Watten Wind Farm

Caithness, Scottish Highlands

Environmental Impact Assessment

Volume 3B of 4:

Technical Appendices (A4)

August 2023

Prepared by Natural Power on behalf of EDF Energy Renewables Limited.

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Volume 3: Technical Appendices

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10 February 2023

EDF Energy Renewables Limited

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1. Introduction

This document has been prepared by Natural Power Consultants (Natural Power) on behalf of EDF Renewables Limited (EDF ER) (The Applicant). The objectives of the Outline Construction Environmental Management Plan (CEMP) are to inform the planning authority and consultees of the principles relating to environmental management and methodologies to be employed during the construction of the proposed Watten Wind Farm (the Proposed Development).

1.1. Background

The Proposed Development Area consists of seven wind turbines and foundations, Battery Energy Storage System (BESS), associated tracks, water crossings, hardstands, substation and control building. Temporary development such as contractor compounds, welfare facilities and laydown areas will be subject to the same standards and principles as those of the Proposed Development Area. It is anticipated that the development proposal, if approved, would be the subject of a suspensive condition requiring submission of a detailed CEMP.

2. Objectives

The detailed CEMP must be a 'site specific' document which should be 'live' for the duration of construction and the post construction restoration of the development. The CEMP must be able to evolve and react to changing circumstances which can be brought about by influences out with developer or contractor control such as weather, unexpected ground conditions, updated guidance or legislation.

3. Construction Management

3.1. Roles and Responsibilities

All operatives will be expected to conduct their operations in accordance with the CEMP.

3.1.1. Principal Contractor

The Principal Contractor is responsible for obtaining all necessary consents, licences and permissions for their activities as required by current legislation governing the protection of the environment.

The Principal Contractor considers all mitigation measures and good practice construction methods in their design and in any detailed environmental plans as required. Where any mitigation measures or construction methods described in other documents deviate in any way from those contained within this document, the Principal Contractor abides by whichever is the most onerous and stringent in terms of environmental protection.

A copy of the CEMP and related files and documents will be kept in the Proposed Development offices and will be available for review at any time.

3.1.2. Principal Designer

The construction works will fall under the Construction Design and Management (CDM) Regulations 2015[1]. As per the CDM Regulations 2015, the Principal Designer will produce a pre-construction safety information pack in accordance with CDM regulations. This plan shall be compliant with the information provided in the CEMP and all documents and conditions of the deemed planning permission if granted.

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1 The Construction (Design and Management) Regulations 2015. Available online: Construction - Construction Design and Management Regulations 2015 (hse.gov.uk) [last accessed 03/10/2023]

3.1.3. Environmental Manager

The developer will have appointed an Environmental Manager to ensure all matters associated with environmental legislation and guidance are adhered to throughout the construction and restoration of the Proposed Development.

3.1.4. Other Roles

Subject to conditions on any permission granted, an Environmental Clerk of Works (ECoW) could be required and appointed to provided independent verification through reporting of the implementation of relevant conditions and documents including the CEMP.

3.2. Inductions and Toolbox Talks (TbTs)

The Principal Contractor will make sure that all contractor employees, sub-contractors, suppliers, and other visitors to the Proposed Development are made aware of the content of this document that is applicable to them. Accordingly, environmental specific induction training will be prepared and presented to all categories of personnel working and visiting the Proposed Development.

During construction, to provide on-going reinforcement and awareness training, site specific environmental and ecological matters will be discussed at regular TbTs provided by the Principal Contractor & Environmental Manager or ECoW.

3.3. Risk Assessment and Method Statement (RAMS)

The Principal Contractor's RAMS will be reviewed for comment by the appointed site Environmental Manager and/or ECoW, prior to commencement of the relevant works/tasks.

3.4. Public Safety

The Proposed Development Area is subject to access by the public under the Land Reform (Scotland) Act 2003[2]. Under section 6 (1) (g) (i) of this legislation access rights are not exercisable where building or civil engineering works are being carried out. It would not be feasible to close a site of this size and therefore warning signage will be used to inform the public of risks. Reasonable steps will be taken by the Principal Contractor to prevent access to high risk areas such as large excavations and compounds.

4. Construction Methods

4.1. Excavation

All excavations will involve the removal of vegetation, topsoil and peat soil (if any), in order to obtain a suitable bearing stratum. The topsoil, together with any incorporated seed bank, will be stored as required for subsequent use in verge reinstatement works. Topsoil shall be stockpiled separately to any sub soil material. Particular attention shall be given to cutting, storing and re-instating topsoil on hardstanding edges and batters in order to encourage regeneration of vegetation following construction.

4.2. Hardstandings

It is anticipated that access tracks, cranepads, compounds and storage areas will be constructed using standard cut and fill founded construction techniques. Hardstands will generally follow the alignment indicated in the Proposed Development general arrangement and layout. However, following detailed site investigation and design they may be subject to micro-siting permissible subject to condition.

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[2] Land Reform (Scotland) Act 2003. Available online: Land Reform (Scotland) Act 2003 (legislation.gov.uk) [last accessed 03/10/2023]

4.3. Water Crossings

A number of watercourse crossings for which are likely to be incorporated into the design and construction of the watercourse crossings to minimise any potential negative impacts. The Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2021 (CAR)[3] regulate activities in, or in the vicinity of, rivers, lochs and wetlands, including engineering activities such as river crossings and culverting.

The Principal Contractor will produce detailed information to obtain the necessary registrations/ licences under CAR prior to the commencement of construction works. The Principal Contractor is responsible for the liaising with and obtaining from Scottish Environment Protection Agency (SEPA), the relevant consents, licences and authorisations relating to the construction of watercourse crossings at the development.

4.4. Turbine Foundations

Turbines will be installed on reinforced concrete foundations. The foundations may be of gravity design bearing on competent ground conditions or piled design where ground conditions dictate.

4.5. Cable Trenches

Underground cabling will link turbines to the off-site switchgear and metering building at the grid connection point. Cable runs will generally be located alongside site tracks at nominally 1 m cover to cables. Cable trenches will be designed to prevent creation of preferential drainage channels for sub-/surface flows and constructed to minimise ground disturbance.

4.6. Temporary Compounds

Site offices and welfare facilities will be provided on site and provide some or all of the following facilities:

- Temporary portable buildings;
- Containers for material and equipment storage;
- Portable site toilets with appropriate provision for waste disposal in accordance with relevant regulations;
- Parking for operatives and visitors;
- Generators;
- Control of Substances Hazardous to Health (CoSHH) stores;
- Re-fuelling points; and
- Waste collection and storage

The compound will have space for deliveries and material storage and handling. It is anticipated that water for all construction activities will be supplied by water bowsers or boreholes.

4.7. Concrete Batching

It is anticipated that concrete batching plants will be set up on site to produce concrete for construction of turbines and building foundations from suitable aggregate.

Lined and bunded concrete washout areas will be provided at appropriate designated areas on site for concrete mixer trucks to wash out their drums. Further pollution mitigation measures will be implemented such as provision of spill kits and plant nappies at the batching plant.

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[3] The Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2021 Available online: The Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2021 (legislation.gov.uk) [last accessed 03/10/2023]

5. Environmental Management and Mitigation

5.1. Pollution Prevention Plan (PPP)

It is highlighted that risks to the environment are generally more significant during the construction phase and as such, pollution prevention measures will be implemented.

5.1.1. Water

There are a number of watercourses in and around the Proposed Development Area. The following presents a hierarchy of interventions for reducing the likelihood for water borne pollution:

i. Minimisation – Reducing the amount of water which comes into contact with materials which will cause siltation. Keep clean water clean;
ii. Filtration – Filtration of water control ditches as a precaution i.e., straw bales, gravels or baffles or silt fences and effective maintenance;
iii. Settlement – Use of sumps and lagoons (flocculant dosing only with SEPA approval);
iv. Mechanical intervention – silt separators;
v. Percolation – Removing remaining particles by discharge over adjacent grasslands subject to ECoW guidance.

All fuels, oils, chemicals and contaminants will be stored in accordance with the relevant CoSHH and Oil Storage Regulations as a minimum.

5.1.2. Dust

Air borne particles can have a detrimental effect on operatives, habitat and amenity. The Principal Contractor should take account of prevailing wind directions when siting temporary soil stores. The following presents a hierarchy of interventions for reducing the likelihood for air borne pollution:

i. Prevention – Keep site traffic speeds lower during dry periods and minimise soil strip as far as practicable;
ii. Suppression – Water bowsers should be used to dampen down haul routes during dry conditions. Water from settlement ponds/lagoons should be used thereby providing capacity;
iii. Containment – Capping or sheeting exposed soil stores.

Where practicable reinstatement should be delivered promptly to minimise susceptibility of exposed soils to wind. The Principal Contractor will provide further details upon appointment on the management of dust arising from construction activities.

5.1.3. Noise and Vibration

The Proposed Development Area is likely to be restricted to specified construction hours by condition. This ensures that while noise and vibration can be a nuisance the temporary nature of construction activity is at carried out during 'normal' working hours.

The Principal Contractor shall ensure that all works are carried out taking full cognisance of BS 5228 : 2009 Code of Practice for Noise and Vibration Control on Construction Sites Parts 1[4] and 2[5].

5.1.4. Light

During the construction phase of the Development, the Principal Contractor may require temporary lighting to be erected. Where task specific or security lighting is required, it will be screened and aligned to prevent nuisance to

[4] Code of practice for noise and vibration control on construction and open sites – Part 1: Noise. Available online: untitled (warrington.gov.uk) [last accessed 03/10/2023]

[5] Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration. Available online: untitled (omegawestdocuments.com) [last accessed 03/10/2023]

sensitive receptors of ecology, residential or passing traffic. Provision of aircraft warning lights on the crane and other tall plant will be used where necessary. Any lighting not in use should be switched off.

5.1.5. Roads

In terms of this CEMP, a closed cycle wheel wash or dry rumble strip should be sited near the entrance to ensure vehicles leaving site and entering the public road network do not leave deposits or debris behind. The Proposed Development access will be monitored throughout the construction of the development to ensure the safety of public road users is maintained. The Proposed Development access and construction traffic will be the subject of a separate Construction Traffic Management Plan.

5.2. Drainage Management Plan (DMP)

The Principal Contractor will be responsible for designing the DMP during the construction of the development. There will be significant crossover from elements of the PPP incorporated into the DMP.

5.2.1. Surface Water

The DMP will deliver the operational measures required throughout the life of the development. The DMP will evolve during construction as contractors react to changing circumstances under guidance from the ECoW. As temporary measures put in place to manage construction runoff and set out in the PPP are removed, trackside drainage and cross drains will remain and form part of the DMP.

5.2.2. Foul Water

During the construction phase, it is expected that foul drainage would be securely stored on-site before being removed and disposed of by a suitably licensed contractor under Duty of Care. There would be no planned discharge of foul drainage to surface waters or groundwater during the construction phase.

Requirements for foul drainage during the operational phase will be advised in the DMP with all requirements taking full cognisance of Building Standards and CAR.

5.2.3. Water Quality Monitoring

A Water Quality Monitoring Plan (WQMP) will be developed to monitor the impact of construction on the surrounding hydrological environment. The Loch, Black and Red Burns are tributaries of the Burn of Acharole and each flow through the development area. A monitoring regime including baseline results and data analysis will be agreed with SEPA and implemented during construction.

5.3. Site Waste Management Plan

In accordance with best practice and legalisation the Principal Contractor will provide and maintain a Site Waste Management Plan (SWMP). The SWMP will ensure that the principles of waste minimisation and sustainability are employed. Site waste will be collected and segregated in appropriate covered containers at designated locations around the Proposed Development Area.

5.4. Forestry Waste Management

Forestry felled to accommodate the development will be brought to market where commercially viable. Any non-commercial timber, brash or excavated stumps generated as a result of the development are to be considered forestry waste. A small proportion of brash could be used in habitat reinstatement but most forestry waste will explore residual uses (such as biomass) where possible.

5.5. Cultural Heritage

There are no designated heritage assets within the Proposed Development Area. There are three known non-designated heritage assets within the Proposed Development Area which would be avoided through design. Heritage assets in close proximity to construction activities will be incorporated into a Construction Exclusion Zone (CEZ) to identify 'no go' areas for operatives.

Any previously unknown heritage assets noted during walkover survey should be avoided through micro-siting where permissible.

Adverse direct (physical) effects during construction may be mitigated by an appropriate level of survey, excavation, recording, analysis and publication of the results, in accordance with a written scheme of investigation to be agreed via condition post consent. It is proposed that mitigation focuses on any groundworks within areas of peat, and also monitors the excavations for wader scrapes in Outline Biodiversity Enhancement Management Plan (OBEMP) Management Unit B (see Figure 7.13).

5.6. Reinstatement and Restoration

Reinstatement has the best chance of success if undertaken quickly following excavation. Minimise soil strip and reinstate as construction activities progress. Where turves are available these should be used promptly to avoid drying out. Turves which are not used promptly must be kept moist to ensure they remain viable.

6. Ecological Surveys

6.1. Species Protection Plan (SPP)

All reasonable protection measures will be undertaken by the Principal Contractor with regard to protected species for the Proposed Development. The SPP aims to deliver measures to safeguard any place of breeding, growth or shelter of protected species from disturbance, injury and death for the duration of construction.

Mitigation will be determined by the ECoW and adhered to by all operatives. Mitigation could include changes to working practices, agreement of micro-siting where permissible or implementation of temporary CEZ's.

6.2. Ground Water Dependent Terrestrial Ecosystems (GWDTE)

Identified GWDTE within the Proposed Development Area will be identified CEZ's and would be avoided through design.

6.3. Invasive Non-Native Species (INNS)

Prior to any works commencing on the Proposed Development, the ECoW will identify any invasive non-native species (INNS) by conducting walkover surveys. Site operatives will be informed of identified INNS through TbTs on site and preventing spread (e.g., soil transfer).

6.3.1. Biosecurity

Biosecurity is considered to be a potential risk primarily through staff or plant inadvertently bringing species on site following contamination on a previous job. This is particularly relevant to tree felling plant and to any plant used for breaking ground or working in / adjacent to watercourses.

The following general biosecurity measures will be implemented in relation to all works:

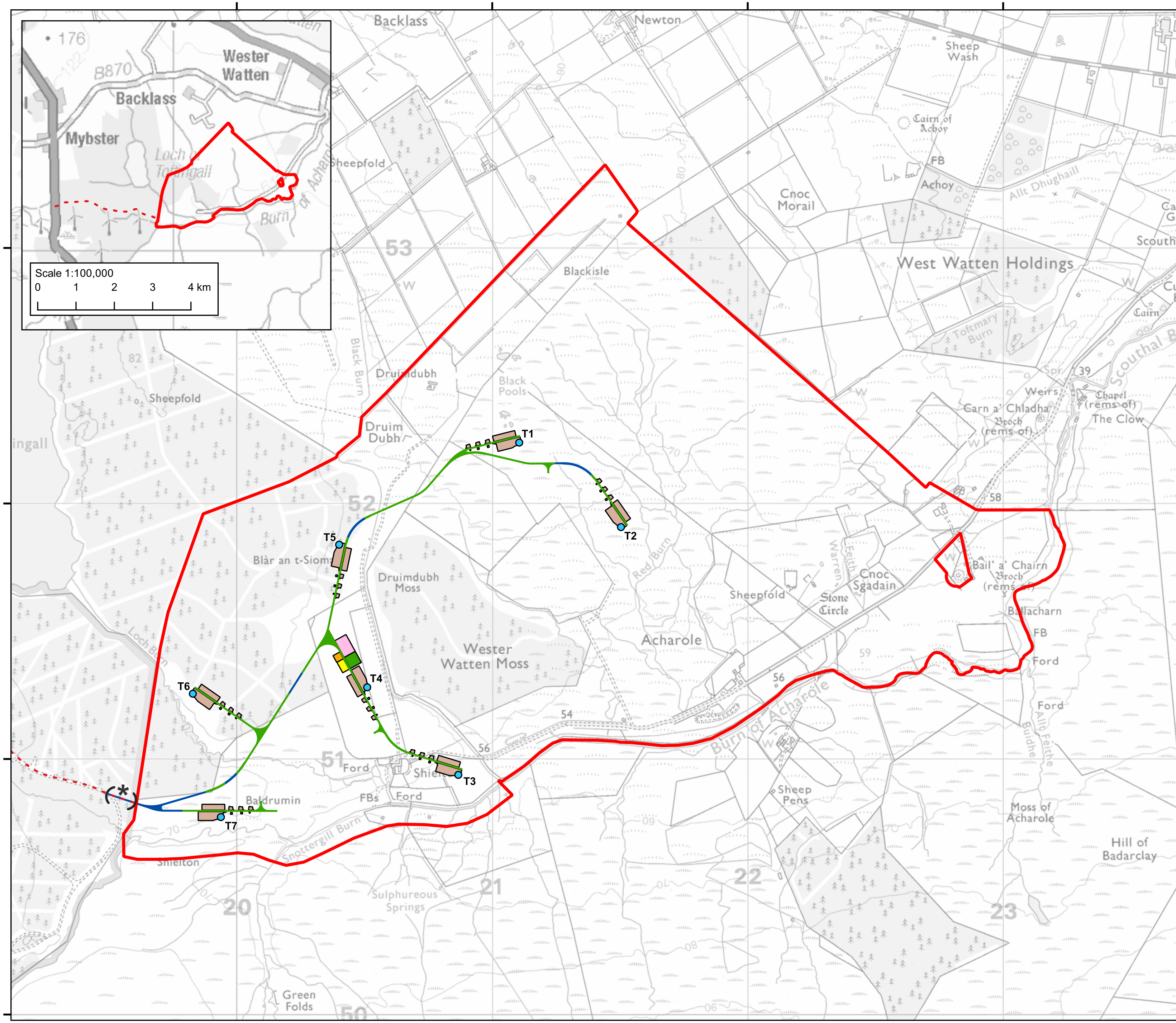
- Staff will arrive at the Proposed Development with clean footwear and vehicles;
- Ensure footwear and equipment is cleaned regularly. Staff to ensure footwear is clean (visually from soil and debris) before leaving the Proposed Development;

- Ensure vehicles are kept clean - in particular remove any accumulated mud before leaving the Proposed Development;
- All new plant or equipment that is brought onto the project should be inspected before leaving the roadside and entering the development area.

Should an INNS be identified whilst working on site, work should cease in the immediate vicinity (within 5 m) of the specimen and the ECoW contacted immediately. The ECoW will determine the species what action should be taken prior to work recommencing.

Appendices

A. Site Layout



Project:

Watten Wind Farm, Caithness, Scottish Highlands

Title:

Figure 1.2: Site Layout

Key

- Proposed Development Area
- Proposed turbine
- Proposed crane hardstanding
- Proposed track
- Proposed floating track
- Proposed access track*
- Proposed substation
- Proposed battery storage
- Proposed construction compound
- Proposed batching plant

*The Applicant is not applying for consent to complete the works of this section of track outwith the redline, it would be the subject of a separate application however this section of track has been assessed to show that it can be delivered and therefore has been included on the plan.

Scale @ A3: 1:15,000

Coordinate System: British National Grid

0 200 400 600 800 m

N

Date: 09-08-23	Prepared by: SA	Checked by: LF
Ref: GB204032_M_006_D	Layout: 060922_7t_A	

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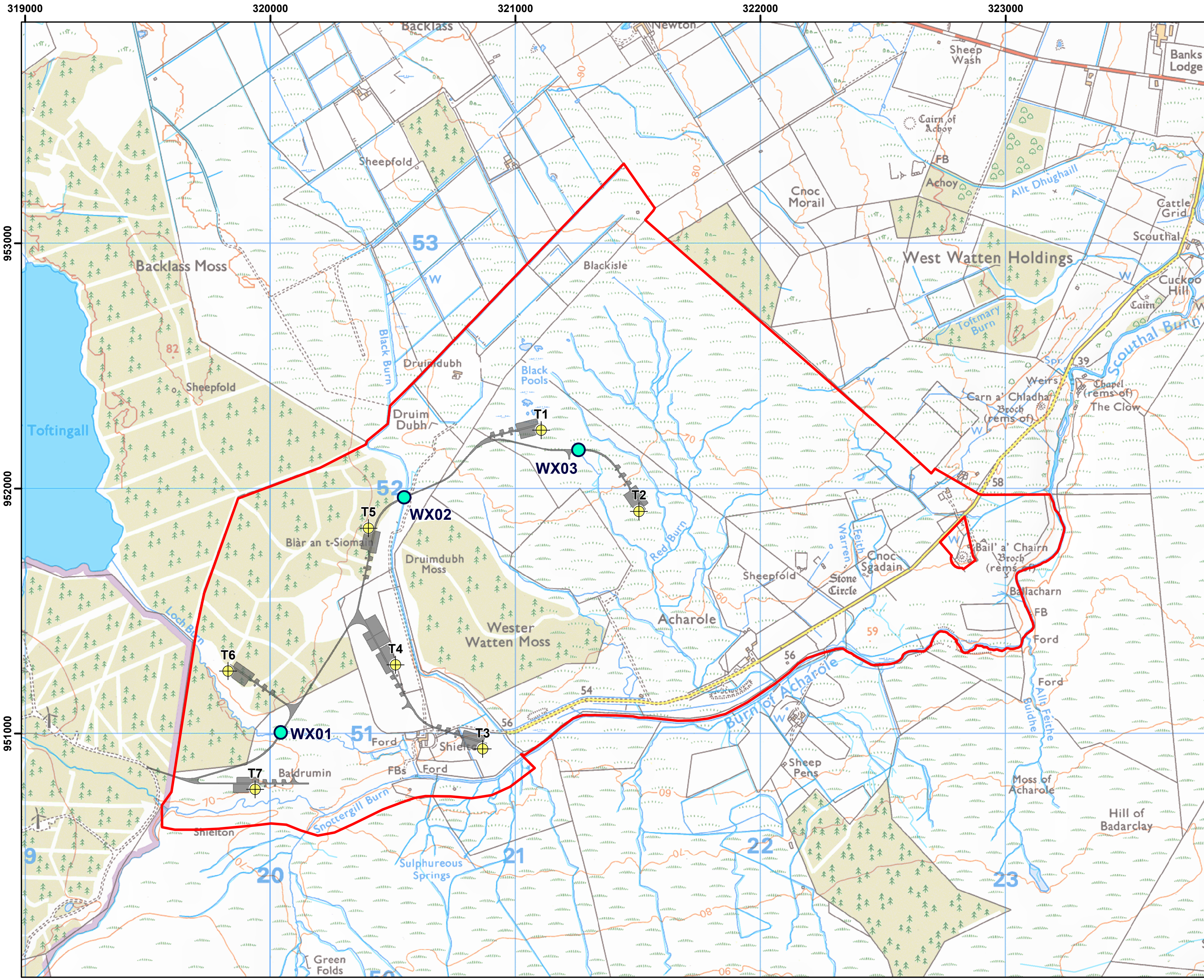
B. Outline Pollution Prevention and Drainage Management Plans

- Sustainable Drainage System (SuDS). This will include the use of check dams at appropriate intervals (as defined by the gradient of the drain) to reduce flow velocity and allow settlement of sediment loads prior to discharge to watercourses.
- Where required, interceptor ditches will divert water to locations downstream of proposed excavation or soil disturbance works associated with the installation of turbine foundations, the development of construction compounds and batching plants, groundworks during the installation of the substation. These will be specified in a Pollution Prevention Plan (PPP).
- Guidance on the requirement for Controlled Activity Regulations (CAR) authorisation is outlined in Technical Appendix A9.1 Watercourse Crossing Assessment. Watercourse crossing construction will be carried out following best practice guidance as detailed in the CEMP.
- As the potential GWDTE areas assessed are not considered likely to be groundwater dependent, specific mitigation with respect to groundwater supplies are not considered to be applicable. However, suitable drainage and surface water measures will be used to maintain hydrological connectivity in peatland and wetland habitats to prevent adverse impacts on surface water flow patterns.
- A Pre-construction Site Investigation will be carried out in order to provide information from which to guide construction and any additional mitigation.

C. Watercourse Crossings



Project:

Watten Wind Farm, Caithness, Scottish Highlands

Title:

Figure 9.3: Watercourse Crossings (1: 25,000)

Key

- Turbine
- Proposed Development Area
- Infrastructure
- Watercourse Crossing

Scale @ A3: 1:15,000
Coordinate System: British National Grid

0 125 250 500 Metres

N

Date: 15-06-23	Prepared by: LM	Checked by: RS
Ref: EIAR_HP_Fig9.3_WCC_OS_ACH	Layout: 060922_7t_A1	

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EDF renewables

D. Legislation and Guidance

Key Guidance

The objectives of this document herewith are aligned with the following regulations and guidance documents;

- The Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2021 (CAR The Water Environment (Oil Storage) (Scotland) Regulations 2006;
- The SuDS Manual C697 (CIRIA);
- Good practice during Wind Farm construction – 4th Edition;
- Drainage of development sites – a guide (CIRIA);
- Flood Risk & Drainage Impact, Supplementary Guidance (The Highland Council);
- CAR Practical Guide (Version 9.1, SEPA). Specifically, GBR 10, 11 and 21; and
- Sewers for Scotland - A technical specification for the design and construction of sewerage infrastructure (Scottish Water).

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National Vegetation Classification & Habitats Survey

Technical Appendix A7.1

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1 INTRODUCTION

MacArthur Green was commissioned by EDF Energy Renewables Limited (EDF-ER, the 'Applicant') to carry out a National Vegetation Classification (NVC) and habitats survey for the proposed Watten Wind Farm (hereafter the Proposed Development), located near Watten, within the area of Caithness, Highland.

The project development area within the site boundary is referred to as the 'Proposed Development Area'.

The aim of the NVC survey is to identify and map the vegetation communities present within the Proposed Development Area in order to identify those areas of greatest ecological interest (i.e., Annex I habitats[1]; potential Groundwater Dependent Terrestrial Ecosystems (GWDTE); and Scottish Biodiversity List (SBL) priority habitats). This information is used to inform the Proposed Development design process and the ecological assessment for the Proposed Development's Environmental Impact Assessment Report (EIAR).

This report details the findings of the NVC surveys together with an evaluation of those communities described.

2 PROPOSED DEVELOPMENT AREA AND SURVEY AREA

2.1 Overview

The Proposed Development Area is located approximately 3 kilometres (km) south-west of Watten and 14 km to the west of Wick. The Proposed Development Area in general is low lying and fairly level to gently undulating, reaching an approximate height of 80 metres (m) above sea level in the north. The land is drained by several small and minor watercourses that are mostly tributaries of Loch Burn, Black Burn and Red Burn, which lie to the south, central and east of the Proposed Development Area respectively.

The Proposed Development Area is upland in character dominated by acid grassland, conifer plantation and bog habitat, particularly across the central area known as Wester Watten Moss. In addition, smaller areas or pockets of marshy grassland, modified bog, and mesotrophic grassland are also found in the Proposed Development Area.

2.2 Designated Sites

The Caithness and Sutherland Peatlands Special Area of Conservation (SAC) and the underlying Shielton Peatlands Site of Special Scientific Interest (SSSI) overlap with part of the Proposed Development Area. There are a further three designated sites with qualifying features relevant to this Technical Appendix within 5 km of the Proposed Development Area.

These designated sites and the qualifying features relevant to this Technical Appendix are presented in Table 2-1 below (the full list of all qualifying features can be found within Chapter 7: Ecology). The locations of the designated sites are presented in Figure 7.1.

[1] As defined by the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora – the 'Habitats Directive'.

Table 2.1 Designated sites with botanical qualifying features within 5 km of the Proposed Development Area

Designated site	Distance from Proposed Development Area (km)	Qualifying interests	Last assessed condition & date
Caithness and Sutherland Peatlands SAC	0 (overlaps with Proposed Development Area)	Acid peat-stained lakes and ponds	04/08/2004 Favourable Maintained.
		Blanket bog	08/06/2017 Unfavourable No Change
		Depressions on peat substrates	16/08/2015 Unfavourable Declining
		Clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels	08/06/2017 Unfavourable No Change
Shielton Peatlands SSSI	0 (overlaps with Proposed Development Area)	Blanket bog	13/06/2007 Favourable Maintained
Loch Watten SSSI	2.52	Base-rich loch	18/08/2016 Unfavourable Declining
		Open water transition fen	11/08/2015 Favourable Maintained
Loch Watten SAC	2.52	Naturally nutrient-rich lakes or lochs which are often dominated by pondweed	18/08/2016 Unfavourable Declining
Blar nam Faoileag SSSI	4.15	Blanket bog	27/03/2007 Unfavourable Declining[2]

2.3 Ancient Woodland

There are four areas of ancient woodland (as listed within the Ancient Woodland Inventory (AWI)) within 5 km of the Proposed Development Area. These consist of one larger (3.8 hectares (ha)) and three smaller (up to 0.3 ha) areas close to Strath Burn, with the closest stand 1.99 km from the Proposed Development Area (see Figure 7.1).

2.4 Carbon and Peatland Map 2016

The Carbon and Peatland Map 2016[3] was consulted to determine likely peatland classes present within the Proposed Development Area. The map is a predictive tool that provides an indication

[2] Management measures are in place that should, in time, improve the feature to Favourable condition (Unfavourable Recovering due to Management).

of the likely presence of peat at a coarse scale. The Carbon and Peatland map has been developed as a high-level planning tool and identifies areas of nationally important carbon-rich soils, deep peat and priority peatland habitat[4] as Class 1 and Class 2 peatlands. Figure 7.2 indicates that, according to this predictive tool and map, the Proposed Development Area contains an area of Class 1 peatland within the central area across Western Watten Moss and an area of Class 1 peatland in the west, located west of Blàr an t-Siomain (N.B. both these Class 1 peatland areas have been planted over with commercial conifer plantation). There are no Class 2 peatland areas within the Proposed Development Area. The Proposed Development Area also includes Class 0 (mineral)[5] and Class 3[6], 4[7] and 5[8] soils. As the Carbon and Peatland Map is a high-level tool, detailed habitat and peat depth surveys have been carried out across the Proposed Development Area to inform siting, design and mitigation and the detailed assessment on peatland and associated habitats. The results of the habitat surveys are discussed here, and the results of the peat depth surveys are presented and discussed in Chapter 9: Hydrology, Geology and Hydrogeology and associated respective Technical Appendices.

2.5 NVC Survey Area

The NVC survey area evolved during the baseline survey period to reflect landowner boundaries and evolving iterations to the proposed infrastructure layouts and the Proposed Development Area. The entire Proposed Development Area, covering 508.92 ha, was surveyed.

In addition, the survey area extends beyond the Proposed Development Area in certain areas, reflecting earlier areas of interest and to provide survey buffers to account for the presence of potential GWDTE (where land access permission allowed). The final extent of NVC survey coverage is highlighted in Figure 7.3, which shows survey coverage within and outwith the Proposed Development Area for the reasons described above. The survey area as shown covers an area of 780.53 ha.

This Technical Appendix reports on the habitats recorded within the entire survey area, however the appropriate scale for the assessment of effects with regards habitat loss has been deemed to be the Proposed Development Area (as per Chapter 7: Ecology).

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[3] SNH. (2016) Carbon and Peatland 2016 map. Available at: https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/soils/carbon-and-peatland-2016-map [Accessed 09/08/2023]

[4] Priority peatland habitat is land covered by peat-forming vegetation or vegetation associated with peat formation.

[5] Mineral soil - Peatland habitats are not typically found on such soils (Class 0). Indicative vegetation - no peatland vegetation.

[6] Class 3 - Class 3 - Dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Predominantly peaty soil with some peat soil.

[7] Class 4 - Area unlikely to be associated with peatland habitats or wet and acidic type. Area unlikely to include carbon-rich soils. Indicative vegetation - heath with some peatland.

[8] Class 5 - Soil information takes precedence over vegetation data. No peatland habitat recorded.

3 METHODOLOGY

3.1 National Vegetation Classification (NVC)

The vegetation was surveyed by suitably qualified and experienced botanical surveyors using the NVC scheme (Rodwell, 1991-2000; 5 volumes) and in accordance with NVC survey guidelines (Rodwell, 2006). The NVC scheme provides a standardised system for classifying and mapping semi-natural habitats and ensures that surveys are carried out to a consistent level of detail and accuracy.

Homogeneous stands and mosaics of vegetation were identified and mapped by eye and drawn as polygons on high resolution aerial imagery field maps. These polygons were surveyed qualitatively to record dominant and constant species, sub-dominant species and other notable species present. The surveyors worked progressively across the survey area to ensure that no areas were missed, and that mapping was accurate. NVC communities were attributed to the mapped polygons using surveyor experience and matching field data against published floristic tables (Rodwell, 1991-2000). Stands were classified to sub-community level where possible, although in many cases the vegetation was mapped to community level only because the vegetation was too species-poor or patches were too small to allow meaningful sub-community determination; or because some areas exhibited features or fine-scale patterns of two or more sub-communities.

Quadrat sampling was not used in this survey because experienced NVC surveyors do not necessarily need to record quadrats in order to reliably identify NVC communities and sub-communities (Rodwell, 2006). Notes were made about the structure and flora of larger areas of vegetation in many places (such as the abundance and frequency of species, and in some cases condition and evident anthropogenic impacts). It can be better to record several larger scale qualitative samples than one or two smaller quantitative samples; furthermore, qualitative information from several sample locations can be vital for understanding the dynamics and trends in local (survey area) vegetation patterns (Rodwell, 2006).

Due to small scale vegetation and habitat variability and numerous zones of habitat transitional between similar NVC communities, many polygons can represent complex mosaics of two or more NVC communities. Where polygons have been mapped as mosaics an approximate percentage cover of each NVC community within the polygon is given so that the dominant community and character of the vegetation could still be ascertained.

3.2 Phase 1 Habitat Characterisation

The NVC and mapping data was also correlated to their equivalent habitats according to the Phase 1 habitat classification (JNCC, 2010), considering the species composition and habitat quality. The Phase 1 characterisation has been utilised to allow a broader visual representation of the habitats within the survey area. Polygons or areas where there are mosaic NVC communities have generally been assigned a single Phase 1 classification based on the dominant NVC type (despite some polygons containing multiple Phase 1 types, often in low percentages). Therefore, the Phase 1 characterisation is generally a broader overview, and the NVC data should be referred to for further detail in any specific area.

Botanical nomenclature in this report follows that of Stace (2019) for vascular plants, Atherton *et al.* (2010) for bryophytes and Smith *et al.* (2009) for lichens.

4 SURVEY DETAILS & LIMITATIONS

Surveys were undertaken within the NVC survey area on the following dates inclusive:

- 23rd to 24th June 2015; and
- 18th to 19th August 2020.

The majority of the Proposed Development Area was surveyed during the 2015 surveys. The 2020 surveys covered smaller additional areas as well as carrying out a walkover of the previously surveyed area to either confirm there were no notable changes in vegetation or make any minor updates to the previous mapping and classifications, where relevant.

The weather conditions in both 2015 and 2020 were amenable to survey (dry, overcast but bright and low wind speeds) and were undertaken during the optimal season for vegetation surveys. All areas of the survey area were accessible within the Proposed Development Area.

The NVC system does not cover all possible semi-natural vegetation or habitat types that may be found. Since the NVC was adopted for use in Britain in the 1980's further survey work and an increased knowledge of vegetation communities has led to additional communities being described that do not fall within the NVC system (e.g., see Rodwell *et al*., 2000, Averis *et al*., 2004, Mountford, 2011, and Averis and Averis, 2020). Where such communities are found and recorded, they are given a non-NVC community code and are described.

It should be noted that the results from this survey, and the matches made in describing communities, represent a current community evaluation at the time of survey (as opposed to one seeking to describe what the community was before any human interference, or what it might become in the future). In light of this, a clear constraint of the vegetation survey and evaluation process as used in this, and other surveys, is that it offers only a snapshot of the vegetation communities present and should not be interpreted as a static long-term reference.

Ecological surveys are limited by factors which affect the presence of plants such as the time of year and weather. The ecological surveys undertaken to support this project have not therefore produced a complete list of plants and the absence of evidence of any particular species should not be taken as conclusive proof that the species is not present or that it will not be present in the future. However, the results of these surveys have been reviewed and are considered to be sufficient to undertake the assessment.

5 RESULTS

5.1 Summary of Habitat Types & NVC Communities

Twenty NVC communities and five non-NVC communities were recorded within the entire survey area, and these corresponded to 16 Phase 1 habitat types. These communities and habitat types, and their respective site-specific correlations are summarised below in Table 5-1.

Table 5-1 Phase 1 habitat type equivalents of NVC communities and other habitats recorded

Phase 1 Habitats	NVC Communities & Other Non-NVC Habitats/Features Recorded
A1.1.2 Broadleaved Plantation Woodland	W7 *Alnus glutinosa – Fraxinus excelsior – Lysimachia nemoreum* woodland BP Broadleaved Plantation (non-NVC type)
A1.2.2 Coniferous Plantation Woodland	CP Coniferous Plantation (non-NVC type)
A2.1 Scrub – Dense/Continuous & Scattered	W23 *Ulex europaeus – Rubus fruticosus* scrub
B1.1 Unimproved Acid Grassland	U2 *Avenella flexuosa* grassland U4 *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland (excluding U4b) U6 *Juncus squarrosus – Festuca ovina* grassland
B1.2 Semi-Improved Acid Grassland	U4b *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland *Holcus lanatus – Trifolium repens* sub-community
B2.1 Unimproved Neutral Grassland	MG9 *Holcus lanatus – Deschampsia cespitosa* grassland
B4 Improved Grassland	MG6 *Lolium perenne – Cynosurus cristatus* grassland
B5 Marsh/Marshy Grassland	MG10 *Holcus lanatus – Juncus effusus* rush-pasture M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture M25b *Molinia caerulea – Potentilla erecta* mire *Anthoxanthum odoratum* sub-community M27 *Filipendula ulmaria – Angelica sylvestris* mire
C1.1 Bracken – Continuous	U20 *Pteridium aquilinum – Galium saxatile* community
D1.1 Dry dwarf shrub heath	H12 *Calluna vulgaris - Vaccinium myrtillus* heath
E1.6.1 Blanket Bog	M2 *Sphagnum cuspidatum/fallax* bog pool community M3 *Eriophorum angustifolium* bog pool community M17 *Trichophorum germanicum – Eriophorum vaginatum* blanket mire M19 *Calluna vulgaris – Eriophorum vaginatum* blanket mire M20 *Eriophorum vaginatum* blanket mire
E1.7 Wet Modified Bog	M25a *Molinia caerulea – Potentilla erecta* mire *Erica tetralix* sub-community
E2.1 Acid/Neutral Flush	M4 *Carex rostrata - Sphagnum fallax* mire M6 *Carex echinata - Sphagnum fallax/denticulatum* mire
J1.2 Amenity Grassland	PG Private Gardens & Lawns, etc (non-NVC type)
J3.6 Buildings	BD Buildings (non-NVC type)
J4 Bare Ground	BG Bare Ground, Tracks, Hardstandings etc (non-NVC type)

The following sections describe each of these Phase 1 habitat types and the communities underpinning these within the survey area. Habitats are described in the order they appear within the Phase 1 classification. The survey results are displayed in Figure 7.3 which combines Phase 1 symbology with NVC data.

A number of target notes (TNs) were also made during surveys, often to pinpoint areas or species of interest. These target notes are shown in Figure 7.3 and detailed within Annex A, target note photographs are included within Annex B. Further photographs of a number of the typical habitat types found within the survey area is provided within Annex C.

5.2 Woodland & Scrub

5.2.1 A1.1.2 Broadleaved Plantation Woodland

Broadleaved plantation woodland was recorded within a small, isolated area within the south-east corner of Wester Watten Moss. This area of woodland did not align closely with an identifiable NVC community at the time of survey, comprising immature planted *Betula* spp. over the existing grassland and mire habitat

A further planted stand was identified as most closely referable to W7 *Alnus glutinosa – Fraxinus excelsior – Lysimachia nemoreum* woodland, north-west of Druimdubh Moss within the centre of the survey area. The main canopy species were *Betula pendula* and *Alnus glutinosa* with a damp field layer dominated by *Juncus effusus*. In this instance, this area of woodland formed a smaller component of a mosaic with the M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture community (see Section 5.3.4 below).

5.2.2 A1.2.2 Coniferous Plantation Woodland

The survey area includes several blocks of densely planted commercial coniferous plantation woodland (CP), the largest of which dominates the western side of the survey area, and the smaller stands were found within the more central and north-eastern areas. These plantation woodlands are mostly dominated by *Picea sitchensis,* integrated with the occasional scattered trees of *Pinus sylvestris*.

These types of plantation woodlands are of negligible botanical value due to over-shading and loss of the field flora; patchy areas of moss, *Eriophorum vaginatum* and/or *Molinia caerulea* is therefore generally all that persists beneath the deep shade and the litter shed by the conifers.

5.2.3 A2.1 Dense/Continuous Scrub

Dense/continuous scrub was recorded in the survey area, the majority of which was found in the north. All areas were of the W23 *Ulex europaeus – Rubus fruticosus* scrub community. The W23 community here appears as homogenous stands of *Ulex europaeus*.

5.3 Grasslands & Marsh

5.3.1 B1.1/B1.2 Unimproved & Semi-Improved Acid Grassland

The acid grassland habitats within the Proposed Development Area are generally secondary in origin. Personal communication with the farmer during surveys in 2015 indicated the Proposed Development Area was historically heather dominated but after an initial spreading of fertiliser and lime, and decades of ongoing grazing and drainage, it has transitioned to grassland/pasture. It is generally used as pasture for a low density of cattle and sheep and has been subject to the spread of *Juncus effusus* that is controlled by mowing.

Semi-improved acid grassland is one of the most extensive communities within the survey area and, to a lesser extent, unimproved acid grassland, often being identifiable by its taller and more rank sward, often in mosaics with marshy grassland communities. The acid grassland within the survey area is predominantly of the U4 *Festuca ovina* – *Agrostis capillaris* – *Galium saxatile* grassland community with much smaller areas of U2 *Avenella flexuosa* grassland and U6 *Juncus squarrosus* – *Festuca ovina* grassland.

As well as community level U4, the following sub-communities were recorded; U4a Typical sub-community, U4b *Holcus lanatus-Trifolium repens* sub-community and U4d *Luzula multiflora - Rhytidiadelphus loreus* sub-community. Overall, the stands of U4 within the survey area were very widespread and common on well-drained gentle slopes. The community often contained a variable mix of *Agrostis capillaris*, *A. vinealis*, *Festuca ovina* and *Anthoxanthum odoratum*. The herbs *Potentilla erecta* and *Galium saxatile* are very common and there can also be small quantities of other vascular species such as *Nardus stricta*, *Festuca rubra*, *Avenella flexuosa*, *Juncus squarrosus*, *Carex binervis*, *C. nigra* and *C. pilulifera*. *Juncus effusus* is occasional to abundant, and locally dominant, within all the U4 grassland communities, and despite often being prominent where present, its presence does not change the identity of the grassland community in which it is spreading (only where *Holcus lanatus* or more mesic elements (such as *Cardamine pratensis*) are widely present is another community indicated (respectively MG10 and M23 in these examples)). Mosses are common, especially *Hylocomium splendens*, *Pleurozium schreberi*, *Hypnum jutlandicum* and *Rhytidiadelphus squarrosus*. The U4b sub-community is the most common form of U4 in the survey area and contained most of the above species.

The areas of the U4d sub-community are similar to U4a above, but the sward contains a noticeable frequency of *Deschampsia cespitosa* and an increased cover of mosses. Additionally, *Carex nigra* was locally abundant and *C. panicea* was frequent. Additional species distinctive to U4d include a mix of mire and grassland elements including: *Poa annua, Eriophorum angustifolium, Polygala serpyllifolia, Luzula multiflora, Pedicularis sylvatica, Cirsium palustre, Nardus stricta* and *Potentilla erecta*. The presence of the mire-related species in U4d here reflects the usual location of this sub-community on areas of peat substrate – a point of distinction from the U4a and U4b sub-communities in the Proposed Development Area that are usually located on mineral soils, or organic-rich soils.

U2 grassland is very limited within the Proposed Development Area and the community is dominated by *Avenella flexuosa*; and the U2b sub-community recorded is indicated by the 'heathy' appearance of the vegetation (in contrast to the grassland character of the U2a *Festuca ovina-Agrostis capillaris* sub-community). *Calluna vulgaris* is frequent and *Vaccinium myrtillus*, *Potentilla erecta* and *Galium saxatile* are occasional amongst the small tussocks of *Avenella flexuosa*.

The U6 community was recorded twice, each time within mosaics, with the following sub-communities being recorded; U6a *Sphagnum* sub-community and the U6d *Agrostis capillaris* – *Luzula multiflora* sub-community. The community is commonly identified by the dominance of *Juncus squarrosus* and is most common on well-drained to quite wet, level to gently sloping ground; typically, as small areas scattered among bogs, marshy grassland or U4 acid grassland. The associated flora of most of the U6 here has much in common with that of the U4 acid grassland communities described above but also includes occasional *Calluna vulgaris, Erica tetralix* and *Luzula multiflora*; additional mosses included *Sphagnum fallax*, *S. capillifolium, Dicranum scoparium* and *Aulacomnium palustre*. The U6a sub-community was identified by the abundance of *Sphagnum fallax* and *S. capillifolium.* The U6d sub-community was slightly more common forming a close association with the U4 grassland community in terms of species composition. U6 within the Proposed Development Area has been derived from the degradation of the original wet heath/blanket mire vegetation, and it can be found in mosaics with this same vegetation.

Areas of semi-improved acid grassland (B1.2) are characterised by the U4b *Holcus lanatus-Trifolium repens* sub-community only and are generally located in the north of the survey area, often in enclosed fields, although it does appear in smaller patches across the survey area generally. These swards are often found where there are fields in which there has been some form of historical agricultural improvement or a long history of intensive grazing and/or nutrient enrichment. The sward tends to be dominated by a semi-improved assemblage which includes typical species such as *Holcus lanatus, Agrostis* spp.*, Cynosurus cristatus, Lolium perenne*, *Trifolium repens* and *Ranunculus repens*. In the U4b swards there is also frequent to occasional *Lotus corniculatus, Cerastium fontanum, Bellis perennis, Taraxacum* sp., *Plantago media, Galium verum* and *Achillea millefolium*. The more closed, grass-rich sward limits the moss cover so that only *Rhytidiadelphus squarrosus* is frequent, in localised wefts there is more occasional *Kindbergia praelonga* and *Pseudoscleropodium purum*.

5.3.2 B2.1 Unimproved Neutral Grassland

Unimproved neutral grasslands are uncommon within the survey area, being found in two areas to the north and being most closely identified with MG9 *Holcus lanatus – Deschampsia cespitosa* grassland community. The MG9 community was recorded as the MG9a *Poa trivialis* sub-community.

The MG9 community forms a damp field layer dominated by tussocky *Deschampsia cespitosa, Holcus lanatus* and *Juncus effusus*. Other species commonly found in these stands included *Agrostis capillaris*, *Rumex acetosa*, *Festuca rubra*, *Anthoxanthum odoratum, Ranunculus repens*, *Cirsium palustre*, *Poa* spp., *Carex nigra* and the moss *Rhytidiadelphus squarrosus*.

5.3.3 B4 Improved Grassland

Improved grassland becomes a more noticeable feature within the south-eastern corner of the survey area, and which encompasses a number of improved and grazed fields. All of these areas are of the MG6 *Lolium perenne – Cynosurus cristatus* grassland community, where the fields and swards have been agriculturally improved over time. These areas were recorded as the MG6a Typical sub-community. Species diversity is poor with the main dominants being *Lolium perenne*, *Cynosurus cristatus*, *Poa* spp., *Trifolium repens* with scattered tufts of *Juncus effusus*. The moss *Rhytidiadelphus squarrosus* can be abundant in small patches. As a result of this modified habitat the botanical interest is low.

5.3.4 B5 Marsh/Marshy Grassland

Marshy grassland is a poorly defined habitat that includes several different sward types in which *Molinia caerulea*, *Juncus* spp. and/or *Carex* spp. can be prominent in mesic conditions. Within the survey area, the M23, M25b and M27 communities are included within its limits. MG10 can fall within either marshy grassland or neutral grassland classifications, however here due to the abundance of *Juncus* spp. it has been included within marshy grassland.

Marsh/marshy grassland is common but widely scattered within the survey area, present mainly along watercourse valleys, and as noted above is predominately made up of MG10 *Holcus lanatus – Juncus effusus* rush-pasture, M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture, M25b *Molinia caerulea – Potentilla erecta* mire *Anthoxanthum odoratum* sub-community and M27 *Filipendula ulmaria – Angelica sylvestris* mire NVC communities. These communities also form mosaics and transitional areas with several other grassland and mire communities. In particular, in an open area to the south-east of Wester Watten Moss, marshy grassland and blanket bog form a close association where many of the communities making up the marshy grassland habitat form mosaics with blanket bog communities. This is most likely to have been influenced by drainage and grazing levels in this area.

In most cases the MG10 community was recorded as the MG10a Typical sub-community, and much less so as the MG10c *Iris pseudacorus* sub-community, with both sub-communities often found within mosaics with acid grassland and mire communities. This community has much in common with the MG9 community (referred to in Section 5.3.2 above) containing many of the same species, and often differentiated by the respective proportions of *Holcus lanatus*, *Deschampsia cespitosa* and *Juncus effusus* in order to dictate the NVC classification. The MG10c community is distinguished according to the dominance or abundance of *Iris pseudacorus* in a similar vegetation composition to that described above for MG10a.

The M23 NVC community is widespread and frequent across the survey area and is often species poor with *Juncus* spp. being the dominant species. Associated with surface water features, it is rather linear in its distribution, following the riparian zone of the watercourses, for example, or appearing where a soakaway or runnel leaves the plantations to pass downslope. Both M23 sub-communities are found within the survey area, however the M23b *Juncus effusus* sub-community is more extensive than the M23a *Juncus acutiflorus* sub-community and occurs on damp or waterlogged riparian soils, rather than being confined to areas of evident surface water movement (more evident with M23a).

Generally, areas of M23 are dominated by mixtures of *Juncus effusus* and/or *Juncus acutiflorus* with patches of a low diversity of grasses such as *Deschampsia cespitosa*, *Holcus lanatus*, *Anthoxanthum odoratum* and *Agrostis* spp. Within the more herb rich areas, a variety of species were frequently to occasionally recorded such as *Galium palustre*, *G. uliginosum*, *Cardamine pratensis*, *Lotus pedunculatus*, *Trifolium repens*, *Epilobium palustre*, *Cirsium palustre, Rumex acetosa*, *Viola palustris*, *Potentilla erecta, Succisa pratensis, Juncus articulatus, Carex nigra, C. echinata, C. panicea,* and *Ranunculus repens*; and more rarely *Iris pseudacorus*, *Filipendula ulmaria*, *Angelica sylvestris*, *Achillea millefolium*, *Stellaria graminea* and *Caltha palustris*. Wefts of mosses are also common through M23 between these species including *Calliergonella cuspidata*, *Kindbergia praelonga*, and *Rhytidiadelphus squarrosus*. M23a also contained some semi-aquatic species such as *Potamogeton polygonifolius* and *Ranunculus flammula*.

The M27 community was recorded in three locations within the survey area, all being identified as the M27c *Juncus effusus – Holcus lanatus* sub-community, both as pure stands and within a mosaic within modified bog. *Filipendula ulmaria* is dominant in these patches with occasional *Juncus* *effusus*, *Epilobium palustre*, *Succisa pratensis*, *Rumex acetosa*, *Holcus lanatus*, and occasional *Deschampsia cespitosa*, *Phragmites australis* and *Galium aparine*.

5.4 Tall Herb & Fern

5.4.1 C1.1 Bracken: Continuous

A single area of bracken appears within the survey area to the south, close to the Snottergill Burn. This area was recorded as the U20a *Anthoxanthum odoratum* sub-community. *Pteridium aquilinum* dominates this sward where the associated species composition forms a more acid grassland assemblage with species such as *Agrostis capillaris*, *Galium saxatile*, *Potentilla erecta* and the mosses *Rhytidiadelphus squarrosus* and *Hylocomium splendens*, having a close affinity with the U4 acid grassland community.

5.5 Heaths

5.5.1 D1.1 Dry Dwarf Shrub Heath

A single small area of dry heath was recorded within the survey area, this is likely because historically most of the suitably free-draining substrate has been converted to grassland (c.f. Section 5.3.1). This was a small patch of H12 *Calluna vulgaris - Vaccinium myrtillus* heath in close association with U2b grassland. It is a narrow (<10 m wide) strip of mature *Calluna vulgaris*, with a closed canopy and *Hypnum jutlandicum*; and marginally, where the canopy is more open, *Vaccinium myrtillus* and other species derived from the adjoining vegetation types.

5.6 Mire

5.6.1 E1.6.1 Blanket Bog

Blanket bog is relatively common within the more elevated parts and watershed plateaus of the survey area and is more extensive outwith the Proposed Development Area (see Figure 7.3). Blanket bog here is mainly represented by the M17 *Trichophorum germanicum – Eriophorum vaginatum* blanket mire community, M19 *Calluna vulgaris – Eriophorum vaginatum* blanket mire community, and the M20 *Eriophorum vaginatum* blanket mire community. The M17 and M19 communities tend to represent areas of relatively more intact, active and better-quality bog, with frequent to abundant *Sphagna* in the basal layer. These communities appear both as pure stands and within mosaics with other grassland and mire communities. The M2 *Sphagnum cuspidatum/fallax* bog pool community and M3 *Eriophorum angustifolium* bog pool community were also infrequently recorded within these blanket bog areas (e.g., see Annex A below).

The area of M2 recorded was of the M2b *Sphagnum fallax* sub-community and comprised a wet lawn of *S. fallax*. This community is present in the east of the survey area in an extensive area of mire. Here it forms a mosaic with the other mire communities, where it occupies the wettest depressions, and forms an unconsolidated surface.

The M3 community appears infrequently within these blanket bog areas as very small bog pools, an example of which was recorded as a target note. The bog pool contained *Eriophorum angustifolium* and occasional *E. vaginatum* over a carpet of *Sphagnum fallax*, *S. cuspidatum*, *S. capillifolium*, and occasionally *S. papillosum*.

M17 occurs most often as homogenous stands of this community within the survey area. This community forms the largest part of this blanket bog resource within the survey area. While recorded at times at community level only, the majority of this type of blanket bog was recorded as the M17a *Drosera rotundifolia – Sphagnum* spp. sub-community and M17c *Juncus squarrosus – Rhytidiadelphus loreus* sub-community. The M17a sub-community that is semi-natural retains a high *Sphagnum* cover; whereas the M17c sub-community is grazed to a short sward and the Sphagna are often subordinate to pleurocarpous mosses. Overall, there is a mix of *Trichophorum germanicum* and *Eriophorum vaginatum*, although the densities can be variable in places. The sward also contains a mix of other species ranging from frequent and occasional, to locally abundant, species present included *Erica tetralix*, *Eriophorum angustifolium*, *Vaccinium myrtillus*, *Molinia caerulea*, *Empetrum nigrum*, *Calluna vulgaris, Narthecium ossifragum*, *Avenella flexuosa* and *Galium saxatile*. The basal layer includes *Sphagnum papillosum*, *S. fallax*, *S. palustre*, *S. capillifolium, Aulacomnium palustre, Hylocomium splendens*, *Pleurozium schreberi, Pseudoscleropodium purum*, *Rhytidiadelphus loreus* and occasional *Polytrichum commune*. Waterlogged hollows in M17a also contain *S. cuspidatum* and/or *S. fallax*; *S. denticulatum* occurs very rarely and generally in association with surface water pathways or the deeper parts of pools. The M17a sub-community contains most of the community constants while the less abundant M17c sub-community was found to have a closer affinity with the M19 blanket bog community detailed below although *C. vulgaris* and *E. vaginatum* are not so dominant in this case, and *Juncus squarrosus* is frequent. Within the survey area, extensive, and more locally intensive grazing has resulted in effects that shift the M17a vegetation composition towards M17c.

The M19 community appears within this blanket bog habitat occurring on peat-covered level to gently sloping ground within the survey area. It is represented by the M19a *Erica tetralix* sub-community. The community is generally distinctive with the bulk of the vegetation consisting of a mixture of *Calluna vulgaris* and *Eriophorum vaginatum*. There is commonly at least a little *Vaccinium myrtillus* and/or *Avenella flexuosa*. The mosses *Hylocomium splendens*, *Polytrichum commune, Pleurozium schreberi*, *Hypnum jutlandicum* and *Sphagnum capillifolium* are collectively very abundant, forming deep and extensive carpets.

M20 was recorded to community level only within the survey area, often as homogeneous stands of vegetation, identified by the dominant tussocks of *Eriophorum vaginatum* and often found in close association with the M19 community. Other species were infrequently noted, namely, *Vaccinium myrtillus*, *Potentilla erecta*, *Galium saxatile* and occasional *Molinia caerulea*. The mosses *Sphagnum fallax* and *Polytrichum commune* were also present throughout this community.

5.6.2 E1.7 Wet Modified Bog

Wet modified bog within the survey area comprises areas of M25a *Molinia caerulea – Potentilla erecta* mire *Erica tetralix* sub-community.

The M25 mire areas were identified due to *Molinia* dominating the sward within the survey area, with a concentration towards the western and central areas. This community appears as the M25a *Erica tetralix* sub-community, and also within mosaics with other mire and grassland communities, particularly M17 blanket mire. The majority of the species found within this assemblage along with *Molinia caerulea* were species poor with *Calluna vulgaris*, *Juncus squarrosus*, *Vaccinium myrtillus*, *Avenella flexuosa*, *Holcus lanatus*, and very occasional

Trichophorum germanicum. Within the wetter areas of this community, the dense patches of *Sphagnum* moss became more abundant, particularly *Sphagnum capillifolium* along with other mosses such as *Polytrichum commune* and *Hylocomium splendens*.

5.6.3 E2.1 Acid/Neutral Flush

Acid/neutral flushes appear in a small number of areas within the survey area, with a large extent of flush vegetation present around the eastern boundary of the Proposed Development Area, east of T2. Here, the flush dominated vegetation spans a large area, most of which is outwith the Proposed Development Area (see Figure 7.3). The majority of this habitat is represented by M6 *Carex echinata – Sphagnum fallax/denticulatum* mire, and to a lesser extent M4 *Carex rostrata – Sphagnum fallax* mire.

The majority of the M6 community was recorded as the M6a *Carex echinata* sub-community, and to a lesser extent, the M6c *Juncus effusus* sub-community. These are rush or sedge mires on wet and mostly flushed ground whose soils appear to be acidic, as judged by the abundance of *Sphagnum* mosses (especially *Sphagnum fallax* and *S. palustre*) and the moss *Polytrichum commune*. The M6a sub-community was dominated by the sedges *Carex echinata* and *C. panicea* amongst the *Juncus effusus* and *J. conglomeratus*. Some of these areas provided a richer species mix with *Succisa pratensis*, *Erica tetralix*, *Dactylorhiza maculata*, *Caltha palustris*, *Galium palustre*, *Anthoxanthum odoratum* and *Rumex acetosa*. The most frequent mosses were recorded as *Polytrichum commune*, *Dicranum scoparium* and *Sphagnum capillifolium*. The M6c sub-community is a rush mire dominated by tall swards of *Juncus effusus* with a carpet of *Sphagnum* moss spread within it, mostly of *S. fallax* with occasional *S. capillifolium*.

Smaller scattered areas of M4 were recorded as homogenous stands. This community was dominated by *Carex rostrata* with a basal layer composed of *Menyanthes trifoliata*, *Succisa pratensis*, *Potentilla palustris* with a thick carpet of *Sphagnum* mosses, these being, *Sphagnum fallax, S. palustre* and *S. capillifolium*.

5.7 Miscellaneous

5.7.1 J1.2 Amenity Grassland

Amenity grassland is a non-NVC community used here for private gardens (PG) within the survey area. Most commonly these areas form lawns within the curtilage of private properties and in some instances may include scattered trees and hedges.

5.7.2 J3.6 Buildings

Buildings is a non-NVC community (BD) to identify buildings or built-up structures within the survey area, both inhabited and vacant, such as private dwelling houses and outbuildings/sheds.

5.7.3 J4 Bare Ground

Bare ground is a non-NVC community (BG) within the survey area and includes existing tracks, hardstandings and public roads. Any areas that were devoid of vegetation and that could not be classified as any other habitat, such as bare rock, have also been included here.

5.8 Invasive Non-Native Species

No Invasive Non-Native Species (INNS) were incidentally recorded during the habitat surveys; however, this does not preclude their presence from the survey area.

5.9 Notable Species

No notable or rare species were incidentally recorded during the habitat surveys; however, this does not preclude their presence from the survey area.

6 EVALUATION OF BOTANICAL INTEREST

6.1 Overview

NVC communities can be compared with a number of habitat classifications in order to help in the assessment of the sensitivity and conservation interest of certain areas. The following sections compare the survey results and the NVC communities identified against three classifications:

- SEPA guidance on Groundwater Dependent Terrestrial Ecosystems (GWDTEs);
- Habitats Directive (92/43/EEC) Annex I habitats; and
- Scottish Biodiversity List (SBL) priority habitats.

6.2 Groundwater Dependent Terrestrial Ecosystems (GWDTE)

SEPA has classified a number of NVC communities as potentially dependent on groundwater (SEPA, 2017a & 2017b). Wetlands or habitats containing these particular NVC communities are to be considered GWDTE unless further information can be provided to demonstrate this is not the case. Many of the NVC communities on the list are very common habitat types across Scotland, and some are otherwise generally of low ecological value. Furthermore, some of the NVC communities may be considered GWDTE only in certain hydrogeological settings.

Designation as a potential GWDTE does not therefore infer an intrinsic biodiversity value, and GWDTE status has not been used as criteria to determine a habitat's respective conservation importance. There is however a statutory requirement to consider GWDTEs and the data gathered during the NVC surveys has been used to inform this assessment (see Chapter 9: Hydrology, Geology and Hydrogeology).

Using SEPA's guidance, Table 6-1 shows which communities recorded within the survey area may be considered potential GWDTE. Those communities which may have limited (moderate) dependency on groundwater in certain settings are marked in yellow and NVC communities recorded that are likely to be considered high, or sensitive GWDTE in certain hydrogeological settings are highlighted in red.

Table 6-1 Communities within the survey area which may potentially be classified as GWDTE

NVC Code	NVC Community Name
M25	*Molinia caerulea – Potentilla erecta* mire
M27	*Filipendula ulmaria – Angelica sylvestris* mire
MG9	*Holcus lanatus – Deschampsia cespitosa* grassland
MG10	*Holcus lanatus – Juncus effusus* rush pasture
U6	*Juncus squarrosus – Festuca ovina* grassland
W7	*Alnus glutinosa – Fraxinus excelsior – Lysimachia nemoreum* woodland
M6	*Carex echinata – Sphagnum fallax/denticulatum* mire
M23	*Juncus effusus/acutiflorus – Galium palustre* rush pasture

The location and extent of all identified potential GWDTE are provided on an appropriate NVC map; see Figure 7.4.

Within Figure 7.4 the potential GWDTE sensitivity of each polygon containing a potential GWDTE is classified on a four-tier approach as follows:

- 'Highly – dominant' where potential high GWDTE(s) dominate the polygon;
- 'Highly - sub-dominant' where potential high GWDTE(s) make up a sub-dominant percentage cover of the polygon;
- 'Moderately – dominant' where potential moderate GWDTE(s) dominate the polygon and no potential high GWDTEs are present; and
- 'Moderately - sub-dominant' where potential moderate GWDTE(s) make up a sub-dominant percentage cover of the polygon and no potential high GWDTEs are present.

Where a potential high GWDTE exists in a polygon it outranks any potential moderate GWDTE communities within that same polygon.

GWDTE sensitivity has been assigned solely on the SEPA listings (SEPA, 2017a & 2017b). However, depending on a number of factors such as geology, superficial geology, presence of peat and topography, many of the potential GWDTE communities recorded may in fact be only partially groundwater fed or not dependent on groundwater. Determining the actual groundwater dependency of particular areas or habitat requires further assessment (see Chapter 9: Hydrology, Geology and Hydrogeology).

6.3 Annex I Habitats

6.3.1 Overview

A number of NVC communities can also correlate to various Annex I habitat types. However, the fact that an NVC community can be attributed to an Annex I type does not necessarily mean all instances of that NVC community constitute Annex I habitat. Its Annex I status can depend on various factors such as quality, extent, species assemblages, geographical setting and substrates.

Using Joint Nature Conservation Committee (JNCC) Annex I habitat listings and descriptions[9], which have then been compared with survey results and field observations, the following NVC communities within the survey area which may constitute Annex I habitat are shown in Table 6-2.

Table 6-2 Annex I Habitats and corresponding NVC communities

Annex I Habitat	Corresponding NVC Communities & Other Non-NVC Habitats/Features Recorded
4030 European dry heath	H12 *Calluna vulgaris - Vaccinium myrtillus* heath
7130 Blanket bog	M2 *Sphagnum cuspidatum/fallax* bog pool community M3 *Eriophorum angustifolium* bog pool community M17 *Trichophorum germanicum – Eriophorum vaginatum* blanket mire M19 *Calluna vulgaris – Eriophorum vaginatum* blanket mire M20 *Eriophorum vaginatum* blanket mire M25a *Molinia caerulea – Potentilla erecta* mire *Erica tetralix* sub-community
7140 Transition mires and quaking bogs	M4 *Carex rostrata - Sphagnum fallax* mire

Further details on the inclusion or omission of certain NVC communities/sub-communities and/or Annex I types are also provided below.

6.3.2 7130 Blanket bog

The blanketing of the ground with a variable depth of peat gives the habitat type its name and results in the various morphological types according to their topographical position. Blanket bogs show a complex pattern of variation related to climatic factors, particularly illustrated by the variety of patterning of the bog surface in different parts of the UK. Such climatic factors also influence the floristic composition of bog vegetation.

'Active' bogs are defined as supporting a significant area of vegetation that is normally peat-forming. Typical species include the important peat-forming species, such as *Sphagnum* spp. and *Eriophorum* spp., or *Molinia caerulea* in certain circumstances, together with *Calluna vulgaris* and other ericaceous species. The most abundant NVC blanket bog types are M17, M18, M19, M20 and M25.

Annex I type 7130 Blanket bog therefore correlates directly with a number of NVC communities within the survey area such as the M17, M19 and M20 mires. However, 7130 Blanket bog can also include bog pool communities (M1-M3) where these occur within blanket mires such as M17-M20. As such M2 and M3 within the survey area are also assigned to the blanket bog Annex I type, as they are often associated with areas of M17, M19 and M20 mire.

[9] Available from - https://sac.jncc.gov.uk/habitat/ [Accessed 09/08/2023]

M25 mire can also fall within the 7130 blanket bog Annex I type where the underlying peat depth is greater than 0.5 m and the associated flora includes typical bog vegetation (as is the case here due to the species composition and its presence in mosaics with other blanket bog communities; Section 5.6.2). These areas have also been classified as potential Annex I blanket bog, to represent a worst-case scenario.

6.3.3 7140 Transition mires and quaking bogs

All examples of M4 *Carex rostrata - Sphagnum fallax* mire within the survey area were assigned to the Annex I type Transition mires and quaking bogs. The term 'transition mire' relates to vegetation that in floristic composition and general ecological characteristics is intermediate between acid bog and alkaline fen.

6.3.4 4030 European dry heaths

European dry heaths typically occur on freely draining, acidic to circumneutral soils with generally low nutrient content. Ericaceous dwarf shrubs dominate the vegetation. The most common dwarf shrub is *Calluna vulgaris*. A small area of H12 dry heath was recorded in the survey area. Scottish Biodiversity List Priority Habitats

6.4 Scottish Biodiversity List Priority Habitats

The SBL is a list of animals, plants and habitats that Scottish Ministers consider to be of principal importance for biodiversity conservation in Scotland. The SBL was published in 2005 to satisfy the requirement under Section 2(4) of The Nature Conservation (Scotland) Act 2004.

The SBL identifies habitats which are the highest priority for biodiversity conservation in Scotland: these are termed 'priority habitats'. Some of these priority habitats are quite broad and can correlate to many NVC types.

The relevant SBL priority habitat types (full descriptions of which can be found on the NatureScot website[10]), and associated NVC types recorded within the survey area are as follows:

- Wet woodland: W7;
- Blanket bog: M17, M19, M20, M2 and M3 (where associated with M17-M20), and M25a where peat depth is greater than 0.5 m;
- Upland heathland: H12, and
- Upland flushes, fens and swamps: M4, M6, M23a, and M27.

These SBL priority habitats correspond with UK Biodiversity Action Plan (BAP) Priority Habitats[11].

6.5 Sensitivity Summary

Table 6.3 provides a summary of all the NVC communities and non-NVC types recorded within the survey area and any associated habitat sensitivities as described in the sections above.

[10] Available from - https://www.webarchive.org.uk/wayback/archive/20210408152132/https://www.nature.scot/landscapes-and-habitats/habitat-types/habitat-definitions [Accessed 09/08/2023]
[11] Available from - https://jncc.gov.uk/our-work/uk-bap-priority-habitats/ [Accessed 09/08/2023]

Table 6-3 Summary of survey area communities and sensitivities

NVC/Non-NVC Codes Recorded	Potential GWDTE Status	Annex I Habitat	SBL Priority Habitat Type
Mires			
M2b	-	7130 Blanket bogs (examples associated with M17-M20)	Blanket bog
M3	-	7130 Blanket bogs (examples associated with M17-M20)	Blanket bog
M4	-	7140 Transition mires and quaking bogs	Upland flushes, fens and swamps
M6, M6a, M6c	High	-	Upland flushes, fens and swamps
M17, M17a, M17c	-	7130 Blanket bogs	Blanket bog
M19a	-	7130 Blanket bogs	Blanket bog
M20	-	7130 Blanket bogs	Blanket bog
M23a, M23b	High	-	Upland flushes, fens and swamps (applies to M23a only)
M25a, M25b	Moderate	7130 Blanket bogs (where peat depth >0.5 m; applies to M25a only)	Blanket bogs (where peat depth >0.5 m; applies to M25a only)
M27c	Moderate	-	Upland flushes, fens and swamps
Dry Heaths			
H12		4030 European dry heaths	Upland heathland
Calcifugous Grasslands & Bracken			
U2b	-	-	-
U4, U4a, U4b, U4d	-	-	-
U6a, U6d	Moderate	-	-
U20a	-	-	-
Mesotrophic Grasslands			
MG6a	-	-	-
MG9a	Moderate	-	-
MG10a, MG10c	Moderate	-	-
Woodland & Scrub			
W7	High	-	Wet woodland
W23	-	-	-

NVC/Non-NVC Codes Recorded	Potential GWDTE Status	Annex I Habitat	SBL Priority Habitat Type
Non-NVC Types			
BD	-	-	-
BG	-	-	-
BP	-	-	-
CP	-	-	-
PG	-	-	-

7 SUMMARY

MacArthur Green carried out NVC and habitat surveys within the survey area on 23rd and 24th July 2015 with further surveys over an extended area on 18th and 19th August 2020 in order to identify those areas of vegetation communities with the greatest ecological or conservation interest.

In total 20 NVC communities were recorded within the respective survey area along with various associated sub-communities; a number of non-NVC habitat types are also present, in particular coniferous plantation woodland which is extensive. Only a small number of communities or habitat types account for the majority of the survey area.

Outwith the coniferous plantation areas, the survey area is mainly open upland habitats, the most common and widespread making up the bulk of the landscape is blanket bog represented most strongly by the M17 *Trichophorum germanicum – Eriophorum vaginatum* blanket mire NVC community and unimproved and semi-improved acid grassland of the U4 *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland NVC community. There are a number of other habitat types present such as improved grassland, neutral grassland, marshy grassland, flush and wet modified bog.

Although some large relatively homogeneous stands of vegetation occur, most of the communities often form complex mosaics and transitional areas across the survey area.

The survey results have also been compared to a number of sensitivity classifications, indicating the presence of Annex I, SBL and potential GWDTE habitats, as summarised in Table 6-3.

8 REFERENCES

Atherton, I., Bosanquet, S. & Lawley, M. (2010). Mosses and Liverworts of Britain and Ireland: a field guide. British Bryological Society.

Averis, A., Averis, B. Birks, J., Horsfield, D., Thompson, D. and Yeo, M. (2004). An Illustrated Guide to British Upland Vegetation. Pelagic, Exeter.

Averis, B and Averis, A. (2020). Plant Communities found in surveys by Ben and Alison Averis but not described in the UK National Vegetation Classification. Available from - http://www.benandalisonaveris.co.uk/wp/wp-content/uploads/2020/11/non-nvc_vegetation_types_found_by_ben_and_alison_averis_2020-06__version_with_image_resolution_reduced_.pdf [Accessed 09/08/2023]

Joint Nature Conservancy Council (JNCC). (2010). Handbook for phase 1 habitat survey – a technique for environmental audit. JNCC, Peterborough.

Mountford, E. (2011). A compilation of proposed additions and revisions to vegetation types in the National Vegetation Classification, JNCC Report No. 448. JNCC, Peterborough, ISBN 0963-8091

Rodwell, J.S. (Ed), et al. (1991 – 2000). British Plant Communities (5 volumes). Cambridge University Press, Cambridge.

Rodwell, J., Dring, J.C., Averis, A.B.G., Proctor, M.C.F., Malloch, AJ.C., Schaminee, J.H.J. and Dargie, T.C.D. (2000). Review of coverage of the National Vegetation Classification. JNCC Report, No. 302. JNCC, Peterborough.

Rodwell, J.S. (2006). NVC Users' Handbook. ISBN 978 1 86107 574 1.

SEPA. (2017a). Land Use Planning System SEPA Guidance Note 31: Guidance on Assessing the Impacts of Windfarm Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. Version 3. Issue date: 11/09/2017.

SEPA. (2017b). Land Use Planning System SEPA Guidance Note 4: Planning guidance on on-shore windfarm developments. Version 3. Issue date: 11/09/2017.

Smith, C.W., Aptroot, A., Coppins, B.J., Fletcher, A., Gilbert, O.L., James, P.W. & Wolseley, P.A. (Eds.) (2009). The Lichens of Great Britain and Ireland. The British Lichen Society.

Stace, C.A. (2019). New Flora of the British Isles. 4th Edition. Cambridge University Press.

ANNEX A. NVC TARGET NOTES

A number of target notes were also made during surveys, often to pinpoint an area or species of interest, these target notes are shown on Figure 7.3 and detailed within Table A.1 below. A representative sample of corresponding target note photographs is provided in Annex B.

Table A-1 Survey Area Target Notes

Target Note ID	Easting	Northing	NVC Community	Description	Photo Reference
1	319897	951392	N/A	Example of flushed drainage channels on site containing *Eriophorum vaginatum, Sphagnum fallax, S. palustre* and some *Juncus sp.*	
2	321623	951191	M3	Example of small bog pools in area too small to map. Contains abundant *Eriophorum angustifolium*, with small patches of *Sphagnum fallax* and *S. cuspidatum*.	B-1
3	321051	952483	M2, M4, M6, M17, M19, M20, M25	Area where there is a mosaic of bog, bog pool, and flush communities locally.	
4	321708	951950	M4	Area of *Carex rostrata* dominated vegetation with open areas of bare peat with *Menyanthes trifoliata* dominating within the wetter areas supplemented with occasional patches of *Eriophorum angustifolium* and *Equisetum palustre*.	B-2

ANNEX B. TARGET NOTE PHOTOGRAPHS

The following photographs correlate to the target notes described within Annex A, Table A-1. Photographs are not provided here for all target notes, due to the similarity in many photographs.

Photo B-1 Target Note 2

Photo B-2 Target Note 4

ANNEX C. GENERAL COMMUNITY PHOTOGRAPHS

The following selected photographs are provided to give a visual representation to a number of the community types present within the survey area.

Photo C-1- M17 *Trichophorum germanicum – Eriophorum vaginatum* blanket mire

Photo C-2 – Conifer Plantation including M17 dominated forest ride

Photo C-3 - W7 *Alnus glutinosa – Fraxinus excelsior – Lysimachia nemoreum* woodland (within surrounding mosaic of M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture)

Photo C-4 – MG6 *Lolium perenne – Cynosurus cristatus* grassland

Photo C-5 – Mosaic of MG10 *Holcus lanatus – Juncus effusus* rush-pasture, M17 *Trichophorum germanicum – Eriophorum vaginatum* blanket mire, U4 *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland and M6 *Carex echinata - Sphagnum fallax/denticulatum* mire

Photo C-6 – Mosaic of U4 *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland and MG10 *Holcus lanatus – Juncus effusus* rush-pasture

MacArthur Green

Watten Wind Farm

Protected Species Survey Report

Technical Appendix A7.2

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1 INTRODUCTION

MacArthur Green was commissioned by EDF Energy Renewables Limited (EDF-ER the 'Applicant') to carry out protected species surveys at Watten Wind Farm (hereafter referred to as the 'Proposed Development').

These surveys primarily focussed on otter (*Lutra lutra*), water vole (*Arvicola amphibius*), badger (*Meles meles*), red squirrel (*Sciuris vulgaris*) and pine marten (*Martes martes*).

A watching brief was also kept throughout these surveys, and during all ecological surveys at the Proposed Development Area, and signs recorded for other protected species potentially inhabiting the survey areas such as adder (*Vipera berus*), wildcat (*Felis silvestris grampia*), common or viviparous lizard (*Zootoca vivipara*), and slow worm (*Anguis fragilis*).

Surveys for bats and fish were carried out and are reported separately in Technical Appendices A7.3 and A7.4.

These protected species surveys were undertaken to aid and inform the design and ecological assessment for the Watten Wind Farm Environmental Impact Assessment Report (EIAR).

2 THE PROPOSED DEVELOPMENT AREA & SURVEY AREA

The Proposed Development is located approximately 14 km to the west of Wick and approximately 2.5 km to the south-west of Loch Watten in the Highlands. The Proposed Development Area is upland in character with a mosaic of mainly mires, calciferous grassland with isolated blocks of coniferous plantation. In addition, smaller pockets of marsh and mesotrophic grassland habitats are also found on the Proposed Development Area, particularly to the southern and eastern boundary. The land is drained by several small and minor watercourses that are mostly tributaries of Loch Burn, Black Burn and Red Burn, which lie to the south, central and east of the Proposed Development Area respectively.

The survey area in which protected species surveys were undertaken incorporated the Proposed Development Area boundary, with specific buffers in some areas as appropriate for the specific species surveyed for. The protected species survey areas are shown in Figure 7.5.

3 LEGAL PROTECTION

Details of the legal protection of the protected species surveyed for are given in **Annex A** of this report.

4 METHODS

4.1 Desk Study

A desk-based study was undertaken to inform the field surveys and assessment with regards the presence of designated sites and species of interest within the Proposed Development Area and survey area.

This study consisted of the consultation of various online resources such as the NBN Atlas[1], NatureScot Sitelink[2], Caithness District Salmon Fishery Board[3], the British Deer Society Deer Distribution Survey[4] and Scottish Wildcat Priority Areas[5] and Saving Scotland's Red Squirrels[6].

4.2 Field Surveys

Surveys for protected species were undertaken on the 4 March, 18th August 2020 and the 12th April 2023 to record the presence or likely absence of otter, water vole, badger, red squirrel and pine marten, with all habitats suitable for protected species surveyed within the Proposed Development Area (see Figure 7.5). Results from protected species surveys undertaken between 25th and 26th June 2015 as part of a previous suite of baseline surveys within the Proposed Development Area have also been considered.

A watching brief for any protected species signs was also undertaken during other survey visits (e.g. ornithology/vegetation/other ecology surveys) throughout the year.

The signs found indicate type and intensity of activity and consequently help in the assessment of the importance of a particular area for the protected species. The survey methods used are described below.

4.2.1 Otter

All accessible watercourses within the survey area were surveyed for otter field signs. Otter field signs and survey methods are described in Bang & Dahlstrøm (2001)[7], Sargent & Morris (2003)[8] and Chanin (2003)[9], and include:

- **Holts:** underground features where otters live. They can be tunnels within bank sides, underneath root-plates or boulder piles, and even man-made structures such as disused drains. Holts are used by otters to rest up during the day and are the usual location of natal or breeding sites. Otters may use holts permanently or temporarily;

[1] NBN Atlas Scotland. (2022). *NBN Atlas*. [Online] Available from - https://scotland.nbnatlas.org/. [Accessed 10/08/2023]
[2] NatureScot. (2022) *SiteLink*. [Online] Available from - https://sitelink.nature.scot/home [Accessed 10/08/2023]
[3] Caithness District Salmon Fishery Board. (2022). *2021 Survey of Juvenile Salmonids in Caithness Rivers*. [Online] Available from - https://caithness.dsfb.org.uk/ [Accessed 10/08/2023]
[4] The British Deer Society (2016). Deer Distribution Survey Results. Available online: https://bds.org.uk/science-research/deer-surveys/deer-distribution-survey/ [Accessed 10/08/2023]
[5] NatureScot. (2022). *Wild cat protected areas.* [Online] Available from - https://cagmap.snh.gov.uk/natural-spaces/dataset.jsp?code=WPA [Accessed 10/08/2023]
[6] Saving Scotland's Red Squirrels (2022) Website. [Online] Available from - https://scottishsquirrels.org.uk/squirrel-sightings/ [Accessed 10/08/2023]
[7] BANG, P., and DAHLSTRØM, P. (2001). Animal Tracks and Signs. Oxford University Press, Oxford.
[8] SARGENT, G., and Morris, P. (2003). *How to Find and Identify Mammals*. The Mammal Society, London.
[9] CHANIN, P. (2003). Monitoring the Otter (*Lutra lutra*). Conserving Natura 2000 Rivers Monitoring Series No.10 English Nature, Peterborough.

- **Couches:** these are above ground resting-up sites. They may be partially sheltered, or fully exposed. Couches may be regularly used, especially in reed beds and on in-stream islands. They have been known to be used as natal and breeding sites. Couches can be very difficult to identify and may consist of an area of flattened grass or earth. Where rocks or rock armour are used as couches, these can be almost impossible to identify without observing the otter *in situ*; and
- **Prints:** otters have characteristic footprints that can be found in soft ground and muddy areas;
- **Spraints:** otter faeces may be used to mark territories, often on in-stream boulders. They can be present within or outside the entrances of holts and couches. Spraints have a characteristic smell and often contain fish remains;
- **Feeding signs:** the remains of prey items may be found at preferred feeding stations. Remains of fish, crabs or skinned amphibians can indicate the presence of otter;
- **Paths:** these are terrestrial routes that otters take when moving between resting-up sites and watercourses, or at high flow conditions when they will travel along bank sides in preference to swimming; and
- **Slides and play areas:** slides are typically worn areas on steep slopes where otters slide on their bellies, often found between holts or couches and watercourses. Play areas are used by juvenile otters in play and are often evident by trampled vegetation and the presence of slides. These are often positioned in sheltered areas adjacent to the natal holt.

Any of the above signs (apart from paths) are diagnostic of the presence of otter. However, it is often not possible to identify couches with confidence unless other field signs are also present. Spraints are the most reliably identifiable evidence of the presence of this species.

4.2.2 Water Vole

All watercourses within the survey area were surveyed for water vole field signs following the methodology prescribed in Dean *et al*. (2016)[10]. This involved searching for the following field signs:

- **Faeces:** recognisable by their size, shape, and content. If not too dried-out these are also distinguishable from rat droppings by their smell;
- **Latrines:** faeces, often deposited at discrete locations;
- **Feeding stations:** food items are often brought to feeding stations along pathways and hauled onto platforms. Recognisable as neat piles of chewed vegetation up to 10cm long;
- **Burrows:** appear as a series of holes along the water's edge distinguishable from rat burrows by size and position;

[10] DEAN, M., STRACHAN, R., GOW, D. and ANDREWS, R. (2016). The Water Vole Mitigation Handbook (The Mammal Society Mitigation Guidance Series). Eds. Fiona Mathews and Paul Chanin. The Mammal Society, London.

- **Lawns:** may appear as grazed areas around land holes;
- **Nests:** where the water table is high above ground woven nests may be found;
- **Footprints:** tracks may occur at the water's edge and lead into bank side vegetation. May be distinguishable from rat footprints by size; and
- **Runways in vegetation:** low tunnels pushed through vegetation near the water's edge; these are less obvious than rat runs.

Dean *et al.* (2016)[10] states that water vole droppings are the only field sign that can be used to determine water vole presence reliably on their own. Experience is required to distinguish feeding signs, burrows and footprints of water voles from those of other species. A collection of these field signs found in close proximity can indicate water vole presence.

4.2.3 Badger

Land with the potential to support badger within the survey area was searched for field signs with particular attention given to areas around woodland and areas underlain by mineral soils. Field signs of badger are described in Neal and Cheeseman[11], Bang and Dahlstrøm [7], and Scottish Badgers[12]. Field evidence searched for included:

- **Setts:** single and/or groups of holes;
- **Prints:** badgers have characteristic footprints that can be found in soft ground and muddy areas;
- **Latrines and dung pits:** these are small, excavated pits in which droppings are deposited. Latrines are a collection of dung pits used as territorial markers;
- **Hairs:** tufts of hair can often be found on fences, or in the entrances to setts;
- **Feeding signs:** small scrapes, also known as snuffle holes, where badgers have searched for insects and plant tubers. Feeding signs can also include dug up wasp or bee nests and ripped up dung of other species including cattle;
- **Scratching posts:** marks on trees (including fallen trees) where badgers have scratched leaving claw marks or ripped at areas of rotten bark to search for food; and
- **Paths:** these are routes that badgers take when moving between setts and foraging areas.

Where setts were recorded their sett entrance classification and sett type were noted, in line with the definitions outlined in Scottish Badgers (2018), which are reproduced below in **Table** 4-1 and **Table** 4-2 below.

[11] NEAL, E., and CHEESEMAN, C.L. (1996). Badgers. Poyser Natural History, London
[12] Scottish Badgers (2018). Surveying for Badgers: Good Practice Guidelines. Version 1.

Table 4-1 Sett entrance classifications and associated descriptions.[12]

Classification	Description
Well Used	Are clear of debris and vegetation, sides worn smooth but not necessarily excavated recently.
Partially Used	Are not in regular use and have debris e.g. twigs and leaves in the entrance. They could be used after only a minimal amount of clearance.
Disused	Not in use for some time, are partially blocked and could not be used without considerable effort. Rabbits and foxes may take over part of a sett and keep disused entrances open.
Collapses	Where a tunnel has collapsed.
Air Holes	Where badgers have made a small hole in a tunnel roof from below.

Table 4-2 Categories of sett and associated descriptions.[12]

Category	Description
Main	Main setts usually have several holes with large spoil heaps, and the sett generally looks well used. There are obvious paths to and from the sett and between sett entrances. In the British National Badger Survey the average number of holes for a main sett was twelve, although main setts may be much smaller, even a single hole in exceptional circumstances. Although normally the breeding sett is in continuous use, it is possible to find a main sett that has some disused or dormant entrances.
Annexe	These are often close to a main sett, normally less than 150 m away, and are connected to the main sett by one or more well-worn paths. Usually there are several holes but the sett may not be in use all the time, even if the main sett is very active. The average number of holes per annexe sett in the British survey was eight.
Subsidiary	These are usually at least 50 m from a main sett, and do not have an obvious path connecting with another sett. They are not continuously active. The average number of holes per subsidiary sett in the British survey was four.
Outlier	These often have little spoil outside the holes, have no obvious path connecting them with another sett, and are only used sporadically. When not in use by badgers, they are often taken over by foxes or even rabbits. However, they can still be recognised as badger setts by the shape of the tunnel (not the actual entrance hole), which is at least 25 cm in diameter, and rounded or a flattened oval shape (i.e. broader than high). Fox and rabbit tunnels are smaller and often taller than they are broad. The average number of holes per outlying sett in the British survey was two.
Other	In some cases, it can be difficult to assess the status of a sett, and it is open to interpretation. It is therefore recommended that if there is uncertainty as to the type of sett present, setts should be referred to as 'Other'.

4.2.4 Pine Marten

Signs of pine marten were searched for within the survey area following guidance from O'Mahony *et al*. (2006)[13]. Survey methods included:

- **Scats**: searches for pine marten scats were made along linear features such as fence lines, stone walls or forestry tracks/rides. Also searches for scats on prominent features such as tree stumps, dead logs or stones, and around rock piles and dense scrub where the species could establish a den.
- **Dens**: identification of features which could be used as a den. Dens can include the utilisation of upturned trees, tree cavities, rocks or manmade structures such as log piles or large bird boxes.

4.2.5 Red squirrel

Areas of woodland that have the potential to support red squirrel were surveyed for squirrels, following guidance from Gurnell *et al.* (2009)[14]. Survey methods included:

- **Sightings**: visual sightings of red squirrels;
- **Dreys**: dreys are usually built close to the main stem of a tree, over 3 m from ground level and over 50 x 30 cm in size; and
- **Feeding signs**: predated cone (cone cores) searches in areas of woodland.

4.2.6 Wildcat

Targeted wildcat surveys were not undertaken; however, incidental records of the following field signs were recorded (as described in Kitchener, 1995)[15]:

- **Scats**: similar to that of a domestic cat, and sometimes used by wildcat as territorial markers on stumps, tracks and other features. Wildcat scat is difficult to distinguish between other similar-sized mammals in the field;
- **Dens**: rocky cairns and boulders, tree hollows, under root plates and areas of dense scrub and gorse vegetation tend to be favoured for denning. Wildcats have been known to use fox earths, badger setts and rabbit burrows. Areas of bracken, tall vegetation and brash vegetation in forestry may be important for temporary use. Den sites tend to be close to food sources, such as rabbit warrens and woodland edges. Scats are not commonly found at den sites;
- **Feeding remains:** remains of prey food items; and

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[13] O'MAHONY D., O'REILLY, C. & TURNER, P. (2006). National Pine Marten Survey of Ireland 2005. COFORD, Dublin.
[14] GURNELL, J., LURZ, P. MCDONALD, R. & PEPPER, H. (2009). Practical Techniques for Surveying and Monitoring Squirrels. Forestry Commission Practice Note.
[15] KITCHENER, A. (1995). The Wildcat. The Mammal Society, London.

- **Prints:** similar to that of a domestic cat. No claws visible on print. Small and delicate palm pad with indentations at the rear.

4.2.7 Reptiles

Targeted reptile surveys were not undertaken, however, incidental records of reptile sightings, or signs such as shed skins, and features of particular importance (i.e. potential hibernacula) were recorded.

4.2.8 Other Species

A watching brief was maintained for all other protected, notable, and/or invasive species during surveys and presence or field signs recorded as appropriate (e.g. smooth newt (*Lissotriton vulgaris*), palmate newt (*Lissotriton helveticus*), hares (*Lepus* spp.), and American mink (*Neovison vison*)).

4.2.9 Species Scoped Out

Surveys for beaver (*Castor fiber*) and great crested newt (*Triturus cristatus*) were scoped out of field surveys due to the absence of suitable habitat or the survey area being located out with the known range or distribution.

5 SURVEY DETAILS & LIMITATIONS/CONSTRAINTS

Surveys for protected species were undertaken on 4 March, 18 August 2020 and 12 April 2023. Results from protected species surveys undertaken between 25th and 26th June 2015 as part of a previous suite of baseline surveys within the Proposed Development Area have also been considered.

As noted above, a watching brief for protected species signs was maintained throughout all other ecology, ornithology, and peat surveys undertaken at and around the Proposed Development Area.

The weather conditions during survey visits were optimal with high cloud cover and dry conditions.

There is uncertainty associated with identifying scats produced by pine marten due to their variability in composition and their similarity with those produced by other species such as fox. DNA analysis is often used as a method to increase reliability of identification, although it is often not possible to determine to species level with this method due to possible degradation of samples or the collection of scat samples from species that cannot be sequenced (Croose *et al.*, 2014)[16]. The scats recorded within survey area that were undeterminable between pine marten and fox were therefore considered as 'potential pine marten' and a precautionary approach is applied when discussing their presence and utilisation of the Proposed Development Area and the habitats within the wider area.

[16] CROOSE, E., BIRKS, J.D.S., SCHOFIELD, H.W., and O'REILLY, C. (2014). Distribution of the pine marten (*Martes martes*) in southern Scotland in 2013. Scottish Natural Heritage Commissioned Report No. 740.

Overall, given the number of times the survey area has been surveyed, it is considered the baseline characterisation of protected species is representative of their presence within and around the Proposed Development Area.

Due to protected species mobile nature, it is possible that new features may be created in the period between surveys and the commencement of construction. It is therefore recommended that pre-construction surveys are undertaken in advance of construction activities progressing across the Proposed Development Area.

6 RESULTS

6.1 Desk Study Results

6.1.1 Designated Sites

There is one designated site with a protected species as a qualifying feature within the Proposed Development Area, the Caithness and Sutherland Peatlands Special Area of Conservation (SAC), which falls within the southern boundary; no works are required within the SAC, and the land has been included within the boundary to account for wind turbine oversail. Designated sites with qualifying interests for protected species within 5 km of the Proposed Development Area are detailed in **Table 6-1**.

Table 6-1 Ecologically designated sites within 5 km of the Proposed Development

Designated site	Distance from site (km)	Protected Species Qualifying interests	Last assessed condition & date
Caithness and Sutherland Peatlands SAC	0	Otter	Unfavourable Declining 09/09/2011
River Thurso SAC	4.1	Atlantic salmon (*Salmo salar*)	Unfavourable Recovering 01/11/2011

6.1.2 Online Resources/Data Searches

A search of the NBN Atlas Scotland[1] within 5 km of the Proposed Development Area boundary in the last 15 years (i.e., from 2008 onwards) returned records of the following protected or notable species:

- otter;
- water vole;
- pine marten;
- common lizard;
- mountain hare (*Lepus timidus*);
- roe deer (*Capreolus capreolus*);
- red deer (*Cervus elaphus*); and

- hedgehog (*Erinaceus europaeus*).

Details regarding licences and data providers for these records are included in **ANNEX B**.

The Deer Distribution Survey[4] results suggested the presence of roe and red deer (both recorded in 2007 and/or 2011 and reconfirmed in 2016).

A Scottish wildcat survey was conducted by NatureScot, between 2004 and 2008[17] which resulted in both possible and probable sightings of individuals to the north and northwest of the Highlands. The nearest wildcat priority site where individuals were recorded in 2014 is in Strathpeffer[18]. This site lies approximately 75 km to the southwest of the Proposed Development, which is outwith the natural territory of the species, being up to 64 km.

An assessment of Saving Scotland's Red Squirrels[19] data resulted in an absence of individuals in the northern most area of the Highlands. It is unlikely for red squirrels to be located on the Proposed Development Area.

As part of a previous planning application covering a similar area to the Proposed Development, a salmonid habitat and electric-fishing survey was carried out on the Burn of Acharole Catchment and Wick River in 2015[20]. It concluded that all four survey sites supported a substantial population of salmonids of mixed age-class composition, with brown trout being biased towards the three upstream sites, and particularly to the two tributaries to the Burn of Acharole.

Surveys conducted by the Caithness District Salmon Fishery Board in 2021[21] recorded low to high values of Atlantic salmon (*Salmo salar*) fry and low values of parr at five locations along Scouthal Burn, which are the nearest sampling points to the Proposed Development, approximately 1 km to the east. Trout (*Salmo trutta*) fry and parr were recorded at these five sample locations along Scouthal Burn, however, parr were infrequent. The 2021 surveys within the Wick River catchment showed much lower levels of productivity than recorded in previous years, which is likely attributable to the severe summer

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[17] DAVIS, A.R. & GRAY, D. (2010) The distribution of Scottish wildcats (*Felis silvestris*) in Scotland (2006-2008). *Scottish Natural Heritage Commissioned Report No. 360.* [Online]. Available from - https://www.nature.scot/sites/default/files/2017-07/Publication%202010%20-%20SNH%20Commissioned%20Report%20360%20-%20Scottish%20Wildcat%20Survey%202006-2008.pdf. [Accessed 10/08/2023]

[18] LITTLEWOOD, N.A., CAMPBELL, R.D., DINNIE, L., GILBERT, L., HOOPER, R., IASON, G., IRVINE, J., KILSHAW, K., KITCHENER, A., LACKOVA, P., NEWEY, S., OGDEN, R. & ROSS, A. (2014). Survey and scoping of wildcat priority areas. *Scottish Natural Heritage Commissioned Report No. 768.* [Online]. Available from - https://www.nature.scot/sites/default/files/2017-07/Publication%202014%20-%20SNH%20Commissioned%20Report%20768%20-%20Survey%20and%20scoping%20of%20wildcat%20priority%20areas.pdf. Accessed 10/08/2023]

[19] Saving Scotland's Red Squirrels (2022). *Sightings*. [Online]. Available from - https://scottishsquirrels.org.uk/squirrel-sightings/ [Accessed 04/11/2022]

[20] YOUNGSON, A., (2018). Caithness District Salmon Fishery Board (2018). *Conductivity Measurements in the Northern Rivers, April - June 2018.* [Online]. Available from - https://caithness.dsfb.org.uk/files/2018/07/Electrical-Conductivity-Measurements-in-the-Northern-Rivers-v-final.pdf. [Accessed 10/08/2023]

[21] Caithness District Salmon Fishery Board (2022). *2021 Survey of Juvenile Salmonids in Caithness Rivers*. [Online]. Available from - https://caithness.dsfb.org.uk/files/2022/06/2021-EF-Report-draft-v2.pdf [Accessed 10/08/2023]

drought. In previous years, the upper catchment of the Wick River has been shown to be very productive.

6.2 Field Survey Results

The survey results are summarised in **Table** 6-2 below, with full detailed results provided within **ANNEX C**, selected photographs are presented in **ANNEX D**. Survey results are displayed on Figure 7.5.

Table 6-2 Protected species survey results summary

Species	Survey Results Summary	General Habitat Suitability
Badger	2015, 2020 and 2023: No evidence of badger was recorded.	Suitable habitat for badger is limited within the Proposed Development Area, with peatland soils dominating which are not optimal for sett building.
Otter	2015: One spraint was recorded on a boulder in the Burn of Acharole. 2019: One incidental sighting of otter recorded during ornithological surveys in November 2019. 2020: One potential couch was recorded (further information in **Confidential Annex D**). A minimum of 34 otter spraints were recorded at 29 locations within the survey area. The majority of the spraint records were made along Loch and Black Burns. Three incidental sightings of otter within Loch of Toftingall were recorded during ornithological surveys (April, June and July 2020). April 2020 record included two otters together; other records were of one individual. 2023: One spraint located on the northern bank of Halsary Burn.	Three watercourses, Loch Burn, Black Burn and Red Burn run to the west, centrally and east of the Proposed Development Area respectively. Numerous minor watercourses are present, the majority of which are tributaries of Red Burn. The minor watercourses which feed into Red Burn provide relatively limited foraging resources, but suitable commuting routes for otter within the wider area. Loch Burn and Black Burn are likely to offer slightly more favourable foraging habitat, as illustrated by the higher density of sprainting locations, and provide connectivity to water bodies such as Loch of Toftingall to the north-west of the Proposed Development Area. None of the watercourses on site provide much suitable shelter for otter, with the exception of some bridges in the south of the Proposed Development Area.
Pine marten	2015 and 2020: No evidence of pine marten was recorded. 2023: Three pine marten scat were recorded upgradient from the culvert in Hectors Burn, within the neighbouring Halsary Wind Farm.	The areas of mixed-age conifer forestry offer potential shelter for pine marten, with the main body of the Proposed Development Area providing more open hunting areas.
Red squirrel	2015, 2020 and 2023: No evidence of red squirrel was recorded.	The areas of coniferous plantation on and adjacent to the Proposed Development Area offer some suitable habitat for foraging and drey building.
Reptiles	2015: No sightings of any reptile species recorded. 2020: No sightings of any reptile species recorded. A potential hibernaculum consisting of piles of stones within the grassland were noted.	The Proposed Development Area has some areas of open grassland habitats suitable for reptiles to forage and bask, in addition to areas of woodland and denser vegetation

Species	Survey Results Summary	General Habitat Suitability
	2023: No sightings of any reptile species recorded. A potential hibernaculum consisting of a loosely placed stone headwall was identified.	and bracken which may offer hibernation potential.
Water vole	2015: Seven potential burrows identified in the north of the Proposed Development Area, without any definitive field signs. 2020: A potential burrow was identified approximately 1 m from Loch Burn, however, no other field signs were noted. A potential water vole run was noted within the riparian grass of Black Burn. 2023: No evidence of water vole was recorded.	Several of the smaller watercourses within the survey area offer habitat that may be suitable for water vole, with steep, soft banks and slow flows. The vegetation is of a type that could provide good foraging for water vole.

ANNEX A. LEGAL PROTECTION

Otter, bats, wildcat and **great crested newt** are European Protected Species and receive protection under the Conservation Regulations (1994) (as amended).[22]

Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)

Under Regulation 39 (1) it is an offence to:

a) deliberately or recklessly to capture, injure or kill a wild animal of a European protected species;

b) deliberately or recklessly:

   i. to harass a wild animal or group of wild animals of a European protected species;

   ii. to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;

   iii. to disturb such an animal while it is rearing or otherwise caring for its young;

   iv. to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place;

   v. to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs; or

   vi. to disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young;

c) deliberately or recklessly to take or destroy the eggs of such an animal; or

d) to damage or destroy a breeding site or resting place of such an animal.

Regulation 44 (2e) allows a licence to be granted for the activities noted in Regulation 39 such that:

Preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment.

Otter is also listed on Appendix I of CITES, Appendix II of the Bern Convention and Annexes II and IV of the Habitats Directive (1994). It is also listed as globally threatened on the IUCN/WCMC Red Data List.

Wildcat is listed on Annexes II and V of the Habitats Directive (1994).

[22] The Conservation Amendment (Scotland) Regulations (2007) removed EPS from Schedule 5 and 8 of the Wildlife and Countryside Act 1981.

Badger are protected under the Protection of Badgers Act 1992 (as amended by the Wildlife and Natural Environment (Scotland) Act 2011.

The following applies under this legislation:

Part 1. – A person is guilty of an offence if, except as permitted by or under this Act, he wilfully kills, injures or takes, or attempts to kill, injure or take, a badger.

1. If, in any proceedings for an offence under subsection (1) above consisting of attempting to kill, injure or take a badger, there is evidence from which it could reasonably be concluded that at the material time the accused was attempting to kill, injure or take a badger, he shall be presumed to have been attempting to kill, injure or take a badger unless the contrary is shown.
2. A person is guilty of an offence if, except as permitted by or under this Act, he has in his possession or under his control any dead badger or any part of, or anything derived from, a dead badger.

Part 3. –

1. A person is guilty of an offence if, except as permitted by or under this Act, he interferes with a badger sett by doing any of the following things–
    a. damaging a badger sett or any part of it;
    b. destroying a badger sett;
    c. obstructing access to, or any entrance of, a badger sett;
    d. causing a dog to enter a badger sett; or
    e. disturbing a badger when it is occupying a badger sett,
    f. intending to do any of those things or being reckless as to whether his actions would have any of those consequences.
2. A person is guilty of an offence if, except as permitted by or under this Act, he knowingly causes or permits to be done an act which is made unlawful by subsection (1) above.

Note: A badger sett is defined in law as any structure or place which displays signs of current use by a badger.

Red squirrel and **pine marten** are protected by the following legislation:

Wildlife and Countryside Act (1981), Nature Conservation (Scotland) Act 2004

Under Section 9, Subsection 1, it is an offence to:

Intentionally or recklessly:

- Kill, injure or take any wild animal listed on Schedule 5;
- Damages or destroys or obstructs access to, any structure or place that any animal listed on Schedule 5 uses for shelter or protection;
- Disturbs any such animal while it is occupying a structure or place which is uses for that purpose;
- Sell, offer or expose for sale, or possess or transport for the purpose of sale, any live or dead wild animal included in Schedule 5, or any part of, or anything derived from, such an animal;
- Publish or cause to be published any advertisement likely to be understood as conveying that he buys or sells, or intends to buy or sell, any of those things.

Freshwater pearl mussels are listed on Annexes II and V of the Habitats Directive and is fully protected under the Wildlife and Countryside Act 1981 (as amended). It is also listed as endangered on the IUCN/WCMC Red Data List.

Adder, slow worm and **viviparous lizard** are protected by the following legislation:

These three species of reptile are noted within Schedule 5 of the Wildlife and Countryside Act (1981). However, Schedule 5 of the 1981 act notes that these species are protected 'in respect of section 9(5) only'.

Section 9(5) states:

- Subject to the provisions of this part, if any person
  a) Sells, offers or exposes for sale, or has in his possession or transports for the purpose of sale, any live or dead wild animal included in Schedule 5, or any part of, or anything derived from, such an animal; or
  b) Publishes or causes to be published any advertisement likely to be understood as conveying that he buys or sells, or intends to buy or sell, any of those things.
- he shall be guilty of an offence

An amendment was made to Schedule 5 on 18 March 1988 relating to slow worm and viviparous lizard to give them protection under Section 9(1). A further amendment was made to Schedule 5 on 27 March 1991 relating to adders which afford them protection under Section 9(1).

Section 9(1) (as amended by the Nature Conservation (Scotland) Act 2004) states:

'Subject to the provisions of this Part, if any person intentionally or recklessly kills, injures or takes any wild animal included in schedule 5, he shall be guilty of an offence.'

Water vole is protected by Section 9, subsection 4 and Section 10 of the Wildlife and Countryside Act [23].

Wildlife and Countryside Act (1981), Nature Conservation (Scotland) Act 2004

Under Section 9, Subsection 4, Paragraphs (a) and (b)[4], it is an offence to:

- Intentionally or recklessly damage or destroy, or obstruct access to, any structure or place which any wild animal included in Schedule 5 uses for shelter or protection; or
- Intentionally or recklessly disturb any such animal while it is occupying a structure or place which it uses for that purpose.

Under Section 10, Subsection 3, Paragraph (c)[4], any person shall not be guilty of an offence by reason of:

- Any act made unlawful by that section if he shows:
  a) That each of the conditions specified in subsection (3A) was satisfied in relation to the carrying out of the unlawful act; or
  b) That the unlawful act was carried out in relation to an animal bred and, at the time the act was carried out, lawfully held in captivity.
- Section 3A states those conditions referred to in Subsection 3c are:
  a) That the unlawful act was the incidental result of a lawful operation or other activity;
  b) That the person who carried out the lawful operation or other activity:
     i. took reasonable precautions for the purpose of avoiding carrying out the unlawful act; or
     ii. did not foresee, and could not reasonably have foreseen, that the unlawful act would be an incidental result of the carrying out of the lawful operation or other activity; and

  That the person who carried out the unlawful act took, immediately upon the consequence of that act becoming apparent to the person, such steps as were reasonably practicable in the circumstances to minimise the damage or disturbance to the wild animal, or the damage or obstruction to the structure or place, in relation to which the unlawful act was carried out.

[23] as amended by the Nature Conservation (Scotland) Act 2004.

ANNEX B. NBN ATLAS SCOTLAND DATA PROVIDERS AND LICENCES

Table B-1 Data Providers and Licence Details for NBN Atlas Scotland Records Used

Species	Reason for Inclusion	Data Provider (Recorder)	Licence
Otter	Protected species (Conservation (Natural Habitats, &c) Regulations 1994 (as amended)) and qualifying feature of the Caithness and Sutherland Peatlands SAC	Highland Biological Recording Group (Dave Jones, David Glass, Martyn Elwell, Neil Redgate, Ro Scott)	CC-BY[24]
Water vole	Protected species (Wildlife and Countryside Act 1981)	Highland Biological Recording Group (David Glass, Flora Donald, Ro Scott)	OGL[25]
		Scottish Natural Heritage (David Glass)	CC-BY
Pine marten	Protected species (Wildlife and Countryside Act 1981)	Highland Biological Recording Group (Sinclair Manson)	CC-BY
Common lizard	Protected species (Wildlife and Countryside Act 1981)	Highland Biological Recording Group (David Glass, Donald Omand)	CC-BY
Mountain hare	Protected species (Wildlife and Countryside Act 1981)	Highland Biological Recording Group (Martyn Elwell)	CC-BY
Roe deer	Welfare and impacts of deer on habitats and on neighbouring land and interests (inc. public roads)	Highland Biological Recording Group (Dave Jones, David Glass)	CC-BY
Red deer	Welfare and impacts of deer on habitats and on neighbouring land and interests (inc. public roads)	Highland Biological Recording Group (David Glass)	CC-BY
Hedgehog	LBAP species	Highland Biological Recording Group (Neil Redgate)	CC-BY

[24] Creative Commons with Attribution 4.0 (CC-BY). Available from: https://creativecommons.org/licenses/by/4.0/ [Accessed 10/08/2023]

[25] Open Government Licence (OGL). Available from: https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ [Accessed 10/08/2023]

ANNEX C. SURVEY RESULTS

Table B-1 below details the relevant data collected for protected species during surveys for the Proposed Development, sorted by species, then survey date (see also Figure 7.4). Confidential information relating to the otter couch is contained within **Confidential Annex E and Figure 7.5C.**

Table B-1 Protected species survey results

Species	Sign	Easting	Northing	Survey date	Notes
Otter	Spraint	321759	951160	04/03/2020	Two old spraints at outflow of culvert next to access track.
Otter	Spraint	321871	951215	04/03/2020	Spraint at culvert outflow.
Otter	Spraint	321072	951596	04/03/2020	Four spraints.
Otter	Spraint	320520	950807	18/08/2020	Large otter spraint under footbridge on rock beside burn.
Otter	Spraint	319721	951319	18/08/2020	Old otter spraint found on in-stream boulder with fish bones present. Potential anal secretion next to spraint which is a black and sticky substance with a pleasant fishy smell.
Otter	Spraint	319773	951239	18/08/2020	Numerous fresh and semi-fresh otter spraints found on in-stream rock with fresh bones present.
Otter	Spraint	319830	951126	18/08/2020	Fresh otter spraint on rock beside burn.
Otter	Spraint	319848	951096	18/08/2020	Old and semi-fresh otter spraint on in-stream rock.
Otter	Spraint	319887	951050	18/08/2020	Semi-fresh otter spraint on rock with fresh bones. Potential anal secretion next to spraint which is a black and sticky substance with a pleasant fishy smell.
Otter	Spraint	319919	951025	18/08/2020	Semi-fresh otter spraint on rock.

Species	Sign	Easting	Northing	Survey date	Notes
Otter	Spraint	319946	951019	18/08/2020	Old otter spraint on rock beside burn.
Otter	Spraint	319971	950995	18/08/2020	Small fresh otter spraint on rock within stream. The frequency of spraints along this burn and the variability and freshness of spraints would suggest an otter family maybe foraging and commuting along this burn.
Otter	Spraint	320083	951013	18/08/2020	Semi-fresh otter spraint on rock within burn.
Otter	Spraint	320170	950984	18/08/2020	Old otter spraint on rock within burn.
Otter	Spraint	320279	950966	18/08/2020	Large flat boulders across burn with one fresh and 3 old spraints found.
Otter	Spraint	320320	950938	18/08/2020	Old otter spraint on rock within burn.
Otter	Spraint	320412	950922	18/08/2020	Old otter spraint on in-stream rock.
Otter	Spraint	320497	950945	18/08/2020	Old otter spraint on in-stream boulder.
Otter	Spraint	320524	950947	18/08/2020	Semi-fresh spraint on rock on bankside of burn.
Otter	Spraint	320768	951189	18/08/2020	Semi-fresh otter spraint on in-stream rock.
Otter	Spraint	320630	951233	18/08/2020	Old otter spraint on in-stream rock.
Otter	Spraint	320566	951390	18/08/2020	Old otter spraint on in-stream rock.
Otter	Spraint	320530	951522	18/08/2020	Fresh otter spraint on in-stream rock.
Otter	Spraint	320490	951739	18/08/2020	Old otter spraint on in-stream rock.
Otter	Spraint	320535	951928	18/08/2020	Semi-fresh otter spraint on in-stream rock.
Otter	Spraint	320547	951970	18/08/2020	Old otter spraint on in-stream rock.

Species	Sign	Easting	Northing	Survey date	Notes
Otter	Spraint	320399	952166	18/08/2020	Old and semi-fresh otter spraint on large in-stream rock.
Otter	Spraint	319882	951219	18/08/2020	Potential otter spraints close to conifer block within dense moss.
Otter	Spraint	321765	951607	19/08/2020	Old otter spraints on rock with fish bones.
Otter	Spraint	319009	949957	12/04/2023	Washed out spraint with fish bones in, approx. 30cm from Northern bank of Halsary Burn.
Pine Marten	Scat	319475	950774	12/04/2023	Seen within grass, on the southern bank approx. 2m from Hectors Burn.
Pine Marten	Scat	319506	950741	12/04/2023	Within moss approx. 3m on southern bank of Hectors Burn.
Pine Marten	Scat	319311	950279	12/04/2023	Within the heath on top of a vegetated bund, approx. 6m south of Hectors Burn.
Reptile	Potential Hibernaculum	320664	952229	19/08/2020	Potential hibernaculum within grassland. Pile of stones with some gaps present.
Reptile	Potential Hibernaculum	319535	950718	12/04/2023	Loosely placed stone on the headwall of the culvert.
Water Vole	Burrow	320131	950994	18/08/2020	Potential water vole 1m from end of burn. Burrow leads towards watercourse. No other field signs such as droppings.
Water Vole	Lawns/Vegetation Runways	320491	951766	18/08/2020	Potential water vole run towards burn with tunnel through grass. No other signs within the area.

ANNEX D. SURVEY PHOTOGRAPHS

Photo 1 Potential Water vole burrow (PS011)

Photo 2 Potential reptile hibernaculum (PS028)

MacArthur Green

Watten Wind Farm
Bat Survey Report

Technical Appendix A7.3

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1 INTRODUCTION

MacArthur Green was commissioned by EDF Energy Renewables Limited (EDF ER) (the Applicant) to carry out bat surveys at the proposed Watten Wind Farm located near Wick, Caithness, (hereafter referred to as the 'Proposed Development').

Bat surveys included:

- Desk study;
- A Preliminary Bat Roost Assessment (PRA); and
- Automated activity surveys.

The aim of the surveys was to quantify Proposed Development Area usage by bats and variation in bat activity levels within the Proposed Development Area, and to inform the ecological impact assessment for the Watten Wind Farm Environmental Impact Assessment (EIA) Report. Within this technical appendix the terms 'Proposed Development Area' and 'the Site' have been used interchangeably.

2 THE SITE AND SURVEY AREA

The Proposed Development Area is located approximately 14 km west of Wick and approximately 2.5 km south-west of Loch Watten in the Highlands. The Proposed Development Area is upland in character with a mosaic of mainly mires, calciferous grassland and isolated blocks of coniferous plantation. In addition, smaller pockets of marsh and mesotrophic grassland habitats are also found within the Proposed Development Area, particularly to the southern and eastern boundary. The land is drained by several small and minor watercourses that are mostly tributaries of Loch Burn, Black Burn and Red Burn, which lie to the south, central and east of the Proposed Development Area respectively.

The temporal (Anabat) survey area covered the main Wind Turbine infrastructure area and consisted of five Anabat deployment locations in 2015 and 10 Anabat deployment locations in 2020, as shown in Figure 7.6.

The area covered during the baseline PRA survey for the Proposed Development Area is shown in Figure 7.6.

3 BATS AND WIND FARMS

3.1 Policy and Guidance

All bat species are protected under the following legislation:

- The Habitats Directive 92/43/EEC (as amended);
- The Wildlife and Countryside Act 1981 (as amended); and
- The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended).

Details pertaining to the legal status of bats are included within Annex A and in Table A-1.

In the UK and Europe, guidelines have been produced with regards to assessing the ecological impact upon bats from wind farm developments. These guidelines help to inform survey and mitigation strategies.

The following guidance documents have been used in the preparation of this report:

- Collins, J. (ed) (2016). *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (3rd edn). The Bat Conservation Trust, London; and
- NatureScot, Natural England, Natural Resources Wales, Renewable UK, Scottish Power Renewables, Ecotricity Ltd, the University of Exeter & Bat Conservation Trust (BCT). (2021). *Bats and Onshore Wind Turbines: Survey Assessment and Mitigation*.

4 METHODS

4.1 Desk-Based Study

A desk-based study was undertaken with regards to the presence of bat species within the Site and its environs.

A National Biodiversity Network (NBN)[1] Atlas Scotland search was completed to obtain bat records from 2007 to 2022 within 10 km of the Site.

4.2 Field Survey Methods

4.2.1 Preliminary Bat Roost Assessment

The PRA followed the assessment methodology as set out in Collins (2016), to identify any Potential Roost Features (PRFs) in trees, buildings and structures, which could support roosting. Where PRFs were identified, they were assigned a value of low, moderate or high suitability which indicates the likelihood of bats being present and informs the requirement for further survey work, such as a climbing inspection and/or dusk and dawn bat activity surveys.

Collins (2016) states the following descriptions for assessing the potential roosting suitability of features:

- Negligible – Negligible habitat features on site likely to be used by roosting bats.
- Low – A structure with one or more potential roost sites that could be used by individual bats opportunistically. However, these potential roost sites do not provide enough space, shelter, protection, appropriate conditions[2] and/or suitable surrounding habitat to be used on a regular basis or by larger numbers of bats (i.e., unlikely to be suitable for maternity or

[1] *NBN Atlas occurrence download at https://nbnatlas.org accessed on Fri Sep 09 16:28:00 UTC 2022.*

[2] For example, in terms of temperature, humidity, height above ground level, light levels or levels of disturbance.

hibernation[3]). A tree of sufficient size and age to contain PRFs but with none seen from the ground or features seen with only very limited roosting potential[4].

- Moderate - A structure or tree with one or more potential roost sites that could be used by bats due to their size, shelter, protection, conditions[2] and surrounding habitat but unlikely to support a roost of high conservation status (with respect to roost type only – the assessments are made irrespective of species conservation status, which is established after presence is confirmed).

- High - A structure or tree with one or more potential roost sites that are obviously suitable for use by larger numbers of bats on a more regular basis and potentially for longer periods of time due to their size, shelter, protection, conditions[2] and surrounding habitat.

The PRA was carried out within the survey area, as shown in Figure 7.6, during 2020.

4.2.2 Automated Activity Surveys

NatureScot *et al.* (2021) recommends that, "*Where developments have more than ten turbines, detectors should be placed within the developable area at ten potential turbine locations plus a third of additional potential turbine sites up to a maximum of 40 detectors for the largest developments.*"

The Proposed Development layout at the time of survey in 2015 and 2020 included seven proposed wind turbines. A seven turbine site requires seven locations to be sampled in accordance with industry guidance (NatureScot et al, 2021).

- In 2020, and in accordance with current guidance, 10 detectors were placed at potential turbine locations across the Proposed Development Area, deployed seasonally (three deployment periods) from July to October. Detector locations are shown in Figure 7.6.
- During the 2015 surveys, five detectors were placed at potential turbine locations across the Proposed Development Area, deployed seasonally (three deployment periods) from May to September. The survey correctly followed the relevant guidance at that time, Hundt L (2012), "*…the survey methods and amount of survey effort required should be selected to allow sufficient information to be collected to achieve the stated aims and objectives of the survey, taking into account the size, nature and complexity of the proposed development site.*"

NatureScot *et al.* (2021) also recommends a minimum of 10 consecutive nights of sampling per seasonal deployment.

- In 2020, Anabat Swift detectors recording full spectrum files were deployed for a minimum period of 14 consecutive nights across the Site (i.e. exceeding minimum survey requirements) and were positioned at a height of 2 m.

[3] Evidence from the Netherlands shows mass swarming events of common pipistrelle bats in the autumn followed by mass hibernation in a diverse range of building types in urban environments (Korsten et al., 2015). This phenomenon requires some research in the UK but ecologists should be aware of the potential for larger numbers of this species to be present during the autumn and winter in large buildings in highly urbanised environments.

[4] This system of categorisation aligns with BS 8596:2015 Surveying for bats in trees and woodland (BSI, 2015).

- In 2015, Anabat Swift detectors recording full spectrum files were deployed for a minimum period of eight consecutive nights across the Site and were positioned at a height of 2 m.

During both survey years each detector recorded bats from dusk to dawn with detectors starting 30 minutes before dusk and finishing 30 minutes after dawn. Detector operating times and a description of the habitat are shown in Table B-1 and B-2 of Annex B.

The full spectrum detector was deployed with the following settings during both survey years:

- Sensitively value of 14;
- Minimum frequency of 15 kHz;
- Maximum frequency of 250 kHz;
- Maximum file length of 15 s;
- Minimum event of -2 ms; and
- Sampling rate of 320 kHz.

Data was analysed using Kaleidoscope Pro Auto ID classifier which assigns a species label to a sound file. To ensure that all bat calls (with the exception of common and soprano pipistrelle which were excluded) were identified correctly by the software, they were manually reviewed by an appropriately trained ecologist using Kaleidoscope Viewer and AnalookW software. This method of analysis is in line with current guidelines for data analysis which recommends the manual checking of all non-*Pipistrellus* calls (excluding Nathusius' pipistrelle) when using automated methods (Collins, 2016). Sound files labelled as noise were not reviewed. Guidance on call parameters was taken from Russ (2012).

For the purposes of this report and for Ecobat analysis, a single bat registration was classed as a single labelled Kaleidoscope file containing a sequence of bat pulses.

In line with NatureScot *et al*. (2021), further analysis of bat data was carried out using the secure online tool Ecobat (Mammal Society, 2017), to gain a measure of relative bat activity at the Proposed Development Area. Ecobat data was then evaluated in accordance with NatureScot *et al.* (2021) guidance to determine the overall Site risk level. The Ecobat analysis automatically analyses data per month and not per season. The results are presented based on this analysis per month.

4.3 Methods for Analysing Bat Activity Levels and Risks

NatureScot *et al*. (2021) details the methodology for analysing bat activity levels. This method is summarised below and involves the following steps:

1. Estimating bat activity levels;
2. Categorising collision risk of the relevant species;
3. Identifying population relevant abundance (size of the populations);
4. Categorising the potential vulnerability of bat populations by combining collision risk with population abundance;

5. Categorising the Site risk level;
6. Completing the overall risk assessment; and
7. An assessment of significance and mitigation.

The following sections outline the methods used in each step.

4.3.1 Step 1: Bat Activity Levels

A measure of relative bat activity was obtained using the secure online tool *Ecobat* (Mammal Society, 2017) for automated data. NatureScot *et al.* (2021) explains that, "*The tool compares data entered by the user with bat survey information collected from similar areas at the same time of year and in comparable weather conditions…. Ecobat generates a percentile rank for each night of activity and provides a numerical way of interpreting the levels of bat activity recorded at a site across regions in Britain*". Table 4-1 below, taken from NatureScot *et al.* (2021) shows the five percentile categories for ease of reference. Only static data from automated activity surveys was analysed with the Ecobat tool.

The reference range data set were stratified to include:

- Only records from within 30 days of the survey date;
- Only records from within 100 km^2 of the survey location; and
- Records using any make/model of bat detector.

Table 4-1 Percentile score and categorised level of bat activity[5]

Percentile Score	Bat Activity
81 to 100	High
61 to 80	Moderate to High
41 to 60	Moderate
21 to 40	Low to Moderate
0 to 20	Low

4.3.2 Step 2: Vulnerability to Collision

Appendix 3 of NatureScot *et al*. (2021) presents a generic assessment of vulnerability to collision for UK species, based on species behaviour, flight characteristics and casualties in the UK and Europe. Table 4-2 provides a summary of the vulnerability of each bat species to collision.

[5] Table sourced from: Scottish Natural Heritage, Natural England, Natural Resources Wales, Renewable UK, Scottish Power Renewables, Ecotricity Ltd, the University of Exeter & Bat Conservation Trust (BCT). (2019). *Bats and Onshore Wind Turbines: Survey Assessment and Mitigation*.

Table 4-2 Vulnerability of bat species to turbine impact in the UK

Risk of Turbine Impact (Collision Risk)		
Low Risk	**Medium Risk**	**High Risk**
Myotis spp.	Serotine	Common pipistrelle
Long-eared bats	Barbastelle	Soprano pipistrelle
Horseshoe bats		Noctule
		Leisler's bat
		Nathusius' pipistrelle

Habitat characteristics at the location of wind turbines can have an important influence on the vulnerability of bat species to collision. For example, proximity to key feeding sites and commuting routes such as water features and woodland edge habitats is known to increase the likelihood of bat collision (NatureScot *et al*. 2021).

4.3.3 Step 3: Population Relative Abundance

NatureScot *et al.* (2021) details the sensitivity of a bat species to impact based on their population's relative abundance in Scotland as detailed in Table 4-3. Species with the rarest relative abundance are more susceptible to significant effects.

Table 4-3 Population relative abundance of bats in Scotland

Relative Abundance	Species
Common	Common pipistrelle (*Pipistrellus pipistrellus*)
	Soprano pipistrelle (*Pipistrellus pygmaeus*)
Rarer	Brown long-eared bat (*Plecotus auritus*)
	Daubenton's bat (*Myotis daubentonii*)
	Natterer's bat (*Myotis nattereri*)
Rarest	Whiskered bat (*Myotis mystacinus*)
	Brandt's bat (*Myotis brandtii*)
	Nathusius' pipistrelle (*Pipistrellus nathusii*)
	Noctule bat (*Nyctalus noctule*)
	Leisler's bat (*Nyctalus leisleri*)

4.3.4 Step 4: Potential Vulnerability of Bat Populations

Table 4-4 below, sourced from NatureScot *et al.* (2021), uses the measure of collision risk, in combination with population relative abundance, to indicate the potential vulnerability of populations of British bat species. The overall potential vulnerability of bat populations is identified as: low (yellow), medium (orange), high (red).

Table 4-4 Level of potential vulnerability of populations of British bat species

Relative Abundance of Bats in Scotland	Collision Risk		
	Low collision risk	Medium collision risk	High collision risk
Common species			Common pipistrelle Soprano pipistrelle
Rarer species	Brown long-eared bat Daubenton's bat Natterer's bat		
Rarest species	Whiskered bat Brandt's bat		Nathusius' pipistrelle Noctule bat Leisler's bat

4.3.5 Step 5: Categorise the Site Risk Level

The Site risk level is categorised through a combination of habitat risk and project size which is then entered into the table matrix as shown below in

Table 4-5 to calculate the overall Site risk level. The full matrix table, as provided within NatureScot *et al.* (2021), is shown in Annex C of this report which includes descriptions on how to determine the habitat risk and project size for the Proposed Development Area.

Table 4-5 Initial site risk assessment

Site Risk Level (1-5) *	Project Size			
		Small	Medium	Large
Habitat Risk	Low	1	2	3
	Moderate	2	3	4
	High	3	4	5
Key: Green (1-2) – low/lowest site risk; Amber (3) – medium site risk; Red (4-5) – high/highest site risk * Some sites could conceivably be assessed as being of no (0) risk to bats. This assessment is only likely to be valid in more extreme environments, such as above the known altitudinal range of bats, or outside the known geographical distribution of any resident British species.				

4.3.6 Step 6: Risk Assessment

The overall risk assessment is undertaken for high collision risk species identified onsite and involves combining Site risk level (Section 4.3.5,

Table 4-5) with the Ecobat activity level (Section 4.3.1, Table 4-1). The overall risk assessment matrix is shown in

Table 4-6 below where 'Low' Site risk level (green) is 0-4, 'Medium' Site risk level (amber) is 5-12, and 'High' Site risk level (red) is 15-25.

Table 4-6 Overall risk assessment

	Ecobat activity category (or equivalent justified categorisation)					
Site Risk Level	Nil (0)	Low (1)	Low-Moderate (2)	Moderate (3)	Moderate-High (4)	High (5)
Lowest (1)	0	1	2	3	4	5
Low (2)	0	2	4	6	8	10
Medium (3)	0	3	6	9	12	15
High (4)	0	4	8	12	15	18
Highest (5)	0	5	10	15	20	25

4.3.7 Step 7: Assessment of Significance and Mitigation

The outputs of the risk assessment detailed in step six above are then used to assess the significance of effect within the Ecological Impact Assessment. At this stage, other Site-specific factors should be considered such as habitat characteristics (and how they may change), behaviour of species at the Proposed Development Area, and location of the Proposed Development Area regarding the natural range of the species and how this could affect favourable conservation status.

Mitigation measures as detailed within NatureScot *et al.* (2021) are then considered where appropriate.

5 BAT SURVEY LIMITATIONS

The guidance recommends the minimum level of pre-application survey required for ground level static detectors to be 10 nights of recordings in each of spring (April - May), summer (June to mid-August) and autumn (Mid-August to October). In Scotland, due to unfavourable weather conditions and low activity levels for bats in April, ground-level automated activity surveys commenced in May and were completed in early October.

Three seasonal deployments were completed during the 2015 and 2020 surveys. However, the spring seasonal deployment was missed due to Covid restrictions during the spring/early summer of 2020. As a result, the three deployments were undertaken between July and October. This potential 2020 spring data gap is mitigated by the 2015 surveys which provide sample data over this period.

Automated activity surveys should capture a sufficient number of nights (minimum of ten nights) with appropriate weather conditions for bat activity (i.e., temperatures at or above 8°C in Scotland at dusk, maximum ground level wind speed of 5 m/s and no, or only very light, rainfall). To account for the potential limitations of weather on the number of suitable nights recorded, surveys were carried out over longer deployment periods, with a minimum of fourteen nights recorded. This was followed in the 2020 surveys but not the 2015 surveys as they were completed before the publication of the 2021 NatureScot *et al.* guidance.

The Ecobat analysis automatically analyses data per month and not per season. The results are presented based on this analysis per month.

Due to unforeseen errors with the detectors, microphones or batteries, it was not always possible to achieve 14 consecutive nights of recordings. In 2020, only one detector failed to record any data during a deployment period (Location 9 in July). As the majority of locations recorded for more than ten nights, with a total of 506 complete nights recorded which is beyond the minimum number of nights (10 Anabats * 10 nights * three seasonable deployments = 300 nights of data) required for a proposed development area of this size, the small loss of data is not considered to have affected the overall assessment of risk. The survey timings can be seen in Annex B, Table B-1.

In 2015, three detectors failed to record any data during the deployment period (Location 5 in May and September and Location 4 in September). As the locations recorded for less than 10 nights, with a total of 77 complete nights recorded which is below the minimum number of nights (five Anabats * 10 nights * three seasonable deployments = 150 nights of data) required for a Proposed Development of this size, the loss of data is considered to have affected the overall assessment of risk. The survey timings can be seen in Annex B, Table B-2.

Some temporal calls were assigned an unknown value (NoID), due to the recording of a very faint call or an incomplete call that could not be identified to species level on the spectrogram. These were not considered further in the Ecobat analysis.

For some *Myotis* spp. calls it was only possible to identify the call to genus level. It is possible that for *Myotis* spp. these recordings could represent species not identified in the analysis of the recorded data. *Myotis* spp. bats are categorised as low collision risk species and are therefore not included in the final risk assessment in accordance with the guidance (NatureScot *et al., 2021)*

Anabat detectors are a commonly used bat detector for acoustic monitoring at wind farm sites, however all bat detectors have limitations and will only monitor bat activity within a limited area, which for Anabats is usually around 30 m, depending on a variety of environmental factors. Furthermore, due to passive monitoring methodologies depending on sound reaching the microphone, the detection rate of bat calls varies with a bias towards loud bat calls with quieter calls, namely brown long-eared bats (low collision risk species), potentially being under-recorded.

Taking all the above limitations into account, it is considered that the combined 2015 and 2020 survey results provide a robust data set to inform the likely collision risk to bat species.

6 SURVEY RESULTS & ANALYSIS

6.1 Desk-Based Study

The NBN Atlas data search[1] returned records of the following bat species within 10 km of the Site between 2007-2022 inclusive:

- Common pipistrelle ; and
- Soprano pipistrelle.

Details regarding licences and data providers for these records are included in Table 6-1 below.

Table 6-1 Data providers for NBN atlas Scotland records used

Species	Data Provider	Licence
Common pipistrelle	Highland Biological Recording Group (HBRG) (David Dodds Associates Ltd), Biological Records Centre (Haddow, J.)	CC-BY[6]
Soprano pipistrelle	HBRG (Dave Jones)	CC-BY[6]
Pipistrelle spp.	HBRG (Mary Legg, Melanie Spirit & Marina Swanson)	CC-BY[6]

6.2 Preliminary Bat Roost Assessment

The PRA survey of the Proposed Development Area was undertaken in August 2020. Associated PRF records are shown in Figure 7.6 with the detailed results (target notes) listed in Table D-1, Annex D.

In summary, there were six features recorded which contained potential suitability for roosting bats: two trees and four structures. Potential roosting suitability were classified as follows; four low, two moderate and zero high (shown in Figure 7.6).

Two features with moderate suitability for roosting bats were recorded within 200 m plus rotor radius of a proposed wind turbine location (T3). The features were assessed as unlikely to support a roost of high conservation status, and given the results of the 2015 inspection (including no bat droppings recorded), the distance from the turbines and its isolated location (with limited connectivity to areas of suitable foraging habitat), as well as the results of the automated activity

[6] Creative Commons with Attribution 4.0 (CC-BY) https://creativecommons.org/licenses/by/4.0/ (Accessed December 2022)

surveys in 2015 and 2020 (detailed below), no further surveys were considered necessary; this was discussed and agreed with NatureScot in December 2022.

6.3 Automated Activity Surveys

MacArthur Green deployed detectors at 10 locations within the Proposed Development Area from July to October in 2020 over a total period of 62 days and collecting 506 complete recording nights of data, see Table B-1 of Annex B and Figure 7.6.

Between July to October, bats were detected on 65 nights. A total of three bat species and one genus classifications were recorded for these locations. The total number of passes recorded for each species across all of the detectors within the Proposed Development Area is shown below in Table 6-2.

A subcontractor (Jenny Wallace) deployed detectors at five locations within the Proposed Development Area from May to September in 2015 over a total period of 20 days and collecting 77 complete recording nights of data, see Table B-2 of Annex B and Figure 7.6.

Between May to September, bats were detected on 23 nights. A total of two bat species were recorded for these locations. The total number of passes recorded for each species across all of the detectors within the Proposed Development Area is shown below in Table 6-3.

Table 6-2 Total number of bat passes for each species across all locations 2020

Species/Species Group	No of Registrations	Percentage of total (%)
Common pipistrelle	4931	98.4
Soprano pipistrelle	8	0.2
Nathusius' pipistrelle	72	1.4
Myotis spp.	2	0
Total	5013	100

Table 6-3 Total number of bat passes for each species across all locations 2015

Species/Species Group	No of Registrations	Percentage of total (%)
Common pipistrelle	2600	99.9
Soprano pipistrelle	2	0.1
Total	2602	100

The survey results were processed using the Ecobat tool (Mammal Society, 2017) to gain a measure of relative bat activity at the Proposed Development Area, the full Ecobat Report is appended in Annex F below. The summarised results and analysis are presented in Steps 1 – 6 below.

6.3.1 Step 1: Bat Activity Levels

Average Annual Site Activity Levels

Table 6-4, Table 6-5, Chart 6-1, Chart 6-2 detail the average annual Site activity levels calculated using the Ecobat tool (Mammal Society, 2017).

Table 6-4 Average annual site activity levels (taken from Ecobat analysis[7]) 2020

Species/ Group	Median Percentile	Activity Level	95% CIs*	Max Percentile	Activity Level	Nights Recorded
Myotis spp.	0	Low	0 - 0	0	Low	2
Nathusius' pipistrelle	0	Low	59 - 64	64	Moderate – High	39
Common pipistrelle	59	Moderate	64.5 - 74.5	99	High	355
Soprano pipistrelle	24	Low – Moderate	47 - 47	47	Moderate	4

*CIs: confidence intervals.

Table 6-5 Average annual site activity levels (taken from Ecobat analysis[8]) 2015

Species/ Group	Median Percentile	Activity Level	95% CIs*	Max Percentile	Activity Level	Nights Recorded
Common pipistrelle	47	Moderate	94.5 - 98.5	100	High	51
Soprano pipistrelle	32	Low – Moderate	0	32	Low – Moderate	1

*CIs: confidence intervals.

[7] Taken from Ecobat analysis report created on the 05/08/2021 from static activity data of the Site in 2020.
[8] Taken from Ecobat analysis report created on the 21/10/2021 from static activity data of the Site in 2015.

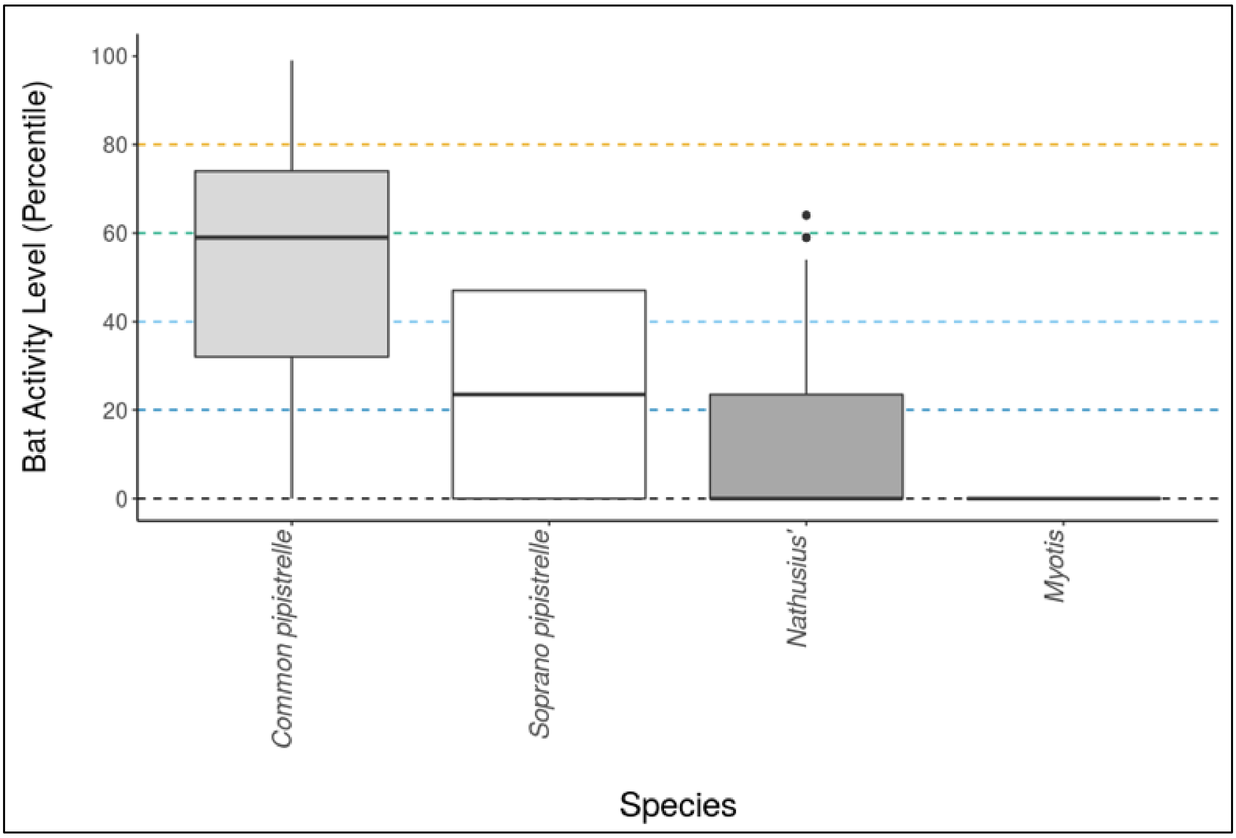


Chart 6-1 Average Annual Site Activity Levels 2020

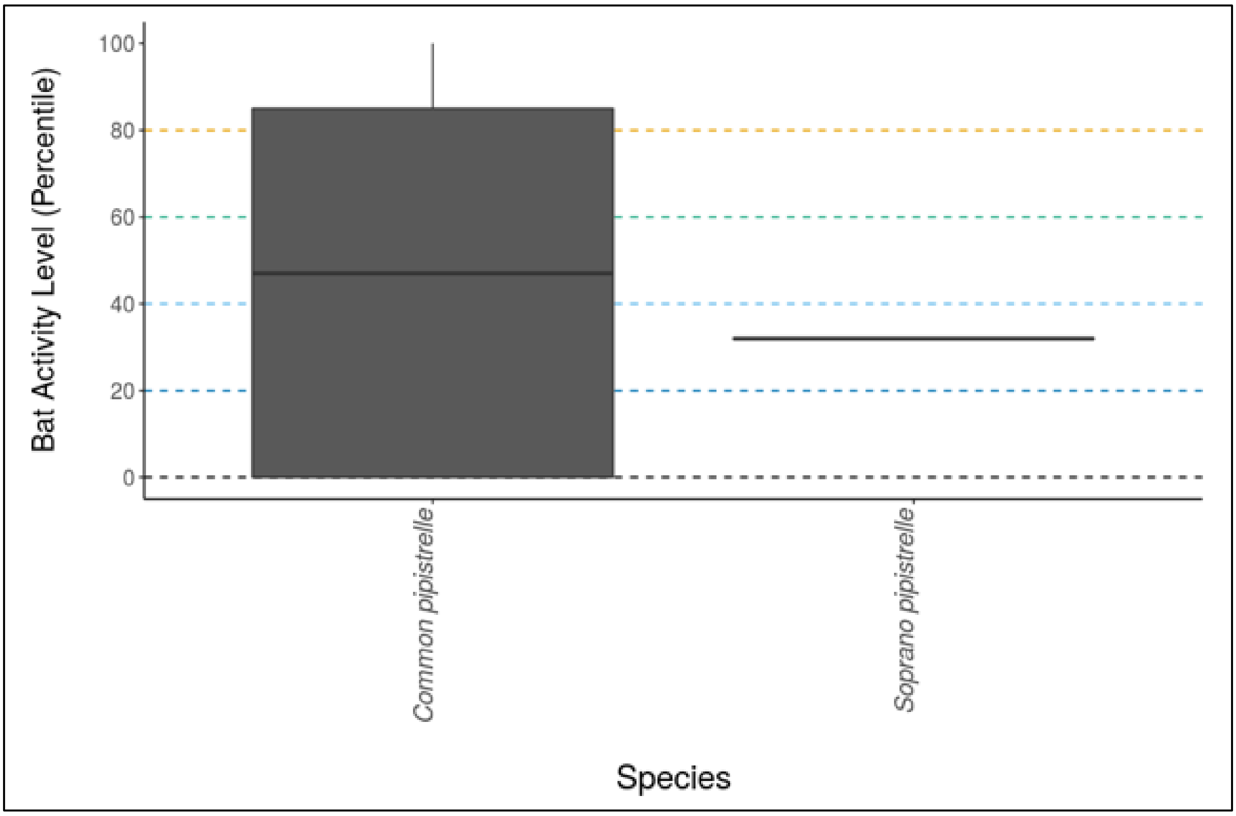


Chart 6-2 Average Annual Activity Levels 2015

Monthly Location Specific Activity Levels

Data on the monthly activity levels per location is provided in Table E-1 of Annex E.

6.3.2 Step 2, 3 and 4: Collision Risk, Population Relative Abundance and Potential Vulnerability

Table 6-6 details the collision risk, population relative abundance and potential vulnerability of the bat species recorded within the Site.

Table 6-6 Collision risk, population relative abundance and potential vulnerability

Bat Species	Collision Risk	Population Relative Abundance	Potential Vulnerability
Common pipistrelle	High	Common	Medium
Soprano pipistrelle	High	Common	Medium
Nathusius'	High	Rarest	High
Myotis spp.	Low	Rarer	Low

6.3.3 Step 5: Categorising Site Risk Level

The Site risk level is determined by project size and habitat risk (see

Table 4-5). The Proposed Development consists of up to seven wind turbines that are over 50 m in height, and so falls within the 'Small' project size, as shown in

Table 4-5 and Table C-1 of Annex C.

In terms of habitat risk for bats, there are a few buildings, structures, or trees with moderate bat roosting potential within 200 m plus the rotor radius of wind turbines. Foraging habitat quality and connectivity within this buffer area is low with a largely treeless environment and small open upland burns and a fairly homogenous area of open grazed moorland habitat present, resulting in a habitat risk classification of 'Moderate' as shown in

Table 4-5 and Table C-1 of Annex C.

According to

Table 4-5 above, the 'Small' project size combined with a 'Moderate' habitat risk level results in an overall Site risk assessment of 'Low/Lowest' (2).

6.3.4 Step 6: Risk Assessment – High Collision Risk Species Only

The overall risk assessment is undertaken for high collision risk species which were identified within the Proposed Development Area. Low-risk species have a low risk of collision with a turbine blade, so the impact of the Proposed Development on the local bat population would likely be negligible.

The overall risk assessment involves multiplying the Site's risk level (Section 7,

Table 4-5) with the median and the maximum Ecobat activity levels (Section 4.3.1, Table 4-1) to calculate both the typical (median) Site risk level, and the maximum Site risk level.

Table 6-7 combines the seasonal data and summarises the overall risk assessment score for high-risk species based on the median and maximum percentiles for the Proposed Development Area in 2020. The overall Site risk scores for all high collision risk species based on the median percentile were 'Low to Medium' (2 - 6), while the overall Site risk score based on the maximum percentiles were 'Medium' (6 - 10).

Table 6-8 combines the seasonal data and summarises the overall risk assessment score for high-risk species based on the median and maximum percentiles for the Proposed Development Area in 2015. The overall Site risk scores for all high collision risk species based on the median percentile were 'Low to Medium' (4 - 6), while the overall Site risk score based on the maximum percentiles were 'Low to Medium' (4 - 10).

Table 6-7 Risk assessment scores based on median and maximum percentiles for high collision risk species 2020

Species	Risk Assessment Score based on Median Percentile	Risk Assessment Score based on Max. Percentile
Common pipistrelle	Medium (6)	Medium (10)
Soprano pipistrelle	Low (4)	Medium (6)
Nathusius'	Low (2)	Medium (8)

Table 6-8 Risk assessment scores based on median and maximum percentiles for high collision risk species 2015

Species	Risk Assessment Score based on Median Percentile	Risk Assessment Score based on Max. Percentile
Common pipistrelle	Medium (6)	Medium (10)
Soprano pipistrelle	Low (4)	Low (4)

Figures 7.7 to 7.11 illustrate the results of the median monthly risk assessment scores for high collision risk bat species recorded in the Proposed Development Area at each survey location, illustrating how bat activity and risk levels varies within the Proposed Development Area across the year and by species. This data is also presented in Table E-1 of Annex E which includes both the median and maximum monthly risk assessment scores.

No high-risk assessment scores were recorded across the Proposed Development per month, with only low to medium scores recorded. To provide an indication of how activity varied across the survey period for high collision risk species, the percentage of locations where a medium risk assessment score was calculated from the median and maximum percentiles.

Table 6-9 shows the percentage of sample locations in 2020 where a medium risk assessment score was recorded. Using this method, August and September appear to be the months with slightly greater risk for all high-risk species, based on median percentiles.

The maximum percentile scores, which can be used to suggest peaks in bat activity, calculated peaks in activity during August and September, as also summarised in Table 6-9 below.

Table 6-9Table 6-10 shows the percentage of sample locations in 2015 where a medium risk assessment score was recorded. Using this method, July appears to be the month with slightly greater risk for all high-risk species, based on median percentiles.

The maximum percentile scores, which can be used to suggest peaks in bat activity, calculated peaks in activity during July, as also summarised in Table 6-10below.

Table 6-9 The percentage of locations with medium risk assessment scores based on monthly median and maximum percentiles for high collision risk species 2020

	Species	July	August	September	October
Median Percentile	Common pipistrelle	30%	60%	60%	40%
	Soprano pipistrelle	0%	0%	0%	10%
	Nathusius'	0%	0%	20%	20%
Maximum Percentile	Common pipistrelle	60%	80%	80%	50%
	Soprano pipistrelle	0%	0%	0%	10%
	Nathusius'	0%	0%	30%	20%

Table 6-10 The percentage of locations with medium risk assessment scores based on monthly median and maximum percentiles for high collision risk species 2015

	Species	May	July	September
Median Percentile	Common pipistrelle	20%	40%	0%
	Soprano pipistrelle	0%	0%	0%
Maximum Percentile	Common pipistrelle	20%	80%	20%
	Soprano pipistrelle	0%	0%	0%

6.4 Proximity of Roost Sites Based on Activity Data

The Ecobat output includes an analysis of bat activity data at sample locations, referenced against the known roost emergence times for each high collision risk bat species (Russ, 2012). This indicates whether a roost site may be present in close proximity to a sample location.

The analysis of the 2020 bat activity indicated the potential for nearby roost sites at all locations which recorded *Pipistrellus* species during their known emergence time ranges, as detailed in Table 6-11. The majority of these registrations were common pipistrelle, with a higher number of bat calls noted in red in Table 6-11, which were recorded out with the maternity roost season (15th June to 30th July). At Locations 1, 2, 3, 4, 5, 8 and 10 common and Nathusius' pipistrelle calls were recorded during the species-specific emergence time range in the maternity roost season. The maximum number of calls during the maternity roost season was eight, so the risk is not considered high.

In 2015, there were no registrations recorded close to a potential roost within the time period inferred from the known emergence times.

Table 6-11 Sample locations within proximity to a roost

Sample Locations	Bat Species	Date	Number of Bat Calls
Location 1	Common pipistrelle	17 - 20, 22, 24 - 27, 30 & 31/07/2020	1 - 5
		01 – 04 & 06 - 12/08/2020	1 - 7
		13, 15 - 18, 23, 24, 26, 27, 28, 29 & 30/09/2020	1 – 6, 16, 21, 35
		02, 03, 05 & 06/10/2020	17, 1 - 3
	Nathusius' pipistrelle	21/07/2020	1
		11/08/2020	1
		28/09/2020	1
Location 10	Common pipistrelle	19, 22, 24 & 31/07/2020	1 - 2
		05, 07 – 09 & 15/08/2020	1 - 4
	Nathusius' pipistrelle	17, 22 & 23/07/2020	1
Location 2	Common pipistrelle	16 - 18, 20 - 25, 27, 30 & 31/07/2020	1 - 8
		01 - 05, 06, 07 - 14, 15 & 16 - 19/08/2020	2 – 11, 18
		10, 12 & 13/09/2020	1 - 2
	Nathusius' pipistrelle	15/08/2020	1
Location 3	Common pipistrelle	16 - 19, 22 - 25, 27 & 29 - 31/07/2020	1 - 4
		01 - 08, 09, 10 - 14, 15, 16 & 17 - 19/08/2020	1 – 8, 12, 13, 22
		10 - 12, 14 - 16, 18 - 20, 23, 24, 26, 27, 28, 29 & 30/09/2020	1 – 4, 19, 13, 15, 17
	Nathusius' pipistrelle	23/07/2020	1
		28/09/2020	1
	Soprano pipistrelle	01/10/2020	1
Location 4	Common pipistrelle	16 - 20, 22 - 26, 30 & 31/07/2020	1 - 6
		01 - 11, 13 & 14 - 19/08/2020	1 – 7, 12
		10, 15 - 19, 21, 24, 26 – 28 & 30/09/2020	1 - 4
Location 5	Common pipistrelle	17, 18, 29 & 31/07/2020	1 - 3
		03 - 07, 09, 10, 13 & 15/08/2020	1 - 3
		16, 28 & 29/09/2020	1
	Nathusius' pipistrelle	23/07/2020	1
Location 6	Common pipistrelle	10, 12, 14, 15, 17 - 20, 22, 23, 26 – 29 & 30/09/2020	1 - 5
		01 - 03/10/2020	1 - 2
	Nathusius' pipistrelle	01/10/2020	2
Location 7	Common pipistrelle	13, 15, 17, 18, 24, 28 & 30/09/2020	1 - 2
		06/10/2020	2
Location 8	Common pipistrelle	16, 18, 20 & 23/07/2020	1

Sample Locations	Bat Species	Date	Number of Bat Calls
		06, 10, 14, 15 & 19/08/2020	1 - 3
		16/09/2020	1
		01, 03/10/2020	1
Location 9	Common pipistrelle	07 - 10, 13 – 16 & 18/08/2020	1 - 3
		11 & 20/09/2020	1

7 REFERENCES

Collins, J. (ed) (2016). Bat Surveys for Professional Ecologists: Good Practice Guidelines (3rd edn). The Bat Conservation Trust, London.

Hundt L (2012). Bat Surveys: Good Practice Guidelines (2nd edn). Bat Conservation Trust.

Mammal Society (2017). Ecobat. Available at: http://www.mammal.org.uk/science-research/ecostat/

Russ, J. (2012). *British Bat Calls: A Guide to species Identification*. Pelagic Publishing.

NatureScot, Natural England, Natural Resources Wales, Renewable UK, Scottish Power Renewables, Ecotricity Ltd, the University of Exeter & Bat Conservation Trust (BCT). (2021). Bats and Onshore Wind Turbines: Survey Assessment and Mitigation.

ANNEX A. BATS LEGAL STATUS

All bat species receive protection under the Conservation Regulations (1994) (as amended).

The information contained in this Annex is a summarised version of the legislation and should be read in conjunction with the appropriate legislation.

It is an offence to:

- Deliberately or recklessly to capture, injure or kill a wild animal of a European protected species;
- Deliberately or recklessly:
  - Harass a wild animal or group of wild animals of a European protected species;
  - Disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;
  - Disturb such an animal while it is rearing or otherwise caring for its young;
  - To obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place (i.e. roost sites);
  - To disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs; or
  - To disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young;
- To damage or destroy a breeding site or resting place of such an animal.

Table A-1 Legal and conservation status of all UK bats[9]

Species	Legislation / Convention													
	Bern Convention Appendix II	Bonn Convention Appendix II	WCA	Habitats Directive Annex IV	Habitats Directive Annex II	Habs Regs 1994 (as amended) *Scotland*	Conservation of Habs & Species Regs 2010	Conservation Regs (N Ireland) 1995	CROW Act 2000	NERC Act 2006	Wild Mammals Protection Act	UK BAP Priority species	IUCN Red List*	EUROBATS Agreement
Greater horseshoe bat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	LC	✓
Lesser horseshoe bat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	LC	✓
Daubenton's bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Natterer's bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Whiskered bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Brandt's bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Bechstein's bat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	NT	✓
Alcathoe bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		DD	✓
Noctule	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	LC	✓
Leisler's bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Serotine	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Common pipistrelle	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Soprano pipistrelle	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	LC	✓
Nathusius' pipistrelle	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Brown long-eared bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	LC	✓
Grey long-eared bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓
Barbastelle	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	NT	✓
Greater mouse-eared bat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		LC	✓

*IUCN categories: LC is Least Concern, NT is Near Threatened, DD is Data deficient; see www.iucnredlist.org for more details.

[9] Source: Bat Conservation Trust http://www.bats.org.uk/pages/bats_and_the_law.html

ANNEX B. SURVEY TIMINGS & ANABAT LOCATIONS

Table B-1 Description of Anabat locations and summary of temporal survey effort 2020

Location	Easting	Northing	Bearing	Habitat	Total Number of Complete Recording Nights		
					Visit 1 16/07/2020 – 05/08/2020	Visit 2 06/08/2020 – 19/08/2020	Visit 3 10/09/2020 – 07/10/2020
1	319780	951655	120	Plantation ride	19	8	27
2	319924	951450	200	Plantation ride	21	13	3
3	320157	952024	170	Plantation ride	21	13	21
4	320275	951680	135	Plantation edge	21	14	19
5	320547	952228	90	Open moorland	21	13	27
6	320640	951850	75	Plantation	21	-	27
7	320893	952186	0	Open moorland. Within 150 m of a Burn	21	14	27
8	321039	952443	135	Open moorland. Within 150 m of a Burn	13	14	27
9	321225	952102	315	Open moorland. Within 55 m of a Burn	0	14	27
10	321561	952029	150	Open moorland. At a Burn edge	21	14	5
Total					**506**		

Table B-2 Description of Anabat locations and summary of temporal survey effort 2015

Location	Easting	Northing	Bearing	Habitat	Total Number of Complete Recording Nights		
					Visit 1 22/05/2015 – 30/05/2015	Visit 2 20/07/2015 – 27/07/2015	Visit 3 04/09/2015 – 10/09/2015
1	319780	951655	120	Plantation ride	8	7	1
2	319924	951450	200	Plantation ride	8	7	5

Location	Easting	Northing	Bearing	Habitat	Total Number of Complete Recording Nights		
					Visit 1 22/05/2015 – 30/05/2015	Visit 2 20/07/2015 – 27/07/2015	Visit 3 04/09/2015 – 10/09/2015
3	320157	952024	170	Plantation ride	8	7	4
4	320275	951680	135	Plantation edge	8	7	0
5	320547	952228	90	Open moorland	0	7	0
Total					77		

ANNEX C. INITIAL SITE RISK ASSESSMENT

Table C-1 Initial site risk assessment[10]micro

Site Risk Level (1-5)[11]	Project Size			
Habitat Risk		Small	Medium	Large
	Low	1	2	3
	Moderate	2	3	4
	High	3	4	5
Key: Green (1-2) – low/lowest site risk; Amber (3) – medium site risk; Red (4-5) – high/highest site risk				

Habitat Risk	Description
Low	Small number of potential roost features, of low quality. Low-quality foraging habitats that could be used by small numbers of foraging bats. Isolated site not connected to the wider landscape by prominent linear features.
Moderate	Buildings, trees or other structures with moderate-high potential as roost sites on or near the site. Habitat could be used extensively by foraging bats. Site is connected to the wider landscape by linear features such as scrub, tree lines and streams.
High	Numerous suitable buildings, trees (particularly mature ancient woodland) or other structures with moderate-high potential as roost sites on or near the site, and/or confirmed roosts present close to or on the site. Extensive and diverse habitat mosaic of high quality for foraging bats. Site is connected to the wider landscape by a network of strong liner features such as rivers, blocks of woodland and mature hedgerows. At/near edge of range and or an important flyway. Close to key roost and /or swarming.

Project Size	Description
Small	Small scale development (<10 turbines). No other wind energy developments within 10 km. Comprising turbines <50 m in height.
Medium	Larger developments (between 10 and 40). May have some other wind development within 5 km. Comprising turbines 50 – 100 m in height.
Large	Largest developments (>40 turbines) with other wind energy developments within 5 km. Comprising turbines >100 m in height.

[10] Sourced from: Scottish Natural Heritage, Natural England, Natural Resources Wales, Renewable UK, Scottish Power Renewables, Ecotricity Ltd, the University of Exeter & Bat Conservation Trust (BCT). (2019). *Bats and Onshore Wind Turbines: Survey Assessment and Mitigation.*

[11] Some sites could conceivably be assessed as being of no (0) risk to bats. This assessment is only likely to be valid in more extreme environments, such as above the known altitudinal range of bats, or outside the known geographical distribution of any resident British species.

ANNEX D. PRELIMINARY BAT ROOST ASSESSMENT

Table D-1 Preliminary bat roost assessment target notes 2020

PRF_ID	Feature	Notes	PRF Category	Grid Reference
B001	Structure	The ruins of Druimdubh are comprised of three old stone built cottages or shelters. Only stone walls are present on two of the structures with the third structure with a metal corrugated roof. Target notes taken in 2015 still valid.	Low	ND 20744 52475
B002	Tree	Old Ash tree with branch wound cavity on branch at 2 m. Cavity extends up tree.	Low	ND 20758 52445
B003	Structure	Stone wall around walled garden which is 2 m high with crevices which may support a hibernating bat roost.	Moderate	ND 20670 50972
B004	Tree	Walled garden with mature sycamore trees which have been well maintained with lichen growth on bark. The presence of a PRF cannot be ruled out due to the size and maturity of the trees. Given precautionary low suitability value.	Low	ND 20635 50983
B005	Structure	Shielton farmhouse and a number of adjoining buildings. Outbuildings are a mixture of stone barns with metal and asbestos crete roofs, modern concrete structures and metal sheds. Previous 2015 PRF notes still valid.	Moderate	ND 20613 50987
B006	Structure	Stone ruin at Backisle. Stone walls with gable end and chimney present. Cavities with stone walls with chimney partially intact. Some limited potential for summer and hibernation roosts.	Low	ND 21486 53118

ANNEX E. MONTHLY LOCATION SPECIFIC DATA

Table E-1 Monthly location specific data for high collision risk species 2020

Location ID	Species	Month	Median Percentile	Median Activity Category (Taken from Table 4-1)	Maximum Percentile	Maximum Activity Category (Taken from Table 4-1)	Site Risk (Taken from Table 4-5)	Overall Median Site Risk Score (Taken from Table 4-6)	Overall Median Category Score	Overall Maximum Site Risk Score (Taken from Table 4-6)	Overall Maximum Category Score
1	*Pipistrellus nathusii*	Jul	0	Low	1	Low	2	2	Low	2	Low
1	*Pipistrellus nathusii*	Aug	0	Low	1	Low	2	2	Low	2	Low
1	*Pipistrellus nathusii*	Sep	0	Low	6	Moderate	2	2	Low	6	Medium
1	*Pipistrellus nathusii*	Oct	47	Moderate	2	Moderate	2	6	Medium	6	Medium
1	*Pipistrellus pipistrellus*	Jul	32	Low-Moderate	13	Moderate-High	2	4	Low	8	Medium
1	*Pipistrellus pipistrellus*	Aug	54	Moderate	12	Moderate-High	2	6	Medium	8	Medium
1	*Pipistrellus pipistrellus*	Sep	81	High	21	High	2	10	Medium	10	Medium
1	*Pipistrellus pipistrellus*	Oct	93	High	6	High	2	10	Medium	10	Medium
1	*Pipistrellus pygmaeus*	Aug	0	Low	1	Low	2	2	Low	2	Low
1	*Pipistrellus pygmaeus*	Sep	0	Low	1	Low	2	2	Low	2	Low
10	*Pipistrellus nathusii*	Jul	0	Low	3	Low	2	2	Low	2	Low
10	*Pipistrellus pipistrellus*	Jul	32	Low-Moderate	8	Moderate	2	4	Low	6	Medium
10	*Pipistrellus pipistrellus*	Aug	16	Low	10	Moderate	2	2	Low	6	Medium
10	*Pipistrellus pipistrellus*	Oct	32	Low-Moderate	2	Low-Moderate	2	4	Low	4	Low
2	*Pipistrellus nathusii*	Aug	0	Low	2	Low	2	2	Low	2	Low
2	*Pipistrellus pipistrellus*	Jul	53	Moderate	14	Moderate-High	2	6	Medium	8	Medium
2	*Pipistrellus pipistrellus*	Aug	79	Moderate-High	19	High	2	8	Medium	10	Medium
2	*Pipistrellus pipistrellus*	Sep	70	Moderate-High	5	Moderate-High	2	8	Medium	8	Medium
3	*Pipistrellus nathusii*	Jul	0	Low	3	Low	2	2	Low	2	Low
3	*Pipistrellus nathusii*	Sep	59	Moderate	5	Moderate-High	2	6	Medium	8	Medium
3	*Pipistrellus pipistrellus*	Jul	54	Moderate	15	Moderate-High	2	6	Medium	8	Medium
3	*Pipistrellus pipistrellus*	Aug	75	Moderate-High	19	High	2	8	Medium	10	Medium
3	*Pipistrellus pipistrellus*	Sep	84	High	22	High	2	10	Medium	10	Medium
3	*Pipistrellus pipistrellus*	Oct	0	Low	1	Low	2	2	Low	2	Low
3	*Pipistrellus pygmaeus*	Oct	47	Moderate	2	Moderate	2	6	Medium	6	Medium
4	*Pipistrellus nathusii*	Aug	0	Low	2	Low	2	2	Low	2	Low
4	*Pipistrellus nathusii*	Sep	0	Low	3	Low	2	2	Low	2	Low
4	*Pipistrellus pipistrellus*	Jul	64	Moderate-High	15	Moderate-High	2	8	Medium	8	Medium
4	*Pipistrellus pipistrellus*	Aug	67	Moderate-High	19	Moderate-High	2	8	Medium	8	Medium
4	*Pipistrellus pipistrellus*	Sep	64	Moderate-High	21	High	2	8	Medium	10	Medium
5	*Pipistrellus nathusii*	Jul	0	Low	2	Low	2	2	Low	2	Low
5	*Pipistrellus nathusii*	Aug	0	Low	2	Low	2	2	Low	2	Low
5	*Pipistrellus nathusii*	Sep	0	Low	1	Low	2	2	Low	2	Low
5	*Pipistrellus nathusii*	Oct	0	Low	1	Low	2	2	Low	2	Low

Location ID	Species	Month	Median Percentile	Median Activity Category (Taken from Table 4-1)	Maximum Percentile	Maximum Activity Category (Taken from Table 4-1)	Site Risk (Taken from Table 4-5)	Overall Median Site Risk Score (Taken from Table 4-6)	Overall Median Category Score	Overall Maximum Site Risk Score (Taken from Table 4-6)	Overall Maximum Category Score
5	*Pipistrellus pipistrellus*	Jul	40	Low-Moderate	6	Moderate	2	4	Low	6	Medium
5	*Pipistrellus pipistrellus*	Aug	47	Moderate	12	Moderate	2	6	Medium	6	Medium
5	*Pipistrellus pipistrellus*	Sep	54	Moderate	15	Moderate-High	2	6	Medium	8	Medium
5	*Pipistrellus pipistrellus*	Oct	47	Moderate	3	Moderate	2	6	Medium	6	Medium
6	*Pipistrellus nathusii*	Sep	47	Moderate	1	Moderate	2	6	Medium	6	Medium
6	*Pipistrellus nathusii*	Oct	47	Moderate	1	Moderate	2	6	Medium	6	Medium
6	*Pipistrellus pipistrellus*	Jul	0	Low	1	Low	2	2	Low	2	Low
6	*Pipistrellus pipistrellus*	Aug	0	Low	1	Low	2	2	Low	2	Low
6	*Pipistrellus pipistrellus*	Sep	70	Moderate-High	21	High	2	8	Medium	10	Medium
6	*Pipistrellus pipistrellus*	Oct	76	Moderate-High	6	High	2	8	Medium	10	Medium
7	*Myotis*	Jul	0	Low	1	Low	2	2	Low	2	Low
7	*Myotis*	Aug	0	Low	1	Low	2	2	Low	2	Low
7	*Pipistrellus nathusii*	Sep	0	Low	1	Low	2	2	Low	2	Low
7	*Pipistrellus nathusii*	Oct	0	Low	1	Low	2	2	Low	2	Low
7	*Pipistrellus pipistrellus*	Aug	0	Low	2	Low	2	2	Low	2	Low
7	*Pipistrellus pipistrellus*	Sep	32	Low-Moderate	16	Moderate-High	2	4	Low	8	Medium
7	*Pipistrellus pipistrellus*	Oct	24	Low-Moderate	2	Moderate	2	4	Low	6	Medium
8	*Pipistrellus pipistrellus*	Jul	0	Low	5	Low-Moderate	2	2	Low	4	Low
8	*Pipistrellus pipistrellus*	Aug	0	Low	6	Moderate	2	2	Low	6	Medium
8	*Pipistrellus pipistrellus*	Sep	0	Low	9	Low-Moderate	2	2	Low	4	Low
8	*Pipistrellus pipistrellus*	Oct	0	Low	3	Low-Moderate	2	2	Low	4	Low
9	*Pipistrellus nathusii*	Sep	0	Low	1	Low	2	2	Low	2	Low
9	*Pipistrellus pipistrellus*	Aug	54	Moderate	12	Moderate	2	6	Medium	6	Medium
9	*Pipistrellus pipistrellus*	Sep	16	Low	10	Moderate	2	2	Low	6	Medium
9	*Pipistrellus pipistrellus*	Oct	47	Moderate	3	Moderate	2	6	Medium	6	Medium

Table E-2 Monthly location specific data for high collision risk species 2015

Location ID	Species	Month	Median Percentile	Median Activity Category (Taken from Table 4-1)	Maximum Percentile	Maximum Activity Category (Taken from Table 4-1)	Site Risk (Taken from Table 4-5)	Overall Median Site Risk Score (Taken from Table 4-6)	Overall Median Category Score	Overall Maximum Site Risk Score (Taken from Table 4-6)	Overall Maximum Category Score
1	*Pipistrellus pipistrellus*	May	0	Low	0	Low	2	2	Low	2	Low
1	*Pipistrellus pipistrellus*	Jul	16	Low	55	Low	2	2	Low	6	Medium
2	*Pipistrellus pipistrellus*	May	79	Moderate-High	99	Low-Moderate	2	8	Medium	10	Medium
2	*Pipistrellus pipistrellus*	Jul	0	Low	0	Low-Moderate	2	2	Low	2	Low
2	*Pipistrellus pipistrellus*	Sep	32	Low-Moderate	47	Low	2	4	Low	6	Medium
3	*Pipistrellus pipistrellus*	May	0	Low	0	Low-Moderate	2	2	Low	2	Low
3	*Pipistrellus pygmaeus*	Jul	32	Low-Moderate	47	Low-Moderate	2	4	Low	6	Medium
3	*Pipistrellus pygmaeus*	Sep	0	Low	0	Moderate-High	2	2	Low	2	Low
4	*Pipistrellus pipistrellus*	May	16	Low	32	Low-Moderate	2	2	Low	4	Low
4	*Pipistrellus pipistrellus*	Jul	55	Moderate	72	Low	2	6	Medium	8	Medium
5	*Pipistrellus pipistrellus*	Jul	97	High	100	Low	2	10	Medium	10	Medium
5	*Pipistrellus pygmaeus*	Jul	32	Low-Moderate	32	Moderate	2	4	Low	4	Low

ANNEX F. ECOBAT REPORT

This report was produced free of charge by the Mammal Society to support evidence-based conservation of bats.

Bat Activity Analysis

Site Name: Acharole

Author: MacArthur Green

21/10/2021

Summary

Bats were detected on **23** nights between **2015-05-21** and **2015-09-08**, using **5** static bat detectors. Throughout this period **2** species were recorded. **Table 1.** Detectors were placed at the following locations:

Detector ID	Latitude	Longitude
loc2	58.44396	-3.373463
loc1	58.44578	-3.376001
loc3	58.44916	-3.369673
loc4	58.44609	-3.367532
loc5	58.45106	-3.363064

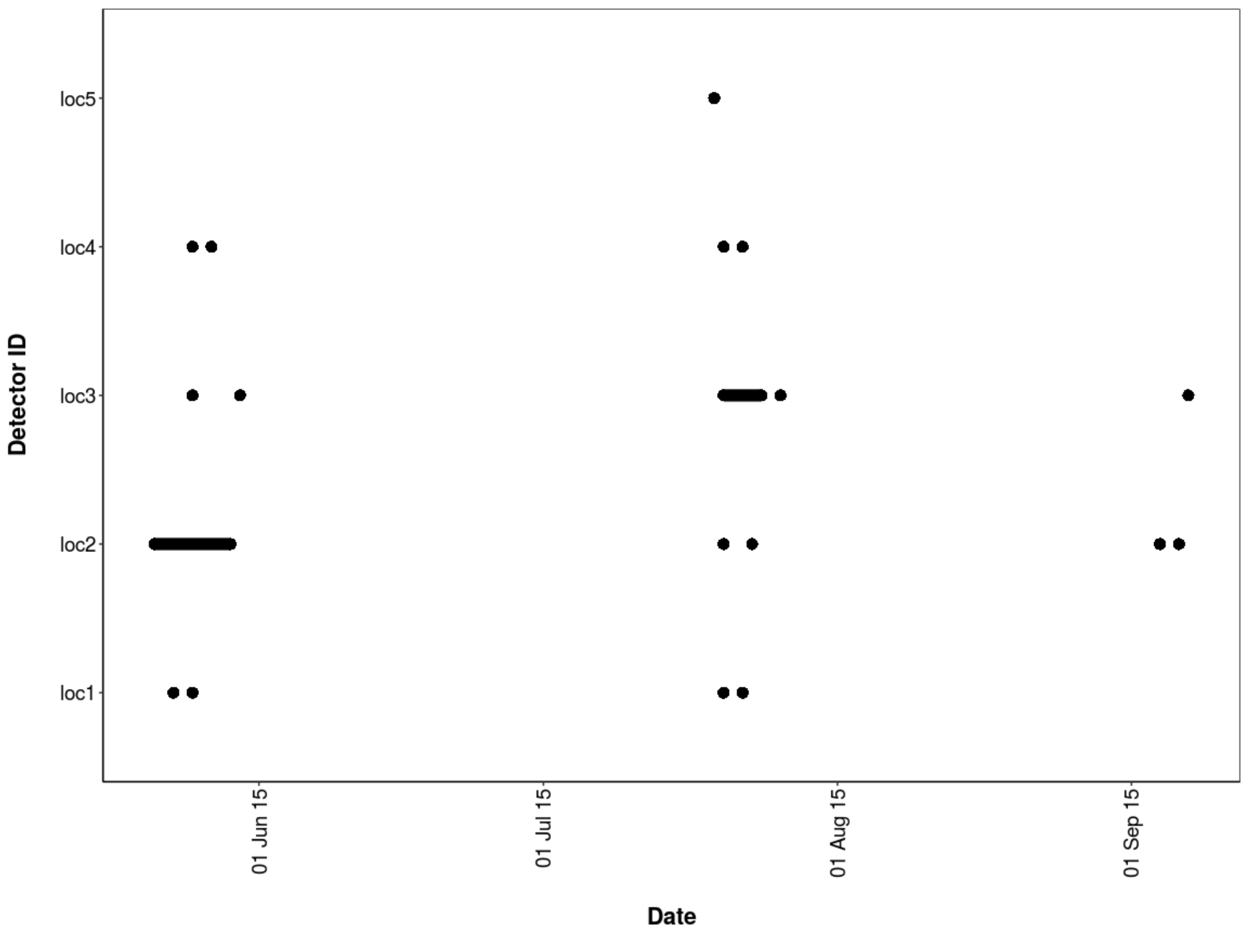
Survey Nights

Table 2. The number of nights that bats were detected on each recorder. This is not the same as the number of nights that detectors were active if there were nights when no bats were detected.

Detector ID	No. of nights
loc1	8
loc2	15
loc3	10
loc4	9
loc5	9

Survey Nights

Figure 1. Horizontal bars show nights when acoustic detectors recorded bats.



PART 1: Percentiles Analysis

This first part of the analysis looks at the relative activity levels of the bats you recorded. We take your value for the total bat passes each night for each species, and compare this to the values in our reference database. We tell you what percentile your data falls at, and therefore what the relative activity level is. For example, if the reference database has values of 5, 10, 15, 20 and you submit a value of 18, this will be the 80th percentile, and be classed as high activity.

The reference range dataset was stratified to include:

- Only records from within 30 days of the survey date.
- Only records from within 100km radius of the survey location.
- Records using any make of bat detector.

PER DETECTOR

Table 3. Summary table showing the number of nights recorded bat activity fell into each activity band for each species.

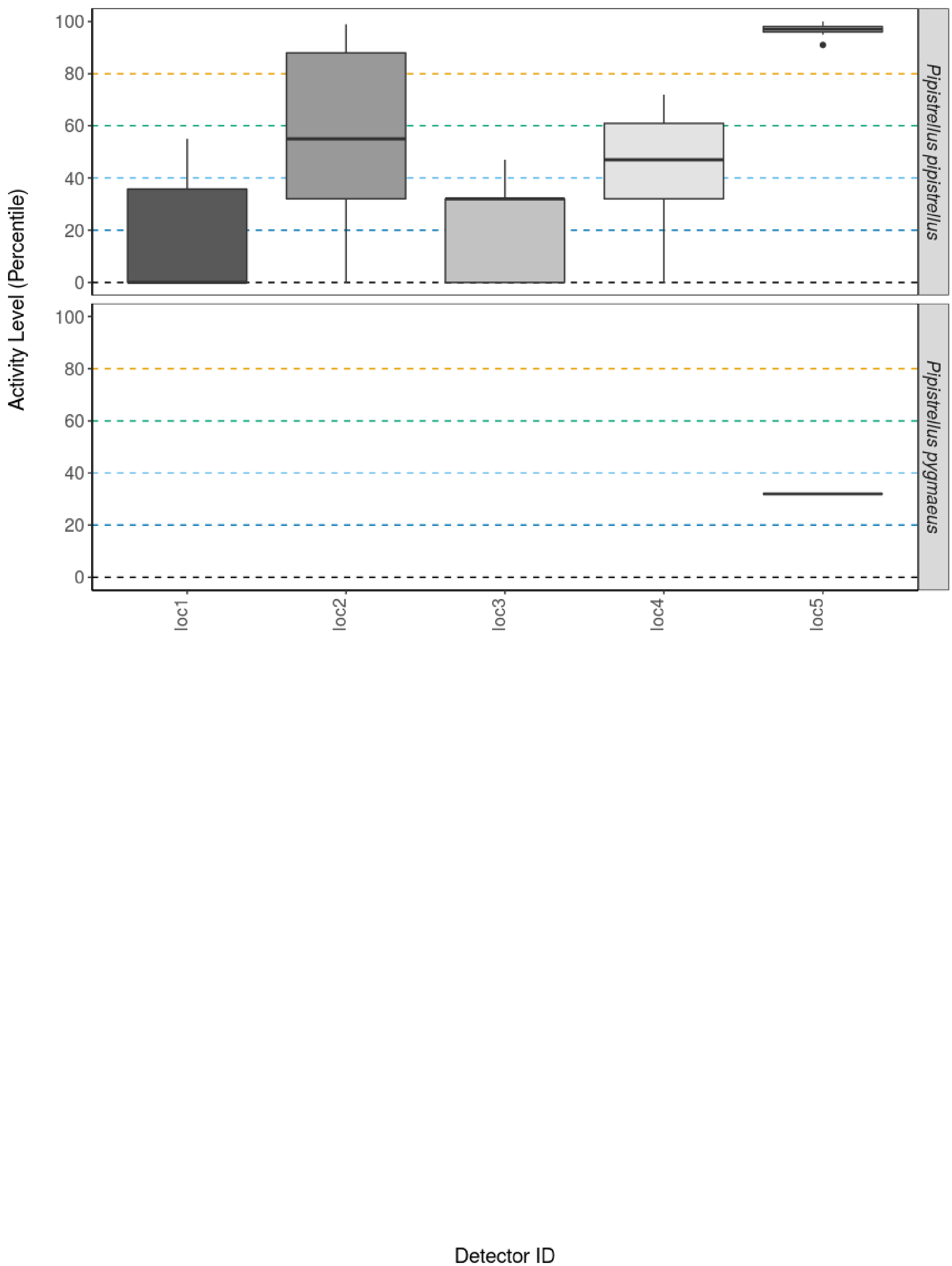
Detector ID	Species/Species Group	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
loc1	*Pipistrellus pipistrellus*	0	0	2	1	5
loc2	*Pipistrellus pipistrellus*	4	2	4	2	3
loc3	*Pipistrellus pipistrellus*	0	0	2	4	4
loc4	*Pipistrellus pipistrellus*	0	3	2	2	2
loc5	*Pipistrellus pipistrellus*	9	0	0	0	0
loc5	*Pipistrellus pygmaeus*	0	0	0	1	0

Table 4. Summary table showing key metrics for each species recorded. The reference range is the number of nights for each species that your data were compared to. We recommend a Reference Range of 200+ to be confident in the relative activity level.

Detector ID	Species/Species Group	Median Percentile	95% CIs	Max Percentile	Nights Recorded	Reference Range
loc1	*Pipistrellus pipistrellus*	0	32 - 55	55	8	2487
loc2	*Pipistrellus pipistrellus*	55	47 - 88	99	15	2487
loc3	*Pipistrellus pipistrellus*	32	32 - 39.5	47	10	2487
loc4	*Pipistrellus pipistrellus*	47	39.5 - 66.5	72	9	2487
loc5	*Pipistrellus pipistrellus*	97	94.5 - 98.5	100	9	2487
loc5	*Pipistrellus pygmaeus*	32	0	32	1	554

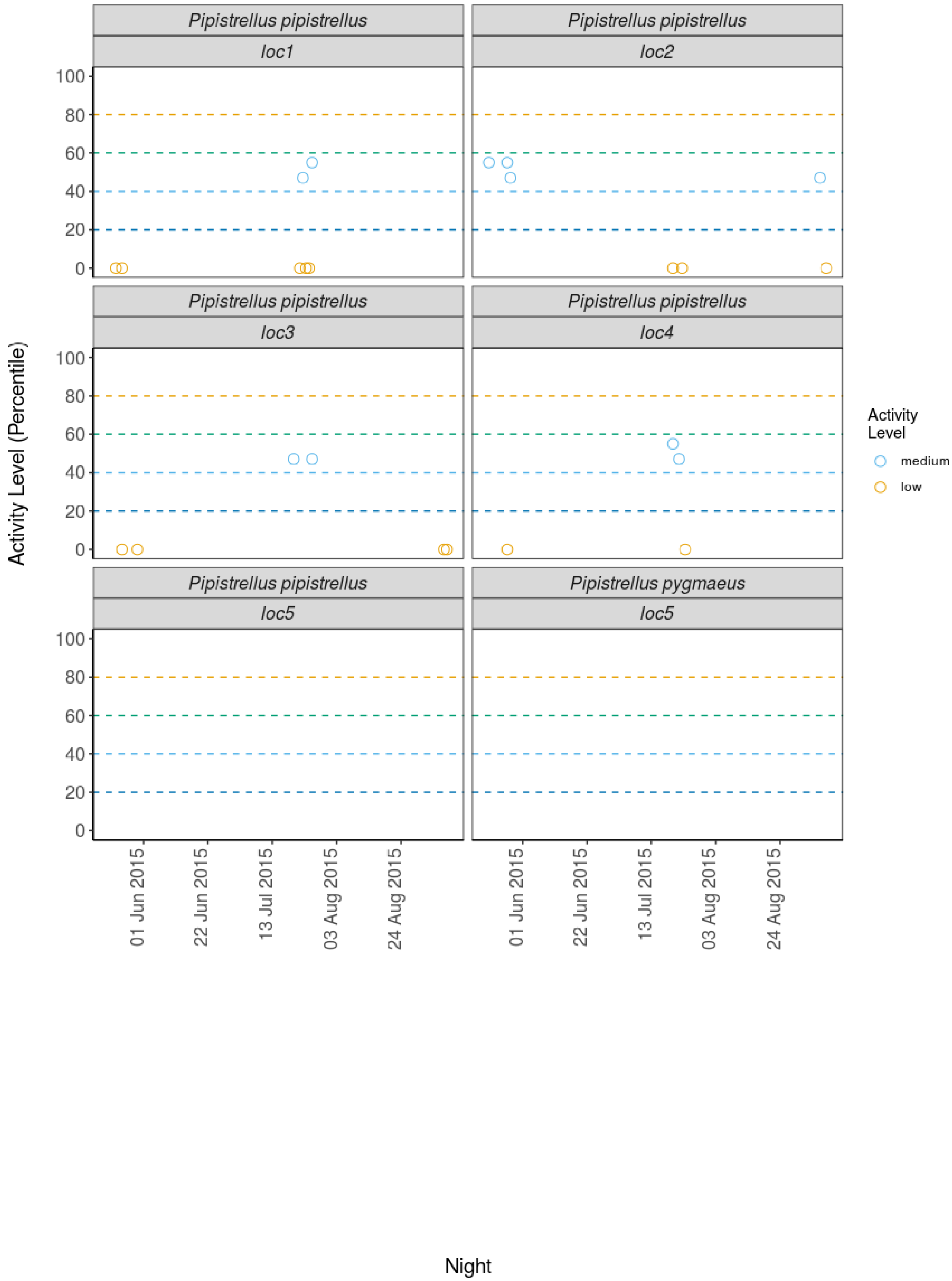
###Figures

Figure 2. The recorded activity of bats during the survey. The centre line indicates the median activity level whereas the box represents the interquartile range (the spread of the middle 50% of nights of activity)



Activity Level (Percentile)
Pipistrellus pipistrellus
Pipistrellus pygmaeus
0
20
40
60
80
100
loc1
loc2
loc3
loc4
loc5
Detector ID

Figure 3. The activity level (percentile) of bats recorded across each night of the bat survey.


Pipistrellus pipistrellus
loc1
Pipistrellus pipistrellus
loc2
Pipistrellus pipistrellus
loc3
Pipistrellus pipistrellus
loc4
Pipistrellus pipistrellus
loc5
Pipistrellus pygmaeus
loc5
Activity Level (Percentile)
100
80
60
40
20
0
01 Jun 2015
22 Jun 2015
13 Jul 2015
03 Aug 2015
24 Aug 2015
Activity Level
medium
low
Night

PER DETECTOR, PER MONTH

Table 5. Summary table showing the number of nights recorded bat activity fell into each activity band for each species at each detector during each month.

Detector ID	Species/Species Group	Month	Nights of High Activity	Nights of Moderate / High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
loc1	*Pipistrellus pipistrellus*	May	0	0	0	0	2
loc1	*Pipistrellus pipistrellus*	Jul	0	0	2	1	3
loc2	*Pipistrellus pipistrellus*	May	4	2	3	0	0
loc2	*Pipistrellus pipistrellus*	Jul	0	0	0	0	2
loc2	*Pipistrellus pipistrellus*	Sep	0	0	1	2	1
loc3	*Pipistrellus pipistrellus*	May	0	0	0	0	2
loc3	*Pipistrellus pipistrellus*	Jul	0	0	2	4	0
loc3	*Pipistrellus pipistrellus*	Sep	0	0	0	0	2
loc4	*Pipistrellus pipistrellus*	May	0	0	0	1	1
loc4	*Pipistrellus pipistrellus*	Jul	0	3	2	1	1
loc5	*Pipistrellus pipistrellus*	Jul	9	0	0	0	0
loc5	*Pipistrellus pygmaeus*	Jul	0	0	0	1	0

Table 6. Summary table showing key metrics for each species recorded per month. Please note that we cannot split the reference range by month, hence this column is not shown in this table.

Detector ID	Species/Species Group	Month	Median Percentile	95% CIs	Max Percentile	Nights Recorded
loc1	*Pipistrellus pipistrellus*	May	0	32 - 55	0	2
loc1	*Pipistrellus pipistrellus*	Jul	16	32 - 55	55	6
loc2	*Pipistrellus pipistrellus*	May	79	47 - 88	99	9
loc2	*Pipistrellus pipistrellus*	Jul	0	47 - 88	0	2
loc2	*Pipistrellus pipistrellus*	Sep	32	47 - 88	47	4
loc3	*Pipistrellus pipistrellus*	May	0	32 - 39.5	0	2
loc3	*Pipistrellus pipistrellus*	Jul	32	32 - 39.5	47	6
loc3	*Pipistrellus pipistrellus*	Sep	0	32 - 39.5	0	2
loc4	*Pipistrellus pipistrellus*	May	16	39.5 - 66.5	32	2
loc4	*Pipistrellus pipistrellus*	Jul	55	39.5 - 66.5	72	7
loc5	*Pipistrellus pipistrellus*	Jul	97	94.5 - 98.5	100	9
loc5	*Pipistrellus pygmaeus*	Jul	32	0	32	1

PER SITE

In this 'Per Site' section of the analysis, all values are taken from across all of the detectors to provide site-wide averages/medians.

Table 7. Summary table showing the number of nights recorded bat activity fell into each activity band for each species.

Species/Species Group	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
Pipistrellus pipistrellus	13	5	10	9	14
Pipistrellus pygmaeus	0	0	0	1	0

Table 8. Summary table showing key metrics for each species recorded.

Species/Species Group	Median Percentile	95% CIs	Max Percentile	Nights Recorded
Pipistrellus pipistrellus	47	94.5 - 98.5	100	51
Pipistrellus pygmaeus	32	0	32	1

###Figures

Figure 4. The activity level (percentile) of bats recorded across each night of the bat survey for the **entire site**.

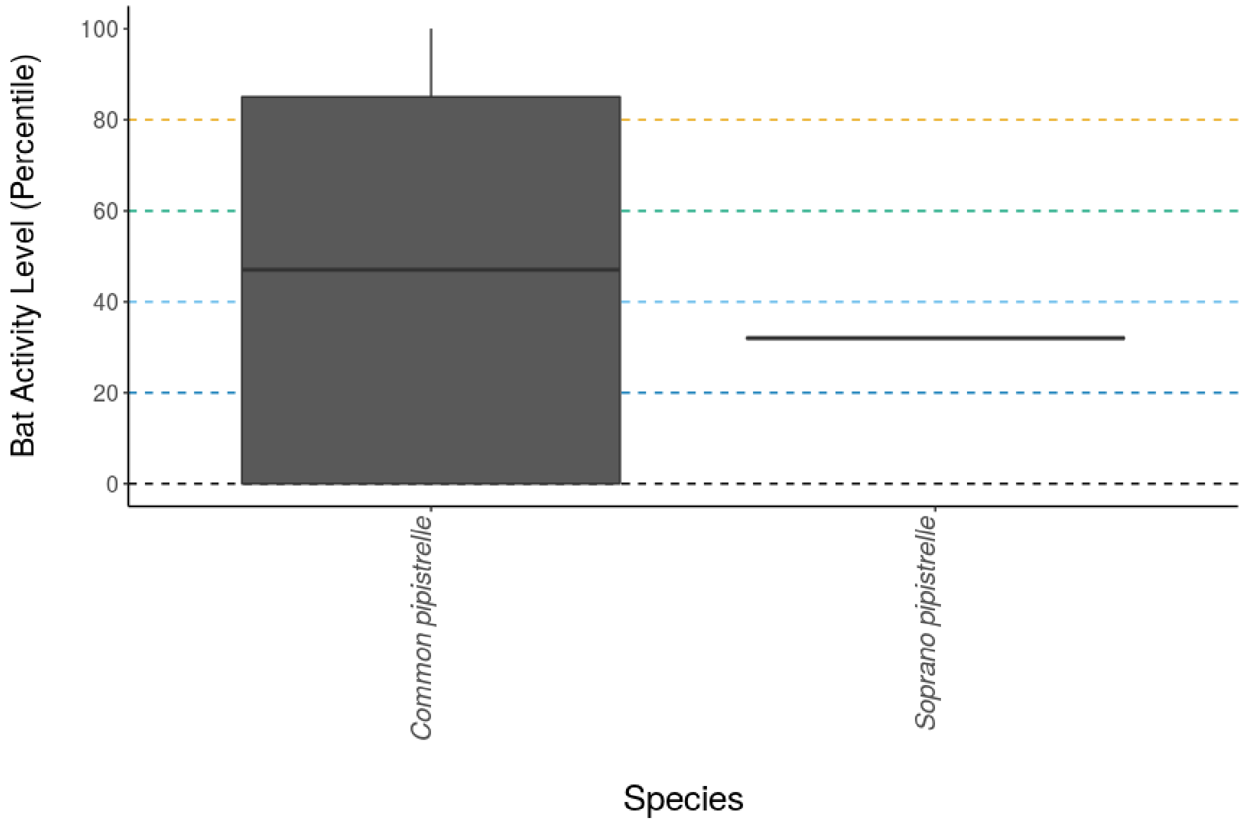
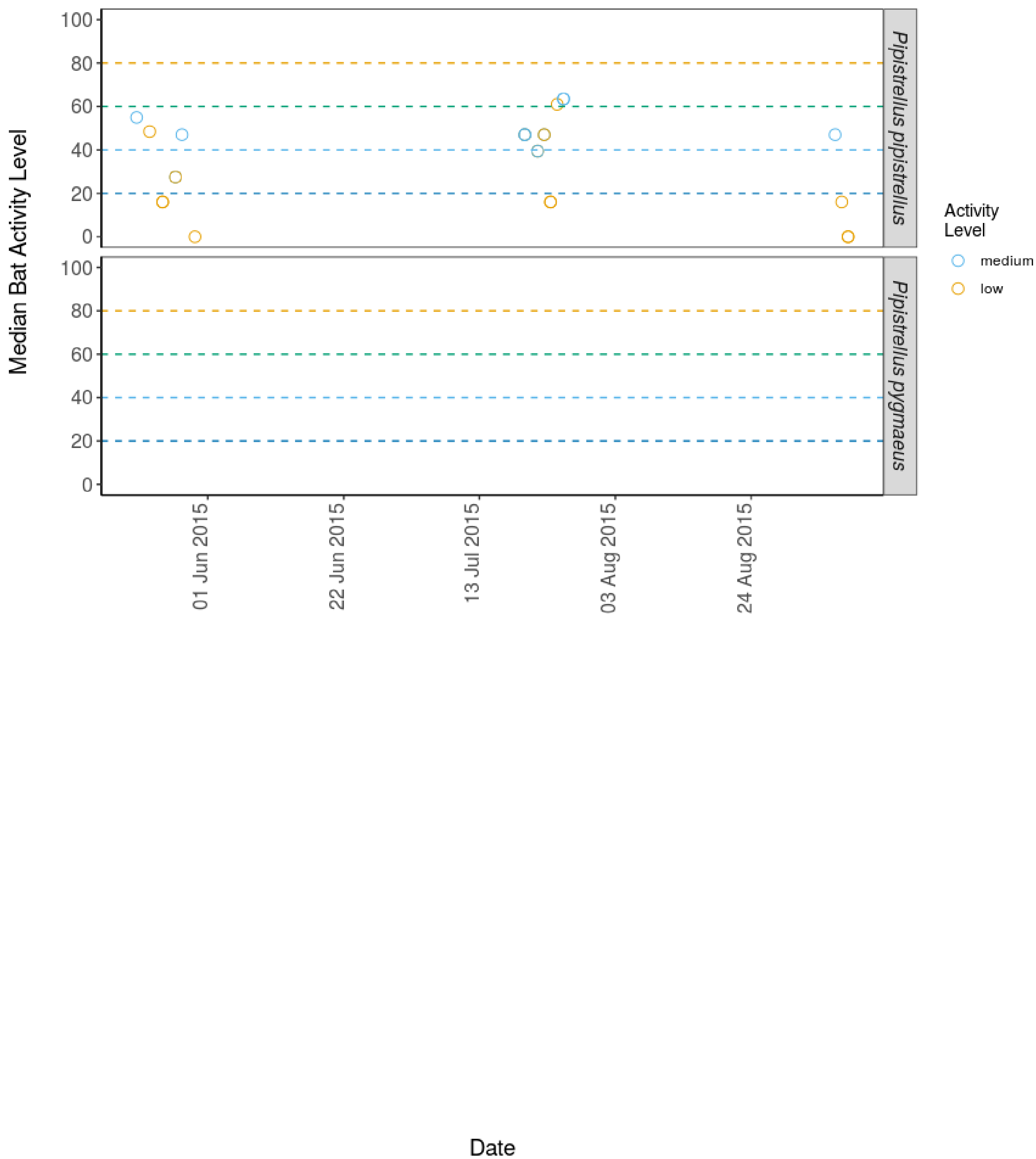


Figure 5. The median activity levels of bats recorded across all detectors each night.



PER SITE, PER MONTH

Table 9. Summary table showing the number of nights recorded bat activity fell into each activity band for each species during each month.

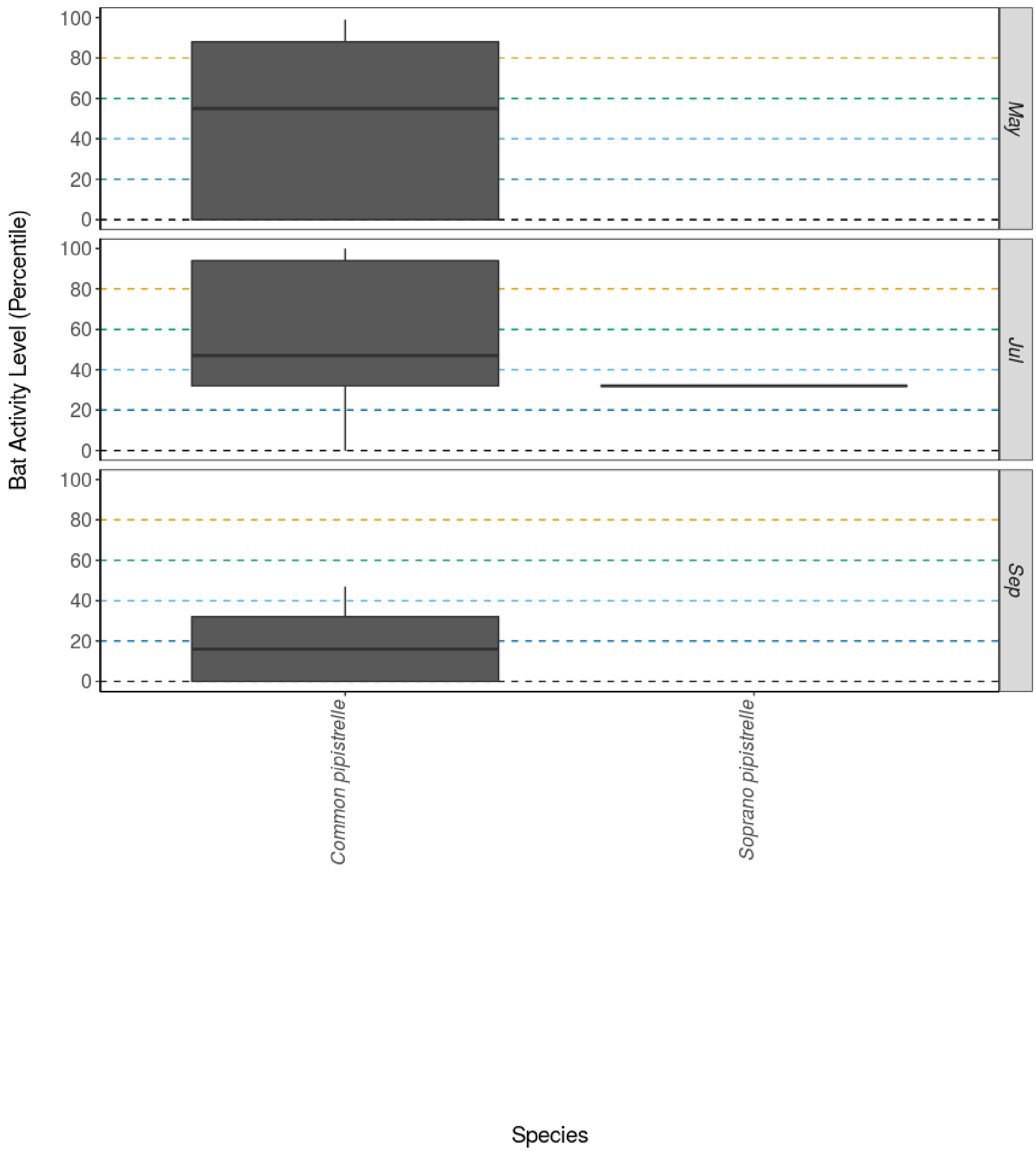
Species/Species Group	Month	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
Pipistrellus pipistrellus	May	4	2	3	1	5
Pipistrellus pipistrellus	Jul	9	3	6	6	6
Pipistrellus pipistrellus	Sep	0	0	1	2	3
Pipistrellus pygmaeus	Jul	0	0	0	1	0

Table 10. Summary table showing key metrics for each species recorded per month.

Species/Species Group	Month	Median Percentile	95% CIs	Max Percentile	Nights Recorded
Pipistrellus pipistrellus	May	55	47 - 88	99	15
Pipistrellus pipistrellus	Jul	47	94.5 - 98.5	100	30
Pipistrellus pipistrellus	Sep	16	47 - 88	47	6
Pipistrellus pygmaeus	Jul	32	0	32	1

###Figures

Figure 6. The activity level (percentile) of bats recorded across each night of the bat survey for the entire site, split between months.



PART 2: Nightly Analysis

ENTIRE SURVEY PERIOD

Sunrise and Sunset Times

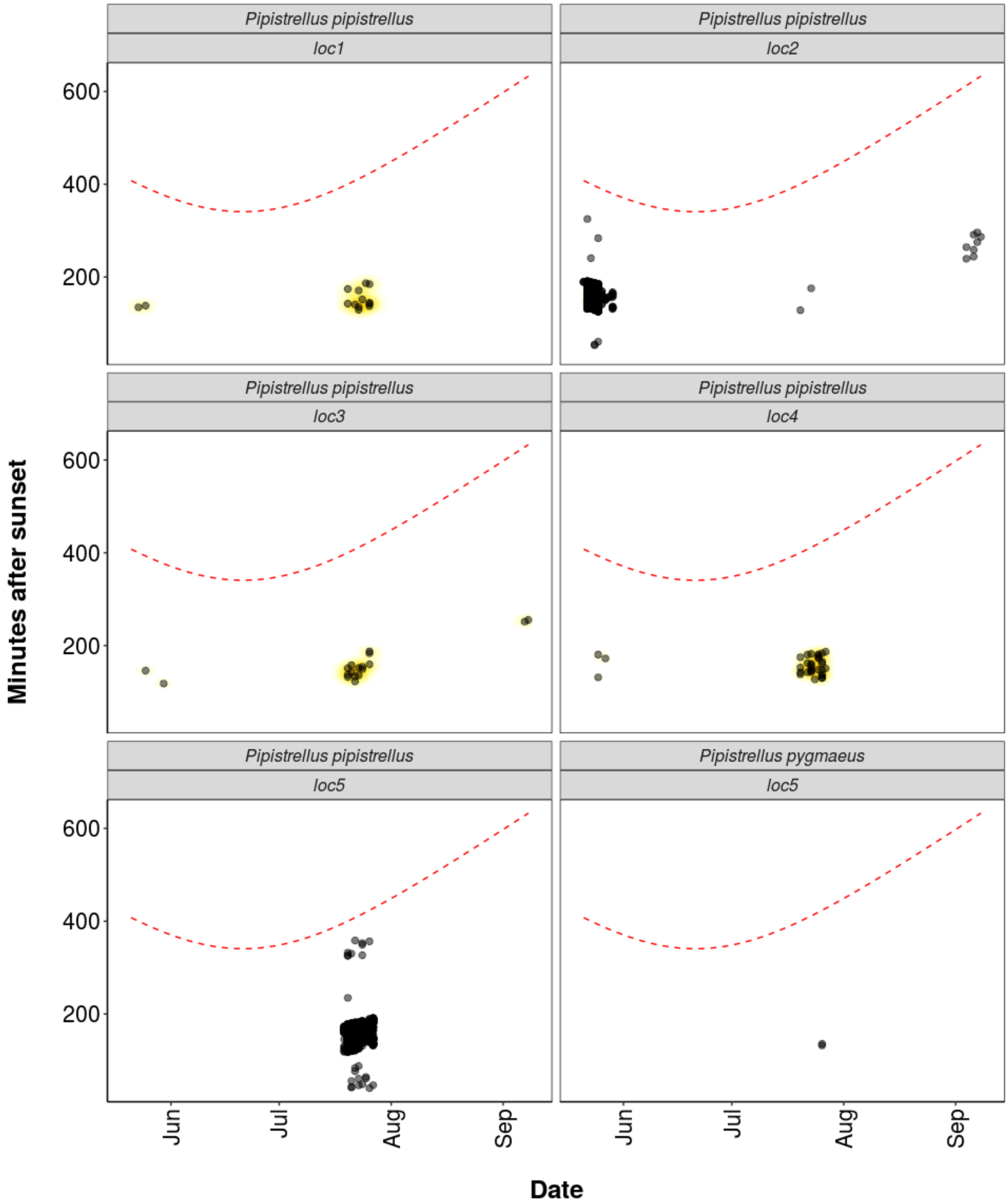
Table 11. The times of sunset and sunrise the following morning for surveys beginning on the date shown.

Night (y-m-d)	Sunset (hh:mm)	Sunrise (hh:mm)	Night Length (hours)
2015-05-21	21:46	04:34	6.8
2015-05-22	21:48	04:32	6.7
2015-05-23	21:50	04:30	6.7
2015-05-24	21:52	04:29	6.6
2015-05-25	21:54	04:27	6.6
2015-05-26	21:56	04:25	6.5
2015-05-27	21:58	04:24	6.4
2015-05-28	21:59	04:22	6.4
2015-05-29	22:01	04:21	6.3
2015-05-30	22:03	04:19	6.3
2015-07-19	22:03	04:40	6.6
2015-07-20	22:01	04:41	6.7
2015-07-21	21:59	04:43	6.7
2015-07-22	21:58	04:45	6.8
2015-07-23	21:56	04:47	6.9
2015-07-24	21:54	04:49	6.9
2015-07-25	21:52	04:51	7.0
2015-07-26	21:50	04:53	7.1
2015-07-27	21:48	04:55	7.1
2015-09-04	20:08	06:21	10.2
2015-09-06	20:03	06:25	10.4
2015-09-07	20:00	06:28	10.5
2015-09-08	19:57	06:30	10.5

Distribution of Bat Activity Across the Night through Time

Per Detector

Figure 7. Timing of bat calls plotted as minutes before/after sunset, whereby 0 on the y axis represents sunset. Sunrise throughout the survey period is depicted as the red dashed line. Colours indicate kernel densities, with darkest colours showing peaks of activity. These colours are comparative only within each plot, and do not account for overall activity.



Pipistrellus pipistrellus
loc1
Pipistrellus pipistrellus
loc2
Pipistrellus pipistrellus
loc3
Pipistrellus pipistrellus
loc4
Pipistrellus pipistrellus
loc5
Pipistrellus pygmaeus
loc5
Minutes after sunset
600
400
200
Jun
Jul
Aug
Sep
Date

Roost Emergence Time and Bat Observation

Based on: *Russ, Jon. 2012. British Bat Calls a Guide to species Identification. Pelagic Publishing.*

For more information see https://rbats-blog.updog.co/2018/05/29/bat-emergence/

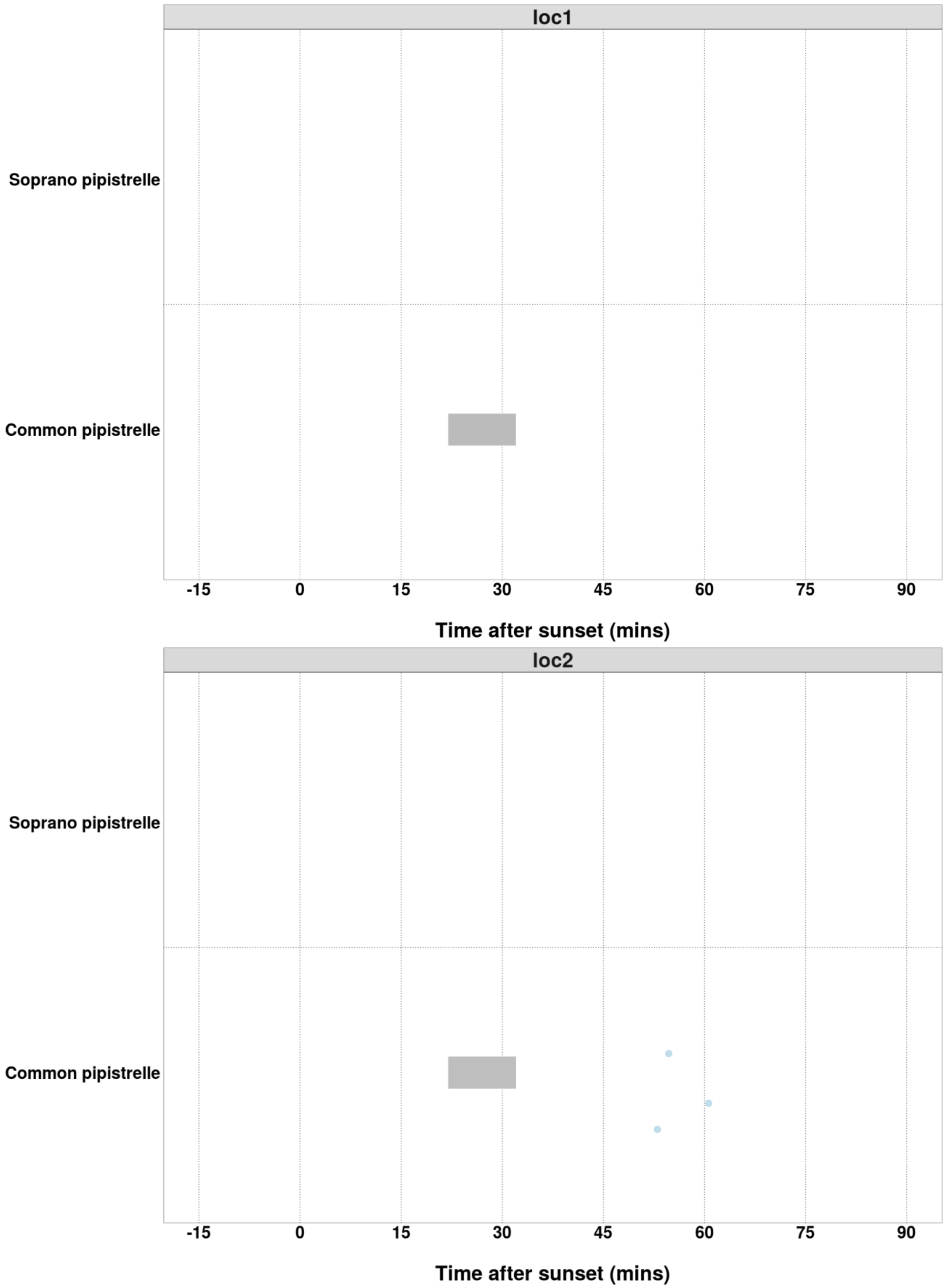
Bat Passes Potentially Indicating Close Proximity to a Roost (Russ 2012) - Table

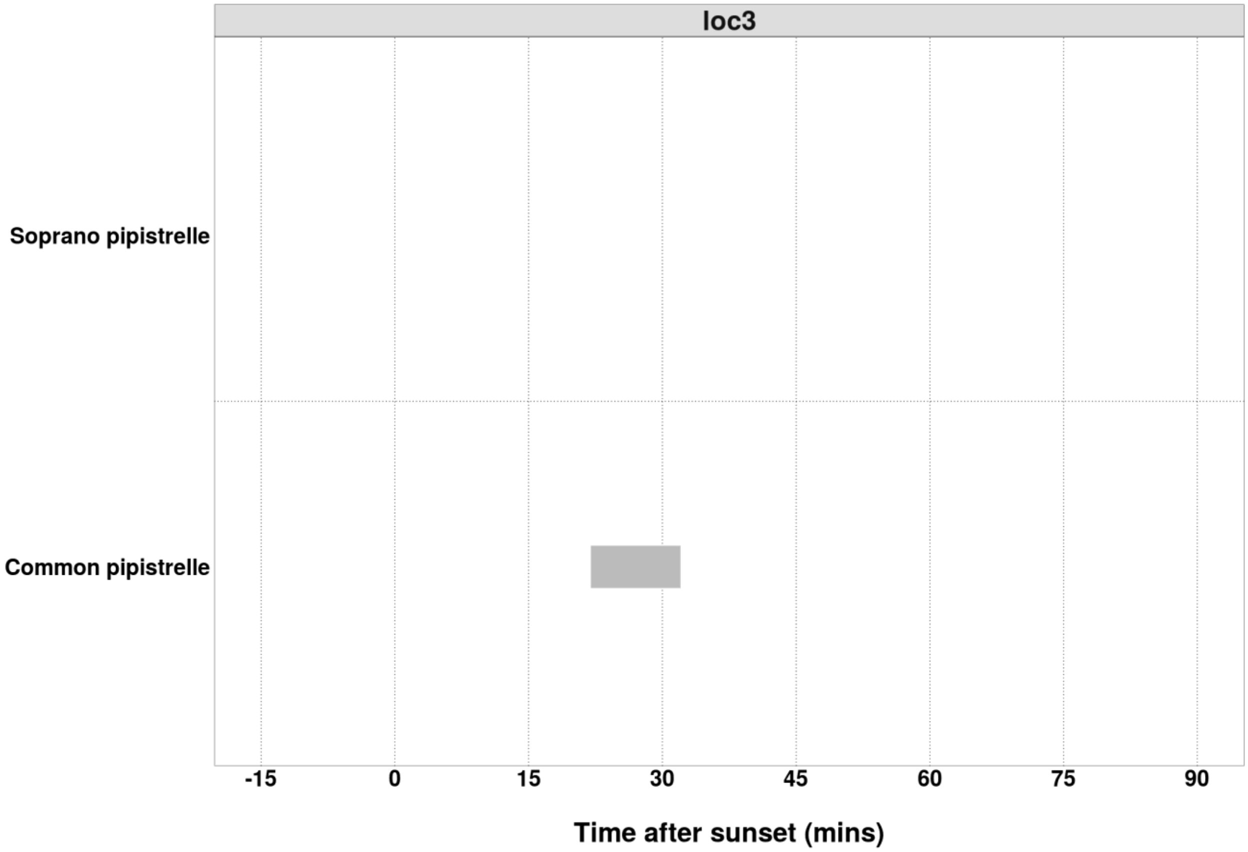
Table 12. Number of bat calls recorded before the upper time of the species-specific emergence time range, and which therefore may potentially indicate the presence of a nearby roost.

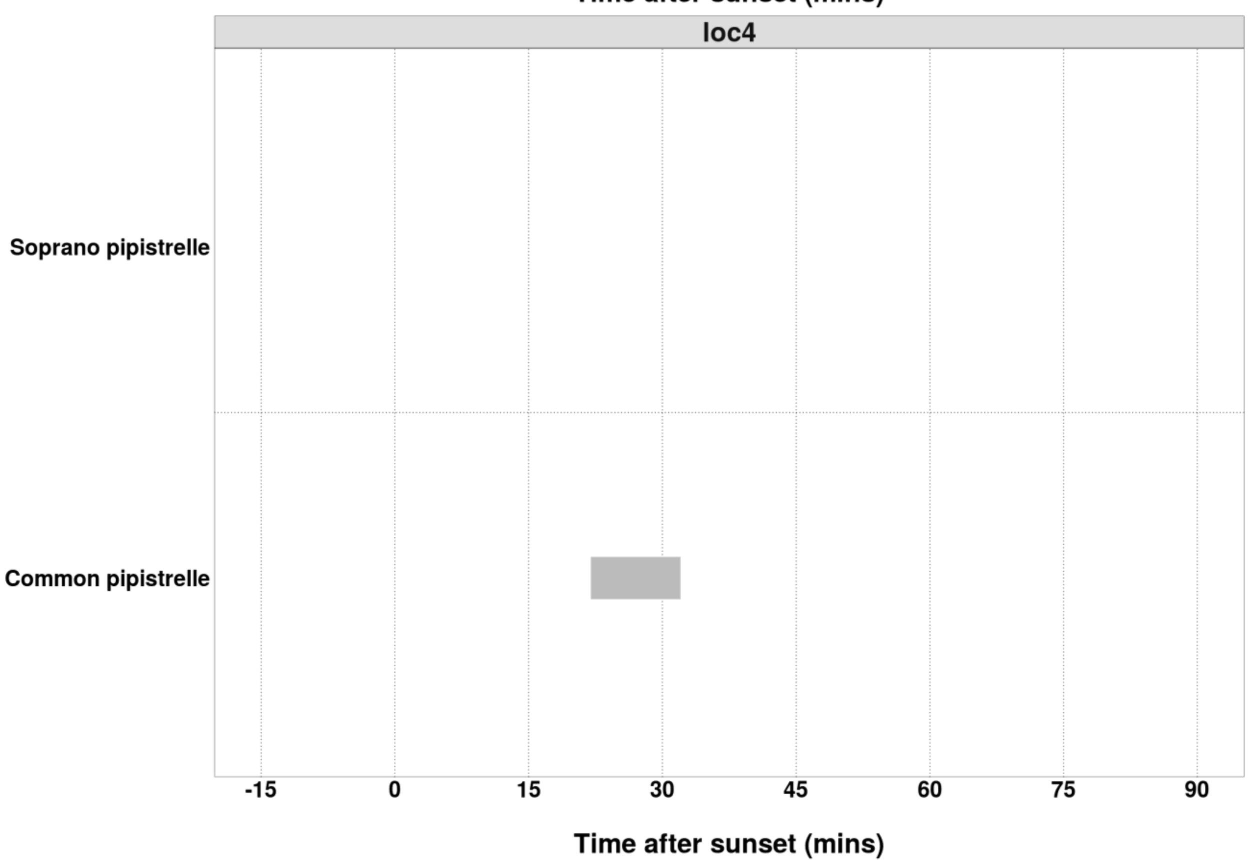
Species	Detector ID

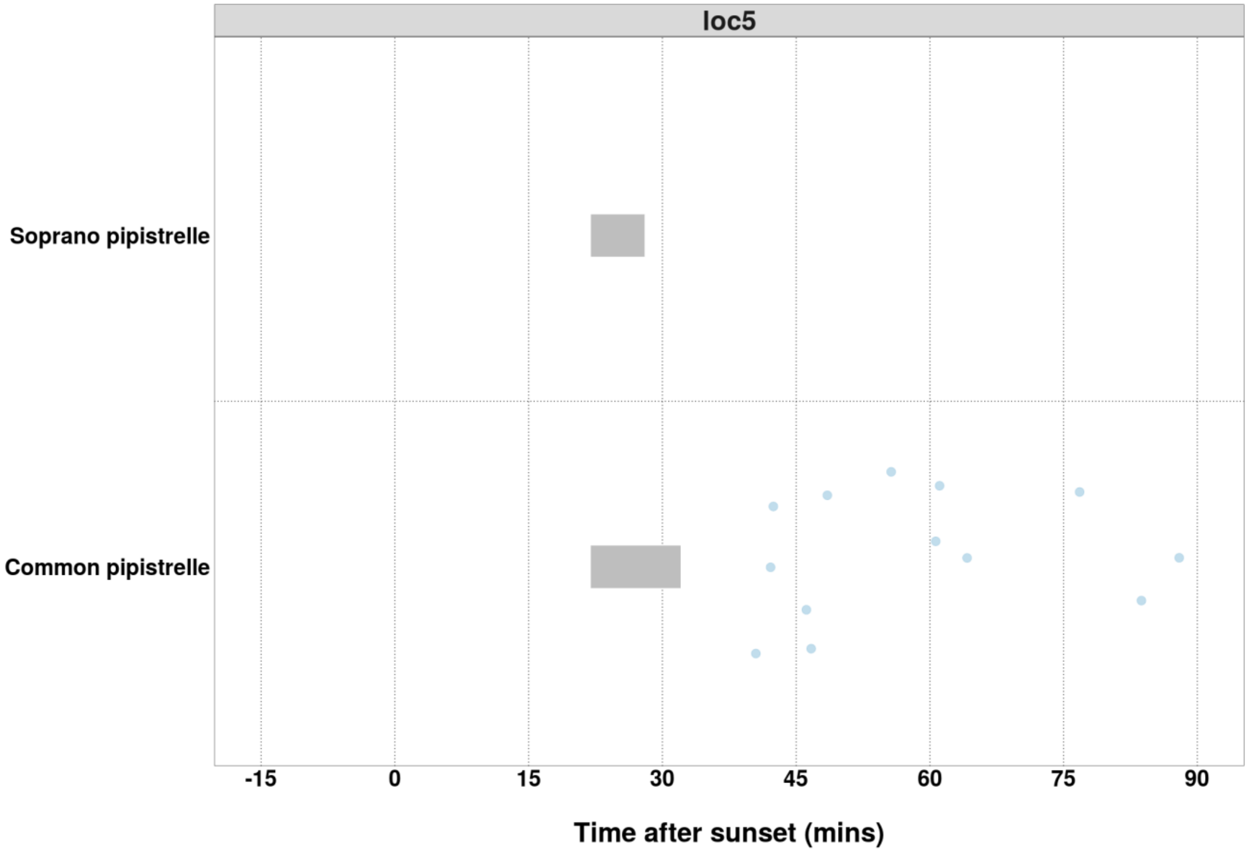
Bat Passes Potentially Indicating Close Proximity to a Roost (Russ 2012) - Figures

Figure 8. Time from 15 minutes before to 90 minutes after sunset. Species-specific emergence time ranges are shown as grey bars. Bat passes overlapping species-specific grey bars, or occuring earlier than this time range, may potentially indicate the presence of a nearby roost.


loc1
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)
loc2
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)


loc3
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)


loc4
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)


loc5
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)

Counts of Bat Passes

All detectors

Table 14. The total number of passes recorded for each species across all of the detectors. The 'Total' percentage may not be exactly 100% due to rounding of the percentages per species.

Species	Passes (No.)	Percentage of total (%)
Common pipistrelle	2600	99.9
Soprano pipistrelle	2	0.1
Total	2602	100.0

Counts of Bat Passes

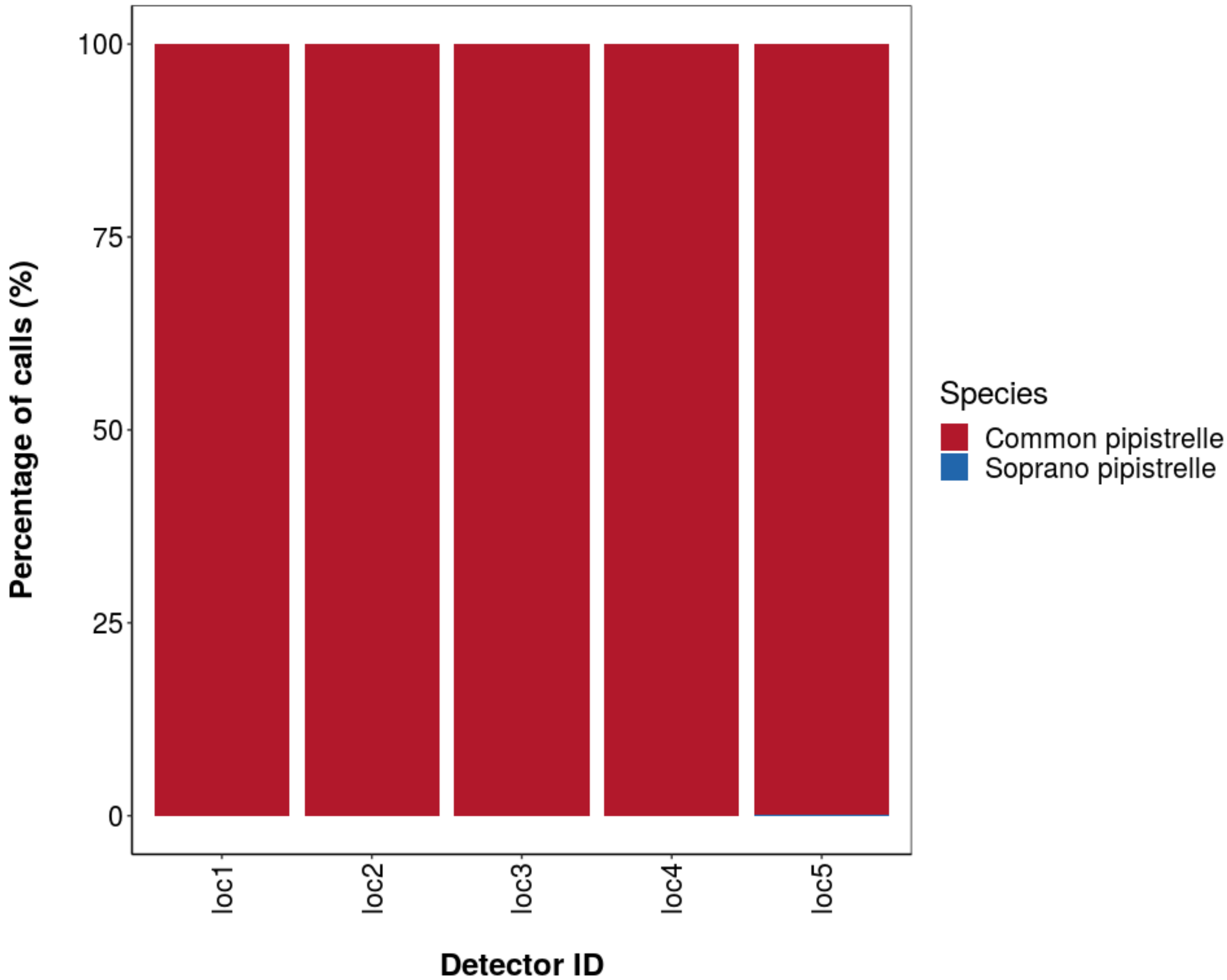
Per Detector

Table 15. The number of passes recorded for each species at each detector.

Species	Detector ID	Count (No)	Percentage by Detector (%)
Common pipistrelle	loc1	14	100.0
Common pipistrelle	loc2	943	100.0
Common pipistrelle	loc3	18	100.0
Common pipistrelle	loc4	33	100.0
Common pipistrelle	loc5	1592	99.9
Soprano pipistrelle	loc5	2	0.1

Species Composition

Figure 10. Percentage species composition of passes at each detector.



PART 2a: Presence Only

THE NEXT SECTION OF THE REPORT FEATURES THE RAW DATA SUPPLIED TO ECOBAT AND ONLY TAKES INTO ACCOUNT THE PRESENCE, AND NOT THE ABSENCE, OF EACH BAT SPECIES. FOR EACH NIGHT, THERE IS NO 'ZERO DATA' FOR WHEN SPECIES WERE NOT DETECTED.

Nightly Bat Pass Rate (Bat passes per hour)

Median Per Detector

Table 16. The median Nightly Pass Rate (bat passes per hour, per night) of each species. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the ‘average’ activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	Median Pass Rate
Common pipistrelle	loc1	0.2
Common pipistrelle	loc2	0.6
Common pipistrelle	loc3	0.3
Common pipistrelle	loc4	0.4
Common pipistrelle	loc5	21.0
Soprano pipistrelle	loc5	0.3

Nightly Bat Pass Rate (Bat passes per hour)

Mean per Detector

Table 17. The mean Nightly Pass Rate (bat passes per hour, per night) of each species at each detector. Values are given to 1 decimal place.

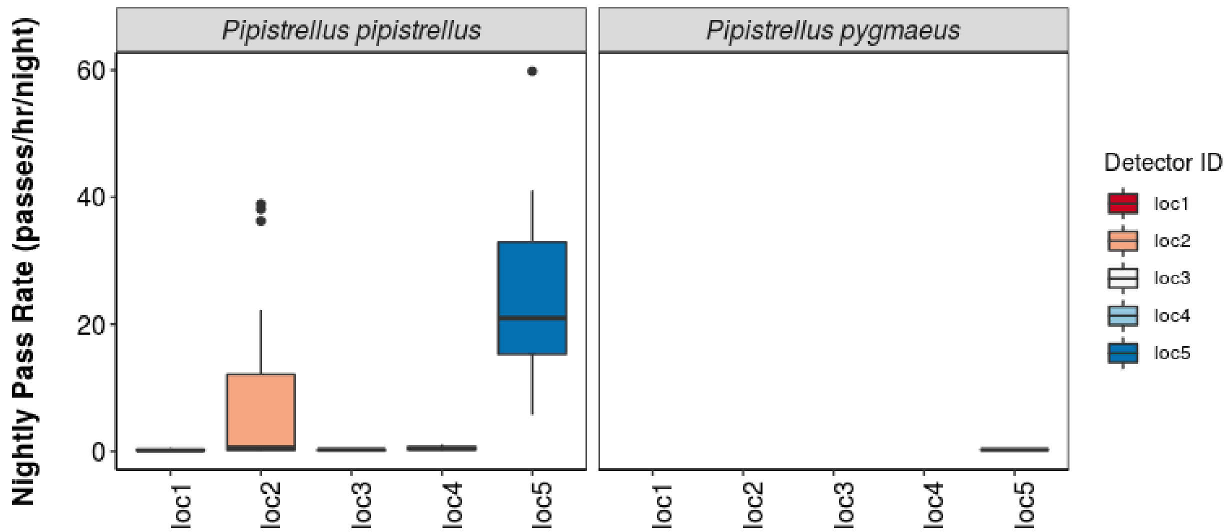
We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

Species	Detector ID	Mean Pass Rate
Common pipistrelle	loc1	0.3
Common pipistrelle	loc2	9.5
Common pipistrelle	loc3	0.3
Common pipistrelle	loc4	0.5
Common pipistrelle	loc5	25.9
Soprano pipistrelle	loc5	0.3

Nightly Bat Passes (Bat passes per hour)

Per Detector - Figures

Figure 11. Boxplots for the number of bat passes per hour each night, for each detector. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.


Pipistrellus pipistrellus
Pipistrellus pygmaeus
Nightly Pass Rate (passes/hr/night)
60
40
20
0
loc1
loc2
loc3
loc4
loc5
Detector ID
loc1
loc2
loc3
loc4
loc5

Detector ID

SPLIT BY MONTH

Total Bat Passes per Detector, each Month

Per Detector

Table 18. The total number of bat passes of each species in each month at each detector. This table simply tells you how many bats of each species were recorded passing each detector during each month. These numbers are not standardised by the night length, or how many nights each detector was active for during each month.

Species	Detector ID	May	Jul	Sep
Common pipistrelle	loc1	2	12	0
Common pipistrelle	loc2	933	2	8
Common pipistrelle	loc3	2	14	2
Common pipistrelle	loc4	3	30	0
Common pipistrelle	loc5	0	1592	0
Soprano pipistrelle	loc5	0	2	0

Survey Effort

Table 19. The number of survey nights per month per detector.

Month	Detector ID	No. of Survey Nights
May	loc1	2
May	loc2	9
May	loc3	2
May	loc4	2
Jul	loc1	6
Jul	loc2	2
Jul	loc3	6
Jul	loc4	7
Jul	loc5	9
Sep	loc2	4
Sep	loc3	2

Nightly Bat Pass Rate for each Month

Median Per Detector

Table 20. The median Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the 'average' activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	May	Jul	Sep
Common pipistrelle	loc1	0.2	0.2	NA
Common pipistrelle	loc2	2.0	0.2	0.2
Common pipistrelle	loc3	0.2	0.3	0.1
Common pipistrelle	loc4	0.2	0.6	NA
Common pipistrelle	loc5	NA	21.0	NA
Soprano pipistrelle	loc5	NA	0.3	NA

Nightly Bat Pass Rate for each Month

Mean per Detector

Table 21: The mean Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. Values are given to 1 decimal place.

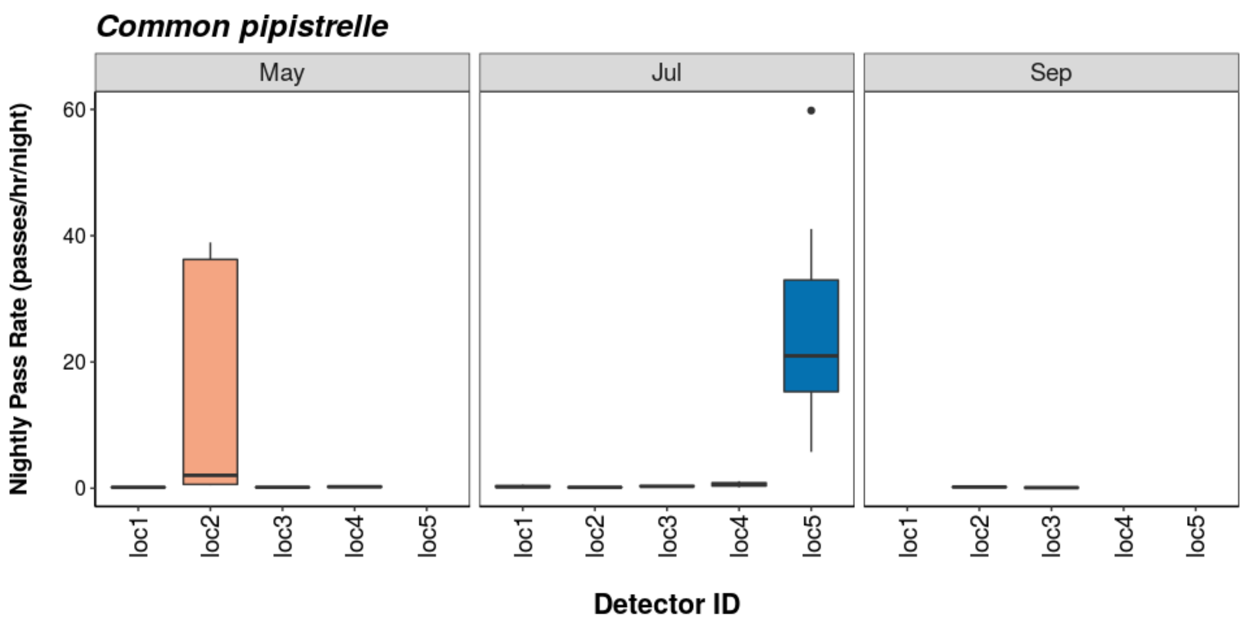
We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

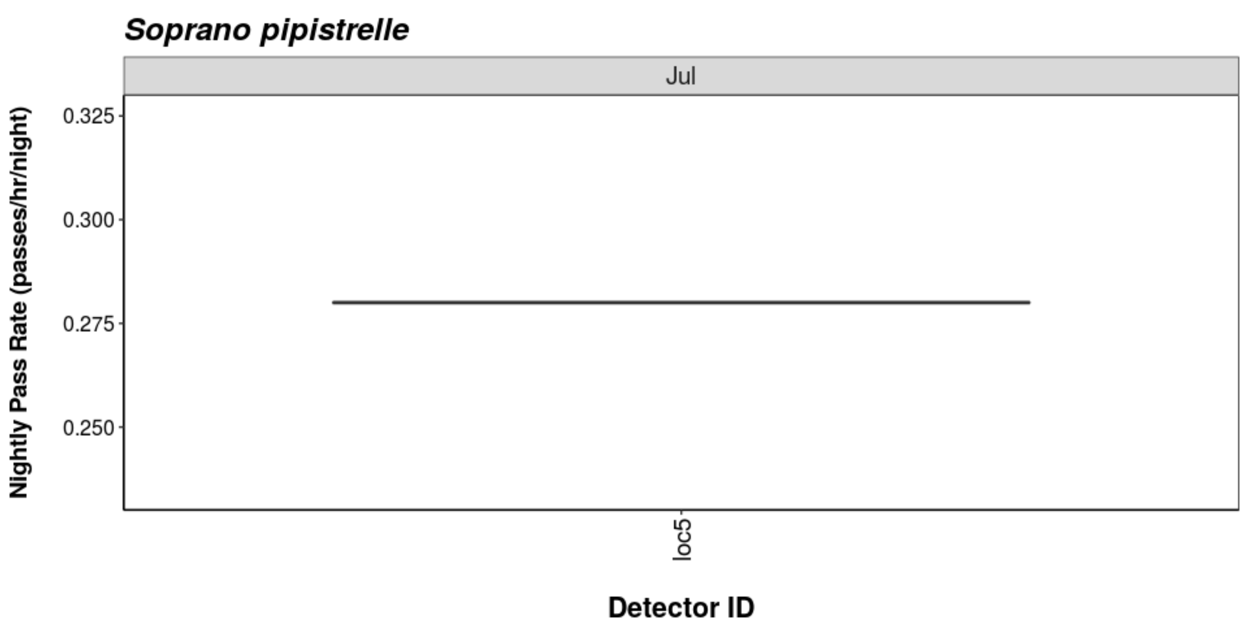
Species	Detector ID	May	Jul	Sep
Common pipistrelle	loc1	0.2	0.3	NA
Common pipistrelle	loc2	15.6	0.2	0.2
Common pipistrelle	loc3	0.2	0.3	0.1
Common pipistrelle	loc4	0.2	0.6	NA
Common pipistrelle	loc5	NA	25.9	NA
Soprano pipistrelle	loc5	NA	0.3	NA

Nightly Bat Pass Rate for each Month

Per Detector - Figures

Figure 12. Figures show boxplots for the number of bat passes per hour by detector, for each month. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.


Common pipistrelle
May
Jul
Sep
Nightly Pass Rate (passes/hr/night)
60
40
20
0
loc1
loc2
loc3
loc4
loc5
Detector ID


Soprano pipistrelle
Jul
Nightly Pass Rate (passes/hr/night)
0.325
0.300
0.275
0.250
loc5
Detector ID

Bat Activity per Detector Location

Figure 13. Detector ID reference:

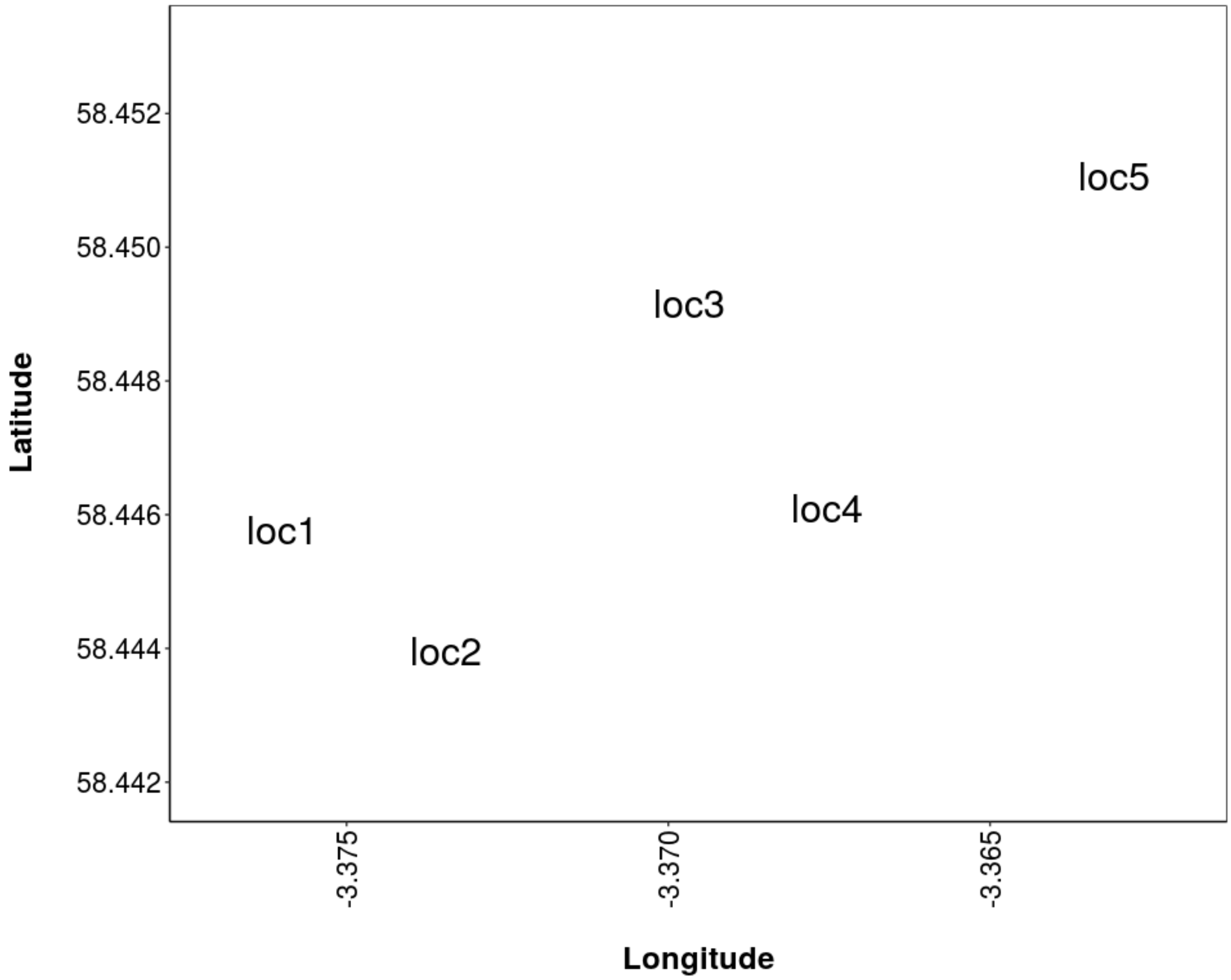


Figure 14. Median Nightly Pass Rate (bat passes/hr/night) throughout the survey period - represented by the size and colour of the point at each detector location.

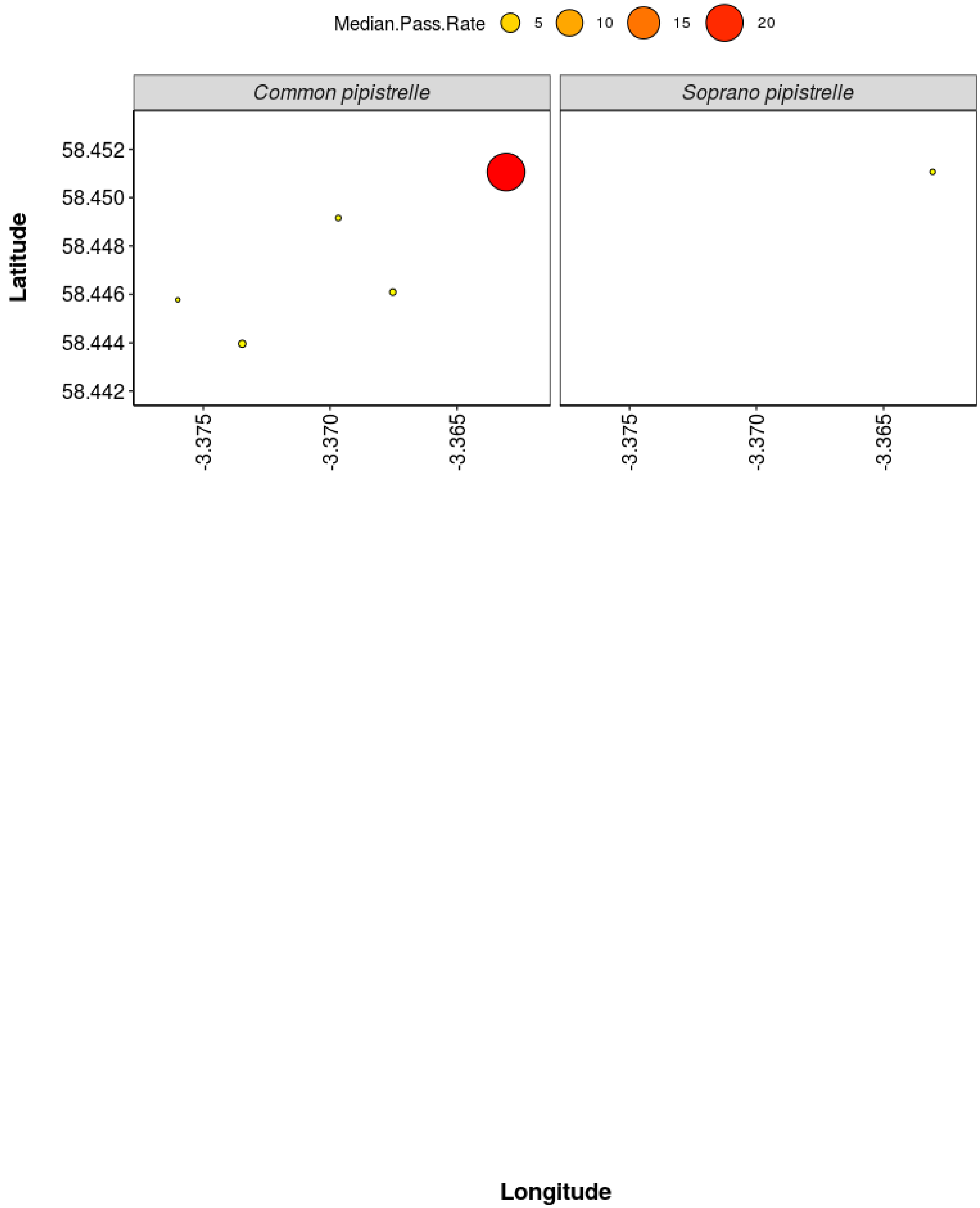
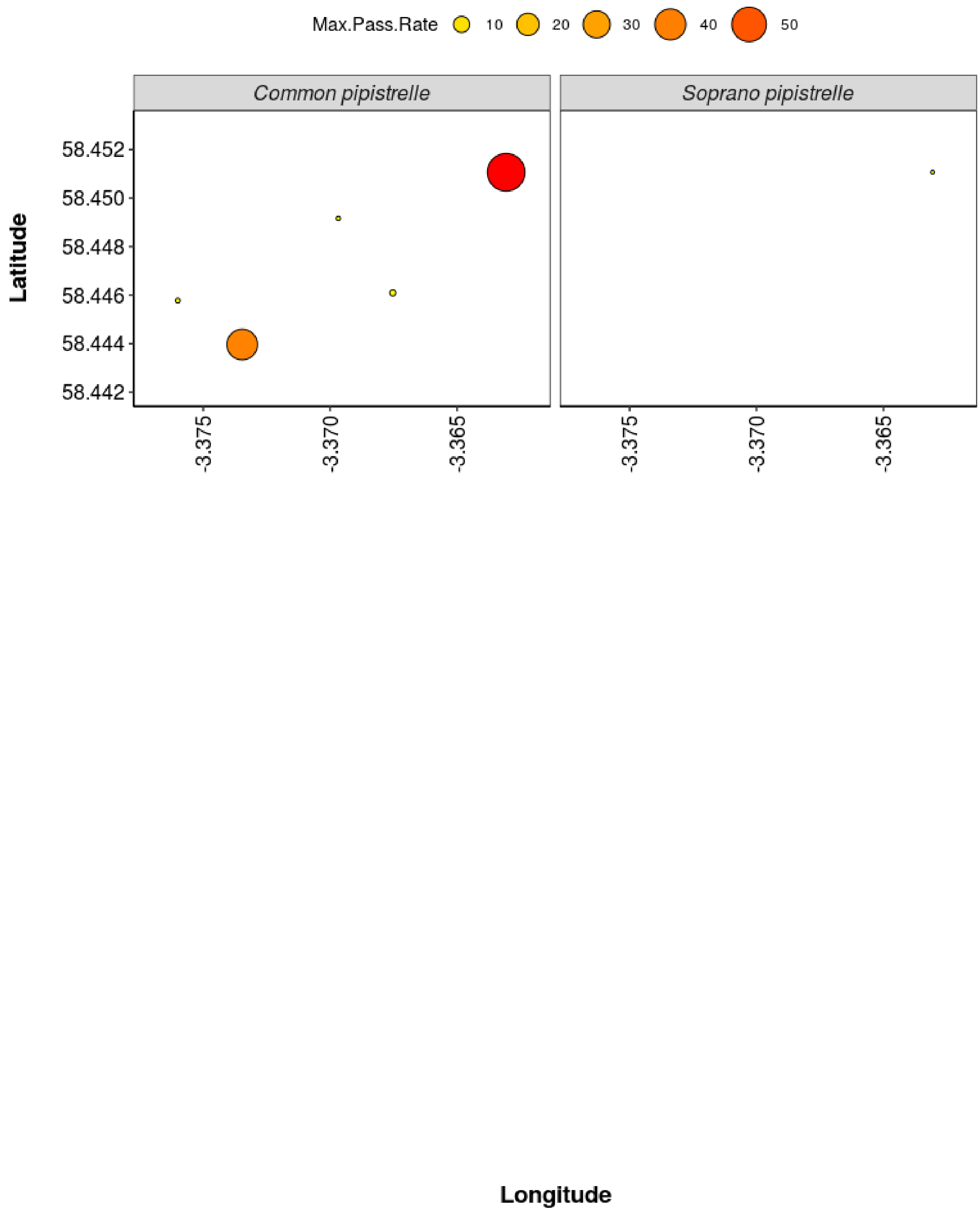


Figure 15. Maximum Nightly Pass Rate (bat passes/hr/night) recorded in a single night throughout the survey period - represented by the size and colour of the point at each detector location.



PART 2B: Includes absences

THE NEXT SECTION OF THE REPORT FEATURES THE DATA SUPPLIED TO ECOBAT BUT TAKES INTO ACCOUNT SPECIES ABSENCES, AND THEREFORE INCLUDES 'ZERO DATA' FOR WHEN SPECIES WERE NOT DETECTED AT EACH DETECTOR ON A NIGHT. THIS DRAMATICALLY LOWERS THE MEANS AND MEDIANS OF THE DATA PRESENTED.

Nightly Bat Pass Rate (Bat passes per hour)

Median Per Detector

Table 22. The median Nightly Pass Rate (bat passes per hour, per night) of each species. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the 'average' activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	Median Pass Rate
Common pipistrelle	loc1	0.2
Common pipistrelle	loc2	0.6
Common pipistrelle	loc3	0.3
Common pipistrelle	loc4	0.4
Common pipistrelle	loc5	21.0
Soprano pipistrelle	loc1	0.0
Soprano pipistrelle	loc2	0.0
Soprano pipistrelle	loc3	0.0
Soprano pipistrelle	loc4	0.0
Soprano pipistrelle	loc5	0.0

Nightly Bat Pass Rate (Bat passes per hour)

Mean per Detector

Table 23. The mean Nightly Pass Rate (bat passes per hour, per night) of each species at each detector. Values are given to 1 decimal place.

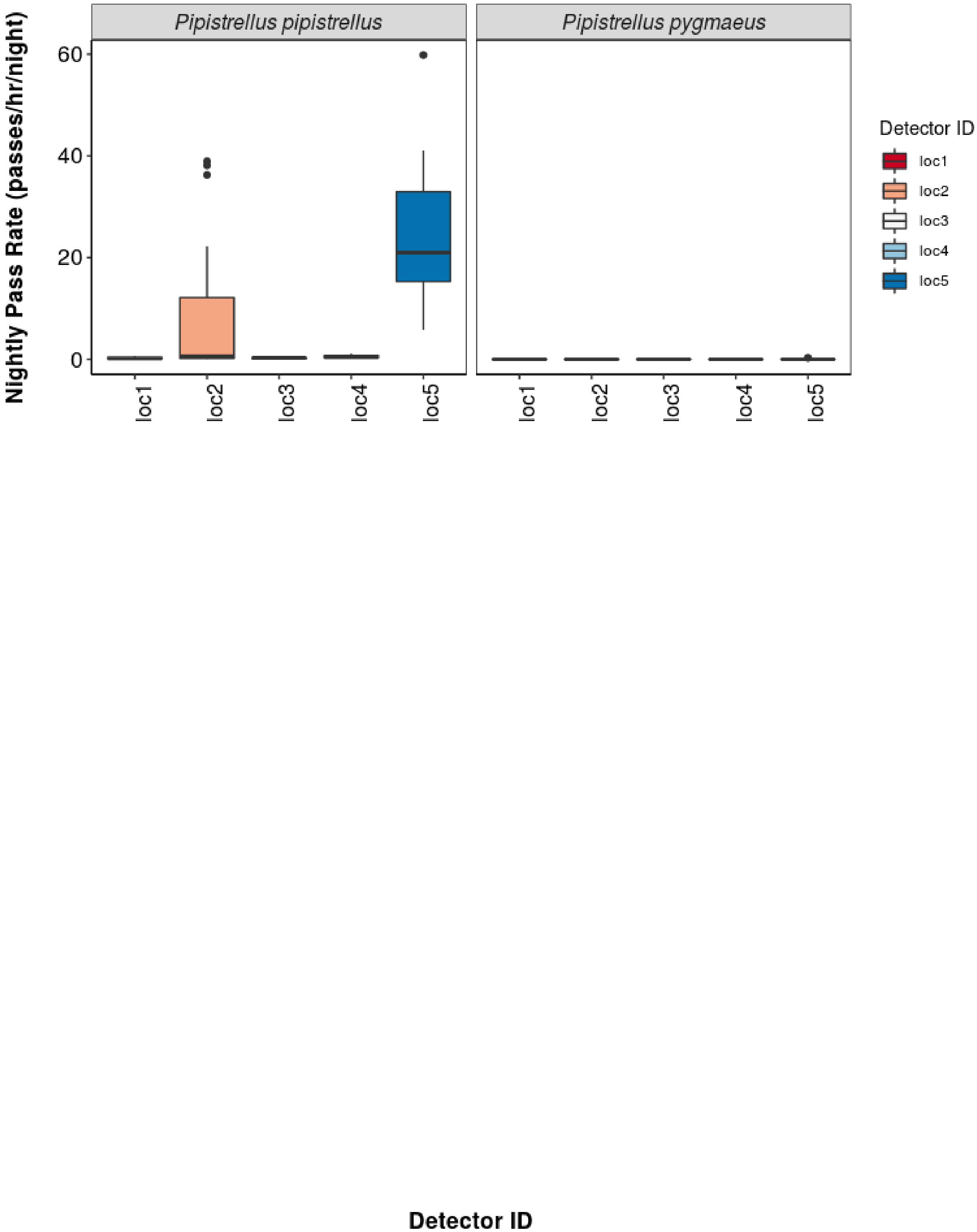
We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

Species	Detector ID	Mean Pass Rate
Common pipistrelle	loc1	0.3
Common pipistrelle	loc2	9.5
Common pipistrelle	loc3	0.3
Common pipistrelle	loc4	0.5
Common pipistrelle	loc5	25.9
Soprano pipistrelle	loc1	0.0
Soprano pipistrelle	loc2	0.0
Soprano pipistrelle	loc3	0.0
Soprano pipistrelle	loc4	0.0
Soprano pipistrelle	loc5	0.0

Nightly Bat Passes (Bat passes per hour)

Per Detector - Figures

Figure 16. Figures show boxplots for the number of bat passes per hour each night, for each detector. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.



Pipistrellus pipistrellus
Pipistrellus pygmaeus
Nightly Pass Rate (passes/hr/night)
60
40
20
0
loc1
loc2
loc3
loc4
loc5
Detector ID
loc1
loc2
loc3
loc4
loc5
Detector ID

Survey Effort

Table 24. The number of nights bats were detected per month per detector.

Month	Detector ID	No of Survey Nights
May	loc1	2
May	loc2	9
May	loc3	2
May	loc4	2
Jul	loc1	6
Jul	loc2	2
Jul	loc3	6
Jul	loc4	7
Jul	loc5	9
Sep	loc2	4
Sep	loc3	2

Nightly Bat Pass Rate for each Month

Median Per Detector

Table 25. The median Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the ‘average’ activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	Jul	May	Sep
Common pipistrelle	loc1	0.2	0.2	NA
Common pipistrelle	loc2	0.2	2.0	0.2
Common pipistrelle	loc3	0.3	0.2	0.1
Common pipistrelle	loc4	0.6	0.2	NA
Common pipistrelle	loc5	21.0	NA	NA
Soprano pipistrelle	loc1	0.0	0.0	NA
Soprano pipistrelle	loc2	0.0	0.0	0.0
Soprano pipistrelle	loc3	0.0	0.0	0.0
Soprano pipistrelle	loc4	0.0	0.0	NA
Soprano pipistrelle	loc5	0.0	NA	NA

Nightly Bat Pass Rate for each Month

Mean per Detector

Table 26. The mean Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. Values are given to 1 decimal place.

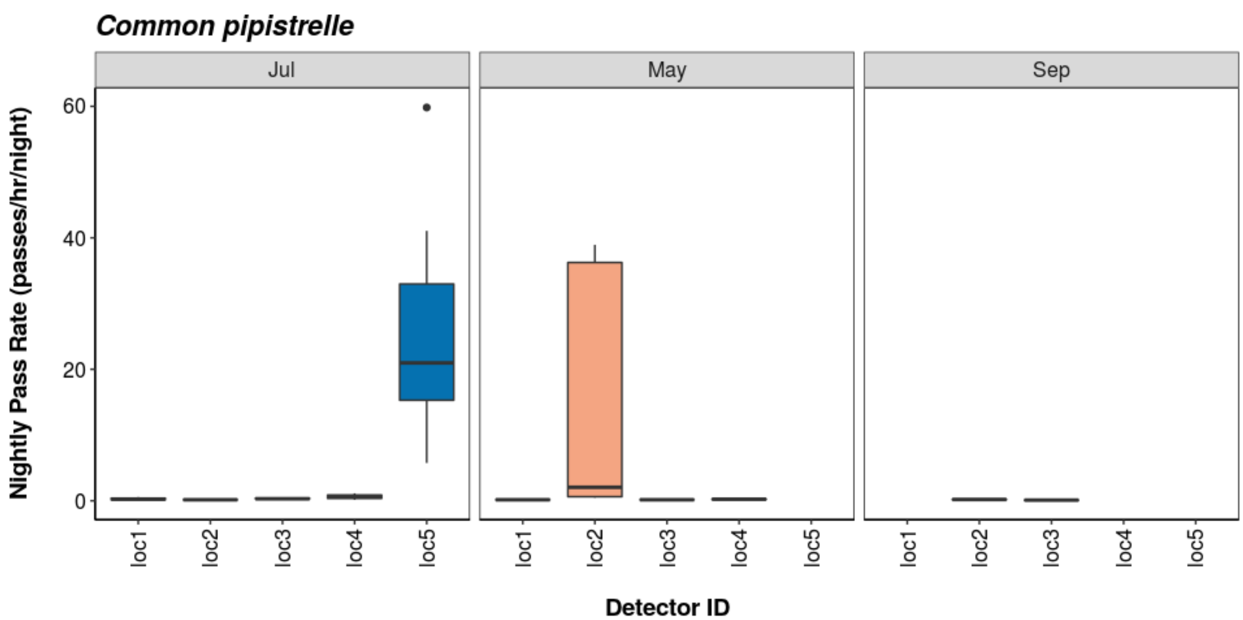
We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

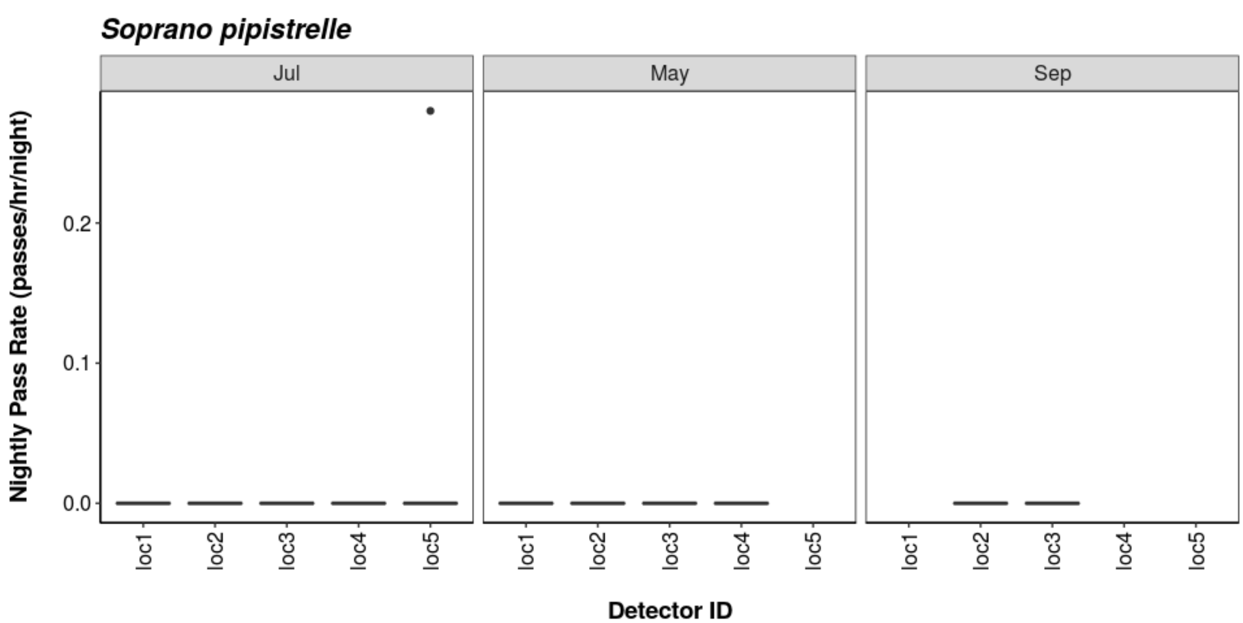
Species	Detector ID	Jul	May	Sep
Common pipistrelle	loc1	0.3	0.2	NA
Common pipistrelle	loc2	0.2	15.6	0.2
Common pipistrelle	loc3	0.3	0.2	0.1
Common pipistrelle	loc4	0.6	0.2	NA
Common pipistrelle	loc5	25.9	NA	NA
Soprano pipistrelle	loc1	0.0	0.0	NA
Soprano pipistrelle	loc2	0.0	0.0	0.0
Soprano pipistrelle	loc3	0.0	0.0	0.0
Soprano pipistrelle	loc4	0.0	0.0	NA
Soprano pipistrelle	loc5	0.0	NA	NA

Nightly Bat Pass Rate for each Month

Per Detector - Figures

Figure 17. Figures show boxplots for the number of bat passes per hour by detector, for each month. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.


Common pipistrelle
Jul
May
Sep
Nightly Pass Rate (passes/hr/night)
60
40
20
0
loc1
loc2
loc3
loc4
loc5
Detector ID


Soprano pipistrelle
Jul
May
Sep
Nightly Pass Rate (passes/hr/night)
0.2
0.1
0.0
loc1
loc2
loc3
loc4
loc5
Detector ID

Bat Activity per Detector Location

Figure 18. Detector ID reference:

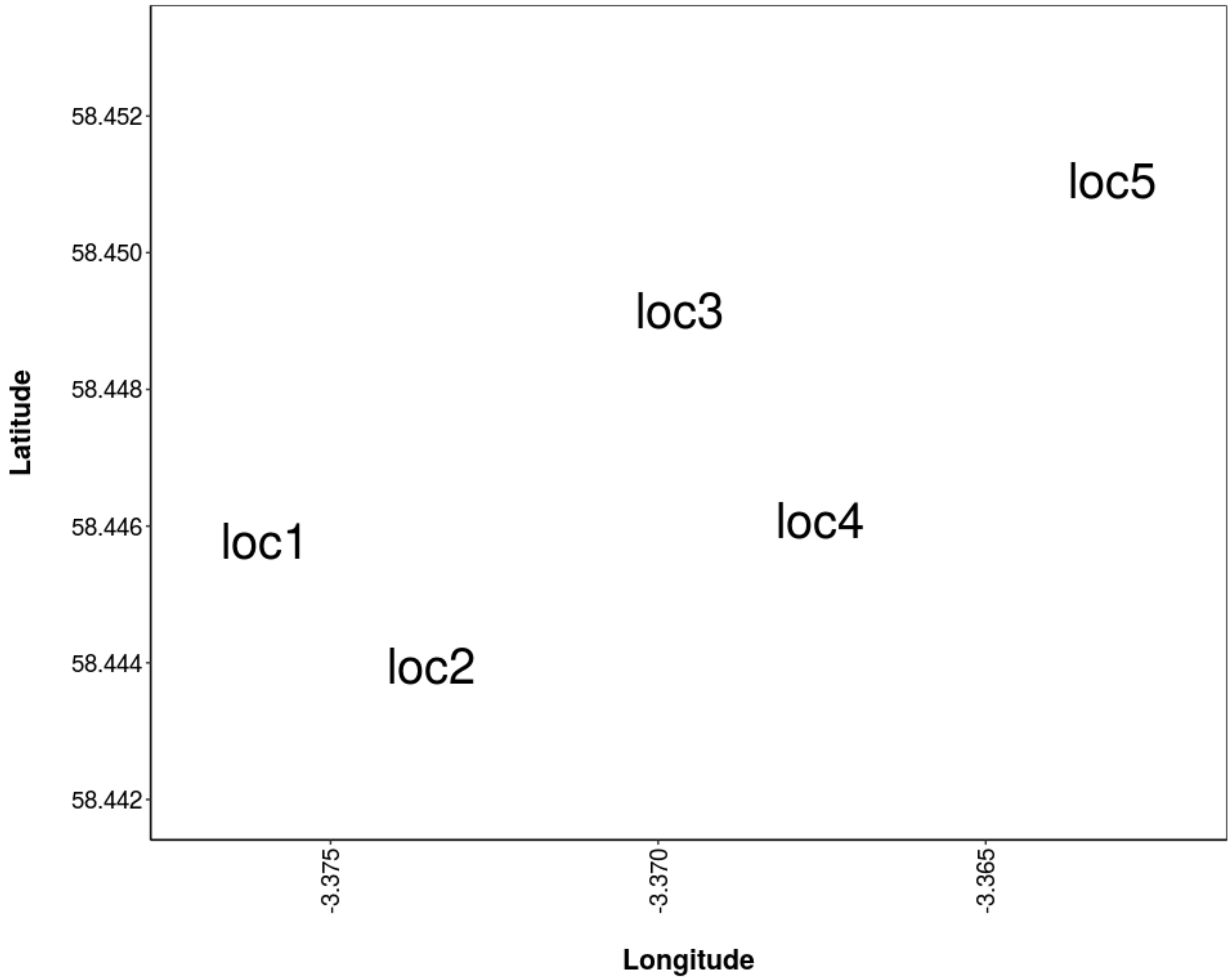


Figure 19. Median Nightly Pass Rate (bat passes/hr/night) throughout the survey period - represented by the size and colour of the point at each detector location.

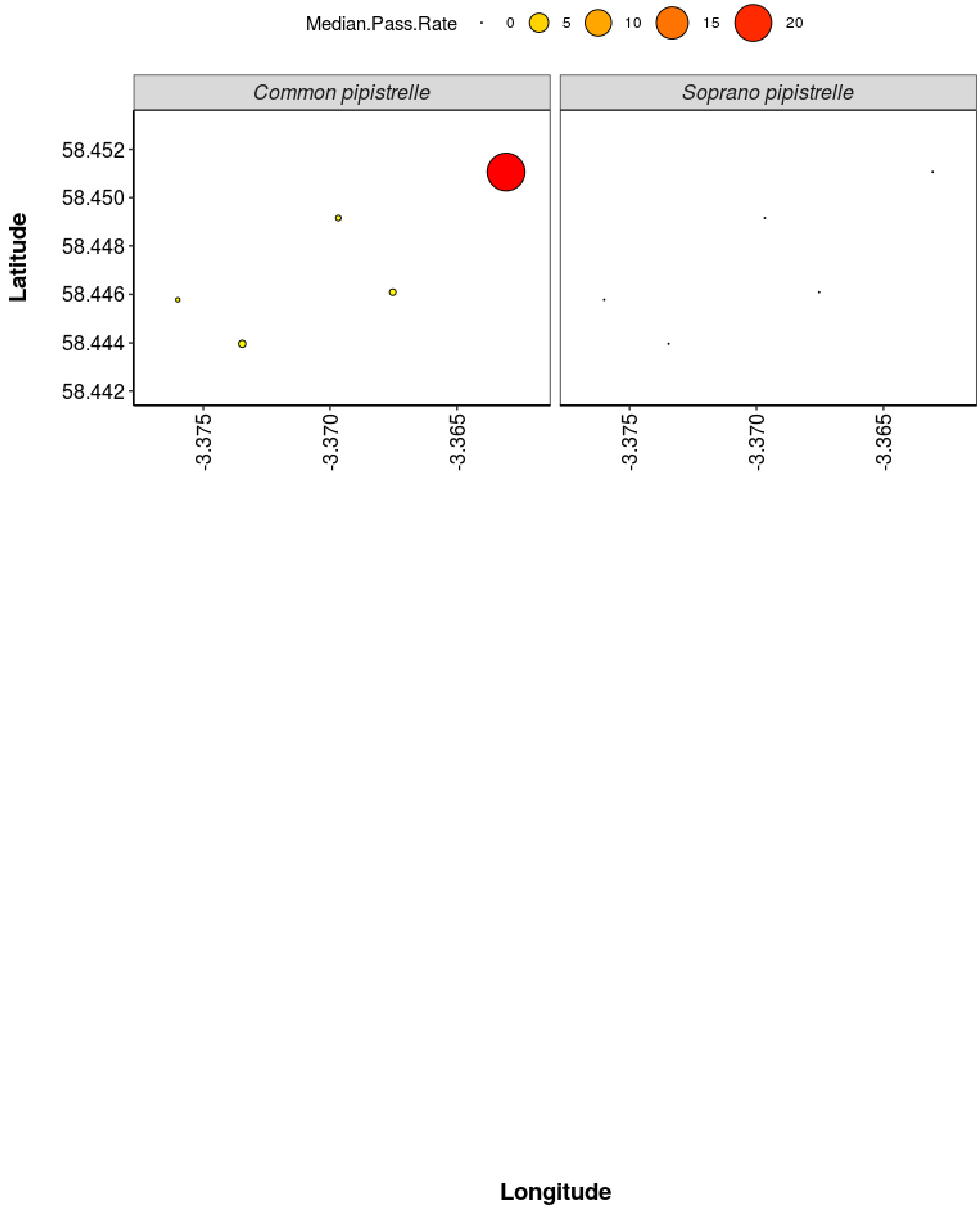
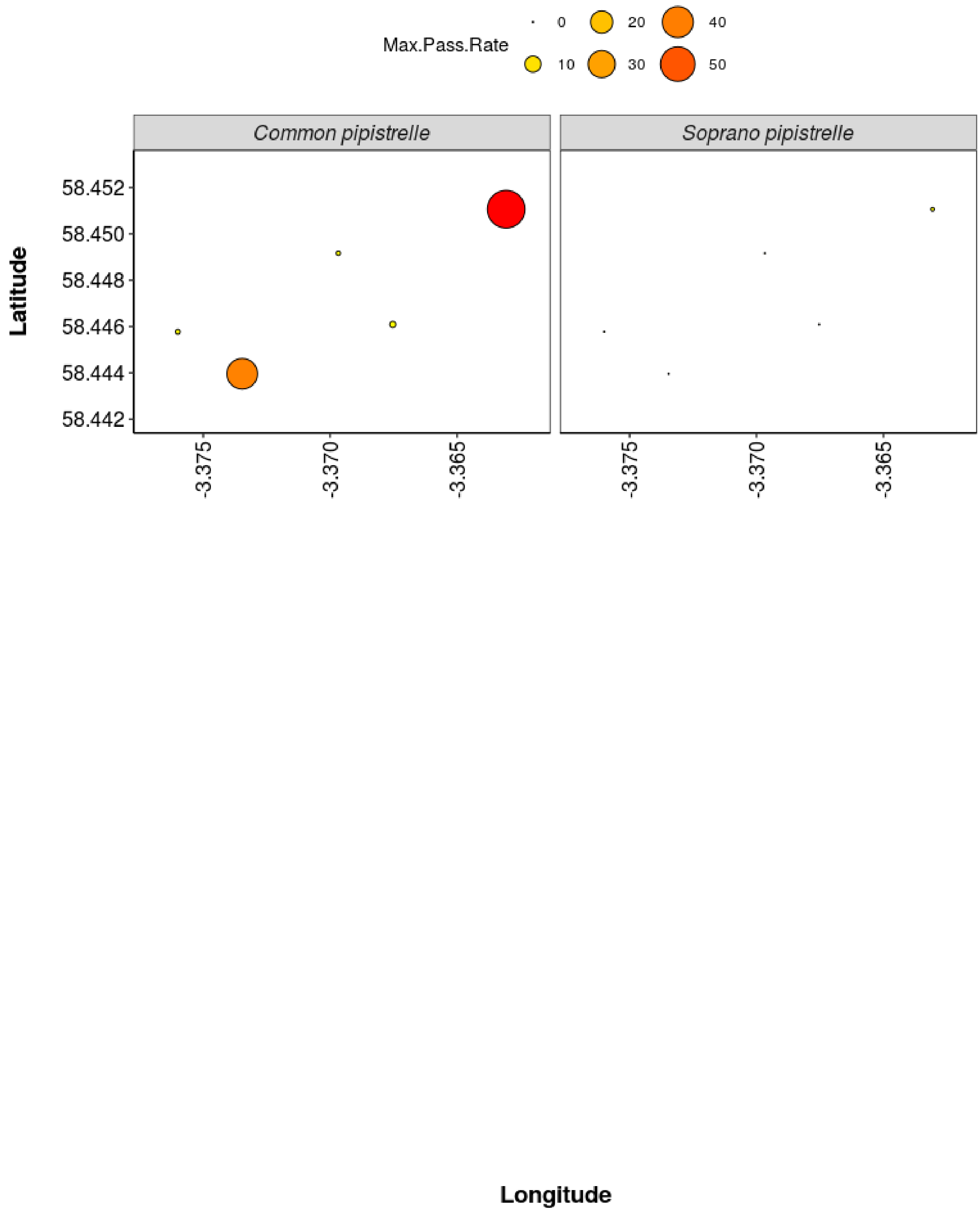


Figure 20. Maximum Nightly Pass Rate (bat passes/hr/night) recorded in a single night throughout the survey period - represented by the size and colour of the point at each detector location.



Thank you for using Ecobat! If you have any questions please email info@themammalsociety.org.uk

This report was produced free of charge by the Mammal Society to support evidence-based conservation of bats.

The following analyses are based on data supplied by the user to the Mammal Society's Ecobat website. The outputs are designed to assist decision-making, but do not replace expert interpretation by the user. The creation of the Ecobat tool was supported by the Natural Environment Research Council (NERC).

Bat Activity Analysis

Site Name: Acharole

Author: MacArthur Green

05/08/2021

Summary

Bats were detected on **65** nights between **2020-07-15** and **2020-10-07**, using **10** static bat detectors. Throughout this period **4** species were recorded. **Table 1.** Detectors were placed at the following locations:

Detector ID	Latitude	Longitude
loc7	58.45075	-3.357123
loc10	58.44946	-3.345628
loc3	58.44916	-3.369673
loc1	58.44578	-3.376001
loc5	58.45106	-3.363064
loc4	58.44609	-3.367532
loc2	58.44396	-3.373463
loc9	58.45005	-3.351408
loc6	58.44768	-3.361340
loc8	58.44709	-3.355646

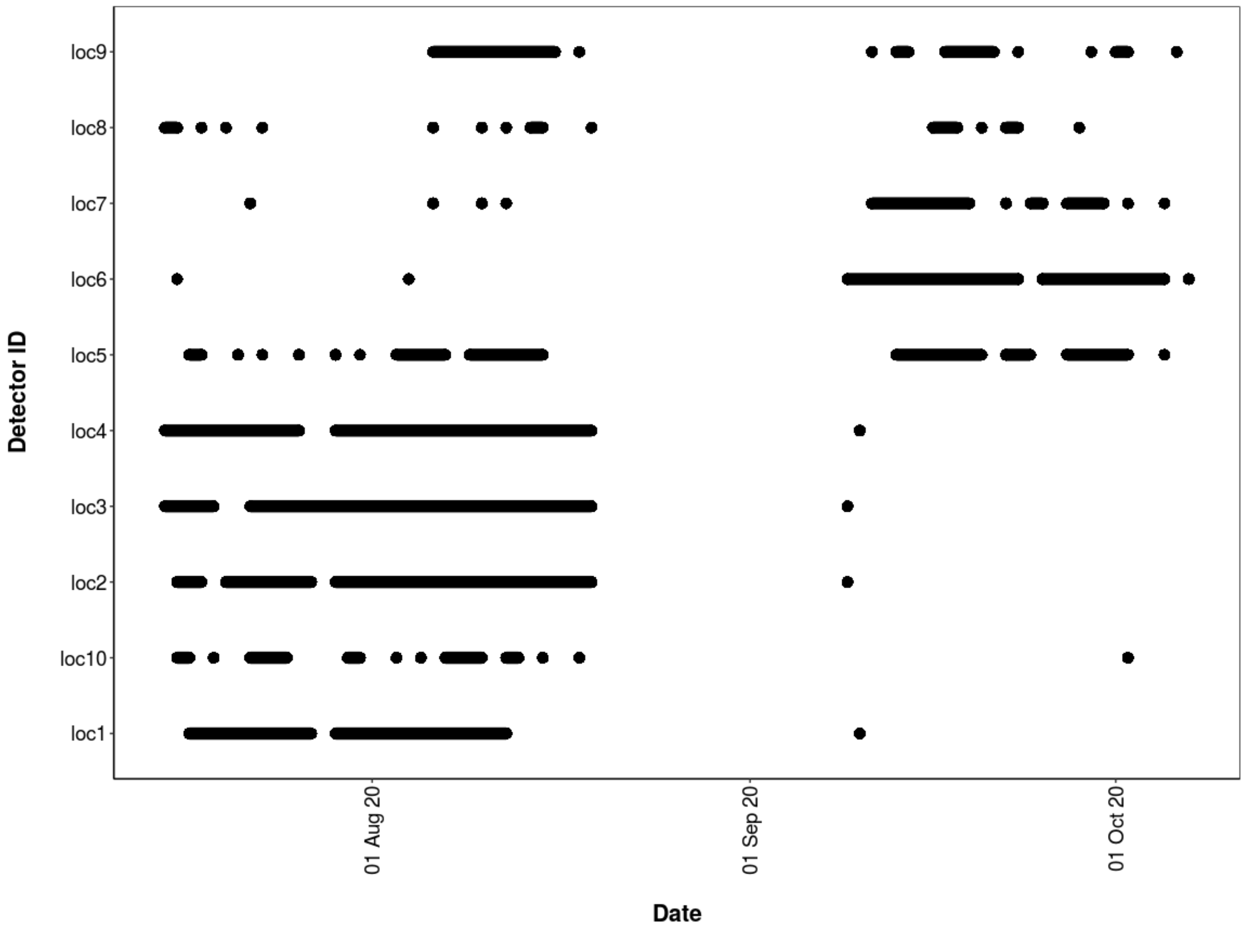
Survey Nights

Table 2. The number of nights that bats were detected on each recorder. This is not the same as the number of nights that detectors were active if there were nights when no bats were detected.

Detector ID	No. of nights
loc1	53
loc10	21
loc2	38
loc3	58
loc4	55
loc5	37
loc6	29
loc7	23
loc8	23
loc9	25

Survey Nights

Figure 1. Horizontal bars show nights when acoustic detectors recorded bats.



PART 1: Percentiles Analysis

This first part of the analysis looks at the relative activity levels of the bats you recorded. We take your value for the total bat passes each night for each species, and compare this to the values in our reference database. We tell you what percentile your data falls at, and therefore what the relative activity level is. For example, if the reference database has values of 5, 10, 15, 20 and you submit a value of 18, this will be the 80th percentile, and be classed as high activity.

The reference range dataset was stratified to include:

- Only records from within 30 days of the survey date.
- Only records from within 100km radius of the survey location.
- Records using any make of bat detector.

PER DETECTOR

Table 3. Summary table showing the number of nights recorded bat activity fell into each activity band for each species.

Detector ID	Species/Species Group	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
loc1	*Pipistrellus nathusii*	0	0	4	0	6
loc1	*Pipistrellus pipistrellus*	19	10	10	7	6
loc1	*Pipistrellus pygmaeus*	0	0	0	0	2
loc10	*Pipistrellus nathusii*	0	0	0	0	3
loc10	*Pipistrellus pipistrellus*	0	0	6	6	8
loc2	*Pipistrellus nathusii*	0	0	0	0	2
loc2	*Pipistrellus pipistrellus*	7	20	10	1	0
loc3	*Pipistrellus nathusii*	0	2	2	0	4
loc3	*Pipistrellus pipistrellus*	16	19	17	4	1
loc3	*Pipistrellus pygmaeus*	0	0	2	0	0
loc4	*Pipistrellus nathusii*	0	0	0	0	5
loc4	*Pipistrellus pipistrellus*	2	38	11	3	1
loc5	*Pipistrellus nathusii*	0	0	0	0	6
loc5	*Pipistrellus pipistrellus*	0	5	19	6	6
loc6	*Pipistrellus nathusii*	0	0	2	0	0
loc6	*Pipistrellus pipistrellus*	7	13	5	1	3

loc7	*Myotis*	0	0	0	0	2
loc7	*Pipistrellus nathusii*	0	0	0	0	2
loc7	*Pipistrellus pipistrellus*	0	3	5	3	9
loc8	*Pipistrellus pipistrellus*	0	0	1	7	15
loc9	*Pipistrellus nathusii*	0	0	0	0	1
loc9	*Pipistrellus pipistrellus*	0	0	15	3	7

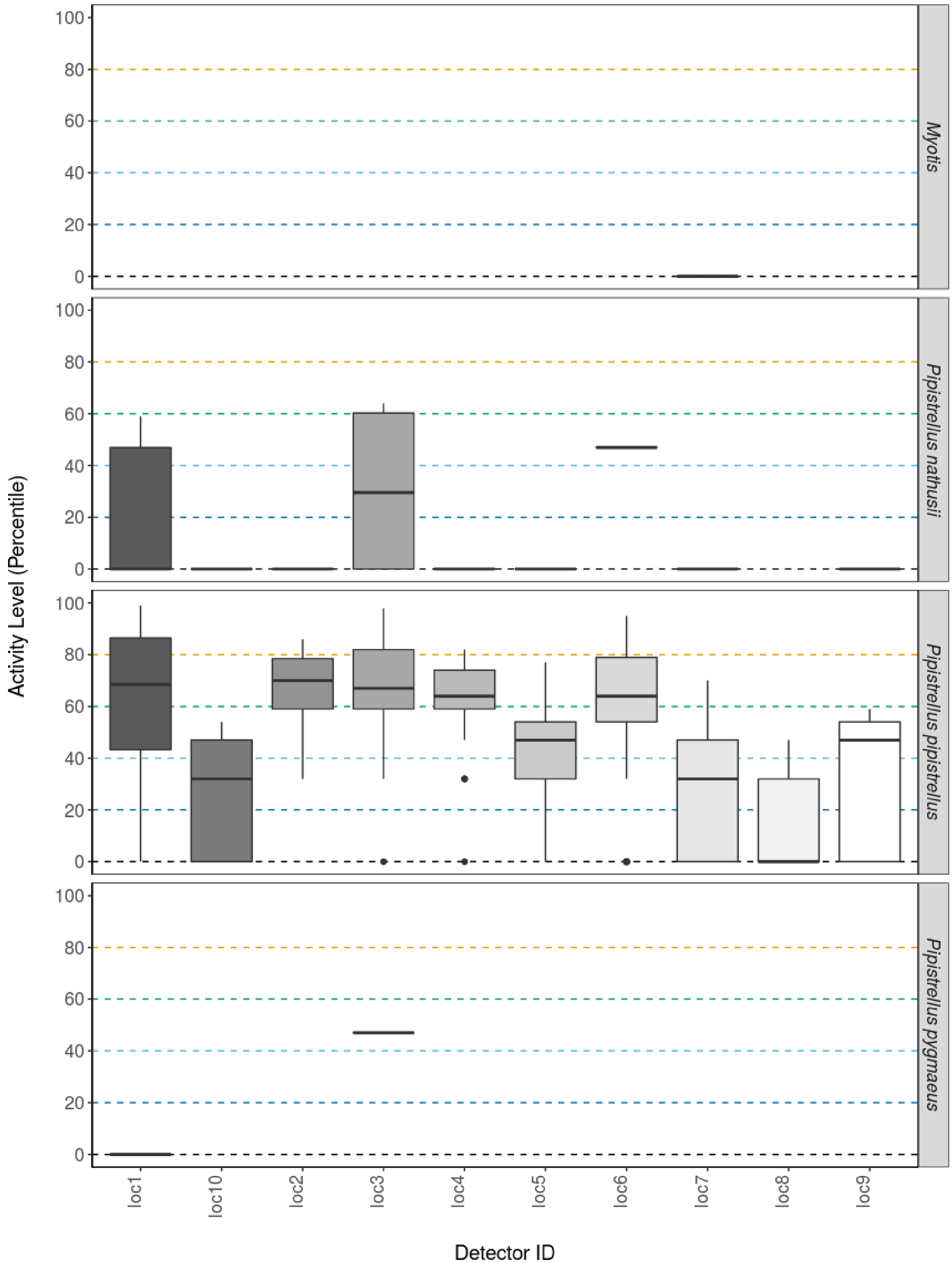
Table 4. Summary table showing key metrics for each species recorded. The reference range is the number of nights for each species that your data were compared to. We recommend a Reference Range of 200+ to be confident in the relative activity level.

Detector ID	Species/Species Group	Median Percentile	95% CIs	Max Percentile	Nights Recorded	Reference Range
loc1	*Pipistrellus nathusii*	0	47 - 54	59	10	44
loc1	*Pipistrellus pipistrellus*	69	63 - 77.5	99	52	1691
loc1	*Pipistrellus pygmaeus*	0	0 - 0	0	2	416
loc10	*Pipistrellus nathusii*	0	0 - 0	0	3	44
loc10	*Pipistrellus pipistrellus*	32	32 - 47	54	20	1691
loc2	*Pipistrellus nathusii*	0	0 - 0	0	2	44
loc2	*Pipistrellus pipistrellus*	70	64.5 - 74.5	86	38	1691
loc3	*Pipistrellus nathusii*	30	59 - 64	64	8	44
loc3	*Pipistrellus pipistrellus*	67	64.5 - 73	98	57	1691
loc3	*Pipistrellus pygmaeus*	47	47 - 47	47	2	416
loc4	*Pipistrellus nathusii*	0	0 - 0	0	5	44
loc4	*Pipistrellus pipistrellus*	64	63 - 69	82	55	1691
loc5	*Pipistrellus nathusii*	0	0 - 0	0	6	44
loc5	*Pipistrellus pipistrellus*	47	47 - 54	77	36	1691
loc6	*Pipistrellus nathusii*	47	47 - 47	47	2	44
loc6	*Pipistrellus pipistrellus*	64	64 - 77	95	29	1691
loc7	*Myotis*	0	0 - 0	0	2	298

loc7	*Pipistrellus nathusii*	0	0 - 0	0	2	44
loc7	*Pipistrellus pipistrellus*	32	39.5 - 58.5	70	20	1691
loc8	*Pipistrellus pipistrellus*	0	32 - 32	47	23	1691
loc9	*Pipistrellus nathusii*	0	0	0	1	44
loc9	*Pipistrellus pipistrellus*	47	43 - 53	59	25	1691

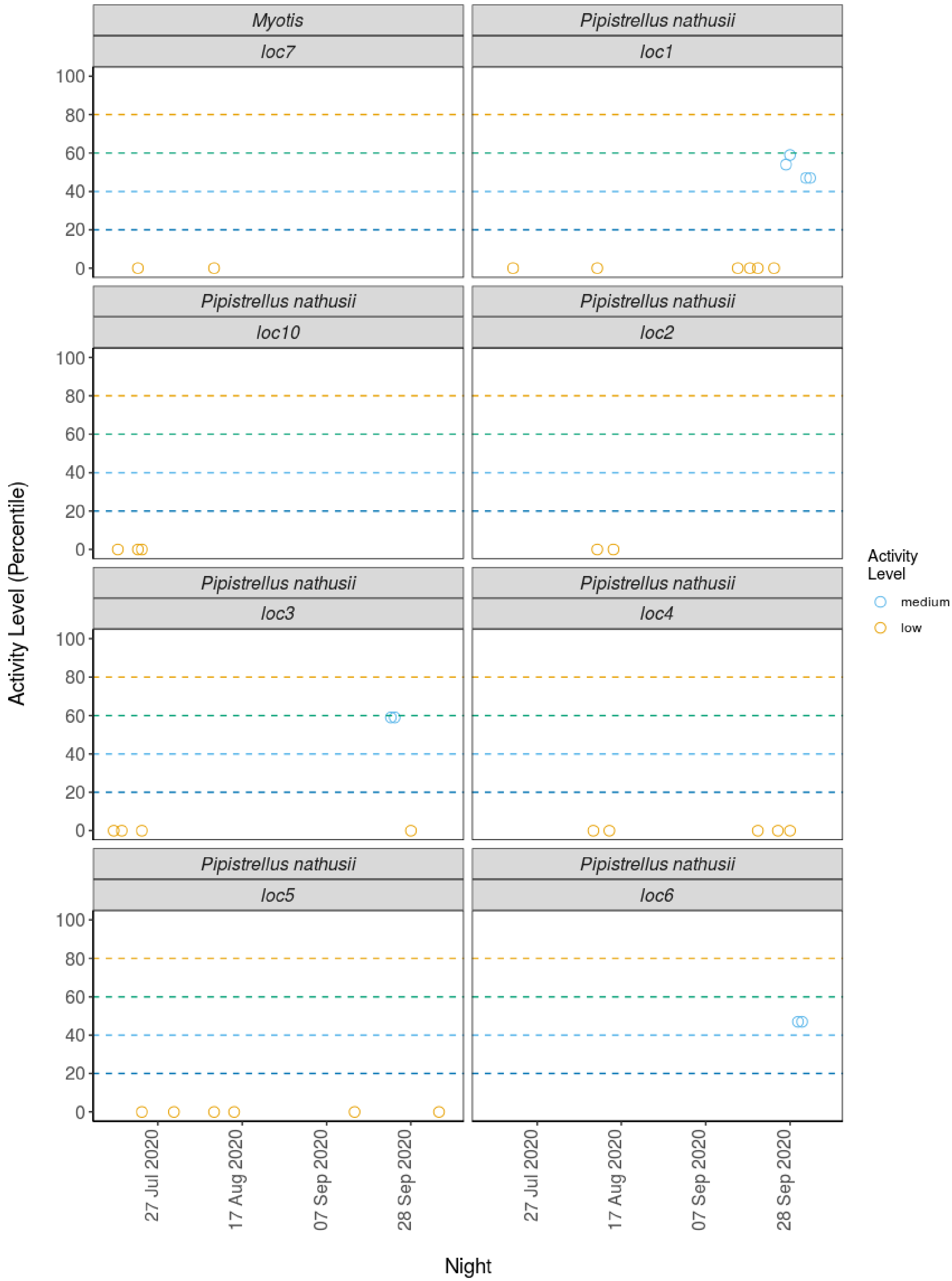
###Figures

Figure 2. The recorded activity of bats during the survey. The centre line indicates the median activity level whereas the box represents the interquartile range (the spread of the middle 50% of nights of activity)

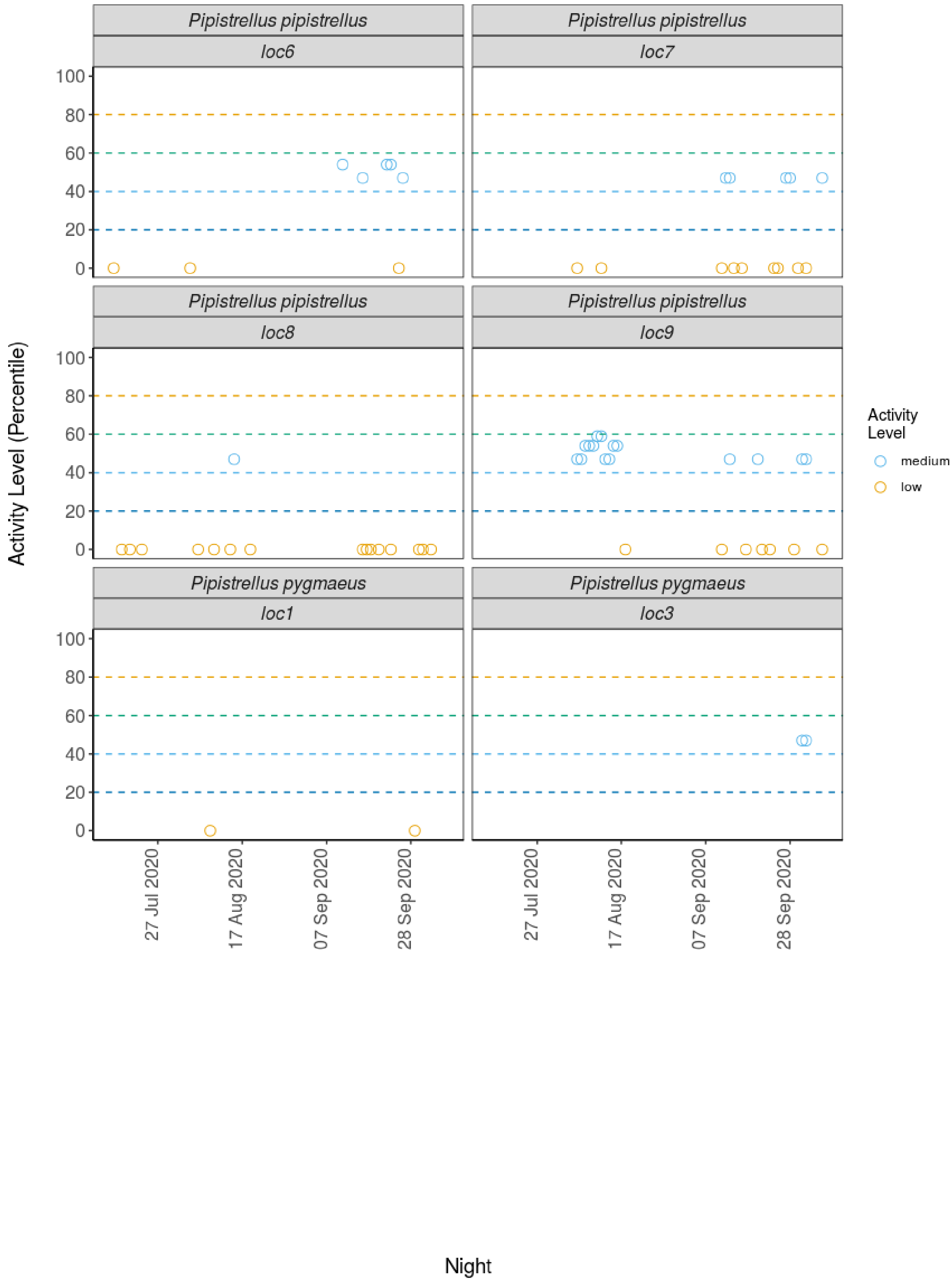


Activity Level (Percentile)
Myotis
Pipistrellus nathusii
Pipistrellus pipistrellus
Pipistrellus pygmaeus
0
20
40
60
80
100
loc1
loc10
loc2
loc3
loc4
loc5
loc6
loc7
loc8
loc9
Detector ID

Figure 3. The activity level (percentile) of bats recorded across each night of the bat survey.



Myotis
loc7
Pipistrellus nathusii
loc1
Pipistrellus nathusii
loc10
Pipistrellus nathusii
loc2
Pipistrellus nathusii
loc3
Pipistrellus nathusii
loc4
Pipistrellus nathusii
loc5
Pipistrellus nathusii
loc6
Activity Level (Percentile)
100
80
60
40
20
0
27 Jul 2020
17 Aug 2020
07 Sep 2020
28 Sep 2020
Night
Activity Level
medium
low


Pipistrellus pipistrellus
loc6
Pipistrellus pipistrellus
loc7
Pipistrellus pipistrellus
loc8
Pipistrellus pipistrellus
loc9
Pipistrellus pygmaeus
loc1
Pipistrellus pygmaeus
loc3
Activity Level (Percentile)
100
80
60
40
20
0
27 Jul 2020
17 Aug 2020
07 Sep 2020
28 Sep 2020
Activity Level
medium
low
Night

PER DETECTOR, PER MONTH

Table 5. Summary table showing the number of nights recorded bat activity fell into each activity band for each species at each detector during each month.

Detector ID	Species/Species Group	Month	Nights of High Activity	Nights of Moderate / High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
loc1	*Pipistrellus nathusii*	Jul	0	0	0	0	1
loc1	*Pipistrellus nathusii*	Aug	0	0	0	0	1
loc1	*Pipistrellus nathusii*	Sep	0	0	2	0	4
loc1	*Pipistrellus nathusii*	Oct	0	0	2	0	0
loc1	*Pipistrellus pipistrellus*	Jul	0	2	2	5	4
loc1	*Pipistrellus pipistrellus*	Aug	0	4	4	2	2
loc1	*Pipistrellus pipistrellus*	Sep	13	4	4	0	0
loc1	*Pipistrellus pipistrellus*	Oct	6	0	0	0	0
loc1	*Pipistrellus pygmaeus*	Aug	0	0	0	0	1
loc1	*Pipistrellus pygmaeus*	Sep	0	0	0	0	1
loc10	*Pipistrellus nathusii*	Jul	0	0	0	0	3
loc10	*Pipistrellus pipistrellus*	Jul	0	0	2	3	3
loc10	*Pipistrellus pipistrellus*	Aug	0	0	4	1	5
loc10	*Pipistrellus pipistrellus*	Oct	0	0	0	2	0
loc2	*Pipistrellus nathusii*	Aug	0	0	0	0	2

loc2	*Pipistrellus pipistrellus*	Jul	0	5	8	1	0
loc2	*Pipistrellus pipistrellus*	Aug	7	11	1	0	0
loc2	*Pipistrellus pipistrellus*	Sep	0	4	1	0	0
loc3	*Pipistrellus nathusii*	Jul	0	0	0	0	3
loc3	*Pipistrellus nathusii*	Sep	0	2	2	0	1
loc3	*Pipistrellus pipistrellus*	Jul	0	2	10	3	0
loc3	*Pipistrellus pipistrellus*	Aug	3	12	3	1	0
loc3	*Pipistrellus pipistrellus*	Sep	13	5	4	0	0
loc3	*Pipistrellus pipistrellus*	Oct	0	0	0	0	1
loc3	*Pipistrellus pygmaeus*	Oct	0	0	2	0	0
loc4	*Pipistrellus nathusii*	Aug	0	0	0	0	2
loc4	*Pipistrellus nathusii*	Sep	0	0	0	0	3
loc4	*Pipistrellus pipistrellus*	Jul	0	9	5	1	0
loc4	*Pipistrellus pipistrellus*	Aug	0	13	6	0	0
loc4	*Pipistrellus pipistrellus*	Sep	2	16	0	2	1
loc5	*Pipistrellus nathusii*	Jul	0	0	0	0	2
loc5	*Pipistrellus nathusii*	Aug	0	0	0	0	2
loc5	*Pipistrellus nathusii*	Sep	0	0	0	0	1
loc5	*Pipistrellus nathusii*	Oct	0	0	0	0	1
loc5	*Pipistrellus pipistrellus*	Jul	0	0	3	1	2

loc5	*Pipistrellus pipistrellus*	Aug	0	0	7	4	1
loc5	*Pipistrellus pipistrellus*	Sep	0	5	7	1	2
loc5	*Pipistrellus pipistrellus*	Oct	0	0	2	0	1
loc6	*Pipistrellus nathusii*	Sep	0	0	1	0	0
loc6	*Pipistrellus nathusii*	Oct	0	0	1	0	0
loc6	*Pipistrellus pipistrellus*	Jul	0	0	0	0	1
loc6	*Pipistrellus pipistrellus*	Aug	0	0	0	0	1
loc6	*Pipistrellus pipistrellus*	Sep	4	11	5	0	1
loc6	*Pipistrellus pipistrellus*	Oct	3	2	0	1	0
loc7	*Myotis*	Jul	0	0	0	0	1
loc7	*Myotis*	Aug	0	0	0	0	1
loc7	*Pipistrellus nathusii*	Sep	0	0	0	0	1
loc7	*Pipistrellus nathusii*	Oct	0	0	0	0	1
loc7	*Pipistrellus pipistrellus*	Aug	0	0	0	0	2
loc7	*Pipistrellus pipistrellus*	Sep	0	3	4	3	6
loc7	*Pipistrellus pipistrellus*	Oct	0	0	1	0	1
loc8	*Pipistrellus pipistrellus*	Jul	0	0	0	2	3
loc8	*Pipistrellus pipistrellus*	Aug	0	0	1	1	4
loc8	*Pipistrellus pipistrellus*	Sep	0	0	0	3	6
loc8	*Pipistrellus pipistrellus*	Oct	0	0	0	1	2
loc9	*Pipistrellus nathusii*	Sep	0	0	0	0	1

loc9	*Pipistrellus pipistrellus*	Aug	0	0	11	0	1
loc9	*Pipistrellus pipistrellus*	Sep	0	0	2	3	5
loc9	*Pipistrellus pipistrellus*	Oct	0	0	2	0	1

Table 6. Summary table showing key metrics for each species recorded per month. Please note that we cannot split the reference range by month, hence this column is not shown in this table.

Detector ID	Species/Species Group	Month	Median Percentile	95% CIs	Max Percentile	Nights Recorded
loc1	*Pipistrellus nathusii*	Jul	0	47 - 54	0	1
loc1	*Pipistrellus nathusii*	Aug	0	47 - 54	0	1
loc1	*Pipistrellus nathusii*	Sep	0	47 - 54	59	6
loc1	*Pipistrellus nathusii*	Oct	47	47 - 54	47	2
loc1	*Pipistrellus pipistrellus*	Jul	32	63 - 77.5	64	13
loc1	*Pipistrellus pipistrellus*	Aug	54	63 - 77.5	77	12
loc1	*Pipistrellus pipistrellus*	Sep	81	63 - 77.5	99	21
loc1	*Pipistrellus pipistrellus*	Oct	93	63 - 77.5	99	6
loc1	*Pipistrellus pygmaeus*	Aug	0	0 - 0	0	1
loc1	*Pipistrellus pygmaeus*	Sep	0	0 - 0	0	1
loc10	*Pipistrellus nathusii*	Jul	0	0 - 0	0	3
loc10	*Pipistrellus pipistrellus*	Jul	32	32 - 47	47	8
loc10	*Pipistrellus pipistrellus*	Aug	16	32 - 47	54	10
loc10	*Pipistrellus pipistrellus*	Oct	32	32 - 47	32	2
loc2	*Pipistrellus nathusii*	Aug	0	0 - 0	0	2
loc2	*Pipistrellus pipistrellus*	Jul	53	64.5 - 74.5	74	14
loc2	*Pipistrellus pipistrellus*	Aug	79	64.5 - 74.5	86	19

loc2	*Pipistrellus pipistrellus*	Sep	70	64.5 - 74.5	75	5
loc3	*Pipistrellus nathusii*	Jul	0	59 - 64	0	3
loc3	*Pipistrellus nathusii*	Sep	59	59 - 64	64	5
loc3	*Pipistrellus pipistrellus*	Jul	54	64.5 - 73	64	15
loc3	*Pipistrellus pipistrellus*	Aug	75	64.5 - 73	86	19
loc3	*Pipistrellus pipistrellus*	Sep	84	64.5 - 73	98	22
loc3	*Pipistrellus pipistrellus*	Oct	0	64.5 - 73	0	1
loc3	*Pipistrellus pygmaeus*	Oct	47	47 - 47	47	2
loc4	*Pipistrellus nathusii*	Aug	0	0 - 0	0	2
loc4	*Pipistrellus nathusii*	Sep	0	0 - 0	0	3
loc4	*Pipistrellus pipistrellus*	Jul	64	63 - 69	74	15
loc4	*Pipistrellus pipistrellus*	Aug	67	63 - 69	77	19
loc4	*Pipistrellus pipistrellus*	Sep	64	63 - 69	82	21
loc5	*Pipistrellus nathusii*	Jul	0	0 - 0	0	2
loc5	*Pipistrellus nathusii*	Aug	0	0 - 0	0	2
loc5	*Pipistrellus nathusii*	Sep	0	0 - 0	0	1
loc5	*Pipistrellus nathusii*	Oct	0	0 - 0	0	1
loc5	*Pipistrellus pipistrellus*	Jul	40	47 - 54	47	6
loc5	*Pipistrellus pipistrellus*	Aug	47	47 - 54	54	12
loc5	*Pipistrellus pipistrellus*	Sep	54	47 - 54	77	15

loc5	*Pipistrellus pipistrellus*	Oct	47	47 - 54	47	3
loc6	*Pipistrellus nathusii*	Sep	47	47 - 47	47	1
loc6	*Pipistrellus nathusii*	Oct	47	47 - 47	47	1
loc6	*Pipistrellus pipistrellus*	Jul	0	64 - 77	0	1
loc6	*Pipistrellus pipistrellus*	Aug	0	64 - 77	0	1
loc6	*Pipistrellus pipistrellus*	Sep	70	64 - 77	95	21
loc6	*Pipistrellus pipistrellus*	Oct	76	64 - 77	89	6
loc7	*Myotis*	Jul	0	0 - 0	0	1
loc7	*Myotis*	Aug	0	0 - 0	0	1
loc7	*Pipistrellus nathusii*	Sep	0	0 - 0	0	1
loc7	*Pipistrellus nathusii*	Oct	0	0 - 0	0	1
loc7	*Pipistrellus pipistrellus*	Aug	0	39.5 - 58.5	0	2
loc7	*Pipistrellus pipistrellus*	Sep	32	39.5 - 58.5	70	16
loc7	*Pipistrellus pipistrellus*	Oct	24	39.5 - 58.5	47	2
loc8	*Pipistrellus pipistrellus*	Jul	0	32 - 32	32	5
loc8	*Pipistrellus pipistrellus*	Aug	0	32 - 32	47	6
loc8	*Pipistrellus pipistrellus*	Sep	0	32 - 32	32	9
loc8	*Pipistrellus pipistrellus*	Oct	0	32 - 32	32	3
loc9	*Pipistrellus nathusii*	Sep	0	0	0	1
loc9	*Pipistrellus pipistrellus*	Aug	54	43 - 53	59	12
loc9	*Pipistrellus pipistrellus*	Sep	16	43 - 53	47	10

loc9	*Pipistrellus pipistrellus*	Oct	47	43 - 53	47	3

PER SITE

In this 'Per Site' section of the analysis, all values are taken from across all of the detectors to provide site-wide averages/medians.

Table 7. Summary table showing the number of nights recorded bat activity fell into each activity band for each species.

Species/Species Group	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
Myotis	0	0	0	0	2
Pipistrellus nathusii	0	2	8	0	29
Pipistrellus pipistrellus	51	108	99	41	56
Pipistrellus pygmaeus	0	0	2	0	2

Table 8. Summary table showing key metrics for each species recorded.

Species/Species Group	Median Percentile	95% CIs	Max Percentile	Nights Recorded
Myotis	0	0 - 0	0	2
Pipistrellus nathusii	0	59 - 64	64	39
Pipistrellus pipistrellus	59	64.5 - 74.5	99	355
Pipistrellus pygmaeus	24	47 - 47	47	4

###Figures

Figure 4. The activity level (percentile) of bats recorded across each night of the bat survey for the **entire site**.

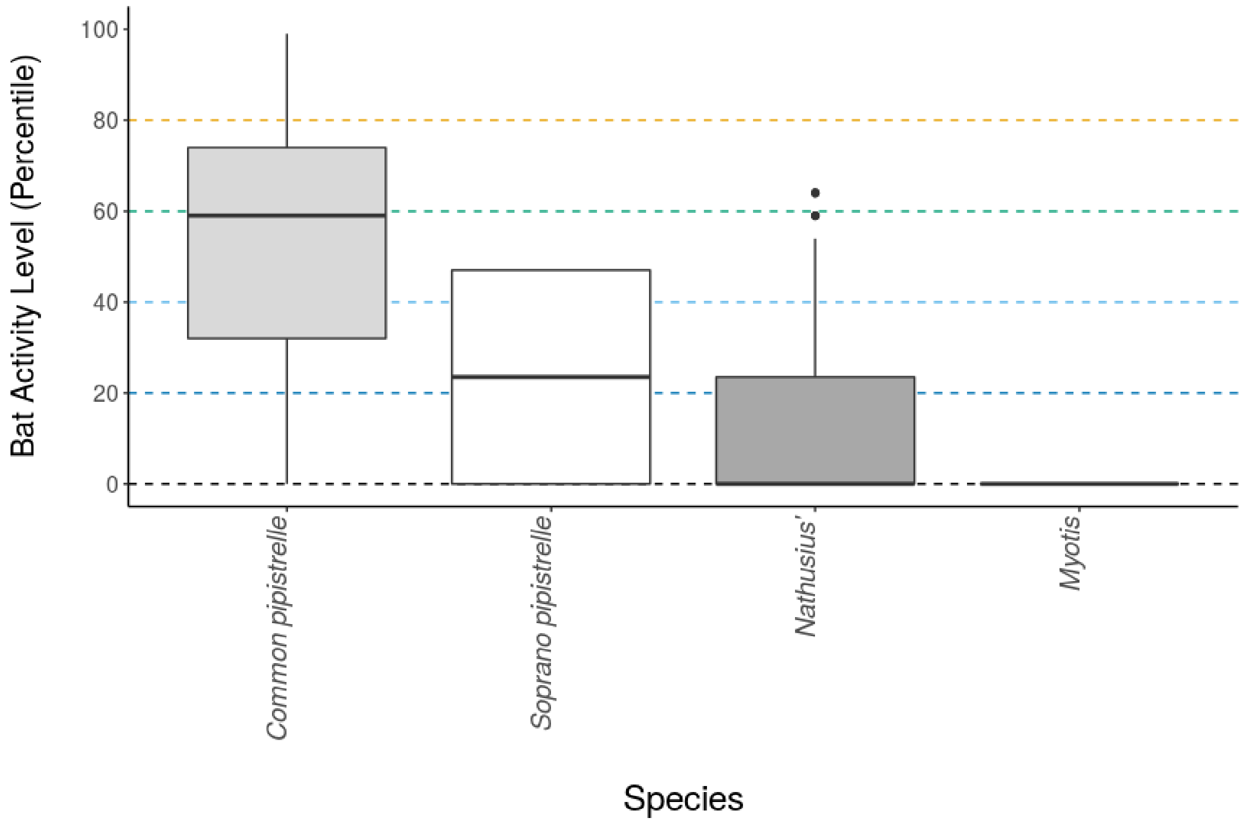
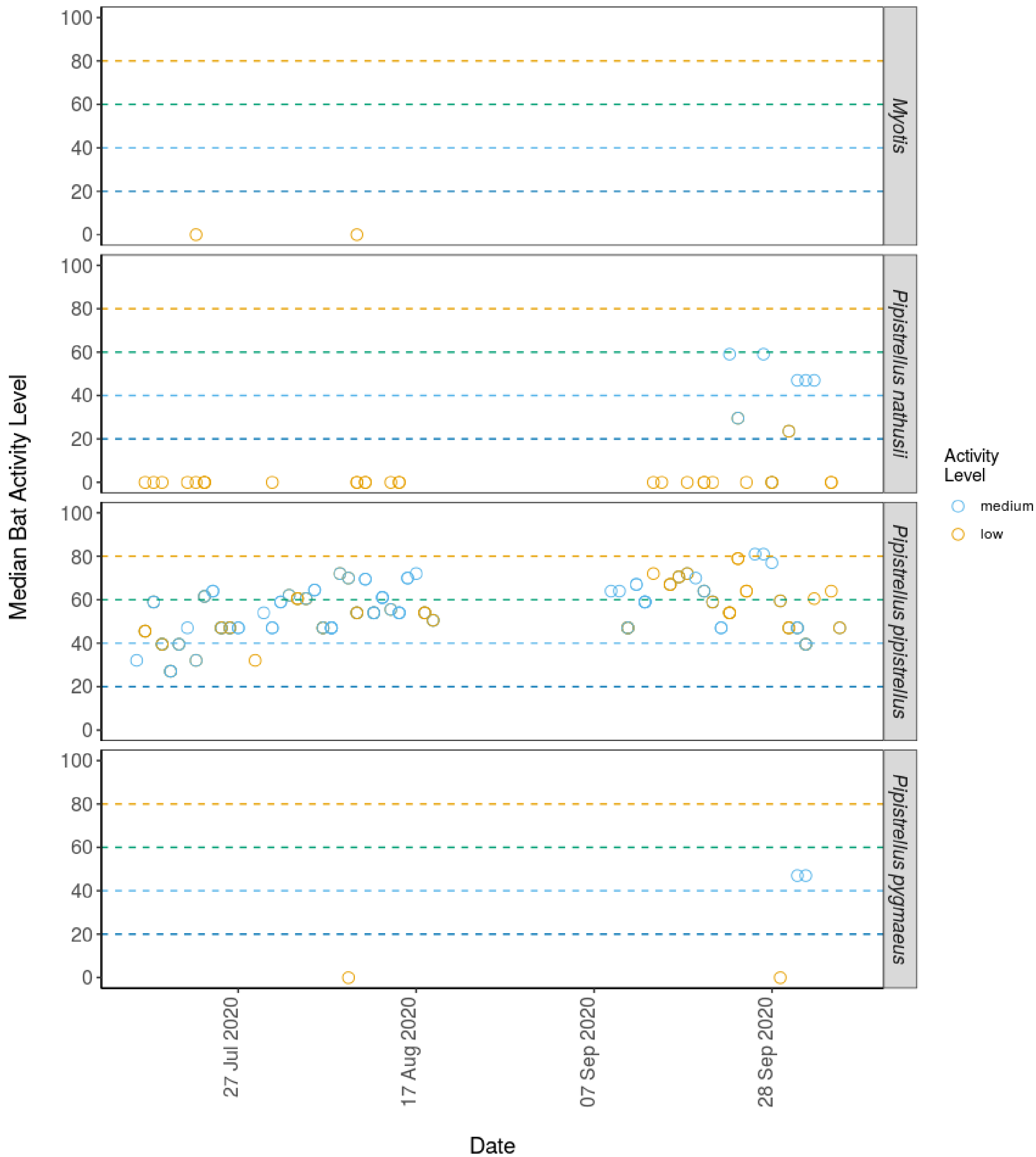


Figure 5. The median activity levels of bats recorded across all detectors each night.



PER SITE, PER MONTH

Table 9. Summary table showing the number of nights recorded bat activity fell into each activity band for each species during each month.

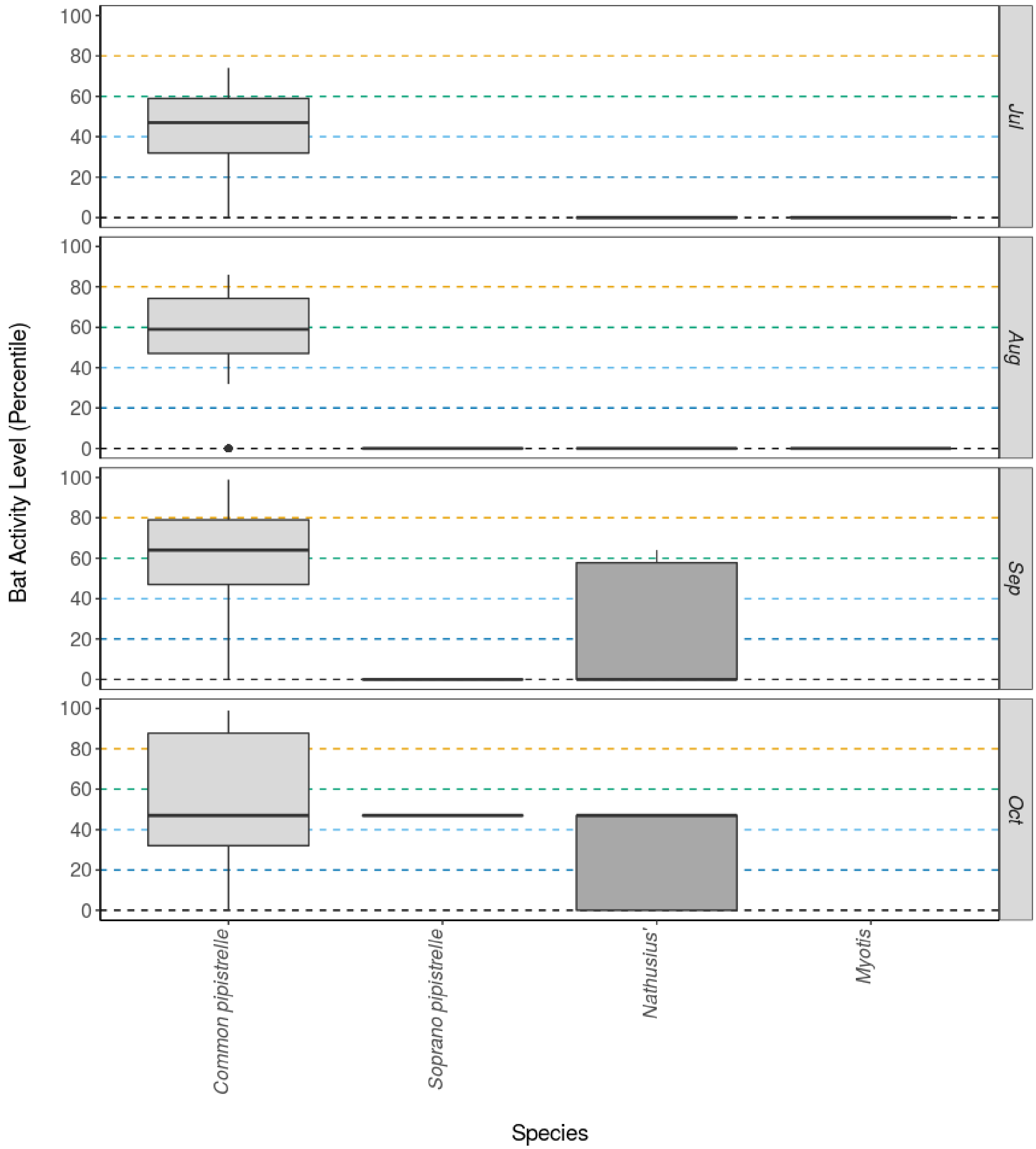
Species/Species Group	Month	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
Myotis	Jul	0	0	0	0	1
Myotis	Aug	0	0	0	0	1
Pipistrellus nathusii	Jul	0	0	0	0	9
Pipistrellus nathusii	Aug	0	0	0	0	7
Pipistrellus nathusii	Sep	0	2	5	0	11
Pipistrellus nathusii	Oct	0	0	3	0	2
Pipistrellus pipistrellus	Jul	0	18	30	16	13
Pipistrellus pipistrellus	Aug	10	40	37	9	16
Pipistrellus pipistrellus	Sep	32	48	27	12	21
Pipistrellus pipistrellus	Oct	9	2	5	4	6
Pipistrellus pygmaeus	Aug	0	0	0	0	1
Pipistrellus pygmaeus	Sep	0	0	0	0	1
Pipistrellus pygmaeus	Oct	0	0	2	0	0

Table 10. Summary table showing key metrics for each species recorded per month.

Species/Species Group	Month	Median Percentile	95% CIs	Max Percentile	Nights Recorded
Myotis	Jul	0	0 - 0	0	1
Myotis	Aug	0	0 - 0	0	1
Pipistrellus nathusii	Jul	0	59 - 64	0	9
Pipistrellus nathusii	Aug	0	47 - 54	0	7
Pipistrellus nathusii	Sep	0	59 - 64	64	18
Pipistrellus nathusii	Oct	47	47 - 54	47	5
Pipistrellus pipistrellus	Jul	47	64.5 - 74.5	74	77
Pipistrellus pipistrellus	Aug	59	64.5 - 74.5	86	112
Pipistrellus pipistrellus	Sep	64	64.5 - 74.5	99	140
Pipistrellus pipistrellus	Oct	47	64.5 - 73	99	26
Pipistrellus pygmaeus	Aug	0	0 - 0	0	1
Pipistrellus pygmaeus	Sep	0	0 - 0	0	1
Pipistrellus pygmaeus	Oct	47	47 - 47	47	2

###Figures

Figure 6. The activity level (percentile) of bats recorded across each night of the bat survey for the entire site, split between months.



PART 2: Nightly Analysis

ENTIRE SURVEY PERIOD

Sunrise and Sunset Times

Table 11. The times of sunset and sunrise the following morning for surveys beginning on the date shown.

Night (y-m-d)	Sunset (hh:mm)	Sunrise (hh:mm)	Night Length (hours)
2020-07-15	22:08	04:34	6.4
2020-07-16	22:07	04:35	6.5
2020-07-17	22:05	04:37	6.5
2020-07-18	22:03	04:39	6.6
2020-07-19	22:02	04:41	6.7
2020-07-20	22:00	04:43	6.7
2020-07-21	21:58	04:45	6.8
2020-07-22	21:56	04:47	6.8
2020-07-23	21:54	04:49	6.9
2020-07-24	21:52	04:51	7.0
2020-07-25	21:50	04:53	7.0
2020-07-26	21:48	04:55	7.1
2020-07-27	21:46	04:57	7.2
2020-07-28	21:44	04:59	7.2
2020-07-29	21:42	05:01	7.3
2020-07-30	21:40	05:03	7.4
2020-07-31	21:38	05:06	7.5
2020-08-01	21:36	05:08	7.5
2020-08-02	21:33	05:10	7.6
2020-08-03	21:31	05:12	7.7
2020-08-04	21:29	05:14	7.8
2020-08-05	21:26	05:16	7.8
2020-08-06	21:24	05:19	7.9
2020-08-07	21:21	05:21	8.0
2020-08-08	21:19	05:23	8.1
2020-08-09	21:17	05:25	8.1
2020-08-10	21:14	05:27	8.2

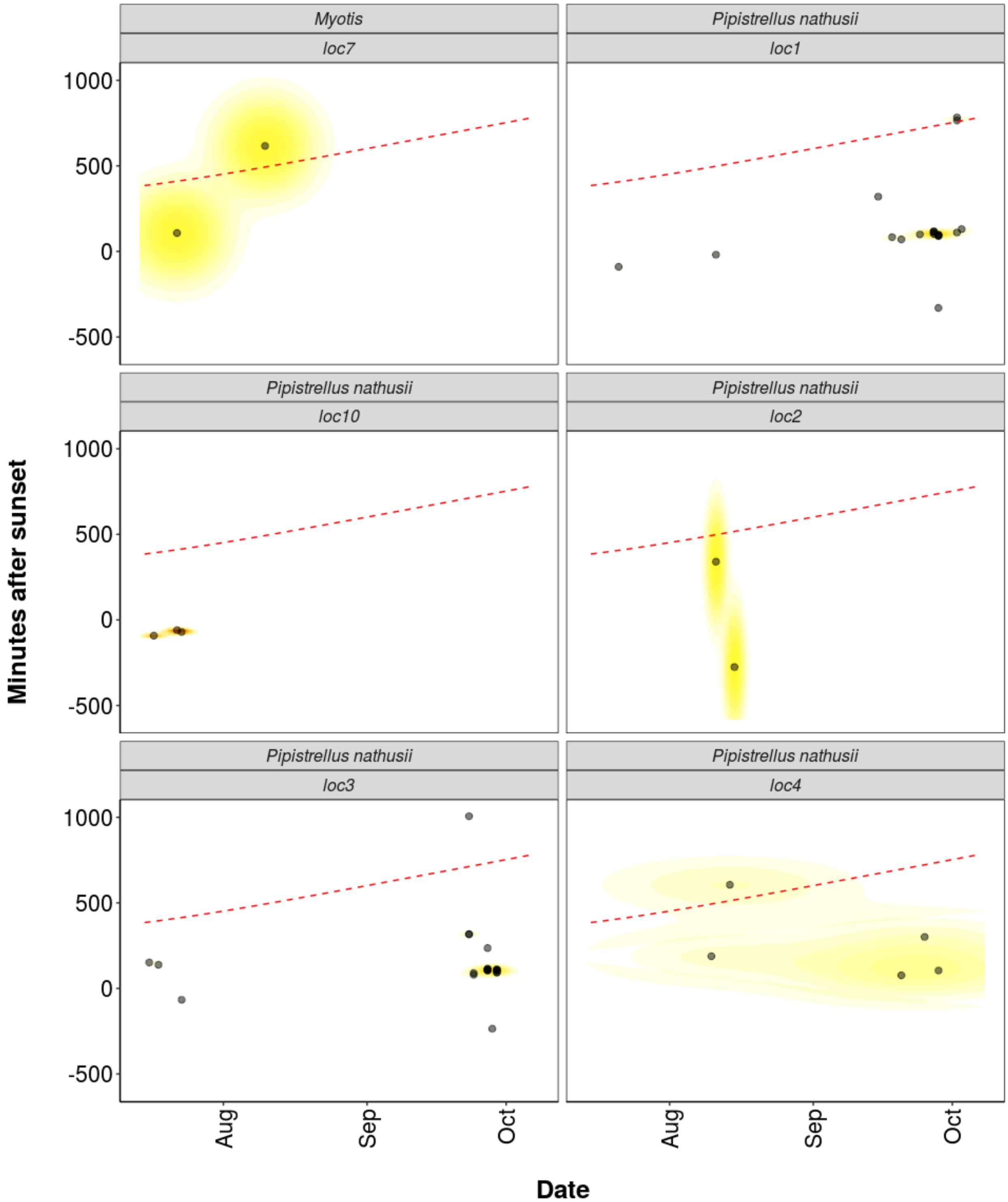
2020-08-11	21:12	05:30	8.3
2020-08-12	21:09	05:32	8.4
2020-08-13	21:06	05:34	8.5
2020-08-14	21:04	05:36	8.5
2020-08-15	21:01	05:39	8.6
2020-08-16	20:59	05:41	8.7
2020-08-17	20:56	05:43	8.8
2020-08-18	20:53	05:45	8.9
2020-08-19	20:51	05:47	8.9
2020-09-09	19:52	06:34	10.7
2020-09-10	19:49	06:36	10.8
2020-09-11	19:46	06:38	10.9
2020-09-12	19:43	06:40	10.9
2020-09-13	19:40	06:42	11.0
2020-09-14	19:38	06:44	11.1
2020-09-15	19:35	06:47	11.2
2020-09-16	19:32	06:49	11.3
2020-09-17	19:29	06:51	11.4
2020-09-18	19:26	06:53	11.5
2020-09-19	19:23	06:55	11.5
2020-09-20	19:20	06:57	11.6
2020-09-21	19:17	07:00	11.7
2020-09-22	19:14	07:02	11.8
2020-09-23	19:11	07:04	11.9
2020-09-24	19:09	07:06	12.0
2020-09-25	19:06	07:08	12.0
2020-09-26	19:03	07:10	12.1
2020-09-27	19:00	07:13	12.2
2020-09-28	18:57	07:15	12.3
2020-09-29	18:54	07:17	12.4
2020-09-30	18:51	07:19	12.5
2020-10-01	18:48	07:21	12.6
2020-10-02	18:45	07:24	12.6
2020-10-03	18:43	07:26	12.7
2020-10-04	18:40	07:28	12.8
2020-10-05	18:37	07:30	12.9

2020-10-06	18:34	07:33	13.0
2020-10-07	18:31	07:35	13.1

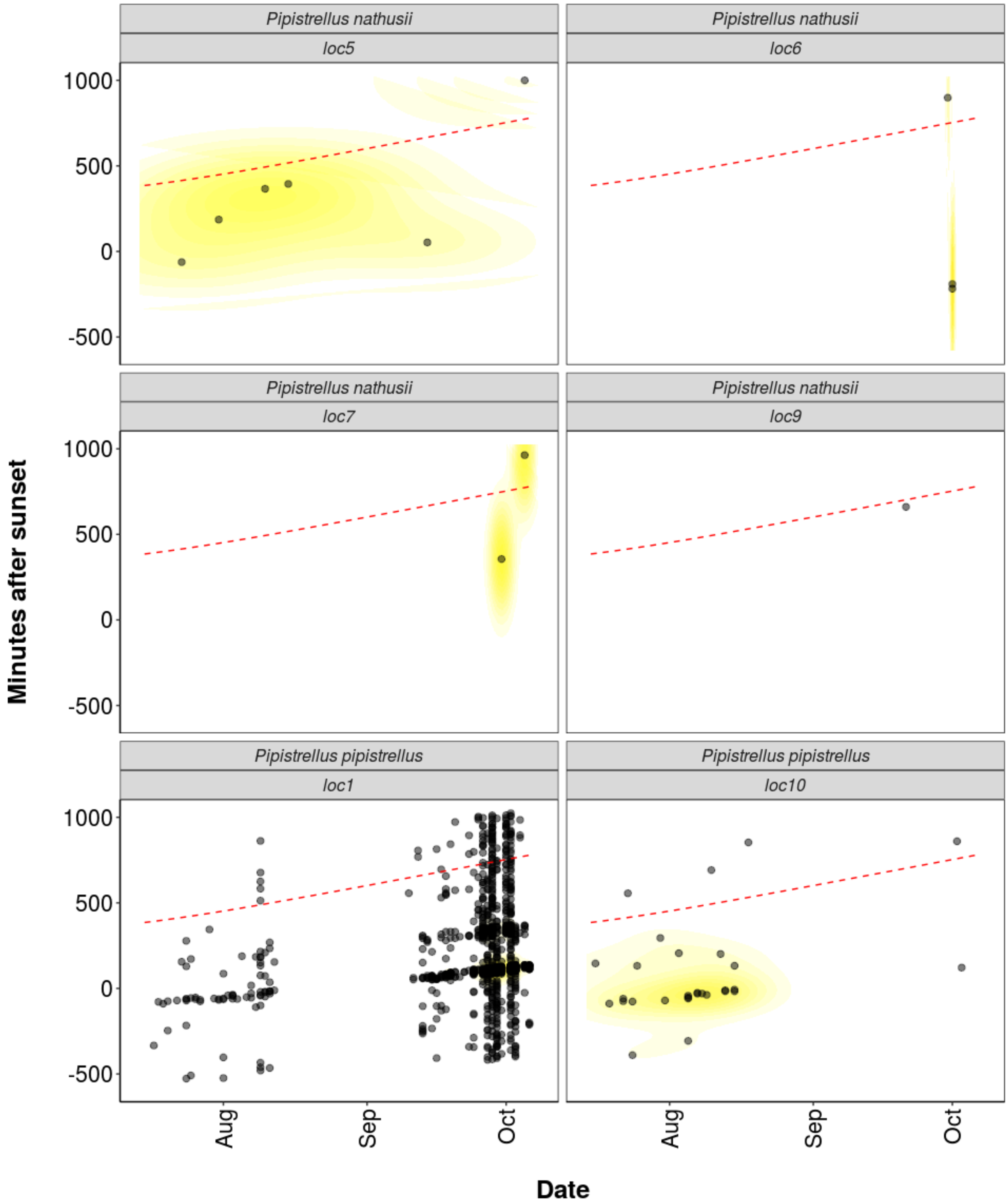
Distribution of Bat Activity Across the Night through Time

Per Detector

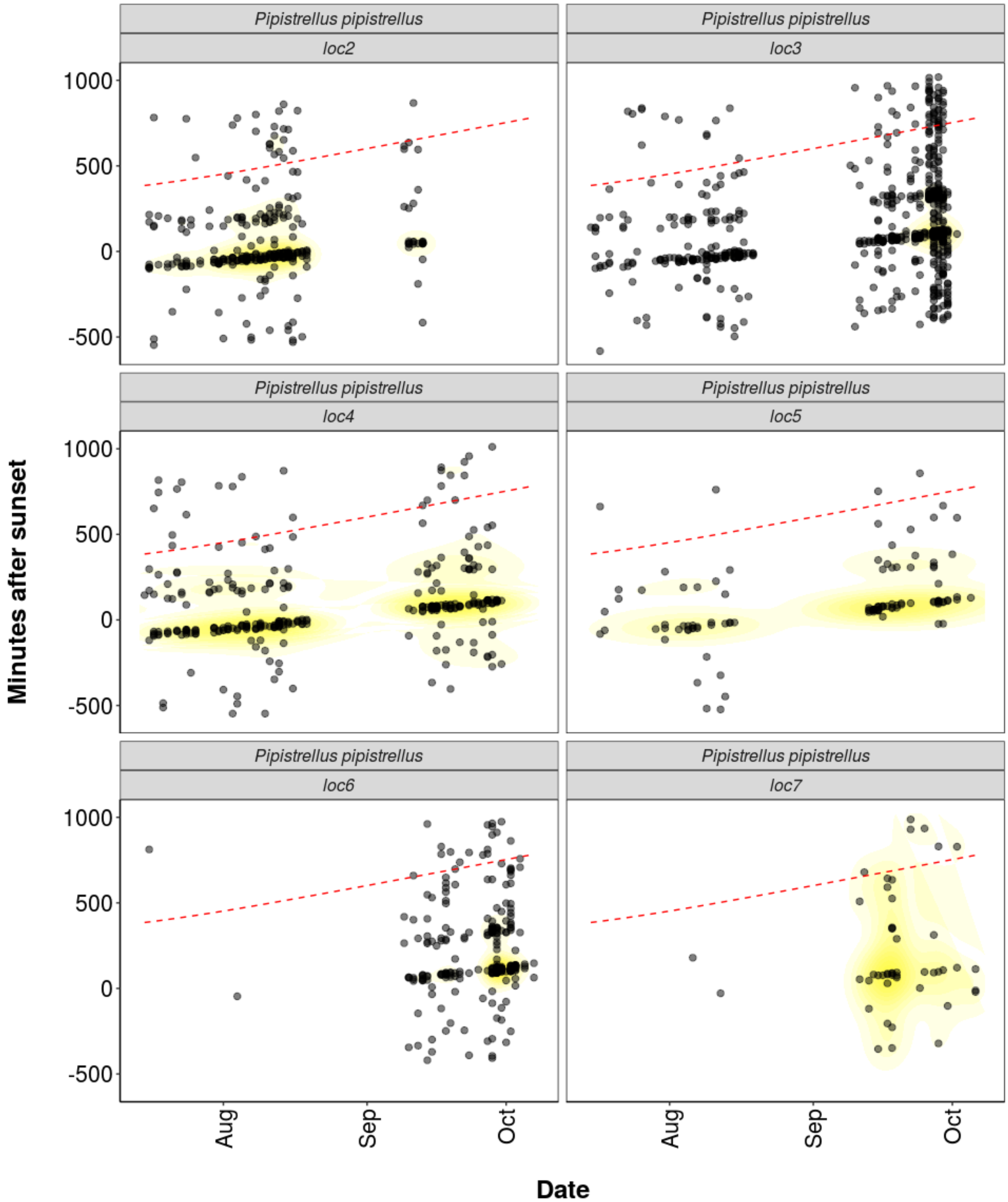
Figure 7. Timing of bat calls plotted as minutes before/after sunset, whereby 0 on the y axis represents sunset. Sunrise throughout the survey period is depicted as the red dashed line. Colours indicate kernel densities, with darkest colours showing peaks of activity. These colours are comparative only within each plot, and do not account for overall activity.



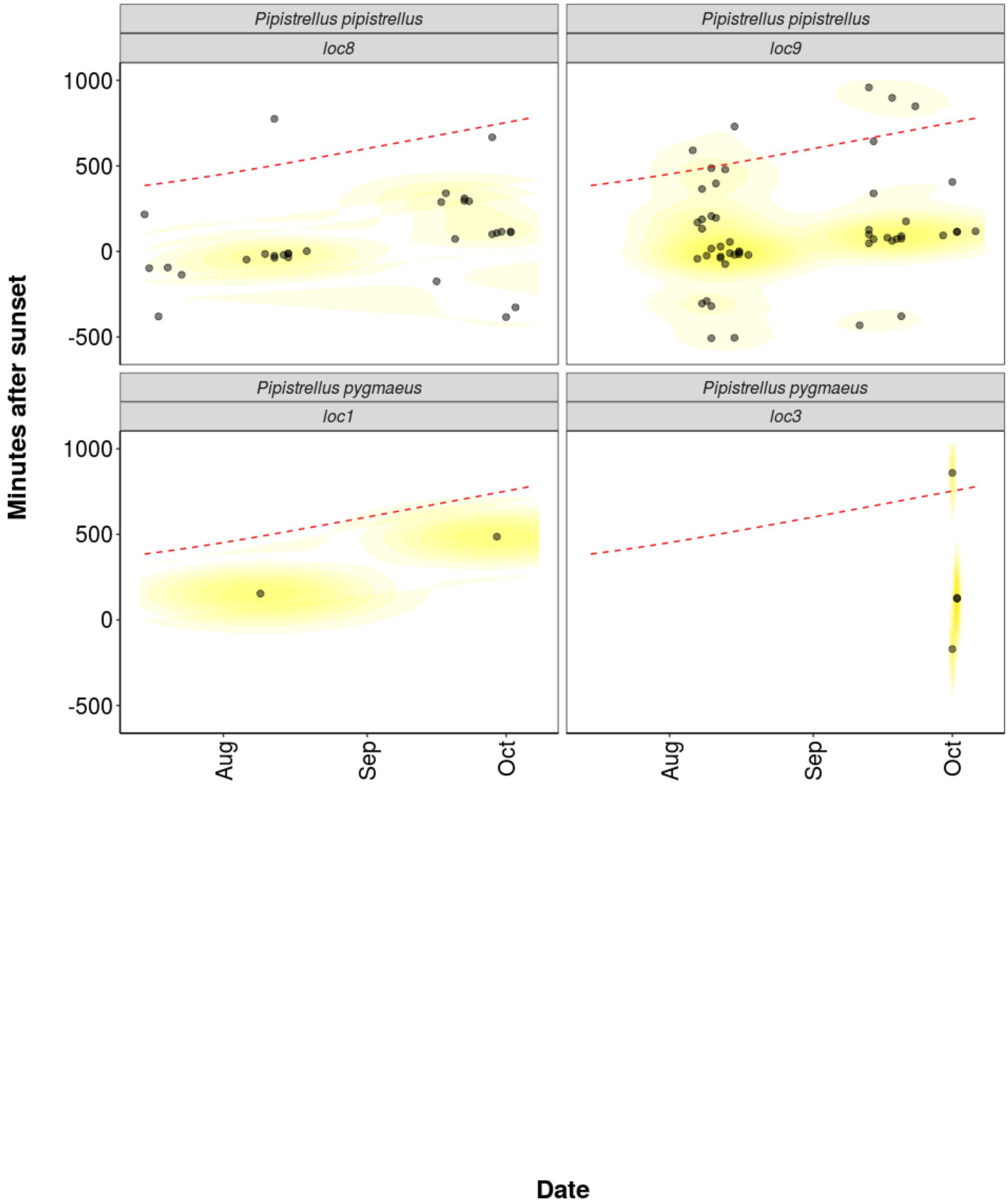
Myotis
loc7
Pipistrellus nathusii
loc1
Pipistrellus nathusii
loc10
Pipistrellus nathusii
loc2
Pipistrellus nathusii
loc3
Pipistrellus nathusii
loc4
Minutes after sunset
1000
500
0
-500
Aug
Sep
Oct
Date



Pipistrellus nathusii
loc5
Pipistrellus nathusii
loc6
Pipistrellus nathusii
loc7
Pipistrellus nathusii
loc9
Pipistrellus pipistrellus
loc1
Pipistrellus pipistrellus
loc10
Minutes after sunset
1000
500
0
-500
Aug
Sep
Oct
Date



Pipistrellus pipistrellus
loc2
loc3
loc4
loc5
loc6
loc7
1000
500
0
-500
Minutes after sunset
Aug
Sep
Oct
Date


Pipistrellus pipistrellus
loc8
Pipistrellus pipistrellus
loc9
Pipistrellus pygmaeus
loc1
Pipistrellus pygmaeus
loc3
1000
500
0
-500
Minutes after sunset
Aug
Sep
Oct
Date

Roost Emergence Time and Bat Observation

Based on: *Russ, Jon. 2012. British Bat Calls a Guide to species Identification. Pelagic Publishing.*

For more information see https://rbats-blog.updog.co/2018/05/29/bat-emergence/

Bat Passes Potentially Indicating Close Proximity to a Roost (Russ 2012) - Table

Table 12. Number of bat calls recorded before the upper time of the species-specific emergence time range, and which therefore may potentially indicate the presence of a nearby roost.

Table continues below

Species	Detector ID	2020-07-16	2020-07-17	2020-07-18	2020-07-19	2020-07-20
Common pipistrelle	loc1	0	1	1	1	2
Common pipistrelle	loc10	0	0	0	1	0
Common pipistrelle	loc2	5	2	1	0	2
Common pipistrelle	loc3	2	3	1	4	0
Common pipistrelle	loc4	1	4	3	2	3
Common pipistrelle	loc5	0	1	1	0	0
Common pipistrelle	loc6	0	0	0	0	0
Common pipistrelle	loc7	0	0	0	0	0
Common pipistrelle	loc8	1	0	1	0	1
Common pipistrelle	loc9	0	0	0	0	0
Soprano pipistrelle	loc3	0	0	0	0	0
Nathusius’	loc1	0	0	0	0	0

Nathusius’	loc10	0	1	0	0	0
Nathusius’	loc2	0	0	0	0	0
Nathusius’	loc3	0	0	0	0	0
Nathusius’	loc5	0	0	0	0	0
Nathusius’	loc6	0	0	0	0	0

Table continues below

2020-07-21	2020-07-22	2020-07-23	2020-07-24	2020-07-25	2020-07-26	2020-07-27
0	1	0	5	2	2	2
0	2	0	2	0	0	0
2	2	3	6	1	0	2
0	1	2	3	2	0	2
0	3	1	6	2	5	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1	0	0	0	0	0	0
0	1	1	0	0	0	0
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	0	1	0	0	0	0
0	0	0	0	0	0	0

Table continues below

2020-07-29	2020-07-30	2020-07-31	2020-08-01	2020-08-02	2020-08-03	2020-08-04
0	1	2	4	1	4	1
0	0	1	0	0	0	0
0	5	8	5	2	6	4
1	3	3	1	1	6	4
0	4	2	4	4	2	4
1	0	3	0	0	1	1
0	0	0	0	0	0	1
0	0	0	0	0	0	0

0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Table continues below

2020-08-05	2020-08-06	2020-08-07	2020-08-08	2020-08-09	2020-08-10	2020-08-11
0	1	3	1	7	3	5
4	0	2	1	1	0	0
7	18	6	5	9	8	8
2	7	4	2	12	6	6
3	6	1	5	7	3	2
3	3	3	0	2	2	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	1	0	0	0	1	0
0	0	1	1	2	3	0
0	0	0	0	0	0	0
0	0	0	0	0	0	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Table continues below

2020-08-12	2020-08-13	2020-08-14	2020-08-15	2020-08-16	2020-08-17	2020-08-18
1	0	0	0	0	0	0
0	2	0	2	0	0	0
11	8	10	18	11	4	5
6	9	3	13	22	4	2

6	12	5	3	2	3	4
2	2	2	1	0	0	0
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	1	3	0	0	0
3	1	1	2	3	0	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Table continues below

2020-08-19	2020-09-10	2020-09-11	2020-09-12	2020-09-13	2020-09-14	2020-09-15
0	0	0	0	6	0	2
0	0	0	0	0	0	0
6	1	0	1	2	0	0
4	2	2	2	0	1	4
3	1	0	0	0	0	1
0	0	0	0	0	0	0
0	1	0	2	0	1	4
0	0	0	0	1	0	1
1	0	0	0	0	0	0
0	0	1	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Table continues below

2020-09-16	2020-09-17	2020-09-18	2020-09-19	2020-09-20	2020-09-21	2020-09-22

4	2	1	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
3	0	4	2	1	0	0
2	1	2	1	0	1	0
1	0	0	0	0	0	0
0	1	1	1	1	0	1
0	2	2	0	0	0	0
1	0	0	0	0	0	0
0	0	0	0	1	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Table continues below

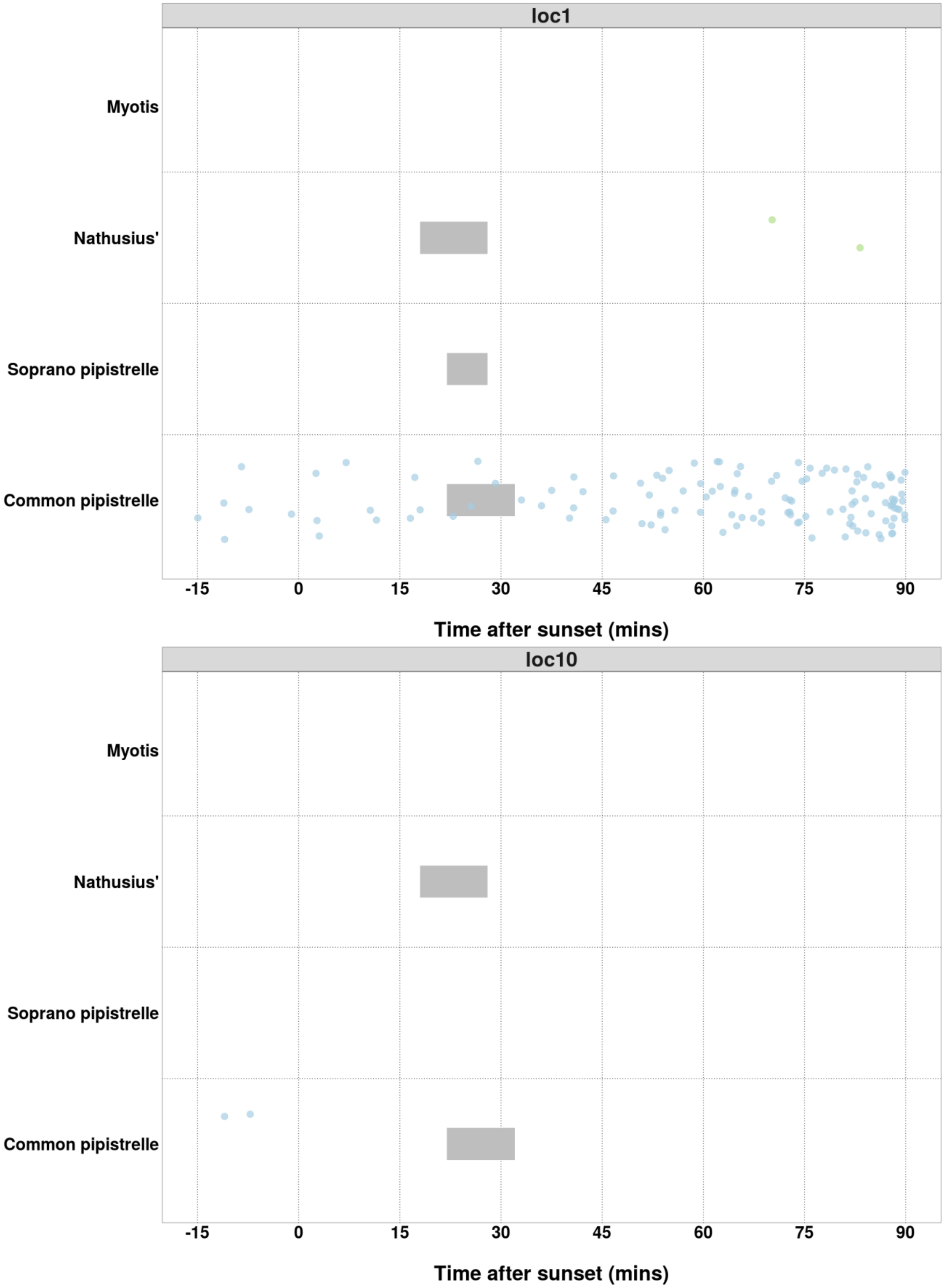
2020-09-23	2020-09-24	2020-09-26	2020-09-27	2020-09-28	2020-09-29	2020-09-30
1	6	1	16	21	35	5
0	0	0	0	0	0	0
0	0	0	0	0	0	0
4	3	1	19	13	15	17
0	2	1	2	4	0	1
0	0	0	0	1	1	0
1	0	1	1	5	1	2
0	1	0	0	1	0	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	1	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	1	0	0
0	0	0	0	0	0	0

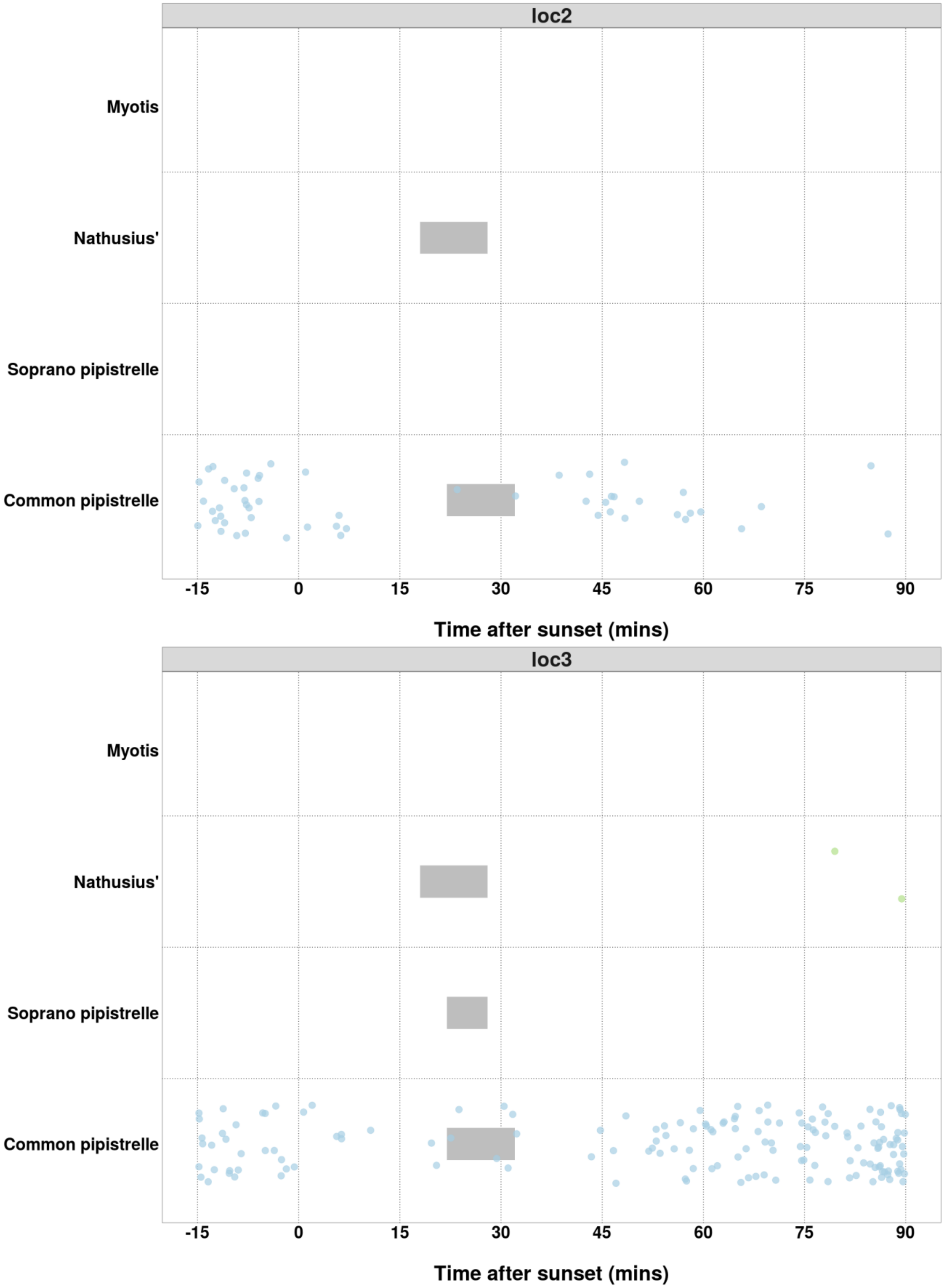
0	0	0	0	0	0	0

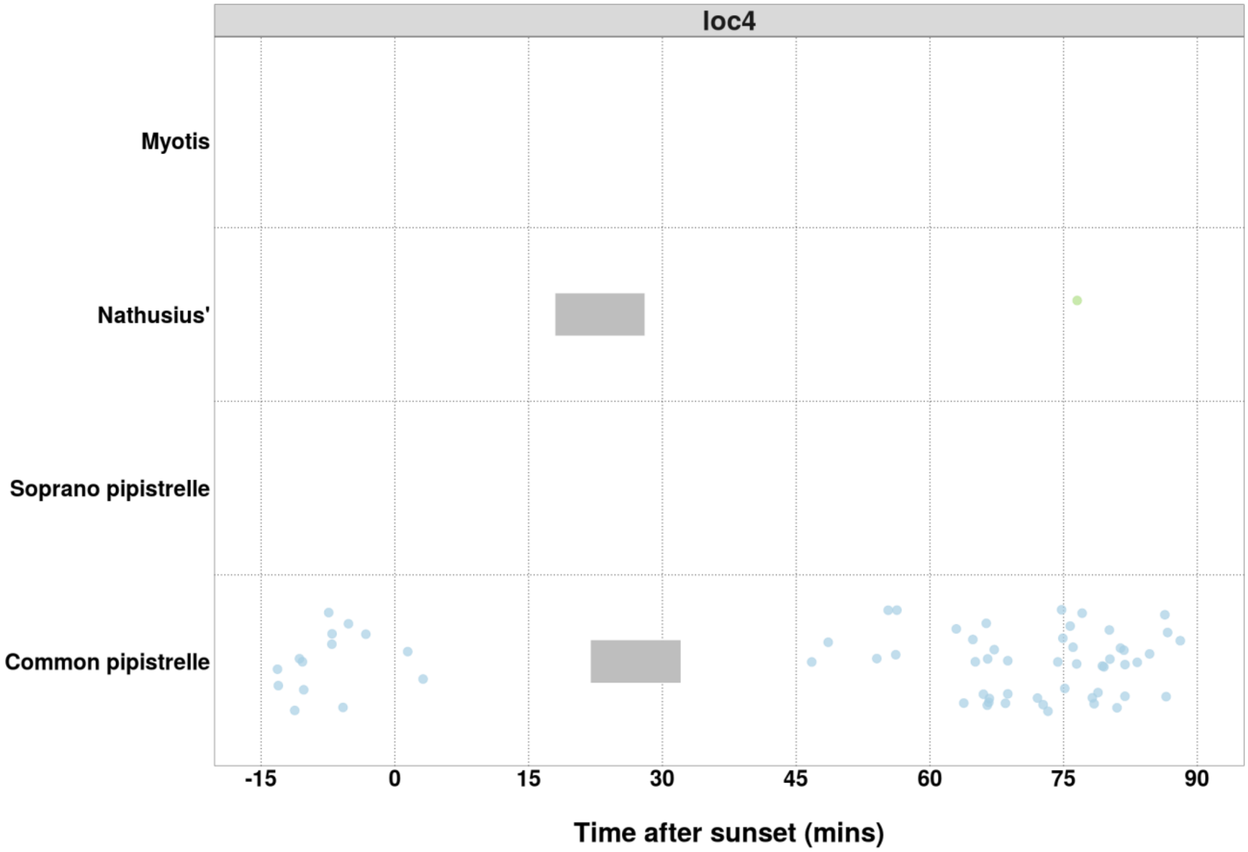
2020-10-01	2020-10-02	2020-10-03	2020-10-05	2020-10-06
0	17	17	1	3
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2	1	1	0	0
0	0	0	0	2
1	0	1	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2	0	0	0	0

Bat Passes Potentially Indicating Close Proximity to a Roost (Russ 2012) - Figures

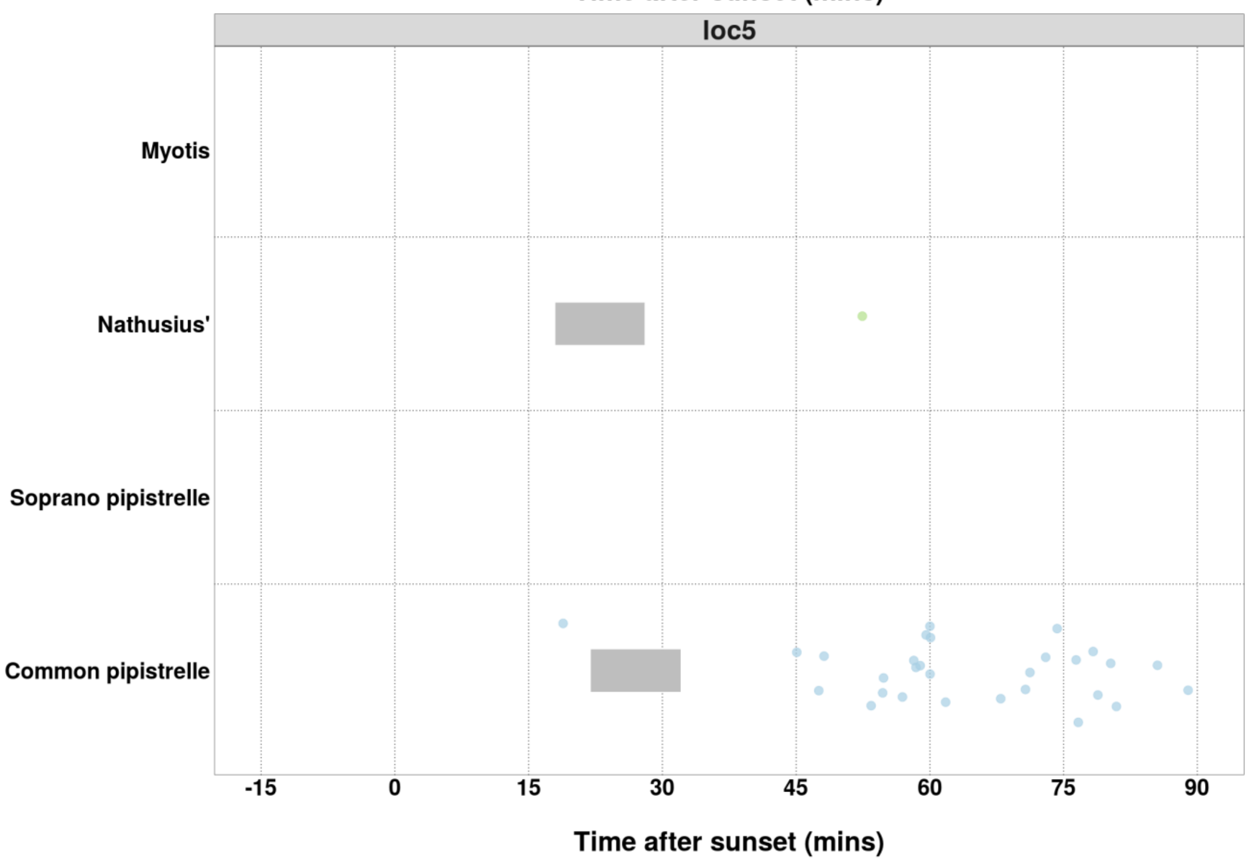
Figure 8. Time from 15 minutes before to 90 minutes after sunset. Species-specific emergence time ranges are shown as grey bars. Bat passes overlapping species-specific grey bars, or occuring earlier than this time range, may potentially indicate the presence of a nearby roost.


loc1
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)
loc10
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)

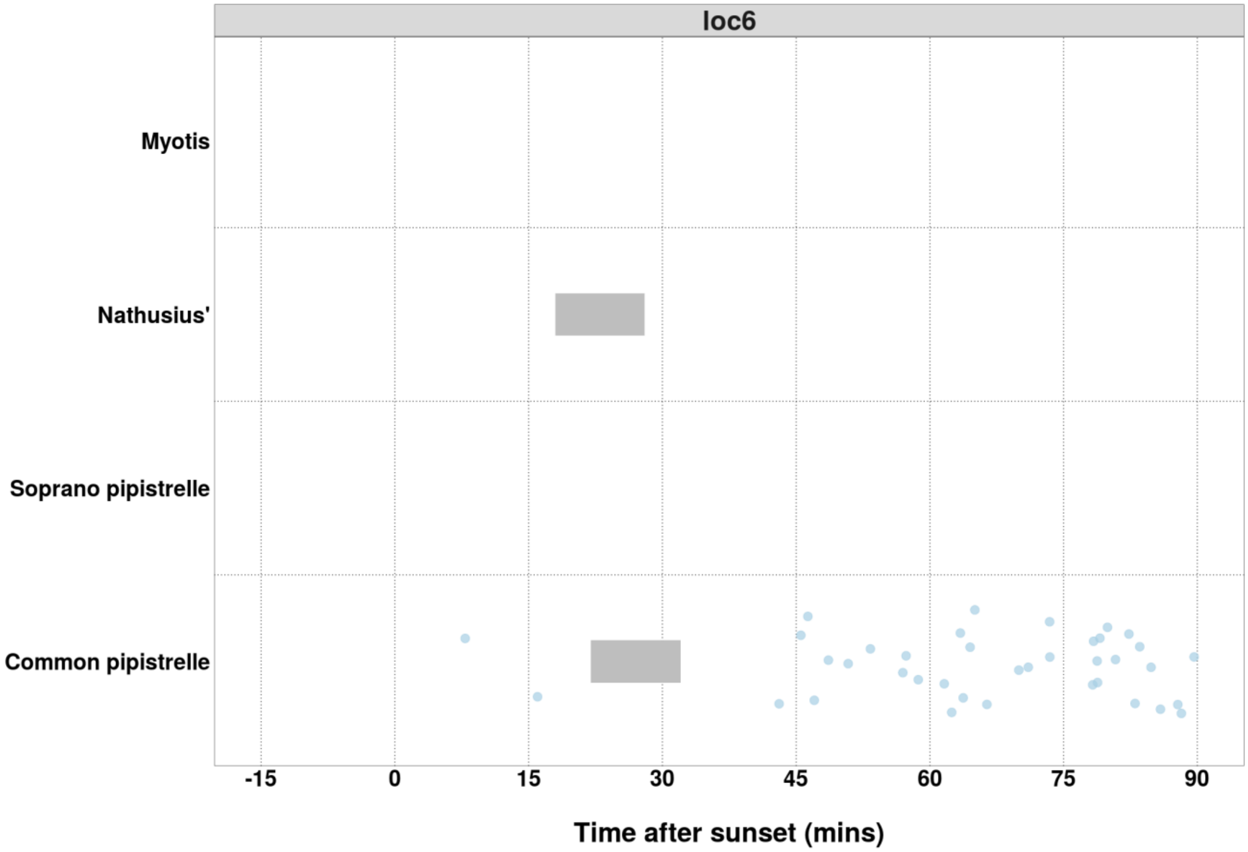

loc2
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)
loc3
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)

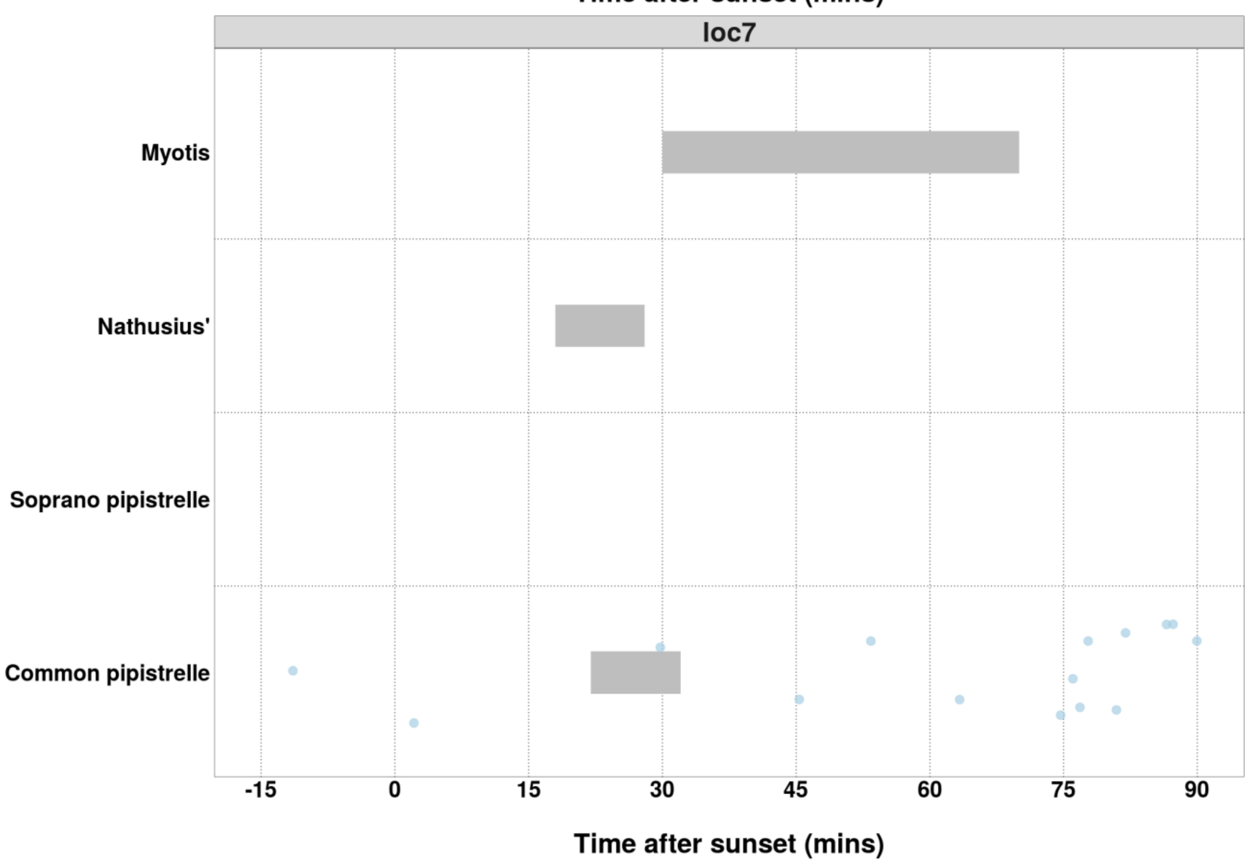


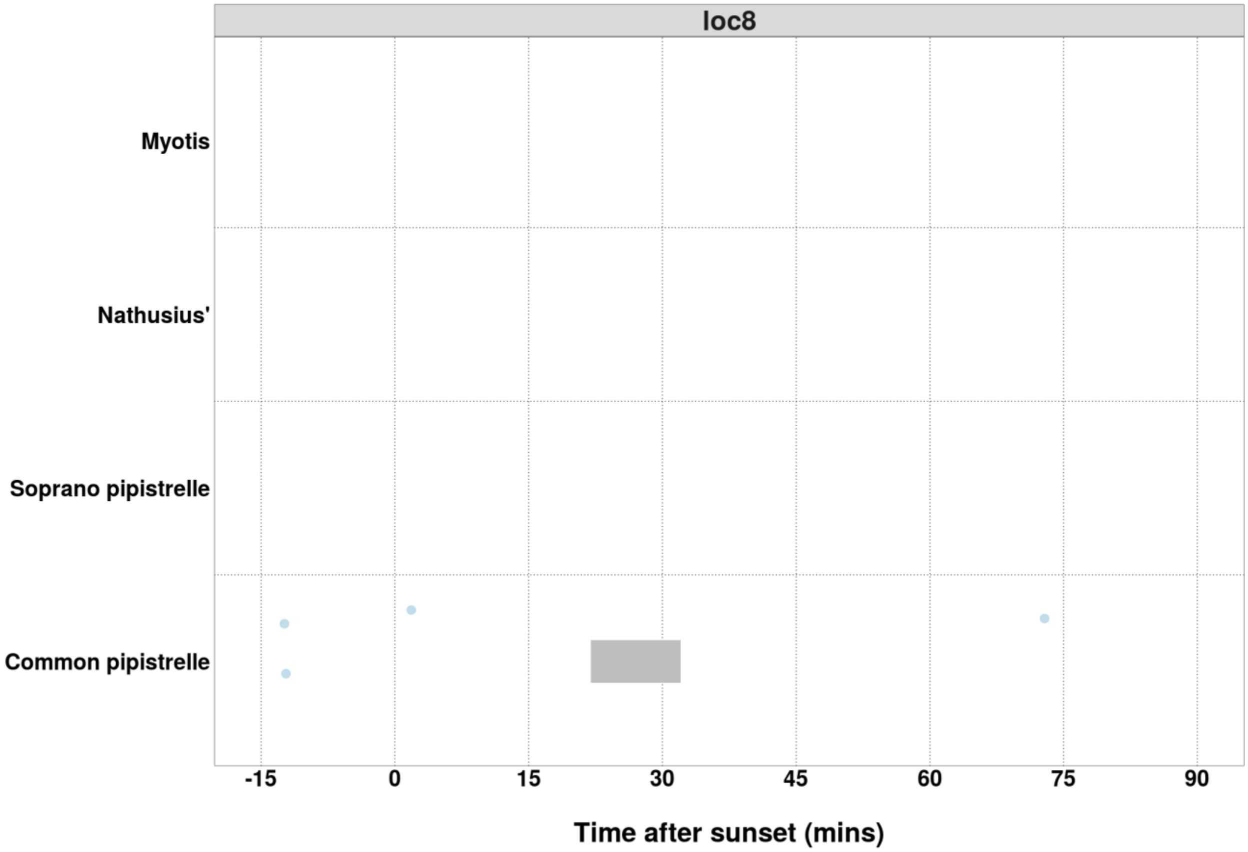
loc4
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)



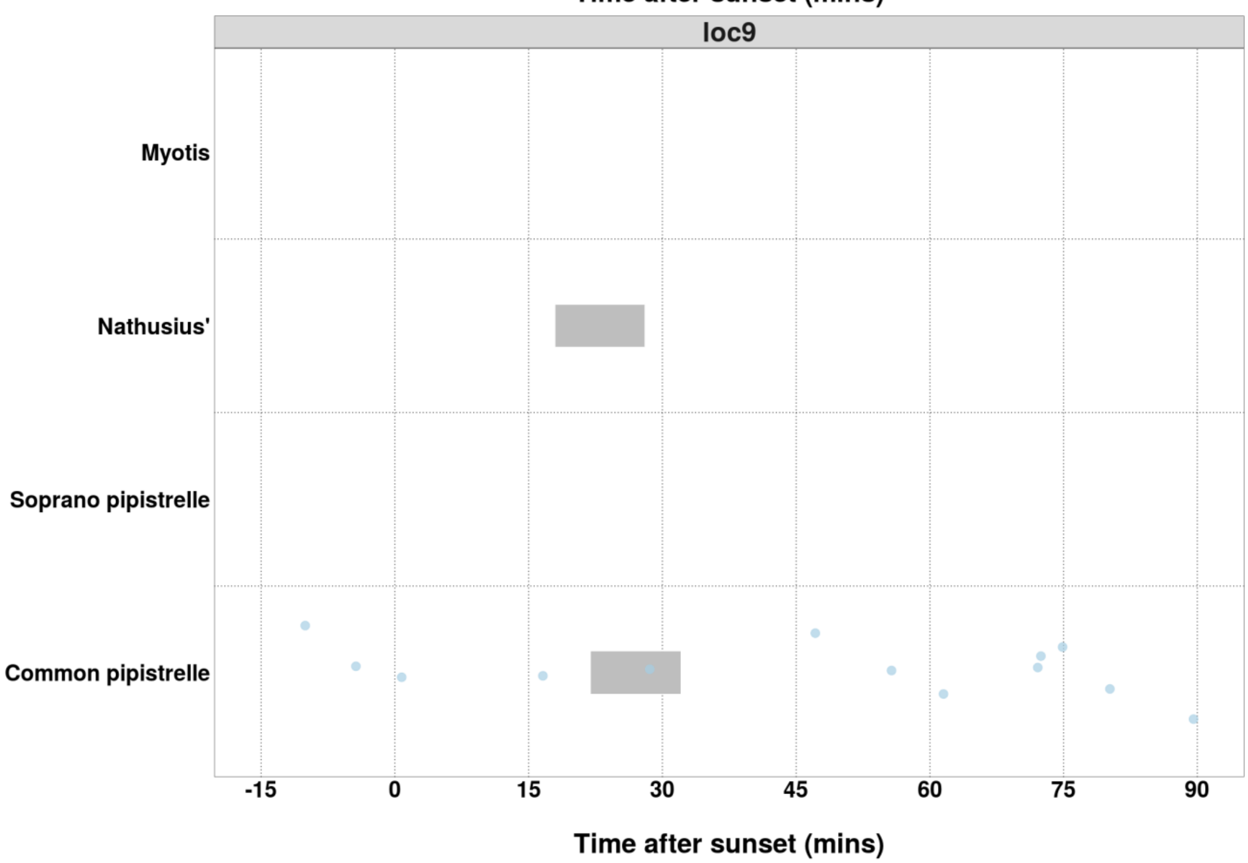
loc5
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)


loc6
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)


loc7
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)



loc8
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)



loc9
Myotis
Nathusius'
Soprano pipistrelle
Common pipistrelle
-15
0
15
30
45
60
75
90
Time after sunset (mins)

Counts of Bat Passes

All detectors

Table 14. The total number of passes recorded for each species across all of the detectors. The 'Total' percentage may not be exactly 100% due to rounding of the percentages per species.

Species	Passes (No.)	Percentage of total (%)
Common pipistrelle	4931	98.4
Soprano pipistrelle	8	0.2
Nathusius'	72	1.4
Myotis	2	0.0
Total	5013	100.0

Counts of Bat Passes

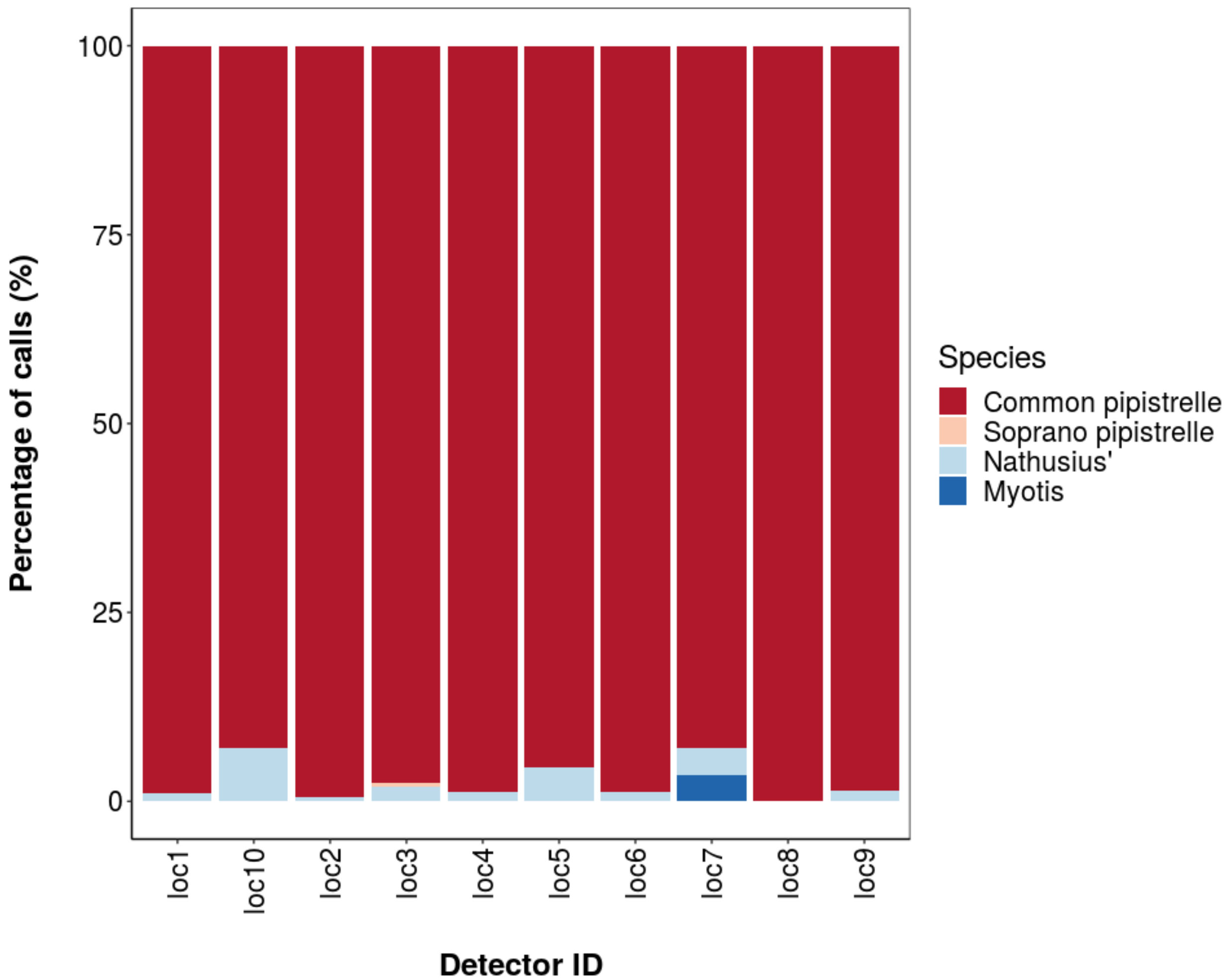
Per Detector

Table 15. The number of passes recorded for each species at each detector.

Species	Detector ID	Count (No)	Percentage by Detector (%)
Common pipistrelle	loc1	2077	98.9
Common pipistrelle	loc10	39	92.9
Common pipistrelle	loc2	388	99.5
Common pipistrelle	loc3	1239	97.5
Common pipistrelle	loc4	407	98.8
Common pipistrelle	loc5	128	95.5
Common pipistrelle	loc6	501	98.8
Common pipistrelle	loc7	53	93.0
Common pipistrelle	loc8	32	100.0
Common pipistrelle	loc9	67	98.5
Soprano pipistrelle	loc1	2	0.1
Soprano pipistrelle	loc3	6	0.5
Nathusius’	loc1	21	1.0
Nathusius’	loc10	3	7.1
Nathusius’	loc2	2	0.5
Nathusius’	loc3	26	2.0
Nathusius’	loc4	5	1.2
Nathusius’	loc5	6	4.5
Nathusius’	loc6	6	1.2
Nathusius’	loc7	2	3.5
Nathusius’	loc9	1	1.5
Myotis	loc7	2	3.5

Species Composition

Figure 10. Percentage species composition of passes at each detector.



PART 2a: Presence Only

THE NEXT SECTION OF THE REPORT FEATURES THE RAW DATA SUPPLIED TO ECOBAT AND ONLY TAKES INTO ACCOUNT THE PRESENCE, AND NOT THE ABSENCE, OF EACH BAT SPECIES. FOR EACH NIGHT, THERE IS NO 'ZERO DATA' FOR WHEN SPECIES WERE NOT DETECTED.

Nightly Bat Pass Rate (Bat passes per hour)

Median Per Detector

Table 16. The median Nightly Pass Rate (bat passes per hour, per night) of each species. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the 'average' activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	Median Pass Rate
Common pipistrelle	loc1	0.9
Common pipistrelle	loc10	0.2
Common pipistrelle	loc2	1.0
Common pipistrelle	loc3	0.9
Common pipistrelle	loc4	0.9
Common pipistrelle	loc5	0.4
Common pipistrelle	loc6	0.6
Common pipistrelle	loc7	0.2
Common pipistrelle	loc8	0.1
Common pipistrelle	loc9	0.3
Soprano pipistrelle	loc1	0.1
Soprano pipistrelle	loc3	0.2
Nathusius'	loc1	0.1
Nathusius'	loc10	0.2
Nathusius'	loc2	0.1
Nathusius'	loc3	0.3
Nathusius'	loc4	0.1
Nathusius'	loc5	0.1
Nathusius'	loc6	0.2
Nathusius'	loc7	0.1
Nathusius'	loc9	0.1
Myotis	loc7	0.1

Nightly Bat Pass Rate (Bat passes per hour)

Mean per Detector

Table 17. The mean Nightly Pass Rate (bat passes per hour, per night) of each species at each detector. Values are given to 1 decimal place.

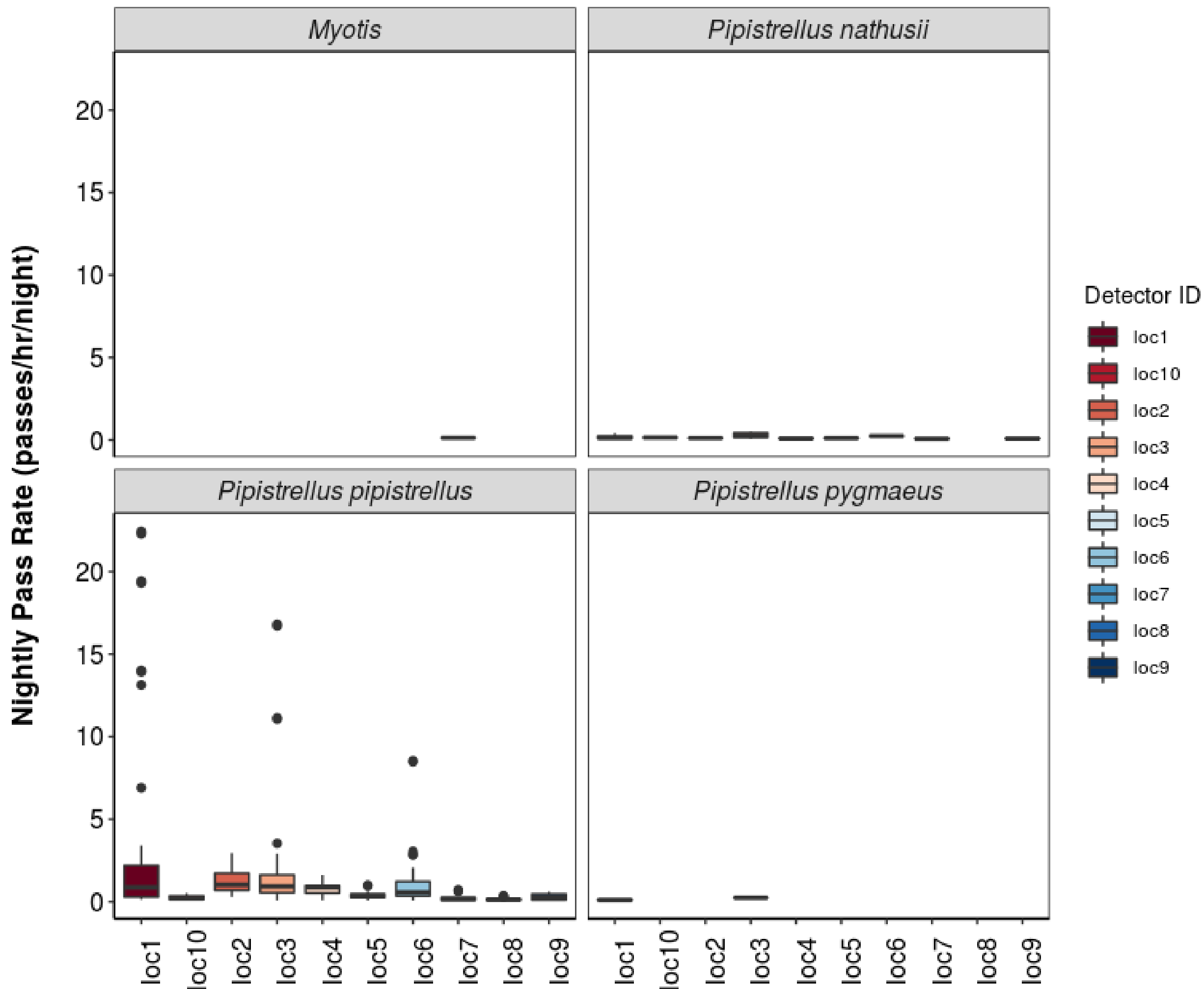
We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

Species	Detector ID	Mean Pass Rate
Common pipistrelle	loc1	3.3
Common pipistrelle	loc10	0.2
Common pipistrelle	loc2	1.2
Common pipistrelle	loc3	2.0
Common pipistrelle	loc4	0.8
Common pipistrelle	loc5	0.4
Common pipistrelle	loc6	1.4
Common pipistrelle	loc7	0.2
Common pipistrelle	loc8	0.2
Common pipistrelle	loc9	0.3
Soprano pipistrelle	loc1	0.1
Soprano pipistrelle	loc3	0.2
Nathusius’	loc1	0.2
Nathusius’	loc10	0.1
Nathusius’	loc2	0.1
Nathusius’	loc3	0.3
Nathusius’	loc4	0.1
Nathusius’	loc5	0.1
Nathusius’	loc6	0.2
Nathusius’	loc7	0.1
Nathusius’	loc9	0.1
Myotis	loc7	0.1

Nightly Bat Passes (Bat passes per hour)

Per Detector - Figures

Figure 11. Boxplots for the number of bat passes per hour each night, for each detector. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.



Myotis
Pipistrellus nathusii
Pipistrellus pipistrellus
Pipistrellus pygmaeus
Nightly Pass Rate (passes/hr/night)
0
5
10
15
20
loc1
loc10
loc2
loc3
loc4
loc5
loc6
loc7
loc8
loc9
Detector ID

Detector ID

SPLIT BY MONTH

Total Bat Passes per Detector, each Month

Per Detector

Table 18. The total number of bat passes of each species in each month at each detector. This table simply tells you how many bats of each species were recorded passing each detector during each month. These numbers are not standardised by the night length, or how many nights each detector was active for during each month.

Species	Detector ID	Jul	Aug	Sep	Oct
Common pipistrelle	loc1	33	65	1248	731
Common pipistrelle	loc10	15	20	0	4
Common pipistrelle	loc2	72	273	43	0
Common pipistrelle	loc3	60	205	973	1
Common pipistrelle	loc4	88	137	182	0
Common pipistrelle	loc5	13	34	74	7
Common pipistrelle	loc6	1	1	387	112
Common pipistrelle	loc7	0	2	47	4
Common pipistrelle	loc8	7	9	12	4
Common pipistrelle	loc9	0	43	17	7
Soprano pipistrelle	loc1	0	1	1	0
Soprano pipistrelle	loc3	0	0	0	6
Nathusius’	loc1	1	1	13	6
Nathusius’	loc10	3	0	0	0
Nathusius’	loc2	0	2	0	0
Nathusius’	loc3	3	0	23	0
Nathusius’	loc4	0	2	3	0
Nathusius’	loc5	2	2	1	1
Nathusius’	loc6	0	0	3	3
Nathusius’	loc7	0	0	1	1
Nathusius’	loc9	0	0	1	0
Myotis	loc7	1	1	0	0

Survey Effort

Table 19. The number of survey nights per month per detector.

Month	Detector ID	No. of Survey Nights
Jul	loc1	14
Jul	loc10	9
Jul	loc2	14
Jul	loc3	15
Jul	loc4	15
Jul	loc5	7
Jul	loc6	1
Jul	loc7	1
Jul	loc8	5
Aug	loc1	12
Aug	loc10	10
Aug	loc2	19
Aug	loc3	19
Aug	loc4	19
Aug	loc5	12
Aug	loc6	1
Aug	loc7	3
Aug	loc8	6
Aug	loc9	12
Sep	loc1	21
Sep	loc2	5
Sep	loc3	22
Sep	loc4	21
Sep	loc5	15
Sep	loc6	21
Sep	loc7	16
Sep	loc8	9
Sep	loc9	10
Oct	loc1	6
Oct	loc10	2
Oct	loc3	2

Oct	loc5	3
Oct	loc6	6
Oct	loc7	3
Oct	loc8	3
Oct	loc9	3

Nightly Bat Pass Rate for each Month

Median Per Detector

Table 20. The median Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the 'average' activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	Jul	Aug	Sep	Oct
Common pipistrelle	loc1	0.3	0.5	1.4	7.7
Common pipistrelle	loc10	0.3	0.2	NA	0.2
Common pipistrelle	loc2	0.6	1.8	0.8	NA
Common pipistrelle	loc3	0.6	1.3	1.8	0.1
Common pipistrelle	loc4	0.9	0.9	0.6	NA
Common pipistrelle	loc5	0.4	0.4	0.4	0.2
Common pipistrelle	loc6	0.2	0.1	0.7	1.3
Common pipistrelle	loc7	NA	0.1	0.2	0.2
Common pipistrelle	loc8	0.2	0.1	0.1	0.1
Common pipistrelle	loc9	NA	0.5	0.1	0.2
Soprano pipistrelle	loc1	NA	0.1	0.1	NA
Soprano pipistrelle	loc3	NA	NA	NA	0.2
Nathusius'	loc1	0.2	0.1	0.1	0.2
Nathusius'	loc10	0.2	NA	NA	NA
Nathusius'	loc2	NA	0.1	NA	NA
Nathusius'	loc3	0.2	NA	0.4	NA
Nathusius'	loc4	NA	0.1	0.1	NA
Nathusius'	loc5	0.1	0.1	0.1	0.1
Nathusius'	loc6	NA	NA	0.2	0.2
Nathusius'	loc7	NA	NA	0.1	0.1
Nathusius'	loc9	NA	NA	0.1	NA
Myotis	loc7	0.2	0.1	NA	NA

Nightly Bat Pass Rate for each Month

Mean per Detector

Table 21: The mean Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. Values are given to 1 decimal place.

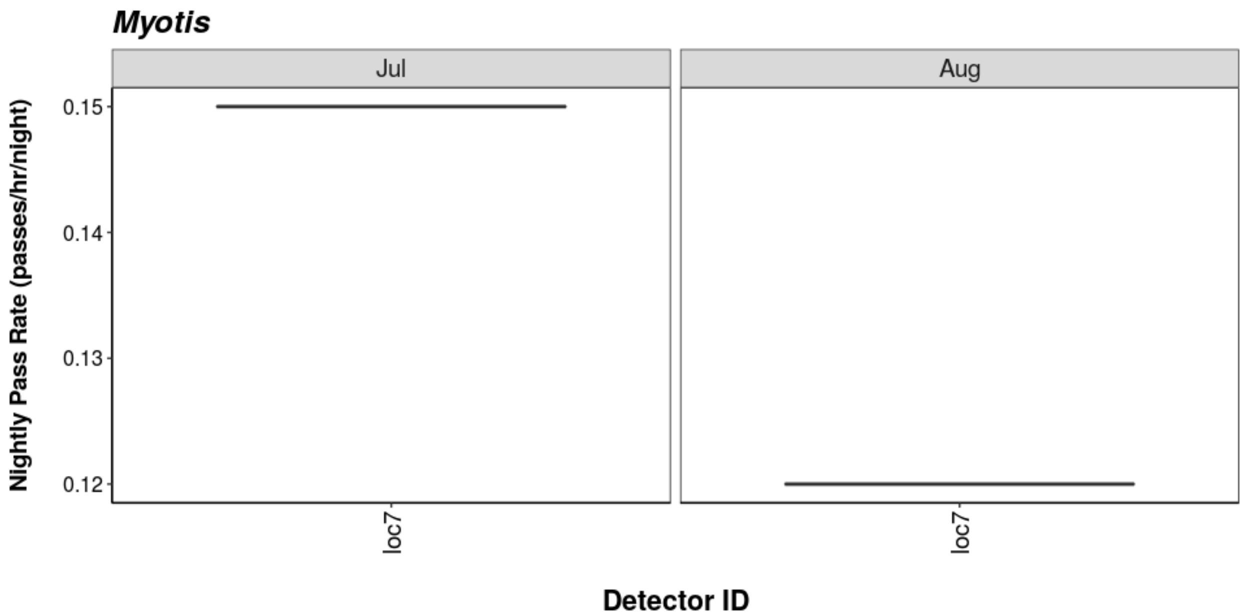
We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

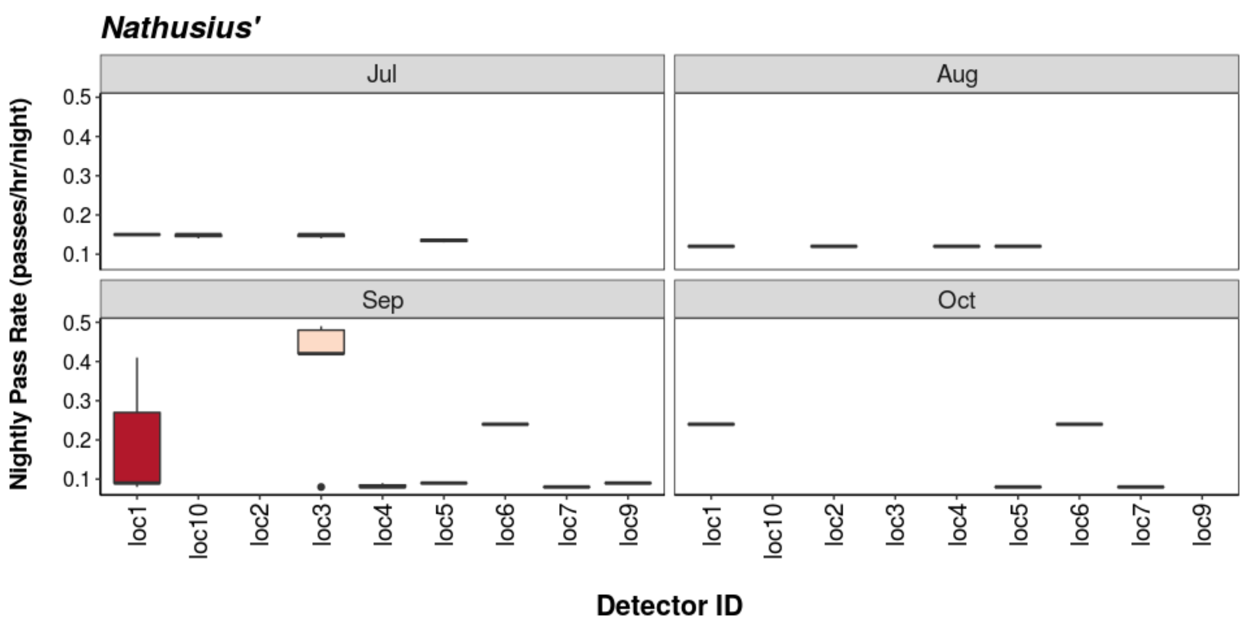
Species	Detector ID	Jul	Aug	Sep	Oct
Common pipistrelle	loc1	0.4	0.7	4.9	9.6
Common pipistrelle	loc10	0.3	0.2	NA	0.2
Common pipistrelle	loc2	0.7	1.7	0.8	NA
Common pipistrelle	loc3	0.6	1.3	3.7	0.1
Common pipistrelle	loc4	0.8	0.9	0.7	NA
Common pipistrelle	loc5	0.3	0.3	0.4	0.2
Common pipistrelle	loc6	0.2	0.1	1.5	1.5
Common pipistrelle	loc7	NA	0.1	0.3	0.2
Common pipistrelle	loc8	0.2	0.2	0.1	0.1
Common pipistrelle	loc9	NA	0.4	0.1	0.2
Soprano pipistrelle	loc1	NA	0.1	0.1	NA
Soprano pipistrelle	loc3	NA	NA	NA	0.2
Nathusius’	loc1	0.2	0.1	0.2	0.2
Nathusius’	loc10	0.1	NA	NA	NA
Nathusius’	loc2	NA	0.1	NA	NA
Nathusius’	loc3	0.1	NA	0.4	NA
Nathusius’	loc4	NA	0.1	0.1	NA
Nathusius’	loc5	0.1	0.1	0.1	0.1
Nathusius’	loc6	NA	NA	0.2	0.2
Nathusius’	loc7	NA	NA	0.1	0.1
Nathusius’	loc9	NA	NA	0.1	NA
Myotis	loc7	0.2	0.1	NA	NA

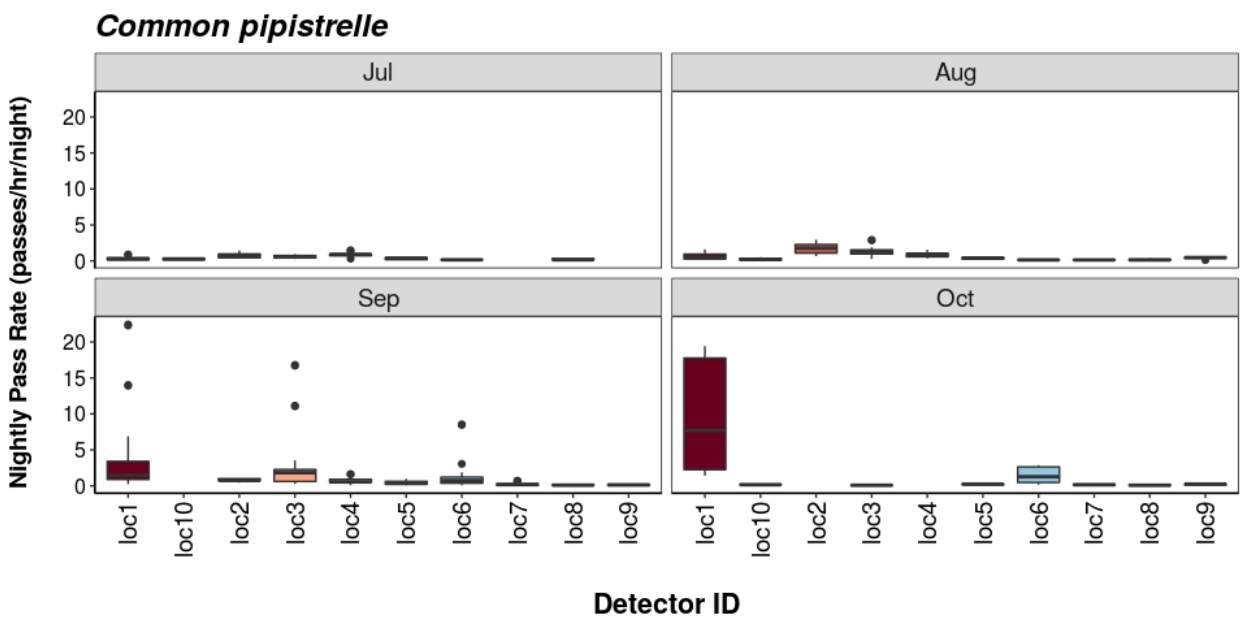
Nightly Bat Pass Rate for each Month

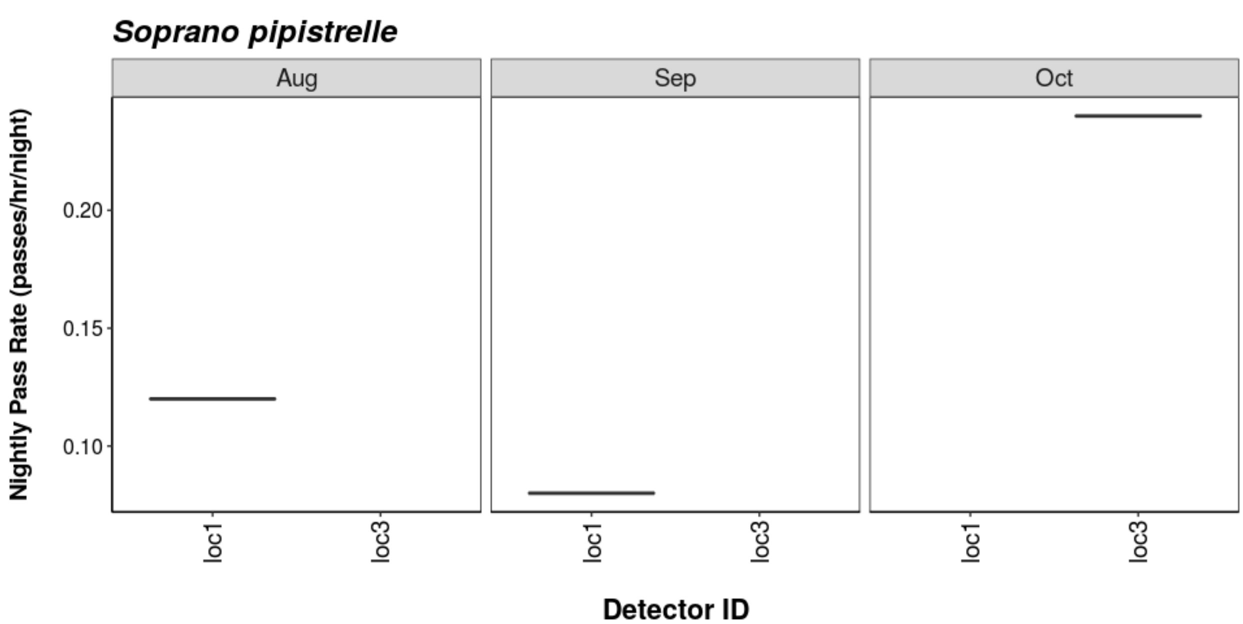
Per Detector - Figures

Figure 12. Figures show boxplots for the number of bat passes per hour by detector, for each month. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.






Common pipistrelle
Jul
Aug
Sep
Oct
Nightly Pass Rate (passes/hr/night)
20
15
10
5
0
loc1
loc10
loc2
loc3
loc4
loc5
loc6
loc7
loc8
loc9
Detector ID


Soprano pipistrelle
Aug
Sep
Oct
Nightly Pass Rate (passes/hr/night)
0.20
0.15
0.10
loc1
loc3
Detector ID

Bat Activity per Detector Location

Figure 13. Detector ID reference:

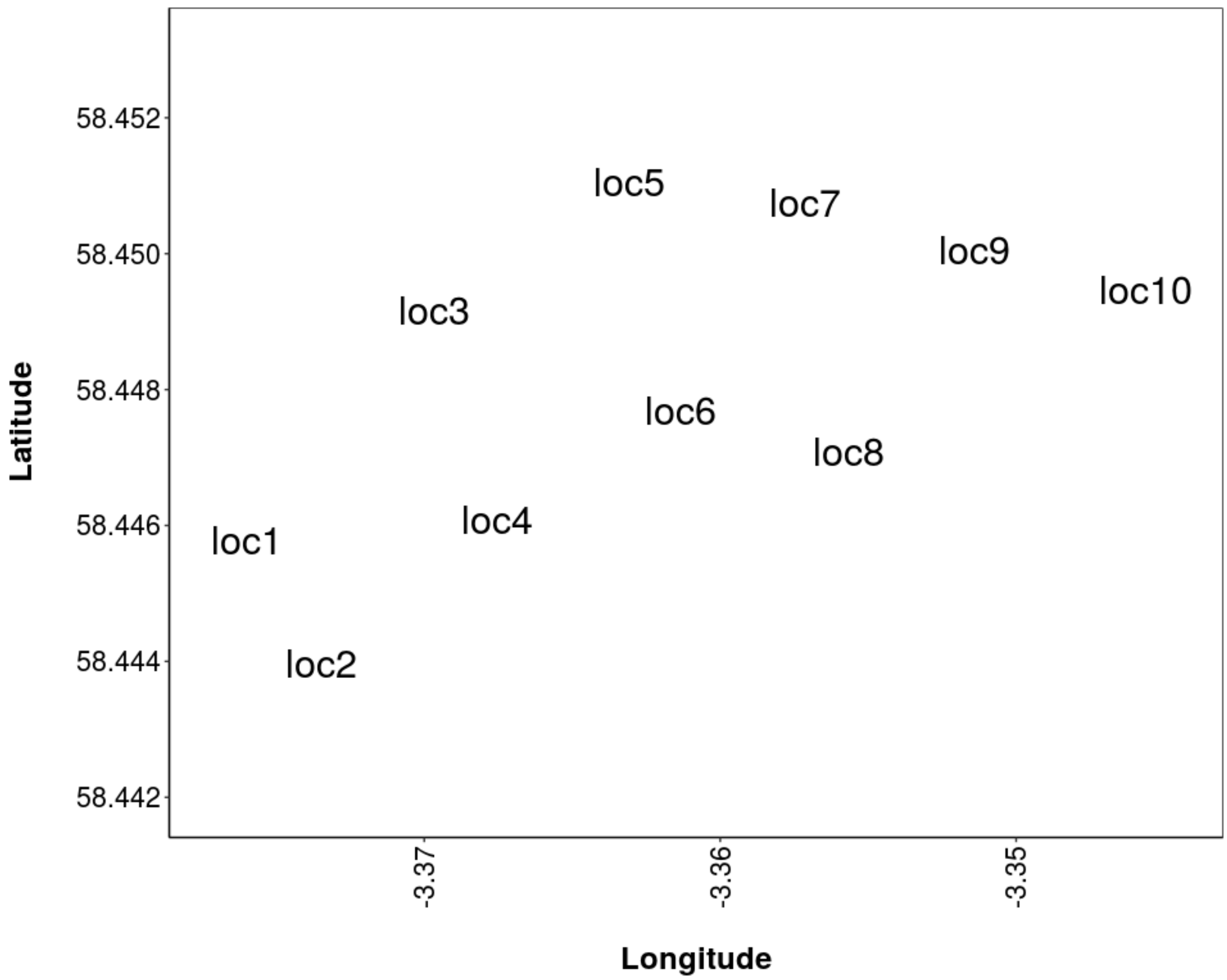


Figure 14. Median Nightly Pass Rate (bat passes/hr/night) throughout the survey period - represented by the size and colour of the point at each detector location.

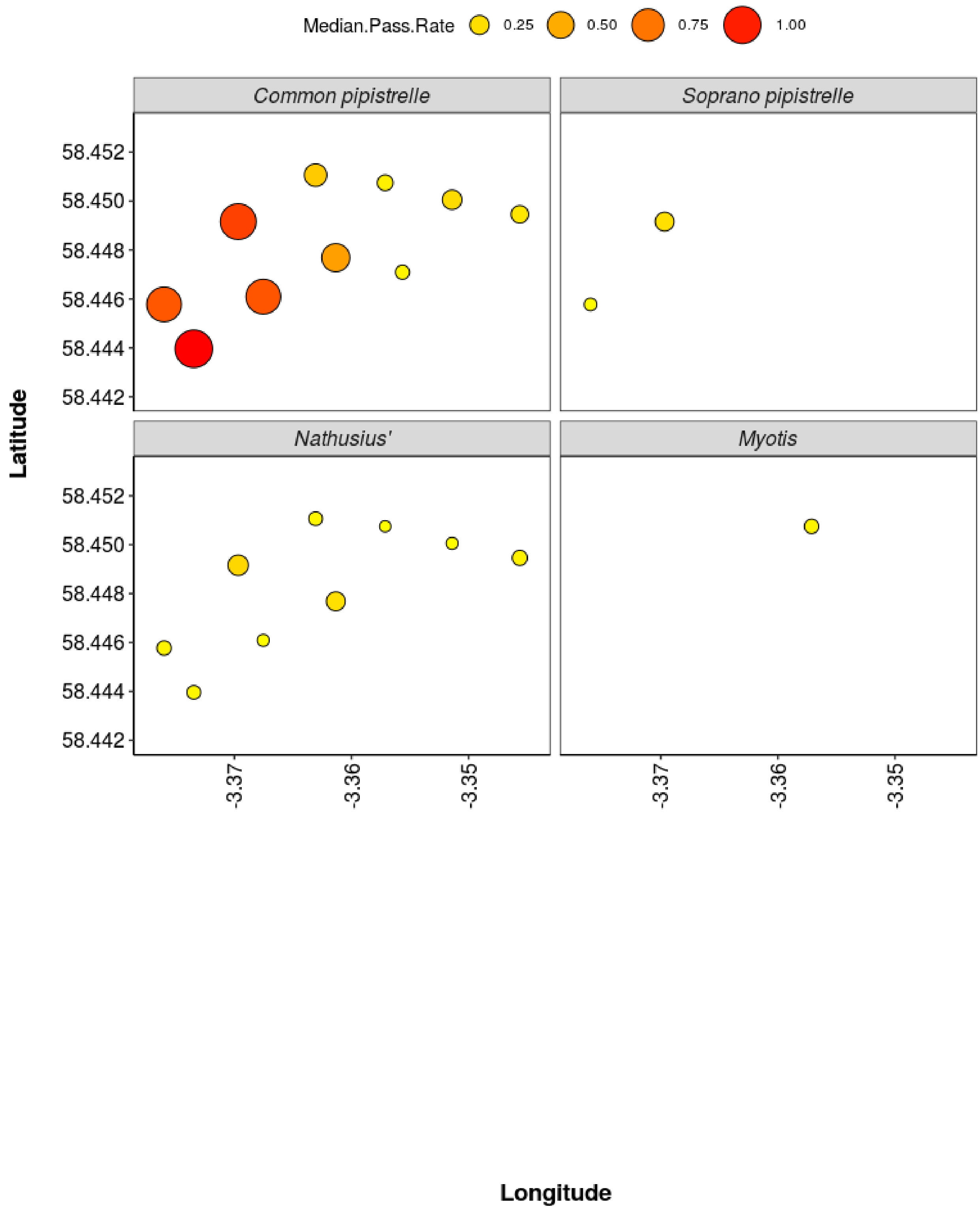
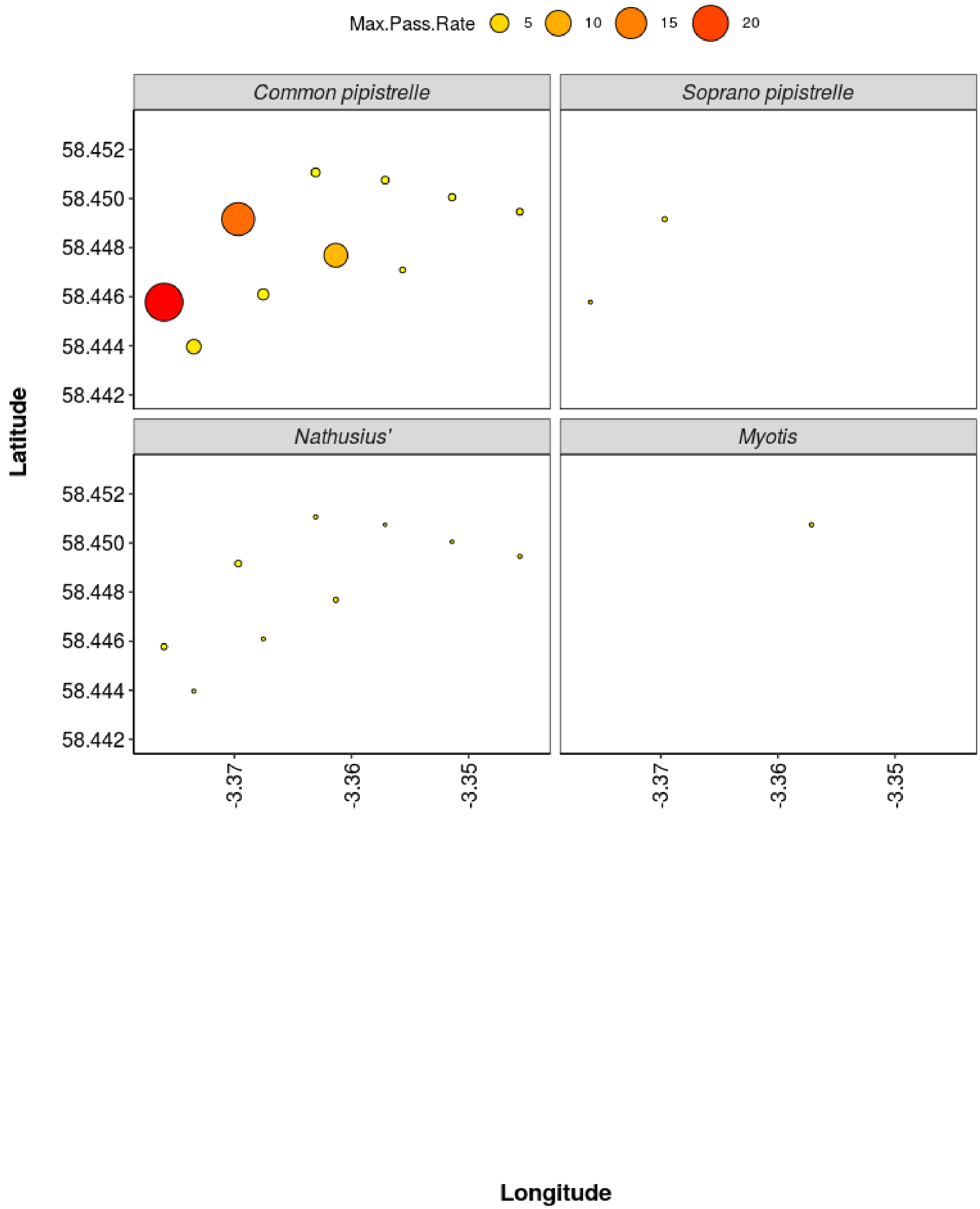


Figure 15. Maximum Nightly Pass Rate (bat passes/hr/night) recorded in a single night throughout the survey period - represented by the size and colour of the point at each detector location.



PART 2B: Includes absences

THE NEXT SECTION OF THE REPORT FEATURES THE DATA SUPPLIED TO ECOBAT BUT TAKES INTO ACCOUNT SPECIES ABSENCES, AND THEREFORE INCLUDES 'ZERO DATA' FOR WHEN SPECIES WERE NOT DETECTED AT EACH DETECTOR ON A NIGHT. THIS DRAMATICALLY LOWERS THE MEANS AND MEDIANS OF THE DATA PRESENTED.

Nightly Bat Pass Rate (Bat passes per hour)

Median Per Detector

Table 22. The median Nightly Pass Rate (bat passes per hour, per night) of each species. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the 'average' activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	Median Pass Rate
Common pipistrelle	loc1	0.9
Common pipistrelle	loc10	0.2
Common pipistrelle	loc2	1.0
Common pipistrelle	loc3	0.9
Common pipistrelle	loc4	0.9
Common pipistrelle	loc5	0.4
Common pipistrelle	loc6	0.6
Common pipistrelle	loc7	0.1
Common pipistrelle	loc8	0.1
Common pipistrelle	loc9	0.3
Myotis	loc1	0.0
Myotis	loc10	0.0
Myotis	loc2	0.0
Myotis	loc3	0.0
Myotis	loc4	0.0
Myotis	loc5	0.0
Myotis	loc6	0.0
Myotis	loc7	0.0
Myotis	loc8	0.0
Myotis	loc9	0.0
Nathusius'	loc1	0.0
Nathusius'	loc10	0.0
Nathusius'	loc2	0.0

Nathusius’	loc3	0.0
Nathusius’	loc4	0.0
Nathusius’	loc5	0.0
Nathusius’	loc6	0.0
Nathusius’	loc7	0.0
Nathusius’	loc8	0.0
Nathusius’	loc9	0.0
Soprano pipistrelle	loc1	0.0
Soprano pipistrelle	loc10	0.0
Soprano pipistrelle	loc2	0.0
Soprano pipistrelle	loc3	0.0
Soprano pipistrelle	loc4	0.0
Soprano pipistrelle	loc5	0.0
Soprano pipistrelle	loc6	0.0
Soprano pipistrelle	loc7	0.0
Soprano pipistrelle	loc8	0.0
Soprano pipistrelle	loc9	0.0

Nightly Bat Pass Rate (Bat passes per hour)

Mean per Detector

Table 23. The mean Nightly Pass Rate (bat passes per hour, per night) of each species at each detector. Values are given to 1 decimal place.

We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

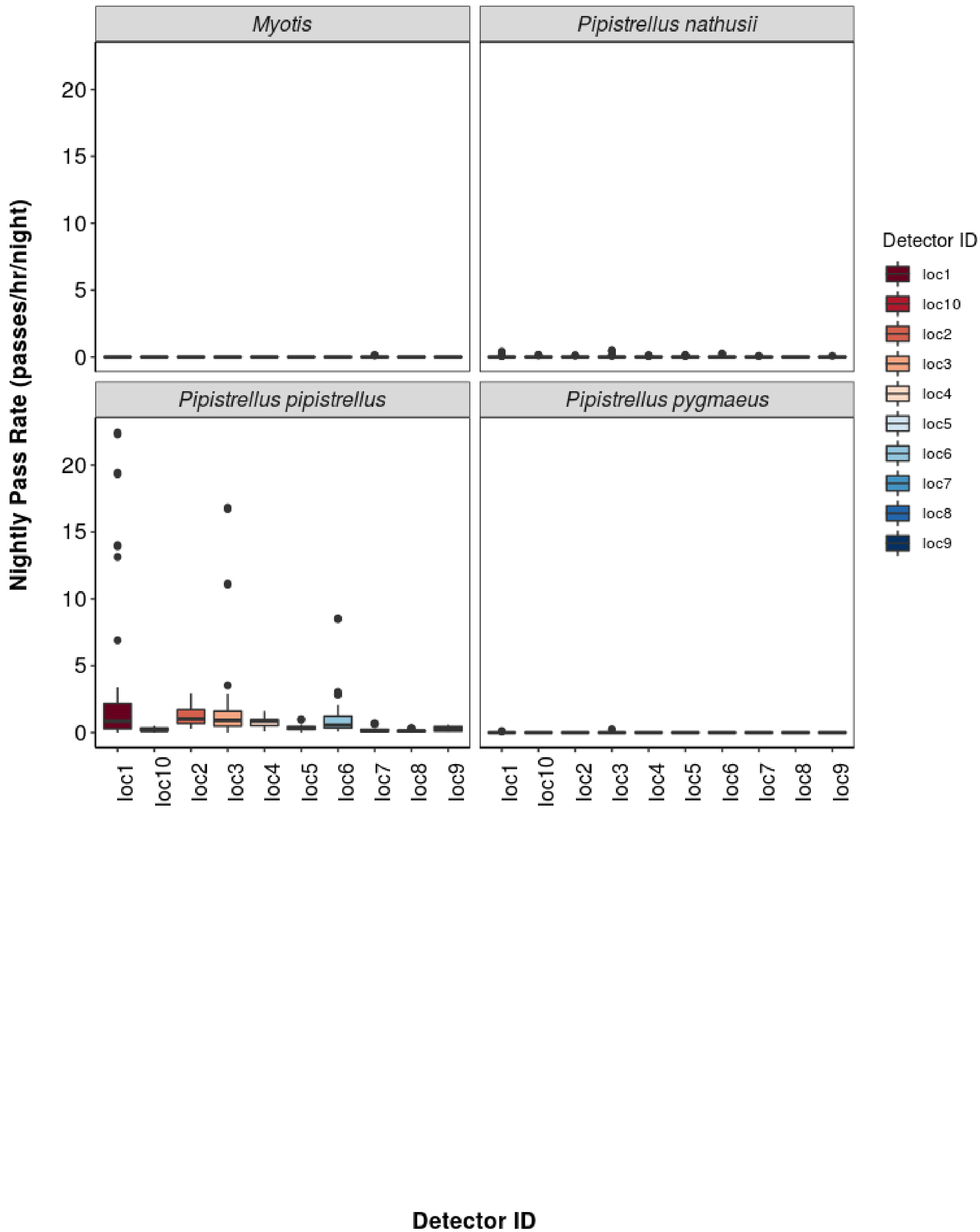
Species	Detector ID	Mean Pass Rate
Common pipistrelle	loc1	3.3
Common pipistrelle	loc10	0.2
Common pipistrelle	loc2	1.2
Common pipistrelle	loc3	2.0
Common pipistrelle	loc4	0.8
Common pipistrelle	loc5	0.4
Common pipistrelle	loc6	1.4
Common pipistrelle	loc7	0.2
Common pipistrelle	loc8	0.2
Common pipistrelle	loc9	0.3
Myotis	loc1	0.0
Myotis	loc10	0.0
Myotis	loc2	0.0
Myotis	loc3	0.0
Myotis	loc4	0.0
Myotis	loc5	0.0
Myotis	loc6	0.0
Myotis	loc7	0.0
Myotis	loc8	0.0
Myotis	loc9	0.0
Nathusius’	loc1	0.0
Nathusius’	loc10	0.0
Nathusius’	loc2	0.0
Nathusius’	loc3	0.0
Nathusius’	loc4	0.0
Nathusius’	loc5	0.0

Nathusius'	loc6	0.0
Nathusius'	loc7	0.0
Nathusius'	loc8	0.0
Nathusius'	loc9	0.0
Soprano pipistrelle	loc1	0.0
Soprano pipistrelle	loc10	0.0
Soprano pipistrelle	loc2	0.0
Soprano pipistrelle	loc3	0.0
Soprano pipistrelle	loc4	0.0
Soprano pipistrelle	loc5	0.0
Soprano pipistrelle	loc6	0.0
Soprano pipistrelle	loc7	0.0
Soprano pipistrelle	loc8	0.0
Soprano pipistrelle	loc9	0.0

Nightly Bat Passes (Bat passes per hour)

Per Detector - Figures

Figure 16. Figures show boxplots for the number of bat passes per hour each night, for each detector. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.


Myotis
Pipistrellus nathusii
Pipistrellus pipistrellus
Pipistrellus pygmaeus
Nightly Pass Rate (passes/hr/night)
0
5
10
15
20
loc1
loc10
loc2
loc3
loc4
loc5
loc6
loc7
loc8
loc9
Detector ID
Detector ID

Survey Effort

Table 24. The number of nights bats were detected per month per detector.

Month	Detector ID	No of Survey Nights
Jul	loc1	14
Jul	loc10	9
Jul	loc2	14
Jul	loc3	15
Jul	loc4	15
Jul	loc5	7
Jul	loc6	1
Jul	loc7	1
Jul	loc8	5
Aug	loc1	12
Aug	loc10	10
Aug	loc2	19
Aug	loc3	19
Aug	loc4	19
Aug	loc5	12
Aug	loc6	1
Aug	loc7	3
Aug	loc8	6
Aug	loc9	12
Sep	loc1	21
Sep	loc2	5
Sep	loc3	22
Sep	loc4	21
Sep	loc5	15
Sep	loc6	21
Sep	loc7	16
Sep	loc8	9
Sep	loc9	10
Oct	loc1	6
Oct	loc10	2
Oct	loc3	2

Oct	loc5	3
Oct	loc6	6
Oct	loc7	3
Oct	loc8	3
Oct	loc9	3

Nightly Bat Pass Rate for each Month

Median Per Detector

Table 25. The median Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. If NA, then no bat passes.

Bat pass rates are often highly variable between nights, with some nights having few or no passes and other nights having high activity. In these circumstances, the median is likely to be a more useful summary of the 'average' activity than is the mean. For further information see: *Lintott, P. R., & Mathews, F. (2018). Basic mathematical errors may make ecological assessments unreliable. Biodiversity and Conservation, 27(1), 265-267.* https://doi.org/10.1007/s10531-017-1418-5

Species	Detector ID	Aug	Jul	Oct	Sep
Common pipistrelle	loc1	0.5	0.3	7.7	1.4
Common pipistrelle	loc10	0.2	0.3	0.2	NA
Common pipistrelle	loc2	1.8	0.6	NA	0.8
Common pipistrelle	loc3	1.3	0.6	0.0	1.8
Common pipistrelle	loc4	0.9	0.9	NA	0.6
Common pipistrelle	loc5	0.4	0.3	0.2	0.4
Common pipistrelle	loc6	0.1	0.2	1.3	0.7
Common pipistrelle	loc7	0.1	0.0	0.1	0.2
Common pipistrelle	loc8	0.1	0.2	0.1	0.1
Common pipistrelle	loc9	0.5	NA	0.2	0.1
Myotis	loc1	0.0	0.0	0.0	0.0
Myotis	loc10	0.0	0.0	0.0	NA
Myotis	loc2	0.0	0.0	NA	0.0
Myotis	loc3	0.0	0.0	0.0	0.0
Myotis	loc4	0.0	0.0	NA	0.0
Myotis	loc5	0.0	0.0	0.0	0.0
Myotis	loc6	0.0	0.0	0.0	0.0
Myotis	loc7	0.0	0.2	0.0	0.0
Myotis	loc8	0.0	0.0	0.0	0.0
Myotis	loc9	0.0	NA	0.0	0.0
Nathusius'	loc1	0.0	0.0	0.0	0.0
Nathusius'	loc10	0.0	0.0	0.0	NA
Nathusius'	loc2	0.0	0.0	NA	0.0

Nathusius’	loc3	0.0	0.0	0.0	0.0
Nathusius’	loc4	0.0	0.0	NA	0.0
Nathusius’	loc5	0.0	0.0	0.0	0.0
Nathusius’	loc6	0.0	0.0	0.0	0.0
Nathusius’	loc7	0.0	0.0	0.0	0.0
Nathusius’	loc8	0.0	0.0	0.0	0.0
Nathusius’	loc9	0.0	NA	0.0	0.0
Soprano pipistrelle	loc1	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc10	0.0	0.0	0.0	NA
Soprano pipistrelle	loc2	0.0	0.0	NA	0.0
Soprano pipistrelle	loc3	0.0	0.0	0.2	0.0
Soprano pipistrelle	loc4	0.0	0.0	NA	0.0
Soprano pipistrelle	loc5	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc6	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc7	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc8	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc9	0.0	NA	0.0	0.0

Nightly Bat Pass Rate for each Month

Mean per Detector

Table 26. The mean Nightly Pass Rate (bat passes per hour, per night) of each species throughout each month. Values are given to 1 decimal place.

We recommend using the median values given above, for the reasons stated above, but provide the mean values in the table below.

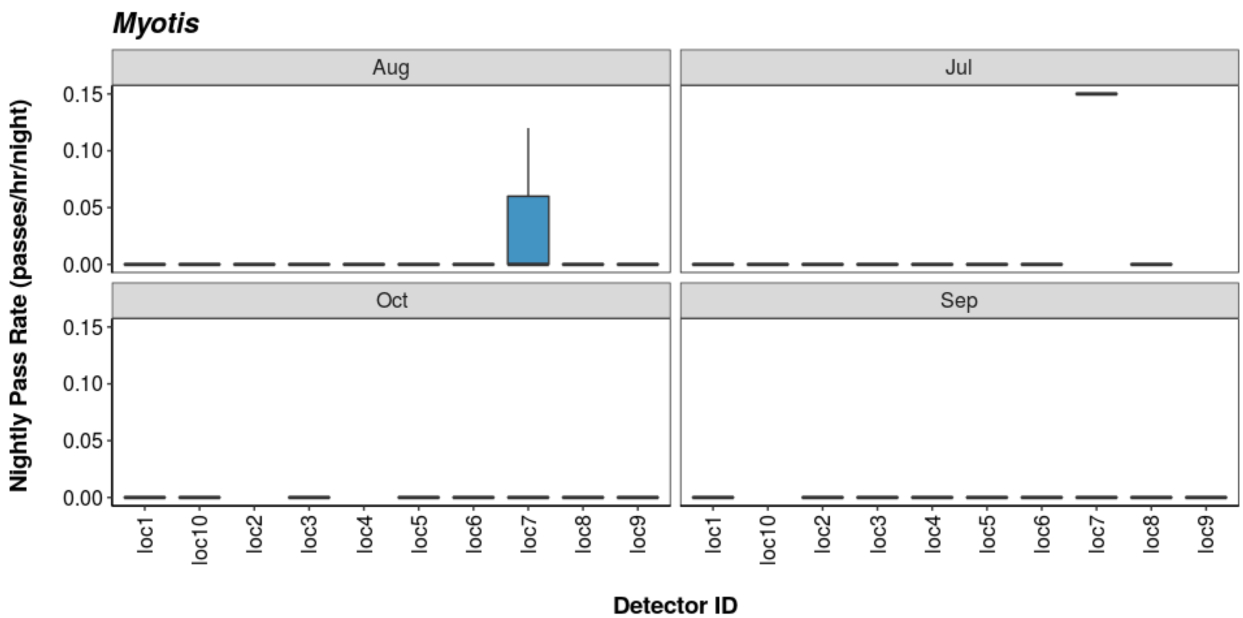
Species	Detector ID	Aug	Jul	Oct	Sep
Common pipistrelle	loc1	0.7	0.3	9.6	4.9
Common pipistrelle	loc10	0.2	0.2	0.2	NA
Common pipistrelle	loc2	1.7	0.7	NA	0.8
Common pipistrelle	loc3	1.3	0.6	0.0	3.7
Common pipistrelle	loc4	0.9	0.8	NA	0.7
Common pipistrelle	loc5	0.3	0.3	0.2	0.4
Common pipistrelle	loc6	0.1	0.2	1.5	1.5
Common pipistrelle	loc7	0.1	0.0	0.1	0.3
Common pipistrelle	loc8	0.2	0.2	0.1	0.1
Common pipistrelle	loc9	0.4	NA	0.2	0.1
Myotis	loc1	0.0	0.0	0.0	0.0
Myotis	loc10	0.0	0.0	0.0	NA
Myotis	loc2	0.0	0.0	NA	0.0
Myotis	loc3	0.0	0.0	0.0	0.0
Myotis	loc4	0.0	0.0	NA	0.0
Myotis	loc5	0.0	0.0	0.0	0.0
Myotis	loc6	0.0	0.0	0.0	0.0
Myotis	loc7	0.0	0.2	0.0	0.0
Myotis	loc8	0.0	0.0	0.0	0.0
Myotis	loc9	0.0	NA	0.0	0.0
Nathusius’	loc1	0.0	0.0	0.1	0.1
Nathusius’	loc10	0.0	0.0	0.0	NA
Nathusius’	loc2	0.0	0.0	NA	0.0
Nathusius’	loc3	0.0	0.0	0.0	0.1
Nathusius’	loc4	0.0	0.0	NA	0.0
Nathusius’	loc5	0.0	0.0	0.0	0.0

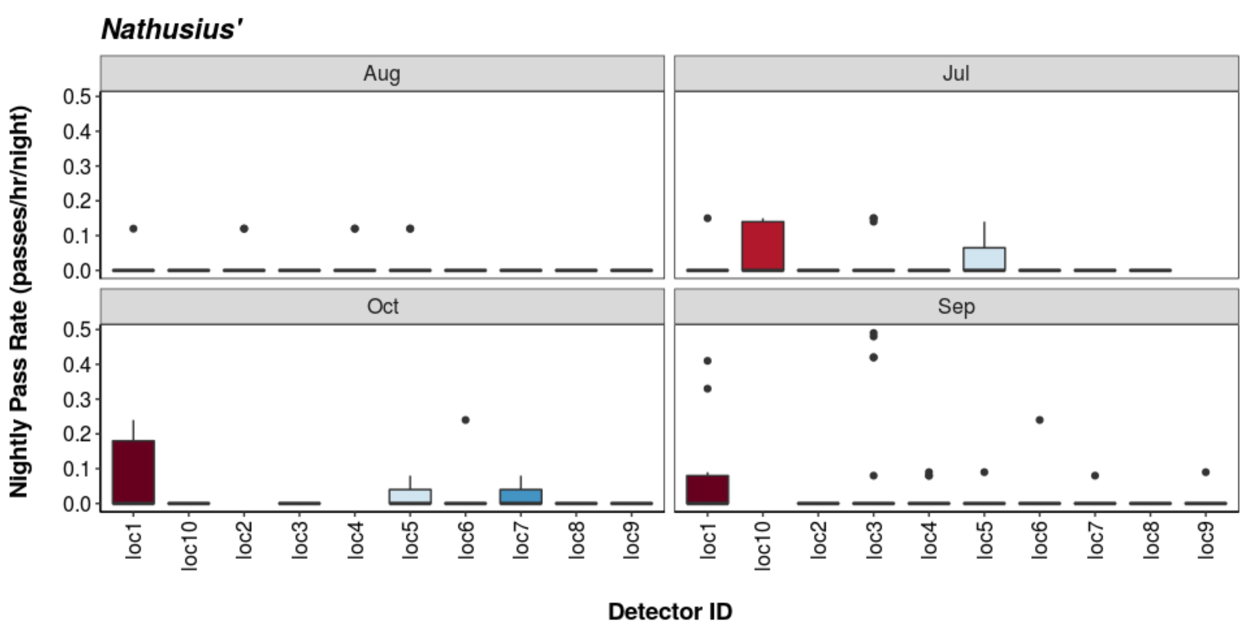
Nathusius’	loc6	0.0	0.0	0.0	0.0
Nathusius’	loc7	0.0	0.0	0.0	0.0
Nathusius’	loc8	0.0	0.0	0.0	0.0
Nathusius’	loc9	0.0	NA	0.0	0.0
Soprano pipistrelle	loc1	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc10	0.0	0.0	0.0	NA
Soprano pipistrelle	loc2	0.0	0.0	NA	0.0
Soprano pipistrelle	loc3	0.0	0.0	0.2	0.0
Soprano pipistrelle	loc4	0.0	0.0	NA	0.0
Soprano pipistrelle	loc5	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc6	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc7	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc8	0.0	0.0	0.0	0.0
Soprano pipistrelle	loc9	0.0	NA	0.0	0.0

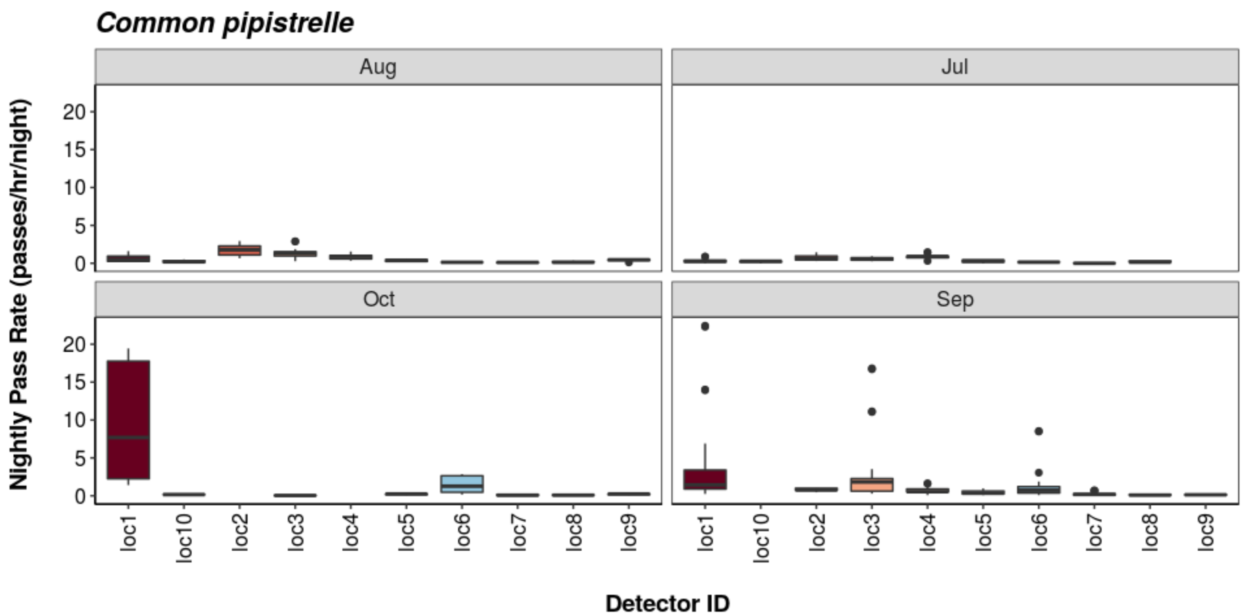
Nightly Bat Pass Rate for each Month

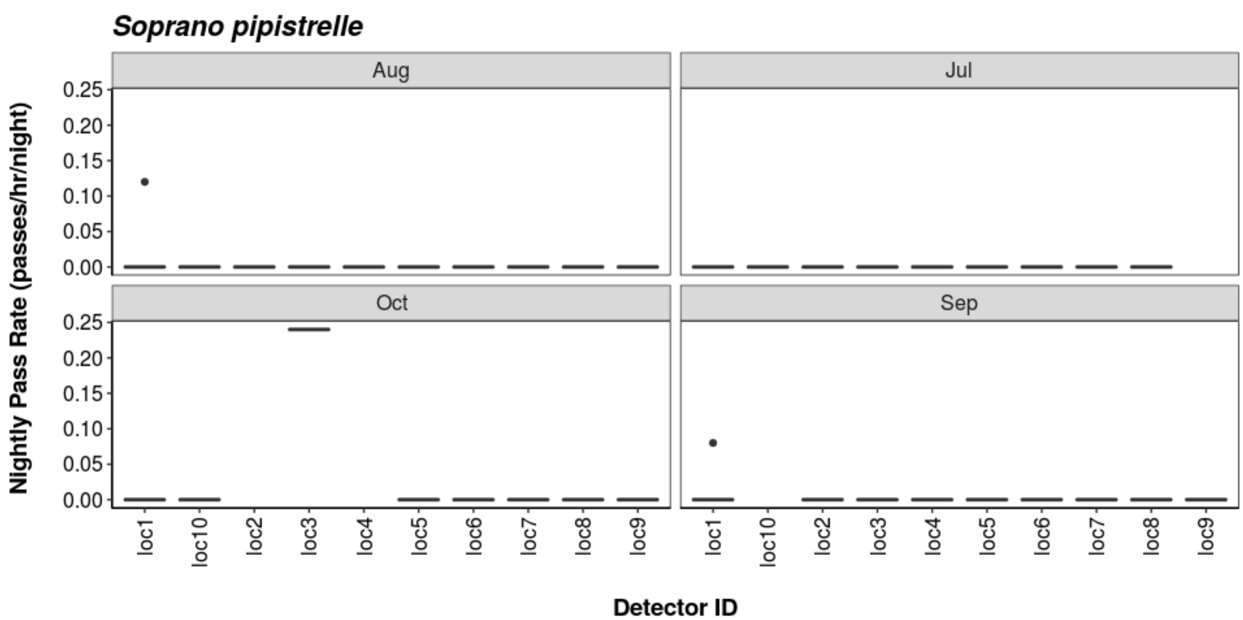
Per Detector - Figures

Figure 17. Figures show boxplots for the number of bat passes per hour by detector, for each month. The 'box' shows the interquartile range, which is where the middle 50% of the data lie. The line dividing the box is the median, the mid-point of the data. The 'whiskers' extend from the box and represent the ranges for the bottom 25% and the top 25% of the data values, excluding outliers. An outlier is any extreme value that lies further away from the box than 1.5 times the interquartile range. Outliers are shown as dots. Where very few passes are recorded it is not possible to produce the box, so the data are shown as a line.






Common pipistrelle
Aug
Jul
Oct
Sep
Nightly Pass Rate (passes/hr/night)
0
5
10
15
20
loc1
loc10
loc2
loc3
loc4
loc5
loc6
loc7
loc8
loc9
Detector ID


Soprano pipistrelle
Aug
Jul
Oct
Sep
Nightly Pass Rate (passes/hr/night)
0.00
0.05
0.10
0.15
0.20
0.25
loc1
loc10
loc2
loc3
loc4
loc5
loc6
loc7
loc8
loc9
Detector ID

Bat Activity per Detector Location

Figure 18. Detector ID reference:

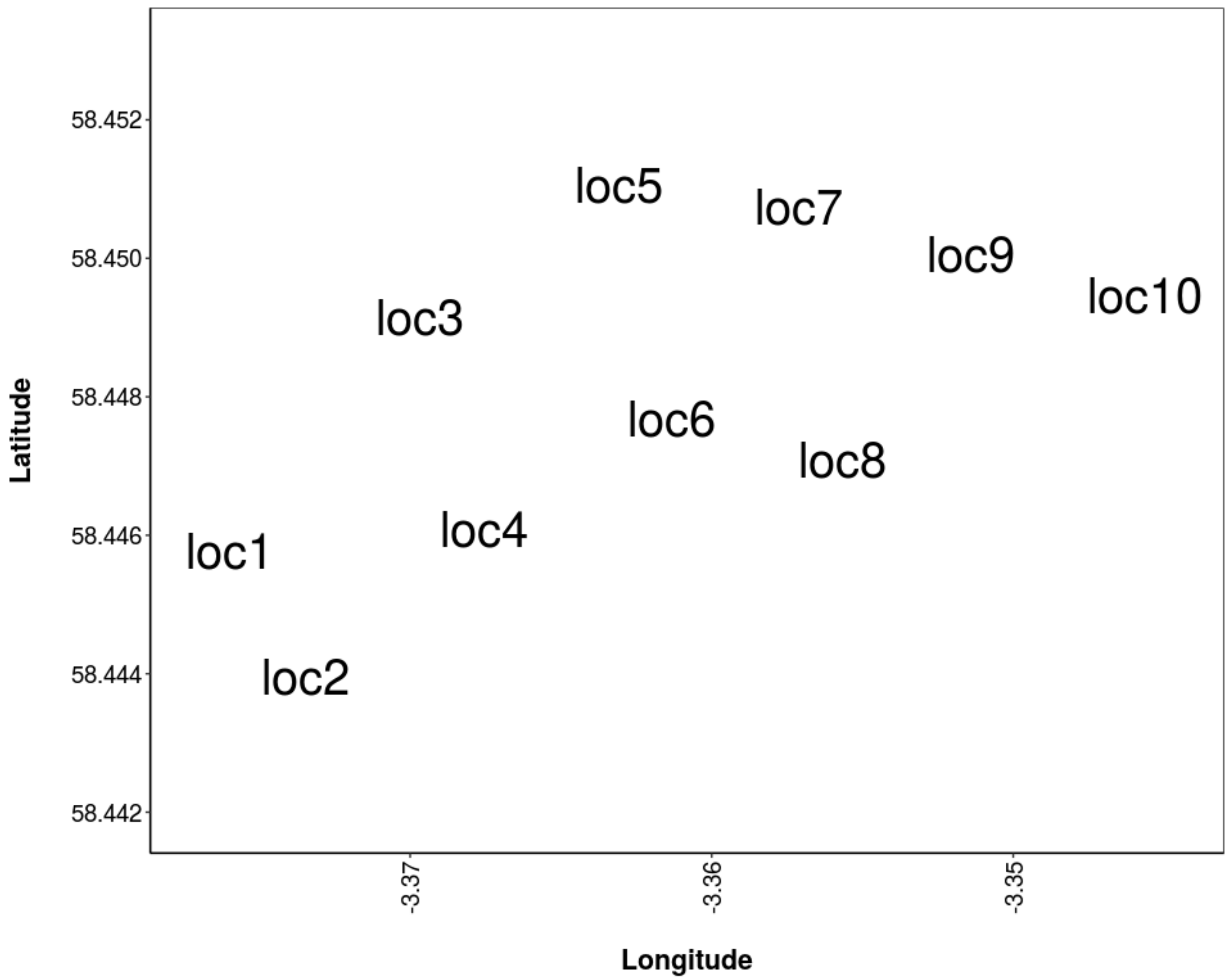


Figure 19. Median Nightly Pass Rate (bat passes/hr/night) throughout the survey period - represented by the size and colour of the point at each detector location.

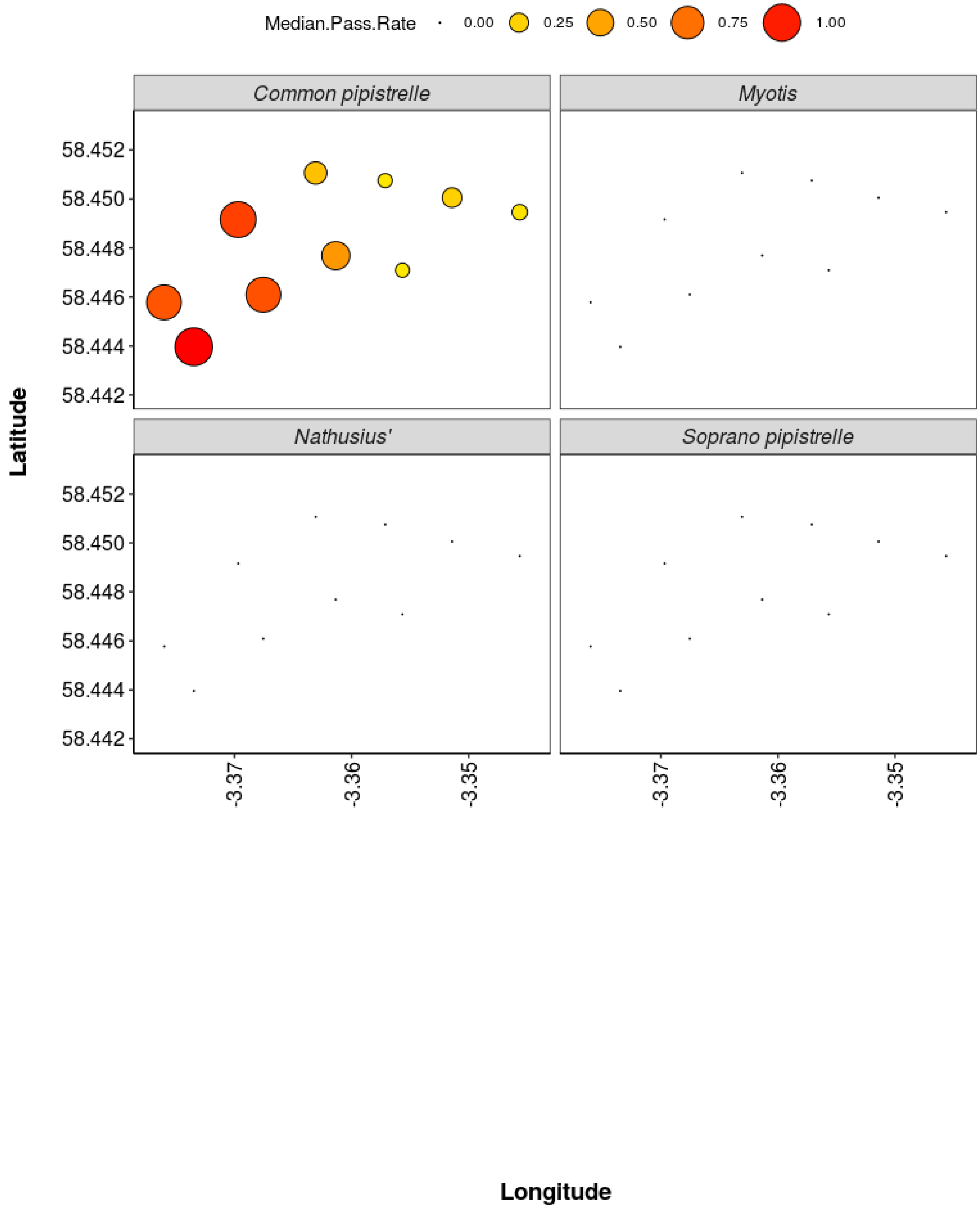
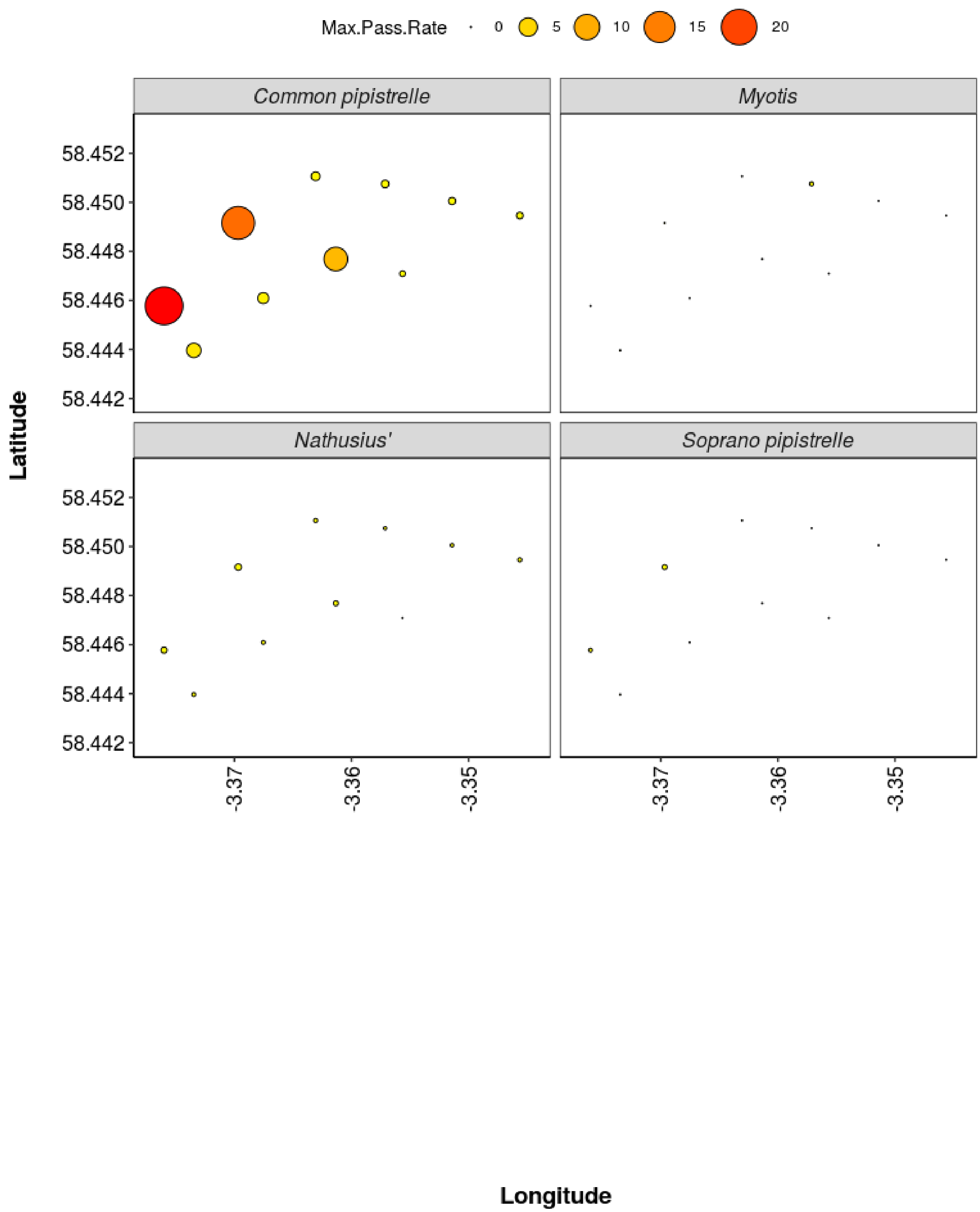


Figure 20. Maximum Nightly Pass Rate (bat passes/hr/night) recorded in a single night throughout the survey period - represented by the size and colour of the point at each detector location.



Thank you for using Ecobat! If you have any questions please email
info@themammalsociety.org.uk

Watten Wind Farm

Fisheries Survey Report

Technical Appendix 7.4

Date:	September 2015
Tel:	0141 342 5404
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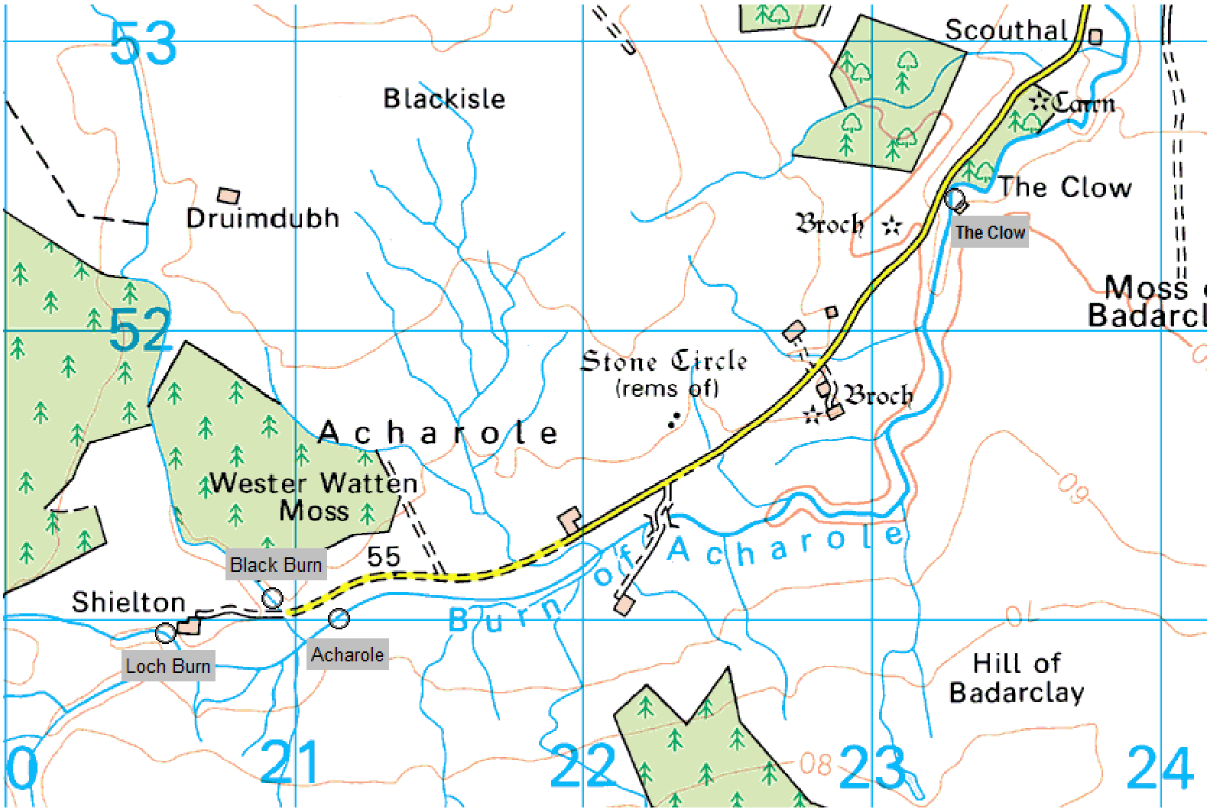
Salmonid Habitat and Electric-fishing Surveys of the Burn of Acharole Catchment, Wick River, September, 2015.

1. Introduction.

This report documents the results of electric-fishing and habitat surveys carried out in the Wick River catchment by the Caithness District Salmon Fishery Board for MacArthur Green in relation to a proposed development near Acharole, Caithness.

There are four survey sites. Three are in the vicinity of Shielton farm, in or near the proposed development area (Black Burn, Loch Burn and Acharole), and the fourth (The Clow) lies downstream of the development site and about 3km distant. The positions of the four sites are shown in the map below.



2. Survey methods.

Electric fishing and habitat surveys were carried out under low water conditions. The methods were those documented by the SFCC although additional methods were used where appropriate in order to increase data quality.

For electric fishing a bankside generator and control box were used to deliver power to the electrode probe. Stop-nets were deployed to prevent fish leaving or entering the survey sector while electric fishing survey was in progress. The three-pass depletion method was used in order to estimate true numbers of fish from the rate of decline in capture numbers on successive passes.

For each pass, salmon and trout were identified to species by inspection, counted and measured (fork length). Fry (aged 0+ years) were distinguished from older fish (parr) by inspection; in cases of doubt, samples of scales were obtained from fry for confirmation of age by scale-reading. Scale samples were taken from parr and individuals were allocated to cohort (mostly age 1+ or 2+ years) on the same basis.

Habitat surveys generally followed the SFCC protocol but, when appropriate, categorisation of habitat features was based on metrics obtained during the survey rather than on judgement alone. In order to support this approach, measurement of stream depth, open stream width and undercutting were made at appropriate intervals along the length of the survey site. Any lateral bar features were also measured.

Stream depth was measured in the central channel and at the right and left bank margins at ca. 10% and 90% of total channel width. In the wider streams at the Acharole and Clow survey sites additional, intermediate values were also obtained at ca. 30% and 70% of total channel width.

Streambed clast composition was estimated by inspection but enhanced by measurements taken from photographs of any exposed bar feature in the survey site.

Photographs were taken of the position of the upper and lower stop-net positions in order to facilitate any future repeat of the survey work. The stop-nets positions can be relocated to define the limits of the standard survey site, allowing direct comparisons of sites between years.

3. Survey data

3.1. Black Burn.

The Black Burn originates in minor field drainage systems ca. 4km to the north of the survey site, beyond the B870 public road. The stream flows southwards through low intensity farmland and skirts two forestry blocks (Western Watten Moss) before joining the Burn of Acharole at the southern edge of the proposed development site. The confluence is about 100m south-east of the end of the minor public road that links the village of Watten with Shielton farm.

Figure 1. The general vicinity of the Black Burn survey site looking northwest.

The stream section selected for survey lies above the access road to Sheilton farm; the lower extremity of the section is ca. 170m upstream of the stream's confluence with the Burn of Acharole. The stream's course is probably natural at the survey site. However, the channel is noticeably linear and deeply incised with vertical, symmetrical banks. If any channel modification has taken place it must be regarded as historical since the channel and its surrounds now appear fully mature.

The stream's banks are dominated by coarse grasses of mixed composition. The wider setting is rather uniform and comprises rough grazing by sheep. There are fences on both sides of the stream and, although exclusion of sheep is evidently imperfect, grazing pressure on the stream margins is low.

The habitat survey was carried out on 14th Sep, 2015 under low flow conditions. Electrical conductivity of the stream water was 376µS.cm^{-1}.

Figure 2. The lower (left) and upper (right) limits of the Black Burn survey site defined by stop-nets. The direction of flow is indicated.

3.1.1. Channel characteristics. The survey section limits were defined by natural constrictions. The section includes two long pool areas bounded by short, shallow riffles and is generally typical of the stream in the wider vicinity. The section length is 51.8m

The stream's water was darkly stained and slightly opaque. As a result, the streambed was not visible in the deeper areas. However, the substrate is loose underfoot and, where visible, composed of elongated clasts that are generally < 200mm on the lesser axis. The approximate composition of the surface substrate is 20% cobble, 40% pebble and 40% gravel.

Figure 2. Exposed clasts at the Black Burn stream channel.

Sand and silt are essentially absent throughout but the surface of the streambed is clothed with fine organic debris in the deeper, slow-flowing areas. Aquatic macrophytes are absent.

The open channel width and undercutting on each bank were measured at 2m intervals; there were no bar intrusions in the survey section.

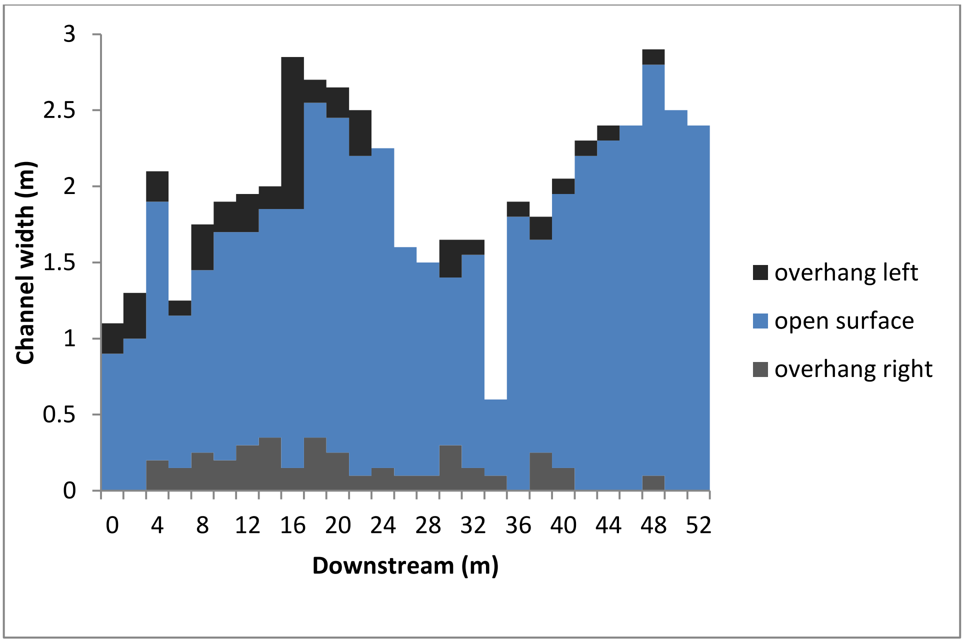


Figure 5. Schematic diagram of the surface features of the channel at the Black Burn survey site.

Figure 5 depicts the conformation of the stream channel in schematic form. The upper limit of the right bank (looking downstream, as per convention) is the zero datum point.

Undercutting is a prominent feature of both banks throughout. The constriction at 32m is due to an isolated discontinuity on the left bank which is clothed in vegetation. The left bank also features two areas of overhanging vegetation at 27.4 to 30.5m and 44.8 to 47.4m.

The average value for measured stream width was 2.00m and since the survey site is 51.8m in length, the wetted area of the survey site is calculated to be 103.6m^2.

Depth measurements were also made at 2.0m intervals from the upstream limit of the section which was defined as the zero datum point.

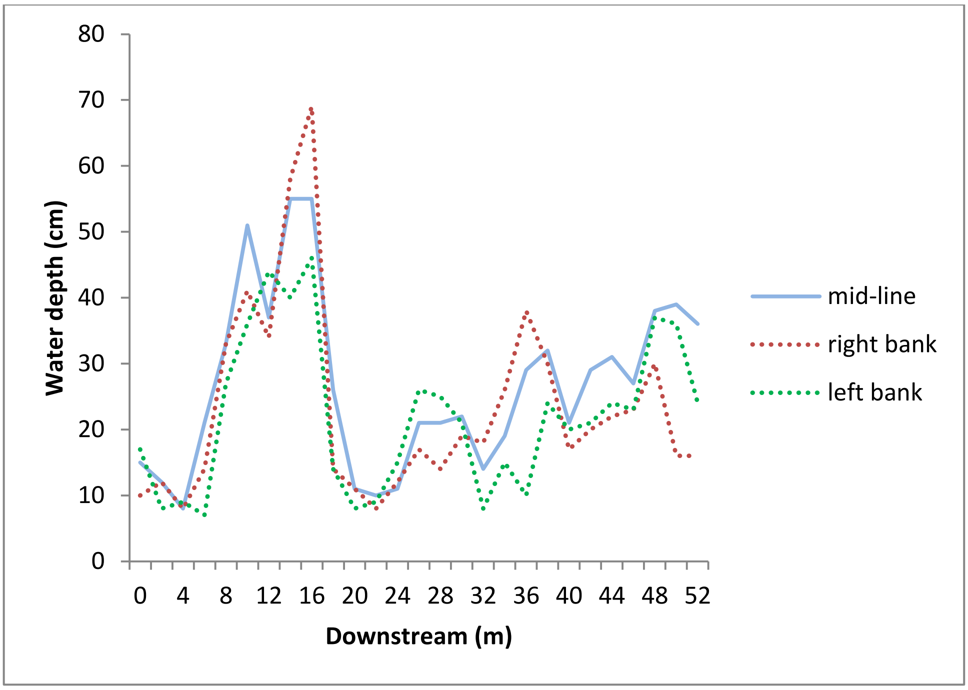


Figure 3. Stream depth profiles for the Black Burn survey site.

Figure 3 illustrates the relative uniformity of channel depth across the stream's width, the positions and extents of the short riffle sections, at around 4 and 20m, and the conformation of the two dominant pool features.

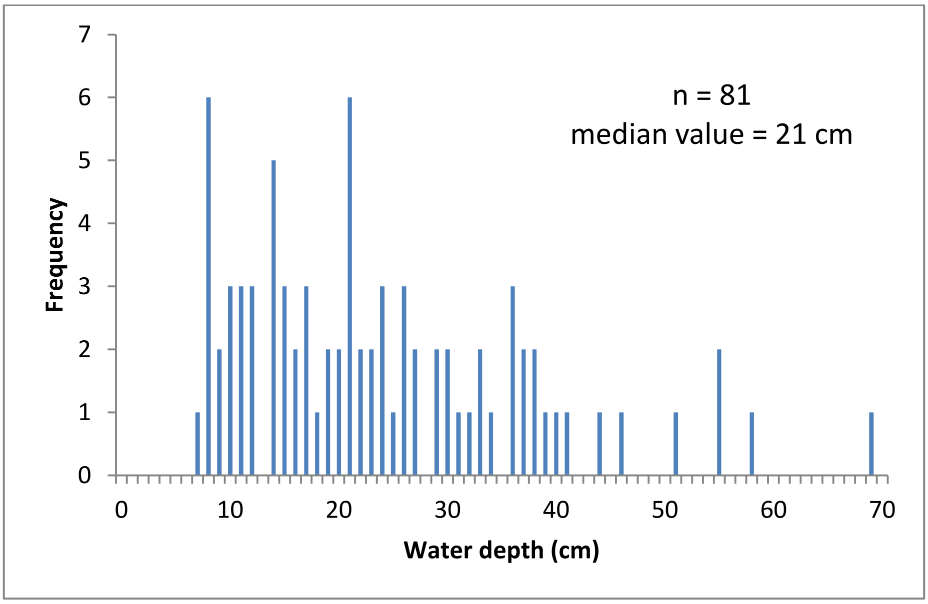


Figure 4. Frequency diagram for stream depths measured at the Black Burn survey site.

Figure 4 shows that the frequencies of occurrence of the measured stream depths was dominated by values in the 10 to 40cm range; the median value was 21cm.

3.1.2. Salmonids and other fish species

The electric fishing survey was carried out on 29th August, 2015 under low water conditions. Juvenile salmon and brown trout were captured. The additional presence of eels and sticklebacks was noted.

Species	**Fry**			**Parr**		
	1st pass	**2nd pass**	**3rd pass**	**1st pass**	**2nd pass**	**3rd pass**
Salmon	27	3	3	22	0	0
Brown trout	7	0	1	24	4	1

Table 1. Black Burn: Observed numbers of salmon and brown trout on successive electric fishing passes.

Table 1 gives the primary electric fishing data - the numbers of fry and parr of each of the target species captured in each of the three successive electric fishing passes.

It can be seen that salmon fry outnumber brown trout fry but that salmon and trout parr are more evenly represented.

Observed density values for salmon were evaluated by comparison with the analysis carried out by Godfrey (2005) using SFCC data. Table 26d of Godfrey's report provides a basis for comparison based on quintile values for observed density as calculated from capture numbers for single-pass electric-fishing - or for the first pass of 3-pass fishing as in the present case.

On this basis, the density of salmon fry observed on the first electric fishing pass ($0.26.m^{-2}$) puts it between the 40th and 60th percentile values proposed by Godfrey. For salmon parr the density observed on the first pass ($0.21.m^{-2}$) was between the 80th and 100th percentile values proposed by Godfrey.

Species	Observed Density (n.m^{-2}) and year of hatch				
	0+ fry (2015)	1+ parr (2014)	2+ parr (2013)	3+ parr (2012)	All parr
Salmon	0.32	0.21	-	-	0.21
Brown trout	0.08	0.23	0.03	0.02	0.28

Table 2. Black Burn: Observed densities of salmon and brown trout by age-class.

Table 2 shows the observed density of each species by age class. Fry and 1+ parr were predominant for both species.

Species	Estimated True Density (n.m^{-2})	
	0+ fry	All parr
Salmon	0.32	0.21
Brown trout	0.08	0.28

Table 3. Black Burn: Estimated true densities of fry and parr.

Table 3 gives the definitive, estimated true densities for fry and parr of both species based on Zippin correction for fishing efficiency. The value for trout fry is carried over from Table 2 because the low numbers observed are not suited to correction.

In Figures 6 and 7, frequency diagrams show body length by age-class for salmon and trout, respectively.

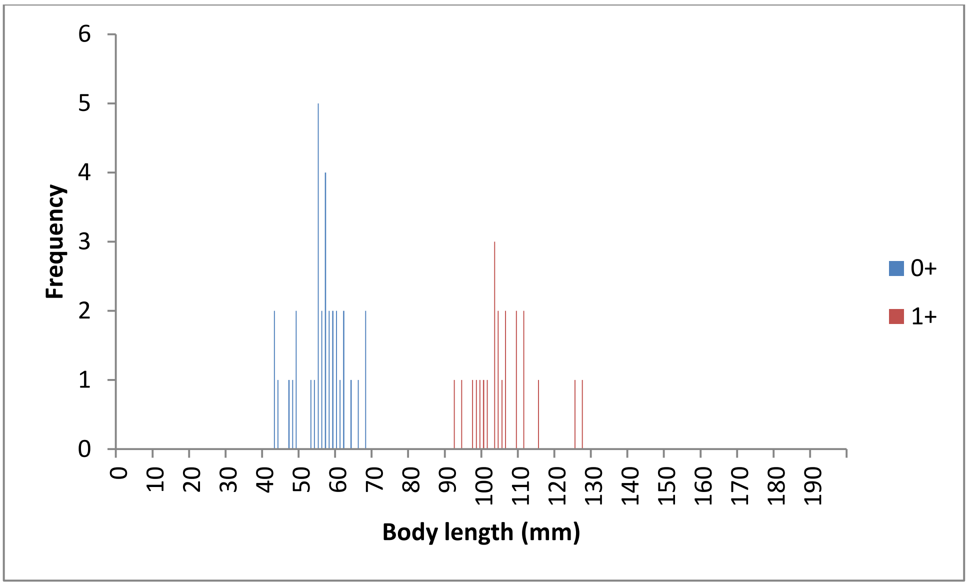


Figure 6. Black Burn: Frequency distribution of salmon body-lengths by age-class.

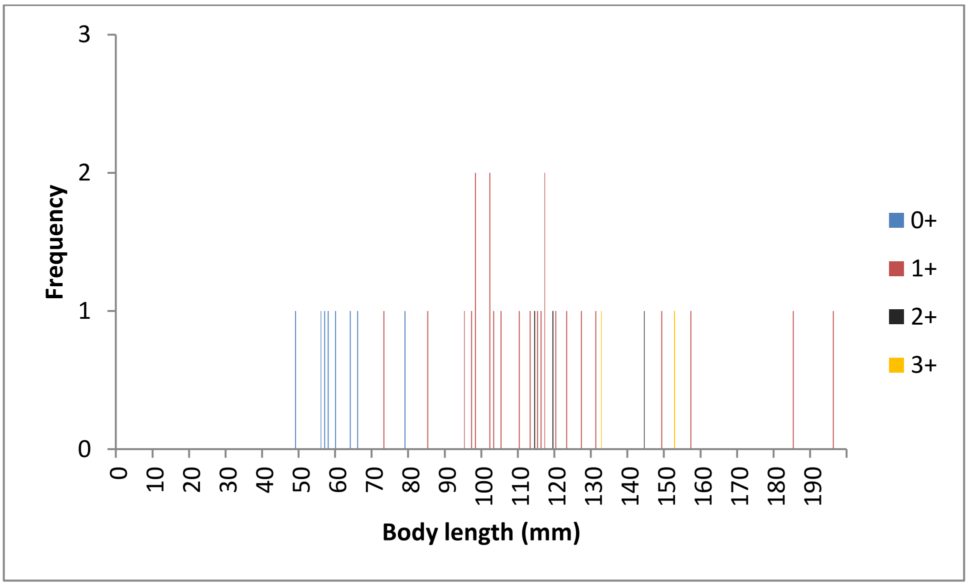


Figure 7. Black Burn: Frequency distribution of brown trout body-lengths by age-class.

Figure 7 shows distributions that are generally as expected. However, among the 1+ class of trout there are three values that are unexpectedly high (but cf. Figure 16).

The values for body length of both species are tabulated in Table 4. For the 1+ class of trout, the median value is given to accommodate the over-dispersed distribution of their lengths.

Species	Mean length (mm).			
	0+ fry	1+ parr	2+ parr	3+ parr
Salmon	56.1 (6.50)	105.5 (8.67)	-	-
Brown trout	61.1 (8.89)	114	126	142

Table 4. Black Burn: The mean body lengths of salmon and trout by age-class. Where the numbers are sufficient, the standard deviation is given in parentheses. The median value is shown for 1+ trout.

3.2. Loch Burn.

The Loch Burn catchment includes minor field drains north of Loch Toftingall and minor streams in the forests on the Moss of Toftingall and Backlass Moss. The main stream originates as the outflow from Loch Toftingall to the north which supports an important sports fishery for brown trout; these fish may well leave the loch outlet to spawn in the Loch Burn. The stream flows southwards through wide buffer zones between two forest blocks for ca. 1 km before entering the extensive area of rough grazing that includes the survey site.

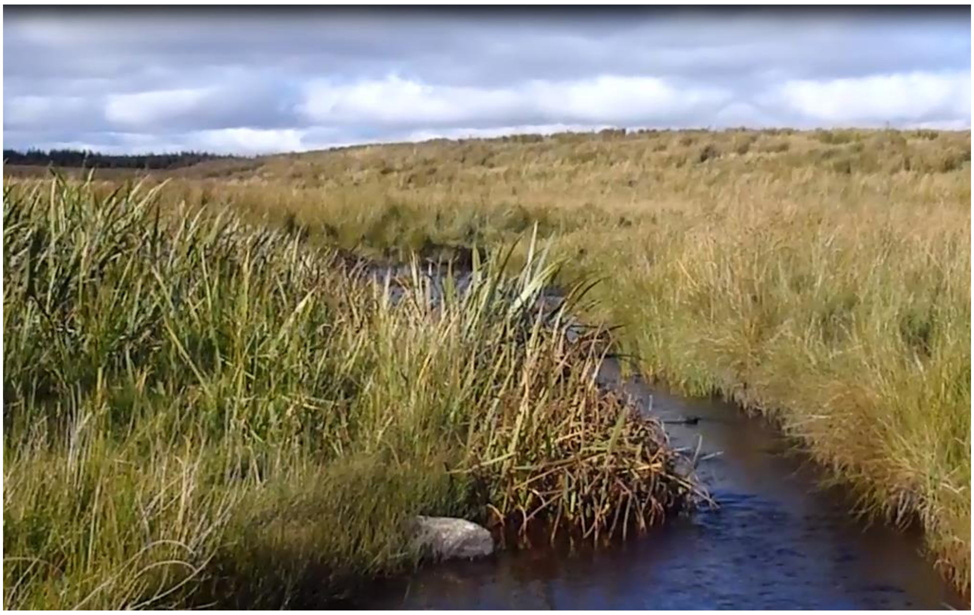


Figure 8. The general vicinity of the Loch Burn survey site looking northwest.

The survey site is near Shielton farm (uninhabited) and extends downstream from the lower margin of the unused ford near the farm buildings for a distance of 52.8m. The outflow from Loch Toftingall is ca. 1.6 km upstream of the survey site. The lower limit of the site is ca. 100m from the stream's confluence with the Burn of Acharole. The stream lies in a setting comprising extensive rushes and rough pasture grazed by sheep. The stream margins are dominated by coarse grasses and the stream is unfenced.

The survey site was selected to be representative of the stream in the wider vicinity. The site's limits were chosen to coincide with existing stream features – a lower constriction and an upper riffle below the ford. The survey section appears to be natural. It comprises two long pool areas headed by riffles. The survey section is 52.8m in length.

Figure 9. The lower (left) and upper (right) limits of the Loch Burn survey site defined by stop-nets. The direction of flow is indicated.

3.2.1. Channel characteristics.

The habitat survey was carried out on 15th September, 2015 under low water conditions. Conductivity was 312µS.cm^{-1}.

The stream water is only very lightly stained. The stream channel is incised and the banks are deeply undercut in parts. Macrophytes are a minor feature confined to parts of the stream margins on bar features.

The stream substrate is of uniform grade throughout and it uncompacted. The streambed clasts are dominated by pebbles and stones of < 100 mm grade. The approximate composition of the surface substrate is 20% cobble, 40% pebble and 40% gravel. Sand and silt are essentially absent.

Figure10. Exposed clasts in the Loch Burn stream channel.

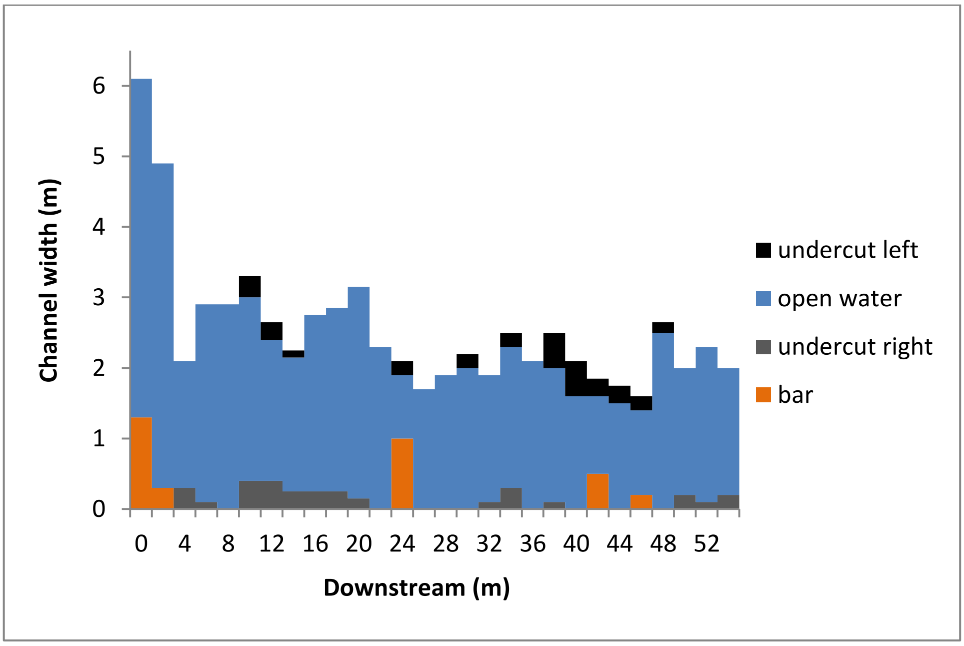


Figure 11. Schematic diagram of the surface features of the channel at the Loch Burn survey site; the zero datum point is defined as the upper, right-bank limit of the site.

Figure 11 shows extensive under-cutting along both banks. On the right bank, areas of undercutting are divided by the intrusion of three bar features. The upper end of the survey section comprises a wide, shallow riffle flanked by a bar feature; the remainder of the section is more uniform but still relatively variable.

The average width of the stream surface is 2.0 m. Since the section is 52.8m in length, the wetted area surveyed is calculated as 105.6 m^2.

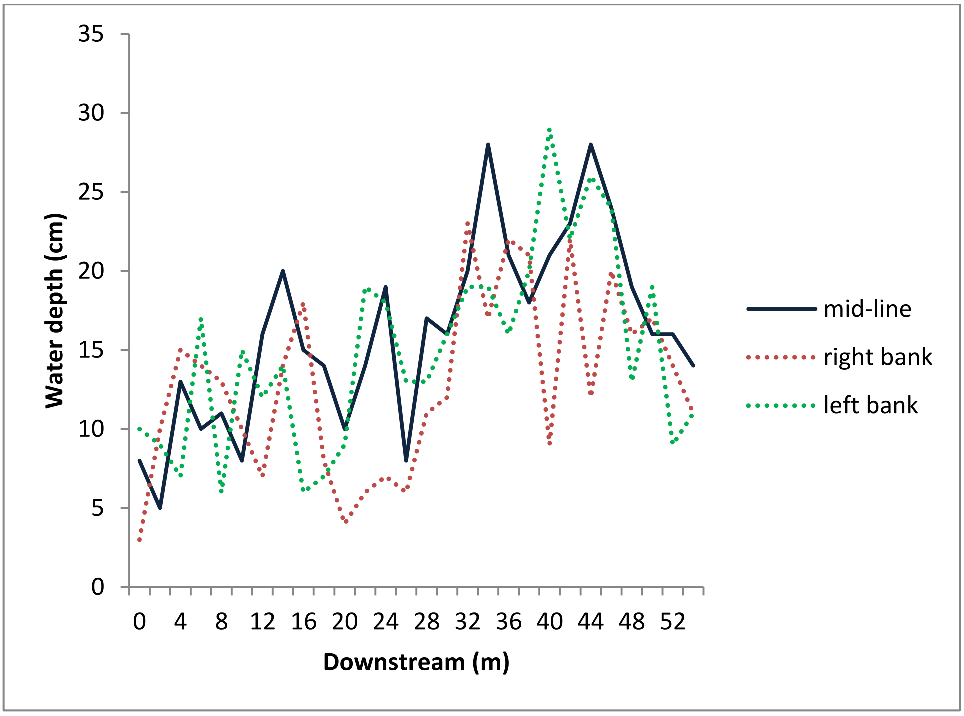


Figure 12. Stream depth profiles for the Loch Burn survey site.

Figure 12 shows that the survey section is relatively heterogeneous with respect to water depth. Depth increases irregularly from the upstream limit of the survey section, with the deeper marginal water being biased to the left bank.

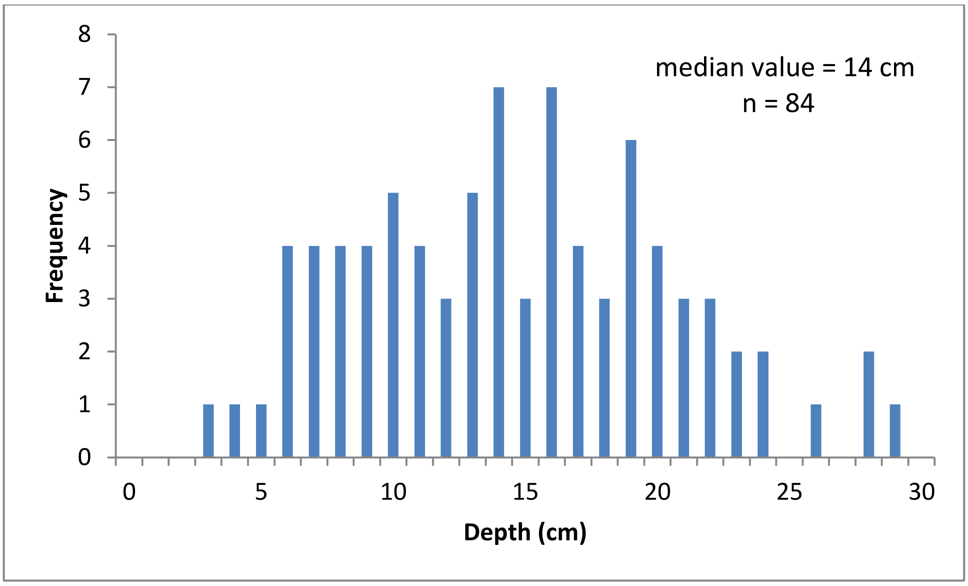


Figure 13. Frequency diagram for stream depths measured at the Loch Burn survey site.

Figure 13 shows the frequency distribution of depth measurements. Most values lie in the 6 – 22 cm range; the median value is 14 cm.

3.2.2. Salmonids and other fish species

The electric fishing survey was carried out on 29th August, 2015 under low water conditions. Juvenile salmon and brown trout were captured. The additional presence of eels and sticklebacks was noted.

Species	**Fry**			**Parr**		
	1st pass	**2nd pass**	**3rd pass**	**1st pass**	**2nd pass**	**3rd pass**
Salmon	67	19	6	29	2	0
Brown trout	5	0	1	12	3	0

Table 5. Loch Burn: Observed numbers of salmon and brown trout on successive electric fishing passes.

Table 5 gives the primary electric fishing data - the numbers of fry and parr of each of the target species captured in each of the three successive electric fishing passes.

It can be seen that salmon fry out-number brown trout fry but that the species are more evenly represented at the parr stage.

Observed density values for salmon were evaluated by comparison with the analysis carried out by Godfrey (2005) using SFCC data. Table 26d of Godfrey's report provides a basis for comparison based on quintile values for observed density as calculated from capture numbers for single-pass electric-fishing - or for the first pass of 3-pass fishing as in the present case.

On this basis, the density of salmon fry observed on the first electric fishing pass ($0.63.m^{-2}$) lies between the 80th and 100th percentile values proposed by Godfrey. For salmon parr the density observed on the first pass ($0.27.m^{-2}$) also lies within the 80th to 100th percentile range proposed by Godfrey.

Species	Observed Density ($n.m^{-2}$) and year of hatch				
	0+ fry (2015)	1+ parr (2014)	2+ parr (2013)	3+ parr (2012)	All parr
Salmon	0.87	0.29	-	-	0.29
Brown trout	0.05	0.13	0.01	-	0.14

Table 6. Loch Burn: *Observed densities of salmon and brown trout by age-class.*

Table 6 shows the observed density of each species by age class as determined by scale-reading. Fry and 1+ parr were predominant for both species; older parr were essentially absent.

Species	Estimated True Density ($n.m^{-2}$)	
	0+ fry	All parr
Salmon	0.89	0.31
Brown trout	0.05	0.14

Table 7. Loch Burn: Estimated true densities of fry and parr.

Table 7 gives the definitive, estimated true densities for fry and parr of both species based on Zippin correction for fishing efficiency. The values for trout fry are carried over from Table 6 because the low numbers observed are not suited to correction.

In Figures 14 and 15, frequency diagrams show body length by age-class for salmon and trout, respectively. The same values are tabulated in Table 8.

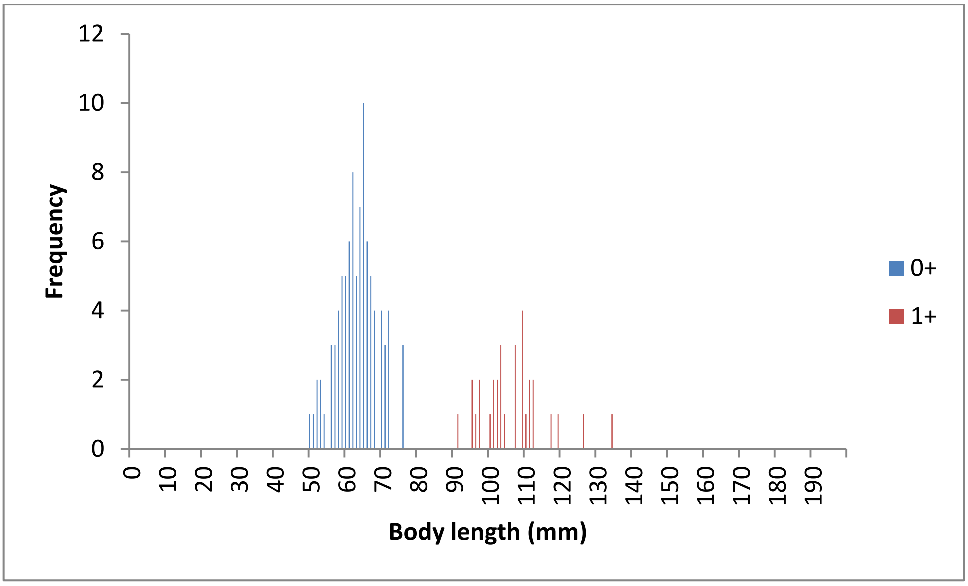


Figure 14. Loch Burn: Frequency distribution of salmon body-lengths by age-class.

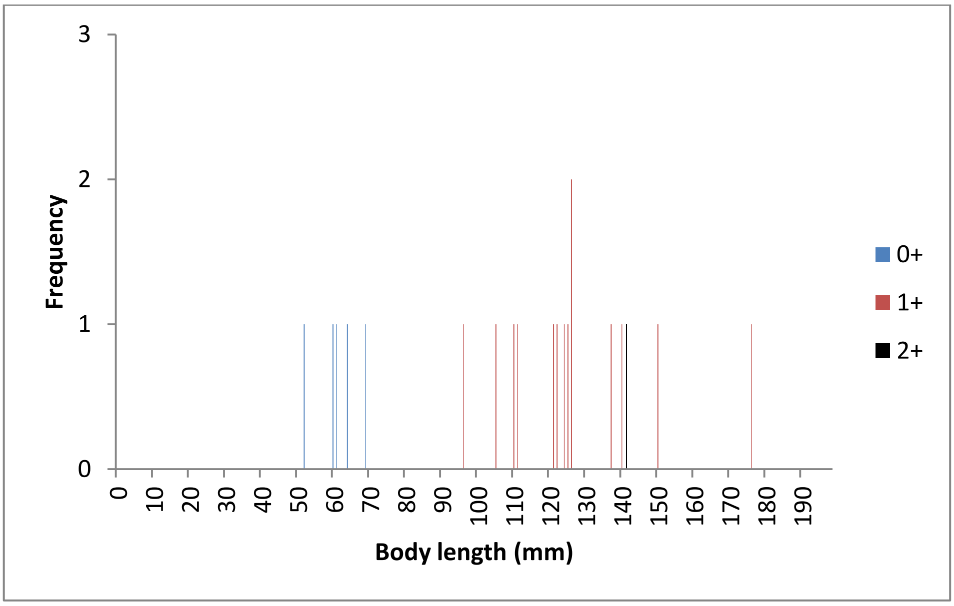


Figure 15. Loch Burn: Frequency distribution of brown trout body-lengths by age-class.

Species	Mean length (mm).			
	0+ fry	1+ parr	2+ parr	3+ parr
Salmon	63.2 (5.59)	106.4 (9.17)	-	-
Brown trout	61.2	126.4 (20.1)	141	-

Table 8. Loch Burn: The mean body lengths of salmon and trout by age-class. Where the numbers are sufficient, the standard deviation is given in parentheses.

3.3. Acharole.

The Burn of Acharole originates in a number of small streams leading from the Green Folds and the Dubh Lochs of Shielton to the south and from Halsary forest to the west. The stream flows eastwards along the southern boundary of the proposed development site. The Acharole survey site lies at ND 211600 51000, downstream of the stream's confluences with the Loch Burn (ca. 600m) and the Black Burn (ca. 100m) and just outside the development site itself.

Again, the stream's vicinity is dominated by extensive rough grassland and bogland and this is grazed by sheep. The channel is incised with vertical banks clothed in the same rough grasses. The survey section is fenced only on the left bank.

Figure16. The general vicinity of the Acharole survey site looking westwards.

The stream is natural. It is predominantly of low gradient and therefore dominated by glides or pools for some distance around the survey site. However, the selected survey section includes a riffle area bounded by a bar feature on the left bank which separates two pool features. The right bank is raised and eroded by water action; the left bank features an extensive lateral bar. The survey section is 29.0m in length.

Figure 17. The lower (left) and upper (right) limits of the Acharole survey site defined by stop-nets. The direction of flow is indicated.

3.3.1. Channel characteristics. The survey was carried out on 14th September, 2015. Conductivity was 244μS.cm^{-1}.

The stream's water is stained from passage through peat. A single area of groundwater ingress (ca. $2m^2$) is evident from streambed discoloration at the lower end of the bar feature.

Instream macrophytes are absent. Filamentous algae clothe the deeper pool features but are absent from the riffle area.

The substrate is loose underfoot and uniform throughout. The clasts tend to be elongated and < 200m on the lesser axis; clasts of < 150 mm are predominant. The approximate composition of the surface substrate is 50% cobble, 25% pebble and 25% gravel. Sand and silt are essentially absent from the surface of the streambed.

Figure18. Exposed clasts in the Acharole stream channel.

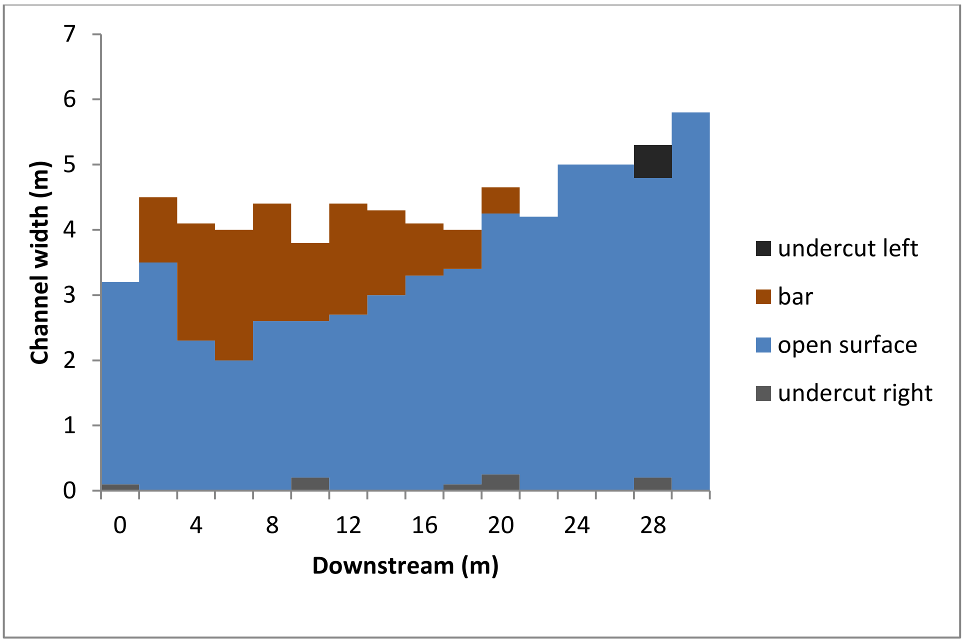


Figure 19. Schematic diagram of the surface features of the channel at the Acharole survey site; the zero datum point is defined as the upper, right-bank limit of the site.

Figure 19 illustrates the high exposure of the right bank and the consequent low occurrence of undercutting which is restricted to areas of bank collapse. The prominent bar feature on the right bank fringes the riffle part of the survey section. The section broadens markedly below the bar.

The average stream width is 3.63m and since the section length is 29.0m the wetted area of the survey section is calculated to be 105.3m^2.

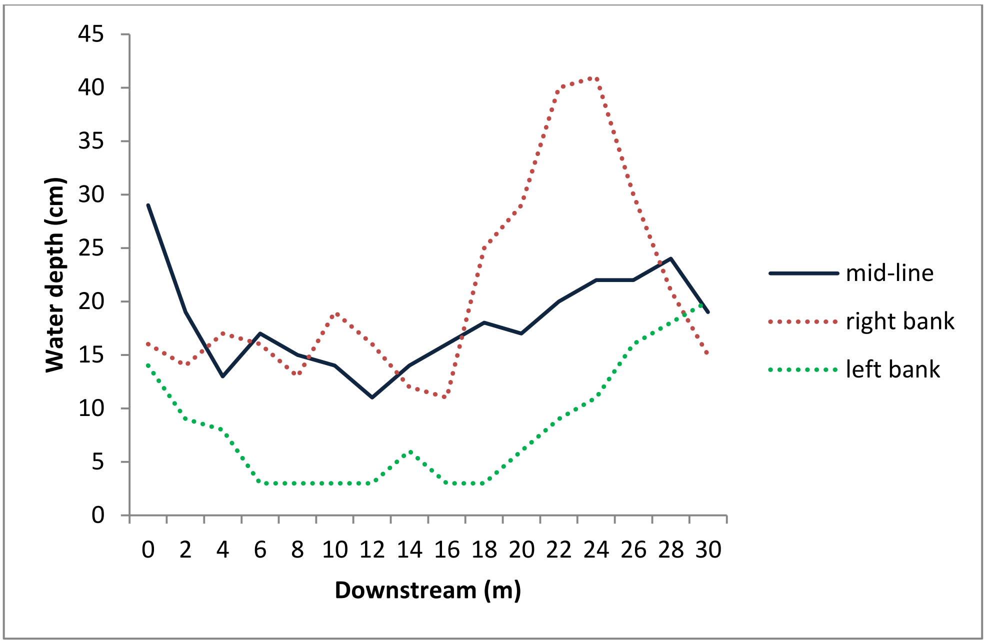


Figure 20. Stream depth profiles for the Acharole survey site.

Figure 20 shows that stream flow is biased, and the water deeper, towards the right bank where erosion is taking place. The left bank margins are shallower, particularly in association with the bar feature.

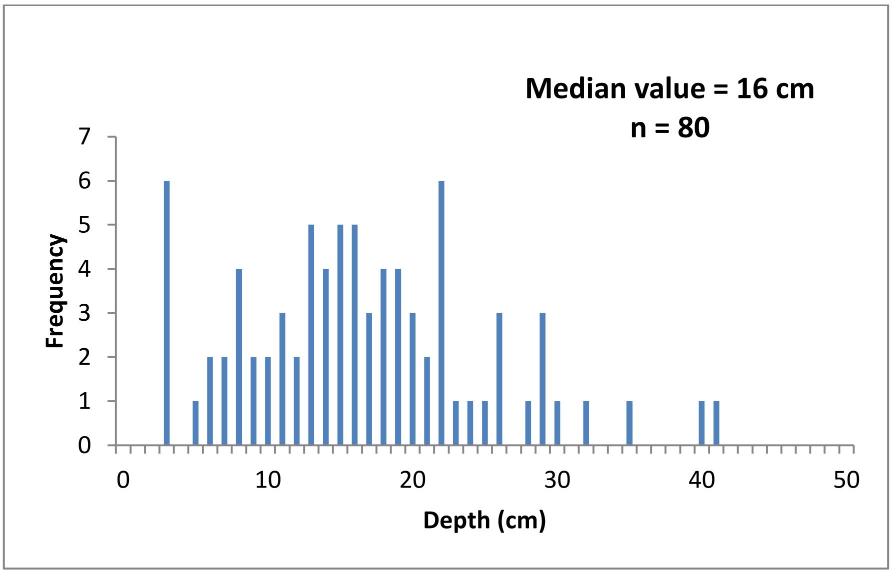


Figure 21. Frequency diagram for stream depths measured at the Acharole survey site.

Figure 21 shows the distribution of the measured values for stream depth. Most values were in the 5 to 30cm range; the median value was 16 cm.

3.3.2. Salmonids and other fish species.

The electric fishing survey was carried out on 29th August, 2015 under low water conditions. Juvenile salmon and brown trout were captured. The additional presence of eels and sticklebacks was noted.

Species	Fry			Parr		
	1st pass	2nd pass	3rd pass	1st pass	2nd pass	3rd pass
Salmon	106	32	17	9	4	1
Brown trout	10	2	2	0	0	0

Table 9. Acharole: Observed numbers of salmon and brown trout on successive electric fishing passes.

Table 9 gives the primary electric fishing data - the numbers of fry and parr of each of the target species captured in each of the three successive electric fishing passes.

It can be seen that salmon greatly out-number brown trout at both the fry and parr stages.

The density of salmon fry observed on the first electric fishing pass (1.01.m^{-2}) greatly exceeded the greatest value proposed by Godfrey (100th percentile value = 0.67.m^{-2}). For salmon parr the density observed on the first pass (0.09.m^{-2}) lay between the 40th and 60th percentile values proposed by Godfrey.

Species	Observed Density (n.m^{-2}) and year of hatch				
	0+ fry (2015)	1+ parr (2014)	2+ parr (2013)	3+ parr (2012)	All parr
Salmon	1.47	0.13	-	-	0.13
Brown trout	0.13	-	-	-	-

Table 10. Acharole: *Observed densities of salmon and brown trout by age-class.*

Table 10 shows the observed density of each species by age class. Salmon fry and 1+ parr were predominant; trout parr were absent.

Species	Estimated True Density ($n.m^{-2}$)	
	0+ fry	All parr
Salmon	1.55	0.14
Brown trout	0.14	-

Table 11. Acharole: Estimated true densities of fry and parr.

Table 11 gives the definitive, estimated true densities for fry and parr of both species based on Zippin correction for fishing efficiency.

In Figures 22 and 23, frequency diagrams show body length by age-class for salmon and trout, respectively. The same values are summarised in Table 12.

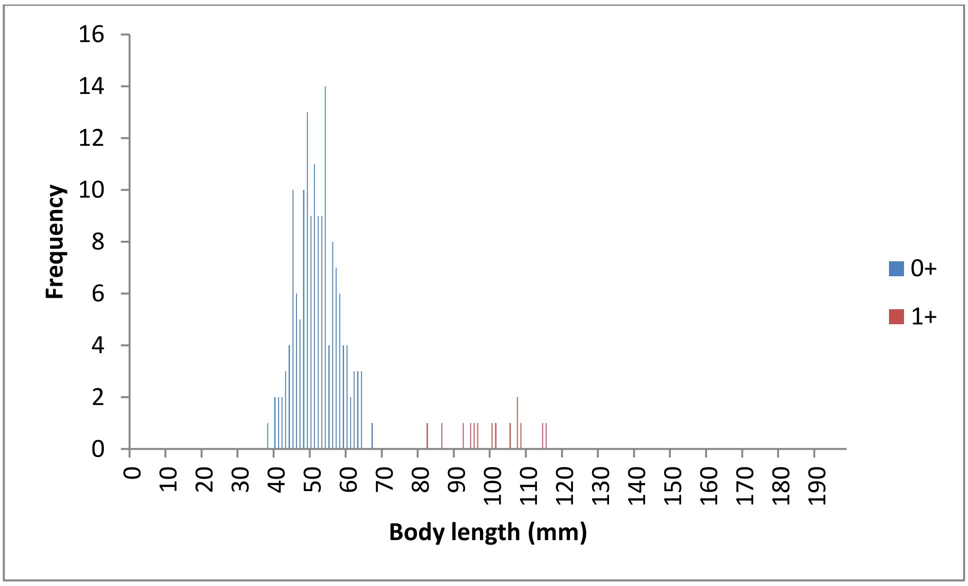


Figure 22. Acharole: Frequency distribution of salmon body-lengths by age-class.

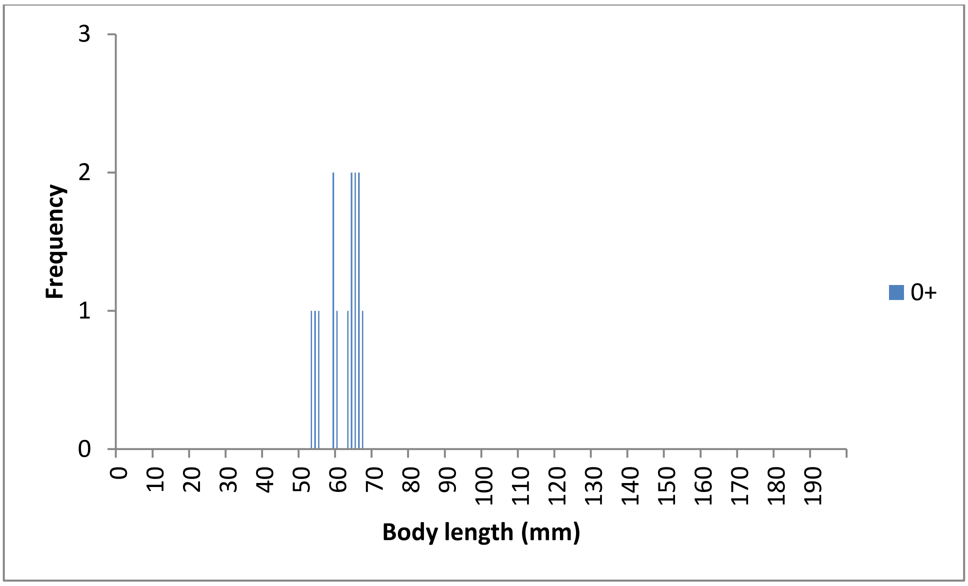


Figure 23. Acharole: Frequency distribution of brown trout body-lengths by age-class.

Species	Mean length (mm).			
	0+ fry	1+ parr	2+ parr	3+ parr
Salmon	52.8 (5.77)	101.1 (9.88)	-	-
Brown trout	61.4 (4.77)	-	-	-

Table 12. Acharole: The mean body lengths of salmon and trout by age-class. Where the numbers are sufficient, the standard deviation is given in parentheses.

3.4. The Clow.

The Clow is one of a set of standard survey sites previously established by the Caithness District Salmon Fishery Board. Therefore, in addition to the data set reported here, equivalent data on fish numbers for the same standard site is available for September, 2013 and September, 2014.

The Clow lies on the Burn of Acharole about 3km downstream of the Acharole site. Between Acharole and The Clow the stream receives water from numerous small streams draining either side of the valley.

The wider setting of The Clow is again unfenced rough pasture grazed by sheep. The Clow differs from Acharole and the other sites in being studded with large clasts (500 – 1000mm). The streambed is lightly clad in fine filamentous algae. The site is generally typical of the stream in the wider vicinity.

The survey was carried out in low water conditions (15 September, 2015). Conductivity was 248µSi.cm^{-1}.

Figure 24. The general vicinity of The Clow site looking southwest.

Figure 25. The lower (left) and upper (right) limits of The Clow survey site defined by stop-nets. The direction of flow is indicated. These photographs are used by CDSFB to define the standard survey section; they were taken in September, 2013.

3.4.1. Channel characteristics.

Much of the right bank of the stream at is > 1.0m high but the upper part is formed of a low-lying bed-rock intrusion. The left bank includes an extensive lateral bar feature.

The average gradient at The Clow is higher than at Acharole and the other sites and, as a result, the stream substrate is generally coarser. The surface substrate is loose. The approximate composition of the surface substrate is 10% boulder, 50% cobble, 20% pebble and 20% gravel. Sand and silt are essentially absent.

Figure26. Exposed clasts in The Clow stream channel.

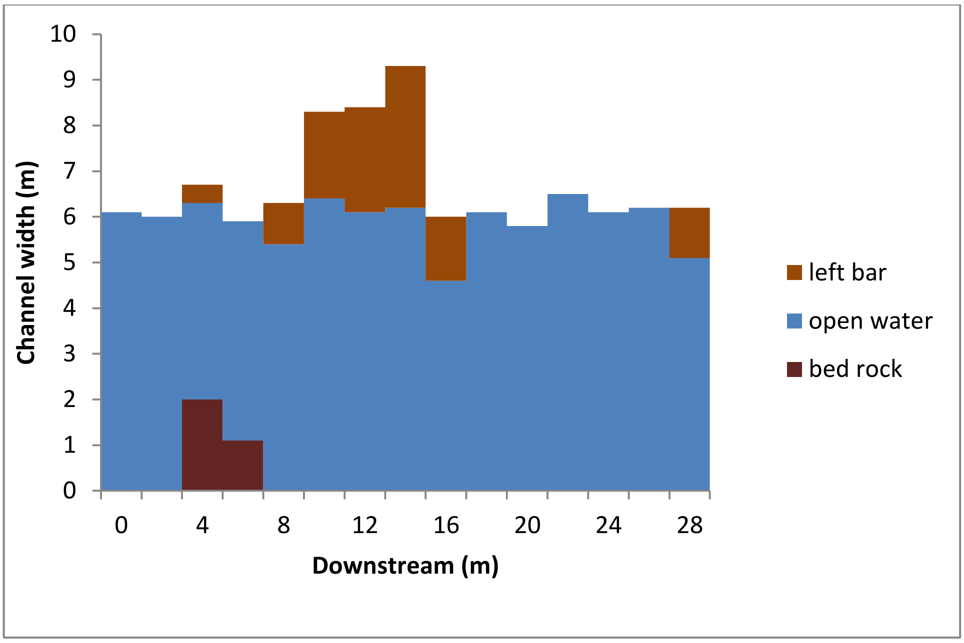


Figure 27. Schematic diagram of the surface features of the channel at The Clow survey site; the zero datum point is defined as the upper, right-bank limit of the site.

Figure 27 shows that the wetted width of the stream is relatively uniform along the length of the survey section. There is a single constriction on the right bank caused by a bed-rock intrusion and only minor constrictions caused by the slightly raised bar feature on the left bank.

The average stream width is 57.1m and the section length is 28.0m, making the wetted area of the survey section 160.0m^2.

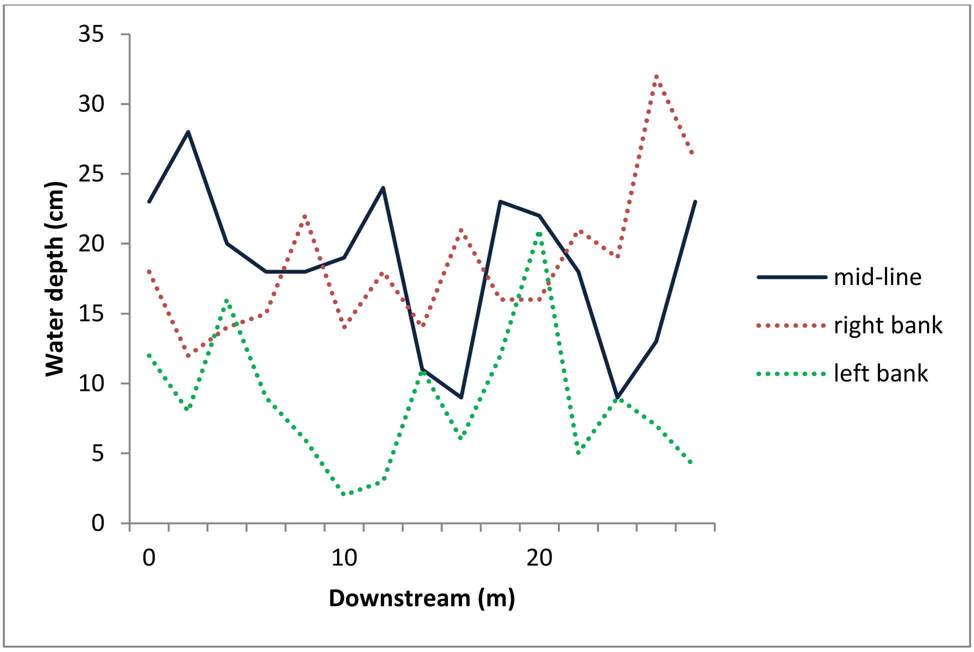


Figure 28. Stream depth profiles for The Clow survey site.

Figure 28 shows that stream depth is relatively heterogeneous along all three longitudinal axes. Flow is biased towards the right bank. Depth is generally less along the left margin, particularly on the fringes of the bar feature.

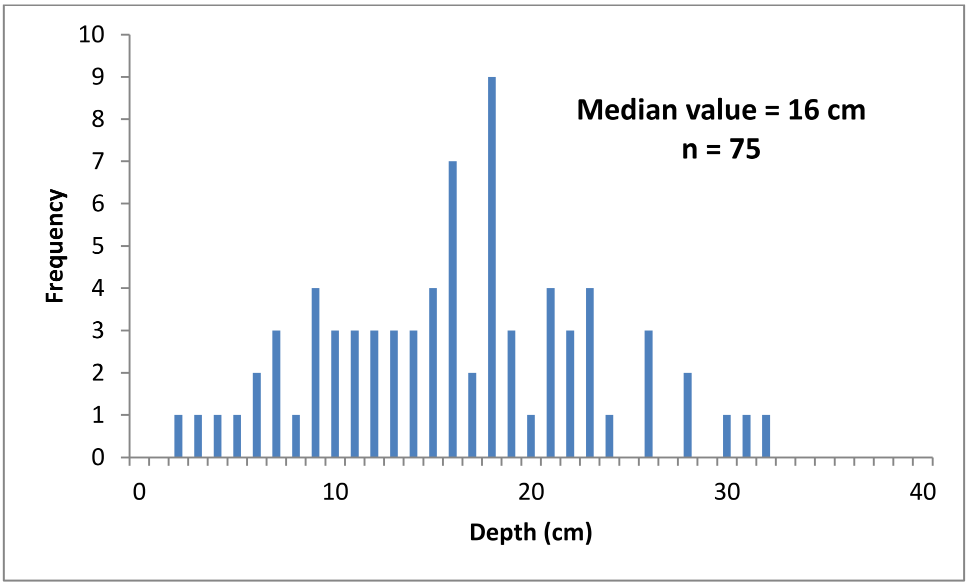


Figure 29. Frequency diagram for stream depths measured at The Clow survey site.

Figure 29 shows that depth values were generally in the 10 to 25cm range; the median value was 16 cm.

3.4.2. Salmonids and other fish species.

The electric fishing survey was carried out on 29th August, 2015 under low water conditions. Juvenile salmon and brown trout were captured. The additional presence of eels and sticklebacks was noted.

Species	**Fry**			**Parr**		
	1st pass	**2nd pass**	**3rd pass**	**1st pass**	**2nd pass**	**3rd pass**
Salmon	168	56	13	100	17	3
Brown trout	1	0	0	1	0	0

Table 13. The Clow: Observed numbers of salmon and brown trout on successive electric fishing passes.

Table 13 gives the primary electric fishing data - the numbers of fry and parr of each of the target species captured in each of the three successive electric fishing passes.

It can be seen that salmon greatly out-number brown trout at both the fry and parr stages.

The density of salmon fry observed on the first electric fishing pass ($1.06.m^{-2}$) greatly exceeded the greatest value proposed by Godfrey (the 100th percentile value is $0.67.m^{-2}$). For salmon parr the density observed on the first pass ($0.63.m^{-2}$) also exceeded the 100th percentile value ($0.28.m^{-2}$) proposed for parr.

Species	Observed Density (n.m^{-2}) and year of hatch				
	0+ fry (2015)	1+ parr (2014)	2+ parr (2013)	3+ parr (2012)	All parr
Salmon	1.48	0.73	0.03	-	0.75
Brown trout	+	-	+	-	+

Table *14. The Clow: Observed densities of salmon and brown trout by age-class; + indicates presence at very low density only.*

Table 14 shows the observed density of each species by age class as determined by scale-reading. Fry and 1+ parr were predominant for salmon; trout were essentially absent.

Species	Estimated True Density (n.m^{-2})	
	0+ fry	All parr
Salmon	1.53	0.75
Brown trout	+	+

Table 15. The Clow: Estimated true densities of fry and parr.

Table 15 gives the definitive, estimated true densities for salmon fry and parr based on Zippin correction for fishing efficiency.

The frequency diagram in Figure 30 shows body length by age-class for salmon.

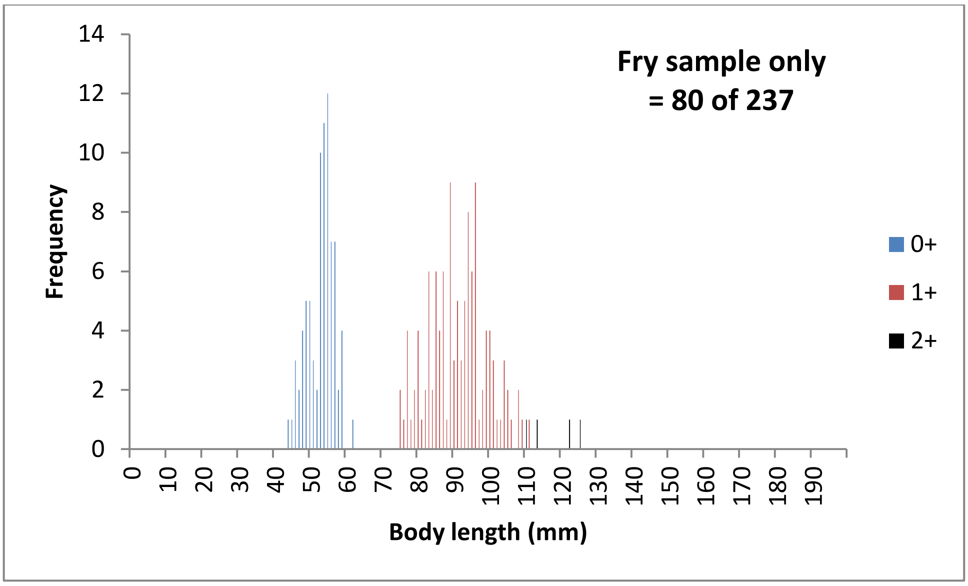


Figure 30. The Clow: Frequency distribution of salmon body-lengths by age-class.

Species	Mean length (mm).			
	0+ fry	1+ parr	2+ parr	3+ parr
Salmon	53.2 (3.74)	91.2 (8.23)	117.5	-
Brown trout	-	-	-	-

Table 16. The Clow: The mean body lengths of salmon and trout by age-class. Where the numbers are sufficient, the standard deviation is given in parentheses.

Table 16 summarises body length by age-class where sufficient data are available.

4. Summary.

All four survey sites supported substantial populations of salmonids of mixed age-class composition. Salmon were present at all four sites but brown trout were biased towards the three upstream sites, and particularly to the two tributaries to the Burn of Acharole.

Reference.

J.D. Godfrey (2005). Site Condition Monitoring of Atlantic Salmon SACs. Report by the SFCC to Scottish Natural Heritage, Contract F02AC608. 274 pp.
http://www.scotland.gov.uk/Resource/Doc/295194/0096508.pdf

MacArthur Green

Watten Wind Farm

Outline Species Protection Plan

Technical Appendix A7.5

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CONTENTS

LIST OF TABLES

1 INTRODUCTION

MacArthur Green has prepared this outline Species Protection Plan (SPP) on behalf of EDF Energy Renewables Ltd (the 'Applicant') to ensure all reasonable protection measures are undertaken with regard to protected species present, or potentially present, at the proposed Watten Wind Farm (referred to within this report as 'the Proposed Development').

Prior to construction, the Principal Contractor will develop this outline SPP, based on updated surveys and working methods, to produce the SPP. The SPP is to be implemented during the construction and decommissioning phases of the proposed wind farm, although it can also be used for guidance should the need arise for maintenance during the operational period.

The SPP will ensure the adequate preservation of protected species' interests into all construction and decommissioning activities within the Proposed Development Area to safeguard the resident populations and ensure compliance with the relevant nature conservation legislation (see ANNEX A).

The SPP will be a live document subject to review and updating and will assist staff in the protection of species during construction and decommissioning, under the guidance of the Environmental Clerks of Works (ECoW).

2 BACKGROUND INFORMATION

Baseline habitats and protected species surveys, including associated desk studies, have been undertaken to inform the Environmental Impact Assessment (EIA) Report for the Proposed Development. Full details and results are reported within Technical Appendix A7.1: National Vegetation Classification & Habitats Survey Report, Technical Appendix A7.2: Protected Species Survey Report and Technical Appendix A7.3: Bat Survey Report. The SPP is designed to reflect the results of the surveys and the distinct ecology and distributions of protected species within the Proposed Development Area.

These baseline surveys have recorded the presence of the following protected or notable species within, or in close proximity to, the Proposed Development:

- Otter (*Lutra lutra*), including a potential couch;
- Water vole (*Arvicola amphibius*), including several potential burrows;
- Pine marten (*Martes martes*);
- Common pipistrelle (*Pipistrellus pipistrellus);*
- Soprano pipistrelle (*Pipistrellus pygmaeus);*
- Nathusius' pipistrelle (*Pipistrellus nathusii*); and
- *Myotis* spp.

With respect to bats, several structures and trees with low to moderate suitability for roosting bats were recorded during surveys; see Technical Appendix A7.3: Bat Survey Report for full details.

No other protected species, or protected plant species, was recorded within the Proposed Development Area during baseline surveys, although there was some suitability for red squirrel

(*Sciurus vulgaris*) and reptiles. See Technical Appendix A7.2: Protected Species Survey Report for further details.

3 AIMS & OBJECTIVES OF THE SPECIES PROTECTION PLAN

The Aim of the SPP is to ensure all reasonable precautions are taken by the Applicant and their contractors to safeguard protected species from disturbance, injury and death and to protect any structure or place, which any such protected species uses for growth, breeding, resting, shelter or protection during the construction and decommissioning of the Proposed Development. The SPP will also contribute to meeting legal obligations should protected species licences be required.

The Aim of the SPP will be fulfilled by the Applicant adopting the following objectives throughout the construction and decommissioning of the Proposed Development:

a) Objective A - Implement a monitoring and protection plan for protected species;

b) Objective B – Follow an approved procedure if an active feature is found; and

c) Objective C – Ensure adequate education and awareness of site personnel.

Objective A addresses the monitoring procedure to be followed to ensure that the Aim of this SPP is achieved. Objective B covers the detailed procedure in the event of a protected species feature being discovered. Objective C addresses the educational needs of appropriate personnel on the Proposed Development to further reduce the risk of an offence being committed. The procedures to be adopted that will fulfil these objectives are detailed in Section 6.

4 RESPONSIBILITIES

The overall responsibility for ensuring that the planning conditions and the conditions of any licence granted are adhered to, in particular those conditions relating to protected species, will lie with the Applicant. The personnel responsible for the day-to-day implementation of the SPP are detailed in Table 4.1 below.

4.1 Role of the Environmental Clerks of Works

The ECoW will have the specific remit of monitoring compliance with the SPP during the construction and decommissioning phases and reporting any breaches to the Applicant's Construction Project Management Team. The ECoW's role shall involve direct monitoring of all activities on the Proposed Development Area to the extent the ECoW considers this to be required, and/or training of nominated personnel to carry these out in a manner likely to minimise the potential for impact on the protected species. The ECoW will also agree changes to construction operations to prevent breaches of the SPP.

Table 4-1: SPP Responsibilities

Task	Responsibility
Implementation of the SPP	The Applicant's Construction Project Management Team
Monitoring and review of the SPP	ECoW
Regular site monitoring for protected species and associated protected features for: otter, bats, pine marten, wildcat, reptiles, badger, water vole and Annex II plants	ECoW or a suitably qualified ecological surveyor
On-going watching brief for the above	All site personnel

5 THE POTENTIAL IMPACTS OF DEVELOPMENT

Impacts on protected species can result from the physical effects of construction such as soil stripping, road laying, turbine foundation construction and noise disturbance. These operations can negatively affect protected species in a number of ways including:

i. Abandonment of a holt/burrow/roost/den/sett/pond etc. due to disturbance;

ii. Abandonment of dependant young due to disturbance;

iii. Damage to or destruction of a protected feature or species;

iv. Damage to navigation/commuting routes (i.e. ditches, burns, fence lines etc.);

v. Fragmentation of territories;

vi. Damage to foraging areas (e.g. areas containing amphibians or fish in the case of otter);

vii. Contamination of water;

viii. Disturbance to a protected species that results in behaviour that negatively impacts their life stage; and

ix. Accidental injury or death to species by machinery, tools or vehicles.

6 SPECIES PROTECTION PROCEDURES

This section details the procedures to be followed to ensure all reasonable precautions have been adopted to protect species from disturbance, injury and death and to protect any structure or place that any such species uses for growth, breeding, resting, shelter or protection.

The extent of disturbance free zones for each species is shown on Table 6.1 below. If other protected species are identified during pre-construction surveys or during construction suitable buffer zones will be advised by the ECoW and agreed in consultation with NatureScot.

Table 6-1: Level of Protection and Recommended Disturbance Free Zones

Species Feature	Level of Protection	Disturbance Free Zone
Otter (holts, etc.)	European	30/200 metres[1]
Bat (roost)	European	30/200+ metres[2]
Badger (sett)	National	30/100 metres[3]
Water vole (burrow)	National	5-10 metres[4]
Red squirrel (drey)	National	5/50 metres[5]
Pine marten (den)	National	30/100 metres[6]
Reptiles (hibernacula)	National	n/a[7]

6.1 Objective A – Monitoring and Protection Plan

6.1.1 Monitoring Plan

It will be the duty of the ECoW to check the status of the protected species and any associated protected features immediately prior to construction activity progressing across the Proposed Development Area, and to continue regular spot checks during construction for any new protected species features in the vicinity of the construction works. Where construction work is staggered across the Proposed Development Area, any watercourses within the vicinity of the works due to be carried out should be monitored and checked immediately prior to the commencement of works. This should occur during each phase of construction.

If it is not possible to determine the status of features during ECoW checks, further monitoring by use of camera traps may be required.

The results from the ecological baseline surveys highlighted a potential otter couch and several potential water vole burrows within the Proposed Development Area. No other active protected species' features were recorded within the Proposed Development Area; however, there is the potential for other protected species to move into the area. Guidelines detailing the monitoring of protected species and associated protected features by the ECoW or suitably qualified ecological surveyor are described below.

[1] The disturbance zone will be 30 m unless a breeding/natal holt is identified, in such an instance the disturbance zone will be increased to 200 m.
[2] The disturbance zone will be 30 m; however, turbines must be positioned 200 m plus turbine rotor radius from high importance roost sites (NatureScot et al., 2021).
[3] Disturbance is defined by NatureScot as any new procedure that approaches within a minimum of 30 m of a sett margin. For piling or blasting activities, this buffer zone is extended to 100 m.
[4] Dependent on burrow location and bank profile.
[5] The disturbance zone will be 5 m or one tree's distance (whichever is less) unless a breeding drey is identified, in such instances the disturbance zone will be increased to 50 m during the red squirrel breeding season (February to September inclusive) (SNH, 2020).
[6] 100 m applied if breeding.
[7] Due to the more limited nature of their protection and their ability to avoid machinery etc. during their active phase, no specified disturbance zone for reptiles is given; however, if a hibernacula is discovered, an appropriate disturbance exclusion zone will be demarcated.

Potential Features

- European Protected Species (otters and bats) & Nationally Protected Species (water vole and reptiles):

Further checks of the potential features will be completed during construction and all potential protection features will be clearly demarcated.

i. If the status of the potential protection feature remains unoccupied, construction may occur in the area, but not damaging the potential feature under close supervision by the ECoW[8]; or

ii. If the status of the feature changes to occupied, then the under-noted procedure for occupied sites will be followed. The ECoW will be responsible for this survey work as required.

Occupied Features and Habitats of Importance

- European Protected Species (otters and bats)

Where an occupied feature exists within the Proposed Development Area or disturbance free zone, and the infrastructure cannot be microsited away:

i. A licence to disturb will be applied for to NatureScot; or

ii. A licence to damage or destroy will be applied for to NatureScot if there are no reasonable alternatives.

- National Protected Species (water vole and reptiles)

iii. Where a water vole burrow exists within the Proposed Development Area or disturbance zone, and the infrastructure cannot be microsited away, the Applicant will discuss any licensing requirements and appropriate mitigation with NatureScot.

iv. Where reptiles are found to be occupying any proposed infrastructure locations during their hibernation period and the infrastructure cannot be microsited away, the Applicant will discuss appropriate mitigation with NatureScot. Reptiles are capable of actively avoiding disturbances during their active phase.

6.1.2 Protection Plan - General

In addition to the mitigation measures detailed above, further general site wide steps should be implemented to increase the protection levels on protected species and reduce general disturbance from the Proposed Development:

i. Covering/securing all excavations and piping. If this is not possible then a means of escape must be provided for any animal that could fall in e.g. a ramp with a gradient of 450 or shallower;

[8] If the infrastructure cannot be microsited away from the potential feature, the monitoring and checks by the ECoW will be used to assess the likelihood of current use, with appropriate species-specific monitoring undertaken as required. For badger, if it is proven the potential feature is not in use, or has not been in recent use, then it would not be considered a protected feature, and could be sensitively destroyed under supervision of the ECoW.

ii. Any temporarily exposed open pipe system should be capped in such a way as to prevent mammals gaining access, as may happen when contractors are offsite. If such pipes are left for an extended time, periodic checks will be carried out to ensure that the pipe is inaccessible to animals;

iii. All excavations will be checked at the start of works and prior to the commencement of any works activities to ensure otters and badgers are not present or have become trapped overnight;

iv. Night time working will be minimised to reduce disturbance to nocturnal and crepuscular fauna. Where this is not possible, security lighting used in the site compound and those areas where lighting is absolutely necessary to ensure safe working conditions will be angled downwards to reduce light spillage into adjacent areas. Lighting outwith the site compound will be switched off when no works are being undertaken. Other required lighting will be directed to where it is needed and away from features (including setts, treelines, watercourses/riparian habitats, mammal paths, etc.) to minimise light disturbance;

v. Works in the vicinity of watercourses (within 50 m) and their tributaries, should commence one hour after sunrise and will cease no later than one hour before sunset;

vi. All works undertaken in proximity to watercourses will be undertaken in line with pollution prevention measures outlined in a detailed Construction Environment Management Plan (CEMP);

vii. An appropriate speed limit (of around 15 to 20 mph) for all vehicles on the site, and vehicle movements will be kept to pre-determined routes wherever possible;

viii. Watercourse crossings will be designed to allow the passage of small mammals on the site, where appropriate;

ix. Vegetation within 50 m of all watercourses should be left undisturbed except in areas of construction of watercourse crossings and access roads leading to crossings as well as construction associated activities (such as drainage and mitigation).

x. Chemicals should not be stored within 100 m of a sett, holt or couch, or within 10 m of hibernacula, or other protected feature, or along mammal paths. All paints, chemicals and sealants used during the construction process will be removed from the working area at the end of each working day. Open tins or other containers will not be left at the works areas but will be stored in a suitable container at the site compound; and

xi. Any areas for location of wind turbines and infrastructure will be subject to inspection by an experienced ecologist prior to any works within these areas. The ECoW will monitor the site so that in-situ materials associated with works will not incidentally create reptile refuges, e.g. piles of cut vegetation. Materials will be removed from site if advised by the ECoW.

6.2 Objective B – Procedure if Active Feature is Found

6.2.1 Procedure if previously unrecorded active feature or protected species found in advance of construction or decommissioning activity

If an active feature or protected species is found by the ECoW's monitoring in advance of construction activity progressing across the Proposed Development Area, the following text outlines the procedure to be followed.

If Obstruction, Damage or Destruction (ODD) to a protected species is likely, a location specific ODD risk assessment will be completed. This will consider all potential mitigation measures to avoid ODD. This may include micrositing of infrastructure away from the location, where topography allows, and outwith the disturbance zone and the demarcation of the protected site.

If Disturbance is likely, a location specific Disturbance Risk Assessment will be completed. This should firstly consider revision to the disturbance zone as a result of the site-specific topography and habitat quality (e.g. if a ridge lies between activity and a holt then the disturbance zone may be reduced). Also, other measures which could reduce disturbance to an acceptable level should be considered (including micrositing and the demarcation of the protected site).

The Disturbance or ODD risk assessments will be submitted to NatureScot for consideration.

If it is not possible to microsite and, in consideration of the risk assessment, NatureScot determines that ODD and/or significant levels of Disturbance is likely to occur, the procedures described in Objective A will be adopted for unoccupied and occupied features. If there is uncertainty over whether the feature is occupied a precautionary approach will be adopted and occupancy will be assumed.

6.2.2 Procedure if previously unrecorded protected feature or protected species found during construction

In the event of any site personnel discovering an unrecorded protected feature or protected species, the following procedure must be followed:

a) Work should stop immediately within the specified disturbance zone;

b) The ECoW should be contacted;

c) The location should be checked by the ECoW to determine the nature of the new find; and

d) If the protected species or feature is confirmed then the procedure detailed in Objective A above should be followed.

6.3 Objective C – Education and Awareness

The Applicant will provide the necessary education and awareness as part of a site induction to all site personnel with regard to the protection of protected species that are or could be present on the Proposed Development Area, in particular the actions that should be taken if protected species are seen on the site. All site personnel (including contractors and sub-contractors) will be informed of the objectives of the SPP to ensure they are aware of any species present in the Proposed Development Area.

This information will include as a minimum:

i. The requirements and use of the SPP;
ii. Identification of protected species and features;
iii. Key risk activities and sensitive areas; and
iv. Site personnel responsible for dealing with protected species.

The Applicant will undertake that any person found on the Proposed Development Area by them to be inadequately trained, or to be disregarding the terms of the SPP is immediately expelled from the site until such time that it is appropriate for them to be allowed to return. In general, such persons will need to undertake retraining in the use and application of the SPP to ensure the impact on protected species is minimised. Species specific Toolbox Talk handouts will be provided by the ECoW as required.

7 REFERENCES

Capreolus Wildlife Consultancy. (2005). The ecology and conservation of water voles in upland habitats. Scottish Natural Heritage Commissioned Report No. 099 (ROAME No. F99AC320).

Collins, J. (ed.) (2016) Bat Surveys for Professional Ecologists: Good Practice Guidelines (3rd edn.) The Bat Conservation Trust, London. ISBN-13 978-1-872745-96-1

European Commission. (1979). Directive 79/409/EEC: Conservation of Wild Birds. HMSO, London.

European Commission. (1992). Directive 92/43/EEC: Conservation of Natural Habitats and of Wild Flora and Fauna. HMSO, London.

Forestry Commission. (2006). Forest operations and red squirrels in Scotland's forests – the law and good practice. FCS Guidance Note 33.

Forestry Commission. (2009). Forest operations and great crested newts in Scotland. FCS Guidance Note 35b.

Forestry Commission (2009). Forest operations and wildcats in Scotland. FSC Guidance Note 35d.

Gent, T. & Gibson, S. (1998). Herpetofauna Workers' Manual. JNCC, Peterborough.

HMSO. (1994). Biodiversity: The UK Action Plan. HMSO, London.

HMSO. (1981). Wildlife & Countryside Act 1981. HMSO, London .

HMSO. (1994). The Conservation (Natural Habitats, &c.) Regulations 1994. HMSO, London.

HMSO. (1992). Protection of Badgers Act 1992. HMSO, London.

Mitchell-Jones, A. J. (2004). Bat Mitigation Guidelines. English Nature, Peterborough.

Mitchell-Jones, A. J. & McLeish, A. P. (2004). Bat Workers Manual – 3rd Edition. JNCC, Peterborough.

Morris, P.A., Morris, M.J., MacPhearson, D., Jefferies, D.J., Strachan, R & Woodroffe, G.L. (1998). Estimating numbers of the water vole Arvicola terrestris: a correction to the published method. Journal of Zoology 246: 61 – 62.

NatureScot, Natural England, Natural Resources Wales, RenewableUK, Scottish Power Renewables, Ecotricity Ltd, the University of Exeter and the Bat Conservation Trust. (2021). Bats and onshore wind turbines – survey, assessment and mitigation.

Scottish Natural Heritage. (2001). Scotland's Wildlife: Badgers and Development. SNH, Battleby.

Scottish Natural Heritage. (1997). Scotland's Wildlife: Otters and Development. SNH, Battleby.

Strachan, R., Moorhouse, T. & Gelling, M. (2011). Water Vole Conservation Handbook 3rd Edition. Wildlife Conservation Research Unit, Oxford.

ANNEX A. LEGAL PROTECTION

Bats and **Otter** receive protection under the Conservation Regulations (1994) (as amended) only[9].

Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)

Under Regulation 39 (1) it is an offence to:

- deliberately or recklessly to capture, injure or kill a wild animal of a European protected species;
- deliberately or recklessly:
    a) to harass a wild animal or group of wild animals of a European protected species;
    b) to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;
    c) to disturb such an animal while it is rearing or otherwise caring for its young;
    d) to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place including bat roost sites;
    e) to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs; or
    f) to disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young;
- deliberately or recklessly to take or destroy the eggs of such an animal; or
- to damage or destroy a breeding site or resting place of such an animal.

Regulation 44 (2e) allows a licence to be granted for the activities noted in Regulation 39 such that:

Preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment.

[9] The Conservation Amendment (Scotland) Regulations (2007) removed EPS from Schedule 5 and 8 of the Wildlife and Countryside Act 1981.

Water Vole is protected by Section 9, subsection 4 and Section 10 of the Wildlife and Countryside Act[10].

Wildlife and Countryside Act (1981)

Nature Conservation (Scotland) Act 2004

Under Section 9 Subsection 1[11] it is an offence to:

- Intentionally or recklessly kill, injure or take any wild animal included in Schedule 5.

Under Section 9, Subsection 4, Paragraphs (a) and (b)4, it is an offence to:

- Intentionally or recklessly damage or destroy, or obstruct access to, any structure or place which any wild animal included in Schedule 5 uses for shelter or protection.
- Intentionally or recklessly disturb any such animal while it is occupying a structure or place which it uses for that purpose.

Under Section 10, Subsection 3, Paragraph (c)4, any person shall not be guilty of an offence by reason of:

- Any act made unlawful by that section if he shows:
  a) That each of the conditions specified in subsection (3A) was satisfied in relation to the carrying out of the unlawful act; or
  b) That the unlawful act was carried out in relation to an animal bred and, at the time the act was carried out, lawfully held in captivity.
- Section 3A states those conditions referred to in Subsection 3c are:
  a) That the unlawful act was the incidental result of a lawful operation or other activity;
  b) That the person who carried out the lawful operation or other activity:
     i. took reasonable precautions for the purpose of avoiding carrying out the unlawful act; or
     ii. did not foresee, and could not reasonably have foreseen, that the unlawful act would be an incidental result of the carrying out of the lawful operation or other activity; and

That the person who carried out the unlawful act took, immediately upon the consequence of that act becoming apparent to the person, such steps as were reasonably practicable in the circumstances to minimise the damage or disturbance to the wild animal, or the damage or obstruction to the structure or place, in relation to which the unlawful act was carried out.

[10] as amended by the Nature Conservation (Scotland) Act 2004
[11] as amended by the Nature Conservation (Scotland) Act 2004

Red Squirrel and **Pine Marten** are protected by the following legislation:

Wildlife and Countryside Act (1981)

Nature Conservation (Scotland) Act 2004

Under Section 9, Subsection 1, it is an offence to:

Intentionally or recklessly:

- Kill, injure or take any wild animal listed on Schedule 5;
- Damages or destroys or obstructs access to, any structure or place that any animal listed on Schedule 5 uses for shelter or protection;
- Disturbs any such animal while it is occupying a structure or place which is uses for that purpose
- Sell, offer or expose for sale, or possess or transport for the purpose of sale, any live or dead wild animal included in Schedule 5, or any part of, or anything derived from, such an animal.
- Publish or cause to be published any advertisement likely to be understood as conveying that he buys or sells, or intends to buy or sell, any of those things.

Badger are protected under the **Protection of Badgers Act 1992** (as amended by the **Nature Conservation (Scotland) Act 2004 (as amended)).**

The following applies under this legislation:

Part 1. –

(1) A person is guilty of an offence if, except as permitted by or under this Act, he wilfully kills, injures or takes, or attempts to kill, injure or take, a badger.

(2) If, in any proceedings for an offence under subsection (1) above consisting of attempting to kill, injure or take a badger, there is evidence from which it could reasonably be concluded that at the material time the accused was attempting to kill, injure or take a badger, he shall be presumed to have been attempting to kill, injure or take a badger unless the contrary is shown.

(3) A person is guilty of an offence if, except as permitted by or under this Act, he has in his possession or under his control any dead badger or any part of, or anything derived from, a dead badger.

Part 3. –

(1) A person is guilty of an offence if, except as permitted by or under this Act, he interferes with a badger sett by doing any of the following things–

a) damaging a badger sett or any part of it;
b) destroying a badger sett;
c) obstructing access to, or any entrance of, a badger sett;
d) causing a dog to enter a badger sett; or
e) disturbing a badger when it is occupying a badger sett,

intending to do any of those things or being reckless as to whether his actions would have any of those consequences.

(2) A person is guilty of an offence if, except as permitted by or under this Act, he knowingly causes or permits to be done an act which is made unlawful by subsection (1) above.

Reptiles

The three native species of **reptile** to Scotland, **adder**, **slow worm** and **viviparous lizard**, are protected by the following legislation:

Wildlife and Countryside Act (1981)

Nature Conservation (Scotland) Act 2004

Under Section 9 Subsection 1[12] it is an offence to:

- Intentionally or recklessly kill, injure or take any wild animal included in Schedule 5.

Under Section 9, Subsection 5, Paragraphs (a) and (b)[10], it is an offence to:

- Sell, offer or expose for sale, or possess or transport for the purpose of sale, any live or dead wild animal included in Schedule 5, or any part of, or anything derived from, such an animal.
- Publish or cause to be published any advertisement likely to be understood as conveying that he buys or sells, or intends to buy or sell, any of those things.

Under Section 10, Subsection 3, Paragraph (c)[10], any person shall not be guilty of an offence by reason of:

- Any act made unlawful by that section if he shows:
  a) That each of the conditions specified in subsection (3A) was satisfied in relation to the carrying out of the unlawful act; or
  b) That the unlawful act was carried out in relation to an animal bred and, at the time the act was carried out, lawfully held in captivity.
- Section 3A states those conditions referred to in Subsection 3c are:
  a) That the unlawful act was the incidental result of a lawful operation or other activity;
  b) That the person who carried out the lawful operation or other activity:
     i. took reasonable precautions for the purpose of avoiding carrying out the unlawful act; or;
     ii. did not foresee, and could not reasonably have foreseen, that the unlawful act would be an incidental result of the carrying out of the lawful operation or other activity; and

  That the person who carried out the unlawful act took, immediately upon the consequence of that act becoming apparent to the person, such steps as were reasonably practicable in the circumstances to minimise the damage or disturbance to the wild animal, or the damage or obstruction to the structure or place, in relation to which the unlawful act was carried out.

[12] as amended by the Nature Conservation (Scotland) Act 2004.

MacArthur Green

Watten Wind Farm
Technical Appendix A7.6

Outline Biodiversity Enhancement Management Plan

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LIST OF TABLES

1 INTRODUCTION

This Outline Biodiversity Enhancement Management Plan (OBEMP) describes the proposed habitat and conservation management measures in relation to Watten Wind Farm (hereafter referred to as the 'Proposed Development').

This OBEMP is set out in the following sections:

- Summary of the Ecological and Ornithological Impact Assessments;
- Biodiversity Enhancement Area;
- Aims, objectives and management prescriptions;
- Monitoring; and
- Management and monitoring timetable.

1.1 Target Habitats and Species

The management recommendations within this OBEMP are based on the findings of Chapter 7: Ecology, Chapter 8: Ornithology and Chapter 9: Hydrology, Geology and Hydrogeology within the Watten Wind Farm Environmental Impact Assessment (EIA) Report. The key habitats addressed are Annex I habitats blanket bog and wet modified bog. The key ornithological species are merlin, hen harrier and a number of wader species. This OBEMP proposes measures to compensate for adverse impacts identified in the above chapters and also to achieve significant biodiversity enhancement at the Proposed Development, in line with objectives outlined in National Planning Framework 4 (NPF4) Policy 3[1].

1.2 Finalisation of the BEMP and Reporting

This OBEMP will be refined and developed into a final BEMP post-consent. The final BEMP will confirm the Biodiversity Enhancement Area (BEA), and any management units therein (if applicable), where the aims, objectives and management prescriptions will apply. The final BEMP will be agreed with The Highland Council (THC) in consultation with NatureScot prior to the commencement of construction of the Proposed Development.

A Biodiversity Management Group (BMG) will oversee and monitor the implementation of the agreed BEMP. The BMG should include representatives from THC, NatureScot and the wind farm owner.

An annual report will be submitted by EDF Energy Renewables Limited (the 'Applicant') to the BMG detailing the tasks (management and monitoring) completed over the last year and those planned for the year ahead. Any monitoring reports will be issued to the BMG as they are produced.

Management prescriptions in the BEMP may be amended in light of monitoring results to ensure progress towards the stated aims and objectives of the plan.

[1] Scottish Government (2023). National Planning Framework 4. Available at: https://www.gov.scot/publications/national-planning-framework-4/ [Accessed 10/08/2023].

2 SUMMARY OF ECOLOGICAL AND ORNITHOLOGICAL IMPACT ASSESSMENTS

2.1 Ecology

The Proposed Development Area is upland in character and dominated by acid grassland, conifer plantation and bog habitat, particularly across the central area known as Wester Watten Moss. In addition, smaller areas or pockets of marshy grassland, modified bog, and mesotrophic grassland are also found in the Proposed Development Area.

Important ecological features scoped-in to the ecological impact assessment comprise bats and blanket bog. Potential collision risk impacts to bats will be mitigated in accordance with the proposals detailed in paragraph 7.3.40 of Chapter 7: Ecology. The Proposed Development would impact up to 6.1 ha of blanket bog (direct 3.15 ha and indirect 2.95 ha) and 0.65 ha of wet modified bog (direct 0.33 ha and indirect 0.32 ha). The impact on blanket bog and wet modified bog was assessed as ‘Minor Adverse’ and not significant in the EIAR however this OBEMP proposes measures to compensate for the non-significant impact on blanket bog and wet modified bog habitats and deliver enhancement

2.2 Ornithology

During the ornithology baseline surveys, merlin was recorded breeding within the Proposed Development Area and hen harrier was recorded breeding and roosting within the proposed Biodiversity Enhancement Area.

Waders, including curlew, snipe and lapwing have been regularly recorded during the baseline breeding season surveys around the Red Burn area close to T2, and in enclosed fields to the east. Curlew and lapwing, now Red Listed species, are considered to be highly sensitive to disturbance (Goodship and Furness et al (2022)[2]).

Important ornithological features scoped-in to the ornithological impact assessment comprise: breeding and roosting hen harrier; breeding merlin, breeding osprey, potentially breeding red-throated divers, breeding curlew, breeding lapwing and Caithness and Sutherlands Peatlands SPA. A Bird Protection Plan (BPP) is proposed to mitigate impacts during the construction phase and habitat management via a BEMP is proposed to mitigate impacts and deliver enhancement during the operational phase.

3 BIODIVERSITY ENHANCEMENT AREA

The OBEMP proposes a BEA comprising three Management Units (Units A, B and C) (**Figure 1**) within which management and monitoring works would be implemented.

The BEA covers 184.4 ha. Details of each management unit are included below in Section 3.1.

The overall goal of the BEMP is to restore and enhance the ecological value of wetland and riparian habitats which will benefit local wader and raptor populations and biodiversity in general.

[2] Available from - https://www.nature.scot/doc/naturescot-research-report-1283-disturbance-distances-review-updated-literature-review-disturbance [Accessed 10/08/2023]

The precise objectives and management prescriptions for the Management Units will depend on the current state of the habitat and the factors acting upon it. In order to inform the objectives and detail appropriate management prescriptions, further surveys are required to be undertaken in developing the final BEMP, these data can also be used to help inform the baseline conditions. These surveys may include, but are not limited to, the following:

- National Vegetation Classification (NVC) surveys of areas not already mapped (majority of management unit C which was out with the survey area required to inform the impact assessment);
- Relevant peatland condition assessments in line with Peatland Action guidance (NatureScot 2021);
- Common Standards Monitoring of Upland Habitats (JNCC, 2009);
- Hydrology walkover to identify opportunities for drain blocking and restoration of the peatland water table;
- Use of 5 m DTM to determine slope and number of drains required;
- Herbivore Impact Assessment (HIA) using methodology from JNCC 2019a; and
- Peat depth surveys to complete phase 1 coverage of the management units (majority of management units A and B).

3.1 Management Units

3.1.1 Management Unit A

Management Unit A is 80.44 ha and comprised of predominantly peatland habitat. Within the management area the aim is to enhance peatland habitat, via measures including managing sheep grazing densities, removing self-seeding Sitka spruce, drain blocking and restoring eroded areas. There are some active peatland erosion areas present and some drains which, whilst occluded and revegetated to a large extent, will still be having a minor adverse effect on the peatland hydrology. As noted above, a detailed drain survey will be carried out to inform ditch damming locations.

Improving these habitats will be of benefit to breeding and foraging merlin and hen harrier, as well as breeding waders, including curlew and snipe.

3.1.2 Management Unit B

Management Unit B is 76.4 ha and covers an area of grassland which has the potential for enhancement for waders. The aim within Management Unit B is to deliver enhancement for waders (curlew, snipe and lapwing) that have been impacted by the wind farm development.

3.1.3 Management Unit C

Management Unit C is 27.6 ha and is situated adjacent to watercourses where the peat depth is less than 0.5 m and botanical conditions are suitable (e.g., avoidance of sensitive GWDTEs[3]). These areas have potential for low density riparian planting of native broadleaf species which will enhance the ecological quality of watercourses (allochthonous material inputs, thermoregulation,

[3] Available from - https://forestry.gov.scot/publications/117-briefing-note-18-publication-of-gwdte-practice-guide [Accessed 10/08/2023]

erosion reduction), shelter opportunities for otter (*Lutra lutra*), establishment of improved habitat corridors, and visual screening of turbines from fish species using the watercourses.

From a hydrology perspective riparian woodland planting is considered beneficial for natural flood management by intercepting rainfall, increasing evaporation and uptake by vegetation and infiltration. Black Burn, Loch Burn and Burn of Acharole are shown on SEPA indicative mapping as having a localised 10% chance of flooding annually, therefore riparian woodland planting along the watercourses would potentially benefit natural flood management in the catchment.

4 AIMS, OBJECTIVES AND MANAGEMENT PRESCRIPTIONS

The Aims define the general BEMP goals, and the related Objectives further define the Aims into quantifiable targets. The Prescriptions detail the indicative management works to be implemented to achieve these Aims and Objectives. Annex 1 provides an indicative timetable for the implementation of the various Prescriptions.

As discussed in Section 3 above, detailed appropriate Objectives and Prescriptions will be developed post-survey for the final BEMP based on survey findings. However, the experience gained from providing and delivering plans for similar upland sites and peatland habitats would suggest that as an outline, the Aims, Objectives and Prescriptions would likely include or be similar to the below.

4.1 Aim 1: Enhance peatland habitat and increase habitat quality for foraging and nesting hen harrier and merlin (Management Unit A)

Objective 1.1	Increase the abundance and distribution of major peat forming species, particularly Sphagna (particularly key blanket mire indicator species such as *Sphagnum papillosum* and *S. medium*).
Objective 1.2	Increase the abundance and structural diversity of dwarf shrubs such as *Calluna vulgaris*, *Erica tetralix* and *Vaccinium* spp. in line with local reference blanket bog.
Prescription 1.1	Manage deer/ and or livestock grazing numbers within Management Unit A if required and in agreement with the landowner, to achieve Objectives 1.1 and 1.2.
Prescription 1.2	Remove regenerating trees from Management Unit A annually, by hand or clearance saw, until a time that monitoring shows that regeneration is no longer an issue or frequency of intervention can be reduced.

Prescription 1.3	Dam active drains[4] (even if vegetated) in order that the water level is raised sufficiently to create conditions suitable for species mentioned within Objective 1.1. This should be carried out under the supervision of a suitably qualified ECoW. As detailed within the guidance, this technique requires donor peat turves to be excavated adjacent to the drain and then keyed into the drain itself. The divot formed by excavating the donor turve is then infilled by pulling and compressing the surrounding peat and peatland vegetation into this area – the donor turve is taken from alternate sides to avoid a line of restored divots forming long one side of the drain. The reason the donor turve needs to be taken adjacent to the drain is to ensure it retains its consolidated structure which enables its reliable use in damming the drain
Prescription 1.4	The following activities would be prohibited within the Management Unit: • clearing out of existing ditches; • supplementary feeding of livestock; • application of any insecticides, fungicides or molluscicides; • application of lime or any other substance to alter the soil acidity; • cutting or topping of vegetation except to control injurious weed species or to improve the biodiversity of the habitat; • burning of vegetation or other materials; • use of roll or chain-harrow; • planting trees; • carrying out any earth moving activities; • use of off-road vehicle activities with the exception of use of low scale agricultural vehicle movements (quad bike and land rover) or low impact vehicles associated with the installation of the overhead line;

[4] According to methodology detailed in 'https://www.nature.scot/doc/peatland-action-technical-compendium-restoration-4-artificial-drains [Accessed 10/08/2023]

	• construction of tracks, roads, yards, hardstandings or any new structures (not associated with the Proposed Development or the installation of the overhead line); and • storage of materials or machinery.

4.2 Aim 2: Enhance habitats for waders (Management Unit B)

Objective 2.1	Enhance 77 ha of grassland habitat for wader breeding and foraging.
Prescription 2.1	Where a tall, dense (>30 % rush cover) sward of rushes has established, cut rushes to create a more open habitat, baling cuttings for removal to avoid ground smothering (FAS 2017).
Prescription 2.2	Construct wader scrapes, following advice set out for this (FAS 2017, RSPB 2003) and with consideration of the local hydrological setting.
Prescription 2.3	Manage grazing within Management Unit B to allow an optimal grassland mosaic to be maintained suitable for wader nesting and foraging. Exclude livestock between early April and mid-May and maintain a stocking density of <1 LU/ha from mid-May until mid-June (FAS 2017)[5].

4.3 Aim 3: Enhance the ecological and hydrological value of watercourses (Management Unit C)

Objective 3.1	Plant approximately 17 ha of riparian woodland and scrub.
Objective 3.2	Visually screen and shade watercourses with suitable trees and shrubs to aid in temperature regulation and mitigate potential visual impacts on riverine species.
Objective 3.3	Stabilise riverbanks, maintain or improve water quality, and reduce flooding risks along sections of watercourse suitable for planting.
Prescription 3.1	Plant low density native broadleaf species along the banks of watercourses in line with SEPA (2009)[6] and the

[5] Available from: https://www.fas.scot/downloads/farm-management-handbook-2022-23/ [Accessed 10/08/2023]
[6] Available from: https://www.sepa.org.uk/media/151010/wat_sg_44.pdf [Accessed 10/08/2023]

Objective 3.1	Plant approximately 17 ha of riparian woodland and scrub.
	Woodland Trust (2016)[7]. Tree tubes should be used and low impact ground preparation techniques such as screening or inverted mounding.

5 MONITORING

5.1 Aim 1: Enhance peatland habitat and increase habitat quality for foraging and nesting hen harrier and merlin (Management Unit A)

The following monitoring would be undertaken to evaluate the success of this aim:

- Scarce Breeding Bird Surveys (SBBS) will be undertaken in years 1, 2, 3, 5, 10 and 15 to determine the distribution of occupied nests/territories for target raptor and owl species within 2 km of the Proposed Development Area.
- Habitat monitoring will evaluate the success of restoration and enhancement of peatland. This will be achieved by recording changes to the structure and composition of the vegetation and species abundance, evenness and diversity. Recording of impacts from deer/livestock will also be included in the monitoring programme, using the HIA methodology described in SNH (1998a and 1998b) guidance at a landscape scale.

  A representative sample of permanent quadrats will be established within Habitat Management Unit A to gather sufficient data to inform future management and assess the trajectory of plant species and habitats. The respective monitoring surveys will be carried out at the most appropriate times of year (e.g., flora surveys versus browsing impact surveys). Repeat surveys will be carried out in the same month in each monitoring year (1, 2, 3, 5 10, 15) to gather comparable data. Photographs will also be taken of each sample quadrat, as well as overview photographs of the management unit. The final detailed methods will be agreed with the BMG.

- Any installed peat dams or reprofiled haggs will be monitored to ensure works are successful over the first three years after works are completed. Remedial measures will be undertaken if restoration works have failed.

5.2 Aim 2: Enhance habitats for waders (Management Unit B)

The following monitoring would be undertaken to evaluate the success of this aim:

- Breeding Bird Surveys (BBS) will be undertaken in years 1, 2, 3, 5, 10 and 15 to determine the distribution of territories for target wader species.
- Habitat monitoring for grassland in line with the approach detailed above for Aim 1.
- Monitoring of wader scrapes to ensure successful establishment.

[7] Available from: https://www.woodlandtrust.org.uk/media/1761/keeping-rivers-cool.pdf [Accessed 10/08/2023]

5.3 Aim 3: Enhance the ecological and hydrological value of watercourses (Management Unit C)

Planted areas will be monitored for the first five years following planting to ensure successful establishment. Trees will be inspected by suitably experienced personnel and evidence of damage (e.g., browsing by deer) or disease will be recorded. Where necessary, failed trees should be replaced in the winter following the inspection (i.e., November to March). Presence of any invasive non-native species will also be a focus of the inspection, with any specimens recorded being removed in a timely and appropriate manner.

6 BIODIVERSITY NET GAIN TOOLKIT

SSE Renewables' Biodiversity Net Gain (BNG) Project Toolkit[8] was used to quantify the biodiversity value of the Proposed Development Area based upon the habitats present and to demonstrate the project would achieve biodiversity enhancements in line with NPF4 requirements.

The BNG assessment method followed that set out in the BNG Toolkit User Guide[9], and was based upon the National Vegetation Classification (NVC) and habitat surveys undertaken in June 2015 and August 2020 (detailed in Technical Appendix A7.1).

The NVC data was correlated to the most appropriate equivalent habitats according to the Phase 1 habitat classification (JNCC, 2010[10]), considering the species composition and habitat quality.

The toolkit was used to calculate the biodiversity baseline of all habitats within the Proposed Development Area, habitat losses due to permanent infrastructure, and biodiversity gains following the implementation of the BEMP, to determine the overall impact on the representative biodiversity value of the site from the Proposed Development. The overall values are provided in

Table 6-1. The proposals outlined in this OBEMP for the Proposed Development would result in a net gain of 511.36 Biodiversity Units (BU) onsite (a 10% net gain from the baseline).

In addition, as detailed in Chapter 11: Forestry, the species composition of the commercial forest would change as a result of the Proposed Development forestry restocking proposals, with the area of broadleaf woodland increasing by 7.33 ha while the area of conifers would decrease by 3.49 ha; this would further enhance the biodiversity value in the Proposed Development Area.

[8] Available from - https://www.sserenewables.com/sustainability/biodiversity-net-gain/ [Accessed 10/08/2023]
[9] SSE Renewables (2022). Biodiversity Net Gain: Toolkit User Guide.
[10] Joint Nature Conservancy Council (JNCC) (2010). Handbook for phase 1 habitat survey – a technique for environmental audit. JNCC, Peterborough.

The BNG toolkit would be refined post-consent/pre-construction in line with the final agreed enhancement areas and would be detailed in the final BEMP.

Table 6-1: Biodiversity Unit Change at each Stage of the Proposed Development

Stage	Total area (ha)	Biodiversity Units	Biodiversity units per hectare (BU/ha)	Biodiversity Units Gained/Lost from Baseline
Baseline	508.92	4953.78	9.73	N/A
During works	503.66	4900.79	9.73	-53 (-1%)
After works	503.66	5465.14	10.85	+ 511.36 (10%)

7 REFERENCES

Farm Advisor Service (FAS) (2017). Management and Conservation for Farmland Waders. Technical Note TN688.

Forestry Land Scotland (2021). Peatland Restoration – Operational Specifications (submitted with Glen Arroch 2 Peatland Restoration Scheme documentation).

JNCC. (2009). Common Standards Monitoring Guidance for Upland Habitats. Version July 2009. ISSN 1743-8160. Available from - https://data.jncc.gov.uk/data/78aaef0b-00ef-461d-ba71-cf81a8c28fe3/CSM-UplandHabitats-2009.pdf [Accessed 10/08/2023]

MacDonald, A., Stevens, P., Armstrong, H., Immirzi, P and Reynolds, P. (1998). A Guide to Upland Habitats - Surveying Land Management Impacts - Volume 2, Field Guide. Scottish Natural Heritage, Edinburgh.

NatureScot Peatland Action (2021). Peat Depth and Peatland Condition Survey. Available at: https://www.nature.scot/sites/default/files/2021-06/Peatland%20Action%20-%20GUIDANCE%20-%20Peat%20depth%20and%20peatland%20condition%20survey%20guidance.pdf [Accessed 10/08/2023]

Peatland Code Field Protocol V1.1, IUCN Peatland Programme (2017). Available at: https://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/PC_Field_Protocol_v1.1.pdf [Accessed 10/08/2023]

RSPB (2003). Creating wader scrapes and flashes on farmland. Information and advice note, Version 1.

SEPA (2009). Engineering in the Water Environment Good Practice Guide. Riparian Vegetation Management. Second Edition. WAT-SG-44.

SNH (1998a). A Guide to Upland Habitats – Surveying Land Management Impacts – Volume 1. Available at: https://www.webarchive.org.uk/wayback/archive/20220406104710/https://www.nature.scot/doc/guide-upland-habitats-surveying-land-management-impacts-volumes-1-and-2#main-content [Accessed 10/08/2023]

SNH (1998b) A Guide to Upland Habitats – Surveying Land Management Impacts – Volume 2. Available at: https://www.webarchive.org.uk/wayback/archive/20220406104710/https:/www.nature.scot/doc/guide-upland-habitats-surveying-land-management-impacts-volumes-1-and-2#main-content [Accessed 10/08/2023]

ANNEX A. MANAGEMENT TIMETABLE

Table A-1 Management Timetable

Activity	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15…
Drain blocking (Unit A)	✓														
Deer and Stock Management (Unit A and B)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sitka spruce regeneration removal (Unit A)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dam active drains and undertake any required hagg reprofiling (Unit A)	✓	✓	✓												
Controlled activities (Unit A and B)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rush management (Unit B)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wader scrapes and maintenance (Unit B)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tree planting & maintenance (Unit C)	✓	✓	✓	✓	✓										

* First year after final commissioning of the Proposed Development

MacArthur Green

Watten Wind Farm

Technical Appendix A9.1: Watercourse Crossing Assessment

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1 INTRODUCTION

MacArthur Green was commissioned by EDF Energy Renewables Limited (The Applicant) to carry out a Watercourse Crossing Assessment for the proposed Watten Wind Farm (the Proposed Development).

The Proposed Development is located on land to the east of the operational Halsary Wind Farm and approximately 3 km to the south-west of Watten settlement. It is centred at National Grid Reference (NGR) ND 21509 51736.

This report has been produced in order to meet the requirements of the Water Framework Directive (2000/60/EC) (WFD) as detailed in Section 1.1 below.

This report provides a conceptual assessment of the proposed watercourse crossing points and details the likely form of crossing solution (e.g. culvert, arch culvert or bridge) with reference to guidance published by the Scottish Environment Protection Agency (SEPA). The final design of each crossing solution would be agreed with SEPA prior to construction and be determined as part of the detailed site design.

1.1 Legislation

The WFD has been transposed into Scottish legislation as the Water Environment and Water Services (Scotland) Act 2003[1] (or WEWS) and has given Scottish Ministers powers to introduce regulatory controls over activities in order to protect and improve Scotland's water environment.

The WFD aims to protect and enhance the quality of surface freshwaters, groundwaters, wetlands, transitional and coastal waters.

The key objectives of the WFD relevant to the watercourse crossing assessment are:

- To prevent deterioration and enhance aquatic ecosystems; and
- To establish a framework of protection for surface freshwater.

The Scottish regulatory controls are known as the Water Environment (Controlled Activities) (Scotland) Regulations 2011[2] (CAR) as last amended in 2017. In relation to watercourse crossings required for the Proposed Development, CAR requires that all engineering works in inland surface waters and wetlands are subject to authorisation and allow for proportionate risk-based regulation which is outlined in the CAR Practical Guide[3].

[1] Scottish Government (2003) *The Water Environment and Water Services (Scotland) Act 2003* [Online] Available at: http://www.legislation.gov.uk/asp/2003/3/contents (Accessed 27/07/2023).
[2] Scottish Government (2011) *The Water Environment (Controlled Activities) (Scotland) Regulations 2011*. [Online] Available from: https://www.legislation.gov.uk/ssi/2011/209/contents/made?view=plain (Accessed 27/07/2023).
[3] SEPA, March 2022. The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) A Practical Guide.

2 CAR AUTHORISATIONS

The authorisation process operates at three levels: General Binding Rules (GBR); Registration; and License (Simple/Complex) as detailed in Section 2.1. These levels cover activities with increasing levels of potential impact upon the hydrological environment.

SEPA will only be required to provide authorisation for watercourse crossings shown on the 1:50,000 scale Ordnance Survey (OS) maps (Landranger Series). All other watercourses are classed as a "minor watercourse" and are considered exempt under CAR.

Likely authorisation levels for the proposed crossings are provided in Section 4.1. The information presented in this document is only intended to act as a guide. The actual design, construction and/or improvements to the crossings would be agreed with SEPA prior to any construction works commencing.

2.1 Levels of Car Authorisation

- General Binding Rules (GBRs) are a set of clear guidelines on how a low-risk activity can be undertaken. There is no requirement to register a GBR activity with SEPA.
- A Registration is required for small-scale activities that pose low environmental risk individually but, cumulatively, can result in greater environmental risk. The Applicant must apply to SEPA to register these activities.
- An application is required to SEPA for obtaining a Simple CAR Licence if site-specific controls are required, particularly if constraints upon the activity are to be imposed for activities which may pose a greater environmental risk.

Crossings do not require authorisation where they are located on minor watercourses which are not marked on OS 1:50,0000 scale mapping or are below the threshold for a Registration. This is with the exception of culverting for land-gain.

3 SITE WALKOVER

The layout of the Proposed Development has been designed to minimise the number of watercourse crossings located across the Proposed Development Area.

A desk-based assessment was initially carried out to identify potential watercourse crossings using 1:10,000 OS mapping and aerial photographs for the area. Three watercourse crossings were identified. No existing watercourse crossings were identified as watercourse crossings to serve the Proposed Development. The proposed new watercourse crossings are located on the watercourses of Loch Burn, Black Burn and a tributary of Red Burn as shown on Figure 9.2.

Following desk-based assessment, details of the watercourse crossings and water features were gathered during a hydrology walkover on 30thAugust 2022 and 15th November 2022. An inspection of each of the identified crossings was carried out to obtain information specific to each watercourse. Photographs and observations were recorded including reporting the dimensions (width and depth) of the watercourse channel and upgradient and downgradient conditions (photographs). The survey details and dimensions are provided in Annex A, Table A.1.

The watercourse crossing survey locations are shown in Table 3- 1: Watercourse Crossing Locations below (as shown in Figures 9.3 and 9.4).

Table 3- 1: Watercourse Crossing Locations

Reference	Details	Watercourse	Easting	Northing	Checked
WX01	New crossing	Loch Burn	320043	951003	15/11/2022
WX02	New Crossing	Black Burn	320546	951962	30/08/2022
WX03	New Crossing	Tributary of Red Burn	321258	952156	15/11/2022

4 PROPOSED CROSSING TYPES

Proposed watercourse crossing types are provided based on the watercourse characteristics and with reference to the SEPA Good Practice Guide for River Crossings[4].

All new watercourse crossings would be permanent and used to access the main site for construction and maintenance purposes during the life of the Proposed Development.

The WX01 channel is greater than 2 m width and the most appropriate crossing type proposed is a bottomless pipe culvert which has been illustrated in Figure 5.13: Indicative Watercourse Crossing

At WX02 and WX03 the infrastructure comprises a single track over watercourses less than 2 m width. Bottomless pipe culverts have been proposed as the most appropriate crossing type.

The culverts for all 3 crossings will be designed to accommodate a 1 in 200-year peak flow and will be subject to a review at the detailed design stage.

4.1 Likely Levels of CAR Authorisation

It is assumed that the watercourse crossings at WX02 and WX03 would require Registration depending on the detailed design where bottomless pipe culverts are proposed and the watercourses are less than 2m wide.

As the watercourse at WX01 is wider than 2 m width a Registration or Simple Licence will be required depending on design of the crossing.

CAR authorisation will be confirmed through consultation with SEPA following the detailed design.

4.2 Construction Requirements

The purpose of this Technical Appendix is to provide details of the proposed watercourse crossing locations rather than to comment on the detailed engineering design, which would be undertaken as part of the detailed site design.

The micro-siting of these crossings would be confirmed as part of the detailed design, post consent. For any new crossings the local variations in channel dimensions and bankside conditions would be considered.

[4] SEPA, 2010. River Crossings: Engineering in the water environment: a good practice guide. Ed 2.

All watercourse crossings should be designed to maintain hydraulic conveyance to convey a minimum 1 in 200 year flood, in addition to consideration of the effects of climate change. Detailed flow calculations would be undertaken by the contractor to inform detailed design and applications for CAR Authorisation. All watercourse crossings should maintain the free passage of mammals and aquatic ecology.

Prior to commencement of works, the Contractor would be required to produce detailed watercourse crossing proposals as agreed with SEPA, NatureScot and the Local Authority within the Construction Environmental Management Plan (CEMP) in line with relevant guidance. Temporary disturbance is anticipated in the vicinity of the watercourse crossings during the construction period of the crossings. The Outline CEMP (EIAR Volume 3: Technical Appendix A5.1) presents how these risks would be minimised and mitigated, during the construction period.

5 REFERENCES

Scottish Government (2003) *The Water Environment and Water Services (Scotland) Act 2003* [Online] Available at: http://www.legislation.gov.uk/asp/2003/3/contents (Accessed 27/07/2023).

Scottish Government (2011) *The Water Environment (Controlled Activities) (Scotland) Regulations 2011*. [Online] Available from: https://www.legislation.gov.uk/ssi/2011/209/contents/made?view=plain (Accessed 27/07/2023).

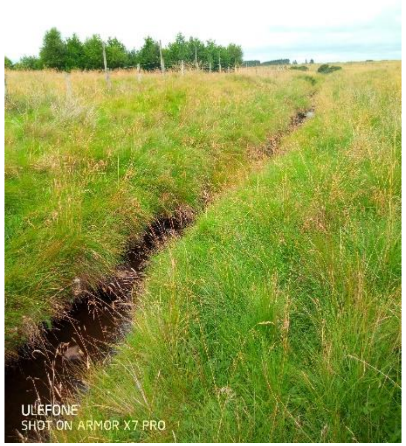
SEPA, 2010. River Crossings: Engineering in the water environment: a good practice guide. Ed 2.

SEPA, March 2022. The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) A Practical Guide.

ANNEX A. WATERCOURSE CROSSING INVENTORY

Table A- 1: Watercourse Crossing Inventory

<table>
<tr><th rowspan="2">WCX No.</th><th rowspan="2">Type (new/ existing/ culverted)</th><th colspan="5">Watercourse</th><th colspan="5">Channel</th></tr>
<tr><th>Orientation (e.g. NW to SE)</th><th>Direction of flow</th><th>Width (cm)</th><th>Depth (cm)</th><th>Flow (VH, H, M, L, VL)</th><th>Width (cm)</th><th>Depth (cm)</th><th>Substrate</th><th>Gradient</th><th>Vegetation in channel (y/n)</th></tr>
<tr><td rowspan="5">WX01</td><td>New</td><td>S to N</td><td>E</td><td>228</td><td>39</td><td>H</td><td>228</td><td>39</td><td>Gravel and rock</td><td>gentle</td><td>N</td></tr>
<tr><td colspan="3">Upstream</td><td colspan="3">Downstream</td><td colspan="5">Lateral</td></tr>
<tr><td colspan="3">
</td><td colspan="3">
</td><td colspan="5">
</td></tr>
<tr><td colspan="3">Notes</td><td colspan="8">Checked 30/08/2022 and 15/11/2022: Active erosion and deposition occurring along banks of the channel visible in August. Crossing located along a straight section of channel. Channel in spate during survey following heavy rainfall in previous 24 hrs. Visual flow assessment observed a high volume and high velocity.</td></tr>
<tr><td colspan="3">Proposed Crossing Type</td><td colspan="8">Single span structure sized to accommodate a 1 in 200 year flood from the upper catchment area. Culvert dimensions will be provided at the detailed design stage.</td></tr>
</table>

WCX No.	Type (new/ existing/ culverted)	Watercourse					Channel				
		Orientation (e.g. NW to SE)	Direction of flow	Width (cm)	Depth (cm)	Flow (VH, H, M, L, VL)	Width (cm)	Depth (cm)	Substrate	Gradient	Vegetation in channel (y/n)
WX02	new	W to E	S	120	10	L	120	65	rock	gentle	Y
	Upstream			Downstream				Lateral			
											
	Notes			Checked 30/08/2022: Shallow, low flow with rush vegetation obscuring channel. Visual flow assessment observed a low volume and moderate flow. Recent weather preceding the survey was dry and warm.							
	Proposed Crossing Type			Bottomless pipe culvert sized to accommodate a 1 in 200 year flood from the upper catchment area. Culvert dimensions will be provided at the detailed design stage.							

WCX No.	Type (new/ existing/ culverted)	Watercourse					Channel				
		Orientation (e.g. NW to SE)	Direction of flow	Width (cm)	Depth (cm)	Flow (VH, H, M, L, VL)	Width (cm)	Depth (cm)	Substrate	Gradient	Vegetation in channel (y/n)
WX03	new	NW to SE	south	31	5.5	L	112	16	peat	gentle	Y
	Upstream			Downstream				Lateral			
											
	Notes			Poorly defined channel in wet boggy conditions, channel densely vegetated (rush) marked on the OS mapping as near the watercourse source. Visual flow assessment observed minimal volume at shallow depth and low velocity.							
	Proposed Crossing Type			Bottomless pipe culvert sized to accommodate a 1 in 200 year flood from the upper catchment area. Culvert dimensions will be provided at the detailed design stage.							

MacArthur Green

Watten Wind Farm

Technical Appendix A9.2 Private Water Supply Risk Assessment

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1 INTRODUCTION

The purpose of this Private Water Supply Risk Assessment (PWSRA) Technical Appendix is to identify the location of Private Water Supplies (PWS) relative to Watten Wind Farm (the Proposed Development), and to undertake an assessment of potential impacts on relevant PWS.

1.1 Background

PWS are defined as any water supply in Scotland that is not provided by a statutory water undertaker (Scottish Water). PWS in Scotland are the responsibility of owners and users and are regulated by local authorities.

PWS may be drawn from a variety of surface and groundwater sources and are considered to be a hydrological potential sensitive feature.

1.2 Legislation and Guidance

This risk assessment has been conducted in line with the legislation and best practice guidance detailed below.

For the purposes of this assessment, a PWS is considered to be a small abstraction of less than 10 m^3 per day from a source such as a borehole, spring/well, or surface water body. Any PWS which exceeds this abstraction volume would be regulated under The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017[1].

As outlined by Scottish Environment Protection Agency (SEPA) Land Use Planning System (LUPS) SEPA Guidance Note 31 2017 v3[2], groundwater abstractions which supply private water supplies within the following distances of a proposed development need to be identified and impacts mitigated against during construction:

- Within 100 m radius of all excavations less than 1m in depth;
- Within 250 m of all excavations deeper than 1m.

2 PRIVATE WATER SUPPLY LOCATIONS

A data study search area of 5 km from the site boundary was defined as shown on Figure 9.12.

The Highland Council (THC) PWS map shows properties which have registered PWS (<10 m^3 per day abstraction rate). The database does not show the location of the source of the supply, nor does it provide an exhaustive list of all PWSs in the area as those that are not registered will not be

[1] The Scottish Government (2017) The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017

[2] SEPA (2017) Land Use Planning System SEPA Guidance Note 31: Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems Version 3. Available at: https://www.sepa.org.uk/media/144266/lups-gu31-guidance-on-assessing-the-impacts-of-development-proposals-on-groundwater-abstractions.pdf Last Accessed: 27/07/2023

shown. A Freedom of Information (FoI) request was made on 8th June 2022 to The THC for publicly available information on registered PWS within the study search area.

The response received 10th June 2022 listed a number of properties with registered PWS within the data search study area. The PWS properties, their source locations and details of their supply are provided in Table 2.1 below.

The risks associated with the construction and operations of the Proposed Development are assessed on a source-by-source basis. This has been achieved through a review of the Proposed Development design to determine if the activities associated with the construction and operation of the wind farm are likely to affect each source. The locations of identified PWSs are shown on Figure 9.12. Where necessary, mitigation measures are proposed to protect those water supplies that could be at risk from the construction and/or operation of the Proposed Development.

Table 2-1: Registered Private Water Supplies with THC (within Hydrology Study Area)

PWS Name	Location (Easting, Northing)	Source Type	Supply Type	Approximate distance from Proposed Development	Assessment of hydrological connectivity
Achingale Mill	324055, 953483	Groundwater-Borehole	Domestic <50 persons	2,680 m	Property was reported by the Applicant as unoccupied and currently not habitable. It Is located downstream in the Wick River catchment, however, PWS located >250m from the Proposed Development, under LUPS-GU31 the borehole is not at risk from the Proposed Development and **no further assessment is necessary.**
Lower Toftingall	317721, 954004	Groundwater-Spring	Domestic <50 persons	2,970 m	Hydrologically disconnected, located in a separate catchment of Loch Toftingall. **No further assessment is necessary.**

Source: THC Private Water Supplies FOI Request (June, 2022).

A number of additional properties within the drainage pathways of the Proposed Development Area were also identified during the desktop study, which although not listed by THC may utilise an unregistered PWS as detailed in Table 2.2 below. Nine properties were contacted by letter questionnaires on 23 August 2022 to confirm if the property was supplied by a PWS and to gather information on details of the source and supply. Of the nine questionnaires sent, responses were received for four properties, all of which confirmed their property was supplied by Scottish Water Mains. No additional PWS were identified and no further assessment was considered necessary.

Table 2-2: PWS Letter Questionnaire Responses

Address	Date Response Received	Response
6 Achingale Watten	None received	n/a
6 Nether banks	16/09/2022	No PWS
6 Milton	12/09/2022	No PWS
17 West Watten	29/08/2022	No PWS
20 West Watten	24/08/2022- undelivered	n/a
21 West Watten	None received	n/a
22 West Watten	None received	n/a
6 West Watten	None received	n/a
18 and 19 West Watten	23/08/2022 (email)	No PWS

3 MITIGATION

Regardless of the lack of identified impact on PWSs, mitigation to prevent pollution impacts on any downstream PWS would be set out in a Water Management Plan which would form part of a Construction Environmental Management Plan (CEMP), to ensure that the Proposed Development would not lead to significant impact to water abstraction activity and other hydrological receptors. The contents of the CEMP and the Water Management Plan would be agreed with SEPA prior to commencement of works.

The best practice measures to be set out in the CEMP would accord with guidance such as that published by NatureScot, SEPA, and would be prepared by the Principal Contractor.

The following best practice measures are considered applicable to the Proposed Development:

- Engineering activities such as culverts, bridges, watercourse diversions, bank modifications and dams would be avoided wherever possible to maintain the natural state of the water environment;
- Appropriate buffer zones between water bodies and construction areas would be established;
- No large capacity build-up of surface water would occur that could lead to additional loadings being placed on the surrounding ground that could lead to soil failure, especially in areas with peat stability concerns;
- Any effects on natural flora and fauna would be minimised, and there would be no indirect impacts on any surrounding designated sites;
- Pollution prevention and environmental protection legislation would be adhered to;
- Works would be allowed to progress efficiently without flash wash-out events affecting partially completed sections; and

- The completed development would be suitably operated with the minimum maintenance to the installed drainage systems.

4 CONCLUSION

The two known PWS registered with THC were considered either to be hydrologically disconnected from the Proposed Development or at a sufficient distance to be not at risk. Of the four questionnaire responses returned, no new PWS were identified. No further assessment was considered necessary, and this assessment has concluded that the risk of potential impact to known PWS as a result of the Proposed Development would be negligible.

5 REFERENCES

SEPA (2017) Land Use Planning System SEPA Guidance Note 31: Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems Version 3. Available at: https://www.sepa.org.uk/media/144266/lups-gu31-guidance-on-assessing-the-impacts-of-development-proposals-on-groundwater-abstractions.pdf Last Accessed: 27/07/2023

The Scottish Government (2017) The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017

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Watten Wind Farm

Technical Appendix: A9.3 Groundwater Dependent Terrestrial Ecosytems Assessment

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1 INTRODUCTION

This Technical Appendix provides an assessment of Groundwater Dependent Terrestrial Ecosystems (GWDTE) in relation to Watten Wind Farm (the Proposed Development).

1.1 Background

GWDTE are types of wetland that are specifically protected under the Water Framework Directive[1]. The presence of GWDTE is used as a visual guide to identify groundwater conditions by demonstrating where groundwater is likely to occur close to the surface.

The guidance regarding GWDTE includes a list of National Vegetation Classification (NVC) communities that are considered to be potentially highly or moderately dependent on groundwater sources. As such, where these communities are present it is possible that groundwater occurs close to the surface. An NVC community's designation as a GWDTE habitat does not denote an ecological value. The ecological value of the habitats within the Proposed Development Area is assessed separately in Chapter 7: Ecology.

This assessment considers the habitats identified through the NVC survey that are classified as moderate or high dependency GWDTE. The assessment concentrates on high and moderate dependency habitats identified within a 250 m buffer from turbines, the substation and/or 100 m from other infrastructure. This assessment is summarised in Chapter 9: Hydrology, Geology and Hydrogeology.

1.2 Classification

NVC communities recorded within the NVC survey area have been mapped as potential GWDTE based on Appendix 4 of SEPA's Land Use Planning System (LUPS) Guidance Note 31[2].

The sensitivity of each mapped polygon containing a potential GWDTE has been classified on a four-tier approach as follows:

- 'Highly – dominant' where potential high GWDTE(s) dominate the polygon;
- 'Highly - sub-dominant' where potential high GWDTE(s) make up a sub-dominant percentage cover of the polygon;
- 'Moderately – dominant' where potential moderate GWDTE(s) dominate the polygon and no potential high GWDTEs are present; and
- 'Moderately - sub-dominant' where potential moderate GWDTE(s) make up a sub-dominant percentage cover of the polygon and no potential high GWDTEs are present.

Where a potential high GWDTE exists in a polygon, it outranks any potential moderate GWDTE communities within that same polygon. The habitat areas determined to be highly dominant, highly sub dominant, moderately dominant and moderately sub-dominant were then subject to

[1] European Commission (2022). The EU Water Framework Directive- Integrated river basin management for Europe. Available online at: https://ec.europa.eu/environment/water/water-framework/index_en.html Accessed 27/07/2023.

[2] SEPA (2017). Land Use Planning System SEPA Guidance Note 31: Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. LUPS-GU31, Version 3.

further site-specific assessment in terms of topography and hydro-ecological context and are discussed in the sections below.

2 BASELINE CONDITIONS

2.1 Topography and Climate

The Proposed Development is located on an area of low-lying topography approximately 14.5 km west of Scotland's north-east coast and approximately 3.7 km west of the settlement of Watten. Ground elevation within the Proposed Development Area boundary ranges from approximately 60 metres Above Ordnance Datum (m AOD) at the south-eastern portion of the Proposed Development Area rising gradually to approximately 70 m AOD to the north-western and western boundaries of the Proposed Development Area. The northern tip of the Proposed Development Area reaches approximately 80 m AOD.

The closest Met Office Station is Wick John O Groats Airport located approximately 15 km to the northwest of the Proposed Development, near the coast at 36 m AOD. The station records an annual average rainfall (between 1991 to 2020) of 793 mm which is lower compared to Scotland North region (1703 mm). The annual average sunshine (between 1991 to 2020) is 1304 hours which is higher than the annual average for Scotland North of 1104 hours.

2.2 Hydrological Setting

The Proposed Development is located within the wider surface water catchment of the Wick River. The Burn of Acharole flows south-west to north-east across the southern site boundary and is a tributary of Scouthal Burn which drains into Wick River to the north-east. There are multiple smaller tributaries of the Burn of Acharole draining the Proposed Development Area predominantly south towards the main channel of the watercourse.

2.3 Hydrogeological Setting

The underlying bedrock geology of the Proposed Development Area is sandstone, siltstone and mudstones of the Berriedale Sandstone and Lybster Flagstone Formations. The parent unit being Lower Caithness Flagstone Subgroup (LCF) which is characterised as mudstone and siltstone with subsidiary conglomerate and sandstone. The groundwater unit underlying the Proposed Development Area is mapped by British Geological Society (BGS) as a Class 2B moderately productive middle old red sandstone aquifer, in places flaggy, with siltstones, mudstones and conglomerates and interbedded lavas which will locally yield a small amount of groundwater. Well cemented conglomerate units would be expected to have a low permeability and poor hydraulic conductivity and the interbedded lavas will limit vertical flow of water.

Superficial deposits of glacial till, peat and alluvium are found to be present across the Proposed Development Area. Glacial till and saturated peat deposits are largely impermeable promoting overland run-off, or shallow interflow within the acrotelm layer of the peat. These impermeable deposits prevent vertical hydraulic connectivity to groundwater and rainwater recharge to groundwater within the bedrock.

Alluvium deposits are concentrated near Acharole Burn at the southern boundary of the Proposed Development. Alluvium deposits are generally highly permeable and will form shallow groundwater units with hydraulic connectivity to watercourses.

The results of the peat coring are detailed in the EIA Report Volume 3: Technical Appendix A9.4: Phase 1 & 2 Peat Depth and Coring Survey Report. The pH of four peat cores collected ranged from 4.3 pH to 6.4 pH which is considered acidic in nature. It is likely that much of this acidity comes from the high rainfall and low evaporation (i.e., ombrotrophic) upland environment and therefore suggests a lack of minetrophic or base-rich groundwater input.

2.4 Potential GWDTE

Potential GWDTEs are shown in Figure 7.4 and the NVC survey area is shown in Figure 7.3. The results of the NVC survey and associated GWDTE analysis appear to support the characterisation of the underlying hydrogeology. The polygons containing potentially highly dependent groundwater habitats appear to follow surface water features across the Proposed Development Area. This corresponds with the geological understanding of the Proposed Development Area bedrock, superficial deposits and soils being low permeability and poorly draining. Therefore, the GWDTEs are likely to be, at least, partly dependent on surface water from runoff and precipitation.

3 ASSESSMENT OF GWDTES

GWDTE sensitivity for these areas has been assigned based on the SEPA listings[2]. However, depending on a number of factors such as geology, soils, topography etc., many of the potential GWDTE communities recorded may in fact be only partially groundwater fed or not dependent on groundwater. Determining the actual groundwater dependency of particular areas or habitat requires further assessment.

3.1 Identified Potential GWDTE

In accordance with the SEPA Guidance[2], GWDTE have been assessed where they are within 100 m of excavations less than 1 m in depth, and 250 m of excavations greater than 1 m in depth. Buffers of 100 m and 250 m have been applied to all proposed infrastructure as a conservative approach.

The potential GWDTE features identified from the NVC survey are shown in Figure 7.4 and summarised in Table 3-1.

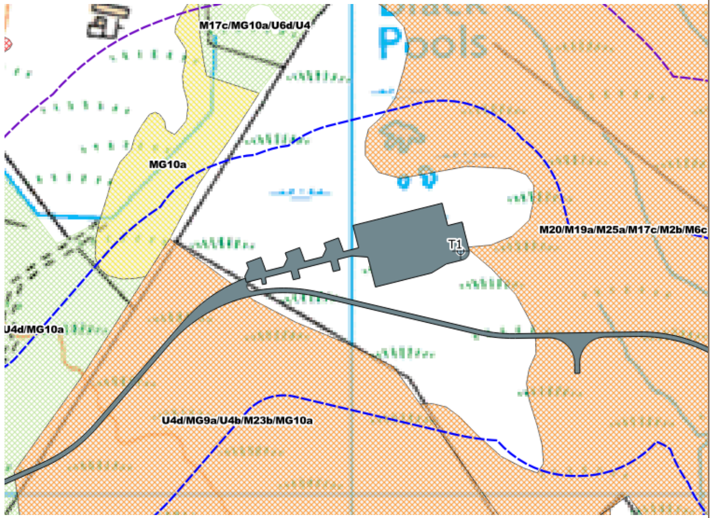
Table 3-1: Identified Potential GWDTE

NVC Code	NVC Community Name	Groundwater Dependency
M25	*Molinia caerulea – Potentilla erecta* mire	Moderate
M27	*Filipendula ulmaria – Angelica sylvestris* mire	Moderate
MG9	*Holcus lanatus – Deschampsia cespitosa* grassland	Moderate
MG10	*Holcus lanatus – Juncus effusus* rush pasture	Moderate
U6	*Juncus squarrosus – Festuca ovina* grassland	Moderate
W7	*Alnus glutinosa – Fraxinus excelsior – Lysimachia nemoreum* woodland	High
M6	*Carex 4chinate – Sphagnum fallax/denticulatum* mire	High
M23	*Juncus effusus/acutiflorus – Galium palustre* rush pasture	High

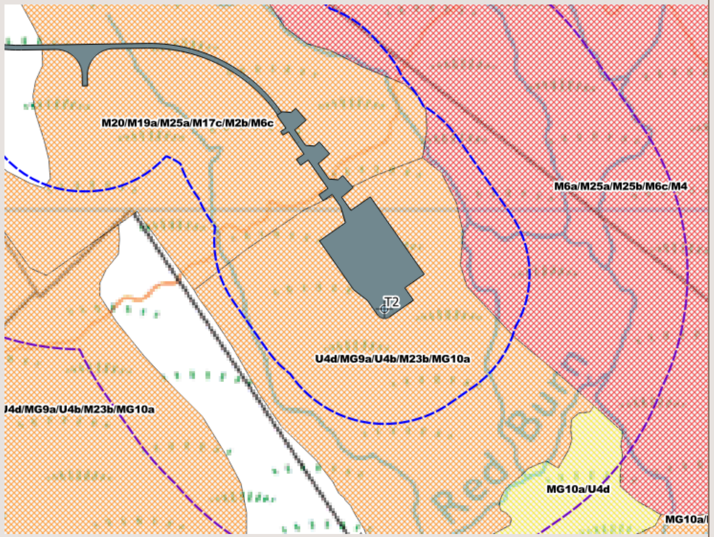
3.2 Site Specific Assessed Groundwater Dependency

The assessed likely true groundwater dependency of the potential GWDTEs is based on the Proposed Development Area-specific hydrology and hydrogeology within the 100 m and 250 m buffers from infrastructure (Figures 7.3 and 7.4). All potential GWDTEs within these buffers were assessed to be of moderate to low groundwater dependency. The assessment of areas of habitat considered to have moderate groundwater dependency was conservative and it is likely these are not truly groundwater dependent due to the organic peat soils present across the Proposed Development Area. This is detailed in Table 3.2 GWDTE Impact Assessment below.

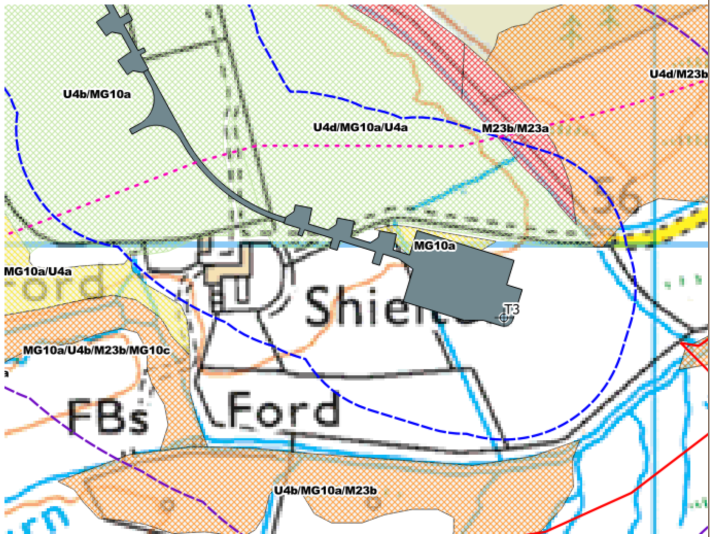
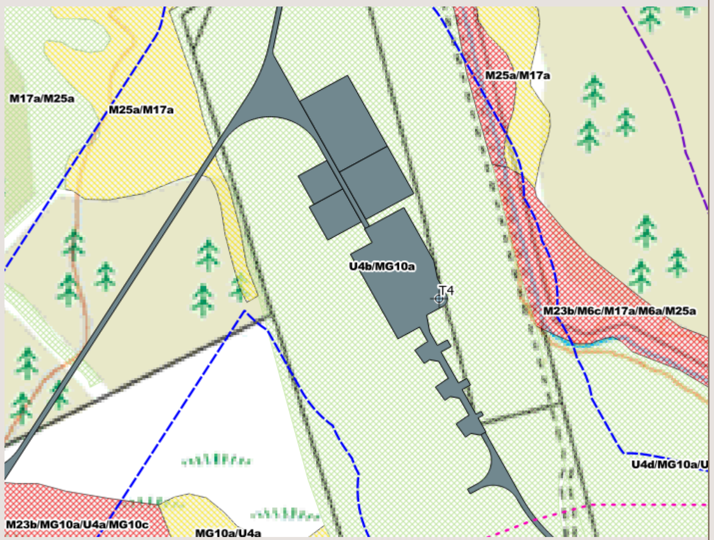
Table 3-2: GWDTE Impact Assessment

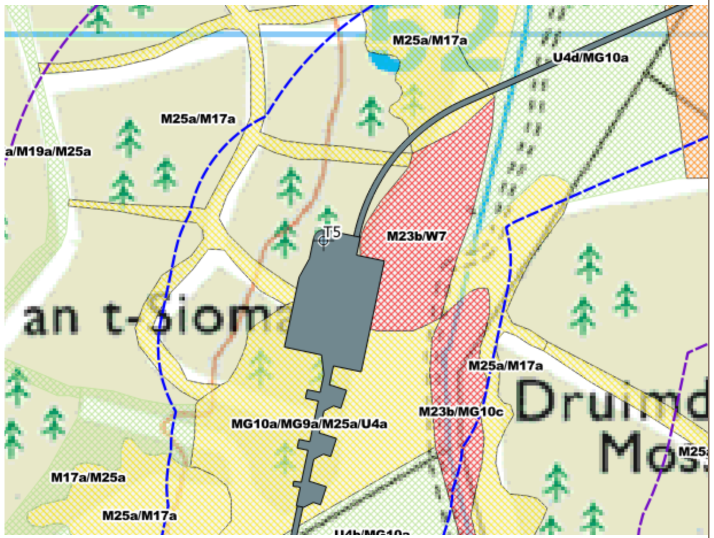
Infrastructure	NVC Habitats[3]	250 m and 100 m Buffers from Infrastructure[4]	Potential Impact	Specific GW dependency
T1	MG9a, M23b, MG10a, M25a, M6a, U6d		The T1 infrastructure is not located on potential GWDTE habitat. The T1 hardstanding does not intersect the flow path to adjacent potential moderate GWDTE habitats and is not considered to have a significant effect on the GWDTE. T1 infrastructure is sited on organic peat soils <0.5 m depth, this is immediately downslope of an area of deeper peat (see Figures 9.9 and 9.10). Gentle topographic slope indicates that vegetation is dependent upon overland flow and shallow sub-surface water in the acrotelm draining from the bog upgradient and not a rock-based aquifer. Potential for groundwater pollution from concrete use in turbine foundations, sediment from excavations and other chemical pollutants used in construction to impact water quality. Deep excavations and potential dewatering at turbine foundations can impact hydrological flow paths both up and down gradient.	Low

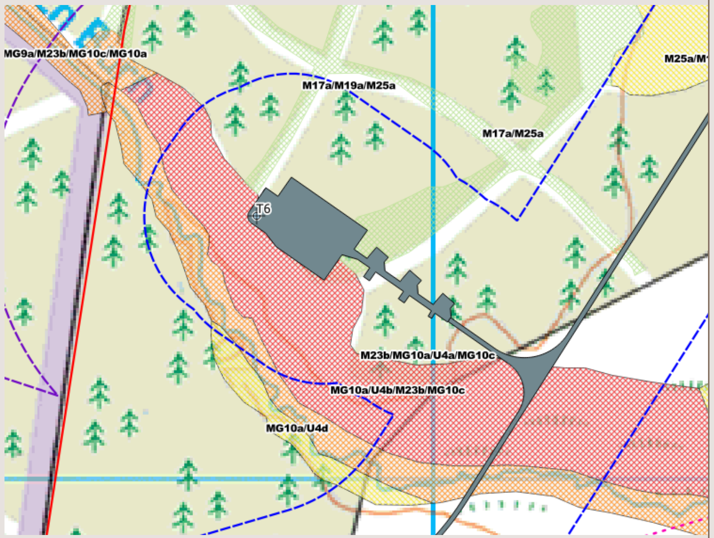
[3] These are the potential GWDTE NVC communities recorded (Table 2.1) within the respective buffers from the infrastructure feature – many of these communities form complex mosaics with each other and other non-GWDTE communities.
[4] 100 m buffer denoted by blue dashed line and 250 m buffer denoted by purple dashed line.

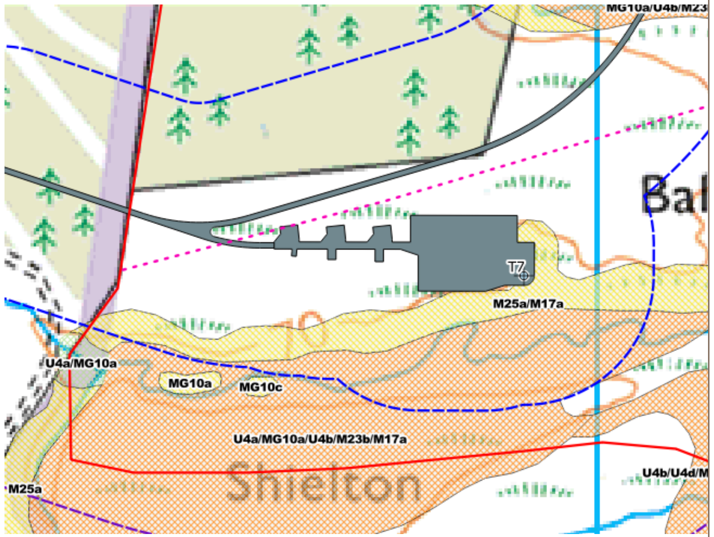
<table>
<tr><th>Infrastructure</th><th>NVC Habitats[3]</th><th>250 m and 100 m Buffers from Infrastructure[4]</th><th>Potential Impact</th><th>Specific GW dependency</th></tr>
<tr><td>T2</td><td>M6a, M25b, M6c,
M25a, M6c, MG9a, M23b, MG10a</td><td>
</td><td>East and north-east of T2 infrastructure is mapped on an area of organic peat soils <0.5 m depth (see Figures 9.9 and 9.10). The gentle topographic slope in this area indicates that vegetation is likely dependent upon overland flow, the surface watercourses and shallow sub-surface water in the acrotelm draining from the blanket bog habitat upgradient and not a rock-based aquifer.
The network of Red Burn tributaries adjacent to the 100 m buffer from T2 infrastructure which will create a hydrological barrier to potentially GWDTE habitats beyond this.

Potential for groundwater pollution from concrete use in turbine foundations, sediment from excavations and other chemical pollutants used in construction to impact water quality. Deep excavations and potential dewatering at turbine foundations can impact hydrological flow paths both up and down gradient.</td><td>Moderate</td></tr>
</table>

Infrastructure	NVC Habitats[3]	250 m and 100 m Buffers from Infrastructure[4]	Potential Impact	Specific GW dependency
T3	M23b, M23a, MG10a, MG10c		T3 infrastructure is located upgradient of habitat associated with the floodplain of the Snottergill Burn. Potentially highly dependent GWDTE habitats are associated with surface water features including watercourses and drains in this area. Black Burn provides a hydrological barrier to habitats to the east of the Burn from T3 infrastructure and Snottergill Burn provides a hydrological barrier to habitats to the south of the burn. Potential for groundwater pollution from concrete use in turbine foundations, sediment from excavations and other chemical pollutants used in construction to impact water quality. Deep excavations and potential dewatering at turbine foundations can impact hydrological flow paths both up and down gradient.	Low
T4	M23b, M6c, M6a, M25a		Infrastructure located upgradient of habitat associated with floodplain margins along Black Burn watercourse. Potential to affect localised surface water and shallow sub-surface flow paths to this habitat. Potential for groundwater pollution from concrete use in turbine foundations, sediment from excavations and other chemical pollutants used in construction to impact water quality. Deep excavations and potential dewatering at turbine foundations can impact hydrological flow paths both up and down gradient. Black Burn provides a hydrological barrier to habitats to the east of the Burn from T4 infrastructure. M25a/ M17a habitat to the west underlain by peat deposits >0.5 m (see Figures 9.9 and 9.10) and a clay horizon underlying the peat (see Technical Appendix A9.4). Therefore the habitats in this area not considered to be truly groundwater dependent but	Low

Infrastructure	NVC Habitats[3]	250 m and 100 m Buffers from Infrastructure[4]	Potential Impact	Specific GW dependency
			rather dependent on water held within the peat and ombrotrophic.	
T5	M23b, W7, MG10c, MG10a, MG9a, M25a		Infrastructure located upgradient of habitat. Potential to affect localised surface water and shallow sub-surface flow paths to this habitat. Potential for groundwater pollution from concrete use in turbine foundations, sediment from excavations and other chemical pollutants used in construction to impact water quality. Deep excavations and potential dewatering at turbine foundations can impact hydrological flow paths both up and down gradient. Black Burn provides a hydrological barrier to habitats to the east of the Burn from T5 infrastructure. Habitat associated with the Burn (M23b, MG10c, W7) is sited on gentle topography and likely associated with the floodplain of the watercourse. M25a habitat is associated with forestry drains and surface water flow upgradient of infrastructure. The crane pads are on an area of peat > 0.5 m (see Figures 9.9 and 9.10). Coring results (See Technical Appendix A9.4) show peat is underlain by clay at the T5 location. As peat and clay substrates are relatively impermeable in nature it is unlikely that any significant vertical groundwater interaction is occurring. The MG10a, MG9a, M25a habitat is therefore not considered to be truly groundwater dependent but rather dependent on water held within the peat and ombrotrophic.	Low

Infrastructure	NVC Habitats[3]	250 m and 100 m Buffers from Infrastructure[4]	Potential Impact	Specific GW dependency
T6	MG10a, M23b, MG10c, MG10a, MG10c, MG9a	 .	Infrastructure located upgradient of habitat. Potential to affect localised surface water and shallow sub-surface flow paths to this habitat. Potential for groundwater pollution from concrete use in turbine foundations, sediment from excavations and other chemical pollutants used in construction to impact water quality. Deep excavations and potential dewatering at turbine foundations can impact hydrological flow paths both up and down gradient. Loch Burn provides a hydrological barrier to habitats to the south-west of the Burn from T6 infrastructure. Infrastructure at T6 is directly overlying peat > 0.5 m (see Figures 9.9 and 9.10). The habitat (M23b, MG10a, MG10c) is therefore not considered to be truly groundwater dependent but rather dependent on water held within the peat and ombrotrophic in nature. The habitat polygon is likely dependent upon surface water draining from the bog upgradient and not a rock-based aquifer.	Low

Infrastructure	NVC Habitats[3]	250 m and 100 m Buffers from Infrastructure[4]	Potential Impact	Specific GW dependency
T7	MG25a, MG10a, M23b		Infrastructure located upgradient of habitat which is likely associated with the watercourse floodplain and margins rather than groundwater dependency. Potential to affect localised surface water and shallow sub-surface flow paths to this habitat. Potential for groundwater pollution from concrete use in turbine foundations, sediment from excavations and other chemical pollutants used in construction to impact water quality. Deep excavations and potential dewatering at turbine foundations can impact hydrological flow paths both up and down gradient. Hectors Burn provides a hydrological barrier to habitats to the south of the Burn from infrastructure.	Low

3.3 Impacts of the Proposed Development

The Proposed Development Area layout was designed based on the principles of avoidance first, minimisation and mitigation across all site constraints such as deep peat. Due to the distribution of potential GWDTE habitats, avoidance of the 250 m buffer of these features was not feasible in all instances amongst other site constraints. However, following assessment of the habitats within the buffers, most potential GWDTEs based on NVC communities and sub-communities were considered low to no groundwater dependency as detailed in Table 3.2. Although the potential GWDTEs in the Proposed Development Area are likely to be ombrotrophic, habitat polygons within the GWDTE assessment buffer at T2 were conservatively assigned as moderate groundwater dependency. However as detailed in Table 3.2 the gentle topographic slope in this area indicates that vegetation is likely dependent upon overland flow, the nearby Red Burn surface watercourses and shallow sub-surface water in the acrotelm draining from the blanket bog habitat upgradient of infrastructure and not a rock-based aquifer.

Several access tracks intersect areas of potential GWDTE habitat. However, these are likely to be of low groundwater dependency based on the local conditions in the Proposed Development Area (gentle topography, peat and clay deposits, blanket bog habitats and network of surface water drains).

It is noted that dewatering may be required at the turbine bases. Due to flow being confined within localised permeable fractures, smaller volumes of water may be disrupted during the excavation, however significant volumes of water within the excavation areas are not anticipated. This should be confirmed following initial ground investigations at the Proposed Development Area.

Mitigation proposed in Section 3.4 where required to minimise the potential effect on the groundwater flow paths.

3.4 Mitigation

To reduce the potential impacts on GWDTE habitats from the Proposed Development, overland flow and the shallow pathways of flow regimes within the peatland and mineral soils should be maintained. This will be achieved by installing cut-off drains around turbines and associated hardstanding.

Access track infrastructure is considered shallow excavation (<1 m excavation), which will have minimal effect on any true groundwater aquifer units. Track will be floated on peat areas >0.7 m to minimise impacts on water flow. If the track cannot be floated, it is proposed that a number of cross drains are constructed where there are downslope GWDTE present, to maintain the hydrological connectivity.

Specific mitigation in relation to dewatering to minimise concrete from interacting with groundwaters may be required once dewatering volumes and locations are known.

The mitigation proposed in this assessment to maintain localised areas of hydrological connectivity, will be built into the detailed design and stated in Technical Appendix A5.1: Outline Construction Environmental Management Plan (CEMP).

Pollution prevention measures outlined in the CEMP and Pollution Prevention Plans (PPP) are considered to be sufficient to minimise the potential for chemical and silt pollution to GWDTE habitats. This will prevent and minimise the release of contaminated water and sediments to the water environment (including groundwater units).

Following the implementation and adherence to mitigation measures to ensure groundwater quantity and quality of supply, the risk to potential GWDTE habitats within the assessment buffer is considered minor.

4 CONCLUSION

The potential GWDTE areas identified across the Proposed Development Area are consistently associated with surface water features at the floodplain and margins of the watercourses and along drains and soakaways. The remaining potential GWDTEs are considered to have limited connectivity to groundwater due to the presence of impermeable peat and clay substrate and blanket bog habitat. These habitats are likely fed by shallow sub-surface flow across the gentle topography of the assessment area. The NVC communities within the 250 m buffer are considered reliant upon surface water or shallow sub-surface across the entirety of the Proposed Development Area and therefore assessed to be of low groundwater dependency. Following implementation and adherence to mitigation measures, no GWDTEs within the assessment buffer are considered to be at significant risk.

Due to the overall low productivity of the underlying aquifer, dewatering of the turbines noted above is not considered to have a significant effect for the Proposed Development. This is based on the assessment that the wider groundwater body is low yielding, and notable groundwater would only be present if the excavation dissected a localised area of weathered bedrock or fracture. Ground investigations should be completed prior to construction to increase confidence in this assumption. Should the investigation identify localised springs which would require dewatering, habitats would be assessed on a site-specific basis.

5 REFERENCES

European Commission (2022). The EU Water Framework Directive- Integrated river basin management for Europe. Available online at: https://ec.europa.eu/environment/water/water-framework/index_en.html Accessed 27/07/2023.

SEPA (2017). Land Use Planning System SEPA Guidance Note 31: Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. LUPS-GU31, Version 3.

Watten Wind Farm

Technical Appendix A9.4
Phase 1 and 2 Peat Depth & Coring Survey Report

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1 INTRODUCTION

MacArthur Green was commissioned by EDF Energy Renewables Ltd (the Applicant) to carry out peat depth and coring surveys to aid the design process and to inform an assessment of the nature and condition of the peatland at the proposed Watten Wind Farm (hereafter the Proposed Development).

This report has been produced by MacArthur Green in accordance with Scottish Environment Protection Agency (SEPA) and NatureScot (formerly Scottish Natural Heritage (SNH) guidelines[1]). Those contributing to the preparation of the technical appendix have undergraduate and/or postgraduate degrees in relevant subjects, have professional experience, and hold professional memberships relating to their field of expertise (e.g., Chartered Institute of Ecology and Environmental Management (CIEEM) or Association of Geographic Information (AGI)).

2 AIMS AND OBJECTIVES

The surveys were split into two phases, with the following aims and objectives:

2.1 Phase 1

- **Aim 1 Gather high resolution peat depth data on a 100 m² systematic grid for the peat Study Area[2].**
    - Objective 1.1 Inform the layout of the Proposed Development's infrastructure to help reduce effects associated with peatland habitats; and
    - Objective 1.2 Provide peat depth data to: 1) inform the effect of the Proposed Development on carbon losses arising from disturbance to peatland habitats; and 2) inform a draft Peat Management Plan (DPMP) for the Proposed Development (Technical Appendix A9.5).

2.2 Phase 2

- **Aim 1 Gather additional high-resolution peat depth data around proposed wind turbine and infrastructure locations.**
    - Objective 1.1 Further inform the layout of the Proposed Development's infrastructure to help reduce effects associated with peatland habitats; and
    - Objective 1.2 Provide peat depth data to inform the effects of the Proposed Development on carbon losses arising from disturbance to peatland habitats.

[1] Scottish Government, Scottish Natural Heritage, SEPA. (2017). *Peatland Survey. Guidance on Developments on Peatland*. https://webarchive.nrscotland.gov.uk/3000/https://www.gov.scot/Resource/0051/00517174.pdf (Accessed 27/07/2023).

[2] The peat Study Area for the Development comprised the area as detailed in Figure 9.8 and covers all infrastructure areas and a minimum buffer of 100 m.

- **Aim 2 Present data on the nature of peat deposits at key infrastructure locations.**
    - Objective 2.1 Provide data to inform a DPMP; and
    - Objective 2.2 Assess the accuracy of peat depth probe samples.

These surveys detail the depth and character of the peatland across the Proposed Development Area. A full and detailed description of the vegetation present within the Proposed Development Area, which may also contribute to the characterisation of the peatland condition, can be found in Technical Appendix A7.1: National Vegetation Classification & Habitats Survey Report.

3 THE PROPOSED DEVELOPMENT AND STUDY AREA

The Proposed Development is for up to seven wind turbines and is located on land to the east of Halsary Wind Farm and approximately 3 km to the south-west of Watten in Caithness in the Scottish Highlands.

The Proposed Development Area is the area within the site boundary as detailed in Chapter 4: Site Design and Design Evolution of the Environmental Impact Assessment (EIA) Report. A full description of the Proposed Development is provided in Chapter 5: Project Description. The peat Study Area for the Proposed Development comprised the area as detailed in Figure 9.8 and covered all infrastructure areas and previous infrastructure search areas during the iterative design process. The area is generally upland in character and dominated by acid grassland, conifer plantation and peatland habitat (see Figure 7.3 of the EIA Report).

The Carbon and Peatland Map 2016[3] was consulted to determine likely peatland classes present in the Proposed Development Area. The map is a predictive tool that provides an indication of the likely presence of peat at a coarse scale. The Carbon and Peatland Map has been developed as a high-level planning tool and identifies areas of nationally important carbon-rich soils, deep peat and priority peatland habitat[4] as Class 1 and Class 2 peatlands. Figure 7.2 of the EIA Report indicates that, according to this predictive tool and map, the Proposed Development Area contains an area of Class 1 peatland within the central area across Western Watten Moss and an area of Class 1 peatland in the west, located west of Blàr an t-Siomain (N.B. both these Class 1 peatland areas have been planted over with commercial conifer plantation). There are no Class 2 peatland areas within the Proposed Development Area. The Proposed Development Area also includes Class 0 (mineral)[5] and Class 3[6], 4[7] and 5[8] soils.

[3] SNH. (2016) Carbon and Peatland 2016 map. Available at: https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/soils/carbon-and-peatland-2016-map Accessed on: 27/07/2023.
[4] Priority peatland habitat is land covered by peat-forming vegetation or vegetation associated with peat formation.
[5] Mineral soil - Peatland habitats are not typically found on such soils (Class 0). Indicative vegetation - no peatland vegetation.
[6] Class 3 - Class 3 - Dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Predominantly peaty soil with some peat soil.
[7] Class 4 - Area unlikely to be associated with peatland habitats or wet and acidic type. Area unlikely to include carbon-rich soils. Indicative vegetation - heath with some peatland.
[8] Class 5 - Soil information takes precedence over vegetation data. No peatland habitat recorded.

A summary table detailing the classification of peatlands of national importance, habitat and altitude in relation to Proposed Development infrastructure is provided in Annex A (Table A-1).

As the Carbon and Peatland Map is a high-level tool, peat depth and coring surveys were carried out across the Proposed Development Area to inform siting, design and mitigation and the detailed assessment on peatland and associated habitats. The results of the peat surveys are discussed here, and the results of the habitat surveys are presented and discussed in Chapter 7: Ecology and associated respective Technical Appendix A7.1.

4 METHODOLOGY

Field surveys followed best practice guidance published at the time of survey with regards surveying for developments on peatland[1,9].

The below methodology describes the methods employed for the Phase 1 and Phase 2 peat surveys carried out for the Proposed Development in March 2020, August, September and November 2022 and April 2023.

4.1 Phase 1 Peat Probing

The adopted sampling frequency took due consideration of good practice and published guidance referred to above.

The following methods were employed by MacArthur Green on behalf of the Applicant during the peat survey conducted in March 2020:

1. The peat Study Area was sampled using a 100 m^2 systematic grid (Figure 9.8). A random point was selected within the peat Study Area and the grid was established around the random point. The grid was orientated north to south for ease of navigation.
2. Geographical Information System (GIS) was used to generate the systematic grid and related sampling locations.
3. 316 samples were generated in total.
4. Sampling locations were downloaded on to handheld Global Positional System (GPS) units, which were used to locate sampling locations in the field.
5. A custom made collapsible solid steel peat depth probe was used at each sample point to establish substratum depth. Full depth recordings were taken to the nearest centimetre (cm). (N.B. As this is a peat assessment, only peat or organo-mineral soil (i.e., peaty soils – peaty podzols or peaty gleys) depths were recorded; where the sample point fell on mineral soil/bare rock the probe depth was recorded as zero.)
6. The underlying substrate was defined if determinable.

[9] Scottish Renewables and SEPA (2012). Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste.

7. Peat depth data were modelled using 'Inverse Distance Weighted' (IDW) interpolation in ArcMAP 10.8.1©. This interpolation method is best suited to situations where the density of samples is great enough to capture the local surface variation needed for the analysis (Childs, 2004[10]).

8. A depth model was generated using the following categories of peat depth: 0; 1-25 cm, 26-50 cm, 51-100 cm and 50 cm intervals thereafter.

4.2 Phase 2 Peat Probing and Coring

4.2.1 Peat Depth Analysis

The first phase of peat depth probing and analysis (Phase 1 peat survey) was carried out on a 100 m^2 systematic grid. This peat depth data and other constraints were used to inform the layout of the Proposed Development, including the wind turbine locations, substation, access track alignments, compounds etc.

The second phase of intensive peat probing (Phase 2 peat survey) supplements the original data and gathers further high-resolution data for the Proposed Development on and adjacent to the footprint of proposed infrastructure.

The following methods were employed by MacArthur Green on behalf of the Applicant in August, September and November 2022 and April 2023:

1. Where infrastructure likely requires the excavation of peat, e.g., at wind turbines, substation, compounds etc., peat depth samples were taken at 10 m intervals along crosshairs from the central point of the infrastructure feature.

2. The alignment of proposed new, and existing, access tracks was sampled at 50 m intervals, with measurements taken on the access track centreline and points 10 m perpendicular to the centreline on either side of the proposed track.

3. GIS was used to generate the sampling locations, samples that fell on existing tracks were removed.

4. 745 Phase 2 sample locations were sampled in total. The Phase 2 peat depth probing locations sampled are also shown in Figure 9.8.

5. Sampling locations were downloaded on to hand-held GPS units, which were used to locate sample points in the field.

6. A custom made collapsible solid steel peat depth probe was used at each sample point to establish peat depth. Full depth recordings were taken. (N.B. As this is a peat assessment, only peat or organo-mineral soil depths were recorded; where the sample point fell on mineral soil/rock the probe depth was recorded as zero.)

7. The underlying substrate was defined if determinable.

8. Peat depth data were combined with the Phase 1 probing data and modelled using IDW interpolation in ArcMap 10.8.1©, as per the Phase 1 probing data.

[10] Childs, 2004. Interpolating surface in ArcGIS Spatial Analysis, ESRI Educational Services.

9. An updated peat depth model was generated using the following categories of peat depth: 0; 1-25 cm, 26-50 cm, 51-100 cm and 50 cm intervals thereafter.

4.2.2 Peat Coring

Peat coring was undertaken by MacArthur Green. Peat coring analysis methods follow those detailed within Hobbs (1986: see Hobbs Appendix A p.78-79) and Hodgson (1974).

1. Peat cores were taken at four locations. Locations were determined after a review of the proposed infrastructure layout at the time of surveys, and analysis of peat depths from the Phase 1 peat survey. Additionally, a peat depth probe was taken adjacent to the core sample. Coring locations are detailed in Table 4-1 below and shown in Figure 9.8.
2. A 'Russian Corer' (volume 0.5 litres (l)) was used to take peat cores.
3. At each core sample location, the full peat depth profile was sampled, which involved taking 50 cm length cores from the surface layer through to the basal layer (where peat meets the underlying substrata).
4. For each sample core, the following information was collected in the field:
    a. A photograph of each 50 cm core;
    b. Depth of the acrotelm;
    c. Degree of humification (as per Hodgson, 1974):
        - Amorphous Peats – most decomposed peats with fibre < 1/3rd volume when not rubbed - reduces to < 1/10 by rubbing, (optional - yields soluble dark humidified matter).
        - Fibrous Peats – least decomposed peats with fibre > 2/3rds volume when not rubbed - reduces to no less than > 4/10 by rubbing, (optional - yields little soluble dark humidified matter).
        - 'Intermediate' if assessment falls between amorphous and fibrous.
    d. Degree of humification due to forestry and the depth of this layer if present;
    e. Degree of humification using the von Post Scale;
    f. Fine Fibre Content: F0 (none), F1, F2, F3 (very high);
    g. Coarse Fibre Content: R0 (none), R1, R2, R3 (very high);
    h. Water Content: B1 (dry) to B5 (very wet); and
    i. Type of substrate underlying the peat (where this could be determined).

Table 4-1 Peat core sample numbers, locations and corresponding infrastructure

Sample Core ID	Number of 50 cm cores sampled	Easting	Northing	Infrastructure
T088	1	320510	951280	T4
T117	2	320400	951838	T5
T146	2	319827	951255	T6
T175	1	319937	950772	T7

5 SURVEY DETAILS & LIMITATIONS

The peat surveys were carried out by MacArthur Green on the following dates:

- 03 March 2020 to 05 March 2020 (Phase 1 probing);
- 29 August to 01 September 2022 (Phase 2 probing);
- 15 November 2022 and 17 November 2022 (Phase 2 coring and additional Phase 2 probing following design change); and
- 12 April 2023 (Phase 2 probing at two micrographs locations: T7 crane pad and the proposed access track connecting with the existing Halsary Wind Farm access track).

Limitations with regard to peat probing relate to the survey method and analysis as follows:

- Obtaining a false depth measurement because of the probe meeting obstructions within the peat (e.g., hitting roots, stones etc). This was mitigated against as far as possible by taking an additional probe at each sample where it was suspected that the probe was hitting a barrier.
- In some cases, peat depth may be over-estimated if the substratum underlying the peat is soft.
- Difficulty with inserting the probes into drier more humified peat, which was mitigated against as far as possible by using a custom-made solid steel probe with detachable steel handles to allow probes to be forced into the peat.
- The Phase 2 probing and coring sample locations were selected based on the infrastructure layout at the time of survey.
- Probe points within a 30 m buffer of an underground cable were excluded for health and safety reasons.
- Nine of the GIS generated probe points were outwith the Proposed Development boundary and were excluded from the survey due to access restrictions.

The above limitations associated with the method used to assess peat depth are not considered a significant factor and the peat and coring data presented are deemed to provide an accurate representation of the typical peat conditions within the Proposed Development Area; this data can be relied upon to inform the objectives of the peat survey.

6 RESULTS

The results are presented as follows:

- Section 6.1 presents the results of the peat depth probing;
- Section 6.2 provides a comparison of probed and cored (true) peat depths; and
- Section 6.3 presents the results of the coring survey.

6.1 Phase 1 & Phase 2 Probing

During the peat depth probing surveys in 2020, 2022 and 2023, a total of 316 peat depth probes were taken during Phase 1 and 745 probes during Phase 2. Therefore, there is a combined peat depth dataset of 1061 probes within the peat Study Area, as shown in Figure 9.8.

Figures 9.9 and 9.10 show the results of the peat depth surveys. Figures 9.9a-c show the specific depth class at each sample location and Figures 9.10a-c show the results of the IDW peat depth modelling based on all available sample depths collected. Figure 9.10 is based on IDW data interpolation and consequently the peat depth contours and boundaries are to a degree indicative; therefore, they cannot be taken as definite boundaries, as actual peat depths 'in the field' may vary to a degree around these boundaries.

Charts 6.1.1 and 6.1.2 present the percentage and frequency of samples falling within the peat depth categories recorded in the peat Study Area.

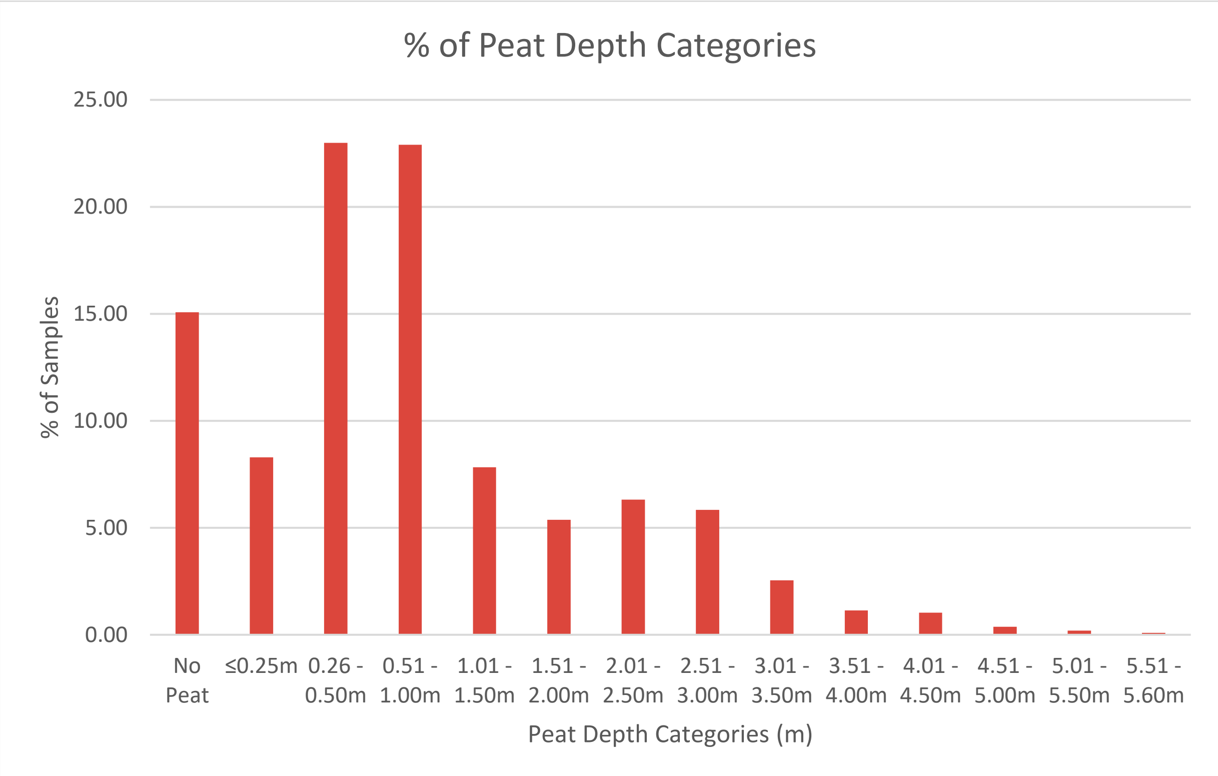

Chart 6.1.1, % Peat Depth Categories

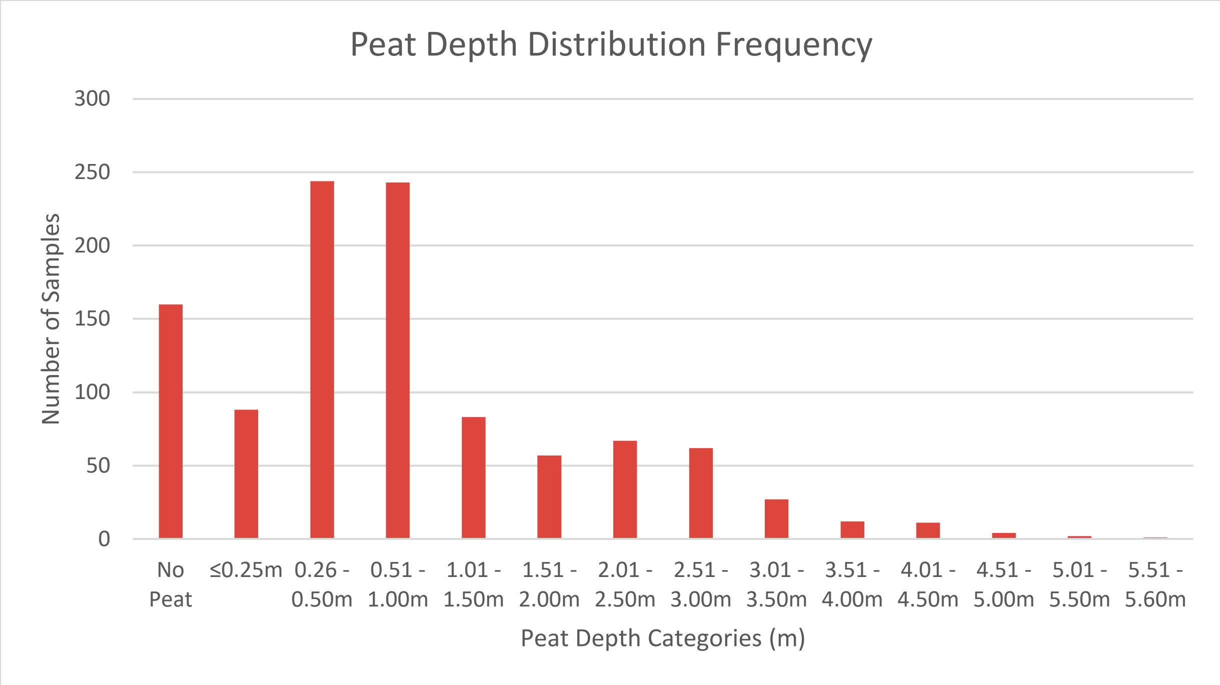

Chart 6.1.2, Peat Depth Frequency Distribution

As shown in Figures 9.9 and 9.10, and further highlighted by Charts 6.1.1 and 6.1.2, most of the peat Study Area has peat and organo-mineral soil depths in the region of 0.01 m to 1.0 m (mean 0.95 m; median 0.55 m) with some quite discrete areas of deeper peat (maximum depth 5.60 m). Overall, 31.3% of samples fell within the 1 to 50 cm depth range; furthermore, the areas of 1-50 cm depth are more appropriately considered to be, and referred to as, organo-mineral soils, or peaty soils. Additionally, 15.1% of the peat Study Area probes had no peat or peaty soils present.

The following considerations are evident from the data:

- 88 samples (8.3%) fell on land with less than or equal to 25 cm depth of peat or organo-mineral/peaty soils;
- 244 samples (23%) fell on land with between 26 cm and 50 cm of peat or organo-mineral/peaty soils;
- 243 samples (22.9%) fell on land with between 51 and 100 cm of peat;
- 83 samples (7.8%) fell on land with between 101 and 150 cm of peat;
- 57 samples (5.4%) fell on land with between 151 and 200 cm of peat;
- 67 samples (6.3%) fell on land with between 201 to 250 cm depth of peat;
- 62 samples (5.8%) fell on land with between 251 to 300 cm depth of peat;
- 57 samples (5.4%) fell on land greater than 301 cm depth of peat; and
- 160 samples (15.1%) fell on land with no peat.

Only sampling points on non-peat or non-organo-mineral habitats (e.g., bare rock or brown mineral soil) were recorded as 0 cm of peat. Peat or organo-mineral soil was recorded at all other points.

Land where peat depth is greater than 50 cm is classified as 'blanket bog' by SNH (now NatureScot) (MacDonald *et al*., 1998) and JNCC (JNCC, 2010); however, some areas with a peat depth of less than 50 cm can still form part of the wider hydrologically connected mire, or macrotope. Areas of peatland at the Proposed Development Area to the west and underlying Wester Watten Moss are designated as Class 1 peatland on the Carbon and Peatland Map, however, these areas are largely disturbed and moribund due to mature commercial conifer plantation; see Technical Appendix A7.1: for further details of Proposed Development Area habitat condition.

6.2 Accuracy of Peat Depth Probes

At each core sample location, a peat depth probe was taken adjacent to the core sample to compare the probed depth against the true depth determined by measuring the depth of peat material retained in the core sample. To ensure the full depth of peat is sampled, a core is extracted that confirms the peat/substratum boundary has been reached. This approach allows a relative assessment of the accuracy of the peat depth probing. Peat or organo-mineral soil was present at all four sample locations. The results are presented in Table 6-1 below.

Table 6-1 Difference between probed and true (cored) depth

Sample Core ID	Probed Depth (cm)	Cored Depth (cm)	Difference (Probed - Cored) (cm)	Infrastructure
T088	56	19	37	T4
T117	74	58	16	T5
T146	104	100	4	T6
T175	32	32	0	T7

As can be seen within Table 6-1 there was a tendency for the peat probes to overestimate the true peat depths determined via coring within the peat Study Area (mean overestimation of 14.25 cm).

The overestimation of peat depth from certain probes is likely due to the peat layer being underlain by other soft non-peat substrates (e.g., clays – N.B. see Annex D: Photos 5 and 6) or a thin layer of penetrable substrates (e.g., gravel) into which the probe could still easily be inserted. As the physical dimensions of the peat probe are narrower than the Russian corer, penetrating beyond the peat layer into soft substrates is easier for the probe. Overall, it is assumed that the probed data will give an accurate representation of peat depth across the peat Study Area and any overestimation will allow consideration of a worst-case depth scenario.

6.3 Core Sample Results

Sections 6.3.1 to 6.3.9 below present the information of the key variables recorded on the nature of peat deposits within the peat Study Area from the coring survey. Annex B presents the results for each of the variables from all the core samples, Annex C details the von Post Classification methodology, and Annex D presents the photographs of each core subsample taken. The cores from all four core sample locations were sent to a laboratory for further analysis.

6.3.1 Depth of Acrotelm

The catotelm and acrotelm represent two distinct layers within undisturbed peat that control the hydrological regime. The catotelm is the bottom layer of peat that is mostly below the water table. The acrotelm overlies the catotelm and is the 'living' layer in which most water table fluctuations occur. The thickness of the acrotelm usually varies up to around 50 cm in undisturbed mires, but it largely depends upon the habitat type (and can reduce/disappear over time under long established forestry). Anaerobic and aerobic conditions alternate periodically with the fluctuation of the water table, favouring more rapid microbial activity than in the catotelm. The acrotelm consists of the living parts of mosses and dead and poorly decomposed plant material. It has a very loose structure that can contain and release large quantities of water in a manner that limits variations of the water table in peat bogs[11].

Three peat core locations were in open unplanted ground, whereas one sample location, T117 (Turbine 5), was within commercial conifer plantation. No discernible acrotelm was recorded at T146 (Turbine 6) and T117 (Turbine 5) sample locations. Acrotelm was recorded at T175 (Turbine 7) and T088 (Turbine 4) sample locations (see Chart 6.3.1), however, the mean depth was low at 1.5 cm which is considered very shallow.

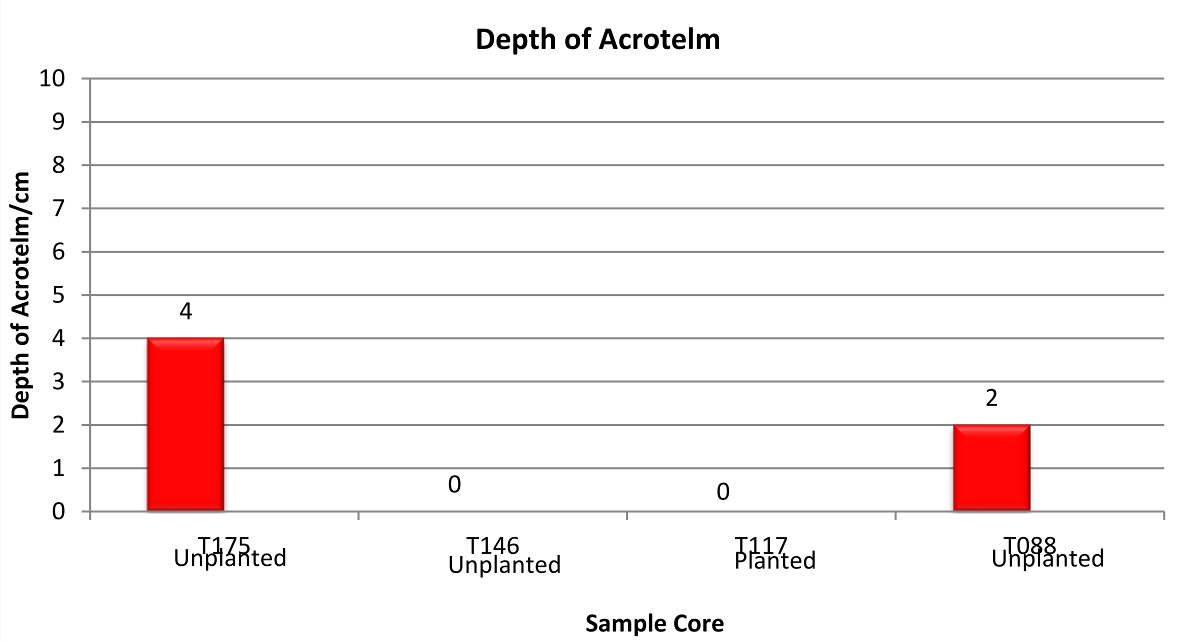

Chart 6.3.1: Depth of Acrotelm

In the context of any development, it is recommended that for the purposes of construction and subsequent reinstatement, where a sufficient peat depth exists, the top 50 cm of material should be treated as acrotelm. This approach will allow excavation of intact turves for reinstatement purposes where they are present, which will in turn facilitate quicker regeneration of disturbed areas. Even if little vegetation is present within this top layer, it should still be treated as acrotelmic

[11] Quinty, F. & Rochefort, L. (2003). *Peatland restoration guide, 2nd ed. Canadian Sphagnum Peat Moss Association and New Brunswick Department of Natural Resources and Energy*. Québec, 106 pp.

material as it may contain a seedbank, particularly in open habitats, which will aid re-vegetation of reinstatement areas.

6.3.2 Degree of Humification

The degree of humification was recorded in the field, in accordance with the methods discussed in Section 4.2.2 above; with each 0.5 m subsample being categorised as either fibrous, intermediate or amorphous peat.

From the four sample cores taken, there were a total of six separate 0.5 m subsamples extracted and analysed. The results are summarised below.

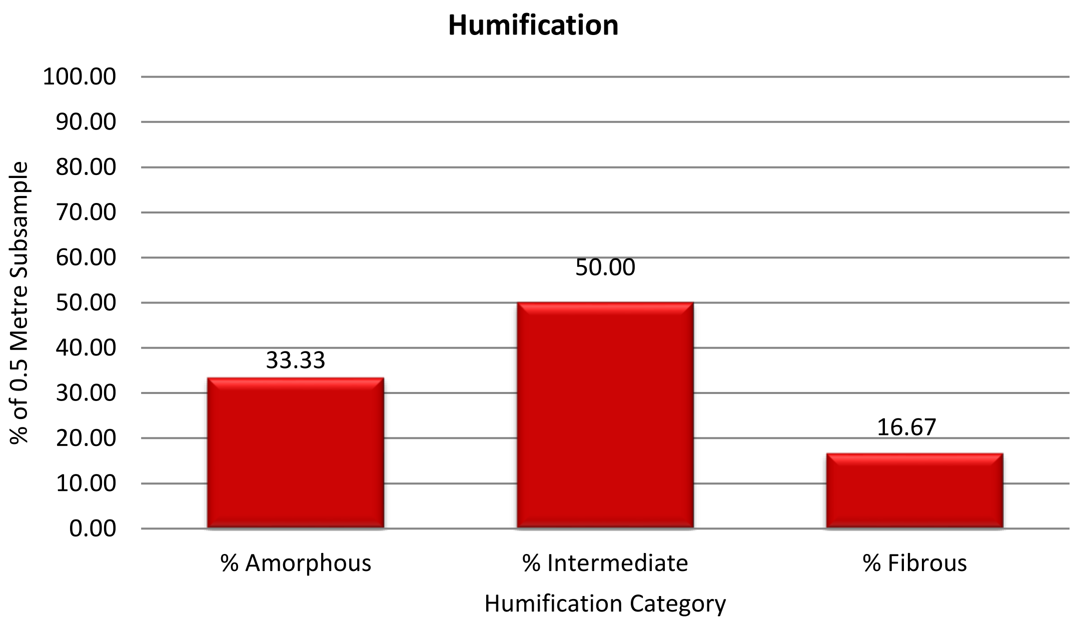

Chart 6.3.2, Degree of humification: % of 0.5 metre subsamples

Chart 6.3.2 above shows the degree of humification, in percentage of 0.5 m subsamples, for four sample locations (comprising six subsamples). The following considerations are highlighted:

- 16.67% of peat from the 0.5 m (n = 1) subsamples was fibrous in nature;
- 50.00 % of the peat from the 0.5 m subsamples (n = 3) was intermediate in nature; and
- 33.33 % of the peat within 0.5 m subsamples (n = 2) was amorphous in nature.

Interpretation of the data suggests that the peat across the Proposed Development Area is generally intermediate in nature and moderately decomposed. One sample was recorded as fibrous, whereas two subsamples from the one core location (at Turbine 5) were amorphous.

The results indicated one subsample (T117A) showed evidence of humification attributed to the effects of forestry plantation. The layer of humified peat was approximately a depth of 7 cm (see also Annex D).

6.3.3 Fibrous Content

The proportions of coarse and fine fibres within the peat samples were ascertained in the field according to the Hobbs scale (see Section 4.2.2). The results are presented below.

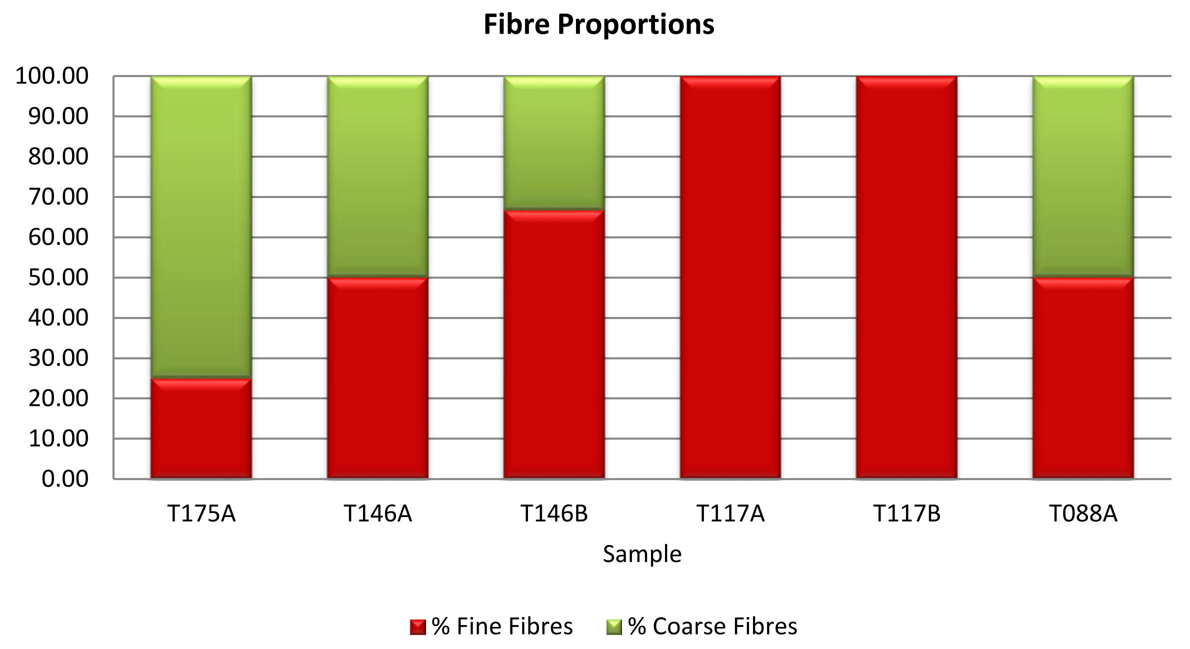

Chart 6.3.3, Proportion of Coarse & Fine Fibres: % 0.5 metre subsamples

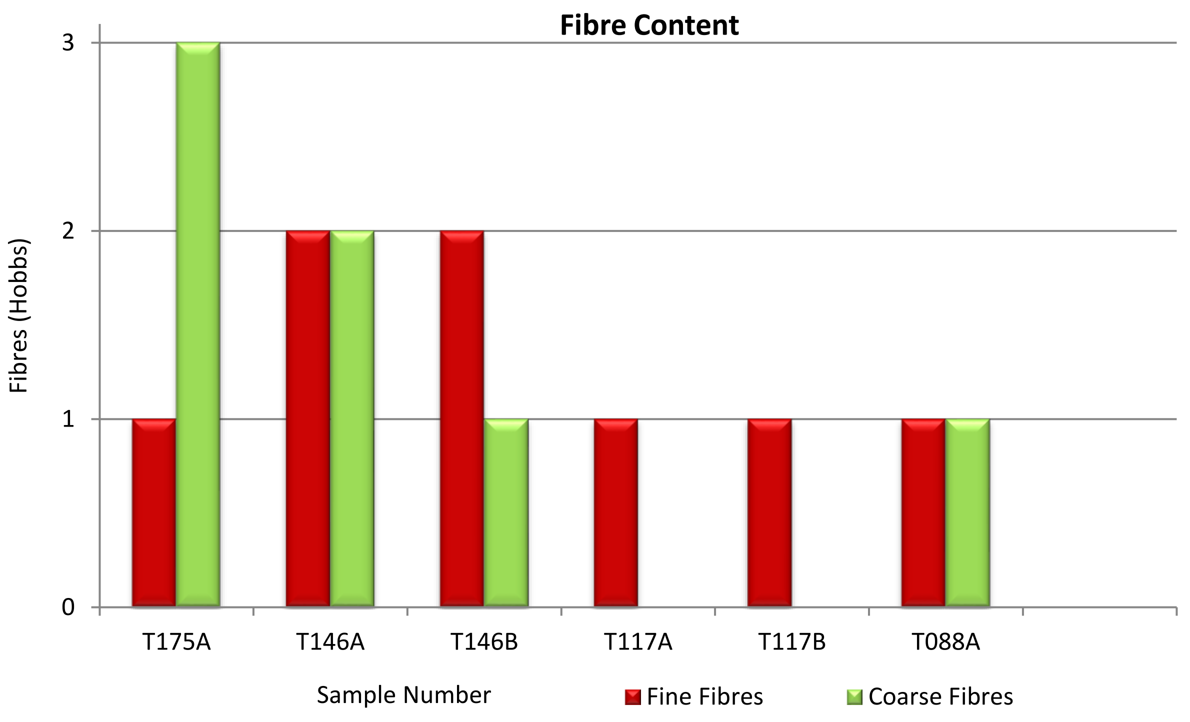

Chart 6.3.4, Level of Fibrous Content: % 0.5 metre subsamples

Chart 6.3.3 above shows the respective proportions of coarse and fine fibres (using the Hobbs scale) present in six core subsample locations and Chart 6.3.4 shows the level of fibrous content for fine and coarse fibres that were present in each of the six subsample locations. The following considerations are highlighted:

- Sample locations T175, T117 and T088 were scored as having a low fine fibre content (F1) according to the Hobbs scale. Sample location T146 was assessed as having a moderate fine fibre content (F2) according to the Hobbs scale.
- Sample location T117 was assessed as having a nil coarse fibre content (F0) in both subsamples according to the Hobbs scale. Sample locations T088 and T146(B) were assessed as having low coarse fibre content (R1); with T146(A) being assessed as having a moderate coarse fibre content (R2) according to the Hobbs scale. T175 was assessed as having a high coarse fibre content (R3) on the Hobbs scale; and
- In summary, the 0.5 m subsamples had a greater proportion of fine fibres than coarse fibres in sample locations T146 and T117. T088 had an even split of fine fibres and coarse fibres and T175 had a greater proportion of coarse fibres than fine fibres.

6.3.4 Water Content

The water content of subsamples was determined in the field using the Hobbs scale (B1 Dry – B5 Very Wet). The results below provide a summary mean for each sample location.

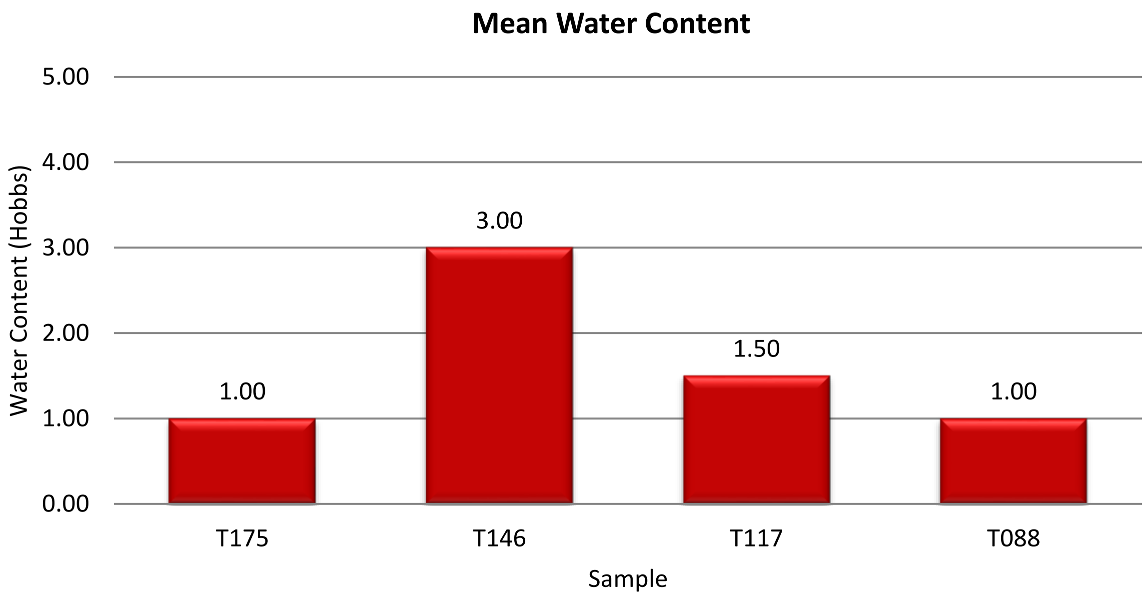

Chart 6.3.5, Mean Water Content: Core Location Summary

- The vertical axis in Chart 6.3.5 above, refers to the water content of sampled peat; 1 = dry to 5 = very wet;
- For the purpose of this analysis, a mean water content was estimated for cores that had more than one 0.5 m subsample;
- All four samples were recorded between B1 to B3 on the Hobbs scale, i.e., dry peats, semi-dry peat with some moisture; and
- No sample locations were recorded as having wet (B4) or very wet peat (B5).

6.3.5 Von Post (Degree of humification)

An estimate of the degree of humification according to the von Post scale (see Annex C) was carried out on samples at all core locations, see Chart 6.3.6 below.

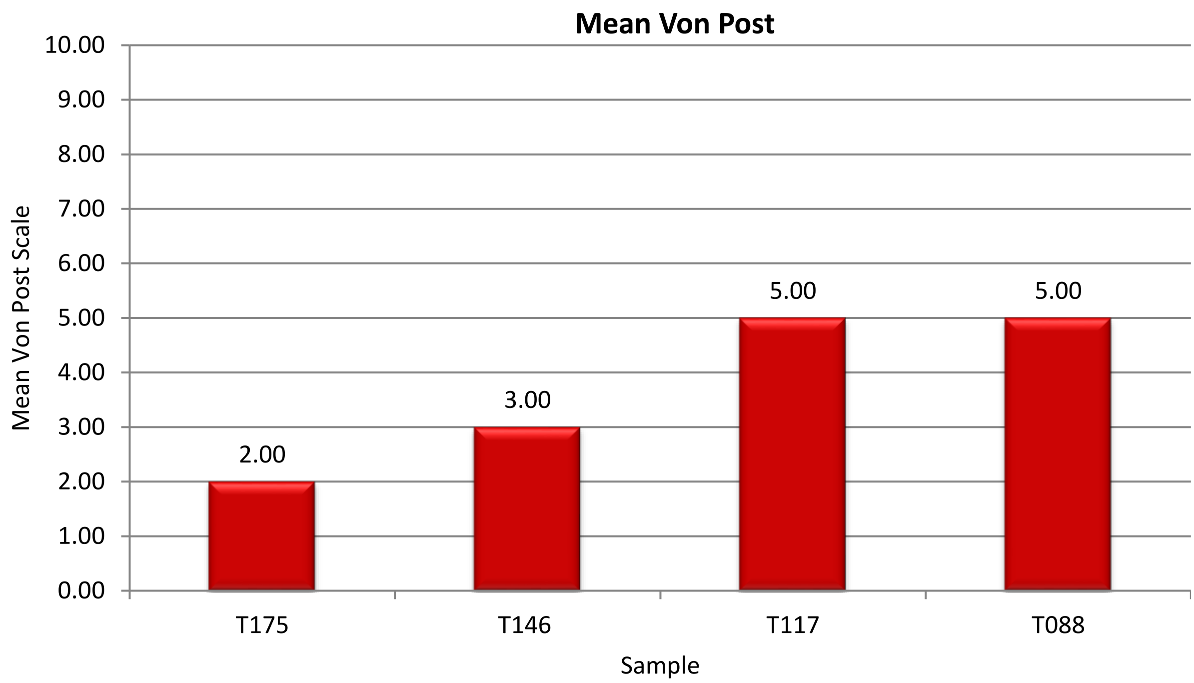

Chart 6.3.6, Mean Von Post

- The vertical axis in Chart 6.3.6, above refers to the Von Post Scale of Peat Decomposition (H1 to H10, see Annex B for details);
- For the purpose of this analysis, a mean degree of humification was estimated for cores that had more than one 0.5 m subsample;
- Two samples (T175 and T146) were scored between H2 and H3 on the Von Post scale, indicating very slight decomposition, this corresponds with a greater proportion of coarse fibres; and
- Two samples (T117 and T088) were scored H5 on the Von Post scale, indicating moderate decomposition.

6.3.6 pH of Peat Samples

Six 0.5 l peat subsamples from four sample core locations were sent to the laboratory for analysis. The pH values determined are provided below.

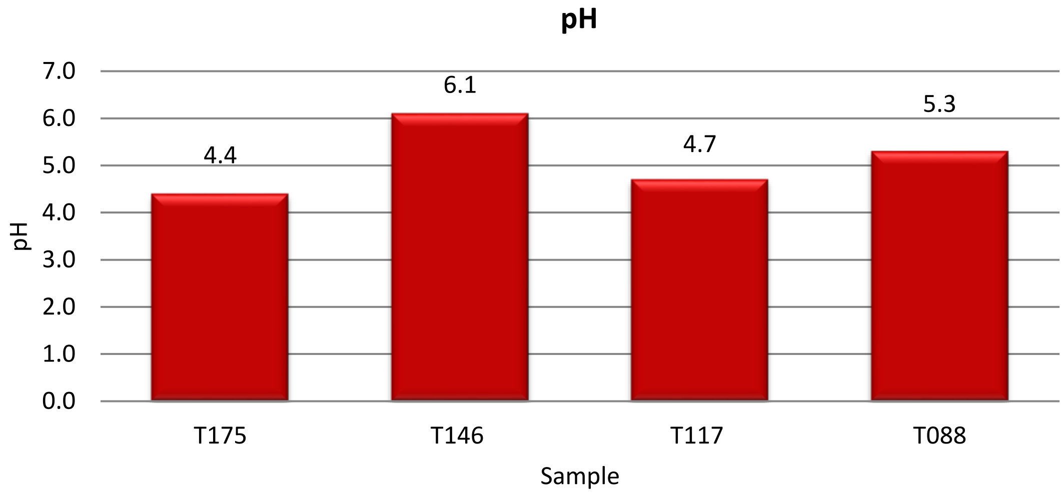

Chart 6.3.7, Mean pH

- The mean pH value of the six subsamples was 5.13, with a range from 4.3 to 6.4 (see Annex B); and
- Chart 6.3.7 provides the mean pH for each core location and indicates that all subsamples were acidic in nature, as would be expected from the environment present within the peat Study Area.

6.3.7 Dry Bulk Density (g/cm^3)

As a result of a lab scheduling error dry bulk density (g/cm^3) values were not correctly calculated for the samples. Values for dry bulk density are therefore estimated using typical values for Scotland as detailed in Carbon Calculator user guidance[12] which states the expected dry bulk density to be "expected = 0.132 g/cm^3; minimum = 0.072 g/cm^3; and maximum = 0.293 g/cm^3".

6.3.8 Total Carbon (%)

Total Carbon content (% dry weight) was calculated for five subsamples sent to the laboratory. T088 was excluded from the resuts due to a scheduling error and the shallow depth of sample. The mean and total carbon content for each core location excluding T088 is illustrated in Charts 6.3.8 and 6.3.9.

[12] https://informatics.sepa.org.uk/CarbonCalculator/assets/Carbon_calculator_User_Guidance.pdf (Accessed 27/07/2023)

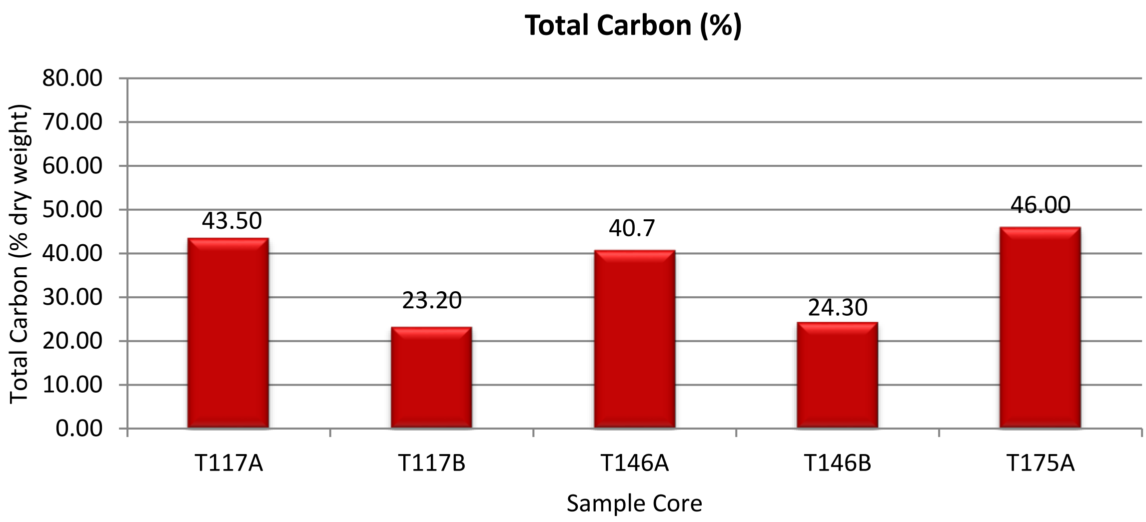

Chart 6.3.8, Core Mean Total Carbon (% weight)

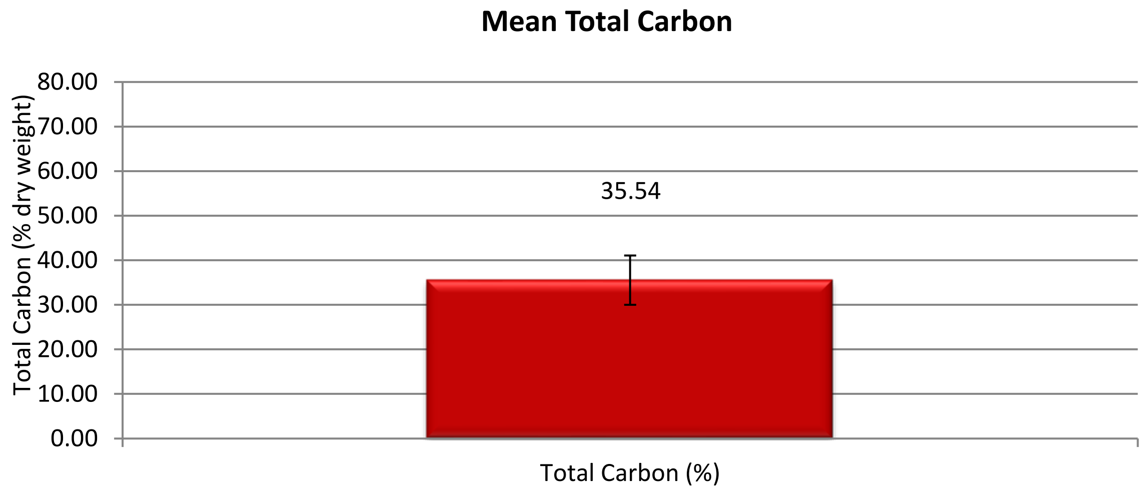

Chart 6.3.9, Subsample Mean Total Carbon (% weight)

Table 6.3.1, Descriptive Statistics

Mean	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper	Precision
35.54	2.82	5.53	30.01	41.07	15.56

Charts 6.3.8 and 6.3.9, and Table 6.3.1 show the total carbon mean and summary statistics for the five subsamples analysed. The following considerations are highlighted:

- The mean total carbon (%) from the cores is 35.54%; with maximum and minimum values of 46.00% and 23.20% respectively (see Annex B).

6.3.9 Underlying Substrates

At each sample location, where possible, a characterisation was made of the underlying substrate below the peat horizon. The raw data is provided in Annex B of this report, with samples T175 (Turbine 7) and sample T146 (Turbine 6) locations indicating gravel/stone material below the peat/soil layer. At sample location T088 (Turbine 4) and T117 (Turbine 5) clay horizons were recorded below the peat layer. Photos of cores are included in Annex D.

7 SUMMARY

7.1 Peat Depth Analysis

Combining the results from the Phase 1 and Phase 2 peat depth surveys shows the majority of the peat Study Area (69.27%) has a peat depth of ≤1.0 m or no peat (see also Figures 9.9 and 9.10). However, these areas where peat depth is less than 0.5 m is more appropriately considered, or referred to as, organo-mineral soils or peaty soils. Some more discrete areas of deeper peat were recorded within the peat Study Area with a maximum depth recorded as 5.6 m.

The data revealed the following key results:

- 88 samples (8.3%) fell on land with less than or equal to 25 cm depth of peat or organo-mineral/peaty soils;
- 244 samples (23%) fell on land with between 26 cm and 50 cm of peat or organo-mineral/peaty soils;
- 243 samples (22.9%) fell on land with between 51 and 100 cm of peat;
- 83 samples (7.8%) fell on land with between 101 and 150 cm of peat;
- 57 samples (5.4%) fell on land with between 151 and 200 cm of peat;
- 67 samples (6.3%) fell on land with between 201 to 250 cm depth of peat;
- 62 samples (5.8%) fell on land with between 251 to 300 cm depth of peat;
- 57 samples (5.4%) fell on land greater than 301 cm depth of peat; and
- 160 samples (15.1%) fell on land with no peat.

7.2 Peat Coring

The peat core sample results presented in Section 6.3, highlight the physical and chemical properties of the peat within the Proposed Development Area. The most notable results from the core analysis are detailed below:

- Peat probes undertaken at the Proposed Development Area tend to marginally overestimate the true depth of peat present due to underlying granular and clay layers below the peat horizon in some areas;
- T175 and T088 had a shallow layer of acrotelm recorded (maximum depth 4 cm). T146 and T117 locations had no discernible acrotelm recorded;

- The peat onsite is generally intermediate to amorphous in nature. The peat generally contains a greater level of fine fibres at all sample locations other than T175 which had a greater level of coarse fibres;
- The mean water content of the peat at the sample locations appears to be consistent with semi dry peats that contain some moisture, no wet to very wet peats were recorded;
- Samples analysed in the field to the Von Post scale were scored between H2- H3 (indicating very slight decomposition) and H5 (indicating moderate decomposition);
- The samples were acidic, pH ranging from 4.30 to 6.40; and
- Total carbon content statistics were calculated from five subsamples sent to the laboratory from four core sample locations.

Overall, the majority of peat and organo-mineral soils sampled across the peat Study Area were <1 m depth, semi-dry with some moisture and intermediate to amorphous in nature and exhibited slight to moderate levels of decomposition.

8 REFERENCES

Childs, C (2004). *Interpolating Surfaces in Arc GIS Spatial Analyst*. ArcUser. www.esri.com.

Hobbs, N.B. (1986). Mire morphology and the properties and behaviour of some British and foreign peats. *Quarterly Journal of Engineering Geology* 19, 7-80.

Hodgson, J.M. (1974). *Soil Survey Field Handbook. Describing and Sampling Soil Profiles.* Harpenden.

JNCC (2010). *Handbook for Phase 1 Habitat Survey*, Joint Nature Conservation Committee, Peterborough.

MacDonald, A., Stevens, P., Armstrong, H., Immirzi, P. and Reynolds, P. (1998). *A Guide to Upland Habitats: Surveying Land Management Impacts (Volume 1)*. Scottish Natural Heritage, Edinburgh.

Quinty, F. & Rochefort, L. (2003). *Peatland restoration guide, 2nd ed. Canadian Sphagnum Peat Moss Association and New Brunswick Department of Natural Resources and Energy*. Québec, 106 pp.

Scottish Government, Scottish Natural Heritage, SEPA. (2017). *Peatland Survey. Guidance on Developments on Peatland.* https://webarchive.nrscotland.gov.uk/3000/https://www.gov.scot/Resource/0051/00517174.pdf (Accessed 27/07/2023).

Scottish Renewables and Scottish Environmental Protection Agency (2012). *Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste.*

ANNEX A. SUMMARY OF PEATLANDS OF NATIONAL IMPORTANCE

Table A-1 below provides a summary of the details of peatlands of national importance, as according to the Carbon and Peatland Map 2016[13], in relation to infrastructure for the Proposed Development; see also Figure 7.2. The Carbon and Peatland Map 2016 is a predictive tool that provides an indication of the likely presence of peat at a coarse scale. It has been developed as a high-level planning tool and identifies areas of nationally important carbon-rich soils, deep peat and priority peatland habitat as Class 1 and Class 2 peatlands. As the Carbon and Peatland Map is a high-level tool, the peat depth and coring surveys as described in this Technical Appendix, in combination with detailed habitat surveys (see Chapter 7: Ecology and associated respective Technical Appendix A7.1), were carried out across the Proposed Development Area to inform detailed siting, design and mitigation and the detailed assessment on peatland and associated habitats. The peat depth and habitat data collected for the Proposed Development is of higher resolution and accuracy than that as presented in the Carbon and Peatland Map 2016, therefore whilst Table A-1 has been included below the detailed data collected for the Proposed Development should take precedence.

Table A- 1: Summary of Key Infrastructure in Relation to Peatlands of National Importance

Infrastructure	Grid Reference[14]		Peat Depth (cm)[15]	Dominant Phase 1 Habitat[16]	NVC Community[16]	Altitude (m)	Peatland Class[17]
	Easting	Northing					
Turbine 1	321106	952238	44	Blanket Bog (E1.6.1)	M17c	75.8	3
Turbine 2	321504	951907	26	Unimproved Acid Grassland (B1.1)	U4d/MG9a/U4b/M23b/MG10a	66	5
Turbine 3	320867	950938	0	Semi-Improved Acid Grassland (B1.2)	U4b	59	0
Turbine 4	320510	951280	56	Semi-Improved Acid Grassland (B1.2)	U4b/MG10a	61.6	3
Turbine 5	320401	951839	74	Coniferous Plantation Woodland (A1.2.2)	CP	66.8	5
Turbine 6	319828	951255	104	Marsh/Marshy Grassland (B5)	M23b/MG10a/U4a/MG10c	73.1	5
Turbine 7	319938	950772	32	Wet Modified Bog (E1.7)	M25a/M17a	71.3	3
Substation	320454	951387	≤25 - 100 cm	Semi-Improved Acid Grassland (B1.2)	U4b/MG10a	62.2	3/5
Construction compound	320403	951388	26 – 100 cm	Semi-Improved Acid Grassland (B1.2)	U4b/MG10a	62.2	3/5

[13] https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/soils/carbon-and-peatland-2016-map (Accessed 27/07/2023).
[14] See EIAR Chapter 5: Project Description.
[15] As per the data presented in this Technical Appendix, see also Figures 9.9 and 9.10.
[16] As per the habitats survey data collected for the Proposed Development, as presented within EIAR Chapter 7: Ecology and Technical Appendix A7.1 National Vegetation Classification & Habitats Survey Report, see also Figure 7.3.
[17] As per the Carbon and Peatland Map 2016.

ANNEX B. PEAT CORING DATA

Sample No.	Infrastructure	X	Y	Planted / Unplanted	Sub-sample	Probed depth (cm)	Cored Depth (cm)	Depth of Acrotelm (cm)	Colour	Depth of Sub Sample	Humified due to Forestry	Depth of humification (cm)	Amorphous	Intermediate	Fibrous	Fine Fibres+	Coarse Fibres+	Water Content+	Von Post Scale #	pH	Total Carbon as % dry weight	Substrate
T175	T7	319937	950772	Unplanted	T175A	32	32	4	Mid brown	0.0-0.50	0	0	No	No	Yes	F1	R3	B1	H2	4.4	46	Gravel/stone
T146	T6	319827	951255	Unplanted	T146A	104	100	0	Mid-dark brown	0.0 -0.5	0	0	No	Yes	No	F2	R2	B3	H3	5.8	40.7	Gravel/stone
T146	T6	319827	951255	Unplanted	T146B	104		0	Light - mid/dark brown	0.5 - 1.0	0	0	No	Yes	No	F2	R1	B3	H3	6.4	24.3	Gravel/stone
T117	T5	320400	951838	Planted	T117A	74	58	0	Dark brown	0.0 -0.5	1	7	Yes	No	No	F1	R0	B2	H5	4.3	43.5	Clay
T117	T5	320400	951838	Planted	T117B	74		0	Mid-dark brown	0.5 to 1.0	0	0	Yes	No	No	F1	R0	B1	H5	5.1	23.2	Clay
T088	T4	320510	951280	Unplanted	T088A	56	19	2	Mid-dark brown	0.0 - 0.5	0	0	No	Yes	No	F1	R1	B1	H5	5.3	5.3	Clay

+ see Section 4.2.2 methodology for description; # see Annex C for description.

ANNEX C. VON POST SCALE OF HUMIFICATION

Table C- 2: Von Post Scale of Humification

Degree of Decomposition	Nature of Squeezed Liquid	Proportion of Peat Extruded	Nature of Plant Residues	Decomposition Description
H1	Clear, colourless or light yellow-brown water	None	Plant structure unaltered. Fibrous, elastic	Undecomposed
H2	Almost clear, yellow-brown	None	Plant structure distinct, almost unaltered.	Almost undecomposed
H3	Slightly turbid, brown	None	Plant structures distinct, most remains easily identifiable	Very weakly decomposed
H4	Strongly turbid, brown	None	Plant structure distinct, most remains identifiable	Weakly decomposed
H5	Strongly turbid, contains a little peat in suspension	Very little	Plant structure clear but indistinct and difficult to identify	Moderately decomposed
H6	Muddy, much peat in suspension	One third	Plant structure indistinct but clearer in residue, most remains undefinable	Well decomposed
H7	Strongly muddy	One half	Plant structure indistinct	Strongly decomposed
H8	Thick mud, little free water	Two thirds	Plant structure very indistinct – only resistant material such as roots	Very strongly decomposed
H9	No free water	Nearly all	Plant structure almost unrecognisable	Almost completely decomposed
H10	No free water	All	Plant structure not recognisable, amorphous	Completely decomposed

ANNEX D. PHOTOGRAPHS OF CORE SAMPLES

Photo 1 Core Sample T175A (Turbine 7)

Photo 2 Core Sample T146A (Turbine 6)

Photo 3 Core Sample T146B

Photo 4 Core Sample T117A (Turbine 5)

Photo 5 Core Sample T117B

Photo 6 Core Sample T088A (Turbine 4)

MacArthur Green

Watten Wind Farm

Draft
Peat Management Plan

Technical Appendix A9.5

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MacArthur Green is helping to combat the climate crisis through working within a carbon negative business model. Read more at www.macarthurgreen.com.

CO_2e Assessed Organisation

CO_2e Negative Organisation

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

MacArthur Green was commissioned by EDF Energy Renewables Limited (the Applicant) to produce a Draft Peat Management Plan (DPMP) for the proposed Watten Wind Farm (the Proposed Development).

This DPMP has been produced in accordance with Scottish Environment Protection Agency (SEPA) and NatureScot (formally Scottish Natural Heritage (SNH)) guidelines[1]. Those contributing to the preparation of this Technical Appendix have undergraduate and/or postgraduate degrees in relevant subjects, have professional experience, and hold professional memberships relating to their field of expertise (e.g., Chartered Institute of Ecology and Environmental Management (CIEEM) or Association of Geographic Information (AGI)).

The Proposed Development Area is the area within the site boundary as detailed in Chapter 4: Site Design and Design Evolution and Chapter 5: Project Description of the Environmental Impact Assessment Report (EIAR). The Proposed Development will include up to seven turbines and associated ancillary infrastructure as described in Chapter 5: Project Description.

Phase 1, Phase 2 peat depth surveys and coring surveys were carried out by MacArthur Green within the peat study area in 2020, 2022 and 2023. A total of 1,061 peat depth probes were collected, including peat coring at four locations. The peat study area[2] for the Proposed Development predominately has peat depths of between 0.26 – 0.5 metres (m) (23.6% of samples) and 0.51 m – 1.00 m (22.9% of samples)[3]; with 15.1% of the peat study area depth samples indicating no peat present (see Technical Appendix A9.4: Phase 1 and 2 Peat Depth and Coring Survey Report and associated Figures 9.9 and 9.10). The Phase 1 and Phase 2 peat surveys have been used to inform the DPMP.

The Proposed Development Area is upland in character dominated by acid grassland, conifer plantation and bog habitat. Smaller areas of marshy grassland, modified bog, and mesotrophic grassland are also present (see Technical Appendix A7.1: National Vegetation Classification & Habitat Survey Report).

This DPMP is completed in accordance with the guidance for assessing peatlands. 'Developments on Peatland, Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste' (Scottish Renewables (SR) and SEPA, 2012), from herein referred to as SR & SEPA (2012). In accordance with this guidance mentioned above, a final Peat Management Plan (PMP) will be prepared post-consent and in advance of construction commencing, when a finalised post-consent layout has been agreed and the infrastructure contractor has been appointed. The final PMP will be informed by further ground investigation surveys and detailed construction plans.

[1] Scottish Government, Scottish Natural Heritage, SEPA. (2017). *Peatland Survey. Guidance on Developments on Peatland*. https://webarchive.nrscotland.gov.uk/3000/https://www.gov.scot/Resource/0051/00517174.pdf (Accessed 27/02/2023)

[2] The peat study area for the Proposed Development comprised the area as detailed in Figure 9.8.

[3] Areas of 0.01 m to 0.5 m depth are more appropriately considered to be, and referred to as, organo-mineral soils, or peaty soils. The peat depth surveys generally recorded these areas as being peaty podzols with occasional patches of peaty gleys (see Appendix A9.4).

2 STRUCTURE OF THE PEAT MANAGEMENT PLAN

While there are no defined requirements for the layout or content of a PMP, SR & SEPA (2012) provides a guide to what should be considered when preparing one. This has been used to inform the structure within this DPMP as noted below:

Section 3 Aims & Objectives

Section 4 Details to Inform the DPMP:

- Section 4.1: Peat conditions at the Proposed Development;
- Section 4.2: Excavation and reuse volume estimates and reuse requirements for peat;
- Section 4.3: Classification of excavated peat;
- Section 4.4: Handling excavated peat;
- Section 4.5: Temporary peat storage; and
- Section 4.6: Is there a requirement for a Waste Management Plan for the Proposed Development?

3 AIMS AND OBJECTIVES

The key aim is to demonstrate, "*how, through site investigation and iterative design, the proposed development has been structured and designed to minimise, so far as reasonably practicable, the quantity of peat which will be excavated*" (SR & SEPA, 2012). The iterative design process that has been followed to achieve this aim is detailed within Chapter 4: Site Design and Design Evolution. The key elements of the design that reduce excavation of peat are, where possible, locating infrastructure in areas of shallower peat. In addition, existing tracks will be used where possible.

This DPMP is written with respect to the peat that is expected to be excavated during the construction of the Proposed Development, which has been specifically designed to minimise the excavation of peat.

The aim of this DPMP is to:

Establish how peat excavated during the construction of the Proposed Development would be managed to allow valid reuse of peat and to avoid, or minimise, the generation of waste peat.

This aim is achieved through the following objectives:

- Objective 1: Detail the peat conditions at the Proposed Development Area.
- Objective 2: Detail expected volumes of peat to be excavated and reused.
- Objective 3: Consider the likely physical nature of the material and confirm it will be suitable for the reuses proposed.
- Objective 4: Consider the validity of the handling and use of peat for restoration.
- Objective 5: Describe how excavated peat will be handled to ensure suitability for reuse.

- Objective 6: Describe if temporary storage of peat will be required during construction and how this will be done to ensure suitability for reuse.
- Objective 7: Consider whether any peat will not be suitable for reuse and whether there is a requirement for a Waste Management Plan for the Proposed Development.

4 DETAILS TO INFORM THE PEAT MANAGEMENT PLAN

The following Sections detail the information available to inform the DPMP.

4.1 Peat Conditions at the Proposed Development (Objective 1)

Technical Appendix A9.4 details the peat depth surveys at the Proposed Development Area. During Phase 1 peat depth surveys in 2020, a total of 316 peat depth probes were taken. The data were interpolated in ARC GIS using Inverse Distance Weighted (IDW) to produce an initial peat depth contour map of the peat study area. This map was then used to help inform the infrastructure layout, aiming to minimise impacts on peatland and avoid the deepest areas of peat.

The initial proposed layout and subsequent micrmicrosited layouts were subject to further detailed Phase 2 peat depth probing surveys in 2022 and 2023, which included probing 50 m intervals along new tracks (with additional depth taken at 10 m perpendicular offsets) and 10 m intervals around turbine and other infrastructure locations. The Phase 2 probing collected a further 745 peat depth samples within the peat study area.

The 2020, 2022, 2023 Phase 1 and Phase 2 peat data were added, to create a combined peat data set of 1,061 peat depth probes within the peat study area (see Figure 9.8). Based on these data, revised peat depth maps and an interpolated contour map were created to juxtapose the Proposed Development layout against peat depth (see Figure 9.9 and Figure 9.10).

The results of the surveys revealed a study area with a dominance of peaty-soil (i.e. organo-mineral soils) depths between 0.26 – 0.5 m and peat between 0.51 m – 1.00 m throughout the peat study area[3]. However, much of the peatland is considered shallow and with a shallow acrotelm (mean acrotelm depth being 1.5 centimetres (cm) - see Technical Appendix A9.4). The Proposed Development Area contains a range of upland habitats; a full description of the habitats within the Proposed Development Area can be found in Technical Appendix A7.1 (see also Figure 7.4).

The deepest pocket of peat within the Proposed Development Area was recorded at 5.60 m depth and located in the south-west of the Proposed Development Area; approximately 204 m from Turbine 6 (see Figure 9.9 and Figure 9.10). Other deep peat deposits are also present under the commercial conifer plantations at Wester Watten Moss, Druimdubh Moss and Blàr an t-Siomain, and these have been avoided by the Proposed Development (Figure 9.9 and Figure 9.10).

4.2 Excavation & Reuse Volume Estimates and Reuse Requirements for Peat (Objective 2)

Table 4.1 below details the construction activities (excluding the temporary works areas or temporary infrastructure to be provided that do not result in a net surplus of peat) that would generate excavated peat and organo-mineral soils (or where surplus peat/soils can be validly reused) and the expected volumes of peat and organo-mineral soils arising from these activities.

These estimates are based on the dimensions of infrastructure as described within Chapter 5: Project Description and associated Figures. The estimates are generated in GIS and based on the peat depth information provided in Technical Appendix A9.4 and the infrastructure layout, as illustrated in Figure 9.11. Table 4.1 of this DPMP summarises the predicted excavation volumes for each individual infrastructure element, including the associated permanent turbine hardstandings, substation, battery storage and new cut tracks. Full detailed breakdowns of the estimated total volume of peat excavated at each infrastructure element is provided in Annex A in Table A-1. Technical Appendix A9.6: Carbon Calculator Assessment provides additional information on the minimum, maximum, and mean (or 'expected') peat depth at various infrastructure, including turbine foundations, hardstanding areas, and access tracks.

The estimation of peat excavation and reuse volumes relies on several design assumptions that may vary on a small scale according to discrete changes in topography and peat depth. Taken together, these estimated peat excavation and reuse volumes describe whether the Proposed Development has a positive, negative, or neutral peat balance.

As per Chapter 5: Project Description, cabling will follow the line of the tracks (up to 5 m beyond the track edge) in cable trenches or cable ploughing may be used if ground conditions are suitable. Regardless, any peat or organo-mineral soils arising from specific cable trench excavations would be backfilled using the same peat and reinstated in the correct order. Backfilling would be on an 'as-you-go' basis to minimise time between excavation of the cable trench and peat reinstatement. Equivalent volumes of peat are excavated and restored for cabling works, which effectively ensures no net surplus of peat is generated. As a result, the peat volumes associated with the cabling are not included within the peat reuse calculations and cabling is not considered further in this DPMP.

The formation of temporary infrastructure and temporary working areas, such as the temporary construction compound, temporary elements of the turbine hardstandings (e.g., assembly areas), batching plant or temporary working areas[4] would also generate a degree of excavated peat and organo-mineral soils. However, this peat/soil would be stored adjacent to the works and reinstated once the temporary structure has been removed (as per Chapter 5: Project Description) and full depth assumed. Table B-1 of Annex B indicates the temporary infrastructure and associated peat excavation volumes if all temporary areas were fully utilised and excavated to full depth (which is unlikely). There would not be any requirement to reuse this peat/organo-mineral soil elsewhere within the Proposed Development. Peat excavated for temporary infrastructure would be handled and stored in line with the principles outlined within this DPMP (Section 4.5). The excavation and subsequent restoration of this peat would create no net surplus of peat, as a result the peat volumes associated with temporary infrastructure or works are not included within the peat excavation, reuse, and balance calculations in Tables 4.1 to 4.3 below.

[4] The Proposed Development includes areas of 'earthworks cut/fill' which may require some excavation to create safe working areas. Areas of earthworks extents have been included the predicted excavation volumes for temporary infrastructure. These areas will be restored prior to construction completion.

Table 4-1 Peat Excavation by Construction Category – Peat Supply

Infrastructure	Estimated Peat/Organo-mineral Soil Volume to be Excavated (m³)
Battery Storage	569.28
Substation	310.45
New Tracks (Excavated)	12021.08
Turbine Hardstandings (excavated x 7)	12031.20
Turbine Foundations (excavated x 7)	1734.55
Total	**26,666.57**

Table 4.2 below provides details on the reinstatement requirements of the Proposed Development and the anticipated demand for peat from the various reinstatement sources.

Table 4-2 Reinstatement Requirements & Estimated Peat Volume Requirement – Peat Demand

Reinstatement Requirements	Restoration Area (m²)	Average Depth of Restoration (m)	Total Demand Estimate (m³)
Turbine – Hardstand Verges x 7	3,843.00	0.5	19,21.50
Turbine – Foundations Finished Ground Level and Compacted Backfill x 7	2,157.10	0.5	8,628.40
Battery Storage Verges	152.00	0.5	114.00
Substation Verges	64.00	0.5	48.00
Cut Track Verges (4.985 km)	18,358.00	0.5	13,768.50
Total			**24,480.40m³**

Table 4.3 below summarises the figures for total supply and demand for peat at the Proposed Development as calculated from the above estimates.

Table 4-3 Total Demand, Supply and Balance of Peat

Peat Demand/Supply	Volume (m³)
Total Peat Demand (from reinstatement)	24,480.40
Total Peat Supply (from excavation)	26,666.57
Surplus (+) or Deficit (-) [Supply-Demand]	**2,186.17**

A number of design assumptions were made when considering the reuse of excavated peat at the Proposed Development Area, as detailed in Table 4.2, including:

- The area for construction of the wind turbine foundations has been estimated to be a maximum 40 m diameter excavation to allow for an excavated working area around the concrete foundation. A concrete foundation slab of approximately 30 m diameter will sit on the underlying rock or suitable substratum with a founding depth of approximately 4 m subject to prevailing ground conditions (Figure 5.5). With regard to backfilling at these foundations, it has been assumed that an area of the 'compacted backfill material' between concrete foundation and excavation face is suitable for excavated peat/organo-mineral soils. Peat would not be used to backfill the excavation void over the 30 m diameter plan footprint of the foundation due to its potential low strength; instead, rockfill, sands, or gravel will be required to backfill here. However, peat could be used as backfill outside the foundation footprint. This area suitable for peat reuse as backfill has been calculated in GIS as 2,157.10 m^2 (average of 308.16 m^2 per turbine) (calculated as the area of the 5 m outer ring of the turbine excavation, excluding the turbine hardstanding). As above, the founding depth will be up to 4 m.

- A 35 m x 113 m crane hardstanding will be required at each turbine location, these will be maintained during the operational phase of the Proposed Development. Table 4.2 assumes that one length and two widths of each hardstanding is available for reinstatement during construction, with verges 3 m in width.
- New access tracks will be flanked by low angle landscaped verges that will seek to provide visual continuity and topographical tie-in between the access tracks and the surrounding environment, as per guidance (FCE & SNH, 2010). In general, the verges used for finishing and landscaping of the new access tracks will be extended to 3 m either side of the full track width.
- A 16 m x 16 m substation and 47 m x 29 m battery storage is required. Table 4.2 assumes that one length and one width are available for verge reinstatement, with verges 3 m in width.

With regards to peat reuse as detailed in Table 4.2 above, the following guiding principles and assumptions are also made, including, in combination with other guidelines and principles described within this DPMP, the following:

- During the excavation and reuse of peat deposits, where any layered structuring within the peat exists, namely the ‘acrotelm’ and underlying ‘catotelm’, these layers would be preserved as far as is practicable. This approach would aid in the successful re-vegetation and prevent drying and desiccation of the peat;
- Any underlying substrate material removed as part of the excavation should also be stored separately (not mixed with the peat material) and used as backfill over the plan area of foundation bases (if suitable);
- Peat would be stored suitably close and reused as close to its source location as far as practicable;
- Where feasible, reinstatement and restoration would be carried out concurrently with construction rather than at its conclusion;
- Verges at the track margins and around infrastructure will be tapered as necessary to provide a suitable landscape and topographical tie-in and be in such a manner as to prevent the ponding of water on tracks or hardstanding surfaces;
- Verges along tracks will be generally ‘wedge-shaped’ with the deepest section adjacent the track before tapering down; verge edges will not sit above the level of the track;
- Limiting the width of the reinstated track verges to 2 m width, will minimise unnecessary smothering of intact vegetation; and

- All peat reuse and landscaping activities should be agreed in advance with the onsite Environmental Clerk of Works (ECoW), and suitably qualified engineer if required.

It can be concluded from Table 4.3 above that the reasonable demand for peat for reinstatement purposes is less than the supply of peat arising from excavation. It is also apparent that there is no spare reuse capacity in the event more peat is excavated than predicted, or reuse areas cannot accommodate the predicted amounts. As such, it is predicted the Proposed Development will generate surplus peat and organo-mineral soils of around 2,186 m^3 using current assumptions and predictions.

4.3 Classification of Excavated Peat (Objective 3)

Peat was characterised from the six separate 0.5 litre (l) peat core subsamples from four sample locations (as detailed in Technical Appendix A9.4). Furthermore, Technical Appendix A9.4 details the physical properties recorded from the six peat core subsamples taken at the Proposed Development Area.

The key measures of peat condition, which are important to establishing the appropriate type of reuse, are noted in Table 4.4 below. Overall, the sample results suggest that the acrotelm layer is shallow in depth and it is recommended that the upper 0.5 m should be reused as part of the reinstatement programme, where this depth of material is available. Excavation of 0.5 m ensures that, where possible, turves are created and the acrotelm remains as intact and captures much of the underlying seed bank material which would aid vegetation regeneration. Even if little vegetation is present within this top layer, it should still be treated as acrotelmic material. With regards to catotelmic material within the Proposed Development Area, the analytical results indicate that the majority of this material is fibrous or intermediate in nature (except at Turbine 5, where amorphous material was recorded), and generally this material will be suitable for sensitive and appropriate reuse.

Table 4-4 Peat Condition

Acrotelm / Catotelm	Measure of Peat Condition	Consideration (Refer to Technical Appendix A9.4 for detail)
Acrotelm	Depth	The depth of the acrotelm was measured at four sample point locations, which ranged from 0 to 4 cm, with a mean depth of 1.5 cm. Due to the difficulties of excavating a thin layer of acrotelm, without causing significant damage to it, it is recommended that 0.5 m of surface peat is excavated (where possible) for reuse as acrotelm material.
Acrotelm / Catotelm	Degree of Humification	50% (n = three subsamples) of 0.5 m subsamples were intermediate in nature. 33.33% (n = 2) of 0.5 subsamples were amorphous in nature. 16.67% (n = 1) of subsamples were in fibrous in nature.
	Fibrous Content (fine and coarse fibres)	Fine Fibre Content: Four samples were assessed as low (F1) and two samples were assessed as having moderate fine fibre content (F2) according to the Hobbs scale. Coarse Fibre Content: Two samples were assessed as nil (R0); two sample locations were assessed as low (R1); one sample location's content was assessed as moderate (R2); one sample location's content was assessed as having high coarse fibre content (R3) according to the Hobbs scale.
	Water Content	The four sample locations (from six subsamples) ranged from 1.00 to 3.00 for water content (1 being dry and 5 being very wet). All four sample locations were assessed as being 3 or lower for water content; indicating the peat within the Proposed Development is relatively dry.
	Von Post	Von Post classification ranges from H1 (low level of humification) to H10 (highly humified and amorphous peat). All six sample locations were, on average, assessed as being between 2 and 5 on the Von Post classification; indicating low to moderate levels of decomposition at the Proposed Development.

4.4 Handling Excavated Peat (Objective 4)

This Section provides guidance to help the infrastructure contractor in both planning and executing the construction works at the Proposed Development Area.

Working in peat cannot be avoided because certain areas of the Proposed Development Area is underlain by peat of various depths. Careful handling of the peat is also required to ensure its suitability for reuse. Peat will be excavated and may be stored temporarily in an appropriate location (see Section 4.5) where temporary storage is necessary.

The infrastructure contractor shall provide a detailed method statement for works in peat habitats, including but not limited to:

- How to minimise the area of impact;
- How to avoid areas of higher quality bog vegetation (with the assistance of the ECoW);
- Means of access to areas of work and to areas where peat will be reused;

- Methods of peat removal;
- Managing water in the peat and pollution prevention;
- Where to avoid unnecessary intrusive work wherever possible;
- Drainage measures and design and use of appropriate techniques to maintain local hydrology; and
- Plans for the deposition of peat in the Proposed Development Area to be agreed with the ECoW.

It will be necessary for the final PMP to detail the methods and timing involved in handling, storing and using peat for reinstatement, all of which will be dependent on the equipment adopted for the construction activities. The final method statement for this should be based on the following principles:

- The surface layer of peat and vegetation (acrotelm) would be stripped separately from the catotelmic peat. Where possible this would involve an excavation depth of 0.5 m and the creation of turves;
- The turves should be as large as practicably possible to minimise desiccation effects during storage;
- The turves should be kept the right way up in a single layer and wet but not saturated, and not allowed to dry out when in temporary storage;
- Contamination of excavated peat with other substrate materials (e.g., gravels, clays or silts) should be avoided and these materials stored separately where excavated;
- Acrotelmic material would be stored separately from catotelmic material even if some of this layer appears to be lacking vegetation, since it may contain a seedbank that is useful for re-establishing vegetation;
- Any risk of peat slide must be considered by a suitably qualified engineer and where risk is identified protective measures developed before further construction works take place;
- Careful handling is essential to retain any existing structure and integrity of the excavated materials and thereby maximise the potential for excavated material to be reused;
- Plan all works to reduce the need for double handling the peat;
- Movement of excavated turves and peat should be kept to a minimum and it is preferable to transport peat intended for translocation to its final destination at the time of excavation;
- Less humified catotelmic peat (consolidated peat), which maintains its structure upon excavation, should be kept separate from any highly humified amorphous peat;
- Consider the timing of excavation activities to avoid very wet weather periods in order to reduce the risk of peat becoming wet and unconsolidated, thereby reducing pollution or peat slide risk;
- Acrotelmic material would be replaced as intact as possible once construction is complete; and

- To minimise handling and transportation of peat, acrotelmic and catotelmic materials would be replaced, as far as is reasonably practicable, in the location from which it was removed. Acrotelmic material must be placed on the surface.

The handling of peat should be monitored by the ECoW and the Applicant to ensure the above principles are adopted and implemented during construction of the Proposed Development.

4.5 Temporary Peat Storage (Objective 5)

It is anticipated that during construction, on most occasions, peat and organo-mineral soil will only be handled once and will be placed at its end use locations (as detailed in Table 4.2). However, during construction a degree of temporary peat storage will be required before the excavated material can be used in restoration and placed in its end use location.

It will be necessary for the final PMP to detail the methods and timing involved in temporary storage, where this is required. It is likely that a degree of temporary peat storage would be required, for instance in association with stripping areas of any area used for temporary land take; this material would then be used in the subsequent restoration of this temporary construction area.

The final method statement for this temporary storage of peat should be based on the following guiding principles:

- Temporary storage of peat should be minimised. Where required it should be temporarily stored in stockpiles/bunds adjacent to and surrounding each infrastructure location;
- Acrotelm, catotelm, and any clay/glacial till or other substrata should be stored separately and appropriately to ensure no mixing of materials and to prevent cross-contamination;
- Suitable storage areas should be sited in areas with lower ecological value (e.g., away from sensitive bog habitats, Groundwater Dependent Terrestrial Ecosystems (GWDTEs), low stability risk areas and at a minimum distance of 50 m from watercourses. Identified suitable areas would form part of the final PMP and should be agreed in advance with the onsite ECoW;
- Peat turves should be stored in wet conditions where possible (e.g., within waterlogged former excavations) or irrigated in order to prevent desiccation;
- Larger stockpiles are preferable to numerous small stockpiles, which minimises exposure to sun and wind, which can lead to desiccation. Stockpiles should not exceed 2 m in height and be sited with due consideration for slope stability. Benching of stored peat may be necessary to provide stability;
- Stores of non-turf, i.e., catotelm, should be bladed off to reduce surface area and desiccation of the stored peat;
- Stores of peat, particularly catotelmic material, should be inspected regularly (at least weekly) and following heavy rainfall or thaw conditions to check for any evidence of movement, tension cracks or instability in the stored peat. If there is any evidence of instability, appropriate remedial measures should be taken as necessary on the advice from a suitably qualified engineer;

- In dry weather periods, consideration should be given to watering stored turves and peat to prevent drying out, wastage and erosion;
- Pollution prevention measures should be installed around peat storage areas;
- Reinstatement would, in all instances, be undertaken at the earliest opportunity to minimise storage of turves and other materials;
- Timing the construction work, as much as possible, to avoid periods when peat materials are likely to be wetter; and
- Where practical, transportation of peat in the Proposed Development Area, from excavation to temporary storage and restoration locations, should be minimised.

4.6 Requirement for a Waste Management Plan (Objective 6)

As per Section 4.2 above, the Proposed Development will reuse much of the excavated peat/organo-mineral soils onsite during reinstatement and restoration. However, the Proposed Development may generate surplus peat and organo-mineral soils of approximately 2,186 m^3 using current assumptions and predictions.

In line with SEPA (2017) guidance, where there is a surplus of peat and there are no valid reuse options onsite the next preferred step for surplus peat is off-site reuse in peatland restoration, this would require an environmental authorisation.

Where the peat cannot be used off-site for peatland restoration, the next step in the hierarchy is recycling/recovery, i.e., it may be spread on land for agricultural benefit, recycled through blending with other materials to form a soil substitute or used in other relevant works. Any such recycling/recovery would require a waste management licence or registration as an exempt activity and compliance with the legal requirements. Disposal is the last option and only considered after all other options have been explored and discounted.

During the post-consent and pre-construction period and following detailed ground investigation works and refinement of the calculations within this DPMP, should a surplus of peat still be expected then the Applicant will explore further potential onsite valid reuses for the surplus peat/organo-mineral soil. Should no onsite use be identified then offsite use in peatland restoration will be explored. If there are no valid options for offsite use in peatland restoration then the other options identified with SEPA (2017) guidance will be followed sequentially, e.g., recycling/recovery. SEPA will be consulted throughout this process. There is therefore potentially a requirement for a Waste Management Plan with respect to peat.

5 LIMITATIONS OF THE DRAFT PEAT MANAGEMENT PLAN

As discussed in Technical Appendix A9.4, the results of the peat depth surveys revealed a Proposed Development Area with a widespread covering of mostly shallow peat or organo-mineral soils. The sampling points provide high resolution coverage of the Proposed Development and peat study area, and it is considered that the peat depth data collected, and interpolations derived from these data, are representative of the Proposed Development Area and have adequately informed the layout of the Proposed Development with respect to avoiding areas of deep peat.

The peat excavation and reuse volumes included in this DPMP are intended as an initial indication. The total peat volumes are based on a series of design assumptions and estimates for the Proposed Development layout and peat depth sample data interpolated across discrete areas of the Proposed Development Area. Such parameters can still vary over a small scale and therefore local topographic changes in the bedrock profile may impact the total accuracy of the volume calculations.

As explained above, this DPMP would be developed into a final PMP post-consent and in advance of construction commencing, when the infrastructure contractor has been appointed. The accuracy of the predictions within this DPMP may be improved though further detailed site investigation prior to and during construction. Such additional data would be used to aid micrositing of turbines away from any pockets of deeper peat into the shallowest areas, thereby minimising impacts on peatland within the micrositing tolerance. It is therefore important that the final PMP remains a live document throughout the pre-construction and construction phases and is encapsulated within the wider Construction and Environmental Management Plan (CEMP). The PMP and volumetric assessments can be updated as more information becomes available and the guiding principles within this DPMP incorporated into relevant construction method statements and plans.

6 REFERENCES & RELEVANT GUIDANCE

Forestry Civil Engineering (FCE) and Scottish Natural Heritage (SNH). (2010). *Floating Roads on Peat – A Report into Good Practice in Design, Construction and Use of Floating Roads on Peat*.

Scottish Government, SNH and SEPA (2017). *Peatland Survey - Guidance on Developments on Peatland*.

Scottish Renewables & SEPA. (2012). *Developments on Peatlands Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste*.

Scottish Renewables, SNH, SEPA, Forestry Commission Scotland, Historic Environment Scotland, Marine Scotland Science & AEECoW. (2019). *Good Practice During Windfarm Construction* (4th Edition).

SEPA. (2010). *Regulatory Position Statement – Developments on Peat*. SEPA, 4pp.

SEPA. (2017). *Developments on Peat and Off-Site Uses of Waste Peat*. SEPA Guidance, 5pp.

Scottish Natural Heritage. (2013). *Constructed Tracks in the Scottish Uplands*. 2nd edition.

ANNEX A. DETAILED EXCAVATION FOR PERMANENT INFRASTRUCTURE

Table A- 1 Full Details of Peat Excavation by Infrastructure Element – Peat Supply

Infrastructure	Estimated Peat Volume to be Excavated (m^3)
Battery Storage	569.28
Substation	310.45
Tracks – New (Excavated) (4.985 km)	12021.08
Turbine No: 01 – Hardstandings	1113.95
Turbine No: 01 – Excavations	130.23
Turbine No: 02 – Hardstandings	1080.02
Turbine No: 02 – Excavations	206.72
Turbine No: 03 – Hardstandings	270.79
Turbine No: 03 – Excavations	0.00
Turbine No: 04 – Hardstandings	1346.33
Turbine No: 04 – Excavations	94.26
Turbine No: 05 – Hardstandings	2563.53
Turbine No: 05 – Excavations	661.58
Turbine No: 06 – Hardstandings	4067.58
Turbine No: 06 – Excavations	516.53
Turbine No: 07 – Hardstandings	1859.78
Turbine No: 07 – Excavations	125.24
Total	**26,666.57**

ANNEX B. EXCAVATION FOR TEMPORARY INFRASTRUCTURE/WORKING AREAS

Table B- 1 Peat Excavated and Reinstated at Temporary Infrastructure

Temporary Infrastructure	Estimated Peat Volume to be Excavated (m³)
Batching Plant	2,109.29
Construction Compound	1,069.39
Earthworks Extent (Cut/Fill)[5]	12,779.00
Temporary Hardstanding Features (e.g., laydown/assembly areas and boom supports)	11,630.33
Total	**27,588.02**

[5] The actual excavation volume for 'Earthworks Extent (Cut/Fill)' will be less than stated here, as peat will be excavated for 'cut' but not 'fill'. The amount of cut would be refined during the pre-construction detailed design phase.

MacArthur Green

Watten Wind Farm

Technical Appendix A9.6

Carbon Calculator Assessment

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CONTENTS

1 INTRODUCTION

MacArthur Green was commissioned by EDF Energy Renewables Limited (the Applicant) to carry out the carbon calculation for the proposed Watten Wind Farm (hereafter the Proposed Development).

The Scottish Government has published an online tool (the "Carbon Calculator")[1] that can be used to calculate the greenhouse gas emissions and carbon payback times for wind farm developments on Scottish peatlands. This online tool, originally published in 2011, is supported by two further documents published by the Scottish Government, and Scottish Renewables and Scottish Environment Protection Agency (SEPA).

The carbon calculator must be used for developments which require consent under Section 36 of the Electricity Act 1989. The calculation compares an estimate of the carbon emissions from the construction, operation, and decommissioning of the Proposed Development to those emissions estimated from other electricity generation sources.

2 PROPOSED DEVELOPMENT DESCRIPTION

The Proposed Development is located on land to the east of Halsary Windfarm and approximately 3 km to the south-west of Watten in Caithness in the Scottish Highlands. The plans include up to seven wind turbines and associated infrastructure (battery energy storage system, site tracks, crane pads, substation, construction compound area, and batching plant).

3 METHODOLOGY

The online carbon calculator tool calculates carbon losses and savings over the lifetime of an onshore wind farm sited on peatland. The methodology adopted to calculate the impact on the carbon balance has been outlined in various literature sources (Nayak *et al*., 2008; Smith *et al.*, 2011; Scottish Government, 2016). This methodology has been used to complete the online carbon calculator, v1.7.0.

This report and assessment should be read in conjunction with the online carbon calculator inputs and outputs, and the project description contained in Volume 1, Chapter 5: Project Description.

Whilst various guidance indicates that actual measurements of the infrastructure are used in the calculations, for projects in the planning stage no infrastructure has yet been constructed. Therefore, the assumptions for the infrastructure are either based on information provided for the Proposed Development (where practical) or standard, default information that is representative. In each case, an explanation of the assumptions adopted, and their respective source is provided in the following sections.

[1] Available from: https://informatics.sepa.org.uk/CarbonCalculator [Accessed 11/08/2023]

4 INPUT PARAMETERS

Information relating to the design, construction and operation of the Proposed Development has been collated, including details of the proposed infrastructure, local ecology and potential for loss of stored carbon and restoration proposals. This information has been entered into the online carbon calculator.

4.1 Wind Farm Characteristics

Planning consent is being sought for up to seven turbines with an expected operational lifetime of 35 years. The candidate turbines will have a power rating of 6.8 MW and blade tips of no more than 220 m.

4.1.1 Capacity factor

For this assessment a conservative approach has been adopted using the five-year average capacity factor between 2017-2021 (Scotland). The Proposed Development is likely to have a notably higher capacity factor, anticipated to be above 35%, due to the greater tip heights proposed when compared to the operational wind farms in the UK during the 2017-2021 period.

The values used in the carbon calculator are from '*Regional Statistics 2009-2021: Standard Load Factors*'[2]. The capacity factor for the Proposed Development is therefore estimated to be 26% (minimum 23% and maximum 28%) using the values from the most recent five-year period. The average capacity factor for Scotland (1998 – 2004) is quoted in Nayak *et al.* (2008) as 30%.

4.1.2 Backup

It is recognised that due to the inherent variability of wind generated electricity, conventional generation facilities will be required to provide stability in the overall supply of electricity. Nayak *et al.* (2008) refers to '*backup power generation*' and identifies that the balancing capacity required is estimated as 5% of the rated capacity of the wind farm. This balancing capacity is necessary where wind power contributes more than 20% of the national supply. It is expected that wind generation will contribute greater than 20% by 2025 in all four of the '*Future Energy Scenarios*'. These represent four potential pathways developed by National Grid, updated each year, and agreed with Ofgem and include scenarios with both fast and slow decarbonisation (Scottish Government, 2016). The values for '*fraction of output to backup*' used in the calculator are expected 5% and maximum 5% to represent full requirement for backup power generation and minimum 0% to represent no backup power generation required, as per Nayak *et al.* (2008).

Where the balancing capacity is obtained from fossil fuel generating stations, emissions will increase by 10% due to reduced thermal efficiency of the reserve generation stations. This value is fixed in the carbon calculator.

4.1.3 CO_2 Emissions from Turbine Life (tCO_2/MW)

Carbon dioxide emissions during the life of a turbine include those emissions that occur during the manufacturing, transportation, erection, operation, dismantling and removal of the structures.

[2] Available from: https://www.gov.uk/government/statistics/regional-renewable-statistics [Accessed 11/08/2023]

The expected value is calculated automatically based on the default values embedded within the carbon calculator.

4.2 Characteristics of Peatland before Wind Farm Development

4.2.1 Type of Peatland

The type of peatland is designated as 'acid bog' in the carbon calculator.

4.2.2 Average Annual Air Temperature at Proposed Development Area (°C)

The average annual air temperature of 8 °C was calculated from Met Office UK climate averages (Wick)[3].

4.2.3 Average Depth of Peat at Proposed Development Area (m)

The average peat depth of 0.96 metres (m) (minimum 0 m, maximum 5.6 m) was calculated in Geographic Information System (GIS) from peat probing survey results, utilising peat depth survey information for the Proposed Development Area (see also Technical Appendix A9.4 Phase 1 and 2 Peat Depth and Coring Report).

Average peat depth was calculated from the Interpolation Area (349.46 ha). There is no interpolated peat depth figure for the full site (508.92 ha) because there is 159.46 ha area of 'no data'.

4.2.4 Carbon Content of Dry Peat (% by weight)

The carbon content of dry peat (percentage by weight) is 35.5% (minimum 23.2%, maximum 46%), from peat coring surveys (see also Technical Appendix A9.4 Phase 1 and 2 Peat Depth and Coring Report, 6.3.8).

4.2.5 Average Extent of Drainage around Drainage Features at Proposed Development (m)

The extent of drainage incorporated into the Proposed Development influences the total volume of peat impacted by construction. Therefore, the extent of drainage has an impact on the carbon payback time.

A review of the available literature (Nayak *et al.*, 2008) found that the extent of drainage effects is reported as being anything from 2 m to 50 m horizontally around a site of disturbance. Research into the effects of moor gripping and water table data from other sites yielded a horizontal draw down distance typically of about 2 m. It is thought that in extreme cases, this may extend between 15 m and 30 m, though 15 m is considered an appropriate distance.

Smith *et al.* (2011), identified the average extent of drainage impact at three sites (Cross Lochs, Farr Windfarm and Exe Head) as ranging from 3 m to 9 m. However, the actual extent of drainage at any given location will be dependent on local site conditions, including underlying substrata and topography.

[3] Available from: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gfmu99nxj [Accessed 11/08/2023]

Site specific values are not available, so the standard values from 'Windfarm Carbon Calculator Web Tool, User Guidance' have been used. Therefore, the expected value is 10 m (minimum 5 m, maximum 50 m).

When determining the carbon loss from peat removed as part of the construction of the drainage works, the area where peat is removed is not included in the extent of drainage calculations because this has already been accounted for in the direct losses.

4.2.6 Average Water Table Depth at Proposed Development (m)

Guidance provided in "*Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands*" (Scottish Government, 2016) indicates that on intact peat sites the depth to water table may be less than 0.1 m, but up to 0.3 m on eroded peat sites.

Site specific values are not available, so the values for 'intact peat' from '*Windfarm Carbon Calculator Web Tool, User Guidance*' have been used. Therefore, the expected value is 0.1 m (minimum 0.05 m, maximum 0.3 m).

Despite the presence of areas of degraded peatland onsite there are also areas of intact peatland (see Technical Appendix A7.1 National Vegetation Classification (NVC) and Habitats Survey Report, and Technical Appendix A9.5 Draft Peat Management Plan). Based on the precautionary principle and worst-case scenario, the values for intact peat have been used.

4.2.7 Dry Soil Bulk Density

As a result of a lab scheduling error, dry bulk density (g/cm^3) values were not correctly calculated for the samples.

Values for dry bulk density are therefore estimated using typical values for Scotland as detailed in Carbon Calculator user guidance[4] which states the expected dry bulk density to be expected = 0.132 g/cm^3; minimum = 0.072 g/cm^3; and maximum = 0.293 g/cm^3, (see Technical Appendix A9.4 Phase 1 and 2 Peat Depth and Coring Report, 6.3.7).

4.3 Characteristics of Bog Plants

4.3.1 Regeneration of Bog Plants

From MacArthur Green's experience of monitoring bog plant restoration, the time for regeneration of bog plants can vary widely depending on the location of the site, the target plants, and whether the ground was previously afforested or open moorland. The Proposed Development is relatively low altitude compared to other windfarms in Scotland and therefore a shorter than average restoration period may be reasonably expected.

However, some of the Proposed Development Area is covered in dense conifer plantation which has reduced vegetation cover and altered peatland hydrology. Regeneration will occur more rapidly in unplanted areas of the site, whereas previously afforested areas will take longer to

[4] Available from: https://informatics.sepa.org.uk/CarbonCalculator/assets/Carbon_calculator_User_Guidance.pdf [Accessed 11/08/2023]

restore. The speed of regeneration will also depend on species present and their colonising ability and traits, as well as the methods of restoration and maintenance of hydrology.

The values stated take this into account, considering available literature[5,6] and anecdotal observations of wind farms in in similar habitats in Scotland. Natural England's biodiversity metric guidance[7] was reviewed for the average time values for successful enhancement of bog habitats based on scientific research (the guidance is produced for England and therefore consideration is given to bog habitats being more commonplace and easier to establish in Scotland than further south). Five years is assumed to be a reasonable precautionary estimate for regeneration of most bog plants, some taking hold sooner (minimum two years) and some requiring longer to establish (maximum 15 years).

4.3.2 Carbon Accumulation

Several factors affect the carbon cycle in peatlands, including plant community, temperature range, extent and type of drainage, depth to water table and peat chemistry. The estimated global average for apparent carbon accumulation rate in peatland ranges from 0.12 to 0.31 tC ha^{-1} yr^{-1} (Botch *et al.*, 1995; Turunen *et al.*, 2001).

The carbon calculator guidance (Technical Note, Version 2.10.0, Scottish Government) suggests a mid-range value of 0.25 tC ha^{-1} yr^{-1}, which falls within the range quoted above. For the purposes of the carbon assessment, this accumulation rate of 0.25 tC ha^{-1} yr^{-1} has been used as the expected value, with the accumulation rates of 0.12 tC ha^{-1} yr^{-1} and 0.31 tC ha^{-1} yr^{-1} adopted as the minimum and maximum values respectively.

4.4 Forestry Plantation Characteristics

A total of 11.24 ha will be felled to enable the construction of the Proposed Development (see Volume 1 Chapter 11 Forestry, 11.3.10).

The total area of woodland within the Proposed Development will increase by 3.84 ha. This is due to onsite replanting and additional planting which offset the areas occupied by the infrastructure (see Volume 1 Chapter 11 Forestry, 11.3.12).

In the online calculator, the value for 'Area of forestry plantation to be felled (ha)' is the area felled minus the area to be replanted. As there is a net gain of forestry in the Proposed Development, this would be -3.84. However, the value in the online calculator is restricted to zero or greater than zero, so zero has been entered.

4.5 Counterfactual Emission Factors

The counterfactual emission factors for three methods of energy generation are fixed in the carbon calculator. Values for both coal-fired and fossil fuel-mix emission factors are updated from DUKES data for the UK which is published annually. The source for the grid-mix emission factor is

[5] Whitelee Phase 3 Technical Appendix 9.1 Appendix B Restoring blanket bog from commercial forestry: summary of monitoring and management interventions at two large windfarm sites 2004 – 2011.
[6] Anderson, R. and Peace, A (2017)

the list of emission factors used to report on greenhouse gas emissions by UK organisations published by BEIS. These values are shown in Table 1 below.

Table 1 Carbon Dioxide Emissions from Electricity Generation (tCO_2 MWh^{-1}), 2022.

Fuel Source	Carbon Dioxide Emissions (tCO_2 MWh^{-1})
Coal-fired plant	1.002
Grid-mix	0.19338
Fossil fuel-mix	0.432

4.5.1 Borrow Pits

No borrow bits are planned for the Proposed Development.

4.5.2 Foundations and Hardstanding Areas

The wind turbine foundations for the Proposed Development are expected to be 30 m in diameter (circular).

The average peat depth in the wind turbine foundations is 0.46 m (minimum 0 m, maximum 2 m).

There are two areas of hardstanding. One for blade laydown (90 x 22.5 m) and the other for turbine assembly (113 x 35 m).

The average peat depth in the hardstands is 0.54 m (minimum 0 m, maximum 3 m).

4.6 Volume of concrete

It is expected that the total volume of concrete used in the entire wind farm will be 7,226 m^3.

4.7 Access Tracks

There are no existing tracks. The tracks within the Proposed Development Area will be all new tracks. During the post consent pre-construction design and construction phases, small changes to the access track layout could be introduced (e.g., as a result of micrositing of the wind turbines), leading to minor variations in the overall track length.

The total length of access track planned is 4,985 m. Of this, 840 m will be floating road, 1,435 m will be excavated and 2,710 will be rock filled. The average depth of peat in the track area is 0.53 m (minimum 0 m, maximum 3 m).

4.8 Cable Trenches

All cabling is to follow access tracks, either incorporated into the access track or in the reinstated verges (see Volume 1 Chapter 5 Project Description, 5.1.1), so the length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (e.g., sand) is 0 m.

4.9 Additional Peat Excavated

The volume of additional peat predicted to be excavated is 880 m^3 (area 2263 m^2). This is the sum of the excavations not already accounted for in the carbon calculator and includes battery storage and substation (control building).

This is discussed in Technical Appendix A9.5 Draft Peat Management Plan.

4.10 Peat Landslide Hazard

The peat landslide hazard is automatically defined by the online carbon calculator and is shown to be 'negligible'. This value is fixed.

4.11 Improvement of Carbon Sequestration at the Proposed Development

Any local improvements to carbon sequestration, such as areas of peatland habitat restoration, would result in a reduction in the net carbon emissions from the Proposed Development.

4.11.1 Improvement of Degraded Bog

The area of degraded bog to be improved is 80.44 ha.

In Technical Appendix A7.6 Outline Biodiversity Enhancement Management Plan, Management Unit A (80.44 ha), is described as predominantly peatland habitat. The aim is to enhance peatland habitat, by managing sheep grazing densities, removing self-seeding Sitka spruce, drain blocking and restoring eroded areas. There are some active peatland erosion areas and some drains which, whilst occluded and revegetated to a large extent, have a minor adverse effect on the peatland hydrology.

Site specific values for the water table depths are not available, so standard values are from "*Windfarm Carbon Calculator Web Tool, User Guidance*". Knowledge of the condition of the peatland in these areas (see Technical Appendix A7.1) in combination with standard values from '*Windfarm Carbon Calculator Web Tool, User Guidance*' have been used to make an estimate of water table depth.

4.11.2 Improvement of Felled Plantation Land

There are no areas of felled plantation to be improved for peatland.

4.11.3 Restoration of peat removed from borrow pits

There are no borrow pits in the Proposed Development Area.

4.11.4 Early removal of drainage from foundations and hardstanding

Temporary drainage would be constructed around the wind turbine foundations and hardstandings. This drainage would be removed on completion of the construction works, and therefore, the area surrounding the foundations and hardstandings can be assumed to be drained only up to the time of completion of backfilling, and removal of any temporary surface water drains. Subsequently, the hydrological regime adjacent to the foundation and hardstanding is assumed to return to its pre-construction condition. For the purposes of the carbon calculator the expected value for completion of backfilling, removal of any surface drains, and restoration of the hydrology is 0.25 years (minimum 0.1 year, maximum 3 years).

4.12 Restoration of the Proposed Development after Decommissioning

The restoration work undertaken as part of the decommissioning phase would be likely to result in a reduction in lost carbon. By restoring the hydrological conditions and returning the remaining stored carbon to anaerobic conditions, further oxidative loss would be limited or prevented. The restoration of existing habitats represents an opportunity to enhance carbon sequestration. For the purposes of the carbon calculation, no benefit has been assumed for the post-decommissioning restoration works, and therefore 100% loss of carbon from the drained volume of soil has been accounted for. During construction, good industry practice will be employed to minimise any disruption to peatland hydrology. It has been assumed that the access tracks constructed would remain in-situ following decommissioning.

4.12.1 Hydrology

In the event that any gullies in peat have formed due to erosion during the operational phase, these would be blocked using good industry practice techniques to promote restoration of the local hydrological conditions. This approach has been assumed in the carbon assessment. It is assumed any drainage channels constructed with the access tracks would be blocked to facilitate re-wetting of adjacent habitats.

4.12.2 Habitats

It is assumed that grazing will be controlled on degraded areas and areas will be managed to favour reintroduction of species in the future. This will form part of a decommissioning and restoration plan for the Proposed Development Area in the future.

4.13 Methodology for Calculating Emission Factors

Whilst two methodologies exist, namely the IPCC method (IPCC, 1997) and Ecosse project method (Smith *et al*., 2007), the latter method is required to be adopted for an application for section 36 consent. The Ecosse method, which is based on site-specific values, is considered to provide appropriate site-specific results, whereas the values determined from the IPCC method are less accurate.

4.14 Summary of Input Data

The values entered into the carbon calculator are summarised in Annex A of this document.

5 CARBON ASSESSMENT OUTPUTS

The outputs from the carbon calculator are shown in Annex B of this report. The total carbon losses in tonnes of CO_2 equivalent are shown in Table 2 below and fully detailed in Annex B along with charts in Annex C.

Table 2 Total Carbon Losses Due to Development.

Source of Losses	Carbon Losses (tCO_2) Expected Value	Carbon Losses (tCO_2) Minimum Value	Carbon Losses (tCO_2) Maximum Value
Turbine life	43,486	43,454	43,517
Backup	31,523	0	31,523
Reduced carbon fixing potential	988	315	5,335
Soil organic matter	7,460	-3,851	164,799
DOC & POC leaching	747	0	22,620
Felling of forestry	0	0	0
Total	**84,204**	**39,919**	**267,794**

The carbon losses calculated are independent of the generation mix used to calculate the overall carbon balance with the exception of the back-up generation capacity (which is assumed to be from conventional fossil fuel sources).

The predicted payback time for the Proposed Development, as determined from the carbon calculator tool, is shown in Table 3 below and fully detailed in Annex B.

Table 3 Carbon Payback Period.

Generation Source	Counterfactual emission factors 2022 ($t\ CO_2\ MWh^{-1}$)	Carbon Payback Period (years)		
		Expected Value	Minimum Value	Maximum Value
Coal-fired plant	1.002	0.6	-0.1	2.8
Grid-mix	0.19338	3.1	-0.5	14.4
Fossil fuel-mix	0.432	1.4	-0.2	6.5

The 'Grid Mix' generation source includes renewable energy sources that are operational, therefore the 'Fossil Fuel Mix' represents the most likely scenario when considering replacing existing generation capacity with electricity generated from the Proposed Development.

Based on the assumptions detailed in Section 4 above, the expected payback time, assuming a requirement for back up generation capacity, and therefore the predictions for the growth in the contribution of wind energy generation to be met, is calculated to be approximately 1.4 years, if replacing generation capacity from the 'Fossil Fuel Mix'. Using the worst-case scenario, represented by adopting the maximum values entered in the carbon assessment and taking account of a requirement for back up generation capacity, the payback time is calculated to be 6.5 years.

6 CONCLUSION

The output from the carbon balance assessment indicates that, based on the best estimate values determined from the information currently available, that the Proposed Development would pay back the carbon emissions associated with its construction, operation and subsequent decommissioning in 1.4 years.

Changes to the factors incorporated into the carbon assessment could impact on the overall carbon payback period calculated, however, the sensitivity analysis embedded within the carbon calculator tool takes such variations into account by considering a range of values for each factor considered. Furthermore, by adopting conservative input values for various factors contributing to the overall carbon payback calculation, the carbon savings resulting from the operation of the Proposed Development (and the diversion of energy generation from a Fossil fuel-mix), could be significantly greater than the carbon emissions predicted to occur from the construction, operation, and subsequent decommissioning of the Proposed Development.

Based on the assumptions within the carbon calculator, the wind farm carbon emission saving when compared with the fossil fuel mix of electricity generation is 46,835 tonnes of CO_2per year after the payback period.

7 REFERENCES

Anderson, R. and Peace, A. (2017). Ten-year results of a comparison of methods for restoring afforested blanket bog. *Mires and Peat*, Volume 19 (2017), Article 06, 1–23, http://www.mires-and-peat.net/, ISSN 1819-754X. DOI: 10.19189/MaP.2015.OMB.214

Botch, M. S., Kobak, K. I., Vinson, T. S., and Kolchugina, T. P. (1995). Carbon pools and accumulation in peatlands of the former Soviet Union. *Global Biogeochem. Cycles* 9: (1), 37–46, doi:10.1029/94GB03156. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/94GB03156

Cannell, M.G.R. (1999). Growing trees to sequester carbon in the UK: answers to some common questions. Forestry 72, 237–247.

Department for Business, Energy & Industrial Strategy (DBEIS) (2021). *Digest of UK Energy Statistics, DUKES Chapter 6: Renewable sources of energy*: Table 6.4: Capacity of, and electricity generated from renewable sources: https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes

Department for Business, Energy & Industrial Strategy (DBEIS) (2021). *Digest of UK Energy Statistics, DUKES Chapter 6: Renewable sources of energy*: Table 6.7: Renewable sources data used to indicate progress under the 2009 EU Renewable Energy Directive (measured using net calorific values): https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes

Department for Business, Energy & Industrial Strategy (DBEIS) (2021). *Digest of UK Energy Statistics 2020, (DUKES) Chapter 5: Electricity:* Table 5.1: Commodity balances. https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes

Gov.UK, National Statistics, Regional Renewable Statistics 2009-2020: Standard Load Factors. https://www.gov.uk/government/statistics/regional-renewable-statistics

Isselin-Nondedeu, F., Rochefort, L., & Poulin, M. (2007). *Long-term vegetation monitoring to assess the restoration success of a vacuum-mined peatland (Québec, Canada).* Proceedings of International Conference Peat and Peatlands 2007 23: 153-166. http://www.gret-perg.ulaval.ca/no_cache/pergspublications/? tx_centrerecherche_pi1%5BshowUid%5D=5439

Nayak D.R., Miller D., Nolan A., Smith P., Smith J.U. (2008). *Calculating Carbon Savings from Windfarms on Scottish Peatlands - Revision of Guidelines*. October 2007 to January 2008. Final Report.

Scottish Government, Scottish Natural Heritage, SEPA (2017). *Peatland Survey. Guidance on Developments on Peatland*. Online version only. http://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings/PSG2011

Scottish Government (2016). Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands, Technical Guidance, Version 2.10.0*:* https://www.gov.scot/publications/carbon-calculator-technical-guidance/

Scottish Renewables & SEPA (2012). Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste: http://www.gov.scot/Resource/0045/00455955.pdf

Smith, J.U., Graves, P., Nayak, D.R., Smith, P., Perks, M., Gardiner, B., Miller, D., Nolan, A., Morrice, J., Xenakis, G., Waldron, S., and Drew, S. (2011). *Carbon Implications of Windfarms Located on Peatlands – Update of the Scottish Government Carbon Calculator Tool: CR/2010/05: Final Report*: http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings/V2UpdReport

Smith, P. & 20 others. (2007). *ECOSSE: Estimating Carbon in Organic Soils - Sequestration and Emissions*. Final Report. SEERAD Report. ISBN 978 0 7559 1498 2.

Turunen, J., Tahvanainen, T., Tolonen, K., and Pitkänen, A. (2001). Carbon accumulation in West Siberian Mires, Russia Sphagnum peatland distribution in North America and Eurasia during the past 21,000 years. *Global Biogeochem. Cycles:* 15 (2), 285-296, doi:10.1029/2000GB001312. https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2000GB001312

Whitelee Phase 3, Technical Appendix 9.1, Appendix B - Restoring blanket bog from commercial forestry: summary of monitoring and management interventions at two large windfarm sites 2004 - 2011.

ANNEX A. INPUT DATA

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	7	7	7	Volume 1 Chapter 5 Project Description, 5.3.2
Duration of consent (years)	35	35	35	Volume 1 Chapter 5 Project Description, 5.2.4
Performance				
Power rating of 1 turbine (MW)	6.8	6.8	6.8	Volume 1 Chapter 5 Project Description, 5.2.4
Capacity factor	26	23	28	For this assessment a conservative approach has been adopted using the UK 5 year average capacity factor between 2017-2021 of 26%. In reality, the Proposed Development is likely to have a notably higher capacity factor, anticipated to be above 35%, due to the greater tip heights proposed when compared to the operational wind farms in the UK during the 2017-2021 period. Regional Statistics 2009-2021: Standard Load Factors https://www.gov.uk/government/statistics/regional-renewable-statistics ... [text truncated in online calculator export, see TA 9.6 for full details]
Backup				
Fraction of output to backup (%)	5	0	5	Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands, Technical Note, Version 2.10.0, Para 19.
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO_2 emission from turbine life (tCO_2 MW^{-1}) (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity	Calculate wrt installed capacity	Calculate wrt installed capacity	
Characteristics of peatland before wind farm development				
Type of peatland	Acid bog	Acid bog	Acid bog	Volume 1 Chapter 5 Project Description, 5.5.11
Average annual air temperature at Proposed Development Area (°C)	8	5	11	Nearest met office station: Wick (https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gfmu99nxj)
Average depth of peat at Proposed Development (m)	0.96	0	5.6	Technical Appendix 9.4 Phase 1 and 2 Peat Depth and Coring Report There is no interpolated Peat depth for the full site (508.92ha) therefore have 159.46ha of "No Data". Average Peat depth has been calculated from the Interpolation Area (349.46 ha).

Input data	Expected value	Minimum value	Maximum value	Source of data
C Content of dry peat (% by weight)	35.5	23.2	46	Technical Appendix 9.4 Phase 1 and 2 Peat Depth and Coring Report, 6.3.8
Average extent of drainage around drainage features at Proposed Development (m)	10	5	50	Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance".
Average water table depth at Proposed Development (m)	0.1	0.05	0.3	Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance". Values for 'intact peat' have been used.
Dry soil bulk density (g cm^{-3})	0.132	0.072	0.293	Technical Appendix 9.4 Phase 1 and 2 Peat Depth and Coring Report, 6.3.7 (Actual values not available due to lab error; default values from carbon calculator guidance used).
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	5	2	15	From MacArthur Green's experience of monitoring bog plant restoration, the time for regeneration of bog plants can vary widely depending on the location of the site, the target plants, and whether the ground was previously afforested or open moorland. The Proposed Development is relatively low altitude compared to other windfarms in Scotland and therefore a shorter than average restoration period may be reasonably expected. However, some of the site is covered in dense conifer plantation which has reduced vegetation cover. [text truncated in online calculator export, see TA 9.6 for full details]
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands, Technical Note, Version 2.10.0, para 25.
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	0	0	0	Volume 1 Chapter 11 Forestry, 11.3.10 ("A total of 11.24 ha will require to be felled to enable the construction and operation of the Proposed Development.") 11.3.12 ("Proposed Development infrastructure accounts for 5.05 ha. However, the total area of woodland within the FSA increases by 3.84 ha. This is due to on site replanting and additional planting which offset the areas occupied by the Proposed Development infrastructure.")
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3	2.4	3.6	Cannel, 1999, Growing trees in the UK to sequester carbon. Sitka spruce, YC 16, 3.6 tC ha-1 yr-1 over 55 years Beech, YC 6, about 2.4 tC ha-1 yr-1 over 92 years
Counterfactual emission factors				
Coal-fired plant emission factor (t CO_2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO_2 MWh^{-1})	0.19338	0.19338	0.19338	

Input data	Expected value	Minimum value	Maximum value	Source of data
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				
Number of borrow pits	0	0	0	There are no planned borrow pits in the Proposed Development
Average length of pits (m)	-	-	-	
Average width of pits (m)	-	-	-	
Average depth of peat removed from pit (m)	-	-	-	
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	30	30	30	Figure: 15558_DET_3002 - REVA - FIGURE 5.5 INDICATIVE WIND TURBINE FOUNDATION.pdf Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23)
Average width of turbine foundations (m)	30	30	30	Figure: 15558_DET_3002 - REVA - FIGURE 5.5 INDICATIVE WIND TURBINE FOUNDATION.pdf Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23)
Average depth of peat removed from turbine foundations(m)	0.46	0	2	Source: GIS calculations 'CD_Infra_IDW_PeatCalcs_EIA_Revo_ACH.xlsx' from MacArthur Green
Average length of hard-standing (m)	203	203	203	Figure: 15558_DET_3004 - REVA - FIGURE 5.4 INDICATIVE WIND TURBINE HARDSTAND.pdf There are two areas of hardstanding. One for blade laydown and the other for turbine assembly. Turbine assembly 113 x 35 m. Blade laydown 90 x 22.5 m (Length = 113 + 90 m) Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23)
Average width of hard-standing (m)	58	58	58	Figure: 15558_DET_3004 - REVA - FIGURE 5.4 INDICATIVE WIND TURBINE HARDSTAND.pdf There are two areas of hardstanding. One for blade laydown and the other for turbine assembly. Turbine assembly 113 x 35 m. Blade laydown 90 x 22.5 m (Width = 35 + 22.5 m) Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23)
Average depth of peat removed from hard-standing (m)	0.54	0	3	Source: GIS calculations 'Acherole_Peat_Calcs_CarbonCalculatior_EIA_Revo.xlsx' from MacArthur Green
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	7226	7126	7326	1000 m^3 per turbine. Assumptions: 0.3m deep foundation, 20 HGV movements are 6 m^3 deliveries, movements are for all BESS items (battery containers, inverters and transformers). Max/Min are +/- 100 m^3. Source: 'Watten CBA Concrete Volumes_RdC_Dec22.xlsx' from Natural Power (received 25/05/23)

Input data	Expected value	Minimum value	Maximum value	Source of data
Access tracks				
Total length of access track (m)	4985	4955	5015	Total = existing tracks + new tracks
Existing track length (m)	0	0	0	Volume 1 Chapter 5 Project Description, 5.12.2 There are no existing tracks. The tracks within the Proposed Development will be all new tracks.
Length of access track that is floating road (m)	840	830	850	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23). Max/Min are +/- 10 m.
Floating road width (m)	5	5	6	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23) and email 'RE: Watten Update 28.04.23' LF, Natural Power (received 11/05/23). "Tracks are generally 4.5m wide, but widening up to 6m at some corners and through hardstands."
Floating road depth (m)	0.7	0.6	0.8	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23).
Length of floating road that is drained (m)	840	830	850	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23) and email 'RE: Watten Update 28.04.23' LF, Natural Power (received 11/05/23). Max/Min are +/- 10 m.
Average depth of drains associated with floating roads (m)	0.4	0.4	0.4	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23) - "unknown as not part of scope". Assumed to be 0.4 m, as per rock filled road drains.
Length of access track that is excavated road (m)	1435	1425	1445	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23) and email 'RE: Watten Update 28.04.23' LF, Natural Power (received 11/05/23). Max/Min are +/- 10 m.
Excavated road width (m)	5	5	6	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23) and email 'RE: Watten Update 28.04.23' LF, Natural Power (received 11/05/23). "Tracks are generally 4.5m wide, but widening up to 6m at some corners and through hardstands."
Average depth of peat excavated for road (m)	0.53	0	3	Source: GIS calculations 'Acherole_Peat_Calcs_CarbonCalculatior_EIA_Rev0.xlsx' from MacArthur Green
Length of access track that is rock filled road (m)	2710	2700	2720	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23) and email 'RE: Watten Update 28.04.23' LF, Natural Power (received 11/05/23). Max/Min are +/- 10 m.
Rock filled road width (m)	5	5	6	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 25/05/23) and email 'RE: Watten Update 28.04.23' LF, Natural Power (received 11/05/23). "Tracks are generally 4.5m wide, but widening up to 6m at some corners and through hardstands."
Rock filled road depth (m)	0.4	0.3	0.5	Source: 'Watten CBA data requitements_RdC.xlsx' (received 01/12/22). Max/Min are +/- 0.1 m.
Length of rock filled road that is drained (m)	2710	2700	2720	Assumed all track drained as per Chapter 5: Project Description, para 5.12.11: 'there would be a requirement for drainage channels along one or both sides of each section of

Input data	Expected value	Minimum value	Maximum value	Source of data
				track depending on the ground conditions along each track segment'. Max/Min are +/- 10 m.
Average depth of drains associated with rock filled roads (m)	0.4	0.4	0.4	Source: 'Watten CBA data requitements_RdC.xlsx' (received 01/12/22)
Cable trenches				
Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (eg. sand) (m)	0	0	0	Source: 'Watten CBA data requirements_KSMay23.xlsx' from Natural Power (received 24/05/23).
Average depth of peat cut for cable trenches (m)	0	0	0	n/a
Additional peat excavated (not already accounted for above)				
Volume of additional peat excavated (m³)	880	870	890	Source: Technical Appendix 9.5 Draft Peat Management Plan & GIS calculations 'CD_Infra_IDW_PeatCalcs_EIA_Revo_ACH.xlsx' (Results tab) from MacArthur Green Battery storage + substation (control building)
Area of additional peat excavated (m²)	2263	2253	2273	Source: Technical Appendix 9.5 Draft Peat Management Plan & GIS calculations 'CD_Infra_IDW_PeatCalcs_EIA_Revo_ACH.xlsx' (Results tab) from MacArthur Green Battery storage + substation (control building)
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments	negligible	negligible	negligible	Fixed
Improvement of C sequestration at site by blocking drains, restoration of habitat etc				
Improvement of degraded bog				
Area of degraded bog to be improved (ha)	80.44	80.44	80.44	Technical Appendix 7.6 Outline Biodiversity Enhancement Management Plan, 3.1.1 Management Unit A is 80.44 ha, predominantly peatland habitat. The aim is to enhance peatland habitat, by managing sheep grazing densities, removing self-seeding Sitka spruce, drain blocking and restoring eroded areas. There are some active peatland erosion areas and some drains which, whilst occluded and revegetated to a large extent, have a minor adverse effect on the peatland hydrology.
Water table depth in degraded bog	0.3	0.1	0.5	Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance". Values for 'degraded peat' have been used.

Input data	Expected value	Minimum value	Maximum value	Source of data
before improvement (m)				
Water table depth in degraded bog after improvement (m)	0.1	0.05	0.3	Site specific values are not available. Knowledge of the condition of the peatland in these areas (from Volume 4: Technical Appendix 7.1 National Vegetation Classification & Habitats Survey Report and Volume 4: Technical Appendix 2.8: Peat Depth Survey & Information to Inform an Assessment of Blanket Mire Condition) in combination with standard values from "Windfarm Carbon Calculator Web Tool, User Guidance" and values for 'intact peat' have been used to make an estimate of water table depth.
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	5	2	15	The speed of regeneration depend on species present and their colonising ability and traits, as well as the methods of restoration and maintenance of hydrology. These estimates have been informed by: Whitelee Phase 3 Technical Appendix 9.1 Appendix B Restoring blanket bog from commercial forestry: summary of monitoring and management interventions at two large windfarm sites 2004 – 2011; NaturalEngland (2023) Biodiversity Metric 4 time to target guidance; other online sources, academic literature (e.g. And… [text truncated in online calculator export, see TA 9.6 for full details]
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	35	35	35	The duration of consent for this development is 35 years.
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	0	0	0	No felled plantation area to be improved
Water table depth in felled area before improvement (m)	-	-	-	
Water table depth in felled area after improvement (m)	-	-	-	
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	-	-	-	
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	-	-	-	
Restoration of peat removed from borrow pits				

Input data	Expected value	Minimum value	Maximum value	Source of data
Area of borrow pits to be restored (ha)	0	0	0	No borrow pits.
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	-	-	-	
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	-	-	-	
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	-	-	-	
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0.3	0.1	0.5	"Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance". Values for 'degraded peat' have been used. "
Water table depth around foundations and hardstanding after restoration (m)	0.1	0.05	0.3	Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance". Values for 'intact peat' have been used.
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0.25	0.1	3	These parameters are estimated values which refer to the removal of drainage around foundations and hardstandings after construction, not the removal of hardstandings and turbine foundations after decommissioning. Volume 1 Chapter 5 Project Description, 5.11.8 (backfiling cable trenches), 5.6.5 (turbine drainage), 5.11.8 (existing watercourses)
Restoration of Proposed Development Area after decommissioning				
Will the hydrology of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the Proposed Development Area in the future.
Will the habitat of the Proposed Development Area	Yes	Yes	Yes	

Input data	Expected value	Minimum value	Maximum value	Source of data
be restored on decommissioning?				
Will you control grazing on degraded areas?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.
Methodology				
Choice of methodology for calculating emission factors	Site specific (required for planning applications)			
Forestry input data				
N/A	-	-	-	
Construction input data				
N/A	-	-	-	

ANNEX B. CARBON CALCULATOR PAYBACK TIME AND CO_2 EMISSIONS OUTPUT

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	108,631	96,096	116,987
...grid-mix of electricity generation (t CO2 / yr)	20,965	18,546	22,578
...fossil fuel-mix of electricity generation (t CO2 / yr)	46,835	41,431	50,437
Energy output from windfarm over lifetime (MWh)	3,794,482	3,356,657	4,086,365

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decommissioning)	43,486	43,454	43,517
3. Losses due to backup	31,523	0	31,523
4. Losses due to reduced carbon fixing potential	988	315	5,335
5. Losses from soil organic matter	7,460	-3,851	164,799
6. Losses due to DOC & POC leaching	747	0	22,620
7. Losses due to felling forestry	0	0	0
Total losses of carbon dioxide	84,204	39,919	267,794

8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	-18,773	0	-37,091
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	0	0	0
8d. Change in emissions due to removal of drainage from foundations & hardstanding	-1,291	0	-14,371
Total change in emissions due to improvements	-20,063	0	-51,462

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	64,141	-11,544	267,794
Carbon Payback Time			
...coal-fired electricity generation (years)	0.6	-0.1	2.8
...grid-mix of electricity generation (years)	3.1	-0.5	14.4
...fossil fuel-mix of electricity generation (years)	1.4	-0.2	6.5

ANNEX C. CARBON CALCULATOR OUTPUT CHARTS

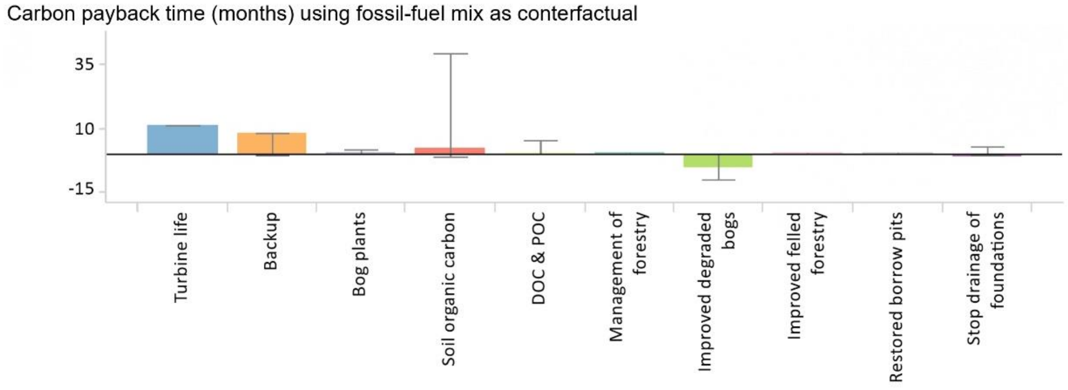

Chart 1 Carbon payback time (months) using fossil-fuel mix as counterfactual.

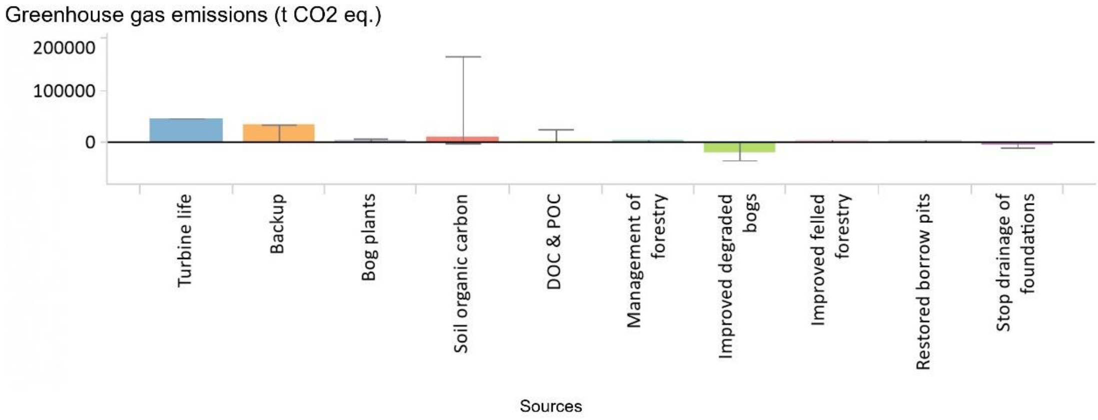

Chart 2 Greenhouse gas emissions (t CO_2 eq.).

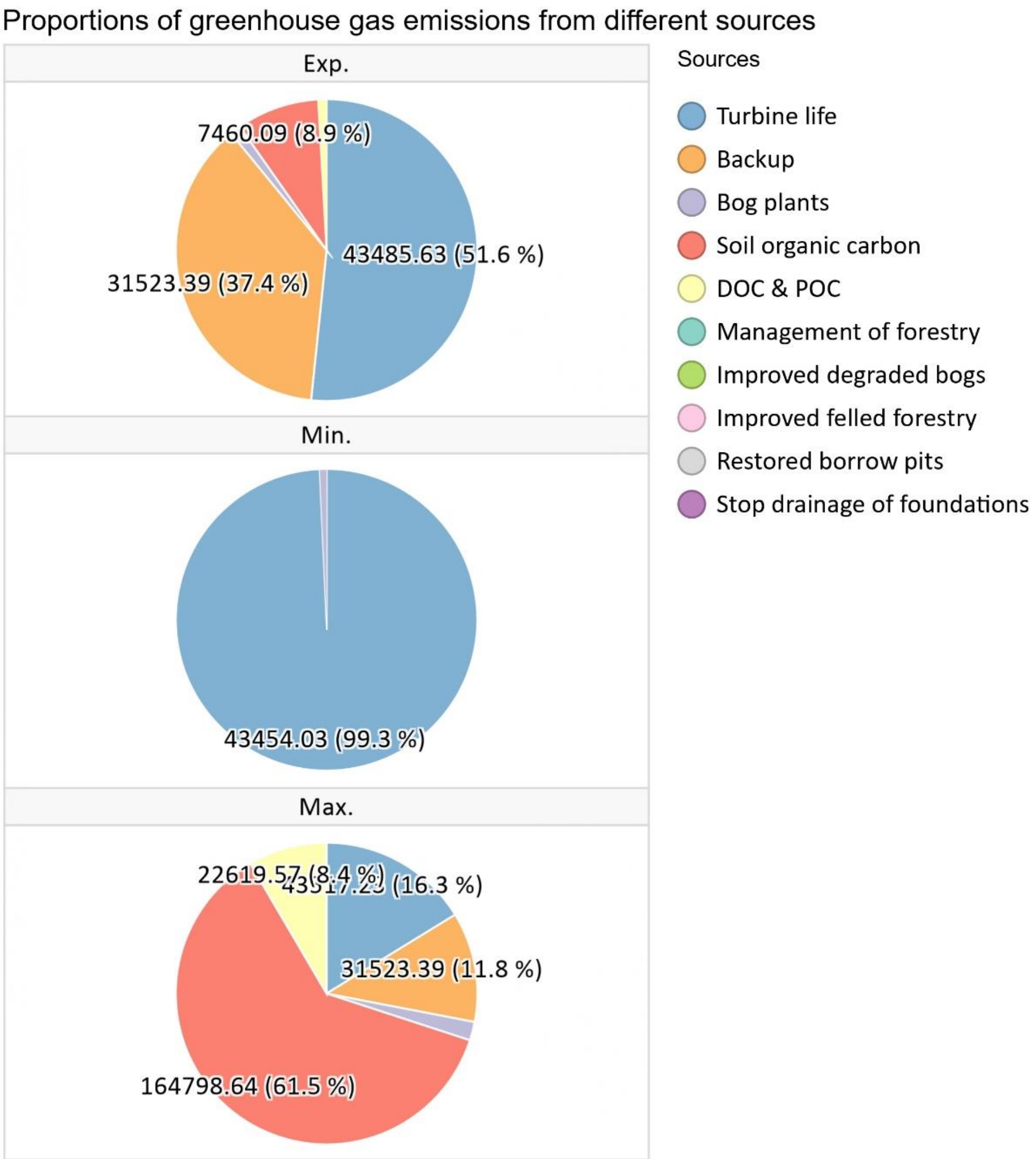

Chart 3 Proportions of greenhouse gas emissions from different sources.

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WATTEN WIND FARM

Technical Appendix A10.1:

Cultural Heritage Baseline and Stage 1 Setting Assessment

EDF Energy Renewables Limited

14/06/2023

HEADLAND ARCHAEOLOGY

WATTEN WIND FARM

Cultural Heritage Baseline and Stage 1 Setting Assessment

for Natural Power

June 2023

Ver 5.0

HA Job no.:	P22-136
NGR:	320878, 951749 (centred)
Parishes:	Watten
Council:	Caithness

Project Manager:	Owen Raybould
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Site Visit:	Fraser McFarlane
Approved by:	Laurence Hayes
Version comments:	Issue following legal review

CONTENTS

CULTURAL HERITAGE BASELINE AND STAGE 1 SETTING ASSESSMENT

1. INTRODUCTION

1.1. PLANNING BACKGROUND

1.1.1. This report was commissioned by Natural Power Consultants Limited (Natural Power) on behalf of the Applicant and presents the results of a combined archaeological desk-based assessment (DBA) and Stage 1 setting assessment which will contribute to the cultural heritage elements of an Environmental Impact Assessment (EIA). The EIA will be produced in support of an application to construct a wind farm on a c.509-hectare site, currently commercial forestry and agricultural land at Wester Watten Moss. The Proposed Development Area is located at NGR 320878, 951749 (post code KW1 5XY), and the nearest settlement is Watten (3 km north-east).

1.1.2. This report describes and assesses the cultural heritage significance and importance of known heritage assets and potential archaeological remains within the Proposed Development Area (i.e. Site boundary, also referred to in this report as the 'inner study area', or ISA). This will inform a Cultural Heritage EIA chapter which aims to identify likely significant environmental effects of the proposed Watten Wind farm ('the Proposed Development') on the cultural significance of heritage assets. A Stage 1 setting assessment provides an assessment of the contribution to significance made by the setting of heritage assets in order to identify potential historic environment planning constraints.

1.1.3. This report is suitable for submission in support of an application, identifies potential heritage constraints for the scheme in accordance with the requirements of national and local planning policies with respect to consideration of the historic environment in the planning process (see Part 2).

1.2. PROPOSED DEVELOPMENT AREA DESCRIPTION

1.2.1. The Proposed Development Area is irregularly shaped and measures c.509 ha in area. The Proposed Development is located at NGR 320878, 951749 (post code KW1 5XY), approximately 4 km south-east of Spittal and 3 km south-west of Watten, in the parish of Watten, Caithness (Highlands).

1.2.2. The route of the proposed access to the Proposed Development follows an existing access track through the operational Halsary Wind Farm.

1.2.3. The land use within the ISA currently comprises some commercial forestry but mostly comprises bounded fields and moorland, drained for rough grazing. The Proposed Development boundaries are defined by field boundaries other than to the south where it follows Snottergill Burn/the Burn of Acharole. Further rough grazing surrounds the ISA on all sides except to the west where commercial forestry continues. Five hundred metres west of the ISA is the Loch of Toftingall, and 1 km to the west is Halsary Wind Farm.

1.2.4. The topography of the ISA slopes from 70 m above Ordnance Datum (AOD) at the west, down to 50 m AOD in the south-east, alongside the Burn of Acharole.

Illus 1. View west from south-east of ISA

1.3. GEOLOGY AND GEOMORPHOLOGY

1.3.1. The bedrock geology within the ISA is sedimentary, comprising Lybster Flagstone Formation - siltstone, mudstone and sandstone in the west, and Berriedale Sandstone Formation - siltstone, mudstone and sandstone in the east.

1.3.2. Superficial deposits are recorded as Peat (http://mapapps.bgs.ac.uk/geologyofbritain/home.html). The National Soil Map of Scotland records this as Dystrophic blanket peat (https://map.environment.gov.scot/Soil_maps/). Nearer to the Burn of Acharole are superficial deposits of the Devensian era – Diamicton Till, Glaciofluvial Deposits of gravel, sand and silt, and Alluvium - clay, silt, sand and gravel.

2. LEGISLATION, POLICY AND GUIDANCE

2.1. STATUTORY PROTECTION

2.1.1. The relevant heritage legislation in the context of the Proposed Development is described in Table 1.

Table 1. Historic Environment Statutory Legislation (Scotland)

Legislation	Key Issues
Historic Environment Scotland Act 2014	The Act defines the role of the public body, Historic Environment Scotland (HES), and the processes for the designation of heritage assets, consents and rights of appeal.
Ancient Monuments and Archaeological Areas Act 1979	It is a criminal offence to carry out any works on or near to a Scheduled Monument without Scheduled Monument Consent. Development must preserve in-situ protected archaeological remains and landscapes of acknowledged significance and protect their settings.
The Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997	Provides for statutory protection of listed buildings and conservation areas. No physical works can be carried out in relation to a listed building and its curtilage without listed building consent. It introduces a requirement to have special regard to the desirability of preserving the building or its setting in considering any Development which may affect these. In conservation areas, the designation introduces general controls to conserve character and appearance within the conservation area.
Protection of Military Remains Act (1986)	Outlines the criteria for designating a military crash site. Certain activities are prohibited at protected sites, without the authority of the Ministry of Defence.
Scots Common Law	The movement or disturbance of human remains without lawful authority is illegal. Any human remains should be reported to the local police or Procurator Fiscal's office. Further disturbance must cease until permission to continue has been granted by the legal authorities.

2.2. NATIONAL PLANNING FRAMEWORK (NPF) 4

2.2.1. National Planning Framework (NPF) 4 Part 1 A National Spatial Strategy for Scotland 2045 describes how the future spatial development of Scotland can contribute to planning outcomes. It shows where there will be opportunities for growth and regeneration, investment in the low carbon economy, environmental enhancement, and improved connections across the country. The NPF4 Glossary defines the historic environment as "*the physical evidence for human activity that connects people with place, linked with the associations we can see, feel and understand*".

2.2.2. Historic Environment Policy for Scotland (HEPS) defines the Historic Environment and Scottish Government Policy. It sets out the vision and key principles on how to care for and protect Scotland's historic environment including designations of ancient monuments, principles for scheduling and listing, contexts for conservation areas, marine protected areas, gardens and designated landscapes, historic battlefields and consents and advice. HEPS provides further policy direction to NPF4 and sets out high level policies and core principles for decision-making affecting the historic environment.

2.2.3. The Scottish Government's planning policies in relation to the historic environment are set out in NPF4 Part 2 National Planning Policy (The Scottish Government, February 2023) Policy 7: Historic assets and places:

"Policy Principles

Policy Intent: To protect and enhance historic environment assets and places, and to enable positive change as a catalyst for the regeneration of places.

Policy Outcomes: The historic environment is valued, protected, and enhanced, supporting the transition to net zero and ensuring assets are resilient to current and future impacts of climate change; Redundant or neglected historic buildings are brought back into sustainable and productive uses; Recognise the social, environmental and economic value of the historic environment, to our economy and cultural identity.

Local Development Plans: LDPs, including through their spatial strategies, should support the sustainable management of the historic environment. They should identify, protect and enhance valued historic assets and places."

2.2.4. NPF4 Policy 7 applies these principles to designated and non-designated assets. Those relevant to the current assessment are as follows:

NPF4 – Part 2: Historic Assets and Places Policy 7

"a) Development proposals with a potentially significant impact on historic assets or places will be accompanied by an assessment which is based on an understanding of the cultural significance of the historic asset and/or place. The assessment should identify the likely visual or physical impact of any proposals for change, including cumulative effects and provide a sound basis for managing the impacts of change.

Proposals should also be informed by national policy and guidance on managing change in the historic environment, and information held within Historic Environment Records.

c) Development proposals for the reuse, alteration or extension of a listed building will only be supported where they will preserve its character, special architectural or historic interest and setting. Development proposals affecting the setting of a listed building should preserve its character, and its special architectural or historic interest.

h) Development proposals affecting scheduled monuments will only be supported where:

i. direct impacts on the scheduled monument are avoided;

ii. significant adverse impacts on the integrity of the setting of a scheduled monument are avoided; or

iii. exceptional circumstances have been demonstrated to justify the impact on a scheduled monument and its setting and impacts on the monument or its setting have been minimised.

o) Non-designated historic environment assets, places and their setting should be protected and preserved in situ wherever feasible. Where there is potential for non-designated buried archaeological remains to exist below a site, developers will provide an evaluation of the archaeological resource at an early stage so that planning authorities can assess impacts. Historic buildings may also have archaeological significance which is not understood and may require assessment.

Where impacts cannot be avoided they should be minimised. Where it has been demonstrated that avoidance or retention is not possible, excavation, recording, analysis, archiving, publication and activities to provide public benefit may be required through the use of conditions or legal/planning obligations.

When new archaeological discoveries are made during the course of development works, they must be reported to the planning authority to enable agreement on appropriate inspection, recording and mitigation measures."

2.3. LOCAL PLANNING POLICY

LOCAL DEVELOPMENT PLAN

2.3.1. The Highland Council (THC) adopted the Highland Wide Local Development Plan (HWLDP) in April 2012. Within the HWLDP Policy 57 Natural, Built and Cultural Heritage is of relevance to this Chapter.

2.3.2. This policy in part states:

"All development proposals will be assessed taking into account the level of importance and type of heritage features, the form and scale of the development, and any impact on the feature and its setting"

"Council also intends to adopt the Supplementary Guidance on the Highland Historic Environment Strategy. The main principles of this guidance will ensure that:

- *Future developments take account of the historic environment and that they are of a design and quality to enhance the historic environment bringing both economic and social benefits;*
- *It sets a proactive, consistent approach to the protection of the historic environment."*

2.3.3. In August 2018 THC adopted the Caithness and Sutherland Local Development Plan (CSLDP) to be used in conjunction with the HWLDP. The CSLDP sets out a number of Key Outcomes, of relevance to this Chapter is the Key Outcome for environment and heritage:

"High quality places where the outstanding environment and natural, built and cultural heritage is celebrated and valued assets are safeguarded"

2.4. GUIDANCE

2.4.1. The methodology for cultural heritage impact assessment is consistent with the Environmental Impact Assessment Handbook (v5 NatureScot & HES 2018), guidance for competent authorities, consultation bodies, and others involved in the Environmental Impact Assessment process in Scotland, Appendix 1.

2.4.2. HES also provides guidance on how to apply NPF4 Policy 7 in a series of documents entitled '*Managing Change in the Historic Environment*' (MCHE). These provide guidance to planning authorities and stakeholders regarding key issues relating to development, the planning process, and key issues pertaining to the historic environment. Most relevant to this assessment are the guidance notes covering Setting (June 2016 updated 2020), and Works on Scheduled Monuments (2016 updated 2020).

2.4.3. HES published Designation Policy and Selection Guidance (DPSG, 2019) to accompany HEPS. DPSG outlines the policy and selection guidance used by HES when designating sites and places of national importance.

2.4.4. Planning Advice Note (PAN) 2/2011: Planning and Archaeology provides local government officers with technical advice to planning authorities and developers on dealing with archaeological remains. Among other issues it considers the balance in planning decisions between the preservation in situ of archaeological remains and the benefits of development; setting; the circumstances under which developers can be required to provide further information, in the form of a field evaluation to allow planning authorities to reach a decision; and measures that can be taken to mitigate adverse impacts.

2.4.5. Standards and Guidance published by the Chartered Institute for Archaeologists (CIfA) have been followed in preparing this assessment, in particular the '*Standard and guidance for commissioning work or providing consultancy advice on archaeology and the historic environment*' (2014, updated 2020) and the '*Standard and guidance for historic environment desk-based assessmen*t' (2014, updated 2017 & 2020).

2.4.6. This assessment has also been prepared with reference to IEMA, IHBC and CIfA's July 2021 publication '*Principles of Cultural Heritage Impact Assessment in the UK*'. This document presents good practice for assessment of the impact of a development proposal on cultural heritage assets which is consistent with the Principles.

2.5. PROFESSIONAL STANDARDS AND ACKNOWLEDGEMENTS

2.5.1. Headland Archaeology (UK) is a Registered Organisation with the Chartered Institute for Archaeologists (CIfA), an audited status which confirms that all work is carried out in accordance with the highest standards of the profession.

2.5.2. Headland Archaeology (UK), as part of the RSK Group, is recognised by the Institute of Historic Building Conservation (IHBC) under their '*Historic Environment Service Provider Recognition*' scheme. This quality assurance standard acknowledges that RSK works to the conservation standards of the IHBC, the UK's lead body for built and historic environment practitioners and specialists.

2.5.3. Headland Archaeology (UK) operates a quality management system to help ensure all projects are managed in a professional and transparent manner, which enables it to qualify for ISO 9001 (Quality Management), ISO 45001 (health and safety management) and ISO 14001 (environmental management).

3. AIMS AND OBJECTIVES

3.1.1. The aim of this DBA is to inform determination of an EIA Report (EIAR) chapter in relation to likely significant environmental effects, specifically those upon the historic environment. The assessment aims to identify all known heritage assets potentially affected by the Proposed Development, and the potential for currently unknown heritage assets to be present within the ISA.

3.1.2. The purpose is to gain an understanding of the historic environment resource in order to formulate an assessment of the potential for heritage assets to survive within the ISA, their significance, and strategies for further evaluation, mitigation or management as appropriate.

3.1.3. The CIfA's *Standard and Guidance for Historic Environment Desk-Based Assessment* (2020) defines a DBA as '…*a programme of study of the historic environment within a specified area or site on land, the inter-tidal zone or underwater that addresses agreed research and/or conservation objectives. It consists of an analysis of existing written, graphic, photographic, and electronic information in order to identify the likely heritage assets, their interests and significance and the character of the Study Area, including appropriate consideration of the settings of heritage assets and, in England, the nature, extent and quality of the known or potential archaeological, historic, architectural and artistic interest. Significance is to be judged in a local, regional, national or international context as appropriate*.'

3.1.4. NPF4 Policy 7(a) requires that "*Development proposals with a potentially significant impact on historic assets or places will be accompanied by an assessment which is based on an understanding of the cultural significance of the historic asset and/or place*." This report, therefore, will determine, as far as is reasonably possible from existing records, the nature, extent, and significance of the historic environment within a specified area, and the impact of the proposed development on the significance of the historic environment or will identify the need for further evaluation to do so.

3.1.5. The specific objectives of this DBA are therefore to:

- Collate all available written, graphic, photographic and electronic information relevant to the ISA and relevant study area;
- Describe the nature, extent and significance and importance of the historic environment within the area potentially affected by the Proposed Development, identifying any uncertainties in existing knowledge;
- Determine the potential for previously unknown archaeological remains; and
- Identify any requirements for further investigation that may be necessary to understand the effects of the Proposed Development on the historic environment.

4. METHODOLOGY

4.1. TERMINOLOGY – 'SIGNIFICANCE' AND 'IMPORTANCE'

4.1.1. Cultural heritage impact assessment is concerned with effects on cultural significance, which is a quality that applies to all heritage assets, and may be artistic, archaeological, architectural, historic, traditional, aesthetic, scientific or social, and may be inherent in the monument itself, its fabric, setting, use, associations, meanings, records, related monuments and related objects.

4.1.2. Impact assessment is concerned with effects on significance, the value or interest that applies to all heritage assets and relating to the ways in which the historic environment is valued both by specialists and the public.

4.1.3. Heritage assets are assessed in this report in terms of their cultural significance and importance. Cultural significance is a quality that applies to all heritage assets, and as defined by Historic Environment Scotland (Naturescot & HES 2018, Appendix 1 page 175) relates to the ways in which a heritage asset is valued both by specialists and the general public; it may derive from factors including the asset's fabric, setting, context and associations.

4.1.4. Cultural significance is assessed in relation to the criteria in DPSG Annexes 1-6, which are intended primarily to inform decisions regarding heritage designations but may also be applied more generally in identifying the 'special characteristics' of a heritage asset, which contribute to its significance and should be protected, conserved and enhanced according to the NPF4 Policy Principles. DPSG Annex 1 is widely applicable in assessing the cultural significance of archaeological sites and monuments, for instance, while the criteria in Annex 2 can be used in defining the architectural or historic interest of buildings, whether listed or not. Cultural significance of assets is considered in terms described in DPSG Annex 1:

- Intrinsic Characteristics- those inherent in the monument i.e., "*how the physical remains of a site or place contribute to our knowledge of the past*";
- Contextual Characteristics – those relating to the monument's place in the landscape or in the body of existing knowledge i.e., "*how a site or place relates to its surroundings and/or to our existing knowledge of the past*"; and
- Associative Characteristics – subjective associations, including those with current or past aesthetic preferences i.e., "*how a site or place relates to people, practices, events and/or historic and social movements*".

4.1.5. This use of the word 'significance', referring to the range of values or interest attached to an asset, should not be confused with the unrelated usage in EIA where the 'significance of an effect' reflects the weight that should be attached to it in a planning decision.

4.1.6. Relative importance of each identified heritage asset potentially affected by the Proposed Development has been determined to provide a framework for comparison between different heritage assets and to inform subsequent stages of archaeological assessment and the development of any appropriate mitigation which may be required (See Table 2 below).

4.2. IDENTIFICATION OF HERITAGE ASSETS THAT MAY BE AFFECTED

STUDY AREA

4.2.1. Overlapping study areas have been used for this assessment. The inner study area (ISA) corresponds with the Proposed Development Area and has been used to gather baseline data on the known and potential archaeological resource of the Proposed Development.

4.2.2. All heritage assets within 2 km of the ISA have been identified and considered to inform the assessment of archaeological potential for hitherto unknown remains to be present (see Part 6.1).

4.2.3. Heritage assets have been included in the assessment for overlapping Outer Study Areas (OSA) based on its level of importance to ensure that likely significant effects are recognised. The OSAs reflect that the more important the asset, the more likely significant effects could be generated over further distances, as follows:

- Up to 2 km from proposed turbines: Category C Listed Buildings and non-designated heritage assets;
- Up to 5 km from proposed turbines: Conservation Areas and Category B Listed Buildings;
- Up to 10 km from proposed turbines: Category A Listed Buildings, Inventory Gardens and Designed Landscapes, Scheduled Monuments and Inventory Historic Battlefields;
- Beyond 10 km from proposed turbines: any asset which is considered exceptionally important, and where long-distance views from or towards the asset are thought to be particularly sensitive, in the opinion of the assessor or consultees.

4.2.4. In addition, beyond the OSA as defined above, any other designated asset which is within the ZTV and considered exceptionally important and/or sensitive to visual change within its setting, and/or where long-distance views from or towards the asset are thought to contribute to cultural significance in the opinion of the assessor or consultees are included in the assessment. This screening exercise is based on the approach set out in Managing Change in the Historic Environment: Setting (Historic Environment Scotland, 2016 updated 2020) and supplemented through scoping and further consultation with statutory consultees. Only those monuments identified beyond the OSA requiring detailed assessment are added to the Gazetteer.

4.2.5. Criteria for the identification of assets of particular sensitivity or importance will be based on the approach set out in Managing Change in the Historic Environment: Setting (Historic Environment Scotland, 2020) that sets out a range of factors which might form part of the setting of a heritage asset as follows:

- *"Current landscape or townscape context;*
- *Views to, from and across or beyond the historic asset or place;*
- *Key vistas: for instance, a 'frame' of trees, buildings or natural features that give the historic asset or place a context, whether intentional or not);*
- *The prominence of the historic asset or place in views throughout the surrounding area, bearing in mind that sites need not be visually prominent to have a setting;*
- *Aesthetic qualities;*
- *Character of the surrounding landscape;*
- *General and specific views including foregrounds and backdrops;*
- *Views from within an asset outwards over key elements in the surrounding landscape, such as the view from the principal room of a house, or from a roof terrace;*
- *Relationships with other features, both built and natural;*
- *Non-visual factors such as historical, artistic, literary, place name, or scenic associations, intellectual relationships (e.g. to a theory, plan, or design), or sensory factors; and*
- *A 'sense of place': the overall experience of an asset which may combine some of the above factors."*

DATA SOURCES

4.2.6. The assessment has been based on a study of all readily available documentary sources, following the relevant CIfA Standards and Guidance. The following sources of information were referred to:

- Designation data downloaded from the Historic Environment Scotland website in January 2022;

- The National Record of the Historic Environment (NRHE), including the Canmore database and associated photographs, prints/drawings and manuscripts held by HES;
- Historic Environment Record (HER) data, digital extract received from Highlands Council in March 2022;
- Historic Landscape Assessment data, viewed through the HLAMap website;
- The National Collection of Aerial Photography (NCAP);
- Geological data available online from the British Geological Survey;
- Historic maps held by the National Library of Scotland;
- Unpublished maps and plans held by the National Records of Scotland;
- Relevant internet resources, including Google Maps, Google Earth, Bing satellite imagery and PastMap;
- Readily available published sources and unpublished archaeological reports.

4.2.7. All heritage assets within the ISA and OSA are compiled in a gazetteer (Annex 1). Designated heritage assets are referenced in this report by their Historic Environment Scotland list entry number. Non-designated assets are referenced by their HER 'MonUID' Reference Number or the National Record of the Historic Environment reference. Any newly discovered assets have been assigned a number prefixed HA for 'Heritage Asset'. A single asset number can refer to a group of related features, which may be recorded separately in the HER and other data sources.

SITE VISIT

4.2.8. A site visit was undertaken on 28th April 2022 in clear weather conditions. Notes were made regarding site characteristics, any visible archaeology and geographical/geological features which may have a bearing on previous land use and archaeological survival, as well as those which may constrain subsequent archaeological investigation.

4.2.9. Records were made regarding extant archaeological features, such as earthworks or structural remains, any negative features, local topography and aspect, exposed geology, soils, watercourses, health and safety considerations, surface finds, and any other relevant information.

HISTORIC MAP REGRESSION

4.2.10. The historic mapping sequence corresponding with the ISA was consulted to collect information on former land use and development throughout the later historic periods.

4.3. LIMITATIONS OF BASELINE DATA

4.3.1. Information held by public data sources is generally considered to be reliable; however, the following general points are noted:

- There is no LIDAR data available for the ISA on the Scottish Remote Sensing Portal;
- HER records can be limited because opportunities for research, fieldwork and discovery depend on the volume and frequency of commercial development and occasional research projects, rather than the result of a more structured research framework. A lack of data within the HER records does not necessarily equal an absence of archaeology;
- Documentary sources are rare before the medieval period;
- Wherever such documentary sources are used in assessing archaeological potential professional judgment is used in their interpretation;

- Where archaeological sites have been identified solely from aerial imagery without confirmation from archaeological excavation or supporting evidence in the form of find-spots for example, it is possible the interpretation may be revised in the light of further investigation;
- The significance of sites can be difficult to identify from HER records, depending on the accuracy and reliability of the original source;
- There can often be a lack of dating evidence for archaeological sites; and
- Any archaeological site visit has inherent limitations, primarily because archaeological remains below ground level may have no surface indicators.

4.4. ASSESSMENT OF IMPORTANCE

4.4.1. The importance of a heritage asset is the overall value assigned to it reflecting its statutory designation or, in the case of non-designated assets, the professional judgement of the assessor (Table 2).

4.4.2. In accordance with the Environmental Impact Assessment Handbook (HES, 2018, Appendix 1: Cultural Heritage Impact Assessment), '*Heritage Assets are features, buildings or places that provide physical evidence of past human activity identified as being of sufficient value to this and future generations to merit consideration in the planning system*'.

4.4.3. Any feature which does not merit consideration in planning decisions due to its significance may be said to have negligible importance. It is the role of the professional judgements made by the assessor to identify any historic remains within the ISA that are considered to be of negligible importance, which may be taken as justification for no further assessment or mitigation works on the feature.

4.4.4. The importance of heritage assets that may be affected by the Proposed Development is identified in the EIAR impact assessment.

Table 2. Criteria for Assessing the Importance of Heritage Assets

Importance of the asset	Criteria
Very High (International)	World Heritage Sites and other assets of equal international importance, that contribute to international research objectives
High (National)	Inventory Gardens and Designed Landscapes, Scheduled Monuments, Protected Wreck Sites, Inventory Historic Battlefields, Category A and B Listed Buildings, Historic Marine Protected Areas, and non-designated heritage assets of equivalent importance that contribute to national research objectives
Medium (Regional)	Conservation Areas, Category C Listed Buildings, undesignated assets of regional importance except where their particular characteristics merit a higher level of importance, heritage assets on local lists and non-designated assets that contribute to Regional research objectives
Low (Local)	Locally listed heritage assets, except where their particular characteristics merit a higher level of importance, undesignated heritage assets of Local importance, including assets that may already be partially damaged
Negligible	Identified historic remains of no importance in planning considerations, or heritage assets and findspots that have already been removed or destroyed (i.e. 'site of')
Unknown / Uncertain	Heritage assets for which a level of importance cannot be defined on current information

Potential for Unknown Heritage Assets

4.4.5. Archaeological features are often impossible to identify through desk-based assessment. The likelihood that significant undiscovered heritage assets may be present within the ISA is referred to as "*archaeological potential.*" Overall levels of potential can be assigned to different landscape zones, following the criteria in Table 3, while recognising that the archaeological potential of any zone will relate to particular historical periods and types of evidence. The following factors are considered in assessing archaeological potential:

- The distribution and character of known archaeological remains in the vicinity, based principally on an appraisal of data in the HER and other data sources such as HES and Canmore;
- The history of archaeological fieldwork and research in the surrounding area, which may give an indication of the reliability and completeness of existing records;
- Environmental factors such as geology, topography and soil quality, which would have influenced land-use in the past and can therefore be used to predict the distribution of archaeological remains;
- Land-use factors affecting the survival of archaeological remains, such as ploughing or quarrying; and
- Factors affecting the visibility of archaeological remains, which may relate to both environment and land-use, such as soils and geology (which may be more or less conducive to formation of cropmarks), arable cultivation (which has potential to show cropmarks and create surface artefact scatters), vegetation, which can conceal upstanding features, and superficial deposits such as peat and alluvium which can mask archaeological features.

Table 3. Archaeological Potential

Potential	Definition
High	Undiscovered heritage assets of high or medium importance are likely to be present.
Medium	Undiscovered heritage assets of low importance are likely to be present; and it is possible, though unlikely, that assets of high or medium importance may also be present.
Low	The study area may contain undiscovered heritage assets, but these are unlikely to be numerous and are highly unlikely to include assets of high or medium importance.
Negligible	The study area is highly unlikely to contain undiscovered heritage assets of any level of importance.
Nil	There is no possibility of undiscovered heritage assets existing within the study area.

4.5. STAGE 1 SETTING SCREENING ASSESSMENT

4.5.1. In the gazetteer (Annex 1) the results of a screening exercise are presented in full to consider whether further detailed assessment in the EIAR chapter is required for heritage assets within the OSA, based on whether it is likely that their cultural significance could be harmed through development within their setting. Summary results are presented in Part 6.2.

4.5.2. The Stage 1 screening assessment methodology considers each heritage asset in the OSA in turn to identify those assets in the ZTV which have a wider landscape setting that contributes to their cultural significance and whether it is likely that cultural significance would be harmed by the Proposed Development. Where heritage assets are located outwith the ZTV, third-party viewpoints within the ZTV which may provide a significant view towards the heritage asset and the Proposed Development are considered.

4.5.3. Further, beyond the defined OSAs, the screening assessment methodology considers all heritage assets in the ZTV to identify any assets of particular importance and/or sensitivity to visual change, based on the approach set out in Managing Change in the Historic Environment: Setting (Historic Environment Scotland, 2020). This is a rapid screening exercise, supplemented through scoping and further consultation with statutory consultees, and only those monuments identified beyond the OSA requiring detailed assessment are added to the Gazetteer.

4.5.4. In the case of this Proposed Development nine scheduled monuments are identified beyond the 10 km OSA and in the ZTV, requiring detailed consideration in the Stage 1 assessment. Eight are in the vicinity of Loch Watenan and Loch of Yarrows. The ninth scheduled monument is SM483 Gallow Hill, long cairns and chambered cairn.

5. RESULTS

5.1. OVERVIEW OF THE HISTORIC ENVIRONMENT

5.1.1. The full list of known heritage assets within the ISA and OSA is presented in the gazetteer (Annex 1). The significance of these assets is discussed by period in the Statement of Significance and Importance section below.

Inner Study Area

5.1.2. There are no designated heritage assets within the ISA, although Scheduled Monument SM13634 Bail A' Chairn, broch is surrounded on all sides by the ISA boundary, having been excluded by the Proposed Development Area .

5.1.3. There are 12 known non-designated heritage assets recorded on the HER/NRHE within the ISA:

- MHG18401 Acharole FARMSTEAD; SHEEP FOLD
- MHG19814 Druim Dubh FARMSTEAD
- MHG20025 Viewfield BUILDING
- MHG18400 Acharole BUILDING
- MHG18396 Ballacharn FARMSTEAD
- MHG1980 Bronze age SHORT CIST; INHUMATION
- MHG1979 Acharole STONE CIRCLE
- MHG19134 West Watten Holdings FARMSTEAD; SHEEP FOLD
- MHG19135 Acharole BUILDING
- MHG1967(a) Shielton HUT CIRCLE / MHG1967(b) Shielton HUT CIRCLE
- MHG19142 Ballacharn ENCLOSURE
- 90907 BUILDING

5.1.4. In addition, surveys for this assessment have identified a further 16 features of potential cultural significance within the ISA from a review of historic mapping and aerial photos, and walkover survey:

- HA1 Square enclosure visible on 1946, 1988, and modern aerial photography
- HA2 Building on 1st ed OS 1877
- HA3 Chalybeate building on 1st ed OS 1877
- HA4 Sheepfold on 1st ed OS 1877
- HA5 Shielton building on 1st ed OS 1877
- HA6 Gravel Pit on 1st ed OS 1877
- HA7 Ford on 1st ed OS 1877
- HA8 Gravel Pit on 1st Rev OS 1907
- HA9 Linear feature on 1st ed OS 1877, observed as a low turf bank during walkover survey
- HA10 Well on 1st ed OS 1877
- HA11 Well on 1st ed OS 1877
- HA12 Gravel pit on 1st ed OS 1877
- HA13 A possible mound

- HA14 A possible mound
- HA15 Sheep shelter on 1st ed OS 1877
- HA16 Sheepfold and 'old lime kiln' on 1st ed OS 1877

OUTER STUDY AREA

5.1.5. Within 2 km of the proposed turbines there are four scheduled monuments and 42 non-designated heritage assets.

5.1.6. Within 2-5 km of the proposed turbines there are 13 scheduled monuments, one Cat A listed building and one Cat B listed building.

5.1.7. Within 5-10 km of the proposed turbines there are 36 scheduled monuments.

5.1.8. Within 10-20 km of the proposed turbines there are 16 Cat A listed buildings, and eight scheduled monuments within the ZTV.

5.1.9. No heritage assets have been identified within the ZTV beyond 20 km for which setting contributes to cultural significance such that a significant effect is anticipated as a result of the Proposed Development over this distance.

5.2. PREVIOUS INVESTIGATIONS

5.2.1. No previous archaeological investigations have been carried out within the ISA.

5.2.2. The nearest previous investigation is EHG3194, a desk-based assessment and walkover survey undertaken for Halsary Wind Farm (CFA Archaeology, July 2008), which identified eight known heritage assets within the application area, two of which were Scheduled Monuments and four of which were newly identified sites. The newly identified sites (4 & 6-8) comprised two farmsteads shown on historic mapping, quarry pits identified from walkover survey, and an area of peat cutting shown on aerial imagery.

5.3. HISTORIC LAND-USE ASSESSMENT (HLA)

5.3.1. HLA records the following wholly within the ISA:

- (5/113) Rough grazing (late 20th century – present) /
  Traditional peat cutting (18th century – present)
- (5/104) Rough grazing (late 20th century – present) /
  Rectilinear fields and farms (18th century – present)
- (5/101) Rough grazing (late 20th century – present) /
  Medieval/post-medieval settlement and agriculture (medieval / post-medieval)
- (12) Plantation (late 20th century – present)
- (1) Rectilinear fields and farms (18th century – present)

5.3.2. In addition, HLA records the following partly within the ISA:

- (5/134) Rough grazing (late 20th century – present) /
  Smallholdings (19th – 20th century)
- (5) Rough grazing (late 20th century – present)
- (41) Holdings (20th century)
- (12) Plantation (late 20th century – present)

- (1) Rectilinear fields and farms (18th century – present)

5.4. WALKOVER SURVEY

5.4.1. The western and central areas of the ISA are characterised by modern forestry and the walkover survey noted evidence for historic deep ploughing for forestry activities at the north-east end of the ISA. In this area, straight, even spaced rigs are still extant in an area of poorly draining bog and it is likely the rigs are evidence of previous forestry; this interpretation is supported by an NCAP photo dating from 1988 which appears to show forestry in this area.

5.4.2. The southern and south-eastern extents, and a strip of land immediately west of the central area of forestry within the ISA, have been improved to allow for livestock grazing. The remainder of the ISA was found to be characterised by poorly drained bog with overall negligible archaeological potential.

5.4.3. Walkover survey of the ISA identified two additional potential heritage assets (HA13 and HA14) and two unrecorded features associated with HA3, a building shown on the 1st ed OS 1877 and with MHG 19814, a farmstead. All heritage assets identified on historic and satellite imagery and assets recorded on the Highland Council's HER within the ISA were visited during the walkover survey.

Features Found During Walkover Survey

5.4.4. Two mounds (HA13 and HA14) were noted in the central part of the ISA immediately east of the area of previous forestation defined by rigs. HA13 is a small, sub-circular mound approximately 0.7 m high and 5 m in diameter; HA14 is larger, measuring approximately 0.7 m high and 16 m in diameter (Illus 2). The wider landscape is largely flat suggesting the mounds may have been man made, although in the absence of archaeological excavation any such interpretation is speculative.

Illus 2. View north of HA14

Features Identified on Historic and Modern Mapping

5.4.5. HA1, a square enclosure visible on 1946, 1988, and modern aerial photography, was found to be largely contained within commercial forestry and was difficult to discern on the ground.

5.4.6. The site of HA2, a building shown on the 1st ed OS 1877 was visited and no extant remains noted.

5.4.7. HA3, a building labelled as 'Chalybeate' on the 1st ed OS 1877, was found to be extant, with a small structure to the south and a hollow to the north-east also noted. 'Chalybeate' denotes a relation with possible mineral springs. The largest building measures approximately 32 m in length, 5 m in width and up to 3.5 m in height (Illus 3). The building comprises a likely byre attached to a possible farmhouse. There is another smaller structure just to the south, another possible farmhouse, measuring 8 m in length, 5 m in width and up to 3 m in height (Illus 3). An enclosure defined by a drystone wall is present to the south of this structure (Illus 3).

Illus 3. View north-east showing enclosure HA3 in foreground, smaller structure in middle and largest structure in background

5.4.8. A hollow, located approximately 17 m to the north-east of HA3 was noted (Illus 4). It measures approximately 13 m in length and 5 m in width and may be the footprint of an earlier structure.

Illus 4. View south-west of hollow to north-east of HA3

5.4.9. HA4, a sheepfold shown on the 1st ed OS 1877, was found to survive as low, circular bank measuring approximately 0.2 m in height enclosing an area of approximately 20 m. No stones were noted, suggesting the sheepfold was robbed out and its stones re-used elsewhere.

5.4.10. HA5, Shielton building on the 1st ed OS 1877, survives as two adjoining, roofed, farmhouses with modern outbuildings. Immediately to the south of HA5 is HA6, a gravel pit shown on the 1st ed OS 1877. The feature remains identifiable, with the areas dug out for gravel still appreciable.

5.4.11. HA7, a ford shown on the 1st ed OS 1877 was found to be no longer visible.

5.4.12. HA8, a gravel pit on the 1st Rev OS 1907, is now characterised by a laydown area and is no longer appreciable as a feature.

5.4.13. HA9, a linear feature (a possible enclosure) shown on the 1st ed OS 1877, was found to survive as a low turf bank measuring approximately 0.3 m in height and 0.5 m in width.

5.4.14. HA10, a well shown on the 1st ed OS 1877, was found to survive as a small sub-rectangular cut blocked by angular stones (Illus 5).

Illus 5. View south-west of HA10, well

5.4.15. HA11, a well shown on the 1st ed OS 1877 was found to be no longer extant.

PREVIOUSLY RECORDED HERITAGE ASSETS

5.4.16. The following known heritage assets located within the area of proposed infrastructure were visited to determine preservation, significance and importance,

5.4.17. MHG18401 Acharole, farmstead and sheepfold (Illus 6) remains extant as a series of enclosure banks and stone structures. Mounds of stones and earth mounds are present within the vicinity of the farmstead and the sheepfold measures 9 m in diameter.

Illus 6. View south-west of MHG18401

5.4.18. MHG19814 Druim Dubh farmstead was found to comprise a rectangular enclosure defined by a turf bank measuring 1 m in width and 0.35 m in height. To the south of this, a rectangular structure sub-divided into three chambers was noted. The building measures approximately 25 m in length, 5 m in width and up to 0.5 m in height. It is formed of up to two courses of roughly hewn stone (Illus 7).

Illus 7. View west of MHG19814

5.4.19. MHG20025 Viewfield building remains extant and measures approximately 12 m in length, 5 m in width and up to 3 m in height. The north-eastern gable end survives, along with a fireplace on the interior (Illus 8).

Illus 8. View east-south east of MHG20025

5.5. HISTORIC MAPPING AND AERIAL PHOTOGRAPHY REVIEW

5.5.1. Two historical aerial images are available on NCAP covering the ISA (listed in full in the references section of this report). The 1946 photo shows moorland, and the 1988 photo shows possible recently deforested moorland, scarred with natural watercourses draining into the Burn of Acharole to the south. On both photos a possible enclosure (HA1) is visible in an area now at the edge of commercial forestry.

5.5.2. Bleau's Atlas of Scotland (1654) shows Medieval settlements in the vicinity of the ISA at Tochnagal [Toftingall]. Roy's Lowlands Map (1747-52) shows the ISA as uncultivated hillsides. Loch Toftingall is named, as are settlements at Knockglas and Toftingall which are surrounded by fields. William Hole's (1607), James Dorret's Map (1750) and Aaron Arrowsmith's Map (1807) are not at a scale useful to identify archaeological potential, only naming nearby settlements.

5.5.3. Eleven features were added to the gazetteer from a review of the historic OS map sequence (HA2-12) comprising four buildings, two sheepfolds, two gravel pits, a ford, and two wells.

5.6. ARCHAEOLOGICAL AND HISTORICAL NARRATIVE

Prehistoric Periods

5.6.1. The wider area is rich in scheduled upstanding prehistoric archaeological remains. The earliest are probable Neolithic chambered cairns such as Fairy Hillock (SM528), Bibster (SM431), Mill of Knockadee (SM468), Oslie (SM472), Gallow Hill (SM483) and Tulloch of Milton (SM499).

5.6.2. Within 2 km of the ISA , evidence of prehistoric activity comprises four scheduled monuments (two brochs, a cairn and burial ground) and five further prehistoric non-designated assets: these comprise a cist inhumation (MHG1980), two hut circles (MHG1967), and possible stone circle (MGH1979) located within the ISA, and a broch. In addition, two mounds HA13 & HA14 identified through walkover survey for this assessment may represent hitherto unknown Prehistoric activity within the ISA.

5.6.3. The stone circle and funerary monuments in the 2 km OSA are ritual monuments typically dating from the Neolithic to Early Bronze Age. The absence of associated Neolithic settlement remains probably reflects the priorities of past research, or the fact that such assets were made of less substantial materials, most probably timber and turf.

5.6.4. The brochs date to the Iron Age. These are amongst the most prominent archaeological sites in Caithness and comprise large cylindrical drystone towers surviving up to 12 m high. Although the exact function of brochs remains under debate they are often considered to be defended farmsteads with the size of the structures providing evidence of social cohesion.

5.6.5. Prehistoric assets are all located in the eastern part of the ISA. It is likely that the area of proposed turbine infrastructure was marsh, unsuitable for settlement during these periods.

Medieval to Modern Periods

5.6.6. The early medieval period in Caithness is dominated by the Norse incursions into the area in the 9th century and their subsequent control of the area from the 10th century to early 13th century. A presence in the surrounding area is recorded in the Orkneyinga Saga. The parish name of Watten is supposedly Danish in origin, meaning water, a reference to Loch Watten.

5.6.7. At Spittal, north-east of the ISA is a disputed battle site of Skida Mire (MHG1352), between Liotus Earl of Orkney and his brother, Sculius, for the Earldom of Caithness, during the reign of Malcolm I (943-54). Torfaeus (1866) says this is the site of the Battle, whilst the New Statistical Accounts of Scotland (NSA) (1845) says the battle took place at Kilmster in Bower parish. Other sources place the battle ground at Skitten, on the coast north east of Watten. In one translation of Torfaeus, the phrase for describing the battle location 'near' Spittal Hill is replaced by 'south of' Spittal Hill in the second account. Whilst no definite conclusions can be reached as to its precise location, it is likely that the battle was fought over a large area. This recorded location of the battle at Toftinghall is currently an enclosed grass field alongside broch SM582 and Spittal Quarries MHG185.

5.6.8. North-west of the ISA lie the remains of St Magnus' Church, burial ground and hospital. The Hospital of St Magnus was mentioned in 1476 and was still in existence in 1633. The dedication is to Norse St Magnus, who was executed in 1116. The church, located on an important crossroads (the modern A9 and B870), was a resting place for pilgrims travelling to Orkney.

5.6.9. Bleau's Atlas of Scotland (1654) shows Medieval settlements in the vicinity of the ISA at Tochnagal [Toftingall]. The assets in the wider area are generally post-medieval in date, though some may therefore have their origins in the medieval period.

5.6.10. Highlighting the importance of the crossroads, north of the ISA is Spittal Hill (Spittal was a parish until combined with Halkirk in the 16th century); the highest point in Halkirk parish, was until about 1827 a traditional meeting place. Here was held an annual market named 'the Jamesmas' according to the NSA (1845) and 'Georgemas Fair' according to the OS Name Book (1872).

5.6.11. From the medieval period through to the early modern period the archaeological record for the 2 km OSA area of Caithness is dominated by agricultural remains consisting of small farmsteads, crofts, sheep folds, enclosures, wells and rig and furrow. Within the ISA there are the remains of 12 buildings interpreted as relating to later historic periods agricultural exploitation (MHG18401, MHG19814, MHG20025, MHG18400, MHG18396, MHG19134, MHG19135, 90907, HA2, HA3, HA5 & HA9), as well as two enclosures (MHG19142 & HA1), three sheepfolds (HA4, HA15 & HA16), a ford (HA7) and two wells (HA10 & HA11). Further remains also survive that provide evidence for alternative economic activities including peat cutting, grain mills, water mills/dams and smithies. Within the ISA there are three gravel pits (HA6, HA8 & HA12) and what is labelled as an 'old lime kiln' (HA16) on the First Edition OS mapping (1877).

5.6.12. Volume XI of the Old Statistical Account of Scotland published in 1794 for the Parish of Wattin [Watten] and Volume XV of the New Statistical Account of Scotland published in 1845 for the Parish of Watten identifies the prevalent antiquities. Extensive drainage operations are noted, which may have included Toftingall Moss.

5.6.13. The OS Name Books for Caithness (1871-73) references ***Toftingall:*** *An extensive district in the north west part of the parish, which embraces a number of Crofts & small farm houses*.

5.6.14. The Caithness flagstone quarries in and around Spittal are historically significant, being well-known around Scotland and the source of much of the street paving in Edinburgh. The First Edition historic OS mapping (1877) shows that quarrying in the study area had commenced by this time.

5.6.15. In the modern period commercial forestry will have resulted in ploughing across parts of the ISA which will have damaged any near-surface archaeological remains in these areas.

6. STATEMENT OF SIGNIFICANCE AND IMPORTANCE

6.1. KNOWN AND POTENTIAL HERITAGE ASSETS

KNOWN HERITAGE ASSETS WITHIN THE INNER STUDY AREA

6.1.1. There are 29 known features located within the ISA, and one Scheduled Monument adjacent to the ISA boundary.

6.1.2. These are of intrinsic significance as they have the potential to hold physical evidence of the society that built and used them. These are listed in the Gazetteer in Annex 1 and presented in Table 4 below with an assessment of importance.

6.1.3. Designated heritage assets are of High (National) importance. Non-designated assets with the potential to contribute to Regional Archaeological Research Frameworks are considered of Medium (Regional) importance. More commonly, known non-designated remains that provide direct evidence of habitation or agricultural practices are considered of Low (local) importance. Features with negligible intrinsic interest, as well as any modern or natural features are considered of Negligible importance.

6.1.4. Heritage assets recorded in the HER and NRHE are presented in Table 4 with NGRs as provided in these datasets. Comparison with correctly geo-referenced historic mapping as part of this assessment has, however, found a number of inconsistencies. The correct NGRs are presented in Table 5.

Table 4. Known/Potential Heritage Assets within/adjacent to the ISA

Ref	Name	Description	E	N	Period	Status	Importance
SM13634	Bail A' Chairn, broch	Prehistoric domestic and defensive: broch	322816	951715	Prehistoric	Scheduled Monument	High
MHG18401	Acharole	FARMSTEAD; SHEEP FOLD	321900	951400	Later historic	Non-designated	Low
MHG19814	Druim Dubh	FARMSTEAD	320600	952200	Later historic	Non-designated	Low
MHG20025	Viewfield	BUILDING	321490	953120	Later historic	Non-designated	Low

Ref	Name	Description	E	N	Period	Status	Importance
MHG18400	Acharole	BUILDING	322308	951398	Later historic	Non-designated	Low
MHG18396	Ballacharn	FARMSTEAD	322902	951519	Later historic	Non-designated	Low
MHG1980	Bronze age cist with inhumation burial - Acharole	SHORT CIST; INHUMATION	322414	951644	Prehistoric	Non-designated	Low
MHG1979	Possible Stone Circle, Acharole	STONE CIRCLE	322343	951664	Prehistoric	Non-designated	Low
MHG19134	West Watten Holdings	FARMSTEAD; SHEEP FOLD	322806	951993	Later historic	Non-designated	Low
MHG19135	Acharole	BUILDING	322106	951889	Later historic	Non-designated	Low
MHG18394	West Watten Holdings	FARMSTEAD. Review of historic mapping shows this asset is located outwith the ISA	322310	952393	Later historic	Non-designated	Low
MHG1967(a)	Hut circle, Shielton	HUT CIRCLE	320567	950759	Prehistoric	Non-designated	Low
MHG1967(b)	Hut circle, Shielton	HUT CIRCLE	320745	950767	Prehistoric	Non-designated	Low
MHG19142	Ballacharn	ENCLOSURE	322614	951398	Later historic	Non-designated	Low
90907		BUILDING	322114	951293	Later historic	Non-designated	Low
HA1	Enclosure	Square enclosure visible on 1946, 1988, and modern aerial photography	320603	951482	Later historic	Non-designated	Low
HA2	Building	Building on first ed OS 1877	321028	952804	Later historic	Non-designated	Low
HA3	Building	Chalybeate building on 1st ed OS 1877	320763	952465	Later historic	Non-designated	Low
HA4	Sheepfold	Sheepfold on 1st ed OS 1877	320270	951098	Later historic	Non-designated	Low

Ref	Name	Description	E	N	Period	Status	Importance
HA5	Building	Shielton building on 1st ed OS 1877	320634	950978	Later historic	Non-designated	Low
HA6	Gravel Pit	Gravel Pit on 1st ed OS 1877	320636	950913	Later historic	Non-designated	Negligible
HA7	Ford	Ford on 1st ed OS 1877	320930	951035	Later historic	Non-designated	Negligible
HA8	Gravel Pit	Gravel Pit on 1st Rev OS 1907	321103	951092	Later historic	Non-designated	Negligible
HA9	Enclosure?	Linear feature on 1st ed OS 1877, observed as a low turf bank during walkover survey	320647	952098	Later historic	Non-designated	Negligible
HA10	Well	Well on 1st ed OS 1877	320689	952442	Later historic	Non-designated	Negligible
HA11	Well	Well on 1st ed OS 1877	320936	952786	Later historic	Non-designated	Negligible
HA12	Gravel Pit	Gravel pit on 1st ed OS 1877	322235	951424	Later historic	Non-designated	Low
HA13	Mound	Possible mound identified during walkover survey	321339	951975	Uncertain	Non-designated	Low
HA14	Mound	Possible mound identified during walkover survey	321295	952082	Uncertain	Non-designated	Low
HA15	Sheep shelter	Sheep shelter on 1st ed OS 1877	322438	951955	Later historic	Non-designated	Low
HA16	Sheep fold and 'Old lime kiln'	Sheep fold and 'Old lime kiln' on 1st ed OS 1877	322153	951680	Later historic	Non-designated	Low

ARCHAEOLOGICAL POTENTIAL OF THE INNER STUDY AREA

6.1.5. The central and north-western extents of the ISA are afforested and the walkover survey was limited to areas of proposed infrastructure. It is possible that upstanding archaeological remains may survive within more densely planted and less accessible areas of the plantation. These areas are not proposed for development.

6.1.6. Surveys of the ISA for the current Proposed Development are likely to have identified and recorded any upstanding cultural heritage assets within the areas proposed for infrastructure (such HA13 & HA14). It is therefore considered that there is negligible potential for further upstanding cultural heritage assets within the ISA. Although there is evidence for Prehistoric activity alongside the watercourses within the ISA, the character of the areas proposed for infrastructure during this period would have largely comprised undrained moorland; the evidence suggests the area of proposed turbines would have been largely unsuitable for settlement throughout the prehistoric periods. Archaeological potential for significant Prehistoric period remains within the areas proposed for infrastructure within the ISA is therefore considered to be low. Any further Prehistoric remains that may be preserved would be below ground and truncated and of up to Medium importance. The areas proposed for habitat management in the eastern part of the ISA are of increased Prehistoric archaeological potential, as evidenced by the presence a scheduled Iron Age broch as well as two Bronze Age hut circles, a possible Neolithic or Bronze Age stone circle and a Bronze Age cist burial. These areas will be avoided by Proposed Development infrastructure.

6.1.7. There is evidence of settlement activity in the later historic period, after drainage was implemented. Surveys carried out for this assessment have identified areas of later historic period activity within the ISA. Archaeological potential for any further historic period remains within the areas proposed for infrastructure within the ISA is therefore considered to be low. Any hitherto unknown archaeological remains within the ISA, if present, are likely to relate to pastoral agriculture and would be of Low importance.

6.1.8. The potential for hitherto unknown archaeological remains is reduced by the establishment of commercial forestry across the ISA and associated deep-ploughing which would have largely destroyed any remains present.

6.1.9. It is acknowledged that in areas of deep peat, there is potential for previously unrecorded assets to survive below-ground and obscured by the masking effect of peat cover.

6.2. HERITAGE ASSETS IN THE OUTER STUDY AREA

6.2.1. All heritage assets in the outer study area are listed in the gazetteer up to the following maximum distances:

- Up to 2 km from proposed turbines: Category C Listed Buildings and non-designated heritage assets;
- Up to 5 km from proposed turbines: Conservation Areas and Category B Listed Buildings;
- Up to 10 km from proposed turbines: Category A Listed Buildings, Inventory Gardens and Designed Landscapes, Scheduled Monuments and Inventory Historic Battlefields;
- Beyond 10 km from proposed turbines: any asset which is considered exceptionally important, and where long-distance views from or towards the asset are thought to be particularly sensitive, in the opinion of the assessor or consultees.

6.2.2. Based on the ZTV, every heritage asset in the outer study area has been considered for further detailed assessment in the EIAR based on whether it is considered likely that its cultural significance could be harmed through development within its setting.

World Heritage Sites

6.2.3. There are no World Heritage Sites (WHS) in the OSA.

6.2.4. The Flow Country is on the tentative list for World Heritage Site status. Nominated as a peatland, the status is proposed for designation as a 'natural' (ecological) site, rather than for cultural reasons, and the area is not considered a heritage asset.

Scheduled Monuments

6.2.5. In summary, following Stage 1 Assessment as outlined below (with full details in Annex 1), the following Scheduled Monuments (SMs) are retained for detailed assessment in the EIAR supported with photomontage and/or wireline visualisations as appropriate:

- SM721 Scouthal Burn, chapel and The Clow
- SM13632 Carn A' Chladha, broch
- SM13634 Bail A' Chairn, broch
- SM450 Gallow Hillock, cairn on Backlass Hill
- SM90056 Grey Cairns of Camster (also a Property in Care)

6.2.6. Of the SMs within the ZTV, and for those outwith the ZTV where third party views have been identified as contributory to significance, for a majority of monuments the general presence of the Proposed Development may constitute a visual change to the setting but this has not been identified as a likely impact on significance. Many SMs within the OSA are designated primarily for their intrinsic archaeological remains with the potential to provide unique information regarding past societies who built and used them. All monuments have a setting which contributes to their significance, being informative about intentional site selection and how it functioned in relation to the landscape and other contemporary monuments. The setting of a heritage asset is the surroundings in which it is experienced, and monuments that are experienced in close proximity only, where the wider landscape context does not contribute to their significance, and/or does not include significant views to or from, or have a significant historical relationship with the ISA, are excluded from detailed assessment in the EIAR.

6.2.7. Scheduled Monuments derive cultural significance from their intrinsic value as they often contain buried archaeological remains that would provide information about the date of construction and the uses of the monument in each case. Settlements have value as they provide physical evidence of the former settlement patterns, whilst religious and funerary sites hold intrinsic value related to ritual practices.

6.2.8. In terms of contextual value, prehistoric funerary monuments and brochs were often intentionally placed in the landscape to be prominently visible. Long range views are therefore likely to contribute to their significance, as with other defensive monuments that may also have been sited in the landscape for strategic purposes, with important sightlines contributing to their significance. Intentional prominence through situation in the landscape will also be the case for some of the religious, ritual and funerary sites, and contextual significance will be relevant for settlement sites identified as intentionally intervisible with contemporary monuments.

6.2.9. Conversely, monuments representing settlement or agriculture that are located within fertile land, close to a water source, sometimes including defences to protect from raiding, are more likely to have been sited in the landscape to exploit resources, rather than in relation to wider landscape views. The setting of these monuments that contributes to their cultural significance does not extend across long distances and, unless they are located directly adjacent to the ISA, are excluded from detailed assessment in the EIAR, as the ISA does not contribute to how these monuments are contextually experienced, understood or appreciated.

Standing stones

6.2.10. SM5301 Halsary Standing Stones comprise a pair of standing stones with a potential relationship. They are located to the south of the ISA and aligned due north-south. A solar or lunar alignment is therefore unlikely. Located within the Halsary Wind Farm site, the stones are short (0.6 m and 1.4 m high) and not prominently visible over any distance other than a position directly adjacent. A site visit has demonstrated that the stones are not intervisible, and views to the north from one to the other do not contribute to cultural significance. No effect is predicted upon the monuments' significance and they are excluded from detailed assessment in the EIAR.

6.2.11. At the request of HES through Scoping, a group of scheduled monuments located beyond the 10 km OSA were considered in the Stage 1 assessment. A group of 37 scheduled monuments located between the Loch of Yarrows and Loch Watenan, between 11.5 – 14 km to the south-east of the ISA have been considered. At the Loch of Yarrows is a promoted Archaeological Trail. Of these monuments, eight lie within the ZTV for the Proposed Development, two of which are standing stones (SM505) or stone rows (SM506). The orientation of the stone rows are north-south, and a solar or lunar alignment is therefore unlikely. The Proposed Development would not be located in views along this axis. It is considered that the prominence of these monuments would remain unaffected by the presence of the Proposed Development at such long distances, and both scheduled monuments are discounted from further detailed assessment in the EIAR.

6.2.12. Monuments where an experience of the wider landscape, or specific (possibly designed or manipulated) long distance views, potentially contribute to cultural significance are outlined below.

Chapels and Churches

6.2.13. The OSA includes scheduled chapels and churches, the contribution to significance made by the setting of which varies. Churches, with their tower or spire, were constructed with the intention of being prominently visible across their parish and beyond. Ecclesiastical sites benefit contextually through their association with their local communities and the communications networks on which they are located (which brought travellers and pilgrims to their doors). Specific sightlines with other religious or secular monuments may be relevant. For places of introspection and sanctuary, however, long-distance views of the wider landscape may not be relevant (such as SM2659 Kirk o' Moss, site of St Duthac's Chapel, SM5296 St Peter's Chapel, SM5732 Chapel of Dunn and SM5413 St Magnus' church, burial ground and hospital).

6.2.14. SM721 Scouthal Burn, chapel and The Clow is a multi-period site having produced evidence of occupation spanning the 13^{th} to 19^{th} Centuries. The monument is identified by HES through Scoping as potentially drawing cultural significance from a visual relationship with the adjacent Carn A' Chladha, broch (SM13632). The monument is therefore retained for detailed assessment in the EIAR. Intervisibility is postulated with Gallow Hillock, cairn on Backlass Hill (SM450), relating to the discovery of groups of skulls buried together at The Clow, thereby potentially indicating a significant relationship with executions on Gallows Hill. However, a site visit carried out for Stage 1 assessment has determined there is no intervisibility between the two monuments. This will be demonstrated with supporting visualisations in the EIAR.

Brochs

6.2.15. The Caithness landscape within the OSA contains a very high concentration of brochs.

6.2.16. Brochs were Iron Age fortified structures that date from approximately 600BCE to 400CE and comprised a squat tower with a small, single and easily defensible entrance. Some of the better-preserved examples contain evidence for a suspended floor, and most were constructed with an inner and outer wall tied together with wide stones, thereby forming galleries or passageways within the structure. They occur throughout coastal highland Scotland, with outliers recorded further south.

6.2.17. The intrinsic archaeological interest in the fabric of brochs lies in their potential data source on the architecture, domestic life and the social motives behind the construction of such massive structures during the Iron Age. The nature of these structures suggests that defence was a priority, although symbols of power and the avoidance of conflict is also a potentially significant factor. Brochs are commonly sited on mounds with views over the surrounding area, along valleys, or to monitor important routes through the landscape; brochs are also often located close to areas of cultivatable land suggesting that agriculture was also of importance to those that constructed them.

6.2.18. The contextual value of brochs comes from their relationship with the surrounding landscape, as prominently visible monuments, often over long distances, with intervisibility with contemporary structures, possibly to assert ownership over a territory. It is understood through excavation that brochs were often constructed over existing Bronze Age remains, possibly further asserting ties and ownership over landscapes.

6.2.19. The high concentration of brochs in the OSA demonstrates that the area of influence of each broch was probably not intended to cover vast areas, but that complex social inter-relationships are a likely factor of their significance which may be understood through analysis of their nested settings. This points to wider community ties stretching across Caithness in the Iron Age.

6.2.20. The following brochs were visited during Stage 1 Assessment and discounted for detailed assessment in the EIAR: SM452 Grey Cairn, broch, SMSM521 Ballone, broch, SM551 Green Hill Broch, SM561 Knockglass, broch, SM582 Spittal Farm, broch, SM609 Nether Banks, broch, SM2235 Achies, broch, SM509 Achies, broch, SM520 Ballachly, broch, SM534 Cairn Merk, broch, SMSM536 Lower Camster, broch, SM537 Camster, broch, SM541 Cnoc Donn, broch, SM545 Dale Farm, broch, SM549 Gearsay, broch, SM555 Greysteil, broch, SM556 Halcro Manse, broch, SM593 Tulach Mor, broch. In each case, these brochs were found to have no setting relationship with the ISA.

6.2.21. Proportionate and detailed assessments for all brochs within the study area are presented in Annex 1.

6.2.22. Those identified as including parts of the landscape in which the Proposed Development is either located or visible such that it potentially contributes to cultural significance, including sightlines between brochs, are:

- SM13632 Carn A' Chladha, broch
- SM13634 Bail A' Chairn, broch

6.2.23. During the Stage 1 site visits, two pairs of brochs in the OSA were identified as potentially intentionally intervisible. These are SM561 and SM582, and SM13632 and SM13634. The Proposed Development is not located along the sightline between SM561 and SM582 and no impact is anticipated. The inter-relationship of SM13632 and SM13634, located in proximity with one another, will however be considered in the EIAR with reference to wireline and/or photomontage visualisations as appropriate.

6.2.24. Spatial analysis demonstrates that the Proposed Development would not be physically located between any of the brochs within the study area except over distances not less than 5.5 km. It is considered that such monuments were not intended to be intervisible over such long distances and these sightlines are not considered possible/ significant.

6.2.25. Other than those selected for further detailed assessment (above), with Stage 1 assessments presented in Annex 1 for each broch, the ability to understand and appreciate the situation of the brochs within the study area in their wider topographic setting would be unaffected by the Proposed Development, which is located at some distance from each of these monuments. The defensive and prominent display properties of their architecture would remain discernible from their foundation remains, as would the relationship with the surrounding cultivatable land over which it was intended to exert control. It is considered that the Proposed Development would have no impact on the cultural significance of the remainder of the brochs in the study area. All other brochs in the OSA, except those named above, are therefore excluded from detailed assessment in the EIAR.

Cairns

6.2.26. Cairn monuments within the OSA form part of a group of chambered cairns in north east Caithness which appear to have been located to serve a community settled on the well-drained soils of the area (Davidson & Henshall, 1991). The intrinsic archaeological interest in the fabric of prehistoric funerary cairns lies in their physical remains, where excavation would allow interpretation of information regarding funerary practices in the Neolithic to Early Bronze Age.

6.2.27. All cairn monuments have a setting which contributes to their significance. Contextually, the siting in the landscape and relative position with other monuments provide insights into the societies that built them, in terms of where contemporary settlement may have been located and whether related features in the landscape were significant. It is likely that cairns would have been placed to be intervisible with contemporary settlement and other prominent monuments. When newly built and at full height, they would have been prominent features in the landscape, and possibly skylined when viewed from certain significant positions. The long axis of chambered cairns are sometimes postulated to align with a landscape focal point (either natural nor man-made) in the near or far distance.

6.2.28. It is these elements of setting that can be identified as the likely the territory of those that built each monument and which contributes to the significance of the monument.

6.2.29. Proportionate and detailed assessments for all cairns within the study area are presented in Annex 1.

6.2.30. Following Stage 1 Assessment two cairn sites are retained for detailed assessment in the EIAR:

- SM450 Gallow Hillock, cairn on Backlass Hill
- SM90056 Grey Cairns of Camster (also a Property in Care)

6.2.31. SM450 Gallow Hillock, cairn on Backlass Hill is identified with a setting that potentially contributes to its cultural significance that includes parts of the landscape in which the Proposed Development is either located, or visible, including sightlines between them. SM450 is a hilltop cairn and views from this monument, as well as long distance views towards it, will be considered with reference to wireline and/or photomontage visualisations as appropriate.

6.2.32. Of four Properties in Care (PiC) within the 20 km OSA, only SM90056 Grey Cairns of Camster lies within the ZTV for the Proposed Development. The monument was visited for Stage 1 Assessment. The monument is intentionally located in an inconspicuous location, with no view of the sea or mountains. It is notable that should long distance views have been intended by the builders of SM90056, there are locations nearby where views of both the sea and distant mountains could have been afforded. The fact that these locations were not chosen indicates that such views do not contribute to significance, and the monuments are intended to be experienced in a relatively enclosed setting, possibly to be 'revealed' on approach. The scheduled cairns are however located in an undulating landscape, with each cairn located on a relative high point. This leads to local prominence, and when viewed from the lower parts of the landscape, the cairns are from some locations skylined and imposing. Detailed assessment is required in the EIAR to consider whether views towards the cairns upon approach would be affected by the Proposed Development.

6.2.33. The following chambered cairns were visited during Stage 1 Assessment and discounted for detailed assessment in the EIAR: SM472 Oslie, chambered cairn 250m S of Lynegar House; SM528 Fairy Hillock, chambered cairn SE of Spittal Mains, SM431 Bilbster, chambered cairn 1040m NNE of Bylbster Bridge; SM468 Mill of Knockdee, chambered cairn SSW of; SM499 Tulloch of Milton, chambered cairn 640 m W of Halkirk. In each case, these chambered cairns were found to have no clear relationship with the ISA in terms of visual alignments, nor a physical setting relationship with it. In two cases the cairns are evidently placed with a relationship with an adjacent river (SM431 & SM499). The results of the Stage 1 Assessment and site visits presented in Annex 1 has identified that whilst there may be visual change within their setting, no cairns' prominence would be adversely affected by the Proposed Development, and no potentially significant sightlines would be obscured, with either contemporary monuments, natural features, or postulated celestial alignments.

6.2.34. The only cairn with an alignment orientated towards the ISA is SM483 Gallow Hill, long cairns and chambered cairn. This monument, located 10.8 km north-west of the ISA, comprises two long cairns and a single round chambered cairn. The long cairns are orientated NNW-SSE and this alignment may be due to a number of individual cairns being joined together over the various phases of construction. There is no visible focal point in the landscape to suggest the alignment was intended to draw significance of a landscape feature in the direction of the ISA. The Proposed Development may potentially be visible on this alignment over 10 km away to the south-east, however, over such a long distance no substantial effect is predicted upon the asset's significance. An understanding of the phasing will remain evident to be understood and appreciated, interpretation of the orientation based on an earlier alignment of individual cairns will remain possible, and any change to a visitor experience of these elements that make up its cultural significance would be negligible.

6.2.35. At the request of HES through Scoping, a group of scheduled monuments located beyond the 10 km OSA were considered in the Stage 1 assessment. A group of 37 scheduled monuments located between the Loch of Yarrows and Loch Watenan, between 11.5 – 14 km to the south east of the ISA have been considered. At the Loch of Yarrows is a promoted Archaeological Trail, the majority of which lies outwith the ZTV. Of these monuments, eight lie within the ZTV for the Proposed Development, five of which are cairns (SM8520, SM8521, SM467, SM507, SM508). This group of intervisible monuments, comprising contemporary and related funerary and settlement remains, are located in an open landscape with views in all directions other than to the south west where these are blocked by the presence of the Hill of Yarrows. The well-preserved group of remains appear to be focussed on the adjacent loch, however as a reservoir the water level is likely to have been artificially raised, and the loch may not have been as prominent in prehistory. The local prominence of the cairns as intended to be visible from adjacent contemporary settlement would be unaffected by the Proposed Development. All the long and chambered cairns in the group are orientated east – west, and the presence of the Proposed Development to the north-west would not be visible in these alignments. Wireline visualisations generated for SM507 South Yarrows long cairn and SM8521 Loch of Yarrows two cairns indicates that the Proposed Development would be entirely screened behind the operational and closer Camster Wind Farm. The fact that Camster Wind Farm does not preclude an experience of the cultural significance and understanding and appreciation of the setting of the group of related monuments demonstrates that the Proposed Development, over 10 km away, would similarly have no effect and these assets are excluded from further detailed assessment in the EIAR.

Listed Buildings

6.2.36. In summary, following Stage 1 Assessment as outlined below (with full details in Annex 1), the following listed building (LB) is retained for detailed assessment in the EIAR supported with photomontage and/or wireline visualisations as appropriate:

- LB14976 Achingale Mill

6.2.37. There is one Cat B Listed Building within the 5 km OSA: LB14975 Achingale Bridge: This bridge benefits contextually through association with the local communications network/associated settlements and the Scouthal Burn over which it crosses. The wider landscape is not relevant and this monument is excluded from detailed assessment.

6.2.38. There is one Cat A LB within the 5 km OSA: LB14976 Achingale Mill, located 3 km NE of the ISA. The mill was visited for Stage 1 assessment and found to be prominently visible in an open landscape, appreciable as a historical monument which contributes to the local historic landscape character. The mill's power source in the form of a race drawn from the Scouthal Burn is obvious and thus the setting of the building contributes to its cultural significance. LB14976 Achingale Mill is retained for detailed assessment in the EIAR.

6.2.39. There are no LBs within the 10 km OSA.

6.2.40. There are 16 Cat A LBs within the 20 km OSA, four of which lie outwith the ZTV and two of which are considered to have a wider landscape setting that contributes to cultural significance: LB14072 Ackergill Tower, garden walls, walled gardens and stable range is located on the coast with a clear aesthetic relationship with the sea, and contextual relationship with surrounding farmland. A view of distant hills 14 km to the west does not contribute to cultural significance; LB14087 Noss Lighthouse is a prominent monument, however, being located on a promontory over 17 km east of the ISA, no challenge to prominence or impact upon significant sightlines are anticipated. The remaining Cat A LBs comprise a harbour (LB14085) a steading (LB14088), two parish churches (LB1888 & LB44946), a heritage centre (LB2286), a house (LB7935) and a dovecot (LB7949). Views of or towards distant hills do not contribute to the significance of any of these buildings.

Other Designated Heritage Assets

6.2.41. There are no Inventory Gardens and Designed Landscapes, Conservation Areas or Inventory Battlefields within the OSA.

Non-designated Heritage Assets

6.2.42. In summary, following Stage 1 Assessment as outlined below (with full details in Annex 1), the following non-designated asset (NDA) is retained for detailed assessment in the EIAR supported with photomontage and/or wireline visualisations as appropriate:

- MHG1979 Possible Stone Circle, Acharole

6.2.43. No other NDAs within the OSA are identified as having a setting contributing to significance which potentially includes part of the ISA, or with significant views of proposed turbines, and all others are excluded from further detailed assessment in the EIAR.

7. CONCLUSIONS

7.1.1. The heritage assets identified in Tables 5 & 6 are considered and assessed in detail in the EIA Report Cultural Heritage chapter.

Potential Direct Impacts

7.1.2. The Proposed Development has been designed to avoid known heritage assets within the ISA. There are 23 known heritage assets located within or adjacent to the ISA boundary (Table 5), of Low or higher importance and thus considered heritage assets for planning purposes. These assets could be directly (physically) impacted by the Proposed Development.

7.1.3. Assessment for this report has identified a number of locational discrepancies in the HER data in comparison with the source material (i.e. correctly georeferenced First Edition OS mapping (1877)). The correct NGRs are provided in Table 5.

Table 5 Known Heritage Assets within/adjacent to the ISA

Ref	Name	Description	E	N	Period	Status	Importance
SM13634	Bail A' Chairn, broch	Prehistoric domestic and defensive: broch	322816	951715	Prehistoric	Scheduled Monument	High
MHG18401	Acharole	FARMSTEAD; SHEEP FOLD	321950	951420	Later historic	Non-designated	Low
MHG19814	Druim Dubh	FARMSTEAD	320655	952242	Later historic	Non-designated	Low
MHG20025	Viewfield	BUILDING	321490	953120	Later historic	Non-designated	Low
MHG18400	Acharole	BUILDING	322340	951462	Later historic	Non-designated	Low
MHG18396	Ballacharn	FARMSTEAD	322910	951590	Later historic	Non-designated	Low
MHG1980	Bronze age cist with inhumation burial - Acharole	SHORT CIST; INHUMATION	322424	951650	Prehistoric	Non-designated	Low
MHG1979	Possible Stone Circle, Acharole	STONE CIRCLE	322342	951680	Prehistoric	Non-designated	Low
MHG19134	West Watten Holdings	FARMSTEAD; SHEEP FOLD	322751	951974	Later historic	Non-designated	Low
MHG19135	Acharole	BUILDING	322187	951938	Later historic	Non-designated	Low
MHG1967(a)	Hut circle, Shielton	HUT CIRCLE	320753	950772	Prehistoric	Non-designated	Low
MHG1967(b)	Hut circle, Shielton	HUT CIRCLE	322673	951465	Prehistoric	Non-designated	Low

Ref	Name	Description	E	N	Period	Status	Importance
MHG19142	Ballacharn	ENCLOSURE	322111	951287	Later historic	Non-designated	Low
90907		BUILDING	321950	951420	Later historic	Non-designated	Low
HA1	Enclosure	Square enclosure visible on 1946, 1988, and modern aerial photography	320603	951482	Later historic	Non-designated	Low
HA2	Building	Building on first ed OS 1877	321028	952804	Later historic	Non-designated	Low
HA3	Building	Chalybeate building on 1st ed OS 1877	320763	952488	Later historic	Non-designated	Low
HA4	Sheepfold	Sheepfold on 1st ed OS 1877	320270	951098	Later historic	Non-designated	Low
HA5	Building	Shielton building on 1st ed OS 1877	320634	950978	Later historic	Non-designated	Low
HA13	Mound	Possible mound	321339	951975	Uncertain	Non-designated	Low
HA14	Mound	Possible mound	321295	952082	Uncertain	Non-designated	Low
HA15	Sheep shelter	Sheep shelter on 1st ed OS 1877	322438	951955	Later historic	Non-designated	Low
HA16	Sheep fold and 'Old lime kiln'	Sheep fold and 'Old lime kiln' on 1st ed OS 1877	322153	951680	Later historic	Non-designated	Low

Potential Setting Effects

7.1.4. The Stage 1 Setting Assessment has found that there may be impacts upon cultural significance through changes within the setting of five Scheduled Monuments, one Category A Listed Building, and one non-designated heritage asset (Table 6).

Table 6. Stage 1 Setting Assessment Results

Ref	Name	Status
2 km OSA		
SM13632	Carn A' Chladha, broch	Scheduled Monument
SM13634	Bail A' Chairn, broch	Scheduled Monument
SM450	Gallow Hillock, cairn on Backlass Hill	Scheduled Monument
SM721	Scouthal Burn, chapel & The Clow	Scheduled Monument
MHG1979	Possible Stone Circle, Acharole	Non-designated
5 km OSA		
LB14976	Achingale Mill	Category A Listed Building
20 km OSA		
SM90056	Grey Cairns of Camster	Scheduled Monument (also a Property in Care)

REFERENCES

BIBLIOGRAPHIC REFERENCES

British Geological Survey (BGS). Available from - https://mapapps.bgs.ac.uk/geologyofbritain/home.html (Accessed 31/07/2023).

Chartered Institute for Archaeologists (CIfA) 2021 *Code of Conduct.* Available from - https://www.archaeologists.net/sites/default/files/Code%20of%20conduct%20revOct2022.pdf (Accessed 31/07/2023).

Chartered Institute for Archaeologists (CIfA) 2020 S*tandard and Guidance for Historic Environment Desk-Based Assessment.* Available from - https://www.archaeologists.net/sites/default/files/CIfAS%26GDBA_4.pdf (Accessed 31/07/2023).

OS Name Books for Caithness (1871-73). Available from - https://scotlandsplaces.gov.uk/digital-volumes/ordnance-survey-name-books/caithness-os-name-books-1871-1873 (Accessed 31/07/2023).

Volume XI of the Old Statistical Account of Scotland published in 1794 for the Parish of Wattin [Watten]. Available from - https://stataccscot.edina.ac.uk/static/statacc/dist/viewer/osa-vol11-Parish_record_for_Watten_in_the_county_of_Caithness_in_volume_11_of_account_1/ (Accessed 31/07/2023).

Volume XV of the New Statistical Account of Scotland published in 1845 for the Parish of Watten. Available from - https://stataccscot.edina.ac.uk/static/statacc/dist/viewer/nsa-vol15-Parish_record_for_Watten_in_the_county_of_Caithness_in_volume_15_of_account_2/ (Accessed 31/07/2023).

Scotland's Soils. Available from - https://map.environment.gov.scot/Soil_maps/?layer=1 (Accessed 31/07/2023).

POLICY AND GUIDANCE DOCUMENTS

Historic England Managing Significance in Decision-Taking in the Historic Environment, 2015 Historic Environment Good Practice Advice in Planning GPA2

Historic England, 2017 The Setting of Heritage Assets Historic Environment Good Practice Advice in Planning GPA3

Historic England 2019, Statements of Heritage Significance: Analysing Significance in Heritage Assets Historic England Advice Note 12

Historic Environment Scotland 2019a, Designation Policy and Selection Guidance

Historic Environment Scotland 2019b, Historic Environment Policy for Scotland

IEMA, IHBC and CIfA July 2021 Principles of Cultural Heritage Impact Assessment in the UK

Scottish Government 2011, Planning Advice Note (PAN) 02/2011: Planning and Archaeology

Scottish Government 2014, Scottish Planning Policy

Scottish Natural Heritage and Historic Environment Scotland, 2018 Environmental Impact Assessment Handbook

The Highland Council (THC) adopted the Highland Wide Local Development Plan (HWLDP) in April 2012

HISTORIC MAPS

Arrowsmith, A 1807, Map of Scotland constructed from original materials

Blaeu Atlas of Scotland, 1654

Dorret, J, 1750, A General Map of Scotland And Islands Thereto Belonging

Ordnance Survey, 1877, Caithness, 1:2500 County Series 1st Edition

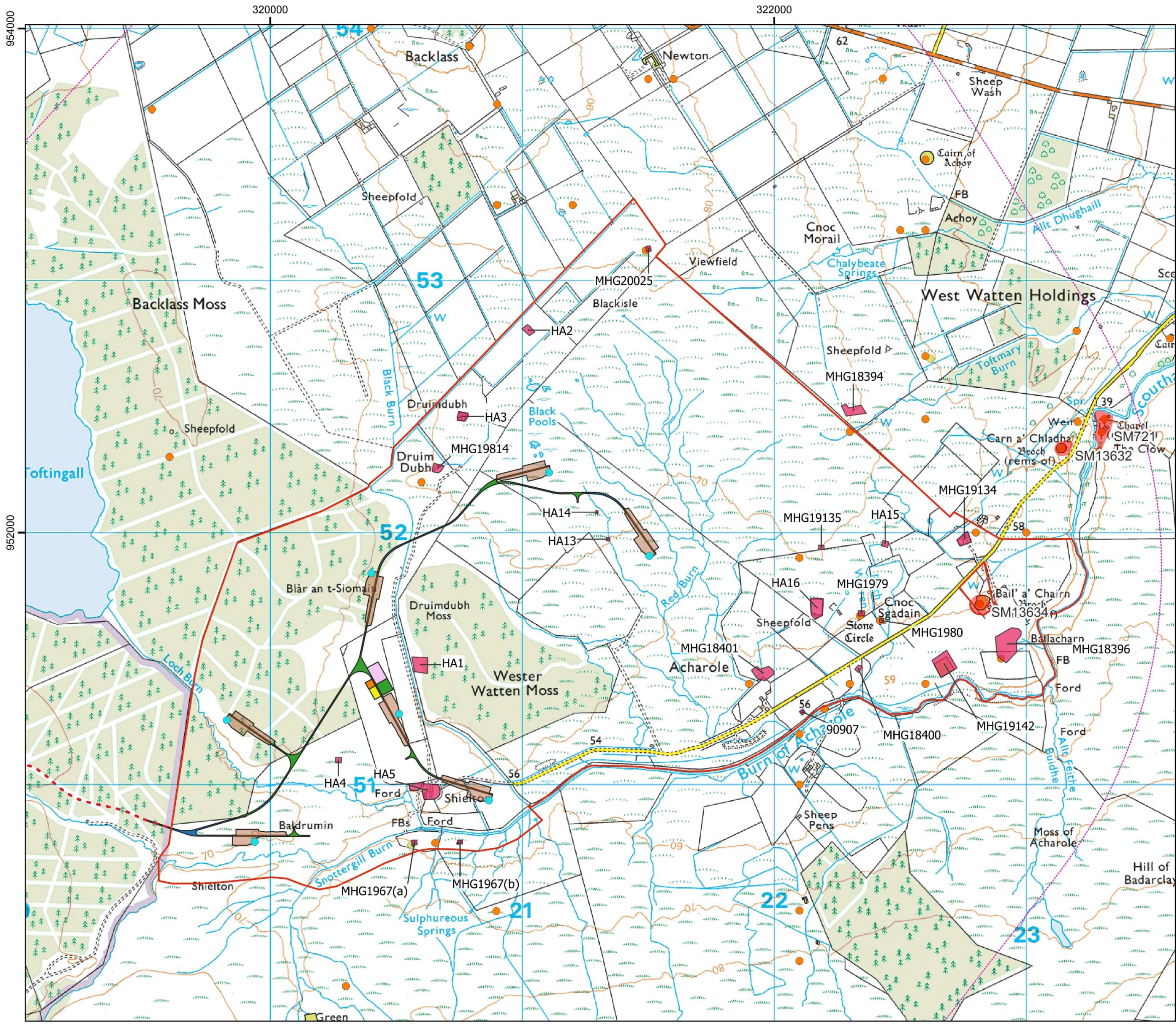
Roy, W 1747-52, Military Survey of Scotland: Lowlands

AERIAL PHOTOGRAPHS

Prints held by National Collection of Aerial Photography (NCAP)

NAME	SORTIE	DATE	FRAME NUMBERS
Shielton, Watten	ASS/60988	7 May 1988	0154
Blackisle, Watten	106G/Scot/UK/0070	9 May 1946	3055

ANNEX 1: KNOWN HERITAGE ASSETS WITHIN THE STUDY AREA



Project:

Watten Wind Farm, Caithness, Scottish Highlands

Title:

Figure 10.1: Known Heritage Assets Within Inner Study Area (ISA)

Key

- Proposed Development Area Inner Study Area (ISA)
- Proposed turbine
- Proposed cranepad
- Proposed track
- Proposed floating track
- Proposed access track
- Proposed substation
- Proposed battery storage
- Proposed construction compound
- Proposed batching plant
- Scheduled Monuments
- THC HER Non-designated heritage asets
- NRHE Non-designated heritage assets
- Known heritage assets (corrected locations)

Scale @ A3: 1:15,000

Coordinate System: British National Grid

N

0 0.25 0.5 0.75 1 km

Date: 22-05-23	Prepared by: OR	Checked by: xx
Ref:P22-136 Watten WF EIA	Layout:	

Drawing by:

HEADLAND ARCHAEOLOGY

SCOTLAND 13 Jane St, Edinburgh EH6 5HE

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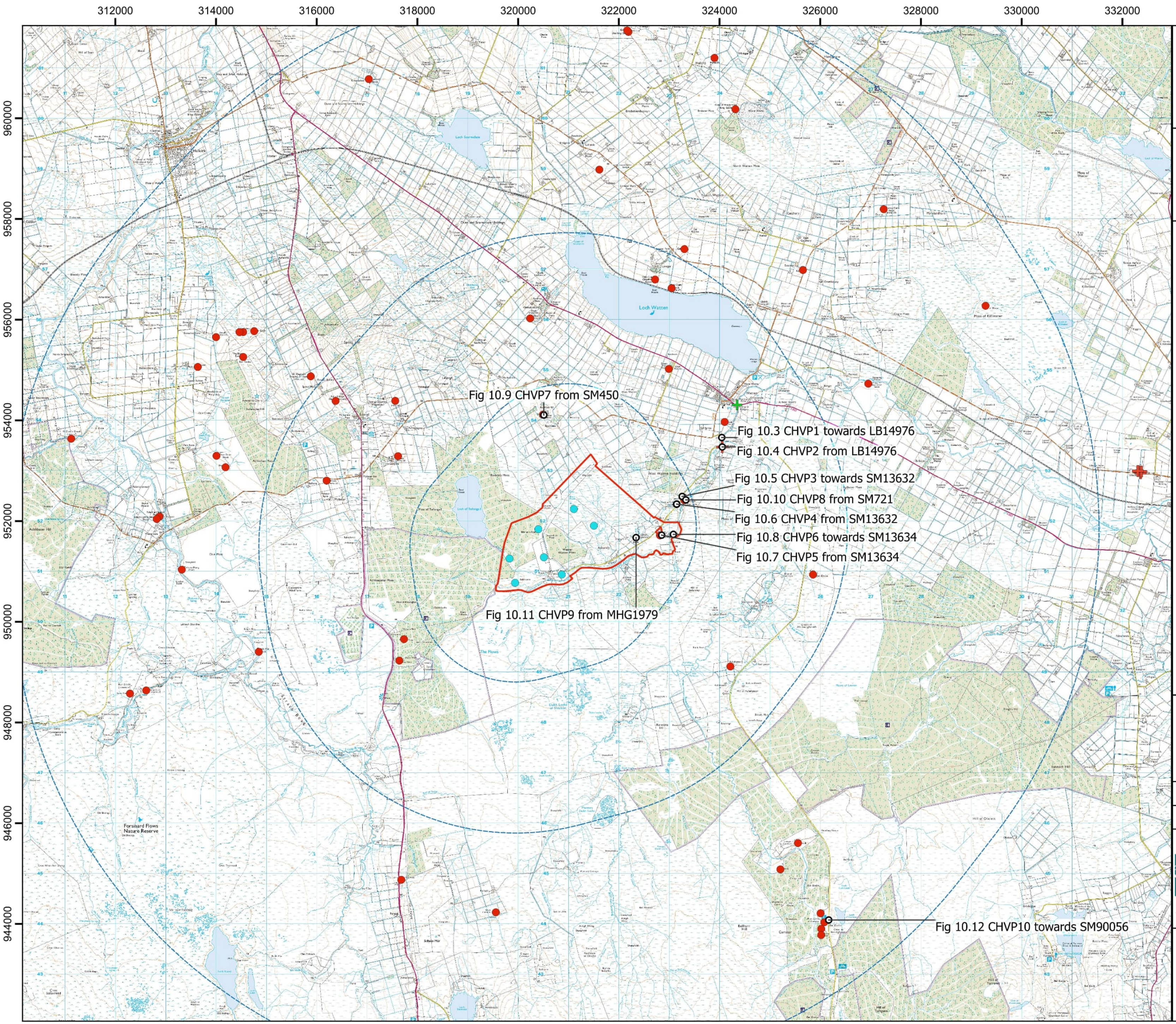

Project:

Watten Wind Farm, Caithness, Scottish Highlands

Title:

Figure 10.2: Cultural Heritage Viewpoints (CHVP) Within Outer Study Area (OSA)

Key

- Proposed Development Area Inner Study Area (ISA)
- Proposed turbines
- 2km, 5km, 10km Outer Study Area (OSA)
- Scheduled Monuments

Listed Buildings

- Cat A
- Cat B
- Cultural Heritage Viewpoint (CHVP)

Scale @ A3: 1:75,000

Coordinate System: British National Grid

N

0 1 2 3 4 km

Date: 22-05-23	Prepared by: OR	Checked by: xx
Ref:P22-136 Watten WF EIA	Layout:	

Drawing by:

HEADLAND ARCHAEOLOGY

SCOTLAND 13 Jane St, Edinburgh EH6 5HE

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Watten Wind Farm

Technical Appendix A12.2
Framework Traffic Management Plan

August 2023

EDF Energy Renewables Ltd

Contents

1. Introduction

This Framework Traffic Management Plan (FTMP) has been prepared for Watten Wind Farm (the Proposed Development), establishing the route and methodology of transportation of the construction plant, equipment, and materials during the construction phase of the Development and to provide an outline of the construction traffic management policies which will be implemented throughout construction. This FTMP has been developed in conjunction with Chapter 12 (Traffic and Transport) of the Environmental Impact Assessment Report (EIAR) as part of the application for the Development.

This FTMP contains the principles that will form the basis for the appointed contractor (post consent) to develop their detailed Construction Traffic Management Plan (CTMP) which will be utilised to manage traffic during construction. It is expected that a condition will be included in any deemed planning permission requiring the CTMP to be submitted for approval by the planning authority prior to construction works commencing.

1.1. Traffic and Transport EIAR Chapter

This FTMP includes a range of specific and good practice mitigation measures that were identified in Chapter 12 of the EIAR to reduce the effect of the traffic associated with the Development and manage construction traffic. The mitigation measures and recommendations from Chapter 12 of the EIAR include:

- HGVs prohibited from travelling through the village of Watten;
- Empty load restriction on the B870 road, empty concrete vehicles are to return via the A9 to reduce traffic on the B870;
- HGVs scheduled to avoid peak times;
- Temporary signage to be installed at key locations; and
- Public notification of construction phasing and peak periods of construction.

The above summarises the key mitigation measures mentioned in Chapter 12, a number of other minor measures are discussed throughout this FTMP.

1.2. Policy and Legislation

1.2.1. Policy Context

1.2.1.1. Scotland's National Planning Framework 4 (2023)

NPF4 is the Scottish Government national spatial strategy for Scotland, setting out spatial principles, regional priorities, national developments and national planning policy. The intention of the policy is to encourage, promote and facilitate development that addresses the global climate emergency and nature crisis. The following policy is applicable in relation to traffic and transport for wind farm development:

- Policy 11: Project design and mitigation will demonstrate how impacts on road traffic and on adjacent trunk roads, including during construction, are addressed.

1.2.1.2. Planning Advice Note: PAN 75 – Planning for Transport

Paragraph 41 of PAN75 notes that:

"All planning applications that involve the generation of person trips should provide information which covers the transport implications of the development. The level of detail will be proportionate to the complexity and scale of

impact of the proposal. This will provide an indication of whether a transport assessment should be carried out. As a change of use could result in different travel characteristics a transport assessment should be requested where the change is likely to result in a material change in trips. For smaller developments the information on transport implications will enable local authorities to monitor potential cumulative impact and for larger developments it will form part of a scoping exercise for a full transport assessment. Development applications will therefore be assessed by relevant parties at levels of detail corresponding to their potential impact."

1.2.1.3. **Onshore Wind Turbines; Online Renewables Planning Advice**

The Scottish Government introduced online renewables planning advice in February 2011. This has subsequently been updated with the most recent specific advice note regarding onshore wind turbines published in May 2014. The advice note identifies the typical planning considerations in determining applications for onshore wind turbines including landscape impact, impacts on wildlife and ecology, shadow flicker, noise, ice throw, aviation, road traffic impacts, cumulative impacts and decommissioning.

Regarding road traffic impacts, the guidance notes that in siting wind turbines close to major roads, pre-application discussions are advisable. This is particularly important for the movement of large components (abnormal load routing) during the construction period, periodic maintenance and for decommissioning.

1.2.1.4. **Transport Assessment Guidance**

The Transport Assessment Guidance has been prepared to assist in the preparation of Transport Assessments for development proposals in Scotland.

The Transport Assessment Guidance sets out requirements according to the scale of development being proposed. The guidance notes that a Transport Assessment will assist planning authorities and relevant decision makers to appraise the operational implications of a development and that the environmental impacts of a development proposal are generally outside the remit of the Transport Assessment process.

1.2.2. **Legislative Context**

1.2.2.5. **Abnormal Indivisible Loads**

All movements of abnormal loads shall be in accordance with the following legislation:

- Part II of the Road Traffic Act 1988
- Road Vehicle (Construction & Use) Regulations 1986
- Road Vehicle (Authorisation of Special Types) (General) Order 2003 (the latter commonly referred to as S.T.G.O.).

An "abnormal indivisible load" is defined in The Road Vehicles (Authorisation of Special Types) (General) Order 2003,:"*In this Order "abnormal indivisible load" means a load that cannot, without undue expense or risk of damage, be divided into two or more loads for the purpose of being carried on a road and that –*

(a) on account of its length or width, cannot be carried on a motor vehicle of category N3 or a trailer of category O4 (or by a combination of such vehicles) that complies in all respects with Part 2 of The Construction and Use Regulations; or(b) on account of its weight, cannot be carried on a motor vehicle of category N3 or a trailer of category O4 (or by a combination of such vehicles) that complies in all respects with –

(i) the Authorised Weight Regulations (or, if those Regulations do not apply, the equivalent provisions in Part 4 of the Construction and Use Regulations); and

(ii) Part 2 of the Construction and Use Regulations."

Notifications for abnormal indivisible loads are required where loads or vehicles exceed maximum gross vehicle weight or dimension limits in any of the following ways:

- a gross vehicle weight of more than 80,000 kg
- a width exceeding 3 m
- a length exceeding 18.75 m

Each load requires at least two clear days' notice to the relevant police and roads authorities, as detailed in Table 1.1. The haulier must also indemnify each road authority against any damage caused to any road, bridge or other structure.

Table 1.1: Weight Regulations

Weight	Action required
Gross weight or axle weights exceeding C&U or Authorised Weight limits up to 80,000 kgs	Two clear days' notice with indemnity to Road and Bridge Authorities
Gross weight (of vehicle carrying the load) exceeding 80,000 kgs up to 150,000 kgs	Two clear days' notice to Police Scotland and five clear days' notice with indemnity to Roads and Bridge Authorities.
Gross weight (of vehicle carrying the load) exceeding 150,000 kgs	Special Order (BE16) (8-10 weeks) plus five clear days' notice to Police Scotland and five clear days' notice with indemnity to Roads and Bridge Authorities
Width	**Action required**
Width exceeding 2.9 m (for C&U loads 3.0 m) up to 5.0 m for other loads	Two clear days' notice to Police Scotland
Width exceeding 5.0 metres up to 6.1 m	Form (VR1) to be issued to Transport Scotland (two weeks) plus two clear days' notice to Police Scotland
Width exceeding 6.1 m	Special Order (BE16) (8-10 weeks) plus five clear days' notice to Police Scotland and five clear days' notice with indemnity to Roads and Bridge Authorities
Length	**Action required**
Length exceeding 18.65 m up to 30 m rigid length (Vehicle or train of vehicles)	Two clear days' notice to Police Scotland
Vehicle combination exceeding 25.9 m	Two clear days' notice to Police Scotland
When exceeding 30.0 m rigid length	Special Order (BE16) (8-10 weeks) plus five clear days' notice to Police Scotland and five clear days' notice with indemnity to Roads and Bridge Authorities

2. Project Details

2.1. Proposed Development

The Proposed Development comprises the construction of up to seven wind turbines with associated access tracks, crane hardstandings, electrical cabling, substation and Battery Energy Storage System (BESS). The Proposed Development is situated in the Scottish Highlands on land to the east of Halsary Windfarm and approximately 3 km to the south-west of the settlement of Watten. The Proposed Development Area is centred on Ordnance Survey (OS) grid reference 320769E, 951676N.

2.2. Routes to Site

Access to the Proposed Development will be taken via the existing Halsary Windfarm Site Entrance off the A9 south of the settlement of Spital and south of the junction with the B870. There are several routes to site depending on the origin of construction material, which is being delivered, these routes are defined in the following sub-sections.

2.2.1. Abnormal Load Route

The overland route for wind turbine components will originate from either the Port of Scrabster or the Port of Nigg. At this stage both of these ports are being considered, the final choice of port(s) will be defined in the detailed CTMP. The relevant route to site for abnormal indivisible loads (AILs) from each port is listed below:

The route from the Port of Nigg for AILs would be as follows:

- From the Port of Nigg, exit onto the B9175 joining the A9.
- Loads would then head northbound on the A9 towards Latheron and then westbound onto the A9 towards the existing Halsary Wind farm site entrance.

The route from Scrabster: for AILs would be as follows

- Loads would exit the harbour onto the A9, continuing south towards the existing Halsary Windfarm site entrance.

2.2.2. Route for Concrete Deliveries

A worst case scenario has been assumed in which all concrete for the wind turbine foundations will be delivered as ready-mix. Given the scale of the Proposed Development and the proximity of nearby sources of ready-mix this is likely to be the chosen method. The final source of concrete has not yet been determined; however the assessment has assumed concrete will be delivered from Bower Quarry, operated by John Gunn & Sons Ltd which is located 10 kilometres (km) by road to the north east of the Proposed Development.

During consultation it was agreed with The Highland Council (THC) that no HGV deliveries would pass through the village of Watten. Furthermore, an ‘empty load restriction’ was agreed for the B870 such that empty concrete waggons departing the Proposed Development will return via a different route to the approach route.

The approach and departure routes for concrete deliveries are listed below.

Approach Route:

- Depart Bower Quarry turning right onto unnamed road South West bound;
- Turn left onto A882 South East bound for approximately 800m;
- Turn right onto unnamed minor road South West bound;
- Turn right onto B870 Westbound;
- Turn left onto A9 Southbound; and
- Turn left into Site Entrance.

Due to the ‘empty load restriction’ on the B870 the departure route for concrete waggons will be as follows:

- Depart Site Entrance, turning right onto A9 Northbound;
- Continue on A9 to Georgemas;
- Turn right onto A882 South East bound;

- Turn left onto unnamed road towards quarry; and
- Turn left into Bower Quarry.

2.2.3. General Construction Traffic Route

General construction traffic would comprise HGVs for the delivery of all plant and materials excluding the AIL turbine components. The origin of these materials is not currently known as suppliers have not yet been appointed however it is reasonable to assume that the majority of such deliveries will originate from centres of population to the south and will approach the Proposed Development via the A9 turning directly into the existing Halsary Windfarm Site Entrance.

General construction traffic should be made aware that there is a restriction for HGVs associated with the Proposed Development and are prohibited from passing through the village of Watten, although it is not anticipated that any such vehicles would wish to use this route in any case as it is unlikely that construction materials would be sourced from Wick.

3. Construction Programme

A construction programme, with key dates for construction works, has been included below, however it should be noted that this is a live document and subject to change without notice. The construction programme is anticipated to be delivered over two calendar years, with a total of 12 months construction.

Table 3.1: Construction Programme

Indicative Date	Description
April 2026	Mobilisation to Site
May 2026	Start of Balance of Plant Construction Works
October 2026	Start of Wind Turbine component deliveries
December 2026	End of Abnormal Wind Turbine component deliveries
October 2026	Start of Turbine Erection
February 2027	End of Wind Farm commissioning
March 2027	End of Construction

4. Traffic Management

4.1. General Information for Traffic Management

4.1.1. Consultation

This FTMP has been developed taking cognisance of the Traffic and Transport chapter of the EIAR. Key to the successful implementation of the FTMP is proactive consultation with the THC Roads, Transport Scotland and the local community and individuals affected by traffic routing to develop and agree appropriate traffic management measures.

Once appointed, the Principal Contractor will update and develop this FTMP to prepare a detailed CTMP. The CTMP will be developed in consultation with the above parties with the traffic management measures agreed and implemented where necessary prior to construction commencing.

A system of communication shall be agreed with the above parties for enabling proactive consultation to take place throughout the construction phase. This is expected to include signage on the road advising of dates for particular construction events affecting the road network (i.e. AIL deliveries, concrete pours, etc) well in advance of the scheduled dates, community meetings and direct notification (i.e. letter drops, face to face, SMS, etc) to affected parties.

Thereafter, the Principal Contractor shall appoint a nominated person to whom all traffic management and road safety issues shall be referred. The nominated contact will liaise with both the relevant stakeholders to review and updated the agreed construction CTMP as required during the construction period.

4.1.2. **Preliminary Traffic Management Measures**

The Traffic and Transport chapter of the EIAR is based on a worst-case scenario of 100% import of materials, including aggregate for tracks and hardstands, and ready-mix concrete deliveries. In adopting this worst-case scenario, the Traffic and Transport chapter identified potential impacts and a number of potential traffic management measures that could be implemented to mitigate the impacts of the construction traffic on the local communities.

The requirement to adopt these mitigation measures should be considered taking account of the actual material source and import. Furthermore, adoption of these measures should consider the final routes to be used by construction traffic once the source of each material has been finalised.

The range of mitigation measures identified in the Traffic and Transport chapter that should be implemented include:

- HGVs prohibited from travelling through the village of Watten;
- Empty load restriction on the B870 road, empty concrete vehicles are to return via the A9 to reduce traffic on the B870;
- HGVs scheduled to avoid peak times;
- Temporary signage to be installed at key locations; and
- Public notification of construction phasing and peak periods of construction.

As part of the construction CTMP, the above measures, as well as any other measures identified during the development and consultation of the construction CTMP, shall be fully developed and detailed including locations, extents and durations.

4.1.3. **Signage**

Any signage required on the public road will be erected and positioned in accordance with the requirements of Chapter 8 of the Traffic Signs Manual, and Safety at Street Works and Road Works – A Code of Practice, and in consultation with Transport Scotland and THC Roads as required.

Any permanent signs and street furniture which require to be relocated to allow AIL loads to pass shall be identified in consultation with the local road authorities and from the trial run. Where possible and agreed with the local road authorities, signs requiring such relocation shall be permanently shifted onto new permanent mountings.

Where signs must be removed to facilitate the passing of the AILs yet must remain at their existing location in the interim, they shall be updated as part of the advance works with temporary mountings designed to facilitate rapid removal. These signs shall be taken down immediately in advance of the passage of abnormal loads and re-erected immediately after the load has passed. This will be undertaken by operatives travelling in the load escort vehicles or specifically appointed and qualified traffic management personnel.

4.1.4. Emergency vehicle access

Details of the HGV site access and egress measures, including emergency procedures and an Emergency Response Plan, shall be included within the Principal Contractor's own site-specific Construction Phase Plan and the CTMP. A draft Construction Phase Plan will be provided as part of any discharge documentation. The Principal Contractor shall be responsible for communicating these details to all operatives, the emergency services and visitors to the Proposed Development. For the avoidance of doubt, the access to the Proposed Development shall remain free of obstruction at all times during the construction phase.

4.1.5. Timing of construction traffic

The hours of construction will be restricted to mitigate impact to neighbouring properties during anti-social hours.

In general, it is assumed that general construction activities will be permitted between the following times:

- Monday to Friday 08:00 – 19:00
- Saturday 08:00 – 13:00

It is anticipated that certain activities such as concrete pours, turbine deliveries and emergency works will be permitted outside the general working hours.

4.1.6. Driving and speed restrictions

All vehicles (cars, LGVs, HGVs and AILS) shall be driven in a manner which is safe and defensive at all times. A zero-tolerance policy shall be adopted by all contractors, such that any infringement results in that person not returning to site.

All cars and drivers of site operatives' vehicles used for commuting to site must be roadworthy and fully and legally compliant.

All commercial vehicles and drivers must be road worthy and fully and legally compliant.

An advisory speed limit of <20 mph onsite will be maintained and all site drivers will be made aware of this.

4.1.7. Operation and maintenance of onsite tracks

The following measures shall be adopted during the construction phase of the project and implemented by the Principal Contractor as and when appropriate:

- The onsite tracks will be in sufficient condition prior to commencement of construction and improvements will be ongoing to keep the tracks in a suitable state for deliveries.
- All access track cross drains shall be kept clear of blockages, and longitudinal drains maintained as necessary.
- The onsite tracks will be inspected frequently by the Site Manager and any deficiencies shall be made good.
- Any aspects resulting in immediate safety concerns shall be subject to immediate temporary rectification.
- The access roads shall be kept clear and swept on an as-needed basis.

4.1.8. Travel plan to minimise private car travel

The traffic impacts associated with commuting to and from the Proposed Development are not expected to be significant.

To minimise private car travel, construction personnel will be sourced locally to site where possible and travel to site in shared vehicles as far as reasonably practicable.

The use of crew buses will be encouraged and would minimise the number of individual trips made to and within the Proposed Development construction site.

Car parking will be provided entirely within the confines of the Proposed Development Area and will not be permitted on the adjacent road network so that sight lines are maintained at the site access junction and to minimise the impact on existing road users.

Car parking will be segregated into clean areas for non-construction use vehicles and "dirty" areas for site-based traffic. Facilities for cleaning vehicles will be provided.

Any off-site temporary park and ride facility location would be planned, agreed and coordinated with the local authority.

A Project 'Winterisation Plan' will be developed which will detail measures to be taken to assess travel to the wind farm and on the wind farm during periods of inclement winter weather to ensure the safety of workers and the general public. The plan will detail communications and plans to ensure safety should the Proposed Development need to be closed during periods of severe weather conditions. The plan will include emergency preparedness procedures.

Given the remoteness of the Proposed Development and the physical nature of the construction works, other initiatives for minimising private car travel, such as promoting public transport or providing opportunities to work from home, may prove to be impractical for introduction on this project.

4.2. Construction Vehicles

4.2.1. Wheel Cleaning

The Principal Contractor shall ensure the public roads are kept clear of deposits from the construction site which may constitute a road safety hazard for users.

Wheel cleaning facilities shall be established and maintained immediately before any vehicles coming from site upon reaching the public road at both identified access/egress points. All vehicles from site carrying mud on their tyres shall be required to use the wheel cleaning facilities.

4.2.2. Construction Vehicle Parking

A temporary parking area for construction related vehicles and LGV's will be established near to the compound area/s. The surface will be hard-core for use by all construction vehicles as well as visitors. It is not acceptable for any vehicles associated with the Proposed Development to park on the public road.

Upon completion of the construction of the Proposed Development, the car park area will be landscaped, and the temporary fencing removed. The hard core will be covered with topsoil and turves stripped from the road widening works which will help to maintain a local seed base and the local geological/hydrological characteristics. If there is not sufficient turf to completely cover the area, then turf will be spread in smaller sections to offer some protection and spread the seed bank rather than leave larger exposed areas. If natural re-vegetation from the existing seed bank is not successful and has not occurred within an agreed period of time (e.g. two growing seasons) then reseeding using a native species mix may be considered.

4.3. Abnormal loads traffic to site

An abnormal load is a vehicle which exceeds certain weight, length or width limits set out in the Road Vehicle (Construction and Use) Regulation 1986.

Generally, these limits are:

- Not exceeding 2.9 m (9'6") overall width.

- Not exceeding 18.3 m (60’0”) overall length.
- Not exceeding 44,000 kgs (44t) gross weight.

4.3.1. Permits

The hauliers will be contractually responsible for applying for the necessary abnormal load BE16 permits and ensuring that such deliveries are undertaken in accordance with the statutory requirements. These permits will apply to the entire abnormal load delivery route to the point of entry to site. The hauliers will ensure that no abnormal loads are allowed to be transported unless the required permits are in place.

4.3.2. Escorts

Where necessary under statutory regulations, abnormal deliveries shall be escorted by service vehicles provided by the transport haulier. Utilising the services of an escort aids in advance warning to other road users of the approaching load and allows traffic to be temporarily held at passing places to allow the AIL convoy to pass. Where escorts are required, there are typically two service vehicles per convoy. If required by the local police, the convoys will also have a police escort.

4.3.3. Advance Arrangements

Each transport haulier will be responsible for agreeing a final delivery schedule with the relevant authorities with regards to the number of deliveries per convoy and the number of those convoys travelling to site per day. It is envisaged that an optimum number of abnormal loads per convoy will be implemented such that it will reduce the overall number of convoys without significantly impacting on local traffic flows.

Once the trailer has delivered its load to site, its length can then be reduced to a standard HGV size. When compressed, these HGV vehicles shall be able to utilise the local trunk network without the assistance of escort vehicles.

4.3.4. Number of Loads

The turbine components will be transported to site using a number of different large vehicles specially designed to carry the wide, heavy and/or long loads.

The following is a general assessment of the standard number of loads required based on standard turbine components for one turbine comprising: three tower sections, one nacelle, three blades, one hub and four fixtures and fittings.

It is estimated that the deliveries would equate to approximately 12 deliveries per turbine. A total of 85 turbine component deliveries would be required for the complete development. This will be reviewed once the final turbine is selected post-consent.

4.3.5. Maximum Loading

The maximum vehicle and axle loadings will be confirmed by the nominated haulier prior to planning for the AIL deliveries, typically maximum axle loadings would not be expected to exceed 12.5 tonnes. All weight restrictions on the delivery route will be complied with.

4.3.6. Timing of AIL Deliveries

The movement of abnormal loads will be timed to avoid periods of heavy traffic flow to minimise disruption to the public. In additional to normal daily rush hour periods, festivals, and major public events will be avoided. The programme for deliveries will be arranged with the police and local authorities prior to taking place.

Consideration shall be given to night-time deliveries to avoid impacts of driver delay on other road users. No movements of major turbines components, cranes or deliveries of materials will take place at peak times (08.30 to 09.30 and 16:00-18:00) unless prior agreement has been reached with THC and Transport Scotland.

Notification will be given to all the relevant road authorities of all deliveries which qualify as abnormal loads.

4.3.7. Contingency planning

The hauliers shall be responsible for preparing their own contingency plan for use in the event that unforeseen circumstances arise during the course of the abnormal load deliveries. Their contingency plans will further elaborate on issues such as road blockages and breakdowns.

The contingency plan will take account the results from any trial runs conducted.

4.3.8. Emergency procedure

The hauliers shall be responsible for developing their own breakdown/emergency procedures that will be implemented ahead of their normal deliveries. It is anticipated that the procedure will follow a similar structure to that outlined below:

- The situation shall be assessed to ascertain the risks involved and to establish the necessary action required to resolve the situation.
- Where possible the vehicle shall be moved off the road or cleared to the nearest suitable location to allow any emergency vehicles to pass
- The vehicle’s emergency flashing lights will be activated, and a reflective emergency triangle placed behind the vehicle to warn other drivers of the potential hazards associated with the breakdown/emergency situation.
- The vehicle will remain immobile until the incident has cleared, and the driver has been given the go ahead to continue from either the police or the haulier Site Manager.

4.3.9. Reporting of incidents

The hauliers will have an incident reporting hierarchy in place which everyone involved in the transportation will be aware of. The reporting of incidents will be escalated externally to the relevant parties, such as the police, if deemed necessary by the hauliers.

The reporting arrangements will require to be linked with the turbine supplier’s own health and safety arrangements.

4.4. Road Condition Surveys

Prior to the commencement of construction, the Applicant will undertake a survey of the condition of the road, or roads, which are to be used by construction traffic. This survey will consist of a video drive over of the route and a short descriptive report of the findings which provides a record of the condition prior to the commencement of construction deliveries.

The roads which are to be surveyed, the extent, and the timing of subsequent surveys are to be agreed in consultation between the Applicant or their appointed consultant and THC Roads/Transport Scotland. It is anticipated that a post completion survey would be undertaken and potentially an interim survey.

5. Improvements to the public road/s to facilitate development

Upgrade works would be required at various locations along the route to accommodate the abnormal loads. The locations are identified within Abnormal Indivisible Load Route Survey prepared by Pell Frischmann November 2022, see EIAR Technical Appendix A12.1, and will be confirmed as the scheme progresses. The proposed works to the pinch points along the public road would be carried out in agreement with the Local Authority with the relevant consent.

6. Trial Run

A trial run would be organised with the haulage contractor appointed by the developer using a vehicle appropriate to simulate carriage of the proposed turbine components. The whole route between the Port of Scrabster or the Port of Nigg would be driven to confirm the validity of the findings of the desk based study and identify any further areas of improvement works required.

7. Summary

This FTMP has been specifically prepared for planning submission to address the transportation needs of the Watten Wind Farm Development and has done so by providing the following information.

- Route to be used by construction traffic;
- Prohibited routes;
- A framework of traffic management measures to be adopted by the Principal Contractor; and
- Details of the abnormal loads assessment process.

Once a final turbine has been selected, a trial run will help to supplement the development of this document with information on specific sections along the complete proposed route that may require further investigation to determine modifications to road infrastructure. These investigations will be undertaken as part of the pre-construction and construction phase works and will involve a full assessment and detailed design of upgrades required and will be carried out by a competent civil engineering contractor.

Management measures have been identified for both the delivery of abnormal loads, HGV vehicles and general construction traffic, which when implemented, will help to ensure that the route to site remains a safe environment and disruption to local traffic flows are kept to a minimum. No long-term road closures are envisaged for the identified route.

Signage will be deployed along the route to warn other road users of potential hazards.

Prior to the transportation of any abnormal loads, the turbine supplier will ensure that all necessary permits are in place and that the accommodations works have been carried out to a satisfactory standard.

Creating a better environment

naturalpower.com
sayhello@naturalpower.com

For full details on our ISO and other certifications, please visit our website.

PAGERPOWER
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Telecommunications Impact Assessment

EDF Energy Renewables Ltd

Watten Wind Farm

December, 2022

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
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- Defence
- Buildings
- Wind
- Airports
- Radar
- Mitigation

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ADMINISTRATION PAGE

Job Reference:	11181E
Date:	August 2022
Author:	Danny Scrivener
Telephone:	01787 319001
Email:	danny@pagerpower.com

Reviewers:	Kai Frolic
Email:	kai@pagerpower.com

Issue	Date	Detail of Changes
1	10 January, 2019	Interim issue of the feasibility assessment – completed by Kai Frolic (9428B)
2	30 January, 2019	Second issue – completed by Kai Frolic (9428B)
1	August 2022	First issue based on new layout – completed by Danny Scrivener (11181E)
2	December 2022	Update with new layout and consultation

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been commissioned to investigate the potential impact of the proposed Watten Wind Farm on wireless telecommunication point-to-point links in the area surrounding the proposed development.

The wind farm is to be located approximately 3km east of Mybster in Caithness, Scottish Highlands, and will consist of seven wind turbines with a maximum tip height of up to 220m above ground level.

Findings

The following operators confirmed in December 2022 they have no concerns regarding the proposed development:

- Arqiva – previously provided link data.
- Atkins on behalf of Scottish Water;
- British Telecom (BT);
- MBNL;
- 02/Virgin.

The following operators confirmed in August 2022[1] they have no concerns regarding the proposed development:

- Airwave;
- Vodafone – previously provided link data.

The Vodafone and Arqiva links have been plotted. The proposed wind turbine locations lie outside of the associated exclusion zones and no objection would be anticipated.

The Joint Radio Company (JRC) has provided an initial objection to the development. Discussions with the JRC are ongoing to better understand their position following their initial objection.

Mitigation

An overview of mitigation options is presented in Section 5 for reference. None of the links for which details are available have been found to require mitigation. Consultation with the JRC is ongoing.

[1] All stakeholders were consulted in December 2022 or earlier based on the current layout however updated responses are yet to be received from these stakeholders. The stakeholders were consulted in August 2022 considering a previous layout which proposed turbines in slightly amended positions, a lower hub height (by 1m) and an increased rotor diameter (+2m), with the overall tip height remaining the same. No change to their position is anticipated.

Next Steps

Pager Power will continue to consult with the JRC to understand their position and to identify a way forward.

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ABOUT PAGER POWER

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The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has been commissioned to investigate the potential impact of the proposed Watten Wind Farm on wireless telecommunication point-to-point links in the area surrounding the proposed development.

The wind farm is to be located approximately 3km east of Mybster in Caithness, Scottish Highlands, and will consist of seven wind turbines with a maximum tip height of up to 220m above ground level. In detail, the report includes:

- Proposed development details;
- Overview of potential interference mechanisms for wind turbines on communications infrastructure;
- Consultation summary;
- Presentation of identified link data;
- 2-D Fresnel Zone clearance calculations where appropriate including exclusion zone chart;
- Reflection calculations for UHF telemetry links (if identified);
- Summary of potential impacts with discussion;
- High-level overview of mitigation options.

Following this, a summary of findings and overall conclusions and recommendations from the desk-based assessment is presented.

1.2 Assessment Data

All co-ordinates used within this report are in British National Grid easting and northing format.

The ground elevations at the base of the turbine have been provided by the developer.

2 WIND FARM DETAILS

2.1 Overview

The following section presents the assessment details for the proposed development.

2.2 Wind Turbine Details

The proposed development will consist of seven wind turbines. The individual turbine details are presented in Table 1 below.

Turbine	Easting	Northing	Turbine Hub Height (m) agl	Turbine Tip Height (m) agl	Ground height at Base of Turbine (m) amsl
1	321106	952238	139	220	72.2
2	321504	951907	139	220	66.9
3	320867	950938	139	220	58.1
4	320510	951280	139	220	61.3
5	320401	951839	139	220	68.4
6	319828	951255	139	220	70
7	319938	950772	139	220	70

Table 1 *Assessed wind farm details*

2.3 Wind Farm Location

The location of the proposed development is shown in Figure 1 below. The red line boundary and wind turbine locations (white radial icons) are shown.

Figure 1 *Wind farm location*

3 CONSULTATION

3.1 Process

Historically, Ofcom has provided on request a list of parties that operate licensed fixed links within a given search radius of a defined location. During 2018, this process was under review following GDPR requirements. Therefore, consultation was undertaken directly with the most prevalent operators[2] in order to obtain link details. Consultation with Ofcom has been undertaken in the usual way. At the time of writing, no further information from Ofcom has been made available.

3.2 Responses

The responses received at the time of writing are summarised in Table 2 on the following page.

[2] Based on Pager Power's experience and contacts database.

Operator	Consultation	Remarks
Airwave	Not consulted during feasibility consultation in January 2019. Consulted in August 2022 for a previous layout, with a request for them to produce their own internal safeguarding assessment. A chaser for proceeding with the Airwave assessment was sent 31 August 2022. Response received September 2022 and the assessment was processed. Airwave assessment received in October 2022 with no objection. Pager Power responded with the current layout details to identify whether this changed their position. No response was received. Airwave chased by email in early and late November, with the latest response stating it is assumed that Airwave's position remains the same in the absence of any response. No further response has been received to date.	Airwave provided an assessment with the results showing that they had no objection to the proposed development. These results were for a previous layout. No link data was supplied within the report. Airwave was subsequently chased regarding the revised layout now proposed, however no response has been received to date. It is assumed that Airwave has no infrastructure in this area considering the details presented in their initial assessment. No objection is expected.
Arqiva	Confirmed they have no objection (27 December 2018). Reconsulted in August 2022. No objection and no link details were provided. Reconsulted with the current layout in December 2022.	Details of links to the west of the development were provided in the initial 2018 consultation. It was stated that the wind farm would require further consideration if turbines were moved west. For completeness, the previously provided link data have been plotted. No objection received.

Operator	Consultation	Remarks
Atkins	Confirmed they have no objection (26 December 2018). Reconsulted in August 2022. No objection and no link details were provided. Reconsulted with the current layout in December 2022.	No link data provided. No objection received.
BT	Confirmed they have no objection (27 December 2018). Reconsulted in August 2022. No objection and no link details were provided. Reconsulted with the current layout in December 2022.	No link data provided. No objection received.
MBNL	Confirmed they have no objection (11 January 2019). Reconsulted in August 2022 with no objection. Link details received. Reconsulted with the current layout in December 2022.	Link path shown with August 2022 consultation however the link path is over 2.5km from the nearest turbine, with the link being outside of the red line boundary. No objection received.

Operator	Consultation	Remarks
JRC	The JRC confirmed an initial objection to the development on 9 January 2019. Details were not provided for the majority of the links and the JRC has formally advised on 22 January 2019 that the local electricity utility will not allow the details to be disclosed. The JRC was reconsulted in August 2022 with an objection received with an overview of high-level constraints. A detailed JRC assessment was therefore requested in September 2022. The assessment was received in October 2022. The assessment was reviewed in October 2022, with clarifications sought from the JRC. Additional constraint information was received from the JRC. In November 2022, the JRC was consulted regarding potential mitigations. A meeting was held in December 2022 to discuss the mitigation options available.	Details were provided for one microwave link during the 2019 consultation, however multiple links were initially referenced within the August 2022 response. Within the August 2022 consultation, the JRC responded with an initial conservative exclusion area showing where turbines should be located outside. Details of the links were not supplied. The JRC assessment received in 2022 narrowed down the constraints to one link. Turbine 7 is currently located within the exclusion zone defined by the JRC. Mitigation discussions are ongoing however an objection is expected. A planning condition to mitigate the impacts would be appropriate in the absence of any mitigation being agreed before the planning application is submitted and decided.
O2/Virgin	Not consulted during feasibility consultation in January 2019 Consulted in August 2022 with no objection. Reconsulted with the current layout in December 2022.	No link data provided. No objection received.

Operator	Consultation	Remarks
Vodafone	Consulted during feasibility consultation in January 2019. Reconsulted in August 2022 with no objection. Link details received. Reconsulted with the current layout in December 2022.	No response received during the feasibility consultation Link details supplied within the August 2022 consultation. No objection is expected.

Table 2 *Consultation summary*

4 TECHNICAL ASSESSMENT

4.1 Methodology

Microwave and UHF[3] wireless communication links are used to transmit information between two antennae via radio waves within a particular frequency band.

Obstructions sited between two link antennae can partially block the radio signal passing between them, thereby reducing the functionality of the link. This can occur even if the obstruction is in not directly between the antennae but close to the link boresight[4].

The exclusion zones associated with the identified links have been calculated based on the telecommunications data provided. Further 2-dimensional clearance calculations have then been undertaken to determine the extent of any clearance or infringement of the proposed development. The following subsections present an overview of the interference mechanisms and methodology.

4.1.1 Diffraction – Microwave and UHF Links

Obstructions which are sited in between two microwave link antennae can partially block the radio signal passing between them, thereby reducing the functionality of the link. This can occur even if the obstruction is not directly between the antennae but close to the link boresight. This kind of blocking is called 'diffraction'.

There are various approaches to safeguarding microwave links from obstruction via wind developments. The most common approaches are:

1. Implementation of a fixed stand-off distance around the link boresight;
2. Safeguarding the relevant Fresnel Zone (discussed below).

The first approach is used by many operators who request a set buffer distance. Set stand-offs are occasionally conservative and produce a large exclusion zone distance. The second approach is to assess an obstruction on a case-by-case basis to calculate the most accurate exclusion zone.

4.1.2 Fresnel Zones

A Fresnel Zone takes the form of an ellipsoid surrounding a link path and represents the area in which obstructions should not be sited in order to avoid diffraction losses. The width of the zone at any point along the link path is determined by the Fresnel Zone number, the frequency of the link and the distance from each link end. The width of the zone is maximal at the midpoint of the link path. Ofcom recommends that wind turbines are assessed with reference to the second Fresnel Zone.

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[3] Ultra-High Frequency

[4] This is the straight line between the two antennae.

4.1.3 Reflections – UHF Links

Reflection effects occur when the transmitted signal from one link end is reflected by the wind turbine towards the other link end which causes multipath signal interference In order to establish whether a wind development will cause interference, it is necessary to calculate the Carrier to Interference Ratio (CIR), also known as the Wanted to Unwanted Ratio. This quantifies the strength of the direct (wanted) signal between the link ends relative to the interfering (unwanted) reflection from the wind turbine.

The JRC considers[5] the minimum CIR that must be maintained by a link to be 38 decibels (dB). This value can be calculated for each turbine in isolation and adjusted to account for cumulative effects. The JRC advises that this should be done by reducing the individual values by '10 $\log_{10}$ (number of turbines)'.

Pager Power's approach for assessment is based on the JRC's methodology. Because the calculation is sensitive to the intervening terrain between the turbine and each link end, it must be undertaken for individual locations. This is why there is no fixed exclusion zone for reflection issues.

4.2 Link Paths

Figure 2 on the following page shows the identified link paths for which details have been made available. The exclusion zone is shown by two lines, marking the edges of the Fresnel zones. An additional 25 metre buffer has been applied to allow for uncertainties in the co-ordinate data.

The turbines are located outside the exclusion zones associated with the identified links however the JRC link identified within their consultation has not been presented due to confidentiality. Consultation with the JRC is ongoing.

No adverse impacts are predicted upon all other identified links.

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[5] JRC, December 2014, Calculation of Wind Turbine clearance zones for JRC managed fixed services with particular reference to UHF (460 MHz) Telemetry Systems when turbine sizes and locations are accurately known, Issue 4.2, Joint Radio Company Ltd.

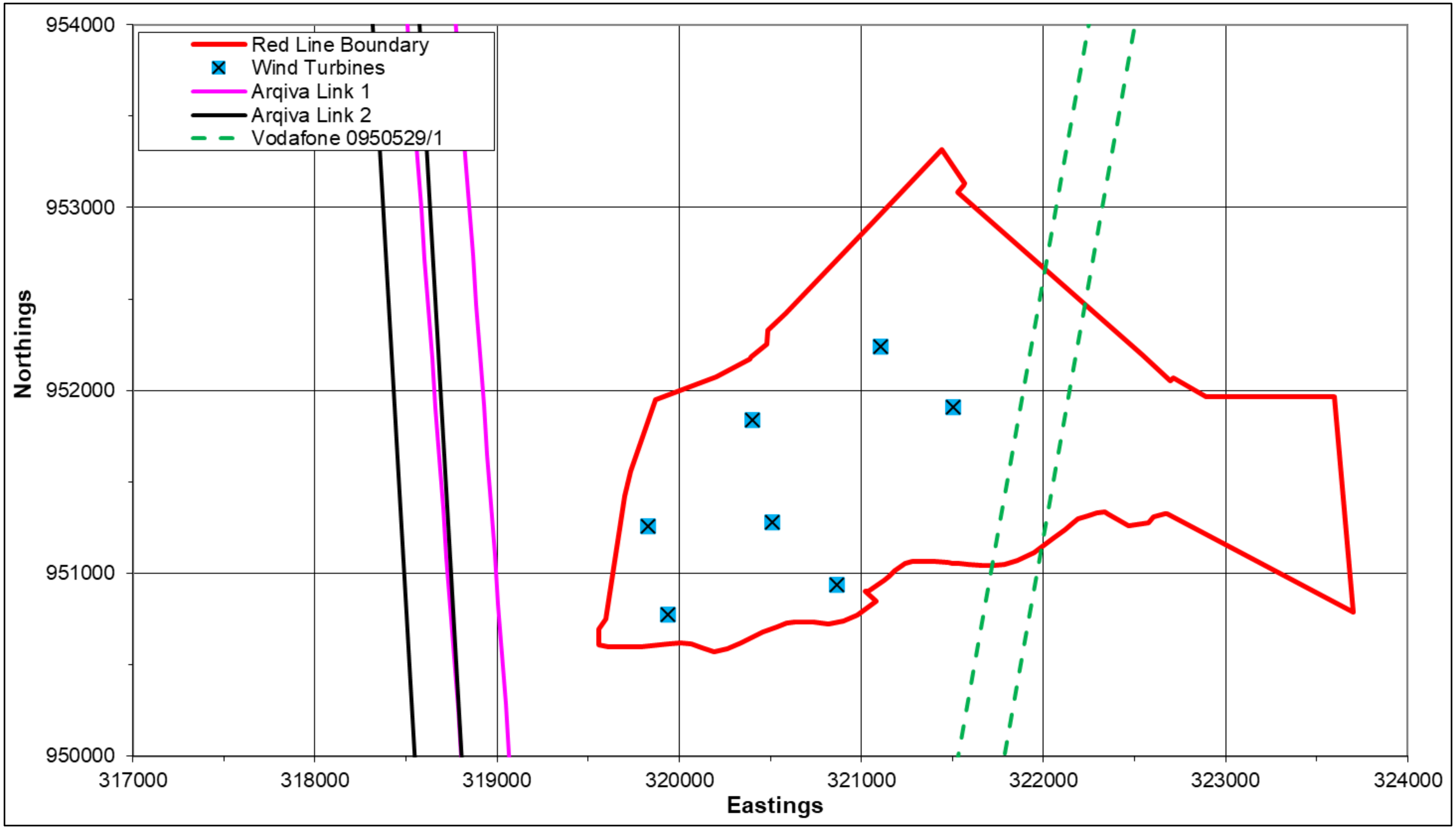

Figure 2 *Redline boundary, identified link paths and wind turbine locations*

5 MITIGATION

5.1 Mitigation Requirement

Based on the link data that has been identified through consultation, no mitigation requirement has been identified However, an initial objection has been raised by the JRC for one communications link with respect to turbine 7. A high-level overview of the most common mitigation options is presented in this section for reference purposes.

5.2 Mitigation Options

The options below should be considered in the event that a potential impact is identified.

5.2.1 Re-networking the link

This is a solution whereby the link path is diverted via an additional mast so that it avoids the proposed development. The requirement for this solution is a suitably located telecommunications mast that has radio line of sight to both existing link ends. Ideally, the additional site would be a telecommunications mast already owned / utilised by the affected link operator.

5.2.2 Increasing the antenna height

This is a solution whereby the link path is diverted via an additional mast so that it avoids or reduces infringement from the new obstruction. The suitability of this solution depends on the level of link infringement in three dimensions.

5.2.3 Use of an alternative technology

This is a solution whereby the microwave link is replaced with an alternative that is not affected by the development. The most common options are:

- A leased line (copper cable).
- A satellite link.
- A fibre-optic connection.
- UHF Telemetry.

5.3 Process

Determining the most suitable mitigation option is only possible if a specific impact has been identified. Impacts have been deemed possible by the JRC, and further consultation is ongoing to understand the mitigation requirement.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Findings

The following operators confirmed in December 2022 they have no concerns regarding the proposed development:

- Arqiva – previously provided link data.
- Atkins on behalf of Scottish Water;
- British Telecom (BT);
- MBNL;
- 02/Virgin.

The following operators confirmed in August 2022[6] they have no concerns regarding the proposed development:

- Airwave;
- Vodafone – previously provided link data.

The Vodafone and Arqiva links have been plotted. The proposed wind turbine locations lie outside of the associated exclusion zones and no objection would be anticipated.

The Joint Radio Company (JRC) has provided an initial objection to the development. Discussions with the JRC are ongoing to better understand their position following their initial objection.

6.2 Next Steps

Pager Power will continue to consult with the JRC to understand their position and to identify a way forward.

[6] All stakeholders were consulted in December 2022 or earlier based on the current layout however updated responses are yet to be received from these stakeholders. The stakeholders were consulted in August 2022 considering a previous layout which proposed turbines in slightly amended positions, a lower hub height (by 1m) and an increased rotor diameter (+2m), with the overall tip height remaining the same. No change to their position is anticipated.

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a Motorola Solutions Company

Motorola Solutions

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160 Victoria Street
London
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United Kingdom

Wind Farm Development

Watten Wind Farm Development
WFPP-024

Airwave network interference assessment

Report reference:	Watten WFPP_024 Iss1
Customer :	Pager Power Ltd
Issue date :	10-10-2022
Prepared by :	Ishfaq Nazir

Development and Developers Details

Applicant Information

Name: Address: Postcode: Contact name: Contact No: Email Address:	Pager Power Ltd Stour Valley Business Centre Sudbury Suffolk CO10 7GB Danny Scrivener 01787 319001 danny@pagerpower.com
Name of development: Location of development:	Watten Wind Farm Watten Wind farm Reference 11181

Technical Information

Number of Turbines on the development----: 7

Airwave’s network interference assessment

Assessment Completed by: Ishfaq Nazir
Transmission Design Authority
Date of Assessment : 10th October 2022

Design Analysis Results

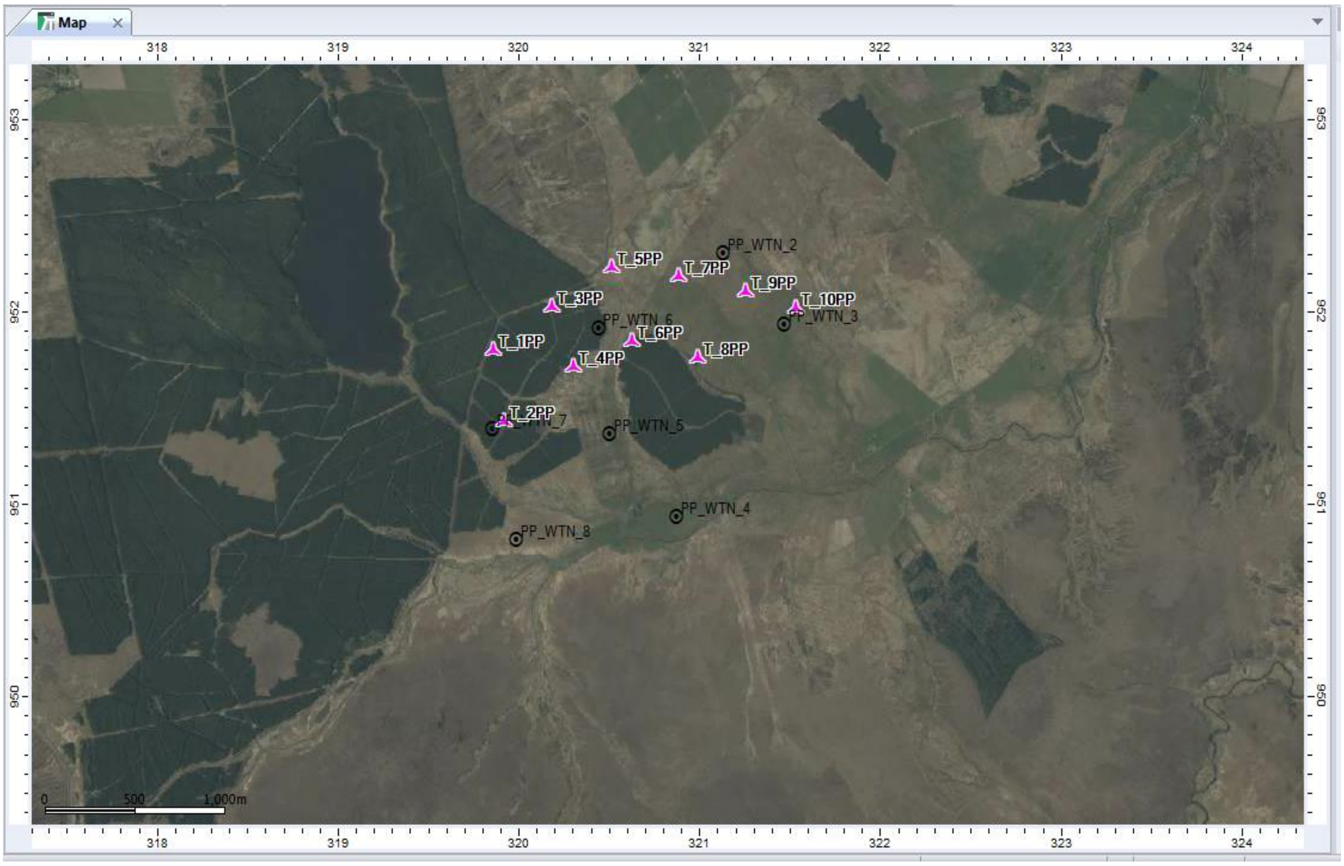
Will any of the wind turbines listed in the application for Watten wind farm in Appendix 1 with respect to their positioned location coordinates cause interference to existing Airwave Microwave Radio links or Tetra Radio Network Coverage:

Y/N: **NO**

Results/Justification

The proposed wind turbine farm at Watten will not present a problem to Airwave Microwave Radio Links or Tetra Radio Network Coverage in the region using coordinates given in Appendix 1. Airwave have no objection to the development of the Windfarm at Watten.

Please advise if there is any movement of the turbine location coordinates as this may have an impact on Airwave MW radio links and Tetra Emergency Services Radio Network coverage in the area.



Appendix 1

Copy of assessment application form

Wind Farm Analysis Application Form		
Please complete this form and send to Wind.farms@airwavesolutions.co.uk		
Airwave use only		
Application Refeerence	Invoice No	Payment received

Applicant Information	
Name	Pager Power
Address	Unit 2, Stour Valley Business Centre, Sudbury, Suffolk
Post Code	CO10 7GB
Contact Name	Danny Scrivener
Contact Email	danny@pagerpower.com
Contact Telephome number	01787 319001

Development Information	
Wind Farm Name	Watten Wind Farm
Wind Farm Reference	11181

Turbine Ref No	National Grid Easting	National Grid Northing	Structure Height	Blade Radius	Comments
2	321129	952309	138	82	Hub height = 138m, tip height 220m
3	321465	951935	138	82	
4	320867	950938	138	82	
5	320502	951367	138	82	
6	320436	951917	138	82	
7	319849	951396	138	82	
8	319985	950821	138	82	

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Aviation Impact Assessment

EDF Energy Renewables Ltd

Watten Wind Farm

December 2022

ADMINISTRATION PAGE

Job Reference:	11181C
Date:	August 2022
Author:	Danny Scrivener
Telephone:	01787 319001
Email:	danny@pagerpower.com

Reviewers:	Kai Frolic
Email:	kai@pagerpower.com

Issue	Date	Detail of Changes
1	August 2022	Initial issue of the Radar Impact Assessment (11181I).
1	December 2022	The Radar Impact Assessment (11181I) was expanded to a full Aviation Impact Assessment (1118C) to accompany the planning application. The report includes additional aviation considerations and consultation details.

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been commissioned to investigate the potential aviation impacts of the proposed Watten Wind Farm. The wind farm is to be located approximately 3km east of Mybster in Caithness, Scottish Highlands, and will consist of seven wind turbines with a maximum tip height of up to 220m above ground level. The previous analysis identified the two following key considerations:

- The potential impacts upon the RAF Lossiemouth military air traffic control (ATC) Primary Surveillance Radar (PSR)[1];
- The potential impact upon Instrument Flight Procedures at Wick Airport[2].

Additional aviation considerations have also been addressed, including NATS radar and aviation lighting.

Overall Conclusions

The overall results of the analysis presented within this report are presented in the table below.

Consultee	Impact	Comment
NATS	Allanshill PSR	All wind turbines are well below line of light to this radar. NATS was consulted regarding the proposed development and they confirmed they had no objection.
MOD	RAF Lossiemouth PSR	Five turbines are visible to the radar by a maximum margin of 21.3m. Two turbines are below radar line of sight by a minimum margin of 19.7m. All turbines are expected to be highly unlikely to be detectable to the PSR. No objection received previously and no change expected based on proposed layout.

[1] Safeguarded by the MOD.

[2] Operated by Highlands and Islands Airport (HIAL).

Consultee	Impact	Comment
MOD	Military low flying	The proposed development is located within a low priority military low flying area where concerns are less likely to be raised. No objection received previously and no change is expected based on proposed layout. Aviation lighting has been requested.
Wick Airport	Instrument Flight Procedures	The proposed development would infringe the clearance requirement for the Minimum Obstacle Clearance Altitude. A maximum reduction in tip height of 14m to 206m above ground level is required to comply with this figure. Consultation is ongoing with Wick Airport to identify whether an airspace change is achievable to accommodate the proposed development. Consultation is ongoing.
CAA	Aviation Lighting	Aviation lighting will be required for the proposed development. It has also been requested by the MOD. This can be determined post-consent via a suitably worded planning condition.

Analysis results summary

Next Steps

Consultation with Wick Airport is ongoing to determine whether an airspace change could be facilitated to accommodate the proposed development. This consultation will continue through submission.

All other radar concerns have been previously signed off through consultation. The MOD has been reconsulted regarding on the proposed development however their position is not expected to change. Pager Power is awaiting their most recent response.

Aviation lighting will be a requirement, and a lighting scheme should be established post-consent.

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- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has been commissioned to investigate the potential aviation impacts of the proposed Watten Wind Farm. The wind farm is to be located approximately 3km east of Mybster in Caithness, Scottish Highlands, and will consist of seven wind turbines with a maximum tip height of up to 220m above ground level. The previous analysis identified the two following key considerations:

- The potential impacts upon the RAF Lossiemouth military air traffic control (ATC) Primary Surveillance Radar (PSR)[3];
- The potential impact upon Instrument Flight Procedures at Wick Airport[4].

Additional aviation considerations have also been addressed, including NATS radar and aviation lighting. In detail, the report includes:

- Proposed development details;
- Radar impact assessment for RAF Lossiemouth PSR with the presentation of MOD consultation;
- Presentation of analysis and consultation undertaken for Wick Airport;
- Overview of NATS consultation;
- Comments regarding aviation lighting;
- Results discussion.

Following this, a summary of findings and overall conclusions and recommendations from the desk-based assessment is presented.

1.2 Assessment Data

All co-ordinates used within this report are in British National Grid easting and northing format.

Terrain data within the modelling is based on OS Panorama 50m DTM[5]. The ground elevations at the base of the turbine have been provided by the developer.

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[3] Safeguarded by the MOD.
[4] Operated by Highlands and Islands Airport (HIAL).
[5] Digital Terrain Model.

2 WIND FARM DETAILS

2.1 Overview

The following section presents the assessment details for the proposed development.

2.2 Wind Turbine Details

The proposed development will consist of seven wind turbines. The individual turbine details are presented in Table 1 below.

Turbine	Easting	Northing	Turbine Hub Height (m) agl	Turbine Tip Height (m) agl	Ground height at Base of Turbine (m) amsl
1	321106	952238	139	220	72.2
2	321504	951907	139	220	66.9
3	320867	950938	139	220	58.1
4	320510	951280	139	220	61.3
5	320401	951839	139	220	68.4
6	319828	951255	139	220	70
7	319938	950772	139	220	70

Table 1 *Assessed wind farm details*

2.3 Wind Farm Location

The location of the proposed development is shown in Figure 1 below. The red line boundary and wind turbine locations (white radial icons) are shown.

Figure 1 *Wind farm location*

3 RAF LOSSIEMOUTH PSR AND THE MOD

3.1 Overview

The MOD was consulted with respect to the most recent layouts of the proposed development between August and December of 2022. The key issue initially identified was that of the potential impact the upon Primary Surveillance Radar (PSR) at RAF Lossiemouth, located approximately 82km south of the proposed development. The PSR is predominantly used for the purpose of managing military air traffic and is safeguarded by the MOD. The PSR is understood to be an S band radar. The location of the RAF Lossiemouth PSR relative to the proposed development, with a zoomed-in radar image inset, is shown in Figure 2 below.

Figure 2 *Wind farm and radar relative locations (inset: zoomed-in radar aerial image)*

3.2 Technical Radar Impact Assessment

A technical impact assessment was therefore completed for the PSR, alongside consultation with the MOD. The results are presented in the following subsections.

When evaluating new infrastructure in the vicinity of radar installations it is necessary to consider:

- Whether there is potential for a technical impact. Simplistically a technical impact means that the behaviour of the physical signals to and from the radar is physically affected in some way by the wind turbines. If there is no technical impact, the radar is unaffected by the wind turbines. Determining technical impact almost entirely a matter of accurately modelling signal propagation and interaction based on technical data for the radar and the turbines;
- Where there is a potential technical impact, it is necessary to evaluate the associated operational impact it causes. Simplistically this means the extent to which the effect on the physical signals is noticeable and/or important for the radar operator. Determining operational impact requires consideration of the technical impact's magnitude and the operational requirements of the radar operator.

Wind turbines that are detectable to a PSR can cause a technical impact because:

1. They can appear as targets on the radar screen – known as clutter;
2. They can cause some shadowing due to physical blocking of the signals;
3. They can cause reflections of inbound and outbound radar signals.

Historically, the main consideration of the MOD is clutter effects, and therefore only the first point is analysed further within this report.

The operational significance of technical impacts is influenced by the radar operator's requirements – which in this case are likely to be confidential to a certain degree. However, it is generally the case that:

- The technical impacts of radar clutter are predominantly of operational concern because:
    - They have the potential to cause a distraction to a radar operator observing the screen;
    - The clutter could be mistaken for return from a genuine radar target;
    - The clutter could 'hide' a genuine radar target;
    - An operator may have to direct traffic of some kind around an area of clutter.
- The technical impacts of shadowing are predominantly of operational concern because genuine targets will be harder to detect behind the obstruction – particularly if they are small/weak;
- The technical impacts of reflected inbound and outbound radar signals are that targets may be displayed on the wrong bearing or at the wrong range.

3.2.1 Technical Analysis Methodology

Technical analysis has been undertaken based on:

- Radar line of sight – which determines how much of a wind turbine is illuminated by the radar signal considering:
  - The radar position;
  - The turbine position;
  - The intervening terrain profile;
  - Radar refraction;
  - Earth curvature.

The box labelled 'certainty' provides the distance (in metres) by which the wind turbine is or is not within line of sight to the assessed radar.

- Assessment of the predicted impact in the context of the existing environment has been undertaken. The modelling described above accounts for the intervening terrain. It does not account for additional obstructions on the ground along the radar line of sight e.g. buildings or vegetation.
- Radar detectability analysis – which determines the likelihood of a turbine being displayed on a radar screen based on additional parameters including:
  - Diffraction losses;
  - Free space path losses;
  - Radar frequency band;
  - Typical antenna characteristics.

The purpose of radar detectability analysis is to understand the likely impact of radar line of sight, where applicable. Radar detectability analysis has been undertaken to determine the likelihood of the turbine causing clutter on a radar screen. Whilst radar line of sight analysis quantifies how much of the turbine is illuminated by the radar beam, detectability analysis incorporates further parameters based on the radar type and intervening terrain in order to quantify not just the level illumination but the likelihood of a noticeable technical impact.

The bands on the charts show the heights[6] at which the likelihood of detection would decrease to 'likely', 'possible', 'unlikely' and 'highly unlikely'.

Appendices A and B present further details on the methodology.

[6] Assuming the proportion of rotor diameter to tip height remained constant.

3.2.2 Radar Line of Sight Assessment

The overall radar line of sight results are presented in Table 2 below. Red text indicates the wind turbine would be illuminated by the radar's beam based on bare earth terrain. Green text indicates the turbines would be hidden from line of sight to the radar.

Turbine	LOS Margin (m)	Comment
1	13.8	Tower not visible, rotor barely visible
2	21.3	Tower not visible, rotor partially visible
3	9.3	Tower not visible, rotor barely visible
4	5.3	Tower not visible, rotor barely visible
5	4.6	Tower not visible, rotor barely visible
6	-26.2	Turbine not visible
7	-19.7	Turbine not visible

Table 2 *Radar line of sight results*

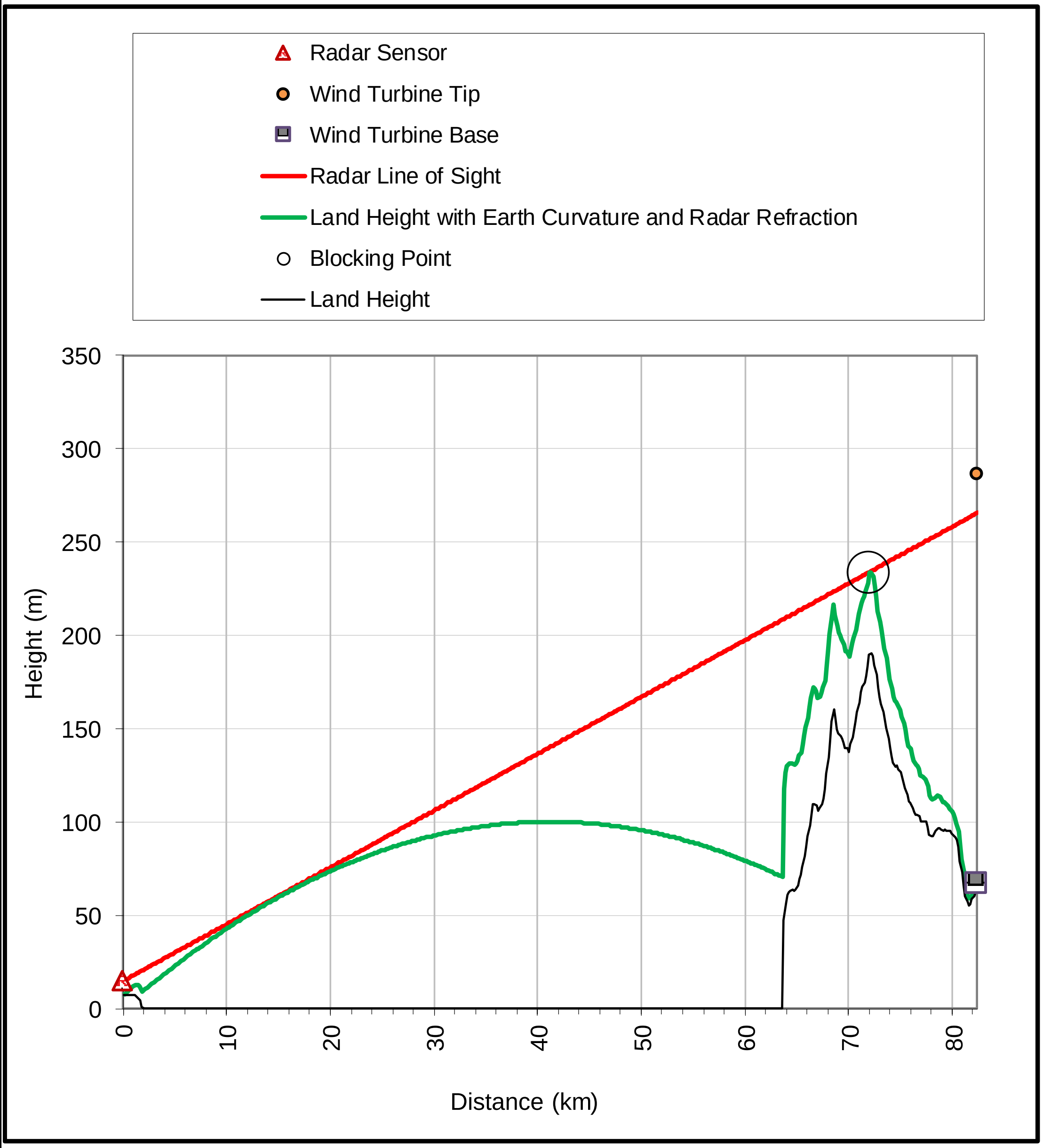
The radar line of sight chart for the most visible turbine (turbine 2) is shown in Figure 3 on the following page, with charts for the remaining turbines being available upon request.

3.2.2.1 Additional Screening

Following a review of the line of sight profile and the available imagery, no significant additional screening (e.g. tall buildings/structures or vegetation) appears to be available. Therefore no amendments to the line of sight profiles have been undertaken.

Radar Line of Sight Calculation	
Lossiemouth PSR	

Watten Wind Farm	
Turbine	T2
Result	VISIBLE
Certainty	21.3 metres



Turbine Height (m)	220
Hub Height (m)	139
Rotor Diameter (m)	162
Turbine Elevation (m)	66.9
Turbine Location	E321504 N951907
Distance to radar (km)	82.4
Blocking Point Location	E321434 N941504
Distance to BP (km)	10.4

Additional Analysis	
Maximum Tip Height	198.67 metres

See Appendix for further information

Figure 3 *Radar line of sight chart for turbine 2*

3.2.3 Radar Detectability Analysis

Previous radar detectability analysis revealed all turbines would be 'highly unikely' to be detectable to the PSR at RAF Lossiemouth. This result is not expected to change considering the proposed layout.

3.3 Radar Impact – Operational Considerations

3.3.1 Context

Relevant operational considerations when a technical impact is identified include:

- The function and safeguarded range of the affected radar;
- Whether the development is in an operationally significant location;
- The magnitude of the potential impact.

The primary impact of concern is radar clutter i.e. the spinning turbine blades being intermittently displayed on a radar operator's screen. Radar clutter is in principle problematic because:

- It could be mistaken for a genuine target such as an aircraft;
- It could cause a radar operator to route genuine traffic around the source of clutter;
- It could cause a distraction for a radar operator.

3.3.2 Radar Function and Safeguarded Range

The function of the radar is to provide military air traffic control to pilots approaching and departing the aerodrome. Formally the MOD safeguard the radar where line of sight exists, meaning there is no official cut-off. In practice, such radar are often nominally instrumented to 60 nautical miles and safeguarded in practical terms to approximately 25 nautical miles. The proposed development is, on average, 44.2 nautical miles from the radar.

3.3.3 Location Significance

The proposed development is north of RAF Lossiemouth PSR, with its relative location shown in Figure 2 on page 12. It is also entirely within a blue 'low priority' military low flying area where the MOD is less likely to raise concerns – see Section 3.4.

The proposed development is not in line with any of the runway centrelines at RAF Lossiemouth. Surveillance within the airspace near the proposed development may not be required however, more importantly, the proposed development is expected to be highly unlikely to be detected by the radar.

3.3.4 Impact Magnitude

The proposed development is highly unlikely to be detectable to the radar based on its tip height of 220m agl. This means there is very little potential for the turbine to appear as clutter on the radar screen.

3.4 Military Low Flying System

Military low flying can take place throughout the UK. The MOD has published a map indicating areas within the UK where military low flying activities are the most likely to cause an objection. The map is colour coded as follows:

- Green – Area with no military low flying concerns.
- Blue – Low priority military low flying areas less likely to raise concerns.
- Amber – Regular military low flying area where mitigation may be necessary to resolve concerns.
- Red – High priority military low flying area likely to raise considerable and significant concerns.

The proposed development is located entirely within a blue 'low priority' military low flying area and previous consultation with the MOD raised no issues with respect to low flying operations. Ongoing consultation with the MOD will identify their position based on the proposed layout however this position is expected to be maintained. Aviation lighting, although mandatory based on the tip height of 220m agl, has also been requested by the MOD.

3.5 MOD Consultation and Conclusions

The MOD was previously consulted with respect to the technical impact of the proposed development for a previous wind turbine layout which had the same number of wind turbines and tip height, in marginally different locations. The MOD had no objection to this layout. Consultation regarding the proposed layout is ongoing however, as the technical modelling results vary negligibly from the previous layout, no change in their position is anticipated. Consultation with the MOD will continue to confirm their position.

4 WICK AIRPORT AND HIAL

4.1 Overview

Wick Airport is safeguarded by Highlands and Islands Airports (HIAL). A number of aviation issues were raised, each of which are discussed in turn in the following section.

4.2 Identified Aviation Considerations

Each of the potential issues raised by HIAL are presented the discussed below:

1. Aerodrome Obstacle Limitation Surfaces (OLS):
    a. Analysis showed that the proposed development is beyond the 10km to which Wick Airport's surfaces extend. On this basis will be no impact upon the OLS at Wick Airport;
    b. This was confirmed and agreed with HIAL.
2. Safeguarding of technical sites and navigation aids:
    a. Analysis showed that at over 10km from Wick Airport, the proposed development would be beyond any of the safeguarding zones associated with the non-radar nav aids located at Wick Airport;
    b. This was confirmed and agreed with HIAL.
3. Aviation lighting:
    a. Aviation lighting is mandatory for a development of this height. The MOD has also requested lighting. Aviation lighting will be dealt with in the form of a suitably worded planning condition to determine the specific lighting design post-consent.
    b. This was confirmed and agreed with HIAL.
4. Instrument Flight Procedures (IFPs):
    a. A detailed IFP assessment was completed by the airport's Approved Procedure Design Organisation (APDO) at the request of HIAL. The analysis showed an impact upon the Minimum Obstacle Clearance Altitude (MOCA) of aircraft in the airspace above the proposed development.

The potential impact upon Wick Airport's IFPs remains the only aviation risk identified. The results are presented and discussed in the following subsection.

4.3 IFP Assessment Results Summary

An IFP assessment was undertaken by Wick Airport's APDO. The results showed that the proposed development would infringe the clearance requirement for the minimum sector altitude. This means a maximum reduction in tip height of 14m to 206m agl would be required to comply with this figure. The maximum allowable tip height does however depend on the ground height at the base of the turbine.

4.4 Conclusions

Wick Airport has been consulted regarding this initial result to discuss mitigation options, and this consultation is ongoing. One mitigation option is to seek to have the minimum sector altitude raised by 100ft to accommodate the wind turbines. This mitigation option requires detailed consultation with Wick Airport and their APDO, with final sign-off being required from the CAA. This consultation will continue through the planning process.

5 NATS INFRASTRUCTURE

5.1 Summary

NATS was consulted in September 2022 regarding the proposed development and confirmed no objection to the proposed development. This agreed with the Pager Power analysis completed previously which showed that the proposed development would be well below the line of sight to the nearest NATS radar (Alanshill at beyond 110km).

NATS was reconsulted in December 2022 regarding the proposed layout and their position remains the same, with no objection.

6 AVIATION LIGHTING

6.1 Aviation Lighting

In accordance with CAP 168[7] and the Air Navigation Order[8], the wind turbines will require at least medium intensity lighting on the nacelle of the wind turbines. It is possible that only the perimeter wind turbines will need to be lit, however this would be subject to further consultation with the Civil Aviation Authority. This can be managed via a suitably worded planning condition.

The wind turbines will need to be marked on the appropriate aviation charts.

[7] Civil Aviation Publication 168, January 2022, twelfth edition.
[8] Air Navigation Order 2016, part 222.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Overall Conclusions

The overall results of the analysis presented within this report are presented in Table 3 below.

Consultee	Impact	Comment
NATS	Allanshill PSR	All wind turbines are well below line of light to this radar. NATS was consulted regarding the proposed development and they confirmed they had no objection.
MOD	RAF Lossiemouth PSR	Five turbines are visible to the radar by a maximum margin of 21.3m. Two turbines are below radar line of sight by a minimum margin of 19.7m. All turbines are expected to be highly unlikely to be detectable to the PSR. No objection received previously and no change expected based on proposed layout.
	Military low flying	The proposed development is located within a low priority military low flying area where concerns are less likely to be raised. No objection received previously and no change is expected based on proposed layout. Aviation lighting has been requested.
Wick Airport	Instrument Flight Procedures	The proposed development would infringe the clearance requirement for the Minimum Obstacle Clearance Altitude. A maximum reduction in tip height of 14m to 206m agl is required to comply with this figure. Consultation is ongoing with Wick Airport to identify whether an airspace change is achievable to accommodate the proposed development. Consultation is ongoing.

Consultee	Impact	Comment
CAA	Aviation Lighting	Aviation lighting will be required for the proposed development. It has also been requested by the MOD. This can be determined post-consent via a suitably worded planning condition.

Table 3 *Analysis results summary*

7.2 Next Steps

Consultation with Wick Airport is ongoing to determine whether an airspace change could be facilitated to accommodate the proposed development. This consultation will continue through submission.

All other radar concerns have been previously signed off through consultation. The MOD has been reconsulted regarding on the proposed development however their position is not expected to change. Pager Power is awaiting their most recent response.

Aviation lighting will be a requirement, and a lighting scheme should be established post-consent.

APPENDIX A – LINE OF SIGHT METHODOLOGY

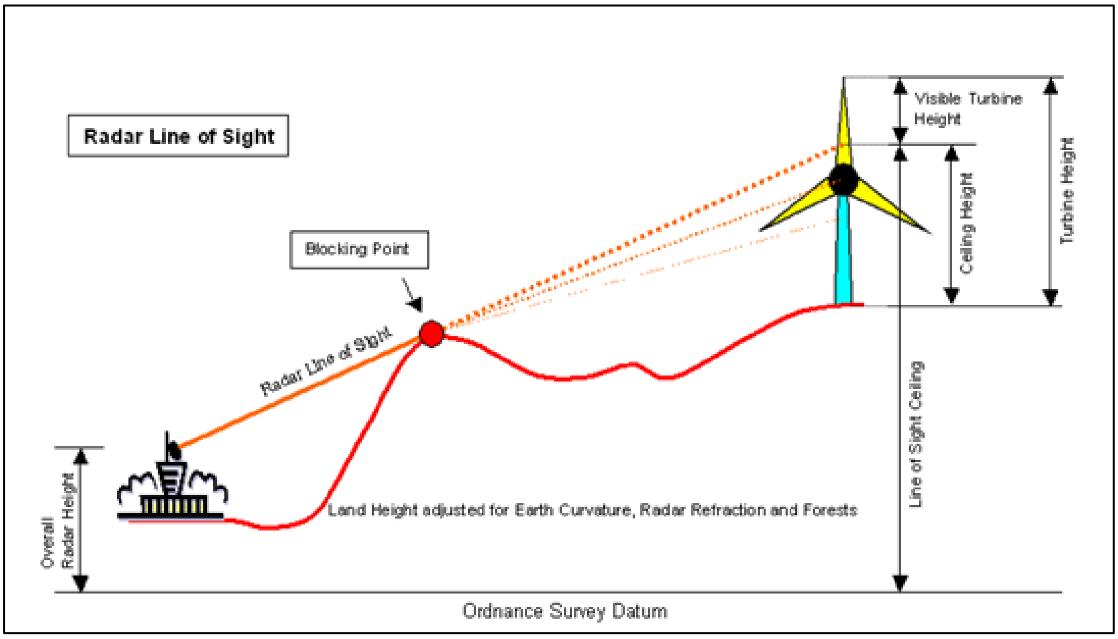
Overview

Line of sight Analysis is used to determine the extent to which a planned wind development could be detected by a specific radar installation.

This analysis takes into account:

- The curvature of the Earth;
- Refraction of the radar signal by the atmosphere;
- The Effective Radar Height;
- The Effective Turbine Height;
- The height profile of the terrain between the radar and turbine.

The figure below shows how Radar line of sight is determined, together with the various terms used in the analysis.



Radar Line of sight

Land height may be adjusted for Forests, Buildings or other obstructions however further shielding analysis will be required for this to be incorporated.

Overall Radar Height

The radar height determines the line of sight angle. This in turn determines the Ceiling Height. The higher the radar, the lower the line of sight Ceiling will be.

The Overall Radar Height is the height of the radar radiation centre above OSGB terrain data.

Turbine Height

Higher wind turbines are more likely to be detected by radar than lower ones. The Turbine Height is calculated by adding the hub height to the rotor radius.

Earth Curvature

Curvature of the Earth limits the distance at which objects can be detected, using visual and radar techniques.

The effect of Earth Curvature increases as the separation between radar and wind turbine increases.

The effect of Earth Curvature is calculated by determining the vertical separation of two lines running between the radar and wind turbine.

The first is the arc of the great circle that passes through the radar and wind turbine. This is the shortest arc between the two points.

The second is the chord between the radar and wind turbine. This line cuts through the Earth's surface.

A curve representing the distance between the Earth's surface and the straight line is plotted.

Appendix B shows how the maximum separation between chord and surface increases with the distance between radar and wind turbine.

Radar Signal Refraction

Radar Signals travel in straight lines in free space. Variations in the atmosphere cause bending of radar signals. This bending is caused by lower denser air having a higher refractive index than higher less dense air.

The result of this bending is that effective radar range is extended beyond the visible horizon. Radar system designers compensate for this effect by using a larger effective Earth Radius in their calculations. This compensation allows radar signals to be treated as straight lines, even though they are actually being refracted.

The Earth Radius is multiplied by a refraction constant k to give an increased effective Earth Radius. The standard figure used for k is 4/3. This value is known as Standard Refraction. Measured values of k in the USA range from 1.25 to 1.90[9].

The Earth Curvature curve is redrawn, by recalculating each point using the adjusted Earth radius. This is shown on the line of sight charts.

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9 Bean, B. R. et al. "A World Atlas of Atmospheric Radio Refractivity," U.S. Dept. of Commerce, ESSA Monograph 1, 1966. Further information for the UK and Europe is also available from Recommendation ITU-R P.453-8 "The radio refractive index: its formula and refractivity data"

Effects of variation in Refraction Constant k discussed separately shows how varying values of k can affect Adjusted Land Height.

Attenuation by Forestry and Obstructions

Areas of land between the Radar and the Wind Farm may be covered with forest, buildings or structures that effectively attenuate radar signals.

Where there are large areas of forestry, or built up areas, these can be considered, and included within the line of sight charts. The standard chart however does not include this.

Line of Sight Profile

A line of sight profile is generated by determining the height of a series of equally spaced points along the line between the radar and a single wind turbine. The terrain data used has the characteristics shown in the table below.

Data source origin	OSGB
Data point interval (m)	50
Height data resolution	1 metre

Terrain data characteristics

The height of a specific point is calculated by taking an average of the height values of the four surrounding data points. The average is weighted using interpolation in both X (Longitude) and Y (Latitude) directions.

The land height profile is shown on the line of sight chart denoted as 'Land Height'.

Adjusted Land Height Profile

The Adjusted Land Height Profile takes Terrain, Earth Curvature and Radar Refraction into account.

It is calculated by adding the 'Land Height' curve, the 'Earth Curvature and Radar Refraction' curve.

Radar Line of Sight

The Radar line of sight is determined by taking the straight line which:

- Originates at the radiation centre of the radar
- Has the highest tangent with the Adjusted Land Height Profile
- Passes through or over the Wind Turbine

Line of Sight Ceiling

The line of sight ceiling is the height, above OSGB data, of the point at which the line of sight passes the wind turbine.

Ceiling Height

The Ceiling Height is the height, above ground level, of the point at which the line of sight passes the wind turbine.

Visible Turbine Height

The Visible Turbine Height is the vertical distance between the point at which the line of sight passes the wind turbine, and the top of the wind turbine.

[Visible Turbine Height] = [Turbine Height] - [Ceiling Height]

If the line of sight passes below the top of the Wind Turbine then Visible Turbine Height is positive.

If the line of sight passes above the top of the Wind Turbine then Visible Turbine Height is negative.

Predominant Blocking Point

The Predominant Blocking Point is defined as the point at which the Radar line of sight is tangential to the Adjusted Land Height Profile.

The Blocking Point is the piece of land that physically prevents or limits the radar's detection of the wind turbine.

Line of Sight Charts

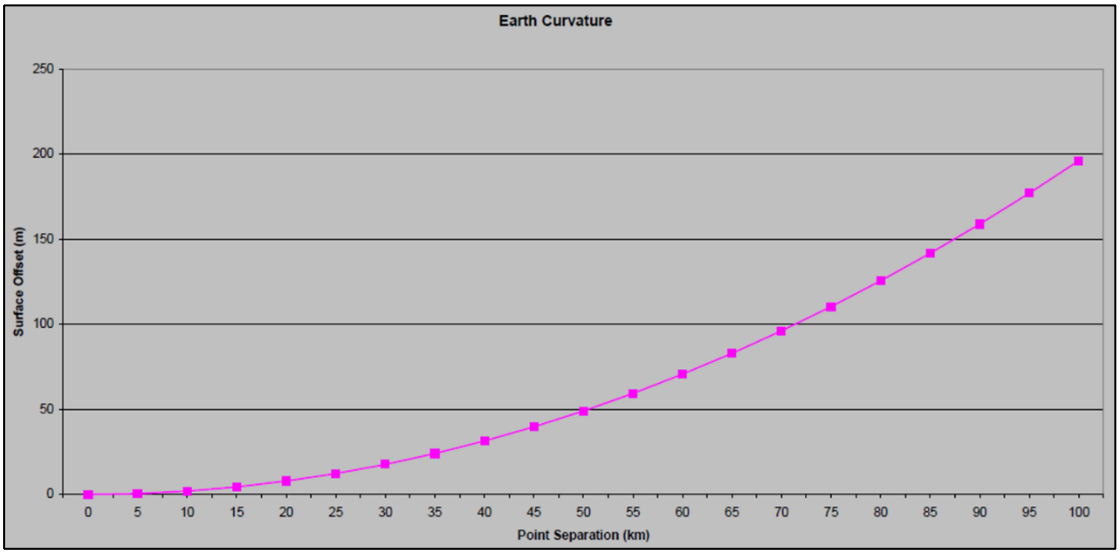
These show the line of sight between the radar and a wind turbine.

The horizontal scale shows the distance between the radar and the wind turbine in kilometres. 0km at the left hand side corresponds to the radar location. The right hand end of the scale represents the point in the wind farm.

The vertical scale shows land height in metres. All heights are with reference to OSGB terrain data.

Earth Curvature

The distance between the Earth's surface and the associated chord passing through the Earth's crust increases with point separation. This is shown in the chart on the following page.



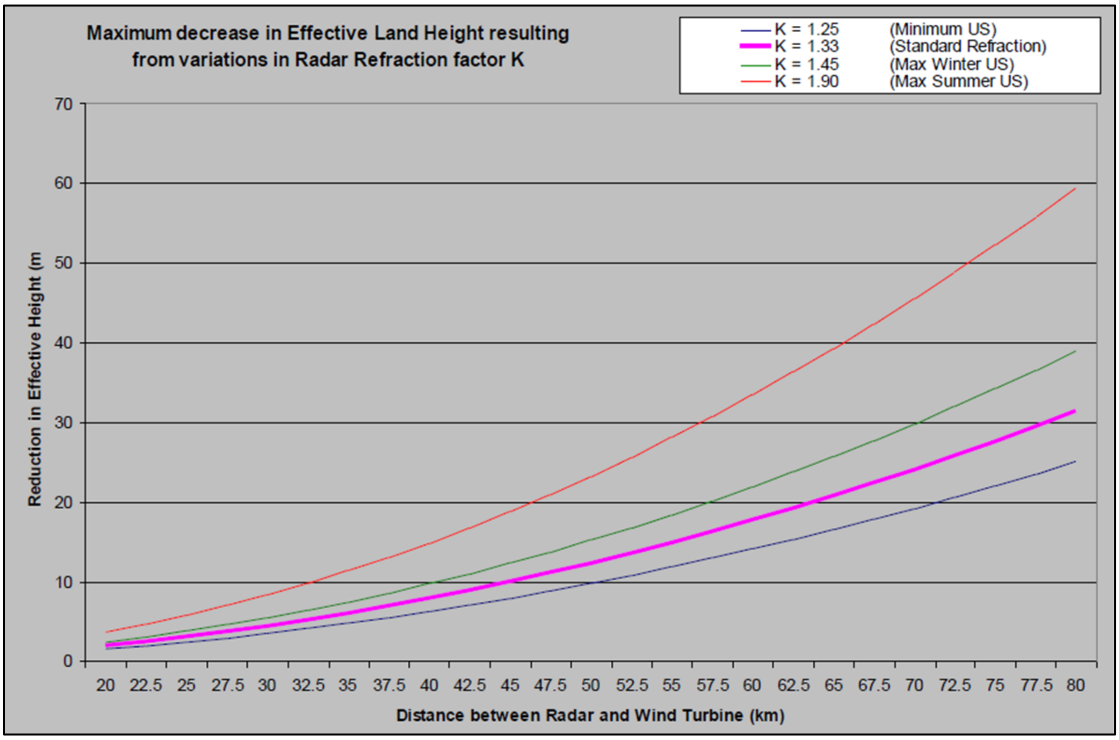
Earth curvature with distance

Effects of variation in Refraction Constant k

The Standard Refraction constant k is 4/3.

Measured values of k in the USA range from 1.25 to 1.90.

The chart below shows the effects of variations in k over a range of distances.



Variations in constant k over a range of distances

APPENDIX B – TERRAIN BASED ANALYSIS

Terrain Based Analysis - Overview

There are many approaches that may be used to undertake terrain based assessments such as radar line of sight profile charts. The overall accuracy of any terrain based assessment is dependent on the following factors:

- Accuracy of co-ordinates and height data for the infrastructure being assessed;
- Resolution and quality of terrain or surface data;
- Choice of algorithm for determining land height from terrain data.

Co-ordinates and height of existing infrastructure may be obtained from the infrastructure owner, custom databases, various forms of mapping or via a site survey. Sometimes the coordinate and height data used may be inaccurate because of coordinate rounding or confusion between height and altitude. Verification of infrastructure position data makes the results of terrain based assessments more reliable.

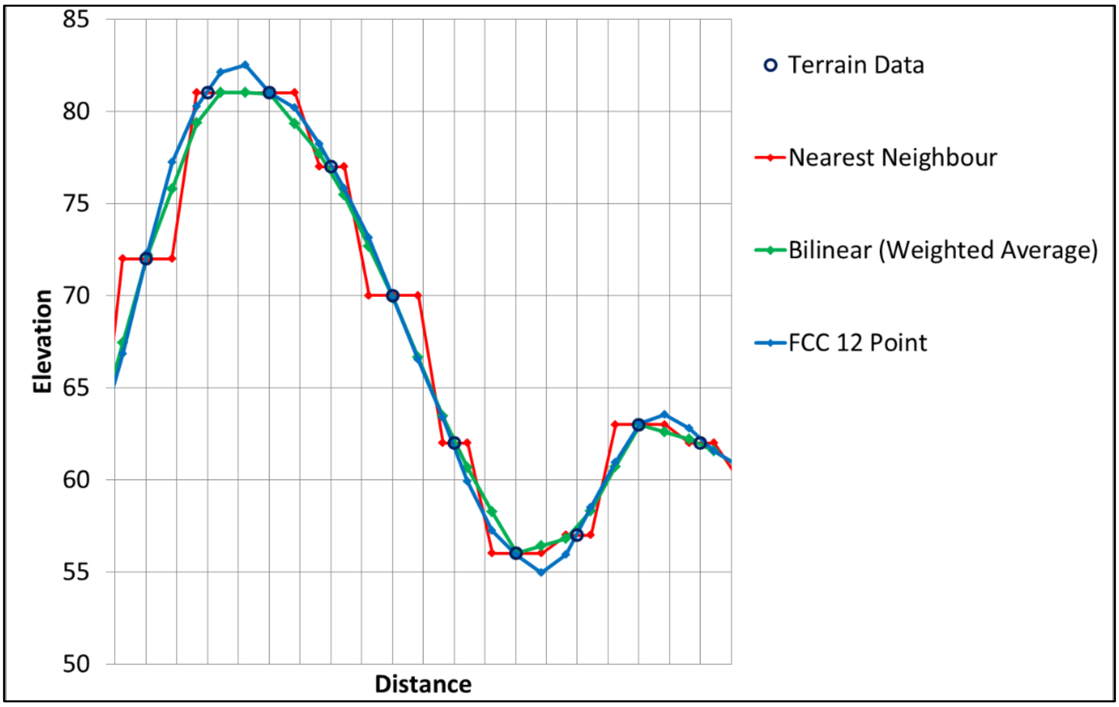
The resolution of digital data is described by its post spacing. Terrain and surface data has a vertical accuracy described by a statistical relationship between database and actual vertical values – a typical rms[1] vertical accuracy being 2 metres.

Terrain data is used to calculate the terrain or surface height at specific locations. There are many processing algorithms for achieving this. These algorithms vary in accuracy and some are more appropriate for certain types of calculations than others. The nearest neighbour algorithm runs quickly and is effective for some applications. A weighted average algorithm is more accurate and generally gives conservative results for wind farm radar calculations. A more advanced algorithm using twelve data points is more accurate yet less conservative when determining the likelihood of a radar detecting a wind turbine.

The figure on the following page shows an example of how terrain data will be interpreted for an algorithm using the nearest neighbour approach, the weighted average approach and the 12 point approach. The circles represent the data points, which are effectively the raw data and can be considered accurate. The coloured lines show the apparent height that will be calculated by the three algorithms. It can be seen that whilst the 12 point method is in most cases more accurate, it is less conservative than the bilinear weighted average method for line of sight analysis and radar detectability analysis. This is because the weighted average method is more likely to reduce the apparent height of the blocking point, thereby increasing the visibility of the turbine.

Pager Power employs the bilinear weighted average method for its analysis.

[1] Root mean square



Example of Terrain Data Algorithms

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Technical Appendix 14.1

Operational Noise Report

Watten Wind Farm

EDF Energy Renewables Limited

15098-004
10 August 2023

COMMERCIAL IN CONFIDENCE

tneigroup.com

Quality Assurance

TNEI Services Ltd, TNEI Africa (PTY) Ltd and TNEI Ireland Ltd operate an Integrated Management System and is registered with The British Assessment Bureau as being compliant with ISO 9001(Quality), ISO 14001 (Environmental) and ISO 45001 (Health and Safety).

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Document Control

Revision	Status	Prepared by	Checked by	Approved by	Date
D0	DRAFT	AD	GC	JM	29/06/2023
D1	CLIENT COMMENTS	GC	GC	JM	09/08/2023
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Executive Summary

TNEI Services was commissioned by Natural Power on behalf of EDF Energy Renewables Limited ('EDF Energy') to undertake predictions of the wind turbine noise that would be emitted by the operation of the proposed Watten Wind Farm (hereinafter referred to as 'the Proposed Development'). The noise predictions were used to assess the potential impact of operational noise from the Proposed Development on the nearest noise sensitive receptors.

The Scottish Government's web based renewables advice on 'Onshore Wind Turbines' states: *'The Report, "The Assessment and Rating of Noise from Wind Farms" (Final Report, Sept 1996, DTI), (ETSU-R-97), describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available. This gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions.'* The advice document then goes on to state: *'The Institute of Acoustics (IOA) has since published Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* [IOA GPG]*. The document provides significant support on technical issues to all users of the ETSU-R-97 method for rating and assessing wind turbine noise, and should be used by all IOA members and those undertaking assessments to ETSU-R-97. The Scottish Government accepts that the guide represents current industry good practice.'* The guidance contained within ETSU-R-97 and current good practice has been used to assess the potential operational noise impact of the Proposed Development.

The operational noise assessment has been undertaken in three stages:

1) deriving the Total ETSU-R-97 Noise Limits (which are applicable to noise from all wind turbines in the area operating concurrently) at noise sensitive receptors;

2) predicting the likely effects (undertaking a cumulative noise assessment where required) to determine whether noise immissions at noise sensitive receptors will meet the Total ETSU-R-97 Noise Limits; and

3) deriving Site Specific Noise Limits for the Proposed Development (taking account of the noise limit that has already been allocated to / could realistically be used by other schemes) and undertaking predictions against those limits.

There are a number of operational wind farms in proximity to the Proposed Development. Background noise monitoring was previously undertaken at a number of properties proximate to the Proposed Development as part of the noise assessment work undertaken for Halsary Wind Farm. Halsary is now an operational wind farm located immediately to the south west of the Proposed Development. Due to the number of existing operational wind farms within the area, additional noise monitoring was not undertaken due to the potential influence of operational wind turbine noise on the measured levels. Background noise data previously collected for Halsary Wind Farm was used to set the Total ETSU-R-97 Noise Limits for the Proposed Development. A correction was applied to the data used from Halsary Wind Farm to take account of wind shear and the difference in hub heights for the turbines at Halsary Wind Farm and the Proposed Development.

A total of twelve noise sensitive receptors were chosen as Noise Assessment Locations (NALs). The NALs were chosen to represent the noise sensitive receptors located closest to the Proposed Development and additional receptors were included to consider cumulative noise impacts. For the assessment locations where no background noise measurements were undertaken, noise data collected at proxy locations deemed representative of the expected background noise environment was used to assess the wind turbine noise impact at those receptors.

Based on the guidance in ETSU-R-97 and to reflect the presence of existing wind turbines in the area, the daytime Total ETSU-R-97 Noise Limit was set at 38 dB(A) or background plus 5 dB whichever is the greater. The night time Total ETSU-R-97 Noise Limit has been set at 43 dB(A) or background plus 5 dB whichever is the greater. The Site Specific daytime limit for noise associated with the Proposed Development has been set such that it never exceeds 35 dB(A) or background plus 5 dB, whichever is the greater. This represents the lower end of the daytime limits that can be applied under ETSU-R-97. The night time Site Specific Noise Limits have been set at 43 dB(A) or background plus 5 dB whichever is the greater.

The exception to the setting of both the daytime and night time fixed minimum noise limits occurs where a property occupier has a financial involvement in the wind farm development where the limit can be increased to 45 dB(A) or a higher permissible limit above background (whichever is greater) during the daytime and night time periods.

Predictions of wind turbine noise for the Proposed Development were made, based upon the sound power level data for a candidate wind turbine, the Vestas V162 6.8 MW with serrated trailing edges and a hub height of 139 m. This wind turbine model has been chosen as it is considered to be representative of the type of turbine that could be installed at the site. Whatever the final turbine choice is, the Proposed Development would have to meet the noise limits determined and contained within any condition applied as part of consent.

Modelling was undertaken using the ISO 9613: 1996 *'Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation'* noise prediction model which accords with current good practice and is considered to provide a realistic impact assessment. For the other schemes, predictions have been undertaken using sound power level data for the installed turbines or a suitable candidate. The model of turbine was either identified through an online search, or through the use of the Council's Planning Application Portal.

A cumulative assessment was undertaken at the NALs where predictions from the Proposed Development were found to be within 10 dB of the noise predictions from all other schemes. The likely cumulative assessment, required at eleven NALs, shows that the Proposed Development can operate concurrently with the proposed and operational wind farms in the area, whilst still meeting the Total ETSU-R-97 Noise Limits at the receptors.

Site Specific Noise Limits have also been derived that take account (where required) of the other wind farm developments. Where wind turbine immissions from the other wind turbines at a given receptor were found to be at least 10 dB below the Total ETSU-R-97 Noise Limit, it is considered that they will be using a negligible proportion of the limit, as such it was considered appropriate to allocate the entire noise limit to the Proposed Development. For the receptors where turbine predictions were found to be within 10 dB of the Total ETSU-R-97 Noise Limit, apportionment of the Total ETSU-R-97 Noise Limits was undertaken in accordance with current good practice. Where cumulative predictions were found to be within 5 dB of the Total ETSU-R-97 Noise Limits, the Site Specific Noise Limits were set 10 dB below to ensure the Proposed Development uses a negligible proportion of the noise limit.

Predicted noise levels indicate that at all noise assessment locations wind turbine noise immissions were below the Site Specific Noise Limits at all NALs except NAL1 where a 0.3 dB exceedance is predicted at 6 $ms^{-1}$when considering the Vestas V162, 6.8 MW as a candidate turbine. The use of low noise modes would mitigate this exceedance and the predicted levels presented in this report include the necessary mitigation.

The use of Site Specific Noise Limits would ensure that the Proposed Development could operate concurrently with other proposed, consented or operational turbines in the area and would also ensure that the Proposed Development's individual contribution could be measured and enforced if required.

Should consent be granted for the Proposed Development it would be appropriate to include a set of noise related deemed planning conditions, which detail the noise limits applicable to the Proposed Development. A set of suggested noise conditions have been included within Annex 9.

There are a number of wind turbine makes and models that may be suitable for the Proposed Development. Should the Proposed Development receive planning consent the final choice of turbine would be subject to a competitive tendering process. As such, predictions of wind turbine noise are for information only. The final choice of turbine would, however, have to meet the noise limits determined and contained within any condition imposed.

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TABLES

ANNEXES

1 Introduction

1.1 Brief

1.1.1 TNEI was commissioned by Natural Power on behalf of EDF Energy Renewables Ltd ('the Applicant') to undertake an operational noise assessment for the proposed Watten Wind Farm (hereinafter referred to as 'the Proposed Development'). The following steps summarise the noise assessment process:

- Determine the most appropriate background noise dataset to be used for each Noise Assessment Location and apply a correction to take account of wind shear;
- Determine the Total ETSU-R-97 Noise Limits applicable to all wind turbines in the area with reference to existing Government Guidance and the recommendations of the Department of Trade and Industry Noise Working Group on Noise from Wind Turbines which are contained within ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms'* (1) and *'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'* (2) (IOA GPG) which represents current good practice;
- Assess and undertake a cumulative noise assessment, where required, to take account of other operational, consented or proposed (in planning) schemes near to the Proposed Development;
- Derive Site Specific Noise Limits for the Proposed Development, suitable for inclusion in the noise related planning condition should the Highland Council be minded to grant planning permission for the Proposed Development;
- Compare predictions of the operational wind turbine noise immissions from the Proposed Development against the Site Specific Noise Limits that will be incident at neighbouring noise sensitive receptors; and
- Assess the impact of noise from the Proposed Development with reference to existing Government Guidance and the recommendations of the Department of Trade and Industry Noise Working Group on Noise from Wind Turbines, which are contained within ETSU-R-97 and the IOA GPG.

1.2 Background

1.2.1 The Proposed Development Area is located approximately 3 km to the south west of Watten on land to the north east of Halsary Wind Farm. The approximate OS Grid Reference for the centre of the site is 320734, 951525 and the proposed layout is shown on Figure A1.1[1] in Annex 1.

1.2.2 In the absence of a confirmed turbine model, this noise assessment models a candidate turbine, the Vestas V162 6.8 MW serrated trailing edge blades and a hub height of 139 m. This turbine has been selected as it is representative of the turbine type which could be installed at the site.

[1] Not to scale. For a scaled version, see EIAR Volume 3, Figure 14.1

1.2.3 The noise assessment has considered schemes which are operational, consented and proposed (planning application submitted) but not those in the pre-planning stage. Schemes which are pre-planning are not included as there is insufficient information available at the scoping stage regarding turbine locations and turbine type. The schemes considered in the assessment are summarised in Table 1.1 and were identified using The Highland Councils publicly available wind turbine map.

Table 1.1 Cumulative Wind Farm/ Turbine Development

Wind Farm/ Wind Turbine	Number of Turbines	Status	Make and Model of Turbine considered in Modelling
Achlachan	5	Operational	Senvion MM92, standard blade
Causeymire	21	Operational	Bonus 2.3, standard blade
Halsary	15	Operational	Vestas V100, serrated blade
Bad a Cheo	13	Operational	Senvion MM92, standard blade
Camster	25	Operational	Vestas V80, standard blade
Bilbster	3	Operational	Nordex N60, standard blade
Wathegar	5	Operational	Senvion MM82, standard blade
Wathegar II	2	Operational	Senvion MM92, standard blade
Harpsdale Mains Halkirk	1	Operational	Gaia 133, standard blade
Myrelandhorn	1	Operational	Kingspan KW15, standard blade
West Watten	1	Operational	Xzeres ARE-442, standard blade
Tacher (A and B)	2	Under Construction	Vensys V115, standard blade
Tacher C	1	Consented	Vensys V115, standard blade
Cogle Moss	12	Consented	Enercon E70, standard blade
Achlachan 2	3	Consented	Senvion MM92, standard blade
Camster II	11	Consented	Vestas V117, Serrated Blade
Tormsdale	12	In Planning	Vestas V136, Serrated Blade

1.2.4 Figure A1.1a[2] in Annex 1 shows the location of the above developments relative to the Proposed Development.

1.2.5 The Site Specific Noise Limits presented in this report for the Proposed Development have taken account the noise limits that have already allocated to, or could potentially be used by, the other schemes in the area.

1.2.6 For the purposes of assessing the above schemes in conjunction with the Proposed Development, the following terms have been referred to throughout the assessment:

[2] Not to scale. For a scaled version, see EIAR Volume 3, Figure 14.2

- 'Total ETSU-R-97 Noise Limits'; defined as being the limit that should not be exceeded from the cumulative operation of all wind farm developments, including the Proposed Development; and
- 'Site Specific Noise Limits'; defined as being the limit that is specific to the Proposed Development only, and derived through the apportionment (where required), of the 'Total ETSU-R-97 Noise Limits' in accordance with current good practice.

1.2.7 Note that in this report, the term 'noise emission' relates to the sound power level actually radiated from each wind turbine, whereas the term 'noise immission' relates to the sound pressure level (the received noise) at any receptor location due to the operation of the wind turbines. All references to dB are dB(A) unless otherwise stated. A full glossary of terms is provided in Section 8.

2 Noise Planning Policy and Guidance

2.1 Overview of Noise Planning Policy and Guidance

2.1.1 In assessing the potential noise impacts of the Proposed Development, the following guidance and policy documents have been considered:

- National Planning Policy [3];
- Local Planning Policy;
- Web Based Renewables Advice: *'Onshore Wind Turbines'* [4];
- Planning Advice Note PAN 1/2011: *'Planning and Noise'* [5];
- ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms'*; and
- Institute of Acoustics *'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'* (IOA GPG) May 2013.

2.2 National Planning Policy

2.2.1 As the Proposed Development has capacity to generate over 50 MW, the Proposed Development requires consent from the Scottish Ministers under Section 36 of the Electricity Act 1989. In such cases the Planning Authority is a statutory consultee in the development management process and procedures.

2.2.2 In determining an application for Section 36 consent, the Scottish Ministers must first have regard to the extent to which the Applicant has met its duties in terms of Schedule 9 (3) of the Electricity Act 1989. The Applicant must assess and, if required, mitigate the effects of the Proposed Development on environmental matters.

2.2.3 Furthermore, decision makers must also consider National Energy and Planning Policy, and, in the context of a Section 36 application, the statutory Development Plan. As of February 2023, National Planning Framework 4 ('NPF4') [6] now forms part of the statutory Development Plan alongside the relevant Local Development Plan and any related Supplementary Guidance. Such plans will often contain policies tailored specifically to control certain kinds of development and such policies should carry more weight and be more dominant in the minds of decision makers.

2.2.4 National Planning Framework 4 ('NPF4') was adopted on 13 February 2023 and supersedes National Planning Framework 3 and Scottish Planning Policy. Policy 11 – Energy states that renewable energy projects must be able to demonstrate how any noise impacts on communities have been addressed through the project's design and any associated mitigation. Policy 23 – Health and Safety outline how *'development proposals that are likely to raise unacceptable noise issues will not be supported'* and states that *'a Noise Impact Assessment may be required where the nature of the proposal or its location suggests that significant effects are likely.'*

2.2.5 The Scottish Government's online Onshore Wind: Policy Statement 2022 (published on 21 December 2022) [7] states (in Section 3.7) that: *''The Assessment and Rating of Noise from Wind Farms' (Final Report, Sept 1996, DTI), (ETSU-R-97) provides the framework for the* *measurement of wind turbine noise, and all applicants are required to follow the framework and use it to assess and rate noise from wind energy developments.'*

2.3 Local Policy

The Highland-wide Local Development Plan

2.3.1 The Highland-wide Local Development Plan (HwLDP) was adopted by Highland Council (THC) on 5 April 2012. The HwLDP sets out the overarching vision statement, spatial strategy and general planning policies for the whole of the Highland Council area (with the exception of the area covered by the Cairngorms National Park Local Plan, which is subject to a separate Development Plan).

2.3.2 Policy 67 of the HwLDP relates to Renewable Energy Development. The policy is supportive of such schemes where the Council is satisfied that they are located, sited and designed such that they will not be significantly detrimental overall, having regard to a number of effects including the safety and amenity of any regularly occupied buildings and the grounds that they occupy having regard to, amongst other things, the likely effect of noise generation.

2.3.3 A Development Plans Newsletter issued by the Highland Council in March 2023 states that:

'*We started the process of reviewing the HwLDP in 2016, but when the Scottish Government published a Planning Bill in 2017 that outlined changes to the Scottish Planning System, we decided to halt the HwLDP review process until more was known about the changes. We also now use NPF4.'*

The Highland Council's 'Onshore Wind Energy Supplementary Guidance' (2016)

2.3.4 The Highland Council's 'Onshore Wind Energy Supplementary Guidance' (2016) details how onshore wind energy development proposals would be managed. The guidance has a section that sets out the assessment methods and key guiding principles that should form the basis of the noise assessment. The guidance states that a noise assessment for proposed large-scale wind turbine development should be undertaken in accordance with ETSU-R-97 and the IOA GPG.

2.3.5 The guidance goes on to state that due to the undeveloped nature of the Highlands, proposals should aim to achieve noise limits at the lower end of ranges given in national guidance at sensitive locations. The noise limits in this assessment have been derived in accordance with ETSU-R-97.

2.3.6 With regard to the cumulative effects of noise from wind farms, THC states: *"Where noise from more than one wind turbine development may have a cumulative impact at any noise sensitive location, applicants must ensure this is adequately assessed in accordance with best practice, which includes consideration of both predicted and consented levels".*

2.4 Planning Advice Note PAN 1/2011: Planning and Noise

2.4.1 PAN 1/2011 provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. Paragraph 29 contains some specific information on noise from wind farms and states the following:

'There are two sources of noise from wind turbines - the mechanical noise from the turbines and the aerodynamic noise from the blades. Mechanical noise is related to engineering design. Aerodynamic noise varies with rotor design and wind speed, and is generally greatest at low speeds. Good acoustical design and siting of turbines is essential to minimise the potential to generate noise. Web based planning advice on renewable technologies for Onshore wind turbines provides advice on 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) published by the former Department of Trade and Industry [DTI] and the findings of the Salford University report into Aerodynamic Modulation of Wind Turbine Noise.'

2.5 Web Based Planning Advice – Onshore Wind Turbines

2.5.1 The 'Onshore Wind Turbines' web-based document describes the types of noise (mechanical and aerodynamic) that wind turbines generate. Mechanical noise is generated by the gearbox and generator and other parts of the drive train, which can be radiated as noise through the nacelle, gear box, tower and supporting structures, together with the aerodynamic noise generated by the action of the blades rotating through the air. The document states '*there has been significant reduction in the mechanical noise generated by wind turbines through improved turbine* design' and goes on to note:

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

2.5.2 The web-based document then refers to the IOA GPG as a source, which provides:

'significant support on technical issues to all users of the ETSU-R-97 method for rating and assessing wind turbine noise, and should be used by all IOA members and those undertaking assessments to ETSU-R-97. The Scottish Government accepts that the guide represents current industry good practice.'

2.5.3 The document also refers to the role of PAN1/2011 'Planning and Noise' to:

'provide advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. The associated Technical Advice Note provides guidance which may assist in the technical evaluation of noise assessment.'

2.5.4 Examination of the Technical Advice Note (8) confirms that it provides advice on wind farms by referring to ETSU-R-97 and relevant parameters for modelling identified in the Institute of Acoustics Bulletin article dated March 2009, on page 37. The article was superseded by the introduction of the IOA GPG in May 2013.

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

2.6.1 As wind farms started to be developed in the UK in the early 1990's, it became apparent that existing noise standards did not fully address the issues associated with the unique characteristics of wind farm developments and there was a need for an agreed methodology for defining acceptable noise limits for wind farm developments. This methodology was developed for the former Department of Trade and Industry (DTI) by the Working Group on Noise from Wind Turbines (WGNWT).

2.6.2 The WGNWT comprised a number of interested parties including, amongst others, Environmental Health Officers, wind farm operators, independent acoustic consultants and legal experts who:

'…between them have a breadth and depth of experience in assessing and controlling the environmental impact of noise from wind farms.'

2.6.3 In this way it represented the views of all the stakeholders that are involved in the assessment of noise impacts of wind farm developments. The recommendations of the WGNWT are presented in the DTI Report – ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms (1996).'*

2.6.4 The basic aim of the WGNWT in arriving at the recommendations was the intention to provide:

'Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding to the costs and administrative burdens on wind farm developers or local authorities.'

2.6.5 ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the environmental impact of the wind farm against the national and global benefits that would arise through the development of renewable energy sources:

'The planning system must therefore seek to control the environmental impacts from a wind farm whilst at the same time recognising the national and global benefits that would arise through the development of renewable energy sources and not be so severe that wind farm development is unduly stifled.'

2.6.6 Where noise at the nearest noise sensitive receptors is limited to an $L_{A90,10min}$ of 35 dB(A) up to wind speeds of 10 ms^{-1} at a height of 10 m, then it does not need to be considered in the noise assessment, as protection of the amenity of these properties can be controlled through a simplified noise limit. In this regard ETSU-R-97 states that:

'For single turbines or wind farms with very large separation distances between the turbines and the nearest properties, a simplified noise condition may be suitable. If the noise is limited to an $L_{A90,10min}$ of 35 dB(A) up to wind speeds of 10 m/s at 10 m height, then this condition alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary.'

2.6.7 The ETSU-R-97 assessment procedure specifies that where wind turbine noise is expected to be above the simplified limit of 35 dB L_{A90} noise limits should be set relative to existing background noise levels at the nearest receptors. These limits should reflect the variation in both turbine source noise and background noise with wind speed. Absolute lower limits, different for daytime and night time, are applied where low levels of background noise are measured. The wind speed range that should be considered ranges between the cut-in wind speed for the turbines (usually about 2 to 3 ms^{-1}) and up to 12 ms^{-1}, where all wind speeds are referenced to a 10 metre measurement height.

2.6.8 Separate noise limits apply for daytime and for night time. Daytime limits are chosen to protect a property's external amenity, and night time limits are chosen to prevent sleep disturbance indoors, with windows open.

2.6.9 The daytime noise limit is derived from background noise data measured during so-called 'quiet periods of the day', which comprise weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00). Multiple samples of 10 minute background noise levels using the $L_{A90,10min}$ measurement index are logged continuously over a range of wind speed conditions. These measured noise levels are then plotted against concurrent wind speed data and a 'best fit' curve is fitted to the data to establish the background noise level as a function of wind speed. The ETSU–R-97 daytime noise limit, sometimes referred to as a 'criterion curve', is then set at a level 5 dB(A) above the best fit curve over the desired wind speed range; subject to an appropriate daytime fixed minimum limit:

'For wind speeds where the best fit curve to the background noise data lies below a level of 30 - 35 dB(A) the criterion curve is set at a fixed level in the range 35 - 40 dB(A). The precise choice of criterion curve level within the range 35 - 40 dB(A) depends on a number of factors: the number of noise affected properties, the likely duration, the level of exposure and the potential impact on the power output of the wind farm. The quiet daytime limits have been set in ETSU-R-97 on the basis of protecting the amenity of residents whilst outside their dwellings in garden areas.'

2.6.10 The night time noise limit is derived from background noise data measured during the night time periods (23:00 to 07:00), with no differentiation being made between weekdays and weekends. The 10 minute L_{A90} noise levels measured over the night time periods are plotted against concurrent wind speed data and a 'best fit' correlation is established. The night time noise limit is also based on a level 5 dB(A) above the best fit curve over the 0 - 12 ms^{-1} wind speed range, with a fixed minimum limit of 43 dB L_{A90}.

2.6.11 The exception to the setting of both the daytime and night time fixed minimum limits occurs where a property occupier has a financial involvement in the wind farm development. Paragraph 24 of ETSU-R-97 states:

'The Noise Working Group recommends that both day and night time lower fixed limits can be increased to 45 dB(A) and that consideration should be given to increasing the permissible margin above background where the occupier of the property has some financial involvement in the wind farm.'

2.6.12 ETSU-R-97 provides a robust basis for determining the noise limits for wind turbine(s) and since its introduction has become the accepted standard for such developments across the UK.

2.7 Current Good Practice

A Good Practice Guide on the Application of ETSU-R-97

2.7.1 In May 2013, the Institute of Acoustics issued *'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'* (IOA GPG). The document provides guidance on background data collection, data analysis and limit derivation, noise predictions, cumulative issues, reporting requirements and other matters such as noise related planning conditions.

2.7.2 The Authors of the IOA GPG sets out the scope of the document in Section 1.2:

'This guide presents current good practice in the application of the ETSU-R-97 assessment methodology for all wind turbine developments above 50 kW, reflecting the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published. The noise limits in ETSU-R-97 have not been examined as these are a matter for Government.'

2.7.3 The guidance document was endorsed, on behalf of Scottish Government by the Cabinet Secretary for Finance, Employment and Sustainable Growth, Mr John Swinney MSP [(9)]. The recommendations included in the IOA GPG have been considered and applied throughout this noise assessment for the Proposed Development.

2.7.4 The IOA GPG refers to six Supplementary Guidance Notes and where applicable these have also been considered in this report.

2.7.5 The guidance contained within ETSU-R-97 and the IOA GPG has therefore been used to assess and rate the operational noise emissions from the Proposed Development.

2.8 WSP BEIS Report

2.8.1 On 10th February 2023, WSP published *'A review of noise guidance for onshore wind turbines'* [(10)]('WSP BEIS report'), a report that had been commissioned by (the former) UK Government Department for Business, Energy & Industrial Strategy (BEIS). The primary aim of the review was to make a recommendation on whether, in view of government policies on noise and Net Zero, and available evidence, the existing guidance requires updating.

2.8.2 The WSP BEIS report concluded that:

'the guidance would benefit from further review and updating of the aspects identified. This could be supported by currently available evidence, which is summarised in this report. However, the study has also highlighted gaps in the state of knowledge, which should be addressed by further research, to support any updates to the guidance.'

2.8.3 A series of recommendations are made regarding further research whilst some additional suggestions are included regarding the development of new or updated guidance. The following recommendation is included on page 15 of the WSP BEIS report:

'the separation of the 'policy position' (addressing the balance between controlling noise impact and enabling renewable energy development), 'technical guidance' (application of the assessment approach), and 'technical justification' (the supporting evidence) into discrete, linked documents'

2.8.4 The WSP BEIS report notes at the outset that *'Any views expressed within it do not necessarily represent the views of the UK government or the governments of any of the devolved administrations'.* The report does state on page 26 that:

'Consideration should be given to including a clear position statement in guidance confirming the intended policy balance between protection from noise impact, and enabling of renewable energy development (to achieve Net Zero), linked with the wider policies that underpin the government approach to noise management.'

2.8.5 At time of writing there has been no official response to the report from BEIS or any of the new Government departments which are being created to replace BEIS. In the event that a decision is made to follow up on the recommendations within the WSP BEIS report, it is unclear how new guidelines would account for the UK or Scottish Governments' Net Zero targets nor is there any indication of timescales within which updated guidance would be produced.

2.8.6 In relation to the guidance that should be used to assess the Proposed Development, the Scottish Government Guidance is clear; the Onshore Wind Policy Statement 2022 states:

'3.7.1. 'The Assessment and Rating of Noise from Wind Farms' (Final Report, Sept 1996, DTI), (ETSU-R-97) provides the framework for the measurement of wind turbine noise, and all applicants are required to follow the framework and use it to assess and rate noise from wind energy developments.'

'3.7.4. Until such time as new guidance is produced, ETSU-R-97 should continue to be followed by applicants and used to assess and rate noise from wind energy developments.'

2.8.7 The guidance contained within ETSU-R-97 and the IOA GPG has therefore been used to assess and rate the operational noise emissions from the Proposed Development.

3 Potential Impacts

3.1 Operational Noise Sources

3.1.1 Wind turbines may emit two types of noise. Firstly, aerodynamic noise is a more natural sounding 'broad band' noise, albeit with a characteristic modulation, or 'swish', which is produced by the movement of the rotating blades through the air. Secondly, mechanical noise may emanate from components within the nacelle of a wind turbine. Potential sources of mechanical noise include gearboxes or generators.

3.1.2 Aerodynamic noise is usually perceived when the wind speeds are fairly low although at very low wind speeds the blades either do not rotate, or rotate very slowly, and so negligible aerodynamic noise is generated. In higher winds aerodynamic noise may be masked by the normal sound of wind blowing through the trees and around buildings. The level of this natural 'masking' noise relative to the level of wind turbine noise is one of the several factors that determine the subjective audibility of the wind turbines [(11)].

3.2 Infrasound, Low Frequency Noise and Vibration

3.2.1 The term infrasound can be defined as the frequency range below 20 Hz, while low frequency noise (LFN) is typically in the frequency range 20 – 200 Hz [(12)]. An average young healthy adult has an audible range from 20 Hz to 20,000 Hz, although the sensitivity of the ear varies with frequency and is most sensitive to sounds with frequencies between 500 Hz and 4,000 Hz. Wind turbines do produce low frequency sounds [(13)], but our threshold of hearing at such low frequencies is relatively high and they therefore go unnoticed. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles.

3.2.2 In 2004, the former DTI commissioned The Hayes McKenzie Partnership to report on claims that infrasound or LFN emitted by wind turbine generators (WTGs) were causing health effects. Of the 126 wind farms operating in the UK, five had reported LFN problems, therefore, such complaints are an exception, rather than a general problem that exists for all wind farms. Hayes McKenzie investigated the effects of infrasound and LFN at three wind farms for which complaints had been received and the results were reported in May 2006 [(14)]. The report concluded that:

- *'infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour;*
- *low frequency noise was measurable on a few occasions but below the existing permitted Night Time Noise Criterion. Wind turbine noise may result in internal noise levels within a dwelling that is just above the threshold of audibility, however at all sites it was always lower than that of local road traffic noise;*
- *that the common cause of complaint was not associated with LFN, but the occasional audible modulation of aerodynamic noise especially at night. Data collected showed that the internal noise levels were insufficient to wake up residents at these three sites. However once awoken, this noise can result in difficulties in returning to sleep.'*

3.2.3 The Applied and Environmental Geophysics Research Group at Keele University was commissioned by the Ministry of Defence (MOD), the DTI and the British Wind Energy Association (BWEA) to undertake microseismic and infrasound monitoring of LFN and vibrations from wind farms for the purposes of siting wind farms in the vicinity of Eskdalemuir in Scotland. Whilst the testing showed that vibration can be detected several kilometres away from wind turbines, the levels of vibration from wind turbines were so small that only the most sophisticated instrumentation can reveal their presence and they are almost impossible to detect. Nevertheless, the Renewable Energy Foundation alleged potential adverse health effects and when that story was picked up in the popular press, notably the Scotsman, the report's authors expressed concern over the way in which their work had been misinterpreted and issued a rebuttal statement (15) in August 2005:

'Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise – they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health.'

3.2.4 In response to concerns that wind turbines emit infrasound and cause associated health problems, Dr Geoff Leventhall, Consultant in Noise Vibration and Acoustics and author of the Defra Report on Low Frequency Noise and its Effects, said in the article in the Scotsman ('Wind farm noise rules 'dated'- James Reynolds, 5 August 2005'):

'I can state quite categorically that there is no significant infrasound from current designs of wind turbines.'

3.2.5 An article (16) published in the IOA Bulletin (March/April 2009) concluded that there is no robust evidence that either low frequency noise (including 'infrasound') or ground-borne vibration from wind farms, has an adverse effect on wind farm neighbours.

3.2.6 Work (17) by Dr Leventhall looked at infrasound levels within the ear compared to external sources and concluded:

'The conclusion is that the continuous inner ear infrasound levels due to internal sources, which are in the same frequency range as wind turbine rotational frequencies, are higher than the levels produced in the inner ear by wind turbines, making it unlikely that the wind turbine noise will affect the vestibular systems, contrary to suggestions made following the measurements at Shirley. The masking effect is similar to that in the abdomen (Leventhall 2009). The body, and vestibular systems, appear to be built to avoid disturbance from the high levels of infrasound which are produced internally from the heartbeat and other processes. In fact, the hearing mechanisms and the balance mechanisms, although in close proximity, have developed to minimise interaction (Carey and Amin 2006).'

3.2.7 During a planning Appeal in Scotland (PPA-310-2028, Clydeport Hunterston Terminal Facility, approximately 2.5 km south-west of Fairlie, 9 Jan 2018), the health impacts related to LFN associated with wind turbines were considered at length by the appointed Reporter (Mr M Croft). The Reporter considered evidence from Health Protection Scotland and the National Health Service. In addition, he also considered LFN surveys undertaken by the Appellant and the Local Authority, both of which demonstrated compliance with planning conditions and did not identify any problems attributable to the turbine operations; some periods with highest levels of low frequency noise were in fact recorded when the turbines were not operating.

3.2.8 The Reporter concluded that:

- The literature reviews by bodies with very significant responsibilities for the health of local people found insufficient evidence to confirm a causal relationship between wind turbine noise and the type of health complaints cited by some local residents;
- The NHS's assessment is that concerns about health impact are not supported by good quality research; and
- Although given the opportunity, the Community Council failed to provide evidence that can properly be set against the general tenor of the scientific evidence.

3.2.9 The WSP BEIS Report notes on page 115 that:

'Several studies have investigated the claimed links between adverse health symptoms and infrasound emissions from wind turbines. Although some experimental studies have linked infrasonic signals with activation of physiological sensory processing[315,316], these have tended to be based on signals that are not representative of wind turbine infrasound. There remains no compelling evidence of adverse health effects associated with wind turbine infrasound exposure at sound frequencies and' levels expected to be present at noise-sensitive receptor locations in the vicinity of wind farms'

3.2.10 The WSP BEIS Report goes on to note on page 116 that:

'Overall, the findings from the existing evidence base indicate that infrasound from wind turbines at typical exposure levels has no direct adverse effects on physical or mental health, and reported symptoms of ill-health are more likely to be psychogenic in origin.'

3.2.11 It is noted that research into infrasound is ongoing but the WSP BEIS report concluded that:

'It is expected that further evidence from ongoing studies into wind turbine infrasound effects will emerge soon, in particular from the NHMRC studies in Australia. However, based on the existing scientific evidence, it does appear probable that the above findings will not be contradicted by newer evidence.'

3.2.12 Since the publication of the WSP BEIS report, the study that was granted funding by NHMRC (the National Health and Medical Research Council of Australia) was published in the Environmental Health Perspectives (EHP) journal which is published by the United States National Institute of Environmental Health. The study [(18)] aimed to test the effect of exposure to 72 hours of infrasound (designed to simulate a wind turbine infrasound signature) exposure on human physiology, particularly sleep. The study concluded that:

'Our findings did not support the idea that infrasound causes WTS[3]. High level, but inaudible, infrasound did not appear to perturb any physiological or psychological measure tested in these study participants.'

[3] WTS stands for Wind Turbine Syndrone which is a term for adverse human health effected related to the proximity of wind turbines.

3.2.13 It is therefore considered unnecessary to carry out specific assessments of Infrasound, LFN and Vibration, and it has not been considered further in the noise assessment.

3.3 Amplitude Modulation of Aerodynamic Noise (AM)

3.3.1 In the context of wind turbine noise, amplitude modulation describes a variation in noise level over time; for example, observers may describe a 'whoosh whoosh' sound, which can be heard close to a wind turbine as the blades sweep past. Amplitude Modulation of aerodynamic noise is an inherent characteristic of wind turbine noise and was noted in ETSU-R-97, on page 68:

'The modulation or rhythmic swish emitted by wind turbines has been considered by some to have a characteristic that is irregular enough to attract attention. The level and depth of modulation of the blade noise is, to a degree, turbine-dependent and is dependent upon the position of the observer. Some wind turbines emit a greater level of modulation of the blade noise than others. Therefore, although some wind turbines might be considered to have a character that may attract one's attention, others have noise characteristics which are considerably less intrusive and unlikely to attract one's attention and be subject to any penalty.

This modulation of blade noise may result in a variation of the overall A-weighted noise level by as much as 3dBA (peak to trough) when measured close to a wind turbine. As distance from the wind turbine [or] wind farm increases, this depth of modulation would be expected to decrease as atmospheric absorption attenuates the high frequency energy radiated by the blade.'

3.3.2 In recent times the Acoustics community has sought to make a distinction between the AM discussed within ETSU-R-97, which is expected at most wind farms and as such may be considered as 'Normal Amplitude Modulation' (NAM), compared to the unusual AM that has sometimes been heard at some wind farms, hereinafter referred to as 'Other Amplitude Modulation' (OAM). The term OAM is used to describe an unusual feature of aerodynamic noise from wind turbines, where a greater than normal degree of regular fluctuation in sound level occurs at blade passing frequency, typically once per second. In some appeal decisions it may also be referred to as 'Excess Amplitude Modulation' (EAM). It should be noted that the noise assessment and rating procedure detailed in ETSU-R-97 fully takes into account the presence of the intrinsic level of NAM when setting acceptable noise limits for wind farms.

3.3.3 On 16 December 2013, RenewableUK (RUK) released six technical papers (19) on AM, which reflected the outcomes of research commissioned over the previous three years, together with a template planning condition. Whilst this research undoubtedly improved understanding of Other Amplitude Modulation (OAM) and its effects, it should be noted that at the time of writing it has not been endorsed by any relevant body such as the Institute of Acoustics (IOA).

3.3.4 On 22 January 2014, the IOA released a statement regarding the RUK research and the proposed planning condition to deal with the issue of amplitude modulation from a wind turbine and stated:

'This research is a significant step forward in understanding what causes amplitude modulation from a wind turbine, and how people react to it. The proposed planning

condition, though, needs a period of testing and validation before it can be considered to be good practice. The IOA understands that RenewableUK will shortly be making the analysis tool publicly available on their website so that all interested parties can test the proposed condition, and the IOA will review the results later in the year. Until that time, the IOA cautions the use of the proposed planning condition.'

3.3.5 Research regarding amplitude modulation continued. In April 2015, the IOA issued a discussion document entitled *'Methods for Rating Amplitude Modulation in Wind Turbine Noise'*. The document presented three methods that can be used to quantify the level of AM at a given measurement location. After extensive consultation a preferred method of measuring OAM, which provides a framework for practitioners to measure and rate AM, was recommended by the IOA.

3.3.6 On 3 August 2015, the UK Department for Energy and Climate Change (DECC), now the Department for Business, Energy and Industrial Strategy (BEIS), commissioned independent consultants WSP Parsons Brinkerhoff to carry out a literature review on OAM (which they refer to simply as AM). The stated aims were as follows:

- *'To review the available evidence on Amplitude Modulation (AM) in relation to wind turbines, including but not limited to the research commissioned and published by RenewableUK in December 2013;*
- *To work closely with the Institute of Acoustics' AM working group, who are expected to recommend a preferred metric and methodology for quantifying and assessing the level of AM in a sample of wind turbine noise data;*
- *To review the robustness of relevant dose response relationships, including the one developed by the University of Salford as part of the RenewableUK study, on which the correction (or penalty) for amplitude modulation proposed as part of its template planning condition is based;*
- *To consider how, in a policy context, the level(s) of AM in a sample of noise data should be interpreted, in particular determining at what point it causes a significant adverse impact;*
- *To recommend how excessive AM might be controlled through the use of an appropriate planning condition; and*
- *To consider the engineering/cost trade-offs of possible mitigation measures.'*

3.3.7 Their report, which was released in October 2016, concluded that there is sufficient robust evidence that excessive AM leads to increased annoyance from wind turbine noise and recommended that excessive AM is controlled through a suitably worded planning condition, which will control it during periods of complaint. Those periods should be identified by measurement using the metric proposed by the work undertaken by the IOA, and enforcement action would rely upon professional judgement by Local Authority Environmental Health Officers based on the duration and frequency of occurrence.

3.3.8 It is not clear within the body of the report which evidence the authors relied upon to arrive at their conclusions, although the Executive Summary states (page 4);

"It is noted that none of the Category 1 or 2 papers have been designed to answer the main aim of the current review in its entirety. The Category 1 studies have limited representativeness due to sample constraints and the artificiality of laboratory

environments, whereas the Category 2 studies generally do not directly address the issue of AM WTN exposure-response. A meta – analysis of the identified studies was not possible due to the incompatibility of the various methodologies employed. Notwithstanding the limitations in the evidence, it was agreed with DECC that the factors to be included in a planning condition should be recommended based on the available evidence, and supplemented with professional experience".

3.3.9 The report [20] states that any planning condition must accord with existing planning guidance, and should be subject to legal advice on a case by case basis. Existing guidance would include compliance with the six tests of a planning condition embodied in Circular 4/98. The report's authors did not dictate a particular condition to be used but did suggest that any condition should include the following elements (p5):

- *"The AM condition should cover periods of complaints (due to unacceptable AM);*
- *The IoA-recommended metric should be used to quantify AM (being the most robust available objective metric);*
- *Analysis should be made using individual 10-minute periods, applying the appropriate decibel 'penalty' to each period, with subsequent analysis;*
- *The AM decibel penalty should be additional to any decibel penalty for tonality; and*
- *An additional decibel penalty is proposed during the night time period to account for the current difference between the night and day limits on many sites to ensure the control method works during the most sensitive period of the day."*

3.3.10 AM was considered in the WSP BEIS report. The report notes that the IOA Method provides a suitable approach to measure and quantify AM (whilst noting that work is ongoing to refine the approach) but also highlights that further work is required to develop a robust mechanism for controlling AM that could be incorporated into a planning condition. In relation to the potential adoption of a penalty scheme to control AM the WSP BEIS report notes on page 208 that:

'In practice, the details of applying such a penalty scheme are complicated by the complexities of wind turbine sound measurements. These often involve a considerable amount of data filtering and data aggregation to address the practical difficulties of measuring a highly variable source, which is often also at a level that is relatively low compared with other, fluctuating residual sounds present in the acoustic environment. Such details will need to be carefully considered in further study, and the example planning condition proposed by a group of IOA members in 2017 [505] should be considered as a starting point.'

3.3.11 Until such a 'further study' is completed, and additional guidance is published, the approach set out in the IOA GPG remains valid, the document states (paragraph 7.2.10):

'7.2.1 The evidence in relation to "Excess" or "Other" Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM.'

3.3.12 THC stated in their Scoping Opinion for the Proposed Development that there is no definitive Planning guidance on AM. They stated that in the event that there were any complaints linked to AM then they could be investigated in terms of the Statutory Nuisance provisions of the Environmental Protection Act 1990. On that basis Amplitude Modulation has not been considered further in this assessment.

4 Methodology

4.1 Assessing Operational Noise Impact

4.1.1 To undertake an assessment of the operational noise impact in accordance with the requirements of ETSU-R-97 and the IOA GPG, the following steps are required:

- Specify the location of the wind turbines for the Proposed Development;
- Determine the background noise levels as a function of on-site wind speed at a selection of representative Noise Monitoring Locations (NML);
- Identify the locations of all nearby noise sensitive receptors and select a sample of relevant Noise Assessment Locations (NAL). For each NAL, identify the most representative measured background noise data;
- Establish for each NAL the 'Total ETSU-R-97 Noise Limits' on analysis of the measured background noise levels;
- Specify the likely noise emission characteristics of the wind turbines for the Proposed Development and all nearby cumulative wind turbines;
- Calculate the likely noise immission levels due to the cumulative operation of all relevant wind turbines and compare it to the Total ETSU-R-97 Noise Limits;
- Determine the 'Site Specific Noise Limits' which take account of the noise limit already allocated to/ that could theoretically be used by other schemes in the area; and
- Calculate the likely noise immission levels due to the operation of the Proposed Development on its own and compare it to the Proposed Development's 'Site Specific Noise Limits'.

4.1.2 In order to consider the steps outlined above the assessment has been split into three separate stages:

- Stage 1 – determine existing Total ETSU-R-97 Noise Limits (which are applicable to noise from all wind turbines in the area operating concurrently) at noise sensitive receptors;
- Stage 2 – undertake a cumulative assessment where noise predictions from the Proposed Development are within 10 dB of the total noise predictions from the other wind farms/turbines within the area; and
- Stage 3 – establish the Proposed Development's Site Specific Noise Limits (at levels below the Total ETSU-R-97 Noise Limits, where limit apportionment is required) and compare the noise predictions from the Proposed Development on its own against the proposed 'Site Specific Noise Limits'.

4.1.3 There are a range of turbine makes and models that may be appropriate for the Proposed Development. In the absence of a confirmed turbine model, this noise assessment models a candidate turbine, the Vestas V162 6.8 MW with serrated trailing edge blades and a hub height of 139 m. The turbine was selected as it is representative of the turbine type which could be installed at the Site. The final selection of turbine will follow a competitive tendering process and thus the final model of turbine may differ from those on which this assessment has been based. However, the final choice of turbine will be required to comply with the noise limits which have been established for the Proposed Development.

4.2 Consultation

The Highland Council Scoping Response (dated July 2022)

4.2.1 In the Scoping Response, the Highland Council (THC) stated that the noise assessment should be undertaken in accordance with ETSU-R-97 and current good practice (IOA GPG). The response stated the following in relation to noise limits:

'the target noise levels are either a simplified 35 dB at wind speed up to 10m/s or if background noise data available a composite standard of 35 dB daytime and 38 dB night time or up to 5dB above background levels. These limits would also apply to cumulative noise levels from more than one development.'

4.2.2 THC requested that the cumulative assessment take account of predicted and consented levels and that if a reduction is made for a controlling property or another reason then it should be made clear in the assessment.

4.2.3 THC recommended that if a background noise assessment was undertaken then monitoring locations be agreed in advance with the Council's Environmental Health Officer (EHO).

4.2.4 TNEI undertook further detailed consultation with the Council in June 2023 regarding the noise limits proposed for the Proposed Development. Further information is detailed in Sections 4.2.7 – 4.2.8 below.

The Scottish Government's Energy Consents Unit Scoping Opinion (dated September 2022)

4.2.5 The Scottish Government's Energy Consents Unit stated '*It is recommended by the Scottish Ministers that the final list of receptors in respect of noise assessment should be agreed following discussion between the Company and the Highland Council.*

4.2.6 The noise assessment report should be formatted as per Table 6.1 of the IOA *"A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise."*

Consultation with Highland Council EHO (June 2023)

4.2.7 In June 2023, TNEI undertook additional consultation with the Council's Environmental Health Officer (EHO) in order to provide further information on the proposed noise assessment methodologies (use of ETSU-R-97 and the IOA GPG) including the proposed re-use of the previously collected background noise datasets from Halsary wind farm, the approach to wind shear and adjusting limits to consider the higher hub heights being proposed for the Proposed Development. In addition, information on proposed noise assessment locations and cumulative turbines to be considered in the cumulative noise assessment were provided.

4.2.8 Information on the choice of FML was also provided. Given the number of existing schemes, a daytime limit towards the upper end of the range 35-40 dB was suggested and that the noise assessment would provide justification for the final choice of FML. An Environmental Health Officer (EHO) from THC stated that they agreed with:

- the proposed assessment methodology (ETSU-R-97 and IOA GPG);
- the re-use of the Halsary data (adjusted to take account of wind shear); and
- to the use of available significant headroom with a +2 dB margin above predicted noise levels when deriving Site Specific Noise Limits for the Proposed Development.

4.2.9 The EHO acknowledged that:

'this a very busy part of the world in terms of wind farm activity and I understand that the only way forward for future development is to increase fixed limits beyond which Highland Council would normally look for. As you have mentioned any proposal to increase daytime fixed limits beyond 35dB LA90 would need to be accompanied by an argument supporting that decision in terms of the criteria identified in ETSU i.e. number of dwellings in the neighbourhood of the wind farm, the effect of noise limits on the number of kWh generated and the duration and level of exposure.'

4.2.10 The fixed minimum limits adopted for this assessment are detailed in Section 6.4. The justification for the choice of fixed minimum limit is included within Table 6.11. The night time noise limits have been based upon 43 dB or background plus 5 dB whichever is the greater in accordance with Government Guidance. A copy of the full consultation letter and subsequent response is included within Annex 2.

4.3 Setting the Total ETSU-R-97 Noise Limits (Stage 1)

Background Noise Levels and Wind Shear

4.3.1 Wind shear can be defined as *'the change in the relationship between wind speed at different heights'.* Due to wind shear, wind speeds recorded on one meteorological mast at different heights are usually different, generally the higher the anemometer the higher the wind speed recorded. For example, if a wind speed of 4 ms^{-1} is recorded at 80 m height, 3.5 ms^{-1} may be recorded at 40 m and 2.5 ms^{-1} may be recorded at 10 m.

4.3.2 Hub height wind speed is the key wind speed for a wind farm noise assessment, as it is the wind speed at hub height which will determine the noise emitted by the wind turbines and informs the turbine control system. Ideally, both wind turbine noise predictions and background noise level measurements should refer to hub height wind speed (or a representation thereof), ensuring that there is no discrepancy between the wind speed at which the noise is emitted and the wind speed at which the corresponding background noise is measured.

4.3.3 The IOA GPG set outs out in Section 5.2.3 four methods which can be used to determine suitable background noise levels in areas where measured levels have the potential to be influenced by operational wind turbines. The fourth option states that assessments can be undertaken:

'utilising background noise level data as presented within the Environmental Statement/s for the original wind farm/s (the suitability of the background noise level data should be established).'

4.3.4 The IOA GPG goes on to state, in Section 5.2.4, that:

'If the developer wishes to utilise previously presented background noise level data, care should also be taken with respect to any differences in wind speed conditions between the original and proposed site. The underlying principle of ETSU-R-97 requires that the background noise levels at any given location must be correlated with the wind speeds measured on the wind farm site of interest. Where a systematic difference exists between the wind conditions on the two sites, then a correction will need to be applied, meaning that the derived background noise curves for the two sites will be different.'

4.3.5 The approach used to account for wind shear when considering background noise levels for properties proximate to the Proposed Development is detailed in Section 5.1 below.

Noise Impact Criteria in ETSU-R-97

4.3.6 As detailed in Section 2.6.9 above, ETSU-R-97 suggests that the daytime fixed minimum limit should be set somewhere in the range between 35 and 40 dB. The precise choice of criterion level within the range 35 - 40 dB(A) depends on a number of factors, including the number of dwellings in the neighbourhood of the wind farm, the effect of noise limits on the number of kWh generated and the duration and level of exposure to any noise. The fixed minimum limits adopted for this assessment are detailed in Section 6.4.

4.3.7 The acceptable limits for wind turbine operational noise are clearly defined for all time periods by the application of the ETSU-R-97 methodology. Consequently, the test applied to operational noise is whether or not the predicted wind turbine noise immission levels at nearby noise sensitive properties lie below the ETSU-R-97 noise limits. Depending on the levels of background noise, the satisfaction of the ETSU-R-97 derived limits can lead to a situation whereby, at some locations under some wind conditions and for a certain proportion of the time, the wind turbine noise would be audible.

4.4 Assessment of likely effects and the requirement for a cumulative assessment (Stage 2)

4.4.1 The IOA GPG (2013) includes a detailed section on cumulative noise and provides guidance on where a cumulative assessment is required. Section 5.1.4 and 5.1.5 of the GPG state:

'During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.

Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary.'

4.4.2 An assessment was undertaken at each of the noise sensitive receptors proximate to the Proposed Development and other nearby operational and consented wind farm developments to determine whether the wind turbine noise immissions from the Proposed Development were within 10 dB of the wind turbine noise immissions from the other schemes. Where predictions were found to be within 10 dB of each other, then a cumulative noise assessment was undertaken to determine the likely impacts of the Proposed

Development, however, if wind turbine immissions were greater than 10 dB apart then a cumulative noise assessment was not required.

Noise Prediction / Propagation Model

4.4.3 The ISO 9613-2: 1996 *'Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation'* (21) model algorithm provides a robust prediction method for calculating the noise immission levels at the nearest receptors. A European Commission (EC) research project into wind farm noise propagation over large distances, published as 'Development of a Wind Farm Noise Prediction Model,' JOULE project JOR3-CT95-0051 in 1998, identified a simplified version of ISO 9613-2 as the most suitable at that time, but the full method has been used for this assessment.

4.4.4 The use of ISO 9613-2 is discussed in the IOA GPG which states, in Section 4.1.4:

'ISO 9613-2 standard in particular, which is widely used in the UK, can be applied to obtain realistic predictions of noise from on-shore wind turbines during worst case propagation conditions (i.e. sound speed gradients due to downwind conditions or temperature inversions), but only provided that the appropriate choice of input parameters and correction factors are made.'

4.4.5 There is currently no standard approach to specifying error bands on noise predictions. Table 5 of ISO 9613-2 suggests, at best, an estimated of accuracy of ± 3 dB(A). The work undertaken as part of the EC research study concluded that the ISO 9613-2 algorithm reliably predicted noise levels that would generally occur under downwind propagation conditions. The error bands referenced in the ISO standard itself relate to the general application of the standard. Additional, wind farm specific studies, have also been undertaken to validate the use of the standard to predict wind farm noise and these are referenced in Section 4 of the IOA GPG which goes on to conclude that: *"The outcome of this research has demonstrated that the ISO 9613-2 standard in particular, which is widely used in the UK, can be applied to obtain realistic predictions of noise from on-shore wind turbines during worst case propagation conditions (i.e. sound speed gradients due to downwind conditions or temperature inversions), but only provided that the appropriate choice of input parameters and correction factors are made."* TNEIs experience of undertaking compliance monitoring for operational wind farms indicates that the predictions undertaken using the guidance in the IOA GPG show a good correlation with measured levels (with predicted noise levels usually slightly higher than measured levels).

4.4.6 The ISO 9613-2 model can take account of the following factors that influence sound propagation outdoors:

- Geometric divergence;
- Atmospheric absorption;
- Reflecting obstacles;
- Screening;
- Vegetation; and
- Ground attenuation.

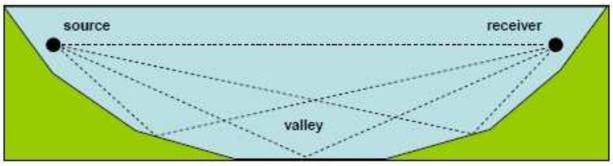
4.4.7 The model uses as its acoustic input data the octave band sound power output of the turbine and calculates, on an octave band basis, attenuation due to the factors above, as appropriate.

4.4.8 The IOA GPG quotes a comparative study undertaken in Australia that indicated ISO 9613-2 can, in some conditions, under-predict ground attenuation effects and the potential for additional reflection paths ‘across a valley’, whilst slightly over-predicting on flat terrain. It should be noted, however, that the wind farm layouts studied were untypical for the UK, with rows of turbines spreading over 10 km on an elevated ridge. It also should be noted that no correction for background contribution was undertaken and the monitoring locations were located as far as 1.7 km from the nearest turbine, where turbine noise may be at similar levels to background noise and therefore difficult to differentiate. For the study’s modelling work topographic height data was included as an input, which is consistent with ISO 9613-2 methodology generally, but not with the requirements of the IOA GPG.

4.4.9 The model used in this assessment does not model barrier attenuation using the method in ISO 9613-2, but instead uses the guidance in the IOA GPG to consider whether any topographical corrections are required as set out below in Sections 4.4.10 to 4.4.13. Any differences in ground height (AOD) between the receptors and the turbines are considered when calculating the propagation distance between each source and receiver.

4.4.10 The IOA GPG states that a *‘further correction of +3 dB should be added to the calculated overall A-weighted level for propagation ‘across a valley’, i.e. a concave ground profile or where the ground falls away significantly between a turbine and the receiver location.’* The potential reflection paths are illustrated in Schematic 4.1 below.

Schematic 4.1: Multiple reflection paths for sound propagation across concave ground



Source: IOA GPG, page 21, Figure 5

4.4.11 A formula from the JOULE Project JOR3-CT95-0051 dated 1998 is suggested for determining whether a correction is required.

$$h_m \geq 1.5 \times (abs\ (h_s - h_r) / 2)$$

where h_m is the mean height above the ground of the direct line of sight from the receiver to the source (as defined in ISO 9613-2, Figure 3), and h_s and h_r are the heights above local ground level of the source and receiver respectively).

4.4.12 The calculation of h_m requires consideration of the digital terrain model and needs to be performed for each path between every turbine and every receiver. Interpretation of the results of the calculation above and the subsequent inclusion of a concave ground profile correction requires careful consideration with any topographical variation considered in the context of a site.

4.4.13 The IOA GPG also discusses the potential for topographical screening effects of the terrain surrounding a wind farm and the nearby noise sensitive receptors. Although barrier screening effects in ISO 9613-2 can make corrections of up to 15 dB, the IOA GPG states that where there is no line of sight between the highest point on the rotor and the receiver location a reduction of no more than 2 dB may be applied.

4.4.14 The modelling parameters used in this assessment are detailed in Section 6.3 below.

4.5 Setting the Site Specific Noise Limits (Stage 3)

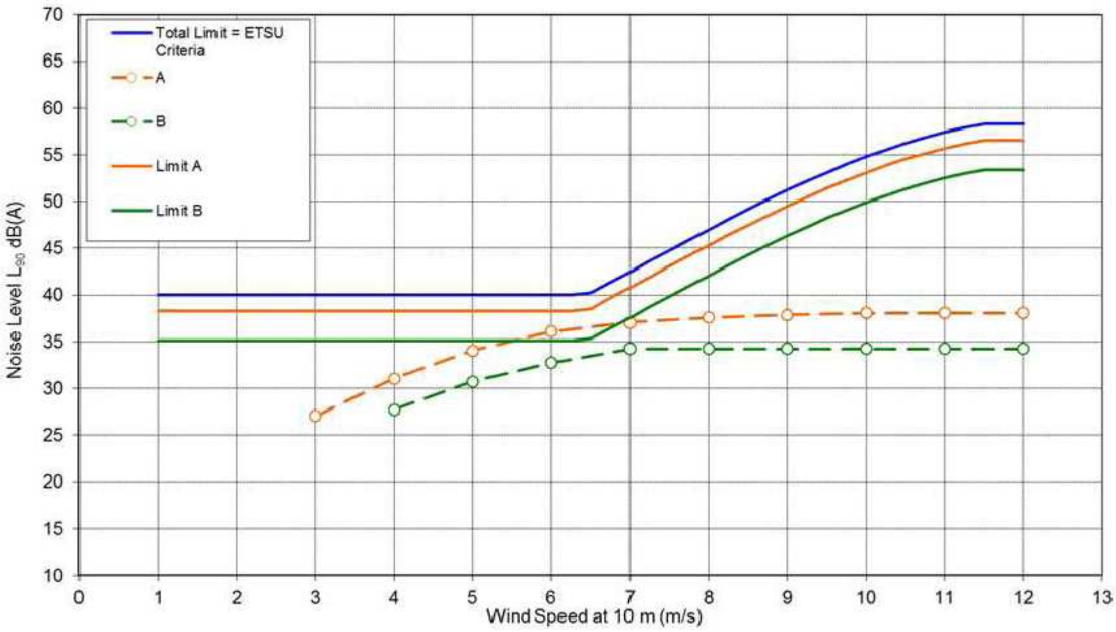
4.5.1 Summary Box 21 of the IOA GPG states:

'Whenever a cumulative situation is encountered, the noise limits for an individual wind farm should be determined in such a way that no cumulative excess of the total ETSU-R-97 noise limit would occur.'

4.5.2 In order to determine site specific noise limits at receptors in proximity to the Proposed Development (where required) limit apportionment has been undertaken. The limit apportionment has considered the noise limit already allocated to other wind farms in the area.

4.5.3 This approach is demonstrated in Graph 4.1 below. In this example the Total ETSU-R-97 Noise Limit (shown in blue) is shared between two proposed developments (A and B). The two noise limits for a given receptor (the solid orange and green lines) when added together equate to the Total ETSU-R-97 Noise Limit, and the predicted levels for each wind farm (the dashed lines) meet the specific limits established for consented wind farm and the Proposed Development.

Graph 4.1: Limit Apportionment Example



4.5.4 The limit derivation can also be undertaken with consideration to the amount of headroom between another schemes(s) predictions and the Total Noise Limit. With regard to this Section 5.4.11 of the IOA GPG states:

'In cases where there is significant headroom (e.g. 5 to 10 dB) between the predicted noise levels from the existing wind farm and the Total Noise Limits, where there would be no realistic prospect of the existing wind farm producing noise levels up to the Total Noise Limits, agreement could be sought with the LPA as to a suitable predicted noise level (including an appropriate margin to cover factors such as potential increases in noise) from the existing

wind farm to be used to inform the available headroom for the cumulative assessment without the need for negotiation or cumulative conditioning. This may be the case particularly at low wind speeds.'

4.5.5 With this in mind, where appropriate, an additional 2 dB buffer has been added to the other schemes' turbine noise predictions. This is considered to be a suitable buffer in accordance with Section 5.4.11 of the IOA GPG and would represent a 60% increase in emitted noise levels from the other schemes.

4.5.6 Where predicted wind turbine noise levels from the individual wind farm/ turbine schemes are found to be >10 dB below the Total ETSU-R-97 Noise Limits then it has been deemed appropriate to allocate the entire noise limit to the Proposed Development. Further information on the approach to apportionment is provided in Section 6.6 below.

5 Baseline

5.1 Background Noise Survey

5.1.1 Background noise monitoring has been undertaken at a number of properties proximate to the Proposed Development as part of the November 2009 Environmental Statement (ES) prepared for Halsary Windfarm. Extracts from the relevant noise reports are included within Annex 3.

5.1.2 The background noise datasets collected as part of Halsary Windfarm have been adjusted to take account of wind shear such that they correlate with wind speeds at the Proposed Development site. The steps below outline the process that was adopted:

- A wind resource model was created by Natural Power.
- The model considered wind speed data from a meteorological mast and Lidar unit and this was used to determine 'speed up values' to determine the ratio of the wind speeds at the height of the 70 m mast used for Halsary Wind Farm and the proposed hub height (139 m) at the Proposed Development. A speed up factor of 1.15 indicates that measurements of 1 ms^{-1} at the mast located near Halsary are expected to equate to a wind speed of 1.15 ms^{-1} at the proposed development. The standard deviation of the speed up factor was also calculated for each 1 ms^{-1} wind speed bin.
- The data provided by Natural Power were then used by TNEI to adjust the background noise data using the following steps:
    - The background noise levels presented for Halsary Wind Farm (which were standardised to 10 m) were presented relative to wind speed at 70 m;
    - The background noise levels were then set relative to hub height (139 m) at the proposed development site. This was achieved by multiplying the values by the average speed up value plus one standard deviation (to represent a cautious approach); and
    - The background noise levels were then set relative to standardised wind speeds at the proposed development site to accord with good practice.

5.1.3 The adjustments applied, along with the accompanying wind shear report are included within Annex 4.

5.2 Prevailing Background Noise Level

5.2.1 Table 5.1 and Table 5.2 summarise the prevailing background noise levels measured during the survey undertaken for Halsary Wind Farm and also the shear adjusted data used in this assessment.

Table 5.1 Daytime background noise curves presented in the Halsary Wind Farm ES and their shear adjusted values for use on the proposed development

NML	Prevailing Background Noise Level $L_{A90,10\ min}$											
	1	2	3	4	5	6	7	8	9	10	11	12
Croft at Mybster (original)	22.9	23.7	25.4	27.7	30.3	33.1	35.7	38.1	39.9	41.1	41.6	41.1
Croft at Mybster† (adjusted)	23.4*	23.4	24.5	26.1	28.0	29.9	32.2	34.3	36.3	38.2	40.0	41.2
Knockglass (original)	23.3	24.0	25.5	27.6	30.0	32.6	35.3	37.8	39.9	41.4	42.2	42.1
Knockglass† (adjusted)	23.6*	23.7	24.7	26.1	27.9	29.6	31.7	33.9	35.9	37.9	40.0	41.5
Backglass (original)	22.5	22.7	23.9	26.1	28.9	32.0	35.2	38.3	41.0	42.9	43.9	43.8
Backglass† (adjusted)	22.6*	22.6	23.3	24.6	26.5	28.5	31.0	33.5	36.0	38.5	41.1	43.1

† Dataset has been adjusted to account for the change in shear from the 70 m mast at Halsary Wind Farm to the 139 m hub heights for the proposed development.

** Dataset has been flatlined due to unavailability of data at 1 ms^{-1} resulting from the shear adjustment.*

Note: The data collected at Tacher and Shielton has not been adjusted as Tacher is not a noise assessment location for the Proposed Development due its separation distance and Shielton is unoccupied and will remain so for the lifetime of Watten Wind Farm should it be consented.

Table 5.2 Night-time background noise curves presented in the Halsary Wind Farm ES and their shear adjusted values for use on the proposed development.

NML	Prevailing Background Noise Level $L_{A90,10\ min}$											
	1	2	3	4	5	6	7	8	9	10	11	12
Croft at Mybster (original)	22.1	22.3	23.4	25.2	27.5	30.0	32.7	35.3	37.7	39.6	40.8	41.3
Croft at Mybster† (adjusted)	22.2*	22.2	22.8	23.8	25.3	27.1	29.0	30.8	32.8	35.7	37.8	39.1
Knockglass (original)	20.8	20.9	21.8	23.3	25.3	27.8	30.5	33.4	36.3	39.1	41.7	44.0
Knockglass† (adjusted)	20.9*	20.9	21.3	22.2	23.4	25.0	26.8	28.6	30.7	33.9	36.4	38.4

NML	Prevailing Background Noise Level $L_{A90,10\ min}$											
	1	2	3	4	5	6	7	8	9	10	11	12
Backglass (original)	21.0	21.5	22.0	22.9	24.4	26.8	30.0	33.8	37.8	41.5	44.3	45.4
Backglass† (adjusted)	21.3*	21.3	21.7	22.2	23.0	24.2	25.8	27.8	30.2	34.5	38.0	40.6

† Dataset has been adjusted to account for the change in shear from the 70 m mast at Halsary Wind Farm to the 139 m hub heights for the proposed development.

** Dataset has been flatlined due to unavailability of data at 1 ms^{-1} resulting from the shear adjustment.*

Note: The data collected at Tacher and Shielton has not been adjusted as Tacher is not a noise assessment location for the Proposed Development due its separation distance and Shielton is unoccupied and will remain so for the lifetime of Watten Wind Farm should it be consented.

6 Noise Assessment Results

6.1 Noise Assessment Locations

6.1.1 Noise assessment locations (NAL) refer to the position on the curtilage denoted by the blue house symbol on Figure A1.1 (Annex 1). A total of twelve noise sensitive receptors were chosen as representative NALs. The NALs chosen were the closest receptors to the Proposed Development and other wind farm developments. Predictions of wind turbine noise have been made at each of the NAL as detailed in Table 6.1.

6.1.2 This approach ensures that the report models the worst case (loudest) noise immission level expected at each group of noise sensitive receptors, as, generally speaking, sound levels decrease due to the attenuating factors described in Section 6.3 and thus the closer to a noise source, the higher the noise level. Table 6.1 details which NML has been used to determine noise limits for each NAL, the rationale setting out the approach used was detailed in the consultation letter sent to the Council (which is included in Annex 2). As detailed in Annex 2, THCs EHO agreed with the choice of background datasets.

Table 6.1 Noise Assessment Locations

Noise Assessment Location (NAL)	Easting (m)	Northing (m)	Elevation (m AOD)	Approximate Distance to Nearest Watten Turbine* (m)	Background Noise Data Used
NAL1 - 21-22 West Watten	322129	951069	54	1,045 (T2)	Backglass
NAL2 - 18 West Watten**	322732	951988	60	1,230 (T2)	Backglass
NAL3 - 17 West Watten	323726	953001	30	2,476 (T2)	Backglass
NAL4 - Banks Lodge	323596	953668	37	2,734 (T2)	Backglass
NAL5 - 14 West Watten	322725	953796	56	2,246 (T1)	Backglass
NAL6 - Newton	321516	953837	81	1,650 (T1)	Backglass
NAL7 - Lanergill	319088	954460	87	2,931 (T5)	Backglass
NAL8 - Backlass Hill	320404	953609	83	1,540 (T1)	Backglass
NAL9 - Leanmore Lodge	320998	953313	87	1,080 (T1)	Backglass
NAL10 - Achnamoine	317790	953867	93	3,306 (T5)	Knockglass
NAL11 - Knockglass House	317440	953236	102	3,102 (T6)	Knockglass
NAL12 – Mybster	316910	952189	100	3,063 (T6)	Croft at Mybster

** Please note the distances to nearest turbines quoted above may differ from those reported elsewhere. Distances for the noise assessment are taken from the nearest turbine to the closest edge of the amenity area (usually the garden).*
*** the occupiers are financially involved with the Proposed Development.*

6.2 Noise Emission Characteristics of the Wind Turbines

6.2.1 There are a range of wind turbine models which may be suitable for installation at the Proposed Development. This assessment considers the Vestas V162 6.8 MW with serrated trailing edge blade and a hub height of 139 m.

6.2.2 The turbines considered in the cumulative assessment are summarised in Annex 5. Details of the sound power level, octave data and measurement uncertainty used for the turbines considered in this assessment are included in Annex 6. Due to the differences in the way in which levels are provided by the different manufacturers, TNEI has accounted for uncertainty using the guidance contained within Section 4.2 of the IOA GPG. The data for some turbines has not been included due to data confidentiality. The detailed noise data would be available upon request subject to the signing of the appropriate Non Disclosure Agreement.

6.2.3 Manufacturer data is usually supplied based on a specific hub height whilst values are presented as standardised to 10 m height. The noise model used in this assessment alters turbine noise data to account for different hub heights, where applicable. The hub height modelled for the Proposed Development is 139 m. The hub heights considered for the other wind farm/turbine developments are summarised in Annex 5.

6.2.4 The location of the wind turbines are shown on Figure A1.1a and grid references are included in Annex 5.

6.3 Noise Propagation Parameters

6.3.1 As detailed in Section 4.4 above, the full version of the ISO 9613-2 model has been used to calculate the noise immission levels at the nearest receptors.

6.3.2 For the purposes of the present assessment, all noise level predictions have been undertaken using a receiver height of 4.0 m above local ground level, mixed ground (G=0.5) and air absorption co-efficients based on a temperature of 10 °C and 70 % relative humidity to provide a realistic impact assessment. The modelling parameters reflect current good practice as detailed within the IOA GPG.

6.3.3 The wind turbine noise immission levels are based on the $L_{A90,10\ minute}$ noise indicator in accordance with the recommendations in ETSU-R-97, which were obtained by subtracting 2dB(A) from the turbine sound power level data (L_{Aeq} indicator).

6.3.4 A topographical assessment has been undertaken between each noise sensitive receptor and wind turbine location to determine whether any concave ground profiles exist between the source and receiver (noise sensitive receptor). Analysis undertaken using a combination of CadnaA [22] and an Excel model found that if the formula in the IOA GPG is applied directly a +3 dB correction is required for some turbines at a number of receptors as summarised in Annex 5.

6.3.5 In addition, an assessment has been undertaken to determine whether any topographical screening effects of the terrain occur where there is no direct line of sight between the highest point on the turbine rotor and the receiver location. Upon analysis of each noise sensitive receptor it was found that a barrier correction of -2 dB could be applied for some turbines at a number of receptors as detailed in Annex 5. In reality, there is significant screening at some of the locations so more attenuation may occur in practice, the use of a 2 dB value is therefore considered to be conservative as it results in the highest predicted levels. All corrections have been applied, where necessary, in all of the Tables and Graphs in this report.

6.3.6 The need to include a concave ground/screening correction may change depending on the final location of the turbines (following micrositing) and the final turbine hub height. Nevertheless, turbine noise levels will have to meet the noise limits detailed in planning conditions regardless of any difference in noise propagation caused by topography. Should planning permission be granted, the need to apply a concave slope correction will need to be considered by the Applicant prior to the final selection of a turbine model for the Proposed Development.

6.3.7 The cumulative assessment has taken into account directivity effects in line with good practice. The directivity of wind turbines has been recognised for some time. Building on earlier work by NASA, in 1988 Wyle Laboratories studied sound propagation using an omnidirectional loudspeaker source elevated 80 ft above ground, in upwind, downwind and cross wind situations, and in both flat and hilly terrain, then compared those measurements to measured data from actual wind turbines. Their study quantified directivity factors for a limited frequency range, but was unable to conclusively demonstrate the anticipated directivity effects on real wind turbines. It also highlighted, but was unable to explain, measured differences observed between flat and hilly terrain.

6.3.8 Hubbard (1990) (IOA GPG Section 4.4.3) described a number of factors believed to influence propagation and directivity, notably refraction caused by vertical wind and temperature gradients. In the downwind direction the wind gradient causes the sound rays to bend toward the ground, whereas in the upwind direction the rays curve upward away from the ground. Upwind of the turbine this results in a region of increased attenuation termed the ‘shadow zone’. The excess attenuation is frequency dependent, with lowest frequencies least attenuated. Relating this to the earlier NASA studies, Hubbard noted that the distance from the source to the edge of the shadow zone is related to the wind speed gradient and the elevation of the source, which for a typical turbine source was calculated to be approximately 5 times the source height.

6.3.9 This observation was adopted in the IOA GPG, which states (Section 4.4.2) ‘Such reductions (due to “shadow zone” refraction effects) will in practice only progressively come into play at distances of between 5 and 10 turbine tip heights’, while Section 4.4.3 provides graphical examples of increasing broadband directivity with increasing tip height scaling in both flat and hilly terrain, without qualifying either of those designations.

6.3.10 The IOA GPG recommends (Section 4.4.1) that directivity attenuation factors adopted in any assessment should be clearly stated. The TNEI noise model can consider the effect of directivity, and in line with current good practice the attenuation values used are in detailed in Table 6.2. These are based upon the examples given in the IOA GPG (Section 4.4.2), using interpolation where required, and adopt a single attenuation value for receptors between located more than 5 tip heights from a receiver.

Table 6.2 Wind Directivity Attenuation Factors used in Modelling

Direction (º)	0	15	30	45	60	75	90	105	120	135	150	165
Attenuation dB(A))	-10	-9.9	-9.3	-8.3	-6.7	-4.6	-2	0	0	0	0	0
Direction (º)	180	195	210	225	240	255	270	285	300	315	330	345
Attenuation (dB(A))	0	0	0	0	0	0	-2	-4.6	-6.7	-8.3	-9.3	-9.9

6.4 Total ETSU-R-97 Noise Limits (Stage 1)

6.4.1 The ETSU-R-97 noise limits are derived by establishing the 'best fit' correlation between background noise level and wind speed. These limits, sometimes referred to as the 'criterion curve', are based on a level 5 dB(A) above this best fit correlation curve, over a wind speed range from 0 to 12 ms^{-1}. Where the derived criterion curve for the daytime period lies below a fixed level in the range 35 – 40 dB(A) then ETSU-R-97 provides that the criterion curve may be set at an absolute level somewhere within that range.

6.4.2 When considering the cumulative impacts of the Proposed Development operating in conjunction with other operational, consented and proposed schemes a Fixed Minimum Limit of 38 dB has been adopted to establish the daytime Total ETSU-R-97 Noise Limit. This limit was chosen following a review of the noise predictions for nearby wind farms and with due regard to the guidance in ETSU-R-97 (see Section 6.7 below)

6.4.3 The only exception being 18 West Watten where the occupiers are financially involved with the Proposed Development therefore the Total ETSU-R-97 Noise Limits have been established based on a fixed minimum of 45 dB(A) or background noise plus 5 dB whichever is the greater during the daytime and night time periods.

6.4.4 Whilst a cumulative daytime Total ETSU-R-97 Noise Limit of 38 dB (or background noise plus 5 dB) is proposed, the Proposed Developments Site Specific Noise Limit has been set such that it never exceeds 35 dB (or background noise plus 5 dB whichever is the greater); this represents the lower end of the daytime limit that can be applied under in ETSU-R-97.

6.4.5 The Total ETSU-R-97 Noise Limits have been established for each of the NALs as detailed in Table 6.3 and Table 6.4 below, based on a fixed minimum of 38 dB(A) (daytime) or 43 dB(A) (Night time) or background plus 5 dB(A).

Table 6.3 Total ETSU-R-97 Noise Limits Daytime

Location	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 - 21-22 West Watten	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
NAL2 - 18 West Watten	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.1
NAL3 - 17 West Watten	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
NAL4 - Banks Lodge	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
NAL5 - 14 West Watten	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1

Location	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL6 - Newton	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
NAL7 - Lanergill	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
NAL8 - Backlass Hill	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
NAL9 - Leanmore Lodge	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
NAL10 - Achnamoine	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.9	40.9	42.9	45.0	46.5
NAL11 - Knockglass House	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.9	40.9	42.9	45.0	46.5
NAL12 - Mybster	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.3	41.3	43.2	45.0	46.2

Table 6.4 Total ETSU-R-97 Noise Limits Night Time

Location	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 - 21-22 West Watten	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL2 - 18 West Watten	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.6
NAL3 - 17 West Watten	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL4 - Banks Lodge	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL5 - 14 West Watten	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL6 - Newton	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL7 - Lanergill	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL8 - Backlass Hill	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL9 - Leanmore Lodge	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
NAL10 - Achnamoine	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4
NAL11 - Knockglass House	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4
NAL12 - Mybster	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.1

6.5 Predicting the requirement for a cumulative assessment and the likely effects (Stage 2)

6.5.1 A comparison has been undertaken of the predicted wind turbine noise immission levels from the Proposed Development alongside all other schemes at each of the identified noise sensitive receptors in order to demonstrate whether predictions are within 10 dB of each other. All turbines have been assumed to be operating in full mode. Table 6.5 below summarises the results and whether a cumulative noise assessment is required. As is detailed in Section 4.4 above, if the predictions are greater than 10 dB apart then a cumulative noise assessment is not required. Where predictions are found to be within 10 dB of each other then a cumulative assessment is required.

Table 6.5 Cumulative Assessment Requirement

Noise Assessment Location (NAL)	Are predicted wind turbine noise levels within 10 dB?	Is a cumulative assessment required?
NAL1 - 21-22 West Watten	YES	YES
NAL2 - 18 West Watten**	YES	YES
NAL3 - 17 West Watten	YES	YES
NAL4 - Banks Lodge	YES	YES
NAL5 - 14 West Watten	YES	YES
NAL6 - Newton	YES	YES
NAL7 - Lanergill	YES	YES
NAL8 - Backlass Hill	YES	YES
NAL9 - Leanmore Lodge	YES	YES
NAL10 - Achnamoine	YES	YES
NAL11 - Knockglass House	YES	YES
NAL12 - Mybster	NO	NO

6.5.2 As summarised in Table 6.5 above a cumulative noise assessment was required at NALs 1 - 11. A detailed list of all of the wind farms/ wind turbine developments considered in the noise predictions are included in Table 1 of Annex 5. In addition, a summary of the noise prediction comparisons are included within Annex 7.

6.5.3 A likely cumulative noise assessment was undertaken at NALs 1-11) and the results are summarised in tabular form in Table 6.6 and Table 6.7. The results show that the predicted cumulative wind turbine noise immission levels meet the 'Total ETSU-R-97 Noise limits' under all conditions at all NALs. The predicted 'likely' cumulative levels are the actual levels expected at an NAL and include the addition of an appropriate level of uncertainty to the turbine data as per Section 4.2 of the IOA GPG. The uncertainty level added is generally +2 dB but this can vary depending on the turbine manufacturer data available for each turbine. Details of the uncertainty added to the wind turbine data is included within Annex 6.

6.5.4 Figures A1.2a-k (Annex 1) show predictions from the Proposed Development and 'cumulative (including Proposed Development)' against the 'Total ETSU-R-97 Noise Limits' at NALs 1 - 11. The individual contribution of the cumulative schemes are also shown. The individual schemes are shown together and comprise Harpsdale Mains Halkirk, West Watten and Myrelandhorn. For the cumulative noise predictions the noise model considers the range of noise data available for each turbine type modelled. For some turbines noise data was not available for wind speeds less than 5 ms^{-1} therefore no cumulative predictions are included for wind speeds less than 5 ms^{-1}.

Table 6.6 ETSU-R-97 Compliance Table – Likely Cumulative Noise - Daytime

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – 21-22 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	33.1	36.2	36.6	37.0	37.1	37.2	37.3	37.3
	Exceedance Level	-	-	-	-	-4.9	-1.8	-1.4	-1.5	-3.9	-6.3	-8.8	-10.8
NAL2 – 18 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.3	34.4	35.0	35.4	35.6	35.7	35.7	35.7
	Exceedance Level	-	-	-	-	-13.7	-10.6	-10.0	-9.6	-9.4	-9.3	-10.4	-12.4
NAL3 – 17 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	27.3	30.4	31.3	31.8	32.0	32.2	32.4	32.5
	Exceedance Level	-	-	-	-	-10.7	-7.6	-6.7	-6.7	-9.0	-11.3	-13.7	-15.6
NAL4 – Banks Lodge	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	26.8	29.8	30.8	31.2	31.5	31.7	31.9	32.1
	Exceedance Level	-	-	-	-	-11.2	-8.2	-7.2	-7.3	-9.5	-11.8	-14.2	-16.0
NAL5 – 14 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	27.6	30.7	31.6	32.1	32.4	32.6	32.9	33.1
	Exceedance Level	-	-	-	-	-10.4	-7.3	-6.4	-6.4	-8.6	-10.9	-13.2	-15.0
NAL6 - Newton	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	29.5	32.7	33.4	33.9	34.1	34.3	34.4	34.4
	Exceedance Level	-	-	-	-	-8.5	-5.3	-4.6	-4.6	-6.9	-9.2	-11.7	-13.7

Location		Wind Speed (ms-1) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Lanergill	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	29.3	31.5	32.4	32.9	33.4	33.6	33.6	33.7
	Exceedance Level	-	-	-	-	-8.7	-6.5	-5.6	-5.6	-7.6	-9.9	-12.5	-14.4
NAL8 – Backlass Hill	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.3	34.1	34.7	35.1	35.4	35.5	35.6	35.6
	Exceedance Level	-	-	-	-	-6.7	-3.9	-3.3	-3.4	-5.6	-8.0	-10.5	-12.5
NAL9 – Leanmore Lodge	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	32.7	35.7	36.2	36.6	36.8	36.9	37.0	37.0
	Exceedance Level	-	-	-	-	-5.3	-2.3	-1.8	-1.9	-4.2	-6.6	-9.1	-11.1
NAL10 - Achnamoine	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.9	40.9	42.9	45.0	46.5
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.4	33.4	34.3	34.7	35.3	35.6	35.6	35.6
	Exceedance Level	-	-	-	-	-6.6	-4.6	-3.7	-4.2	-5.6	-7.3	-9.4	-10.9
NAL11 – Knockglass House	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.9	40.9	42.9	45.0	46.5
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	33.4	35.2	36.2	36.6	37.2	37.5	37.5	37.5
	Exceedance Level	-	-	-	-	-4.6	-2.8	-1.8	-2.3	-3.7	-5.4	-7.5	-9.0

Table 6.7 ETSU-R-97 Compliance Table – Likely Cumulative Noise – Night time

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – 21-22 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	33.1	36.2	36.6	37.0	37.1	37.2	37.3	37.3
	Exceedance Level	-	-	-	-	-9.9	-6.8	-6.4	-6.0	-5.9	-5.8	-5.7	-8.3
NAL2 – 18 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.3	34.4	35.0	35.4	35.6	35.7	35.7	35.7
	Exceedance Level	-	-	-	-	-13.7	-10.6	-10.0	-9.6	-9.4	-9.3	-9.3	-9.9
NAL3 – 17 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	27.3	30.4	31.3	31.8	32.0	32.2	32.4	32.5
	Exceedance Level	-	-	-	-	-15.7	-12.6	-11.7	-11.2	-11.0	-10.8	-10.6	-13.1
NAL4 – Banks Lodge	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	26.8	29.8	30.8	31.2	31.5	31.7	31.9	32.1
	Exceedance Level	-	-	-	-	-16.2	-13.2	-12.2	-11.8	-11.5	-11.3	-11.1	-13.5
NAL5 – 14 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	27.6	30.7	31.6	32.1	32.4	32.6	32.9	33.1
	Exceedance Level	-	-	-	-	-15.4	-12.3	-11.4	-10.9	-10.6	-10.4	-10.1	-12.5
NAL6 - Newton	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	29.5	32.7	33.4	33.9	34.1	34.3	34.4	34.4
	Exceedance Level	-	-	-	-	-13.5	-10.3	-9.6	-9.1	-8.9	-8.7	-8.6	-11.2

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Lanergill	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	29.3	31.5	32.4	32.9	33.4	33.6	33.6	33.7
	Exceedance Level	-	-	-	-	-13.7	-11.5	-10.6	-10.1	-9.6	-9.4	-9.4	-11.9
NAL8 – Backlass Hill	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.3	34.1	34.7	35.1	35.4	35.5	35.6	35.6
	Exceedance Level	-	-	-	-	-11.7	-8.9	-8.3	-7.9	-7.6	-7.5	-7.4	-10.0
NAL9 – Leanmore Lodge	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	32.7	35.7	36.2	36.6	36.8	36.9	37.0	37.0
	Exceedance Level	-	-	-	-	-10.3	-7.3	-6.8	-6.4	-6.2	-6.1	-6.0	-8.6
NAL10 - Achnamoine	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.4	33.4	34.3	34.7	35.3	35.6	35.6	35.6
	Exceedance Level	-	-	-	-	-11.6	-9.6	-8.7	-8.3	-7.7	-7.4	-7.4	-7.8
NAL11 – Knockglass House	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	33.4	35.2	36.2	36.6	37.2	37.5	37.5	37.5
	Exceedance Level	-	-	-	-	-9.6	-7.8	-6.8	-6.4	-5.8	-5.5	-5.5	-5.9

6.6 Derivation of Site Specific Noise Limits (Stage 3)

6.6.1 In order to protect residential amenity, the IOA GPG (2013) recommendations are that cumulatively, all schemes operate within the Total ETSU-R-97 Noise Limits. This can be found in summary box SB21 of the IOA GPG (2013) which states:

'Whenever a cumulative situation is encountered, the noise limits for an individual wind farm should be determined in such a way that no cumulative excess of the total ETSU-R-97 noise limit would occur.'

6.6.2 As detailed in Section 6.4.4 above, the daytime Site Specific Noise Limits have been derived based on the lower daytime fixed minimum limit of 35 dB. Where the occupiers of a property are financially involved both the day and night time fixed limits has been increased to 45 dB.

6.6.3 Site Specific Noise Limits have been derived for each of the noise sensitive receptors considered within Table 6.1 above. Table 6.8 below summarises the approach adopted at each NAL in order to derive the Site Specific Noise Limits for the Proposed Development. Figures A1.3a-k show the addition of the buffers as detailed in Table 6.8 below.

Table 6.8 Limit Derivation Strategy

NAL	Limit Derivation Strategy
NALs 1, 3-9	The likely predictions level from other schemes were found to be within 5 - 10 dB of the Total Noise Limits. As such, the limit has been apportioned based on a cautious prediction of cumulative turbine noise. The noise predictions for the other consented and operational schemes show that there is, in theory, significant headroom between the likely predicted levels and the Total ETSU-R-97 Noise Limit (>5 dB). In accordance with Section 4.5 above, a 2 dB buffer was therefore added to the turbine noise predictions for each of the other developments; this is considered to be a suitable buffer in accordance with Section 5.4.11 of the IOA GPG and would represent a 60% increase in emitted noise levels from the other schemes. The resulting 'cautious' predictions of cumulative wind turbine noise have then been logarithmically subtracted from the Total ETSU-R-97 Noise Limit to determine the 'residual noise limit'. The Site Specific Noise Limits are then determined as follows: • The night time limit is set to the residual noise limit. • The daytime noise limit is determined by taking the lowest of either: o The residual noise limit; or o Background noise plus 5 dB or the daytime fixed minimum limit of 35 dB (whichever is greater).
NAL 2	The likely predictions level from other schemes were found to be more than 10 dB below the Total ETSU-R-97 Noise Limits and as such the entire noise limits has been allocated to the Proposed Development.
NALs 10-11	The likely predictions level from other schemes were found to be within 5 dB of the Total ETSU-R-97 Noise Limits therefore significant headroom was not available. The Site Specific Noise Limit has been set 10 dB below the Total ETSU-R-97 Noise Limit at the relevant wind speeds.

6.6.4 Please note the buffers detailed above are in addition to the appropriate level of uncertainty already added to the turbine data as per Section 4.2 of the IOA GPG. A set of graphs showing the cautious predictions are included within Annex 1 as Figure A1.3a-k.

6.6.5 Table 6.9 and Table 6.10 show the daytime and night time Site Specific Noise Limits derived in accordance with Table 6.8, noise predictions for the Proposed Development and the exceedance level. A negative exceedance demonstrates compliance with the Site Specific Noise Limits.

6.6.6 Predicted noise levels assuming all turbines operate in unconstrained mode meet the limits at all receptors except at NAL1 where an exceedance of 0.3 dB would occur at $6ms^{-1}$ during the day time period. Predicted noise levels have therefore been reduced by 0.3 dB at NAL1 to ensure that the limits are met, this would be achieved by the adoption of low noise modes but this would only be required at $6ms^{-1}$ for a limited range of wind directions. The Tables show that, subject to the adoption of low noise modes to ensure compliance at NAL1, the predicted wind turbine noise immission levels meet the Site Specific Noise Limits under all conditions and at all locations for both daytime and night time periods.

6.6.7 A series of graphs to show the predicted wind turbine noise from the Proposed Development compared to the Site Specific Noise Limits are included as Figures A1.4a - A1.4k (Annex 1). There is a set of graphs for each of the NAL, which show the Total ETSU-R-97 Noise Limit (solid red line), the Site Specific Noise Limit (dashed red line with triangles) and the predicted wind turbine noise from the Proposed Development (solid blue line).

Table 6.9 Site Specific Noise Limits Compliance Table – Daytime

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – 21-22 West Watten	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	36.5	39.8	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	26.0	27.0	31.9	**35.0***	35.4	35.8	35.9	35.9	35.9	36.0
	Exceedance Level	-	-	-9.0	-8.0	-3.1	**0.0***	-0.6	-0.7	-3.9	-7.6	-10.2	-12.1
NAL2 – 18 West Watten	Site Specific Noise Limit L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	23.4	24.4	29.3	32.7	32.8	33.2	33.3	33.3	33.3	33.4
	Exceedance Level	-	-	-21.6	-20.6	-15.7	-12.3	-12.2	-11.8	-11.7	-11.7	-12.8	-14.7
NAL3 – 17 West Watten	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	37.5	41.0	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	17.1	18.1	23.0	26.4	26.5	26.9	27.0	27.0	27.0	27.1
	Exceedance Level	-	-	-17.9	-16.9	-12.0	-8.6	-9.5	-10.6	-14.0	-16.5	-19.1	-21.0
NAL4 – Banks Lodge	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	37.5	41.0	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	16.3	17.3	22.1	25.5	25.6	26.1	26.1	26.1	26.2	26.2
	Exceedance Level	-	-	-18.7	-17.7	-12.9	-9.5	-10.4	-11.4	-14.9	-17.4	-19.9	-21.9
NAL5 – 14 West Watten	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	37.5	41.0	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	18.6	19.5	24.4	27.8	27.9	28.3	28.4	28.4	28.5	28.5
	Exceedance Level	-	-	-16.4	-15.5	-10.6	-7.2	-8.1	-9.2	-12.6	-15.1	-17.6	-19.6
NAL6 - Newton	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	37.2	40.2	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	21.2	22.2	27.1	30.5	30.6	31.0	31.1	31.1	31.1	31.2
	Exceedance Level	-	-	-13.8	-12.8	-7.9	-4.5	-5.4	-6.2	-9.1	-12.4	-15.0	-16.9

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Lanergill	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	36.7	39.9	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	16.8	17.8	22.6	26.0	26.1	26.6	26.6	26.7	26.7	26.7
	Exceedance Level	-	-	-18.2	-17.2	-12.4	-9.0	-9.9	-10.1	-13.3	-16.8	-19.4	-21.4
NAL8 – Backlass Hill	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	36.7	39.9	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	22.5	23.5	28.4	31.8	31.9	32.3	32.3	32.4	32.4	32.5
	Exceedance Level	-	-	-12.5	-11.5	-6.6	-3.2	-4.1	-4.4	-7.6	-11.1	-13.7	-15.6
NAL9 – Leanmore Lodge	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	36.6	39.8	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	24.9	25.9	30.8	34.2	34.3	34.7	34.8	34.8	34.8	34.9
	Exceedance Level	-	-	-10.1	-9.1	-4.2	-0.8	-1.7	-1.9	-5.0	-8.7	-11.3	-13.2
NAL10 - Achnamoine	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	28.0	28.9	38.8	41.6	44.2	46.5
	Predicted Wind Turbine Noise L_{A90}	-	-	15.6	16.6	21.4	24.8	24.9	25.4	25.4	25.4	25.5	25.5
	Exceedance Level	-	-	-19.4	-18.4	-13.6	-10.2	-3.1	-3.5	-13.4	-16.2	-18.7	-21.0
NAL11 – Knockglass House	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	28.0	28.0	28.0	28.9	30.9	40.5	43.7	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	15.9	16.9	21.8	25.2	25.3	25.7	25.8	25.8	25.8	25.9
	Exceedance Level	-	-	-19.1	-18.1	-6.2	-2.8	-2.7	-3.2	-5.1	-14.7	-17.9	-19.7

**mode management applied at 6 ms^{-1}*

Table 6.10 Site Specific Noise Limits Compliance Table – Night time

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – 21-22 West Watten	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	26.0	27.0	31.9	35.3	35.4	35.8	35.9	35.9	35.9	36.0
	Exceedance Level	-	-	-17.0	-16.0	-11.1	-7.7	-7.6	-7.2	-7.1	-7.1	-7.1	-9.6
NAL2 – 18 West Watten	Site Specific Noise Limit L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	23.4	24.4	29.3	32.7	32.8	33.2	33.3	33.3	33.3	33.4
	Exceedance Level	-	-	-21.6	-20.6	-15.7	-12.3	-12.2	-11.8	-11.7	-11.7	-11.7	-12.2
NAL3 – 17 West Watten	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	17.1	18.1	23.0	26.4	26.5	26.9	27.0	27.0	27.0	27.1
	Exceedance Level	-	-	-25.9	-24.9	-20.0	-16.6	-16.5	-16.1	-16.0	-16.0	-16.0	-18.5
NAL4 – Banks Lodge	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	16.3	17.3	22.1	25.5	25.6	26.1	26.1	26.1	26.2	26.2
	Exceedance Level	-	-	-26.7	-25.7	-20.9	-17.5	-17.4	-16.9	-16.9	-16.9	-16.8	-19.4
NAL5 – 14 West Watten	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	18.6	19.5	24.4	27.8	27.9	28.3	28.4	28.4	28.5	28.5
	Exceedance Level	-	-	-24.4	-23.5	-18.6	-15.2	-15.1	-14.7	-14.6	-14.6	-14.5	-17.1
NAL6 - Newton	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	21.2	22.2	27.1	30.5	30.6	31.0	31.1	31.1	31.1	31.2
	Exceedance Level	-	-	-21.8	-20.8	-15.9	-12.5	-12.4	-12.0	-11.9	-11.9	-11.9	-14.4

Location		Wind Speed (ms-1) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Lanergill	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	16.8	17.8	22.6	26.0	26.1	26.6	26.6	26.7	26.7	26.7
	Exceedance Level	-	-	-26.2	-25.2	-20.4	-17.0	-16.9	-16.4	-16.4	-16.3	-16.3	-18.9
NAL8 – Backlass Hill	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	22.5	23.5	28.4	31.8	31.9	32.3	32.3	32.4	32.4	32.5
	Exceedance Level	-	-	-20.5	-19.5	-14.6	-11.2	-11.1	-10.7	-10.7	-10.6	-10.6	-13.1
NAL9 – Leanmore Lodge	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	24.9	25.9	30.8	34.2	34.3	34.7	34.8	34.8	34.8	34.9
	Exceedance Level	-	-	-18.1	-17.1	-12.2	-8.8	-8.7	-8.3	-8.2	-8.2	-8.2	-10.7
NAL10 - Achnamoine	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	42.1	42.0	41.8	41.7	41.7	42.3
	Predicted Wind Turbine Noise L_{A90}	-	-	15.6	16.6	21.4	24.8	24.9	25.4	25.4	25.4	25.5	25.5
	Exceedance Level	-	-	-27.4	-26.4	-21.6	-18.2	-17.2	-16.6	-16.4	-16.3	-16.2	-16.8
NAL11 – Knockglass House	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	42.2	41.8	41.4	41.3	40.9	40.7	40.7	41.4
	Predicted Wind Turbine Noise L_{A90}	-	-	15.9	16.9	21.8	25.2	25.3	25.7	25.8	25.8	25.8	25.9
	Exceedance Level	-	-	-27.1	-26.1	-20.4	-16.6	-16.1	-15.6	-15.1	-14.9	-14.9	-15.5

6.6.8 The assessment shows that the predicted wind turbine noise immission levels (which account for the use of mode management to meet the limits at NAL1) meet the Site Specific Noise Limits under all conditions and at all locations for both daytime and night time periods at all receptors.

6.6.9 In the event that consent is granted for the Proposed Development it would be appropriate to set noise limits equal to the Site Specific Noise Limits contained Table 6.9 and Table 6.10.

6.7 Choice of Daytime Fixed Minimum Noise Limit (35 – 40 dB)

6.7.1 Having due regard to the guidance in ETSU-R-97 and considering the cumulative impacts of the Proposed Development operating in conjunction with other consented or operational schemes a cumulative daytime Total fixed minimum limit of 38 dB has been adopted.

6.7.2 Whilst a cumulative daytime Total ETSU-R-97 Noise Limit of 38 dB is proposed, the Proposed Developments Site Specific Noise Limit are set separately and can be established using a value between 35 and 40 dB. For the Proposed Development, the Site Specific Noise Limits have been derived based upon the lower fixed minimum limit of 35 dB or background plus 5dB during the daytime period and 43 dB or background plus 5 dB during the night time.

6.7.3 The choice of daytime fixed minimum limit depends on three factors which are discussed on page 65 of ETSU-R-97 and in Section 3.2.4 of the IOA GPG. The IOA GPG notes that:

'It can be argued that assessing these factors do not represent an acoustic consideration but ultimately a planning consideration, and therefore are difficult for noise consultants to fully determine.'

6.7.4 Although the proposed Site Specific Noise Limits for the Proposed Development are based on the lower fixed minimum limit (35 dB), some commentary on each of the three factors discussed in ETSU-R-97 and the IOA GPG are included within Table 6.11 below.

Table 6.11 Consideration of Guidance provided on Choice of Fixed Minimum Limit for the Total Noise Limits and Site Specific Noise Limits

Factor	Guidance in ETSU-R-97	Guidance in IOA GPG	Commentary for the Proposed Development
1) The number of noise affected properties	*"The planning process is trying to balance the benefits arising out of the development of renewable energy sources against the local environmental impact. The more dwellings that are in the vicinity of a wind farm the tighter the limits should be as the total environmental impact will be greater. Conversely if only a few dwellings*	*"The number of neighbouring properties will depend on the nature of the area, (rural, semi-rural, urban) and is sometimes considered in relation to the size of the scheme and study area. The predicted 35 dB LA90 contour (at maximum noise output up to 12 m/s) can provide a*	The Site itself is located in a rural area with a relatively low number of scattered dwellings which surround the site. Although the Total ETSU-R-97 Noise Limit has been derived based on the a 38 dB Fixed Minimum Limit (FML), it is worth noting that, based on likely predicted noise levels, the total cumulative day time noise level is actually below the limits set using 35 dB or background plus 5 dB limit at 7 of the 11 NALs considered in the cumulative assessment. Of the remaining four properties one is financially involved. Accordingly just three properties (NALs 1, 9 and 11) are affected by the choice of day time FML.

Factor	Guidance in ETSU-R-97	Guidance in IOA GPG	Commentary for the Proposed Development
	are affected, then the environmental impact is less and noise limits towards the upper end of the range may be appropriate. Developers still have to consider the interests of individuals as protected under the Environmental Protection Act 1990."	*guide to the dwellings to be considered in this respect."*	Whilst likely cumulative predictions of noise meet limits based on 35 dB of background plus 5 dB at the vast majority of receptors, a higher Total Noise Limit is required given the need (in Stage 3 of the assessment presented in this report) to assume developments operate at a cautious level determined in accordance with the IOA GPG). Whilst this approach is appropriate and necessary it is important to recognise that it is cautious and that the actual impact on noise sensitive receptors is based on the likely predicted noise levels. Consideration of this test suggests that a Total ETSU-R-97 Noise Limit towards the upper end of the range permitted in ETSU-R-97 would be appropriate. The proposed Site Specific Noise Limit have been derived using a lower FML of 35 dB or background plus 5 dB during the daytime period.
2) The effect of using tighter limits on the potential power output of the wind farm:	*"Similar arguments can be made when considering the effect of noise limits on uptake of wind energy. A single wind turbine causing noise levels of 40dB(A) at several nearby residences would have less planning merit (noise considerations only) than 30 wind turbines also causing the same amount of noise at several nearby residences."*	*"This is in practice mainly based on the relative generating capacity of the development, as larger schemes have relatively more planning merit (for noise) according to the description in ETSU-R-97. In cases when the amenity fixed limit has little or no impact on the generating capacity (i.e. noise is not a significant design constraint) then a reduced limit may be applied."*	The Proposed Development, if approved, would generate a significant amount of renewable energy with the rated capacity of 67.6 MW. If the Total ETSU-R-97 Noise Limit was derived based on a lower FML of 35 dB it would result in the derivation of significantly lower Site Specific Noise Limits and exceedances of the noise limits would occur (as detailed in Annex 8). To put the exceedences into context it would result in the requirement to shut down 5 of the 7 turbines for a range of wind speeds and wind directions. In addition, an additional turbine would require some mode management with only one turbine requiring none. This would result in a significant loss of renewable energy generation. Consideration of this test suggests that a Total Noise Limit towards the middle/upper of the range permitted in ETSU-R-97 would be appropriate. The use of 38 dB results in a very small amount of mode management being required. This does not change if 39 or 40 dB is used.

Factor	Guidance in ETSU-R-97	Guidance in IOA GPG	Commentary for the Proposed Development
3) The duration of exposure of these properties.	*"The proportion of the time at which background noise levels are low and how low the background noise level gets are both recognised as factors which could affect the setting of an appropriate lower limit. For example, a property which experienced background noise levels below 30dB(A) for a substantial proportion of the time in which the turbines would be operating could be expected to receive tighter noise limits than a property at which the background noise levels soon increased to levels above 35dB(A). This approach is difficult to formulate precisely and a degree of judgement should be exercised."*	*"This last test is more difficult to formulate. But ETSU-R-97 notes that the likely excess of turbine noise relative to background noise levels should be a relevant consideration. In rural areas, this will often be determined by the sheltering of the property relative to the wind farm site. Account can also be taken of the effects of wind directions (including prevailing ones at the site) and likely directional effects. For cumulative developments, in some cases the effective duration of exposure may increase because of cumulative effects."*	Background noise levels vary across the NMLs but in general the daytime noise levels are relatively low and are broadly consistent with levels measured at rural locations in the UK. As noted above, for the vast majority of locations the level of exposure is low when considering the likely cumulative predictions. Consideration of the locations of the properties shown on Figure A1.1 relative to the proposed wind turbines shows that the closest properties to the site (which are located to the north and east of the Proposed Development) will be downwind of the proposed wind farm relatively frequently (as winds from the south west are relatively common). There are however no other turbines located to the north of the Proposed Development and the turbines to the east are located several kilometres away from the NALs. Consideration of this test suggests a Total ETSU-R-97 Noise Limit towards the middle / lower end of the range permitted in ETSU-R-97 would be appropriate.

6.7.5 If consent is granted for the Proposed Development it would be appropriate to set noise limits equal to the Site Specific Noise Limits contained within Table 6.9 and Table 6.10 which have been derived based on the use of the 35 dB day time fixed minimum limit. In the event that an alternative daytime fixed minimum limit is deemed appropriate new Site Specific Noise Limits would need to be calculated in accordance with the methodology presented in this report.

6.8 Micrositing

6.8.1 It should be noted that the need to include a concave ground profile correction and/or barrier correction may change depending on the final location of the turbines (following micrositing) and the final turbine hub height. Nevertheless, turbine noise levels will have to meet the noise limits established in this report regardless of any increases and decreases in noise propagation caused by topography. Should planning permission be granted, the need to apply a concave ground profile/ barrier correction will need to be considered by the Applicant prior to the final selection of a turbine model for the site.

7 Summary and Conclusions

7.1.1 This report has assessed the potential impact of operational noise from the Proposed Development on the residents of nearby receptors. The guidance contained within ETSU-R-97 and current good practice (IOA GPG) has been used to assess the potential noise impact of the Proposed Development.

7.1.2 Background noise levels measured as part of the assessment for Halsary Wind Farm were adjusted to account for wind shear using analysis of wind data undertaken by Natural Power. For the assessment locations where no background noise measurements were undertaken, noise data collected at proxy locations was used to assess the noise impact at those receptors.

7.1.3 A Total ETSU-R-97 Noise Limit of 38 dB(A) daytime or background plus 5dB (whichever is the greater) and 43 dB(A) night time or background plus 5dB (whichever is the greater) was used in this assessment.

7.1.4 There are a number of operational and proposed wind farms in proximity to the Proposed Development. A cumulative assessment was undertaken where predicted levels from Proposed Development were found to be within 10 dB of the predicted cumulative levels from other schemes in the area. The results show that the predicted cumulative wind farm noise immission levels meet the Total ETSU-R-97 Noise Limits at all locations.

7.1.5 'Site Specific Noise Limits' have also been derived based on a daytime fixed minimum limit of 35 dB or background plus 5 dB and a night time limit of 43 dB or background plus 5 dB. The limit derivation took account (where required) of the other consented wind farms in the area. Where immissions from other wind farms at a given receptor were found to be at least 10 dB below the 'Total ETSU-R-97 Noise Limit'; then the other wind farms would be using a negligible proportion of the limit. As such it is considered appropriate to allocate the entire noise limit to the Proposed Development. For receptors where turbine predictions were found to be within 10dB of the Total ETSU-R-97 Noise Limits, apportionment of the Total ETSU-R-97 Noise Limits was undertaken.

7.1.6 An assessment was undertaken to determine whether the Proposed Development could operate within the 'Site Specific Noise Limits' and it was found that at all receptors wind turbine noise immissions were below the Site Specific Noise Limits when considering the Vestas V162 6.8 MW with serrated trailing edge blades as a candidate turbine. In order to achieve the day time noise limits at NAL1 it has been assumed the use of low noise modes for 6 ms^{-1}, this would only be required for certain wind directions; this has been included in all predictions presented in this report.

7.1.7 The Vestas turbine model was chosen as it is considered to be representative of the type of turbine that could be installed at the site. There are a number of wind turbine makes and models that may be suitable for the Proposed Development. Should the proposal receive planning permission, the final choice of turbine would be subject to a competitive tendering process. The final choice of turbine would, however, have to meet the noise limits determined and contained within any condition imposed. A suggested set of noise conditions are included within Annex 9.

8 Glossary of Terms

AOD: Above Ordnance Datum is the height above sea level.

Amplitude Modulation: a variation in noise level over time; for example observers may describe a 'whoosh whoosh' sound, which can be heard close to a wind turbine as the blades sweep past.

Attenuation: the reduction in level of a sound between the source and a receiver due to any combination of effects including: distance, atmospheric absorption, acoustic screening, the presence of a building façade, etc.

Background Noise: the noise level rarely fallen below in any given location over any given time period, often classed according to daytime, evening or night time periods. The L_{A90} indices (see below) is often used to represent the background noise level.

Bin: subset or group into which data can be sorted; in the case of wind speeds, bins are often centred on integer wind speeds with a width of 1 m/s. For example the 4 m/s bin would include all data with wind speeds of 3.5 to 4.5 m/s.

Dawn Chorus: noise due to birds which can occur at sunrise.

Broadband Noise: noise with components over a wide range of frequencies.

Decibel (dB): the ratio between the quietest audible sound and the loudest tolerable sound is a million to one in terms of the change in sound pressure. A logarithmic scale is used in noise level measurements because of this wide range. The scale used is the decibel (dB) scale which extends from 0 to 140 decibels (dB) corresponding to the intensity of the sound level.

dB(A): the ear has the ability to recognise a particular sound depending on its pitch or frequency. Microphones cannot differentiate noise in the same way as the ear, and to counter this weakness the noise measuring instrument applies a correction to correspond more closely to the frequency response of the human ear. The correction factor is called 'A Weighting' and the resulting measurements are written as dB(A). The dB(A) is internationally accepted and has been found to correspond well with people's subjective reaction to noise. Some typical subjective changes in noise levels are:

- a change of 3 dB(A) is just perceptible;
- a change of 5 dB(A) is clearly perceptible;
- a change of 10 dB(A) is twice (or half) as loud.

Directivity: the property of a sound source that causes more sound to be radiated in one direction than another.

Frequency: the pitch of a sound in Hz or kHz. See Hertz.

Ground Effects: the modification of sound at a receiver location due to the interaction of the sound wave with the ground along its propagation path from source to receiver. Described using the term 'G', and ranges between 0 (hard), 0.5 (mixed) and 1 (soft).

Hertz (Hz): sound frequency refers to how quickly the air vibrates, or how close the sound waves are to each other (in cycles per second, or Hertz (Hz)).

L_w: is the sound power level. It is a measure of the total noise energy radiated by a source of noise, and is used to calculate noise levels at a distant location. The L_{WA} is the A-weighted sound power level.

L_{eq}: is the equivalent continuous sound level, and is the sound level of a steady sound with the same energy as a fluctuating sound over the same period. It is possible to consider this level as the ambient noise encompassing all noise at a given time. The $LA_{eq,T}$ is the A-weighted equivalent continuous sound level over a given time period (T).

L_{90}: index represents the noise level exceeded for 90 percent of the measurement period and is used to indicate quieter times during the measurement period. It is often used to measure the background noise level. The $L_{A90,10min}$ is the A-weighted background noise level over a ten minute measurement sample.

Noise emission: the noise energy emitted by a source (e.g. a wind turbine).

Noise immission: the sound pressure level detected at a given location (e.g. the nearest dwelling).

Night Time Hours: ETSU-R-97 defines the night time hours as 23.00 to 07.00 every day.

Quiet Daytime Hours: ETSU-R-97 defines the amenity hours as 18.00 to 23.00 Monday to Friday, 13.00 to 23.00 on Saturdays and 07.00 to 23.00 on Sundays.

Sound Level Meter: an instrument for measuring sound pressure level.

Sound Power Level: the total sound power radiated by a source, in decibels.

Sound Pressure Level: a measure of the sound pressure at a point, in decibels**.**

Standardised Wind Speed: a wind speed measured at a height different than 10 m (generally measured at the turbine hub height) which is expressed to a reference height of 10 m using a roughness length of 0.05 for standardisation purpose (in accordance with the IEC 61400-11 standard).

Tonal Noise: noise which covers a very restricted range of frequencies (e.g. a range of ≤20 Hz). This noise can be more annoying than broadband noise.

Wind Shear: the increase of wind speed with height above the ground.

9 References

1. **ETSU for the DTI (Department of Trade and Industry.** *The Working Group on Noise from Wind Turbines ETSU-R-97 The Assessment and Rating of Noise from Wind Farms'.* 1996.

2. **Institute of Acoustics.** *Good Practice Guidance on the application of ETSU-R-97 for wind turbine noise assessment.* 2013.

3. **The Scottish Government.** Web Based Renewables Advice: 'Onshore Wind Turbines' – http://www.scotland.gov.uk/Resource/0045/00451413.pdf. [Online] 28 May 2014.

4. —. Web Based Renewables Advice: 'Onshore Wind Turbines' – http://www.scotland.gov.uk/Resource/0045/00451413.pdf. [Online] 28 May 2014.

5. —. Planning Advice Note PAN 1/2011: Planning and Noise - http://www.scotland.gov.uk/Resource/Doc/343210/0114180.pdf. [Online] 2011.

6. **National Planning Policy Framework 4. *https://www.transformingplanning.scot/national-planning-framework/what-is-the-national-planning-framework/.* [Online]**

7. Government's, Scottish. Online Onshore wind: policy statement 2022 .

8. The Scottish Government. Technical Advice Note Assessment of Noise (http://www.scotland.gov.uk/Resource/Doc/343341/0114220.pdf). [Online]

9. Letter John Swinney, MSP Cabinet Secretary for Finance, Employment and Sustainable Growth to Prof B Shield, IOA, 29 May 2013. *http://www.ioa.org.uk/pdf/scottish-government-endorsement-of-ioa-gpg.pdf.* [Online]

10. WSP. A review of noise guidance for onshore wind turbines. [Online] 10 02 2023. https://www.wsp.com/en-gb/insights/wind-turbine-noise-report.

11. *Visual and acoustic impact of wind turbine farms in residents Final report.* Frits van den Berg et al. s.l. : FP6-2005-Science-and-Society-20 Specific Support Action, 3 June 2008.

12. *Low frequency noise and annoyance* . HG, Leventhall. s.l. : Noise & Health Journal, 2004, Vol. 6.

13. *Do wind turbines produce significant low frequency sound levels? Conference paper 11th International Meeting on Low Frequency Noise and Vibration and its Control* . Berg, G.P. van den. Maastricht The Netherlands : s.n., 2004.

14. Department of Trade and Industry. *The Measurement of LFN at three UK Wind Farms* . 2006 : s.n.

15. Keele University Rejects Renewable Energy Foundation. http://archive.is/d3WB. *Low Frequency Noise Research Claims* . [Online]

16. Institute of Acoustics Bulletin. *Prediction and assessment of wind turbine noise.* 2009.

17. *Infrasound and the ear, 5th International conference on Wind Turbine Noise.* Leventhall, G. Denver : s.n., 2013.

18. The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomized Crossover Study in Noise-Sensitive, Healthy Adults - PMC (nih.gov).

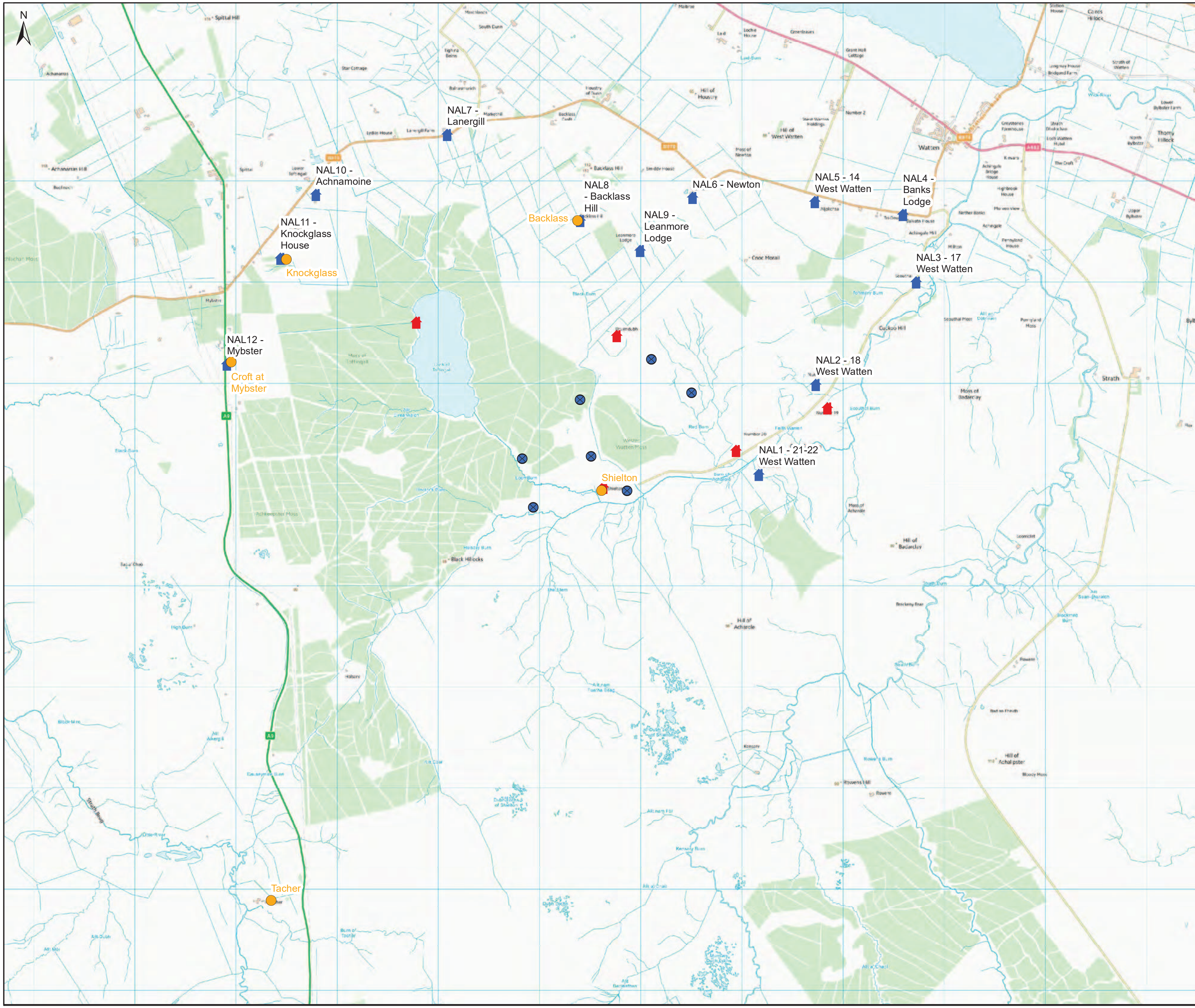
19. renewable UK. http://www.renewableuk.com/search/all.asp?bst=amplitude+modulation. [Online]

20. Department of Energy & Climate Change. *Wind Turbine AM Review Phase 2 Report.* 2016.

21. International Standards Organisation. *ISO9613:1996 'Acoustics – Attenuation of sound during propagation outdoors' – Part 2: General method of calculation.* 1996.

22. DataKustik Gmbh. CadnaA Version 4.4.

Annex 1 – Figures



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LEGEND

- Halsary Noise Monitoring Locations (NMLs)
- Noise Assessment Locations (NALs)
- Derelict/ Unoccupied/ Non-residential
- Proposed Development

Rev.	Date	Amendment Details	Drw'n	Chk'd	App'd
01	09/08/23	Minor Update	JCM	GC	GC
00	29/06/23	First Issue	JCM	GC	GC

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tnei

Client

EDF renewables

Drawing Status: FOR PLANNING

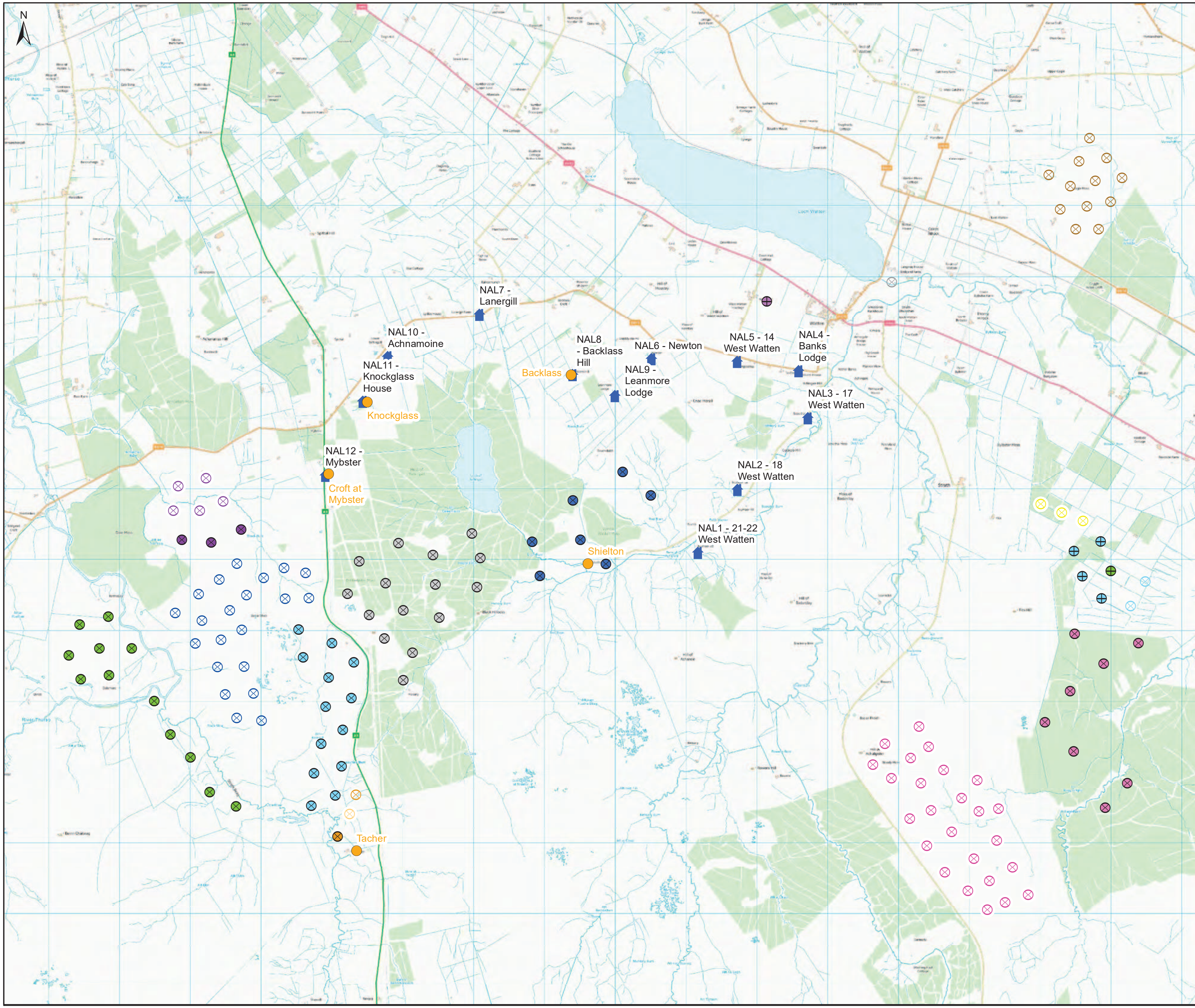
Project Title: Watten Wind Farm

Drawing Title: Figure A1.1 - Noise Assessment and Wind Turbine Locations

Scale	Designed	Drawn	Checked	Approved
NTS	JCM	JCM	GC	GC
Original Size	Date	Date	Date	Date
A3	29/06/2023	29/06/2023	29/06/2023	29/06/2023

Drawing Number: 15098 - 006

Revision: 1



LEGEND

- Halsary Noise Monitoring Locations (NMLs)
- Noise Assessment Locations (NALs)
- Proposed Development

Operational / Consented Schemes

- Achlachan
- Achlachan 2
- Bad a Cheo
- Bilbster
- Camster
- Camster II
- Causeymire
- Cogle Moss
- Halsary
- Harpsdale Mains Halkirk
- Tacher A
- Tacher B
- Tacher C
- Tormsdale
- Myrelandhorn
- Wathegar
- Wathegar 2
- West Watten

Rev.	Date	Amendment Details	Drw'n	Chk'd	App'd
00	29/06/23	First Issue	JCM	GC	GC

tnei

Client: EDF renewables

Drawing Status: FOR PLANNING

Project Title: Watten Wind Farm

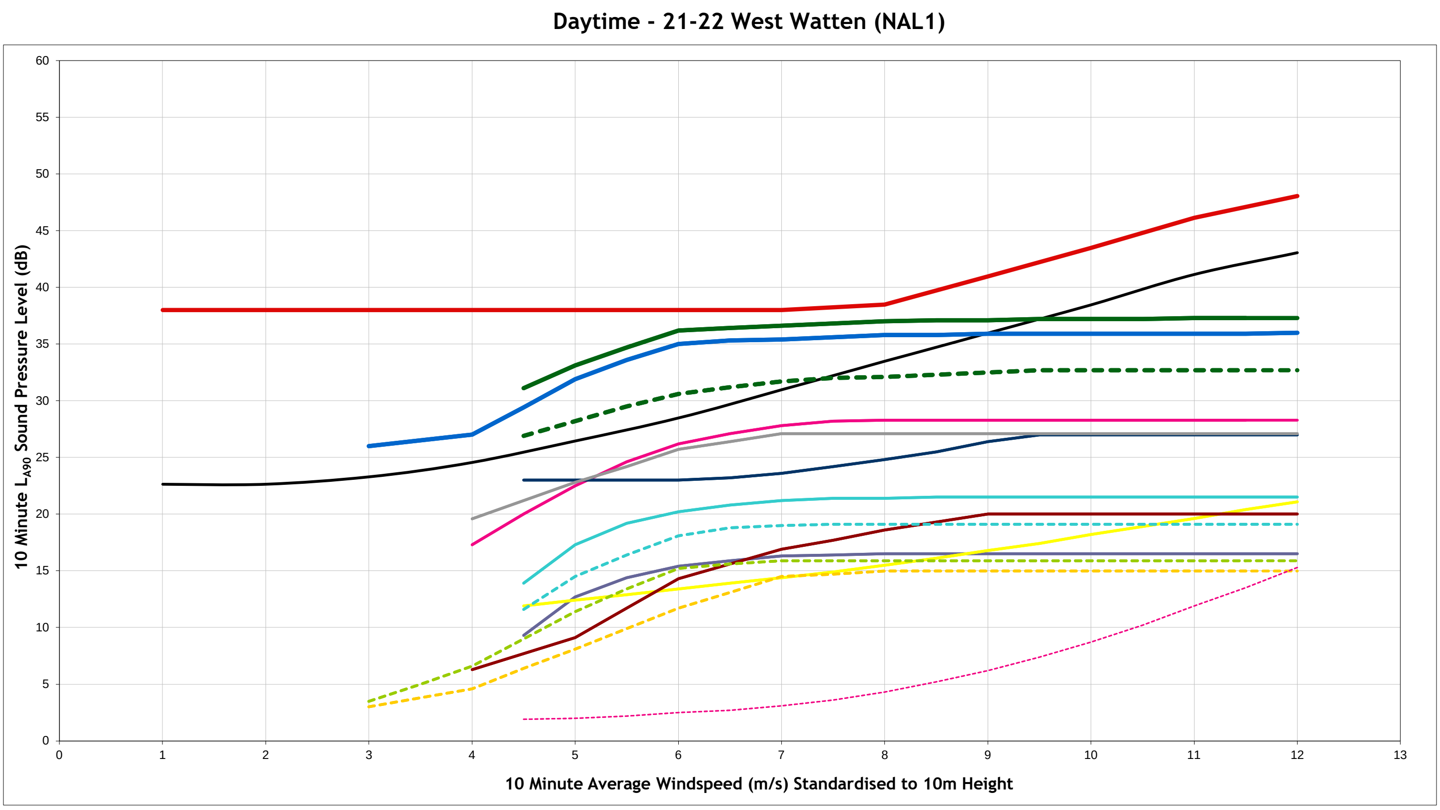
Drawing Title: Figure A1.1a - Cumulative Wind Turbine Locations

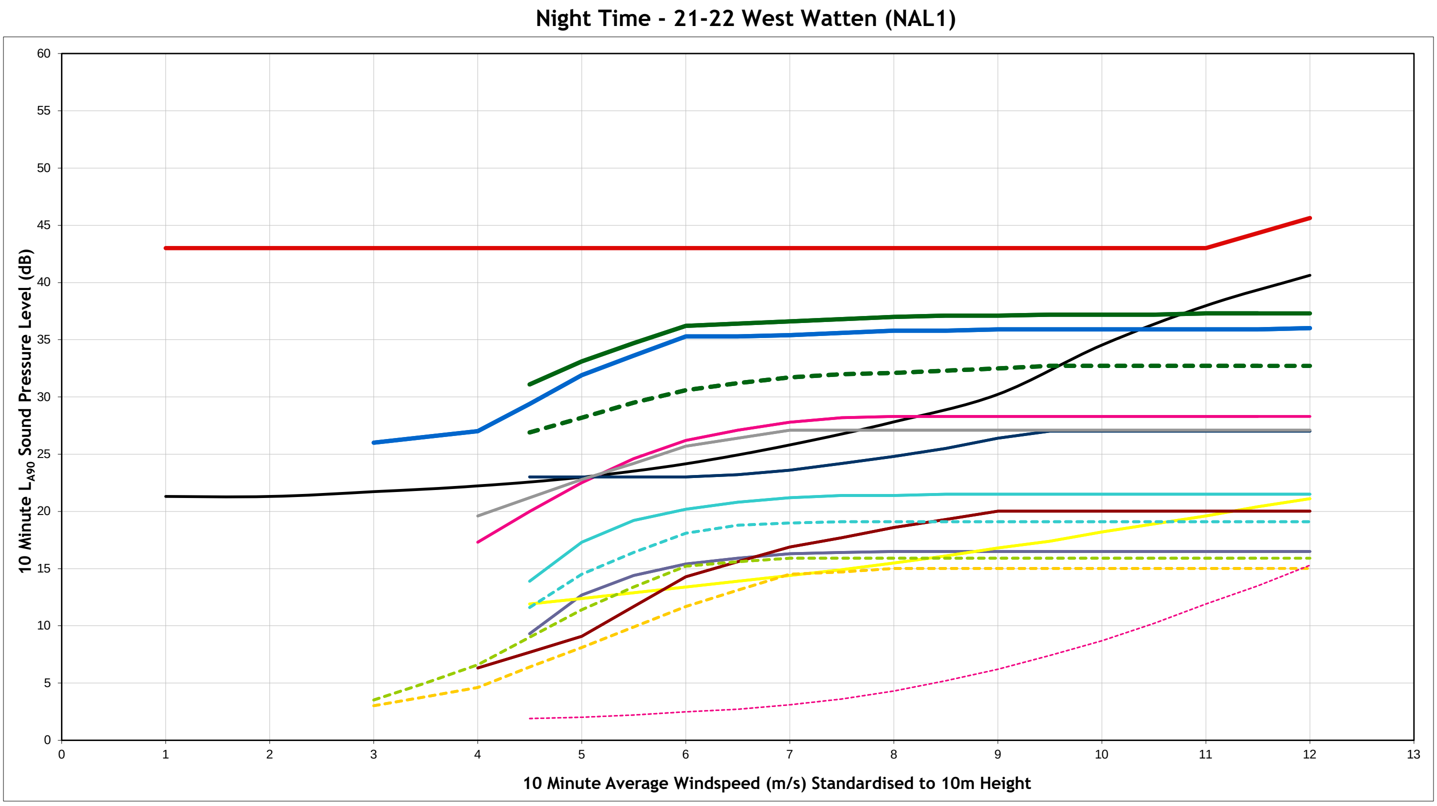
Scale	Designed	Drawn	Checked	Approved
NTS	JCM	JCM	GC	GC
Original Size	Date	Date	Date	Date
NTS	29/06/2023	29/06/2023	29/06/2023	29/06/2023

Drawing Number: 15098 - 007

Revision: 0

Figures A1.2a-k - Likely Noise Predictions



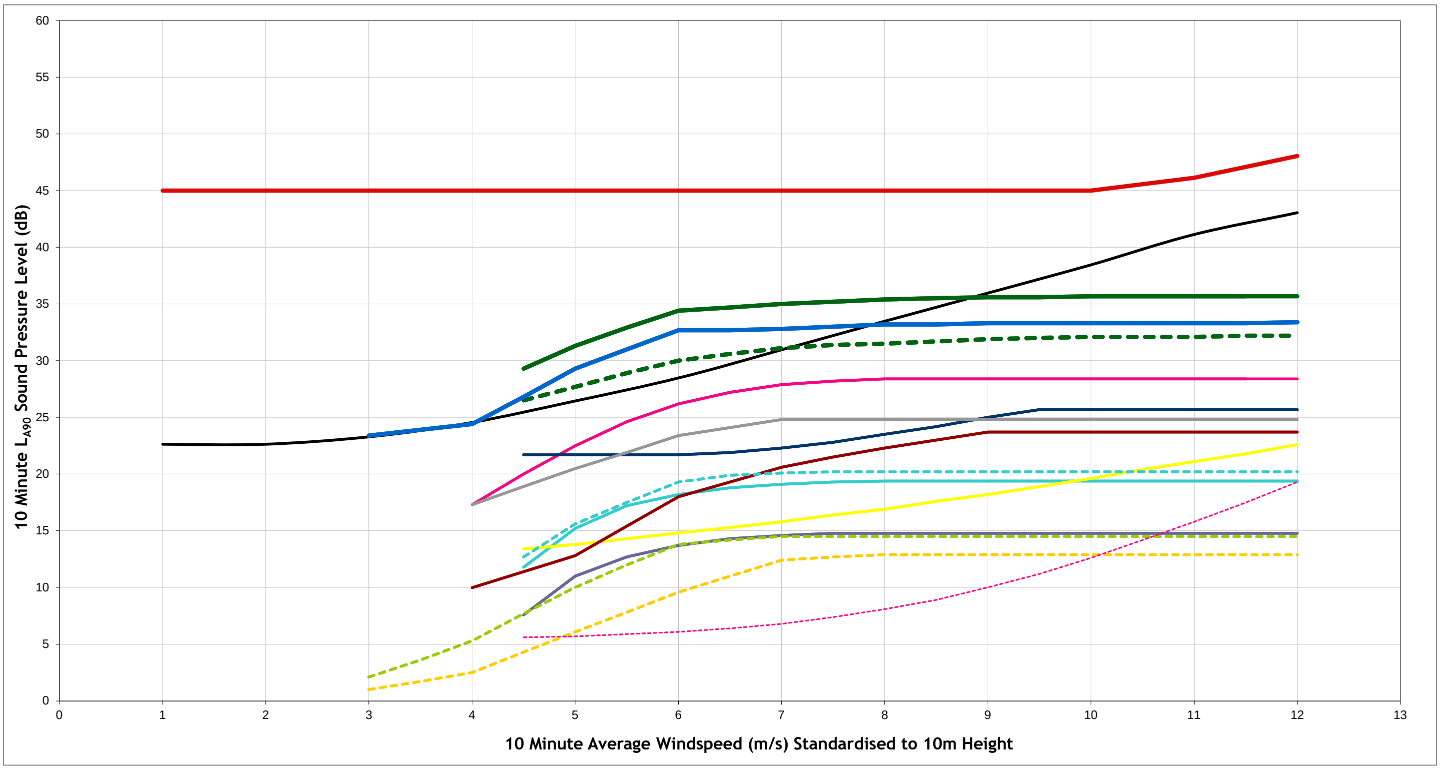


Legend:

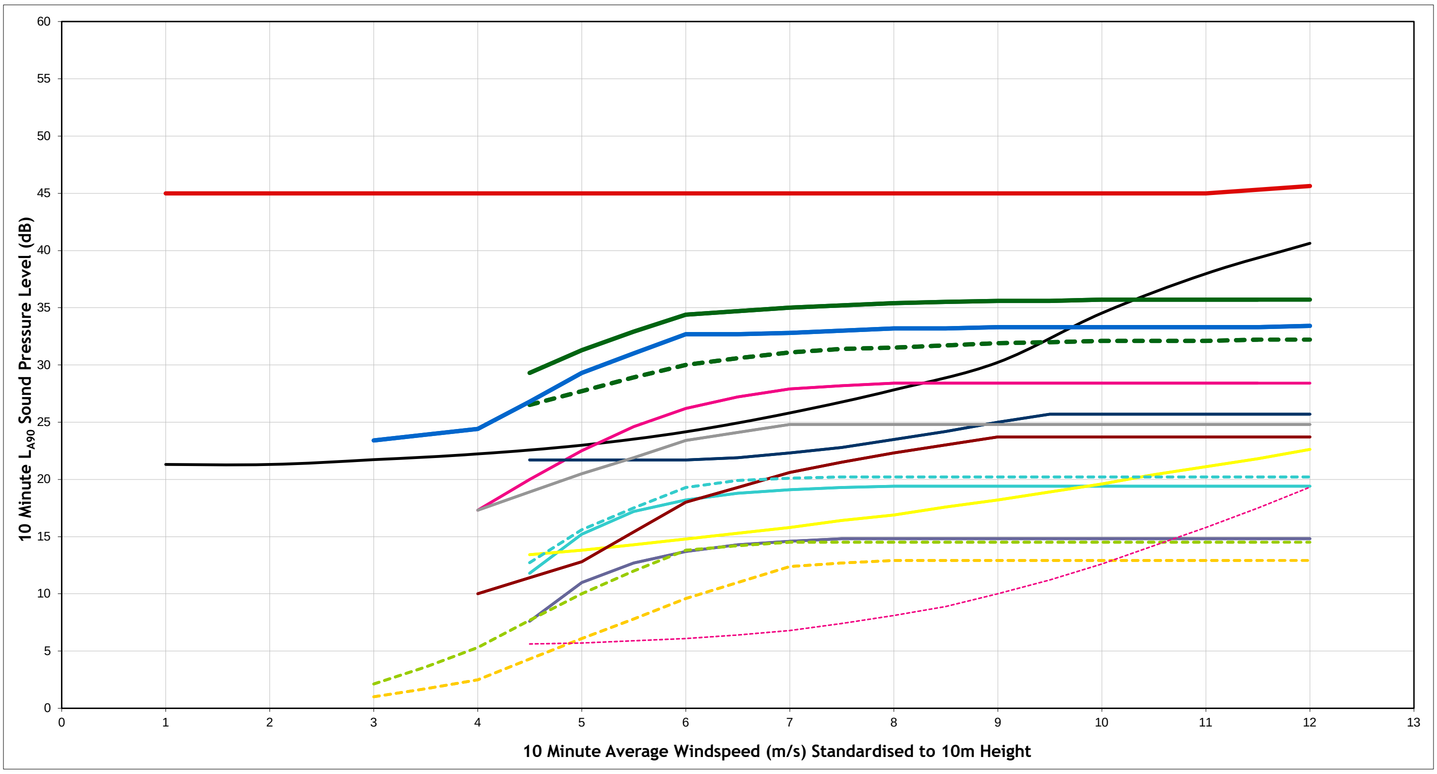
- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development *includes mode management at 6 m/s daytime
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions 21-22 West Watten (NAL1)
Figure Number	A1.2a
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - 18 West Watten (NAL2)



Night Time - 18 West Watten (NAL2)



Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions 18 West Watten (NAL2)
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Date	28/06/2023
Document Reference	15098-Models

EDF renewables

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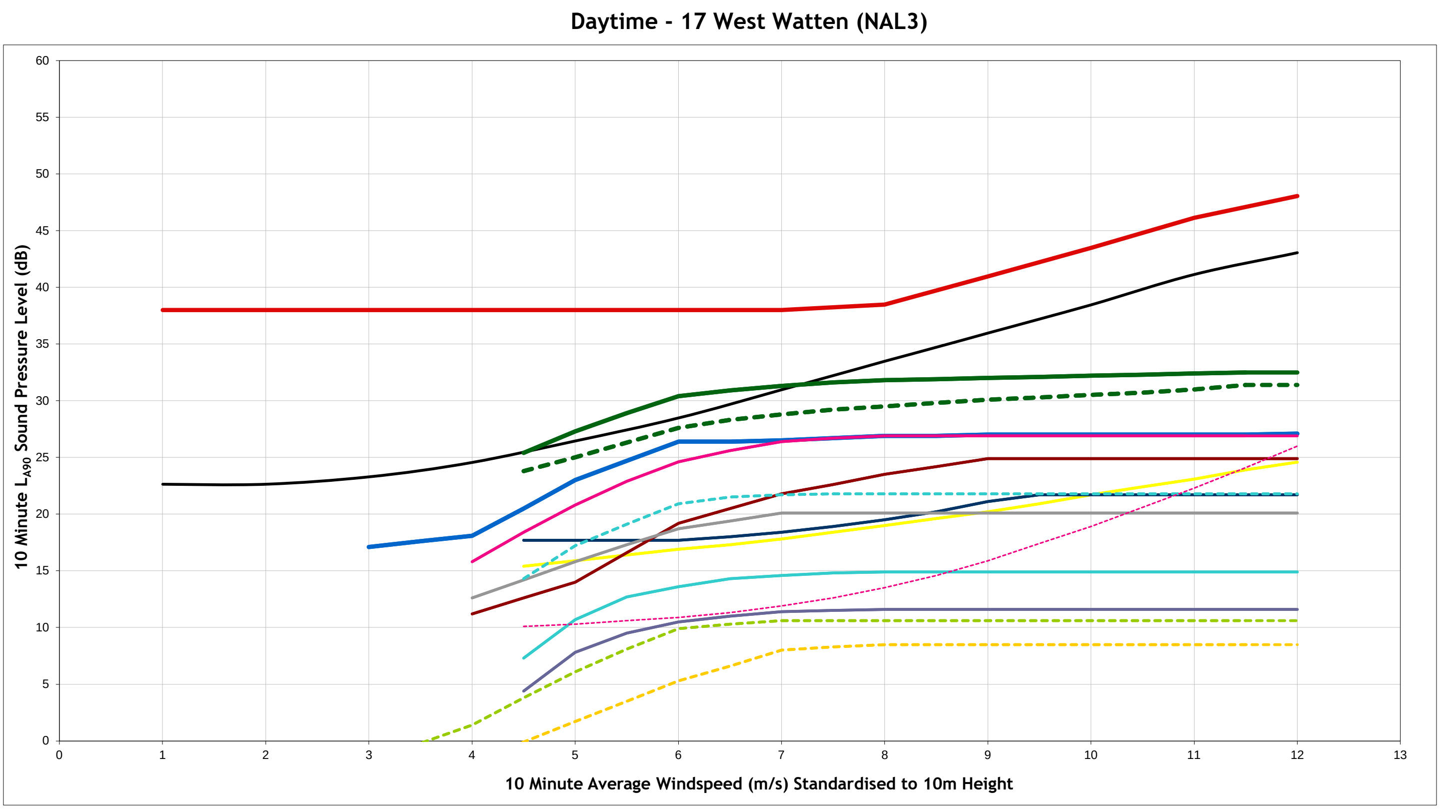

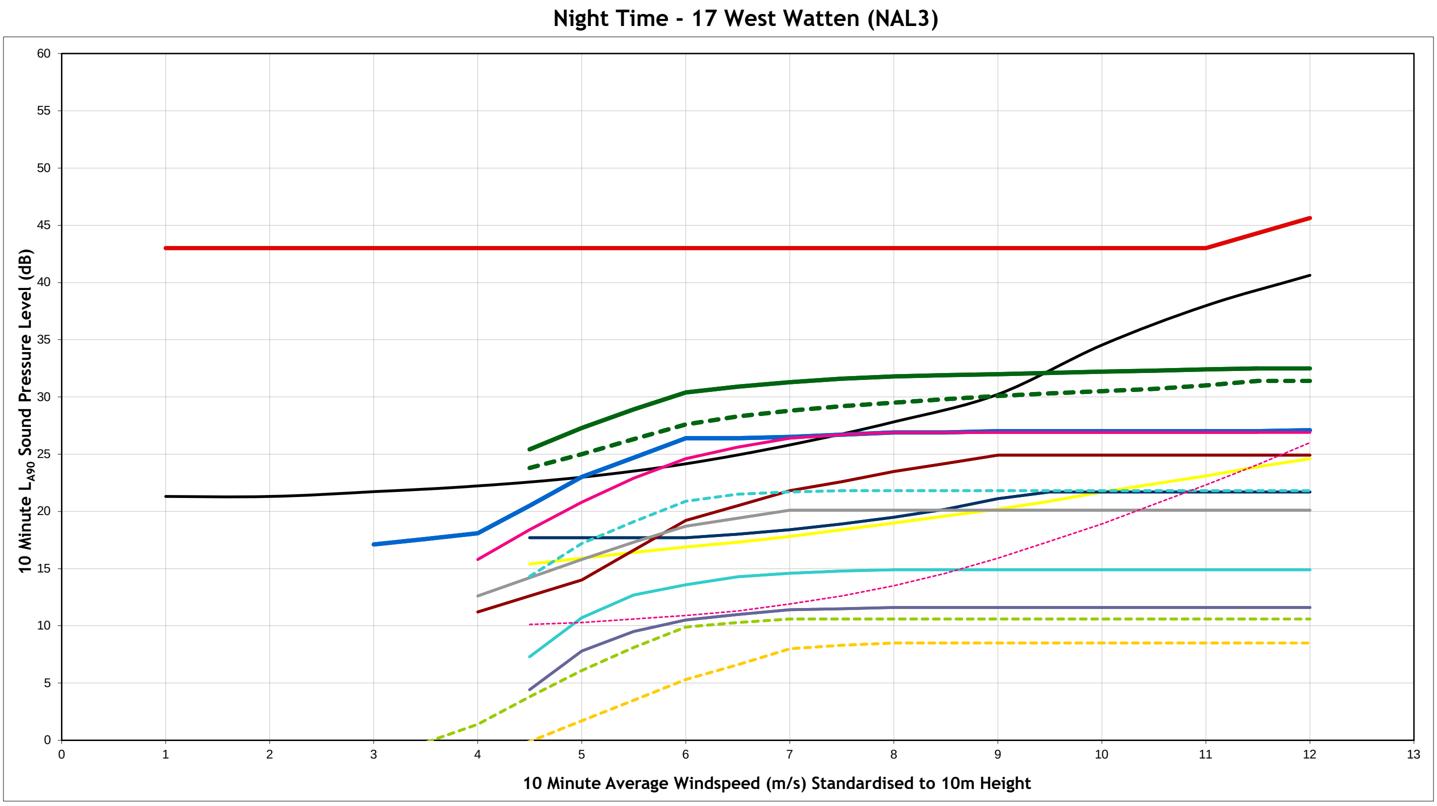

Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions 17 West Watten (NAL3)
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Scale	NTS
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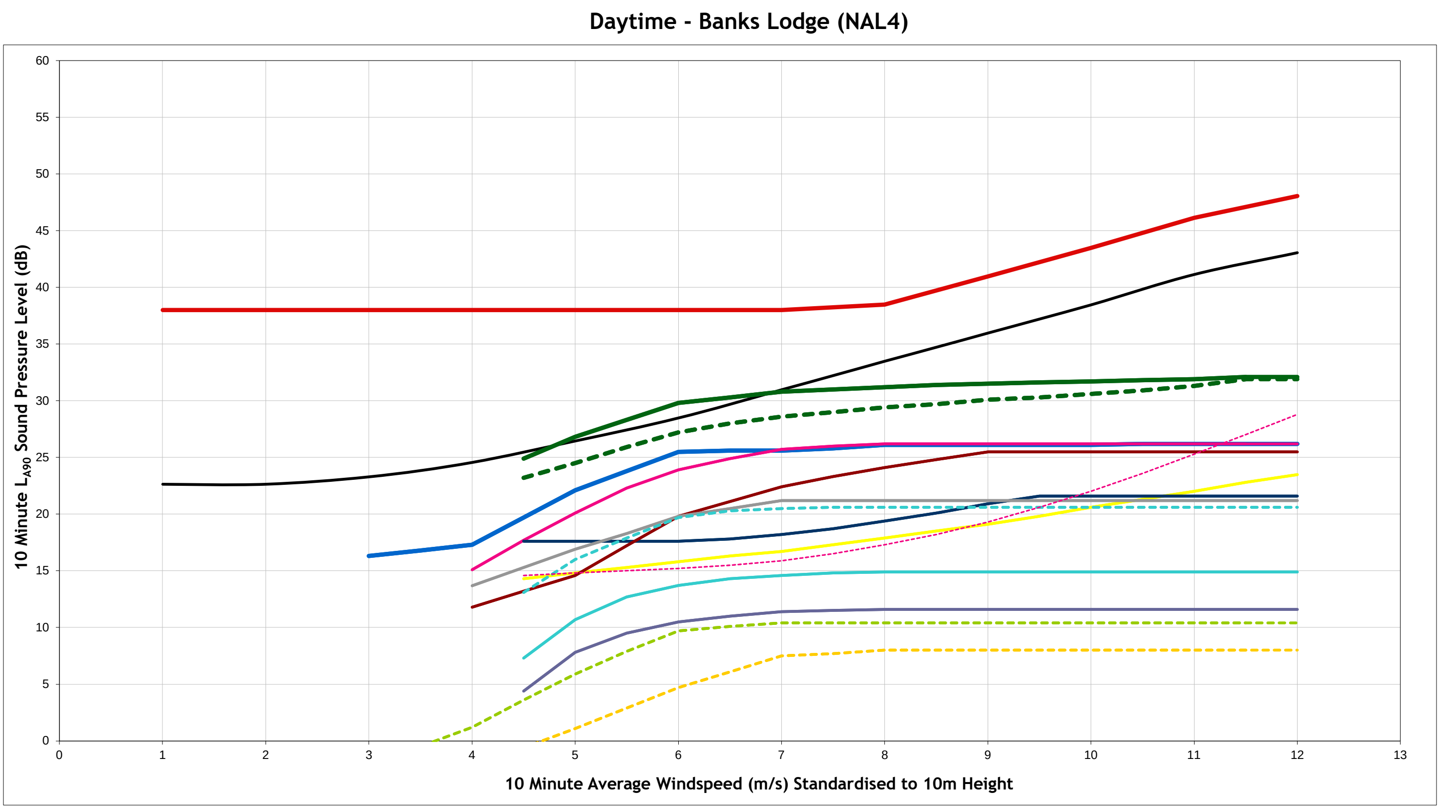
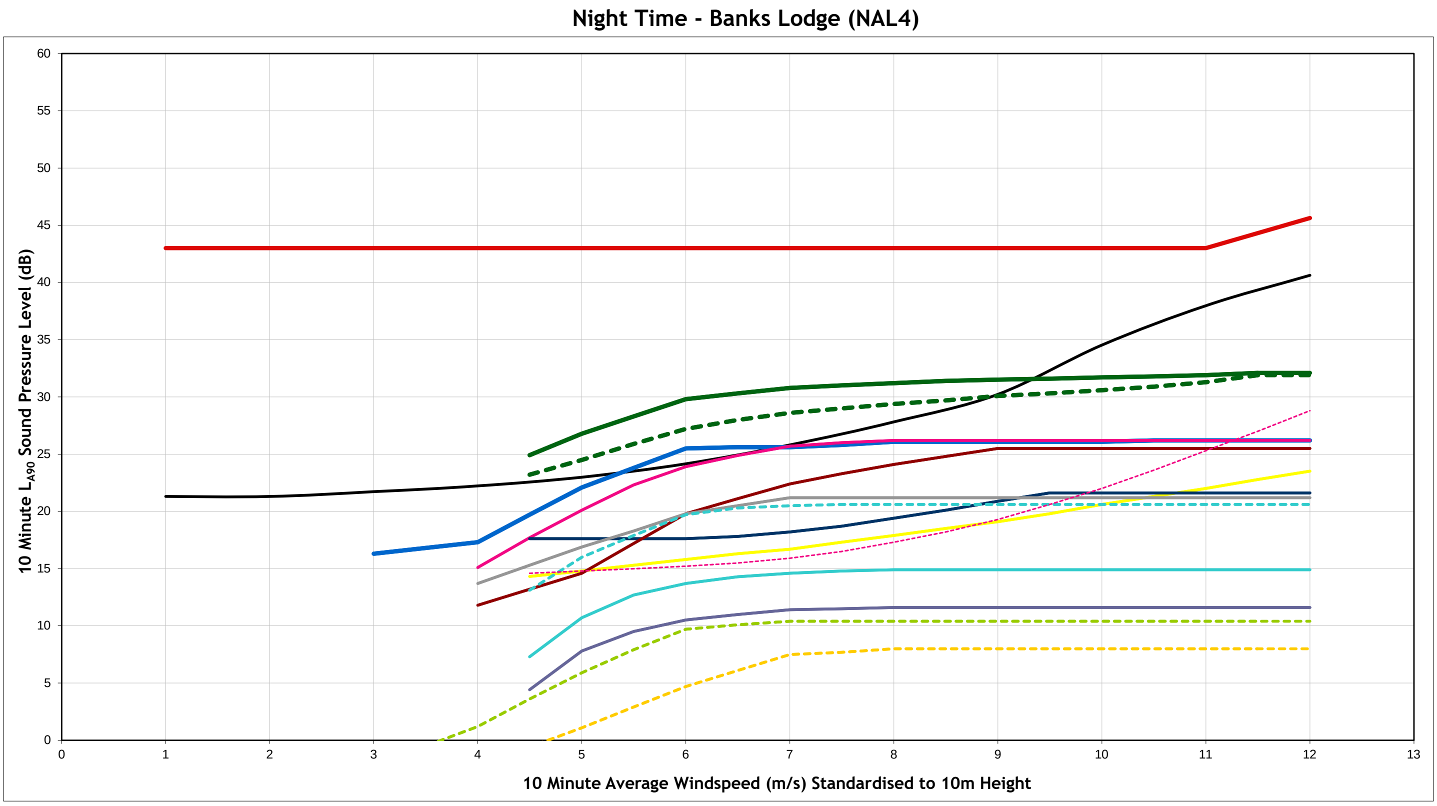
Date	28/06/2023
Document Reference	15098-Models

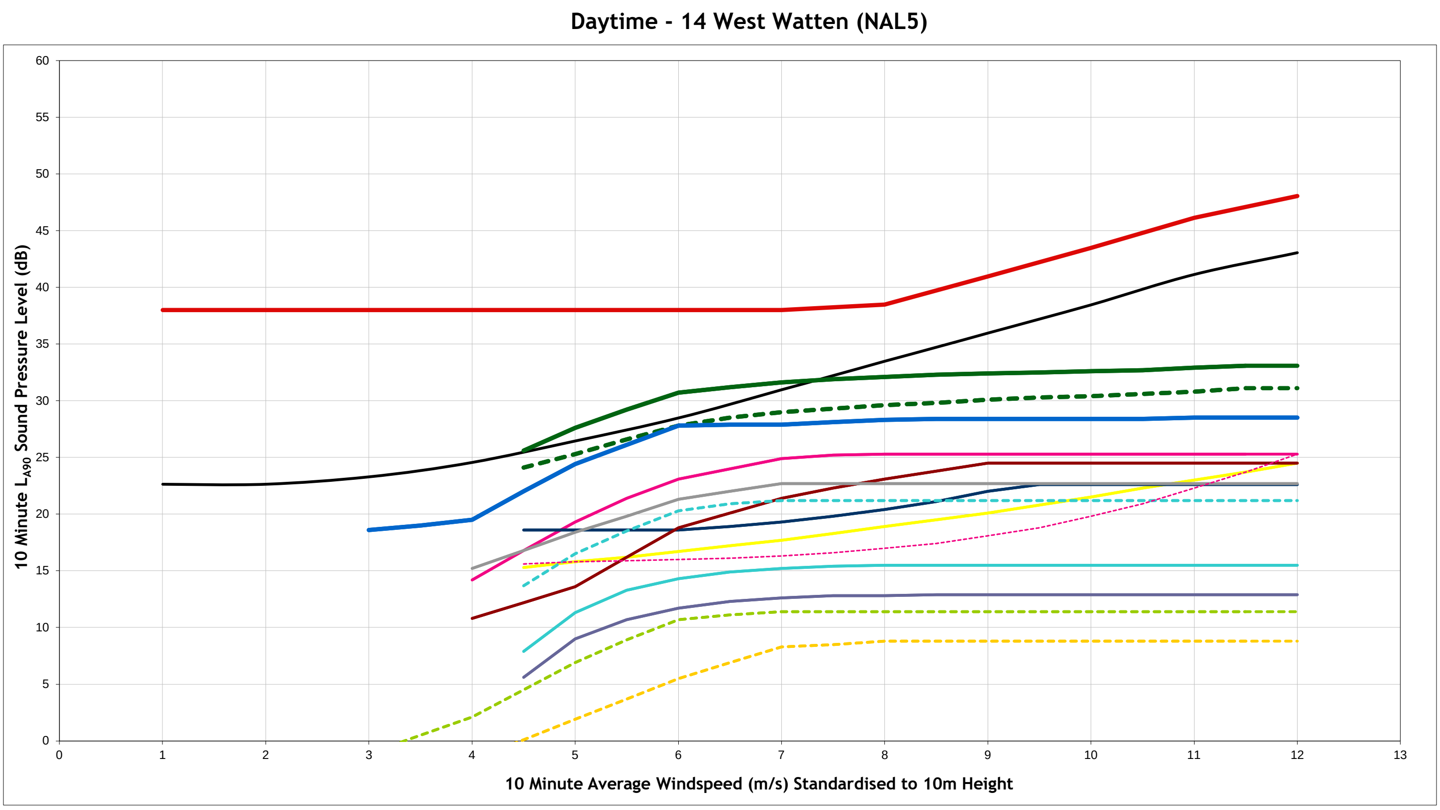


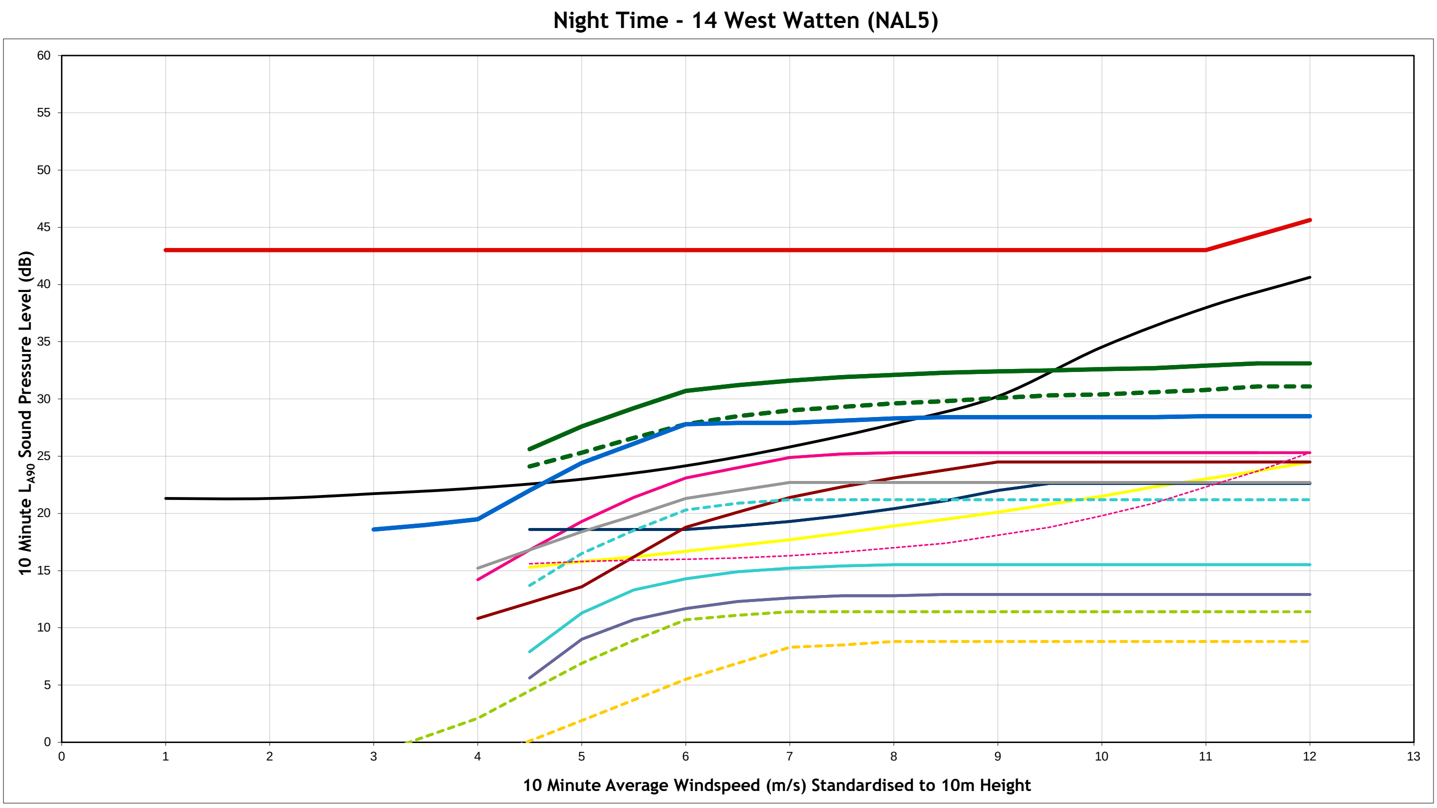


Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions Banks Lodge (NAL4)
Figure Number	A1.2d
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

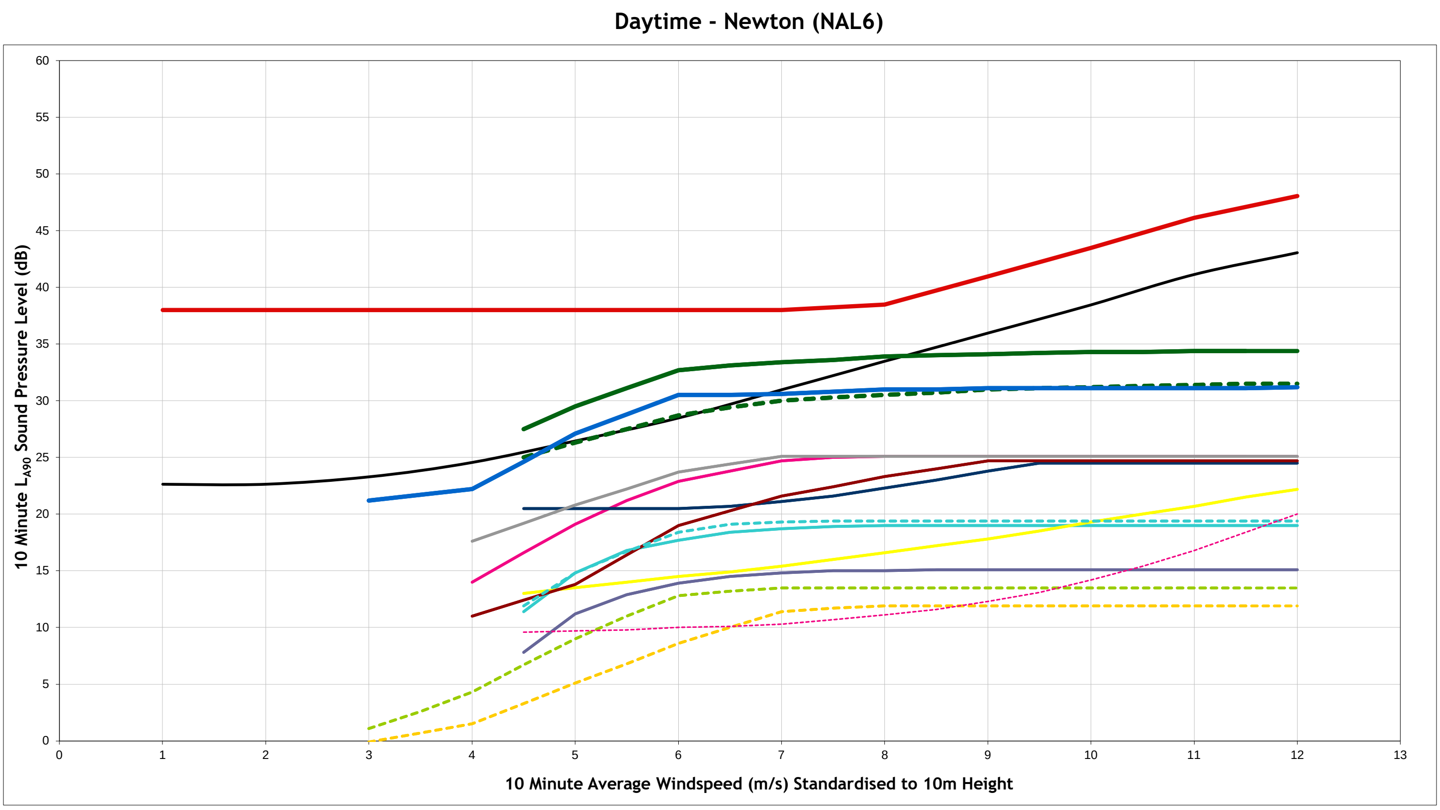


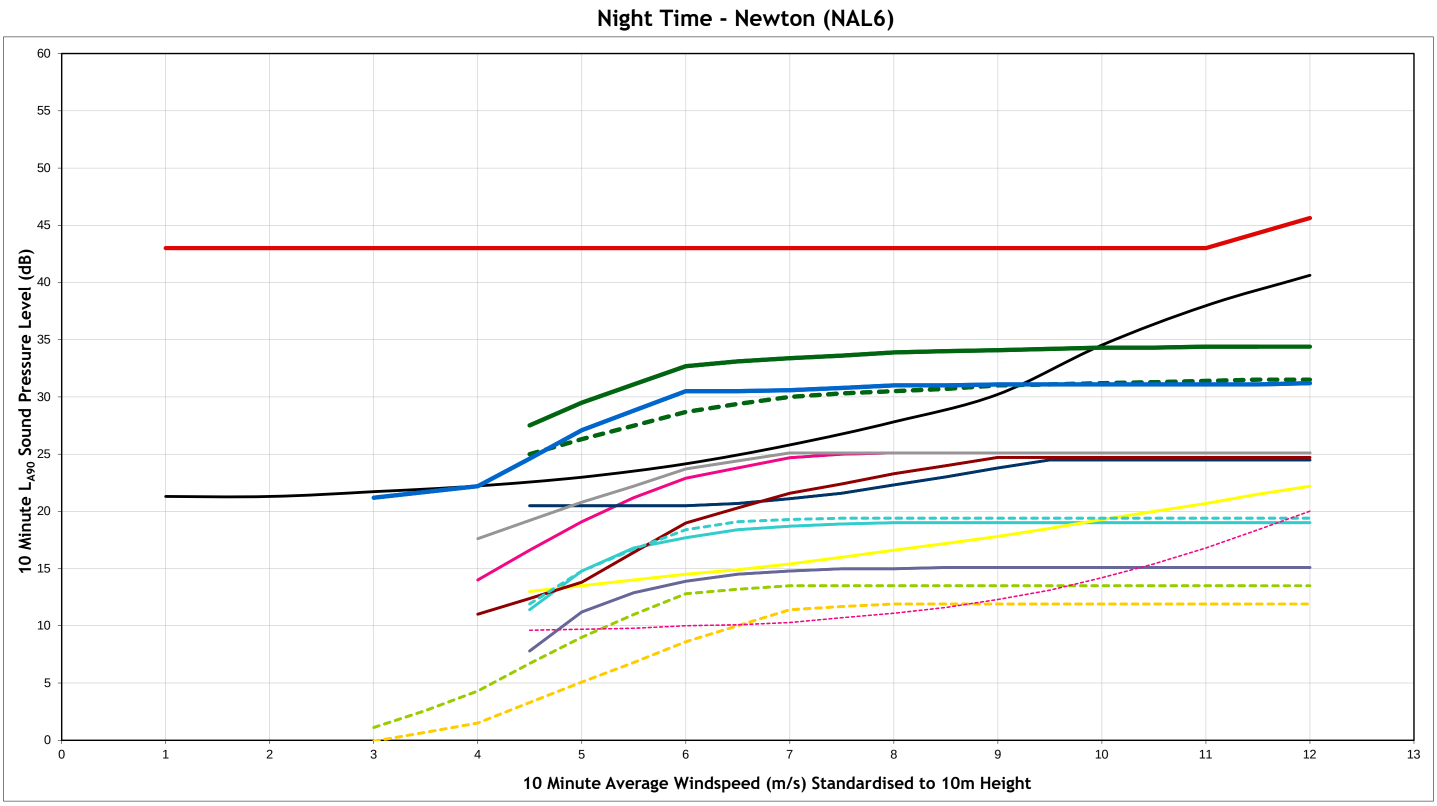


Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions 14 West Watten (NAL5)
Figure Number	A1.2e
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models



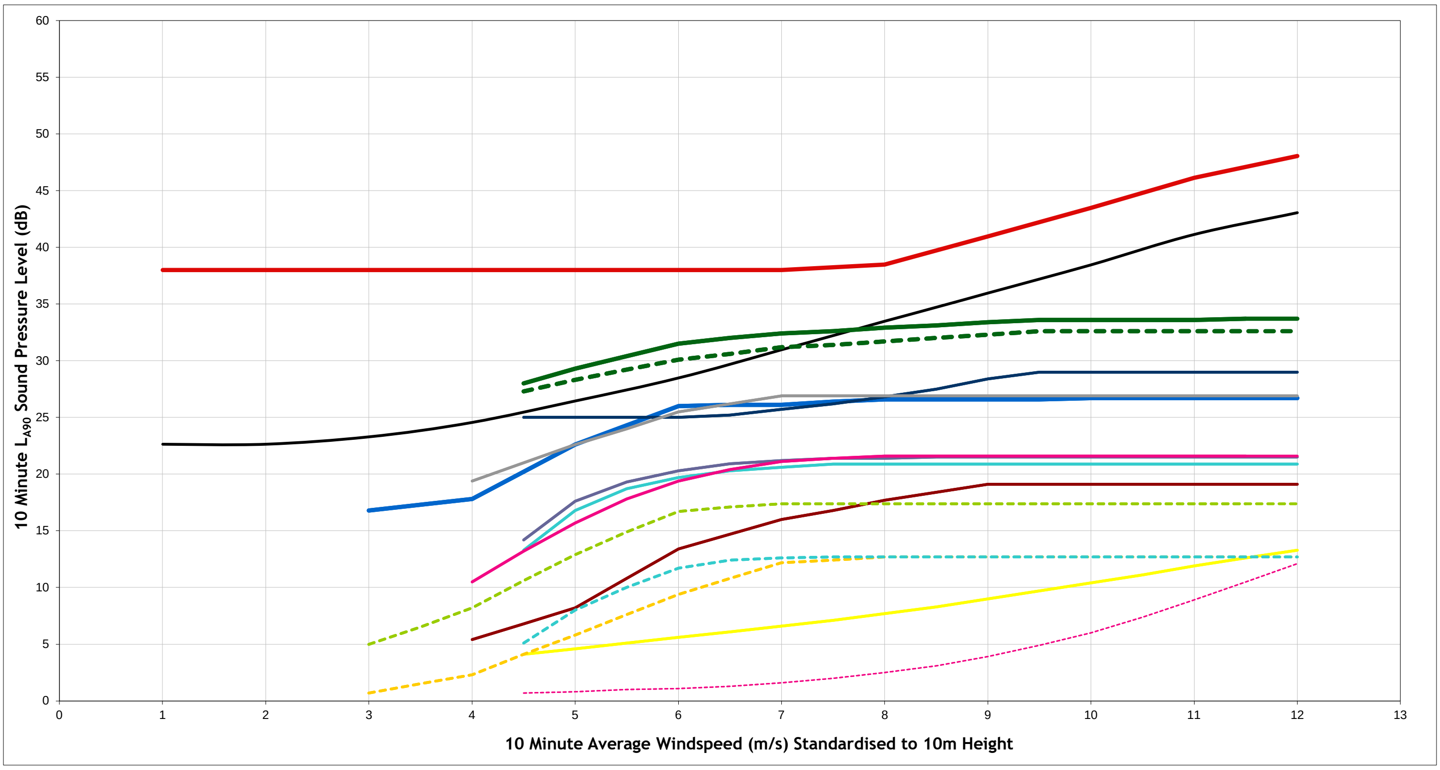


Legend:

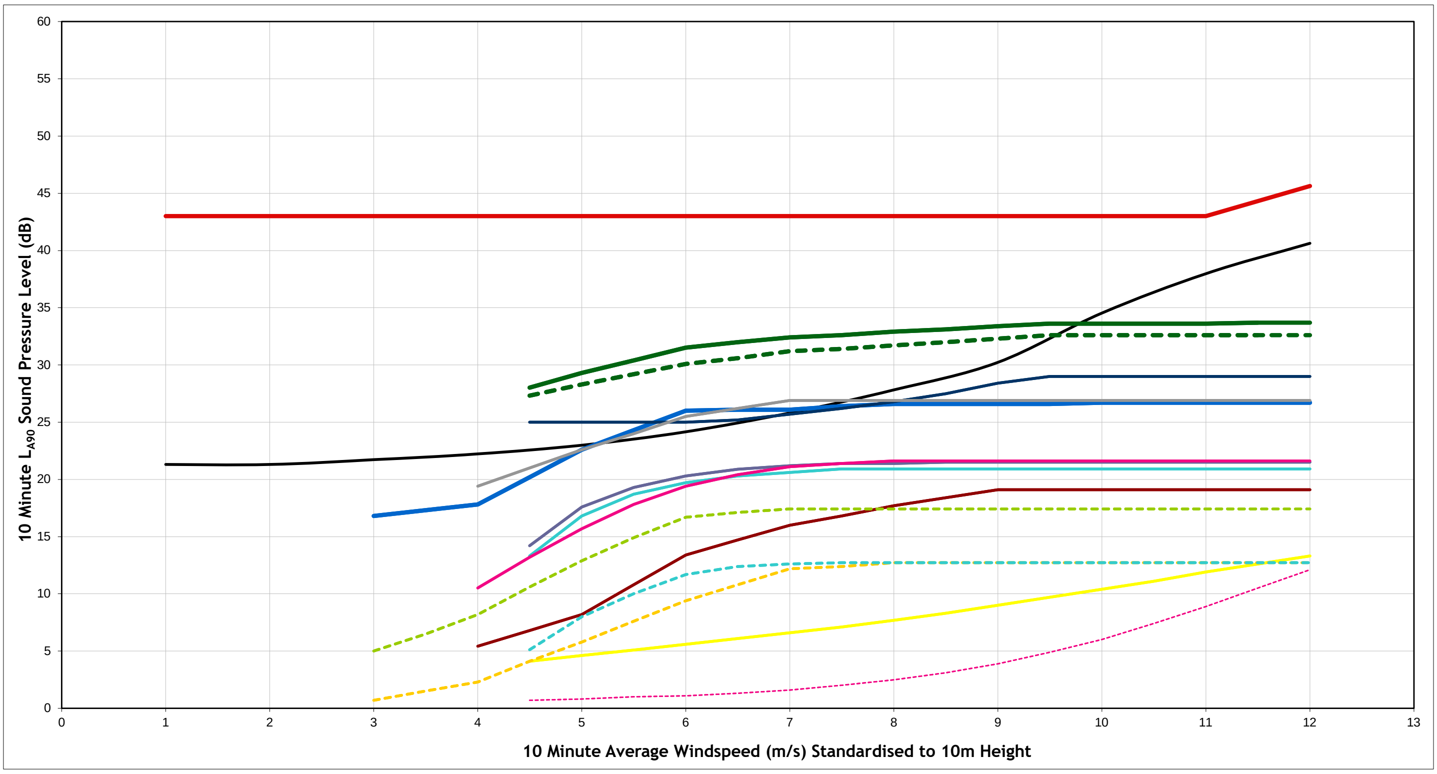
- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions Newton (NAL6)
Figure Number	A1.2f
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Lanergill (NAL7)



Night Time - Lanergill (NAL7)



Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions Lanergill (NAL7)
Figure Number	A1.2g
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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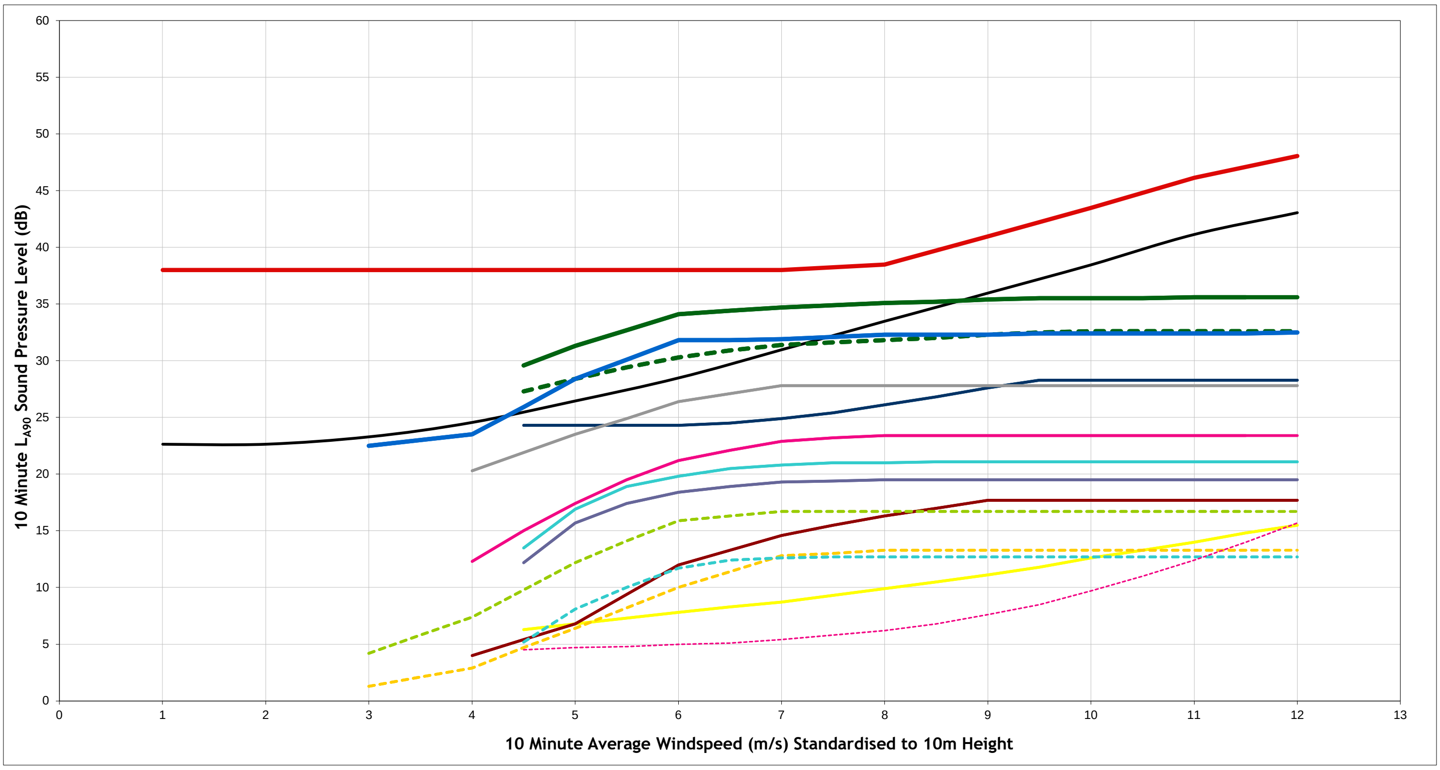
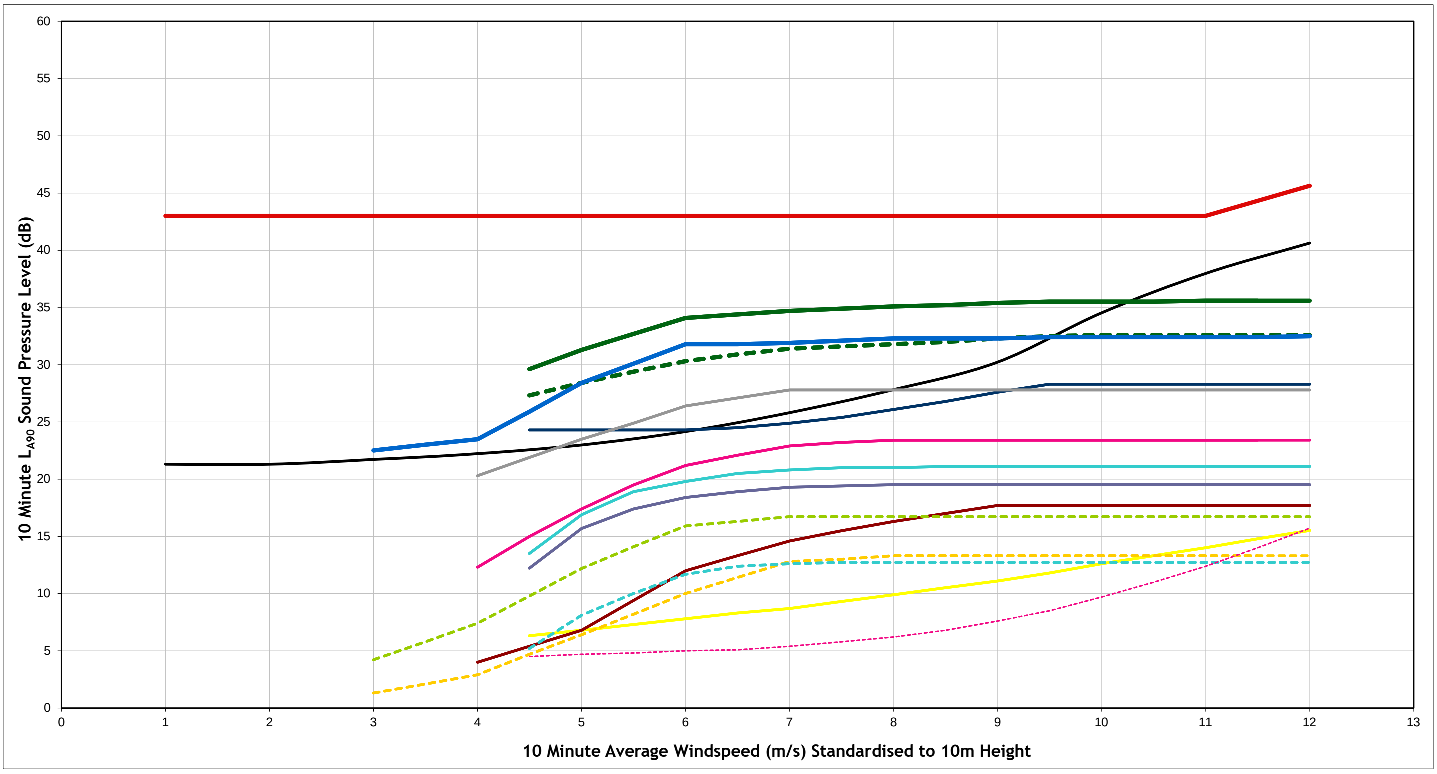


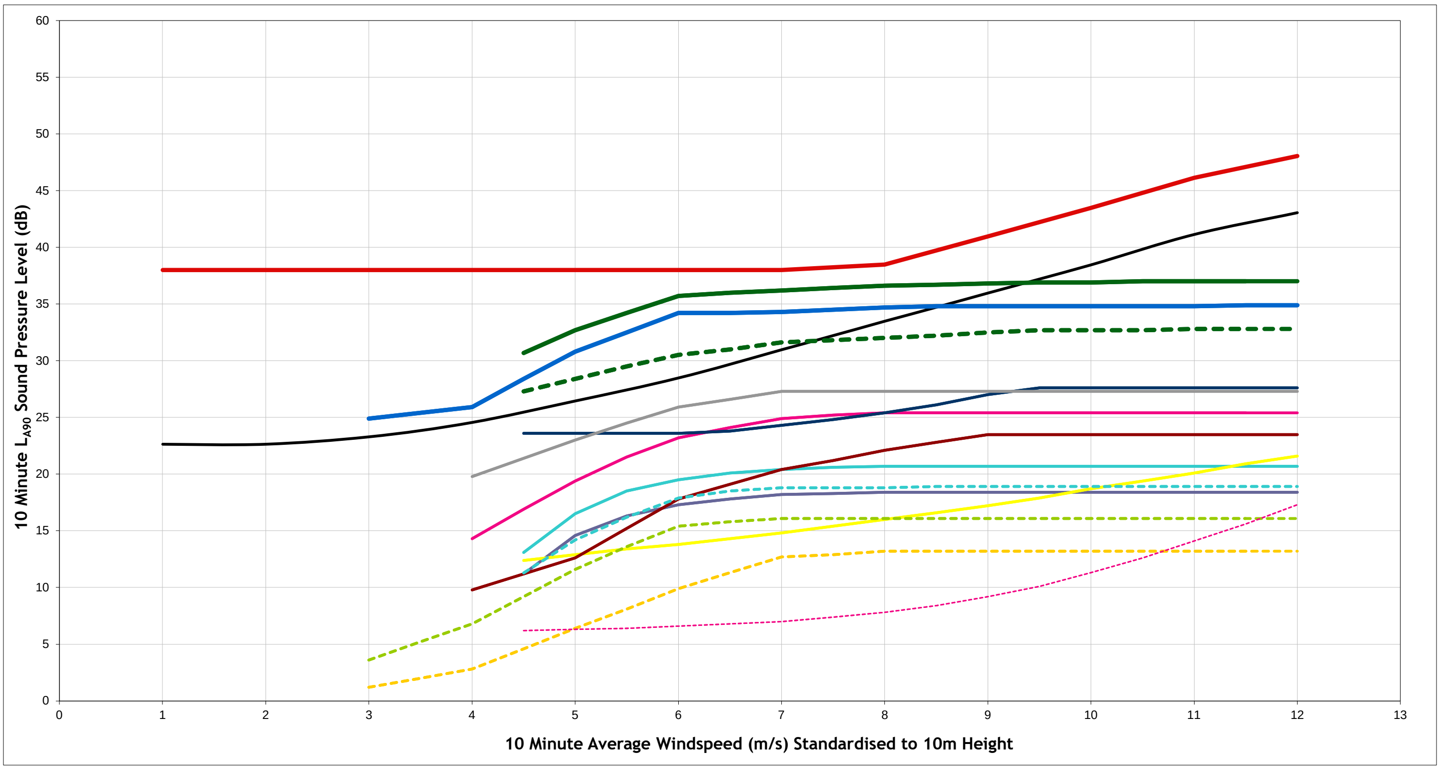


Legend:

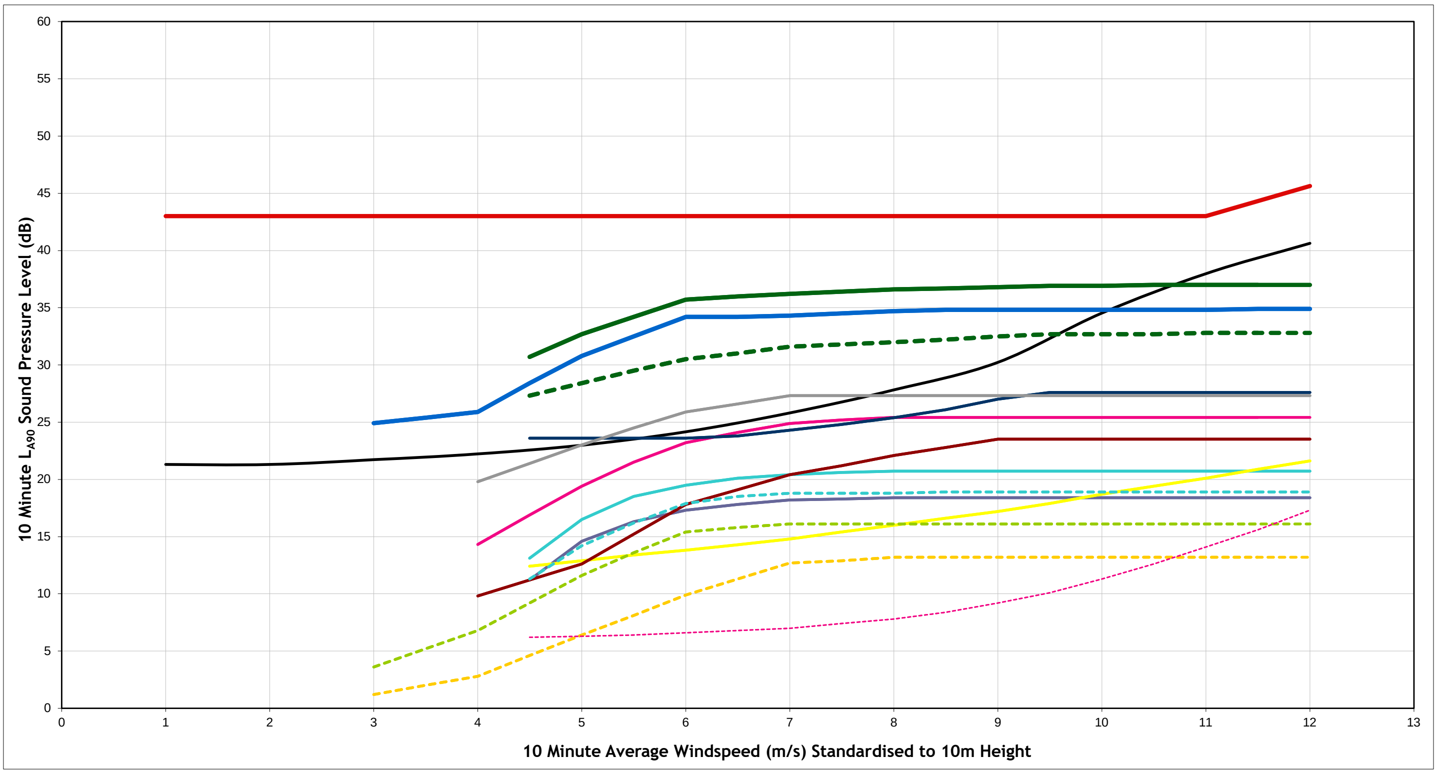
- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions Backlass Hill (NAL8)
Figure Number	A1.2h
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Leanmore Lodge (NAL9)



Night Time - Leanmore Lodge (NAL9)

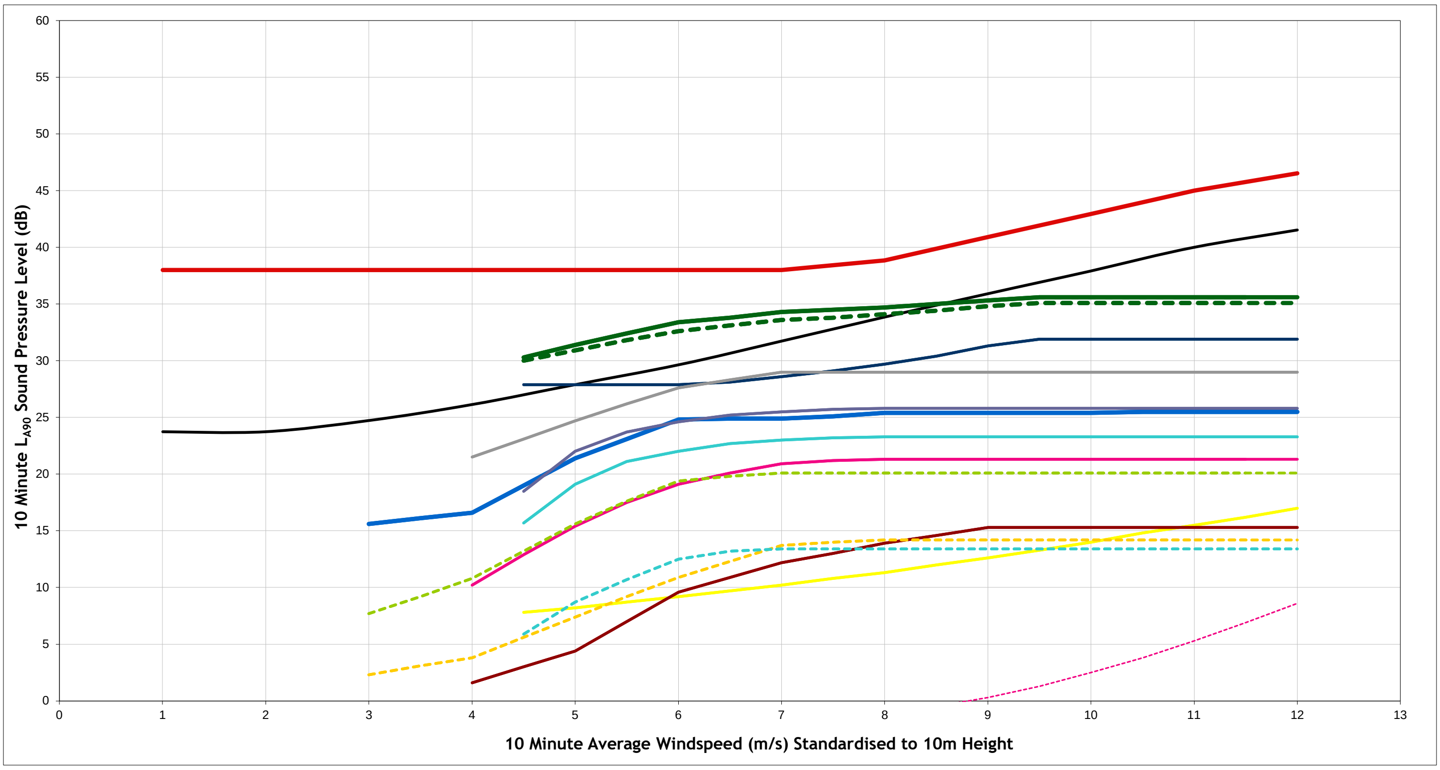


Legend:

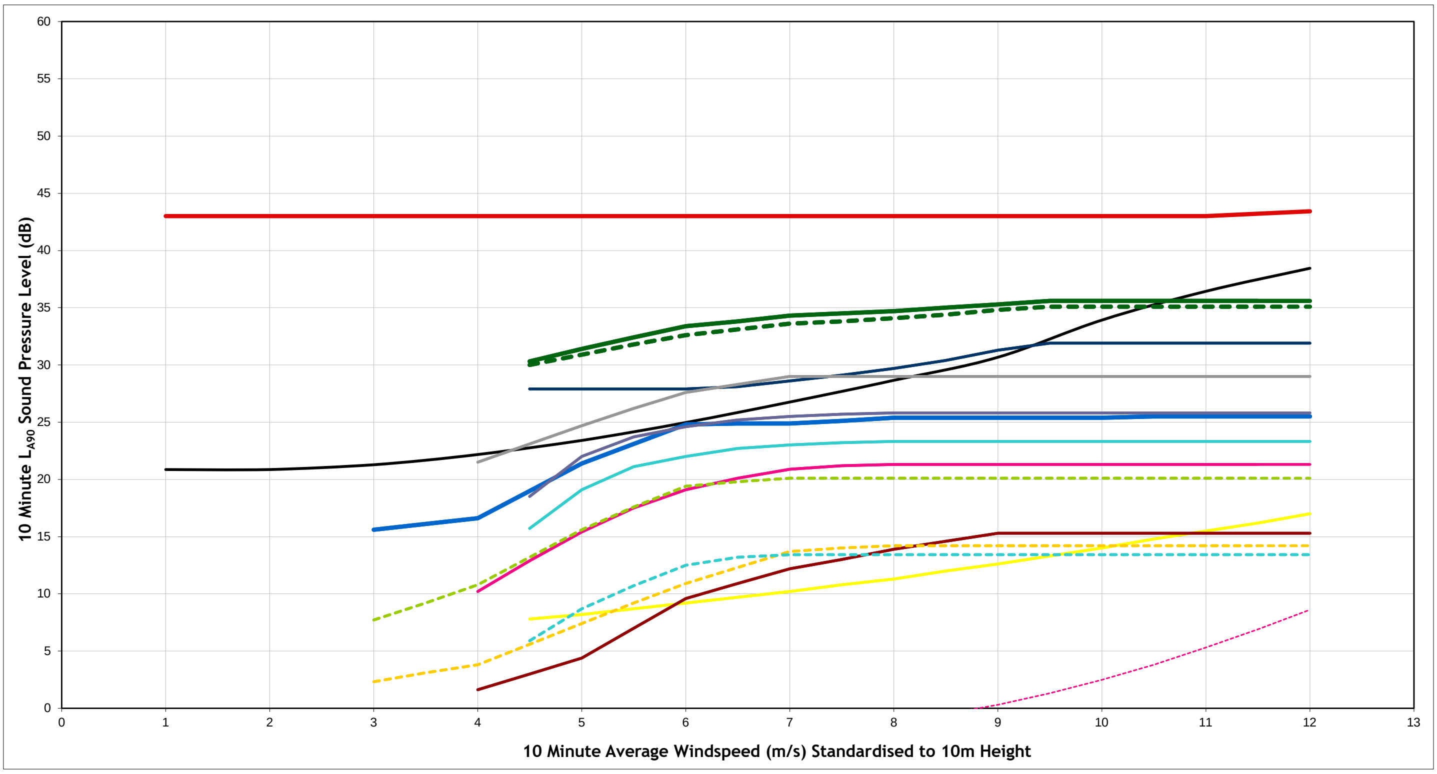
- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions Leanmore Lodge (NAL9)
Figure Number	A1.2i
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Achnamoine (NAL10)



Night Time - Achnamoine (NAL10)



Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions Achnamoine (NAL10)
Figure Number	A1.2j
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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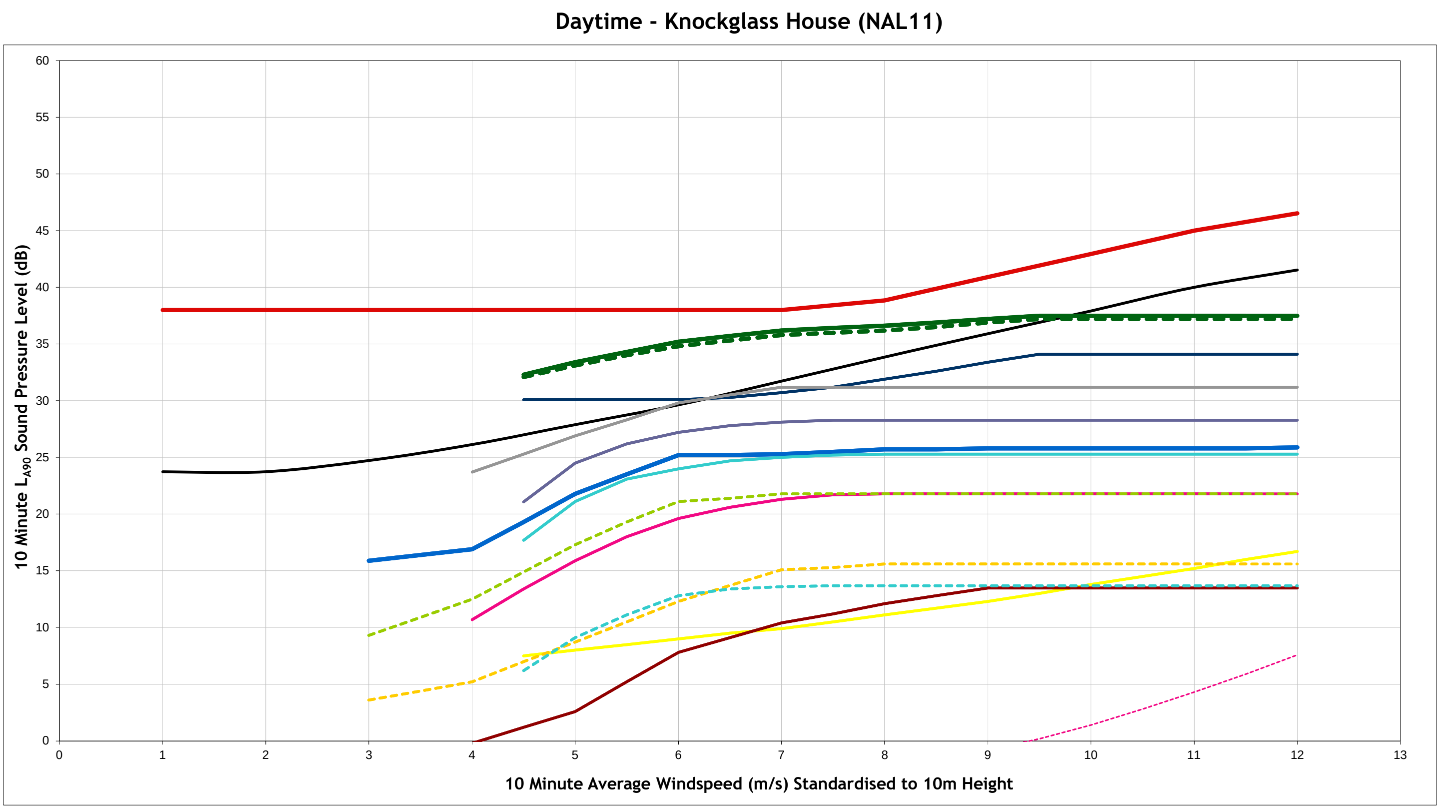

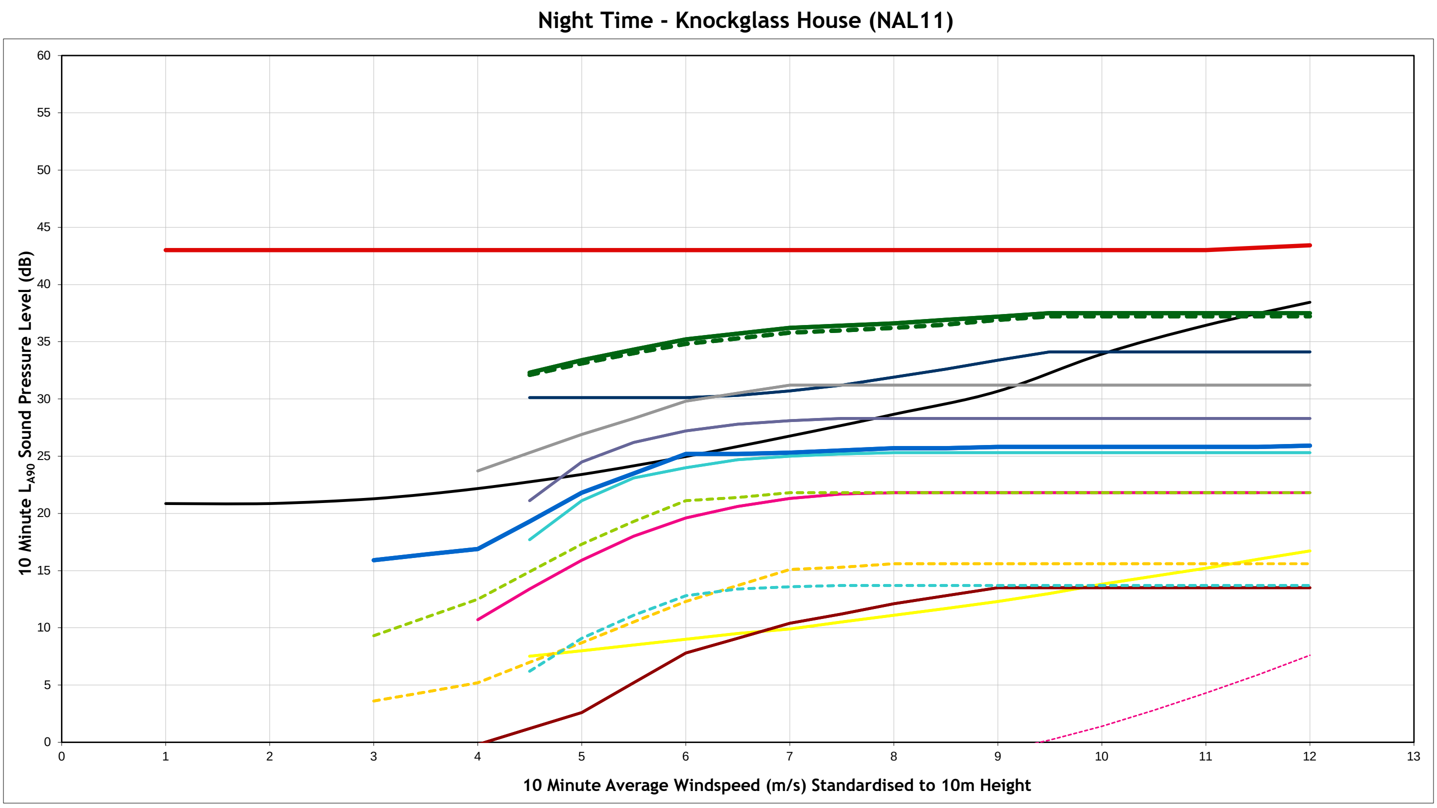

Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (including the Proposed Development)
- Cumulative (excluding the Proposed Development)
- Proposed Development
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Likely Predictions Knockglass House (NAL11)
Figure Number	A1.2k
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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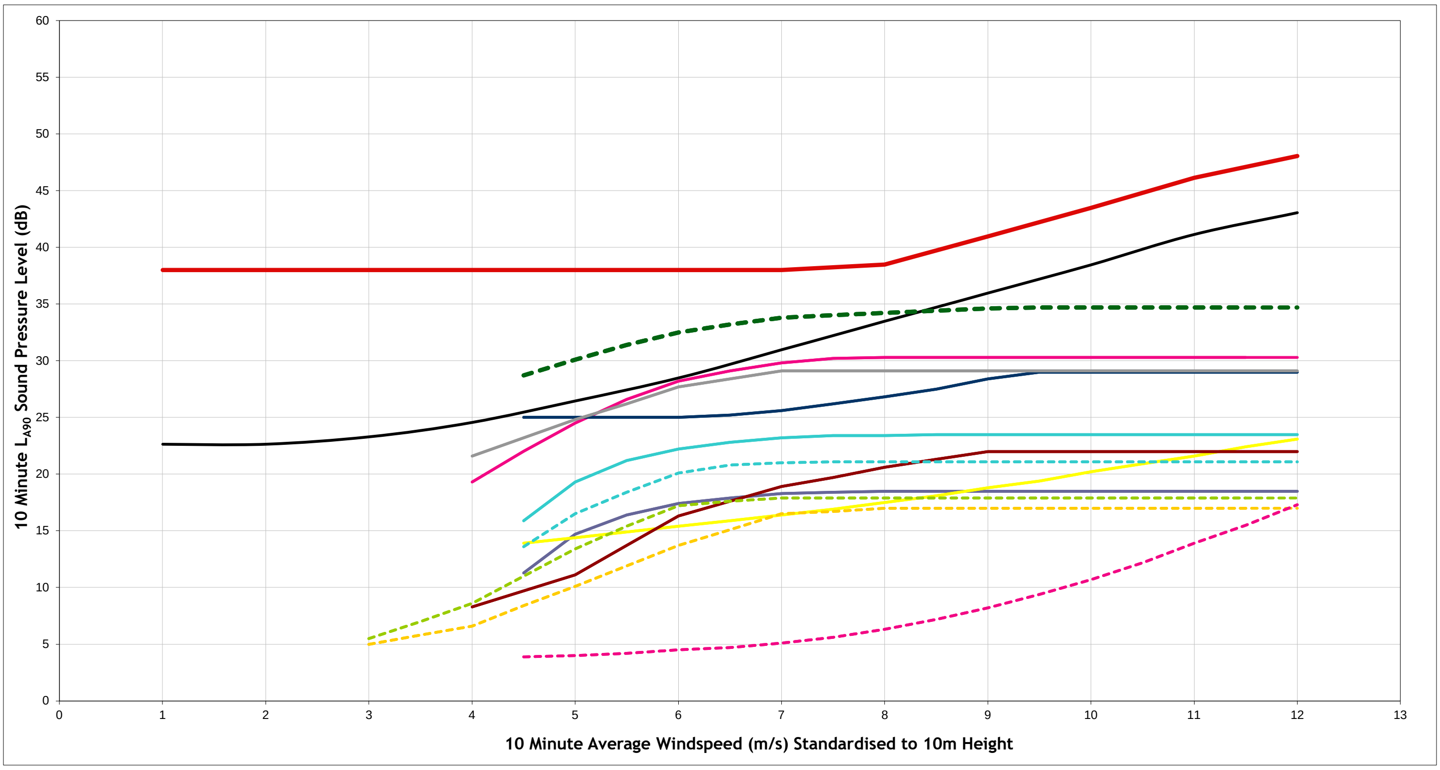
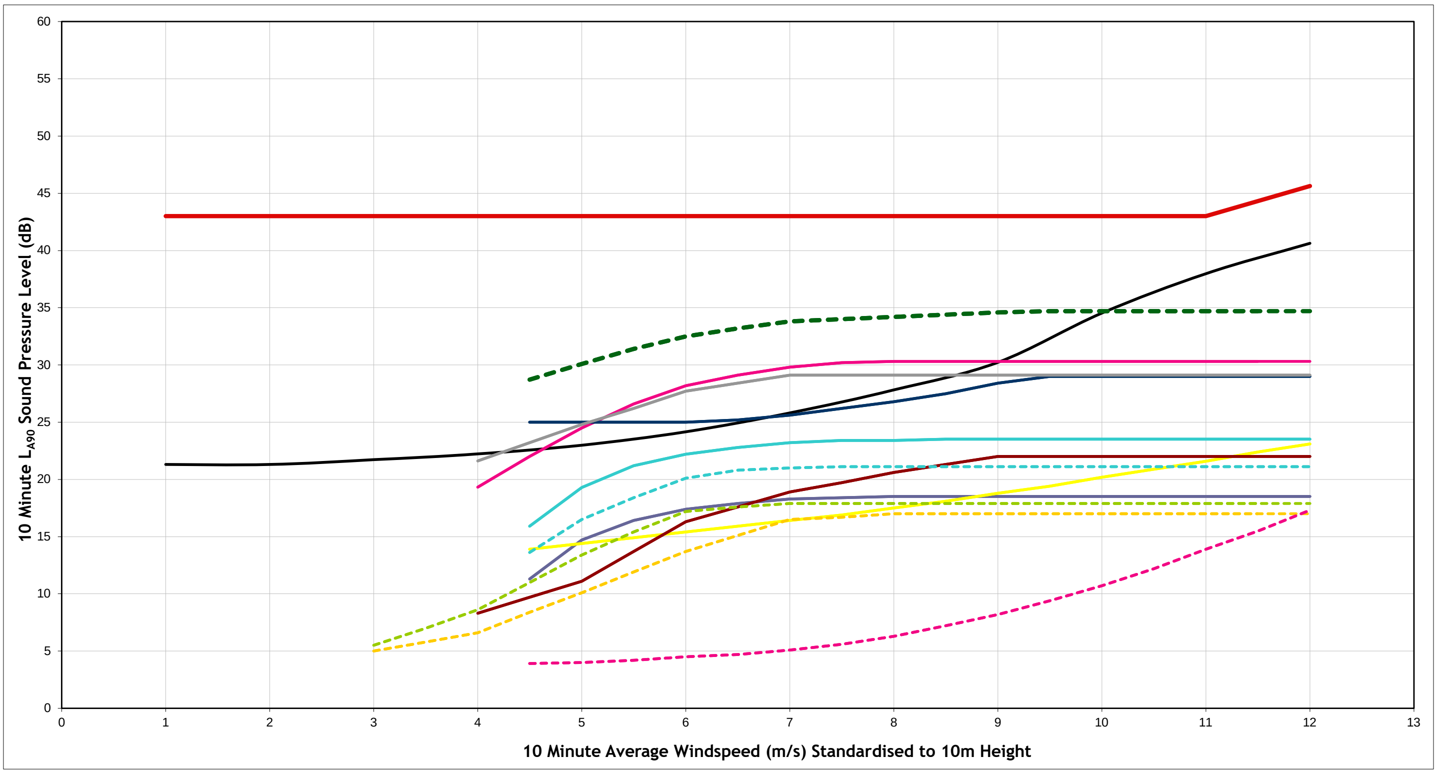
Figures A1.3a-k - Cautious Noise Predictions

Daytime - 21-22 West Watten (NAL1)



Night Time - 21-22 West Watten (NAL1)



Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions 21-22 West Watten (NAL1)
Figure Number	A1.3a
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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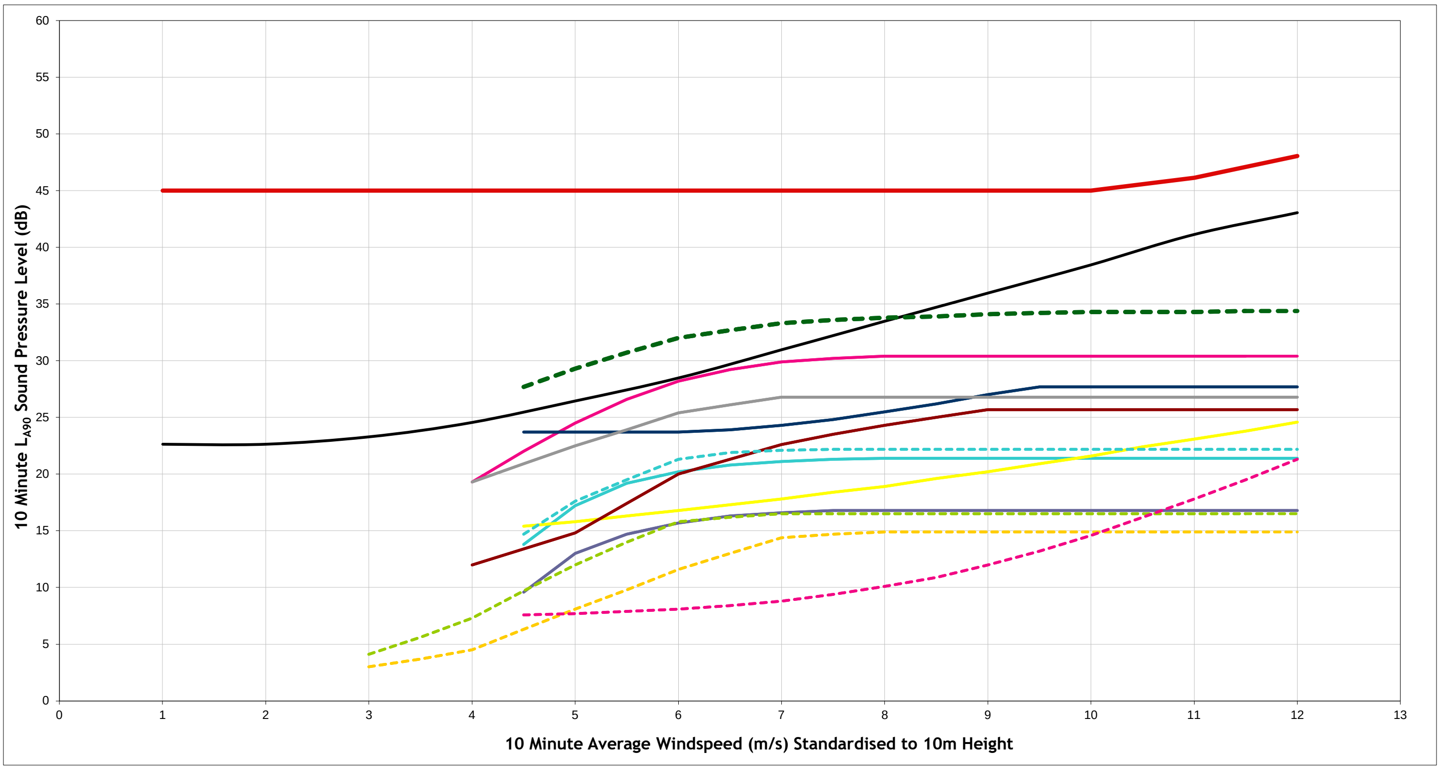
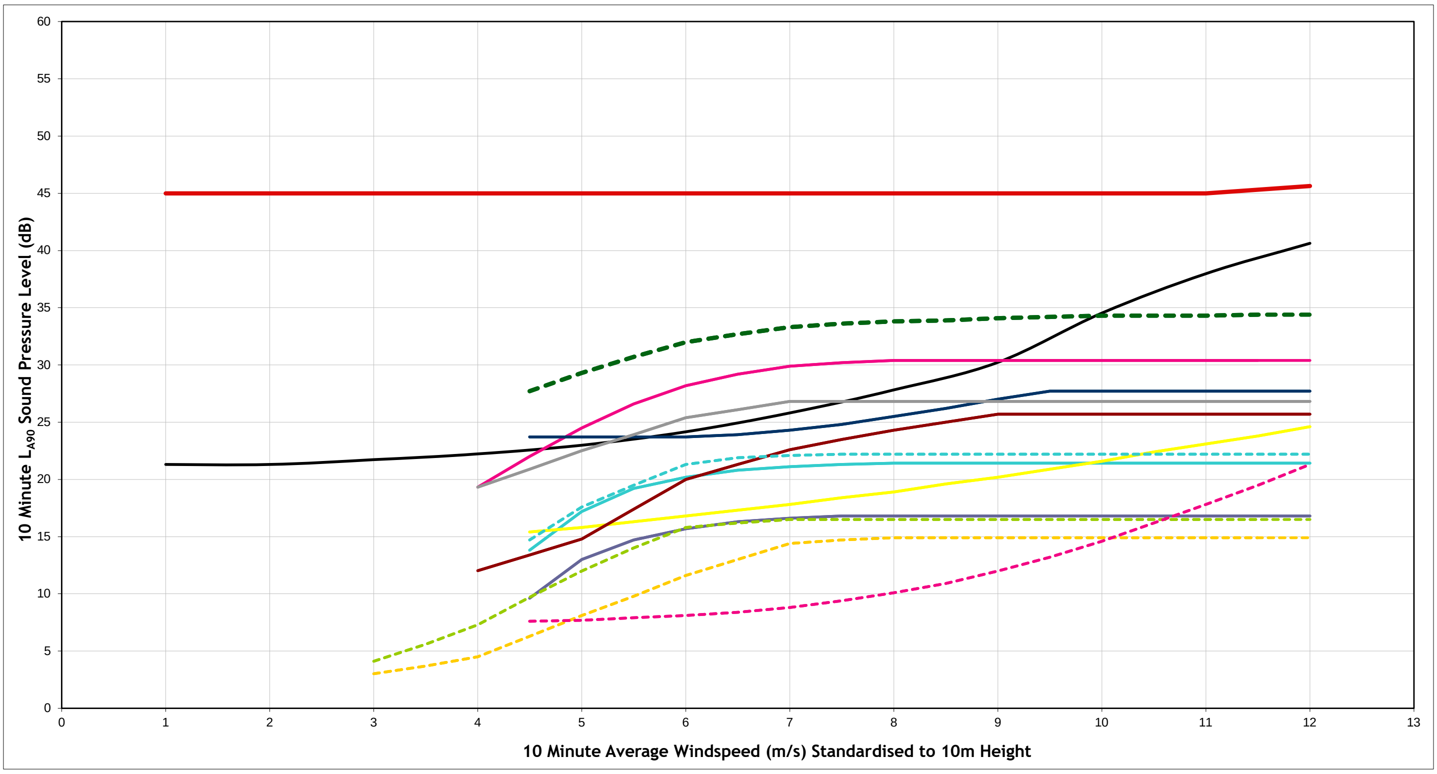
Daytime - 18 West Watten (NAL2)



Night Time - 18 West Watten (NAL2)



Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions 18 West Watten (NAL2)
Figure Number	A1.3b
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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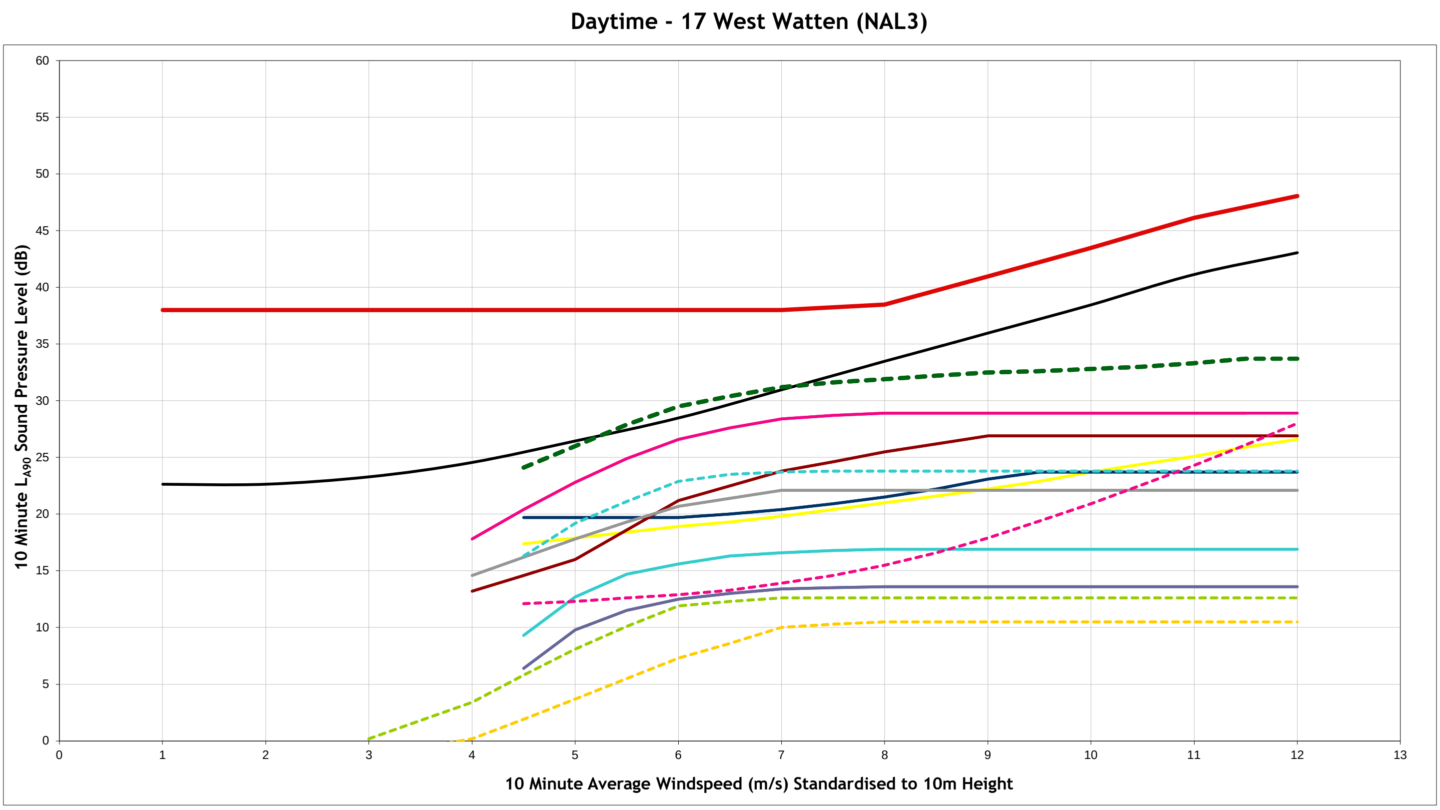

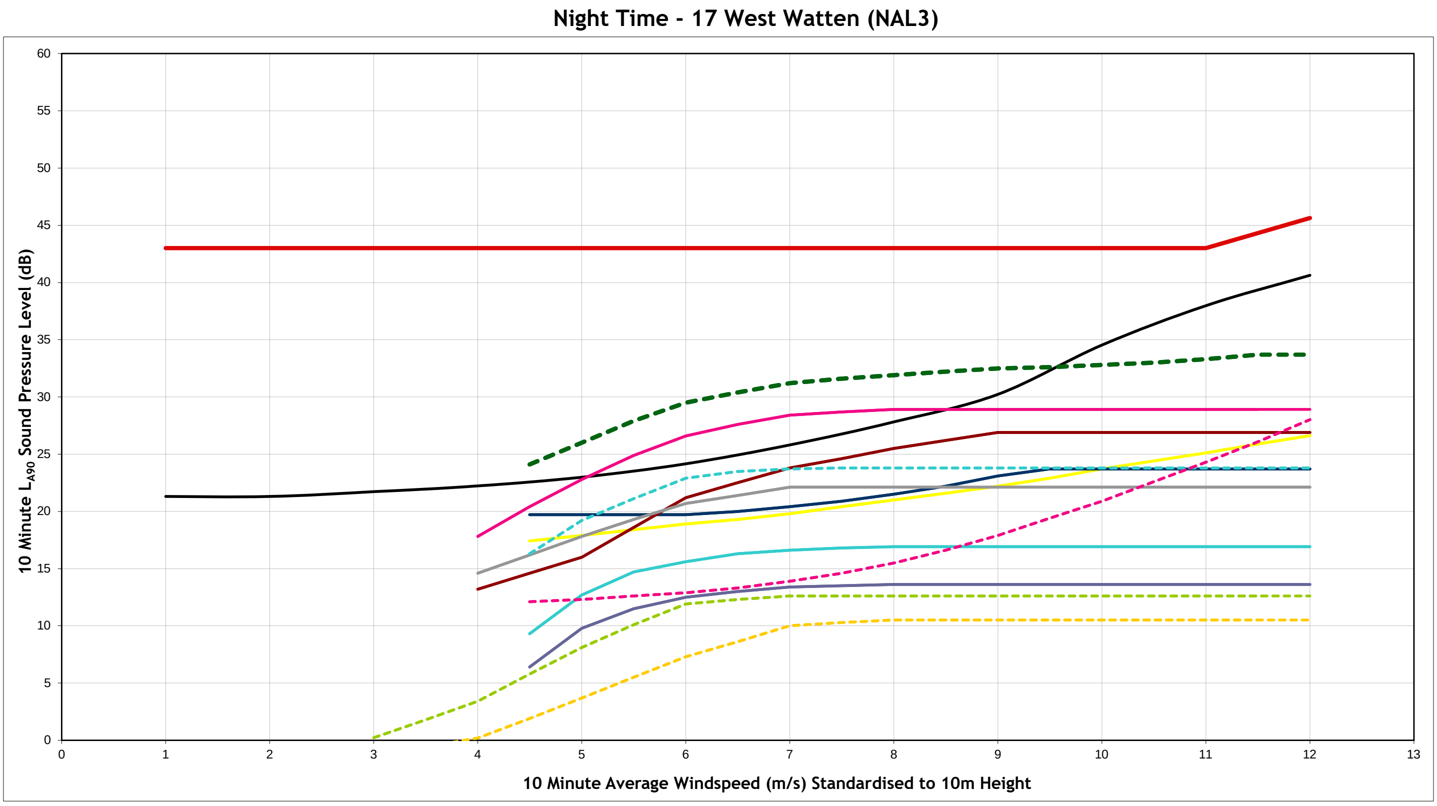

Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions 17 West Watten (NAL3)
Figure Number	A1.3c
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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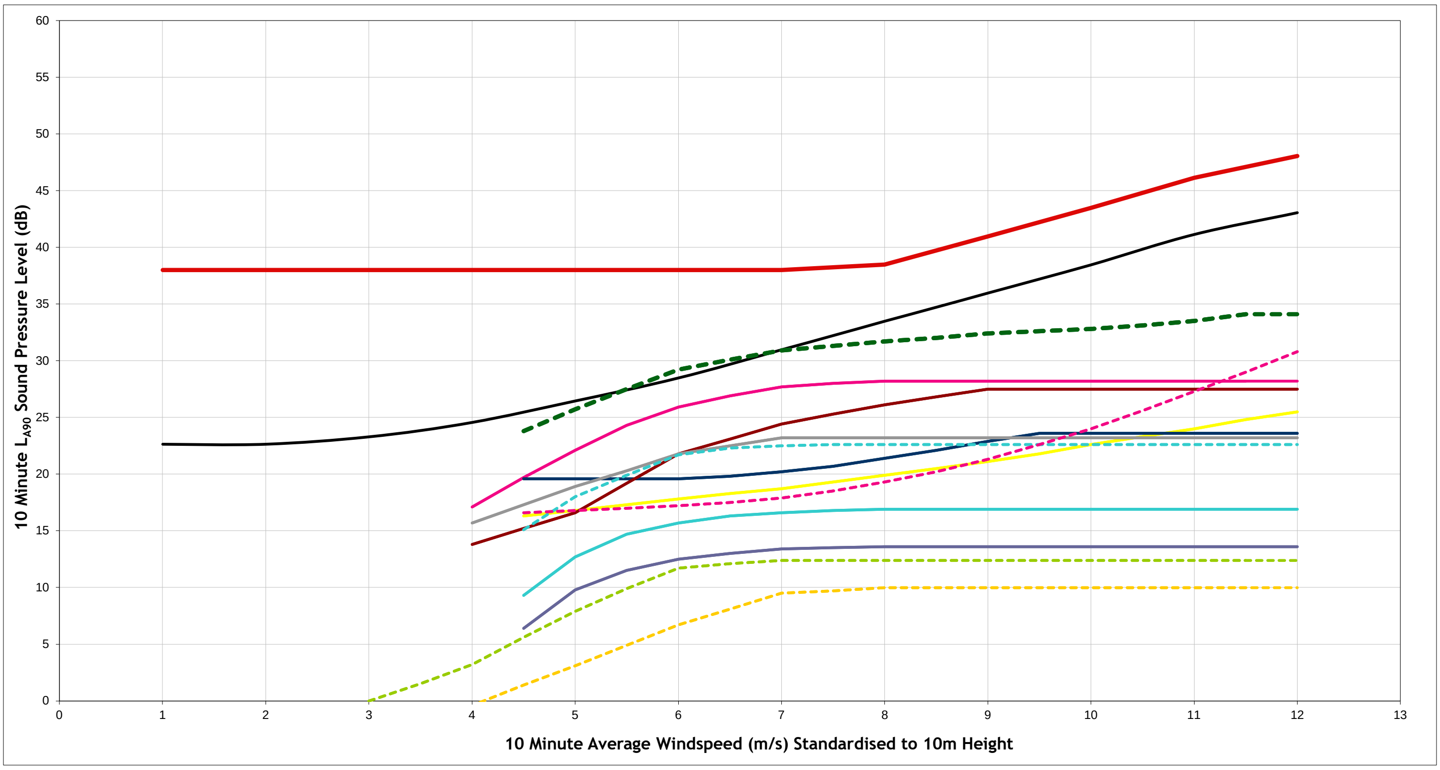
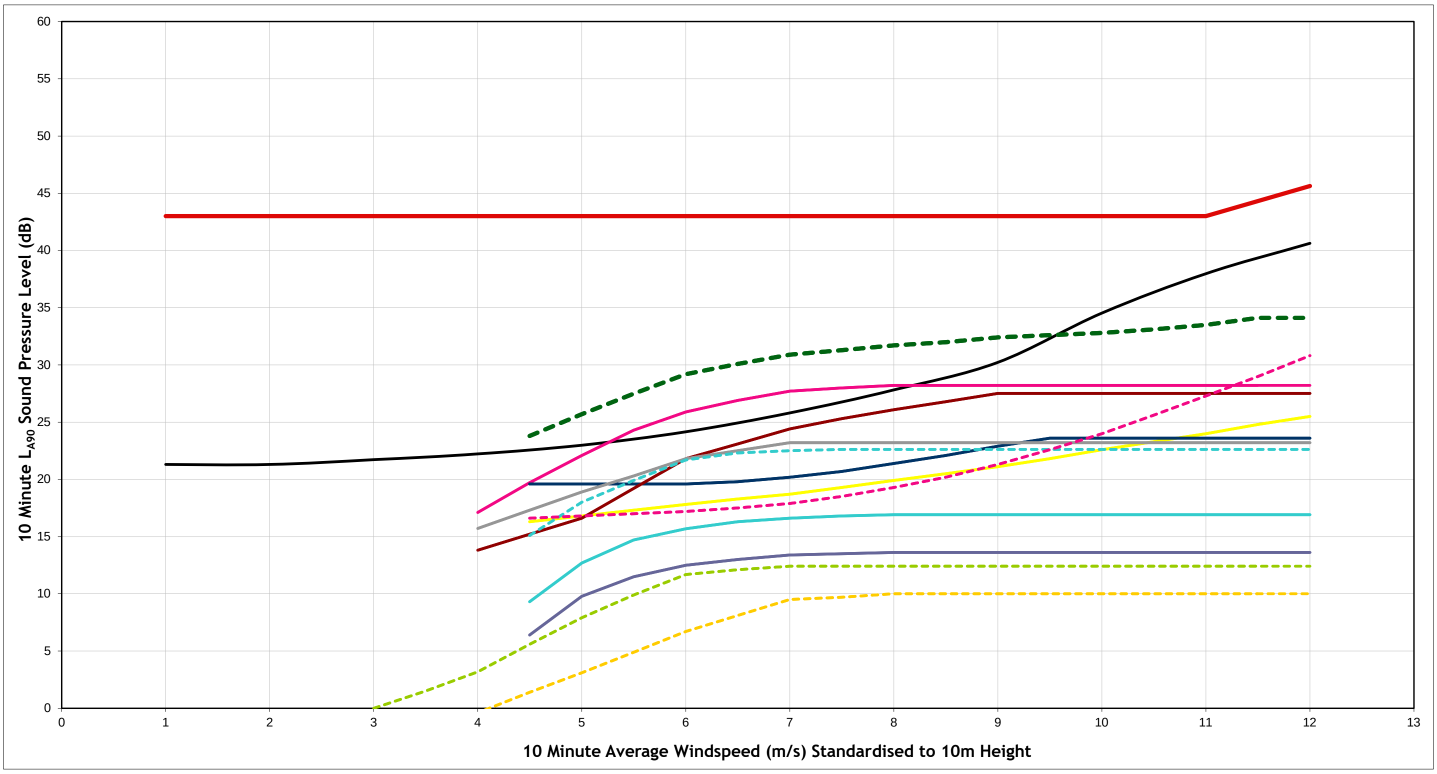
Daytime - Banks Lodge (NAL4)



Night Time - Banks Lodge (NAL4)

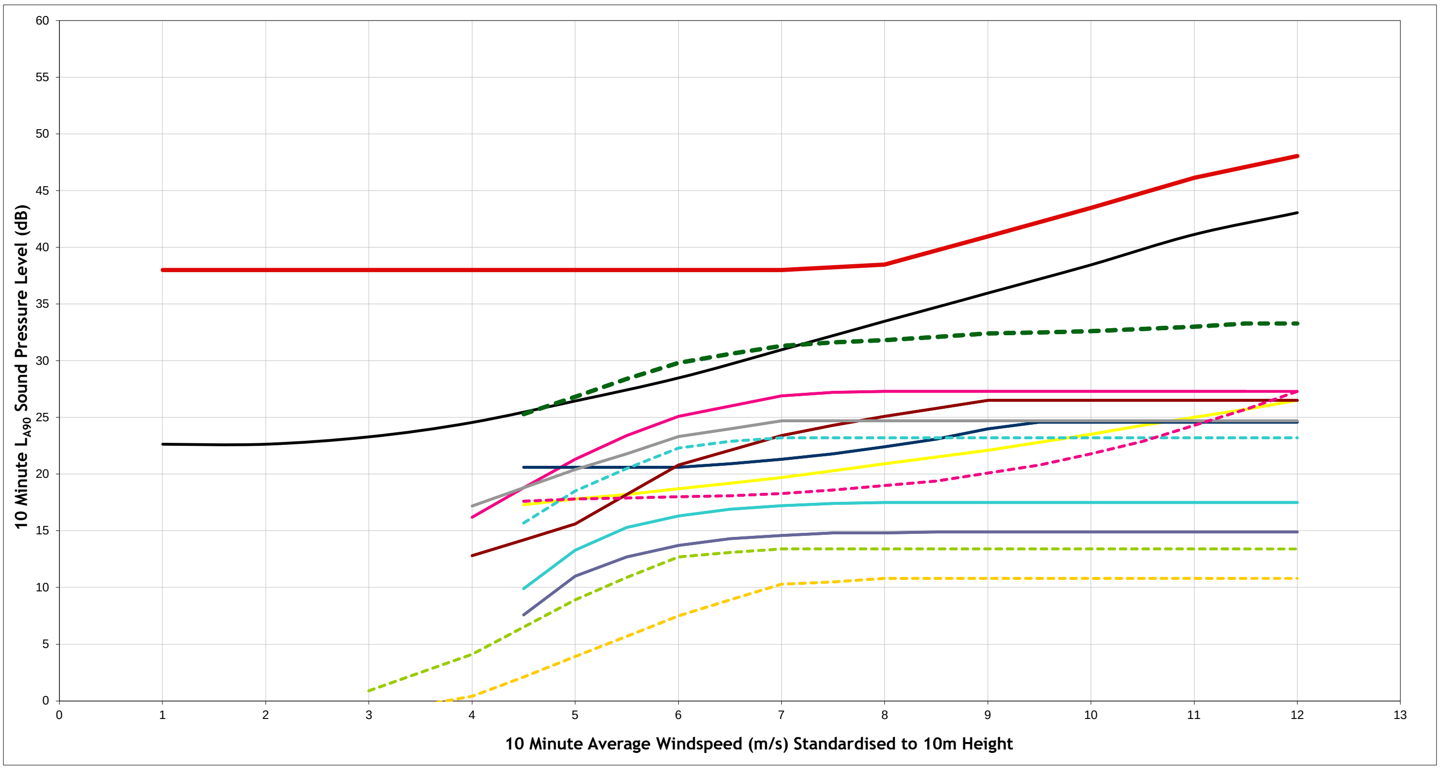


Legend:

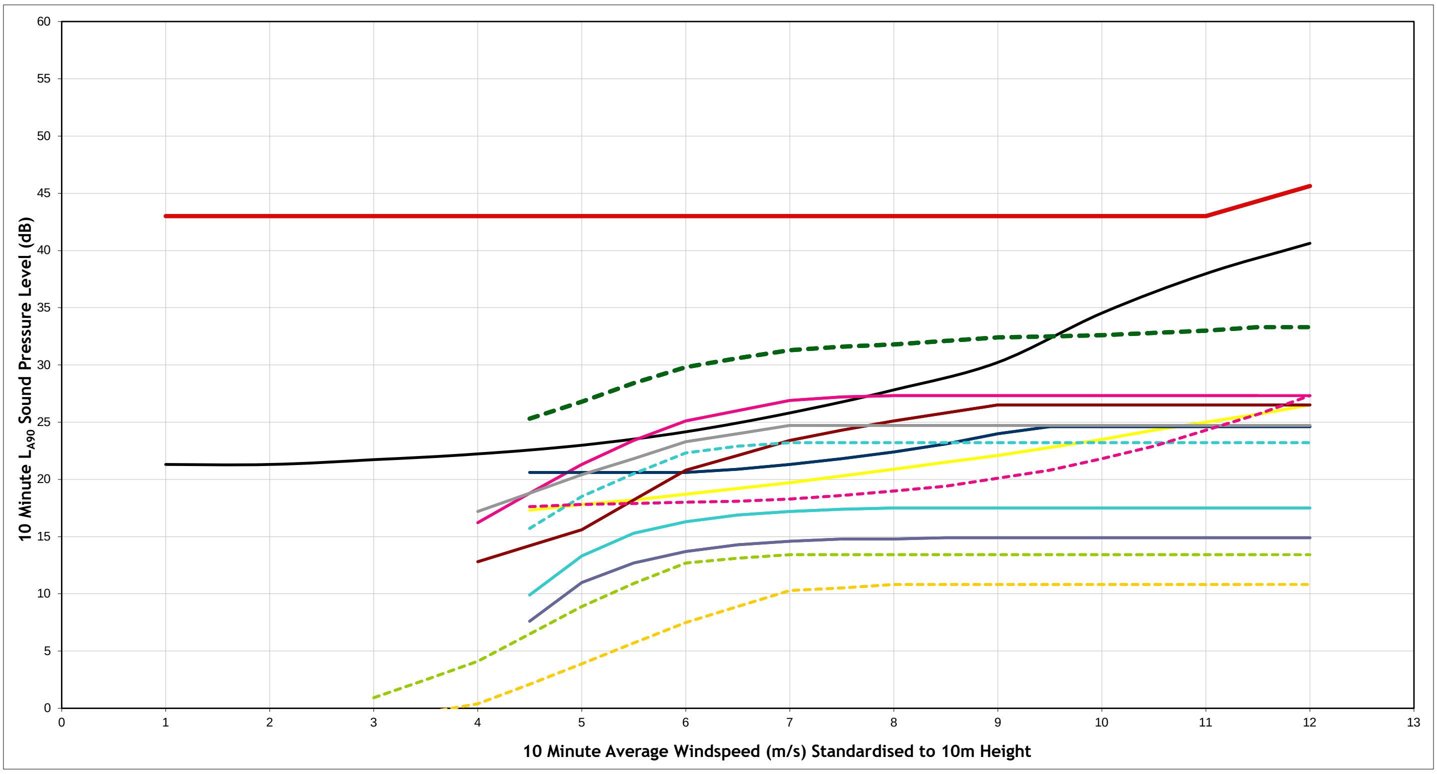
- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions Banks Lodge (NAL4)
Figure Number	A1.3d
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - 14 West Watten (NAL5)



Night Time - 14 West Watten (NAL5)



Legend:

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- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
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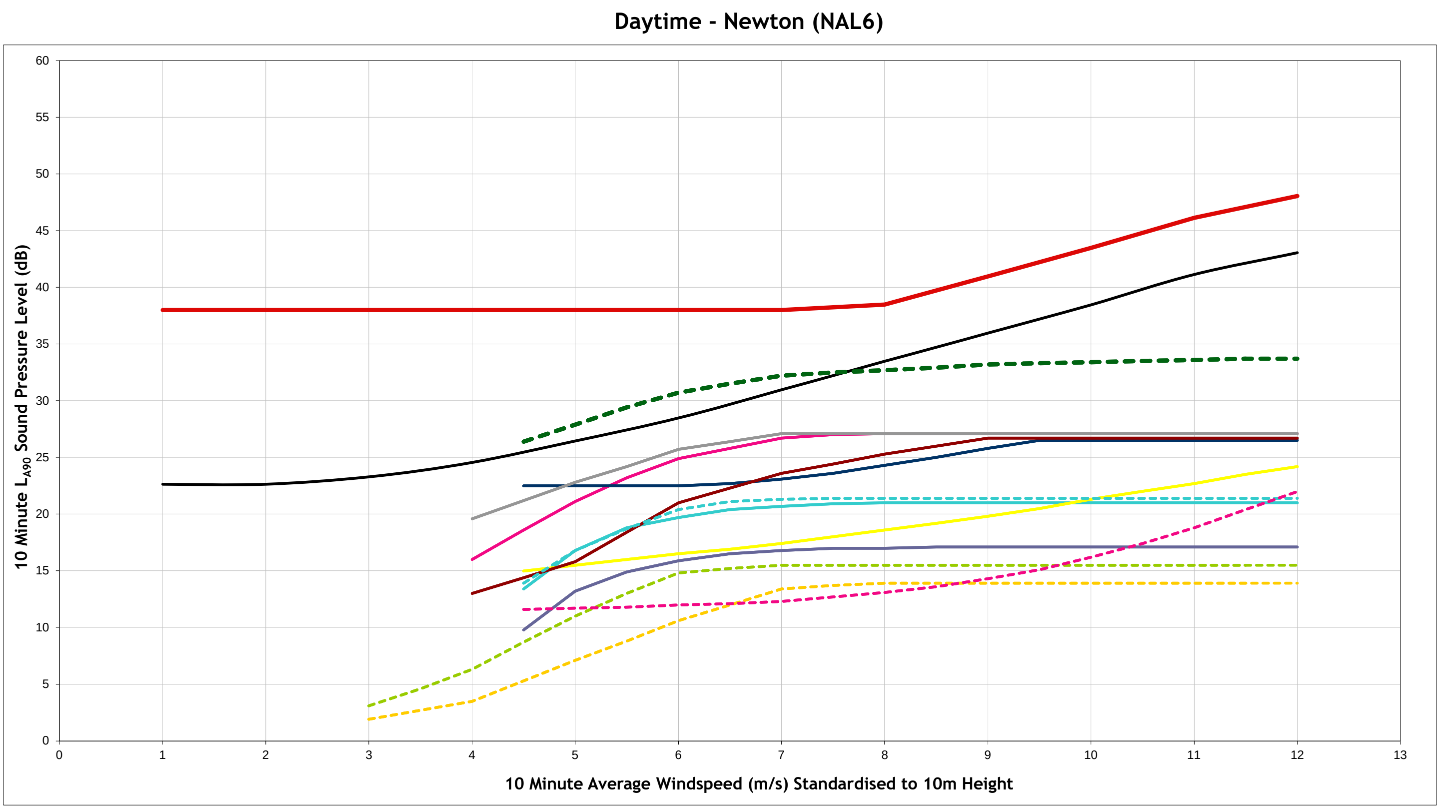
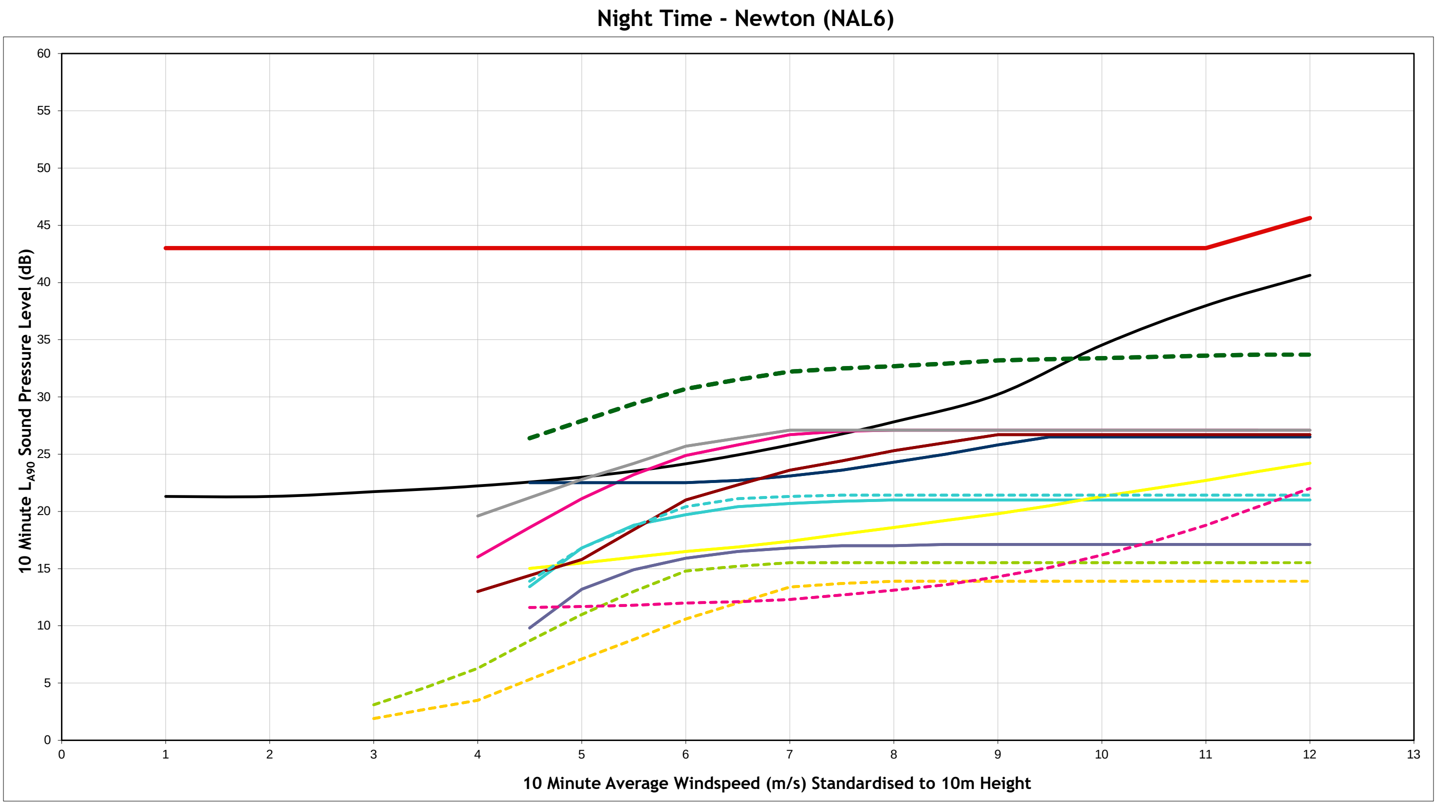
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions 14 West Watten (NAL5)
Figure Number	A1.3e
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Newton (NAL6)



Night Time - Newton (NAL6)

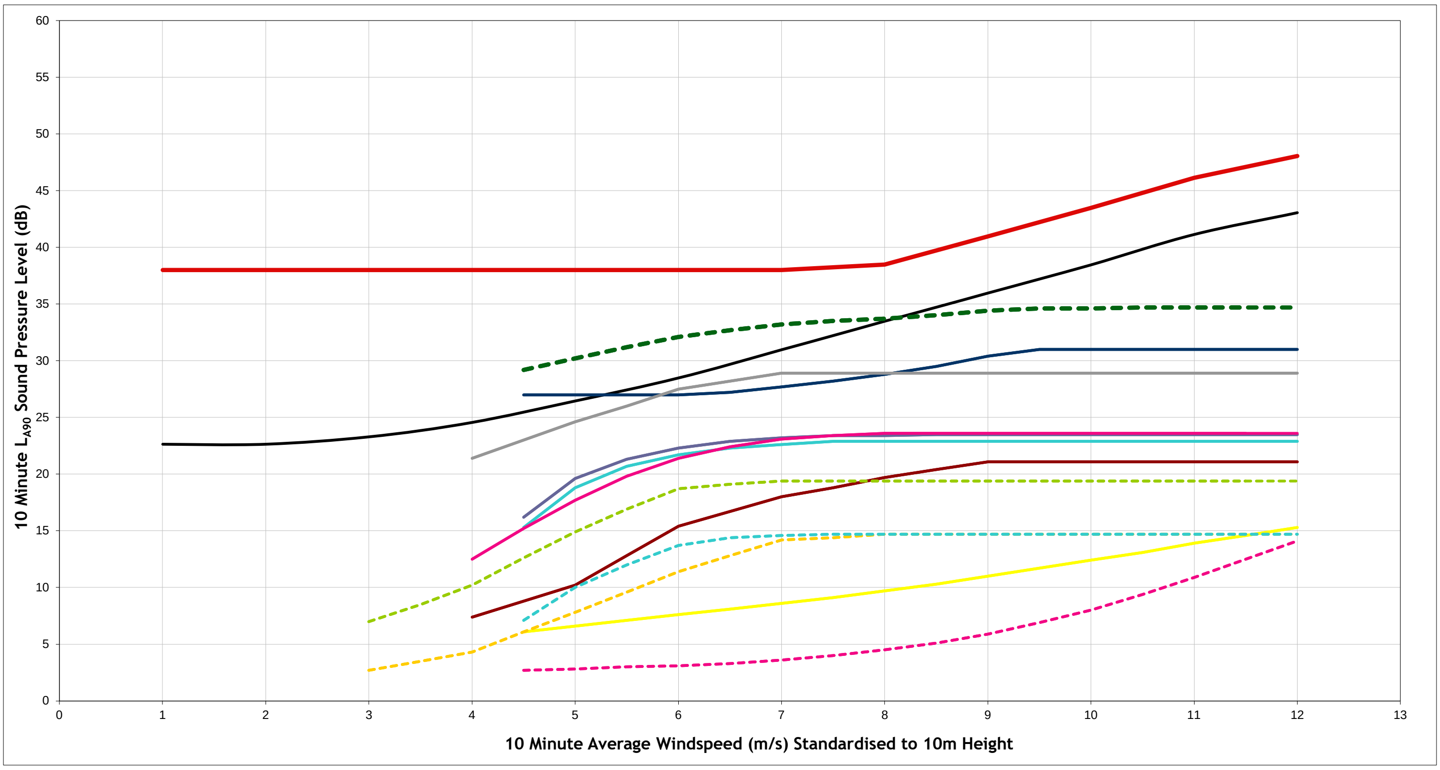


Legend:

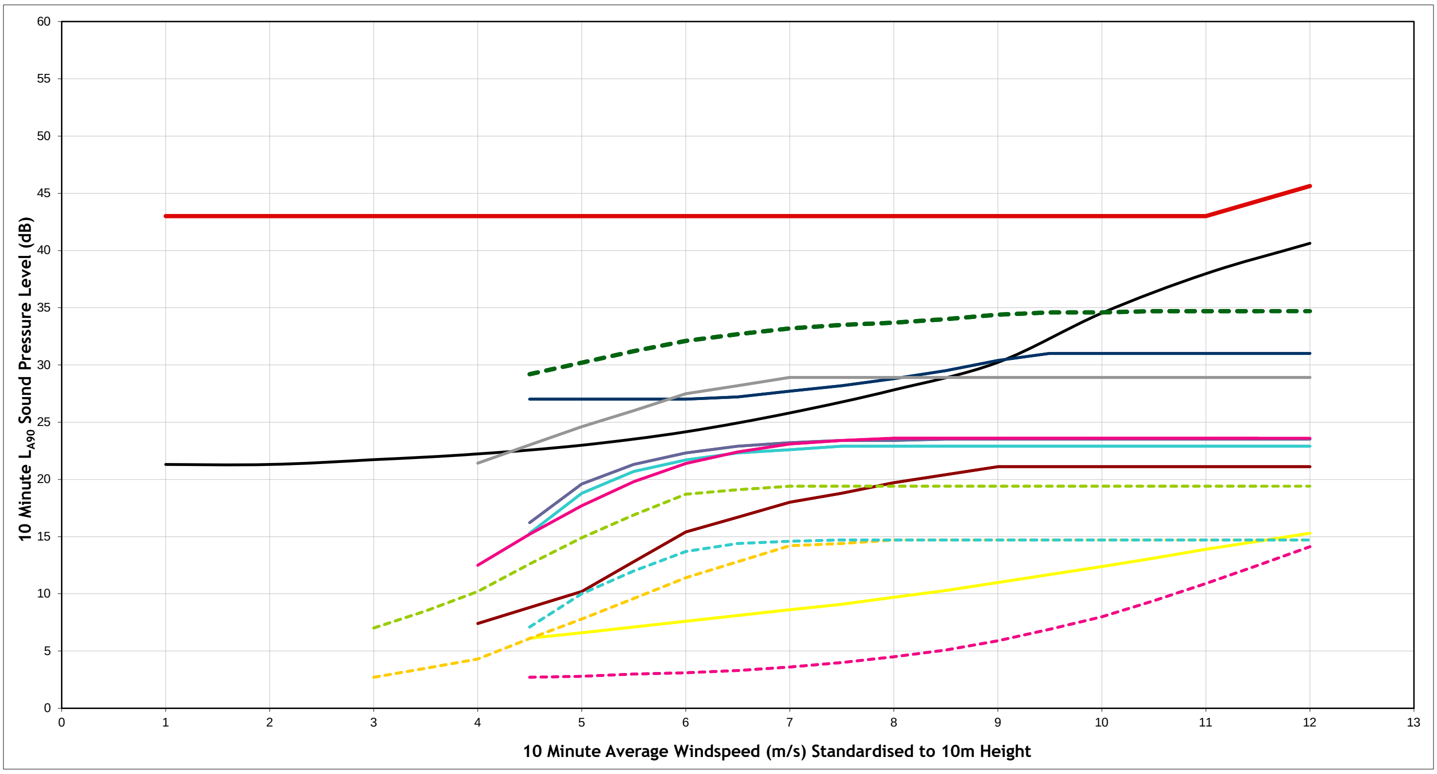
- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions Newton (NAL6)
Figure Number	A1.3f
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Lanergill (NAL7)



Night Time - Lanergill (NAL7)



Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
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- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions Lanergill (NAL7)
Figure Number	A1.3g
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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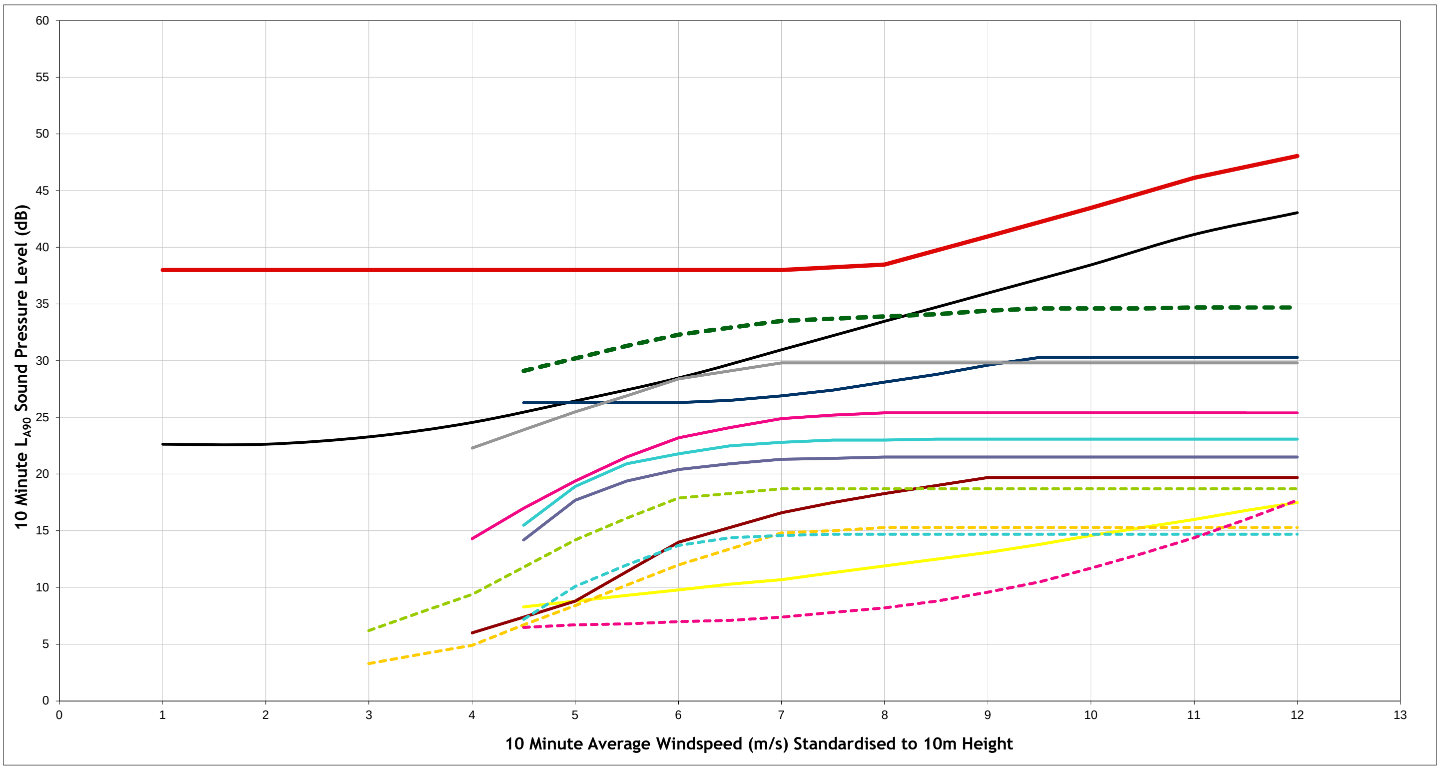
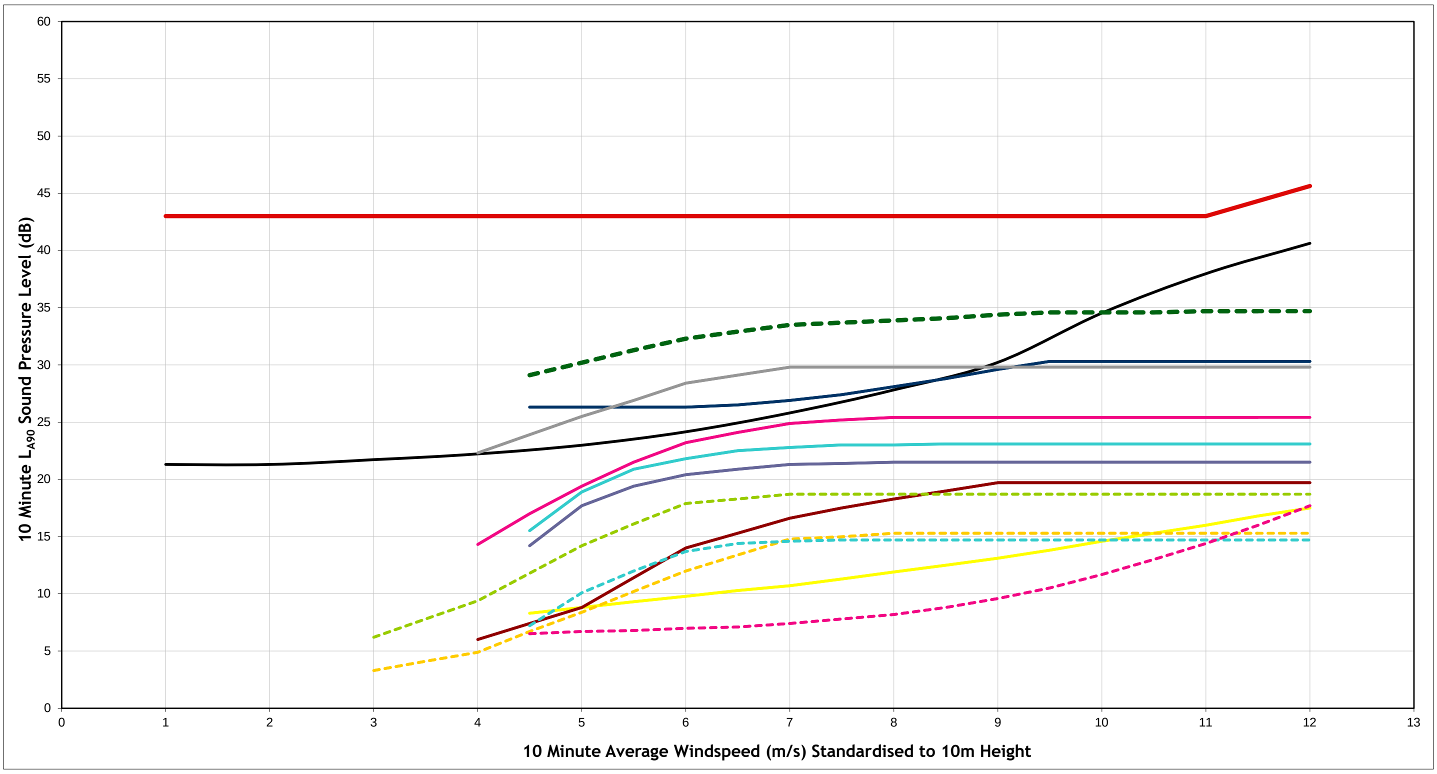
Daytime - Backlass Hill (NAL8)



Night Time - Backlass Hill (NAL8)

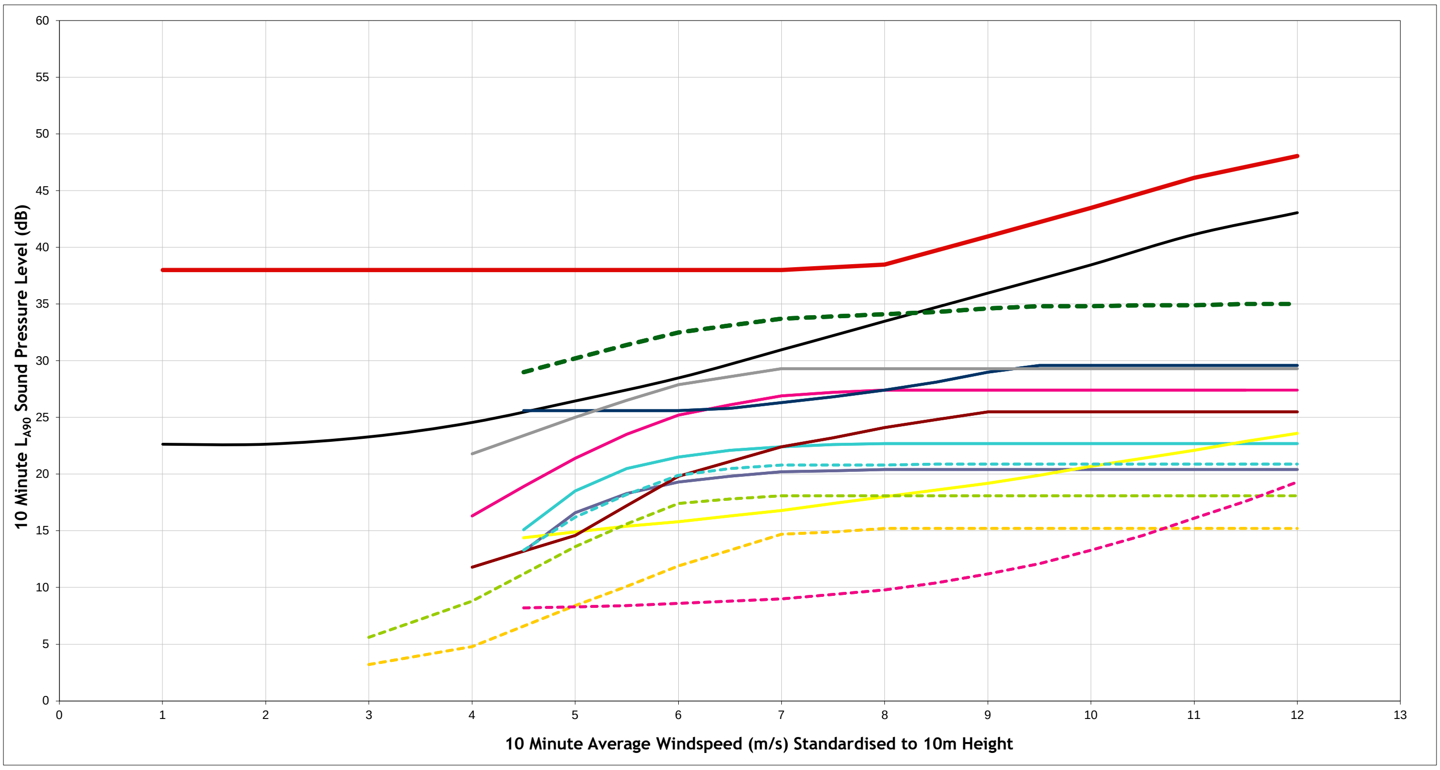


Legend:

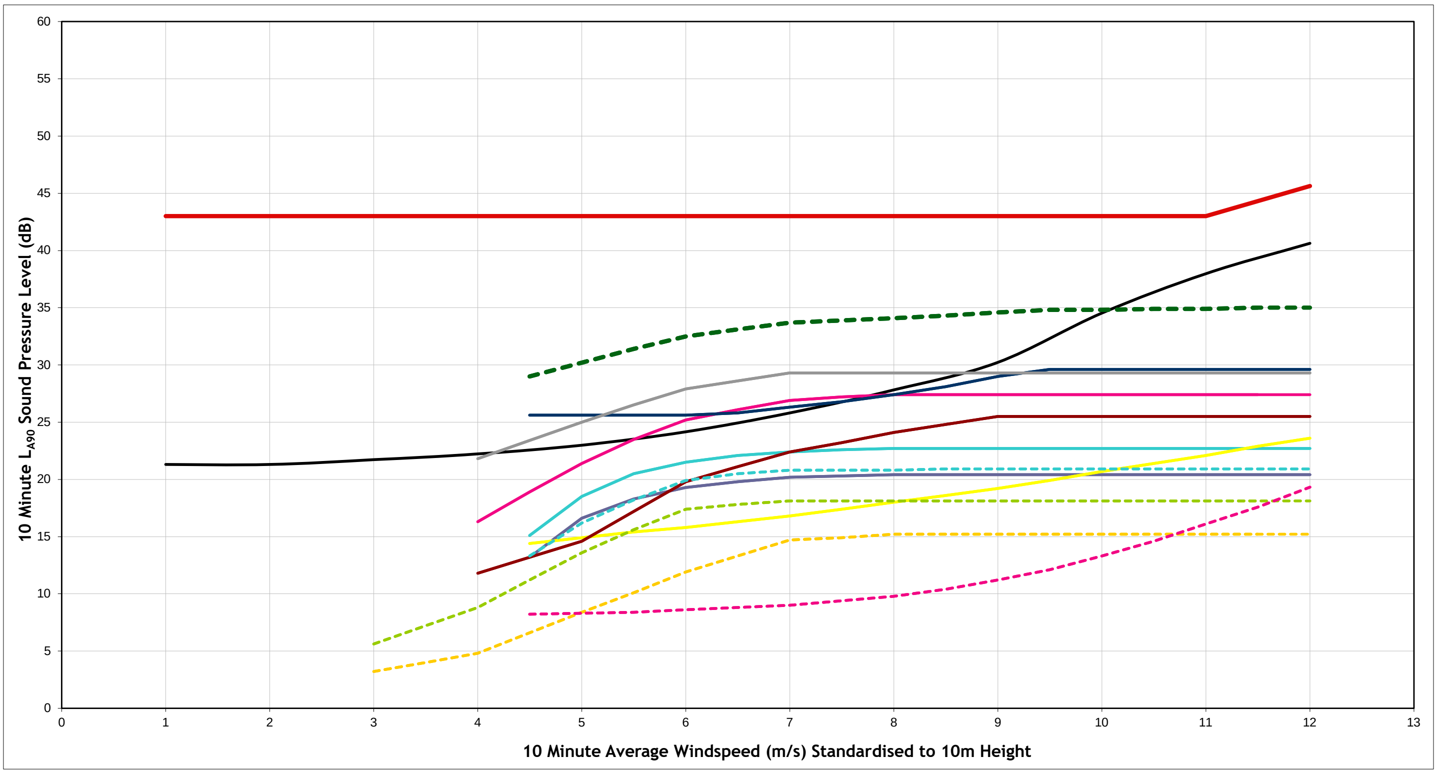
- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions Backlass Hill (NAL8)
Figure Number	A1.3h
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Leanmore Lodge (NAL9)



Night Time - Leanmore Lodge (NAL9)



Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
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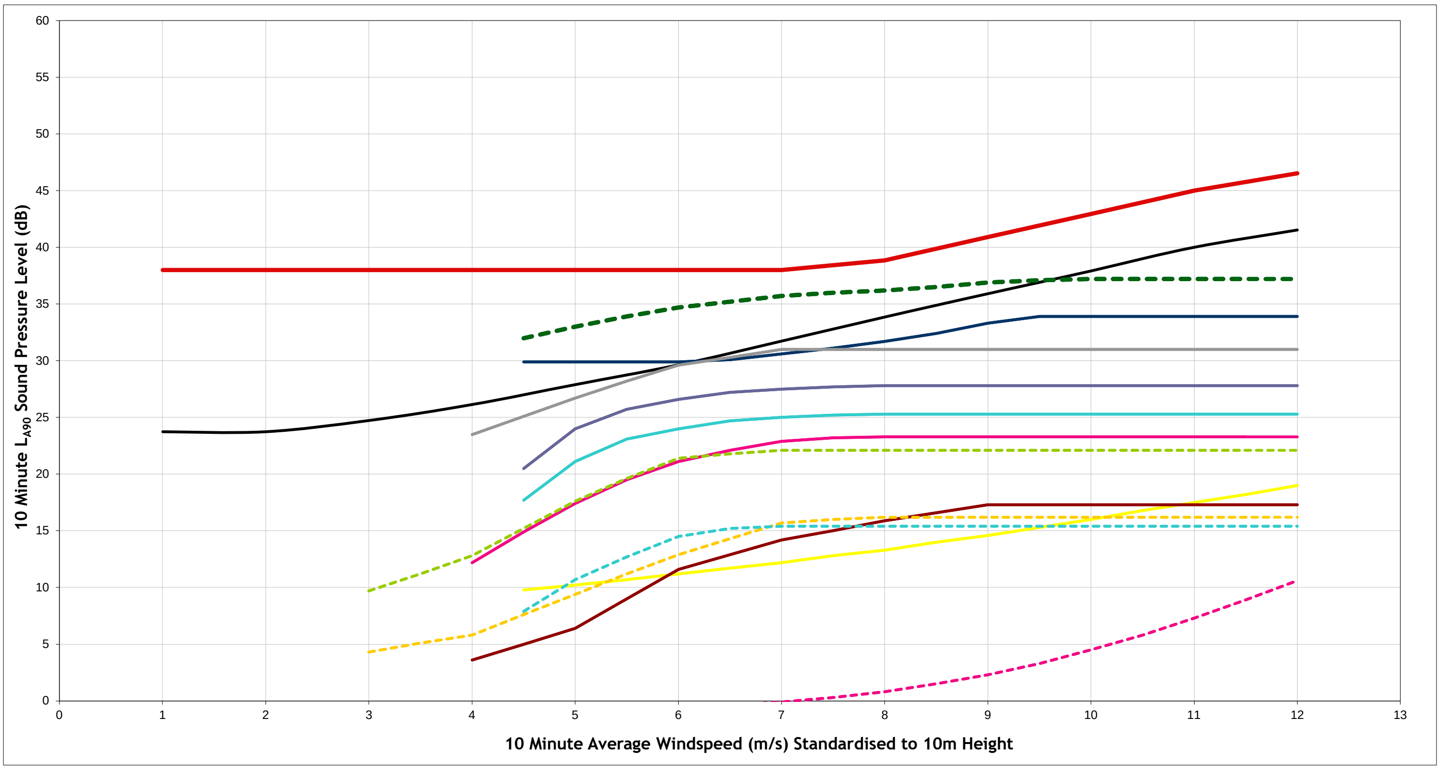
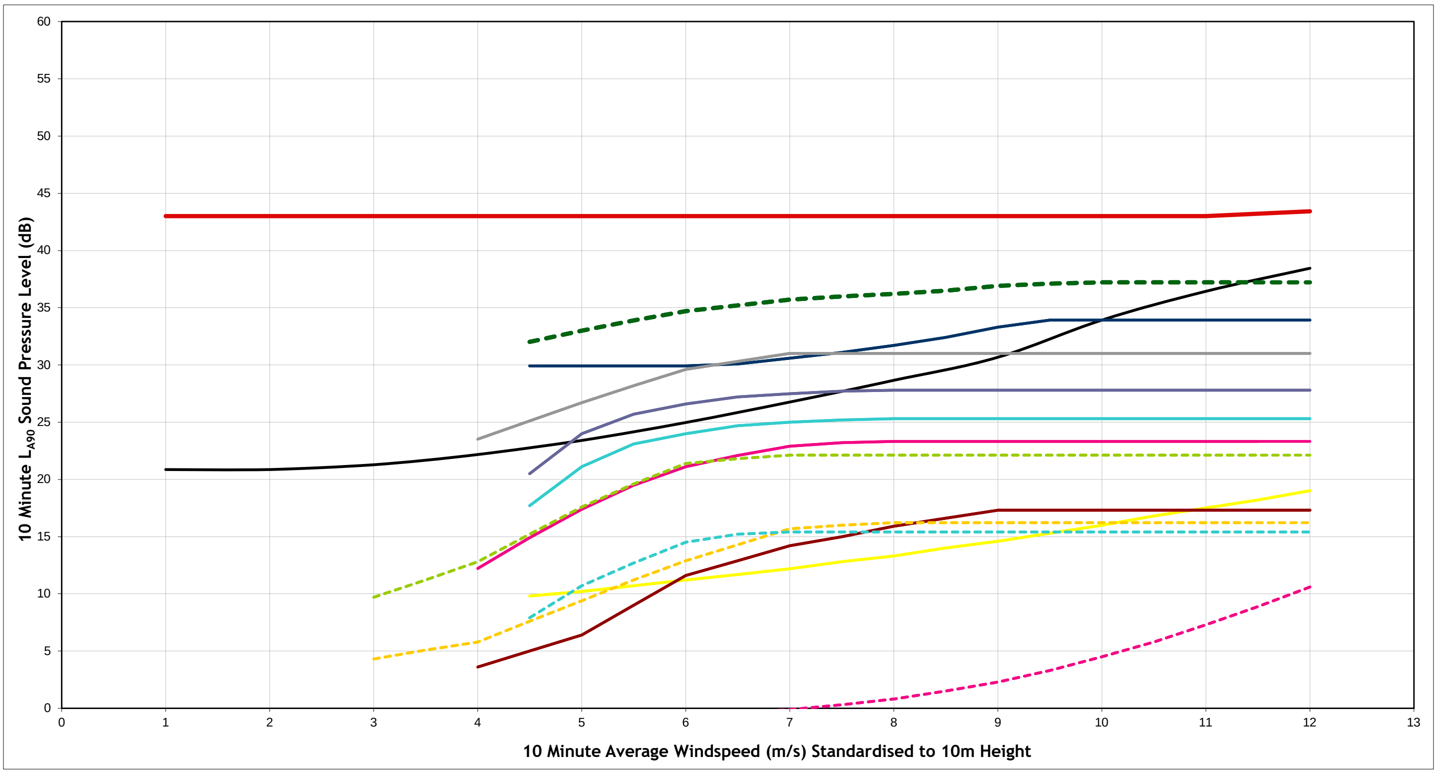
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions Leanmore Lodge (NAL9)
Figure Number	A1.3i
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Achnamoine (NAL10)



Night Time - Achnamoine (NAL10)



Legend:

- Background Noise Trendline
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- Cumulative (excluding the Proposed Development)
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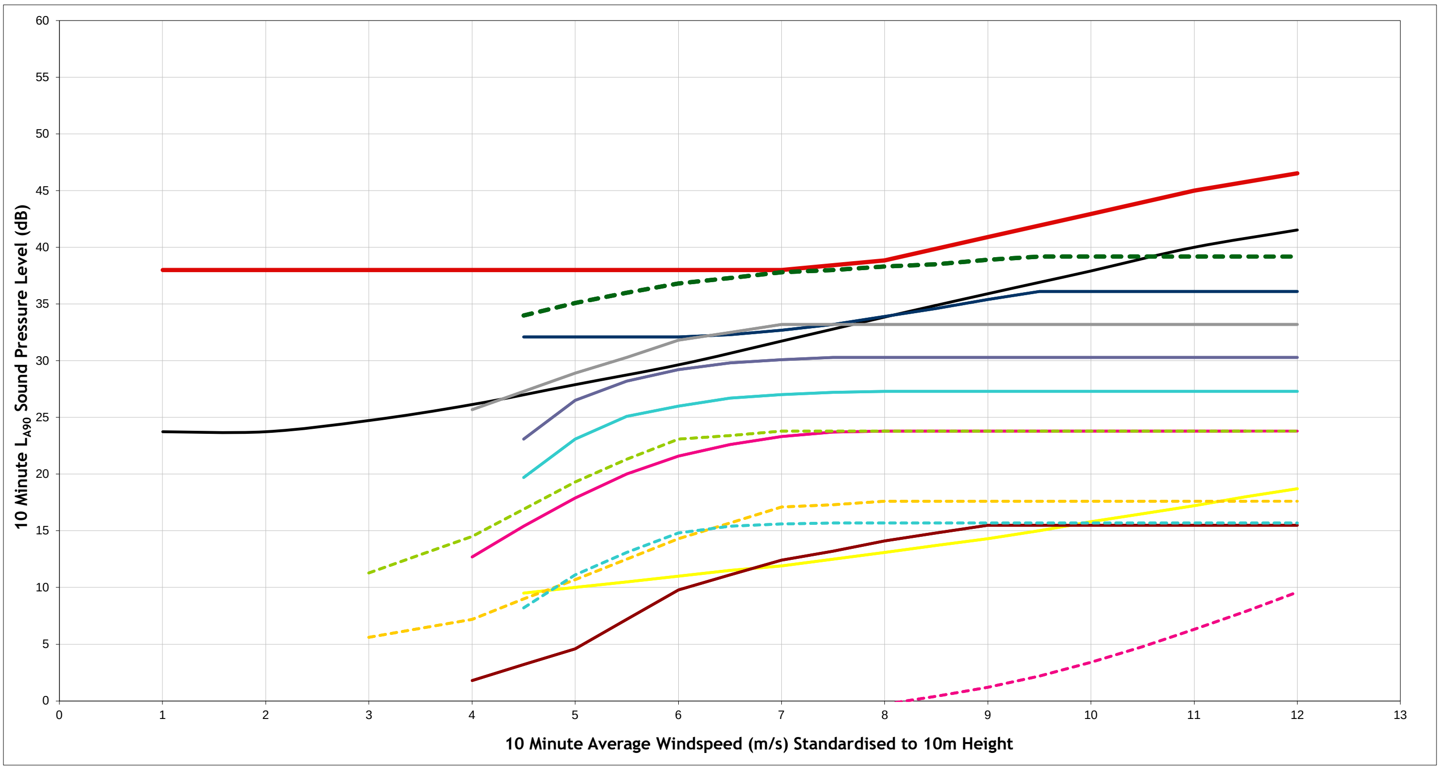
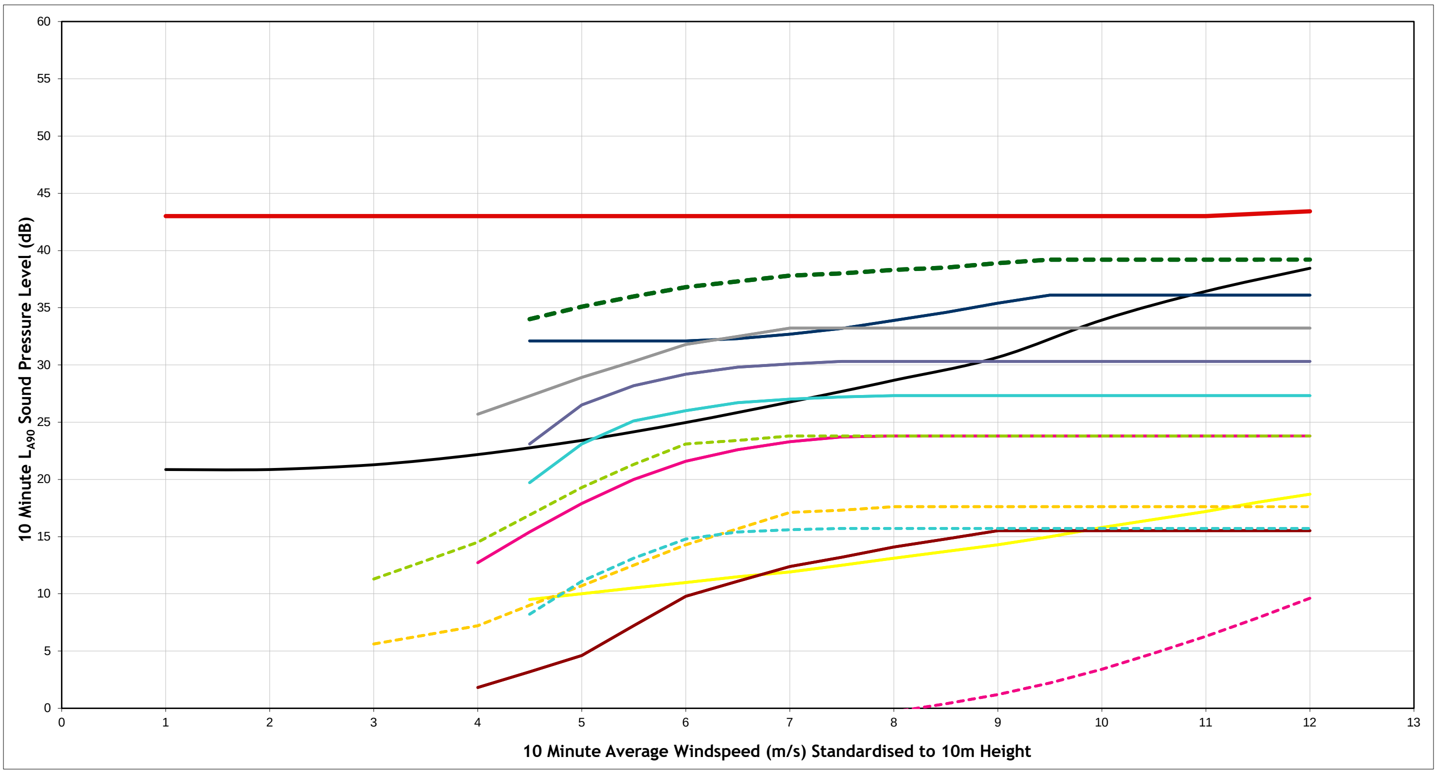
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions Achnamoine (NAL10)
Figure Number	A1.3j
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Knockglass House (NAL11)



Night Time - Knockglass House (NAL11)



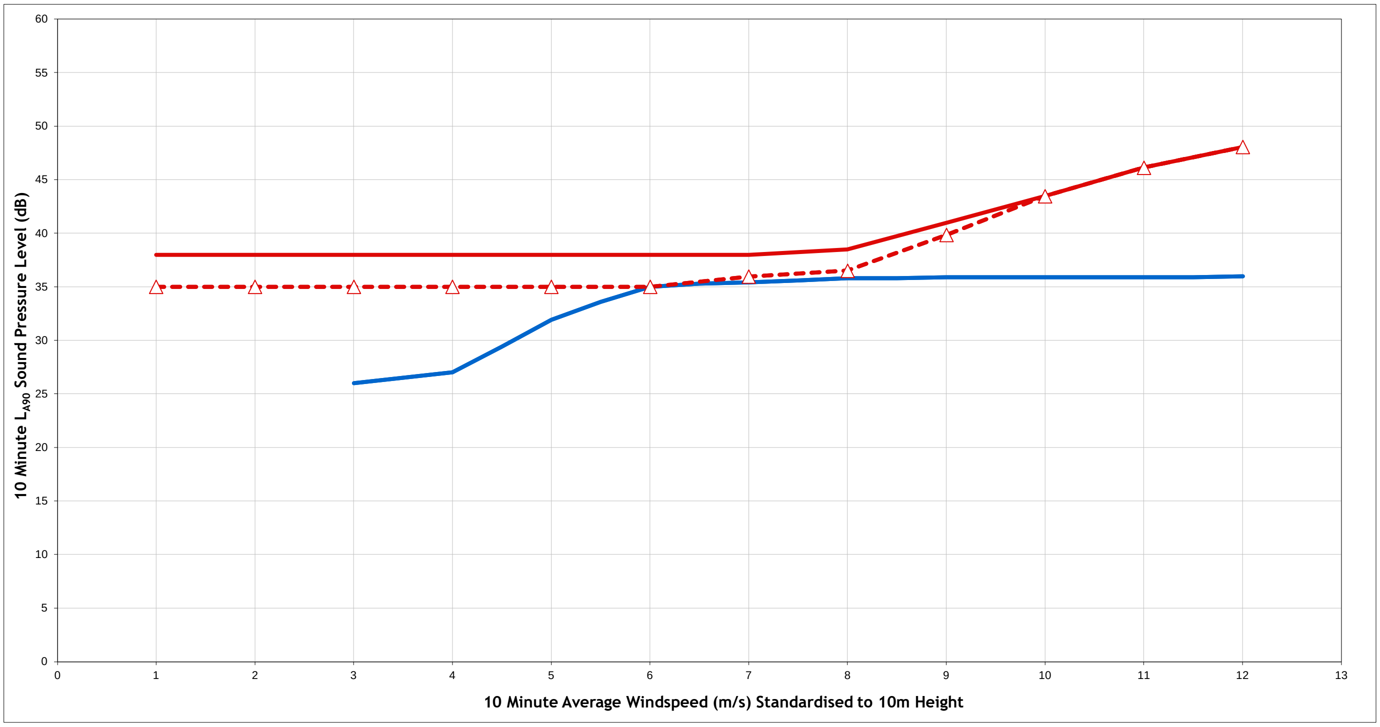
Legend:

- Background Noise Trendline
- Total ETSU-R-97 Noise Limit
- Cumulative (excluding the Proposed Development)
- Achlachan & Achlachan 2
- Bad a Cheo
- Bilbster
- Camster & Camster II
- Causeymire
- Cogle Moss
- Halsary
- Tacher (A, B and C)
- Tormsdale
- Wathegar & Wathegar 2
- Individual Turbines

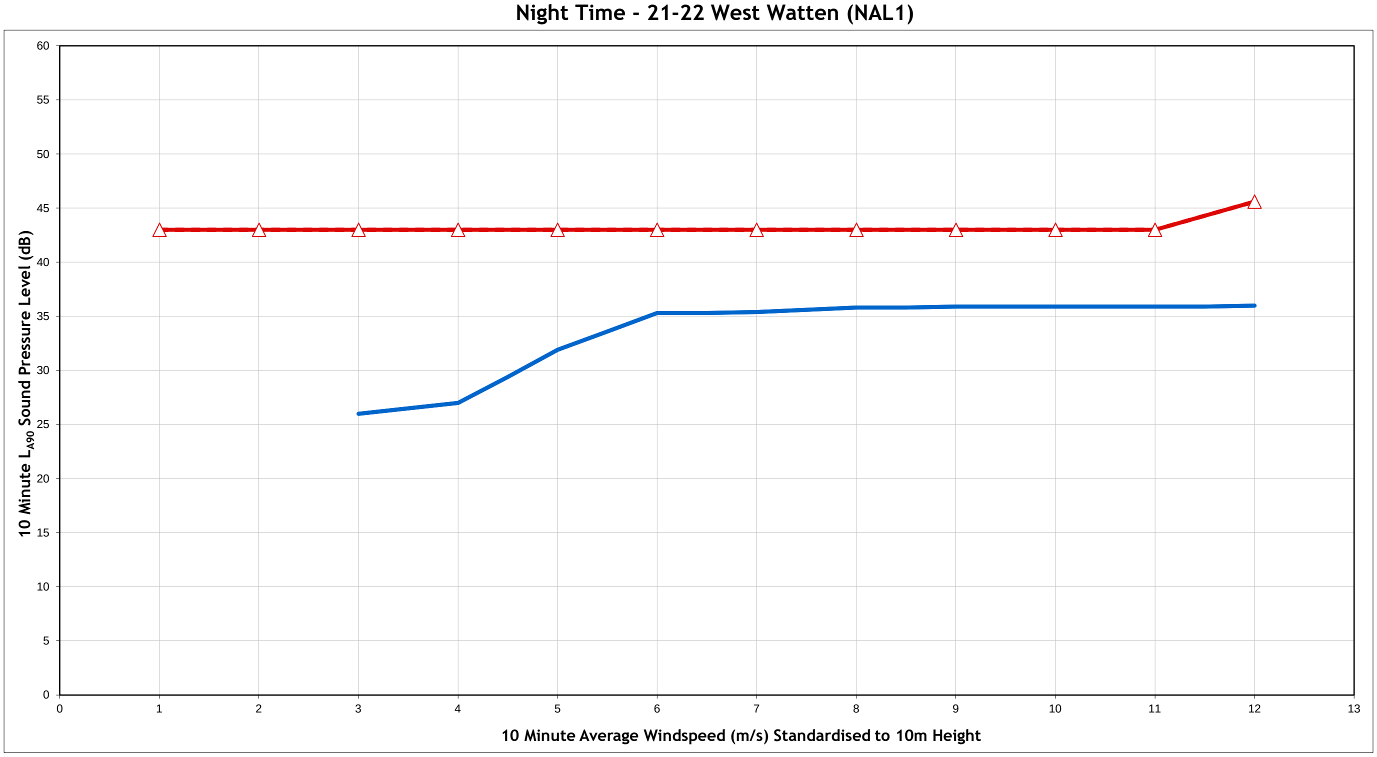
Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment - Cautious Predictions Knockglass House (NAL11)
Figure Number	A1.3k
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Figures A1.4a-k – Site Specific Noise Predictions

Daytime - 21-22 West Watten (NAL1)



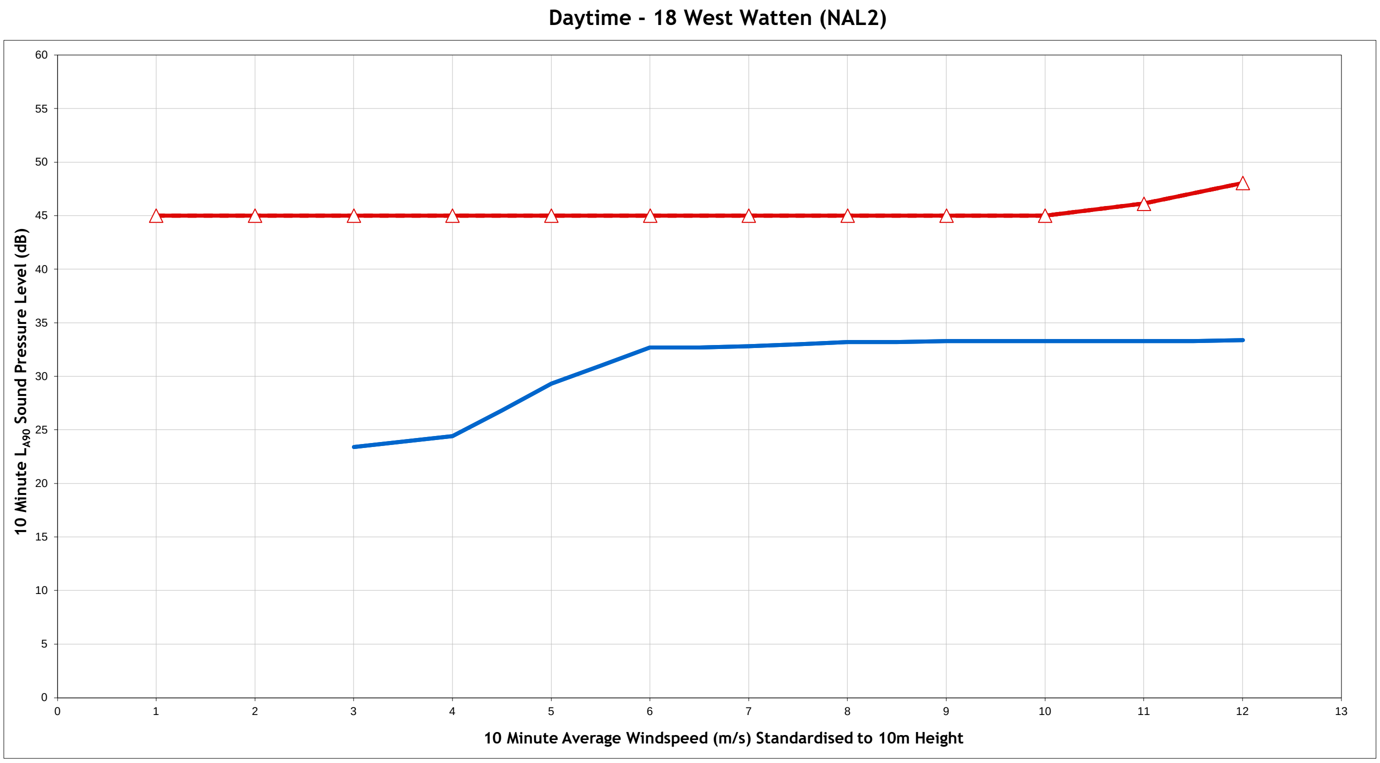
Night Time - 21-22 West Watten (NAL1)

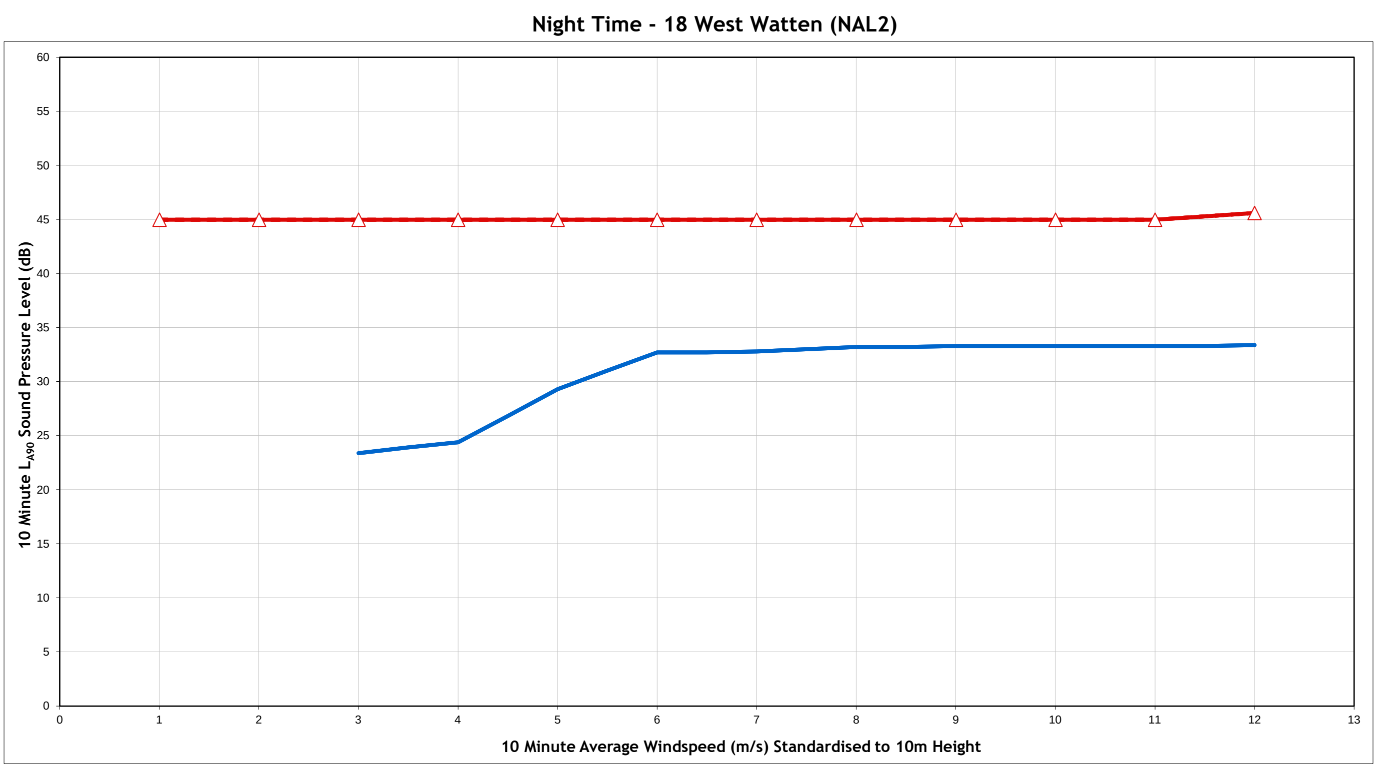


Legend:

- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment 21-22 West Watten (NAL1)
Figure Number	A1.4a
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models



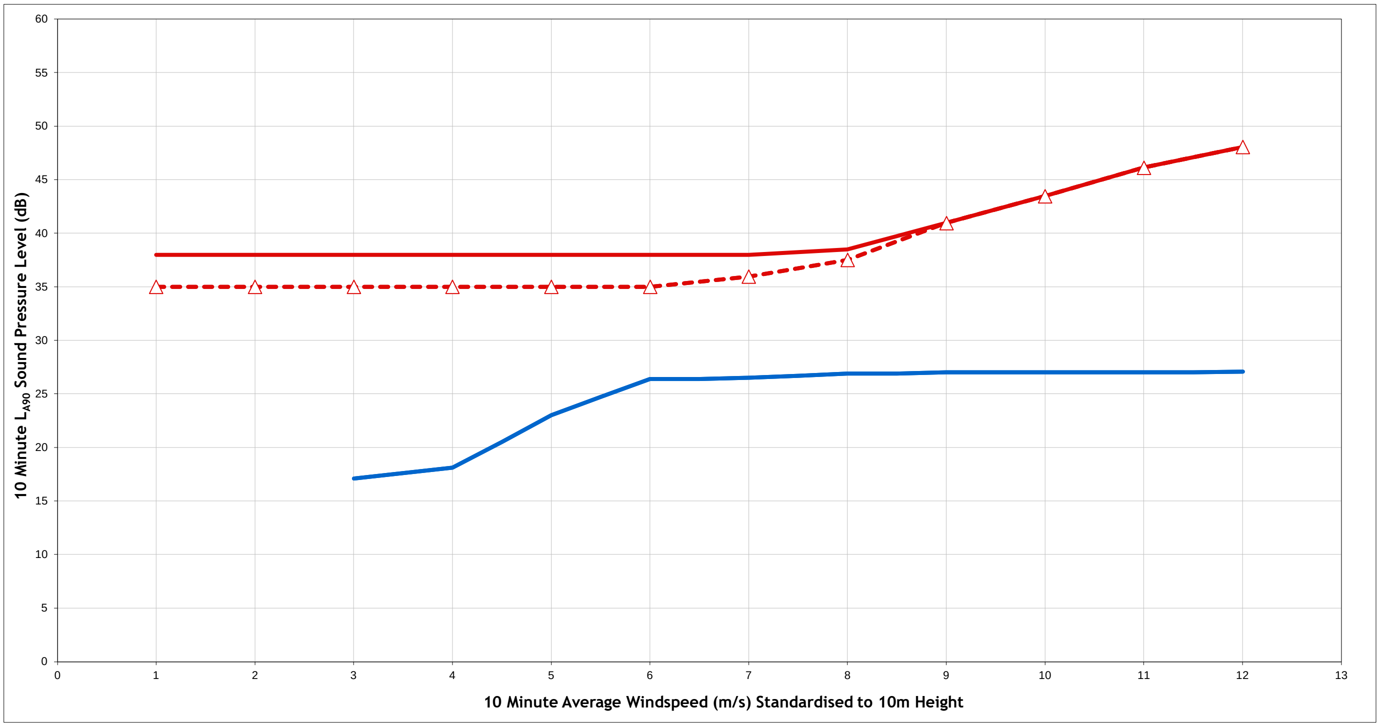


Legend:

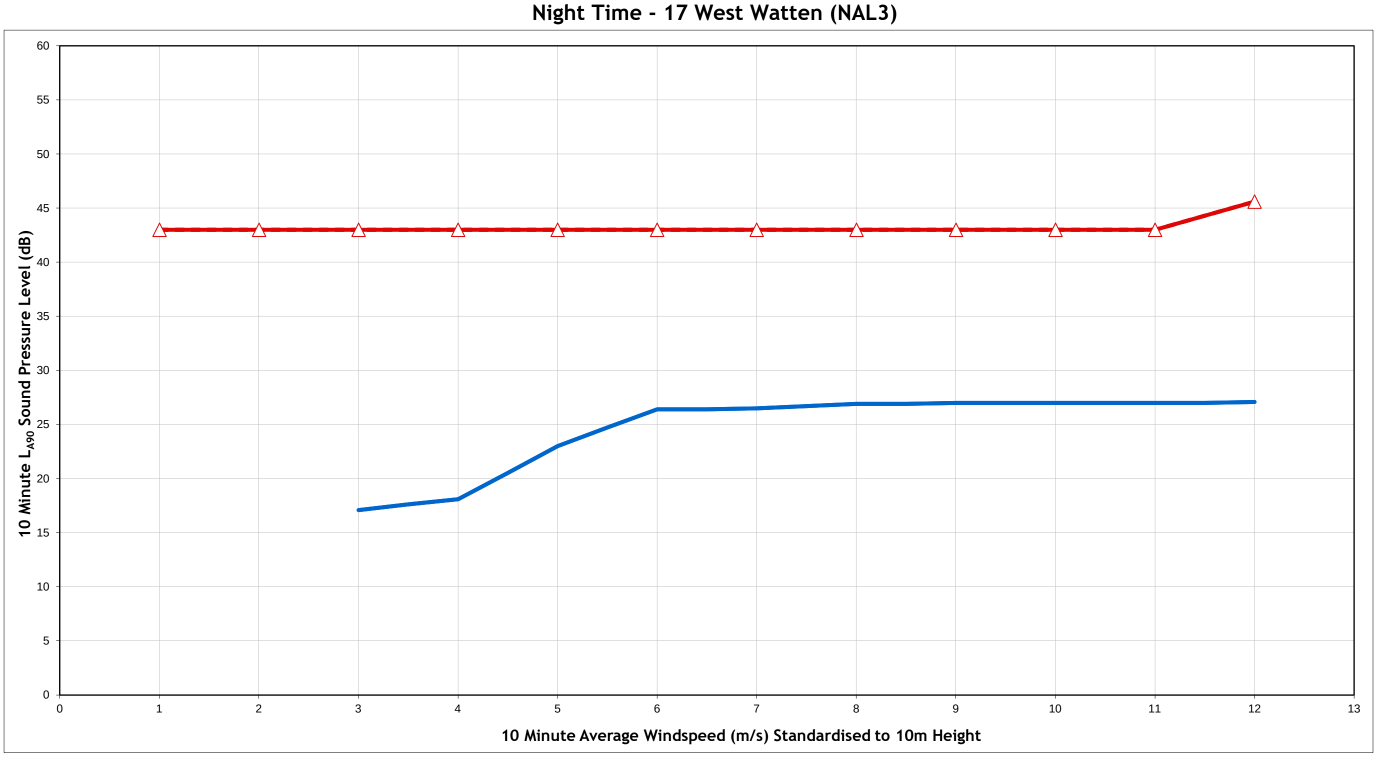
- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment 18 West Watten (NAL2)
Figure Number	A1.4b
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - 17 West Watten (NAL3)



Night Time - 17 West Watten (NAL3)



Legend:

- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment 17 West Watten (NAL3)
Figure Number	A1.4c
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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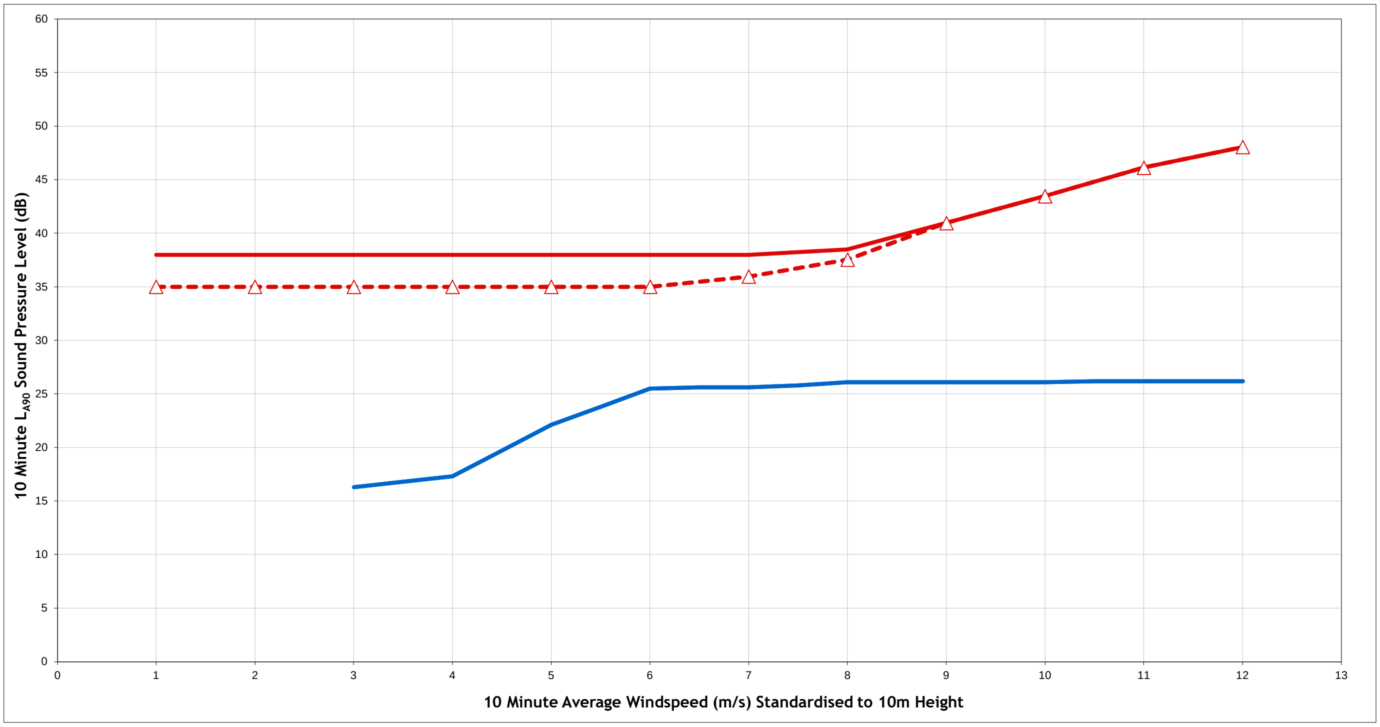
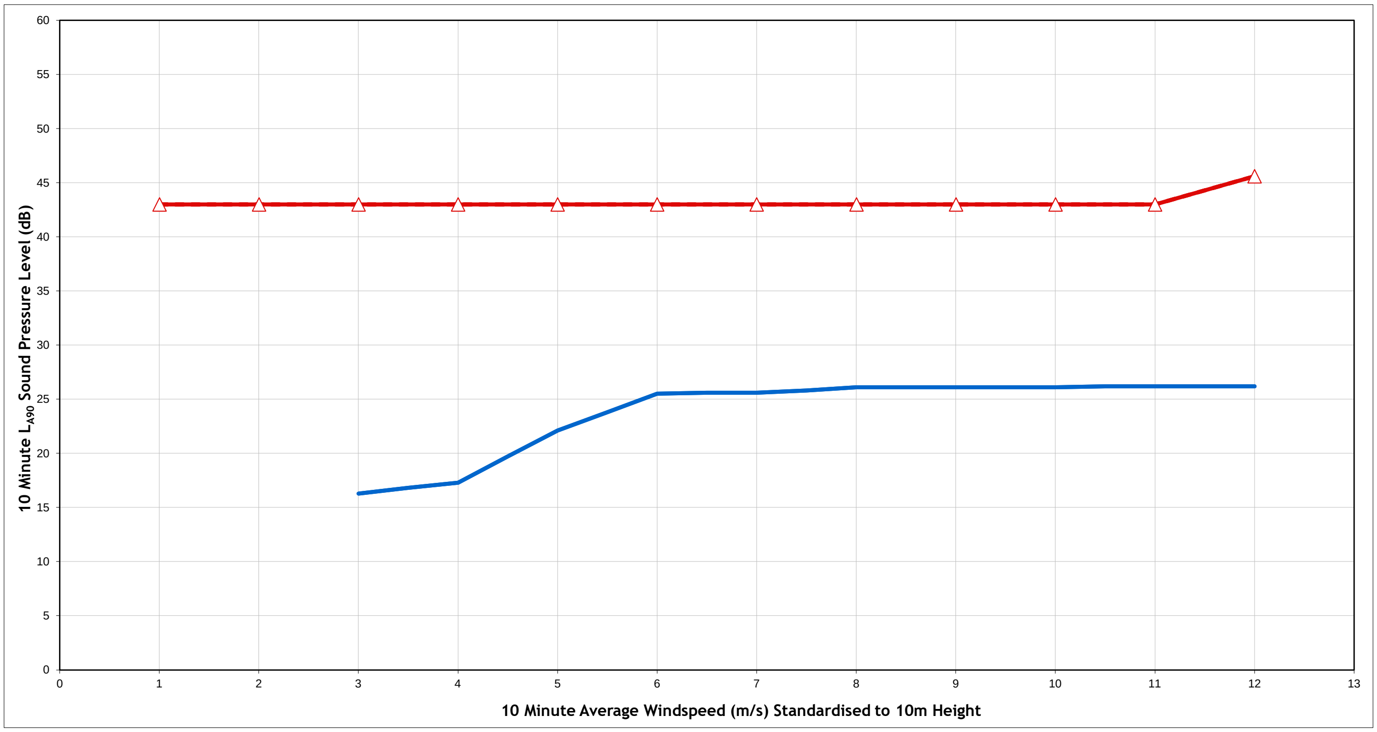
Daytime - Banks Lodge (NAL4)



Night Time - Banks Lodge (NAL4)



Legend:

- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment Banks Lodge (NAL4)
Figure Number	A1.4d
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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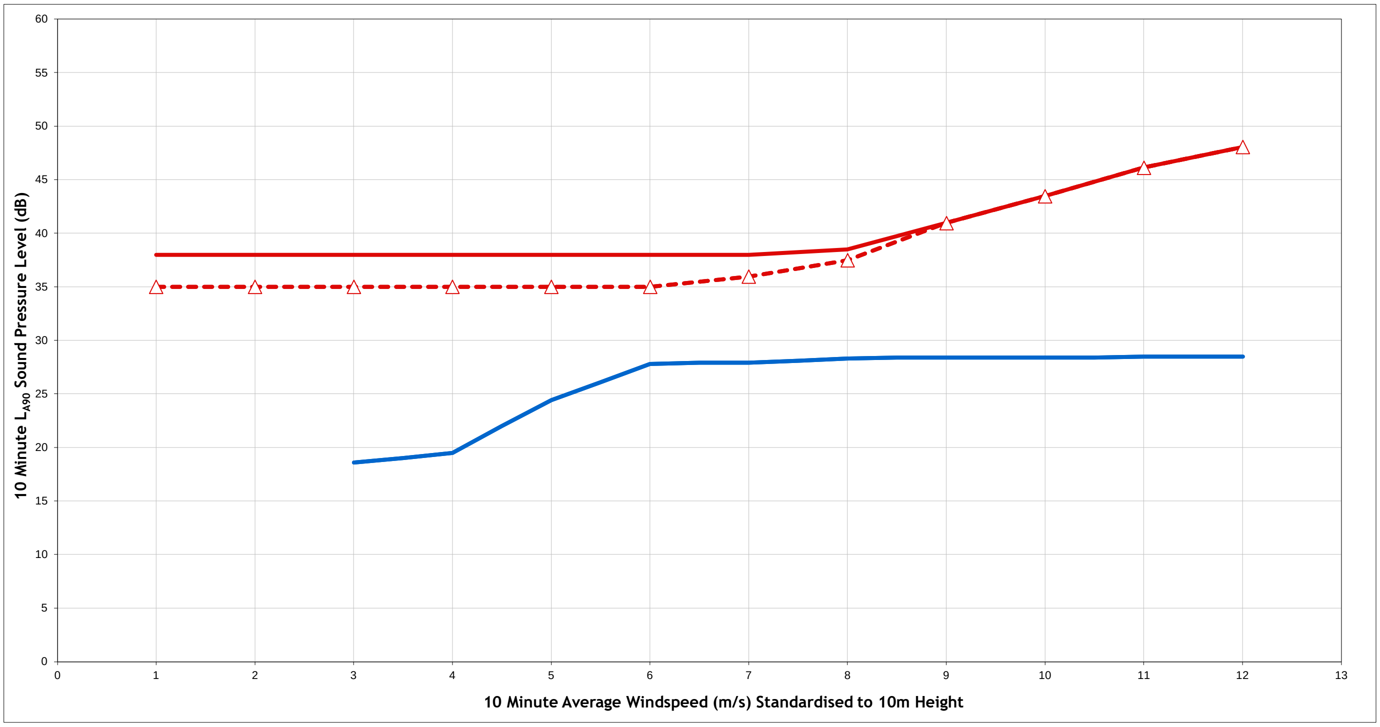
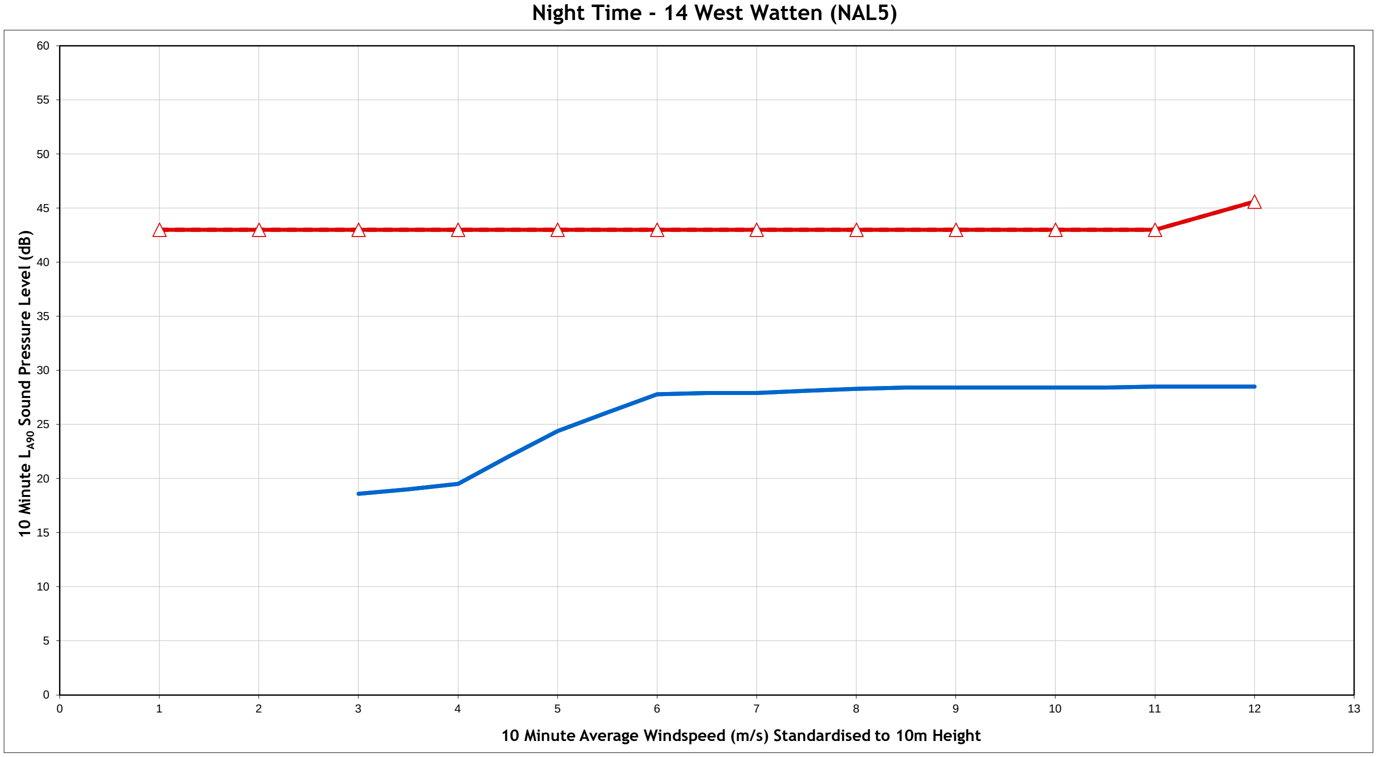
Daytime - 14 West Watten (NAL5)



Night Time - 14 West Watten (NAL5)

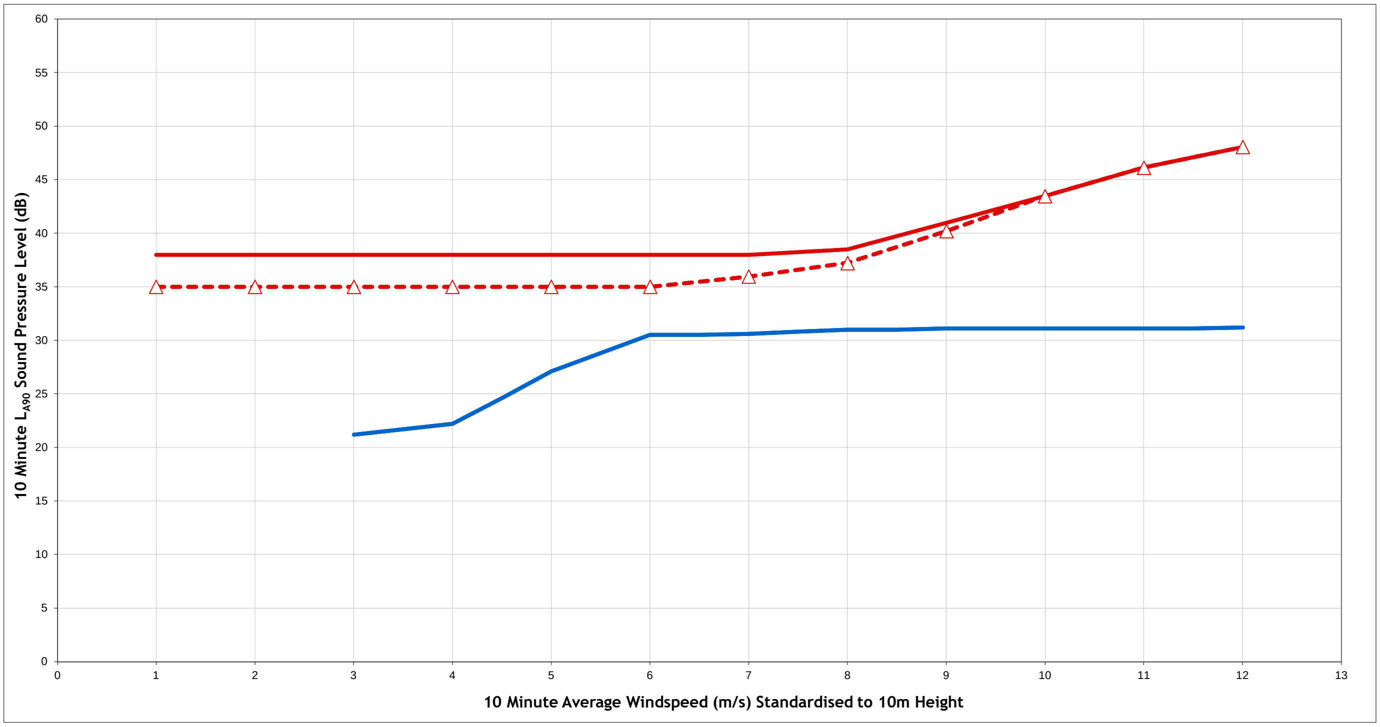


Legend:

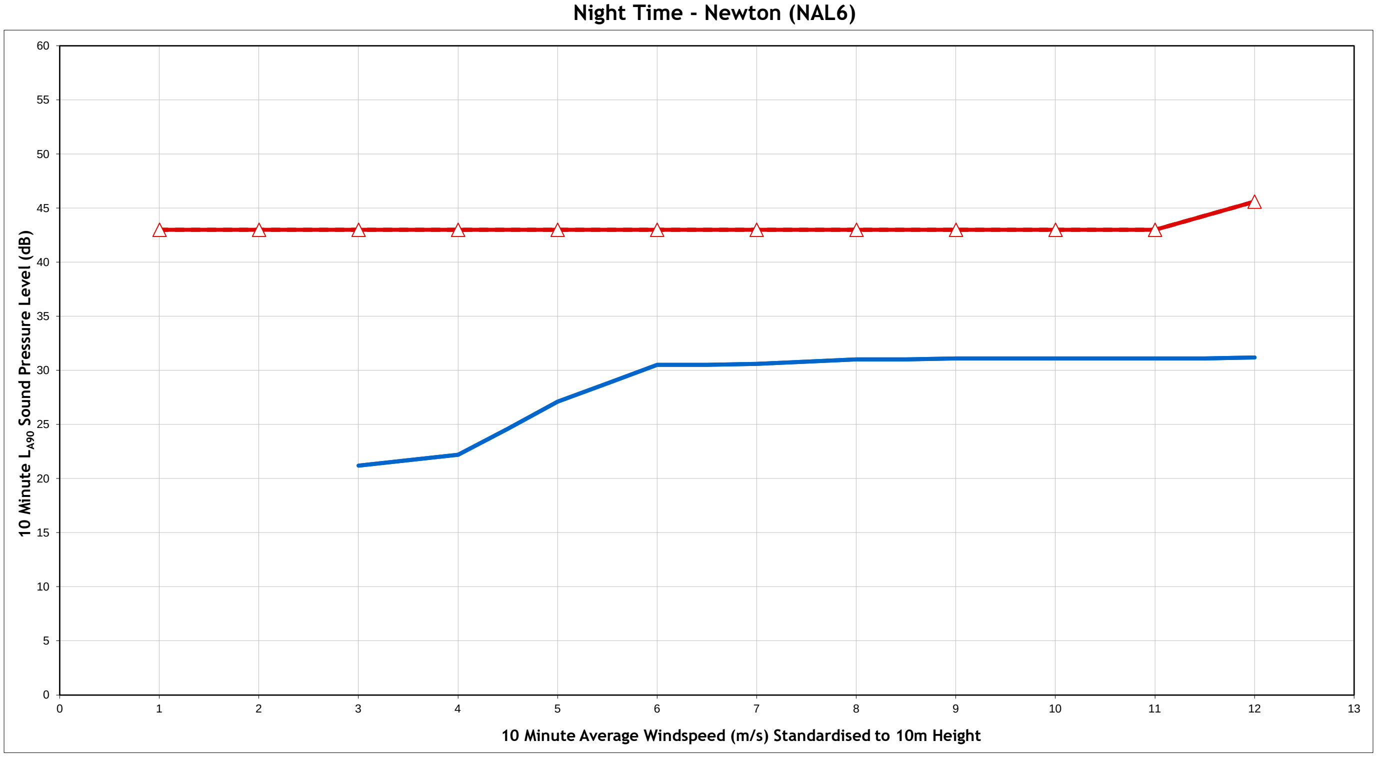
- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment 14 West Watten (NAL5)
Figure Number	A1.4e
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Newton (NAL6)



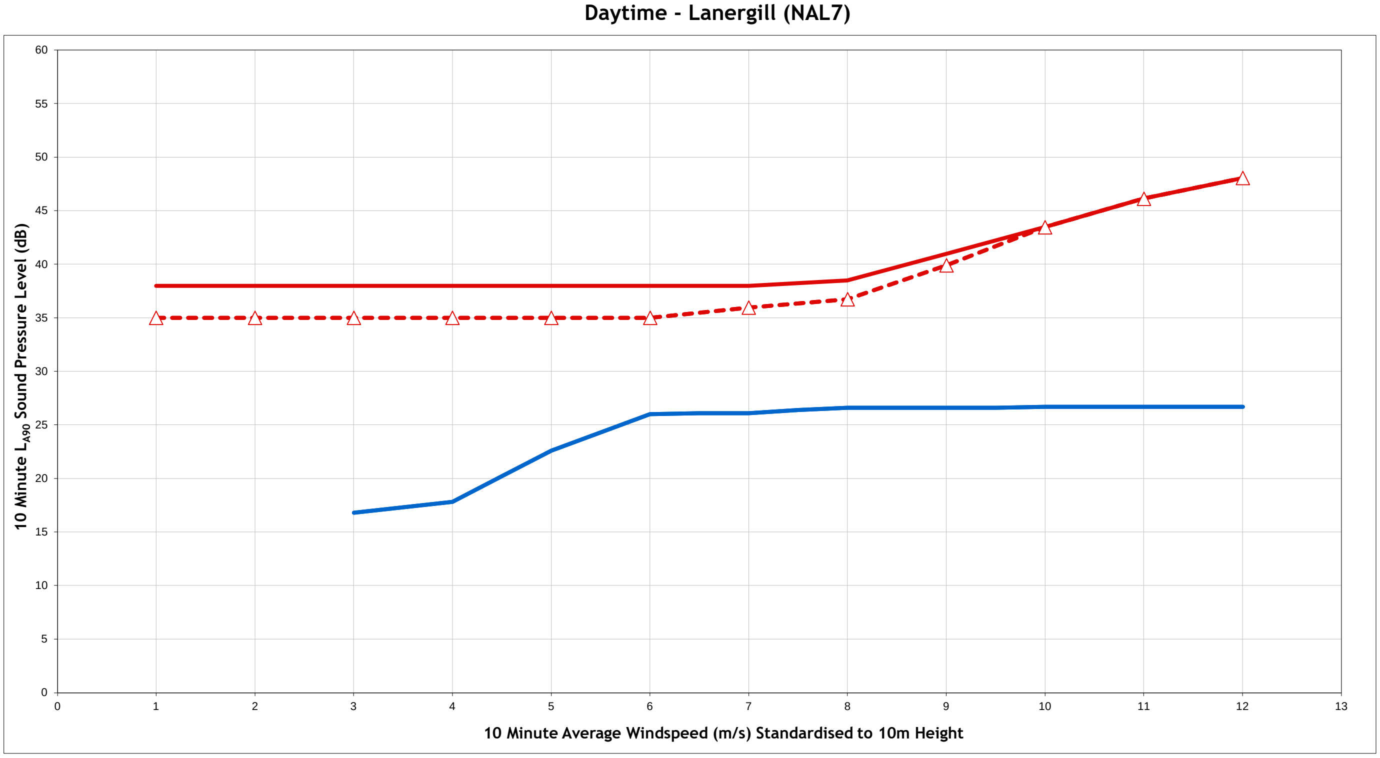
Night Time - Newton (NAL6)

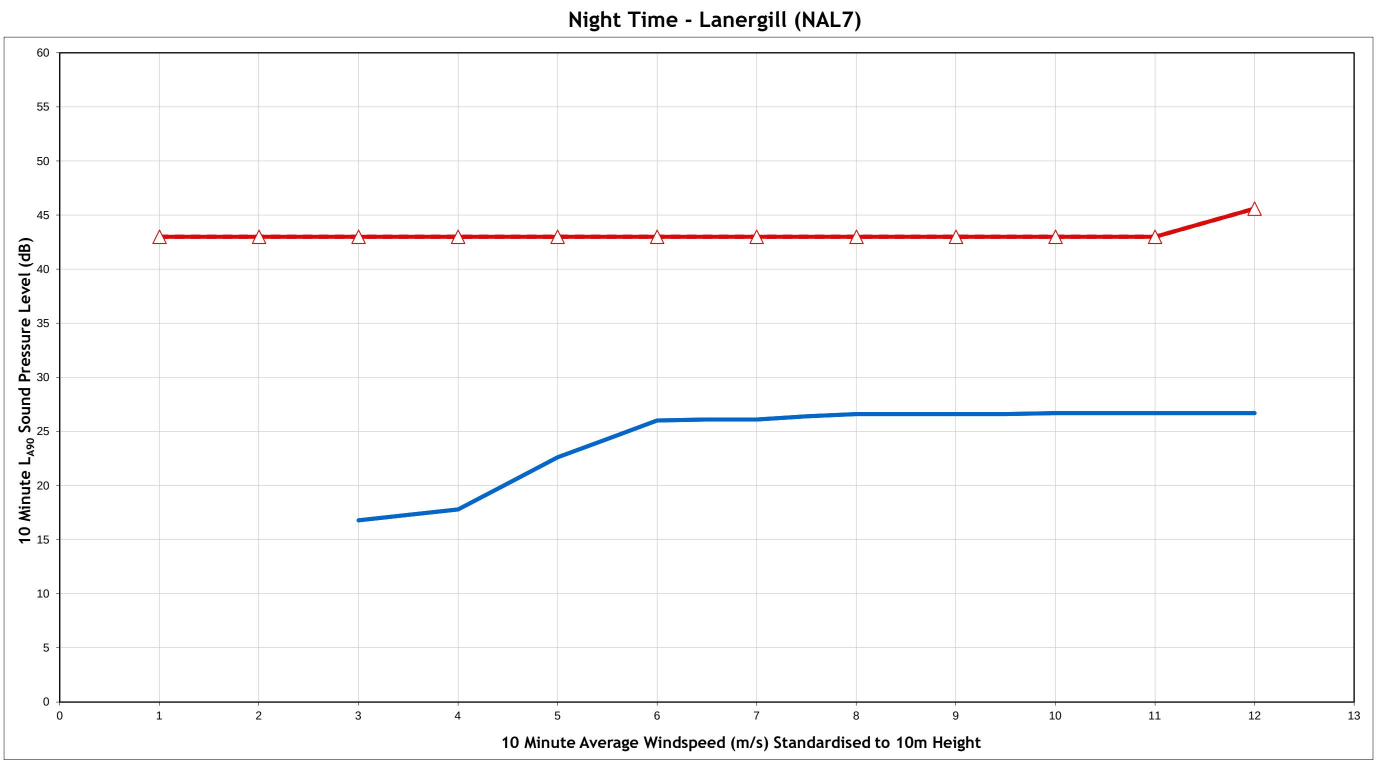


Legend:

- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment Newton (NAL6)
Figure Number	A1.4f
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models



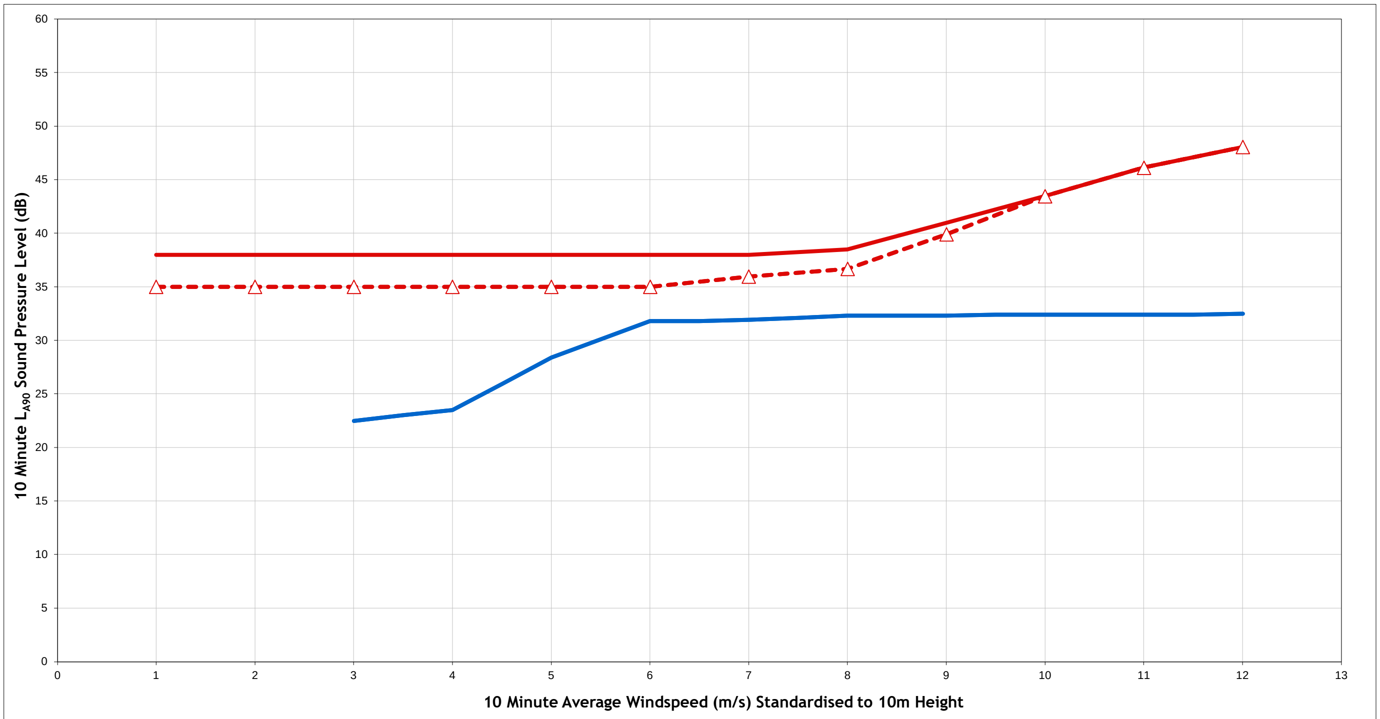


Legend:

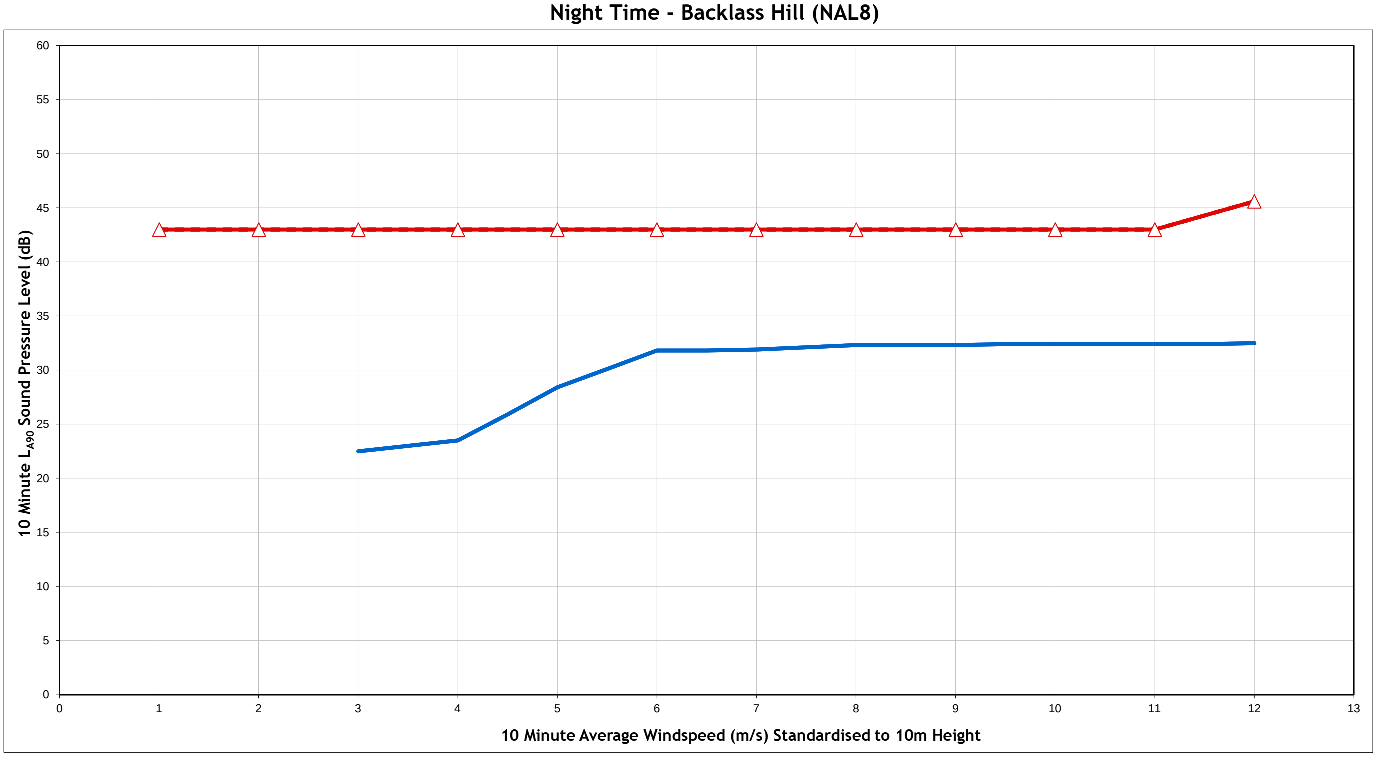
- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment Lanergill (NAL7)
Figure Number	A1.4g
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Daytime - Backlass Hill (NAL8)



Night Time - Backlass Hill (NAL8)



Legend:

- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment Backlass Hill (NAL8)
Figure Number	A1.4h
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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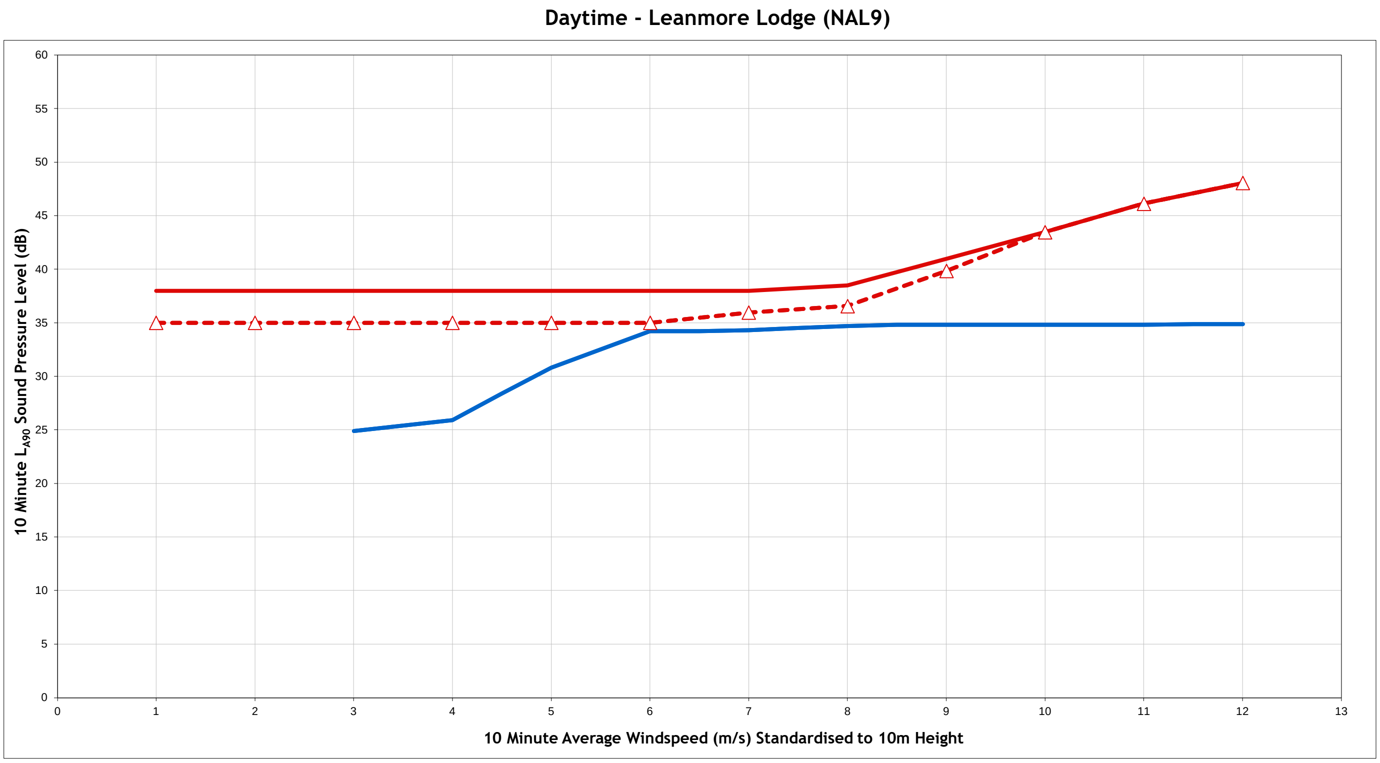

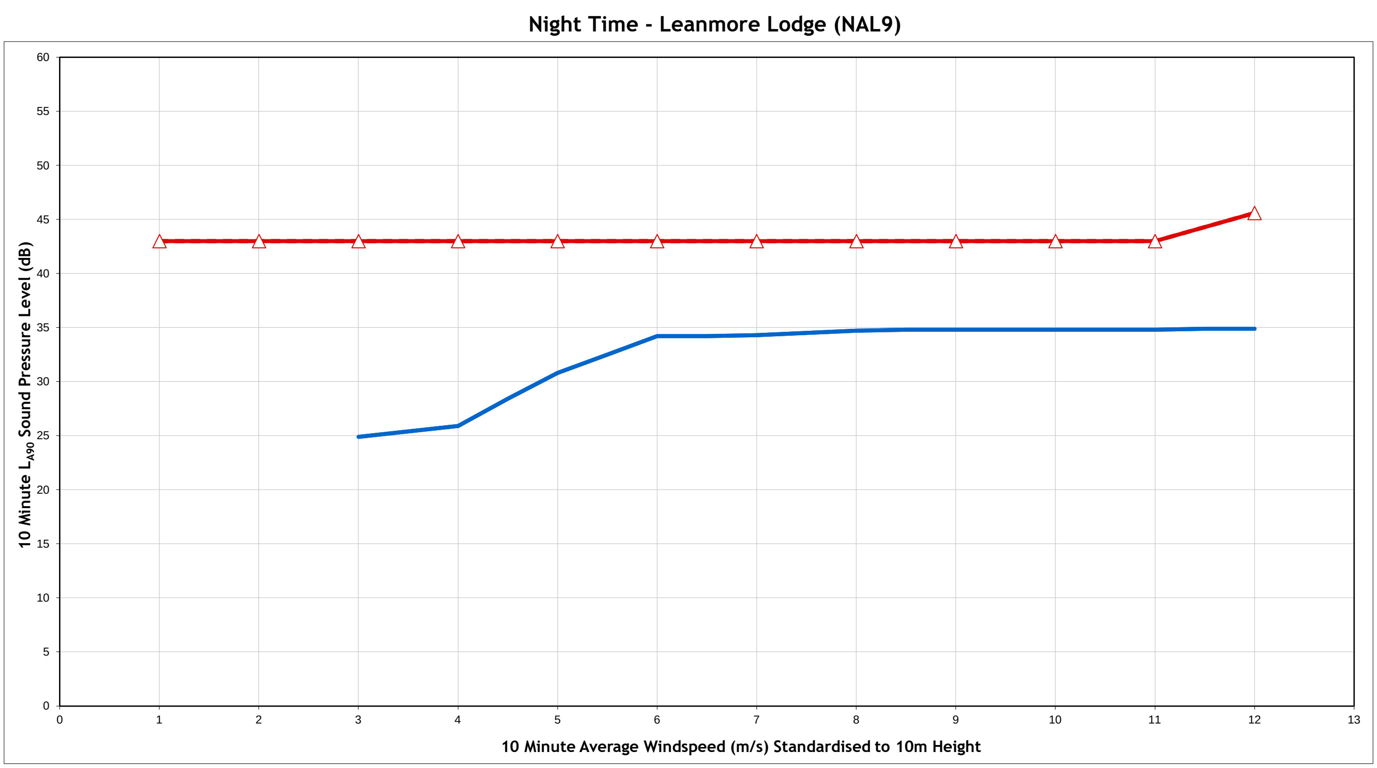

Legend:

- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment Leanmore Lodge (NAL9)
Figure Number	A1.4i
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

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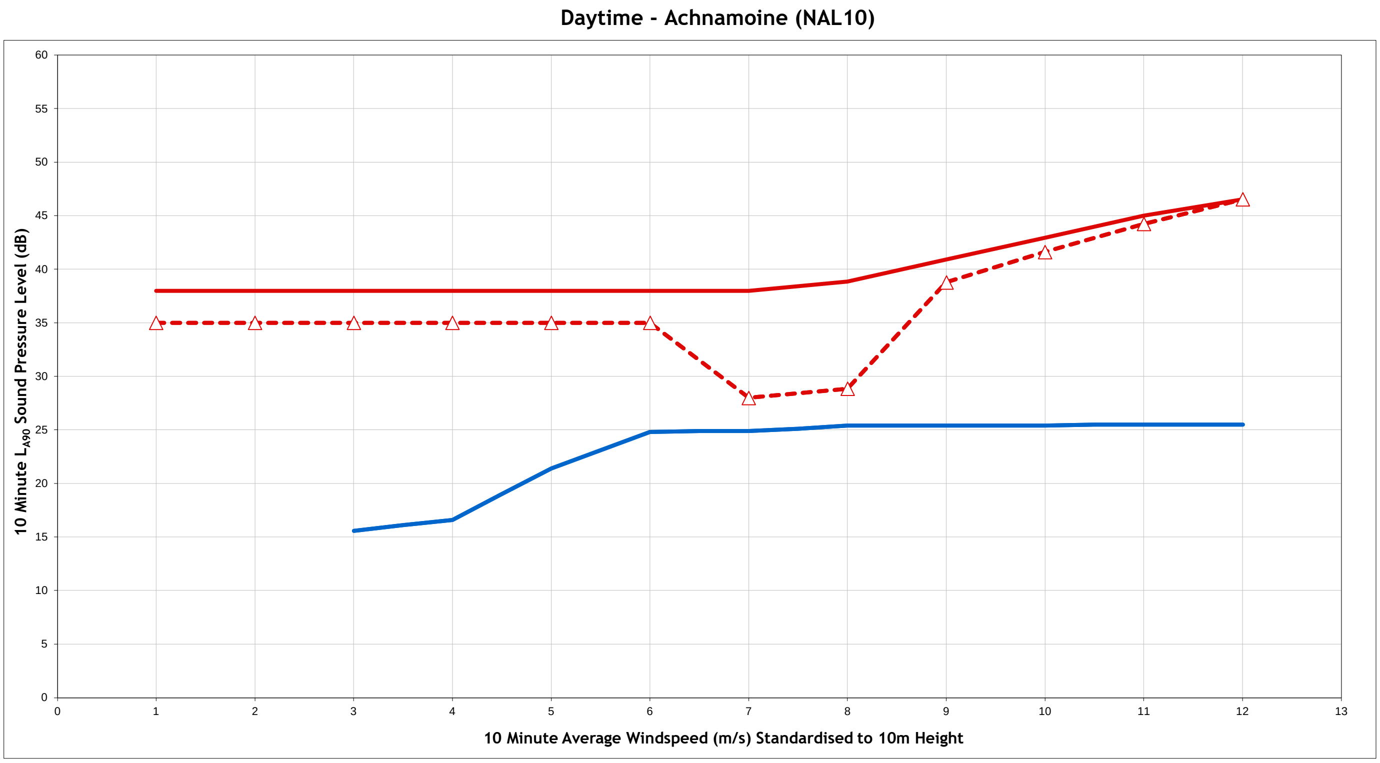
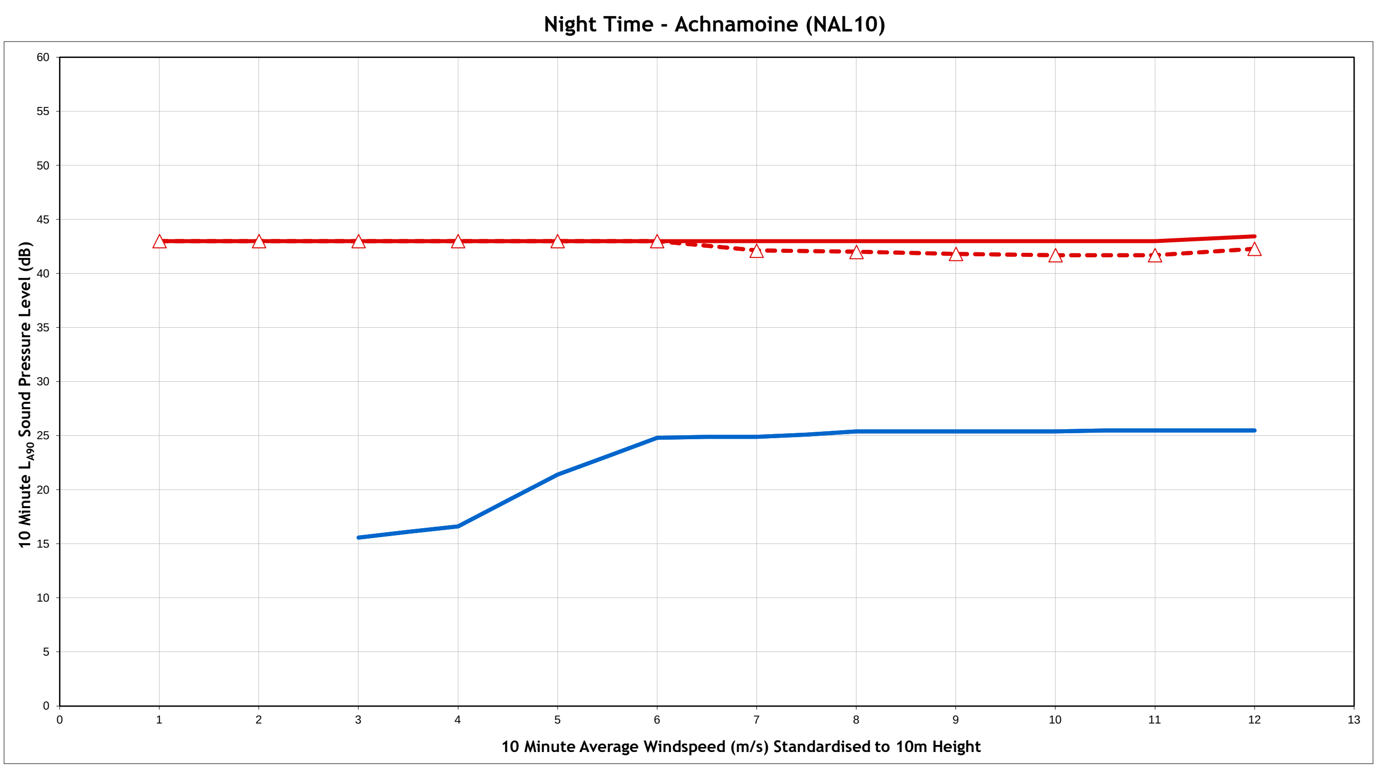
tnei





Legend:

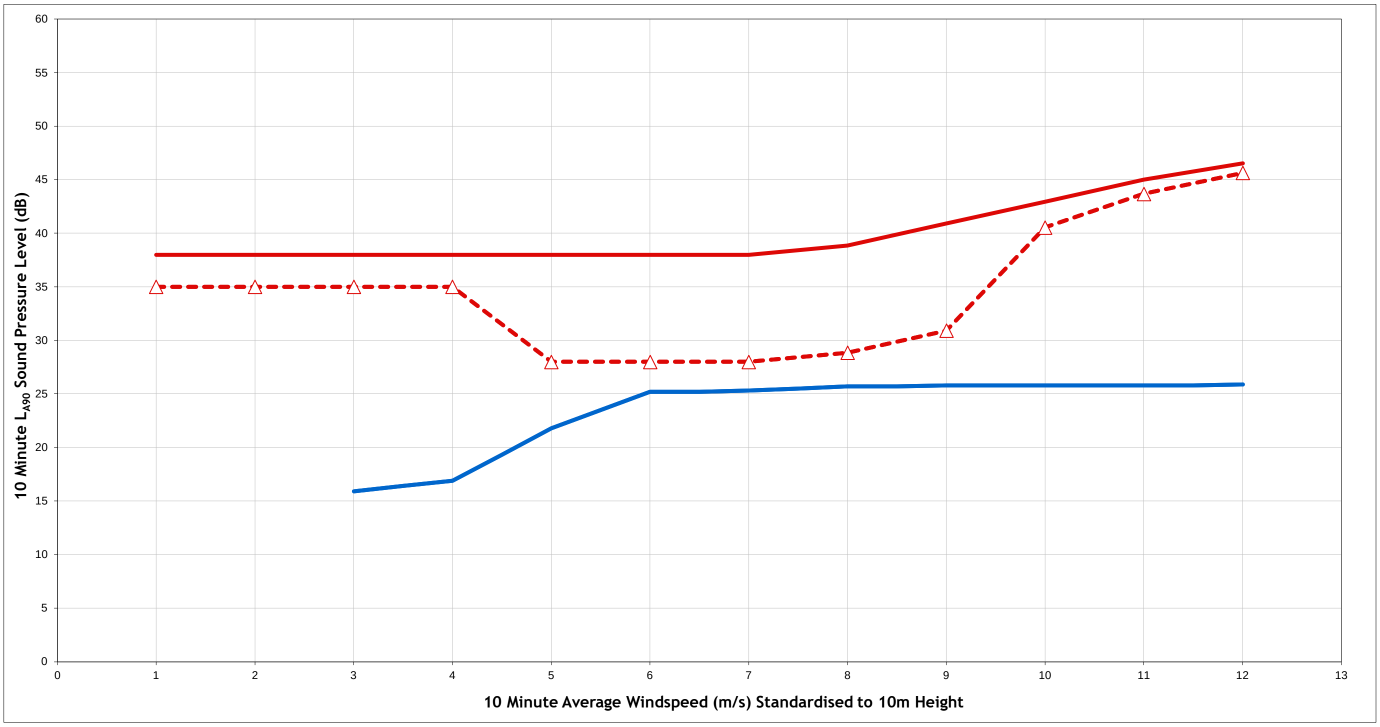
- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment Achnamoine (NAL10)
Figure Number	A1.4j
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

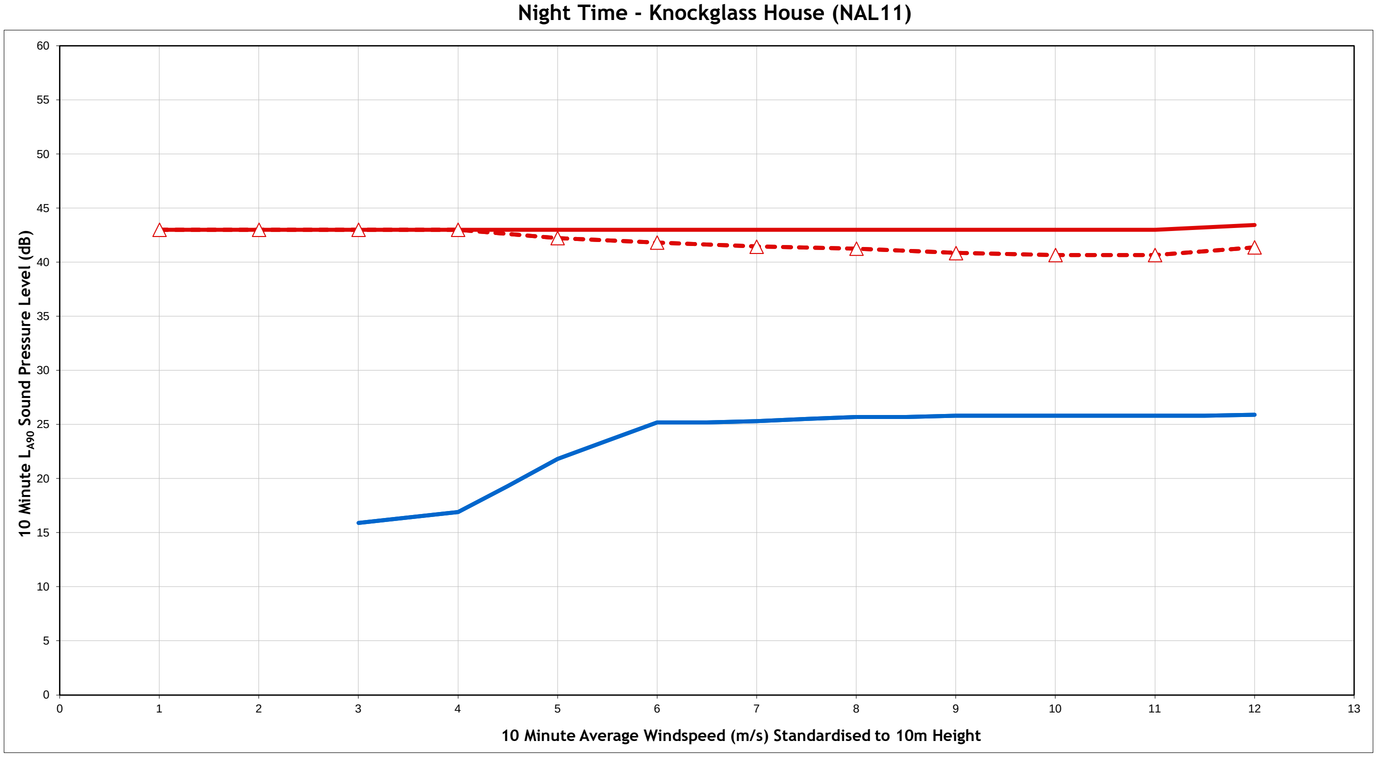
edf renewables

tnei

Daytime - Knockglass House (NAL11)



Night Time - Knockglass House (NAL11)



Legend:

- Total ETSU-R-97 Noise Limit
- Site Specific Noise Limit
- Proposed Development

Project	Watten Wind Farm
Client	EDF Renewables
Title	Noise Assessment Knockglass House (NAL11)
Figure Number	A1.4k
Scale	NTS
Drawn	AD
Checked	GC
Date	28/06/2023
Document Reference	15098-Models

Annex 2 – Correspondence with the Environmental Health Department at the Council

29 June, 2023

Ref: 15098-003 R0

Copy: Sent by email only

Robin Fraser
Environmental Health Officer
Highland Council,
Community Services,
38 Harbour Road,
Inverness,
IV1 1UF

Dear Robin,

PROPOSED WATTEN WIND FARM ON LAND TO THE SOUTH WEST OF WATTEN, HIGHLANDS: NOISE ASSESSMENT

EDF Energy Renewables Ltd ('hereinafter referred to as the Applicant') are proposing to develop a wind farm ('the Proposed Development') on land to the east/ north east of Halsary Windfarm and approximately 3 km to the south west of Watten. The Applicant submitted a Scoping Report for the Proposed Development in April 2022. An indicative turbine layout is shown on the enclosed Figure 1 (Annex 1).

TNEI Services Ltd (TNEI) has been appointed by the Applicant to undertake the noise assessment for the Proposed Development, and we would like to agree the noise assessment methodology with you.

Noise would be emitted from the Proposed Development during the construction, operation and decommissioning phases. Noise emitted during the construction and decommissioning phases would be temporary and short term in nature and can be minimised through careful construction practices. Operational noise would be controlled through the use of appropriate noise limits, which would be imposed to protect the amenity of neighbouring properties without unduly restricting wind energy development. Operational noise limits need to be derived at an early stage of the development to ensure they are satisfied throughout the design process.

Construction Noise

Noisy work activities out-with the typical working hours of 8am to 7pm Monday to Friday and 8am to 1pm on Saturdays will not be undertaken, therefore a detailed construction noise assessment will not be undertaken as part of the EIA. This accords with the scoping opinion provided by the Highland Council.

Operational Noise

An operational noise assessment will be undertaken in accordance with ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms'* (ETSU-R-97) and the Institute of Acoustics document *'A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise'* (IOA GPG). In relation to wind turbine noise PAN 1/2011 *'Planning and Noise'* refers to the Scottish Governments 'Onshore Wind Turbines' web based document which states that:

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Forth Banks
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NE1 3PA
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VAT Reg. GB 239 0146 20 | Company Reg. 03891836

"ETSU-R-97 describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available".

and;

"The Institute of Acoustics (IOA) has since published Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise. The document provides significant support on technical issues to all users of the ETSU-R-97 method for rating and assessing wind turbine noise, and should be used by all IOA members and those undertaking assessments to ETSU-R-97. The Scottish Government accepts that the guide represents current industry good practice."

The noise limits derived in the assessment would inform appropriate noise related planning conditions should an application be made and should Scottish Ministers be minded to grant consent.

ETSU-R-97

ETSU-R-97 describes the findings of the Working Group on Noise from Wind Turbines, the aim of which was to provide information and advice to developers and planners on the environmental assessment of operational noise from wind turbines.

ETSU-R-97 recommends noise limits should be set at 5 dB(A) above existing background noise levels, or a fixed minimum limit of 35-40 dB during the daytime and 43 dB during the night-time periods where background noise levels are low, and that these limits should reflect the variation in background noise with wind speed. Different limits apply to those properties that have a financial interest in the wind energy development (45 dB or background plus 5 dB (whichever is the greater) for both daytime and night-time).

The choice of quiet daytime fixed minimum limits should be considered in light of the guidance contained within ETSU-R-97 and the IOA GPG. Extracts of the guidance contained within ETSU-R-97 and the IOA GPG are included in Annex 1. Noise limits established at properties in accordance with ETSU-R-97 shall be applicable to all existing / proposed (in planning) wind farms in the area and will henceforth be referred to as the 'Total ETSU-R-97 Noise Limits'. Given the number of operational and consented wind farms in the area, we anticipate a daytime Total ETSU-R-97 Noise Limit based on a fixed minimum limit towards the middle/ upper end of the range.

The Site Specific Noise Limits will be based on the lower daytime fixed minimum noise limit of 35 dB or background plus 5 dB whichever is the greater. The Total and Site Specific night time noise limits will be based on 43 dB or background plus 5 dB.

The Site Specific Noise Limits will be derived using the principles contained within the IOA GPG (which may include the use of the controlling property principal / determining if there is significant headroom etc). The Site Specific Noise Limits will be the limits that the Proposed Development would have to operate within, should consent be granted.

Paragraph 5.4.11 of the IOA GPG states; *"In cases where there is significant headroom (e.g. 5 to 10 dB) between the predicted noise levels from the existing wind farm and the total ETSU-R-97 limits, where there would be no realistic prospect of the existing wind farm producing noise levels up to the total ETSU-R-97 limits, agreement could be sought with the LPA as to a suitable predicted noise level (including an appropriate margin to cover factors such as potential increases in noise) from the existing wind farm to be used to inform the available headroom for the cumulative assessment without the need for negotiation or cumulative conditioning. This may be the case particularly at low wind speeds."*

Where there is significant headroom we propose to utilise the available headroom to derive the Site Specific Noise Limits for the Proposed Development and consider a +2 dB addition to predicted cumulative levels (excluding the Proposed Development) to be "an *appropriate margin to cover factors such as potential increases in noise".* We would be grateful if the Council would confirm its agreement to this approach.

In order to establish Total ETSU-R-97 Noise Limits in accordance with ETSU-R-97 it is necessary to determine the relationship between wind speed measured at the Proposed Development site and background noise levels measured at the closest noise sensitive receptors. Measured background noise levels should not be influenced by noise from operational wind turbines, this is an important consideration for this assessment given the number of operational wind turbines in the area.

The IOA GPG provides guidance on the methods that can be used to determine background noise levels in areas which are potentially influenced by operational wind turbines. The IOA GPG states that:

'In the presence of an existing wind farm, suitable background noise levels can be derived by one of the following methods:

- *switching off the existing wind farm during the background noise level survey (with associated significant cost implications);*
- *accounting for the contribution of the existing wind farm in the measurement data e.g. directional filtering (only including background data when it is not influenced by the existing turbines e.g. upwind of the receptor, but mindful of other extraneous noise sources e.g. motorways) or subtracting a prediction of noise from the existing wind farm from the measured noise levels;*
- *utilising an agreed proxy location removed from the area acoustically affected by the existing wind farm/s; or*
- *utilising background noise level data as presented within the Environmental Statement/s for the original wind farm/s (the suitability of the background noise level data should be established).'*

With due regard to the location of key properties relative to operational turbines and the existing background noise data presented previously, it is proposed that the background noise data gathered as part of the November 2009 Environmental Statement (ES) for Halsary Windfarm is reused (as per the fourth bullet point above).

The IOA GPG goes on to state, in Section 5.2.4, that:

'If the developer wishes to utilise previously presented background noise level data, care should also be taken with respect to any differences in wind speed conditions between the original and proposed site. The underlying principle of ETSU-R-97 requires that the background noise levels at any given location must be correlated with the wind speeds measured on the wind farm site of interest. Where a systematic difference exists between the wind conditions on the two sites, then a correction will need to be applied, meaning that the derived background noise curves for the two sites will be different.'

Whilst the dataset collected for Halsary Windfarm is suitable in regards to providing the background noise levels at key receptors to the Proposed Development, the noise levels were derived based upon a hub height of 70 m. As the maximum hub height for the Proposed Development is 139 m, the background noise levels derived for Halsary Windfarm are not appropriate for use in the Watten Wind Farm assessment if left unaltered. TNEI has worked with wind resource experts at Natural Power to agree a methodology to adjust the data with reference to the guidance in the IOA GPG (further detail on this process is set out in the section below titled 'Wind Shear Adjustments'.

The following steps summarise the proposed noise assessment process for this scheme:

- determine the daytime and night-time criterion curves (i.e. Total ETSU-R-97 noise limits) by applying the appropriate adjustment to the background noise curves derived as part of the Halsary Wind Farm ES;
- specify the type and noise emission characteristics of all existing / proposed wind farms using candidate / operational wind turbine noise data;
- undertake a cumulative assessment for locations where noise predictions from the proposed wind farm development are within 10 dB of the total noise predictions from any other wind farms/turbine developments in the area and compare the total cumulative predicted noise levels to the Total ETSU-R-97 Noise Limits;
- determine the 'Site Specific Noise Limits' which take account of the noise limit already allocated to, or could theoretically be used by other wind farm developments in the area using the guidance in the IOA GPG; and
- compare the predicted wind farm noise immission levels for the Proposed Development with the Site Specific Noise Limit.

TNEI believe the noise monitoring locations used for the Halsary Windfarm would provide a sufficient sample of representative background noise data for the area. The monitoring locations are shown on Figure 1 (in Annex 1 of this letter) and are also detailed in Table 1 below. Figure 1 also details a number of Noise Assessment Locations 'NALs' which will be considered in the assessment.

Table 1 - Noise Monitoring Locations (NMLs) from the Halsary Wind Farm ES

Property/Location	Justification
Tacher (317347, 946888)	The data collected at this NML will not be used as the property is located >4.5 km from the Proposed Development and as such is not being considered as a NAL.
Croft at Mybster (316953, 952209)	Croft of Mybster is an NAL (NAL12) for the Proposed Development and therefore the dataset will be used to derive noise limits at that NAL.
Backglass (320376, 953609)	Backlass (NAL8) is located to the north of the Proposed Development and has been chosen as a representative location for all NALs located to the north, east and south of the Proposed Development (NALs 1-9). The adjusted background noise data collected at this location was found to be the quietest of all the datasets recorded at the key wind speed ranges.
Shielton (320615, 950943)	This NML will not be used due to other NML datasets being more conservative. In addition, Shielton is an unoccupied property and will remain so for the lifetime of the Proposed Development.
Knockglass (317497, 953228)	The data collected at Knockglass (NAL11) is deemed representative of NAL10 which is located in close proximity.

Table 2 details buildings that are not considered to be a noise sensitive receptor as they are uninhabitable/ unoccupied and as such will not be included as a noise assessment location. If you have any further information regarding the status of these buildings or would like to discuss these further we would be grateful if you could let us know. These building are shown as a red house symbol on Figure 1.

Table 2 - Building not considered as noise sensitive receptors.

Property/Location	Justification
Building to the south of NAL2 (322850, 951756)	The building appears to be non-residential.
Building on the north west edge of Loch Toftinghall (318782, 952604)	The building appears to be non-residential.
Shielton (320615, 950943)	This property is unoccupied and has not been permanently occupied for over 20 years. The property will not be inhabited for the lifetime of the Proposed Development. On that basis it will not be considered as a noise sensitive receptor.
20 West Watton/ Acharole (321945, 951336)	This building is unoccupied and has not been permanently occupied for over 20 years. The property will not be inhabited for the lifetime of the Proposed Development. On that basis it will not be considered as a noise sensitive receptor.
Druimdubh (320766, 952470)	The building is derelict/ uninhabitable.

Cumulative Noise Assessment

TNEI is aware of a number of operational, consented and proposed wind farm schemes in the area (see Figure 1 in Annex 1). TNEI understand that the proposed Loch Toftinghall Wind Farm has not been progressed past the scoping stage and as such it will not be included within the cumulative noise assessment. We would be grateful if you could bring to our attention any other wind farm/ turbine developments that you are aware of in the area that may merit consideration within the cumulative noise assessment.

Wind Shear Adjustments

As detailed above, the baseline datasets collected as part of Halsary Windfarm have been adjusted to take account of wind shear such that they correlate with wind speeds measured on the Watten Wind Farm site. The steps below outline the process that was adopted:

- A wind resource model was created by Natural Power.
- The model considered wind speed data from a meteorological mast and Lidar unit and this was used to determine 'speed up values' to determine the ratio of the wind speeds at the height of the 70 m mast used for Halsary Windfarm and the proposed hub height at the Proposed Development. A speed up factor of 1.15 indicates that measurements of 1 ms^{-1} at the mast located near Halsary are expected to equate to a wind speed of 1.15 ms^{-1} at the Proposed Development. The standard deviation of the speed up factor was also calculated for each 1 ms^{-1} wind speed bin.
- The data provided by Natural Power were then used by TNEI to adjust the background noise data using the following steps:
    - o The background noise levels presented for Halsary Windfarm (which were standardised to 10 m) were presented relative to wind speed at 70 m;
    - o The background noise levels were then set relative to hub height (139 m) at the Proposed Development site. This was achieved by multiplying the values by the average speed up value plus one standard deviation (to represent a cautious approach); and

- The background noise levels were then set relative to standardised wind speeds at the Proposed Development site to accord with good practice.

The adjustments applied are summarised in Tables 2 and 3 below. The wind shear report provided by Natural Power is included within Annex 3.

Adjustment to Halsary Background noise curves

As per Section 4.4.2 of SGN4 of the IOA GPG, the average speed up factor plus one standard deviation has been used to calculate the adjusted background noise curves for Watten. Details of the adjusted background noise curves for daytime and night time periods are presented in Tables 2 and 3, respectively and graphs showing the adjustments are included within Annex 3.

Table 2 – Daytime background noise curves presented in the Halsary Windfarm ES and their shear adjusted values for use on the Proposed Development

Noise Monitoring Location	Prevailing Background Noise Level $L_{A90,10\ min}$, Standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
Croft at Mybster (original)	22.9	23.7	25.4	27.7	30.3	33.1	35.7	38.1	39.9	41.1	41.6	41.1
Croft at Mybster† (adjusted)	23.4*	23.4	24.5	26.1	28.0	29.9	32.2	34.3	36.3	38.2	40.0	41.2
Knockglass (original)	23.3	24.0	25.5	27.6	30.0	32.6	35.3	37.8	39.9	41.4	42.2	42.1
Knockglass† (adjusted)	23.6*	23.7	24.7	26.1	27.9	29.6	31.7	33.9	35.9	37.9	40.0	41.5
Backglass (original)	22.5	22.7	23.9	26.1	28.9	32.0	35.2	38.3	41.0	42.9	43.9	43.8
Backglass† (adjusted)	22.6*	22.6	23.3	24.6	26.5	28.5	31.0	33.5	36.0	38.5	41.1	43.1

† Dataset has been adjusted to account for the change in shear from the 70 m mast at Halsary Windfarm to the 139 m hub heights for the Proposed Development.

** Dataset has been flatlined due to unavailability of data at 1 ms^{-1} resulting from the shear adjustment.*

Note: The data collected at Tacher and Shielton has not been adjusted as Tacher is not a noise assessment location for the Proposed Development due its separation distance and Shielton is unoccupied and will remain so for the lifetime of Watten Wind Farm should it be consented.

Table 3 – Night-time background noise curves presented in the Halsary Windfarm ES and their shear adjusted values for use on the Proposed Development.

Noise Monitoring Location	Prevailing Background Noise Level $L_{A90,10\,min}$, Standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
Croft at Mybster (original)	22.1	22.3	23.4	25.2	27.5	30.0	32.7	35.3	37.7	39.6	40.8	41.3
Croft at Mybster† (adjusted)	22.2*	22.2	22.8	23.8	25.3	27.1	29.0	30.8	32.8	35.7	37.8	39.1
Knockglass (original)	20.8	20.9	21.8	23.3	25.3	27.8	30.5	33.4	36.3	39.1	41.7	44.0
Knockglass† (adjusted)	20.9*	20.9	21.3	22.2	23.4	25.0	26.8	28.6	30.7	33.9	36.4	38.4
Backglass (original)	21.0	21.5	22.0	22.9	24.4	26.8	30.0	33.8	37.8	41.5	44.3	45.4
Backglass† (adjusted)	21.3*	21.3	21.7	22.2	23.0	24.2	25.8	27.8	30.2	34.5	38.0	40.6

† Dataset has been adjusted to account for the change in shear from the 70 m mast at Halsary Windfarm to the 139 m hub heights for the Proposed Development.

** Dataset has been flatlined due to unavailability of data at 1 ms^{-1} resulting from the shear adjustment.*

Summary

To enable us to progress the assessment we would be very grateful if you confirm whether:

- You are happy with the proposed assessment methods outlined above (ETSU-R-97 and the IOA GPG);
- You agree with the use of the background noise levels derived in the 2009 Halsary Windfarm ES when adjusted for the new shear profile using the methodology detailed above;
- You agree with the proposed approach that, in line with IOA GPG, the cumulative assessment and derivation of Site Specific Noise Limits for the Proposed Development will utilise available significant headroom with an appropriate margin +2 dB above predicted noise levels;
- If the Council is aware of any schemes which should be included in the cumulative noise assessment or any other dwellings (other than those shown on Figure 1) which should be considered in the assessment of noise impacts.

If you have any immediate concerns or queries, please do not hesitate to contact me or my colleague James Mackay. We look forward to hearing from you soon.

Yours sincerely,

Gemma Clark
BSc(Hons), MSc, AMIOA

Principal Consultant
gemma.clark@tneigroup.com
Tel: 0191 211 1418

Reviewed and approved by:

James Mackay
BSc(Hons), Dip, MIOA

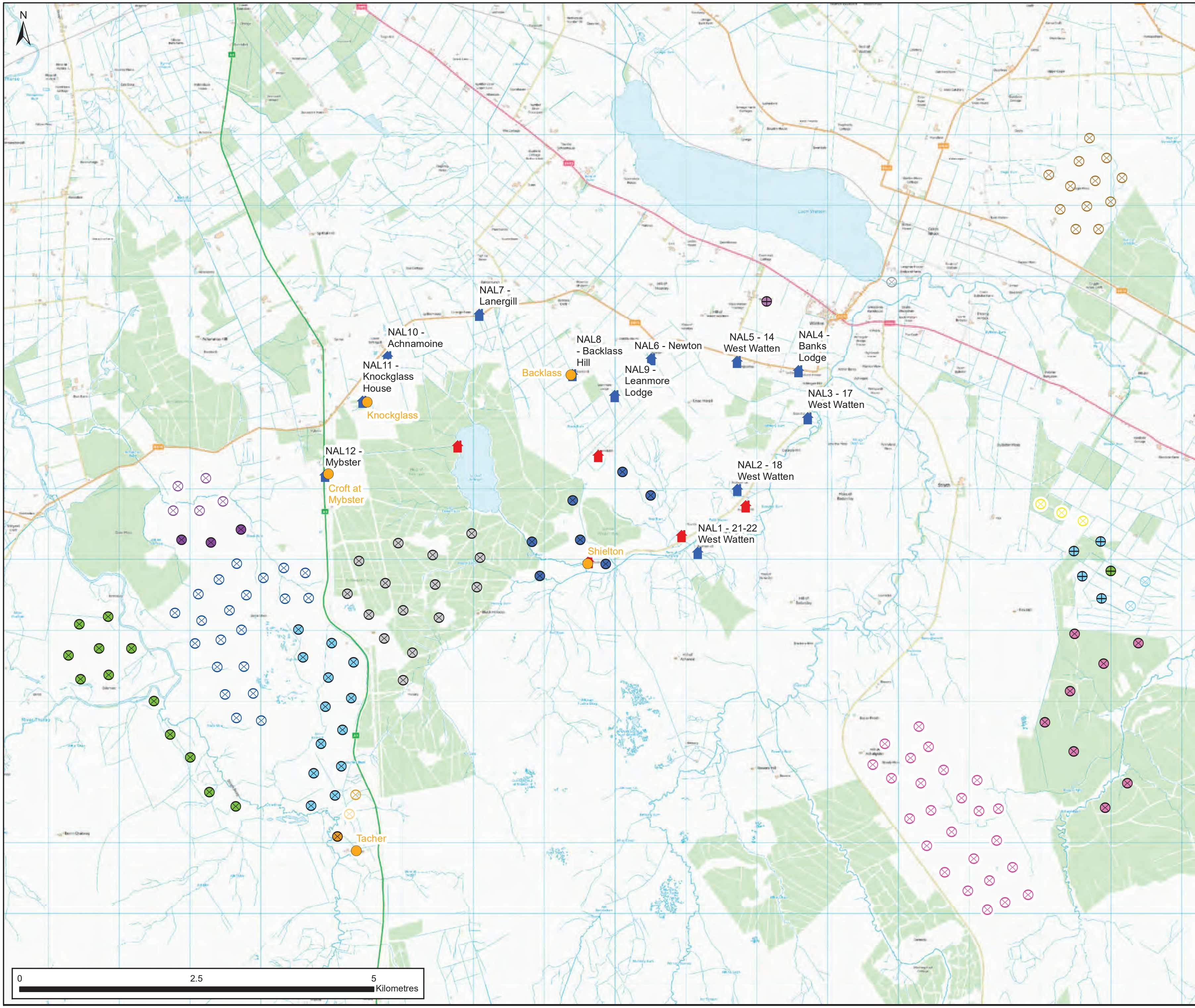
Director of Environment & Engineering
James.mackay@tneigroup.com
Tel: 0191 211 1414

Annex 1 - Figure 1 – Noise Assessment and Wind Turbine Locations

Annex 2 - Determining the Fixed Part of the Daytime Amenity Noise Limit

Annex 3 - TNEI Wind Shear Adjustment Graphs and Natural Power Report Wind Shear Report

Annex 1: Figure



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LEGEND

- Halsary Noise Monitoring Locations (NMLs)
- Noise Assessment Locations (NALs)
- Derelict/ Unused Property
- Proposed Watten Turbine Location

Operational / Consented Schemes

- Achlachan
- Achlachan 2
- Bad a Cheo
- Bilbster
- Camster
- Camster II
- Causeymire
- Cogle Moss
- Halsary
- Harpsdale Mains Halkirk
- Tacher A
- Tacher B
- Tacher C
- Tormsdale
- Myrelandhorn
- Wathegar
- Wathegar 2
- West Watten

Rev.	Date	Amendment Details	Drw'n	Chk'd	App'd
00	29/06/23	Client Comments	JCM	GC	GC
00	08/06/23	First Issue	JCM	GC	GC

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which TNEI Services Ltd was commissioned. TNEI Services Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. Any party which breaches the provisions of this disclaimer shall indemnify TNEI Services Ltd for all loss or damage arising therefrom.

tnei

Client: EDF renewables

Drawing Status: FOR INFORMATION

Project Title: Watten Wind Farm

Drawing Title: Figure 1 - Noise Assessment and Wind Turbine Locations

Scale	Designed	Drawn	Checked	Approved
1:50,000	JCM	JCM	GC	GC
Original Size	Date	Date	Date	Date
A3	29/06/2023	29/06/2023	29/06/2023	29/06/2023

Drawing Number: 15098 - 005

Revision: 1

Annex 2: Determining the Fixed Part of the Daytime Amenity Noise Limit

In relation to determining the fixed part of the Daytime Amenity Noise Limit the ETSU-R-97 notes (on page 65) that:

"The actual value chosen for the daytime lower limit, within the range of 35-40 dB(A), should depend upon a number of factors:

• Number of dwellings in the neighbourhood of the wind farm.

The planning process is trying to balance the benefits arising out of the development of renewable energy sources against the local environmental impact. The more dwellings that are in the vicinity of a wind farm the tighter the limits should be as the total environmental impact will be greater. Conversely if only a few dwellings are affected, then the environmental impact is less and noise limits towards the upper end of the range may be appropriate. Developers still have to consider the interests of individuals as protected under the Environmental Protection Act 1990. It is our belief however, in accordance with the report of the Welsh Affairs Committee [23], that there have been no cases of complaints of noise at levels similar to those caused by wind farms leading to a successful prosecution as a statutory nuisance. It should be noted however that the Welsh Affairs Committee also reports that although the noise may not be a statutory nuisance it can clearly be a cause for distress and disturbance, particularly if residents have been promised inaudibility and the noise has a particular quality leading to complaints.

• The effect of noise limits on the number of kWh generated.

Similar arguments can be made when considering the effect of noise limits on uptake of wind energy generated. A single wind turbine causing noise levels of 40 dB(A) at several nearby residences would have less planning merit (noise considerations only) than 30 wind turbines also causing the same amount of noise at several nearby residences.

• Duration and level of exposure.

The proportion of the time at which background noise levels are low and how low the background noise level gets are both recognised as factors which could affect the setting of an appropriate lower limit. For example, a property which experienced background noise levels below 30 dB(A) for a substantial proportion of the time in which the turbines would be operating could be expected to receive tighter noise limits than a property at which the background noise levels soon increased to levels above 35 dB(A). This approach is difficult to formulate precisely and a degree of judgement should be exercised."

The IOA GPG adds some further guidance:

"3.2.2 The day amenity noise limits have been set in ETSU-R-97 on the basis of protecting the amenity of residents whilst outside their dwellings in garden areas. The daytime amenity noise limits are formed in two parts: Part 1 is a simple relationship between the prevailing background noise level (with wind speed) with an allowance of +5 dB; Part 2 is a fixed limit during periods of quiet. ETSU-R-97 describes three criteria to consider when determining the fixed part of the limit in the range of 35 dB to 40 dB L_{A90}, all of which should be considered. They are:

1) the number of noise-affected properties;

2) the potential impact on the power output of the wind farm; and

3) the likely duration and level of exposure.

3.2.3 The rationale for a choice of this limit, or factors which would assist the determining authority in this respect should be set out in the assessment. It is beneficial to the decision maker to display both sets of limits to illustrate the range available and/or the noise limit for the development if agreed previously with the LPA.

3.2.4 Current practice on the three criteria is as follows:

1. The number of neighbouring properties will depend on the nature of the area, (rural, semi-rural, urban) and is sometimes considered in relation to the size of the scheme and study area. The predicted 35 dB L_{A90} contour (at maximum noise output up to 12 m/s) can provide a guide to the dwellings to be considered in this respect.

2. This is in practice mainly based on the relative generating capacity of the development, as larger schemes have relatively more planning merit (for noise) according to the description in ETSU-R-97. In cases when the amenity fixed limit has little or no impact on the generating capacity (i.e. noise is not a significant design constraint) then a reduced limit may be applied.

3. This last test is more difficult to formulate. But ETSU-R-97 notes that the likely excess of turbine noise relative to background noise levels should be a relevant consideration. In rural areas, this will often be determined by the sheltering of the property relative to the wind farm site. Account can also be taken of the effects of wind directions (including prevailing ones at the site) and likely directional effects. For cumulative developments, in some cases the effective duration of exposure may increase because of cumulative effects.

3.2.5 It can be argued that assessing these factors do not represent an acoustic consideration but ultimately a planning consideration, and therefore are difficult for noise consultants to fully determine. However this is described as part of ETSU-R-97 and therefore represents a relevant consideration when determining applicable noise limits. Furthermore, it is necessary, as part of the EIA process to evaluate the noise impacts, which is arguably not fully possible without a complete determination of the ETSU-R-97 limits. Finally, consideration of cumulative noise impacts may require the determination of partial noise limits which may be difficult to obtain unless the amenity noise limit is precisely determined.

3.2.6 Other planning considerations, such as the identification in local planning policy of areas of preferred wind farm development, may also influence or determine the choice of the absolute fixed amenity noise limit."

Gemma Clark

From: Robin Fraser (Environmental Health (Mid 3)) <Robin.Fraser@highland.gov.uk>
Sent: 14 July 2023 10:11
To: Gemma Clark
Cc: James Mackay; Alex Dell; Lucy Freeman
Subject: RE: 15098 - Proposed Watten Wind Farm - Noise Consultation

Hi Gemma, apologies for the delay in responding. Re your letter of 29th June I would comment as follows.

Obviously, this is a very busy part of the world in terms of wind farm activity and I understand that the only way forward for future development is to increase fixed limits beyond which Highland Council would normally look for. However, if the proposals are still in line with ETSU-R-97 and IOA GPG, then there would be no grounds on which I could object. As you have mentioned any proposal to increase daytime fixed limits beyond 35dB LA90 would need to be accompanied by an argument supporting that decision in terms of the criteria identified in ETSU i.e. number of dwellings in the neighbourhood of the wind farm, the effect of noise limits on the number of kWh generated and the duration and level of exposure.

With regard to the properties identified in Table 2 as being uninhabited/derelict or otherwise not a noise receptor, this would be something you would need to agree with the Planning Officer. There is no mention of any financially involved properties. Again, this would be something that would need to be agreed by Planning if relevant. I am aware that there may be some properties which have a financial involvement with other developments but that does not necessarily mean that a relaxation on noise limits would apply for this development.

I am happy for previous background monitoring results to be used amended to account for differences in height. I note that only three locations from the previous Halsary background survey will be used however, the levels at Backlass were found to be the lowest and will be used for the majority of NALs as a conservative measure. I'm happy with that approach.

To answer your specific queries; -

You are happy with the proposed assessment methods outlined above (ETSU-R-97 and the IOA GPG); Yes
You agree with the use of the background noise levels derived in the 2009 Halsary Windfarm ES when adjusted for the new shear profile using the methodology detailed above; Yes
You agree with the proposed approach that, in line with IOA GPG, the cumulative assessment and derivation of Site Specific Noise Limits for the Proposed Development will utilise available significant headroom with an appropriate margin +2 dB above predicted noise levels; Yes
If the Council is aware of any schemes which should be included in the cumulative noise assessment or any other dwellings (other than those shown on Figure 1) which should be considered in the assessment of noise impacts. I would advise that you would need to obtain this information from the Planning Service.

If there is anything you wish to discuss further, please get in touch.

Regards,
Robin Fraser
Environmental Health Officer
Highland Council, Community Services, 38 Harbour Road, Inverness, IV1 1UF
Telephone: +447879661365 E-Mail: robin.fraser@highland.gov.uk

Environmental Health welcomes your feedback. Please help us improve our service by taking our short customer survey by clicking on this link
https://www.surveymonkey.com/s/highlandeh

From: Gemma Clark <gemma.clark@tneigroup.com>
Sent: 29 June 2023 18:47
To: Robin Fraser (Environmental Health (Mid 3)) <Robin.Fraser@highland.gov.uk>
Cc: James Mackay <james.mackay@tneigroup.com>; Alex Dell <alex.dell@tneigroup.com>; Lucy Freeman <lucyf@naturalpower.com>
Subject: 15098 - Proposed Watten Wind Farm - Noise Consultation

CAUTION: This email was sent from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Hi Robin,

I hope that you are keeping well. As you may already be aware, EDF Energy Renewables Ltd is considering developing a wind farm on land approximately 3 km to the south west of Watten, Highlands. TNEI has been commissioned to undertake the noise assessment work for the proposed development and would like to agree in advance the methodology proposed for the noise assessment.

Please find attached a consultation letter detailing our proposed methodology for your consideration.

If you have any questions or require additional information, please do not hesitate to contact me or my colleague James. We look forward to hearing from you soon.

Kind regards

Gemma

Gemma Clark
Principal Consultant

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Annex 3 – Extract from Noise Assessment undertaken for Halsary Wind Farm

Appendix H5
Noise Levels Criterion Curves

Environmental Statement

Volume III

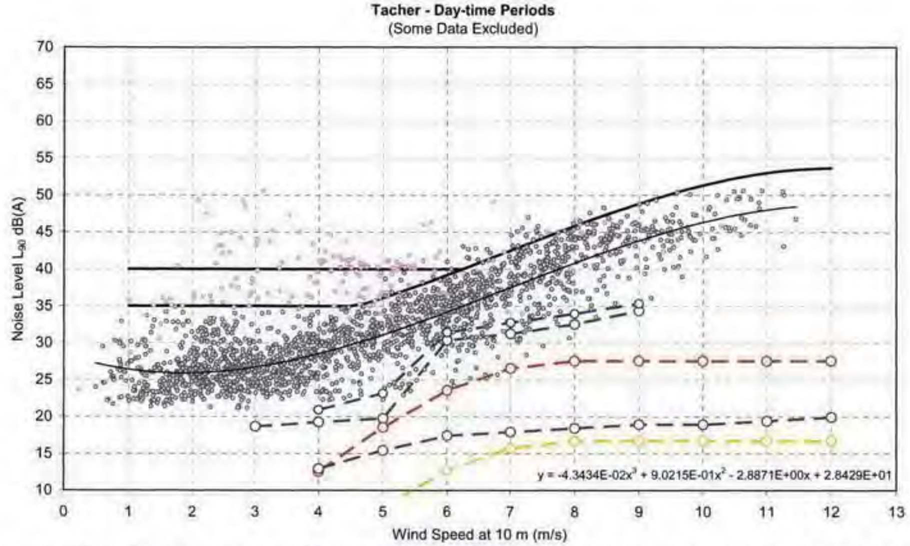


Figure H5.1 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the range of derived noise limit curves (thick black lines) for Tacher during quiet day-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

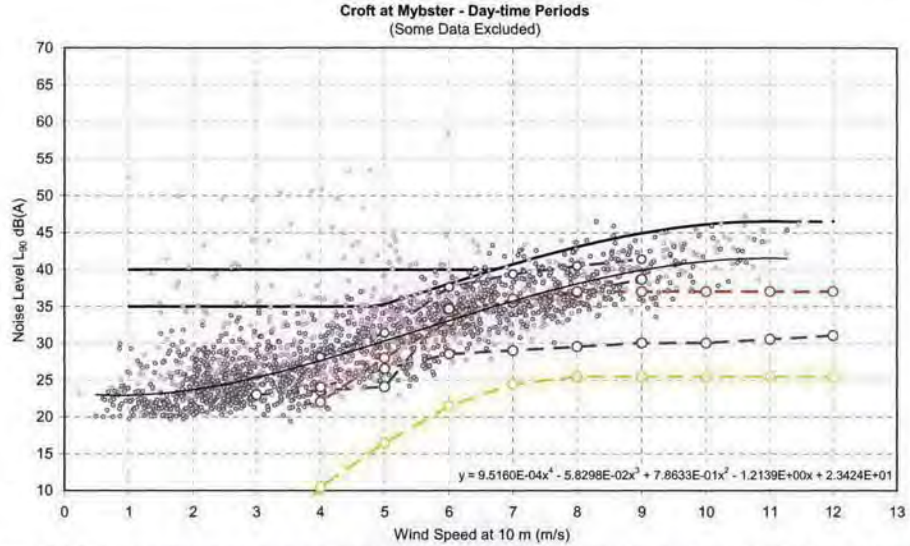


Figure H5.3 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the range of derived noise limit curves (thick black lines) for Croft at Mybster during quiet day-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

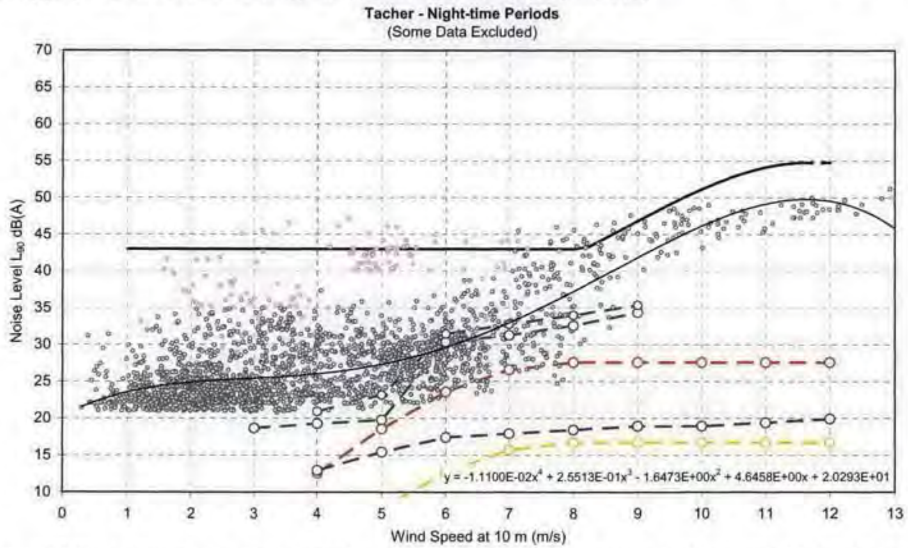


Figure H5.2 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the derived noise limit curve (thick black line) for Tacher during night-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

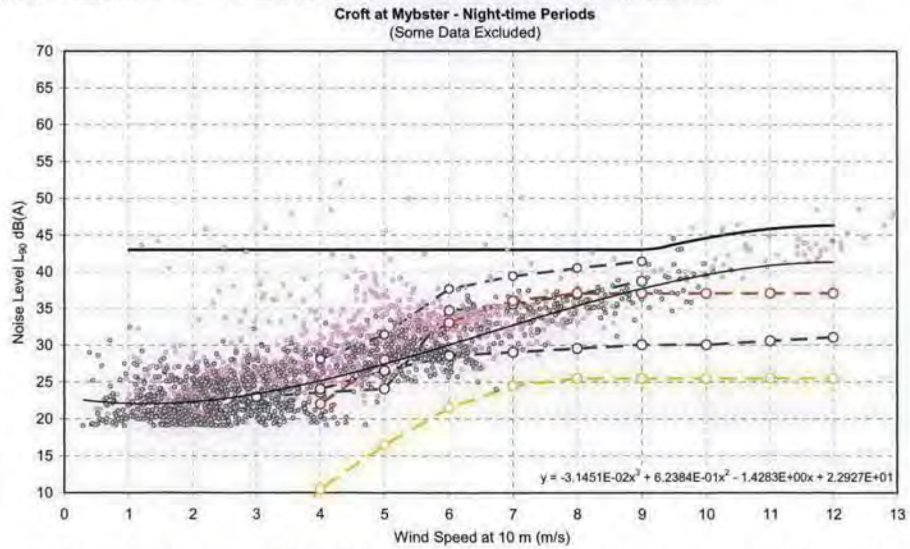


Figure H5.4 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the derived noise limit curve (thick black line) for Croft at Mybster during night-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

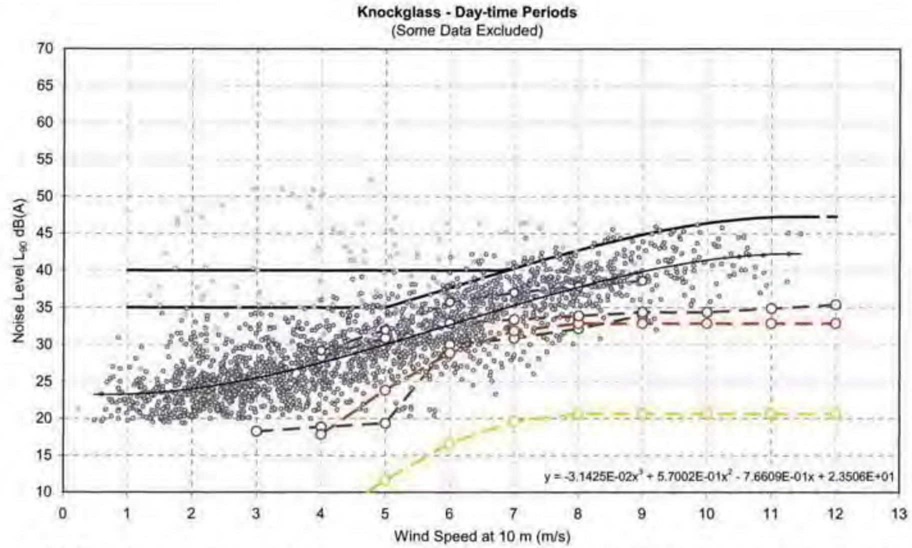


Figure H5.5 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the range of derived noise limit curves (thick black lines) for Knockglass during quiet day-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

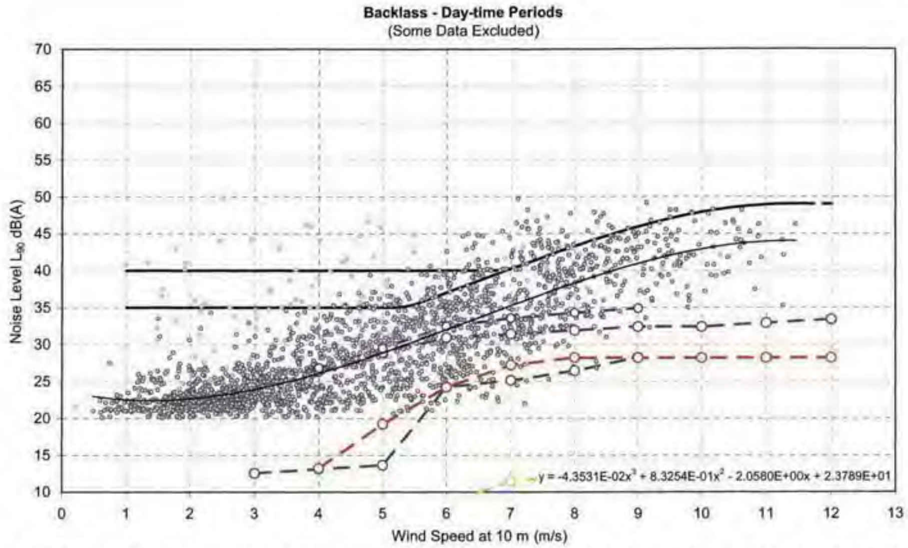


Figure H5.7 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the range of derived noise limit curves (thick black lines) for Backlass during quiet day-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

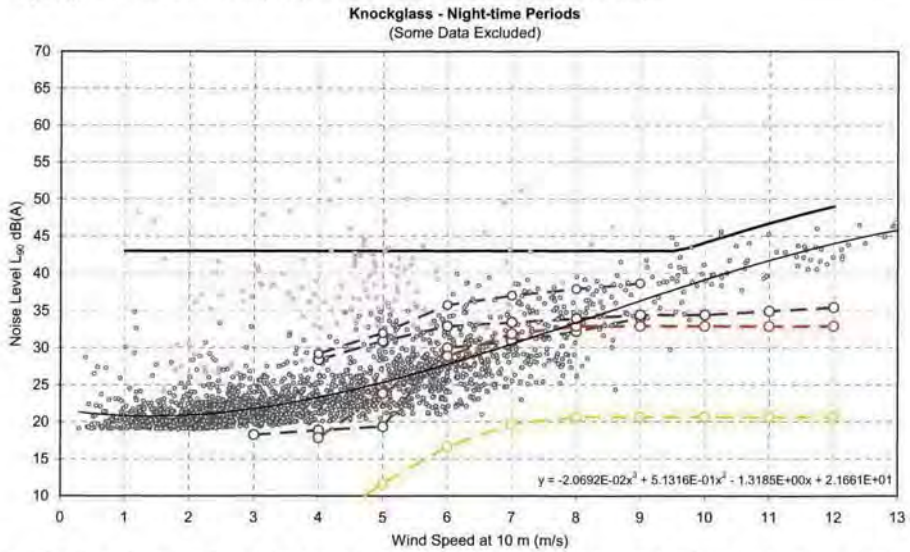


Figure H5.6 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the derived noise limit curve (thick black line) for Knockglass during night-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

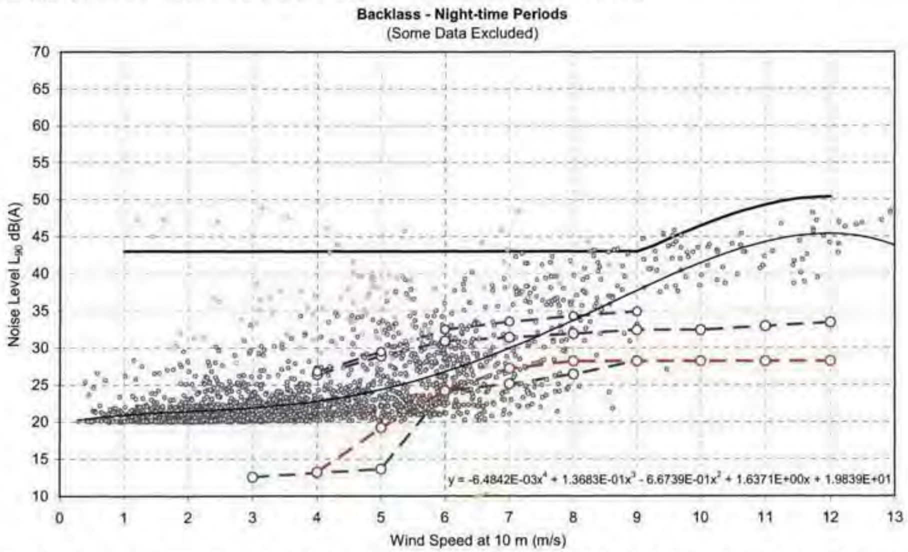


Figure H5.8 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the derived noise limit curve (thick black line) for Backlass during night-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

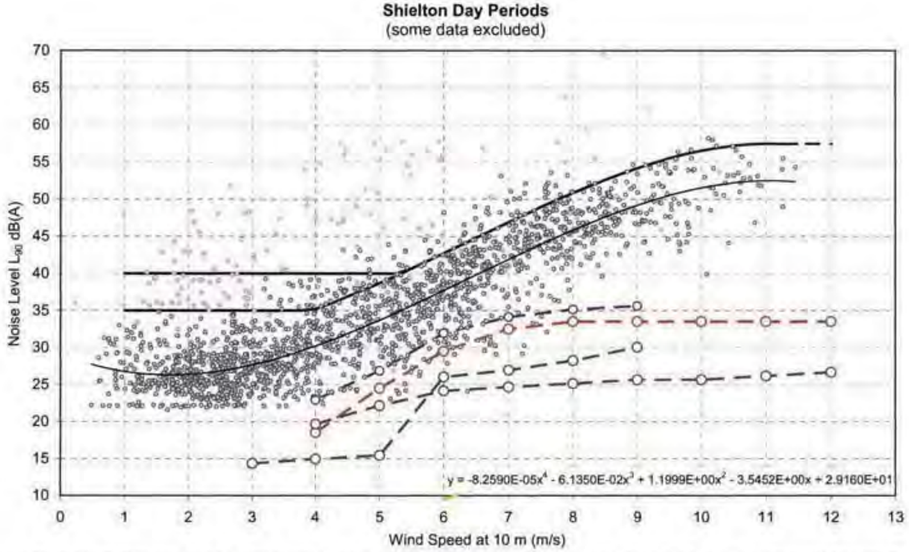


Figure H5.9 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the range of derived noise limit curves (thick black lines) for Sheilton during quiet day-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

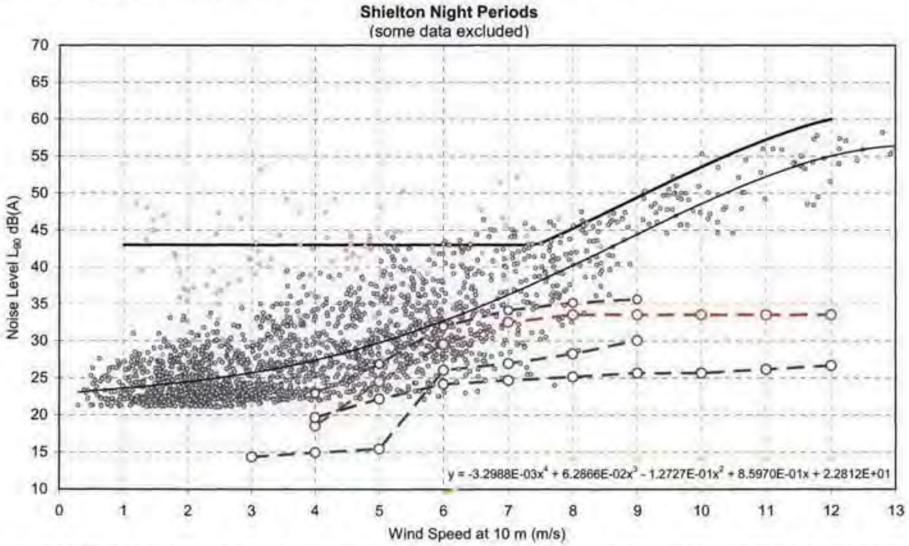


Figure H5.10 Chart of background noise levels against wind speeds (open grey circles), the best-fit curve (thin black line) to these data, the derived noise limit curve (thick black line) for Sheilton during night-time periods. Predicted immission noise levels (thick dashed lines with open circles) for Causeymire (green), Causeymire Extension (yellow), Spittal Hill (purple), Halsary (red) and the cumulative total (blue). Excluded data also shown (open pink circles).

Annex 4 – Wind Shear Report and Adjustment Graphs

Wind shear adjustments for Watten Wind Farm
22/06/2023

Introduction
This spreadsheet uses speed up factors as calculated by Natural Power to adjust background noise levels as measured for Halsary Windfarm

Input Data

Halsary Windfarm Hub Height	70	m
Watten Wind Farm Hub Height	139	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	4	
NML Name	Backglass	

Formulas used in this sheet

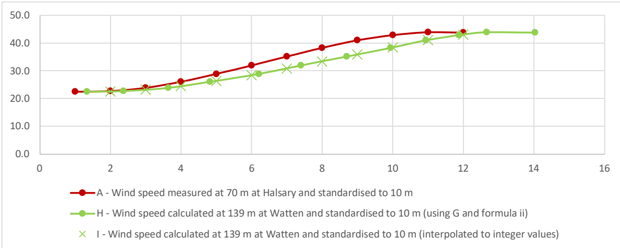
i vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

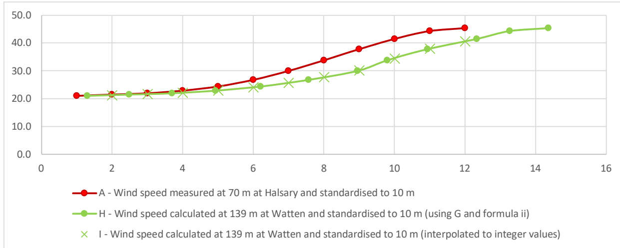
Day-time

A - Wind speed measured at 70 m at Halsary and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from Halsary assessment)	22.5	22.7	23.9	26.1	28.9	32.0	35.2	38.3	41.0	42.9	43.9	43.8
C - Wind speed calculated at 70 m at mast (using A and formula i)	1.37	2.73	4.10	5.47	6.84	8.20	9.57	10.94	12.31	13.67	15.04	16.41
D - Average speed up factor (between 70 m at Halsary and 139 at Watten)	1.16	1.18	1.22	1.23	1.24	1.24	1.24	1.22	1.21	1.18	1.16	1.17
E - One standard deviation (s.d.) of the speed up factor	0.29	0.11	0.12	0.09	0.12	0.11	0.12	0.14	0.12	0.12	0.10	0.11
F - Speed up factor used for modeling (average plus one s.d.)	1.46	1.30	1.33	1.32	1.36	1.35	1.36	1.36	1.33	1.30	1.26	1.28
G - Wind speed calculated at 139 m at Watten (C * F)	2.00	3.55	5.46	7.22	9.30	11.07	13.02	14.88	16.37	17.77	18.95	21.00
H - Wind speed calculated at 139 m at Watten and standardised to 10 m (using G and formula ii)	1.33	2.38	3.64	4.82	6.21	7.40	8.70	9.94	10.93	11.88	12.66	14.03

Night-time

A - Wind speed measured at 70 m at Halsary and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from Halsary assessment)	21.0	21.5	22.0	22.9	24.4	26.8	30.0	33.8	37.8	41.5	44.3	45.4
C - Wind speed calculated at 70 m at mast (using A and formula i)	1.37	2.73	4.10	5.47	6.84	8.20	9.57	10.94	12.31	13.67	15.04	16.41
D - Average speed up factor (between 70 m at Halsary and 139 at Watten)	1.18	1.20	1.22	1.24	1.25	1.26	1.27	1.23	1.22	1.24	1.21	1.22
E - One standard deviation (s.d.) of the speed up factor	0.25	0.16	0.13	0.11	0.11	0.12	0.14	0.11	0.11	0.12	0.11	0.08
F - Speed up factor used for modeling (average plus one s.d.)	1.42	1.36	1.35	1.35	1.36	1.38	1.40	1.34	1.33	1.35	1.32	1.31
G - Wind speed calculated at 139 m at Watten (C * F)	1.94	3.72	5.54	7.38	9.30	11.32	13.40	14.66	16.37	18.46	19.85	21.49
H - Wind speed calculated at 139 m at Watten and standardised to 10 m (using G and formula ii)	1.30	2.48	3.70	4.93	6.21	7.56	8.95	9.79	10.93	12.33	13.26	14.36





Interpolation of data

	Day 1	2	3	4	5	6	7	8	9	10	11	12	Night 1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 139 m at Watten and standardised to 10 m (interpolated to integer values)	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
J - Background noise level to be used for Watten	#N/A	22.6	23.3	24.6	26.5	28.5	31.0	33.5	36.0	38.5	41.1	43.1	#N/A	21.3	21.7	22.2	23.0	24.2	25.8	27.8	30.2	34.5	38.0	40.6

Wind shear adjustments for Watten Wind Farm
22/06/2023

Introduction
This spreadsheet uses speed up factors as calculated by Natural Power to adjust background noise levels as measured for Halsary Windfarm

Input Data

Halsary Windfarm Hub Height	70	m
Watten Wind Farm Hub Height	139	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	2	
NML Name	Croft At Mybster	

Formulas used in this sheet

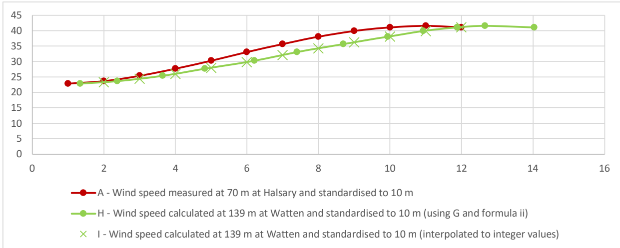
i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

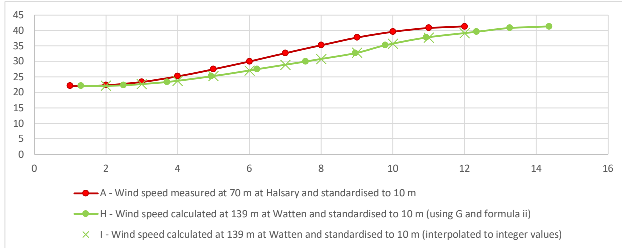
Day-time

A - Wind speed measured at 70 m at Halsary and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from Halsary assessment)	22.9	23.7	25.4	27.7	30.3	33.1	35.7	38.1	39.9	41.1	41.6	41.1
C - Wind speed calculated at 70 m at mast (using A and formula i)	1.37	2.73	4.10	5.47	6.84	8.20	9.57	10.94	12.31	13.67	15.04	16.41
D - Average speed up factor (between 70 m at Halsary and 139 at Watten)	1.16	1.18	1.22	1.23	1.24	1.24	1.24	1.22	1.21	1.18	1.16	1.17
E - One standard deviation (s.d.) of the speed up factor	0.29	0.11	0.12	0.09	0.12	0.11	0.12	0.14	0.12	0.12	0.10	0.11
F - Speed up factor used for modeling (average plus one s.d.)	1.46	1.30	1.33	1.32	1.36	1.35	1.36	1.36	1.33	1.30	1.26	1.28
G - Wind speed calculated at 139 m at Watten (C * F)	2.00	3.55	5.46	7.22	9.30	11.07	13.02	14.88	16.37	17.77	18.95	21.00
H - Wind speed calculated at 139 m at Watten and standardised to 10 m (using G and formula ii)	1.33	2.38	3.64	4.82	6.21	7.40	8.70	9.94	10.93	11.88	12.66	14.03

Night-time

A - Wind speed measured at 70 m at Halsary and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from Halsary assessment)	22.1	22.3	23.4	25.2	27.5	30	32.7	35.3	37.7	39.6	40.8	41.3
C - Wind speed calculated at 70 m at mast (using A and formula i)	1.37	2.73	4.10	5.47	6.84	8.20	9.57	10.94	12.31	13.67	15.04	16.41
D - Average speed up factor (between 70 m at Halsary and 139 at Watten)	1.18	1.20	1.22	1.24	1.25	1.26	1.27	1.23	1.22	1.24	1.21	1.22
E - One standard deviation (s.d.) of the speed up factor	0.25	0.16	0.13	0.11	0.11	0.12	0.14	0.11	0.11	0.12	0.11	0.08
F - Speed up factor used for modeling (average plus one s.d.)	1.42	1.36	1.35	1.35	1.36	1.38	1.40	1.34	1.33	1.35	1.32	1.31
G - Wind speed calculated at 139 m at Watten (C * F)	1.94	3.72	5.54	7.38	9.30	11.32	13.40	14.66	16.37	18.46	19.85	21.49
H - Wind speed calculated at 139 m at Watten and standardised to 10 m (using G and formula ii)	1.30	2.48	3.70	4.93	6.21	7.56	8.95	9.79	10.93	12.33	13.26	14.36





Interpolation of data

	Day-time												Night-time											
I - Wind speed calculated at 139 m at Watten and standardised to 10 m (interpolated to integer values)	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
J - Background noise level to be used for Watten	#N/A	23.4	24.5	26.1	28.0	29.9	32.2	34.3	36.3	38.2	40.0	41.2	#N/A	22.2	22.8	23.8	25.3	27.1	29.0	30.8	32.8	35.7	37.8	39.1

Wind shear adjustments for Watten Wind Farm
22/06/2023

Introduction
This spreadsheet uses speed up factors as calculated by Natural Power to adjust background noise levels as measured for Halsary Windfarm

Input Data

Halsary Windfarm Hub Height	70	m
Watten Wind Farm Hub Height	139	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	3	
NML Name	Knockglass	

Formulas used in this sheet

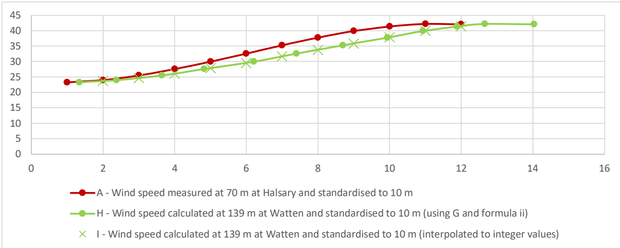
i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

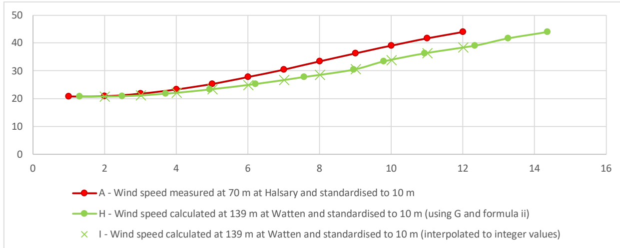
Day-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 70 m at Halsary and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from Halsary assessment)	23.3	24	25.5	27.6	30	32.6	35.3	37.8	39.9	41.4	42.2	42.1
C - Wind speed calculated at 70 m at mast (using A and formula i)	1.37	2.73	4.10	5.47	6.84	8.20	9.57	10.94	12.31	13.67	15.04	16.41
D - Average speed up factor (between 70 m at Halsary and 139 at Watten)	1.16	1.18	1.22	1.23	1.24	1.24	1.24	1.22	1.21	1.18	1.16	1.17
E - One standard deviation (s.d.) of the speed up factor	0.29	0.11	0.12	0.09	0.12	0.11	0.12	0.14	0.12	0.12	0.10	0.11
F - Speed up factor used for modeling (average plus one s.d.)	1.46	1.30	1.33	1.32	1.36	1.35	1.36	1.36	1.33	1.30	1.26	1.28
G - Wind speed calculated at 139 m at Watten (C * F)	2.00	3.55	5.46	7.22	9.30	11.07	13.02	14.88	16.37	17.77	18.95	21.00
H - Wind speed calculated at 139 m at Watten and standardised to 10 m (using G and formula ii)	1.33	2.38	3.64	4.82	6.21	7.40	8.70	9.94	10.93	11.88	12.66	14.03

Night-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 70 m at Halsary and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from Halsary assessment)	20.8	20.9	21.8	23.3	25.3	27.8	30.5	33.4	36.3	39.1	41.7	44
C - Wind speed calculated at 70 m at mast (using A and formula i)	1.37	2.73	4.10	5.47	6.84	8.20	9.57	10.94	12.31	13.67	15.04	16.41
D - Average speed up factor (between 70 m at Halsary and 139 at Watten)	1.18	1.20	1.22	1.24	1.25	1.26	1.27	1.23	1.22	1.24	1.21	1.22
E - One standard deviation (s.d.) of the speed up factor	0.25	0.16	0.13	0.11	0.11	0.12	0.14	0.11	0.11	0.12	0.11	0.08
F - Speed up factor used for modeling (average plus one s.d.)	1.42	1.36	1.35	1.35	1.36	1.38	1.40	1.34	1.33	1.35	1.32	1.31
G - Wind speed calculated at 139 m at Watten (C * F)	1.94	3.72	5.54	7.38	9.30	11.32	13.40	14.66	16.37	18.46	19.85	21.49
H - Wind speed calculated at 139 m at Watten and standardised to 10 m (using G and formula ii)	1.30	2.48	3.70	4.93	6.21	7.56	8.95	9.79	10.93	12.33	13.26	14.36





Interpolation of data

Day-time

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 139 m at Watten and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for Watten	#N/A	23.7	24.7	26.1	27.9	29.6	31.7	33.9	35.9	37.9	40.0	41.5

Night-time

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 139 m at Watten and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for Watten	#N/A	20.9	21.3	22.2	23.4	25.0	26.8	28.6	30.7	33.9	36.4	38.4

Watten Wind Farm

Wind analysis for noise assessment

EDF Energy Renewables UK

22 June 2023 1321213/B

Document history

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Issue	Date	Revision Details
A	30/05/2023	First release
B	22/06/2023	Update to include revised time interval limits

Contents

1. Summary

This technical memo details the method applied to derive tables of reference wind speeds at the Halsary Wind Farm and proposed Watten Wind Farm for noise assessments to be carried out to support the EIA submission for the proposed Watten Wind Farm. The purpose of the assessment is to provide estimates of the average hub height free (i.e. non waked) wind speeds at the Halsary site and Watten site. This data has then been related to the equivalent 10m above ground level (AGL) wind speed at the Halsary site using a log law shear profile (z_0=0.05) applied to the Halsary mean free wind speeds averaged across all turbines. The assessment has been carried out for two proposed hub heights at Watten, 119m AGL and 139m AGL.

The work is based on a wind data collected from an off-site 80m tall met mast and supported with data collected from a lidar remote sensing device close to the Watten turbine locations, as given in Table 1.1 below.

Table 1.1: Dataset summary

Anemometry Device	Location (British National Grid)	Base Elevation ASL (m)	Top Measurement Height (m)	Period of Record
Toftingall 80m mast	317971, 952488	94	80.65	02/11/2018 – 02/11/2019
Watten lidar (ZX-Lidar ZX300)	319879, 951960	79	140	24/01/2019 – 06/05/2019

The use of the time series based approach is considered appropriate due to the typical shear variations in wind conditions during daytime and night time hours and alignment with the ETSU time intervals relating to noise limits.

ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms'* states that separate noise limits apply for daytime and for night time. The daytime noise limit reflects data collected during the so-called 'quiet periods of the day', which comprise weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00). The data has been filtered to consider the quiet daytime periods as defined by ETSU-R-97 and these values have been applied to represent the daytime period 07:00 – 23:00.

1.1. Process

The following process has been utilised with the data sets mentioned above:

- Mast and lidar data have been quality controlled through standard processes as used in finance grade energy yield analysis work[1].
- A de-waking process has been carried out on the mast and lidar datasets to remove the wake effects from existing operational wind farms to create a time series of wake free conditions, representative of the ambient wind conditions with no turbines present.
- The lidar data set has been extended to cover the same period as the mast through a measure correlate predict process with the data binned on a time-of-day basis.

Details of the individual wind farm analyses follows:

Halsary Wind Farm

- The 80m Toftingall mast dataset was sheared on a per timestep basis to the 70 m hub height of the operational Halsary turbines.

[1] Watten Wind Farm: Wind Resource Assessment, Natural Power Report 1304918/A, 03 February 2023.

- The WASP wind spatial model has been applied to model from the Toftingall mast location to all of the Halsary turbines at a hub height of 70m to give a synthetic time series of hub height wind speeds at the Halsary turbines. The wake free wind speeds averaged across all Halsary turbines has been extracted from this data series.
- A log law wind shear profile has been applied to the Halsary hub height free wind speed using a roughness length of 0.05m to shear the Halsary mean wind speed to 10m AGL to create the reference 10m AGL wind speeds against which the Halsary and Watten speeds are referenced.

Watten Wind Farm

- The Watten lidar dataset has been sheared on a per timestep basis to the hub height of the proposed Watten turbines (119 m and 139 m AGL). This ensures the temporal variations in shear are conserved, thus ensuring the wind conditions for time intervals required for the analysis are most accurately captured. Due to the generally simple nature of the site, the dominant factor in the speed ups between Watten and Halsary is the difference in hub height of the two sites driven by shear variations that show large differences across the hours of the day, primarily due to atmospheric stability. Figure 1.1 illustrates the differences in shear at the Watten lidar for different periods of the day, showing that the highest shear conditions occur during the evening period (1800-2300) and are very similar to the night period (2300-0700), with day-time shear lower than both night time and evening shear.

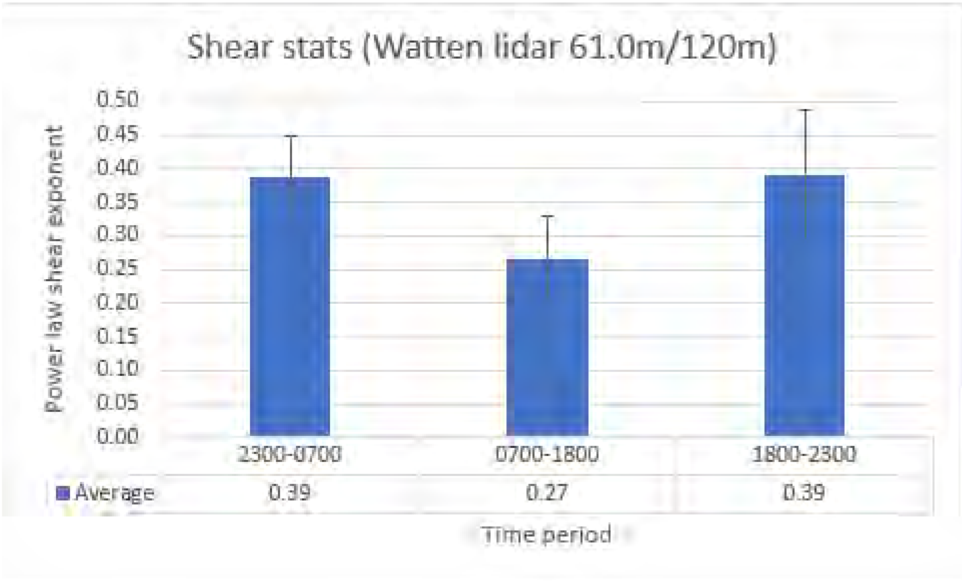

Figure 1.1: Lidar shear

- The WASP wind spatial model has been applied to model from the lidar location to all of the proposed Watten turbines at a hub height of 119 m/ 139 m to give a synthetic time series of hub height wind speeds at the Watten turbines. The wake free wind speeds averaged across all Watten turbines has been extracted from this data series.

1.2. Data Analysis and Results

The time series data from the processes above have been combined in to one time series before splitting into quiet periods of the day [weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00)] and night (2300-0700) conditions. The quiet day/night times series have then been split into 1m/s wide wind speed bins based on the Halsary 10m AGL wind speed and the average of each time series extracted with reference to the 10m speed bin. As a measure of the uncertainty of the approach the standard deviation of the binned wind speed time series has also been provided.

Table 1.2 below presents the results of this approach and the speed up factors between Halsary at 10 m and Watten at 119 m, and Table 1.3 presents the speed up factors Watten at 139 m AGL.

Table 1.2: Speed up factors between Halsary and Watten at 119 m

Watten Wind Farm at 119 m AGL															
Quiet day-time (weekdays 1800-2300, Saturday 1300-2300, Sunday 0700-2300)															
Wind speed measured at 70 m at HWF and standardised to 10 m bin floor (m/s)	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5
Wind speed measured at 70 m at HWF and standardised to 10 m bin lid (m/s)	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5
Wind speed measured at 70 m at HWF and standardised to 10 m (m/s)	1.1	2.0	3.0	4.0	5.0	6.0	7.0	7.9	9.0	10.0	10.9	12.0	12.9	14.0	14.9
Wind speed calculated at 70 m at HWF (m/s)	1.5	2.8	4.1	5.5	6.8	8.2	9.5	10.9	12.3	13.6	14.9	16.4	17.7	19.2	20.3
Wind speed calculated at 119m at WWF (m/s)	1.6	3.1	4.8	6.4	8.1	9.7	11.3	12.7	14.2	15.5	16.5	18.3	19.4	22.2	23.8
Std dev of speed up @ 119m at WWF	0.28	0.11	0.11	0.09	0.11	0.10	0.11	0.13	0.12	0.11	0.09	0.10	0.07	0.07	0.08
Average speed up factor (between 70 m at HWF and 119 m at WWF)	1.11	1.13	1.16	1.17	1.19	1.19	1.19	1.17	1.16	1.13	1.11	1.12	1.10	1.15	n/a
Average speed up factor (between 70 m at HWF and 119 m at WWF) +1SD	1.39	1.24	1.27	1.26	1.30	1.29	1.30	1.30	1.28	1.24	1.20	1.22	1.17	1.22	n/a
Night-time (2300-0700)															
Wind speed measured at 70 m at HWF and standardised to 10 m bin floor (m/s)	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5
Wind speed measured at 70 m at HWF and standardised to 10 m bin lid (m/s)	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5
Wind speed measured at 70 m at HWF and standardised to 10 m (m/s)	1.1	2.0	3.1	4.0	5.0	6.0	7.0	8.0	8.9	10.0	10.9	11.9	13.0	13.8	n/a
Wind speed calculated at 70 m at HWF (m/s)	1.5	2.8	4.2	5.5	6.8	8.2	9.5	10.9	12.2	13.6	14.9	16.2	17.8	18.9	n/a
Wind speed calculated at 119m at WWF (m/s)	1.6	3.2	4.9	6.5	8.1	9.8	11.5	12.8	14.2	16.1	17.2	19.0	20.8	21.2	n/a
Std dev of speed up @ 119m at WWF	0.24	0.15	0.12	0.11	0.11	0.12	0.13	0.10	0.11	0.11	0.11	0.08	0.08	0.07	n/a

Watten Wind Farm at 119 m AGL															
Average speed up factor (between 70 m at HWF and 119 m at WWF)	1.12	1.14	1.16	1.18	1.19	1.20	1.21	1.17	1.16	1.18	1.15	1.17	1.17	1.12	n/a
Average speed up factor (between 70 m at HWF and 119 m at WWF) +1SD	1.36	1.30	1.29	1.29	1.30	1.32	1.34	1.28	1.27	1.29	1.26	1.25	1.25	1.19	n/a

Table 1.3: Speed up factors between Halsary and Watten at 139 m

Watten Wind Farm at 139 m AGL															
Quiet day-time (weekdays 1800-2300, Saturday 1300-2300, Sunday 0700-2300)															
Wind speed measured at 70 m at HWF and standardised to 10 m bin floor (m/s)	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5
Wind speed measured at 70 m at HWF and standardised to 10 m bin lid (m/s)	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5
Wind speed measured at 70 m at HWF and standardised to 10 m (m/s)	1.1	2.0	3.0	4.0	5.0	6.0	7.0	7.9	9.0	10.0	10.9	12.0	12.9	14.0	14.9
Wind speed calculated at 70 m at HWF (m/s)	1.5	2.8	4.1	5.5	6.8	8.2	9.5	10.9	12.3	13.6	14.9	16.4	17.7	19.2	20.3
Wind speed calculated at 139m at WWF (m/s)	1.7	3.3	5.0	6.7	8.5	10.2	11.8	13.2	14.8	16.1	17.3	19.2	20.3	23.2	24.9
Std dev of speed up @ 139m at WWF	0.29	0.11	0.12	0.09	0.12	0.11	0.12	0.14	0.12	0.12	0.10	0.11	0.08	0.08	0.08
Average speed up factor (between 70 m at HWF and 139 m at WWF)	1.16	1.18	1.22	1.23	1.24	1.24	1.24	1.22	1.21	1.18	1.16	1.17	1.15	1.21	n/a
Average speed up factor (between 70 m at HWF and 139 m at WWF)+1SD	1.46	1.30	1.33	1.32	1.36	1.35	1.36	1.36	1.33	1.30	1.26	1.28	1.22	1.29	n/a
Night-time (2300-0700)															
Wind speed measured at 70 m at HWF and standardised to 10 m bin floor (m/s)	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5
Wind speed measured at 70 m at HWF and standardised to 10 m bin lid (m/s)	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5

Watten Wind Farm at 139 m AGL														
Wind speed measured at 70 m at HWF and standardised to 10 m (m/s)	1.1	2.0	3.1	4.0	5.0	6.0	7.0	8.0	8.9	10.0	10.9	11.9	13.0	13.8	n/a
Wind speed calculated at 70 m at HWF (m/s)	1.5	2.8	4.2	5.5	6.8	8.2	9.5	10.9	12.2	13.6	14.9	16.2	17.8	18.9	n/a
Wind speed calculated at 139m at WWF (m/s)	1.7	3.4	5.1	6.8	8.5	10.3	12.1	13.4	14.9	16.8	18.0	19.9	21.8	22.2	n/a
Std dev of speed up @ 139m at WWF	0.25	0.16	0.13	0.11	0.11	0.12	0.14	0.11	0.11	0.12	0.11	0.08	0.08	0.08	n/a
Average speed up factor (between 70 m at HWF and 139 m at WWF)	1.18	1.20	1.22	1.24	1.25	1.26	1.27	1.23	1.22	1.24	1.21	1.22	1.23	1.18	n/a
Average speed up factor (between 70 m at HWF and 139 m at WWF)+1SD	1.42	1.36	1.35	1.35	1.36	1.38	1.40	1.34	1.33	1.35	1.32	1.31	1.31	1.25	n/a

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Annex 5 – Topographical Corrections/ Turbine Coordinates

Table 1: Topographical (concave ground/ barrier) Noise Prediction Adjustment Table

Notes/Comments

Requirement to include a concave ground profile correction of +3dB has been calculated in accordance with section 4.3.9 of the IOA GPG (July 2011)

A barrier correction of -2dB is included where the landform completely obscures a turbine at the noise assessment location

Where analysis indicates that both are required the barrier correction take precedence and a correction of -2dB is applied

			Noise Senstive Receptor											
Wind Farm	**Hub**	**T ID**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Achlachan	64.8	1	0	-2	-2	-2	-2	-2	0	0	0	0	0	0
Achlachan	64.8	2	0	-2	-2	-2	-2	-2	0	0	0	0	0	0
Achlachan	64.8	3	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Achlachan	64.8	4	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Achlachan	64.8	5	0	-2	-2	-2	-2	-2	0	0	0	0	0	0
Achlachan 2	65	6	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Achlachan 2	65	7	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Achlachan 2	65	8	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	9	0	0	-2	0	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	10	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	11	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	12	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	13	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	14	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	15	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	16	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	17	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	18	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	19	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	20	0	0	-2	-2	-2	0	0	0	0	0	0	0
Bad a Cheo Wind Farm	60	21	0	0	-2	0	-2	0	0	0	0	0	0	0
Bilbster Wind Farm	60	22	0	0	0	0	3	3	-2	-2	3	3	3	3
Bilbster Wind Farm	60	23	0	0	0	0	3	3	-2	-2	3	3	3	3
Bilbster Wind Farm	60	24	0	0	0	0	3	3	-2	-2	3	3	3	3
Camster II Wind Farm	68	25	0	0	0	0	0	3	0	-2	3	3	3	3
Camster II Wind Farm	68	26	0	0	0	0	0	3	0	0	3	3	3	3
Camster II Wind Farm	68	27	0	0	0	0	0	3	0	0	3	3	3	3
Camster II Wind Farm	68	28	0	0	0	0	0	3	3	3	3	3	3	3
Camster II Wind Farm	68	29	0	0	0	0	0	0	0	0	0	0	3	0
Camster II Wind Farm	68	30	-2	0	0	0	0	0	0	0	0	0	3	0
Camster II Wind Farm	68	31	-2	0	0	0	0	0	0	0	0	0	0	0
Camster II Wind Farm	68	32	0	0	0	0	3	3	3	3	3	3	3	3
Camster Wind Farm	80	33	0	0	0	0	0	0	3	0	3	3	3	3
Camster Wind Farm	80	34	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	35	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	36	0	0	0	0	0	3	3	3	3	3	3	3
Camster Wind Farm	80	37	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	38	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	39	0	0	0	0	0	3	3	0	3	3	3	3
Camster Wind Farm	80	40	-2	0	-2	0	0	0	0	0	0	0	3	0
Camster Wind Farm	80	41	0	0	-2	0	0	0	0	0	0	3	3	0
Camster Wind Farm	80	42	0	0	0	0	0	0	3	0	0	3	3	0
Camster Wind Farm	80	43	0	0	0	0	0	3	3	3	3	3	3	3
Camster Wind Farm	80	44	-2	0	-2	0	0	0	0	0	0	3	3	0
Camster Wind Farm	80	45	-2	0	-2	0	0	0	0	0	0	3	3	0
Camster Wind Farm	80	46	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	47	-2	0	-2	0	0	0	0	0	0	0	3	0
Camster Wind Farm	80	48	0	0	0	0	0	3	3	0	3	3	3	3
Camster Wind Farm	80	49	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	50	0	0	-2	0	0	0	0	0	0	3	3	0
Camster Wind Farm	80	51	-2	0	-2	0	0	0	0	0	0	0	3	0
Camster Wind Farm	80	52	-2	0	-2	0	0	0	3	0	3	3	3	3
Camster Wind Farm	80	53	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	54	-2	0	-2	0	0	0	0	0	0	0	0	0
Camster Wind Farm	80	55	-2	0	-2	0	0	0	0	0	0	0	3	0
Camster Wind Farm	80	56	-2	0	-2	0	0	0	3	0	0	3	3	3
Camster Wind Farm	80	57	-2	0	-2	0	0	0	0	0	0	0	0	0
Causeymire Wind Farm	60	58	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	59	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	60	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	61	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	62	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	63	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	64	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	65	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	66	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	67	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	68	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	69	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	70	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	71	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	72	0	0	-2	-2	-2	0	0	0	0	0	0	0
Causeymire Wind Farm	60	73	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	74	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	75	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	76	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	77	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Causeymire Wind Farm	60	78	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Cogle Moss	64	79	0	0	0	0	0	3	0	-2	3	-2	-2	0
Cogle Moss	64	80	0	0	0	0	0	3	0	-2	3	-2	-2	0
Cogle Moss	64	81	0	3	0	0	3	3	0	-2	3	0	-2	0
Cogle Moss	64	82	0	3	0	0	0	3	3	-2	3	0	-2	0
Cogle Moss	64	83	0	3	0	0	0	3	0	-2	3	-2	-2	0
Cogle Moss	64	84	0	0	0	0	0	3	0	-2	3	-2	-2	0
Cogle Moss	64	85	0	3	0	0	3	3	3	-2	3	0	-2	0
Cogle Moss	64	86	0	3	0	0	0	3	3	-2	3	0	-2	0
Cogle Moss	64	87	0	3	0	0	0	3	3	-2	3	0	-2	0
Cogle Moss	64	88	0	3	0	0	0	3	0	-2	3	0	-2	0
Cogle Moss	64	89	0	0	0	0	0	3	-2	-2	3	-2	-2	0
Cogle Moss	64	90	0	0	0	0	0	3	-2	-2	3	-2	-2	0
Halsary Wind Farm	70	91	0	0	0	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	92	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	93	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	94	0	0	0	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	95	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	96	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	97	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	98	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	99	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	100	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	101	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	102	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	103	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	104	0	0	-2	0	0	0	0	0	0	0	0	0
Halsary Wind Farm	70	105	0	0	-2	0	0	0	0	0	0	0	0	0
Tacher A	72.4	106	0	0	-2	-2	-2	0	0	0	0	0	0	0
Tacher B	72.4	107	0	0	-2	-2	-2	0	0	0	0	0	0	0
Tacher C	72.4	108	0	0	-2	-2	-2	0	0	0	0	0	0	0
Tormsdale Wind Farm	82	109	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	110	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	111	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	112	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	113	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	114	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	115	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	116	0	0	-2	-2	-2	0	0	0	0	0	0	0
Tormsdale Wind Farm	82	117	0	0	-2	-2	-2	0	0	0	0	0	0	0
Tormsdale Wind Farm	82	118	0	0	-2	-2	-2	0	0	0	0	0	0	0
Tormsdale Wind Farm	82	119	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Tormsdale Wind Farm	82	120	0	0	-2	-2	-2	-2	0	0	0	0	0	0
Wathegar	59	121	0	0	0	0	3	3	-2	-2	3	3	3	3
Wathegar	59	122	0	0	0	0	3	3	3	-2	3	3	3	3
Wathegar	59	123	0	0	0	0	3	3	3	-2	3	3	3	3
Wathegar	59	124	0	0	0	0	3	3	-2	-2	3	3	3	3
Wathegar	59	125	0	0	0	0	3	3	-2	-2	3	3	3	3
Wathegar 2	68.5	126	0	0	0	0	0	3	-2	-2	3	0	3	0
Wathegar 2	68.5	127	0	0	0	0	0	3	0	-2	3	0	3	3
Harpsdale Mains Halkirk	18.3	128	0	0	0	0	0	0	0	0	0	0	0	0
Myrelandhorn	15	129	0	0	0	0	0	0	0	0	0	0	0	0
West Watten	15.4	130	0	0	0	0	0	0	0	0	0	0	0	0
Watten Wind Farm	139	131	0	0	0	0	0	0	0	0	0	0	0	0
Watten Wind Farm	139	132	0	0	0	0	0	0	0	0	0	0	0	0
Watten Wind Farm	139	133	0	0	0	0	0	0	0	0	0	0	0	0
Watten Wind Farm	139	134	0	0	0	0	0	0	0	0	0	0	0	0
Watten Wind Farm	139	135	0	0	0	0	0	0	0	0	0	0	0	0
Watten Wind Farm	139	136	0	0	0	0	0	0	0	0	0	0	0	0
Watten Wind Farm	139	137	0	0	0	0	0	0	0	0	0	0	0	0

Table 2: Wind Farms/ Turbines Modelled

Wind Farm	Easting	Northing	Height	Hub Height Modelled
Achlachan	314827	952039	68	65
Achlachan	315223	952151	72	65
Achlachan	315462	951822	70	65
Achlachan	315134	951688	70	65
Achlachan	314760	951688	66	65
Achlachan 2	315715	951422	73	65
Achlachan 2	315293	951239	72	65
Achlachan 2	314878	951280	68	65
Bad a Cheo Wind Farm	317309	949546	72	60
Bad a Cheo Wind Farm	317151	948594	89	60
Bad a Cheo Wind Farm	316849	948401	79	60
Bad a Cheo Wind Farm	317136	948082	83	60
Bad a Cheo Wind Farm	316744	947981	80	60
Bad a Cheo Wind Farm	317044	947669	80	60
Bad a Cheo Wind Farm	316708	947523	84	60
Bad a Cheo Wind Farm	316951	949335	86	60
Bad a Cheo Wind Farm	316593	949621	83	60
Bad a Cheo Wind Farm	317001	949821	77	60
Bad a Cheo Wind Farm	316529	950014	90	60
Bad a Cheo Wind Farm	316912	948924	90	60
Bad a Cheo Wind Farm	317274	949043	89	60
Bilbster Wind Farm	327307	951666	86	60
Bilbster Wind Farm	327009	951785	90	60
Bilbster Wind Farm	327606	951547	90	60
Camster II Wind Farm	328391	949821	85	68
Camster II Wind Farm	327902	949530	78	68
Camster II Wind Farm	327426	949139	89	68
Camster II Wind Farm	327070	948706	74	68
Camster II Wind Farm	327478	948288	82	68
Camster II Wind Farm	328235	947840	80	68
Camster II Wind Farm	327920	947497	89	68
Camster II Wind Farm	327489	949950	84	68
Camster Wind Farm	325172	948198	80	80
Camster Wind Farm	325405	946960	94	80
Camster Wind Farm	325754	947155	90	80
Camster Wind Farm	324642	948104	86	80
Camster Wind Farm	326413	947482	81	80
Camster Wind Farm	325894	947635	90	80
Camster Wind Farm	325429	948358	90	80
Camster Wind Farm	325160	947340	88	80
Camster Wind Farm	325316	947842	90	80
Camster Wind Farm	324903	947914	90	80
Camster Wind Farm	324810	948402	90	80
Camster Wind Farm	325982	946320	90	80

Camster Wind Farm	326287	946465	66	80
Camster Wind Farm	325461	947461	60	80
Camster Wind Farm	326614	946656	80	80
Camster Wind Farm	325291	948643	80	80
Camster Wind Farm	326388	947034	74	80
Camster Wind Farm	325640	948033	70	80
Camster Wind Farm	326835	946267	70	80
Camster Wind Farm	326260	946054	67	80
Camster Wind Farm	326140	947447	66	80
Camster Wind Farm	326066	946773	63	80
Camster Wind Farm	326114	947882	62	80
Camster Wind Farm	326509	946161	70	80
Camster Wind Farm	325658	946582	80	80
Causeymire Wind Farm	314787	950245	81	60
Causeymire Wind Farm	316338	950451	90	60
Causeymire Wind Farm	315656	950945	88	60
Causeymire Wind Farm	316033	950742	85	60
Causeymire Wind Farm	316321	950882	83	60
Causeymire Wind Farm	315161	950138	80	60
Causeymire Wind Farm	316006	948724	80	60
Causeymire Wind Farm	315890	949112	80	60
Causeymire Wind Farm	315494	949096	90	60
Causeymire Wind Farm	315407	950720	90	60
Causeymire Wind Farm	315556	950286	90	60
Causeymire Wind Farm	315725	950008	90	60
Causeymire Wind Farm	315794	950501	88	60
Causeymire Wind Farm	316626	950814	90	60
Causeymire Wind Farm	316675	950455	100	60
Causeymire Wind Farm	315761	949487	92	60
Causeymire Wind Farm	315382	949483	90	60
Causeymire Wind Farm	315067	949812	106	60
Causeymire Wind Farm	315432	949868	90	60
Causeymire Wind Farm	315115	950511	90	60
Causeymire Wind Farm	315652	948766	99	60
Cogle Moss	327662	955991	93	64
Cogle Moss	327287	955948	96	64
Cogle Moss	327431	956276	100	64
Cogle Moss	327782	956352	104	64
Cogle Moss	328159	956391	101	64
Cogle Moss	327996	956055	102	64
Cogle Moss	327942	956671	91	64
Cogle Moss	327553	956624	98	64
Cogle Moss	327701	956950	97	64
Cogle Moss	327127	956432	90	64
Cogle Moss	327506	955663	96	64
Cogle Moss	327828	955665	100	64
Halsary Wind Farm	318977	951369	110	70

Halsary Wind Farm	317939	951230	90	70
Halsary Wind Farm	318426	951062	92	70
Halsary Wind Farm	319096	951024	90	70
Halsary Wind Farm	317383	950977	107	70
Halsary Wind Farm	317759	950665	95	70
Halsary Wind Farm	318460	950649	56	70
Halsary Wind Farm	319048	950609	71	70
Halsary Wind Farm	317218	950518	74	70
Halsary Wind Farm	318009	950286	61	70
Halsary Wind Farm	318514	950184	64	70
Halsary Wind Farm	317523	950222	49	70
Halsary Wind Farm	317740	949884	49	70
Halsary Wind Farm	318137	949685	51	70
Halsary Wind Farm	318005	949297	59	70
Tacher A	317247	947409	56	72
Tacher B	317081	947087	57	72.4
Tacher C	317339	947679	65	72.4
Tormsdale Wind Farm	313842	950194	68	82
Tormsdale Wind Farm	314170	949747	69	82
Tormsdale Wind Farm	313433	950085	51	82
Tormsdale Wind Farm	313716	949746	56	82
Tormsdale Wind Farm	313849	949370	50	82
Tormsdale Wind Farm	314490	949001	75	82
Tormsdale Wind Farm	314718	948531	80	82
Tormsdale Wind Farm	315001	948210	84	82
Tormsdale Wind Farm	315274	947717	90	82
Tormsdale Wind Farm	315647	947513	74	82
Tormsdale Wind Farm	313283	949647	80	82
Tormsdale Wind Farm	313450	949309	80	82
Wathegar	327857	951256	81	59
Wathegar	327602	950766	85	59
Wathegar	327871	950452	87	59
Wathegar	328000	950840	84	59
Wathegar	327481	951120	54	59
Wathegar 2	328490	950691	54	68.5
Wathegar 2	328281	950344	54	68.5
Harpsdale Mains Halkirk	328000	950840	73	18.3
Myrelandhorn	324908	954919	70	15
West Watten	323140	954647	72	15.4
Watten Wind Farm	321106	952238	70	139
Watten Wind Farm	321504	951907	66	139
Watten Wind Farm	320867	950938	62	139
Watten Wind Farm	320510	951280	70	139
Watten Wind Farm	320401	951839	70	139
Watten Wind Farm	319828	951255	70	139
Watten Wind Farm	319938	950772	70	139

Annex 6 – Summary of Wind Turbine Noise Source Data

Noise data for the Vestas V162 6.8 MW turbine has not been included due to data confidentiality. Detailed noise data would be available upon request following the signing of the appropriate Non Disclosure Agreement

A copy of the noise data modelled for the other windfarms has been provided below.

Table A6.1: Sound Power Level Data

Wind Farm	Turbine	Hub height modelled (m)	Uncertainty Included	Reference Wind Speed (ms^{-1}) Standardised to 10m Height									
				3	4	5	6	7	8	9	10	11	12
Achlachan	Senvion MM92, standard blade	65	2	-	95.3	102.4	104.4	105.1	105.2	105.2	105.2	105.2	105.2
Causeymire	Bonus 2.3, standard blade	60	2	-	104.2	104.2	104.2	105.1	106.4	108.2	108.2	108.2	108.2
Halsary	Vestas V100, serrated blade	70	2	-	98.5	101.7	104.6	106.0	106.0	106.0	106.0	106.0	106.0
Bad a Cheo	Senvion MM92, standard blade	60	2	-	95.3	102.4	104.4	105.1	105.2	105.2	105.2	105.2	105.2
Camster	Vestas V80, standard blade	80	2	-	95.2	100.6	104.7	106.3	107.0	107.0	107.0	107.0	107.0
Bilbster	Nordex N60, standard blade	60	2	-	99.5	100.5	101.5	102.5	103.7	105.0	106.5	108.0	109.5
Wathegar	Senvion MM82, standard blade	59	2	90.9	96.1	101.7	105.6	106.0	106.0	106.0	106.0	106.0	106.0
Wathegar II	Senvion MM92, standard blade	68.5	2	-	95.3	102.4	104.4	105.1	105.2	105.2	105.2	105.2	105.2
Harpsdale Mains Halkirk	Gaia 133, standard blade	18.3	2	-	84.0	85.0	86.1	87.1	88.1	89.0	90.0	90.0	90.0
Myrelandhorn	Kingspan KW15, standard blade	15	2	75.7	79.6	83.4	87.2	91.0	94.8	98.6	102.4	106.2	110.0
West Watten	Xzeres ARE-442, standard blade	15.4	2	-	88.0	88.2	88.3	88.5	88.7	88.9	89.1	89.2	89.4
Tacher (A and B)	Vensys V115 Mode 0, standard blade	72.4	2	94.9	96.5	100.1	103.6	106.4	106.9	106.9	106.9	106.9	106.9
Tacher C	Vensys V115 Mode 0, standard blade	72.4	2	94.9	96.5	100.1	103.6	106.4	106.9	106.9	106.9	106.9	106.9
Cogle Moss	Enercon E70 OMII, standard blade	64	2	-	91.8	94.6	99.8	102.4	104.1	105.5	105.5	105.5	105.5
Achlachan 2	Senvion MM92, standard blade	65	2	-	95.3	102.4	104.4	105.1	105.2	105.2	105.2	105.2	105.2
Camster II	Vestas V117, Serrated Blade	68	2	94.3	97.3	101.8	105.8	108.4	108.8	108.8	108.8	108.8	108.8
Tormsdale	Vestas V136, Serrated Blade	82	2	93.4	96.5	101.2	105.1	105.9	105.9	105.9	105.9	105.9	105.9
Watten*	Vestas V162 6.8MW, Serrated Blade	139	-	-	-	-	-	-	-	-	-	-	-

* Sound power level data for the Vestas V162 6.8 MW with Serrated blades have not been presented due to confidentiality.

Table A6.2: Octave Band Data

Scheme	Turbine Modelled	Reference Wind Speed (m/s)	Octave Band (Hz)								
			63	125	250	500	1000	2000	4000	8000	Overall
Achlachan	Senvion MM92, standard blade	8.0	87.6	93.4	97.5	100.1	99.9	95.6	90.6	77.0	105.2
Causeymire	Bonus 2.3, standard blade	8.0	92.0	98.7	99.7	99.5	98.3	98.3	93.6	82.4	106.4
Halsary	Vestas V100, serrated blade	8.0	87.7	93.9	98.3	99.9	99.2	99.2	95.3	80.8	106.0
Bad a Cheo	Senvion MM92, standard blade	8.0	87.6	93.4	97.5	100.1	99.9	95.6	90.6	77.0	105.2
Camster	Vestas V80, standard blade	8.0	86.6	95.9	101.2	101.9	99.3	97.9	93.5	79.2	107.0
Bilbster	Nordex N60, standard blade	10.0	92.6	96.9	98.2	98.8	100.1	99.9	95.3	84.6	106.5
Wathegar	Senvion MM82, standard blade	8.0	88.2	94.2	98.4	100.9	100.6	96.4	91.5	78.3	106.0
Wathegar II	Senvion MM92, standard blade	8.0	87.6	93.4	97.5	100.1	99.9	95.6	90.6	77.0	105.2
Harpsdale Mains Halkirk	Gaia 133, standard blade	8.0	68.4	75.3	80.7	80.1	82.2	82.0	77.7	68.8	88.1
Myrelandhorn	Kingspan KW15, standard blade	8.0	69.7	75.9	84.4	89.1	90.5	87.1	82.6	75.2	94.8
West Watten*	Xzeres ARE-442, standard blade	8.0	-	-	88.7	-	-	-	-	-	88.7
Tacher (A and B)	Vensys V115 Mode 0, standard blade	9.0	88.8	94.3	99.0	100.2	101.0	100.9	93.1	75.3	106.9
Tacher C	Vensys V115 Mode 0, standard blade	9.0	88.8	94.3	99.0	100.2	101.0	100.9	93.1	75.3	106.9
Cogle Moss	Enercon E70 OMII, standard blade	10.0	89.4	98.0	100.5	99.1	97.6	94.3	87.4	79.8	105.5
Achlachan 2	Senvion MM92, standard blade	8.0	87.6	93.4	97.5	100.1	99.9	95.6	90.6	77.0	105.2
Camster II	Vestas V117, Serrated Blade	7.0	89.8	97.5	100.6	102.3	102.8	100.2	96.2	84.8	108.4
Tormsdale	Vestas V136, Serrated Blade	7.0	86.5	93.4	98.0	100.3	100.2	97.9	93.3	86.4	105.9
Watten**	Vestas V162 6.8MW, Serrated Blade	-	-	-	-	-	-	-	-	-	-

* No octave data available, assumed overall sound power level occurs at 250 Hz.

** Octave band data for the Vestas V162 7.2 MW with Serrated blades has been used as octave band data for the 6.8 MW turbine was not available. This data has not been presented due to confidentiality.

Annex 7 – Likely Noise Predictions

Likely Effects Calculations

Location		Wind Speed (ms^{-1}) as standardised to 10m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – 21-22 West Watten	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	26	27	31.9	35	35.4	35.8	35.9	35.9	35.9	36
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	28.2	30.6	31.7	32.1	32.5	32.7	32.7	32.7
	Difference	-	-	-	-	3.7	4.4	3.7	3.7	3.4	3.2	3.2	3.3
NAL2 – 18 West Watten	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	23.4	24.4	29.3	32.7	32.8	33.2	33.3	33.3	33.3	33.4
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	27.7	30	31.1	31.5	31.9	32.1	32.1	32.2
	Difference	-	-	-	-	1.6	2.7	1.7	1.7	1.4	1.2	1.2	1.2
NAL3 - 17 West Watten	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	17.1	18.1	23	26.4	26.5	26.9	27	27	27	27.1
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	25	27.6	28.8	29.5	30.1	30.5	31	31.4
	Difference	-	-	-	-	2	1.2	2.3	2.6	3.1	3.5	4	4.3
NAL4 - Banks Lodge	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	16.3	17.3	22.1	25.5	25.6	26.1	26.1	26.1	26.2	26.2
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	24.3	27.1	28.4	29.3	30	30.4	31.2	31.8
	Difference	-	-	-	-	2.2	1.6	2.8	3.2	3.9	4.3	5	5.6
NAL5 – 14 West Watten	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	18.6	19.5	24.4	27.8	27.9	28.3	28.4	28.4	28.5	28.5
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	25.3	27.8	29	29.6	30.1	30.4	30.8	31.1
	Difference	-	-	-	-	0.9	0	1.1	1.3	1.7	2	2.3	2.6
NAL6 - Newton	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	21.2	22.2	27.1	30.5	30.6	31	31.1	31.1	31.1	31.2
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	26.3	28.7	30	30.5	31	31.2	31.4	31.5
	Difference	-	-	-	-	-0.8	-1.8	-0.6	-0.5	-0.1	0.1	0.3	0.3
NAL7 - Lanergill	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	16.8	17.8	22.6	26	26.1	26.6	26.6	26.7	26.7	26.7
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	28.3	30.1	31.2	31.7	32.3	32.6	32.6	32.6
	Difference	-	-	-	-	5.7	4.1	5.1	5.1	5.7	5.9	5.9	5.9
NAL8 - Backlass Hill	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	22.5	23.5	28.4	31.8	31.9	32.3	32.3	32.4	32.4	32.4
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	28.4	30.3	31.4	31.8	32.3	32.6	32.6	32.6
	Difference	-	-	-	-	0	-1.5	-0.5	-0.5	0	0.2	0.2	0.2
NAL9 - Leanmore Lodge	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	24.7	25.7	30.5	33.9	34	34.5	34.5	34.5	34.6	34.6
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	28.4	30.5	31.6	32	32.5	32.7	32.8	32.8
	Difference	-	-	-	-	-2.1	-3.4	-2.4	-2.5	-2	-1.8	-1.8	-1.8
NAL10 – Achnamoine	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	15.6	16.6	21.4	24.8	24.9	25.4	25.4	25.4	25.5	25.5
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	30.9	32.6	33.6	34.1	34.8	35.1	35.1	35.1
	Difference	-	-	-	-	-9.5	-7.8	-8.7	-8.7	-9.4	-9.7	-9.6	-9.6
NAL11 - Knockglass House	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	15.9	16.9	21.8	25.2	25.3	25.7	25.8	25.8	25.8	25.9
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	33.1	34.8	35.8	36.2	36.9	37.2	37.2	37.2
	Difference	-	-	-	-	-11.3	-9.6	-10.5	-10.5	-11.1	-11.4	-11.4	-11.3
NAL12 - Mybster	Predicted Wind Turbine Noise L_{A90} Proposed Development	-	-	15.7	16.6	21.5	24.9	25	25.5	25.5	25.5	25.6	25.6
	Predicted Wind Turbine Noise L_{A90} Other Schemes	-	-	-	-	37.4	38.9	39.9	40.4	41.1	41.5	41.5	41.5
	Difference	-	-	-	-	-15.9	-14	-14.9	-14.9	-15.6	-16	-15.9	-15.9

Annex 8 – Total Noise Limit – 35dB

Table A8.1 - ETSU-R-97 Compliance Table – Likely Cumulative Noise - Daytime

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – 21-22 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	33.1	36.2	36.6	37.0	37.1	37.2	37.3	37.3
	Exceedance Level	-	-	-	-	-1.9	**1.2**	**0.6**	-1.5	-3.9	-6.3	-8.8	-10.8
NAL2 – 18 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.3	34.4	35.0	35.4	35.6	35.7	35.7	35.7
	Exceedance Level	-	-	-	-	-13.7	-10.6	-10.0	-9.6	-9.4	-9.3	-10.4	-12.4
NAL3 – 17 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	27.3	30.4	31.3	31.8	32.0	32.2	32.4	32.5
	Exceedance Level	-	-	-	-	-7.7	-4.6	-4.7	-6.7	-9.0	-11.3	-13.7	-15.6
NAL4 – Banks Lodge	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	26.8	29.8	30.8	31.2	31.5	31.7	31.9	32.1
	Exceedance Level	-	-	-	-	-8.2	-5.2	-5.2	-7.3	-9.5	-11.8	-14.2	-16.0
NAL5 – 14 West Watten	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	27.6	30.7	31.6	32.1	32.4	32.6	32.9	33.1
	Exceedance Level	-	-	-	-	-7.4	-4.3	-4.4	-6.4	-8.6	-10.9	-13.2	-15.0
NAL6 - Newton	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	29.5	32.7	33.4	33.9	34.1	34.3	34.4	34.4
	Exceedance Level	-	-	-	-	-5.5	-2.3	-2.6	-4.6	-6.9	-9.2	-11.7	-13.7

Location		Wind Speed (ms⁻¹) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Lanergill	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	29.3	31.5	32.4	32.9	33.4	33.6	33.6	33.7
	Exceedance Level	-	-	-	-	-5.7	-3.5	-3.6	-5.6	-7.6	-9.9	-12.5	-14.4
NAL8 – Backlass Hill	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.3	34.1	34.7	35.1	35.4	35.5	35.6	35.6
	Exceedance Level	-	-	-	-	-3.7	-0.9	-1.3	-3.4	-5.6	-8.0	-10.5	-12.5
NAL9 – Leanmore Lodge	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.0	38.5	41.0	43.5	46.1	48.1
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	32.7	35.7	36.2	36.6	36.8	36.9	37.0	37.0
	Exceedance Level	-	-	-	-	-2.3	**0.7**	**0.2**	-1.9	-4.2	-6.6	-9.1	-11.1
NAL10 - Achnamoine	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.7	38.9	40.9	42.9	45.0	46.5
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	31.4	33.4	34.3	34.7	35.3	35.6	35.6	35.6
	Exceedance Level	-	-	-	-	-3.6	-1.6	-2.4	-4.2	-5.6	-7.3	-9.4	-10.9
NAL11 – Knockglass House	Total Noise Limit: ETSU-R-97 L_{A90}	35.0	35.0	35.0	35.0	35.0	35.0	36.7	38.9	40.9	42.9	45.0	46.5
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	33.4	35.2	36.2	36.6	37.2	37.5	37.5	37.5
	Exceedance Level	-	-	-	-	-1.6	**0.2**	-0.5	-2.3	-3.7	-5.4	-7.5	-9.0

Table A8.2 Site Specific Noise Limits Compliance Table – Daytime

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – 21-22 West Watten	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	33.3	25.0	26.0	36.5	39.8	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	26.0	27.0	31.9	35.3	35.4	35.8	35.9	35.9	35.9	36.0
	Exceedance Level	-	-	-9.0	-8.0	-1.4	**10.3**	**9.4**	-0.7	-3.9	-7.6	-10.2	-12.1
NAL2 – 18 West Watten	Site Specific Noise Limit L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	23.4	24.4	29.3	32.7	32.8	33.2	33.3	33.3	33.3	33.4
	Exceedance Level	-	-	-21.6	-20.6	-15.7	-12.3	-12.2	-11.8	-11.7	-11.7	-12.8	-14.7
NAL3 – 17 West Watten	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	34.3	33.5	34.4	37.5	41.0	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	17.1	18.1	23.0	26.4	26.5	26.9	27.0	27.0	27.0	27.1
	Exceedance Level	-	-	-17.9	-16.9	-11.3	-7.1	-7.9	-10.6	-14.0	-16.5	-19.1	-21.0
NAL4 – Banks Lodge	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	35.0	33.7	34.5	37.5	41.0	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	16.3	17.3	22.1	25.5	25.6	26.1	26.1	26.1	26.2	26.2
	Exceedance Level	-	-	-18.7	-17.7	-12.9	-8.2	-8.9	-11.4	-14.9	-17.4	-19.9	-21.9
NAL5 – 14 West Watten	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	34.2	33.4	34.3	37.5	41.0	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	18.6	19.5	24.4	27.8	27.9	28.3	28.4	28.4	28.5	28.5
	Exceedance Level	-	-	-16.4	-15.5	-9.8	-5.6	-6.4	-9.2	-12.6	-15.1	-17.6	-19.6
NAL6 - Newton	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	34.0	33.0	33.7	37.2	40.2	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	21.2	22.2	27.1	30.5	30.6	31.0	31.1	31.1	31.1	31.2
	Exceedance Level	-	-	-13.8	-12.8	-6.9	-2.5	-3.1	-6.2	-9.1	-12.4	-15.0	-16.9

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Lanergill	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	33.2	25.0	26.0	36.7	39.9	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	16.8	17.8	22.6	26.0	26.1	26.6	26.6	26.7	26.7	26.7
	Exceedance Level	-	-	-18.2	-17.2	-10.6	**1.0**	**0.1**	-10.1	-13.3	-16.8	-19.4	-21.4
NAL8 – Backlass Hill	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	33.2	25.0	26.0	36.7	39.9	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	22.5	23.5	28.4	31.8	31.9	32.3	32.3	32.4	32.4	32.5
	Exceedance Level	-	-	-12.5	-11.5	-4.8	**6.8**	**5.9**	-4.4	-7.6	-11.1	-13.7	-15.6
NAL9 – Leanmore Lodge	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	33.2	25.0	26.0	36.6	39.8	43.5	46.1	48.1
	Predicted Wind Turbine Noise L_{A90}	-	-	24.9	25.9	30.8	34.2	34.3	34.7	34.8	34.8	34.8	34.9
	Exceedance Level	-	-	-10.1	-9.1	-2.4	**9.2**	**8.3**	-1.9	-5.0	-8.7	-11.3	-13.2
NAL10 - Achnamoine	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	25.0	25.0	26.7	28.9	38.8	41.6	44.2	46.5
	Predicted Wind Turbine Noise L_{A90}	-	-	15.6	16.6	21.4	24.8	24.9	25.4	25.4	25.4	25.5	25.5
	Exceedance Level	-	-	-19.4	-18.4	-3.6	-0.2	-1.8	-3.5	-13.4	-16.2	-18.7	-21.0
NAL11 – Knockglass House	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	25.0	25.0	26.7	28.9	30.9	40.5	43.7	45.6
	Predicted Wind Turbine Noise L_{A90}	-	-	15.9	16.9	21.8	25.2	25.3	25.7	25.8	25.8	25.8	25.9
	Exceedance Level	-	-	-19.1	-18.1	-3.2	**0.2**	-1.4	-3.2	-5.1	-14.7	-17.9	-19.7

Annex 9 – Suggested Noise Conditions

Noise

1) The rating level of noise immission from the combined effects of the wind turbines hereby permitted (including the application of any tonal penalty), when determined in accordance with the attached Guidance Notes, shall not exceed the values for the relevant integer wind speeds set out in or derived from Tables 1 and 2 attached to these conditions and:

   A) Prior to the First Export Date, the wind farm operator shall submit to the Local Authority for written approval a list of proposed independent consultants who may undertake compliance measurements in accordance with this condition. Amendments to the list of approved consultants shall be made only with the prior written approval of the Local Authority.

   B) Within 21 days from receipt of a written request of the Local Authority, following a complaint to it alleging noise disturbance at a dwelling, the wind farm operator shall, at its expense, employ an independent consultant approved by the Local Authority to assess the level of noise immission from the wind farm at the complainant's property (or a suitable alternative location agreed in writing with the Local Authority) in accordance with the procedures described in the attached Guidance Notes. The written request from the Local Authority shall set out at least the date, time and location that the complaint relates to. Within 14 days of receipt of the written request of the Local Authority made under this paragraph (B), the wind farm operator shall provide the information relevant to the complaint logged in accordance with paragraph (H) to the Local Authority in the format set out in Guidance Note 1(e).

   C) Where there is more than one property at a location specified in Tables 1 and 2 attached to this condition, the noise limits set for that location shall apply to all dwellings at that location. Where a dwelling to which a complaint is related is not identified by name or location in the Tables attached to these conditions, the wind farm operator shall submit to the Local Authority for written approval proposed noise limits selected from those listed in the Tables to be adopted at the complainant's dwelling for compliance checking purposes. The proposed noise limits are to be those limits selected from the Tables specified for a listed location which the independent consultant considers as being likely to experience the most similar background noise environment to that experienced at the complainant's dwelling. The submission of the proposed noise limits to the Local Authority shall include a written justification of the choice of the representative background noise environment provided by the independent consultant. The rating level of noise immission resulting from the combined effects of the wind turbines when determined in accordance with the attached Guidance Notes shall not exceed the noise limits approved in writing by the Local Authority for the complainant's dwelling.

   D) Prior to the commencement of any measurements by the independent consultant to be undertaken in accordance with these conditions, the wind farm operator shall submit to the Local Authority for written approval the proposed measurement location identified in accordance with the Guidance Notes where measurements for compliance checking purposes shall be undertaken. Where the proposed measurement location is close to the wind turbines, rather than at the complainants property (to improve the signal to noise ratio), then the operators submission shall include a method to calculate the noise level from the wind turbines at the complainants property based on the noise levels measured at the agreed location (the alternative method). Details of the alternative method together with any associated guidance notes deemed necessary, shall be submitted to and agreed in writing by the Local Authority prior to the commencement of any measurements. Measurements to assess compliance with the noise limits set out in the Tables attached to these conditions or approved by the Local

Authority pursuant to paragraph (C) of this condition shall be undertaken at the measurement location approved in writing by the Local Authority.

E) Prior to the submission of the independent consultant's assessment of the rating level of noise immission pursuant to paragraph (F) of this condition, the wind farm operator shall submit to the Local Authority for written approval a proposed assessment protocol setting out the following:

   i) the range of meteorological and operational conditions (the range of wind speeds, wind directions, power generation and times of day) to determine the assessment of rating level of noise immission.

   ii) a reasoned assessment as to whether the noise giving rise to the complaint contains or is likely to contain a tonal component.

   The proposed range of conditions shall be those which prevailed during times when the complainant alleges there was disturbance due to noise, having regard to the information provided in the written request of the Local Authority under paragraph (B), and such others as the independent consultant considers necessary to fully assess the noise at the complainant's property. The assessment of the rating level of noise immission shall be undertaken in accordance with the assessment protocol approved in writing by the Local Authority and the attached Guidance Notes.

F) The wind farm operator shall provide to the Local Authority the independent consultant's assessment of the rating level of noise immission undertaken in accordance with the Guidance Notes within 2 months of the date of the written request of the Local Authority made under paragraph (B) of this condition unless the time limit is extended in writing by the Local Authority. The assessment shall include all data collected for the purposes of undertaking the compliance measurements, such data to be provided in the format set out in Guidance Note 1(e) of the Guidance Notes. The instrumentation used to undertake the measurements shall be calibrated in accordance with Guidance Note 1(a) and certificates of calibration shall be submitted to the Local Authority with the independent consultant's assessment of the rating level of noise immission.

G) Where a further assessment of the rating level of noise immission from the wind farm is required pursuant to Guidance Note 4(c) of the attached Guidance Notes, the wind farm operator shall submit a copy of the further assessment within 21 days of submission of the independent consultant's assessment pursuant to paragraph (F) above unless the time limit for the submission of the further assessment has been extended in writing by the Local Authority.

H) The wind farm operator shall continuously log power production, wind speed and wind direction, all in accordance with Guidance Note 1(d) of the attached Guidance Notes. The data shall be retained for a period of not less than 24 months. The wind farm operator shall provide this information in the format set out in Guidance Note 1(e) of the attached Guidance Notes to the Local Authority on its request within 14 days of receipt in writing of such a request.

Note: For the purposes of this condition, a "dwelling" is a building within Use Classes 7, 8 and 9 of the Town and Country Planning (Use Classes) (Scotland) Order 1997 which lawfully exists or had planning permission at the date of this permission.

Table 1 - Between 07:00 and 23:00 - Noise level dB $L_{A90,\ 10\text{-minute}}$

Location (easting, northing grid coordinates)	Standardised wind speed at 10 metres height (m/s) within the site averaged over 10-minute periods											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	L_{A90} Decibel Levels											
21-22 West Watten (322129, 951069)	35	35	35	35	35	35	36	37	40	44	46	48
18 West Watten (322732, 951988)	45	45	45	45	45	45	45	45	45	45	46	48
17 West Watten (323726, 953001)	35	35	35	35	35	35	36	38	41	44	46	48
Banks Lodge (323596, 953668)	35	35	35	35	35	35	36	38	41	44	46	48
14 West Watten (322725, 953796)	35	35	35	35	35	35	36	38	41	44	46	48
Newton (321516, 953837)	35	35	35	35	35	35	36	37	40	44	46	48
Lanergill (319088, 954460)	35	35	35	35	35	35	36	37	40	44	46	48
Backlass Hill (320404, 953609)	35	35	35	35	35	35	36	37	40	44	46	48
Leanmore Lodge (320998, 953313)	35	35	35	35	35	35	36	37	40	44	46	48
Achnamoine (317790, 953867)	35	35	35	35	35	35	28	29	39	42	44	47
Knockglass House (317440, 953236)	35	35	35	35	28	28	28	29	31	41	44	46

Table 2 - Between 23:00 and 07:00 - Noise level dB $L_{A90,\ 10\text{-minute}}$

Location (easting, northing grid coordinates)	Standardised wind speed at 10 metres height (m/s) within the site averaged over 10-minute periods											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	L_{A90} Decibel Levels											
21-22 West Watten (322129, 951069)	43	43	43	43	43	43	43	43	43	43	43	46
18 West Watten (322732, 951988)	45	45	45	45	45	45	45	45	45	45	45	46
17 West Watten (323726, 953001)	43	43	43	43	43	43	43	43	43	43	43	46
Banks Lodge (323596, 953668)	43	43	43	43	43	43	43	43	43	43	43	46
14 West Watten (322725, 953796)	43	43	43	43	43	43	43	43	43	43	43	46
Newton (321516, 953837)	43	43	43	43	43	43	43	43	43	43	43	46
Lanergill (319088, 954460)	43	43	43	43	43	43	43	43	43	43	43	46
Backlass Hill (320404, 953609)	43	43	43	43	43	43	43	43	43	43	43	46

Location (easting, northing grid coordinates)	Standardised wind speed at 10 metres height (m/s) within the site averaged over 10-minute periods											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Leanmore Lodge (320998, 953313)	43	43	43	43	43	43	43	43	43	43	43	46
Achnamoine (317790, 953867)	43	43	43	43	43	43	42	42	42	42	42	42
Knockglass House (317440, 953236)	43	43	43	43	42	42	41	41	41	41	41	41

Note to Tables 1 & 2: The geographical coordinates references set out in these tables are provided for the purpose of identifying the general location of dwellings to which a given set of noise limits applies. The standardised wind speed at 10 metres height within the site refers to wind speed at 10 metres height derived from those measured at hub height, calculated in accordance with the method given in the Guidance Notes.

Guidance Notes for Noise Condition

These notes are to be read with and form part of the noise condition. They further explain the condition and specify the methods to be employed in the assessment of complaints about noise immission from the wind farm. The rating level at each integer wind speed is the arithmetic sum of the wind farm noise level as determined from the best-fit curve described in Note 2 of these Guidance Notes and any tonal penalty applied in accordance with Note 3 with any necessary correction for residual background noise levels in accordance with Note 4. Reference to ETSU-R-97 refers to the publication entitled "The Assessment and Rating of Noise from Wind Farms" (1997) published by the Energy Technology Support unit (ETSU) for the Department of Trade and Industry (DTI).

Note 1

(a) Values of the $L_{A90,10\text{-}minute}$ noise statistic should be measured at the complainant's property (or an approved alternative representative location as detailed in Note 1(b)), using a sound level meter of EN 60651/BS EN 60804 Type 1, or BS EN 61672 Class 1 quality (or the equivalent UK adopted standard in force at the time of the measurements) set to measure using the fast time weighted response as specified in BS EN 60651/BS EN 60804 or BS EN 61672-1 (or the equivalent UK adopted standard in force at the time of the measurements). This should be calibrated before and after each set of measurements, using a calibrator meeting BS EN 60945:2003 "Electroacoustics – sound calibrators" Class 1 with PTB Type Approval (or the equivalent UK adopted standard in force at the time of the measurements) and the results shall be recorded. Measurements shall be undertaken in such a manner to enable a tonal penalty to be calculated and applied in accordance with Guidance Note 3.

(b) The microphone shall be mounted at 1.2 - 1.5 metres above ground level, fitted with a two-layer windshield or suitable equivalent approved in writing by the Local Authority, and placed outside the complainant's dwelling. Measurements should be made in "free field" conditions. To achieve this, the microphone shall be placed at least 3.5 metres away from the building facade or any reflecting surface except the ground at the approved measurement location. In the event that the consent of the complainant for access to his or her property to undertake compliance measurements is withheld, the wind farm operator shall submit for the written approval of the Local Authority details of the proposed alternative representative measurement location prior to the commencement of measurements and the measurements shall be undertaken at the approved alternative representative measurement location.

(c) The $L_{A90,10\text{-}minute}$ measurements should be synchronised with measurements of the 10-minute arithmetic mean wind speed and wind direction data and with operational data logged in accordance with Guidance Note 1(d) and rain data logged in accordance with Note 1(f).

(d) To enable compliance with the conditions to be evaluated, the wind farm operator shall continuously log arithmetic mean wind speed in metres per second (m/s) and arithmetic mean wind direction in degrees from north in each successive 10-minutes period in a manner to be agreed in writing with the planning authority. Each 10 minute arithmetic average mean wind speed data as measured or calculated at turbine hub height shall be 'standardised' to a reference height of 10 metres as described in ETSU-R-97 at page 120 using a reference roughness length of 0.05 metres. It is this standardised 10 metre height wind speed data which is correlated with the noise measurements determined as valid in accordance with Note 2(b), such correlation to be undertaken in the manner described in Note 2(c). All 10-minute periods shall commence on the hour and in 10-minute increments thereafter synchronised with Greenwich Mean Time and adjusted to British Summer Time where necessary.

(e) Data provided to the Local Authority in accordance with paragraphs (E) (F) (G) and (H) of the noise condition shall be provided in comma separated values in electronic format with the exception of data collected to asses tonal noise (if required) which shall be provided in a format to be agreed in writing with the Local Authority.

(f) A data logging rain gauge shall be installed in the course of the independent consultant undertaking an assessment of the level of noise immission. The gauge shall record over successive 10-minute periods synchronised with the periods of data recorded in accordance with Note 1(d).

Note 2

(a) The noise measurements should be made so as to provide not less than 20 valid data points as defined in Note 2 paragraph (b).

(b) Valid data points are those measured during the conditions set out in the assessment protocol approved by the Local Authority under paragraph (E) of the noise condition but excluding any periods of rainfall measured in accordance with Note 1(f).

(c) Values of the $L_{A90,10\text{-minute}}$ noise measurements and corresponding values of the 10-minute standardised ten metre height wind speed for those data points considered valid in accordance with Note 2(b) shall be plotted on an XY chart with noise level on the Y-axis and wind speed on the X-axis. A least squares, "best fit" curve of an order deemed appropriate by the independent consultant (but which may not be higher than a fourth order) shall be fitted to the data points to define the wind farm noise level at each integer speed.

Note 3

(a) Where, in accordance with the approved assessment protocol under paragraph (E) of the noise condition, noise immission at the location or locations where compliance measurements are being undertaken contain or are likely to contain a tonal component, a tonal penalty shall be calculated and applied using the following rating procedure.

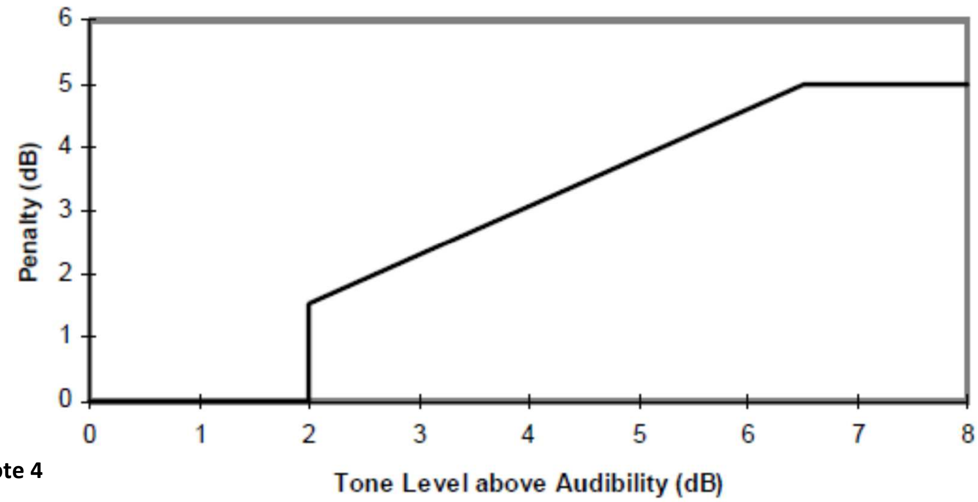
(b) For each 10-minute interval for which $L_{A90,10\text{-minute}}$ data have been determined as valid in accordance with Note 2, a tonal assessment shall be performed on noise immission during 2-minutes of each 10-minute period. The 2-minute periods should be spaced at 10-minute intervals provided that uninterrupted uncorrupted data are available ("the standard procedure"). Where uncorrupted data are not available, the first available uninterrupted clean 2-minute period out of the affected overall 10-minute period shall be selected. Any such deviations from the standard procedure shall be reported.

(c) For each of the 2-minute samples the tone level above audibility shall be calculated by comparison with the audibility criterion given in Section 2.1 on pages 104 -109 of ETSU-R-97.

(d) The tone level above audibility shall be plotted against wind speed for each of the 2-minute samples. Samples for which the tones were below the audibility criterion or no tone was identified, a value of zero audibility shall be substituted.

(e) A least squares "best fit" linear regression shall then be performed to establish the average tone level above audibility for each integer wind speed derived from the value of the "best fit" line fitted to values within ± 0.5m/s of each integer wind speed. If there is no apparent trend with wind speed then a simple arithmetic mean shall be used. This process shall be repeated for each integer wind speed for which there is an assessment of overall levels in Note 2.

(f) The tonal penalty is derived from the margin above audibility of the tone according to the figure below derived from the average tone level above audibility for each integer wind speed.



Note 4

(a) If a tonal penalty is to be applied in accordance with Note 3 the rating level of the turbine noise at each wind speed is the arithmetic sum of the measured noise level as determined from the best fit curve described in Note 2 and the penalty for tonal noise as derived in accordance with Note 3 at each integer wind speed within the range set out in the approved assessment protocol under paragraph (E) of the noise condition.

(b) If no tonal penalty is to be applied then the rating level of the turbine noise at each wind speed is equal to the measured noise level as determined from the best fit curve described in Note 2.

(c) If the rating level at any integer wind speed lies at or below the values set out in the Tables attached to the conditions or at or below the noise limits approved by the Local Authority for a complainant's dwelling in accordance with paragraph (C) of the noise condition then no further action is necessary. In the event that the rating level is above the limit(s) set out in the Tables attached to the noise conditions or the noise limits for a complainant's dwelling approved in accordance with paragraph (C) of the noise condition, the independent consultant shall undertake a further assessment of the rating level to correct for background noise so that the rating level relates to wind turbine noise immission only.

(d) The wind farm operator shall ensure that all the wind turbines in the development are turned off for such period as the independent consultant requires to undertake the further assessment. The further assessment shall be undertaken in accordance with the following steps:

i. Repeating the steps in Note 2, with the wind farm switched off, and determining the background noise (L_3) at each integer wind speed within the range set out in the approved noise assessment protocol under paragraph (E) of this condition.

ii. The wind farm noise (L_1) at this speed shall then be calculated as follows where L_2 is the measured level with turbines running but without the addition of any tonal penalty:

$$L_1 = 10\log\left[10^{L_2/10} - 10^{L_3/10}\right]$$

iii. The rating level shall be re-calculated by adding the tonal penalty (if any is applied in accordance with Note 3) to the derived wind farm noise L_1 at that integer wind speed.

iv. If the rating level after adjustment for background noise contribution and adjustment for tonal penalty (if required in accordance with note (iii) above) at any integer wind speed lies at or below the values set out in the Tables attached to the conditions or at or below the noise limits approved by the Local Authority for a complainant's dwelling in accordance with paragraph

(C) of the noise condition then no further action is necessary. If the rating level at any integer wind speed exceeds the values set out in the Tables attached to the conditions or the noise limits approved by the Local Authority for a complainant's dwelling in accordance with paragraph (C) of the noise condition then the development fails to comply with the conditions.

Watten Wind Farm

Shadow Flicker Summary Report

20 December 2022

1301455/C

Commercial in Confidence

EDF Energy Renewables Limited

Document history

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Issue	Date	Revision Details
A	15/11/2022	First release
B	24/11/2022	Minor typos amended. Shadow map update to new format. Error with projection of CRS in Windfarmer software corrected leading to marginally changed results. Conclusions unchanged.
C	20/12/2022	At request of the client, the analysis area was reduced to 10 RD. Minor changes to results. Conclusions unchanged.

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Contents

1. Introduction

The Natural Power Consultants Limited ("Natural Power") was commissioned by EDF Energy Renewables Limited (the "Client") to conduct an independent shadow flicker assessment for the proposed Watten Wind Farm in Caithness, Northern Scotland.

This work is to determine the extent of the worst-case shadow flicker effects on nearby residential or commercial properties.

This report details the inputs and assumptions made when undertaking the analysis and presents the results and findings.

1.1. Site Description

The Watten project site is composed of seven turbines situated approximately 14 km west of the town of Wick. The wind farm is nearby the village of Watten with several dwellings approximately 1 km to 2 km to the north-east. The surrounding areas consist of agricultural land with a large area of forestry to the north-west.

The layout presented in Table 1.1 was considered in this assessment.

Table 1.1: Watten Wind Farm Turbine layout

Turbine ID	Easting	Northing	Maximum tip height (m)	Rotor diameter (m)	Elevation (m ASL)
T1	321106	952238	220	162	75
T2	321504	951907	220	162	66
T3	320867	950938	220	162	59
T4	320510	951280	220	162	62
T5	320401	951839	220	162	69
T6	319828	951255	220	162	73
T7	319938	950772	220	162	69

Note that coordinates are in British National Grid.

The project is surrounded by a number of settlements which could potentially be impacted by shadow flicker. Natural Power have been provided with a reference point for each settlement, within a range of 1.6 km of the site, which is the closest to the proposed wind farm and modelled this as a receptor location in this analysis, with five locations ultimately provided. Receptor locations were selected to represent a worst-case scenario for the settlements near the proposed development. The locations of the five receptors are presented in Table A. and the layout of the seven turbines and five receptors are illustrated in Figure B.1. A worst-case scenario map detailing the areas potentially impacted by shadow flicker, represented as propagation patterns from each turbine at the Watten site, is presented in Figure B.2. Cumulative shadow flicker effects from existing or proposed neighbouring wind farms have not been explicitly calculated in this analysis. It is assumed that as there are no neighbouring wind farms within 10 RD from the receptors identified that there will be no cumulative effects.

2. **Shadow Model**

Shadow flicker may occur under certain combinations of geographical position and time of day when the sun passes behind the blades of a wind turbine and casts a shadow over the neighbouring properties. As the blades rotate, a dynamic shadow effect occurs, known as shadow flicker. The effect occurs inside buildings where the flicker appears, generally through a narrow window opening. The likelihood and duration of the effect depends upon several variable factors:

- Location of the property relative to the turbine. Please note that Natural Power's shadow flicker assessment does not take into consideration the orientation of properties or the presence of windows/openings and therefore each receptor is modelled as a worst-case (glass-house) scenario. Equally the model assumes no sheltering from vegetation or other obstacles is present between the turbine and the receptor.
- Distance from turbine. The further an observer is from the turbine, the less pronounced the effect will be.
- Wind speed and direction. The wind speed at the turbine will need to be greater than the cut-in wind speed of the turbine (typically 3 m/s), and below the cut-out wind speed, in order for the blades to be rotating. Furthermore, the shape of the shadow will be determined by the position of the sun relative to the blades, which will be yawed to face the wind.
- Turbine height and rotor diameter.
- Time of year and day as this determines the height of the sun in the sky.
- Weather conditions at the time – direct sunshine is required to create the flicker effect and therefore cloud cover reduces the risk of shadow flicker.

While all these factors impact the prevalence of shadow flicker effect occurring at a site, not all factors can be effectively modelled, and a number of assumptions need to be made as part of the modelling process.

2.1. **Assessment Methodology**

When assessing the impact of shadow flicker at a site, two possible conditions can be considered:

- Worst-case – this determines the maximum number theoretical hours of shadow flicker that can occur, not accounting for the likelihood of direct sunshine occurring in the region, coinciding with periods where shadow flicker is possible. This is a geometric-based calculation, dependant on the location of the sun with respect to the turbine blade, and alignment with the receptor of interest. Outside of these periods, irrespective of the cloud cover and sunshine status, flicker cannot physically occur. The outcome of this process is the maximum number of hours (per annum) at which flicker could, in theory, occur.
- Real-case – this takes the worst-case scenario, and then adjusts the duration of the total potential flicker events by the likelihood that direct sunshine occurs in a region. Typically, this utilises sunshine data from a ground-based meteorological station to apply monthly scaling factors to the worst-case scenario results. This results in a more accurate representation of the number of hours per year, that a receptor location may experience shadow flicker. The turbines are still modelled as though they are yawed perpendicularly to the line between the receptor and the sun at all times, inducing maximum shadow effect. The real-case does not take into account wind direction and the influence on this to the shadows.

The scope of this assessment is to determine the worst-case, which is derived using the WindFarmer software package. The model makes the following assumptions:

- The turbines are always rotating.
- The sun can be represented as a single point.
- The turbine rotor is modelled as a sphere around the hub to account for all possible turbine yaw directions relative to the line of sight with the position of the sun.
- Terrain effects are considered although this is assumed to be bare terrain and therefore surface effects from cover such as forestry or other buildings are not considered.

- The calculation is purely geometric and does not account for the sensitivity of perception of the observer.
- The likelihood of wind direction and speed is not taken into account.
- Shadow flicker is calculated for a height of 2 m Above Ground Level (AGL) to represent an observer at a ground floor window.
- The shadow receptors are simulated as mounted horizontal plates representing the worst-case scenario (glass-house) while real windows would be facing towards a particular, selective direction.
- The simulations have been carried out with a resolution of 10 minutes; if shadow flicker occurs at all within any 10-minute period, the model records this as 10 minutes of shadow flicker.
- The shadow flicker effects have been calculated for the area within 10 rotor diameters (1620 m) from the centre of each turbine at the request of the client. At distances beyond 10 rotor diameters (RD) the shadows are likely to be diffuse and will have minimal impact. Recommended best practice from Scottish planning advice is 10 RD[1], however, Natural Power usually increase this to 20 RD due to shadow flicker from some turbines extending beyond 10 RD. Increasing the analysis length to 20 RD allows the shadows to extend to the maximum length considering the angle of the line from receptor to turbine to sun.

2.2. **Results**

The results for the worst-case shadow flicker assessment are detailed in Table C.1. In addition, the number of days per year where any shadow flicker could occur, and the turbines which contribute to the flicker effect, are also shown in the table. This does not account for wind direction.

The results indicate that across affected receptors, the worst-case impact is between 13.7 and 41.6 hours per year. There is one receptor (R2) that experiences shadow flicker above the maximum allowed 30 minutes/day and 30 hours/year. It is recommended that a real-case shadow flicker assessment be carried out to determine if the flicker at this receptor is still above the acceptable level. There are two further receptors (R1 and R3) that experience 30 minutes/day; however, this is expected to reduce below the threshold in a real-case study. Two Receptors, R4 and R5, experienced no shadow flicker effects from the wind farm. It should be noted that this assessment does not calculate the impact from neighbouring wind farms explicitly. However, as noted above, it is assumed that as there are no neighbouring wind farms within 10 RD from the receptors identified that there will be no cumulative effects.

Once final shadow flicker receptors are defined, and the final turbine layout consented, Natural Power can update the assessment and calculate potential losses associated with the shutdown of turbines due to shadow flicker.

[1] Planning Advice Note (PAN) 45: Renewable Energy Technologies, Scottish Executive (2002)

3. **Conclusion and Recommendations**

The Client is advised of the following conclusions and recommendations:

- For the basis of the assessment Natural Power have been provided a point in each settlement which is closest to the proposed wind farm and modelled this as a receptor location in this analysis, with five locations ultimately selected. Receptor locations were selected to represent a worst-case scenario for the settlements near the proposed development. It is recommended that the Client carries out a full and thorough survey to confirm all potential receptors.
- The shadow model makes a number of assumptions with respect to the shadow receptors, including the assumption that they have windows directly facing the wind farm, that the direction of the wind is aligned with the line between the receptor and the sun at all times, and that there is no screening from vegetation or buildings which would otherwise mitigate the potential shadow flicker effect. It is recommended that, if specific dwellings are modelled, affected dwellings are visited to confirm the conditions for shadow flicker are present, and if not, then these receptors are removed from inclusion in the curtailment calculation. For this assessment, the closest point to the wind farm in the nearest settlement have been modelled as receptors.
- One of the receptors identified exceeded the shadow flicker limit of 30 hours per year or 30 minutes per day on the worst affected day. However, this will reduce in a real-case assessment. It is recommended that a real-case shadow flicker assessment be carried out to determine if the flicker at this receptor is still above the acceptable level.
- It is recommended that the locations of the receptors are visited to establish if there is a direct line of sight between the receptors and the turbines causing shadow flicker before a shadow flicker curtailment scheme is derived.
- The ability to implement shutdown of turbines to mitigate potential shadow flicker effects, requires the appropriate shadow module / sunshine sensors to be installed on the turbine and programmed into the turbine SCADA. As such, it is recommended that this equipment is installed on turbines which have been predicted to cause an impact.

Appendices

A. Receptor Locations

Table A.1: Shadow receptor locations

Receptor ID	Easting	Northing
R1	322135	951060
R2	320960	953313
R3	320368	953607
R4	321516	953871
R5	318782	952604

Note that coordinates are in British National Grid.

B. Shadow Flicker Results

Table B.1: Results of shadow flicker assessment at each receptor for GE Scenario

ID	Easting	Northing	No. of days with shadow flicker occurrences	Worst-case maximum shadow flicker (mins/day)	Worst-case shadow flicker (hrs / annum)	Turbines causing flicker
R1	322135	951060	35	30	13.7	T3
R2	320960	953313	50	80	41.6	T1 T2 T5
R3	320368	953607	63	30	24.5	T1
R4	321516	953871	0	0	0.0	None
R5	318782	952604	0	0	0.0	None

Note that coordinates are in British National Grid.

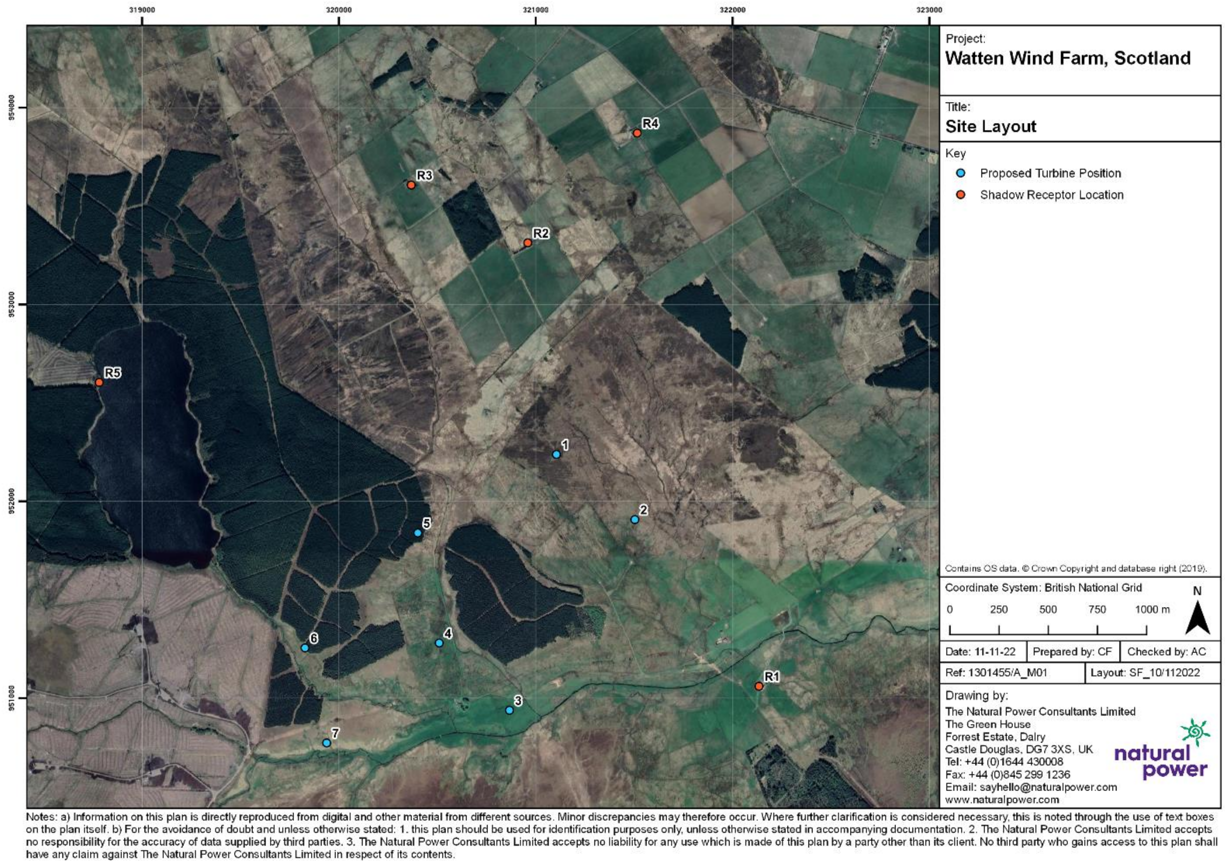

Figure B.1: **Watten Wind Farm seven turbine site layout (T1-T7) with receptors (R1-R5)**

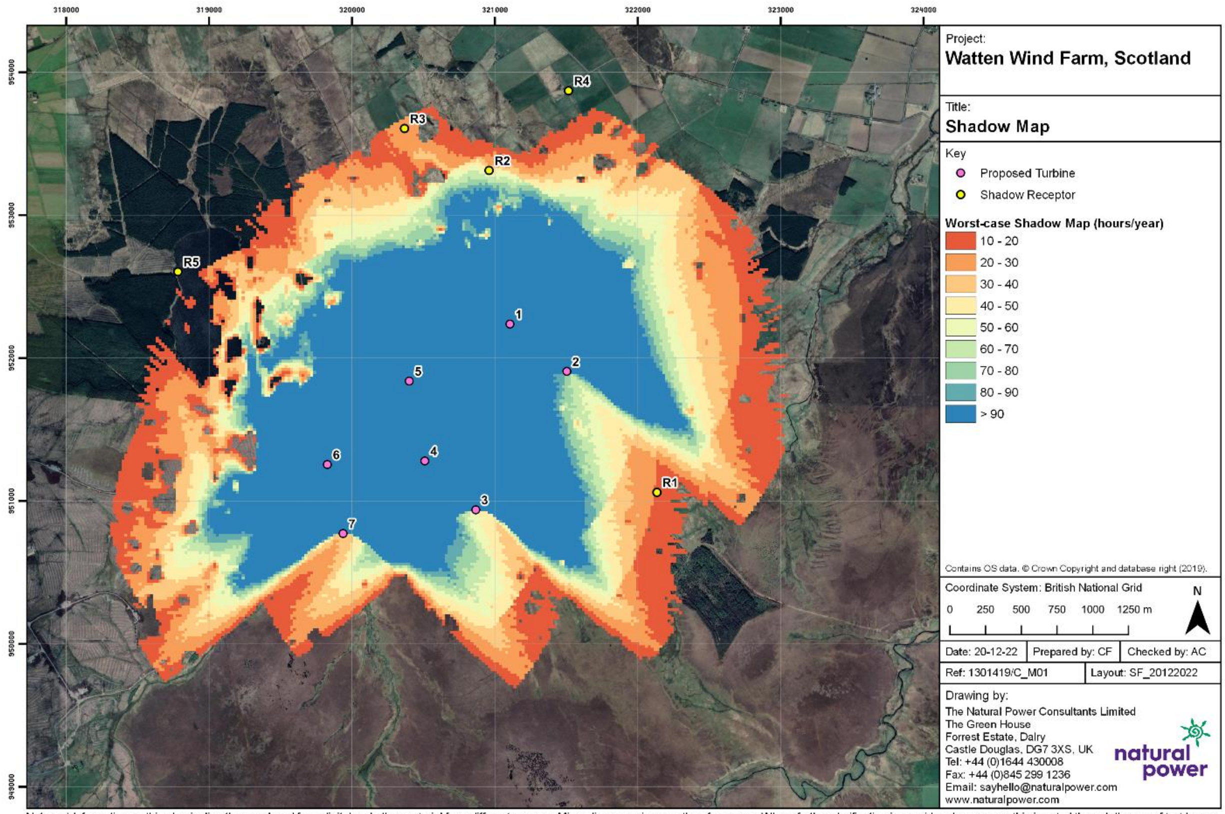

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Figure B.2: **Watten Wind Farm worst-case shadow flicker map**

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