor file = 'Crossing 22.csv'
Catchment decriptor file exported from CD ROM version 3
Catchment descriptor file exported on 23-May-2013 15:40
BFIHOST value of 0.325 used
PROPWET value of 0.68 used
SAAR value of 1531 used
DPLBAR value of 1.7 used
DPSBAR value of 88.2 used
URBEXT value of 0 used
C value of -0.03 used
D1 value of 0.48396 used
D2 value of 0.40211 used
D3 value of 0.36719 used
E value of 0.298 used
F value of 2.48327 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.81 applied
ReFH design standard Areal Reduction Factor of 0.96 applied

Loss Model
C_{max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard αfactor used

Routing Model

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

APPENDIX 8.9: PEAT MANAGEMENT PLAN

1.1 Introduction

1.1.1 This draft Peat Management Plan (PMP) document has been prepared for the construction of the Llanbrynmair Wind Farm (the 'Development'). It is further developed from the original PMP submitted with the original application in 2007.

1.1.2 The PMP would be implemented if the proposal receives planning consent from Powys Council. Further details and specific plans will be determined during the detailed design process and once further site investigations have been undertaken. These details will then be included in a PMP as a part of the required Contractor's detailed Construction Environmental Management Plan (CEMP).

1.1.3 The PMP has been developed because, at Llanbrynmair, peat habitats (including blanket bog, mire and heath) were identified as important and sensitive. It should be read in conjunction with the Habitat Management Plan (HMP) which appears in Appendix 5.2 and the Consolidated Supplementary Environment Information July 2013.

1.1.4 The PMP addresses the management of peat during construction and immediate restoration. The HMP then looks at habitat restoration and management post construction.

1.2 Objectives

1.2.1 The PMP demonstrates that peat has been afforded significant consideration and will be treated with the utmost importance during the construction should consent be granted. Together with the HMP, it aims to propose mitigation measures that will minimise any impacts, and the long term habitat restoration and management plans for key areas of the site that are designed to enhance the site.

1.2.2 The PMP outlines the overall approach of minimisation of peatland disruption that has been adopted. It aims to ensure that all further opportunities to minimise peat disturbance and extraction will be taken.

1.2.3 The PMP seeks to identify that appropriate proposals to re-use the surplus peat can be accommodated within the site layout, without significant environmental or health and safety implications, to minimise risk in terms of carbon release and human health.

1.3 Layout

1.3.1 The layout of the PMP is as follows:

- Legislation, guidance and classification of excavated material
- Details of the basic peatland characteristics
- Peat Balance between excavation and reuse on site of surplus peat
- Peat excavation and handling methods and controls
- Temporary peat storage
- Reuse in infrastructure construction restoration and in habitat enhancement
- Tables showing:
    - where surplus peat will be generated and what the quantities will be.
    - what quantity of this surplus peat will be catotelmic and what quantity will be acrotelmic;
    - the principles of where catotelmic and acrotlemic peat will be re-used and approximately how much will be re-used

1.4 Policy and Guidance for Peat Management

Legislation and Guidance

1.4.1 Peat as a carbon landscape has a capacity to act as a carbon sink. The management of peat therefore has implications for carbon emissions and climate change. There is much relevant legislation and guidance regarding climate change and carbon which is relevant to the management of peat including:

- The Kyoto Protocol (1997) and the Kyoto Protocol and National Accounting for Peatlands (2012)
- The UK Climate Change Act (2008)
- Carbon Landscapes and Drainage, 2012 'The Carbon and Water Guidelines', www.clad.ac.uk
- Forestry Commission, 2011, 'Forests and climate change: UK Forestry Standard Guidelines.

1.4.2 There is also a large amount of guidance specifically relating to wind farm construction and peatland restoration:

- Best Practice Guidance to Planning Policy Statement 18 'Renewable Energy', August 2009.
- CCW latest policy is demonstrated in 'Assessing the Impacts of Windfarms on Peatlands', 2010. In particular it is noted that NRW adopt a policy whereby deep peat is 0.5 m.

1.4.3 Other key documents we have relied upon include:

- Good practice during windfarm construction, A joint publication by Scottish Renewables, Scottish Natural Heritage, Scottish Environment Protection Agency, Forestry Commission Scotland, Version 1, October 2010.
- Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste Scottish Renewables, 17 January 2012.

Classification of Excavated Peat Material

1.4.4 Waste is an environmental issue regulated by both European and National legislation. The overarching framework for National (i.e. UK) legislation is set by European Community (EC) Directives, with the relevant Directive on waste matters being 2008/98/EC (the Waste Framework Directive (WFD)) which came into force 12 December 2008. Article 4 of this Directive sets out the waste hierarchy and requires that it is applied 'as a priority order in waste prevention and management legislation and policy'. The waste hierarchy is defined as follows:

a. Prevention;

b. Preparing for re-use;

c. Recycling;

d. Other recovery e.g. energy recovery; and

e. Disposal.

1.4.5 The Directive also states that 'Member States shall take into account the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts.'

1.4.6 The main national legislation potentially relevant to waste management activities involving waste peat is the Environmental Permititng Regulations (England and Wales (2010) as amended.

1.4.7 Where excavated or disturbed peat does not have a genuine and identified re-use for which it is suitable, the peat will be classified as a waste material and regulated as such under the relevant legislation. However, Natural Resources Wales (NRW) the Regulatory Authority aims to regulate in a proportionate manner and ensure that the ultimate management of any excavated peat will be designed to deliver environmental benefits. This will include consideration, on a site by site basis, of ecological and carbon stock benefits as well as economic, social and practical aspects. For the purposes of waste description, excavated peat that does not have a genuine and identified re-use would fall under Chapter 17 of the European Waste Catalogue (EWC), 'Construction and demolition wastes', and the EWC Code '17 05 04, soil and stones' (non-hazardous) would apply.

1.4.8 The construction of the Development will aim to ensure that appropriate environmental management steps are taken to avoid 'waste' peat. However, as excavated peat may or may not be classed as waste in accordance with the legal definition of waste, in order to ensure compliance with relevant waste legislation, excavated materials will be required to be classified on site.

1.4.9 The following criteria will be used will be used to determine whether peat is classified as waste or whether it can be reused as part of the works:

- The use is a necessary part of the planned works
- The material is suitable for that use
- The material does not require any processing or treatment before it is reused
- No more than the quantity necessary is to be used
- The use of the material is not a mere possibility but a certainty; and
- Use of the material will not result in pollution of the environment or harm to human health.

1.4.10 Any peat that is not immediately suitable for reuse on site without the requirement for treatment will be classed as waste and requires to be dealt with in accordance with the Contractor's developed Site Waste Management Plan under the CEMP which will be prepared should consent be granted.

1.5 Peat Conditions

Definitions of Peat

1.5.1 Peat can be separated into three main layers: turf, acrotelmic (the upper layer) and catotelmic (the lower layer) peat:

- Peat turf is the surface layer of living vegetation and underlying fibrous subsoil.
- Acrotelmic peat is generally found within the top layer of peat depending on the degree of decomposition and fibrous nature of the peat. The water table fluctuates in this layer and conditions vary from aerobic to anaerobic. Material may be fibrous or pseudofibrous (plant remains recognisable), spongy, and when excavated strength is lost but retains integral structure and can stand unsupported when stockpiled >1m.
- Catotelmic peat is found deeper than acrotelmic peat and has organic matter which decomposes anaerobically. Material has high water content and is permanently below the water table. Material is amorphous (recognisable plant remains absent), plastic, and low tensile strength and is unable to stand unsupported >1m when stockpiled.

Peat Conditions on Site

1.5.2 Reference should be made here to the Consolidated Supplementary Environment Information.

1.5.3 The site was assessed for peat vegetation through desktop review of maps and plans, the plotting of height contours from OS data at 1:10000, a number of site walkovers by ecologists, hydrologists and an engineering geologist and intrusive site investigation in terms of extensive depth probing and coring across the wind farm site and access track route.

1.5.4 Initial probing and walkover and coring assessments sought to identify peat character in order to minimise overall carbon losses, avoid damaging valuable active peat forming habitats. An extensive depth of penetration probing exercise was carried out on site.

1.5.5 Afforestation, mainly on the southern boundary of the site and grazing, on the western boundary of the site has resulted in both modification and damage to some of the peat habitats on the site.

1.5.6 In general the peat across the site was found to be mainly between 0 and 1 metre in depth under the proposed infrastructure. Fewer probes were between 1 and 1.5 metres and very few over 1.5.

1.5.7 The two most common and widespread mire communities were M25 and M6 Carex echinata – Sphagnum fallax/denticulatum (Star Sedge – Bog-moss) mire. Those communities covered large areas of both deep and shallow peat, as well as mineral soils and graded from one into the other. Some areas were wetter with deeper peat, indicating modified mire, whereas on the steeper slopes there was extensive flushing and often shallower peat. Much of the blanket bog appeared to fit NVC categories M19 (*Calluna vulgaris* – *Eriophorum vaginatum* mire) and M20 (*Eriophorum vaginatum* blanket and raised mire) although the fit was not always good.

1.5.8 The more important areas of mire (blanket bog and acid flush) were those that were less modified by drainage and other activities, so they were wetter, often more species-rich and held abundant bog-mosses. These are UK priority habitats in the UK Biodiversity Action Plan (UKBAP) and, when active bog, also a priority habitat in the European Habitats Directive, and listed under Section 42 of the NERC Act 2006, requiring the Welsh Assembly to 'have regard, in exercising its functions, to conserve biodiversity' and a duty to list species and habitats of principle importance.

1.5.9 The mire vegetation types at this site are often in a mosaic, with richer patches interspersed with species-poor bog, semi-improved or modified areas, and small patches of heath vegetation. Due to the difficulty in defining individual patches and the integral hydrological conditions of bogs the mosaics have been all treated as sensitive.

1.5.10 All the valued habitats identified above were considered sensitive to developments. They will be sensitive to both direct loss from construction and, especially the wetter habitats, may be sensitive to changes in hydrology caused by construction.

1.5.11 During the period of the preparation of this report several new deep drains have been dug, or old drains cleaned out, in some mire areas. If left unblocked, or if new drains continue to be dug then further deterioration of these areas of mire will occur.

1.6 Excavation and Reuse Volume Estimates and Reuse Requirements

Further Minimisation

1.6.1 The detailed occurrence of peat across the site has been examined extensively following ongoing feedback from consultees in order to design the most optimal infrastructure layout and to minimise and define impacts.

1.6.2 in addition to the optimizing work already carried out, the disturbance of peat by the constuction of the tracks, crane pads and foundations will be minimised as much as practicably possible in order to try and reduce any peat waste on site and reduce potential carbon losses from the peat excavation process.

1.6.3 Throughout the construction process, the Contractor (and / or Designer) will ensure that all possible methods are employed to minimise the volumes of excavated peat. As far as possible appropriate handling and storage of excavated materials will be undertaken such that their integrity and subsequent reuse is not jeopardised.

1.6.4 It is clear that the Site in many areas comprises a detailed mosaic with some sensitive pockets of habitat within wider areas of less sensitive habitat. In walking the site it became clear that the scale of mapping available and the differences between accuracy of individual GPS systems meant it was not always possible to clearly identify these pockets. Therefore the ecological clerk of works will walk the site with engineers before construction commences, pointing out areas of sensitive habitat and identifying where impact can be reduced by minor movement of infrastructure within the micro-siting available. These areas will be clearly marked with post and tape. The ecological clerk of works will also ensure that any micro-siting does not lead to movements into more sensitive habitats.

1.6.5 Further measures to minimise peat disturbance will be incorporated in the development and construction process. The principles of the waste hierarchy (outlined above) will be adhered to in order to:

- Avoid and/or minimise production of excavated peat
- Ensure that where possible, excavated peat is reused on site in landscaping and re-profiling works, to minimise visual impacts and facilitate habitat and ecological restoration, improvement and enhancement.
- Where feasible, ensure that waste peat will not be sent for disposal, recovery and/or reuse off site.

1.6.6 All contractors will be made aware of the sensitivity of peat habitats and the Ecological Clerk of Works will ensure that sensitive habitats near to constuction areas are clearly marked. Contractors will be required to work within the narrowest practical construction corridor when working in or near areas of peat.

1.6.7 Extra care will be taken when working within peat areas to keep all activities within the narrowest practical construction envelope.

1.6.8 All plans and method statements will be accompanied by justification of the final design and/or construction methods identified by the Contractor, including reasons for discounting alternative methods. This is required in order to demonstrate that all avenues for avoiding hydrological disruption and reducing the disturbance and excavation of peat have been considered.

Peat Balance

Excavated Volumes

1.6.9 Appendix I to the Geology, Hydrolgy and Hydrogeology Chapter of the Consolidated Supplementary Environment Information gives the peat excavation volumes associated with the project. These have been calculated using the GIS package ArcGIS based on the following data and assumptions:

- A contour map of assumed peat depth based on interpolation of values from probing across the site;
- Dimensions of the proposed areas for excavation for site infrastructure;
- An estimated acrotelm depth of 0.2m across the site; and
- An assumption that the probe depth is representative of the actual depth of the peat.

1.6.10 The updated peat volume estimates have been revised to take into account the amendments to the wind farm layout and NRW comments The table also provides further clarification (as requested by NRW) on the reuse options (on-site uses), dimensions and other assumptions used to generate these conservative and preliminary volume estimates.

1.6.11 At this stage of development and based on the location of site infrastructure in relation to peat depth and site topography it is calculated that the excavation of soils and the cut and fill required as part of Development will lead to an estimated maximum surplus of 120,000 m3 of peat. Table 1 gives details of the intital estimates of peat exscavations.

Table 1 Excavated volumes for all infrastructure

Name	Peat Depth Average (m)	Area (m^2)	Acrotelm volume (m^3)	Catotelm volume (m^3)	Total Volume (m^3)
Met Mast and	0.18	436	78	0	78
Substation	0.16	4,028	640	0	640
Welfare Building (south)	0.17	38	7	0	7
Welfare Building (north)	0.13	38	5	0	5
Construction Compound 1	0.07	3,000	224	0	224
Construction Compound 2	0.54	3,000	600	963	1,563
Construction Compound 3	0.06	3,000	95	0	95
Construction Compound 4	0.41	3,000	600	619	1,219
Construction Compound 5	0.00	3,000	0	0	0
Borrow Pit 1	0.00	3,600	5	0	5
Borrow Pit 2	0.08	3,600	328	0	328
Borrow Pit 3	0.13	3,600	462	0	462
Borrow Pit 4	0.55	3,600	720	1,236	1,956
Borrow Pit 5	0.07	3,614	221	0	221
Borrow Pit 6	0.05	3,600	184	0	184
Batching Plant	0.05	6,400	324	0	324
Turbine R4 including crane pad	0.46	4,768	954	1,448	2,402
Turbine R5 including crane pad	0.46	4,768	954	1,037	1,991
Turbine R6 including crane pad	0.56	4,768	954	1,721	2,674
Turbine R7 including crane pad	0.28	4,768	954	376	1,330
Turbine R8 including crane pad	0.55	4,768	954	1,616	2,570
Turbine R9 including crane pad	0.46	4,768	954	1,272	2,226
Turbine R12 including crane pad	0.60	4,768	954	1,904	2,858
Turbine R13 including crane pad	0.28	4,768	954	309	1,262
Turbine R14 including crane pad	0.24	4,768	954	249	1,202
Turbine R15 including crane pad	0.55	4,768	954	1,699	2,653
Turbine R16 including crane pad	0.31	4,768	954	593	1,546
Turbine R17 including crane pad	0.56	4,768	954	1,752	2,706
Turbine R18 including crane pad	1.27	4,768	954	4,978	5,932
Turbine R19 including crane pad	0.42	4,768	954	1,078	2,032
Turbine R23 including crane pad	0.04	4,768	186	0	186
Turbine R24 including crane pad	0.10	4,768	470	0	470
Turbine R25 including crane pad	0.72	4,768	954	2,496	3,450
Turbine R26 including crane pad	0.63	4,768	954	2,026	2,980
Turbine R27 including crane pad	0.30	4,768	954	439	1,393
Turbine R31 including crane pad	0.59	4,768	954	1,928	2,881
Turbine R32 including crane pad	0.12	4,768	563	0	563

Name	Peat Depth Average (m)	Area (m^2)	Acrotelm volume (m^3)	Catotelm volume (m^3)	Total Volume (m^3)
Turbine R35 including crane pad	1.52	4,768	954	6,333	7,287
Turbine R36 including crane pad	0.88	4,768	954	3,256	4,209
Turbine R37 including crane pad	0.54	4,768	954	1,632	2,585
Turbine R38 including crane pad	0.72	4,768	954	2,466	3,419
Turbine R39 including crane pad	0.80	4,768	954	2,729	3,682
Turbine R40 including crane pad	0.39	4,768	954	844	1,797
Turbine R41 including crane pad	0.30	4,768	954	459	1,412
Turbine R42 including crane pad	0.36	4,768	954	756	1,709
Turbine R43 including crane pad	0.07	4,768	345	0	345
Total			**30,850**	**48,210**	**79,060**
Track			**19,511**	**22,275**	**41,786**
Total Volume infrastructure + Tracks			**50,361**	**70,485**	**120,846**

1.6.12 In order to determine accurate peat volumes detailed probing of the proposed access tracks and other infrastructure areas will be undertaken as part of pre construction site works. Additional peat probing and / or other ground investigation techniques will be employed as necessary prior to and during the works in order to inform micrositing requirements.

1.6.13 Final implementtation of peat reuse and classification will be subject to geotechnical on site tests eg shear vane testing, to determine peat stability and type and use potential.

Peat Reuse Volumes

1.6.14 From Table 1 above, the volume of peat that will be removed by excavation of the infrastructure is ~50,000 m^3 of acrotelm and ~70,000 m^3 of catotelm. This volume of peat will be reused around the site in the 5 forestry restoration areas and in appropriate locations around the infrastructure. This is described in more detail below.

Table 2 Estimated Reuse volumes

Reuse Type	Area (m^2)	Acrotelm volume (m^3)	Catotelm volume (m^3)	Total Volume (m^3)
Post forestry felling drain blocking for peat restoration	250,000[1]	20,000	20,000	40,000
Open site drain blocking for peatland restoration	20,000[1]	2,000	2,000	4,000
Borrow Pits	18,000	11,000	25, 00	36,000[2]
Access Track shoulders - revegetation of berms, batter reinstatement and screening bunds at vantage points[3]		14,000	14,000	28,000
Turbine excavations	3,000	4,000	10,000	14,000
Total		**~50,000**	**~70,000**	**~120,000**

1 Area of drains and furrows for infill
2 wetland creation to 2 m depth – design to be detailed post consent
3 Approximate assuming average 0.3m fill- side slopes and heights to be agreed post consent

1.6.15 It is assumed that the cable trenches will have no impact on peat as the removed volume will be replaced and clay will be used at regular intervals to prevent preferential pathways developing in the sand/cable layer at the base of the trench.

1.6.16 In practice, the volumes of peat excavated are expected to be significantly less due to evidence from peat coring and as micrositing is applied.

Net Balance

1.6.17 Over the life time of the wind farm it is expected that there will be a net gain in the amount and quality of the blanket bog habitat and peat carbon stocks at Llanbrynmair. This conclusion is based on the following assumptions:

- Appoximately 14.8 ha of peatland habitat will be directly lost to tracks, turbines and other infrastructure;
- However, all excavated material will be reused on site;
- There will be a large area of around 200 ha of blanket bog and mire habitat that will be improved and maintained;
- Approximately 149 ha of forestry on previous peat habitat will be removed and restored to peatland;
- The peatland habitats that have been afforested are of conservation importance and the felling of these habitats along with the blocking of drains and filling in of furrows with peat will restore these; and
- Current losses of carbon via fluxes of DOC and POC via inappropriate drainage will be reduced as drains are blocked.

1.7 Handling Excavated Materials

Excavation

1.7.1 Areas of peat within the footprint of excavation will have the top layer of vegetation stripped off as turf prior to construction by an experienced specialist contractor. When excavating areas of peat, excavated turfs should be as intact as possible. Often it is easiest to achieve this by removing large turfs. Elsewhere RES have agreed up to 500mm in order to keep the peat intact.

1.7.2 These turfs should be stored adjacent to the construction area in a way that ensures they remain moist and viable (see temporary storage below). Excavated turfs should be as intact as possible so as to minimise carbon losses.

1.7.3 Peat will then be removed and stored separately and kept damp. (Carbon and Water Guidelines 2012).

1.7.4 Excavated soils and turfs will be handled so as to avoid cross contamination between distinct horizons and ensure reuse potential is maximised.

1.7.5 Prior to any excavations, the Contractor will produce a detailed Method Statement identifying where and how excavated peat will be used in reinstatement or landscaping works. Specific requirements for the excavation, handling, storage and reinstatement of peat will be outlined in this Method Statement. The Contractor will consider potential impacts on downstream hydrological receptors and also the potential for instability issues with the excavated material.

1.7.6 Care will be taken when stripping and removing topsoil and peat turfs and appropriate storage methods used on site, i.e. excavated material will be stored in separate horizons and vegetation rich top layers will be stored vegetation side up.

1.7.7 Classification of excavated materials will depend on their identified re-use in reinstatement works. At this site it is anticipated that the material to be excavated will comprise peat (which may be sub-divided into catotelmic, acrotelmic and turf), clay and mineral soils (subsoil and topsoil).

Temporary Storage

1.7.8 Following excavation, peat will be required to be temporarily stored before reuse or disposal. Excavated peat should be stored in stockpiles to minimise carbon losses while being stored.

1.7.9 Where possible excavated turfs will be stored adjacent to the construction area in a way to ensure that they remain moist and viable.

1.7.10 Areas for temporary storage areas required for peat will be identified in the Contractors Method Statement taking into account constraints and mitigation requirements identified in the consoliodated supplementary environmental information. This will describe any intended drainage, pollution prevention and material stability mitigation measures that may be required.

1.7.11 The appropriate temporary storage areas for excavated peat will also be as close to the excavation as practicable.

1.7.12 The design and location of stockpiles, including incorporated drainage elements, will be agreed with the ECoW and Geotechnical Consultant / Geotechnical Clerk of Works prior to excavation works commencing.

1.7.13 Temporary peat storage areas should located so that erosion and run off is limited, leachate from the material is controlled, and stability of the existing peatland in the vicinity is not affected;

1.7.14 Excavated material is to be stockpiled at least 50m away from watercourses. This will ensure that any wetting required on stored peat does not runoff and discharge into adjacent watercourses.

1.7.15 Any edges of cut peat that may remain exposed, or areas of peat excavation on steep slopes, will be covered with geotextile or similar approved. This will allow re-turfing and re-vegetation and reduce erosion risks.

1.7.16 Suitable storage areas are more appropriately sited in areas with lower ecological value and low slopes. Cleared areas of forestry are preferred to areas of higher ecological value or areas close to watercourses.

1.7.17 Created temporary peat storage should be in locations where the water table can be kept artificially high.

1.7.18 An up-gradient cut off ditch should be installed around the edge of the storage bund in order to collect up-gradient surface water runoff and divert water runoff from eroding the bund foot.

1.7.19 It is desirable to keep haul distances of excavated peat as short as possible and as close to intended re-use destinations to minimise plant movements in relation to any earthworks activity including peat management in order to minimise the potential impact on the peat structure. It is important that temporary storage is safe and keeps the material suitable for its planned reuse.

1.7.20 The handling and storage of peat will seek to ensure that excavated peat does not lose either its structure or moisture content. Peat turves require careful storage and wetting and to be maintained to prevent drying out and subsequent oxidisation to ensure that they remain fit for re-use.

1.7.21 Stockpiling of peat should be in large volumes, taking due regard to potential loading effects. Piles should be bladed off at the side to minimise the available drying surface area.

1.7.22 Higher piles are more likely to become dewatered, while smaller piles expose a greater area to evaporation. Reducing mound size may also increase likelihood of erosional losses as POC. Overall volumes of stockpiling should be minimised and height and surface areas kept to a minimum – for example against rock faces in borrow pits.

1.7.23 Stockpiles should be battered so as to limit instability and erosion and should be bunded using impermeable material. The bunds should extend to a level above the toe of the stockpiled material to provide restraint to surface runoff.

1.7.24 When planning the temporary storage areas any additional disturbance areas should be minimised.

1.7.25 Transport of peat to temporary storage areas, restoration areas or designated spoil areas will be by low ground pressure vehicles to avoid excessive compaction of the peat.

1.8 Reuse of Peat in Infrastructure and Borrow Pit Restoration.

Bare Peat

1.8.1 A core aim will be to minimise the time any bare peat is exposed. The phasing of work should be carried out so as to minimise the amount of total exposed ground at any one time. By stripping turf and replacing as soon as possible after peat has been re-distributed there will be minimal areas of bare peat.

1.8.2 Any peat areas on steep ground or that remains partially bare will be covered using geotextile or a similar method to stop erosion. Any areas of bare peat, where vegetation is not re-growing, will be seeded with a seed mixture obtained from the existing habitat. Areas where full recovery is complete will have fences removed.

1.8.3 This approach has been shown to work on other peat sites and the turfs re-grow quickly both establishing vegetation and consolidating the peat. The re-vegetated areas will be monitored. Any areas of bare peat, where vegetation is not re-growing, will be seeded with a seed mixture obtained from the existing habitats on site. Stock exclusion in these areas will continue until vegetation is properly established.

Infrastructure Reuse

1.8.4 The Contractor will be required to provide appropriate plant for undertaking all reinstatement works such that no unnecessary disturbance of the ground surface occurs. In order to minimise disturbance and damage to the ground surface, any mobile plant required for reinstatement and landscaping works will be positioned on constructed access tracks, hard standing areas or existing disturbed areas wherever possible. The use of a long reach excavator for excavations and reinstatement works is preferable as it enables sufficient room to allow initial side casting and subsequent pulling back of turves over reinstated peat or soil.

1.8.5 Excavated catotelmic peat will only be used in restoration works where the topography allows straight forward deposition with no pre-treatment or containment measures and without risk to the environment. Suitable scenarios may be present in those disturbed areas where natural topography profile allows such use.

1.8.6 Reinstatement of vegetation will be focused on natural regeneration utilising peat vegetated turfs. To encourage stabilisation and early establishment of vegetation cover, where available, peat turfs (acrotelmic material) or other topsoil and vegetation turves in keeping with the surrounding vegetation type will be used to provide a dressing for the final surface.

1.8.7 Consideration should also be given to the impacts of poor drainage control in any areas where peat is used in reinstatement, for instance track verges and reinstatement of construction compounds etc.

1.8.8 Any reinstatement and re-profiling proposals will consider, and mitigate against identified significant risks to environmental receptors. In particular, in areas of replaced peat, water management will be considered in the Contractor’s Construction Method Statements to ensure that as far as possible an appropriate hydrological regime is re-established within areas of disturbance. Particular attention will be paid to maintaining hydrological continuity and preventing the creation of preferential subsurface flow paths (for instance within backfilled cable trenches).

1.8.9 Any surplus peat will spread in areas identified by the geotechnical clerk of works in conjunction with the ecological clerk of works as suitable.

1.8.10 Peat turfs should be replaced on all disturbed areas, including constructed roadside drainage channel embankments where possible.

1.8.11 When constructing tracks rapid restoration will be undertaken as track construction progresses.

1.8.12 Immediately following construction some turfs will be replaced along the road edges to allow quicker re-vegetation and soften the road edges

1.8.13 The site access tracks have been orientated to allow for traditional cut and fill construction methods, i.e. the avoidance of steep sections of the site whilst minimising depths of excation of all material. Excavated peat from cut and fill sections of access tracks will be used for dressing the side slopes of track sections and for screeing bunds at vantage points.

1.8.14 Only fibrous peat is likely to be suitable for battering road verges. Any landscaping or road batters should be limited to the areas of ground already disturbed.

1.8.15 Track edges and passing places would be reinstated post construction through the removal of capping material and the reuse of peat turves. Where peat turves are used to reinstate track edges this will be done in a manner to ensure works tie in with the surrounding topography, landscape and ground conditions. Where gradients permit, peat edges may be built up slightly above the road level to reduce visual effects from the surrounding area if NRW feel it necessary to limit track visibility.

1.8.16 The design and construction of tracks on peat shall be done in such a way so as to reduce impacts on the existing peat hydrology at the site. The built track should allow for the transmittance of water, so natural drainage can be maintained as much as possible.

1.8.17 Peat will be replaced around the turbine base excavations, and re-turfed. Peat will be spread over thetemporary hardstanding areas of the crane pads, rotor assembly pads and other areas used in the construction and re-turfed.

1.8.18 The revegetation of temporary hardstanding areas will depend on the identified reinstatement use and associated vegetation character bounding the areas of restoration, with the aim being to match turves and topsoil to similar ground conditions. Where appropriate, excess peat turves, if acrotelm in nature and considered suitable by the ECoW, could be used for screening bunds, landscaping or as part of the HMP in conjunction with reseeding. The seed mix used on site would be agreed with the ECoW, SNH and SLC and would use local native species akin to the local ecological baseline.

1.8.19 Peat will be used for reinstatement and landscaping of site infrastructure.

Borrow Pit

1.8.20 Borrow pits should be restored to wetland habitat where possible. Borrow pit reinstatement using excavated peat will depend on the final restoration profiles of the borrow pit areas and will be subject to the ground conditions close to borrow pits (to be confirmed in the final PMP).

1.8.21 The borrow pit's design will allow for unconsolidated peat to be used at depths of up to 2 m to create a wetland habitat in line with habitat management plan objectives for the site.

1.8.22 The Contractors method statement will provide information on intended final restoration profile and method statement for how this is to be achieved, the likely volumes of material required in addition to peat, where the material is to be sourced and hydrology design to create and maintain peat wetland status.

1.8.23 Borrow pit design will take account of medium and long term restoration objectives relating to habitat and environment. In particular they should be designed such that water levels within the restored habitat can be maintained at ground level.

1.8.24 For example, the borrow pits will be excavated downslope where possible and the downslope worked face designed to retain high water levels within the restored area thus preventing peat drying out. Acrotelmic material (turves) will be used where available on the surface.

1.8.25 Any aggregate removed from decommissioned infrastructure will be put back into borrow pits and covered with an appropriate layer of peat. This is likely to be a volume neutral exercise as the aggregate removed would be replaced by peat used to reinstate the residual surface.

1.9 Reuse of Peat for Other Restoration Purposes

1.9.1 The Habitat Management Plan has identified five forestry areas on site where peatland restoration will be undertaken comprising a total area of 150.5 hectares and further open moorland restoration areas. The methodology for peat restoration in these areas and the assessment of the potential volume of peat that can be reused are presented in the HMP and will be further developed by the Contractor and the HMP Committee. Some initial comments are made below.

1.9.2 In developing the original peat management programme for Llanbrynmair evidence of best practice was collected from a variety of current schemes. These included Moors for the Future in Derbyshire, restoration following the construction of a pipeline across the Brecon Beacons, Black Law windfarm restoration project in Scotland, the LIFE bog restoration project in North Wales, management and peat cutting damming at Borth Bog, grip blocking and grazing management in Bowland and the Peak District and the SCaMP programme in Lancashire. Examples were included in the proceeding sections. In addition the original peat management plan and Habitat management Plan for Llanbrynmair benefitted from on-site advice from Mike Bailey, CCW.

1.9.3 These confirm that all the proposals can be achieved. Subsequent to that there has been significant development of policy and thinking on peat habitats and peat as a carbon source.

1.9.4 The formation of peatland is reliant on a high water table, whether temporary or permanent, therefore the current drainage in these areas must be controlled to allow restoration to take place. In these five forested areas it is assumed that once the forestry has been felled the drains can be blocked to raise the water levels in the drains and therefore the groundwater level across these areas.

1.9.5 As the project site presents both extensive natural and anthropogenic drainage systems along with the impact from forestry, which have led to a severely altered blanket bog, the first step and main activity to restore the natural habitat will include a comprehensive effort to block most of the ditches on the site. These blockings will benefit the characteristic vegetation and species of the peatland, as well as decrease the risk of soil erosion and flash flooding.

1.9.6 Peat will be used for drain and furrow blocking in the restoration areas to re-wet areas and prevent carbon loss by drainage.

1.9.7 A detailed ditch blocking method statement will be agreed with NRW prior to the commencement of construction. The most appropriate methods would be used, chosen on a site by site basis as described in the HMP. The aim will be to restore the areas to pre-planting blanket bog habitat – the habitats present in the existing rides indicate that this will be successful. From the evidence of the rides it is thought that there will be sufficient seed available within the existing peat to allow re-growth of heather and other species across the site post felling. There is also already sphagnum present in many of the ditches. If this does not occur the area will be sprayed with heather brash, collected from elsewhere on site and other methods such as inoculation of wet areas with sphagnum will be considered, based on methods used successfully elsewhere.

1.9.8 It is generally recommended that drain blocking is undertaken used either highly decomposed peat or plastic piling. Peat turves do have the highest dam failure rate if not installed correctly but if they are installed correctly they tend to be the most cost effective solution. There are however a number of considerations that must be taken into account when selecting the dam material which include slope, drain size and exposure of mineral substrate.

1.9.9 A survey of the smaller drains, ditches and furrows will be undertaken and the area mapped in detail from LIDAR data.

1.9.10 Ditches will be blocked, often with blocks of intact peat, at regular intervals along their length. This allows water tables to rise and the surface to be more water-logged slowing down decomposition of organic matter and creating the wet conditions for Sphagnum regeneration.

1.9.11 Peat dams can be built by hand and have proven to be very effective (Armstrong et al., 2009) on bare peat sites, if correctly installed. For larger ditches, other techniques can be used i.e. machinery to push down the sides of the drain using an excavator bucket or using an excavator bucket to scoop material out and place it in the drain. It is important to get a complete, firm contact between wet peat to create a seal. Then, a piece of turf should be laid on top of the bare peat to prevent it drying out, increase stability and improve aesthetics.

1.9.12 The ideal dam spacing depends on slope angle and volume of water: drains on steeper slopes and with greater supply area draining into them should be blocked at shorter intervals as stream powers will be higher. However, they should not be more than 12 m apart.

1.9.13 For any larger drains (greater than 2m wide and/or more than 1 m deep) plastic piling will be used as they are both stronger (to prevent erosion) and easy to transport (they come in small, light weighted sections).

1.9.14 Once the drains have been blocked with a combination of plastic sheeting and peat it is recommended that catotelm peat that has been excavated on site is deposited into the existing furrows between the trees which will become saturated as the drains will no longer maintain groundwater levels at depth.

1.9.15 To determine how much peat could be used within the forest areas an examination was completed insofar as possible given the extent of tree cover and the limited options for examining all drains and furrows. Site observations indicate a variety of conditions in forested areas ranging from areas between rows of trees that were essentially flat to broad furrows of about 1m or more wide and up to 0.3m deep. In places the furrows alternate between rows of trees with a deep furrow adjacent to a shallow one. These tend to be about 2m apart. In other locations the deeper furrows are located every 2m or 3m. In addition drainage ditches cross the forested areas however these have no specific frequency although they do not tend to be wide (~0.5m) and vary in depth between about 0.3m and 0.6m although there are deeper sections in places. Furthermore a number of natural drainage channels cross the forested areas and the drains and furrows are all linked to these.

1.9.16 Furrows were of an average dimension of 0.5m wide by 0.2m deep at an average spacing of 3m. The drains do not really add a great deal to this as they are not that frequent and will be minor in volume compared to the furrows.

1.9.17 A volume of 330 m^3 per hectare for a total area of forestry of 150.5 hectare was identified. Therefore the estimated volume that could be used in these area is about 50,000 m^3.

APPENDIX 9.1: NOISE ASSESSMENT FIGURES

Figure 9.1 Predicted Noise Footprint for Proposed Wind Farm

1.1.1 Grid Intervals At 1 km; The $L_{A90,10min}$ descriptor has been used.

1.1.2 The noise footprint has been calculated at a standardised 10 m wind speed of 8 ms-1 using the ISO 9613-2 propagation model.

1.1.3 The figure may show slightly different results than those numerically calculated and should be considered illustrative only as all barrier attenuation has been removed (more conservative) and the correction for propagation across valleys has not been applied (less conservative).

1.1.4 Red receiver icons indicate that background noise measurements made at those locations.

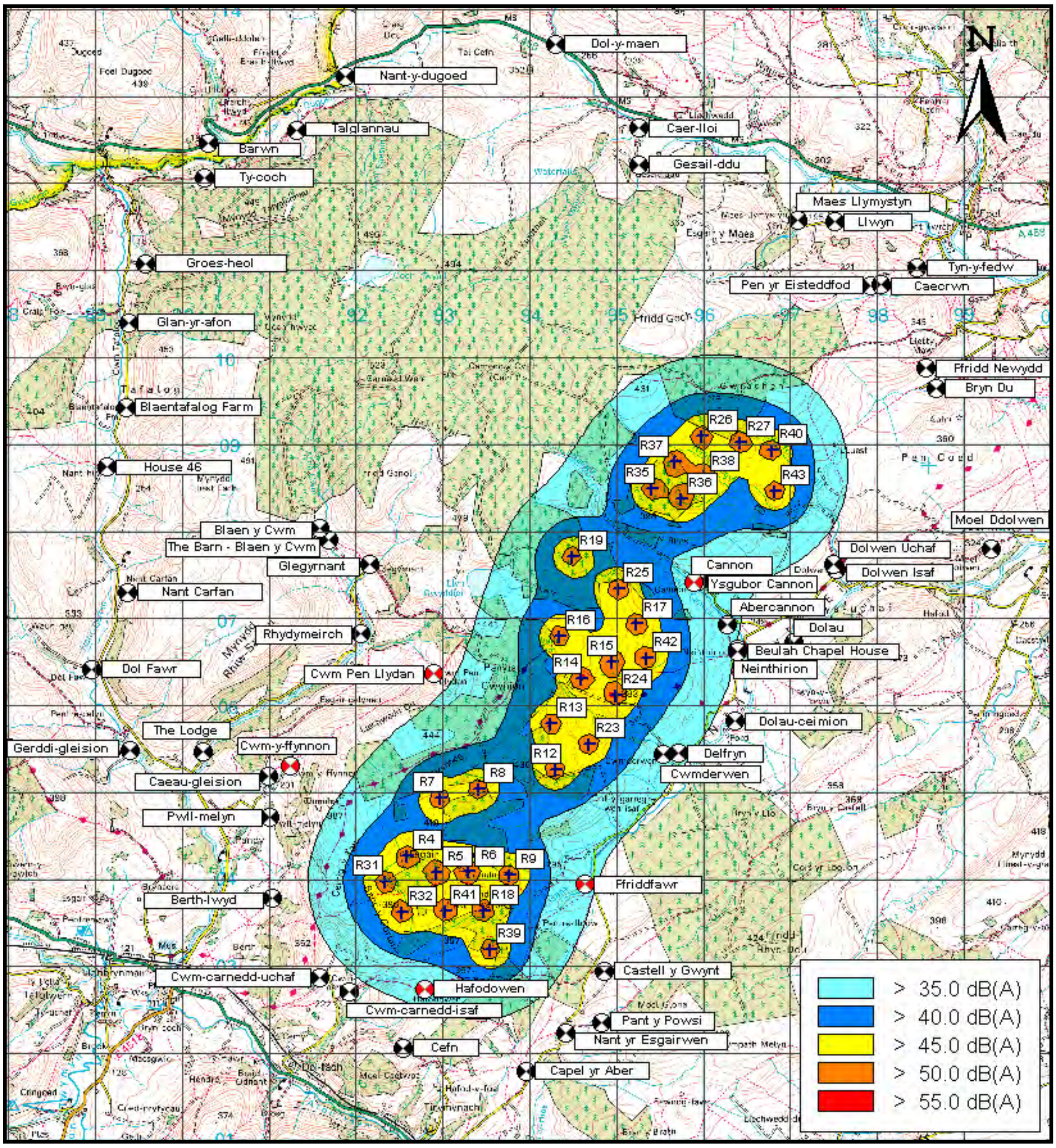


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Figure 9.2 Measured Wind Rose at Llanbrynmair over Extended Period

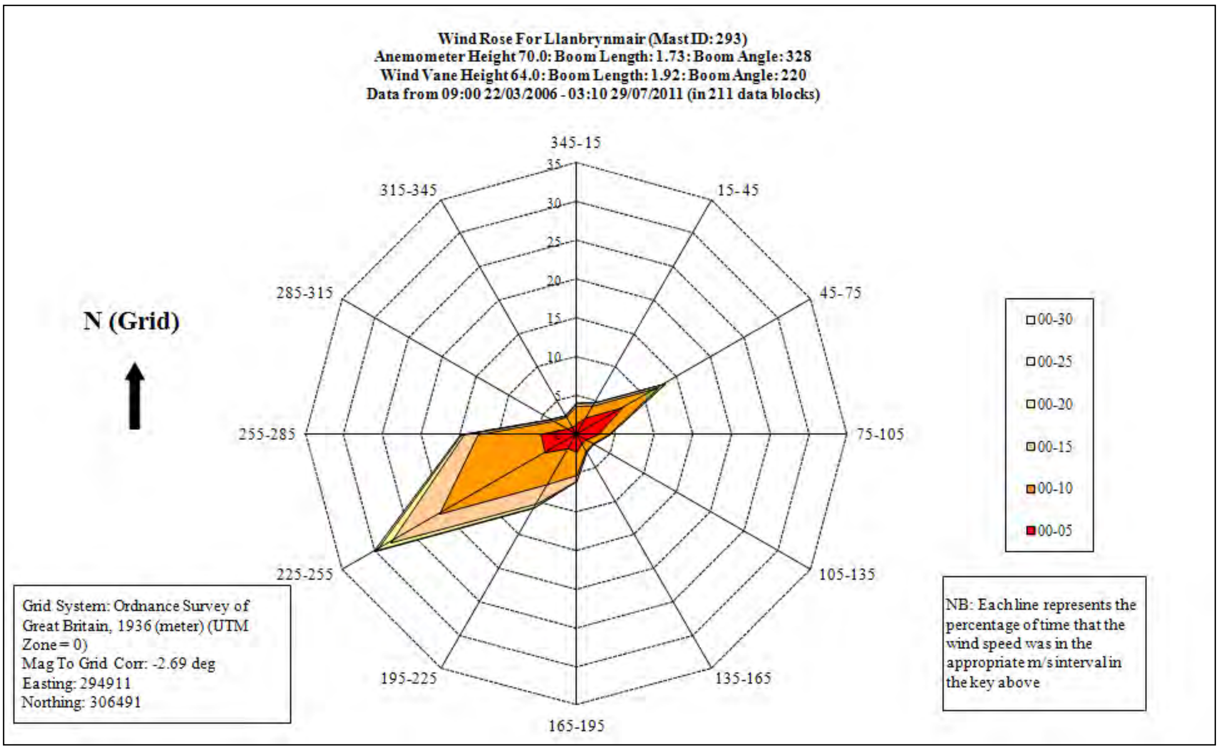


Figure 9.3 Wind Speed and Direction during RES Background Noise Survey

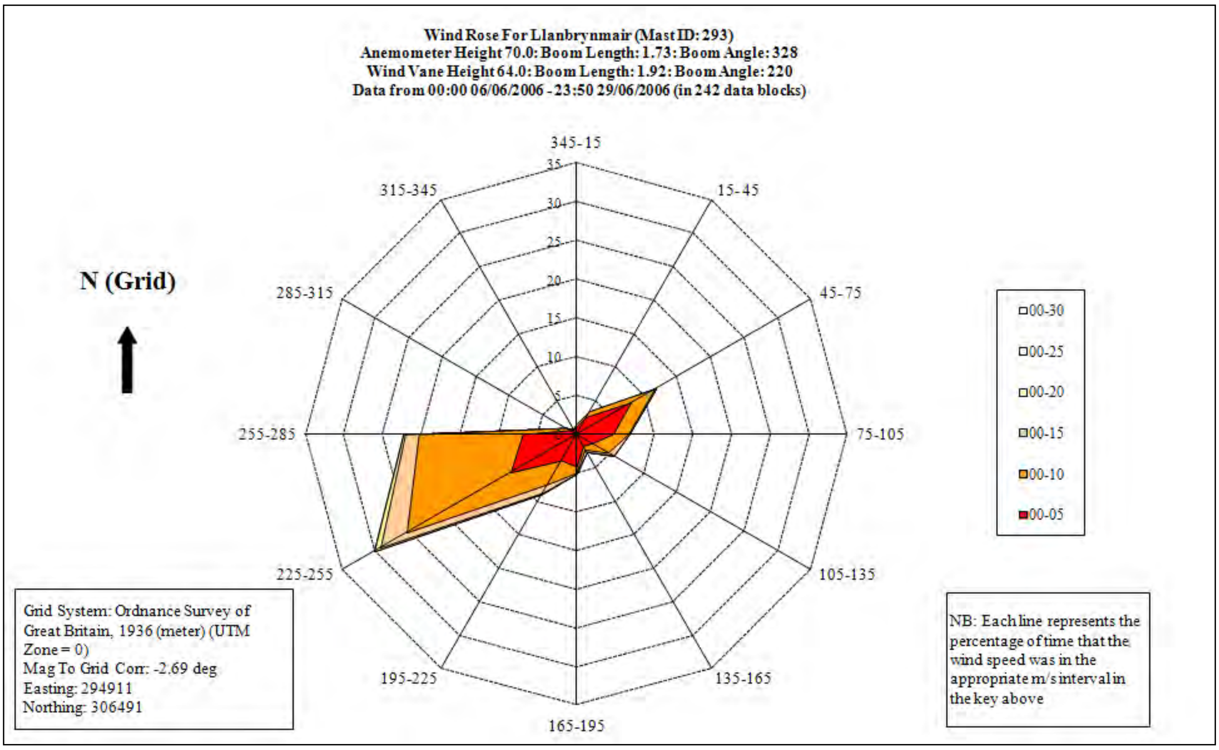


Figure 9.4 Measured Background Noise Levels at Llanbrynmair (RES Survey)

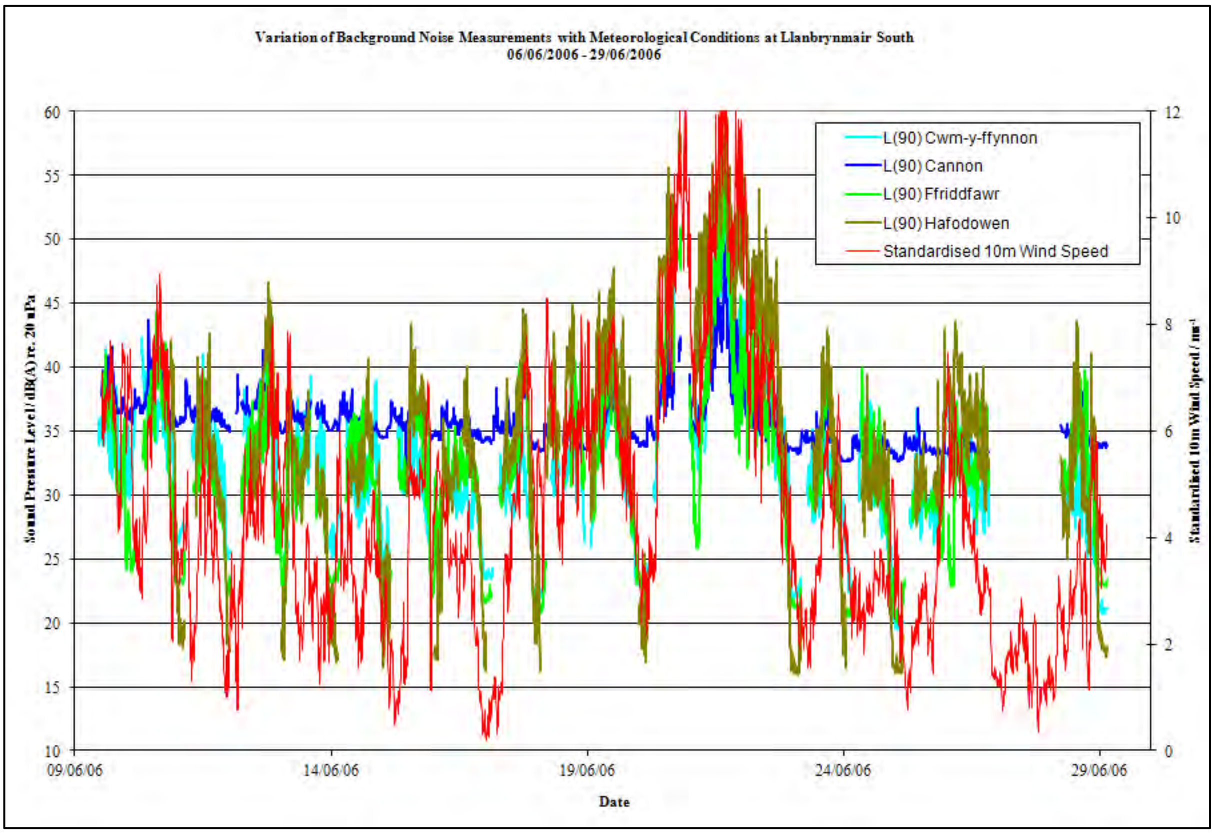


Figure 9.5 Background Noise Levels and Derived Limits During Quiet Waking Hours at Cannon

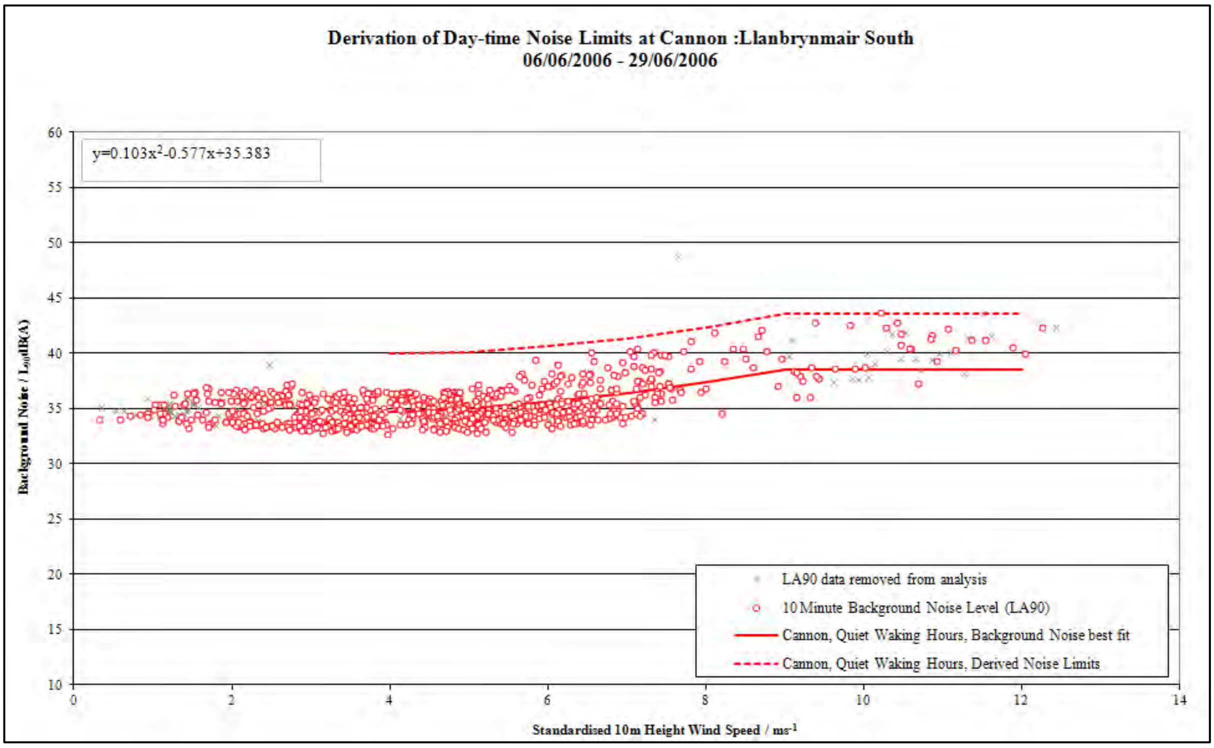


Figure 9.6 Background Noise Levels and derived limits During Quiet Waking Hours at Cwm-y-ffynnon

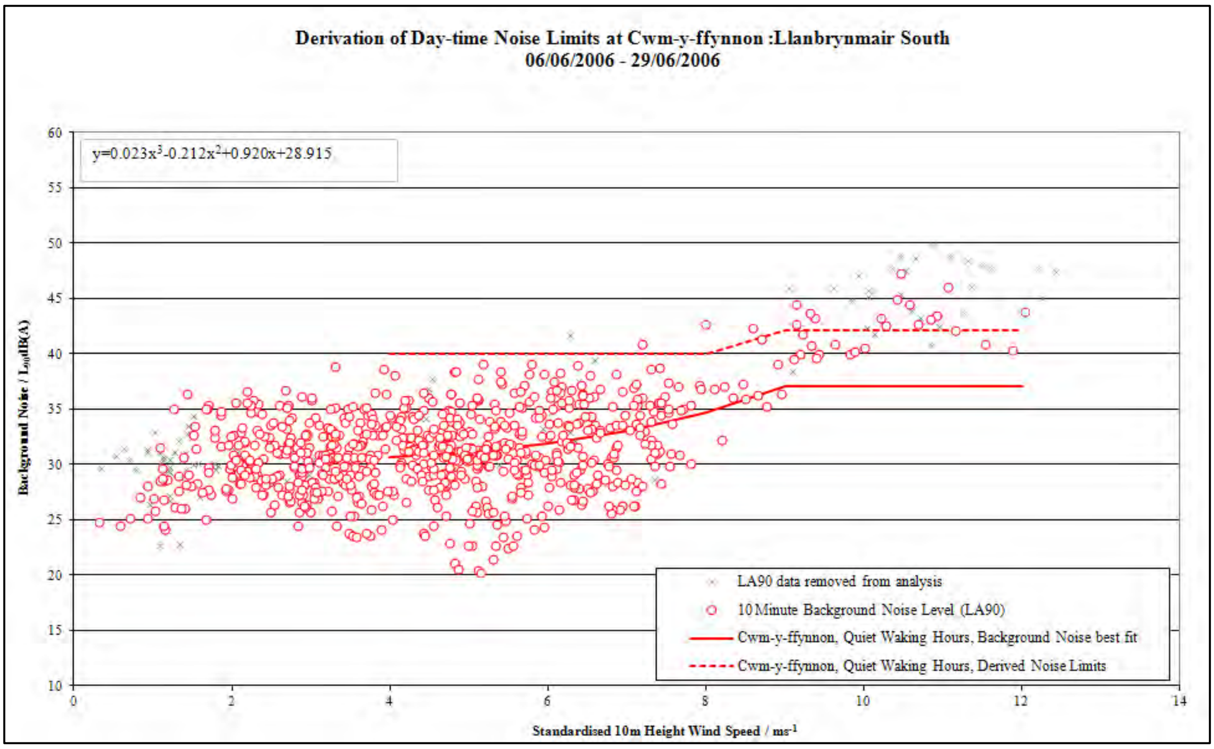


Figure 9.7 Background Noise Levels and Derived Limits During Quiet Waking Hours at Ffriddfawr

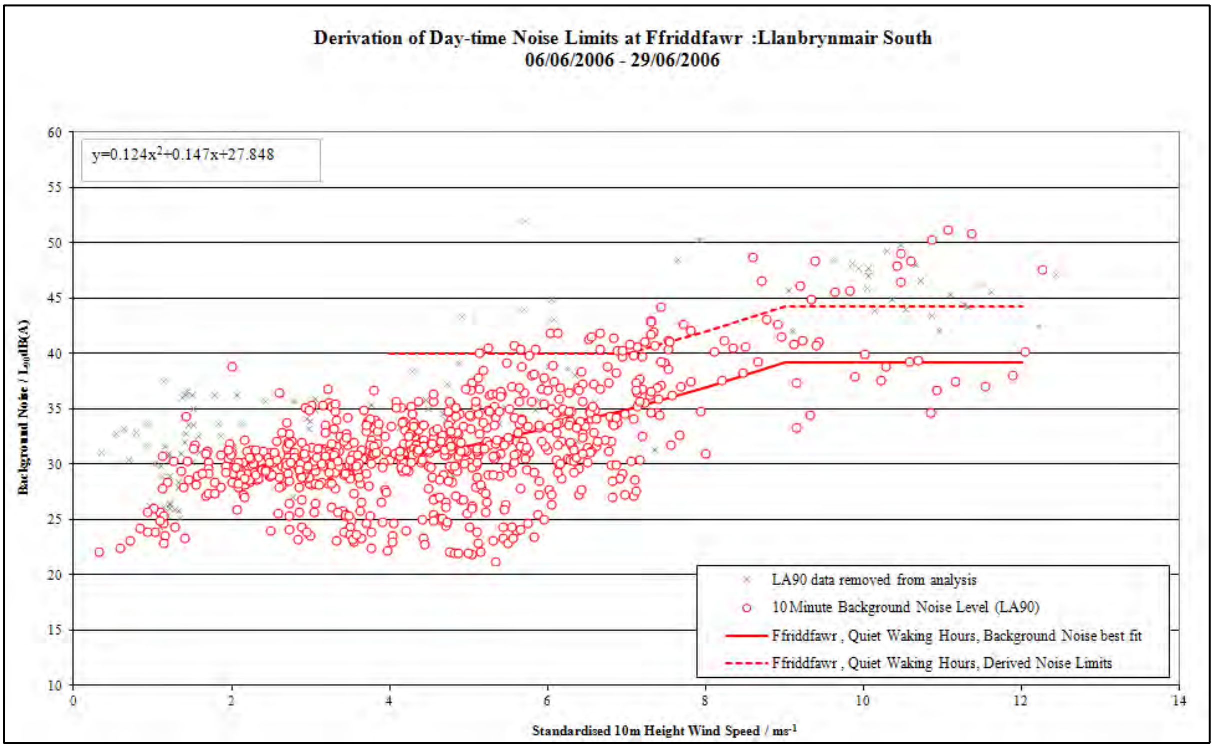


Figure 9.8 Background Noise Levels and Derived Limits During Quiet Waking Hours at Hafodowen

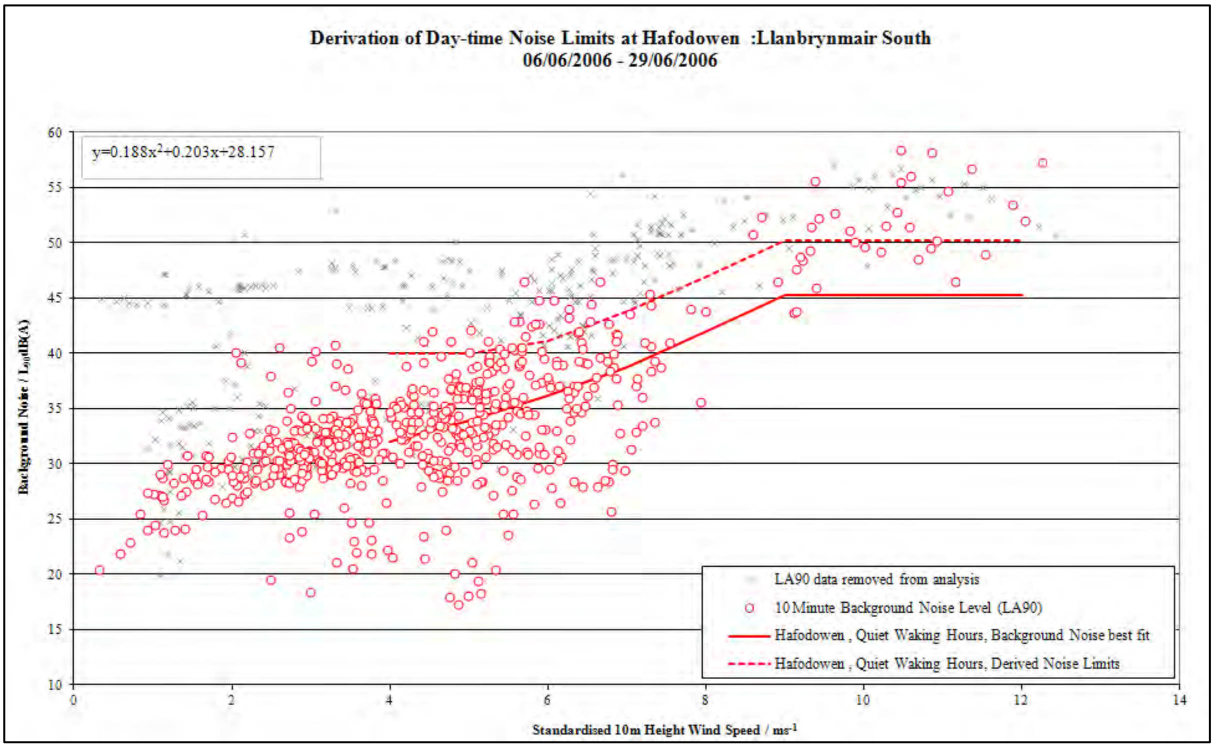


Figure 9.9 Background Noise Levels During Quiet Waking Hours at Cwm Pen Llydan (as supplied by Hoare Lea Acoustics)

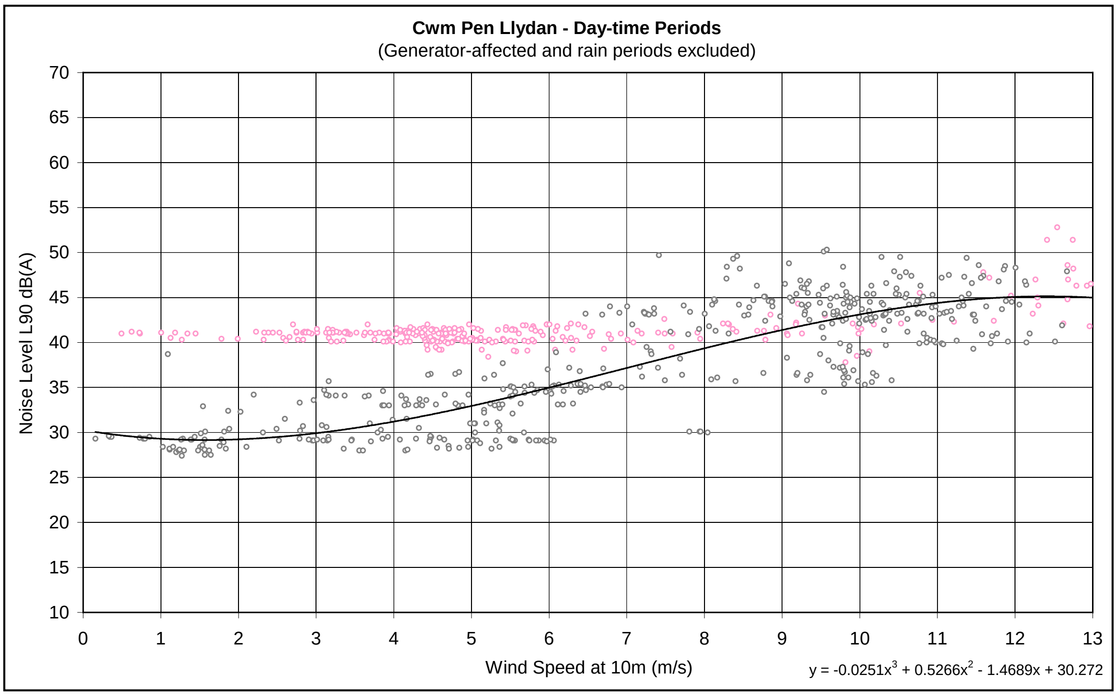


Figure 9.10 Background Noise Levels and Derived Limits during Night-Time Periods at Cannon

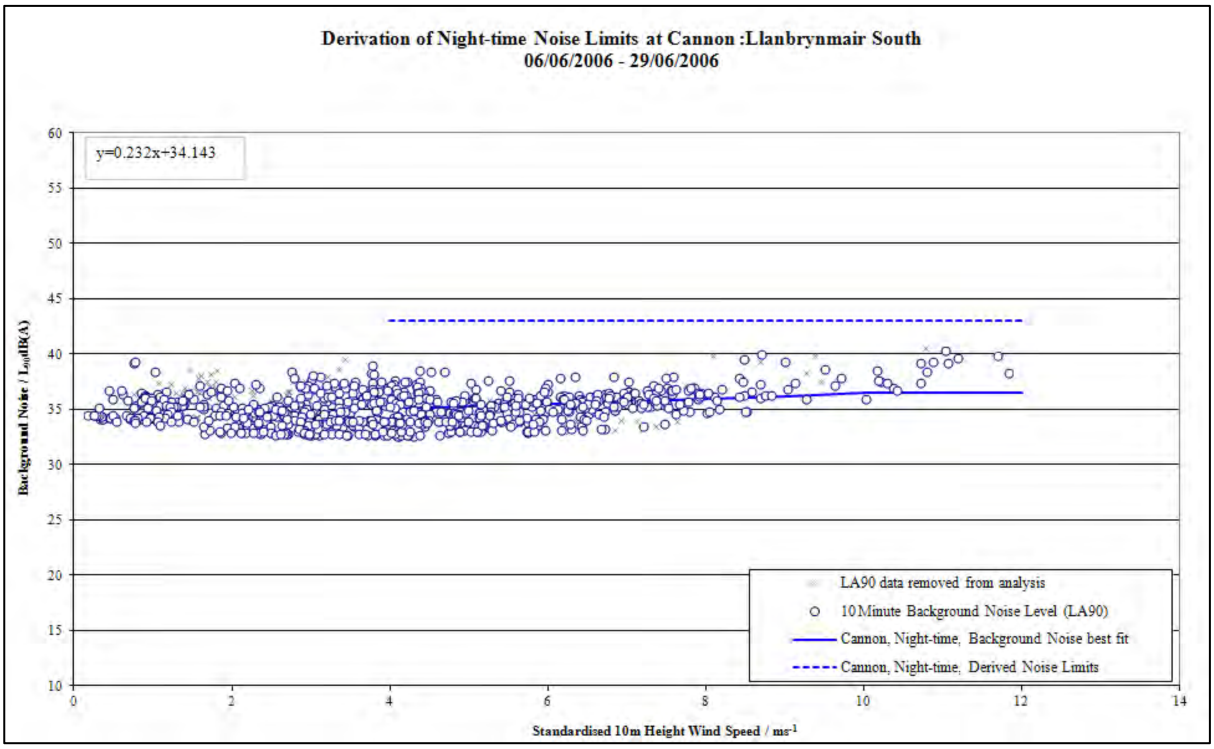


Figure 9.11 Background Noise Levels and Derived Limits During Night-Time Periods at Cwm-y-ffynnon

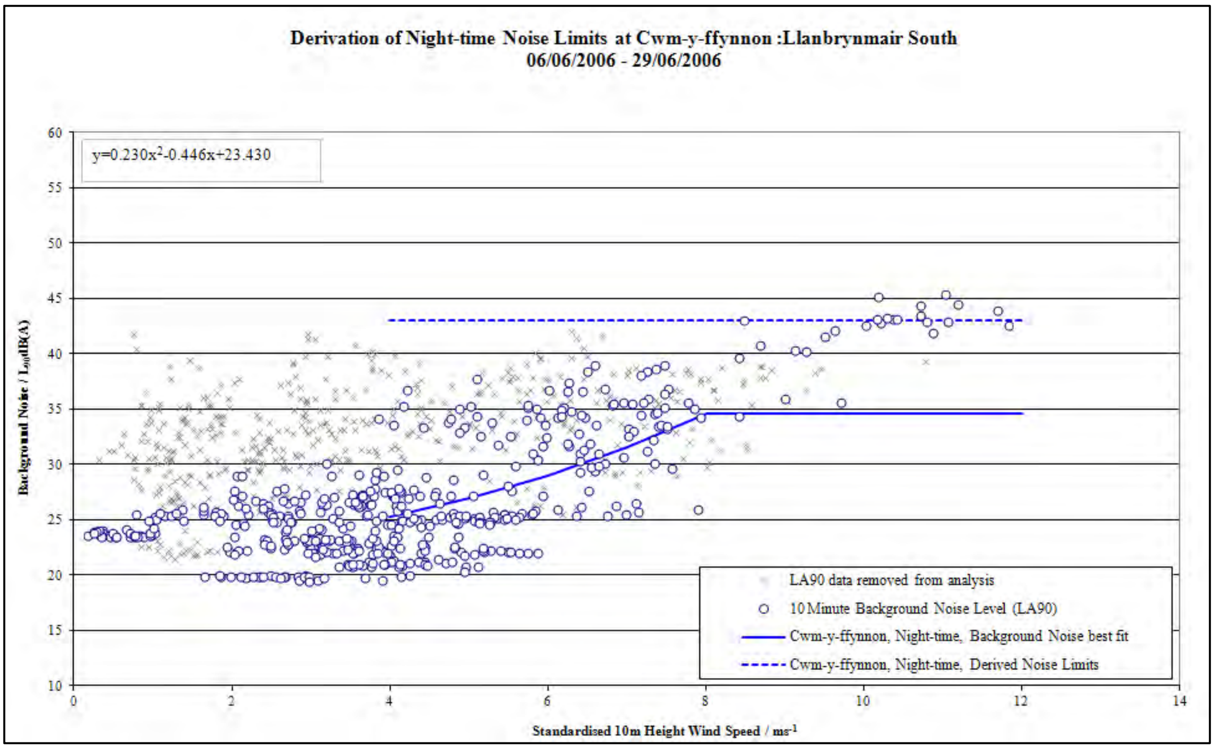


Figure 9.1 Background Noise Levels and Derived Limits During Night-Time Periods at Ffriddfawr

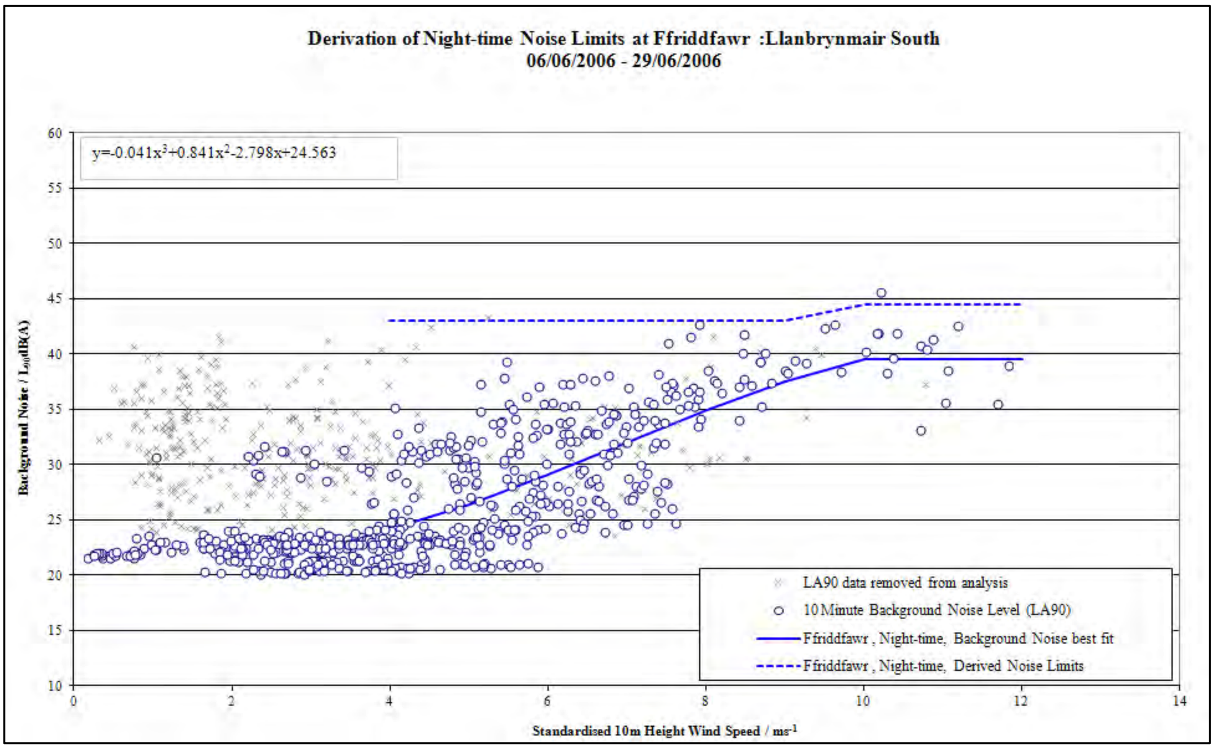


Figure 9.13 Background Noise Levels and Derived Limits During Night-Time Periods at Hafodowen

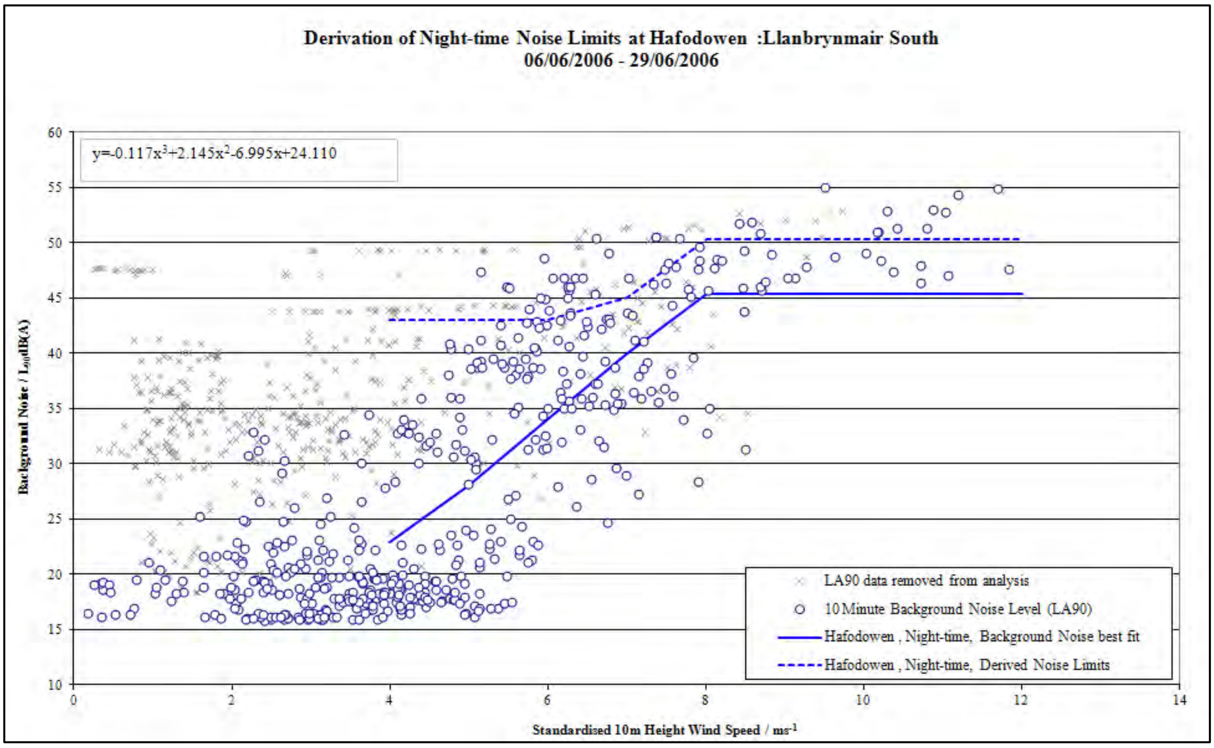
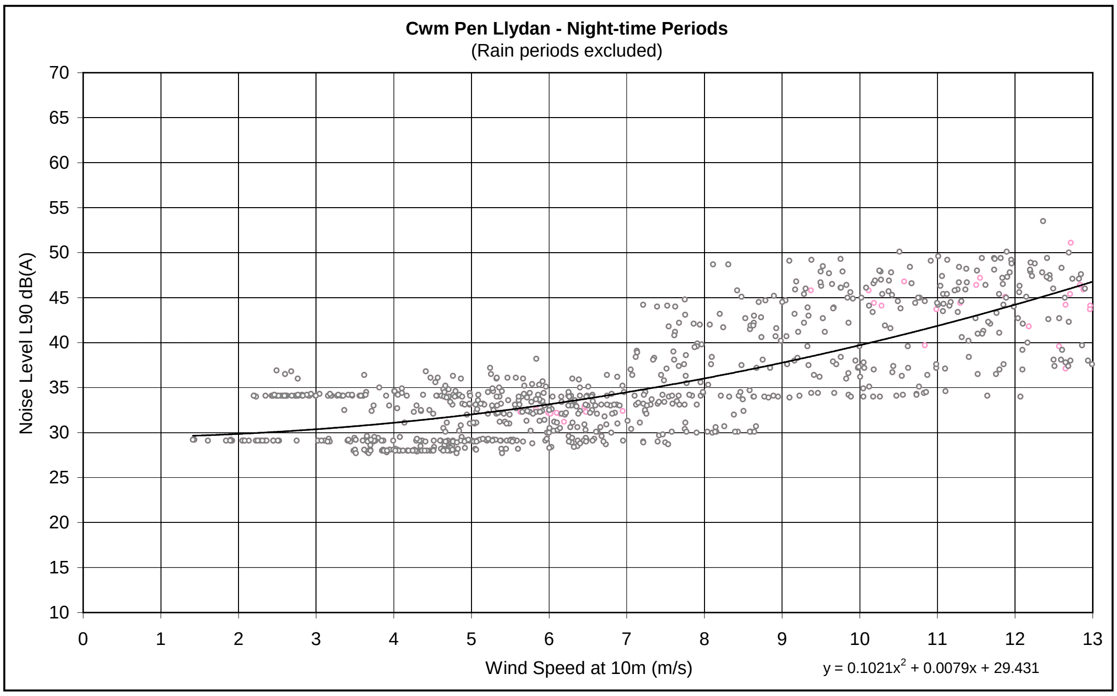


Figure 9.14 Background Noise Levels During Night-Time Periods at Cwm Pen Llydan (as supplied by Hoare Lea Acoustics)



APPENDIX 9.2: METHODOLOGY FOR CALCULATING STANDARDISED WIND SPEED

1.1.5 The basis of the ETSU-R-97 methodology recommended for assessment of wind farms is to compare predicted noise levels (due to turbine emissions) with background noise levels over a range of wind speeds. In order to derive appropriate noise limits the ETSU-R-97 guidance requires the correlation of background noise survey data with 10m height wind speed data which, it states, may be derived from wind speed measurements at other heights.

1.1.6 However, acoustic emission measurements on wind turbines are generally undertaken following national, or international, standards which specify that the turbine noise emission should be reported as a function of a 'standardised' wind speed at 10m height. In practice this translates as extrapolation of wind speed at hub height[1] down to 10m height, using a specified, and fixed, wind shear model.

1.1.7 Whilst there are good reasons for this approach, for example it allows developers to compare noise emission data from different makes and models of wind turbine, it does create potential problems. If, for example, the wind shear on a site where the turbines are to be deployed differs from the assumed values/model, the result is that, for a given 'standard' wind speed at 10 m height, the hub height wind speed may be very different. The consequence is that the turbine generates a different amount of power, and emits a different level of sound power, than might be expected from the standardised wind speed alone.

1.1.8 Two options are available in order to reconcile potential anomalies:

1. The turbine sound power levels are re-calculated taking due consideration of site-specific wind shear;
2. The noise limits are derived with reference to the same wind speed as the turbine noise levels.

1.1.9 In this assessment RES have chosen to apply the second option. This approach was presented as appropriate by a group of independent acoustic consultants working for both wind farm developers, local planning authorities and third parties in an article published in the Institute of Acoustics Bulletin (Institute of Acoustics, 2009) and the subsequent Good Practice Guide (Institute of Acoustics, 2013). The methodology outlined below therefore is employed to those wind speeds measured on-site concurrently with the background noise survey:

(1) **Wind Speeds are Calculated for Hub Height**

1.1.10 During the background noise survey campaign concurrent wind speed was measured at 51m & 70m heights. The hub height (80m) wind speed may be calculated by means of a calculated wind shear exponent:

$$v_{hub} = v_{70}\left(\frac{h_{hub}}{h_{70}}\right)^{\alpha} \qquad \text{(B.1)}$$

where: v_{70} = 70m height wind speed at site
v_{hub} = wind speed at turbine hub
h_{70} = 70m
h_{hub} = turbine hub height, 80m
a = calculated wind shear exponent for each 10 minute period (between 51 & 70m heights)

(2) **"Standardised" 10m Wind Speeds are Calculated**

[1] Wind speed at hub height may be derived from the resultant power output using warranted power curves or from measured hub height wind speed.

1.1.11 As described, wind turbine noise reports contain sound power level data for the turbine as a function of the 'standardised' wind speed at 10 m height. As defined in the international standard IEC 61400-11, this 'standardised' wind speed is calculated from the height at which wind speed is actually measured according to the following formula:

$$v_S = v_Z \left[\frac{\ln \frac{z_{ref}}{z_{0ref}} \ln \frac{H}{z_0}}{\ln \frac{H}{z_{0ref}} \ln \frac{z}{z_0}} \right] \qquad \text{(B.2)}$$

Where: v_s is the standardised wind speed

v_z is the wind speed measured at anemometer height z (here, the derived hub height wind speed from Step 1)
z_{0ref} is the reference roughness length (0.05m)
z_0 is the roughness length
H is the rotor centre height, 80m
z_{ref} is the reference height, 10m
z is the anemometer height - the height of the derived hub height wind speed, 80m

1.1.12 Therefore, to derive the standardised 10m wind speed from the hub height wind speed (from step 1) the equation may be simplified to:

$$v_S = v_Z \left[\frac{\ln \frac{10}{0.05}}{\ln \frac{80}{0.05}} \right] \qquad \text{(B.3)}$$

(3) **Correlation of "Standardised" 10m Wind Speeds with Background Noise Data**

1.1.13 As described in the chapter.

APPENDIX 9.3: PHOTOGRAPHS OF APPARATUS USED FOR BASELINE NOISE SURVEYS

Photo 9.1 Noise Apparatus in Relation to Cannon (H28)

Photo 9.2 Noise Apparatus in Relation to Cwm-y-ffynnon (H24)

Photo 9.3 Noise Apparatus in Relation to Ffriddfawr (H26)

Photo 9.4 Noise Apparatus in Relation to Hafodowen (H15)

Photo 9.5 Noise Apparatus in Relation to Cwm Pen Llydan (H23)

APPENDIX 9.4: NOISE INSTRUMENTATION RECORDS (RES SURVEY)

Survey Location	Cannon (H28)	Cwm-y-ffynnon (H24)	Ffriddfawr (H26)	Hafodowen (H15)
Sound Level Meter Type	Rion NL-31	Rion NL-31	Rion NL-31	Rion NL-31
Sound Level Meter Serial No.	00952272	00952273	01131285	00952274
Sound Level Meter Calibration Certificate No.	CAL020607	CAL020608	CAL040608	CAL020609
Date of Issue	03/02/2006	03/02/2006	20/04/2006	03/02/2006
Microphone Serial No.	309098	309101	310267	309102
Preamp Serial No.	17123	17125	13692	17126
Calibrator Type	Rion NC-74	Rion NC-74	Rion NC-74	Rion NC-74
Calibrator Serial No.	34851904	34851904	34851904	34851904
Calibrator Certificate No.	CAL020606	CAL020606	CAL020606	CAL020606
Date of Issue	03/02/2006	03/02/2006	03/02/2006	03/02/2006

APPENDIX 9.5: QUALITY CONTROL OF BACKGROUND NOISE DATA

1.1 Removal of Extraneous Noise Affected Data

1.1.1 Prior to any analysis being carried out on the data collected during the background noise survey the data has been inspected in order that instances of unexpected 'peaks' can be removed – these may be been caused by infrequent human activities, for example the periodic or intermittent operation of farm machinery.

1.1.2 Periods of measured background noise data thought to be affected by extraneous, i.e. non-typical, noise sources are generally identified by means of inference. In practice this means close inspection of the measured background noise data and comparison with concurrent data measured at nearby locations. All such non-typical data are removed prior to analysis.

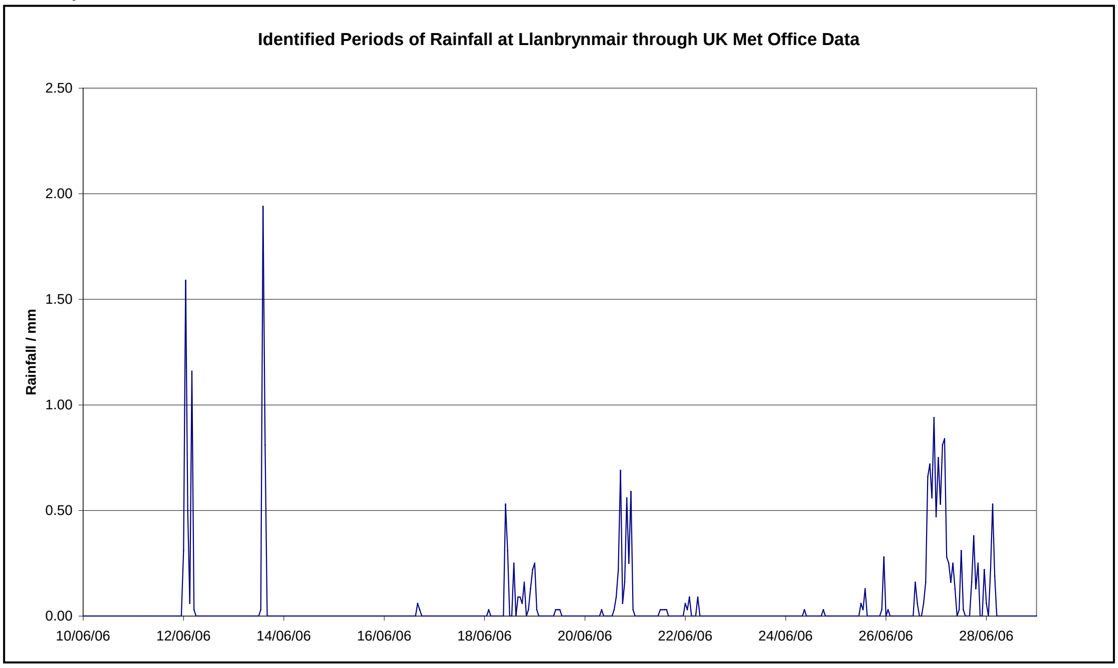
1.1.3 Whilst this 'extraneous' data may actually be real, in practice it tends to bias any trends lines upwards, so that its removal is adopted as a conservative measure.

1.2 Removal of Rainfall Affected Data

1.1.4 A more systematic approach is adopted to remove rainfall affected data from the record and, to assist in the detection of rainfall, hourly rainfall data has been purchased for the coordinate (294900, 306500) from the UK Met Office rainfall radar.

1.1.5 The rainfall data assists in the identification of acoustic data that must be excised from the record prior to further analysis.

Rainfall Identified by UK Met Office Rainfall Radar Over the Period of Background Noise Survey

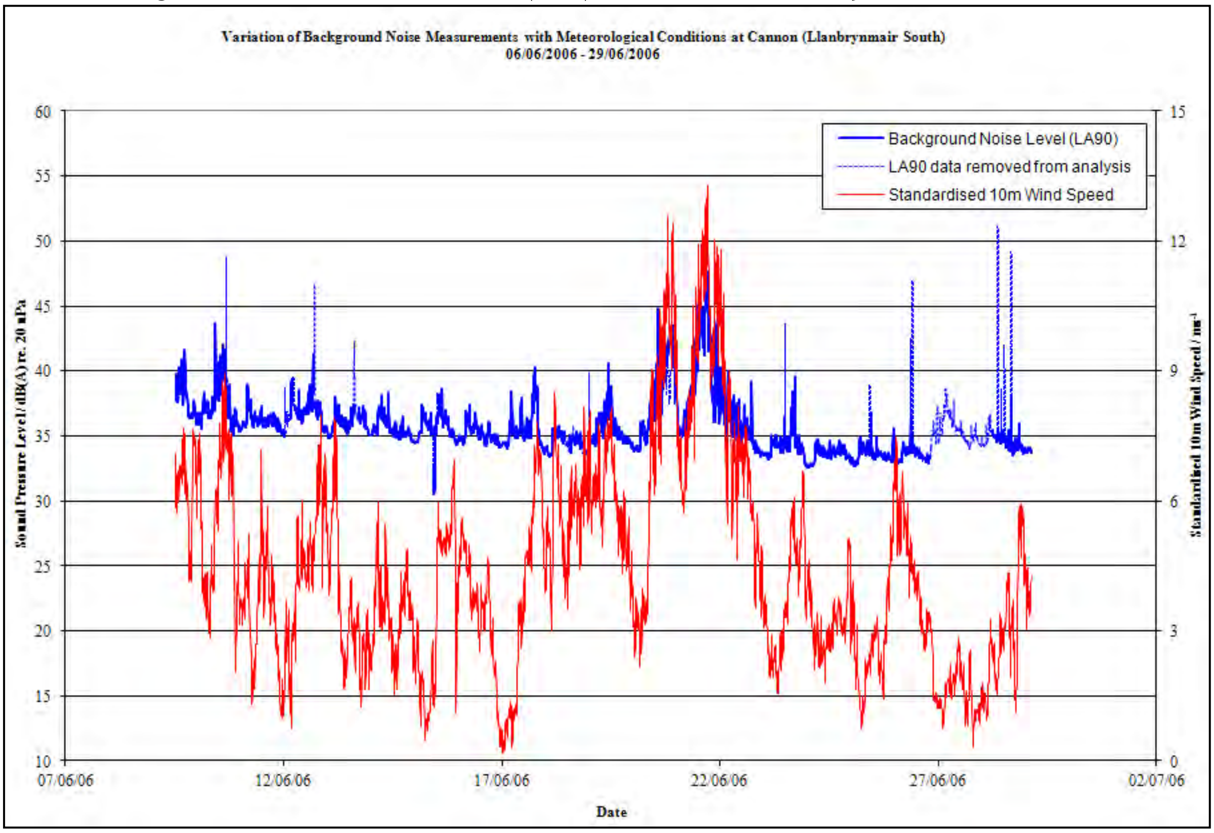


1.3 Resulting Quality Controlled Background Noise Data

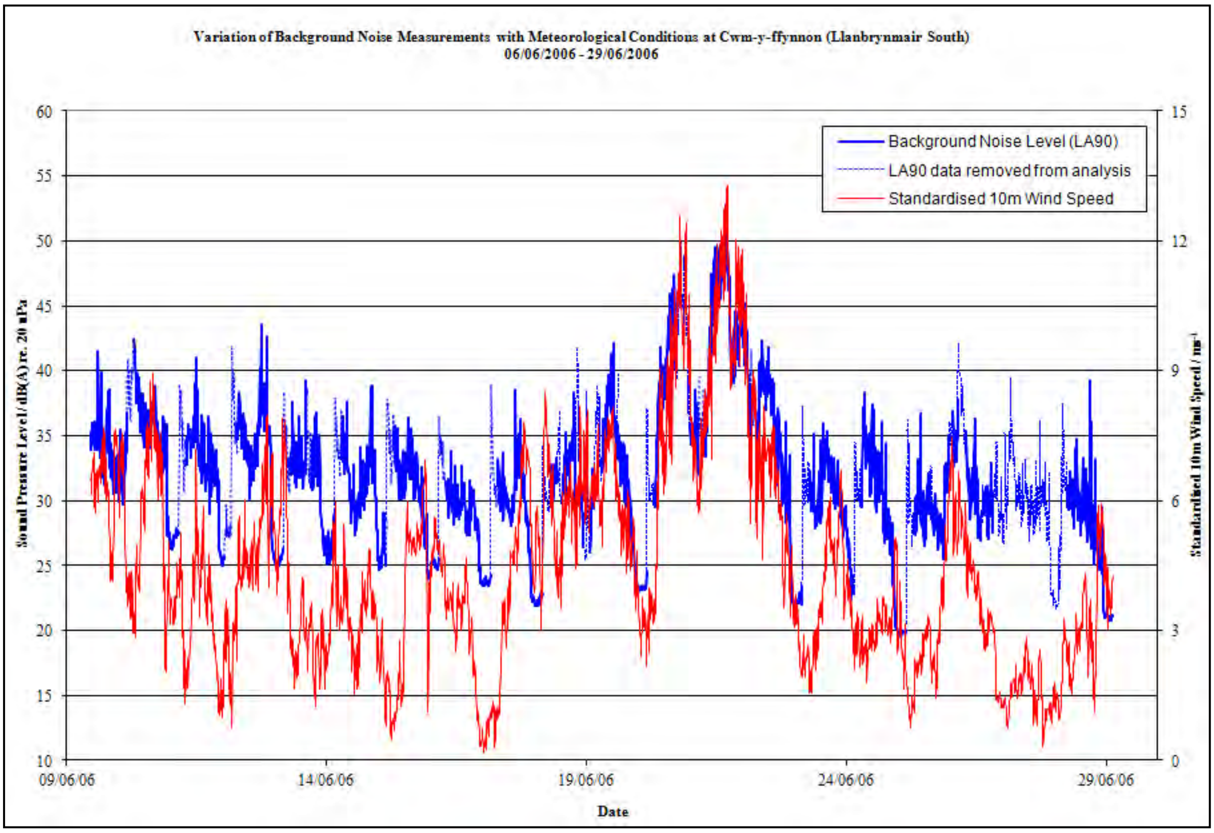
1.1.6 Illustrations of the acoustic data removed and the acoustical data used are provided below at each of the four background noise measurement locations, as measured by RES. At Cannon data was excluded during periods of rainfall and short periods of increased noise levels. At Cwm-y-ffynnon and Ffriddfawr data was excluded due to rainfall, short periods of increased noise levels and the dawn chorus (between the hours of 04:00 and 08:00). At

Hafodowen data was excluded due to rainfall, the dawn chorus and some unexplained periods of increased noise levels, possibly due to the operation of machinery.

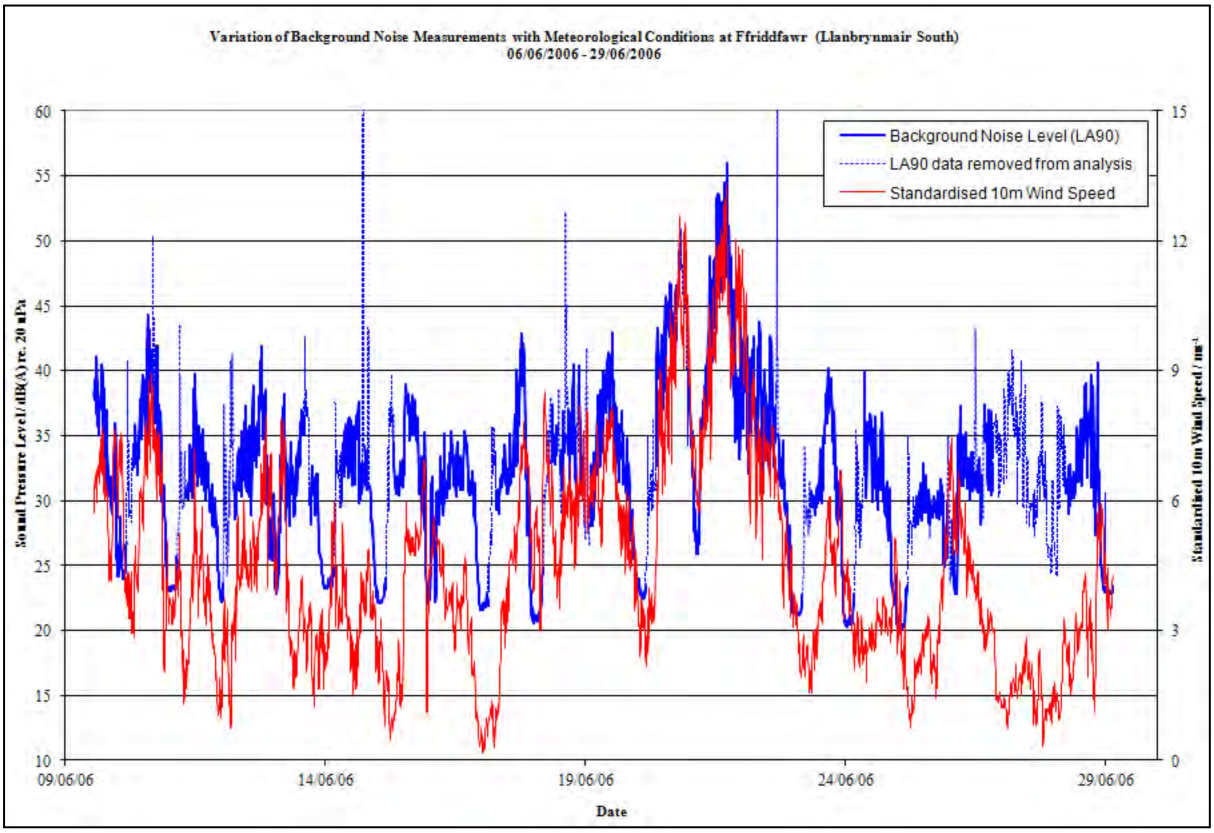
Background Noise Data at Cannon (H28): Pre and Post Quality Control



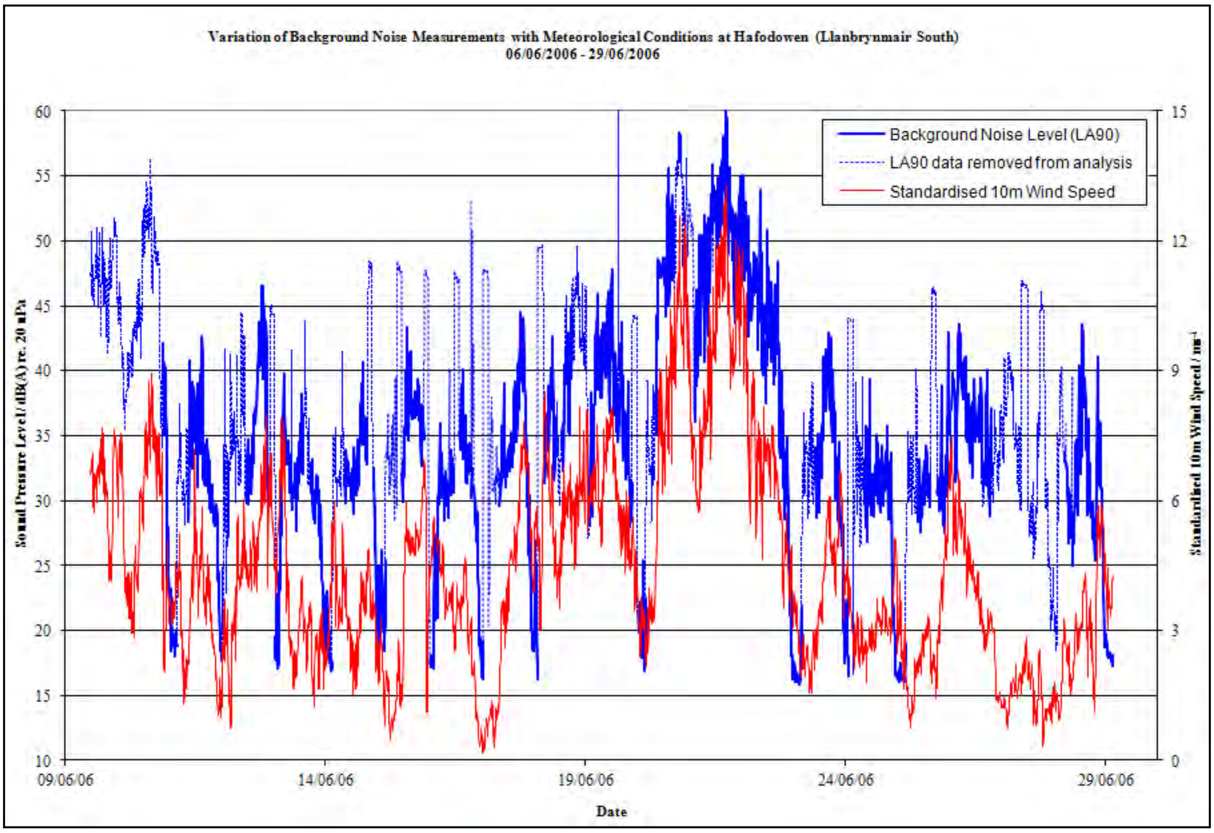
Background Noise Data at Cwm-y-ffynnon (H24): Pre and Post Quality Control



Background Noise Data at Ffriddfawr (H26): Pre and Post Quality Control



Background Noise Data at Hafodowen (H15): Pre and Post Quality Control



APPENDIX 9.6: CUMULATIVE IMPACT ASSESSMENT

1.1 Introduction

1.1.7 Planning permission has been sought by NPower for a wind farm adjacent to the proposed Llanbrynmair wind farm named Carnedd Wen. In order for both developments to exist alongside each other RES and NPower have cooperated together so that the ETSU-R-97 noise limits would be adhered to should both projects be realised.

1.1.8 An assessment of the cumulative acoustic impact of the proposed Llanbrynmair and Carnedd Wen schemes has been undertaken in accordance with ETSU-R-97 guidance. Information relating to Carnedd Wen has been obtained from the Supplementary Environmental Information (SEI) submitted in September 2011 (NPower, 2011).

1.2 Methodology

1.1.9 The methodology employed to assess the cumulative acoustic impact of both projects is identical to that detailed in Section 9.1 of the chapter.

1.1.10 Noise Emission Characteristics of the Wind Turbines

1.1.11 Acoustic emission data for the proposed Llanbrynmair wind turbines is as detailed in Section 9.4 of the chapter.

1.1.12 As specified in the Supplementary Environmental Information for the proposed Carnedd Wen wind farm, the turbine type has yet to be decided but the assessment is based on a Vestas V90 3MW turbine operating in Mode 0. This Appendix uses the acoustic data provided in the Carnedd Wen SEI for all analysis. Details are as follows:

- a hub height of 80m;
- a rotor diameter of 90m;
- a sound power level, LWA, for 10 m height wind speeds (v10) as shown in Table 9.6.1;
- an 1/1 octave band spectrum, in reference conditions, as shown in Table 9.6.2[2];
- tonal emission characteristics such that no clearly audible tones are present at any wind speed.

Table 9.6.1 Turbine Sound Power Levels for 10m Height Wind Speeds for the Vestas V90 3MW Mode 0 Wind Turbine

Standardised 10m Height Wind Speed, v_{10} / ms^{-1}	A-Weighted Sound Power Level / dB(A) re 1 pW	
	Warranted noise levels	+1dB uncertainty
4	98.0	99.0
5	101.3	102.3
6	104.5	105.5

[2] Note these differ from those in the Carnedd Wen SEI as they are scaled to the warranted sound power level.

Standardised 10m Height Wind Speed, v_{10} / ms^{-1}	A-Weighted Sound Power Level / dB(A) re 1 pW	
	Warranted noise levels	+1dB uncertainty
7	106.2	107.2
8	107.0	108.0
9	106.9	107.9
10	105.4	106.4
11	105.2	106.2
12	105.3	106.3

Table 9.6.2 1/1 Octave Band Sound Power Level Spectrum for the Vestas V90 3MW Mode 0 Wind Turbine at Standardised v_{10} = 8 ms^{-1}

Octave Band / Hz	A-Weighted Sound Power Level / dB(A) re 1 pW
63	92.2
125	94.3
250	96.9
500	99.2
1000	101.7
2000	100.9
4000	97.1
8000	86.7
OVERALL	107.0

1.3 Locations of Wind Turbines

1.1.13 The locations of the 30 proposed Llanbrynmair and 50 proposed Carnedd Wen wind turbines are shown in Figure 9.6.1. It is worth noting that the Carnedd Wen project has been reduced from an initial layout of 65 turbines.

1.4 Locations of Nearest Neighbours

1.1.14 The properties considered in this assessment are those detailed in Section 9.4 of the chapter. The distances from each house to the nearest proposed turbine from either wind farm is shown in Table 9.6.3. Turbines prefixed "R" are the proposed Llanbrynmair wind turbines, turbines prefixed "N" are the proposed Carnedd Wen turbines.

1.1.15 The minimum house-to-turbine separation is 609m to a proposed Carnedd Wen turbine, however this relates to a property where the occupant has a financial interest in the Carnedd Wen wind farm[3]. For the nearest neighbour without a financial interest in either wind farm, the minimum house-to-turbine separation is 873m.

Table 9.6.3 Distances from Nearby Properties to Nearest Proposed Turbine

House ID	House Name	Distance / m	Nearest Turbine
H1	Ysgubor Cannon	862	R17
H2	Pen yr Eisteddfod	1438	N22
H3	Dolwen Isaf	1154	R43
H4	The Barn - Blaen y Cwm	1789	N17
H5	Rhydymeirch	1267	N4
H6	Abercannon	1014	R42
H7	Beulah Chapel House	1055	R42
H8	Neinthirion	1048	R42
H9	Delfryn	984	R24
H10	Berth-lwyd	1310	R31
H11	Castell y Gwynt	1338	R39
H12	Pant y Powsi	1530	R39
H13	Nant yr Esgairwen	1293	R39
H14	Capel yr Aber	1455	R39
H15	Hafodowen	881	R39
H16	Cwm-carnedd-isaf	1100	R32
H17	Cwm-carnedd-uchaf	1206	R32
H18	Dolau	1710	R42
H19	Dolau-ceimion	1260	R42
H20	Bryn Du	1694	N22

[3] Three properties have been identified within the Carnedd Wen application as financial beneficiaries of this project: Cwm Pen Llydan, Maes Llymystyn and Dol-y-maen.

House ID	House Name	Distance / m	Nearest Turbine
H21	Glegyrnant	1404	N17
H22	Blaen y Cwm	1877	N17
H23	Cwm Pen Llydan	609	N4
H24	Cwm-y-ffynnon	1163	N3
H25	Pwll-melyn	1501	N1
H26	Ffriddfawr	873	R9
H27	Cwmderwen	862	R23
H28	Cannon	810	R17
H29	Dolwen Uchaf	1085	R43
H30	Ffridd Newydd	1582	N22
H31	Caecrwn	1532	N22
H32	Llwyn	1557	N26
H33	Maes Llymystyn	1250	N26
H34	Moel Ddolwen	2583	R43
H35	Tyn-y-fedw	1964	N22
H36	Gesail-ddu	1211	N36
H37	Caer-lloi	1535	N38
H38	Dol-y-maen	2191	N39
H39	Nant-y-dugoed	2708	N42
H40	Talglannau	2698	N42
H41	Barwn	3427	N49
H42	Ty-coch	3229	N49
H43	Groes-heol	3432	N50
H44	Glan-yr-afon	3414	N50
H45	Blaentafalog Farm	3381	N50
H46	House 46	3712	N50

House ID	House Name	Distance / m	Nearest Turbine
H47	Nant Carfan	3573	N3
H48	Dol Fawr	3588	N3
H49	Gerddi-gleision	3005	N3
H50	The Lodge	2165	N3
H51	Cefn	1515	R39
H52	Caeau-gleision	1425	N3

1.5 Estimation of Noise Levels at Receivers

1.1.16 For the proposed Llanbrynmair and Carnedd Wen wind farms the noise immission levels at the nearest neighbours have been calculated in an identical fashion to that detailed in Section 9.4 of the chapter. Table 9.6.4 shows the predicted cumulative noise imission levels from both Llanbrynmair and Carnedd Wen at the 39 properties where there is a cumulative acoustic impact4. The maximum predicted cumulative noise immission level is 40.5 dB(A) at Cannon at a standardised 10 m wind speed of 8 ms-1.

1.1.17 Figure 9.6.1 shows an isobel (i.e. noise contour) plot for the site at a standardised 10 m height wind speed of 8 ms^{-1}. Such plots are useful for evaluating the noise 'footprint' of a given development.

Table 9.6.4 Predicted Noise Levels At Nearby Dwellings Due to Cumulative Impact (dB(A) re 20 μPa)

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}								
		4	5	6	7	8	9	10	11	12
H1	Ysgubor Cannon	31.6	35.3	38.1	39.5	40.2	39.9	39.2	39.1	39.1
H3	Dolwen Isaf	27.5	31.0	33.8	35.4	36.3	36.1	35.1	35.0	35.1
H4	The Barn - Blaen y Cwm	27.1	30.0	32.9	34.9	36.0	35.9	34.6	34.4	34.5
H5	Rhydymeirch	29.3	32.3	35.2	37.1	38.1	38.1	36.7	36.5	36.6
H6	Abercannon	29.8	33.4	36.2	37.7	38.4	38.2	37.4	37.3	37.3
H7	Beulah Chapel House	28.9	32.5	35.4	36.8	37.6	37.4	36.6	36.5	36.5
H8	Neinthirion	28.9	32.5	35.3	36.8	37.6	37.4	36.5	36.5	36.5

[4] Where the difference in immission levels due to each wind farm is greater than 10 dB(A) it is considered that there is no cumulative impact and the smaller source can be ignored. This applies to 13 of the 52 properties considered (Pen yr Eisteddfod, Cwm Pen Llydan, Caecrwn, Llwyn, Maes Llymystyn, Gesail-ddu, Caer-lloi, Dol-y-maen, Nant-y-dugoed, Talglannau, Barwn, Ty-coch and Groes-hoel). In each instance the predicted noise levels from Carnedd Wen are greater than 10 dB(A) above those from Llanbrynmair at all of the wind speeds considered.

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}								
H9	Delfryn	29.6	33.3	36.2	37.6	38.3	38.0	37.3	37.2	37.2
H10	Berth-lwyd	24.1	27.5	30.4	32.1	32.9	32.8	31.8	31.7	31.7
H11	Castell y Gwynt	28.0	31.7	34.5	36.1	37.0	36.8	35.9	35.9	35.9
H12	Pant y Powsi	24.0	27.7	30.5	32.1	32.9	32.7	31.9	31.8	31.9
H13	Nant yr Esgairwen	22.9	26.6	29.4	30.8	31.7	31.5	30.7	30.7	30.7
H14	Capel yr Aber	21.4	25.1	28.0	29.5	30.3	30.2	29.4	29.3	29.4
H15	Hafodowen	29.5	33.5	36.3	37.4	38.0	37.7	37.2	37.1	37.2
H16	Cwm-carnedd-isaf	24.3	28.0	30.8	32.3	33.1	32.9	32.1	32.1	32.1
H17	Cwm-carnedd-uchaf	24.7	28.4	31.2	32.6	33.3	33.1	32.4	32.3	32.3
H18	Dolau	27.1	30.7	33.5	35.1	35.9	35.8	34.9	34.8	34.8
H19	Dolau-ceimion	27.8	31.3	34.1	35.7	36.5	36.2	35.4	35.3	35.3
H20	Bryn Du	25.8	28.9	31.8	33.7	34.8	34.8	33.4	33.3	33.4
H21	Glegyrnant	28.6	31.6	34.5	36.4	37.4	37.4	36.0	35.8	35.9
H22	Blaen y Cwm	26.6	29.6	32.5	34.5	35.6	35.6	34.2	34.0	34.1
H24	Cwm-y-ffynnon	26.9	30.1	33.0	34.8	35.8	35.8	34.5	34.3	34.4
H25	Pwll-melyn	25.3	28.6	31.5	33.3	34.3	34.1	33.0	32.8	32.9
H26	Ffriddfawr	29.6	33.3	36.1	37.5	38.2	37.9	37.2	37.1	37.2
H27	Cwmderwen	30.5	34.3	37.1	38.4	39.1	38.9	38.1	38.1	38.1
H28	Cannon	31.9	35.7	38.5	39.8	40.5	40.3	39.5	39.4	39.5
H29	Dolwen Uchaf	27.6	31.1	33.9	35.5	36.4	36.1	35.3	35.2	35.2
H30	Ffridd Newydd	25.5	28.6	31.5	33.4	34.4	34.3	33.1	32.9	33.0
H34	Moel Ddolwen	21.0	24.3	27.2	29.2	30.3	30.3	29.1	29.0	29.0
H35	Tyn-y-fedw	23.6	26.5	29.5	31.5	32.6	32.5	31.2	31.0	31.1
H44	Glan-yr-afon	19.0	22.0	25.0	27.5	28.8	28.9	27.6	27.4	27.5
H45	Blaentafalog Farm	19.4	22.5	25.4	27.8	29.1	29.3	27.9	27.7	27.8
H46	House 46	19.6	22.6	25.6	27.8	29.1	29.2	27.8	27.6	27.7

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}								
H47	Nant Carfan	21.1	24.2	27.1	29.4	30.6	30.8	29.5	29.3	29.4
H48	Dol Fawr	20.2	23.4	26.3	28.6	29.8	29.8	28.6	28.4	28.5
H49	Gerddi-gleision	21.1	24.4	27.2	29.1	30.3	30.3	29.1	29.0	29.1
H50	The Lodge	22.1	25.3	28.2	30.2	31.3	31.3	29.9	29.8	29.9
H51	Cefn	24.6	28.4	31.2	32.6	33.4	33.2	32.5	32.4	32.5
H52	Caeau-gleision	25.6	28.8	31.7	33.5	34.5	34.4	33.1	33.0	33.0

1.6 Simplified Noise Assessment Procedure

1.1.18 Considering the simplified assessment method described in Section 9.4 of the chapter, Table 9.6.5 shows a comparison of the predicted noise levels at the appropriate standardised 10 m wind speed with the recommended 35 dB(A) noise limit for each house where a cumulative impact may be expected. The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit. A negative value indicates that the predicted noise level is within the limit.

Table 9.6.5 Comparison of Predicted Cumulative Noise Levels and Simplified Noise Limit (dB(A) re 20 μPa)

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}		
		Up to $10ms^{-1}$		
		L_p	Limit	ΔL
H1	Ysgubor Cannon	40.2	35.0	5.2
H3	Dolwen Isaf	36.3	35.0	1.3
H4	The Barn - Blaen y Cwm	36.0	35.0	1.0
H5	Rhydymeirch	38.1	35.0	3.1
H6	Abercannon	38.4	35.0	3.4
H7	Beulah Chapel House	37.6	35.0	2.6
H8	Neinthirion	37.6	35.0	2.6
H9	Delfryn	38.3	35.0	3.3
H10	Berth-lwyd	32.9	35.0	-2.1
H11	Castell y Gwynt	37.0	35.0	2.0
H12	Pant y Powsi	32.9	35.0	-2.1

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}		
		Up to $10ms^{-1}$		
		L_p	Limit	ΔL
H13	Nant yr Esgairwen	31.7	35.0	-3.3
H14	Capel yr Aber	30.3	35.0	-4.7
H15	Hafodowen	38.0	35.0	3.0
H16	Cwm-carnedd-isaf	33.1	35.0	-1.9
H17	Cwm-carnedd-uchaf	33.3	35.0	-1.7
H18	Dolau	35.9	35.0	0.9
H19	Dolau-ceimion	36.5	35.0	1.5
H20	Bryn Du	34.8	35.0	-0.2
H21	Glegyrnant	37.4	35.0	2.4
H22	Blaen y Cwm	35.6	35.0	0.6
H24	Cwm-y-ffynnon	35.8	35.0	0.8
H25	Pwll-melyn	34.3	35.0	-0.7
H26	Ffriddfawr	38.2	35.0	3.2
H27	Cwmderwen	39.1	35.0	4.1
H28	Cannon	40.5	35.0	5.5
H29	Dolwen Uchaf	36.4	35.0	1.4
H30	Ffridd Newydd	34.4	35.0	-0.6
H34	Moel Ddolwen	30.3	35.0	-4.7
H35	Tyn-y-fedw	32.6	35.0	-2.4
H44	Glan-yr-afon	28.9	35.0	-6.1
H45	Blaentafalog Farm	29.3	35.0	-5.7
H46	House 46	29.2	35.0	-5.8
H47	Nant Carfan	30.8	35.0	-4.2
H48	Dol Fawr	29.8	35.0	-5.2

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}		
		Up to $10ms^{-1}$		
		L_p	Limit	ΔL
H49	Gerddi-gleision	30.3	35.0	-4.7
H50	The Lodge	31.3	35.0	-3.7
H51	Cefn	33.4	35.0	-1.6
H52	Caeau-gleision	34.5	35.0	-0.5

1.1.19 Noise levels at 20 of the 39 properties considered are below the 35 dB(A) limit, indicating that the noise immission levels would be regarded as acceptable and the householders' amenities as receiving 'sufficient protection'. There are 19 properties that do not pass this simplified noise criteria so that the 'full' acoustic assessment need only be considered here. Seven of these properties are occupied by financial beneficiaries of the Llanbrynmair scheme.

1.7 Acoustic Acceptance Criteria

1.1.20 The criteria used to assess the proposed Llanbrynmair wind farm, detailed in Section 9.4 of the chapter, have been adopted as the acoustic acceptance criteria for the cumulative impact of both wind farms.

1.8 Acoustic Assessment

1.1.21 Table 9.6.6 shows a comparison of the predicted cumulative noise levels with the recommended quiet waking hours noise limits for the 19 properties where the 'full' cumulative assessment has been undertaken. The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit. A negative value indicates that the predicted noise level is within the limit. Table 9.6.7 shows a comparison with the recommended night-time noise limits.

1.1.22 The minimum margin of predicted noise levels below derived noise limits, for all wind speeds considered, during quiet waking hours, is -1.6 dB(A). Similarly the minimum margin during night time periods, for all wind speeds considered, is -2.5 dB(A). However, the minimum margin occurs at a property where the occupant has a financial interest in one of the proposed wind farms. Where properties are occupied and without a financial interest in either wind farm the minimum margin of predicted noise levels below derived noise limits is -2.4 dB(A) during quiet waking hours, and -4.7 dB(A) during night time periods.

Table 9.6.6 Comparison of Downwind Cumulative Noise Levels and Quiet Waking Hours Limits - (dB(A) re 20 μPa) Resulting from the operation of the Llanbrynmair and Carnedd Wen Wind Farms

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}											
		4			5			6			7		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	Ysgubor Cannon	31.6	40.0	-8.4	35.3	40.1	-4.7	38.1	40.6	-2.5	39.5	41.4	-1.9
H3	Dolwen Isaf	27.5	40.0	-12.5	31.0	40.1	-9.1	33.8	40.6	-6.8	35.4	41.4	-6.0
H4	The Barn - Blaen y Cwm	27.1	40.0	-12.9	30.0	40.0	-10.0	32.9	40.0	-7.1	34.9	42.2	-7.3
H5	Rhydymeirch	29.3	40.0	-10.7	32.3	40.0	-7.7	35.2	40.0	-4.8	37.1	42.2	-5.0
H6	Abercannon	29.8	40.0	-10.2	33.4	40.1	-6.6	36.2	40.6	-4.4	37.7	41.4	-3.7
H7	Beulah Chapel House	28.9	40.0	-11.1	32.5	40.1	-7.6	35.4	40.6	-5.3	36.8	41.4	-4.6
H8	Neinthirion	28.9	40.0	-11.1	32.5	40.1	-7.6	35.3	40.6	-5.3	36.8	41.4	-4.6
H9	Delfryn	29.6	40.0	-10.4	33.3	40.0	-6.7	36.2	40.0	-3.8	37.6	40.0	-2.4
H11	Castell y Gwynt	28.0	40.0	-12.0	31.7	40.0	-8.3	34.5	40.0	-5.5	36.1	40.0	-3.9
H15	Hafodowen	29.5	40.0	-10.5	33.5	40.0	-6.5	36.3	41.2	-4.9	37.4	43.8	-6.4
H18	Dolau	27.1	40.0	-12.9	30.7	40.1	-9.4	33.5	40.6	-7.1	35.1	41.4	-6.3
H19	Dolau-ceimion	27.8	40.0	-12.2	31.3	40.1	-8.8	34.1	40.6	-6.5	35.7	41.4	-5.7

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}											
		4			5			6			7		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H21	Glegyrnant	28.6	40.0	-11.4	31.6	40.0	-8.4	34.5	40.0	-5.5	36.4	42.2	-5.8
H22	Blaen y Cwm	26.6	40.0	-13.4	29.6	40.0	-10.4	32.5	40.0	-7.5	34.5	42.2	-7.7
H24	Cwm-y-ffynnon	26.9	40.0	-13.1	30.1	40.0	-9.9	33.0	40.0	-7.0	34.8	40.0	-5.2
H26	Ffriddfawr	29.6	40.0	-10.4	33.3	40.0	-6.7	36.1	40.0	-3.9	37.5	40.0	-2.5
H27	Cwmderwen	30.5	40.0	-9.5	34.3	40.0	-5.7	37.1	40.0	-2.9	38.4	40.0	-1.6
H28	Cannon	31.9	40.0	-8.1	35.7	40.1	-4.4	38.5	40.6	-2.1	39.8	41.4	-1.6
H29	Dolwen Uchaf	27.6	40.0	-12.4	31.1	40.1	-8.9	33.9	40.6	-6.7	35.5	41.4	-5.9

The term L_p is used to denote the predicted noise level due to the operation of the proposed wind farm
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit.

Table 9.6.6 (continued)

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}														
		8			9			10			11			12		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	Ysgubor Cannon	40.2	42.4	-2.2	39.9	43.5	-3.6	39.2	43.5	-4.4	39.1	43.5	-4.4	39.1	43.5	-4.4
H3	Dolwen Isaf	36.3	42.4	-6.1	36.1	43.5	-7.5	35.1	43.5	-8.4	35.0	43.5	-8.5	35.1	43.5	-8.5
H4	The Barn - Blaen y Cwm	36.0	44.4	-8.4	35.9	46.4	-10.5	34.6	48.1	-13.6	34.4	49.4	-15.1	34.5	50.1	-15.6
H5	Rhydymeirch	38.1	44.4	-6.3	38.1	46.4	-8.3	36.7	48.1	-11.5	36.5	49.4	-12.9	36.6	50.1	-13.5
H6	Abercannon	38.4	42.4	-3.9	38.2	43.5	-5.4	37.4	43.5	-6.2	37.3	43.5	-6.3	37.3	43.5	-6.2
H7	Beulah Chapel House	37.6	42.4	-4.8	37.4	43.5	-6.1	36.6	43.5	-7.0	36.5	43.5	-7.1	36.5	43.5	-7.0
H8	Neinthirion	37.6	42.4	-4.8	37.4	43.5	-6.2	36.5	43.5	-7.0	36.5	43.5	-7.1	36.5	43.5	-7.1
H9	Delfryn	38.3	42.0	-3.7	38.0	44.2	-6.3	37.3	44.2	-7.0	37.2	44.2	-7.0	37.2	44.2	-7.0
H11	Castell y Gwynt	37.0	42.0	-5.0	36.8	44.2	-7.5	35.9	44.2	-8.3	35.9	44.2	-8.4	35.9	44.2	-8.3
H15	Hafodowen	38.0	47.0	-9.0	37.7	50.2	-12.6	37.2	50.2	-13.1	37.1	50.2	-13.1	37.2	50.2	-13.1
H18	Dolau	35.9	42.4	-6.4	35.8	43.5	-7.8	34.9	43.5	-8.7	34.8	43.5	-8.8	34.8	43.5	-8.7
H19	Dolau-ceimion	36.5	42.4	-5.9	36.2	43.5	-7.3	35.4	43.5	-8.2	35.3	43.5	-8.3	35.3	43.5	-8.2
H21	Glegyrnant	37.4	44.4	-6.9	37.4	46.4	-9.0	36.0	48.1	-12.1	35.8	49.4	-13.6	35.9	50.1	-14.2
H22	Blaen y Cwm	35.6	44.4	-8.8	35.6	46.4	-10.8	34.2	48.1	-14.0	34.0	49.4	-15.4	34.1	50.1	-16.0

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}														
		8			9			10			11			12		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H24	Cwm-y-ffynnon	35.8	40.0	-4.2	35.8	42.1	-6.3	34.5	42.1	-7.6	34.3	42.1	-7.8	34.4	42.1	-7.7
H26	Ffriddfawr	38.2	42.0	-3.8	37.9	44.2	-6.3	37.2	44.2	-7.0	37.1	44.2	-7.1	37.2	44.2	-7.1
H27	Cwmderwen	39.1	42.0	-2.8	38.9	44.2	-5.4	38.1	44.2	-6.1	38.1	44.2	-6.2	38.1	44.2	-6.1
H28	Cannon	40.5	42.4	-1.8	40.3	43.5	-3.3	39.5	43.5	-4.0	39.4	43.5	-4.1	39.5	43.5	-4.1
H29	Dolwen Uchaf	36.4	42.4	-6.0	36.1	43.5	-7.4	35.3	43.5	-8.3	35.2	43.5	-8.4	35.2	43.5	-8.3

The term L_p is used to denote the predicted noise level due to the operation of the proposed wind farm
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit.

Table 9.6.7 Comparison of Downwind Cumulative Noise Levels and Night Time Limits - (dB(A) re 20 μPa) Resulting from the operation of the Llanbrynmair and Carnedd Wen Wind Farms

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}											
		4			5			6			7		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	Ysgubor Cannon	31.6	43.0	-11.4	35.3	43.0	-7.7	38.1	43.0	-4.9	39.5	43.0	-3.5
H3	Dolwen Isaf	27.5	43.0	-15.5	31.0	43.0	-12.0	33.8	43.0	-9.2	35.4	43.0	-7.6
H4	The Barn - Blaen y Cwm	27.1	43.0	-15.9	30.0	43.0	-13.0	32.9	43.0	-10.1	34.9	43.0	-8.1
H5	Rhydymeirch	29.3	43.0	-13.7	32.3	43.0	-10.7	35.2	43.0	-7.8	37.1	43.0	-5.9
H6	Abercannon	29.8	43.0	-13.2	33.4	43.0	-9.6	36.2	43.0	-6.8	37.7	43.0	-5.3
H7	Beulah Chapel House	28.9	43.0	-14.1	32.5	43.0	-10.5	35.4	43.0	-7.6	36.8	43.0	-6.2
H8	Neinthirion	28.9	43.0	-14.1	32.5	43.0	-10.5	35.3	43.0	-7.7	36.8	43.0	-6.2
H9	Delfryn	29.6	43.0	-13.4	33.3	43.0	-9.7	36.2	43.0	-6.8	37.6	43.0	-5.4
H11	Castell y Gwynt	28.0	43.0	-15.0	31.7	43.0	-11.3	34.5	43.0	-8.5	36.1	43.0	-6.9
H15	Hafodowen	29.5	43.0	-13.5	33.5	43.0	-9.5	36.3	43.0	-6.7	37.4	45.0	-7.6
H18	Dolau	27.1	43.0	-15.9	30.7	43.0	-12.3	33.5	43.0	-9.5	35.1	43.0	-7.9
H19	Dolau-ceimion	27.8	43.0	-15.2	31.3	43.0	-11.7	34.1	43.0	-8.9	35.7	43.0	-7.3

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}											
		4			5			6			7		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H21	Glegyrnant	28.6	43.0	-14.4	31.6	43.0	-11.4	34.5	43.0	-8.5	36.4	43.0	-6.6
H22	Blaen y Cwm	26.6	43.0	-16.4	29.6	43.0	-13.4	32.5	43.0	-10.5	34.5	43.0	-8.5
H24	Cwm-y-ffynnon	26.9	43.0	-16.1	30.1	43.0	-12.9	33.0	43.0	-10.0	34.8	43.0	-8.2
H26	Ffriddfawr	29.6	43.0	-13.4	33.3	43.0	-9.7	36.1	43.0	-6.9	37.5	43.0	-5.5
H27	Cwmderwen	30.5	43.0	-12.5	34.3	43.0	-8.7	37.1	43.0	-5.9	38.4	43.0	-4.6
H28	Cannon	31.9	43.0	-11.1	35.7	43.0	-7.3	38.5	43.0	-4.5	39.8	43.0	-3.2
H29	Dolwen Uchaf	27.6	43.0	-15.4	31.1	43.0	-11.9	33.9	43.0	-9.1	35.5	43.0	-7.5

The term L_p is used to denote the predicted noise level due to the operation of the proposed wind farm
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit.

Table 9.6.7 (continued)

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}														
		8			9			10			11			12		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	Ysgubor Cannon	40.2	43.0	-2.8	39.9	43.0	-3.1	39.2	43.0	-3.8	39.1	43.0	-3.9	39.1	43.0	-3.9
H3	Dolwen Isaf	36.3	43.0	-6.7	36.1	43.0	-6.9	35.1	43.0	-7.9	35.0	43.0	-8.0	35.1	43.0	-7.9
H4	The Barn - Blaen y Cwm	36.0	43.0	-7.0	35.9	43.0	-7.1	34.6	44.7	-10.2	34.4	46.9	-12.5	34.5	49.2	-14.8
H5	Rhydymeirch	38.1	43.0	-4.9	38.1	43.0	-4.9	36.7	44.7	-8.0	36.5	46.9	-10.4	36.6	49.2	-12.6
H6	Abercannon	38.4	43.0	-4.6	38.2	43.0	-4.8	37.4	43.0	-5.6	37.3	43.0	-5.7	37.3	43.0	-5.7
H7	Beulah Chapel House	37.6	43.0	-5.4	37.4	43.0	-5.6	36.6	43.0	-6.4	36.5	43.0	-6.5	36.5	43.0	-6.5
H8	Neinthirion	37.6	43.0	-5.4	37.4	43.0	-5.6	36.5	43.0	-6.5	36.5	43.0	-6.5	36.5	43.0	-6.5
H9	Delfryn	38.3	43.0	-4.7	38.0	43.0	-5.0	37.3	44.5	-7.2	37.2	44.5	-7.3	37.2	44.5	-7.3
H11	Castell y Gwynt	37.0	43.0	-6.0	36.8	43.0	-6.2	35.9	44.5	-8.6	35.9	44.5	-8.7	35.9	44.5	-8.6
H15	Hafodowen	38.0	50.4	-12.3	37.7	50.4	-12.7	37.2	50.4	-13.2	37.1	50.4	-13.2	37.2	50.4	-13.2
H18	Dolau	35.9	43.0	-7.1	35.8	43.0	-7.2	34.9	43.0	-8.1	34.8	43.0	-8.2	34.8	43.0	-8.2
H19	Dolau-ceimion	36.5	43.0	-6.5	36.2	43.0	-6.8	35.4	43.0	-7.6	35.3	43.0	-7.7	35.3	43.0	-7.7
H21	Glegyrnant	37.4	43.0	-5.6	37.4	43.0	-5.6	36.0	44.7	-8.7	35.8	46.9	-11.0	35.9	49.2	-13.3

House ID	House Name	Reference Wind Speed (Standardised v_{10}) / ms^{-1}														
		8			9			10			11			12		
		L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H22	Blaen y Cwm	35.6	43.0	-7.4	35.6	43.0	-7.4	34.2	44.7	-10.5	34.0	46.9	-12.9	34.1	49.2	-15.1
H24	Cwm-y-ffynnon	35.8	43.0	-7.2	35.8	43.0	-7.2	34.5	43.0	-8.5	34.3	43.0	-8.7	34.4	43.0	-8.6
H26	Ffriddfawr	38.2	43.0	-4.8	37.9	43.0	-5.1	37.2	44.5	-7.3	37.1	44.5	-7.4	37.2	44.5	-7.3
H27	Cwmderwen	39.1	43.0	-3.9	38.9	43.0	-4.1	38.1	44.5	-6.4	38.1	44.5	-6.4	38.1	44.5	-6.4
H28	Cannon	40.5	43.0	-2.5	40.3	43.0	-2.7	39.5	43.0	-3.5	39.4	43.0	-3.6	39.5	43.0	-3.5
H29	Dolwen Uchaf	36.4	43.0	-6.6	36.1	43.0	-6.9	35.3	43.0	-7.7	35.2	43.0	-7.8	35.2	43.0	-7.8

The term L_p is used to denote the predicted noise level due to the operation of the proposed wind farm
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit.

1.9 Directional Assessment

1.1.23 As reported thus far, all predictions of wind farm noise levels have been presented assuming that the wind is blowing directly from every turbine (in both wind farms) to every house simultaneously. Even with this consideration it may be seen that the proposed wind farm can satisfy the relevant criteria.

1.1.24 However, to inform the reader of more realistic noise levels rather than making this conservative assumption a more detailed assessment considering the directionality of the wind has been made. This accounts for the fact that noise levels at a property will be less when the property is crosswind or upwind of a wind turbine compared to when it is downwind of a wind turbine. The directional attenuation factors applied are detailed in Table 9.6.8 and are based on a nominal 10 dB attenuation for upwind propagation, decreasing to 2 dB for cross-wind propagation and 0 dB for propagation angles of less than 90 degrees based upon measurements made in the verification of propagation modelling (Bass, Bullmore and Sloth, 1998).

Table 9.6.8 – Directional Attenuation

Directional Offset from Directly Downwind	Directional Attenuation Factor (dB)
0	0.0
30	0.0
60	0.0
90	-2.0
120	-6.7
150	-9.3
180	-10.0
210	-9.3
240	-6.7
270	-2.0
300	0.0
330	0.0

1.1.25 Figures 9.6.2 and 9.6.3 show the results of such a directional assessment during quiet daytime periods at Cannon and Cwmderwen, the properties with the smallest margins between the cumulative predicted noise levels assuming downwind propagation and noise limits, at the wind speed where the minimum margin occurs, 7m/s. Both of these properties are occupied by financial beneficiaries of Llanbrynmair. Figure 9.6.4 details the results of a directional assessment during quiet daytime periods at the property with the smallest margin that is not a financial beneficiary of either scheme; Delfryn.

1.1.26 Figure 9.6.5 details the results of a directional assessment during night time periods at Cannon, the property with the smallest margin between cumulative predicted noise levels assuming downwind propagation and noise limits, at the wind speed where the minimum margin occurs, 8m/s. This property is occupied by a financial beneficiary of Llanbrynmair. Figure 9.6.6 details the results of a directional assessment during night time periods at the property with the smallest margin that is not a financial beneficiary of either scheme; Delfryn.

Figure 9.6.1 Cumulative *Predicted Noise Footprint*

1.1.27 Grid Intervals At 1 km; The $L_{A90,10min}$ descriptor has been used

1.1.28 The noise footprint has been calculated at a standardised 10 m wind speed of 8 ms^{-1} using the ISO 9613-2 propagation model (downwind propagation). The figure may show slightly different results than those numerically calculated and should be considered illustrative only as all barrier attenuation has been removed (more conservative) and the correction for propagation across valleys has not been applied (less conservative)

Turbines prefixed “R” are the proposed Llanbrynmair wind farm
Turbines prefixed “N” are the proposed Carnedd Wen wind farm
Red receiver icons indicate that background noise measurements made at those locations

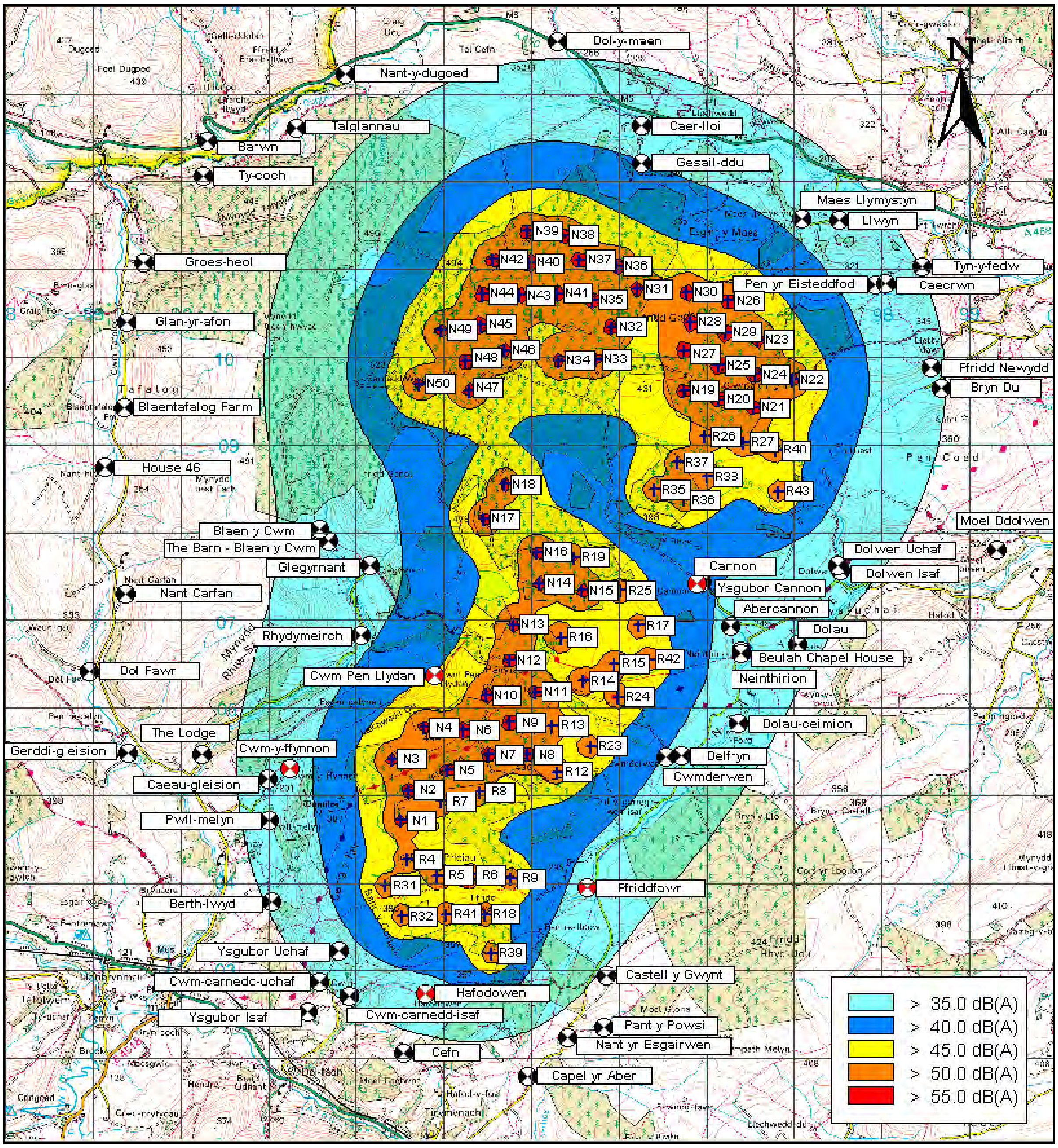


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Figure 9.6.2 – Predicted noise level by direction at Cannon at 7m/s during Quiet Daytime Periods

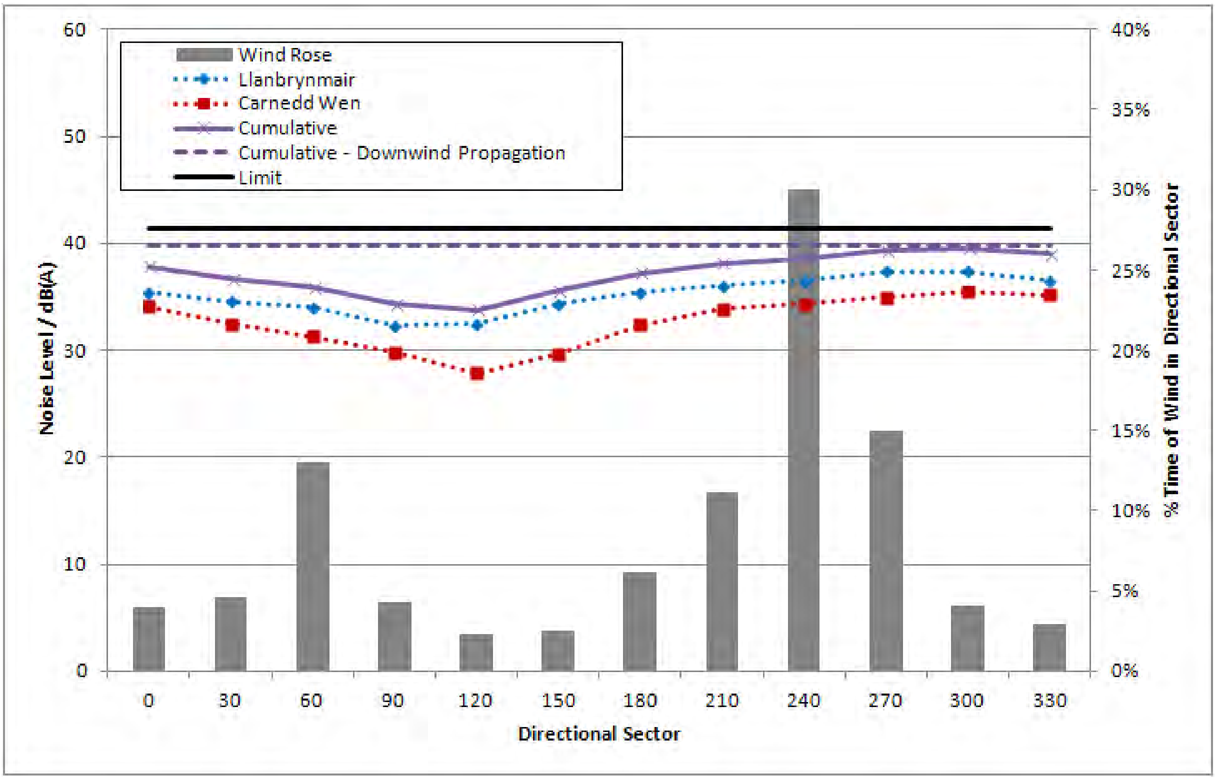


Figure 9.6.3 – Predicted noise level by direction at Cwmderwen at 7m/s during Quiet Daytime Periods

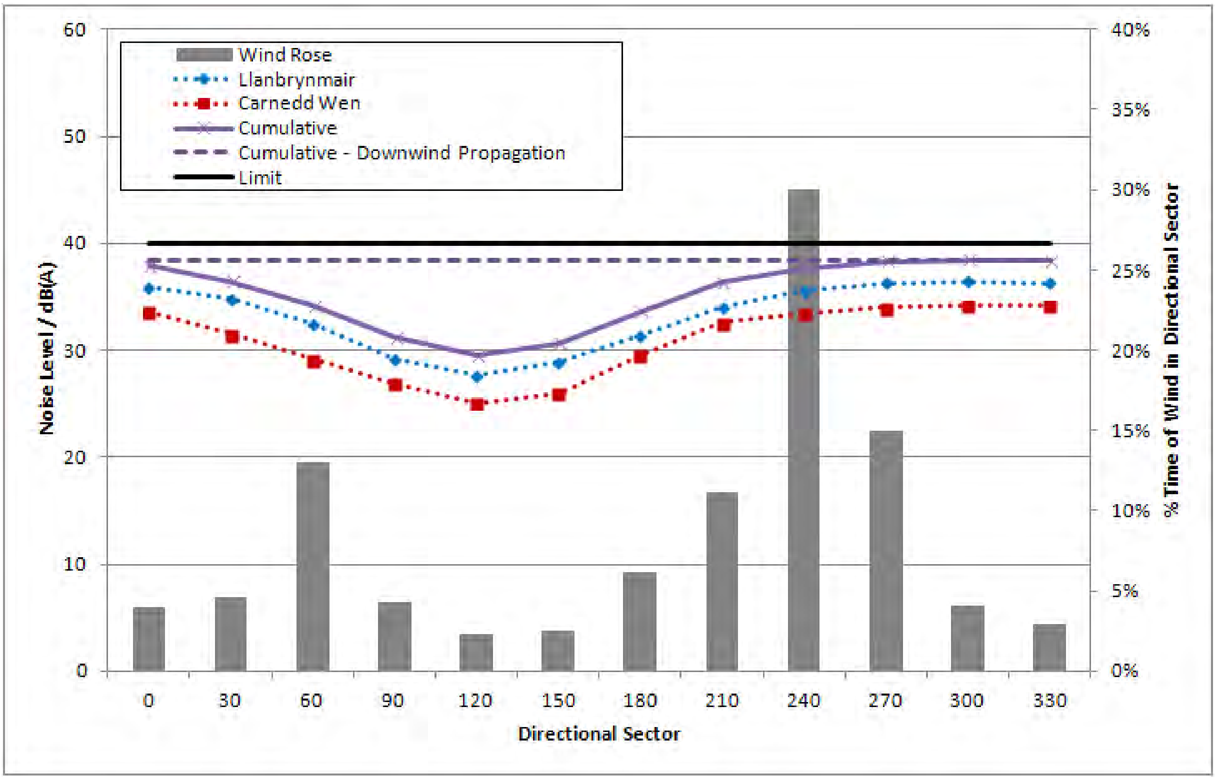


Figure 9.6.4 – Predicted noise level by direction at Delfryn at 7m/s during Quiet Daytime Periods

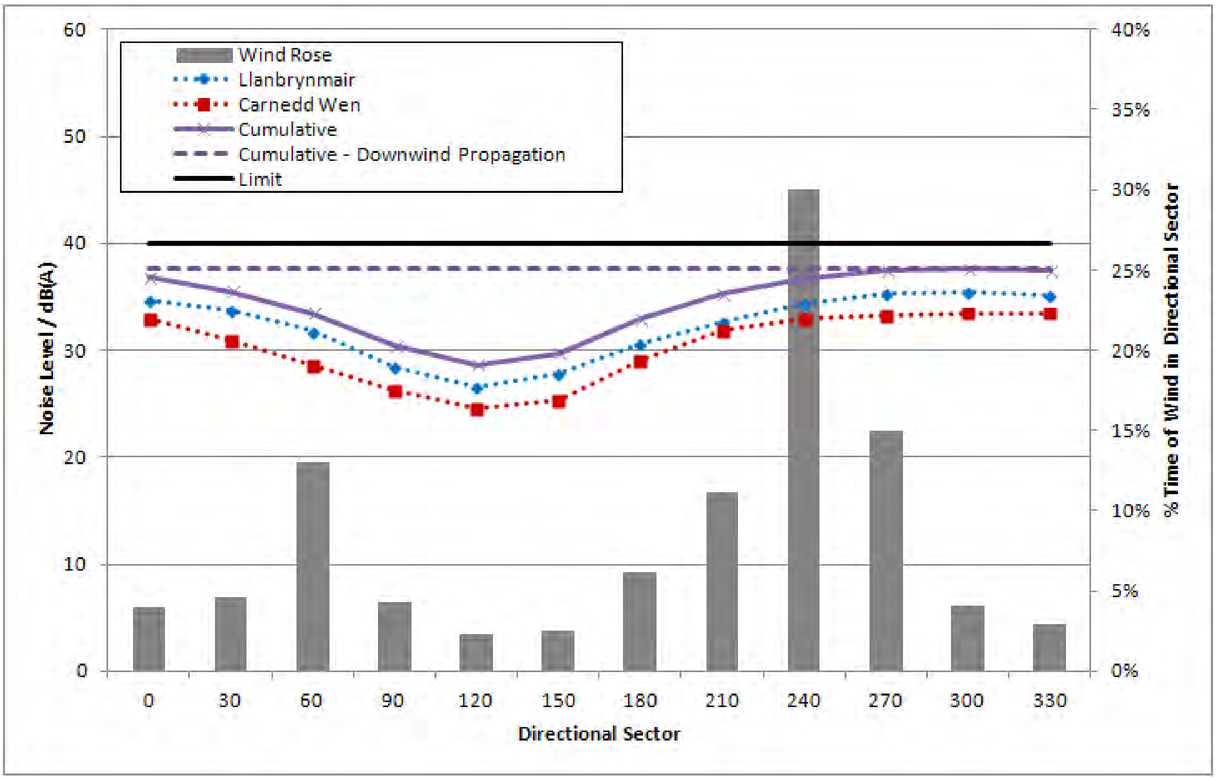


Figure 9.6.5 – Predicted noise level by direction at Cannon at 8m/s during Night Time Periods

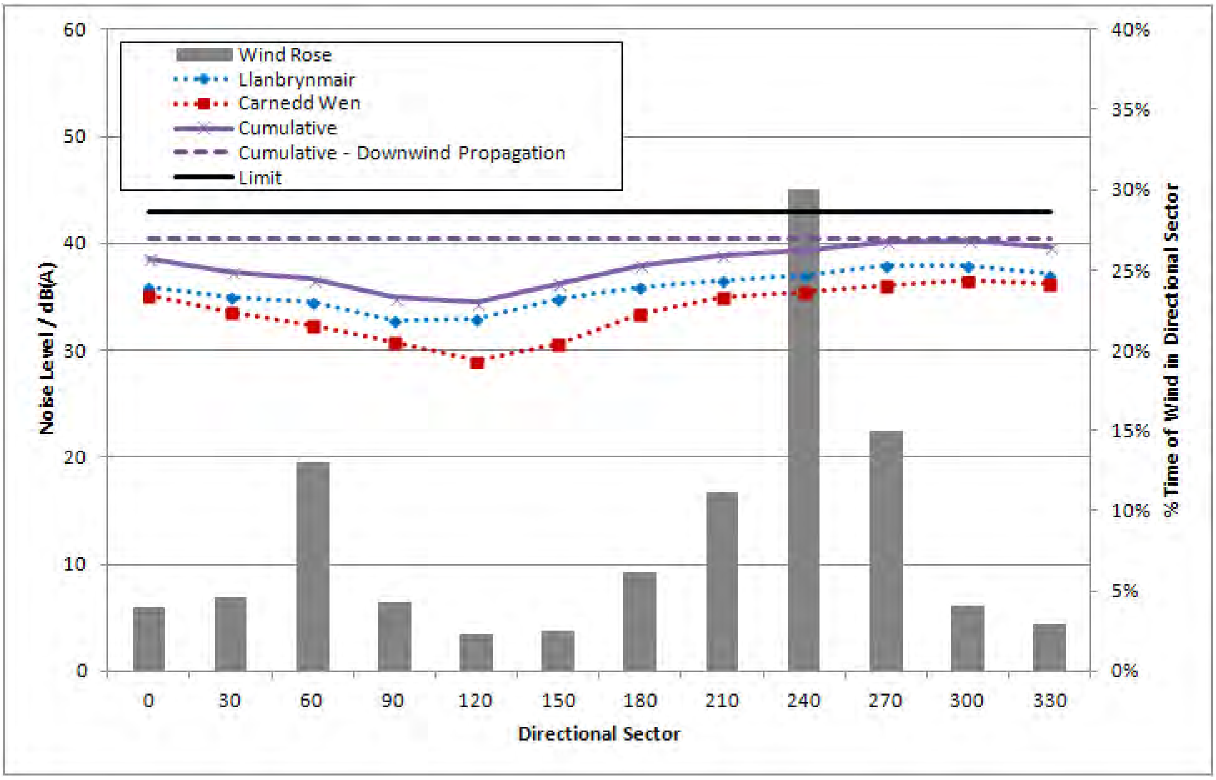
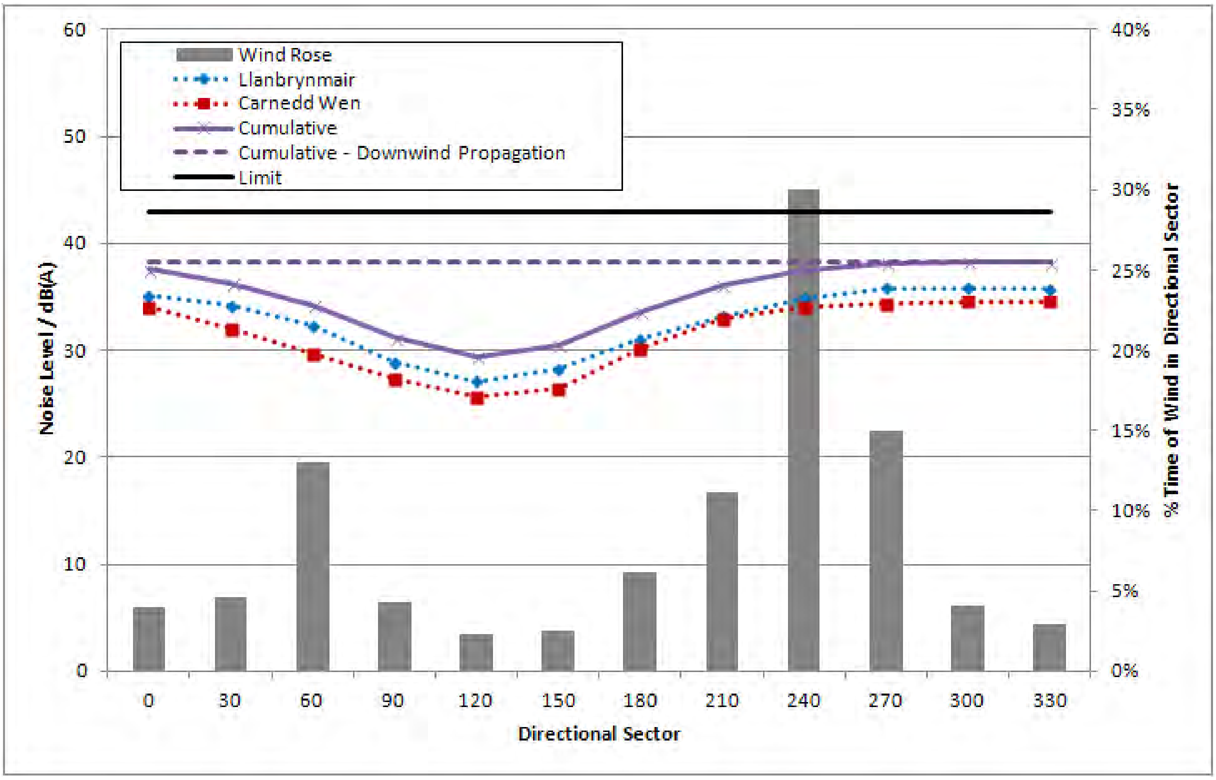


Figure 9.6.6 - Predicted noise level by direction at Delfryn at 8m/s during Night Time Periods



1.10 Cumulative Construction Noise Assessment

1.1.29 Should construction of the Carnedd Wen wind farm take place at the same time as the construction of Llanbrynmair wind farm then suitable mitigation measures, as discussed in Section 9.5, may need to be applied.

1.11 Summary

1.1.30 An assessment considering the cumulative acoustic impact of the proposed Llanbrynmair and Carnedd Wen wind farms has been undertaken. The cumulative assessment demonstrates that both wind farms may operate within the noise limits according to 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) at all of the properties considered.

APPENDIX 11.1: ELECTROMAGNETIC INTERFERENCE CONSULTEES

Table 11.1: Electromagnetic Consultees

Consultee	Response
Ofcom	Six potential civil fixed links found
Arqiva	No objection
CSS Spectrum Management	No response
Joint Radio Company	No objection
Orange	No objection
T-Mobile	No objection subject to cell being avoided by >500m [achieved in Proposal layout]
Cable and Wireless	No objection
National Grid Wireless Group	Not their area – no objection
BBC	See text, Chapter 11.
MML Telecom Ltd	No Objection
BT Wholesale	No objection

APPENDIX 12.1: TOURISM IMPACT ASSESSMENT REPORT

THE UNIVERSITY *of* EDINBURGH

TOURISM IMPACT ANALYSIS

Llanbrynmair Wind Farm Proposal

Powys

Wales

Conducted by Professor Cara Aitchison

University of Edinburgh

On Behalf of

RES UK & Ireland

June 2012

CONTENTS

1. QUALIFICATIONS AND EXPERIENCE

1.1 This report has been compiled by Professor Cara Carmichael Aitchison. Professor Aitchison holds an MA (Honours) degree in Geography (Edinburgh), specialising in integrated rural development, a Postgraduate Diploma in Recreation and Leisure Practice, a Certificate in Education, a postgraduate MA in Social Science and a PhD in Geography and Leisure Studies (Bristol).

1.2 Professor Aitchison is an Academician (Fellow) of the Society for the Social Sciences, elected in 2003. She has been a member of the Leisure Studies Association since 1989 and was Chair of the Association from 2001-2004. She is a Fellow of the World Leisure Academy and held the position of Commission Chair of one of the eight World Leisure Research Commissions from 2002-2008. In 2004 Professor Aitchison was appointed as the tourism and leisure expert to the UK government's Research Assessment Exercise (2008) to assess the quality of research in UK universities between 2001 and 2008. In 2010 she was appointed as Chair of the subsequent Research Excellence Framework (2014) Sub-Panel for Sport and Exercise Sciences, Leisure and Tourism to lead the assessment of research between 2008 and 2013. This Sub-Panel is one of 36 covering all areas of research in UK universities and is the only panel to explicitly include tourism within its remit.

1.3 Professor Aitchison is an Associate Editor of *Annals of Tourism Research*, recognised as the leading international peer reviewed tourism research journal. She is an Editorial Board member of the *Journal of Leisure Studies*, recognised as the leading international peer reviewed leisure research journal. She is regularly invited to review research papers and research proposals for major research funding bodies including the UK Research Councils. She was a member of the Arts and Humanities Research Council (AHRC) Peer Review College from 2004-2007 and is currently a member of the Economic and Social Research Council (ESRC) Peer Review College, having been nominated by the UK Association of Tourism in Higher Education (ATHE).

1.4 Professor Aitchison has been employed in higher education tourism education and research for 24 years. She was the Programme Leader of the UK's first BA (Honours) Leisure and Tourism Management degree and then the Programme Leader of the UK's longest established Masters degree in Leisure and Tourism Studies, both at the University of North London where she was a Senior Lecturer and then Principal Lecturer in Leisure and Tourism Studies between 1990 and 1997. She developed her research career to become the Head of the Leisure and Sport Research Unit at the University of Gloucestershire in 2001 where she was also a Reader in the world-renowned Countryside and Community Research Institute under the Directorship of Professor Nigel Curry. In 2003 she was appointed Professor in Human Geography at the University of the West of England and subsequently established and became the Director of the Centre for Leisure, Tourism and Society.

1.5 In 2008 Professor Aitchison was appointed Dean of the Faculty of Education, sport and Tourism at the University of Bedfordshire and Professor in Leisure and Tourism Studies where she managed a Faculty of over 4,000 students and over 100 permanent academic staff. The University of Bedfordshire was judged to have 'world leading research activity' in tourism in the Research Assessment Exercise (2008) and was one of only three UK universities to achieve the highest grade for tourism in the previous Research Assessment Exercise (2001).

1.6 In 2010 Professor Aitchison was appointed to the role of Head of Moray House School of Education at the University of Edinburgh where she also took up an established Chair in Social and Environmental Justice. Moray House is the largest School of Education in Scotland and the second largest in the UK with over 200 permanent staff, over 200 fixed term, seconded and visiting staff and over 3,000 students, including over 100 PhD students. The University of Edinburgh is Scotland's premier research university and was graded 6th among UK Universities in the national Research Assessment Exercise (2008). Research, including tourism and leisure studies, submitted by Moray House School of Education to the RAE (2008), received the highest award of all Education submissions in Scotland and the second highest in the UK.

1.7 Professor Aitchison's research focuses on three areas:

- Sustainable rural economies and communities: the development and impact of tourism, leisure and recreation and their integration with other sectors of sustainable rural development, particularly energy and food production
- Social inclusion, equality, diversity and identity: the integration of social, cultural and spatial theories and policies to enhance equality, diversity and inclusion in and through leisure, sport and tourism
- Sociology of education: epistemology, methodology and pedagogy within leisure, sport and tourism education and wider social science

1.8 Professor Aitchison's assessment of the Llanbrynmair Wind Farm project draws on her extensive academic and theoretical research in tourism studies, together with her knowledge of research methodology, to inform her applied research and consultancy in rural tourism. She has taught tourism studies and research methods at postgraduate level, has supervised nine doctoral students to completion and has published research on qualitative research methods in tourism. She has an international reputation for her research in tourism and leisure with almost 200 research outputs including: nine books; 49 refereed academic research papers and book chapters; 58 invited presentations and lectures including keynote papers at international tourism and leisure conferences in Australia, Brazil, Iran, Latvia, the Netherlands, the UK and the USA; 46 peer reviewed presentations at national and international conferences and over 60 other non-refereed research reports and published articles.

1.9 Professor Aitchison has an interest in developing both original conceptual research and theory-informed applied research that contributes to policy and practice in leisure, sport, tourism and rural development. As Principal Investigator she has managed over 20 funded research projects including needs analyses, community consultations, feasibility studies, impact assessments, policy evaluation studies and research networks. These projects have been funded by the ESRC, British Academy and national, regional and local bodies in the public, commercial and third sectors including the Countryside Council for Wales, local authorities in England and Scotland, the Forestry Commission, renewable energy companies, a number of national disability organisations and professional bodies in leisure, sport and recreation including the Institute for Sports, Parks and Leisure.

1.10 Professor Aitchison's experience in research specifically examining the tourism impact of wind farms has been developed over the last eight years. In 2004 she undertook extensive survey research of the tourism impacts of existing wind farms in Mid Wales and Cornwall and of a proposed wind farm (Fullabrook) in Devon. She then acted as an Expert Witness at the Public Inquiry into the Fullabrook Wind Farm proposal in North Devon in 2006-2007. In 2009 she undertook research into the potential tourism impact of proposed wind farms in Northumbria, focusing particularly on the Moorsyde Wind Farm proposal by Your Energy Ltd. and, in the same year, she then acted as an Expert Witness at the Moorsyde Planning Appeal. In 2011 Professor Aitchison undertook a tourism impact analysis of the proposed Bryn Llywelyn Wind Farm in Carmarthenshire, Wales on behalf of RES Ltd. The analysis presented here forms Professor Aitchison's second study conducted in relation to wind farm proposals by RES Ltd.

in Wales. It draws on her previous research including her earlier survey research of tourists at and around the wind farms of Carno and Bryn Titli in Mid Wales.

1.11 Professor Aitchison's research has been disseminated in documentary form for academic and policy audiences, including to the recent Scottish Government Renewables Inquiry. She has presented evidence as an Expert Witness at both a Public Inquiry and Planning Appeal and her research has been scrutinised at the highest level in academic, planning and legal fora including the High Court. In all cases her research has been found to meet the highest standards of originality, significance and rigour as specified by assessment criteria of the UK Research Excellence Framework. In addition, the Planning Inspector for the Fullabrook Wind Farm Public Inquiry drew particular reference to the quality of Professor Aitchison's research relative to other tourism research that had been presented at the 2006-2007 Public Inquiry.

2. PURPOSE AND SCOPE OF EVIDENCE

2.1 The evidence submitted here is designed to provide data, information and informed analysis of the actual and potential impact of wind farms on tourism and, specifically, the potential impact on tourism of a wind farm at Llanbrynmair, Powys. This evidence is compiled to supplement that provided in chapter 13 of the *Llanbrynmair Wind Farm Environmental Statement* Volume II produced by RES (2012) and, in particular, sections 13.3 and 13.4 of the Environmental Statement which address Recreation and Tourism respectively (pp 327-331).

2.2 The evidence presented here is divided into four sections which progress from the general to the specific in order to relate the wider evidence available on tourism impacts of wind farms to the particular policy context and proposal to develop a wind farm at Llanbrynmair.

2.3 Section 3 of this report summarises and evaluates secondary evidence of the impact of wind farms on tourism. The analysis progresses from a general introduction to tourism research and rural economic development to a more detailed examination of previous research on the tourism impact of wind farms. Section 3.5 in particular draws on the findings of the two largest studies conducted to date into the tourism impact of wind farms: University of the West of England (2004) and Glasgow Caledonian University (2008a).

2.4 The University of the West of England study was commissioned by Devon Wind Power and designed and conducted by Professor Aitchison and hereafter referred to as Aitchison (2004). The study formed the basis of Professor Aitchison's evidence as an Expert Witness at the Public Inquiry into the 66MW Fullabrook Wind Farm in 2006-07.

2.5 Particular significance is given to the findings of the two studies conducted by UWE and GCU and their relevance to the Llanbrynmair proposal for the following reasons:

- the two studies form the largest pieces of academic research conducted to date and therefore offer the greatest 'evidence' relating to the impact of wind farms on tourism
- the studies were conducted by highly qualified academic research teams that adopted rigorous research methodologies and used multiple research methods to triangulate findings, thus providing a high degree of validity and reliability

- the studies were conducted in different areas of the UK but in areas that have a number of similarities with Llanbrynmair and the surrounding countryside in relation to landscape, access, visitor attractions, tourist accommodation, tourism patterns and tourist profile

2.6 Located in Powys, Mid Wales, Llanbrynmair is situated at the north-west of the county and within easy access of Snowdonia National Park and other attractions formally located in Gwynedd, North Wales. Section 4 of this report therefore assesses the policy context of rural tourism in Mid *and* North Wales, although focussing on the area in and around Llanbrynmair and the area bordering Powys and Gwynedd. The evidence presented takes four forms: first, section 4.2 presents an overview of tourism policy in Wales; secondly, section 4.3 examines tourism policy in Mid Wales and Powys; thirdly, section 4.4 evaluates the volume and value of tourism in Mid Wales and Powys; fourthly, section 4.5 assesses the nature of tourism in the vicinity of Llanbrynmair and evaluates the significance of this area to tourism within the wider context of Mid Wales.

2.7 Section 5 assesses tourism in the Llanbrynmair area in more detail by examining the range of visitor attractions and visitor accommodation within the area. Three important forms of tourism for the area surrounding Llanbrynmair are identified: industrial heritage; castles, museums and crafts; and nature and wildlife. This section also evaluates the provision for outdoor and active recreation, highlighting the importance of particular forms of tourism and recreation for the area, most notably walking and mountain biking.

2.8 Finally, section 6 synthesises the evidence presented in the previous sections to provide an assessment of the potential economic impact of the Llanbrynmair Wind Farm on tourism by evaluating the likely impact of the wind farm development on the specific visitor attractions and visitors attracted to this area of Wales.

3. EVIDENCE FROM PREVIOUS TOURISM STUDIES

3.1 Introduction

3.1.1 This section outlines secondary evidence of the impact of wind farms on tourism and addresses five aspects of tourism-related evidence. First, a general introduction to tourism research and rural economic development is presented in section 3.2. Secondly, a critical review of the research methods employed in previous studies of tourism impacts of wind farms is given in section 3.3. The results of all previous major studies of the tourism impact of wind farms are discussed in section 3.4 with the findings evaluated in relation to developing a wind farm at Llanbrynmair. Finally, section 3.5 examines in more detail the findings from the two largest and most rigorous studies conducted to date: Aitchison's (2004) University of the West of England's report titled *The Potential Impact of Fullabrook Wind Farm Proposal, North Devon: Evidence Gathering of the Impact of Wind Farms on Visitor Numbers and Tourist Experience*, commissioned by Devon Wind Power, and Glasgow Caledonian University's (GCU) (2008a) report titled *The Economic Impact of Wind Farms on Scottish Tourism* which was commissioned by the Scottish Government.

3.2 Tourism Research

3.2.1 Tourism plays an increasingly important role in contributing to rural regeneration in the UK. New forms of rural tourism associated with landscape, culture and active recreation are increasingly important to rural tourism economies (Scottish Government 2012). Activities related to natural history and birdlife, cultural heritage and historic gardens, local food and drink and a range of active outdoor pursuits, including walking and mountain biking, are increasingly promoted as policy priorities through which wider agendas of sustainable development can be addressed. The prevalence of high wind speeds in these same upland and coastal areas means that they are also the preferred destinations for wind farm developments. In spite of this proximate and apparent inter-relationship between wind farms and tourism it is only recently that research examining tourists' attitudes towards the location of wind farms in or near areas that they visit for holiday and/or leisure has been conducted in any depth (Aitchison, 2004; British Wind Energy Association 2006; Glasgow Caledonian University, 2008a; MORI Scotland, 2002; Starling, 2006).

3.2.2 Although tourism research relating to wind farm developments is limited compared with that on policy, design, visual impact, ecology, ornithology, hydrology, acoustics and transport it is increasingly evident that there is an emerging consensus within the research examining the actual and potential impact of wind farms on tourism. The clear consensus is that there has been no measurable economic impact, either positively or negatively, of wind farms on tourism. Similarly, there is consensus among researchers of studies that have sought to predict the potential economic impact of wind farms on tourism. Here again, there is no evidence to support the assertion that wind farms are likely to have a negative economic impact on tourism. Moreover, all of the studies that have sought to predict impact have demonstrated that any negative impact of wind farms on tourism will be more than outweighed by the increase in tourists that are attracted by wind farms or by the increase in employment brought about by the development of wind farms or by the continuing growth of tourism.

3.2.3 However, it is clear that some local authorities, business owners and residents in rural areas that fall within Strategic Search Areas for wind farm developments continue to voice opposition to such developments, increasingly citing negative impact on tourism as a reason to reject planning applications. This report therefore seeks to clarify the evidence relating to tourism impacts of wind farms so that remaining opposition to development is based on *fact* rather than unfounded, but nonetheless understandable, *fear*.

3.2.4 It is clear that tourism research data must be interpreted carefully. The care with which such research must be approached was highlighted by the Inspector to the Fullabrook Wind Farm Public Inquiry in 2007 when he stated that '*...the question of impacts on tourism is extremely nebulous and vulnerable to assessment by assumption rather than by evidence; it is an area where it is easy to hold opinions but harder to back them up with firm data. There is also the fact that in 15 years or so of wind farm development no evidence has emerged from developed sites that tourism has suffered as a result*' (The Planning Inspectorate, 2007: 48). This lack of evidence has been documented in reports from a number of previous Inquiries. A recent report recommending approval of the Middlemoor proposal in Northumberland stated in relation to tourism that '*Although attention is drawn to this matter by objectors, little or no evidence based analysis is supplied*' (The Planning Inspectorate, 2008: 89).

3.2.5 The next section of this report therefore highlights the need for careful and critical assessment of the methodology adopted, the research methods employed and the research conclusions drawn in each study when evaluating the 'evidence' from research designed to assess the impact of wind farm development on tourism.

3.3 Research Methods

3.3.1 Whereas the research methodologies designed to assess the impacts *of* tourism in rural areas have been developed and honed over many decades, the methodologies developed to evaluate impacts of other sectors of industry *on* tourism in rural areas are still in their infancy. As a result, when considering research into the impact of wind farms on tourism it is vital to scrutinise the methodology adopted, the research methods employed and the research conclusions drawn in each study when evaluating the 'evidence' from each piece of research. The lack of maturity of the field of study has, to date, resulted in a lack of rigorous peer review of research methodology, methods, analysis and findings resulting in some poor research and spurious findings being used in planning applications, inquiries and appeals.

3.3.2 Two major errors have been identified in previous research and, when primary research containing errors is used to inform secondary research, these initial errors can become compounded. The first error relates to survey methodology and sampling used in primary research and the second to the interpretation and extrapolation of data from secondary research.

3.3.3 Some primary survey research commissioned by local authorities and tourist boards has adopted inappropriate and biased sampling methods that have distorted results. In a number of surveys, such as that undertaken by the Western Isles Tourist Board (2005), tourism businesses rather than tourists have been taken as the sampling frame. These research findings therefore provide some insights into *business owners'* views but are wholly unrepresentative findings of *tourists'* perceptions of wind farms. In a number of other surveys, where tourists have provided the sampling frame, the actual sampling methodology has been fundamentally flawed. Such a shortcoming was identified by the Inspector in the Public Inquiry into Fullabrook Wind Farm in Devon where North Devon Marketing Bureau (NDMB) commissioned a public relations company, Bray Leino, to conduct a survey and then used the 'evidence' collected to support their argument that the wind farm would have a detrimental impact on tourism. The validity of the survey was called into question by the Inspector who stated '*I have considerable reservations about the validity and usefulness of the NDMB survey. Under this,* *5000 questionnaires were distributed to tourist accommodation and attractions in North Devon. 626 questionnaires were completed and analysed (giving a 13% response rate). First, I agree with Devon Wind Power* [Aitchison, 2004] *that there is simply no guarantee that the results of a self completion questionnaire can be representative of public opinion. Such questionnaires tend to be filled in by those who have strong opinions about an issue, and thus who are motivated to express those opinions, as opposed to those who may have more measured views. Secondly, the response rate was very low, again throwing into doubt the reliability of the results. In contrast, the methodology employed by UWE* [Aitchison, 2004] *was far more likely to provide a representative sample of views. Thus, 196 interviews were conducted in representative tourist locations in North Devon, by interviewers trained in tourism research techniques. The technique was to question tourists in order of their arrival ... The survey was supplemented by comparative studies at two existing wind farms in Cornwall and two others in Mid Wales. In total, 379 day visitors and tourists were interviewed at these locations...My conclusion is that of the various studies put before me, it is the findings of Devon Wind Power* [Aitchison, 2004], *supported by those of the Green Business Forum, that provide the most likely prediction of the overall impact upon tourism. That prediction is that tourist numbers, as well as income, would be maintained.*' (The Planning Inspectorate, 2007: 147-149).

3.3.4 The second major error relates to the interpretation and extrapolation of data where, instead of conducting primary research, conclusions have been drawn by extrapolating data, often in a selective or even biased way, in an attempt to demonstrate that conclusions reached in one study at one time and in one location will not only hold true in other temporal and spatial environments but can be applied to much larger areas with an exaggerated effect. Clearly, it is inconceivable that one wind farm, or even a group of wind farms such as those proposed in the Carno-Llanbrynmair-Cemmaes area, would impact across the entire area of Powys or Mid Wales. As the authors of the Glasgow Caledonian University (2008a) research emphasised in relation to the economic impact of wind farms in Scotland, 'the total impact is not equal to all the local area effects added together' (Glasgow Caledonian University, 2008b: 6).

3.3.5 Moreover, reliance is often placed on selective studies, the findings of which have been discredited or disproved by later research, rather than the whole body of research being considered. For example, the NFO System 3 (2002) survey conducted by for VisitScotland has been widely discredited as a result of its highly flawed and biased sampling technique which deliberately 'deselected' a number of groups of respondents and then used leading questions and prompts. The survey, carried out by the Western Isles Tourist Board in the Western Isles in 2005, used local tourist board members and *not* actual tourists as respondents. Selective references can also be made, such as emphasising from the 2008 Glasgow Caledonian Study that 'nearly 18% of respondents indicated that they would not visit an area if a wind farm was constructed' but ignoring the conclusion considering the economic impact of wind farms to Scottish tourism as representing a 0.18% reduction in *growth* prospects for tourism employment: '*It should be remembered that these are not job losses that will be felt instantaneously, rather it is a reduction in the number of jobs that will be created in future as a result of tourism spending*' (Glasgow Caledonian University, 2008b: 6). This potential reduction in growth in tourism employment is likely to be more than off-set by the potential growth in employment related to wind farm development and operation.

3.4 Tourism and Wind Farms

3.4.1 The findings of academic research on tourism impacts, together with the tourism policy priorities outlined by a range of public and commercial sector tourism organisations, informed the 2006 *Good Practice Guide on Planning for Tourism* which replaced *Policy Planning Guidance for Tourism* (PPG 21) (Department for Communities and Local Government, 2006). The *Guide* informs planners of the economic, social and environmental significance of tourism and seeks to ensure they take due account of tourism in planning decisions. The guidance does not seek to limit other forms of development; rather, it emphasises that tourism development is compatible with a range of other economic, social and environmental objectives including the development of renewable energy. Such a conclusion is supported by other research including that by Gee (2005) who found that existing economic activities, such as farming, can continue unaffected by the development of wind farms. Within the *Guide* tourism is identified as a key element in promoting sustainable development through: rural farm diversification, aiding the revitalisation of market towns and villages, supporting important rural services and facilities and as a means by which environmental schemes and improvements to the built and natural environment can be enhanced (Department for Communities and Local Government, 2006: 20-21). Moreover, the policies outlined in the *Guide* are intended to be consistent with the principles *of Planning Policy Statement 7: Sustainable Development in Rural Areas* which sets out national planning policies for the development of rural tourism and leisure (Department for Communities and Local Government, 2004).

3.4.2 Research undertaken by Young (1993), and subsequent research undertaken by Starling (2006), has similarly demonstrated that the development of wind farms is compatible with the development of other economic activities including the service industries of leisure, recreation and tourism.

3.4.3 Young's later research, conducted in relation to the development of the Delabole wind farm in North Cornwall, found that concerns expressed by residents relating to both noise and visual impact fell significantly between pre- and post-construction questionnaires thus indicating that levels of concern can fall after construction of a development (Young, 2003). These findings were further supported by those of Eltham, Harrison and Allen (2008) who demonstrated in their study of residents' attitudes before and after a wind farm was constructed in Cornwall that 'No statistically reliable change in opinion was identified for the residents' general acceptance of the wind farm between 1991 and 2006. However, the majority of the population was in support of the development both 'before and after' (Eltham, Harrison and Allen 2008: 32).

3.4.4 Echoing the findings of the two studies outlined above, Starling (2006) conducted a comparative study of the impact on residents of the existing wind farm at Delabole, Cornwall and a, then, proposed wind farm at Red Tile, Cambridgeshire and concluded that residents living near to the existing wind farm (Delabole) were more accepting of wind farm development than those at Red Tile where the wind farm had yet to be constructed.

3.4.5 These findings are also similar to those highlighted in a range of earlier research surveys examining the impact of wind farms on tourism. Table 1 below indicates the percentage of tourists that would *not* be discouraged from visiting an area if a wind farm was developed. There are two important points to note when drawing conclusions from these results. The first is that those surveyed are generally tourists visiting areas where wind farms do not yet exist but where there is a level of public anxiety as to the development and impact of proposed wind farms. As outlined in 3.4.3 above, opposition to wind farms tends to fall after the wind farm is developed and in operation. The second point to note is that the sampling frame is not all potential tourists but those tourists who have chosen to visit a particular area at a particular time, usually in the absence of a wind farm. To make an accurate assessment of the impact of wind farms on tourism requires that potential as well as actual tourists be taken into account. However, even among existing samples of tourists it is clear that a significant number of tourists are more and not less likely to visit an area if there is a wind farm. The research carried out in North Devon, for example, demonstrated that the majority of tourists (51%) thought that wind farms could also be visitor attractions for tourists and, in research conducted by NFO in Wales, 68% of tourists said they would be interested in attending a visitor centre at a wind farm development (Aitchison, 2004; NFO, 2003). These findings have clear implications for the Llanbrynmair Wind Farm development as the nearest visitor attraction to the proposed site is the Centre for Alternative Technology north of Machynlleth. There is potential for an innovative and collaborative approach to tourism between the wind farm development and this existing visitor attraction that already draws in over 30,000 tourists annually with an interest in renewable energy.

Table 1. Percentage of tourists not discouraged from visiting an area with a wind farm

Date	Author	Survey Locality	% Tourists Not Discouraged
1996	Robertson Bell Associates	Cornwall	94
1997	Robertson Bell Associates	Wales	83
2000	Cornwall Tourist Board	Cornwall	81.5
2001	Wales Tourist Board	Wales	96
2002	Centre for Sustainable Energy	Somerset	91.5
2002	MORI Scotland	Scotland	95
2004	University of the West of England (Aitchison)	North Devon	93.9
2006	Whinash	Cumbria	91
2008	Glasgow Caledonian University	Scotland	93-99
Average			**91.3**

3.5 Relevant Findings From the UWE and GCU Studies

3.5.1 Two major academic studies of the impact of wind farms on tourism have been conducted in the UK: the University of the West of England's (Aitchison, 2004) study titled *The Potential Impact of Fullabrook Wind Farm Proposal, North Devon: Evidence Gathering of the Impact of Wind Farms on Visitor Numbers and Tourist Experience* and Glasgow Caledonian University's (2008a) study *The Economic Impact of Wind Farms on Scottish Tourism*. Both of these studies address many of the shortcomings of earlier research in relation to weaknesses in the use of survey methods, sampling, interpretation and extrapolation of data as highlighted in section 3.3 above. The two university studies also meet the criteria of 'originality, significance and rigour' set out in the UK Government's Research Excellence Framework which is designed to identify high quality research in UK universities (Higher Education Funding Councils, 2011). Arguably, the two studies provide the most reliable knowledge base from which to draw conclusions about the impact of wind farms on tourism.

3.5.2 This report therefore accords greater weight to the findings of the studies conducted by UWE and GCU than to other smaller studies that have adopted less rigorous methodologies. Moreover, the findings of the UWE and GCU research are significant in relation to Llanbrynmair; not only because of the quality of the evidence presented but also because of the comparability between the tourism environments and policy contexts investigated in the UWE and GCU research (Devon, Cornwall, Wales, Scotland) and the tourism environment and policy context of Mid Wales. The relevant findings from these two studies are considered in turn below.

3.5.3 The UWE study is of relevance to the Llanbrynmair application because of the number of similarities between the two areas in relation to geography (rural and peripheral to main centres of population), landscape (predominantly rolling hills), proximity to National Parks (Exmoor in the case of Fullabrook and Snowdonia in the case of Llanbrynmair), proximity to coastal tourism areas (North Devon coastal resorts such as Ilfracombe in the case of Fullabrook and Cardigan Bay in the case of Llanbrynmair), tourist profile (wide-ranging tourist profile spanning high season mass tourism in the form of caravan users at coastal resorts through to more discerning tourists inland and in the shoulder season and with interests in the outdoors, active recreation, nature, historic sites and gardens, arts and crafts and food tourism) and, finally, tourism policy where in both Devon and Mid Wales the focus is upon developing sustainable tourism in the form of extending the tourism season and tourist expenditure by improving the quality of the tourist offer and experience in an effort to attract higher spending tourists, thus emphasising tourism value over tourist volume.

3.5.4 The sustainable development of the tourism sector has been identified as a strategic priority in both the South West of England and Mid Wales. In the case of Mid Wales this strategic direction aligns with wider Welsh Assembly Government spatial planning and economic development priorities for Wales and outlined in the following policy documents: *People, Places Futures: The Wales Spatial Plan* (2004a); *The Wales Spatial Plan Update* (2008); *Sustainable Development Strategy: Starting to Live Differently* (2004b); *Wales: A Vibrant Economy* (2005a); and *The Rural Development Plan for Wales Strategic Approach 2007-2013* (2005b).

3.5.5 The objectives outlined by South West Tourism for the development of tourism in the South West of England are almost identical to those of the Welsh Assembly Government and reiterated at a national level in *Achieving Our Potential: Tourism Strategy for Wales* (2006a) *and Tourism Strategy for Wales Mid Term Review* (2009) and at a regional level in the *Mid Wales Tourism Strategy* (Tourism Partnership Mid Wales, 2011). This similarity in policy context and strategic planning is both a reflection and consequence of the similar tourism environments and tourist profiles in both areas. Notwithstanding the different national contexts, it is appropriate to draw on the findings from the extensive research conducted in Devon and Cornwall to inform conclusions about the potential impact of wind farms in Mid Wales. Moreover, when combined with further primary research conducted by Professor Aitchison in other similar areas of Powys, Carmarthenshire and Northumbria, and further secondary research conducted in relation to Wales, Scotland and England, a clear body of evidence is amassed to build a consensus that, with current levels of development, wind farms do not have a negative impact on tourism.

3.5.6 In working with the South West Regional Development Agency to develop the ten year action plan *Towards 2015: Shaping Tomorrow's Tourism*, South West Tourism emphasised the following aims for tourism development in the region:

- Increase the proportion of GDP in the region from tourism and leisure
- Provide opportunities for new entrants and tourism-related businesses
- Make tourism a year-round activity
- Enhance the distinctive character and quality of local destinations

(South West Tourism, 2004)

3.5.7 Similarly, priority objectives for Visit Wales are identified as:

- Realising the importance of understanding and responding to customer needs
- Accepting that there is value to be gained from doing things differently to our competitors through innovative ways of working

- Acknowledging the need to secure a sustainable, long-term future through responsible destination and business management
- Seeking to maximise business profitability to drive growth in the tourism economy

(Visit Wales, 2006: 10)

3.5.8 The UWE study formed the basis of Professor Aitchison's evidence at the Public Inquiry into the Fullabrook proposal in 2006-07 (The Planning Inspectorate, 2007). The evidence presented also considered the unreliability of alternative research findings published in the North Devon Marketing Bureau's Wind Farm Research Report (North Devon District Council, 2006). The research methodology, analysis and presentation of the UWE study findings relating to the tourism impact of wind farms were fully accepted by the Inspector in his report and were seen as a model of good practice in research design, implementation and analysis (The Planning Inspectorate, 2007).

3.5.9 The UWE study was designed to establish the specific impact on visitor numbers, tourist experience and tourism expenditure of the proposed wind farm development at Fullabrook in North Devon. Fullabrook Down consists of 22 turbines with a combined capacity of 66,000 MW and has been in operation since January 2012.

3.5.10 The Fullabrook tourism impact research conducted formed the largest academic study to date at the time of publication and had the following aims:

- To provide evidence and analysis of the attitudes of tourists towards renewable energy in general and wind energy in particular
- To provide evidence and analysis of the impact of existing wind farms in areas popular with tourists
- To provide evidence and analysis of the potential impact on visitor numbers of a wind farm at Fullabrook, North Devon
- To provide evidence and analysis of the potential impact on the tourist experience of a wind farm at Fullabrook, North Devon
- To provide evidence and analysis of the potential impact on the local tourism economy of a wind farm at Fullabrook, North Devon
- To assess the views of tourists relating to the development of wind farms as tourist attractions

3.5.10 The research was designed to provide evidence of the potential impact of the proposed wind farm development on both visitor numbers (tourism volume) and tourist expenditure (tourism value). To provide additional data relating to the impact of existing wind farms comparative studies were conducted at Bears Down and St Breock wind farms in Cornwall and Carno and Bryn Titli wind farms in Mid Wales. The data gathered from the research in Mid Wales and Cornwall, combined with subsequent research results from Northumbria and Carmarthenshire is also of relevance to Llanbrynmair, again because of the similarities in tourism environment and tourist profile between the areas.

3.5.11 A total of 379 day visitors and tourists were interviewed in Devon, Cornwall and Mid Wales during May 2004 using an interviewer-administered questionnaire with 21 questions. In North Devon 196 interviews were conducted in coastal towns and villages including Ilfracombe, Woolacombe, Braunton and Barnstaple in addition to tourist sites at a range of quieter locations inland that are popular with walkers and closer to the wind farm site. In Cornwall 90 interviews were conducted at various locations within a 10km radius of the two established wind farms at Bears Down and St Breock north east of Newquay. In Mid Wales 93 interviews were conducted near the two established wind farms of Bryn Titli and Carno.

3.5.12 Interviewer-administered questionnaires were used as interviewers could ensure that the sample of respondents was obtained from a representative range of tourism locations. Whilst it is not possible to guarantee a truly representative sample of respondents in such a survey as the total population of tourists is not known exactly, the sample obtained was deemed to be as representative as possible. Interviewer-administered questionnaires were completed at a range of sites visited by tourists in North Devon. The interviewers were all trained in tourism research techniques with each interviewer questioning tourists in order of their arrival as soon as the interviewer became free. This method of research is therefore preferable to self-completion or postal questionnaires which have entirely self-selecting samples, notoriously low response rates and are open to misuse as one individual can complete more than one questionnaire.

3.5.13 Because there are difficulties in measuring the impact of something that has not yet been constructed, the comparative studies undertaken in Cornwall and Mid Wales were particularly important. It is significant that the findings from both Mid Wales and Cornwall, where interviewees were questioned near existing wind farms, supported the findings in North Devon; that wind farm developments do not have a detrimental impact on tourism.

3.5.14 The research findings revealed overwhelming support for renewable energy in general and the proposed wind farm in particular. The findings demonstrated that the construction of Fullabrook wind farm would not have a detrimental impact on visitor numbers, tourist experience or tourist expenditure in the area of North Devon.

3.5.15 The findings from the North Devon study demonstrated that the potential impact of a wind farm in North Devon on day visitor and tourist numbers would be as follows:

- A total of 86.7% (n=170) respondents stated that the presence of a wind farm would neither encourage nor discourage them from visiting
- A further 7.2% (n=14) of those surveyed said that a wind farm would either marginally encourage or strongly encourage them to visit the area
- A further 6.1% (n=12) said that the presence of a wind farm would either marginally discourage or strongly discourage them from visiting

3.5.16 The potential impact of wind farms on the tourist experience was as follows:

- The majority of respondents (58.2%, n=114) thought that wind farms have 'no overall impact' on the visitor or tourist experience
- A total of 18.4% (n=36) of those questioned thought that wind farms have a positive impact on the visitor or tourist experience
- A total of 14.8% (n=29) thought that wind farms have a negative impact on the visitor or tourist experience

3.5.17 The findings of the research therefore contradicted the argument that tourists would inevitably view the wind farm as having a detrimental impact on the attractiveness of the landscape and would therefore be put off visiting North Devon as suggested by North Devon Marketing Bureau (2004) on behalf of North Devon District Council. Indeed North Devon's own research reported that more tourists surveyed (33%) stated that 'the wind farm would be aesthetically pleasing' than stated that it would be 'a blot on the landscape' (25%). Words such as 'graceful', 'elegant' and beautiful' were used to describe wind turbines/farms by respondents to the North Devon Marketing Bureau survey. Moreover, in a number of studies that have adopted qualitative measures, respondents have referred to synergies between green energy and green (or sustainable) tourism and the area around Llanbrynmair and Machynlleth has potential to develop this connection.

3.5.18 As the construction of the proposed wind farm at Fullabrook was found to have no adverse effect on day visitor or tourist numbers it could not be deemed to have a likely negative impact on day visitor or tourist expenditure.

3.5.19 When asked 'Do you think wind farms can be tourist attractions?' just over half of those questioned (51.0%, n=98) answered 'yes'. A total of 43.8% (n=84) respondents said that they did not think wind farms could be tourist attractions and a further 5.2% (n=10) stated that they did not know or had no opinion. Interestingly, the *Investigation into the Potential Impact of Wind Farms on Tourism in Wales*, by the Wales Tourist Board in 2003 found that 68% of those questioned would be interested in attending a visitor centre at a wind farm. At Rheidol, for example, the hydroelectric power station and wind farm receives approximately 10,000 visitors per year to the visitor centre (British Wind Energy Association, 2010).

3.5.20 The findings related to the potential impact of the development of the proposed wind farm indicate there would be neither an overall decline in the number of tourists visiting the area nor any overall financial loss in tourism-related earnings as a result of the wind farm. In fact, it is quite possible that the wind farm could result in an increase in visitor numbers and tourist-related expenditure.

3.5.21 The findings from the UWE study in North Devon broadly accord with those of the other major academic study of the impact of wind farms on tourism; that conducted by Glasgow Caledonian University in 2008 into *The Economic Impact of Wind Farms on Scottish Tourism*.

3.5.22 Previous research has demonstrated that the development of sustainable tourism, and the attraction of tourists with an interest in the environment, natural heritage and culture, is wholly compatible with the development of renewable energy including wind farms. Predictions outlined in the GCU research examining the impact of wind farms on tourism are that 'If the renewables target (to generate at least 50% of Scotland's electricity from renewable sources by 2020) is met via substantial wind farm development, Scottish tourism revenues in 2015 are forecast to be 0.18% lower (£7.6 million) than they would have been if there were no wind farms in Scotland (Glasgow Caledonian University, 2008b: 1). It is vital to note here that the authors of the report emphasise that this figure of 0.18% does not represent a reduction from current levels of tourism revenue but a reduction in the predicted level of growth between 2008 and 2015. Moreover, as the authors of the study stress, 'Those areas with fewer wind farms are likely to see greater increases in tourism than they would otherwise and this will act to offset slower growth in other parts of the country. Only a negligible fraction of tourists will change their decision whether to return to Scotland as a whole because they have seen a wind farm during their visit' (Glasgow Caledonian University, 2008b: 6).

3.5.23 Indeed, the authors of *The Economic Impact of Wind Farms on Scottish Tourism*, concluded that 'Overall the finding of the research is that if the tourism and renewable industries work together to ensure that suitably sized wind farms are sensitively sited, whilst at the same time affording parts of Scotland protection from development, then the impacts on anticipated growth paths are expected to be so small that there is no reason to believe that Scottish Government targets for both sectors are incompatible' (Glasgow Caledonian University, 2008b: 8).

3.5.24 Similarly, the research conducted by GCU stated that 'Importantly, respondents that had seen a wind farm were less hostile than those who had not' (Glasgow Caledonian University, 2008b: 3). Starling's and Glasgow Caledonian University's findings therefore lend support to Young's 2003 research; namely, that opposition to wind farms tends to fall after construction.

3.5.25 The GCU research also reiterates findings from the research conducted in North Devon by Professor Aitchison and discussed in detail above. In particular, the Scottish research found that 'The vast majority (93-99%) of tourists that had seen a wind farm in the local area suggested that the experience would not have any effect on their decision to return to that area, or to Scotland as a whole (Glasgow Caledonian University, 2008b: 4).

3.5.26 The UWE and GCU studies are therefore consistent in their conclusion that the development of wind farms will not result in a reduction in tourist numbers, tourist experience or tourism revenue. Given the similarity between North Devon, Scotland and Mid Wales in tourism landscapes, visitor attractions and tourists themselves, it is quite likely that it will also be the case that the development of a wind farm at Llanbrynmair will induce no overall financial loss in tourism-related earnings.

3.5.27 It is quite possible that the development at Llanbrynmair could result in a small increase in visitor numbers and tourist-related expenditure if developed to collaborate with the Centre for Alternative Technology just north of Machynlleth.

4. TOURISM POLICY CONTEXT OF LLANBRYNMAIR WIND FARM

4.1 Introduction

4.1.1 This section synthesises the evidence outlined and evaluated above to provide an informed judgement of the potential impact on tourism of the Llanbrynmair Wind Farm. This comparative assessment is set alongside an actual assessment of tourism in the Llanbrynmair area with this assessment undertaken through a combination of primary and secondary research comprising:

- Analysis of tourism policy at national, regional and county level
- Field visit to the Llanbrynmair area including visits to the proposed wind farm sites, surrounding villages and visitor attractions
- Review of literature and information on visitor attractions, visitor accommodation and tourism activities in the Llanbrynmair area
- Follow up conversations and telephone calls with the managers of the only visitor attraction in Llanbrynmair and of a nearby country house bed and breakfast

4.1.2 The evidence presented below takes three forms:

- Evaluation of tourism policy in Wales and, specifically, Mid Wales, including an assessment of any potential conflict between local tourism policy and renewable energy development
- Evaluation of the nature of tourism within the vicinity of Llanbrynmair, including an assessment of any potential conflict between local tourism and renewable energy development
- Assessment of the likely impact on specific visitor attractions and visitors of a wind farm development at Llanbrynmair

4.1.3 In presenting an evaluation of the likely impact of Llanbrynmair wind farm on specific visitor attractions and visitors, the assessment focuses in detail on the defined site development area and visitor attractions and tourist accommodation within 10 miles of Llanbrynmair village. The assessment is contextualised within an evaluation of visitor attractions, tourist accommodation and tourism activities within the wider surrounding area which includes the TAN 8 Boundary and the smaller Powys Refined SSA which sits almost entirely within the TAN 8 Boundary. Cognisant of the guidance provided in section 3.3.4, which stressed the danger of exaggerating impact (which could be either positive or negative) by extrapolating data gathered in one specific location and applying the data to a wider regional context in some kind of cumulative or multiplier effect, this assessment focuses on the impact on tourism in the specific area in question. It is noted that Llanbrynmair village does not represent the central point of the wind farm site. Instead, it is located just over 2km west-south-west of the most south-westerly turbine (No. 30 sited on Banc y Gorlan). However, the vast majority of visitor attractions and accommodation within and around the TAN 8 area are located to the south and west of the village. Thus by taking Llanbrynmair village as the central point for the survey a wider range of tourist sites are incorporated in the analysis than if the radius of the search area were drawn from the central point of the wind farm site.

4.1.4 The nearest major settlements lie to the west and north-west of Llanbrynmair village although the town of Newtown is located 18 miles to the south-east and Welshpool just over 30 miles to the north-east. The area to the north, east and south of Llanbrynmair is sparsely settled with the main farms and communities from north to east located at Pandy, Pentre Celyn, Clegyrnant, Dolwen, Sychtyn, Llangadfan, Llanerfyl, Neinthirion, Cwmderwen and Rhyd. Along the A470, which runs east to west through Llanbrynmair village, are the settlements of Carno, Talerddig and Dolfach to the east and Tafolwern, Comins Coch and Cemmaes Road to the west. Two miles south of Llanbrynmair, on the B4518 and on the original site of the village of Llanbrynmair, is Bont-Dolgadfan. The larger town of Machynlleth is located approximately 10 miles west of Llanbrynmair village. Aberangell, Dinas Mawddy and Mallwyd are all located within 10 miles to the north-west of Llanbrynmair and accessible on the A470 to Dolgellau.

4.2 Tourism Policy in Wales

4.2.1 National and local government, together with national and regional tourist boards, have recently adopted tourism-related policies and practices designed to maximise the economic and social benefits of tourism whilst simultaneously minimising tourism's negative environmental impacts. This policy agenda is particularly important for those authorities and agencies with responsibility for developing tourism in rural and remote areas such as Mid Wales. To ensure the sustainable development of tourism attention has thus focussed on developing strategies that seek to promote *quality* of experience and level of tourist expenditure over *quantity* of tourists. *Achieving Our Potential: Tourism Strategy for Wales 2006-2013 Mid Term Review* (Welsh Assembly Government, 2009) and the *Sustainable*

Tourism Framework (Welsh Assembly Government, 2007) set out the strategies for tourism and sustainable development across Wales.

4.2.2 The *Sustainable Tourism Framework* for Wales has been developed within the context of both the overarching national tourism strategy for Wales *Achieving Our Potential: Tourism Strategy for Wales 2006-2013* (Welsh Assembly Government, 2006) and wider national strategies that respond to the *Wales Spatial Plan: People, Places Futures* (Welsh Assembly Government, 2004a). These wider national strategies have been developed in relation to economic, social, cultural and environmental policy priorities identified by the Welsh Assembly Government and are outlined in the following policy documents addressing economic, social and environmental policy priorities:

- *Wales: A Vibrant Economy* (2005)
- *The Rural Development Plan for Wales Strategic Approach 2007-2013* (2005)
- *Well-being in Wales* (2002)
- *Health Challenges Wales* (2004c)
- *The Environment Strategy for Wales* (2006b)
- *Starting to Live Differently: Sustainable Development Strategy* (2004b)

4.2.3 Tourism, and the associated policy areas of culture, leisure and sport are addressed within a comprehensive set of strategy documents to emerge within the last decade and which seek to identify and promote mechanisms for utilising tourism as a vehicle to achieve the wider economic, social and environmental objectives outlined in the strategies above. In particular, the following current policy documents are of relevance to any analysis of tourism in the Llanbrynmair area:

- *Cultural Tourism Strategy for Wales*
- *Coastal Tourism Strategy*
- *Creative Futures*
- *Climbing Higher: Sports Strategy for Wales*
- *Sport Tourism in Wales: A Framework for Action*
- *Catching the Wave: Wales Tourism Watersports Strategy*
- *Moving Up a Gear: A Cycling Tourism Strategy for Wales*
- *Best Foot Forward: A Walking Tourism Strategy for Wales*
- *Saddling Up For Success: A Riding Tourism Strategy for Wales*
- *Angling For Growth: A Fishing Tourism Strategy for Wales*

- *Time For Action: An Adventure Tourism Strategy for Wales*
- *WTB Activity Tourism Action Plan*
- *National Events Strategy*
- *Action Plan for the Countryside Experience*

4.2.4 The policies and strategies adopted for tourism in Wales accord with the principal policies outlined in the *Good Practice Guide on Planning for Tourism* which identifies tourism, like renewable energy development, as a key element in:

- rural farm diversification
- an aid to the revitalisation of market towns and villages
- a support for important rural services and facilities
- and a means by which environmental schemes and improvements to the built and natural environment can be enhanced

(Department for Communities and Local Government, 2006: 20-21)

4.2.5 Current thinking related to the development of sustainable tourism, as stated in the 2006 *Good Practice Guide on Planning for Tourism*, fully recognises that tourism needs to be developed alongside local community needs for energy and other forms of industry in addition to the development of related forms of service sector provision (Department for Communities and Local Government, 2006).

4.2.6 As such, the proposal being considered here, to develop a wind farm at Llanbrynmair, is aligned with the policies and strategies adopted for tourism in Wales. The proposal is also in accord with the principles outlined in the Planning Policy Statement 7: *Sustainable Development in Rural Areas* which sets out national planning policies on the development of tourism and leisure in rural areas and is consistent with the *Good Practice Guide on Planning for Tourism* (Department for Communities and Local Government, 2006).

4.3 Tourism Policy in Mid Wales and Powys

4.3.1 At regional level, policy priorities for tourism are developed by one of the four Regional Tourism Partnerships in Wales; Tourism Partnership Mid Wales (TPMW). Like the other three Regional Tourism Partnerships, TPMW is a public-private sector partnership funded by the Welsh Government to develop and promote tourism within one of the four regions. TPMW covers the counties of Powys, Ceredigion to the west and the Meirionnydd area of Gwynedd to the north. Although located within Powys it is important to note that Llanbrynmair is in the north-west of the region and as near to the coast of Ceredigion in the west and the mountains of Snowdonia National Park in the north as it is to the administrative centre of Powys in Llandrindod Wells to the south. This location influences the destination 'brand' of the area surrounding Llanbrynmair, the kinds of tourism provided in the area and the types of tourist who visit the area.

4.3.2 The Mid Wales Tourism Strategy (Tourism Partnership Mid Wales, 2011) recognises the extent and diversity of the Mid Wales Region. The document defines the Region as 'A Polyglot Area' and emphasises the impact of this lack of both homogeneity and clarity of identity for tourism policy, planning, development and marketing:

- Mid Wales extends over 80 miles (as the crow flies) from Porthmadog in the north to Crickhowell in the south and 50 miles from Aberaeron on the west coast to Presteigne on the English border
- It is not a homogenous physical area being made up of the Cardigan Bay coast (part), the Cambrian Mountains (part), Snowdonia (part), the more gentle rural areas of Montgomeryshire and Radnorshire and the wild, upland area of the Brecon Beacons
- This local geography suggests four natural tourism destinations across the Region i.e. Ceredigion, the Brecon Beacons, Snowdonia (part) and that part of Powys outside the National Park
- The individual destinations within the Region vary in physical and social terms and although there are some common products and themes, they differ in what they offer
- What the Region does have in common is a generally low population density living in a rural, but varied, landscape where agriculture dominates and there are common problems associated with the rural economy.

4.3.3 The challenges associated with the rural economy in Powys have been well documented and are evidenced in economic data in *Productivity in Powys 2004-2008* (Powys County Council, 2011a). Seven factors have been identified as constraining economic development in Mid Wales (Greaves and Morgan, 2011). Two of these factors relate to the structure of the economy and employment in rural areas and the other four factors represent particular concerns for the tourism industry:

- High levels of self employment (although entrepreneurship is an economic catalyst an over-reliance on self-employment prevents the formation of large and more profitable enterprises)

- Small size of business (the majority of tourism businesses are SMEs with most rural businesses usually employing fewer than 10 staff)
- Slow broad band speed (tourism is increasingly reliant on digital technology for marketing, sales and the enhancement of the visitor experience)
- Fewer hours worked per week (the casual and seasonal nature of tourism employment means that full-time and permanent jobs are low in number)
- Lower wages (the casual and seasonal nature of tourism employment means that professional jobs and employment career tracks are available for only a few workers)

4.3.4 Tourism policy in Powys seeks to stimulate the rural economy and is contextualised within both the County Council's Corporate Plan *The Powys Change Plan* (2011b) and the *Powys Regeneration Strategy* (2011c) and specified within the *Mid Wales Tourism Strategy* (Tourism Partnership Mid Wales, 2011). Tourism forms one of nine 'key themes' in the Powys *Regeneration Strategy* and the *Mid Wales Tourism Strategy* highlights four objectives for sustainable tourism development in Mid Wales:

- To organise tourism resources in the most effective manner across the Region
- To provide the appropriate infrastructure and high quality, sustainable, distinctive destinations, facilities and services, that will encourage more visitors to visit throughout the year, thereby encouraging growth in the visitor economy
- To encourage more local people to follow and develop worthwhile careers in the tourism industry
- To maximise opportunities for tourism development with and between different agencies

(Tourism Partnership Mid Wales, 2011)

4.4 The Volume and Value of Tourism in Mid Wales and Powys

4.4.1 The volume and value of tourism is often difficult to determine in relation to specific regions and even more so in respect of local areas. Clarity of definitions is essential and, in this particular context, differentiating between business tourism and leisure tourism, overnight stays and day visits, and visits to Wales and within Wales present challenges to obtaining accurate economic data. Notwithstanding these difficulties, the Welsh Assembly Government, drawing on data from the Welsh Economy Research Unit (WERU) at Cardiff University, has placed the value of tourism to the Welsh economy at £1.8 billion for 2010, up from £1.1 billion in

2000. This figure is derived from almost 10 million visits including almost one million international visitors. In addition, day visitor expenditure attributable to tourism is deemed to be approximately £1.5 billion.

4.4.2 The volume and value of tourism in Wales is unevenly spread. Various sources agree that visitor numbers and levels of expenditure (tourist volume and value) are lower in Mid Wales than other areas of Wales. For example, the Welsh Assembly Government (2011) estimated that in 2010 tourists to Mid Wales made slightly fewer trips (1.59 million) than tourists to either South West Wales (1.84 million) or North Wales (3.4 million). According to the same source, tourists to Mid Wales also stayed for fewer nights (6.53 compared to 7.29 in South West Wales) and contributed less to the tourism economy (£269 million compared to £330 million in South West Wales and £518 million in North Wales). Powys Country Council estimated the volume and value of tourism in 2010 at 3 million day visitors and 1.5 million overnight visitors with an average length of stay of 5.06 nights and an average combined visitor spend from day visitors and overnight visitors of £638.8 million (Greaves and Morgan, 2012). Tables 2 and 3 below illustrate figures for tourist numbers (tourism volume) and expenditure (tourism value) from 2005 to 2010 respectively (Powys County Council, 2011d). Of particular note is the decrease in visitor numbers year on year over a six year period from 4.9 million in 2005 to 4.4 million in 2010. There has been an increase in visitor spending from £595 million in 2005 to £639 million in 2010 although the 2010 figure is a significant drop from the six year high of £672 million in 2007; the last year before the current economic downturn.

Table 2. Powys tourism volume 2005-2010

Tourist Numbers (thousands)	2005	2006	2007	2008	2009	2010
Serviced Accommodation	438	421	406	419	373	376
Non-serviced Accommodation	756	808	840	909	876	874
SFR (Staying with Friends & Relatives	202	203	202	204	205	203
Day Visitors	3,508	3,394	3,373	3,216	3,116	3,001
TOTAL (rounded)	**4,904**	**4,825**	**4,821**	**4,748**	**4,571**	**4,455**

Table 3. Powys tourism value 2005-2010

Revenue by Category of Visitor (£ million)	2005	2006	2007	2008	2009	2010
Serviced Accommodation	88.7	86.0	88.9	92.5	81.5	81.8
Non-serviced Accommodation	388.8	411.8	429.9	470.1	449.6	453.1
SFR (Staying with Friends & Relatives	23.9	24.1	24.0	24.2	24.3	24.1
Day Visitors	93.2	90.1	89.6	85.5	82.9	79.8
TOTAL (rounded)	**594.6**	**611.9**	**632.4**	**672.3**	**638.3**	**638.8**

4.5 The Nature of Tourism in Mid Wales and Powys

4.5.1 The Mid Wales Tourism Partnership area includes all of Powys and a stretch of the Cardigan Bay coast, which is a popular destination for family seaside holidays, and the southern part of Snowdonia National Park, which is popular with walkers and climbers. Within the county of Powys, Montgomeryshire forms the most northerly of the three established 'shires'. Llanbrynmair is one of the most westerly areas of Montgomeryshire and thus, as stated earlier in this report, is proximate to both the region of Ceredigion which encompasses the Cardigan Bay coast and the Region of Gwynedd which encompasses Snowdonia National Park. The location of Llanbrynmair, at the intersection of these different regions and landscapes, results in a destination that is attractive to different types of tourists, many of whom are attracted to the area because of its proximity to a range of visitor attractions reflecting the diversity of the landscape: mountain, coastal and rural.

4.5.2 The variety of tourism destinations around Llanbrynmair makes the area attractive to different types of tourists seeking different kinds of activities and experiences. These range from the established tourism market catering for family holidays, often in park accommodation, through to niche markets specialising in heritage tourism, sport tourism and nature tourism.

4.5.3 The Llanbrynmair area has a low density of visitor attractions and tourist accommodation relative to many other areas of Wales. Those day visitors and tourists attracted to the area are drawn by a range of features, most notably the landscape which provides scenic beauty and tranquil environments for a range of outdoor leisure, recreation and sport. The area to the south-west of the proposed wind farm site has a number of camping and caravan sites and is popular with walkers and mountain bikers. The River Dyfi to the west and its tributaries the Laen to the east, Twymyn to the south and west and Rhiwsaeson to the north are popular for fishing. A range of landscapes from upland plateau to dense forest also provide attractive environments for birdwatchers, particularly those wishing to view red kites.

4.5.4 It is these types of environment that both Visit Wales and Mid Wales Tourism Partnership have sought to market through their branding of the area as an attractive destination for outdoor activities and sustainable rural tourism. This 'brand', and the strategies required to develop sustainable rural tourism, are outlined in a number of national policy documents including *Sustainable Tourism: A Framework for Wales* (Welsh Assembly Government, 2007) and the *Action Plan for the Countryside* (Welsh Assembly Government and Wales Tourist Board, 2004). *Sustainable Tourism: A Framework for Wales* (2007) develops a vision for tourism, together with four key objectives to support the vision, where:

> *Wales is recognised internationally as a leading sustainable tourism destination that promotes local economic prosperity, supports community well being and engagement, enhances its natural environment and culture and delivers a high quality experience to visitors.*
>
> *There are four key objectives supporting the vision:*
>
> - *Promoting local prosperity*
> - *Supporting community well being and involvement*
> - *Minimising tourism's environmental impact*
> - *Protecting and giving value to natural heritage and culture*
>
> (Welsh Assembly Government, 2007: 5)

The 2004 Report of the Working Party on Countryside Tourism to the Welsh Assembly Government formed an 'Action Plan for the Countryside Experience' in which the vision for the countryside experience in Wales is:

The destination of choice for visitors seeking a varied and quality countryside experience, whether this is as an activity enthusiast or the general visitor attracted by the quality environment, range of attractive accommodation, food and things to do.

The experience is delivered to visitors in an integrated manner by prosperous self-confident rural businesses and communities, who have taken responsibility for their own destiny. The experience is presented in a way that uses a distinctive Welsh sense of place that differentiates the experience from that offered by competitors, and provides economic benefits for the host communities whilst also supporting their local Welsh culture.

(Welsh Assembly Government and Wales Tourist Board, 2004: 6)

4.5.6 At a regional level the priority, as in many rural tourism locations, is to enhance quality, diversify provision and develop tourism more evenly both temporally, by extending the season, and spatially, through leveraging and sustaining rural development. With an emphasis on tourism value over tourist volume tourism growth is focussed on niche markets in adventure tourism, cultural tourism, ecotourism, film tourism, food tourism, geotourism, golf tourism, heritage tourism, nature tourism, and sport tourism attracting more national and international tourists. In 2006, the national tourism body for Scotland, VisitScotland, identified six characteristics as essential for such growth:

- *Offering a wide product and experience base which is well marketed and offers discovery and experience as key themes*
- *Targeting growing interest in outdoor activities, cities, culture, well-being and business tourism*
- *using traditional culture and heritage to differentiate from other destinations, and using special events to boost profile and visitor numbers*
- *making heavy use of the internet to promote themselves*
- *Using private/public partnerships to deliver key roles*
- *depending on domestic tourism as well as the international market, convincing local people of benefits of tourism and tourist-friendly attitudes*

4.5.7 Moving from a national and regional to a local level, Powys County Council has reinforced the visions outlined above in a range of strategies recently encapsulated in the £2.6 million *Sustainable Tourism Powys* project which is designed to promote tourism. In an around Llanbrynmair tourism is largely concentrated on small family-run businesses that are also reliant on repeat business from local people to sustain them. This means that businesses are frequently diverse and need to be adaptable.

5 TOURISM IMPACT OF LLANBRYNMAIR WIND FARM

5.1 Introduction

5.1.1 This section of the report examines the range of visitor attractions and tourist accommodation in the wider region surrounding LLanbrynmair. By mapping the tourism businesses in both the wider region and in the more immediate area it becomes possible to ascertain the extent of tourism businesses that might *perceive* a potential impact from the development of a wind farm at LLanbrynmair. Here it is important to differentiate between tourism businesses and tourists themselves. There has been no actual research of the potential impact on tourists in the LLanbrynmair area and there is no evidence from any research anywhere else in the UK that supports the view that wind farm developments impact negatively on tourist volume (visitor numbers), value (tourist expenditure) or experience (tourist satisfaction). There is, however, understandable concern among tourism businesses that such a development might impact negatively upon their business and thus the fewer number of businesses in the vicinity of the wind farm site the easier it is to demonstrate that there is neither a legitimate concern over real or perceived impact.

5.1.2 In previous research undertaken by Aitchison in relation to the proposed Devon Wind Power development at Fullabrook in Devon, wind farms at Carno and Bryn Titli provided sites for conducting surveys of tourist attitudes. The results of the surveys accorded broadly with those evaluated in section 3 of this report; that is that the development of a wind farm would not impact negatively on tourism.

5.1.3 The following analysis demonstrates that there is a low concentration of tourism businesses in the vicinity of the Llanbrynmair site. This is to be expected given that upland areas with high wind speeds are favourable locations for wind farms but less favourable as locations for settlements. It should be noted, however, that such landscapes also provide attractive and appropriate environments for a number of rural recreation pursuits and tourism activities. Notwithstanding the attractiveness of the landscape in the Llanbrynmair area, it is notable that there is a lower concentration of tourism businesses and tourists than in other areas of the UK with similar landscapes, including other areas of Mid Wales.

5.1.4 The assessment made focuses on the predominant forms of tourism and tourism businesses in the area, namely visitor attractions, tourist accommodation and tourist activities. Visitor attractions comprising pay to enter and free admission were mapped with the mapping exercise indicating that there are few visitor attractions in the Llanbrynmair area. Tourist accommodation was similarly mapped and again the exercise illustrates a relatively low concentration of accommodation with a particularly low concentration of high value accommodation such as hotels. Notwithstanding the relatively low concentration of formal visitor attractions and tourist accommodation it is important to identify other activities and attractions that encourage tourists and day visitors to visit the Llanbrynmair area albeit without visiting formal tourist attractions or staying in local tourist accommodation. This final form of analysis enables account to be taken of the importance of day visits to this area of Wales, particularly for active sport and recreation.

5.2 Visitor Attractions

5.2.1 As previously stated, tourism in Wales is organised into four regions and the large Mid Wales Tourism Partnership region includes the area around Llanbrynmair. The Welsh Assembly Government (2012) report titled *Visits to Tourist Attractions in Wales 2011: Report for Visit Wales* lists 214 attractions in Wales with 44 or 20.5% located in the MWTP area. This figure suggests that the concentration of visitor attractions in the MWTP area is slightly lower than in the other three regions.

5.2.2 Of the 117 visitor attractions that charge an entry fee listed in the *Visits to Tourist Attractions in Wales 2011*, 31 (26%) are in Mid Wales (Welsh Assembly Government, 2012). A slightly lower proportion of free attractions are located in the MWTP area with 13 (13.4%) of the 97 attractions that are free to enter and listed in the 2012 report located in the MWTP area.

5.2.3 Of the top ten pay to enter visitor attractions in Wales in 2011 only one, Portmeirion, was defined by Visit Wales as being in 'Mid Wales' or the MWTP region. Located in Gwynedd, and approximately 50 miles and over one hour's travel from Llanbrynmair, it is unlikely that many visitors to Portmeirion would also be visitors to the Llanbrynmair area. In the course of the research undertaken for this report, business owners in the Llanbrynmair area pointed out that the A470, that runs east-west through Llanbrynmair, tends not to be used as an access route by visitors to the coast and North Wales due to perceived levels of traffic in the Newtown area. This was perceived to be a recent change that had impacted negatively on visitor numbers in the Llanbrynmair area.

5.2.4 Of the top ten free to enter attractions in Wales in 2011 none were in Mid Wales.

5.2.5 The MWTP region does include a representative number of visitor attractions but these are not as popular as visitor attractions in other parts of Wales and none of the popular visitor attractions are located in or near the LLanbrynmair area. The most popular 20 visitor attractions (pay to enter and free to enter) in Mid Wales in 2011 are listed in Table 4 below (Welsh Assembly Government, 2012). Of these, 11 attractions are pay to enter and nine are free. None of the 20 most popular visitor attractions in Mid Wales are within 10 miles of Llanbrynmair.

Table 4. Top Twenty Visitor Attractions in Mid Wales (2011)

	Visitor Attraction (Pay to Enter)	Adult Entry Fee (£s)	Number of Visitors in 2011	% Change from 2010	Miles from Llanbrynmair
1	Portmeirion	£9.00	234,098	-3.0%	46
2	Elan Valley Visitor Centre	Free	134,614	-3.0%	37
3	Brecon Beacons Mountain Centre	Free	132,358	-7.3%	74
4	Bwlch Nant yr Arian Visitor Centre	Free	125,037	NA	36
5	Brecon Cathedral and Heritage Centre	Free	120,000	NA	68
6	Powys Castle and Garden	£11.80	116,464	8.3%	31
7	Harlech Castle	£3.80	92,404	0.1%	43
8	Talyllyn Railway	£13.00	46,934	NA	26
9	Aberystwyth Cliff Electric Railway	£3.50	45,259	NA	30
10	Vale of Rheidol Railway	£14.50	41,319	NA	29
11	Cantref Adventure Farm	£8.00	39,336	NA	70
12	King Arthur's Labyrinth	£7.90	38,583	NA	17
13	Devil's Bridge Waterfalls	£3.50	35,124	-7.0%	39
14	Centre for Alternative Technology	£8.50	34,603	NA	14
15	Ceredigion Museum	Free	31,371	NA	29
16	Uni Wales Aberystwyth Gallery/Museum	Free	27,000	NA	29
17	Museum of Modern Art	Free	22,317	12.6%	11
18	Welsh Wildlife Centre	Free	22,000	NA	72
19	Ynys Hir Reserve Information Centre	£3.00	21,857	NA	18
20	Bala Lake Railway	£9.50	20,420	15.6%	33

5.2.6 The perceived and potential impact of any development should be assessed in relation to all visitor attractions. The Machinations Museum of Automata is a significant visitor attraction within the Llanbrynmair area and not listed in the *Visits to Tourist Attractions in Wales 2011 Report for Visit Wales* (Welsh

Government, 2012). Entries are the result of self-reporting by each visitor attraction and the owner-manager of Machinations stated that she neither had the means to monitor visitor numbers nor so the value in doing so. The Machinations Museum of Automata is located in the Old Village Hall in Llanbrynmair and comprises the only permanent exhibition of contemporary Automata (mechanical moving models) in the UK. The museum is also the 'home of the world famous timber kits' and houses a cafe, shop 'rabbit village' and play barn. The attraction is targeted at young children and families and the entry fee is £2.75 for children over the age of two. Unlike many visitor attractions in Wales, Machinations is open seven days a week and all year. This year-round opening is only possible because Machinations is as reliant on local repeat visits and the hosting of birthday parties and other events, as it is on tourism. The business has diversified over the years to remain viable.

5.2.7 Other visitor attractions in the wider area surrounding Llanbrynmair can largely be grouped into three main categories: industrial heritage; castles, museums and crafts; and nature and wildlife. There is, however, one significant visitor attraction that does not fall into any of these specific categories. The Centre for Alternative Technology, just north of Machynlleth, is the 14th most popular visitor attraction in Mid Wales. It has developed over the last 35 years to cover a site of over seven acres of hands-on displays and gardens focussed on alternative technology for renewable energy and sustainable food production. Were the Centre for Alternative Technology to link some of its education initiatives specifically to the wind farm at Llanbrynmair and vice versa then the combined developments, perhaps supported by a visitor centre at the wind farm, have the potential to define this area of Wales as a national centre for visitor attractions relating to renewable energy.

5.2.8 The rich industrial heritage of Mid Wales has provided a resource for a number of visitor attractions most of which showcase or celebrate either mining or steam trains. Corris Mine Explorers at Corris provides an insight into the workings of an old Welsh slate mine where visitors can enter and travel along the abandoned tunnels in guided tours. The Corris slate mine is also near King Arthur's Labyrinth, the 12th most popular pay to enter visitor attraction in Mid Wales. Other visitor attractions based on mining are found further afield at Sygun Copper Mine in Snowdonia National Park and at Go Below Underground Adventure just south of Betws-y-Coed. The Welshpool and Llanfair Railway runs north-east of Llanbrynmair between Welshpool and Llanfair Caereinion from April to October.

West of Llanbrynmair the Talyllyn Railway, the 8th most popular pay to enter attraction in Mid Wales, runs from Tywyn Wharf to Nant Gwernol between the months of April to October with additional opening at half term and Christmas holidays. There are a number of other steam railways and trains that act at visitor attractions in the region and these include the Fairbourne Railway from Fairbourne to Barmouth Ferry Station; the Vale of Rheidol Railway which runs from Aberystwyth to Devil's Bridge; the Bala Lake Railway from Llanuwchllyn to Bala Station at Penybont and the well known Ffestiniog Railway from Porthmadog to Blaenau Festiniog.

5.2.9 Powys Castle and Gardens near Welshpool is the 6th most popular pay to enter visitor attraction in Mid Wales and is approximately 30 miles from Llanbrynmair. Harlech Castle is the 7th most popular pay to enter visitor attraction in Mid Wales but is further than Powys Castle at 43 miles from Llanbrynmair. The National Owain Glyndwr Centre, housed in The Parliament Building in Machynlleth, is open from March to December and is approximately 10 miles from Llanbrynmair. The Oriel Gallery and Shop in Machynlleth sells a wide variety of local arts and crafts as does the Corris Craft Centre just north of Machynlleth. Slightly further north the Meirion Mill Shop, housed in the former terminus of the old Mawddwy Railway at Dinas Mawddwy, stocks a range of clothing and gifts and has a coffee shop.

5.2.10 Although nature and wildlife are factors that draw visitors to the area there are relatively few visitor attractions. The Animalarium Borth Zoo, located between Aberystwyth and Machynlleth is open all year round and The Magic of Life Butterfly House at Cwm Rheidol is open from March to November but neither of these is particularly near Llanbrynmair. Lake Vyrnwy RSPB centre is 30 miles north of Llanbrynmair and popular with birdwatchers.

5.2.11 Within Llanbrynmair itself there are no visitor attractions other than Machinations although in and around the village there are a few hospitality businesses and three caravan and camping sites. There is one public house within the village; the Wynnstay Arms and a further eight within 10 miles, although the nearest is over five miles away at Carno and most are in or near Machynlleth and Welshpool. The nearest cafes, snack bars, tea rooms, fish and chip shops and take away outlets, as listed in the Thomson local directory, are in Machynlleth which is 10 miles to the west. There is one restaurant, Duffryn, near Llangadfan on the A458 and 7.5 miles to the north of Llanbrynmair. The next nearest restaurants are in Dolgellau, Newton, Welshpool, Llanidloes and Machynlleth and are all over 10 miles from Llanbrynmair.

5.3 Visitor Accommodation

5.3.1 The visitor guide *Explore Mid Wales and the Brecon Beacons* (Powys County Council, 2012) lists 11 pages of visitor accommodation but none within 10 miles of Llanbrynmair. Although there is no one comprehensive list of visitor accommodation in the area, independent research has ascertained that there is a range of visitor accommodation within 10 miles road travel of Llanbrynmair. This accommodation includes seven hotels, six guest houses/bed and breakfasts and six self catering holiday let properties as shown in table 5.

Table 5. Visitor Accommodation: Hotels, Guest Houses and Bed and Breakfast

Visitor Accommodation Hotels, Guest Houses and Bed & Breakfast	Location	Miles from Llanbrynmair
HOTELS		
Penrhos Arms	Cemmaes	4.4
Aleppo Merchant Inn	Carno	5.5
Brigands Inn	Mallwyd	6.4
Buckley Arms	Dynnas Mawddwy	7.4
Plas Dolguog	Felingerrig	8.8
Wynnstay	Heol Maengwyn	9.8
White Lion	Heol Pentrehedyn	9.9
GUEST HOUSES/BED AND BREAKFAST		
Aberhiriaeth Cottage	Cemmaes	4.3
Mathafarn	Llanwrin	6.1
Maenllwyd	Machynlleth	9.4
EG Edwards	Dinas Mawddwy	9.6
Ty Derw	Dinas Mawddwy	9.7
Dulas Valley	Corris	9.6
SELF CATERING		
Barlings Barn	Barlings Barn	0.9
Dwr Y Felin Log Cabins	Carno	5.2
Cledin Valley Tipis Ltd.	Carno	5.6
Cottages in Paradise	Lower Dalgenau	7.7
Felin Crewi	Penegoes	8.2
Braich Goch Bunkhouse	Corris	9.6

5.3.2 There are also 11 caravan parks and campsites, with the two nearest to Llanbrynmair each having around 30 pitches. This area of Mid Wales is popular for caravanning and camping, the sites are generally of a high standard with good facilities and most are well-established family-owned and run businesses. Table 6 shows the location of caravan and camp sites and their distance from Llanbrynmair.

Table 6. Visitor Accommodation: Caravan Parks and Camp Sites

Visitor Accommodation Caravan Parks and Campsites	Location	Miles from Llanbrynmair
Cringoed Caravan Park	Cringoed	1.6
Caravan Club	Gwern Y Bwlch	1.6
Bryn Uchel Caravan Park	Bryn Uchel	4.5
Pendoll	Pendoll	5.4
Twin Rivers Caravan Park	Foel	7.6
Warren Parc	Penegoes	7.9
Carmel Caravan Park	Ty Newydd	7.9
Riverbend Caravan Park	Llangadfan	8.3
Trannon Caravan Park	Tefeglwys	8.7
Corris Caravan Park	Ceinws	9.5
Llwyncelyn Holiday Park	Llwyncelyn	9.6

5.4 Active Recreation in the Llanbrynmair Area

5.4.1 Sections 5.2 and 5.3 above have illustrated that there are few visitor attractions and only a small amount of visitor accommodation in the area around Llanbrynmair. The lack of visitor attractions is not necessarily synonymous with a lack of tourists. There is an absence of primary research indicating actual visitor numbers to the Llanbrynmair area but it is clear that the area does receive visitors to the attractions already mentioned above and for purposes other than visiting formal visitor attractions. Walking, mountain biking, cycling, horse riding, fishing, and bird watching are forms of active recreation and sport tourism that attract tourists and day visitors to the area surrounding Llanbrynmair. Sport and adventure tourism companies have brought additionality to the local tourism economy through their year-round activity. In an area where most visitor attractions close between October and March these companies offer attractions to visitors and a small amount of employment in the local hospitality trade in addition to the employment offered by the companies themselves.

5.4.2 The two most popular activities in the Llanbrynmair area are walking and mountain biking. Glyndŵr's Way is a long distance trail that attracts walkers to the Llanbrynmair area. The 135 mile trail starts at Knighton on the Welsh-English border and meanders west up to Machynlleth and then runs east through Llanbrynmair village. The trail then runs north, just to the west of the proposed location of around half of the turbines. It then cuts through the planned wind farm at proposed turbine number 14 and then runs north-east to the east of the remaining turbines in the northern half of the proposed site. Thus walkers on Glyndŵr's Way will walk through Llanbrynmair wind farm. This may not be problematic and RES have offered various mitigation measures to accommodate Glyndŵr's Way and a number of other rights of way. Locally, it is recognised that such measures have the potential to enhance the rights of way and encourage more visitors to the Llanbrynmair area. Of note too, is the current Countryside Council for Wales leaflet that publicises Glyndŵr's Way with a map and 18 images reflecting attractions along the route. The image immediately to the east of Llanbrynmair is a red kite and the image immediately to the north-west is a wind turbine, representing the 18-turbine wind farm at Cemmaes operated by Cumbria Wind Farms (Countryside Council for Wales, 2012). Further afield the Wales Coast Path runs through Machynlleth and is therefore within relatively easy access from Llanbrynmair as are many other rights of way in addition to the more established Glyndŵr's Way.

5.4.3 Wales has 13 dedicated mountain bike centres and bases and mountain biking is increasingly identified as a reason for visiting Mid Wales. Three of the thirteen centres/bases are within relatively easy access of Llanbrynmair: Machynlleth, Coed-y-Brenin and Nant yr Arian. Machynlleth is a dedicated mountain biking base and has three purpose-built trails (Mach 1-3) and a more recently built trail, the Cli-machx trail, which is a 15km round trail running high into the Dyfi Forest to the north. The trails were developed by Dyfi Mountain Biking, a local community group that raised funds to develop and way-mark Mach 1, 2 and 3 using existing rights of way. In collaboration with Ecodyfi, a local community regeneration group, the fourth trail, Cli-machx, was constructed. Throughout the development of the trails the inter-relationship between mountain biking, the Centre for Alternative Energy, as a visitor attraction, and the generation of income via increased tourism to the area has been evident. Further mountain biking is available at the purpose built centres at Coed-y-Brenin in Snowdonia and Nant yr

Arian Forest east of Aberystwyth. Forest Freeride, based four miles south of Llanbrynmair at Pennant, is a small business that offers guided mountain biking, coaching and bike hire. It may be worth noting that there is evidence from previous research that mountain bikers to Wales spend less per head per visit than other types of tourists (Aitchison, 2004; Powell, Aitchison and Wragg, 2003). There is also evidence to demonstrate that the presence of wind farms in Mid Wales has not deterred mountain bikers from visiting those areas with wind farms (Aitchison, 2004).

5.4.4 Cycling is also popular in Mid Wales. The National Cycle Network Route 8, known as Lôn Las Cymru, passes through Machynlleth en route from Holyhead to Cardiff Bay.

5.4.5 Horse riding is also a popular recreational and tourist activity in Mid Wales although there do not appear to be any commercial riding stables in the Llanbrynmair area. It should be noted however, that sections of Glyndŵr's Way incorporate bridle paths and are likely to be used by horse riders.

6 ECONOMIC IMPACT ON TOURISM OF LLANBRYNMAIR WIND FARM

6.1 Introduction

6.1.1 The economic value of tourism in the vicinity of Llanbrynmair is difficult to estimate because figures relating to visitor numbers and visitor spend are not gathered officially at such a local level. However, such data might not be required as there is no evidence from any previous research anywhere in the UK or internationally that demonstrates that wind farms result in a decrease in tourist numbers (volume) or tourism expenditure (value).

6.1.2 Visit Wales state that the annual value of tourism to Mid Wales is £269 million. Income is associated with those areas where there is a high density of visitor attractions and tourist accommodation, mostly in the south and the north of the Mid Wales Tourism Partnership region as these areas include the National Parks of Snowdonia and Brecon Beacons respectively. The data outlined in section 5 above demonstrate that there is a low concentration of tourism-related activity in the Llanbrynmair area relative to other parts of Mid Wales. It can therefore be concluded that the economic impact of tourism in the Llanbrynmair area is less than in other areas of Mid Wales.

6.1.3 In an area where many of the visitor attractions are closed for almost half of the year occupancy rates in visitor accommodation will be lower than in areas with year-round visitor attractions. The negative economic impact of visitor attraction closure in the winter months will be slightly off-set by the year-round outdoor activities that take place in Mid Wales. However, in rural tourism areas dominated by self-catering, B&B and park accommodation, additional spending is low relative to that in coastal resorts with a greater density of visitor attractions, hotels, hospitality, catering and retail outlets.

6.1.4 An accepted indicator of the level of tourist activity within an area is the number of Tourist Information Centres (TICs). Aberystwyth, Dolgellau and Welshpool offer the nearest information services with a seasonal service at Bala. There is an information outlet at Machynlleth although the only information currently held and relating to Llanbrynmair is one leaflet publicising Machinations.

6.1.5 The proposed location of the wind farm, at Llanbrynmair, is not a highly popular tourist area and, as has been demonstrated above, the vast majority of visitor attractions in Powys are not located near the proposed site. Indeed, Visit Wales emphasises the National Parks and coastline as the main attractions in Wales. In relation to Mid Wales, Visit Wales highlights the Brecon Beacons as the main attraction and, although mention is made of the Llanfair to Welshpool railway and the Centre for Alternative Technology, the Visit Wales web site points to the southern end of Mid Wales as the location of most visitor attractions.

6.2 Developing Sustainable and Integrated Rural Economies

6.3.1 It should be noted that there is nothing in the *Good Practice Guide on Planning for Tourism* (2006) that supports the refusal to grant planning permission on the grounds that such developments would impact adversely on tourism. In contrast, the *Guide* stresses the importance of sustaining rural communities through the development of viable local economies. Viable and sustainable economies are generally mixed economies able to withstand downturns in individual sectors of the economy. Thus a rural economy built on sustainable forms of tourism, alongside other equally sustainable forms of economic development such as renewable energy, is more likely to sustain its rural population, economic development and its environment in the long term. The development of a wind farm at Llanbrynmair would therefore not detract from the objectives outlined in the *Mid Wales Tourism Strategy* (Mid Wales Tourism Partnership, 2011) or *Powys Regeneration Strategy* (Powys County Council, 2011c). Indeed, local business owners have recognised the need to diversify their businesses to remain viable.

6.3 Lack of Evidence of Negative Impact

6.4.1 Previous research from other areas of the UK has demonstrated that wind farms are very unlikely to have any adverse impact on tourist numbers (volume), tourist expenditure (value) or tourism experience (satisfaction) (Glasgow Caledonian University, 2008; Aitchison, 2004). Moreover, to date, there is no evidence to demonstrate that any wind farm development in the UK or overseas has resulted in any adverse impact on tourism.

6.4.2 The Inspector's Report into Middlemoor in Northumbria emphasised both the lack of general evidence relating to any detrimental impact to tourism as a result of wind farm development and the lack of any specific negative impact in the Northumberland area. He stated in paragraphs 478-480 '*There appears to be no evidence from other parts of the country or abroad to suggest that the presence of wind farms in open countryside has harmed the tourist industry. Both Cumbria and Cornwall have experienced a rise in tourist numbers since the first wind farms* *were installed. According to the presentation prepared by the British Wind Energy Association to the All-Party Parliamentary Group on Tourism, 24 May 2006, surveys and reports investigating wind energy and tourism demonstrate that the effect on tourism is negligible at worst, with many respondents taking a positive view of wind farms'*. The inspector went on to find that the distance of Middlemoor from the major centres of tourist activity in Northumberland would mean that '*there would be no adverse cumulative effects on tourism, beyond consideration of visual impact*' and that '*there is no reason to suppose that local businesses would be affected by the wind farm development*' (The Planning Inspectorate, 2008).

6.4.3 In circumstances very similar to those of Llanbrynmair, the Inspector stated that '*In the case of the Middlemoor proposal, tourist provision, in terms of attractions and accommodation, appears to be concentrated in the coastal strip to the east; Rothbury and Coquetdale well to the south west of Alnwick; and the fringes of the national park to the west, including Wooler, Ford and Etal. Middlemoor lies between and relatively distant from these areas and this is one of the reasons North/South Charlton was assessed as a Broad Area of Least Constraint (BALC) in the RSS*' (The Planning Inspectorate, 2008: 89).

6.4.4 In summary, drawing on related evidence from studies in similar rural locations such as Scotland, Devon, Cornwall, Northumbria and Carmarthenshire, from the conclusions drawn from Inspectors' reports where tourism has been discussed in detail (Fullabrook in Devon and Middlemoor in Northumbria), and from the decision by Berwick-Upon-Tweed Borough Council not to contest the Wandylaw proposal on the grounds of tourism impact, it can be concluded that there is no evidence to support the assertion that the development of a wind farm at Llanbrynmair will have a detrimental economic impact on tourism in Powys.

6.4.5 During the course of the research conducted to write this report it was evident that many business owners accepted much of the evidence outlined above. Indeed, one local business owner described the turbines as 'red herrings' stating that the only real concern with the proposal related to the construction phase and the potential increase in the already existing level of traffic congestion in and around Newtown. A number of local business owners pointed to the benefits the development could bring in mitigation measures, increased employment in an area of few opportunities and low wages, and potential links with a wider identity for the area at the forefront of renewable energy technology and related education and visitor attractions.

7. CONCLUSIONS

7.1 Although tourism research relating to wind farm developments is limited compared with that on policy, design, visual impact, ecology, ornithology, hydrology, acoustics and transport policy, it is increasingly evident that there is an emerging consensus within the research examining the actual and potential impact of wind farms on tourism. The clear consensus is that there has been no measurable economic impact, either positively or negatively, of wind farms on tourism. Similarly, there is now consensus among researchers of studies that have sought to predict the more specific potential economic impact of wind farms on tourism. Here, again, there is no evidence to support the assertion that wind farms are likely to have a negative economic impact on tourism.

7.2 The opposition to wind farms on tourism grounds appears to be informed more by fear than fact. The research conducted by GCU stated that 'Importantly, respondents that had seen a wind farm were less hostile than those who had not' (Glasgow Caledonian University, 2008a: 3). Starling's and Glasgow Caledonian University's findings therefore lend support to Young's (2003) research; namely, that opposition to wind farms tends to fall after construction.

7.3 There is no empirical research that demonstrates the impact of wind farms on tourism numbers (tourism volume), expenditure (tourism value) or experience (tourist satisfaction) in the specific area of Llanbrynmair or indeed in the wider surrounding area of Powys.

7.4 It is possible, however, to gauge the potential impact by drawing on evidence from a range of relevant sources. This analysis and extrapolation of data to reach legitimate conclusions must be undertaken with care and requires an understanding of and experience in research methodology and tourism impact analysis in rural areas.

7.5 A number of conditions must be borne in mind when determining the legitimacy of the findings of previous research that has sought to determine the impact of wind farms on tourism as the quality of the research is highly varied:

- The research should take the form of a survey of tourists rather than tourism businesses
- The survey methodology and sampling frame must be rigorous, reliable and valid

- The findings obtained from the survey should not be extrapolated across broad geographical areas that will not be impacted to the same degree by any wind farm development
- The findings of all tourism research should be seen within the context of tourism as a growth industry and thus any limited negative impact is likely to be an impact on growth rather than on current levels of tourism
- The research should acknowledge that the tourism business is dynamic and self-generating such that when a particular type of tourist ceases to visit an area they are frequently replaced by a different type of tourist thus continuing 'the tourist lifecycle' of destinations and resorts

7.6 National, regional and local policies of prioritising both the development of sustainable rural tourism and renewable energy form the political-economic context to this planning application. Within the local, regional and national context it is clear that the area surrounding Llanbrynmair receives low numbers of visitors and income from tourism relative to other areas in Mid Wales. This reflects the lower concentration of visitor attractions and tourist accommodation than seen in many other areas of Mid Wales.

7.7 Taking the above factors into account in a critical review of previous research, and contextualising such research in relation to both the tourism geography of the Llanbrynmair area and wider Mid Wales tourism policy, it can be concluded that:

- The development of Llanbrynmair wind farm is likely to have little or no impact on tourist numbers (volume), expenditure (value) or experience (satisfaction)
- Any impact is as likely to result in more tourist visitors as it is fewer tourists because of mitigation measures and the strengthening of identification of the area with the popular Centre for Alternative Technology
- Although a very small number of current visitors might choose not to repeat their visit because of the presence of a wind farm this number is likely to be off-set by additional tourists who visit irrespective of the presence of a wind farm, return because of the wind farm or visit for the first time because of the wind farm
- Tourist numbers are likely to increase significantly if the wind farm is accompanied by a visitor attraction and the proximity of the Centre for Alternative Technology makes Llanbrynmair a very realistic site for such a centre.

7.8 In conclusion, the findings from the secondary research relating to the potential impact of Llanbrynmair Wind Farm indicate, as did those for Fullabrook in North Devon, Moorsyde in Northumbria and Bryn Llywelyn in Carmarthenshire, that there is likely to be neither an overall decline in the number of tourists visiting the area nor any overall financial loss in tourism-related earnings as a result of the wind farm development. Indeed, with appropriate attention paid to cumulative impacts, it is likely that the conclusion of the Planning Inspector to the Fullabrook Down Public Inquiry will also hold true for Llanbrynmair: *that tourist numbers, as well as income, would be maintained*.' (The Planning Inspectorate, 2007: 147-149).

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