Gordonbush Extension Wind Farm: Assessment of Fish Habitats and Populations

Commissioned Report to SSE Renewables Developments (UK) Ltd

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COMMISSIONED REPORT

Summary

Contractor: Waterside Ecology

Background

SSE Renewables Developments (UK) Ltd propose extending the operational Gordonbush Wind Farm by the addition of 16 turbines to be located to the south of the existing array. The site lies entirely within the catchment of the River Brora and is bounded by two watercourses: the Allt a' Mhuilinn to the west of the site and the Allt Smeorail to the east. Allt a' Mhuilinn flows into the River Brora at NC 827 106 while Allt Smeorail flows into Loch Brora at NC 844 093. Waterside Ecology was commissioned to carry out a survey of fish habitats and populations to inform the Environmental Statement for the Development.

A walkover habitat survey and an electric fishing survey of streams potentially affected by construction were carried out during early autumn 2014. The surveys extended well downstream of the wind farm site into stream reaches that might receive runoff from the site.

The objectives of the survey were to:

(i) Describe stream habitats in the various watercourses draining the site of the Development. In particular, to describe their suitability for the various fish species potentially present.

(ii) Identify the main obstacles to migration in the above streams, in particular the likely upper limits for the distribution of salmon, sea trout or loch trout.

(iii) Carry out an electric fishing survey to describe species composition and distribution within target watercourses. In particular, to confirm the distribution of migratory salmonids.

Main Findings

- Waterfalls and a dam restrict migratory salmonids to the lower 1.2 km of the Allt a' Mhuilinn, some 2 km downstream of the nearest proposed turbine. Salmon, trout, eels and brook lampreys were present in the accessible reaches. Salmon fry and parr densities were poor and moderate respectively based on regional standards described by Godfrey (2006). Trout fry and parr densities were good and very poor respectively.
- Brown trout were the only fish species present at electric fishing sites in the inaccessible reaches of Allt a' Mhuilinn. The stream provides long reaches of habitat that are suited to trout production. Electric fishing suggested that trout densities were low, possibly as a result of lack of good quality spawning habitat. The presence of trout in Allt nan Nathraichean is considered near-certain as stream habitats are suitable and there are no obstacles preventing access to this stream from Allt a' Mhuilinn.
- A waterfall restricts migratory salmonids to the lower 0.6 km of Allt Smeorail. Salmon, trout, eels and lampreys were present in the accessible reaches. Average salmon fry and parr densities were both excellent by regional standards. Average trout fry and parr densities in the accessible reaches were good and very poor respectively.
- Brown trout were present at all survey sites (n=3) in the Allt Smeorail catchment upstream of the waterfall. Trout parr density at the quantitative site was good, but fry density was poor. Densities at other sites, which were fished qualitatively, appeared low.
- The walkover habitat survey of the inaccessible reaches of Allt Smeorail found that substrate was mainly cobble and boulder. Smaller materials suitable for spawning were scarce and largely unstable. It seems likely that trout numbers may be limited by availability of spawning habitat.

- The Ristocky Burn and Badan Burn provide very poor quality habitat for trout and these streams may be fishless. Allt a' Breac-achaidh is suitable for trout and their presence was confirmed by electric fishing.

1 Introduction

1.1. Background

This report provides an assessment of fish habitats and populations in streams draining the site of the proposed Gordonbush Extension Wind Farm. The development site is located on the hills immediately to the north of the River Brora and Loch Brora (see Appendix 1). The site lies entirely within the catchment of the River Brora and is bounded by two watercourses: the Allt a' Mhuilinn to the west of the site and the Allt Smeorail to the east. Allt a' Mhuilinn flows into the River Brora at NC 827 106 while Allt Smeorail flows into Loch Brora at NC 844 093.

The River Brora has been identified as a salmonid water under the Freshwater Fish Directive (78/659/EEC) requiring certain, mainly chemical, standards to be met for quality of water. The objective of the fish survey was to provide information on the presence and distribution of fish species to inform the Environmental Statement (ES) for the Development. In their scoping response, Marine Scotland Science (MSS) requested that the potential downstream effects of construction on fish habitats and populations should be considered in the ES[1]. In particular, MSS raised concern over spawning gravels that might be used by Atlantic salmon.

1.2. Fish species potentially present

The River Brora sustains valuable fisheries and significant populations of Atlantic salmon (*Salmo salar)* and sea trout (*S. trutta*.) Interrogation of fish data through the National Biodiveristy Network (NBN) Gateway found records of Arctic charr (*Salvelinus alpinus)* from Loch Brora and brook lamprey (*Lampetra planeri)* are also known to be present (Watt and Ravenscroft 2005) along with European eels (*Anguilla anguilla)* and three-spined sticklebacks (*Gasterosteus aculeatus)*.

Atlantic salmon, brown trout, Arctic charr and eels are listed as priority species on the UK Biodiversity Action Plan (BAP). Atlantic salmon and brook lampreys are listed on Annex IIa of the Habitats Directive and brook lamprey are also listed on Appendix III of the Bern Convention. The European eel is of increasing conservation concern due to recent declines and is listed as endangered on the IUCN Red List.Other species potentially present include sea lamprey (*Petromyzon marinus)*, which is also listed on Annex II of Habitats Directive and the UK BAP.

Infrastructure associated with the wind farm will be restricted largely to the hilltops and upper hill slopes. The streams in these elevated areas are small and may be inaccessible to migratory fish species. Nevertheless the Development may have potential to impact important freshwater habitats downstream from the site itself. Typical concerns raised in relation to similar developments elsewhere include the potential for siltation or other changes to water quality that may affect sensitive aquatic habitats and species, including populations of salmonids and other fish. Therefore, the survey covered stream habitats downstream from the wind farm site as well as stream habitats within the site, as the former may receive run-off as a result of the Development.

1.3. Fish habitat requirements

1.3.1. Salmon and trout

The physical habitat requirements of juvenile salmonids have been subject to a considerable amount of detailed study (for reviews see e.g. Crisp 1993; Hendry andCragg-Hine 2003; Klemetsen*et al.* 2003; Summers *et al*. 1996; Youngsonand Hay 1996). Trout and salmon spawn in late autumn and early winter, depositing their eggs in redds which they excavate in gravel and pebble substrates. Spawning depth can range from 5 cm to 90 cm (review by Neary 2006), but it is likely that habitat is selected on the basis of suitable substrate and flow rather than depth per se. Eggs are often deposited in areas of accelerating flow, such as the tails of pools and glides, upstream from riffles. However, in upland

[1] MSS letter dated 1/5/2014 (ref 19/7)

streams eggs may be deposited in any areas of gravel that can be physically moved. A good supply of oxygen is essential for eggs to develop and this is facilitated by a flow of water through the gravel. Clogging with fine sediment such as silt and fine sand reduces water flow resulting in egg mortality due to lack of oxygen. Egg survival is also affected by redd 'washouts' during winter spates – the direct, physical, scouring out of eggs from the gravel. Substrate stability, the dynamics of water flow and the weather all determine the extent of siltation and washouts.

After hatching the young fry remain in the gravel as alevins, absorbing nutrient from the remaining yolk sac. On emergence, usually between March and early May, the young fry disperse and set up territories which they defend aggressively. Salmon fry prefer fast flows (>30 cm/s) and favour areas with surface turbulence (riffle habitat). They require a rough bed of pebble, cobble and gravel. Trout fry prefer areas of relatively low velocity water near the streambed and often inhabit slower flows than salmon fry. Cover from stones, plants or debris is required and good cover is essential for maintaining high fry densities.

Salmon that have survived their first winter (parr) prefer deeper water than fry (typically 15 to 40 cm) and a coarser substrate often consisting of pebbles, cobbles and boulders. Trout parr generally favour areas of relatively low current speed where cover is available. Juvenile trout are often to be found in cover alongside the banks, in undercuts, among tree roots or in marginal vegetation. Cover remains important for adult trout and salmon particularly in smaller streams. In larger rivers and lochs this may be less important, as deep water provides refuge.

1.3.2. Arctic charr

The Arctic charr is predominantly a lake dwelling fish, although riverine populations are known. Many populations in the northern parts of its range are anadromous but all British populations are freshwater resident (Maitland *et al*. 2007). There are some 258 Scottish lochs where charr have been recorded, but only 142 of these have been verified as having charr in recent years (Maitland *et al* 2007). The charr's lifecycle follows a broadly similar pattern to that of resident brown trout, the main difference being that most (but by no mean all) populations spawn in lochs. Breeding usually takes place in the autumn, eggs being deposited in appropriately sized gravels, pebbles and cobbles in lochs. After hatching the fry and older stages will migrate to deeper areas to feed and grow before returning to the spawning areas for breeding. Deviations from this typical breeding pattern are not unknown and records of stream spawning charr are quite widespread in Scotland, but relatively scarce (Walker 2007).

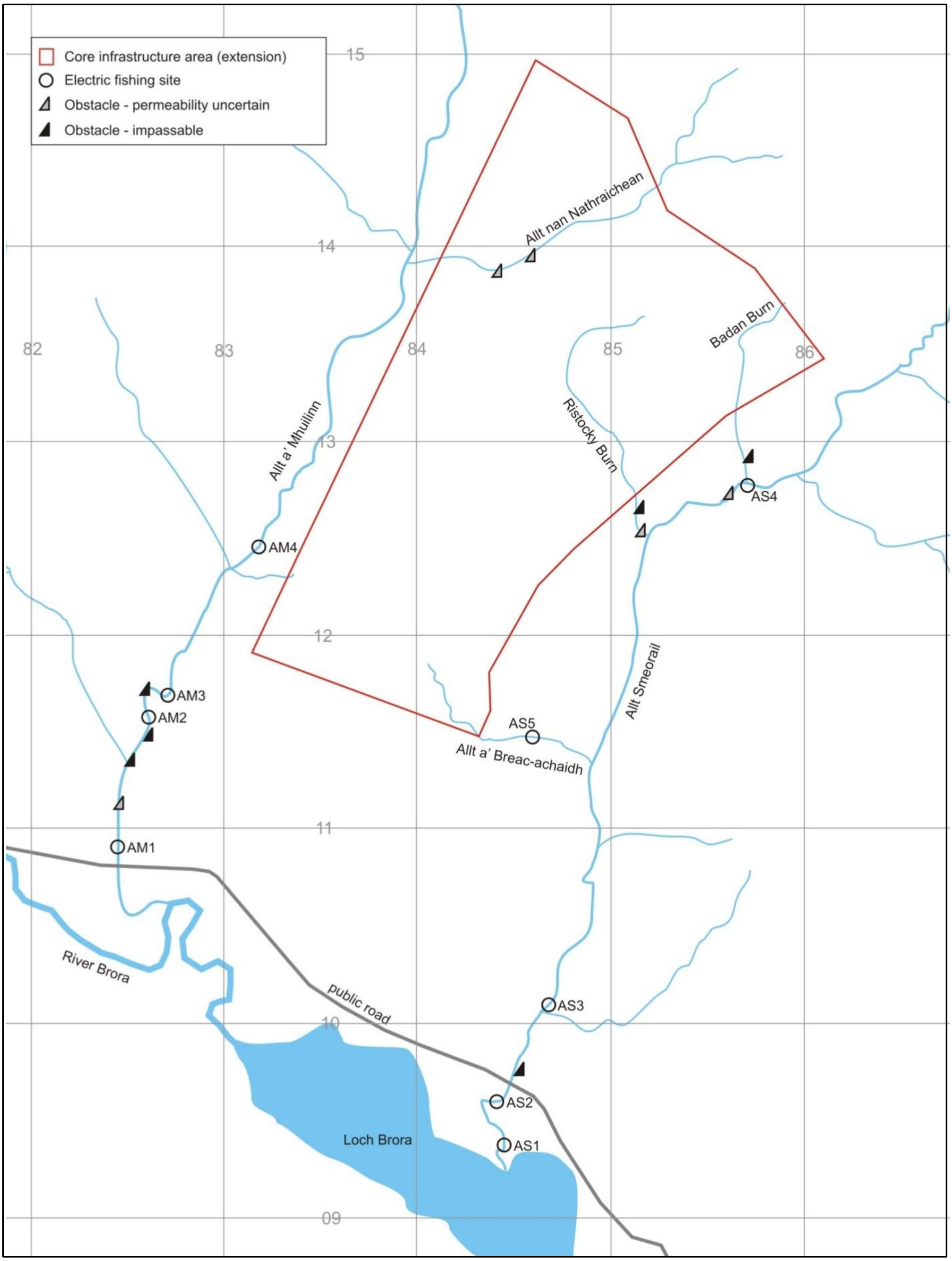
1.3.3. Eels

Eel habitat requirements have received less attention than those of salmonid fish. Tesch (2003) suggests that so long as temperature and oxygen requirements are met, there are few stretches of water that are not suitable for eels. The main requirement for eels is cover, as they are averse to light and require suitable refuges during daylight hours. Eels of different size show different substrate preferences. Larger eels require large hollows, crevices or weed beds whereas small eels are sometimes abundant in cobble substrates, where they can burrow between the stones. Tree stumps, roots and other large structures provide ideal cover for eels. Eel diet is diverse, but the majority of diet consists of benthic species (Moriarty 1978; Kottelat and Freyhof 2007).

1.3.4. Lampreys

Three lamprey species occur in the UK: brook lamprey, river lamprey (*Lampetra fluviatilis)*and sea lamprey. Adult lampreys aggregate to spawn and extrude their eggs into 'nests' excavated in the river bed. After hatching the young lamprey larvae, known as ammocoetes, drift downstream with the current. They settle in nursery habitat consisting of fine, soft substrate in well oxygenated, slow flowing water. The ammocoetes are blind and feed on fine particulate matter such as diatoms, algae and bacteria. Ammocoetes spend several years in this muddy nursery habitat before metamorphosing (or transforming) from larval to adult form. Upstream migrating lampreys may be prevented from reaching spawning grounds by both natural and man-made barriers. They are weak jumpers, so can be prevented from moving upstream by relatively low vertical barriers.

Figure 1 Study streams and electric fishing sites in relation to core infrastructure area[2]



[2] The core area above was the basis of the current surveys. The latest turbine layout is given in Appendix 1.

2 Objectives

The objectives of the survey were to:

(iv) Describe stream habitats in the various watercourses draining the site of the Development. In particular, to describe their suitability for the various fish species potentially present.

(v) Identify the main obstacles to migration in the above streams, in particular the likely upper limits for the distribution of salmon, sea trout or loch trout.

(vi) Carry out an electric fishing survey to describe species composition and distribution within target watercourses. In particular, to confirm the distribution of migratory salmonids in the two watercourses; Allt a' Mhuilinn and Allt Smeorail.

3 Methods

3.1. Salmonids

3.1.1. Salmonid habitats

A walkover survey of salmonid habitats was carried out on 30th October 2014. The survey covered:

(i) Allt a' Mhuilinn from its confluence with the River Brora (NC 827 106) upstream to NC 840 142;
(ii) Allt nan Nathraichean from its confluence with Allt a' Mhuilinn upstream to NC 850 141;
(iii) Allt Smeorail from its inflow to Loch Brora (NC 844 093) upstream to NC 857 128;
(iv) Ristocky Burn from its confluence with Allt Smeorail upstream to NC 848 132; and
(v) Badan Burn from its confluence with Allt Smeorail upstream to NC 856 135.

Reaches that were judged potentially accessible for migratory salmonids (salmon or sea trout) were surveyed quantitatively based on protocols described by Hendry and Cragg-Hine (1997), Summers *et al*. (1996) and SEPA (2010). These characterise in-stream habitats according to depth, substrate, flow and thus suitability for different age classes of salmonid. The habitat categories used during the survey and in this report are set out in Table 1. Surveys were based on contiguous sections of approximately 200m in length.

Table 1 Salmonid habitat categories used for walkover survey

Habitat category	Description
Fry habitat	Shallow habitats of <20 cm with some cover for smaller fish in cobble and pebble. Cover not large enough to hold parr or adults that would displace fry.
Mixed juvenile habitat	Habitats with mixed depth up to 40 cm. Cobble and/or boulder substrate providing cover for juvenile salmonids.
Pool	Over 60 cm deep. Slow or eddying current. Suitable for adult salmonids if cover is present. If >1 m deep cover may be less important, as depth can provide refuge.
Glide	Low gradient alluvial channel with small substrates of sand, gravel or pebble. Lacking cover for fish. May be productive if instream macrophytes or good bankside cover are present.
Spawning	Ideally well oxygenated, stable and not compacted. Typically comprising gravel and pebble. Fines (sand and fine gravel <2 mm) less than 20%. Not silted.
Bedrock	Sheet bedrock covering majority of streambed. No cover. Unproductive habitat.
Incised peat	Small channels incised through peat. No bed transport. Hard substrates if present are set in peat matrix and do not provide cover. Poor or unproductive.

Within each section areas of each habitat type were marked on 1:10,000 scale maps. The broad suitability for juvenile and adult salmonid of each section was noted. Habitats were categorised as productive if they provided areas of suitable cover for fish. Sheet bedrock areas were categorised as unproductive (SEPA 2010).

Obstacles to migration were recorded and photographed. Their likely permeability for adult salmon and trout was assessed. Areas of suitable spawning substrate were recorded. Other variables recorded in each survey section were:

- Up and downstream grid reference;
- Wet width;
- Stability (of substrate);
- Compaction (of substrate); and
- Availability of cover for fish alongside banks.

No quantitative survey was conducted in reaches that were clearly inaccessible to migratory salmonids. Instead, an experienced fish biologist carried out linear inspections during the walkover survey. The approach was consistent with the meso-scale assessment described by Summers *et al*. (1996). The purpose of this non-quantitative survey was to describe the general distribution and quality of fish habitats in the various streams draining the site and to identify any key areas such as spawning habitats requiring particular protection.

3.1.2. Salmonid populations

An electric fishing survey was carried out to provide data on fish species presence and abundance, focussing on reaches potentially accessible to sea trout or salmon. Brief, qualitative (presence versus absence) assessments were also made upstream of waterfalls to confirm the presence of trout or other fish species.

Site locations are shown on Figure 1 and site details are provided in Table 2 and Appendix 4. Surveys were mainly conducted using semi-quantitative and qualitative methods (SFCC 2007). A single fully quantitative survey was conducted on Allt Smeorail to provide a measure of survey efficiency. Stop nets were used at the fully quantitative site.

Table 2 Electric fishing survey sites, Gordonbush Extension Wind Farm.

Site	**Stream**	**NGR**	**Dimensions**			**Survey type**
			Length	Width	Area	
AM1	Allt a’ Mhuilinn	NC 82431 10856	20.5	5.3	109	Semi-quantitative
AM2	Allt a’ Mhuilinn	NC 82618 11553	24	5.3	127	Semi-quantitative
AM3	Allt a’ Mhuilinn	NC 82712 11666	NA	NA	NA	Qualitative
AM4	Allt a’ Mhuilinn	NC 83187 12443	NA	NA	NA	Qualitative
AS1	Allt Smeorail	NC 84473 09370	32	3.9	125	Semi-quantitative
AS2	Allt Smeorail	NC 84383 09575	19.5	5.5	107	Fully quantitative
AS3	Allt Smeorail	NC 84651 10040	39	4.8	187	Semi-quantitative
AS4	Allt Smeorail	NC 85666 12757	NA	NA	NA	Qualitative
AS5	Allt a’Breac-achaidh	NC 84590 11442	NA	NA	NA	Qualitative

Survey sites covered the full stream width and incorporated a representative range of habitat types. Water level at the time of survey was low. All sites were surveyed using smooth DC and hand-held dip nets were used to capture fish.

Captured fish were placed in bins of clean water where they were held until ready for processing. Salmonid fork length was measured to the nearest 1mm and eel total length was measured to the nearest cm. Scales were collected from salmon and trout to assist with age determination. All fish were allowed to recover fully in clean water before being released back into the survey reach. Habitat descriptions at electric fishing survey sites were collected according to the SFCC protocol (SFCC 2007).

Salmonid densities are presented as the number of fish per 100 square metres of wetted survey area (fish 100 m^{-2}). The density classifications provided by Godfrey (2006) are used to describe the abundance of salmon and trout within a regional context. These classifications are based on large data sets held by SFCC. The quintile ranges of trout densities (Appendix 5) allow for comparison of fishery performance against regionally based reference points. The classification system is based on single run fishing.

3.2. Lampreys

No quantitative assessment of lamprey habitats was carried out, but the presence of suitable habitats was recorded during the walkover survey. Where significant accumulations of suitable larval habitat (stable fine sand and silt) were found, the location was recorded and notes on suitability were made based on descriptions given by Harvey and Cowx (2003). Optimal habitat was defined as stable, fine sediment (silt and fine sand) to a depth of 15 cm or more, in slow flowing well oxygenated water, often with a fine layer of organic detritus. Sub-optimal habitat was defined as a patchy or shallow (<15 cm) covering of fine sediment among larger substrates.

Lamprey numbers were assessed at one site on each of the Allt a’ Mhuilinn and Allt Smeorail by semi-quantitative, timed electric fishing. Surveyors fished suitable habitat using backpack electric fishing gear and smooth DC. Lamprey ammocoetes attracted from the substrate were captured in dip nets. The total time fished was recorded. On completion, the area covered was measured in order that a minimum density could be calculated. Lampreys were anaesthetised, identified to the lowest possible taxonomic level (Gardiner 2003) and measured to the nearest millimetre on white measuring boards.

4 Results

4.1. Salmonid habitats

4.1.1. River Brora

The 1 km of river between the Allt a’ Mhuilinn confluence and Loch Brora is deep and very slow flowing. At low water level this reach appears almost as an extension of Loch Brora although the presence of depositional features and bank erosion indicate this not the case at higher flows. Maximum depth is unknown, but clearly over 1.5 m. Wet width is 40 to 60 m. Visible substrates comprise sand and peat. Cover for salmonid fish, other than that provided by deep water, appears to be almost entirely lacking. No salmonid spawning habitat was recorded. Large expanses of sand and silt on the inside of meanders appear to provide suitable habitat for larval lampreys.

4.1.2. Allt a’ Mhuilinn

A number of obstacles to upstream migration are present along the Allt a’ Mhuilinn, several of which were considered impassable to salmon or trout. The most significant of these are listed in Table 3. The culvert at the road was considered passable as was the 1.3 m high waterfall some 350 m further upstream at NC 8245 1111. A difficult series of waterfalls, including a 3 m high drop, is present at NC 8246 1119. The permeability of this obstacle is uncertain. The absolute upstream limit for migration of salmon or trout is likely to be the dam at NC 8249 1131, some 1.2 km upstream from the River Brora. This is approximately 3 m high. The water falls vertically onto a shallow ledge that forms the lip of a natural waterfall. The height of this waterfall is approximately 1.8 m. The ledge and lack of plunge pool make the dam impassable for upstream migrating salmonids.

Figure 2 Dam at NC 8249 1131

Two further natural waterfalls that are clearly impassable were recorded at (approx.) 200 m and 300 m upstream of the dam. The more downstream of these at NC 8260 1148 was estimated to be between 4 m and 5.5 m in height. It could not safely be approached to measure. Two ledges in the face of this waterfall compound the difficulty of a jump that is clearly beyond the leaping ability of trout or salmon. This waterfall probably represented the natural upstream migratory limit prior to the construction of the dam. A further 100 m upstream an even larger waterfall, estimated to be 6 or 7 m high, is also clearly impassable for salmonids. This waterfall drops vertically between bare, overhanging bedrock banks which also seem likely to be impassable for eels. Photographs of these obstacles are provided in Appendix 8.

Table 3 Obstacles to migration Allt a' Mhuilinn

NGR	Passable	Type	Notes
NC 8243 1077	Yes (s/f)	Culvert	Concrete shelf over 1 m in width and 20 cm high.
NC 8245 1111	Yes (s/f)	Waterfall	1.3 m vertical fall with deep water at base.
NC 8246 1119	Unknown	Series waterfalls	One large ~3 m waterfall followed by three bedrock chutes. Fish may be able to swim up the latter.
NC 8249 1131	No	Dam	Over 3 m in height. Water falls on to a shallow ledge. Second fall below bedrock chute. Impassable.
NC 8260 1148	No	Waterfall	Unsafe to approach. Estimated height 4 to 5.5 m.
NC 8260 1163	No	Waterfall	Unsafe to approach. Estimated height 6 to 7 m.

Note: s/f indicates that permeability is likely to be species and/or flow dependent.

The accessible reaches of the Allt a' Mhuilinn provide some good rearing habitats for juvenile salmon and trout. The downstream 250 m have a slow or moderate current speed. Substrates are mainly small cobbles, pebbles and sand providing relatively little cover for fish (Appendix 1). Deep pool habitat is present that would be expected to hold adult trout and larger trout parr and some high quality spawning habitat is available, particularly on the bends at NC 8252 1057 where over 20 m^2 of potential spawning habitat was identified (Table 4, Appendix 2).

The next 0.5 km of stream, from around 120 m downstream of the road to Ascoile (NC 825 111), has substrates of boulder, cobble and gravel providing good fish cover. The banks are lined with alder and birch, so additional cover in roots is present along both banks. The streambed is mainly stable. Flow types and depths show good variation and these reaches provide very good quality habitats for juvenile trout and salmon. Typical stream width in these lower reaches is between 4 and 6 m.

Table 4 Summary of wetted area of each habitat type in accessible reaches of Allt a' Mhuilinn

Accessible length (m)	Wetted area of habitat (m^2)						
	Fry	Mixed juvenile	Pool	Bedrock	Glide	Spawning	Total
1.1 km	380	3250	1910	1050	480	45	7115

The gradient increases upstream of Ascoile, where the stream flows through an incised, tree clad gorge. The impassable dam and waterfalls are in this area. There are large expanses of unproductive bedrock in this reach, until the gradient eases around NC 8271 1167.

Figure 3 Allt a' Mhuilinn (NC 8292 1215)

The next 0.7 km of stream is fast flowing with substrates of boulder, cobble and some patches of bedrock. Flow types are varied and the stream is mainly between 3 and 5 m wet width. Habitat appears suitable for trout production and fish were seen during the habitat survey.

The dam that used to impound Loch Mhuilinn (NC 832 124) has been removed in recent years and the loch no longer exists. From the site of the old dam up to the confluence with Allt nan Nathraichean (NC 8395 1389) the stream is typically 3 to 4 m wet width with a moderate gradient. Substrate is mainly coarse and dominated by boulder and cobble. Other than in a short reach of bedrock-dominated habitat at NC 8384 1357 the stream appears well suited to trout production. A few deposits of unstable gravel and pebble are present at the edges of pools and glides but spawning opportunities appear to be scarce and this may limit trout numbers.

Habitat upstream of the Allt nan Nathraichean confluence is similar to that downstream, although the stream is somewhat narrower with a typical wet width of 2.5 m. It continues to provide suitable habitat for trout, with good instream cover but limited spawning potential.

4.1.3. Allt nan Nathraichean

Allt nan Nathraichean drains the southwest sector of the operational Gordonbush Wind Farm. A number of turbines within the proposed extension would be located in this drainage.

In its lower reaches the Allt nan Nathraichean has a typical wet width of 1.5 m. It has a moderate to steep gradient. No obstacles to migration were identified between its confluence with Allt a' Mhuilinn at NC 8395 1389 and NC 8441 1390, some 0.5 km upstream, where there is a 1.7 m high waterfall (see Appendix 8 for photograph). This waterfall is non-vertical and the horizontal distance from lip to plunge pool is 1.2 m. It is uncertain whether it is passable for stream dwelling trout. Habitat in the lower 0.5 km of the stream comprises pool and run sequences. Substrate is predominantly a mix of cobble, boulder and pebble. Spawning calibre substrate is limited to small patches gathered in lower gradient reaches and at the edges of pools. Nonetheless, the stream provides suitable habitat for trout.

Figure 4 Allt nan Nathraichean (NC 8458 1396)

Productive trout habitat continues for approximately 200 m upstream of the waterfall. Habitat quality deteriorates at NC 8463 1396 and for the next 200 m much of the streambed is formed of sheet bedrock. There are many shallow steps and ledges that may impede upstream fish movements and the habitat itself is largely unsuitable for trout.

Habitat quality improves at NC 8482 1412, approximately 1 km upstream of Allt a' Mhuilinn. From here to the top of the survey reach (NC 850 141) most of the stream appeared suitable for trout production with mixed substrates, depth and flow types. Wet width varies from 1 m to 1.5 m and is mainly the same as channel width. Some good overhead cover is present from undercut banks.

4.1.4. Allt Smeorail

Allt Smeorail is accessible to migratory salmonids only as far as the lower gorge, which starts at the public road (NC 845 097). Here the stream becomes torrential with bedrock habitat. A waterfall at NC 8451 0973 marks the absolute upstream limit. This obstacle is some 7 to 8 m in height. It is non vertical with a slope of around 35 degrees culminating in a 3 to 4 m high near-vertical drop at the downstream end (see Figure 5). There is no significant downstream constriction and while it was unsafe to approach to measure the precise height this obstacle is clearly impassable for salmonids. Due to the lack of suitable climbing substrate it is also likely to be very difficult and potentially impassable for eels.

Figure 5 Waterfallat NC 8451 0973

The accessible reach of Allt Smeorail, from Loch Brora to the waterfall, is approximately 0.6 km long with a wetted area of approximately 2,800 m^2 (Table 5). An estimated 89% of this habitat was classified as mixed juvenile salmon habitat and this is mainly of good quality with ample cover for salmon fry and parr. The gradient is moderate and flow types are mixed with riffle, run and glide sequences. Wet width is typically between 4 and 6 m. Some erosion is present on the outside of bends, but the streambed is moderately stable. Deposits of pebble and gravel at the tails of pools and glides provide some high quality spawning habitat for salmon. Much of the spawning calibre substrate is rather coarse for trout, although some suitable patches are present (see Appendix 3).

Figure 6 Allt Smeorail (NC 8441 0942)

Habitat changes abruptly at the public road and an incised gorge extends from here upstream to the footbridge at NC 8461 1003, a distance of approximately 0.4 km. Some of the habitat in the gorge is potentially suitable for trout, but non-bedrock substrates are unstable and habitat quality is poor.

Upstream of the gorge the Allt Smeorail is typically 4 m wet width. The banks are tree lined and mainly very stable, formed either of boulder or bedrock. In places the channel is constricted between steep bedrock banks and habitat is gorge like. Other reaches are more open with substrates of boulder and cobble. Except in the short reaches of bedrock habitat, the entire length of Allt Smeorail from the footbridge upstream to the survey limit (NC 857 128) appears suitable for trout. The gradient is moderate and flow types are varied, with long reaches of run interspersed with pools. The presence of large boulders creates structural diversity and instream cover is plentiful. Overhead cover alongside the banks is not particularly abundant, but widely scattered root cover and a few undercuts do provide some refuges. Spawning habitat appears to be rather scarce and many of the smaller substrates are unstable.

Table 5 Summary of wetted area of each habitat type in accessible reaches of Allt Smeorail

Accessible length (m)	**Wetted area of habitat (m^2)**						
	Fry	Mixed juvenile	Pool	Bedrock	Glide	Spawning	Total
630	150	2530	120	0	0	49	2849

Figure 7 Allt Smeorail (NC 8492 1076)

4.1.5. Allt a' Breac-achaidh

This small stream flows into Allt Smeorial at NC 8491 1136. It has a moderate to steep gradient and a typical wet width of 0.7 to 1.5 m. The channel is mainly cut through peat and earth. Substrates are of cobble, boulder and gravel. Depth is mainly between 5 and 20 cm. Some potential spawning habitat is present and the stream appears suitable for trout.

4.1.6. Ristocky Burn

Ristocky Burn flows into Allt Smeorail at NC 8520 1249. There is a three-tier waterfall at the confluence. The two lower tiers are both 1.6 m high and near vertical. These are followed by a 1.2 m high fall. This obstacle may prevent trout access into the stream from Allt Smeorail. From here to the track at NC 8515 1261 the stream is steep and mainly runs between bedrock banks. Habitat quality is very poor due to the high gradient and large areas of bedrock. Wet width is approximately 1.2 m.

The perched culvert at the track (NC 8515 1261) is impassable to upstream migrating trout. Upstream of the track the stream is mainly an incised channel through peat. It is densely vegetated with rushes and hard substrates are largely lacking. It appears unsuitable for trout production.

4.1.7. Badan Burn

Badan Burn flows into Allt Smeorail at NC 8570 1275. It is a small stream with a wet width that is typically around 0.5 m. There is a 1.5 m high waterfall at the confluence with Allt Smeorail that may be passable when the stream is in spate. Approximately 70 m further upstream there is a 3 m high waterfall that is clearly impassable.

Habitat quality for trout in the lower 70 m of stream (potentially accessible from Allt Smeorail) is very poor. Substrates are hard and immobile and spawning habitat is lacking. Upstream of the larger waterfall the stream is 0.4 m wide with typical depths of 5 to 15 cm. Substrate is a mix of peat and bedrock with occasional deposits of gravel and pebble. This small, shallow stream appears unlikely to support a trout population.

4.2. Habitat for other fish species

Larval lamprey habitat is present in the lower reaches of Allt a' Mhuillin and Allt Smeorail. Locations of significant patches of suitable habitat are given in Appendices2c and 3c.

Six patches with a total area of 37 m^2 were identified in Allt a' Mhuilinn, all of which are accessible from the River Brora. Most of this habitat was classified as sub-optimal as substrate composition was quite gritty and organic matter appeared scarce. Some better habitat was present, particularly where well established piles of decaying twig and detritus had accumulated. No suitable larval habitat was noted upstream of the dam and waterfalls. Any patches of sand were very small, unstable and gritty. Spawning habitat suitable for all lamprey species lampreys is present.

Only two patches of larval lamprey habitat were identified in Allt Smeorail. The largest of these is in a backwater channel some 200 m upstream of Loch Brora. Spawning habitat suitable for lampreys is present.

The lower reaches of the River Brora, between the Allt a' Mhuilinn confluence and Loch Brora, are slow flowing with extensive deposits of sand and silt along the inside of bends. These appear to provide large areas of habitat suited to larval lampreys. No spawning habitat suitable for larval lampreys is present downstream of the Allt a' Mhuilinn confluence.

Both Allt a' Mhuillin and Allt Smeorail provide habitat that is suitable for eels. However, as noted above access for eels may be restricted to the lower reaches of these streams due to the presence of waterfalls.

4.3. Fish populations

4.3.1. Salmon

Salmon were present at sites in Allt a' Mhuilinn and Allt Smeorail that are accessible to upstream migrating salmonids (Table 6). They were absent from sites on Allt a' Mhuilinn upstream from the dam and waterfallsdescribed above. Salmon were also absent from sites on Allt Smeorail upstream of the lower gorge, which starts at the public road.

Salmon fry and parr densities at site AM1 on the Allt a' Mhuilinn were 7.4 and 9.2 fish per 100 m^2 respectively. These densities would both be classified as poor and good respectively by regional standards (see Appendix 5). Salmon fry length in the Allt a' Mhuillin ranged from 50 mm to 67 mm (Figure 8). Parr ranged in size from 86 mm to 122 mm. Scale readings indicated that two parr year classes, 1+ and 2+, were present. The 1+ year class was very weak and represented by only two individuals.

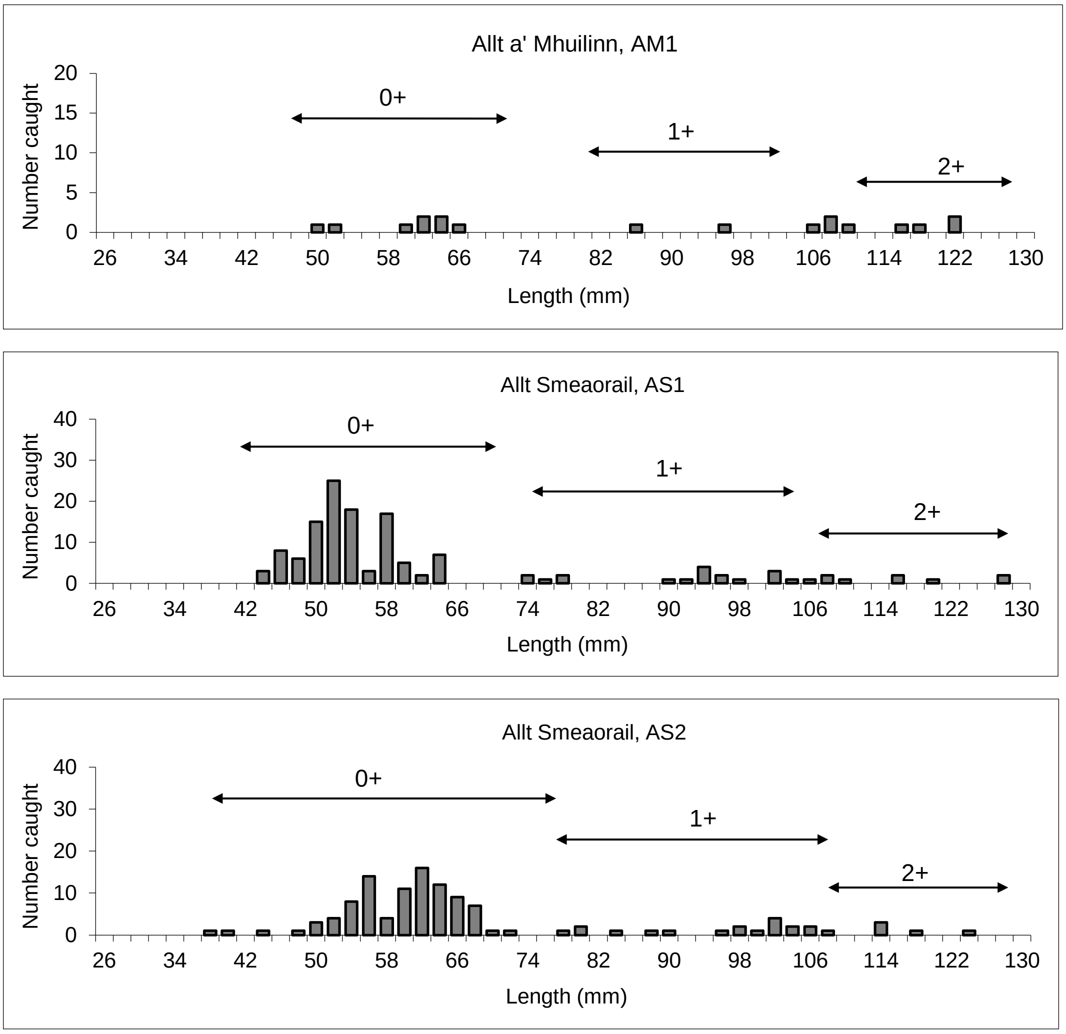
Table 6 Fish densities (single run minimum density) at electric fishing sites.

Site	Watercourse	**Salmon** (fish 100m^{-2})		**Trout** (fish.100m^{-2})	
		fry (0+)	parr (1++)	fry (0+)	parr (1++)
AM1	Allt a' Mhuilinn	7.4	9.2	9.2	1.8
AM2	Allt a' Mhuilinn	0.0	0.0	1.6	4.7
AM3	Allt a' Mhuilinn	absent	absent	present	present
AM4	Allt a' Mhuilinn	absent	absent	present	present
AS1	Allt Smeorail	119.4	21.6	8.0	4.0
AS2	Allt Smeorail	56.9	16.8	12.1	0.9
AS3	Allt Smeorail	0.0	0.0	3.7	8.0
AS4	Allt Smeorail	absent	absent	present	present
AS5	Allt a' Breac-achaidh	absent	absent	present	present

Note: Italics indicate Zippin density (±95% c.l.). Other figures are all runs minimum densities.

Salmon fry and parr were present at the two more downstream survey sites on the Allt Smeorail. Densities were much higher than on the Allt a' Mhuilinn with mean fry and parr densities of 88.0 and 19.2 fish per 100 m^2 respectively. These densities would both be classified as excellent by regional standards. Salmon fry ranged in length from 41 mm to 73 mm and there was some evidence at both sites of a bimodal distribution is length (Figure 8). Two parr age class, 1+ and 2+ were present at both sites with a predominance of 1+ parr. Growth rates were variable and there appeared to be some overlap in the lengths of the two year classes.

Figure 8 Length distribution of salmon.



4.3.2. Trout

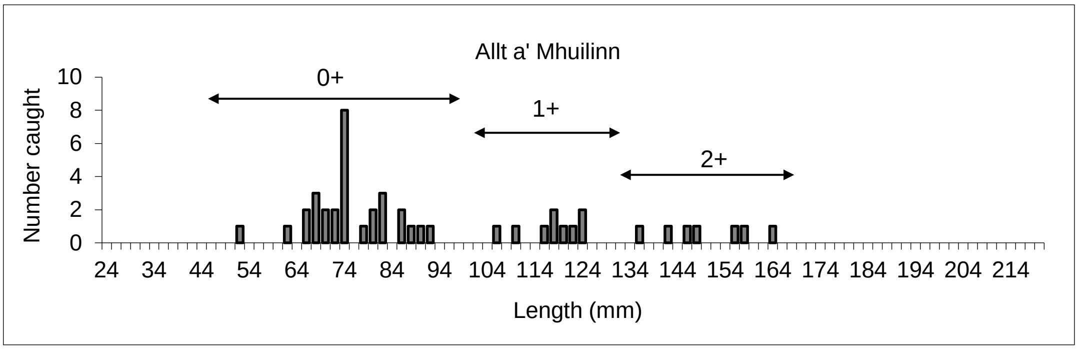
Trout fry and parr were present at all survey sites including those upstream of waterfalls (Table 6).

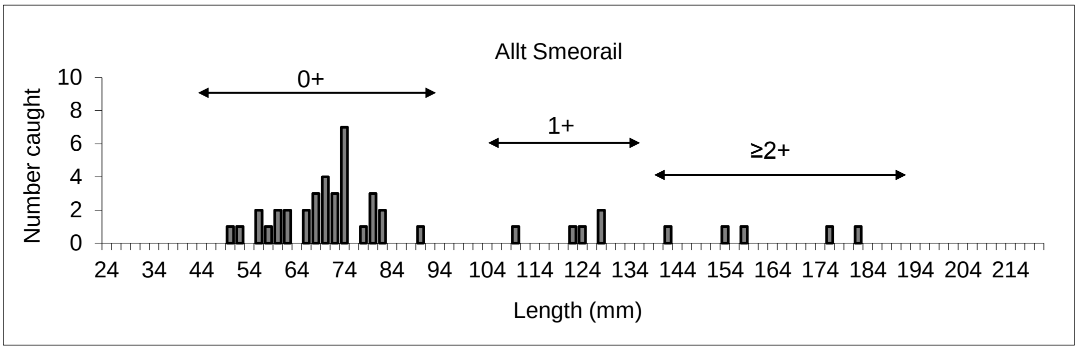
Trout fry and parr densities at AM1, which is accessible to sea trout, were good and very poor respectively. Trout fry density at AM2, upstream of the dam and an impassable waterfall was very poor. Parr density at this site was moderate. No densities were calculated at AM3 or AM4 but the impression during the qualitative surveys was that densities were low.

Trout fry densities at AS1 and AS2 were moderate and good respectively. Parr density was poor at AS1 and very poor at AS2. Both sites are accessible from Loch Brora. Upstream of the waterfall, at AS3, fry density was very poor but parr density was good. Fry and parr densities at the qualitative site AS4, close to the upper survey limit, appeared to be very low. One fry and one parr (probably aged 2+) were caught in approximately 60 linear metres of stream. Trout fry density at AS5 in Allt a’ Breac-achaidh appeared relatively high, but parr were scarce.

In both the Allt a' Mhuilinn and Allt Smeorail trout populations downstream of waterfalls showed a predominance of fry. This suggests that young trout drop down into the River Brora and Loch Brora during or prior to their first winter. Upstream of waterfalls, where there would be little migratory tendency, the relative abundance of older age classes was generally greater.

Figure 9 Length distribution of trout.





4.3.3. Other fish species

Eels (n=3) were caught on Allt a' Mhuilinn site AM1. These ranged in length from 25 cm to 35 cm. Eels were not found at the three upper sites on Allt a' Mhuilinn, suggesting that the waterfalls may be impassable. Eels were also caught at sites AS1 (n=5) and AS2 (n=6). These ranged in length from 13 cm to 32 cm. No eels were caught at sites AS3 to AS5, upstream of the waterfall, suggesting that eels may be restricted to the lower reaches of Allt Smeorail.

Two targeted, semi-quantitative surveys of lampreys were carried out. The first was at NC 8253 1056in the lower reaches of Allt a' Mhuilinn, a short distance upstream from the River Brora confluence. The second was in a backwater in the lower reaches of Allt Smeorail at NC 8443 0941. Lamprey larvae were present at both sites. All of those caught (n=58) were *Lampetra* species i.e. brook or river lamprey.

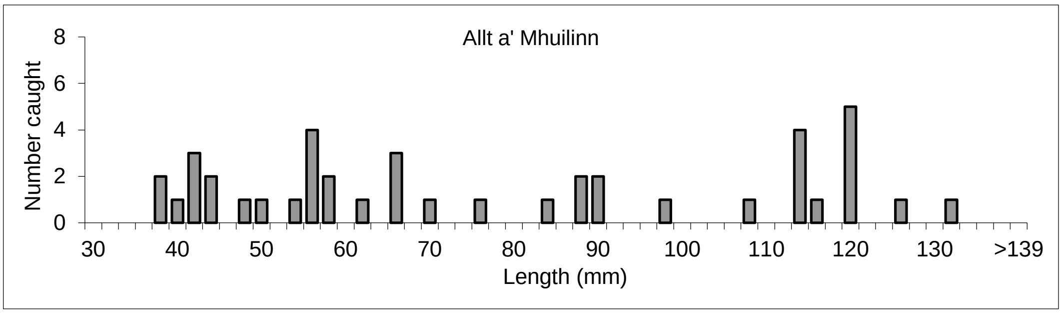
Seven *Lampetra* transformers were caught in the lower reaches of Allt a' Mhuilinn. All were identified as brook lampreys based on overall appearance, size and eye length to body length ratio[3].The largest larva caught in Allt Smeorail was 166 mm long. Larvae over 120 mm long are almost certain to be brook lamprey (Gardiner 2003), suggesting that this is the species present in both streams.

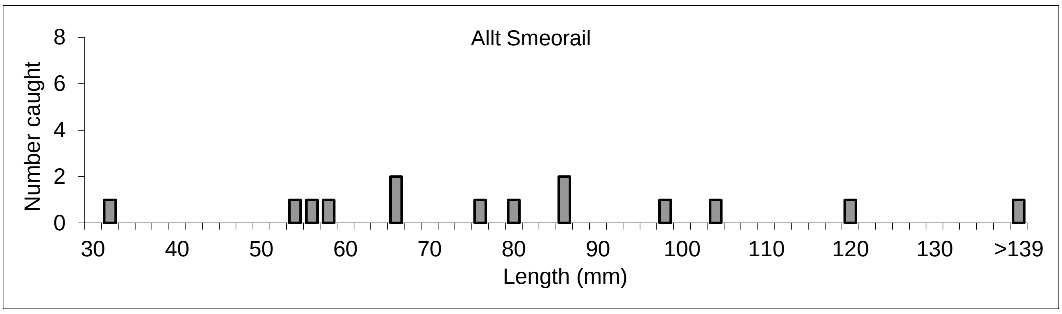
Small 0+ larvae were present at both sites along with a range of larger larvae (Figure 10), suggesting successful recruitment in most or all years. As some suitable spawning habitat is present in the streams, it is very likely that brook lamprey breed in these stream during most years.

[3] In brook lamprey transformers the ratio of eye length to total length is generally less than 2.4% while in river lampreys it is greater than 2.4% (Gardiner 2003).

Larval density at the Allt a' Mhuilinn site was 28.7 larvae m^{-2}. Density at the Allt Smeorail site was 6.0 larvae m^{-2}. Habitat at both sites was mainly sub-optimal and these densities compare quite favourably with the population targets set out Harvey and Cowx (2003).

Figure 10 Length distribution of larval lampreys.





5 Interpretation

The only fish species identified in the streams draining directly from the Development site was the brown trout. Access to the Development site by migratory species is prevented by a dam and/or natural waterfalls on both the Allt a' Mhuilinn and Allt Smeorail. Downstream of these obstacles both streams support populations of Atlantic salmon, brown/sea trout and eels. Lampreys, most probably the brook lamprey, are also present in the accessible reaches.

Upstream of the waterfalls both the Allt a' Mhuilinn and Allt Smeorail provide long reaches of suitable habitat for trout. However, trout densities were not particularly high for streams of this size and trout fry appeared to be quite scarce in both streams. A lack of spawning habitat was noted in both streams during the walkover habitat survey and it seems possible that a lack of spawning opportunities may limit trout abundance in these reaches.

Of the tributary streams draining directly from the proposed Development site (Figure 1), the Allt nan Nathraichean and Allt a' Breac-achaidh both provide suitable habitat for trout. The presence of trout was confirmed in the latter. As there are no impassable obstacles between Allt nan Nathraichean and electric fishing site AM4 where trout were present, there is little doubt that this stream also supports a trout population.

Access for trout to the Ristocky Burn is made difficult by waterfalls at its confluence with Allt Smeorail. The impassable culvert where Ristocky Burn passes beneath the track is of little consequence as habitat upstream is mainly incised peat channel, much of it filled with rushes, and unsuited to trout production. Downstream of the track habitat quality is also very poor due to gradient and bedrock and, if present at all, trout numbers in this stream would be expected to be very poor.

Only the lower 70 m of Badan Burn is potentially accessible from Allt Smeorail, due to the presence of a waterfall. The lower 70 m of stream is very shallow and cover for trout is lacking. Upstream of the waterfall the stream is a narrow incised channel with substrates mainly of peat or bedrock. It seems unlikely that the stream supports trout. If trout are present, densities and total numbers are expected to be very low.

Juvenile salmon were present at all accessible sites that were included in the electric fishing survey. Densities were variable but in Allt Smeorail were excellent by regional standards. The measured densities of salmon in the RiverBrora catchment have not been enhanced by stocking in recent years (John McMorran, Balnacoil Estate, pers. comm.) and it can be assumed that all were wild spawned. Spawning habitats in both the Allt Smeorail and Allt a' Mhuilinn were of good quality and both streams clearly make useful contributions to the salmon fisheries of the River Brora catchment.

Eels were caught in small numbers and may be restricted to the lower reaches of Allt a' Mhuilinn and Allt Smeorail by waterfalls. The bare, smooth bedrock of the gorges in both streams provide poor climbing substrate for eels and it is possible that they are absent from the upper reaches. Nevertheless, the dispersal powers of eels are remarkable and it would certainly not be safe to assume that eels are absent based on the limited effort in the current survey.

The distribution of larval lampreys reflected the distribution of suitable habitats, which were confined mainly to the lower reaches of the Allt a' Mhuilinn and Allt Smeorail. A previous survey of the River Brora (Watt and Ravenscroft 2005) only identified brook lamprey and this is consistent with the findings of the current survey. It is likely that this is the only species present in the study area. Both streams provide potential spawning habitat as well as juvenile habitat for brook lampreys. The presence of multiple year classes, including 0+ larvae, suggests regular spawning in both streams.

Arctic charr potentially have access to the lower reaches of both streams from Loch Brora. While most charr populations spawn in lochs, eight extant Scottish populations are known to spawn in streams or rivers (Walker 2007). Typically, stream spawning charr migrate a relatively short distance upstream to spawn. Where known, fluvial spawning habitat tends to be in gently flowing water over substrates comprising gravel, sand and silt. As such, the pebble and cobble substrates of the lower Allt a' Mhuilinn and Allt Smeorail would be considered sub-optimal for spawning charr and it is very unlikely that the species is present in either stream.

6 Potential Scheme Impacts

Typical issues relating to wind farm developments and salmonid fish relate to the exposure of large quantities of soil and the potential for siltation. Inputs of silt and other fine material including peat can cause damage to fish habitats and direct mortality to fish and ova. Similar or greater impacts would be expected in the event of any peat slide resulting from the proposed Development. Should the scheme proceed, silt management would be one of the most significant issues relating to watercourses. Spawning habitat in the upper reaches of Allt a' Mhuilinn and Allt Smeorail and their tributaries appears to be very limited in extent and any loss or damage to suitable areas may be detrimental to trout populations. Given the relatively high gradients in these streams, any such impact might be short-lived as silts would likely be flushed downstream quite quickly. Nonetheless, serious short term impacts might be severe depending on the scale of any siltation event.

High quality spawning habitats are present in the lower, accessible reaches of both Allt a' Mhuilinn and Allt Smeorail. The electric fishing data suggest that these habitats are utilised by both Atlantic salmon and sea/brown trout. Lampreys were also present in these reaches and undoubtedly these too spawn in both streams. Impacts on the above species might result from any major siltation event or from chronic, ongoing siltation during construction or decommissioning. The magnitude of any impact would, however, be highly dependent on the scale, timing and duration of such an event or events. As the existing road network would be used during construction, there is a considerable distance between the stream reaches and the majority of the proposed new infrastructure, which may help ameliorate any impact.The proposed construction compound is an exception as it would be located approximately 1km upstream of the accessible reaches of Allt a’ Mhuilinn (see Appendix 1).

Wider potential effects on water quality are outside the scope of this report. Monitoring of water quality during construction of the main Gordonbush Wind Farm identified few significant impacts (Dargie 2012). Occasional (but minor) increases in levels of turbidity, suspended solids and phosphate were recorded. However, none appear to have been at levels that would threaten fish. The data should be fully reviewed in order to assist in determining any water quality monitoring needs for the proposed Development.

No new watercourse crossings are proposed during construction or operation of the Development. Any watercourse crossings are already in place, having been created during construction of the existing access track network for the original GordonbushWind Farm. As a result, no direct physical impacts on spawning or juvenile habitats habitat are predicted.

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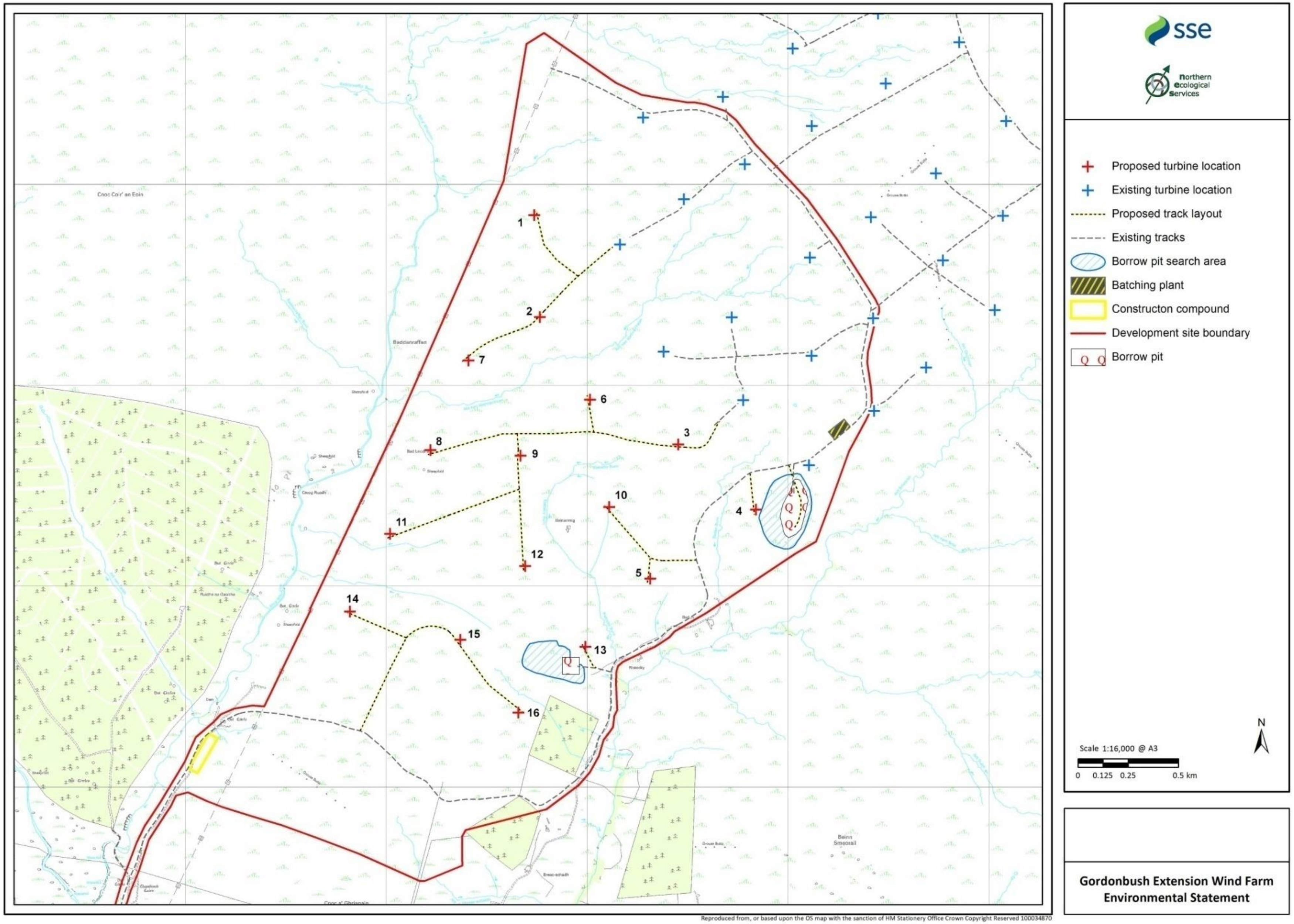
Appendix 1

Proposed Development



Appendix 2a: Quantitative stream survey sections and instream habitat descriptions, Allt a'Mhuilinn (accessible reaches).

Watercourse	Section Code	NGR		Notes: instream habitat	Notes: bankside habitat
		Downstream	Upstream		
Allt a' Mhuilinn	AM1	NC 82709 10620	NC 82523 10562	Gravel, cobble and pebble. Slow flowing. Deep pool in lower reaches with some cobble, gravel and sand. Middle of section more cobble. Upper is shallow fry habitat with pebble/gravel base.	Bank collapsed on outside of bends, high undercut provides no cover.
Allt a' Mhuilinn	AM2	NC 82523 10562	NC 82429 10774	Lower part of section has two short stretches of shallow run/riffle with substrates of pebble and cobble. Middle part of section is mainly deep pool with alder root cover. Upper mixed boulder and cobble with some gravel and pebble. Mixed depths and flow types.	Lower is bare sand, towards top is more stable with gorse, alder and grasses.
Allt a' Mhuilinn	AM3	NC 82429 10774	NC 82453 11010	Good mixed juvenile habitat with stable moss covered boulder, cobble and a little gravel and sand. Increases in gradient at upstream end.	Conifers on left bank are over 20 m back. Alders provide shade and cover on both banks.
Allt a' Mhuilinn	AM4	NC 82453 11010	NC 82440 11010	Lower part of reach is moderate quality mixed juvenile habitat. River exits towards upstream end, which is bedrock chutes and pools.	Steep bare bedrock banks with deciduous trees.
Allt a' Mhuilinn	AM5	NC 82440 11010	NC 82411 11490	Most is mixed juvenile habitat with large boulders with some bedrock stretches and pools below falls. Dam renders the upper part of this section inaccessible.	Conifers to 5 m from bank in places at downstream end. Upper section is grass and bracken bank tops, bare bank faces.

Appendix 2b: Quantitative stream survey data, Allt a' Mhuilinn(accessible reaches).

Section Code	Length (m)	Width (m)		Bankside cover		Substrate		Area (m^2) of each habitat type						Migratory access
		Wet	*Bank*	*Left*	*Right*	*Stability*	*Compaction*	*Fry*	*Mixed juv.*	*Pool*	*Bedrock*	*Glide*	*Spawning*	
AM1	270	6	6	Moderate	Moderate	Stable	Uncompacted	240	0	900	0	480	0	Yes
AM2	250	7	7	Good	Moderate	Stable	Uncompacted	140	1050	560	0	0	36	Yes
AM3	230	5	5	Good	Good	Stable	Uncompacted	0	1150	0	0	0	5	Yes
AM4	250	5	5	Poor	Poor	Stable	Uncompacted	0	300	150	800	0	4	Yes
AM5	260	5	5	Poor	Poor	Stable	Uncompacted	0	750	300	250	0	0	Part

Appendix 2c: Larval lamprey habitats identified during survey,Allt a' Mhuilinn

Code	NGR	Area (m^2)	Notes
AML1.1	NC 82595 10527	2	Too deep to assess, on edge of pool below alder.
AML1.2	NC 82584 10513	20	Backchannel - suboptimal poor towards upstream end of channel with gritty base.
AML1.3	NC 82559 10556	4	Left and right banks.
AML1.4	NC 82532 10558	6	Mixed. Mainly gritty and poor. Left bank. Some stable woody debris.
AML1.5	NC 82499 10565	2	Poor, over stones, in pool.

ABL2.1	Various	3	Sub-optimal patches in below alders - difficult access for electric fishing.

Appendix 3a: Quantitative stream survey sections and instream habitat descriptions, Allt Smeorail (accessible reaches).

Watercourse	Section Code	NGR		Notes: instream habitat	Notes: bankside habitat
		Downstream	Upstream		
Allt Smeorail	AS1	NC 84427 09283	NC 84423 09415	Moderate to fast flow with cobble and boulder substrate. Large cobbles provide good cover. Deep pool in lower reaches. Spawning habitat present.	Exposed side and point bars. Rock reinforcement on outside of lower bend.
Allt Smeorail	AS2	NC 84423 09415	NC 84320 09562	Cobble and boulder substrate with very mixed depths and flow types. Scours on bends create deep pool habitat. Runs, glides and riffles provide very good juvenile salmon habitat. Spawning habitat present.	Some root cover. Erosion and deposition both present. Some instability.
Allt Smeorail	AS3	NC 84320 09562	NC 84470 09642	Run, riffle and glide with a single deep pool at the top of the section. Most of reach is good quality juvenile salmon habitat. Cobble and boulder substrate. Spawning habitat present.	Stable banks with scattered trees providing some root cover.

Appendix 3b: Quantitative stream survey data, Allt Smeorail (accessible reaches).

Section Code	Length (m)	Width (m)		Bankside cover		Substrate		Area (m^2) of each habitat type						Migratory access
		Wet	*Bank*	*Left*	*Right*	*Stability*	*Compaction*	*Fry*	*Mixed juv.*	*Pool*	*Bedrock*	*Glide*	*Spawning*	
AS1	210	5	8	Poor	Absent	Moderate	Uncompacted	150	550	0	350	0	13	Yes
AS2	220	5	8	Absent	Poor	Moderate	Uncompacted	0	900	0	150	0	22	Yes
AS3	200	6	6	Poor	Poor	Stable	Uncompacted	0	1080	0	120	0	14	Yes

Appendix 3c: Larval lamprey habitats identified during survey,Allt Smeorail

Code	NGR	Area (m^2)	Notes
ASL1.1	NC 84441 09373	1	Eddy at right bank. Sub-optimal.
ASL1.2	NC 84427 09405	5	In backwater channel. Gritty substrate but some well-established twiggy debris present.

Appendix 4 Electric fishing site and event details

Code	Stream	NGR	Location	Survey type	Runs	Length (m)	Width (m)	Volts	Conductivity (µS.cm^{-1})	Temp (°C)	Level	Colour
AM1	Allt a' Mhuilinn	NC 82431 10856	Bottom of site is riffle that is 2 m upstream of 1st alder on left bank above gap in trees (approx. 70 m upstream of road).	Semi-quantitative	1	20.5	5.3	200	95	12.0	Low	Clear
AM2	Allt a' Mhuilinn	NC 82618 11553	On bend. Downstream end is bedrock ledge. Upstream end is run out of long pool below waterfall.	Semi-quantitative	1	24	5.3	200	80	12.5	Low	Clear
AM3	Allt a' Mhuilinn	NC 82712 11666	On the big bend upstream of the ford.	Qualitative	1	NA	NA	200	77	13.0	Low	Clear
AM4	Allt a' Mhuilinn	NC 83187 12443	At the old Loch a' Mhuilinn	Qualitative	1	NA	NA	200	Not recorded			
AS1	Allt Smeorail	NC 84473 09370	Bottom of site is 7 m downstream of lone birch on left bank. Top is riffle and constriction at NC 84478 09399.	Semi-quantitative	1	32	3.9	200	80	12.0	Low	Clear
AS2	Allt Smeorail	NC 84383 09575	Downstream end is the run out of the glide. Top end is 2 m upstream of the mature ash tree on the left bank.	Fully quantitative	3	19.5	5.5	200	80	12.0	Low	Clear
AS3	Allt Smeorail	NC 84651 10040	Downstream end is the left bank tributary (approx. 15 m upstream of footbridge).	Semi-quantitative	1	39	4.8	200	81	12.5	Low	Clear
AS4	Allt Smeorail	NC 85666 12757	Downstream and immediately upstream of Badan Burn confluence.	Qualitative	1	NA	NA	200	Not recorded			
AS5	Allt a' Breac-achaidh	NC 84590 11440	Downstream and immediately upstream of track.	Qualitative	1	NA	NA	200	Not recorded			

Appendix 5 Salmonid density classification system for watercourses of <6 m wet width in North Region (Godfrey 2006). The classification is based on large data sets held by SFCC. The quintile densities allow for comparison of fishery performance against regionally based reference points. Classifications are based on single run minimum densities.

	Density (fish.100m^{-2})			
	Salmon 0+	Salmon 1++	Trout 0+	Trout 1++
Min	1.0	1.2	1.0	1.2
20th percentile	7.1	1.7	4.4	3.0
40th percentile	9.3	4.6	5.2	4.4
60th percentile	12.7	8.5	8.5	7.1
80th percentile	20.1	13.0	12.6	8.6
Max	48.9	21.3	98.5	14.7

Density in regional classification	**Descriptive category used in text**
Min to 20th percentile	Very poor
20th to 40th percentile	Poor
40th to 60th percentile	Moderate
60th to 80th percentile	Good
80th to 100th percentile	Excellent

Appendix 6 Depletion in fish numbers attained at fully quantitative site AS2

Site	Salmon fry			Salmon parr			Trout fry			Trout parr		
	run 1	run 2	run 3	run 1	run 2	run 3	run 1	run 2	run 3	run 1	run 2	run 3
AS2	61	30	10	18	4	2	13	6	5	1	0	0

Appendix 7 Instream habitats at quantitative electric fishing sites

SITE	DEPTH						SUBSTRATE								FLOW TYPES								
	<10	*11-20*	*21-30*	*31-40*	*41-50*	*>50*	*HO*	*SI*	*SA*	*GR*	*PE*	*CO*	*BO*	*BE*	*OB*	*SM*	*DP*	*SP*	*DG*	*SG*	*RU*	*RI*	*TO*
AM1	10	75	15	0	0	0	0	0	5	5	15	50	25	0	0	5	0	15	0	20	50	10	0
AM2	5	45	25	25	0	0	0	0	5	10	25	35	20	5	0	0	20	40	0	0	30	10	0
AS1	20	55	25	5	0	0	0	0	2	3	20	60	15	0	0	10	0	5	5	10	40	30	0
AS2	10	55	30	5	0	0	0	0	10	10	15	45	20	0	0	0	0	10	5	50	30	5	0
AS3	10	50	35	5	0	0	0	0	3	7	10	45	35	0	0	0	5	25	0	0	50	20	0

Substrates: HO = high organic (peat); SI = silt; SA = sand; GR = gravel; PE = pebble; CO = cobble; BO = boulder; BE = bedrock; OB = obscured.
Flow types: SM = shallow marginal; DP = deep pool; SP = shallow pool; DG = deep glide; SG = shallow glide; RU = run; RI = riffle; TO = torrent.

SITE	Left Bank				Right Bank				Cover in wider channel
	UC	DR	BA	MA	UC	DR	BA	MA	
AM1	30	0	70	0	35	0	60	5	Good
AM2	10	0	90	0	15	0	85	0	Moderate
AS1	15	0	85	0	0	0	100	0	Moderate-good
AS2	0	0	100	0	0	10	65	30	Good
AS3	0	0	100	0	5	5	95	0	Good

Bankside fish cover: UC = undercut bank; DR = draped vegetation; BA = bare (no cover); MA = marginal vegetation (incl. tree toots).

Appendix 8.1 Habitat survey photographs, Allt a' Mhuilinn catchment

	Allt a' Mhuilinn AB1 Typical low gradient habitat a short distance upstream from River Brora.
	Allt a' Mhuilinn AB2 Mixed juvenile and spawning habitat downstream from road.

	Allt a' Mhuilinn AB3 Runs and riffles over boulder and cobble upstream of the road.

	Allt a' Mhuilinn The waterfall at NC 8260 1148 is unsafe to approach. It was estimated to be at least 4 m high and clearly impassable. This is the most downstream natural obstacle, although the dam at NC 8249 1131 (see Figure 2 in text) is also likely to be impassable.

	Allt a' Mhuilinn The waterfall at NC 8260 1163 was estimated to be between 6 and 7 m high. It is clearly impassable. This and the waterfall pictured above render the proposed Development site inaccessible to migratory salmonids.
	Allt a' Mhuilinn NC 8321 1246 This is the location of Loch a' Mhuilinn, which was recently drained by removal of the impoundment. The old shoreline is still visible.

	Allt a' Mhuilinn Braided channel at NC 8349 1297. Some spawning habitat was present in this area. However, most of the channel has cobble and boulder substrate that provides little spawning opportunity for trout.
	Allt a' Mhuilinn Short reach of bedrock dominated habitat at NC 8348 1357. This reach is about 100 m long. Most of the channel has cobble and boulder substrate.
	Allt a' Mhuilinn Looking upstream from the confluence with Allt nan Nathraichean (NC 8397 1395).

	Allt nan Nathraichean Just upstream of the confluence with Allt a' Mhuilinn at NC 8410 1393. Stick is 1.5 m high.
	Allt nan Nathraichean Spawning calibre substrates are mainly limited to patches of gravel and pebble deposited at the edge of pools and glides.

Allt nan Nathraichean

Waterfall at NC 8441 1390. Height 1.7 m. Possibly impassable for smaller, stream dwelling trout.

Allt nan Nathraichean

NC 8458 1396

Suitable habitat for trout is present throughout much of the stream.

	Allt nan Nathraichean NC 8467 1398 A section of stream extending for about 300 m is dominated by bedrock. Some parts are shallow and steep and may limit of prevent fish movement.
	Allt nan Nathraichean NC 8482 1412 This is close to the upper survey limit. Habitat is suitable for trout with mixed substrate and overhead cover from undercut banks.

Appendix 8.2 Habitat survey photographs, Allt Smeorail catchment

	Allt Smeorail AS1 Looking downstream to Loch Brora.
	Allt Smeorail AS2 Looking upstream from NC 8441 0942
	Allt Smeorail Spawning habitat in section AS2 at NC 8437 0946

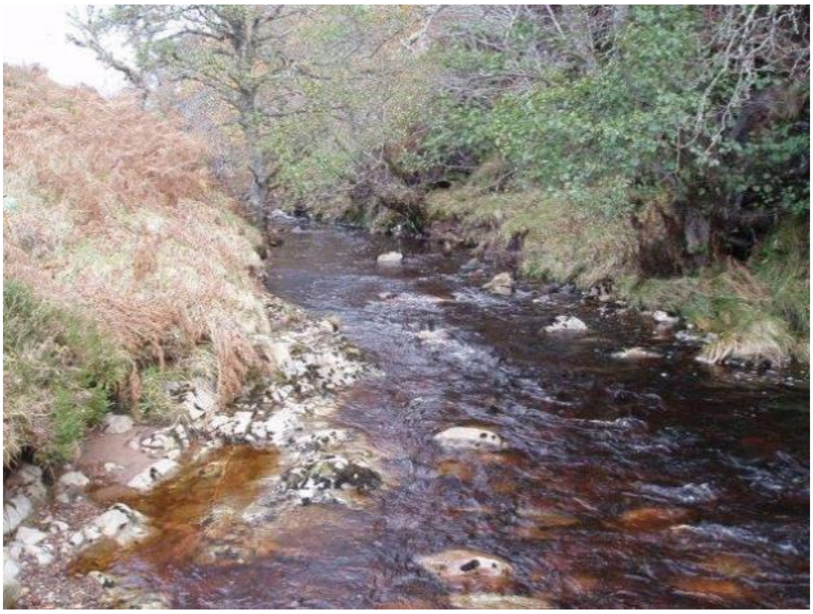
<table>
<tr><td></td><td>Allt Smeorail

AS3

Typical mixed juvenile salmon habitat at NC 8445 0960</td></tr>
<tr><td></td><td>Allt Smeorail

Waterfall at NC 8451 0973

This long curving waterfall is approximately 7 to 8 m high. It ends in a near-vertical drop of approximately 4 m (arrow). There is no significant downstream constriction and the waterfall is clearly impassable.</td></tr>
</table>

	Allt Smeorail NC 8492 1084. This photograph shows typical habitat in Allt Smeorail upstream of the lower gorge. Substrate is boulder and cobble with patchy bedrock. Smaller substrates are unstable and mainly deposited in pools and glides.

	Allt Smeorail NC 8506 1171

	Allt Smeorail Waterfall at NC 8561 1269 The waterfall is 2.2 m high. While the plunge pool is deep and there is a well-defined standing wave the lack of a downstream constriction means its height will not reduce significantly at high flow. It is probably impassable for trout.
	Allt Smeorail At NC 8570 1275 near the confluence with Allt Badan and upstream of the waterfall pictured above. Trout are present.
	Allt a' Breac-achaidh NC 8459 1144 Stream is approximately 0.8 m wide and appears suitable for trout (electric fishing found trout present).

	Ristocky Burn One of three waterfalls near the confluence with Allt Smeorail (NC 8520 1249).This 1.6m fall is followed by a second 1.6 m high fall and a 1.2 m high waterfall. It is uncertain whether trout could ascend these to enter Ristocky Burn.
	Ristocky Burn NC 8517 1256 Downstream of the track the burn is steep and meanders between bedrock banks. Habitat quality is poor due to large areas of bedrock and high gradient.

	Ristocky Burn NC 8515 1261 The perched culvert at the track is impassable.
	Ristocky Burn NC 8498 1309 Most of the habitat upstream of the existing track is unsuitable for trout production. It is densely vegetated with substrate of peat.
	Badan Burn NC 8572 1287

	Badan Burn Waterfall at NC 8571 1284 Height is 3 m and the waterfall would be impassable for trout.
	Badan Burn NC 8571 1278 (approximately 20 m upstream from Allt Smeorail confluence). Stream is 0.4 m wide and shallow. It appears unlikely to support a fish population.

Appendix 9. Salmonid electric fishing sites

	Allt a' Mhuilinn AM1 from downstream NC 82431 10856 Net at downstream end of site
	Allt a' Mhuilinn AM1 downstream end from right bank
	Allt a' Mhuilinn AM2 from downstream NC 82618 11553 Net at downstream end of site

	Allt a' Mhuilinn AM3 from downstream NC 82712 11666 Qualitative site (trout present)
	Allt a' Mhuilinn AM4 NC 83187 12443 Qualitative site (trout present)

Allt Smeorail

AS1 from downstream

NC 84473 09370

Net at downstream end of site

Allt Smeorail

AS2

NC 84383 09575

Site from upstream (stop net at upstream end)

Allt Smeorail

AS3 from downstream

NC 84651 10040

The downstream end of the site is marked by a tributary entering from the left side.

	Allt Smeorail AS4 from downstream NC 85666 12757 The site extended downstream and upstream of the Badan Burn confluence. Trout were present.

	Allt a' Breac -achaidh AS5 NC 84590 11440 Site was immediately downstream and upstream of the track. Trout present both up and downstream

Appendix 10. Lamprey electric fishing sites

	Allt a' Mhuilinn AML NC 82534 10559 Lamprey survey site from upstream
	Allt Smeorail ASL NC 84427 09405 Lamprey survey site from right bank of backwater

	Bucket of *Lampetra* larvae from lower reaches of Allt a' Mhuilinn. Several years classes are present and the arrow points to a 0+ larva.
	*Lampetra* larvae
	Brook lamprey transformer