ARECLEOCH WINDFARM EXTENSION

Phase 1 Peat Depth Survey &

Information to Inform an Assessment of Blanket Mire Condition

Technical Appendix 10.6

Prepared by: Michael Hill MIFM
Reviewed by: Euan Murray; Brian Henry MCIEEM

Date: 01/05/2019

Tel: 0141 342 5404
Web: www.macarthurgreen.com
Address: 93 South Woodside Road | Glasgow | G20 6NT

Document Quality Record

Version	Status	Person Responsible	Date
0.1	Draft	Michael Hill	21/03/2019
0..2	Reviewed	Euan Murray	01/04/2019
0.3	Updated	Michael Hill	03/04/2019
1	Internal Approval	Brian Henry	08/04/2019
2	Updated after Client Comments	Brian Henry	01/05/2019

CONTENTS

List of Associated Figures

EXECUTIVE SUMMARY

MacArthur Green was commissioned by ScottishPower Renewables to carry out a peat depth survey and gather information to inform an assessment of blanket mire condition at the proposed Arecleoch Windfarm Extension (hereafter referred to as the 'proposed Development').

The purpose of this survey and assessment is to inform the following aims and objectives:

- **Aim 1 Gather high resolution peat depth data on a 100 m^2 systematic grid for the peat study area[1].**
  - Objective 1.1 Inform the layout of the proposed Development's infrastructure to help reduce impacts associated with blanket mire habitats; and
  - Objective 1.2 Provide peat depth data to: 1) inform the impact of the proposed Development on carbon losses arising from disturbance to peat-based habitats; and 2) inform a peat management plan for the Site.
- **Aim 2 Determine blanket mire condition within the mire assessment area.**
  - Objective 2.1 Inform the Ecological Impact Assessment on the condition of the blanket mire and to determine its status according to the Carbon and Peatland Map classifications.

The peat study area was surveyed by MacArthur Green in November 2018. Depths were collected at 882 sample points located on a 100 m^2 systematic grid orientated in a north to south direction across the peat study area.

The peat study area is dominated by conifer plantation and clearfell, however, small areas of more semi-natural habitats are also present, including mire and heathland along watercourses and forest rides.

A few deeper pockets of peat are found scattered throughout the peat study area, with more extensive areas of deeper peat located in the west and south of the Site. A maximum sample depth of 9.24 m was recorded.

Overall, approximately 833.63 hectares (ha) of the 1004.15 ha peat study area may be classified as having some form of underlying blanket mire due to the peat depths recorded, where blanket mire is defined as habitats with a peat depth of greater than 50 cm (MacDonald *et al*., 1998; JNCC, 2010). 170.52 ha of the peat study area have shallow peat deposits of less than 51 cm, with the remainder of the samples (7.54 ha) recorded as non-peat substrates.

1. INTRODUCTION

MacArthur Green was commissioned by ScottishPower Renewables to undertake a peat depth survey and gather information to inform an assessment of blanket mire condition within the proposed Arecleoch Windfarm Extension (hereafter referred to as the 'proposed Development'), which is located approximately 3 km south west of Barrhill, South Ayrshire.

This report has been produced by MacArthur Green in accordance with Scottish Environmental Protection Agency (SEPA) and Scottish Natural Heritage (SNH) guidelines. 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 assessment has the following aims and objectives:

- **Aim 1 Gather high resolution peat depth data on a 100 m^2 systematic grid for the peat study area.**
  - Objective 1.1 Inform the layout of the proposed Development infrastructure to help reduce impacts associated with blanket mire habitats; and
  - Objective 1.2 Provide peat depth data to: 1) inform the impact of the proposed Development on carbon losses arising from disturbance to peat-based habitats, and 2) inform a peat management plan for the Site.
- **Aim 2 Determine blanket mire condition within the mire assessment area.**
  - Objective 2.1 Inform the Ecological Impact Assessment on the condition of the blanket mire and to determine its status according to the Carbon and Peatland Map classifications.

3. THE PEAT STUDY AREA

The peat depth and mire assessment study area ('peat study area') covered approximately 1004.15 ha and reaches an elevation of 229 metres (m) above sea level (a.s.l.), within an area of commercial forestry to the east of the existing Arecleoch Windfarm (see Figure 10.6-1 within this Technical Appendix).

The majority of the peat study area is commercial conifer plantation; however, some areas of mire and heath are present within the Site along forest rides and along watercourses (Technical Appendix 8.1). For a full description of the Site, see Chapter 2: Site Description and Design Evolution.

---

[1] The peat study area for the proposed Development comprised the area as detailed in Figure 10.6-1 within this Technical Appendix.

4. METHODOLOGY

The surveys were carried out by MacArthur Green on the following dates:

- 5 to 9 of November 2018 inclusive;
- 12 to 14 of November 2018 inclusive; and
- 24 November 2018.

Surveys followed best practice guidance with regard to surveying for developments on peatland (Scottish Government *et al*., 2017 and Scottish Renewables & SEPA, 2012).

The methods employed for peat depth analysis and the blanket mire condition are detailed further in Sections 4.1 and 4.2 below.

4.1 Peat Depth Analysis

The adopted sampling frequency took due consideration of good practice and published guidance referred to above.

The following methods were employed:

1. The peat study area was sampled using a 100 m^2 systematic grid (Figure 10.6-1 within this Technical Appendix). A random point was selected within the peat study area and the grid was established around the random point, to provide sampling points every 100 m across the entire peat study area. 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. 882 samples were generated in total.
4. Sampling locations were downloaded on to hand held 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 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 as peat-based or non-peat based.
7. Peat depth data were modelled using 'Inverse Distance Weighted' interpolation in ArcMAP 10.6©. 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).
8. A depth model was generated using the following categories of peat depth:
    - 0; 0.01-0.5 m; 0.51-1.0 m, 1.01-2.00 m and 1 m intervals thereafter.

4.2 Blanket Mire Condition

The assessment of ecological impacts conducted as part of the EIA Report for the proposed Development assesses the condition of blanket mire habitats within the Site. This report provides information that will help inform that assessment (in combination with the habitat data and discussion in Technical Appendix 8.1: National Vegetation Classification & Habitats Survey).

The 100 m^2 sampling grid was superimposed over The Carbon and Peatland map 2016 (SNH, 2016) using GIS software for reference. The Carbon and Peatland Map (2016) is a predictive tool that provides an indication of the likely presence of important carbon-rich soil, deep peat, and priority peatland habitat (land covered by peat forming vegetation or vegetation associated with peat formation) (SNH, 2016). The map shows various classifications of peat habitat, with priority given to nationally important Classes 1 and 2, as defined below:

- Class 1:
    - nationally important carbon-rich soils, deep peat and priority peatland habitat; and
    - areas likely to be of high conservation value.
- Class 2:
    - nationally important carbon-rich soils, deep peat and priority peatland habitat; and
    - areas of potentially high conservation value and restoration potential.

The following methods were employed throughout the field survey:

1. Whether the sample fell in planted, felled or unplanted habitat was recorded for comparison between mire in areas subject to the effects of intensive conifer plantation.
2. Presence or absence, and type of peat erosion within approximately 50 m^2 of each sampling point. Peat erosion is defined as bare peat that shows signs of erosion (principally as a consequence of water movement). Peat erosion was classified by its visible characteristics into one of the following categories:
    - hagging;
    - bog burst/peat slide;
    - tension cracks;
    - thrusted peat/compression ridge;
    - extrusion features; peat pipe; and
    - collapsed peat pipe.
3. At each sampling point where a drain dissected within 2 m of the point, a 2 m section of 'drain' was surveyed to establish its activity. The following three categories of activity were recorded:
    - active: <30 % occluded (visibly active);
    - semi-active: 30-90 % occluded (some signs of running water current or recent); and

- inactive: 90-100 % occluded (no sign of running water current or recent).

Drains include: agricultural drains, plough furrows; and subsidiary drains. No distinction between drain categories were made during the survey. Whether or not the base of the drain reached the bedrock or underlying till was also recorded.

4. At each of the 882 sampling points a 2 m^2 vegetation quadrat was sampled to record a number of variables. The blanket mire condition assessment recorded percentage coverage of key plant groups within the foliar and basal vegetation layers (assessed by eye). These were recorded, as detailed in Table 4.2.1, and described below.

Table 4.2.1: Key plant groups within the foliar and basal vegetation layers

Foliar Layer	Basal Layer
Calluna vulgaris	Non-*Sphagnum* Mosses and Lichens
Other Dwarf Shrubs	*Polytrichum commune*
Eriophorum vaginatum	Bare Ground/Conifer Needles
Molinia caerulea	*Sphagnum* mosses (species present recorded)
Juncus spp.	
Other Vascular Plants	

5. The data collected under the points above were used to undertake a blanket mire condition assessment using the following variables:
   - the mean % cover of *Sphagnum* mosses;
   - the presence of broad branched *Sphagnum* species (comprising *Sphagnum magellanicum* and/or *Sphagnum papillosum*);
   - the mean % cover of Non-*Sphagnum* Mosses and Lichens;
   - the mean % cover of *Calluna vulgaris*;
   - the mean % cover of Other Dwarf Shrubs
   - the mean % cover of *Eriophorum vaginatum*;
   - the mean % cover of *Molinia caerulea*;
   - the mean % cover of *Juncus* spp.;
   - the mean % cover of Other vascular plants;
   - the mean % cover of Bare Ground/Conifer Needles;
   - the mean % cover of *Polytrichum commune*;
   - presence or absence of peat erosion; and
   - drain activity and distribution.

Standard descriptive statistics are used to describe the data where appropriate.

5. RESULTS

The results of the Phase 1 peat depth survey are detailed below and shown on Figures 10.6-2 and 10.6-3 within this Technical Appendix.

5.1 Peat Depth Analysis

Figure 10.6-2 within this Technical Appendix shows the specific depth class at each sample location and Figure 10.6-3 illustrates the results of the peat depth modelling based on 882 sample points. Figure 10.6.4 depicts mire and non-mire areas based upon the arbitrary 50 cm peat depth cut-off value for these habitats (MacDonald *et al.*, 1998; JNCC, 2010). Figures 10.6-3 and 10.6-4 are based on data interpolation and consequently the peat depth boundaries are 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 5.1.1 and 5.1.2 present the percentage and frequency of samples falling within the peat depth categories recorded in the peat study area.

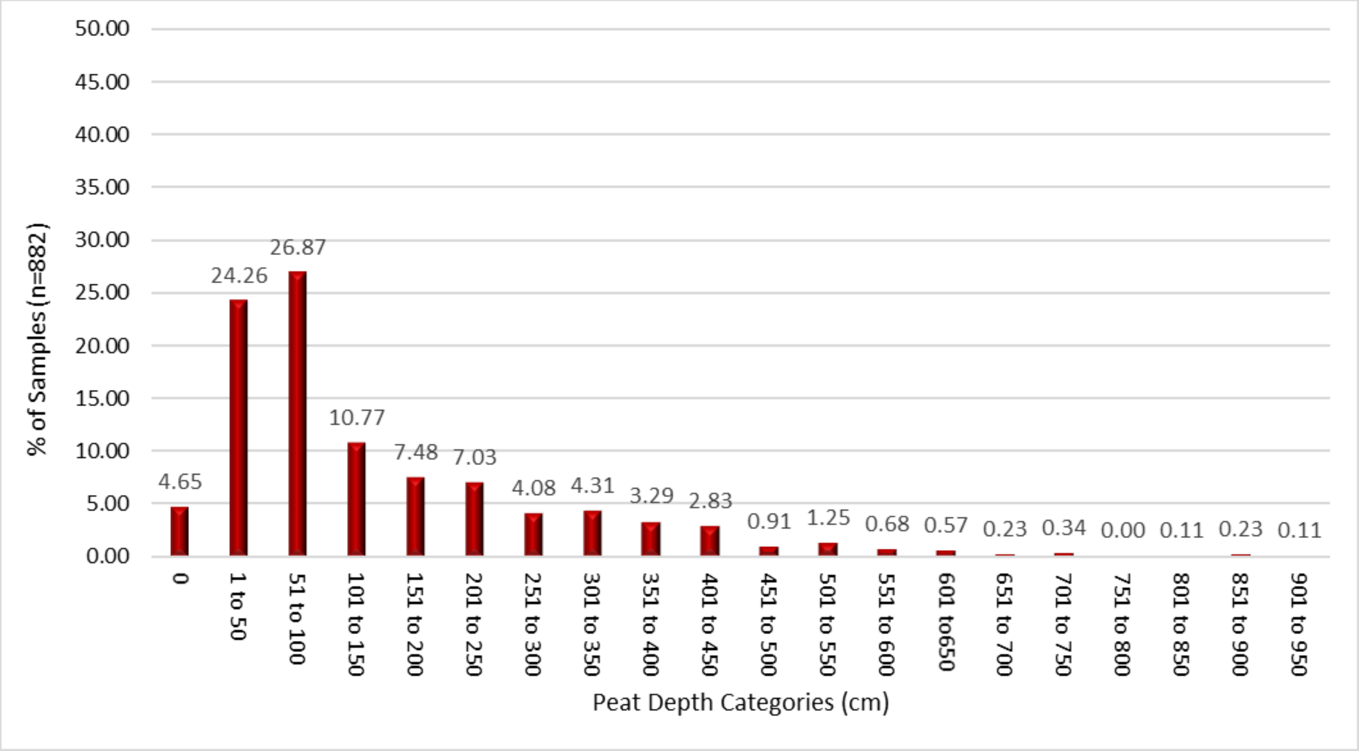


Chart 5.1.1: % Peat Depth

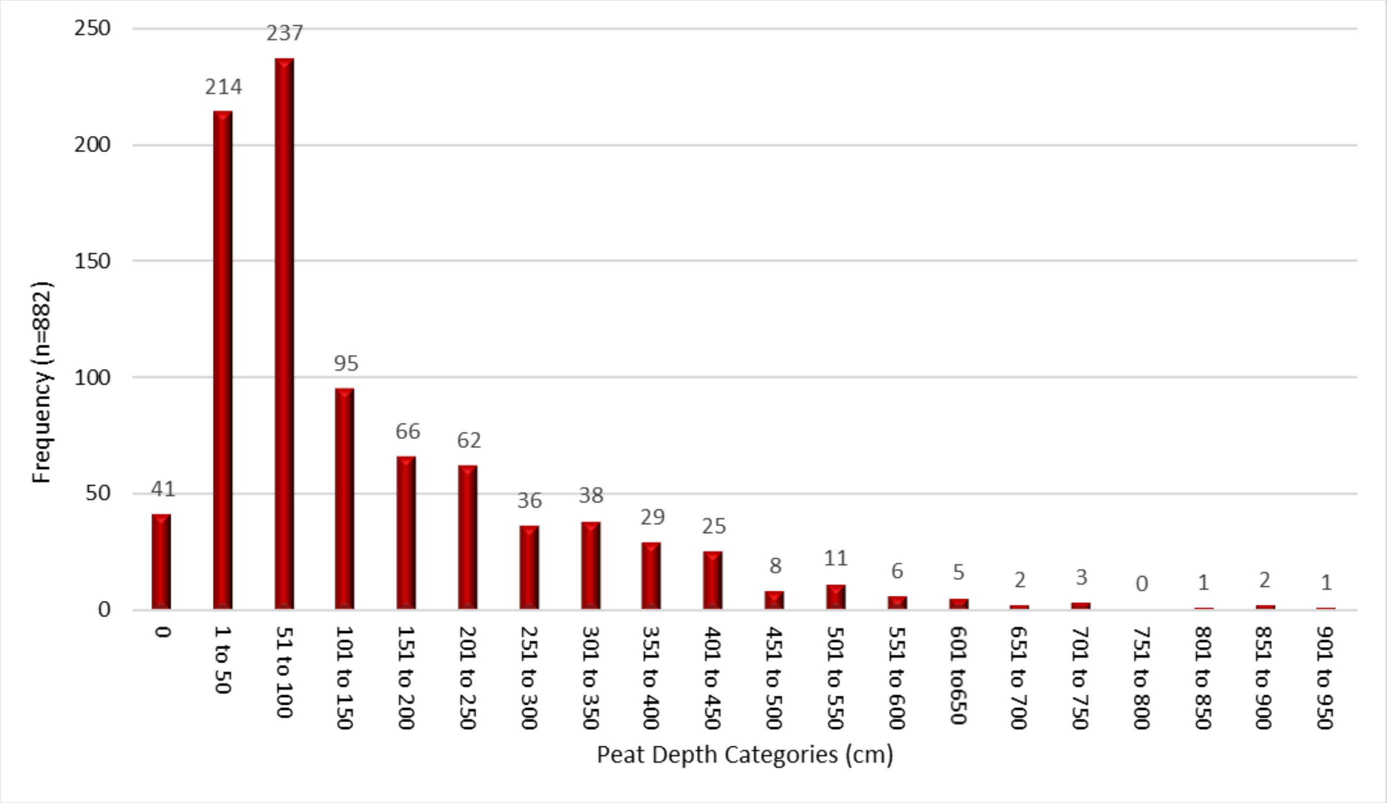


Chart 5.1.2: Peat Depth Frequency Distribution

As shown in Figures 10.6-2 to 10.6-4 within this Technical Appendix, most of the peat study area has peat depths of 50 cm or greater (mean 145 cm; median 79 cm) and some isolated deep peat pockets (maximum 924 cm).

Figure 10.6.4 shows the extent and locations of areas with peat of 0-50 cm and >50 cm in depth based on data interpolation. The following considerations are evident:

- 627 samples (71.09 %) fell on land with more than 50 cm depth of peat;
- 214 samples (24.26 %) fell on land with less than or equal to 50 cm depth of peat;
- 93 samples (10.54 %) fell on land with more than 350 cm depth of peat; and
- 41 samples (4.65 %) fell on land with no peat.

Only points existing over non-peat habitats (e.g. bare rock, spoil, clay) were recorded as 0 cm of peat. Peat or organo-mineral soil was recorded at all other points.

Approximately 833.63 ha of the interpolated study area are >50 cm peat depth and 170.52 ha are 1-50 cm peat depth. These areas are based upon GIS Inverse Distance Weighting, which gives a more accurate depiction of peat depths as a continuum, as opposed to calculating areas from point value samples.

5.2 Blanket Mire Condition

This section presents the results of the mire condition survey that will help inform the Ecological Impact Assessment (EIA) on the condition and quality of the blanket mire present.

Of the 882 sample points where data was collected, peat was present at 841 locations. 41 non-peat-based (mineral soil, rock etc) samples were excluded from the dataset for the purposes of mire condition assessment. A total of 841 peat-based sample points comprises the mire assessment area and were subject to blanket mire condition assessment using an approximated 2 m^2 quadrat.

With respect to the analysis in the following sections:

- Blanket mire has been arbitrarily defined as habitat with more than 50 cm of underlying peat (MacDonald *et al*., 1998; JNCC, 2010). However, within the peat study area, some areas with less than 50 cm of peat present are still likely to be a constituent of the wider blanket mire hydrological unit, or macrotope. For instance, in Figure 10.6-3 and 10.6-4 some small pockets of peat less than 50 cm are encompassed and surrounded by deeper peat. It is clear that these areas form part of and are connected with the overall blanket mire complex.

The following analysis is presented using comparisons of mire-condition between Planted/Felled and Unplanted habitats. Figure 10.6-5 within this Technical Appendix shows areas of Planted/Felled and Unplanted Habitat within the peat study area and should be cross-referred to when viewing the species-specific presence and abundance figures to enable comparisons of vegetation distribution and abundance between these habitats.

5.2.1 Distribution and Abundance of Sphagnum spp.

Figure 10.6-6 within this Technical Appendix illustrates the distribution and abundance of all *Sphagnum* species recorded within the mire assessment area. Overall *Sphagnum* abundance is typically low-moderate.

The mean % of *Sphagnum* per quadrat in unplanted habitats was 23.84 % and 12.66 % in planted/felled habitats. As would be expected, *Sphagnum* is more common in the mire areas than the non-mire areas. Areas of highest *Sphagnum* abundance are also strongly correlated to the areas of deeper peat (c.f. Figure 10.6-3 within this Technical Appendix); however, *Sphagnum* it is also often present in lower abundance in areas of wet heath where the peat depth is between 1-50 cm.

Overall, the abundance of *Sphagnum* spp. throughout the Site is low-moderate, with *Sphagnum* cover being generally restricted to mire areas and deeper and wetter peat. *Sphagnum* coverage is generally lesser or absent in drier and non-mire areas, or under very dense and mature conifer plantation.

The comparison of *Sphagnum* cover in planted/felled and unplanted habitats is illustrated in in Chart 5.2.1 and Table 5.2.1 below.

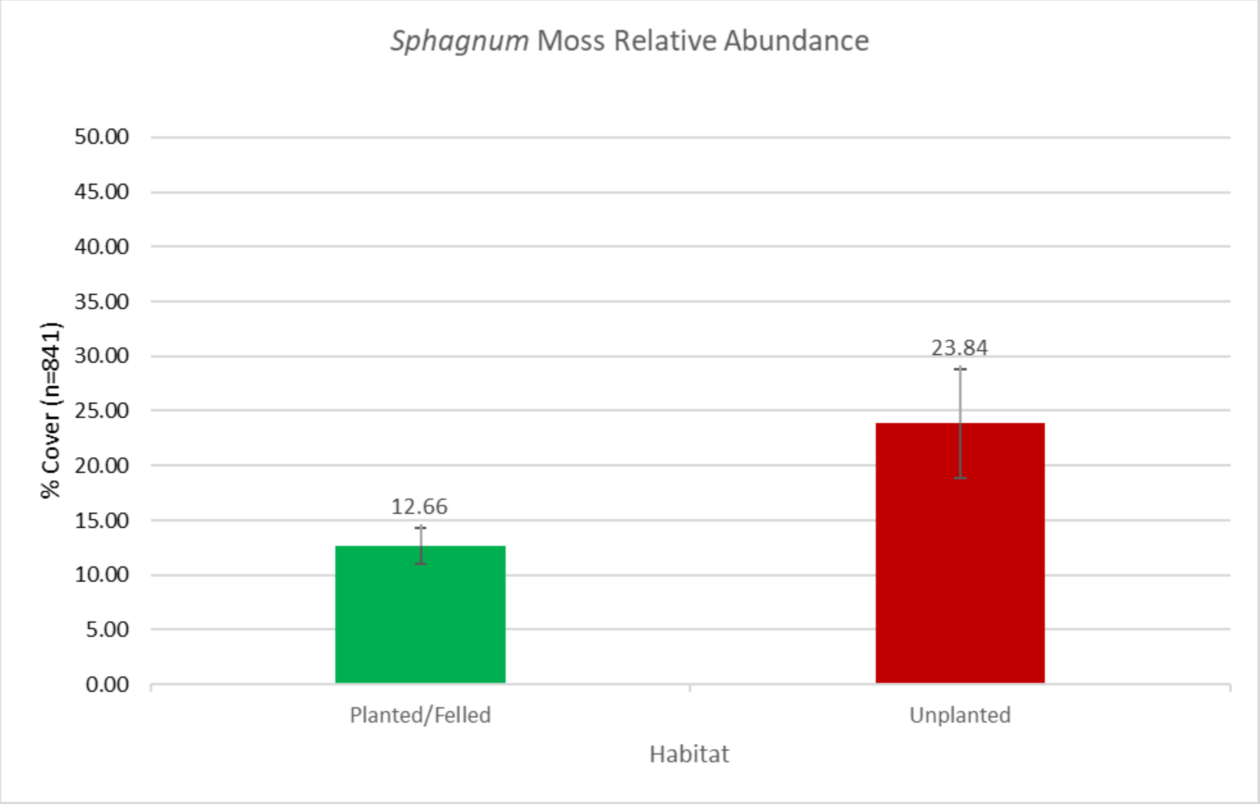


Chart 5.2.1: Mean % Cover of *Sphagnum* species showing 95% confidence intervals.

Table 5.2.1: Descriptive Statistics

Species	No. Samples Present	% Samples Present
S. fallax	233	27.71
S. palustre	123	14.63
S. capillifolium	122	14.51
S. cuspidatum	37	4.40
S. papillosum	9	1.07
S. tenellum	1	0.12
S. compactum	1	0.12

Of the *Sphagnum* species present, the most commonly encountered at sample quadrats was *S. fallax, S. palustre,* and *S. capillifolium.* These species were recorded at 27.71 %, 14.63 %, and 14.51 % of the sample points respectively. Specific details of *Sphagnum* species are detailed in Chart 5.2.2 and Table 5.2.2 below.

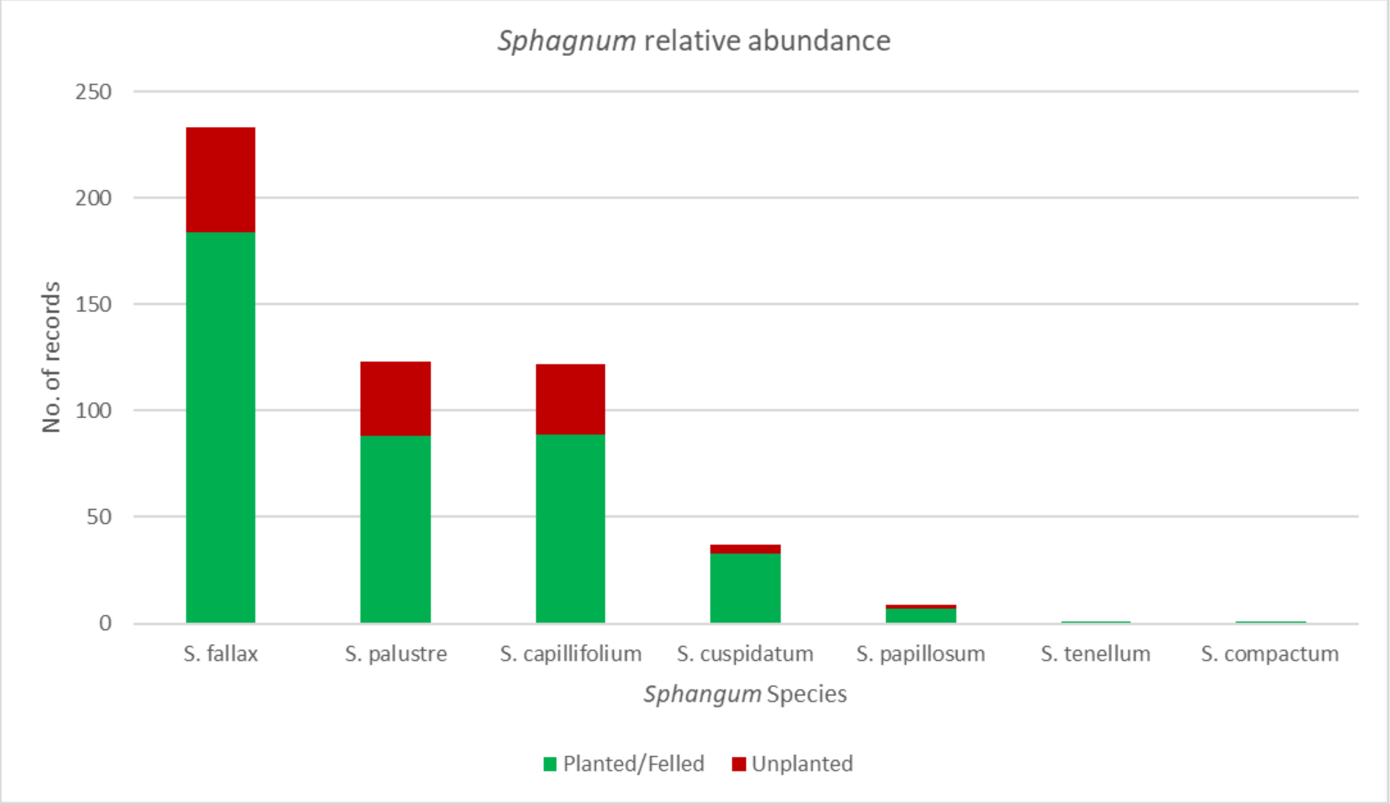


Chart 5.2.2: Presence of *Sphagnum* species throughout the mire assessment area

Table 5.2.2: *Sphagnum* species and abundances

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	12.66	521.58	22.84	0.85	1.66	10.99	14.32
Unplanted	23.84	770.08	27.75	2.55	5.01	18.83	28.85

5.2.2 *Distribution and Presence of Sphagnum magellanicum and Sphagnum papillosum*

Figure 10.6-7 within this Technical Appendix illustrates the presence and distribution of the important peat-forming broad branched species *S. papillosum* recorded within the mire assessment area. There is a sparse presence of *S. papillosum* within the Site, with only 9 records (1.07 %) made within the mire assessment area (see Table 5.2.2 above). *S. magellanicum* was not recorded at any sample points within the mire assessment area. The presence of these species is generally related to areas of deeper and wetter peat, evidenced by records only made within areas of mire. The comparison between the broad-branched *Sphagnums* is shown in Chart 5.2.3.

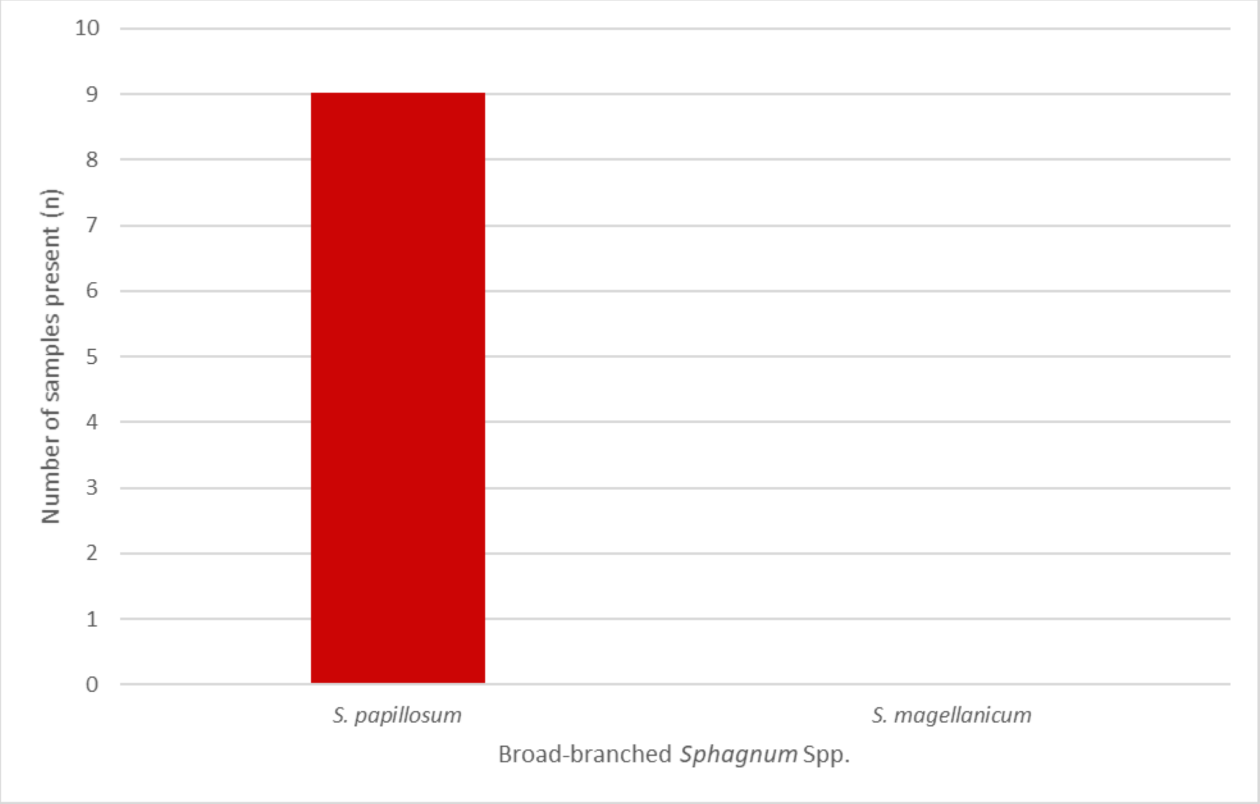


Chart 5.2.3: Broad-branched *Sphagnum* spp. samples

5.2.3 *Distribution and Abundance of Non-Sphagnum Mosses and Lichen*

Figure 10.6-8 within this Technical Appendix illustrates the distribution and abundance of Non-*Sphagnum* mosses and lichen recorded across the mire assessment area. The cover of Non-*Sphagnum* mosses and lichen is high, and from visual observation of Figure 10.6-8, relatively evenly distributed throughout the mire assessment area.

The mean % cover of Non-*Sphagnum* mosses and lichen per quadrat in planted/felled and unplanted habitats were almost identical at 40.37 % and 40.97 %, respectively. Non-*sphagnum* mosses and lichens were recorded in 792 quadrats in the mire assessment area (94.17 % of samples). These figures are represented in Chart 5.2.4 and Table 5.2.3 below.

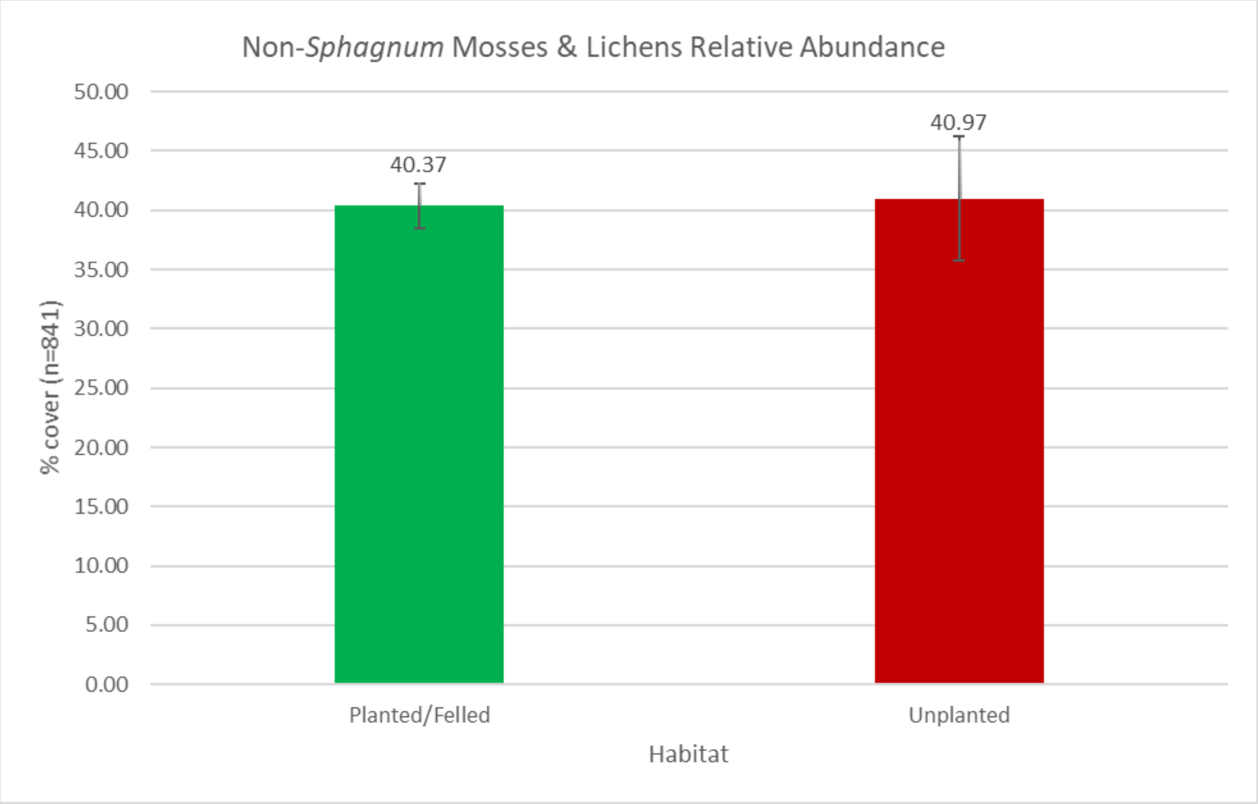


Chart 5.2.4: Mean % cover of Non-*Sphagnum* Mosses and Lichen showing 95% confidence intervals.

Table 5.2.3: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	40.37	659.01	25.67	0.95	1.87	38.50	42.24
Unplanted	40.97	845.02	29.07	2.68	5.25	35.73	46.22

5.2.4 *Distribution and Abundance of Polytrichum commune*

Figure 10.6-9 within this Technical Appendix illustrates the distribution and abundance of the moss *Polytrichum commune* recorded within the mire assessment area. Although a non-*Sphagnum* moss as discussed in Section 5.2.3 above; the specific presence and abundance of *P. commune* was also recorded individually due to its presence in mire habitats being an indication of the presence of disturbed or modified peatlands.

The mean % cover of *P. commune* per quadrat in planted/felled and unplanted habitats was 3.68 % and 7.94 % respectively. These figures are represented in Chart 5.2.5 and Table 5.2.4 below. *P. commune* was recorded frequently throughout the Site, at 246 (29.25 %) of sampling locations, and was widespread throughout the mire assessment area, however in relatively low abundance (Figure 10.6-9).

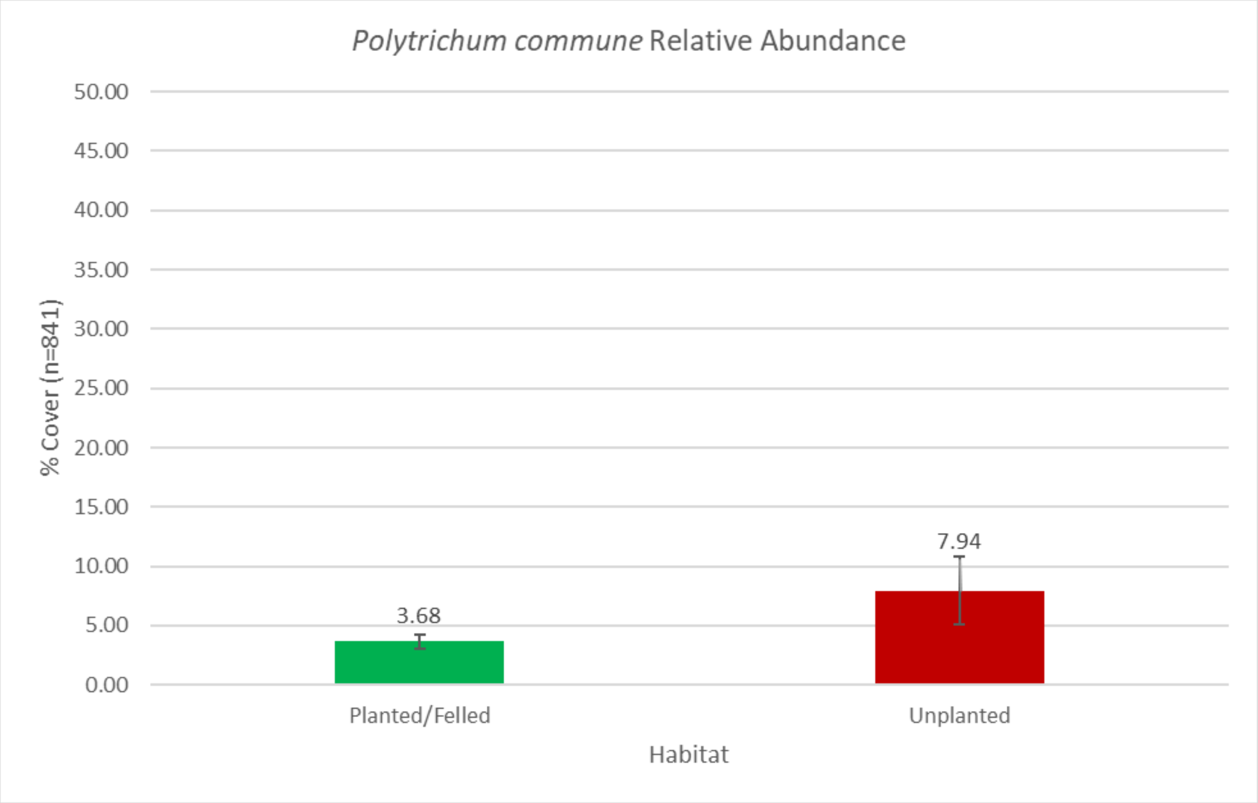


Chart 5.2.5: Mean % cover of *Polytrichum commune* showing 95% confidence intervals

Table 5.2.4: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	3.68	64.90	8.06	0.30	0.59	3.09	4.27
Unplanted	7.94	249.90	15.81	1.46	2.85	5.09	10.79

5.2.5 *Distribution and Abundance of Calluna vulgaris*

Figure 10.6-10 within this Technical Appendix illustrates the distribution and abundance of *Calluna vulgaris* (heather) recorded across the mire assessment area. The general coverage of *C. vulgaris* is low and visual observation of Figure 10.6-10 shows that this species is unevenly distributed throughout the Site; being recorded more commonly and in higher abundances in the central-west of the Site. *C. vulgaris* was recorded at 157 (18.66 %) of samples.

The mean % cover of *C. vulgaris* per quadrat was 2.94 % and 7.67 % in planted/felled and unplanted habitats respectively. These figures are represented in Chart 5.2.6 and Table 5.2.5 below.

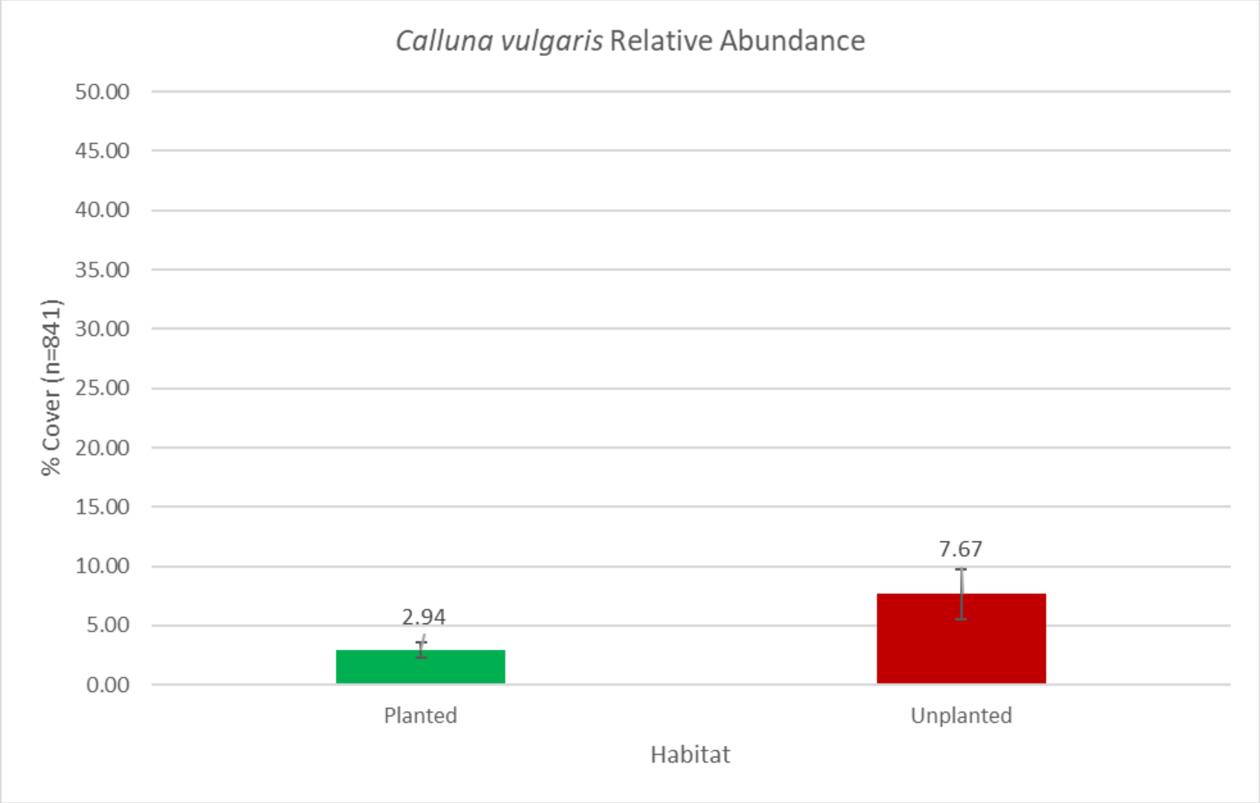


Chart 5.2.6: Mean % cover of *Calluna vulgaris* showing 95 % confidence intervals.

Table 5.2.5: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	2.94	89.87	9.48	0.35	0.69	2.25	3.63
Unplanted	7.67	138.00	11.75	1.08	2.12	5.55	9.79

5.2.6 *Distribution and Abundance of Other Dwarf Shrubs*

Figure 10.6-11 within this Technical Appendix illustrates the distribution and abundance of other dwarf shrubs recorded within the mire assessment area. This category includes the following species that were recorded in the Site; *Erica tetralix, Erica cinerea, Vaccinium* spp., and *Empetrum nigrum*. Other dwarf shrubs were recorded in low abundance, and have a low-moderate distribution; being recorded at 21.28 % of all sample points. The mean % cover of other dwarf shrubs per quadrat in planted/felled and unplanted habitats is 1.75 % and 5.95 % respectively. These figures are represented in Chart 5.2.7 and Table 5.2.6 below.

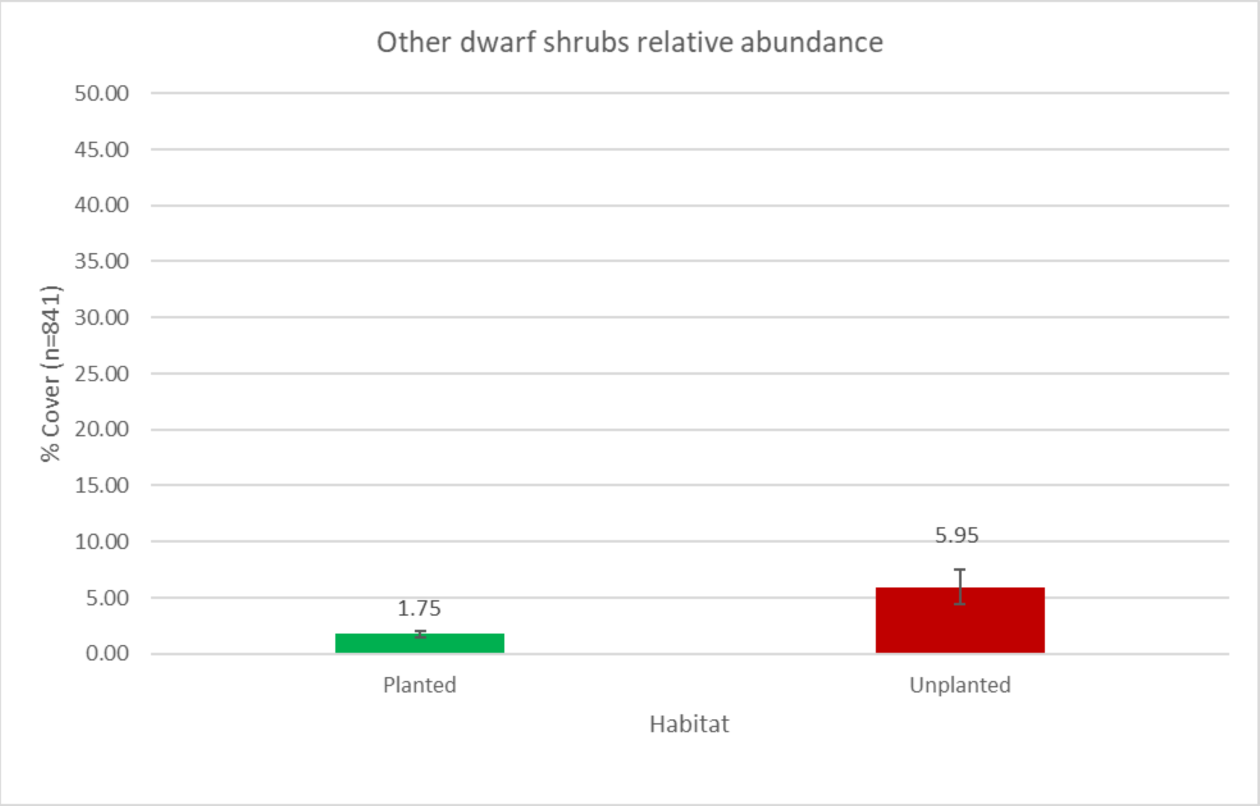


Chart 5.2.7: Mean % cover of other dwarf shrubs showing 95 % confidence intervals.

Table 5.2.6: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	2.53	73.16	8.55	0.32	0.62	1.91	3.15
Unplanted	4.36	80.74	8.99	0.83	1.62	2.74	5.99

5.2.7 Distribution and Abundance of Eriophorum vaginatum

Figure 10.6-12 within this Technical Appendix illustrates the distribution and abundance of *Eriophorum vaginatum* recorded within the mire assessment area. *E. vaginatum* abundance is typically low, with small patches of higher growth recorded, typically in areas of deeper peat. *E. vaginatum* was recorded in 135 (16.05 %) of all peat sample locations.

The mean % cover of *E. vaginatum* per quadrat in planted/felled and unplanted habitats was 2.53 % and 4.36 % respectively. These figures are represented in Chart 5.2.8 and Table 5.2.7 below.

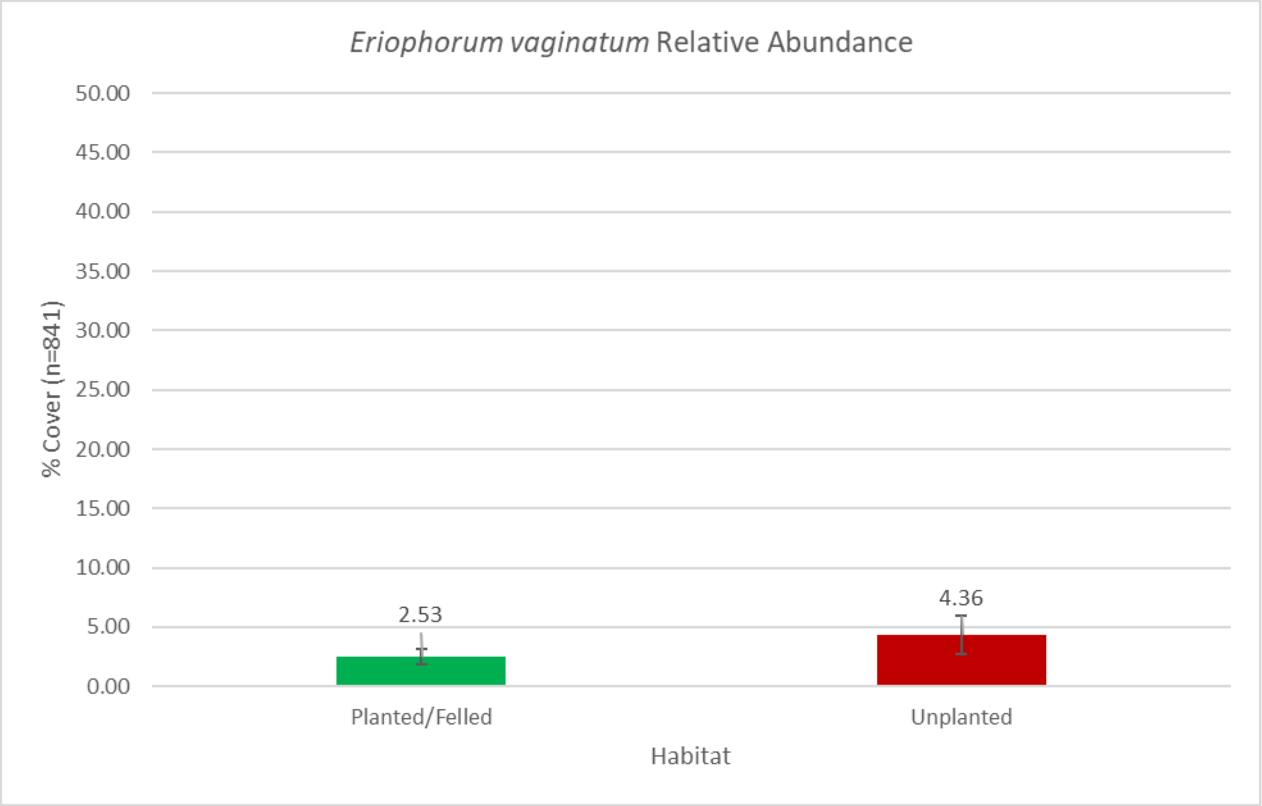


Chart 5.2.8: Mean % cover of *Eriophorum vaginatum* showing 95% confidence intervals

Table 5.2.7: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	1.75	21.31	4.62	0.17	0.34	1.41	2.09
Unplanted	5.95	70.57	8.40	0.77	1.52	4.43	7.46

5.2.8 Distribution and Abundance of Molinia caerulea

Figure 10.6-13 within this Technical Appendix illustrates the distribution and abundance of *Molinia caerulea* (purple moor-grass) recorded within the mire assessment area. Overall, the abundance of *M. caerulea* was low-moderate, with a relatively widespread distribution throughout the Site. It was commonly observed in forestry rides and was recorded more frequently in unplanted, mire habitats. In total *M. caerulea* was recorded at 199 of all sampling locations (23.66%).

The mean % cover of *M. caerulea* per quadrat in planted/felled and unplanted habitats was 3.71 % and 27.09 % respectively. These figures are represented in Chart 5.2.9 and Table 5.2.8 below.

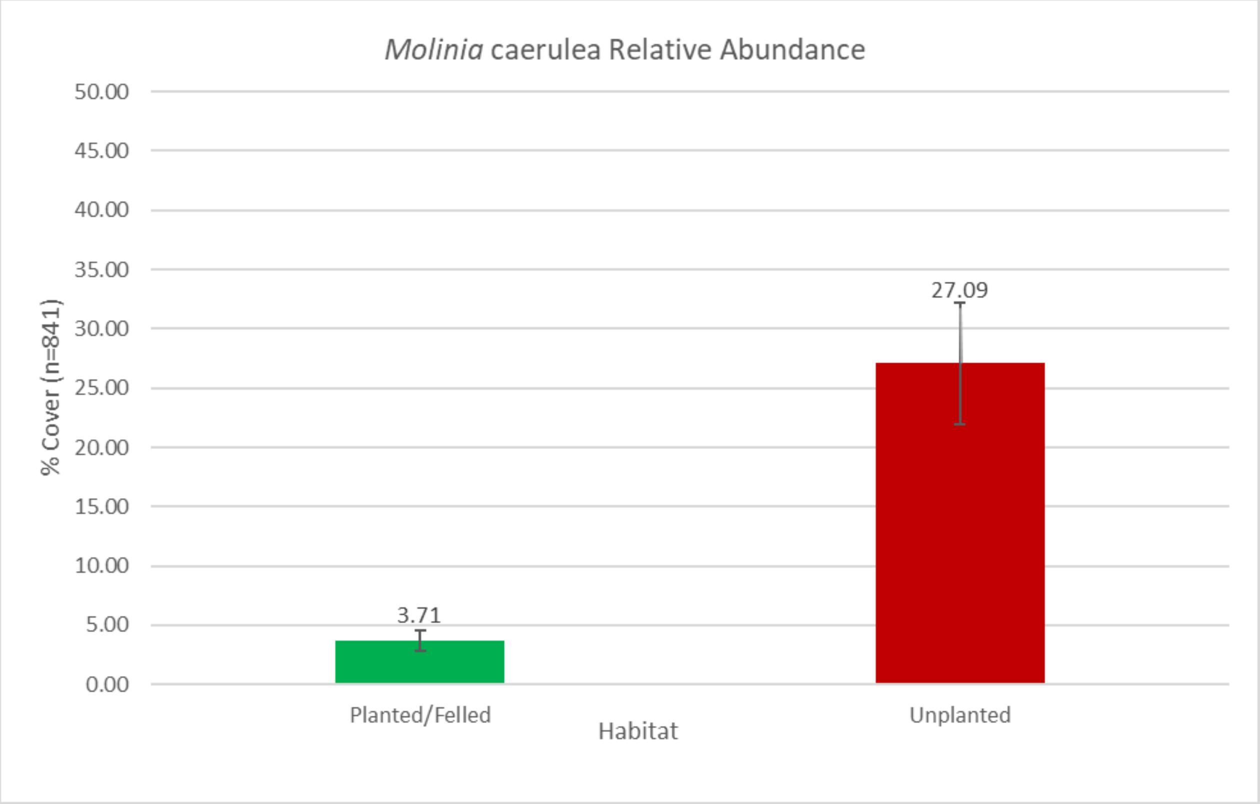


Chart 5.2.9: Mean % cover of *Molinia caerulea* within mire showing 95% confidence intervals

Table 5.2.8: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	3.71	145.11	12.05	0.45	0.88	2.83	4.58
Unplanted	27.09	798.41	28.26	2.60	5.10	21.99	32.19

5.2.9 Distribution and Abundance of Juncus spp.

Figure 10.6-14 within this Technical Appendix illustrates the distribution and abundance of *Juncus* spp. recorded within the mire assessment area. Overall, the highest growth of *Juncus* spp. is in the central section of the Site, however it was recorded in most areas with the exception of some large, drier stands of plantation. The most common rush species present were *Juncus effusus* (soft rush).

The mean % cover in planted/felled and unplanted habitats was 3.35 % and 10.89 % respectively, and in total was record at 147 sampling locations (17.47 %). These figures are represented in Chart 5.2.10 and Table 5.2.9 below.

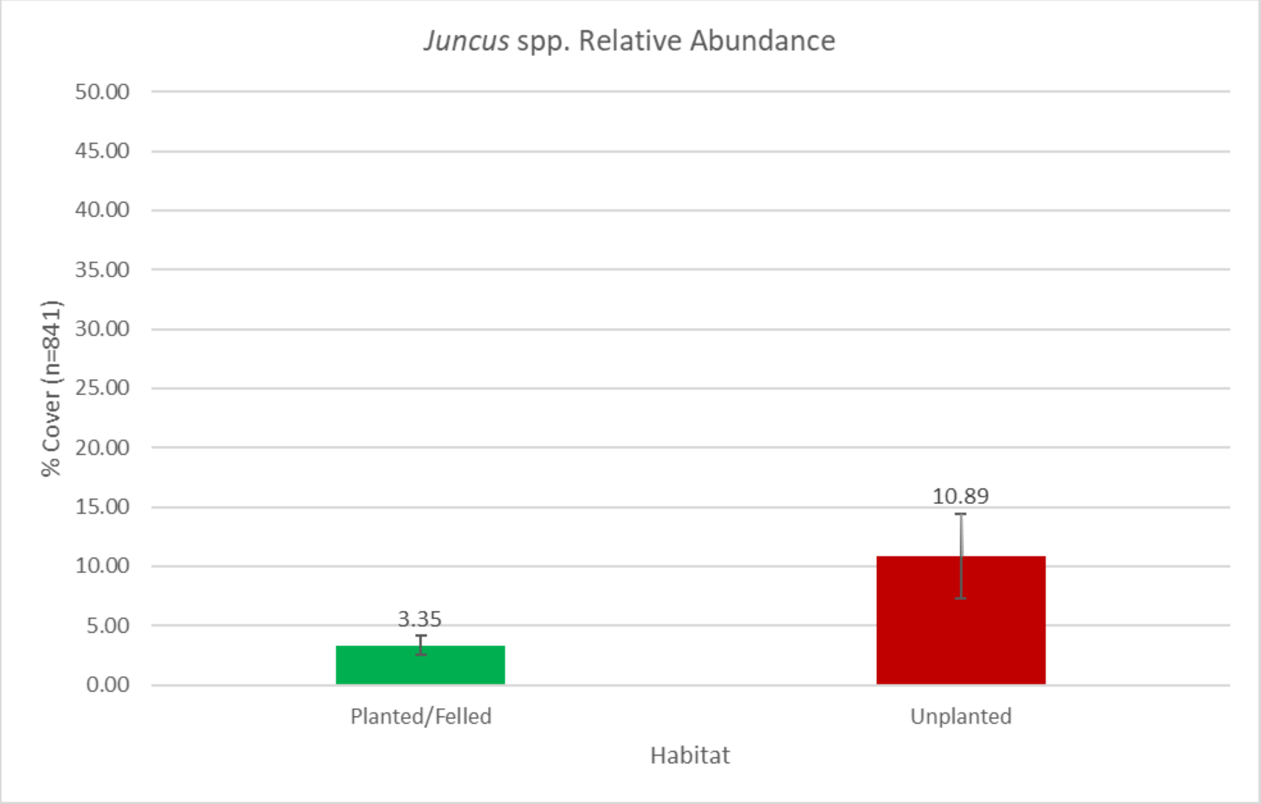


Chart 5.2.10: Mean % cover of *Juncus* spp. within mire showing 95% confidence intervals

Table 5.2.9: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	3.35	116.79	10.81	0.40	0.79	2.56	4.13
Unplanted	10.89	391.79	19.79	1.82	3.57	7.32	14.46

5.2.10 Distribution and Abundance of Other Vascular Plants

Figure 10.6-15 within this Technical Appendix illustrates the distribution and abundance of other vascular plants, not reported above, recorded within the mire assessment area. This vegetation group is mainly comprised of commonly recorded grass species which include *Deschampsia cespitosa, Deschampsia flexuosa, Agrostis* spp. and *Festuca* spp., in addition to the main sedges *Eriophorum angustifolium* and *Carex echinata* forming much of this category's vegetation within the mire assessment area. Herbaceous species were generally more limited in extent, but contained a wide range of common species. For full vegetation descriptions of the Site and its respective habitats, communities and flora refer to Technical Appendix 8.1.

The distribution of other vascular plants was wide across the mire assessment area, although, more commonly found in open areas of habitat not enclosed by dense forest canopy. The mean % cover of other vascular plants per quadrat in planted/felled and unplanted areas was 5.93 % and 14.22 % respectively. These figures are represented in Chart 5.2.11 and Table 5.2.10 below. Other vascular plants were recorded in 35.67 % of all samples within the Site.

This assessment group encompasses a broad range of species and vegetation types; therefore, it is expected that the likelihood of recording within this category at any given point is high. However, recording the % cover of this vegetation class at each sample location will provide information and insight on the distribution of this often non-mire vegetation against peat depths recorded across the Site.

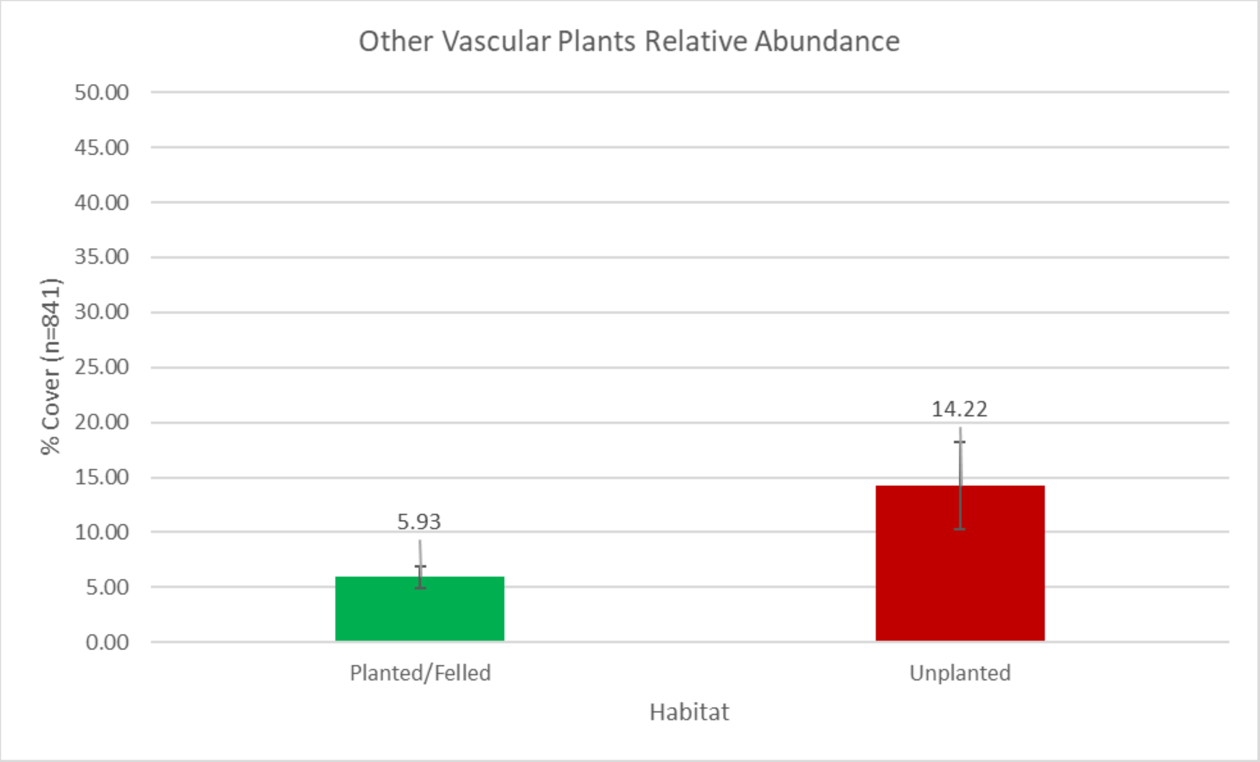


Chart 5.2.11: Mean % cover of Other Vascular Plants showing 95% confidence intervals

Table 5.2.10: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	5.93	185.33	13.61	0.51	0.99	4.94	6.92
Unplanted	14.22	489.43	22.12	2.04	3.99	10.23	18.21

5.2.11 Distribution and Abundance of Bare Ground/Conifer Needles

Figure 10.6-16 within this Technical Appendix illustrates the distribution and abundance of bare ground and conifer needles recorded within the mire assessment area.

The mean % cover of bare ground/needles per quadrat in planted/felled and unplanted habitats was 36.09 % and 1.10 % respectively. These figures are represented in Chart 5.2.12 and Table 5.2.11 below.

Bare ground/needles were recorded at almost two thirds (65.63 %) of all sampling points. The high incidence of bare ground/needles, particularly in planted/felled habitats, highlights the blanketing effects of fallen conifer needles on the forest floor and the bare ground or bare peat arising from forestry operations disturbance.

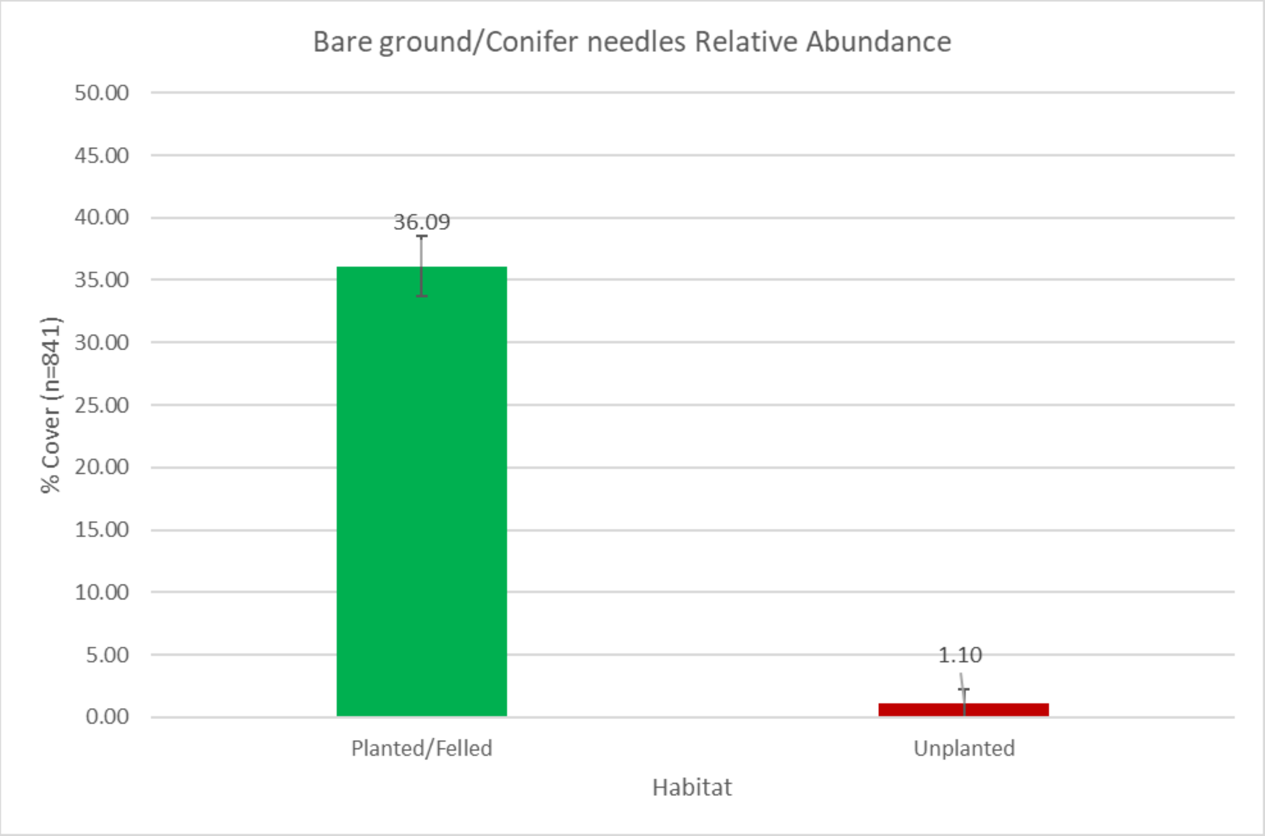


Chart 5.2.12: Mean % cover of Bare Ground/Needles showing 95% confidence intervals

Table 5.2.11: Descriptive Statistics

Habitat	Mean	Variance	Standard Deviation	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper
Planted/Felled	36.09	1089.49	33.01	1.23	2.41	33.68	38.49
Unplanted	1.10	39.46	6.28	0.58	1.13	-0.03	2.24

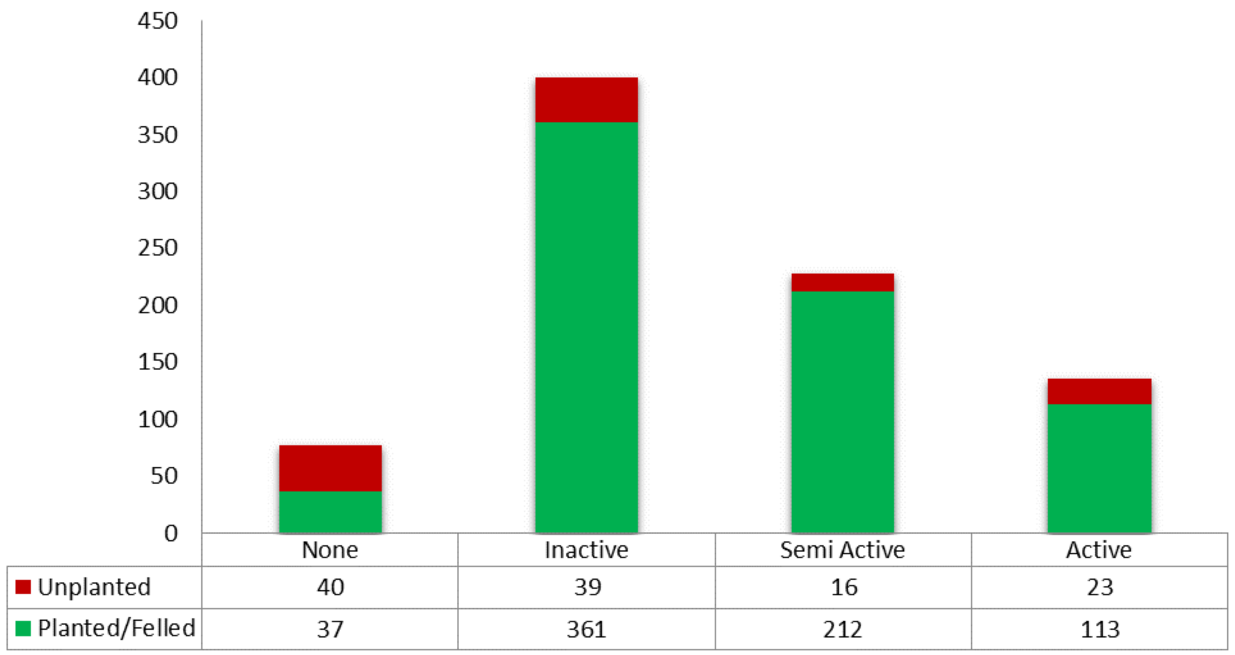
5.2.12 Presence or Absence of Peat Erosion

No peat erosion was recorded within the peat study area.

5.2.13 Drainage Activity

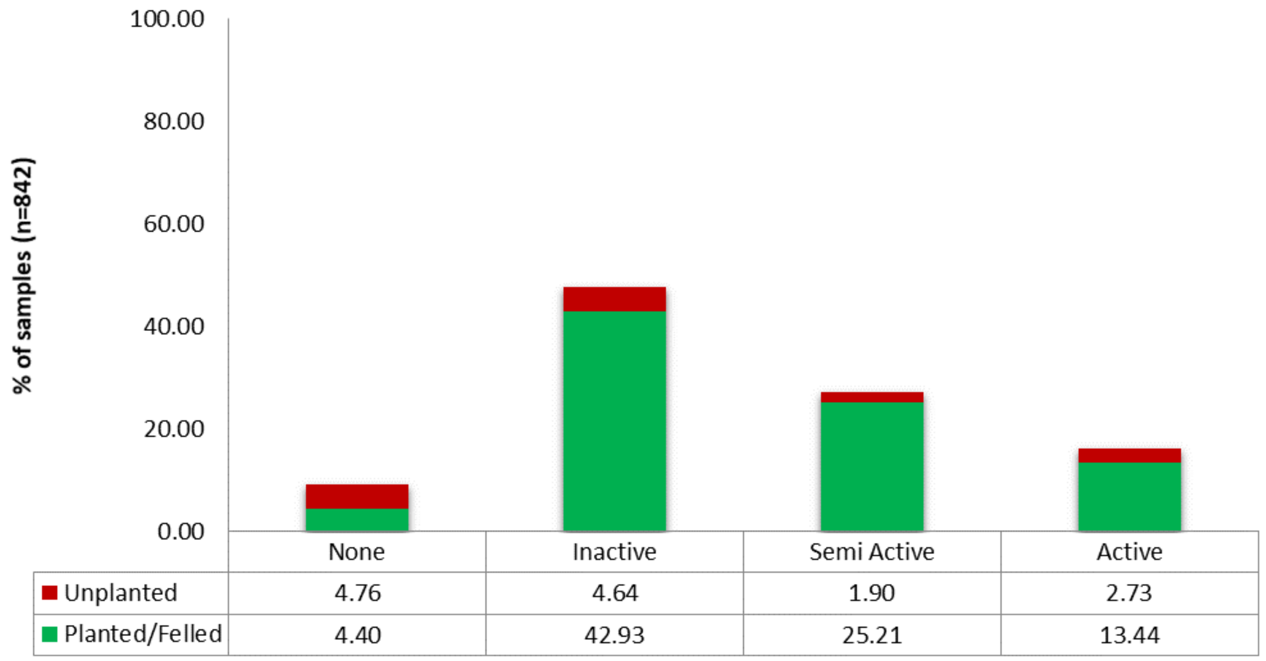
Figure 10.6-17 within this Technical Appendix illustrates the distribution of inactive, semi-active and active drains throughout the mire assessment area. Drainage features were recorded more frequently in planted/felled habitats, and included plantation furrows within the assessment.

764 samples out of 841 had some form of drainage structure present (90.84 %); of which 400 (47.56 %) were inactive, 228 (27.11 %) were semi-active and 136 (16.17 %) were active. 77 samples had no drain present (9.16 %). These figures are represented in Charts 5.2.13 and 5.2.14 below.



	None	Inactive	Semi Active	Active
🟥 Unplanted	40	39	16	23
🟩 Planted/Felled	37	361	212	113

Chart 5.2.13: Drainage Activity Presence



	None	Inactive	Semi Active	Active
🟥 Unplanted	4.76	4.64	1.90	2.73
🟩 Planted/Felled	4.40	42.93	25.21	13.44

Chart 5.2.14: Drain activity within samples (% of Samples)

5.2.14 Presence or Absence of Herbivore Impacts

The peat study area has a natural population of roe (*Capreolus capreolus*) and red deer (*Cervus elaphus scoticus*) and evidence of their presence was noted throughout the peat study area through incidental observations of deer faeces and prints recorded during survey work.

There is little data available on the local deer densities, however it is likely that the deer grazing in the peat study area is primarily limited to clearings, forest rides and areas of regenerating forestry.

During the survey period, no sheep were observed within the peat study area. It is likely that the effects of grazing within the peat study area are low with respect to the potential degrading effects that grazing can have on bog habitats.

6. DISCUSSION

The following section is split into two subsections: (1) peat depth analysis and, (2) information to inform an assessment of blanket mire condition.

6.1 Peat Depth Analysis

The peat depth analysis has the following Aim and related Objectives:

- **Aim 1 Gather high resolution peat depth data on a 100 m^2 systematic grid for the peat study area.**
    - Objective 1.1 Inform the layout of the proposed Development's infrastructure to help reduce impacts associated with blanket mire habitats; and
    - Objective 1.2 Provide peat depth data to: 1) inform the impact of the proposed Development on carbon losses arising from disturbance to peat-based habitats, and 2) inform a peat management plan for the Site.

6.1.1 Peat Depth and Types of Habitat and Vegetation

Section 5.1 of this report presents the results of the peat depth assessment for the peat study area, with regard to the types of habitat within the peat study area. The key results from the peat depth analysis are:

- 627 samples fell on land with more than 50 cm depth of peat – this equates to an area of 833.63 ha based upon sample distribution and the Inverse Distance Weighting depicting peat depths as a continuum;
- 214 samples fell on land with between 1 and 50 cm depth of peat – this equates to an area of 170.52 ha based upon sample distribution and the Inverse Distance Weighting depicting peat depths as a continuum;
- 41 samples fell on land with no peat equating to an area of 7.54 ha; and
- Mire habitats are dominant, widespread, with deeper peat areas found in the south west of the peat study area.

Land where peat depth is greater than 50 cm is classified as 'blanket bog' by SNH (MacDonald *et al*., 1998) and JNCC (JNCC, 2010); however, in reality many areas with a peat depth of less than 50 cm are still part of the wider hydrologically connected blanket bog, or macrotope. Peat based habitats with under 50 cm peat depth in this location can be classified as a number of habitats depending on the species present, including mires, heaths, acid and marshy grasslands.

Based on the above sample estimates, very broad habitat classifications based on peat depth and total extent of the peat study area, approximately 833.63 ha of the peat study area may be classified as having some form of underlying blanket mire habitat and 170.52 ha of non-mire peatland or organo-mineral habitats. The majority of these mires are planted over with commercial conifer plantation.

Finally, the following limitations to peat depth probing and analysis should be considered:

- 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 and/or saturated. This consideration will be mitigated as part of the Phase 2 peat probing and coring surveys, where the accuracy of peat depth probes will be assessed; and
- 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 above limitations associated with the method used to assess peat depth are not considered a significant factor and the data can be relied upon to inform the objectives of the Phase 1 peat survey.

6.2 Blanket Mire Condition

A definition and description of blanket mire is provided within Annex 1 of this report.

The information presented in this section is sufficient to inform the following Aim and related Objective:

- **Aim 2 Determine blanket mire condition within the mire assessment area.**
    - Objective 2.1 Inform the Ecological Impact Assessment on the condition of the blanket mire and to determine its status according to the Carbon and Peatland Map classifications.

6.2.1 Information to Inform the EIA Report on the Present Condition of Blanket Mire

The methods used to inform the present condition of the blanket mire habitats in the mire assessment area are outlined in Section 4.2. This methodology uses surface features such as species present, erosion and drains to determine the current condition of the mire.

The variables used to establish the present condition (condition indicators) of blanket mire within the mire assessment area are stated in Section 4.2. The results with respect to each of these variables, and their significance, are discussed in turn below.

6.2.2 Commercial Forestry

Figure 10.6-5 within this Technical Appendix illustrates the distribution of current and recently felled conifer plantation throughout the peat study area. The single largest factor affecting the condition of blanket mire in much of Scotland is often commercial forestry and the number of negative impacts this has on peatland habitats. This has been well documented by a number of authors (e.g. Pyatt *et al*., 1992; Anderson *et al*., 1995; Wheeler and Shaw, 1995; Brooks and Stoneman, 1997; Anderson *et al*., 2000; Wilkie and Mayhew, 2003; Holden *et al*., 2004). In summary, these effects include:

- lowering of the water table via installation of high-density drainage networks and ploughing (typically 0.5 m to 2 m between drains);
- lowering of the water table via evapotranspiration;
- increased peak flow runoff and lowered baseflow;
- peat subsidence caused by consolidation of the peat through both its thickness and shrinkage of the drained layer;
- modification of mire vegetation communities as a result of fertiliser application;
- loss of typical mire vegetation communities as a result of drying;
- loss of typical mire vegetation communities as a result of canopy closure; and
- erosion of peat as a result of subsidence, peat compression, vegetation loss and drying of the lower catotelmic peat layers.

Often the largest impact on the blanket mire is considered to be the damaging effects of the artificial drainage and the resulting lowering of the natural water table. The relative position of the water table within the peat ultimately controls the balance between accumulation and decomposition of peat. A lowering of the water-table permits the entry of oxygen into the formerly anaerobic catotelmic zone resulting in peat 'wastage' (via erosion) and/or microbial decomposition (Hobbs, 1986; Wheeler and Shaw, 1995).

Drainage and loss of vegetation can ultimately lead to the cessation of peat accumulation and the erosion of peat from a blanket mire complex. Furthermore, this can lead to blanket mires switching from carbon sinks to carbon sources as a result of increased oxidation of organic matter (Holden *et al*., 2004; Holden, 2005).

Mire vegetation communities are directly affected by decreases in the water table. The magnitude of effect will depend on the degree of water-table change. A small, but sustained reduction in water level in blanket mire is likely to cause a shift in species composition away from the natural hummock-hollow complex, towards those species normally associated with hummocks, with increases in species such as *Calluna vulgaris* and *Molinia caerulea* and possibly the invasion of tree species. A large sustained reduction in water levels is likely to lead to an eventual loss of many mire species together with loss of the original acrotelm and aeration of the upper catotelm peat. This ultimately results in a cessation of peat accumulation (Wheeler and Shaw, 1995).

Commercial forestry abutting open and unplanted peatland habitats can also have a negative impact on the mire resource. There may still be adverse effects on mire habitats as the effects of water drawdown from the trees and forestry drainage are not solely limited to the ground underneath plantation but also any adjacent hydrologically connected mire.

Commercial forestry within the peat study area is extensive and it is likely to have had an adverse effect on the blanket mire for the reasons detailed above and greatly impacted on the vegetation present. As the plantation is of a relatively mature age, the negative effects will likely have already caused degradation of the underlying blanket mire.

6.2.3 Distribution and Abundance of Sphagnum spp.

Sphagnum spp. are of great importance to the development and maintenance of many types of mire. They are often the major peat-producing species due to their high resistance to decomposer microbes (Lindsay, 1995) and they also help to create the characteristically acidic environment of mires (Clymo, 1963). *Sphagnum* also contribute to the regulation of the water balance of a mire's surface, through the storage of water, a 'mulching' effect during dry periods and a capacity for 'bleaching' when drought-stressed, which helps to reflect solar radiation (Wheeler and Shaw, 1995).

Sphagnum species are adapted to various ecological niches, particularly in relation to the water table; *S. capillifolium* commonly grows some way above the water table, *S. papillosum* and *S. magellanicum* grow just above the water table, and species such as *S. cuspidatum* usually grow in the water or close to it (Clymo, 1983). *S. papillosum* is the least resistant to desiccation (Clymo, 1997).

The mean % of *Sphagnum* per quadrat in unplanted habitats was 23.84 % and 12.66 % in planted/felled habitats in mire areas and was considered low-moderate in abundance. There are areas with slightly higher *Sphagnum* abundance and these areas correspond closely with the areas of deeper mire, which were often also noticeably wetter and of relatively better quality.

The most common *Sphagnum* species in the mire assessment area is *S. fallax*, followed by *S. palustre* and *S. capillifolium*. *S. fallax* is commonplace where there has been some form of ground disturbance and impacts on the mire and its prevalence as the most prominent *Sphagnum* species indicates a degree of disturbance to the mire. *S. palustre* is commonly found in acid mires, however is scarce in bogs, which may indicate drier conditions within the Site. *S. capillifolium* being common within the mire assessment area is an indicator of drier mire habitat due to its tolerance to drier conditions and a lower water table than other *Sphagnum*'s, in particular the broad-branched species.

The adverse effects of commercial plantation within the Site, such as drainage, are likely to have influenced *Sphagnum* spp. composition and abundance in the mire assessment area.

6.2.4 Distribution and Presence of Sphagnum magellanicum and Sphagnum papillosum

S. magellanicum and *S. papillosum* are indicative of better-quality mire habitat due to their low tolerance to dry conditions and requirement to be close to the water table throughout the year (see above). They are also good peat forming species.

S. magellanicum was not recorded within the mire assessment area and *S. papillosum* was found at only 9 sample locations (1.07 %). The low incidence of these species in the mire assessment area limits the patterns that can be inferred in relation to their distribution, nonetheless they are usually indicative of small areas of relatively intact, deep and wet mire habitat.

However, overall the presence of broad-branched *Sphagnum* throughout the Site in both planted/felled and unplanted habitats is very low and this would indicate the mire is generally in relatively poor condition as the water table may have lowered and the conditions to sustain these species have been altered or lost. The causes of this alteration or loss can include drainage, overgrazing, topography, and altitude. The largest contributing factor for the low cover of these species is likely the effects of the extensive land use for commercial forestry, and the associated loss and shading of surface vegetation and disruption and lowering of the local water table.

6.2.5 Distribution and Abundance of Non-Sphagnum Mosses and Lichen

As drying and degradation of mire areas increases through various processes such as drainage, evapotranspiration, cutting-over, heavy grazing and erosion, Non-*Sphagnum* mosses such as *Pleurozium schreberi, Hylocomium splendens*, *Polytrichum* spp., *Rhytidiadelphus* spp. and *Hypnum* spp. generally become more dominant in mire habitats; as do *Cladonia* spp. lichens.

The abundance of Non-*Sphagnum* Mosses and Lichens is high throughout the mire assessment area, which indicates a dry mire surface or increased drying in areas. The mean % cover of Non-*Sphagnum* Mosses and Lichens across all habitats was 40.45 %, indicating they comprise a larger proportion of the basal cover of the mire surface than *Sphagnum* mosses (14.23 %).

Due to the disturbance and drying effects of commercial forestry on the Site, highly tolerant and fast colonising species of Non-*sphagnum* moss and lichen are likely to have established opportunistically throughout the Site. This vegetation group also encompasses many species and therefore the likelihood of being recorded at any given sampling point is high.

6.2.6 Distribution and Abundance of Polytrichum commune

As detailed in the previous text, species included in the genus *Polytrichum* can become increasingly dominant in areas of disturbed, modified and degraded mire compared to more sensitive mire species, such as *Sphagnum* spp. The most common of the *Polytrichum* mosses is *P. commune* (common haircap), which is an obvious, distinctive moss that grows in hummocks on a wide range of moist, acidic habitats. This species is tolerant to moderate amounts of pollution and eutrophication, and can be used to indicate disturbed mire, particularly after burning events.

The abundance of *P. commune* within the mire assessment area was generally low, with some patches of higher abundances, and was recorded at 29.25 % of all sampling locations (Figure 10.6.9 within this Technical Appendix). Where *P. commune* was recorded, such locations may indicate a degree of disturbance to the mire caused by the commercial forestry operations within the Site.

6.2.7 Distribution and Abundance of Calluna vulgaris

Calluna vulgaris (common heather) is a major component of many NVC mire types (e.g. M17, M18, and M19), wet heath (M15, M16) and most dry heaths (see Rodwell *et al*., 1991).

Figure 10.6-10 within this Technical Appendix shows the percentage cover of *C. vulgaris* is low throughout the mire assessment area and was recorded at 18.66 % of all sampling locations. The distribution of *C. vulgaris* was concentrated more in the south and west of the mire assessment area. *C. vulgaris* abundance can be limited by planting over, shading, disturbance, grazing pressure and the encroachment and co-abundance of other species present.

6.2.8 Distribution and Abundance of Other Dwarf Shrubs

The vegetation group 'other dwarf shrubs' encompasses species from woody stemmed dwarf shrubs, including species from the genera *Erica* spp., *Vaccinium* spp., and *Empetrum* spp. Many of the species in these groups are typically also associated with peaty habitats, including in particular blanket bog and wet heath.

Other dwarf shrubs were recorded at 21.28 % of all sample points indicating a low-moderate distribution throughout the mire assessment area. Additionally, the mean abundance within sample quadrats across all habitats was low (2.34 %) and may suggest a general loss of such species due to the effects of conifer plantation.

6.2.9 Distribution and Abundance of Eriophorum vaginatum

Eriophorum vaginatum (hare's tail cotton grass) is a key species of blanket mire communities, particularly M17 - M20 NVC types (Rodwell *et al*., 1991; JNCC, 2009).

The abundance of *E. vaginatum* throughout the mire assessment area is low and while presence was recorded throughout the Site at 16.05 % of samples, typically these were associated with areas of deeper peat in the south and west of the Site.

The management of the Site for forestry will have reduced the habitat suitability for *E. vaginatum*. As the plantation matures, the drying of the substrate and enclosure of the canopy will further decrease the abundance of *E. vaginatum* within and around the plantation area.

6.2.10 Distribution and Abundance of Molinia caerulea

Molinia caerulea (purple moor-grass) is the key species of NVC type M25 mire and is often very common in M15 wet heath. It is the main constituent of vegetation communities found on moist, but well aerated acid to neutral peats and peaty mineral soils, which have relatively free movement of water through the upper horizons (Rodwell *et al*., 1991).

The abundance of *M. caerulea* in the mire assessment area is low-moderate and was recorded more frequently in unplanted habitats (Figure 10.6-13 within this Technical Appendix). The surface vegetation loss and shadowing effects of plantation are likely to limit *M. caerulea* from large areas in the Site, whereas the effects of drainage are likely to encourage the proliferation of *M. caerulea* in areas that would normally contain other types of blanket mire vegetation; as observed through the abundance of *M. caerulea* within forestry rides and as reported in Technical Appendix 8.1.

In instances where *M. caerulea* has been recorded in higher abundances over other typical mire species in peatland areas this may indicate that the upper peat horizons may have been aerated by ground disturbance; indicating that the mire surface is drying.

6.2.11 Distribution and Abundance of Juncus spp.

The genus *Juncus* encompasses distinctive, common species of rush including hard rush (*J. inflexus*), sharp-flowered rush (*J. acutiflorus*), jointed rush (*J. articulatus*), and soft rush (*J. effusus*). While all of these species are common in most damp/wet soils, *J. effusus* can be used to indicate disturbed habitats caused by felling, track/verge construction and grazing.

The abundance of *Juncus* spp. in the mire samples is generally low-moderate throughout the mire assessment area, with an increased abundance noted in the central section of the Site. The shadowing and draining effects of the plantation are likely to limit *Juncus* spp. from large areas in the Site.

The presence of *Juncus* spp. on unplanted habitat may indicate the increased presence of rush-mires (e.g. NVC type M23) rather than typical blanket mires (e.g. NVC types M17-M20).

6.2.12 Distribution and Abundance of Other Vascular Plants

Other vascular plants are distributed relatively moderately throughout the mire assessment area, however, despite this vegetation group encompassing many species the mean abundance per quadrat sample within the Site is typically low. This may be due to the competition effects caused by shadowing from dense forestry canopy. Other vascular plant cover is greater in unplanted habitats (14.22 %).

Where conditions enable other vascular plants are allowed to dominate, the resulting effect may impact on the coverage of basal layer species, reducing the percentage coverage of *Sphagnum* and Non-*Sphagnum* mosses. Some other vascular plants (e.g. grass species) are usually expected within a mire habitat, however, higher dominance of certain species within this group tends to indicate poorer conditions within the mire.

6.2.13 Distribution and Abundance of Bare Ground/Conifer Needles

The amount of bare ground can be an indication as to the condition of the mire. Bare ground is undesirable as it allows oxidation and wastage of the peat and it is easier for the erosional forces of wind, rain and temperature to have an impact. It also means surface vegetation has been lost and the first species to disappear are often the major peat forming species such as *Sphagnum* mosses. Therefore, the occurrence of bare peat can imply certain areas will no longer be peat forming.

Similarly, a high abundance of conifer needles can cause blanketing of the forest floor, causing a loss of surface vegetation including peat forming species. A high abundance of conifer needles is indicative of a mature, dense forest that is likely degrading the condition of the underlying peat.

Bare ground/needle abundance was high in planted/felled habitats, largely due to much of the forested areas containing a dense needle layer, as described above, and the exposure of bare ground in clear-felled areas. In unplanted habitats, the abundance of bare ground was very low, highlighting that some areas of unplanted mire may still be active.

6.2.14 Presence or Absence of Peat Erosion

No records of peat erosion were recorded in the mire assessment area. However, as previously stated, the unplanted habitats within the Site have still been subject to indirect effects from extensive conifer plantation.

Similarly, hagging and peat erosion is typically associated with open, unplanted peat habitats that have been subject to modification for the purposes of land management for grazing and shooting. The vast areas of conifer plantation are likely causing degradation through drying and drainage, rather than the promotion of peat erosion.

6.2.15 Drainage Activity

As explained in preceding sections, the drainage of blanket mire habitat can have significant adverse effects on its condition and the flora present – ultimately leading to cessation of peat forming and erosion of the mire. The impacts of drains are not limited to the immediate vicinity of the drain but can have much wider reaching influences on water movement and drainage of the peatland.

Drainage structures were highly abundant in the mire assessment area, and more dominant in planted/felled habitats, where extensive furrow and drain networks are present.

47.56 % of recorded drains (n = 400) were deemed inactive, however these may still act as transport for water under particularly high rain conditions, and may have historically been highly active prior to modification of surrounding topography and maturation of conifer plantations.

43.28 % of recorded drains (n = 364) were deemed to be semi/fully active. These drains represent 41.26 % of the total sample points (n = 882) within the mire assessment area, highlighting the extensive drainage capacity present within the Site.

It is likely that the drainage features, particularly within planted/felled habitats are contributing considerably to the lowering of the water table, to the consequent degradation of mire and key species of peat forming vegetation.

6.2.16 Presence or Absence of Herbivore Impacts

High densities of sheep, cattle or deer can result in reductions in plant species diversity and a loss of plant cover, the loss of the acrotelm and subsequent bare surfaces and peat erosion for the catotelm (MacGowan, 2002; Holden *et al.*, 2004). Heavy trampling and poaching can also expose underlying peat that can lead further to its aeration and wastage.

Incidental records of deer field signs were evident within the peat study area. No sheep were recorded in the peat study area. The grazing pressures and associated movements and impacts of herbivores over the peat study area have the potential to impact negatively on the condition of the mire, however, the presumed low densities of herbivores within the Site are unlikely to contribute high levels of degradation relative to the forestry on Site.

The health of the mire may become worsened in circumstances where localised deer densities increase or are maintained at high levels. In the absence of any dedicated surveys to establish the current grazing pressure present within the peat study area, no statistical inferences can be made on the current grazing regime and associated effects on the mire.

6.2.17 Conclusions of the Condition Assessment

In summary, the key conclusions of the condition assessment above are as follows:

- *Sphagnum* abundance is generally low-moderate and distributed more so in the west and south of the Site compared to the north and east;
- good, peat forming, broad branched, *Sphagnum* species are scarce within the mire but can indicate small areas of better quality, wetter mire;
- the most common *Sphagnum* species are *S. fallax, S. palustre,* and *S. capillifolium,* indicating the relatively dry and disturbed nature of much of the mire, as these species are more resistant to drying out;
- Non-*Sphagnum* mosses and lichen abundance is high within the mire assessment indicating drier and disturbed conditions. Additionally, *Polytrichum commune* was recorded in some areas supporting further evidence of disturbance to the mire;
- *Calluna vulgaris* abundance is low within the mire assessment area, which may highlight the effects of disturbance. *C. vulgaris* distribution is concentrated more in the west and south of the Site and is correlated with *Eriophorum vaginatum*, which is also found in these areas;
- Other dwarf shrubs are widespread but have a low abundance across the mire assessment area, potentially highlighting effects of plantation and shading;
- the bog indicator species, *Eriophorum vaginatum,* is low in abundance within the mire assessment area, but correlates positively in areas with deeper peat;
- *Molinia caerulea* abundance is low-moderate across the mire assessment area, but more commonly recorded in unplanted habitats and may indicate surface aeration and drying of the mire;
- patches of bare ground/needles within the planted/felled habitats was high, highlighting the effects of canopy closure and needle blanketing on the forest floor;
- peat erosion is low across the mire assessment area; however, it is likely that the traditional land management practices promoting extensive erosion have not occurred recently within the Site; and
- Drainage structures were present throughout the area but particularly in planted/felled habitats where extensive furrow/drain networks are present.

7. REFERENCES

Anderson, A.R., Pyatt, D.G., and White I.M.S. (1995). Impacts of conifer plantations on blanket bogs and prospects of restoration. In Wheeler, B.D., Shaw, S.C., Fojt, W., and Robertson, R.A. (Eds) *The restoration of temperate wetlands*. John Wiley & Sons, Chichester, 533-548.

Anderson, A.R., Ray, D., and Pyatt, D.G. (2000). Physical and hydrological impacts of blanket bog afforestation at Bad a' Cheo, Caithness: the first 5 years. *Forestry* 73, 467-478.

Brooks, S., and Stoneman, R. (1997). Tree Removal at Langlands Moss. In Parkyn, L., Stoneman, R.E. and Ingram, H.A.P. (Eds) *Conserving Peatlands*. CAB International, Wallingford, 315-322.

Childs, C (2004). *Interpolating Surfaces in Arc GIS Spatial Analyst*. ArcUser. www.esri.com.

Clymo, R.S. (1963). Ion exchange in Sphagnum and its relation to bog ecology. *Annals of Botany*, New Series, 27, 309-324.

Clymo, R.S., & Reddaway, E.J.F. (1971). Productivity of Sphagnum (bog-moss) and peat accumulation. *Hydrobiologia*, 12, 181-192.

Clymo, R.S. (1983). Peat. In Gore, A.J.P. (Ed) *Ecosystems of the World 4A Mires: Swamp, Bog, Fen and Moor*. Elsevier, Oxford, 159-224.

Clymo, R.S. (1997). The Roles of *Sphagnum* in Peatlands. In Parkyn, L., Stoneman, R.E. and Ingram, H.A.P. (Eds) *Conserving Peatlands*. CAB International, Wallingford, 95-102.

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.

Holden, J. (2005). Peatland hydrology and carbon release: why small-scale processes matter. *Philosophical Transactions of the Royal Society A* 363; 2891-2913.

Holden, J., Chapman, P.J., and Labadz, J.C. (2004). Artificial drainage of peatlands: hydrological and hydrochemical process and wetland restoration. *Progress in Physical Geography* 28 (1); 95-123.

Joosten, H. & Clarke, D. (2002). *Wise use of Mires and Peatlands – Background and Principles Including a Framework for Decision-Making*. International Mire Conservation Group & International Peat Society.

JNCC (2009). *Common Standards Monitoring for Upland Habitats*. ISSN 1743-8160 (online).

JNCC (2010). *Handbook for Phase 1 Habitat Survey*, Joint Nature Conservation Committee, Peterborough.

Lindsay, R. (1995). *Bogs: The Ecology, Classification and Conservation of Ombrotrophic Mires*. SNH, Battleby, Perth.

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.

MacGowan, F. (2002). *Overgrazing, cutting and trampling and their effects on the ecology of bogs*. Irish Peatland Conservation Council Information Sheet.

Pyatt, D. G., John, A. L., Anderson, A. R. and White, I. M. S. (1992). The drying of blanket peatland by 20-year-old conifer plantations at Rumster Forest, Caithness. In *Peatland ecosystems and man: an impact assessment*, edited by O. M. Bragg, P. D. Hulme, H. A. P. Ingram and R. A. Robertson. Department of Biological Sciences, University of Dundee.

Rodwell, J.S. (Ed), et al. (1991). *British Plant Communities Volume 2; Mires and Heaths*. Cambridge, Cambridge University Press.

Scottish Government, Scottish Natural Heritage, SEPA. (2017). *Peatland Survey. Guidance on Developments on Peatland*. http://www.gov.scot/Resource/0051/00517174.pdf

Scottish Natural Heritage (2016). *Carbon and Peatland 2016 map*. Accessed Online [https://gateway.snh.gov.uk/natural-spaces/dataset.jsp?dsid=PEAT]

Scottish Renewables and Scottish Environmental Protection Agency (2012). *Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste*.

Wheeler, B.D., and Shaw, S.C. (1995). *Restoration of Damaged Peatlands*. Department of the Environment. HMSO, London.

Wilkie, N.M., and Mayhew, P.W. (2003). The Management and Restoration of Damaged Blanket Bog in the north of Scotland. *Botanical Journal of Scotland* 55 (1); 125-133.

ANNEX 1 DEFINITION OF BLANKET MIRE

The definition of 'blanket mire' habitat is used within this report to refer to blanket peat systems in aggregate. This includes both pure ombrogenous blanket bogs, which receive their water input solely from rain water, and minerotrophic peatlands. Minerotrophic peatlands receive their water input from a mixture of sources comprising ombrogenous, topogenous[2] and soligenous[3] inputs.

The primary **conditions essential for blanket mire habitat to establish** is regularity of water supply and persistence of saturated conditions (Lindsay, 1995. P11., Wheeler, 1995. P2). These conditions are achieved through inputs of water exceeding outputs via seepage, evaporation and evapotranspiration. Inputs of water can arise from ombrogenous, topogenous or soligenous sources as detailed above. The type of peatland system and associated vegetation communities is dependent on the nature of the water supply (see Lindsay, 1995. P12 and Wheeler, 1995).

Persistent saturation creates the **ideal conditions for peat formation**, these comprise: (1) Low levels of available oxygen (Anoxic conditions), (2) Low pH (Acidic conditions), and (3) Low temperatures. These variables limit microbial activity and therefore the rate of decomposition in mires. This ultimately results in incompletely decomposed dead plant material building up over time. It is this incomplete decomposition and accumulation of organic matter which creates the 'carbon sink' properties of blanket mires (Joosten & Clarke, 2002. P25).

Peat accumulation can typically occur at a rate of approximately 0.02 to 0.08 cm per year (Hobbs, 1986) in 'active' blanket mire where this process of incomplete decomposition is occurring. However, Clymo and Reddaway (1971) recorded rates of up to 0.2 cm per year in *Sphagnum* dominated habitats. This higher rate of accumulation is a result of *Sphagnum's* high resistance to decomposer microbes (Lindsay, 1995. P12), this makes it a key species for peat accumulation.

Blanket mire habitat has a simple two-layer (diplotelmic) structure which is critical to its maintenance and continued development. The surface layer, called the acrotelm, is a thin protective layer of living vegetation and some underlying recently dead vegetation. This layer is usually no more than 20-30 cm deep and lies on top of a layer of peat (Wheeler and Shaw, 1995., Lindsay 2005. P16). The acrotelm serves a number of functions including (see Lindsay, 2005. P16):

- Protecting the underlying peat (catotelmic peat) from erosion and drying;
- Regulates water input and output from the blanket mire system; and
- Acts as the principle mechanism of water discharge from the system.

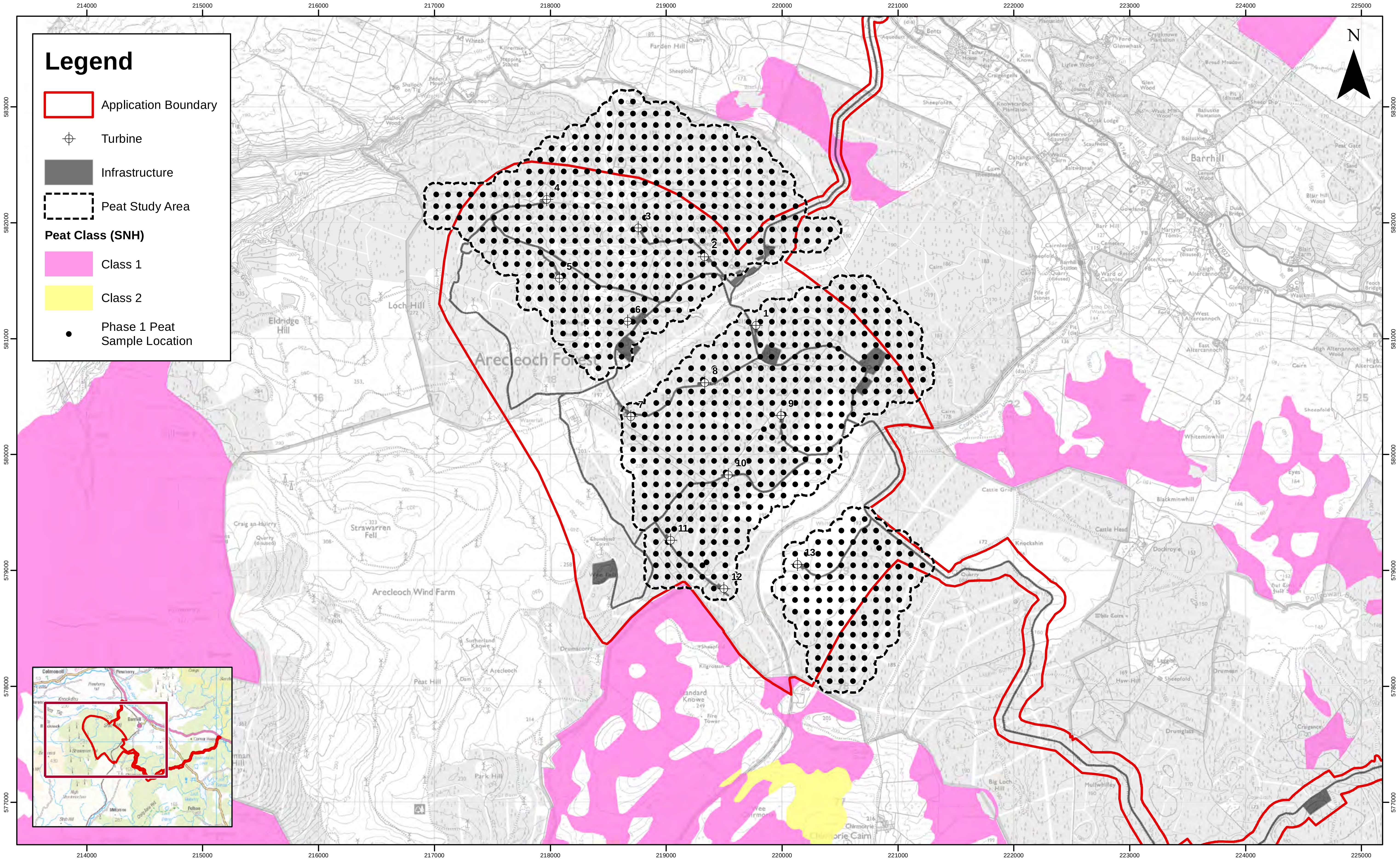
The underlying peat layer (or catotelm) also has a number of important functions:

- Sustaining nutrient poor conditions: It effectively separates the living vegetation in the acrotelm from the more mineral rich influence of the ground water table and underlying mineral sub-soil. This helps create nutrient poor conditions, which are more suitable for *Sphagnum* growth and peat accumulation;
- Water Regulation: It remains completely saturated and consequently water movement through the catotelm is extremely slow although some faster movement may occur through peat pipes (Holden, 2005).
- Maintenance of perched water table: Although catotelmic peat can exhibit some layered stratigraphy (Hobbs, 1986) it has a largely amorphous nature. This attribute, in additional to the water retaining attributes of dead *Sphagnum* remains, limits water release from the catotelm and helps to sustain a perched water table.

---

[2] Topogenous: 'topogenous mires depend on topographic conditions and are relatively independent of climate, because they "develop in terrestrialising lakes or river valleys, or at springs" (Joosten & Clarke, 2002. P41).

[3] 'In soligenous mires, peat formation is not only induced and continued by direct precipitation, but "also by meteoric water running off from the surrounding terrain" (Von Post & Granlund 1926)' (Joosten & Clarke, 2002. P41).



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:30,000
Scale @ A3

0 0.5 1 Km

© Crown Copyright 2019.
All rights reserved. Ordnance Survey Licence 0100031673.
Contains SNH information licensed under the Open Government Licence v3.0.

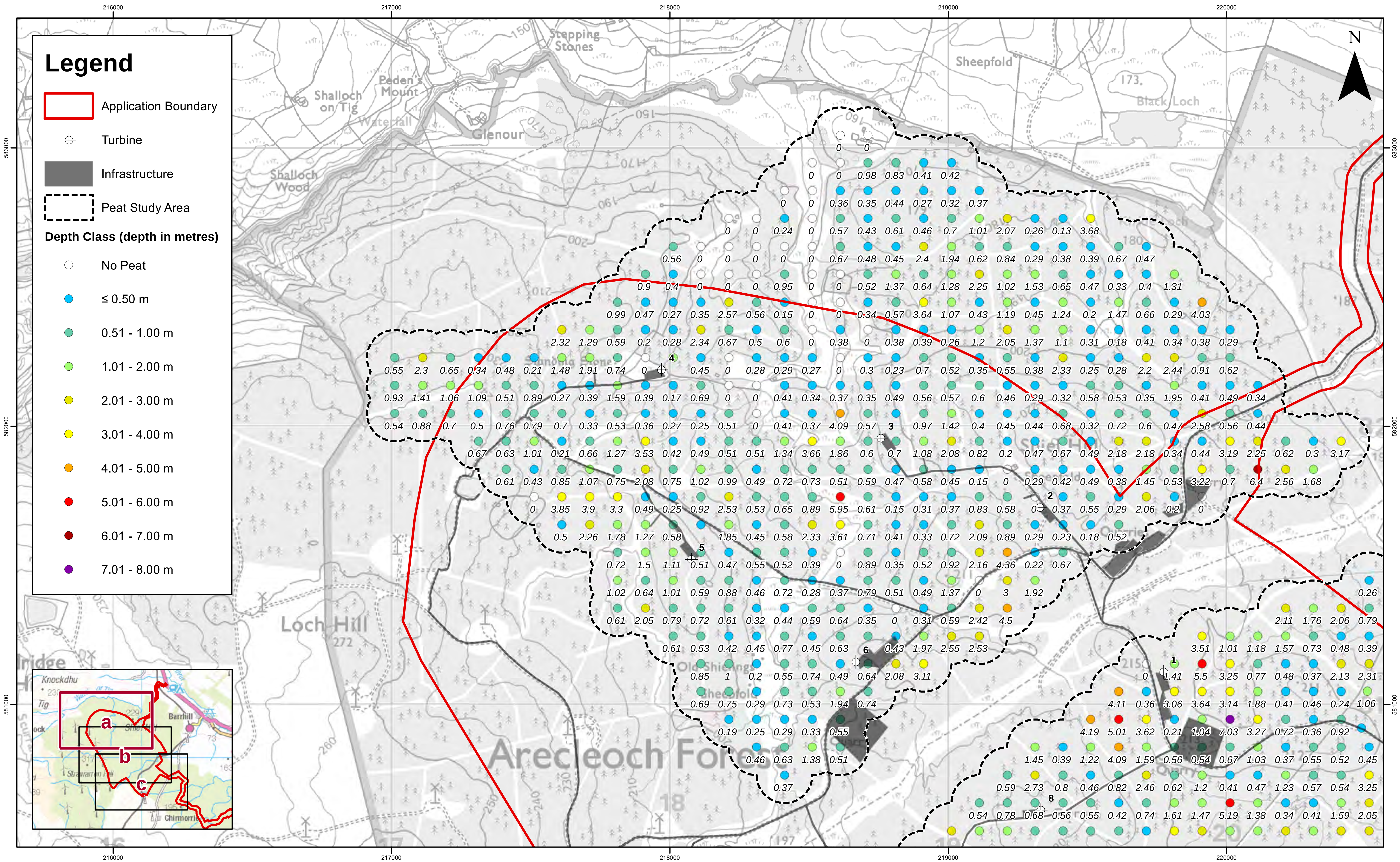
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Phase 1 Site Location, Sample Locations and Carbon/Peatland Class

Drg No	P_EIAR_Fig10.6.1_P1_SL_SL_CPC_ARE
Rev	B
Date	01/05/19
Figure	10.6-1

Datum: OSGB36
Projection: OSNG



B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.
Rev	Date	By	Comment

1:12,500
Scale @ A3

0 0.25 0.5 Km

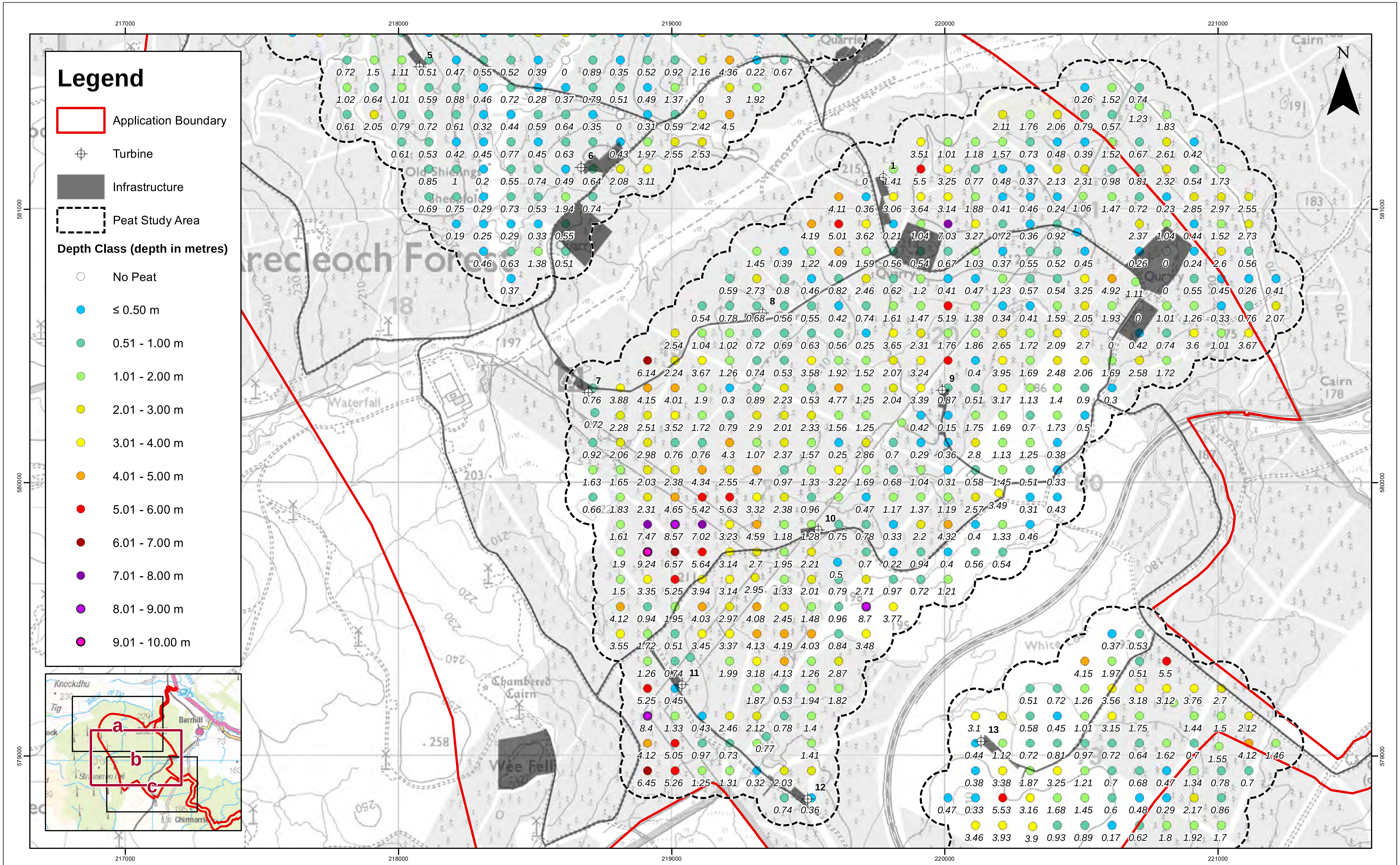
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Phase 1 Peat Depth Sample Locations

Drg No	P_EIAR_Fig10.6.2_P1_PDepth_ARE
Rev	B
Date	01/05/19
Figure	10.6-2a

Datum:
OSGB36
Projection:
OSNG



B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.
Rev	Date	By	Comment

1:12,500
Scale @ A3

0 0.25 0.5 Km

© Crown Copyright 2019.
All rights reserved. Ordnance Survey Licence 0100031673.

SCOTTISHPOWER RENEWABLES

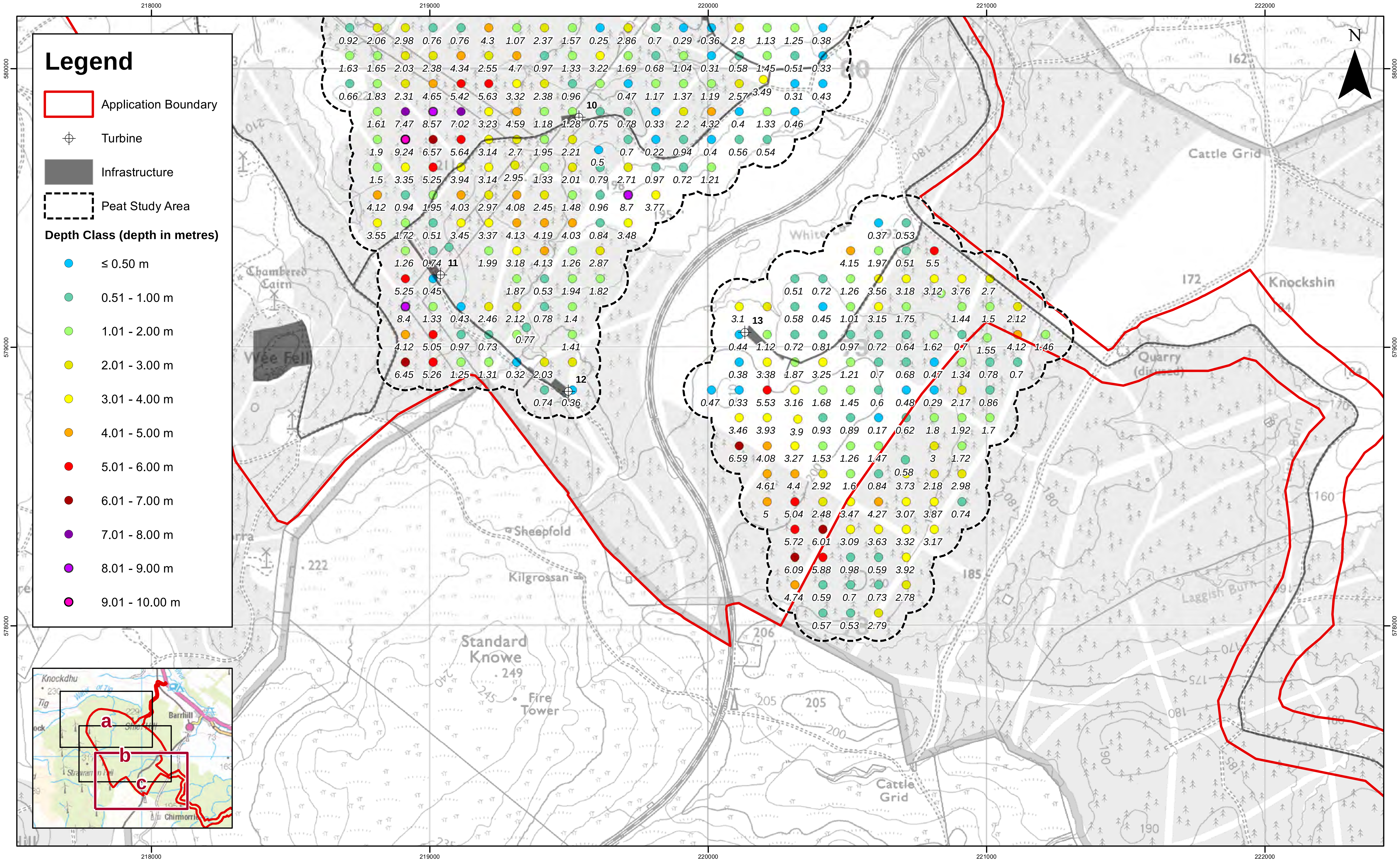
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Phase 1 Peat Depth Sample Locations

Drg No	P_EIAR_Fig10.6.2_P1_PDepth_ARE
Rev	B
Date	01/05/19
Figure	10.6-2b

Datum: OSGB36
Projection: OSNG



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

© Crown Copyright 2019.
All rights reserved. Ordnance Survey Licence 0100031673.

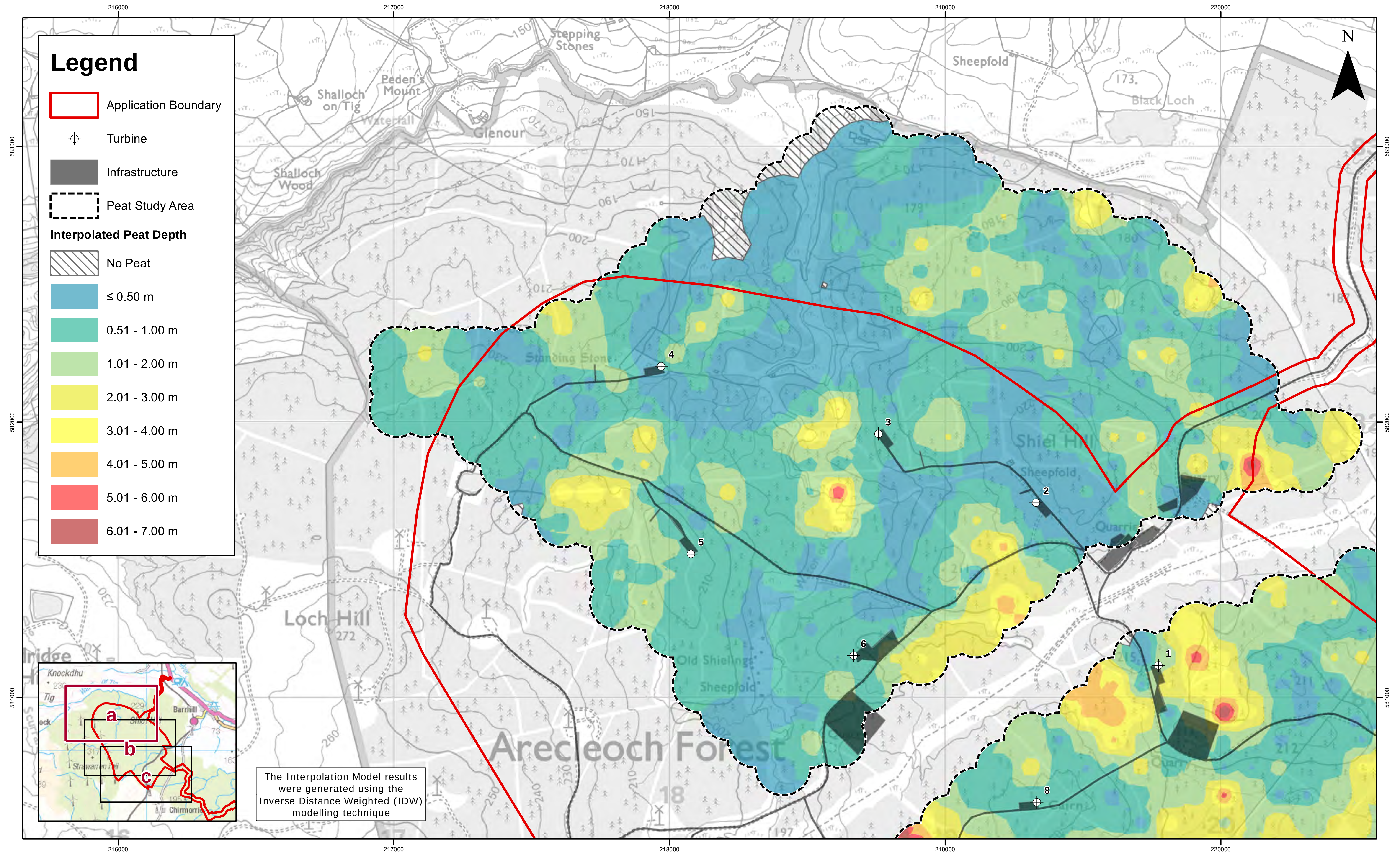
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Phase 1 Peat Depth Sample Locations

Drg No	P_EIAR_Fig10.6.2_P1_PDepth_ARE
Rev	B
Date	01/05/19
Figure	10.6-2c

Datum:
OSGB36
Projection:
OSNG



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

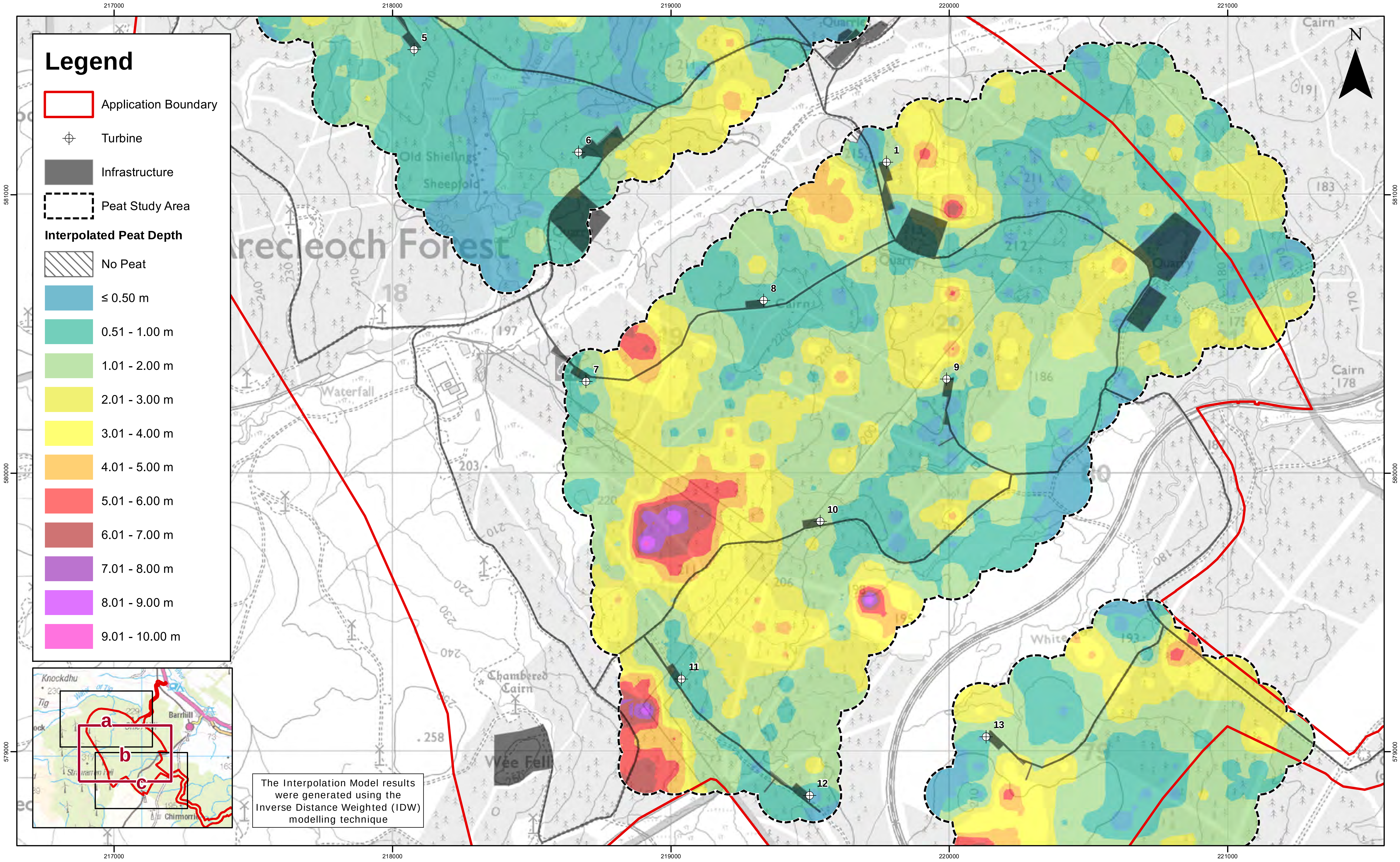
0 0.25 0.5 Km

Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Phase 1 Interpolated Peat Depth

Drg No P_EIAR_Fig10.6.3_P1_InterpolatedPDepth_ARE
Rev B
Date 01/05/19
Figure 10.6-3a
Datum: OSGB36
Projection: OSNG



Legend

- 🟥 Application Boundary
- ⌖ Turbine
- ⬛ Infrastructure
- ⬚ Peat Study Area

Interpolated Peat Depth

- ▨ No Peat
- ≤ 0.50 m
- 0.51 - 1.00 m
- 1.01 - 2.00 m
- 2.01 - 3.00 m
- 3.01 - 4.00 m
- 4.01 - 5.00 m
- 5.01 - 6.00 m
- 6.01 - 7.00 m
- 7.01 - 8.00 m
- 8.01 - 9.00 m
- 9.01 - 10.00 m

The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

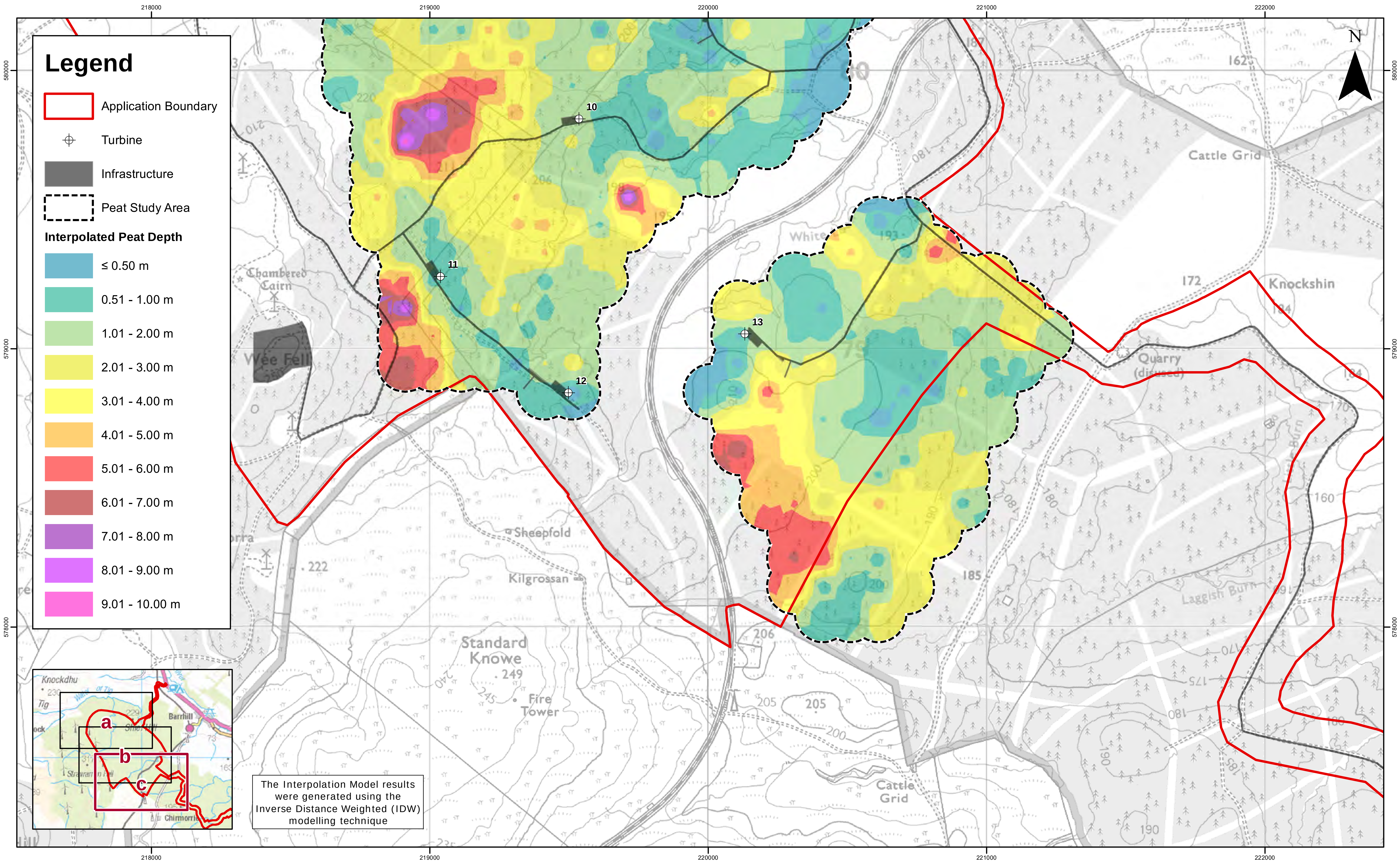
0 0.25 0.5 Km

Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Phase 1 Interpolated Peat Depth

Drg No	P_EIAR_Fig10.6.3_P1_InterpolatedPDepth_ARE	
Rev	B	Datum: OSGB36 Projection: OSNG
Date	01/05/19	
Figure	10.6-3b	



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

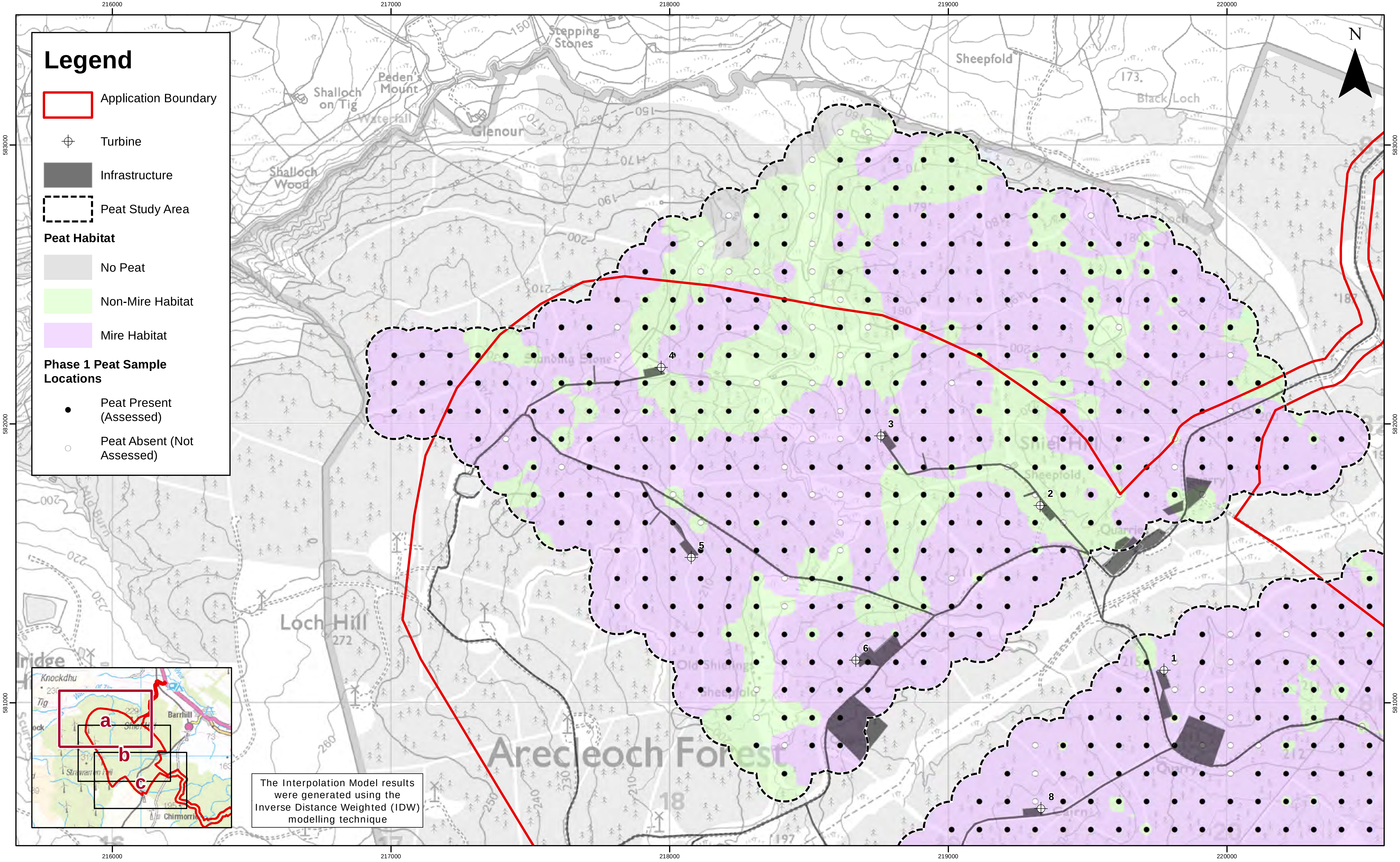
SCOTTISHPOWER RENEWABLES

Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Phase 1 Interpolated Peat Depth

Drg No P_EIAR_Fig10.6.3_P1_InterpolatedPDepth_ARE
Rev B
Date 01/05/19
Figure 10.6-3c
Datum: OSGB36
Projection: OSNG



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

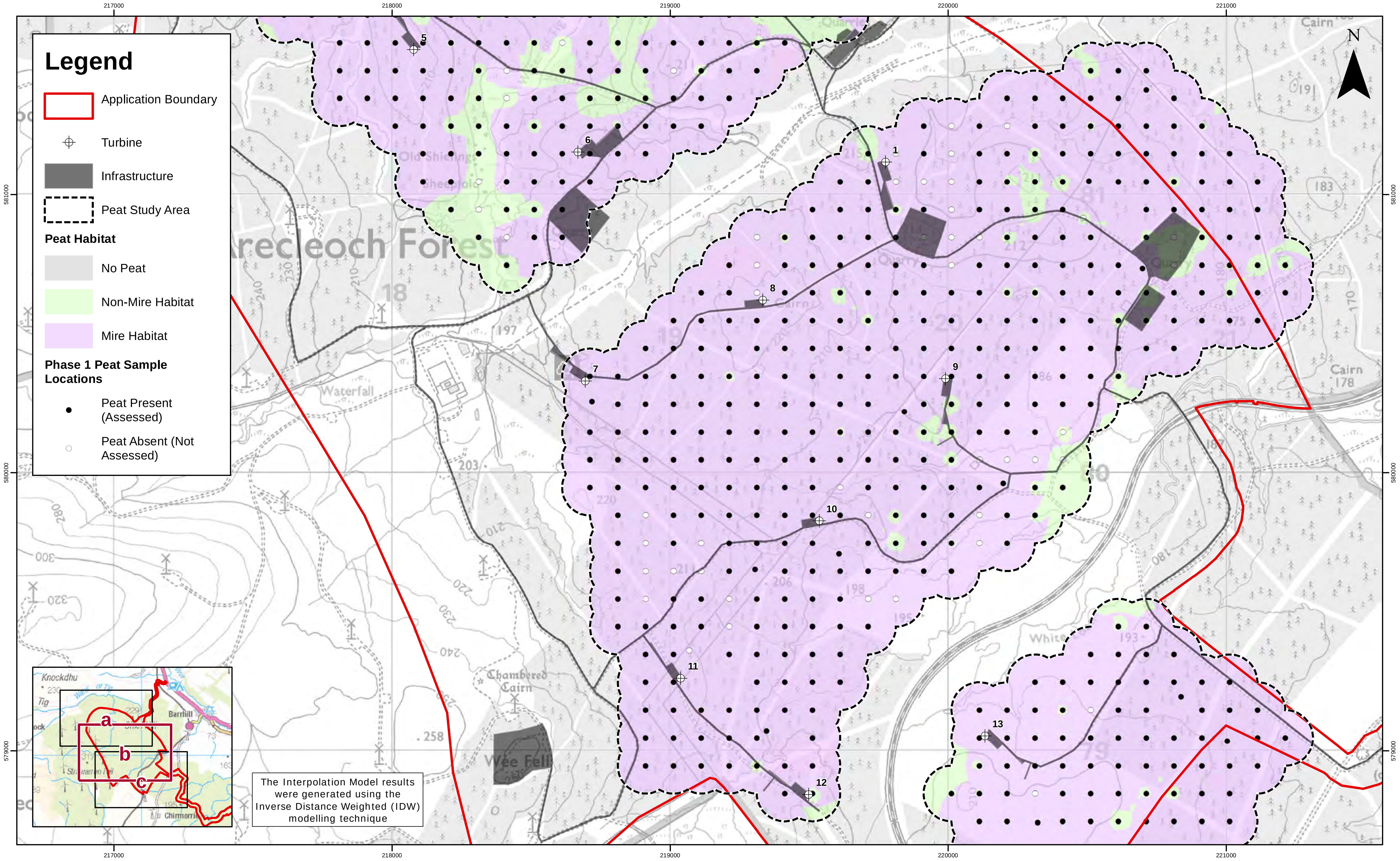
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Interpolated Peat Depth Mire and Non-Mire Habitats

Drg No	P_EIAR_Fig10.6.4_P1_Mire_NonMire_ARE
Rev	B
Date	01/05/19
Figure	10.6-4a

Datum:
OSGB36
Projection:
OSNG



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES					1:12,500 Scale @ A3
	B	01/05/19	ATA	Second Issue.	
	A	09/04/19	ATA	First Issue.	
	Rev	**Date**	**By**	**Comment**	

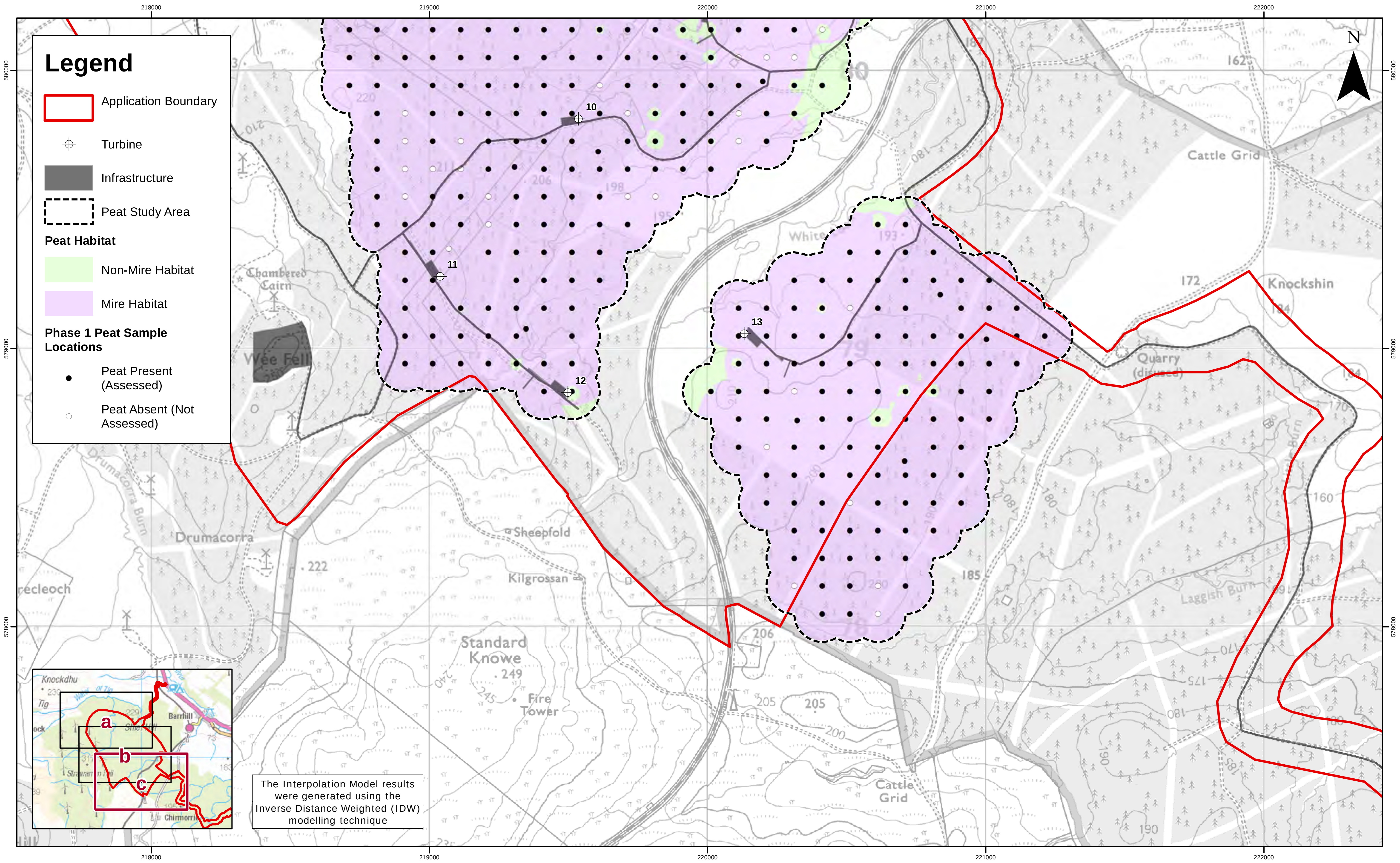
0 0.25 0.5 Km

Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Interpolated Peat Depth Mire and Non-Mire Habitats

Drg No	P_EIAR_Fig10.6.4_P1_Mire_NonMire_ARE	
Rev	B	Datum: OSGB36 Projection: OSNG
Date	01/05/19	
Figure	10.6-4b	



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

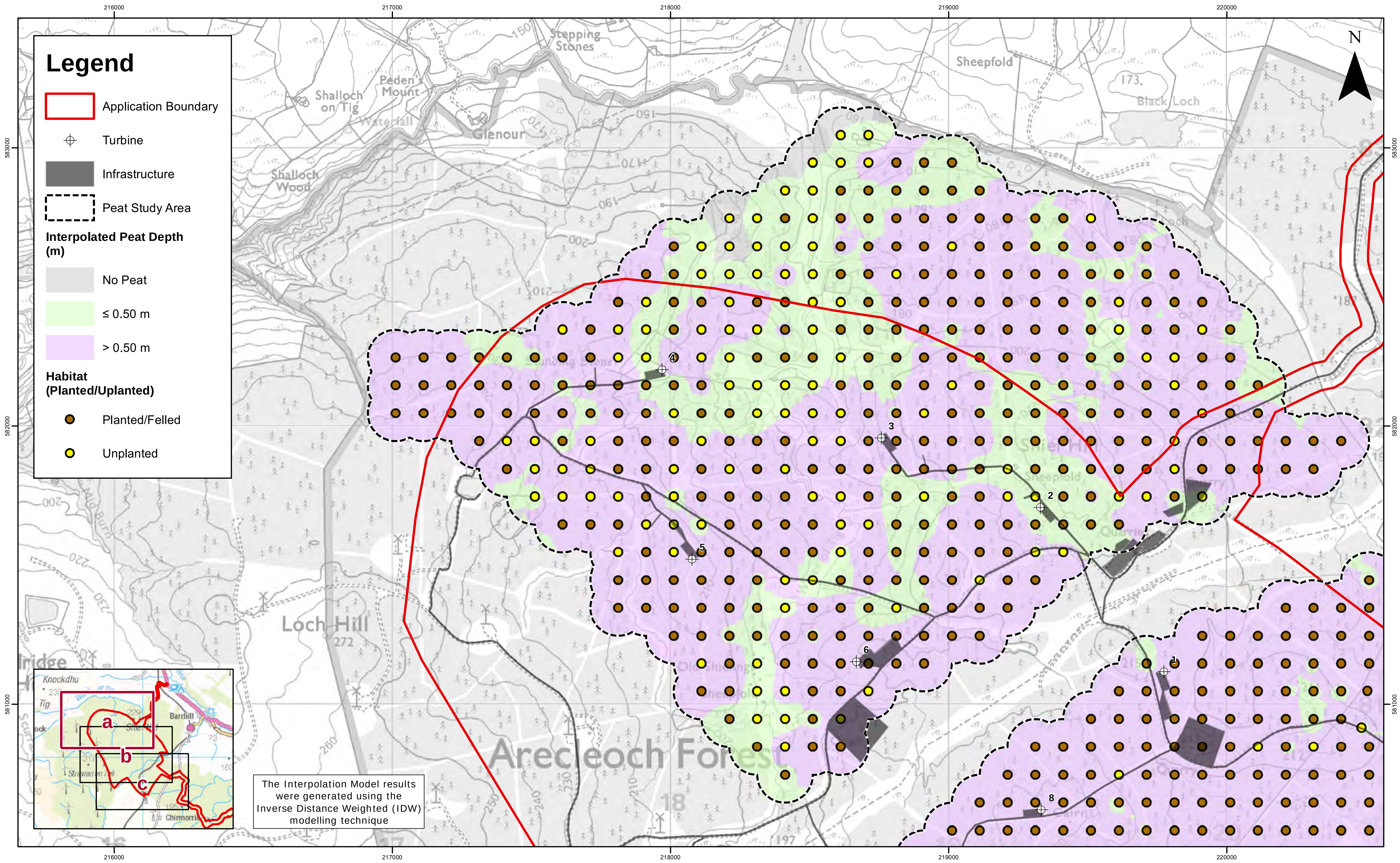
0 0.25 0.5 Km

Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Interpolated Peat Depth Mire and Non-Mire Habitats

Drg No P_EIAR_Fig10.6.4_P1_Mire_NonMire_ARE
Rev B
Date 01/05/19
Figure 10.6-4c
Datum: OSGB36
Projection: OSNG



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

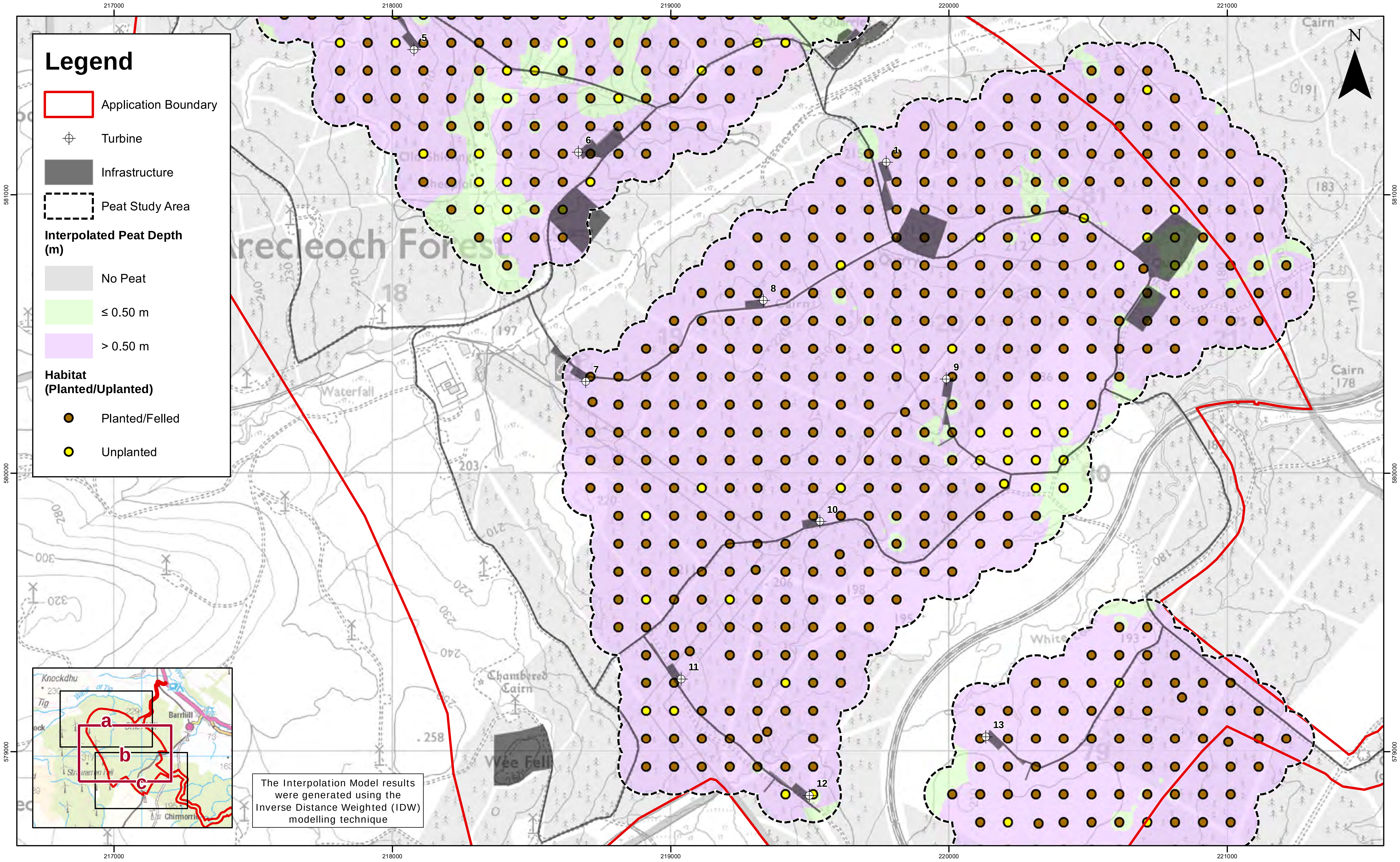
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Planted/Felled and Unplanted Habitat

Drg No	P_EIAR_Fig10.6.5_P1_Planted_Unplanted_ARE
Rev	B
Date	01/05/19
Figure	10.6-5a

Datum: OSGB36
Projection: OSNG



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER
RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

© Crown Copyright 2019.
All rights reserved. Ordnance Survey Licence 0100031673.

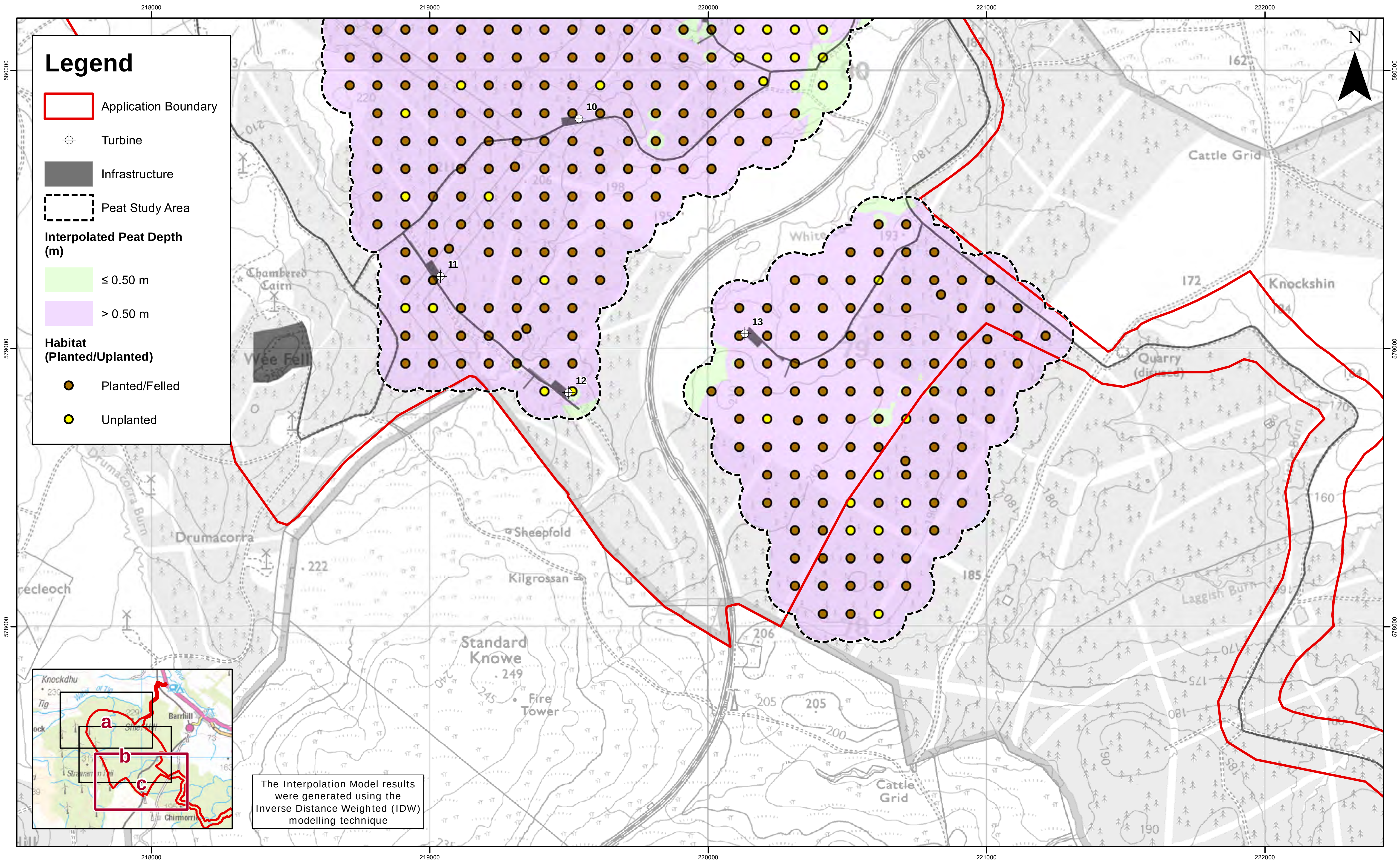
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Planted/Felled and Unplanted Habitat

Drg No	P_EIAR_Fig10.6.5_P1_Planted_Unplanted_ARE
Rev	B
Date	01/05/19
Figure	10.6-5b

Datum: OSGB36
Projection: OSNG



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

© Crown Copyright 2019.
All rights reserved. Ordnance Survey Licence 0100031673.

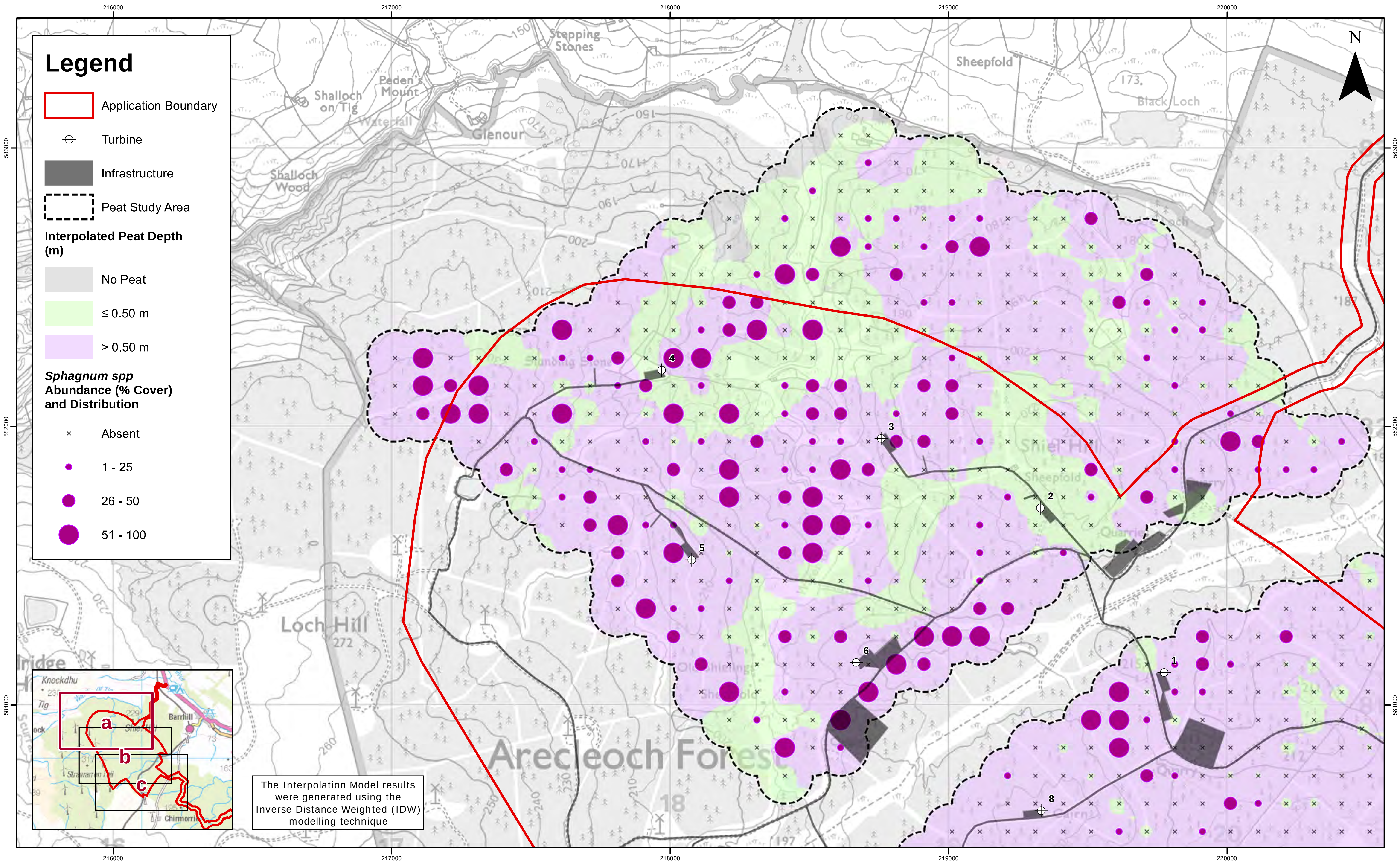
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Planted/Felled and Unplanted Habitat

Drg No	P_EIAR_Fig10.6.5_P1_Planted_Unplanted_ARE
Rev	B
Date	01/05/19
Figure	10.6-5c

Datum: OSGB36
Projection: OSNG



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

© Crown Copyright 2019.
All rights reserved. Ordnance Survey Licence 0100031673.

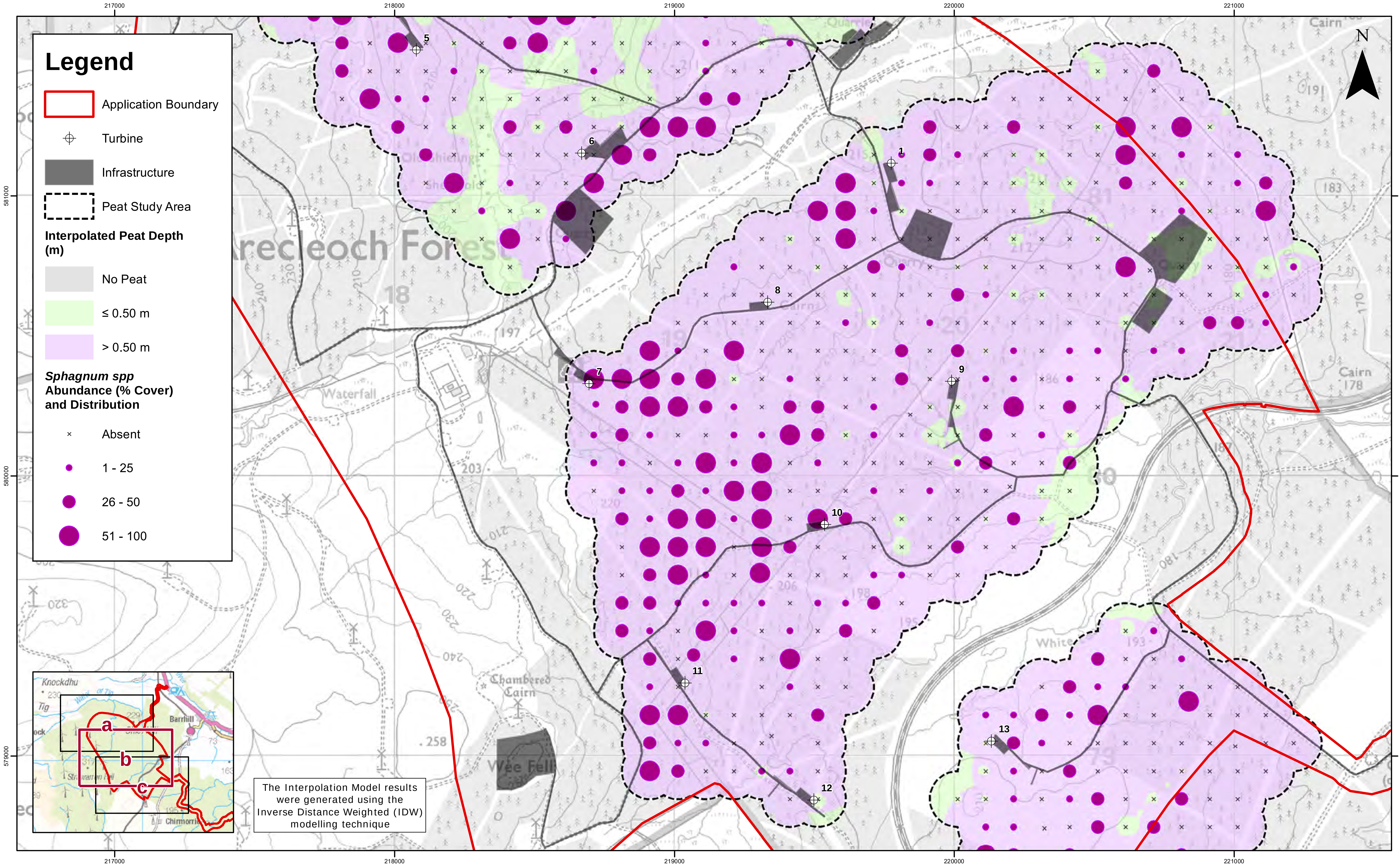
Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Sphagnum spp.
Abundance and Distribution

Drg No	P_EIAR_Fig10.6.6_P1_Sphagnum_AD_ARE
Rev	B
Date	01/05/19
Figure	10.6-6a

Datum: OSGB36
Projection: OSNG



Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

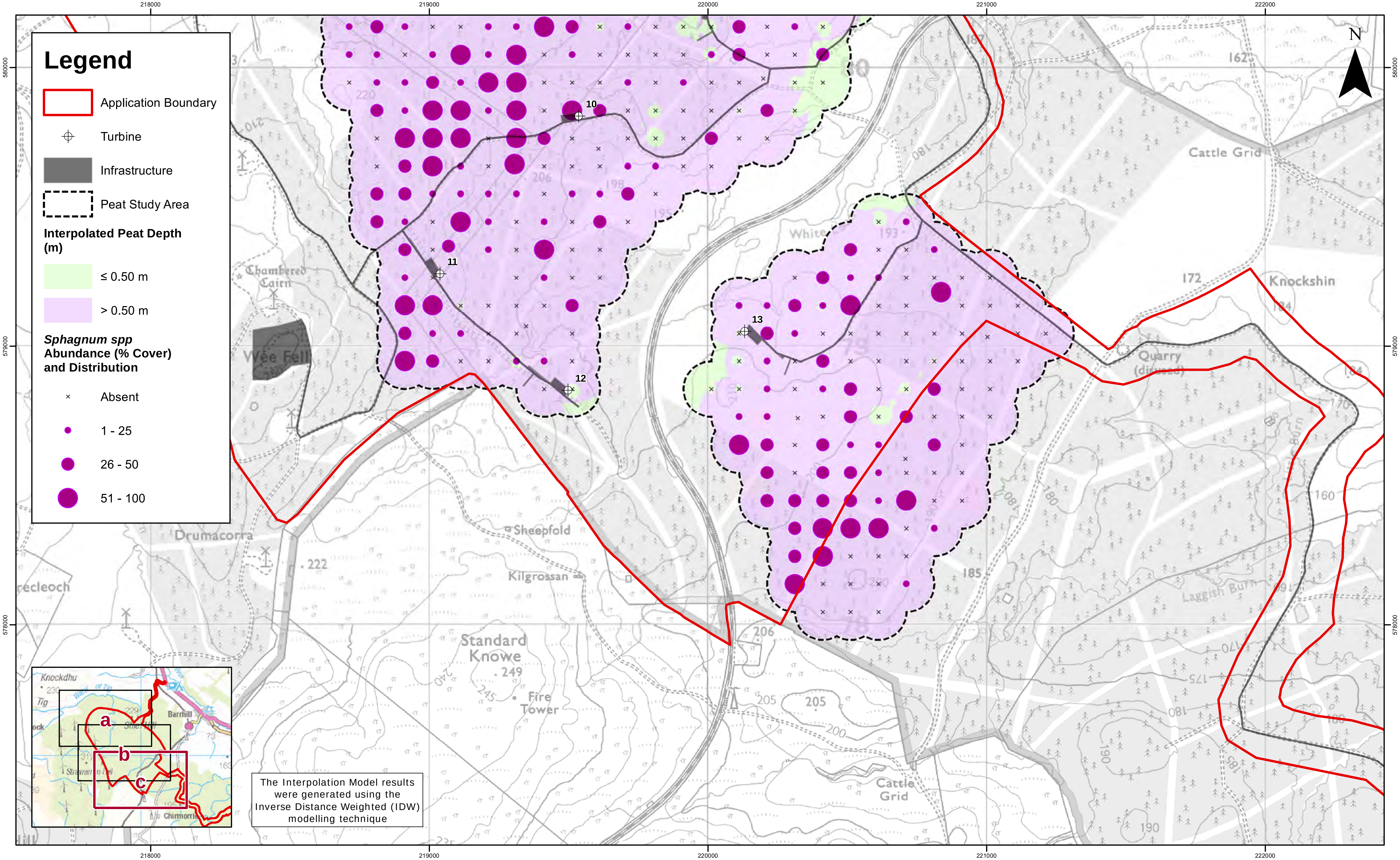
0 0.25 0.5 Km

Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Sphagnum spp.
Abundance and Distribution

Drg No P_EIAR_Fig10.6.6_P1_Sphagnum_AD_ARE
Rev B
Date 01/05/19
Figure 10.6-6b
Datum: OSGB36
Projection: OSNG



The Interpolation Model results were generated using the Inverse Distance Weighted (IDW) modelling technique

SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
B	01/05/19	ATA	Second Issue.
A	09/04/19	ATA	First Issue.

1:12,500
Scale @ A3

0 0.25 0.5 Km

Arecleoch Windfarm Extension

TA 10.6 Phase 1 Peat Depth and Mire Condition Survey Report

Sphagnum spp.
Abundance and Distribution

Drg No	P_EIAR_Fig10.6.6_P1_Sphagnum_AD_ARE
Rev	B
Date	01/05/19
Figure	10.6-6c

Datum:
OSGB36
Projection:
OSNG