



# Appendix 6.5

## Watercourse Crossings Report

# Table of contents

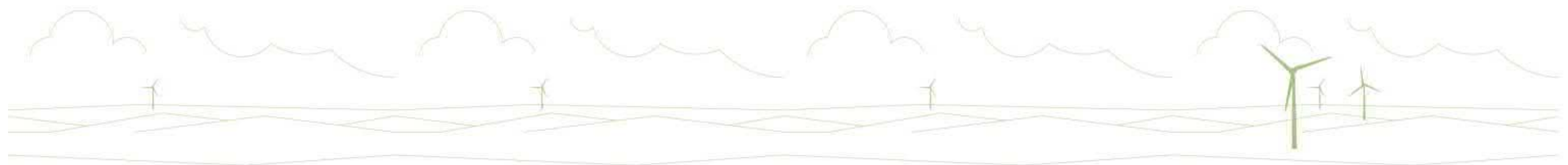
<b>6.1</b>	<b>Introduction</b>	<b>3</b>
<b>6.2</b>	<b>Route Selection</b>	<b>4</b>
6.2.1	Access to the Proposed Development	4
6.2.2	Access Tracks	4
<b>6.3</b>	<b>Crossing Descriptions</b>	<b>4</b>
6.3.1	Assessment Method	4
6.3.2	Desk Study	4
6.3.3	Walkover Survey	4
6.3.4	Ecological Provision	5
6.3.5	Watercourse Crossing Assessment	5
<b>6.4</b>	<b>Summary</b>	<b>6</b>
<b>6.5</b>	<b>References</b>	<b>6</b>
<b>Annex A – Watercourse Crossing Selection Guidelines</b>		<b>6</b>
A.8.1.	Small, Medium and Large Crossings	9
A.8.2.	Bridges	9
A.8.3.	Rectangular Culverts/Arches	9
A.8.4.	Circular Culverts	9
A.8.5.	Multiple Culverts (Circular)	9
A.8.6.	Multiple Culverts (Rectangular)	9
A.8.7.	Ecological Provision	10
A.8.8.	Construction	10
<b>Annex B - Description Sheets for CAR-Applicable Watercourse Crossings</b>		<b>17</b>

## Annex C – Minor Watercourse Crossings

24

### Photographs

24



## 6 Watercourse Crossings Report

### 6.1 Introduction

1. This report provides additional information to **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** of the Environmental Impact Assessment Report (EIAR) and should be read with reference to the chapter and associated figures. Hydrological features, including catchments, are shown in **Figure 6.7 Hydrology Overview** of the EIAR.
2. Consent for a 13 wind turbine windfarm (the Proposed Development) is sought by ScottishPower Renewables (hereafter referred to as the Applicant) under Section 36 of the Electricity Act 1989. The Proposed Development is located approximately 6 kilometres (km) south of Straiton, in the south west of Scotland.
3. The Site consists mainly of mature coniferous woodland, dominating much of the northern part of the Site, and some areas of clear felled plantation. Peat is notable in open areas, such as forestry rides, clearings and in the vicinity of surface water bodies.
4. Elevation of the Site undulates between 242.7 – 430.2 metres (m) above ordnance datum (AOD). The highest point is Garleffin Fell (430.2m AOD), the summit of which lies at the western extent of the Site. The majority of the Site is within the Palmullan Burn catchment, encompassing the majority of the western and central parts of the Site. The Tairlaw Burn catchment encompasses the eastern part of the Site. There are a number of small watercourses which are situated within or border the Site.
5. The main catchments of the Water of Girvan and the River Stinchar are referenced in **Figure 6.7 Hydrology Overview** of the EIAR. The Water of Girvan catchment has an area of approximately 250km<sup>2</sup> and the River Stinchar has a catchment area of approximately 253km<sup>2</sup>.
6. The northern part of the Site is drained by the Water of Girvan catchment and its tributaries, including Palmullan Burn (6.50km<sup>2</sup> catchment area), which drains the majority of the northern Site extent, flowing in a north easterly direction to join the Water of Girvan, approximately 4.7km downstream.
7. The majority of the central and south-western part of the Site is drained by the River Stinchar and its tributaries, including Linfern Loch Burn (4.10km<sup>2</sup> catchment area) and Dalquhairn Burn (2.10km<sup>2</sup> catchment area). Tairlaw Burn (7.10km<sup>2</sup>), drains the eastern extent of the Site via tributaries including Pulreoch Burn (0.75km<sup>2</sup> catchment area), flowing in a north east direction to join Water of Girvan.
8. Compliance with the Water Framework Directive (WFD) (2000/60/EC) is required due to potential impacts of the Proposed Development on the water environment. The WFD has been transposed into Scottish legislation as the Water Environment and Water Services (Scotland) Act 2003 (WEWS) and has given Scottish Ministers powers to introduce regulatory controls over activities in order to protect and improve Scotland's water environment. The water environment includes wetlands, rivers, lochs, transitional waters (estuaries), coastal waters and groundwater. These regulatory controls, the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (known as CAR), specify that it is an offence to undertake the following activities without a CAR authorisation:
  - discharges to all wetlands, surface waters and groundwater (replacing the Control of Pollution Act 1974 (CoPA));
  - disposal to land (replacing the Groundwater Regulations 1998);
  - abstractions from all wetlands, surface waters and groundwaters;
  - impoundments (dams and weirs) of rivers, lochs, wetlands and transitional waters; and
  - engineering works in inland waters and wetlands.
9. Watercourse crossings (engineering works in inland waters and wetlands) comes under Section 6 of CAR. Three different types of authorisation under CAR allow for proportionate and risk-based regulation. The authorisation process operates at three levels which are:
  - General Binding Rules(GBR);
  - Registration; and
  - Licence.
10. These levels cover activities with increasing potential impact upon the environment. Minor watercourses, which do not feature on the 1:50,000 scale Ordnance Survey (OS) mapping, are not within the remit of CAR regulations. However, these minor watercourse crossings have been listed within this report.
11. It would be the objective of the Applicant to ensure that all activities remain within the General Binding Rules (Engineering Activities) identified in The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended): A Practical Guide, Version 8.4, October 2019 (Scottish Environmental Protection Agency (SEPA) (SEPA, 2019)). Should activities be determined to be outwith the above General Binding Rules (GBR) and Registration authorisations, it would be appropriate to consider a licence application (simple or complex). The SEPA Regulatory Method (WAT-RM-02) Regulation of Licence-level Engineering Activities (SEPA, 2019) lists conservation, environmental standards for morphology and good practice as tests for any licence application. During the determination, SEPA shall consider the specific location, type, size and existing water quality of the local water features.
12. The applicable Engineering Activities GBR and Registrations that this application shall adhere to are as follows:
  - General Binding Rule 6 – Minor bridges with no construction on bed or banks;
  - General Binding Rule 8 – Controlling bank erosion by green bank reinforcement or re-profiling;
  - General Binding Rule 9 – Operating any vehicle, plant or equipment (machinery) when undertaking other GBR activities (which includes GBR 6 and 8);
  - Registration – bridges with no construction on bed and <20m of total bank affected (open-based culverts would be anticipated to fall within this category);
  - Registration – where cables are not appropriately located to cross water channels via newly installed track infrastructure, it would be anticipated a Registration would be required, as cables would be anticipated being installed via isolated open-cut technique, due to small channel size; and
  - Simple Licence – for all other bridges, fords and causeways, such as those with construction on bed and greater than 20m of total bank affected.

## 6.2 Route Selection

13. Before considering watercourse crossings in detail, SEPA will wish to satisfy themselves that ‘good practice’ has been followed, which in their terms means avoidance or minimisation of the number of crossings. The number of crossings is a function of the Access Track route through the Site. In the case of most windfarms the purpose of the access tracks is to link up the wind turbines, although occasionally there are ancillary purposes such as provision of haulage routes for timber extraction or borrow pit access.
14. The main factors that would be considered in determining a route include:
  - wind turbine and other infrastructure locations;
  - suitability of existing access tracks;
  - maximum track gradient suitable for the type of traffic and loads;
  - other track geometry factors such as bends and junction layouts;
  - stability and bearing capacity of the ground and adjacent slopes;
  - the volumes of ‘cut’ and ‘fill’ to ensure a suitable track alignment;
  - land take (primarily determined by route length);
  - the type and nature of bridging structures;
  - sensitivity (flora, fauna, soils, water, human, etc.); and
  - whole life costs (construction and maintenance).
15. Given this non-exhaustive list, optimum track geometry has been determined to link up the wind turbines and other development infrastructure. The development of Access Tracks is inevitably a compromise between several constraints: the desire to locate wind turbines on areas of stable and/or shallow peatland; environmental constraints; and routing Access Tracks away from difficult terrain, where practicable, means that the track geometry is constrained by ecological and topographical features to arrive at an optimum strategy.
16. There is not a direct link between ‘optimum’ and ‘good practice’ in the WFD context, which is oriented towards the water environment; however, watercourse crossings should be avoided or minimised. In addition, the use of existing crossings, where feasible, would reduce the impact on the water environment.

### 6.2.1 Access to the Proposed Development

17. Access to the Site would be via two existing forestry tracks linking the Proposed Development to Newton Stewart Road (C46w) in the east at two junctions located approximately 4.5km south of Straiton. The Access Tracks proposed are shown on **Figure 6.7 Hydrology Overview** of the EIAR.

### 6.2.2 Access Tracks

18. The Access Tracks within the Site would run from the eastern entrances and connect all wind turbine locations, wind turbines 1 to 13.

19. Potential upgrades to all five existing watercourse crossings present within the Site may be required as part of the Proposed Development and would be subject to CAR.
20. Approximately 7.4km of new Access Tracks would be constructed and approximately 8.8km of existing forestry track would be upgraded, which will require two new watercourse crossings (WC05 and WC07), subject to CAR.
21. A key objective of the WFD is that water bodies achieve at least ‘Good’ status by 2027. SEPA classify surface water bodies using five classes: ‘High’, ‘Good’, ‘Moderate’, ‘Poor’ or ‘Bad’. The classifications take into account pressures and their potential effects, compared to near natural conditions for the respective water body.
22. The WFD classification (2018) for SEPA water bodies have been provided in **Tables 6.8 and 6.10 of Chapter 6: Hydrology, Hydrogeology, Geology and Soils** of the EIAR with River Stinchar (u/s Water of Gregg), and Water of Minnoch classified as having moderate overall status, while Dobbington/Lindayston Burn, Dalquhairn Burn and Palmullan Burn have high overall status.

## 6.3 Crossing Descriptions

### 6.3.1 Assessment Method

23. The catchment-based approach in this assessment follows that discussed in **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** of the EIAR.
24. The project involved a desk study and walkover surveys. This work is underpinned by the watercourse crossings selection guidelines that have been developed by WSP in support of windfarm projects. These guidelines have evolved over a number of windfarm projects and have incorporated valuable input from SEPA and NatureScot<sup>1</sup>. The guidelines, presented in **Annex A**, assist in selecting an appropriate type of watercourse crossing dependent on the physical and ecological characteristics of the watercourse.

### 6.3.2 Desk Study

25. The desk study consisted of a review of the information regarding the Proposed Development, principally involving an examination of the proposed track layout and the identification of watercourses marked on the OS 1:50,000 scale map which would require crossings, under the CAR Regulations. Crossings of minor watercourses were also identified at OS 1:10,000 scale mapping, where possible. This information informed the design to minimise crossing locations of all mapped watercourses.

### 6.3.3 Walkover Survey

26. Subsequent to the initial desk study, walkover surveys of the Site were conducted between March 2020 and August 2020, during which the identified crossings were visited to obtain specific information about each location. Photographs and detailed field notes were taken reporting channel and valley dimensions, channel substrate, and type of either the existing or proposed crossing. A hand-held global positioning system (GPS) unit was used to obtain locations with greater than 10m accuracy.

<sup>1</sup> Formerly Scottish Natural Heritage (SNH).



27. A number of unmarked watercourses were observed during the walkover surveys and details were recorded to give as complete a list of crossings as possible, to help inform the track construction process.
28. All watercourse crossings (both CAR and non-CAR crossings) are shown on **Figure 6.7 Hydrology Overview** of the EIAR.

### 6.3.4 Ecological Provision

29. For each crossing, there is provision to indicate the likelihood of the watercourse being used by mammals, principally otters and water vole, and fish.
30. Where mammal or migratory fish presence is confirmed or suspected, appropriate design features would be included within the crossing design. These may include incorporation of ledges or additional dry passages to allow passage at high water levels, in-channel baffles or low water channels to aid fish passage, and other design features appropriate for the crossing location. Track design has considered good practice guidance and recommendations in the Design Manual for Roads and Bridges (Highways Agency, 2020). A 50m hydrological buffer has been applied to all infrastructure except where watercourse crossings are required, with track construction minimised within this buffer.
31. The protected mammals' surveys found evidence of the presence of otter within the Site, with signs of activity on Palmullan Burn. Abundant water vole evidence was recorded along the Pulreoch Burn and its unnamed tributaries and unnamed tributaries of the Tairlaw Burn. Areas considered to provide moderate habitat for mammal protected species including both otters and water voles include tributaries of Tairlaw Burn and Dalquhairn Burn (**Appendix 7.1 Ecology Baseline Report** of the EIAR).
32. Fish surveys were undertaken to provide baseline information on the riparian habitat and fish populations of the major watercourses. Tairlaw Burn and Pallmullan Burn were noted to be important spawning and rearing areas for trout, while Dalquhairn Burn was noted to be an important spawning and rearing area for both trout and salmon (**Appendix 7.5 Aquatic Ecology Baseline Report** of the EIAR).

### 6.3.5 Watercourse Crossing Assessment

33. The watercourse crossing guidelines in **Annex A** provide a generic approach to crossing various types and sizes of watercourse.

#### 6.3.5.1 CAR Watercourse Crossings

34. A total of seven watercourse crossings where CAR apply have been identified from the final Access Track layout (**Figure 4.1 Site Layout**), with reference to 1:50,000 OS mapping. These are required to accommodate construction and operation of the Proposed Development.
35. **Annex B** contains information about each CAR watercourse crossing, providing location data and photographs of the watercourse and ecology data. An assessment of the catchment area upstream of the crossing is given so that the required conveyance capacity of the bridging culvert or bridge may be calculated or checked at the design stage to confirm appropriate sizing.
36. A summary of the CAR watercourse crossings is provided in **Table 6.5.1**, giving the classification by watercourse size, with the different types of crossings across the development. Watercourse sizes are defined in **Annex A**.

Track Crossing Type	Watercourse Size			
	Large (Greater than 3m)	Medium (Between 1m and 3m)	Small (Less than 1m)	Total
Bridge	-	-	-	-
Rectangular culvert/arch	-	-	-	-
Open-base arch structure	-	-	-	-
Circular culvert	WC01*	WC02*, WC04*, WC06*, WC07	WC03*, WC05	7
Circular Pipe	-	-	-	-
Drainage layer	-	-	-	-
Total new crossings	-	1	1	2
Total existing crossings, potentially requiring upgrade	1	3	1	5
TOTAL (new + upgraded existing)	1	4	2	7

Table 6.5.1: Summary of Types and Sizes of CAR-Applicable Watercourse Crossings

\*Existing crossings

#### 6.3.5.2 Minor Watercourse Crossings

37. Minor watercourse crossings noted within the 1:25,000 OS map are summarised in **Annex C** and would help to inform the track construction process, as these, and others similar, would be likely to be regularly encountered where new Access Track is created. It should be noted that this list is not considered comprehensive.

## 6.4 Summary

38. The design of the infrastructure has attempted to minimise the number of new watercourse crossings, resulting in the proposal to use five existing watercourse crossing structures (WC01, WC02, WC03, WC04, and WC06) to cross watercourses shown on the OS 1:50,000 mapping, subject to CAR. These locations would be required for access across the Site and would require structural upgrades to widen the access track at watercourse crossings, using the existing structure as support to minimise disruption to channel bed or banks, if possible. In addition to these existing structures to be upgraded, two new CAR watercourse crossings (WC05 and WC07) would be required.
39. There would also be a requirement for a number of non-CAR applicable crossings, anticipated as open-bottom arch (con/span) culverts or circular culverts, depending on the size of the watercourse. The location of minor crossing locations have been provided (**Annex C**), which represent typical stream characteristics that would require crossing structures on Access Tracks.
40. Prior to the construction of the Proposed Development, it is anticipated that additional data to that provided in this report would be required. This information would include more detailed measurements in relation to structure dimensions and further refinements for flow conveyance and any ecological provision at each crossing, forming the detailed design stage. A number of the existing crossings may not need upgrade, with this engineering decision to be determined pre-construction.
41. It is anticipated that six crossing structures would require CAR Registration (as no in-channel supports are anticipated). However, should bridge structures require work that affects 20m or more of total riverbank, these would escalate to Simple Licence applications.
42. Watercourse Crossing WC01 is anticipated to require a CAR Simple Licence given its 4.0m channel width for culvert. If a bridge was selected at the detailed design stage, assuming less than 20m of total bank was affected, this would require a CAR Registration.

## 6.5 References

Highways Agency (2020). Design Manual for Roads & Bridges. Highways Agency. [online]. Available from: <https://www.standardsforhighways.co.uk/dmrb/> [accessed October 2021]

SEPA (2019a). Regulatory Method (WAT-RM-02) Regulation of Licence-level Engineering Activities, Version 6.1, January 2019. Scottish Environment Protection Agency.

SEPA (2019b). Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended): A Practical Guide, Version 8.4, October 2019. [online]. Available from: [https://www.sepa.org.uk/media/34761/car\\_a\\_practical\\_guide.pdf](https://www.sepa.org.uk/media/34761/car_a_practical_guide.pdf) [accessed October 2021]

SEPA (2018). Water Classification Hub. [online]. Available from: <https://www.sepa.org.uk/data-visualisation/water-classification-hub/> [accessed October 2021]

WSP (2021). EIAR Chapter 6: Hydrology, Hydrogeology, Geology and Soils for Carrick Windfarm.

## Annex A – Watercourse Crossing Selection Guidelines

### A.1. Introduction

1. Windfarms have been proposed and constructed in a wide range of landscapes which have varying forms of topography, land use and habitat. In any new development there is the likelihood of new access roads being constructed which would require crossing watercourses, ditches and other features, such as peat hags. In some instances, there may also be existing crossings that require a structural upgrade. Additionally, some of the features may only intermittently convey water.
2. In Scotland, many of the windfarms are on hilltops thus the majority of the crossings are over small headwater burns or minor watercourses. In engineering terms, the usual approach has been to place circular culverts into the stream bed and build the access track on an embankment above the culvert. This approach, and associated good practice, as given in The Forests and Water Guidelines (Forestry Commission, 2011), has been used for over 30 years in the construction of forestry access roads. Where a single circular culvert would be inadequate, twin or triple culverts have been used or, on wider watercourses, rectangular culverts or conventional abutment bridges may be installed.
3. Although windfarm developments may be located in areas of similar terrain to forestry plantations, higher standards for watercourse crossings are expected. In part, this is because some developments are in forestry areas that would not have been considered in the past and there is a limited history of practical engineering solutions. The main driver for a change from past practice is the introduction of the WFD and its associated Regulations. Under these regulations, it is ecological status that has primacy over engineering and the conveyance of flows.
4. Most proposals which would involve engineering activity in the vicinity of water have to be submitted to SEPA for appraisal and, depending on the scale of the work and sensitivity of the waters, may require registration or licensing.
5. The adoption of best practice guidelines is recommended in the design of watercourse crossings in order to remain compliant with CAR regulations. Such guidelines should include a procedure for watercourse characterisation and a list of appropriate options for spanning each watercourse type. This would provide a tool for evaluating the numbers, types and potential impacts of the crossings. It is intended that full acknowledgement should still be taken of the Forest and Water Guidelines as well as the Construction Industry Research and Information Association (CIRIA) Culvert, screen and outfall manual (C786F) (CIRIA, 2019), which focuses mainly on engineering features.

### A.2. Method

6. The morphological conditions of watercourses, namely planform, cross-sectional form, bank form and floodplain type and characteristics were defined. These were considered in conjunction with the range of potential engineering activities associated with watercourse crossings, such as fords, culverts (circular

and rectangular), arches and abutment supported bridges. A set of guidelines were used to define appropriate watercourse crossing type based upon the watercourse (morphological) characteristics and required ecological considerations.

7. Ecological issues should consider not only the operational aspects of the proposed watercourse crossing structures, but also the risks and duration of construction impacts on ecological receptors. Key risks to ecology may include the requirement of stream-bed continuity (to avoid significant negative local effects on aquatic ecological and fishery receptors) or the passage of mammals.

### A.3. Watercourses

8. Windfarm developments may potentially cross many types of water features. Thus, in the context of this document 'watercourse' needs to be seen in a broader sense than a burn or stream alone and needs to encompass the following:
  - natural burns and streams as normally perceived;
  - ditches and drains as encountered alongside roads, in moor gripping or forested areas;
  - incised channels in peat (also known as haggs or gullies);
  - peat pipes; and
  - flushes.
9. Of these features, it is the natural watercourses that typically display the greatest morphological diversity (such as size and cross-sectional profile). They may also be regarded as being the most ecologically sensitive as they typically tend to support the most valuable assemblages of aquatic flora and fauna with high individual nature conservation and fishery value. However, it must be recognised that this guideline is not intended to cover major river crossings where many other factors would come into play.
10. In cross-section, ditches and drains tend to be regular and trapezoidal and have a flow regime which may be transient. Nevertheless, they provide refuge, corridors for movement and offer damp habitats for certain species, such as frogs.
11. Haggs and peat pipes are natural features within areas of blanket bog. Gullies between haggs are formed where the force of water has eroded the peat; these could be up to 5m deep and frequently take the form of a narrow irregular 'V' or broad 'U' shape. They act as drainage channels following periods of prolonged rainfall. The formation of peat pipes is not well understood, but these often occur at the peat/mineral soil interface and could be 0.5m diameter but are usually significantly smaller.
12. Flushes usually occur at the headwaters of watercourses where flow is predominantly sub-surface interflow with perhaps some overland flow during wetter periods. Flushes are usually located within a concave part of the hillside; they have no defined channel and the width of the flush may vary considerably depending on the terrain.
13. Within watercourses, a large range of channel substrate and bank materials may be encountered including organic soils, clays, gravels, boulders and bedrock.
14. Some channels within the Site only convey intermittent flow. Furthermore, for aquatic ecology, fish are confined to burns and streams with amphibians having a more widespread habitat and may utilise the wet and damp conditions of ephemeral watercourses.

### A.4. Structures

15. The envisaged structural components of the crossing may comprise circular or rectangular culverts, segmental arch sections or a bridge deck set upon abutments. Construction may use a variety of techniques and materials – steel, precast and in-situ concrete, plastics and timber.
16. **Table A1** sets out the generally available sizes and materials in which these elements may be procured.

Type	Materials	Size Range (mm <sup>1</sup> )		Comments
Circular Culvert	Precast concrete	200 <sup>1</sup>	2400	High strength and durable
	Corrugated metal	300	6000	
	Plastic	100	600	
Rectangular Culvert	Precast concrete	1000 x 600	4800 x 3000	Large range of widths and heights
Open-Base/Segmental Arch	Pre-cast concrete	2000	10000	No interference with stream bed
	Corrugated metal			
Bridge Decking	Pre-cast concrete	4000	10000	Standard Beam with in-situ deck
	Steel & Concrete			Steel Beam with in-situ deck
	Timber	2000	4000	Limited life/load capacity
Abutments	In-situ concrete	-	-	Conventional construction
	Pre-cast sections	-	-	Reinforced earth techniques
	Masonry	-	-	May be in the form of gabions

Table A1: Sizes and Materials for Structural Components

<sup>1</sup> Although pipes may be available in these smaller sizes the CIRIA minimum recommended diameter for any circular culvert is 450 millimetres (mm).

17. The suggested range of diameters or spans for which these different structures may be applied should be regarded as indicative. Particular manufacturers of pipes, box culverts and arch systems have a greater or lesser range and bespoke solutions such as bridges can be almost of any size.

### A.5. Ecological Provisions

18. Ecological provision for fish and mammals need only be provided where there is reasonable evidence that these animals occupy or migrate through the locus of the proposed crossing. For example, fish may be entirely absent upstream of a natural barrier, such as a waterfall or a reach with a non-navigable gradient and high flow velocities. Similarly, field surveys may have failed to establish the presence of any of the designated mammals and that habitats are such as to be unlikely to attract inward migration.
19. Conversely, if the need for ecological provision has been established then this should take an appropriate form, which would depend on the species and the physical nature of the crossing. In general, the provisions at burns and streams may encompass:



- mammal ledges within the crossing and at top of bank elevation;
  - mammal tunnels adjacent to the watercourse and accessible from bank level;
  - continuity of stream bed comprising natural indigenous material;
  - absence of a step in the water levels in excess of 300mm;
  - no reduction in overall width or natural fluctuation of depth; and
  - reinstatement of natural vegetation to provide 'cover'.
20. This guideline does not provide any methodology for assessing the ecology of the Site in general, or the specific location of the proposed watercourse crossing. This guidance only provides information on the requirement for ecological provision at the proposed watercourse crossings.

## A.6. Hydraulic Sizing

21. The CIRIA Guidelines provide recommendations on calculation methods for the design flood to be passed through a culvert without risk of structural damage. In the absence of a historically significant period of actual flow records, the recommendation is to use the Flood Studies Report (Institute of Hydrology, 1993). Although valid at the time the guidelines were produced, the normal method would be to use the Flood Estimation Handbook Web Service (Centre for Ecology and Hydrology, 2020) and the associated digital model of channel networks.
22. The design standard in terms of flood severity is normally expressed as a return period. Windfarms are typically located in rural areas with Access Tracks generally conforming to forestry type roads where bridging culverts have been designed to a 1:50 year return period. Due to climate change it is suggested that a 0.5% annual exceedance probability (1:200 year) plus climate change allowance standard is now adopted. For information, on the basis of the Flood Studies Report the approximate growth factors on Qbar (about two a year return period) for Region 1 (Scotland) for various return periods is set out in **Table A2**.

Return Period	Growth Factor
15	1.7
25	1.9
50	2.2
100	2.5
200	2.8
300	3.0
400	3.1
500	3.2

Table A2: Return Period Growth Factors

23. This shows that, between the 1:50 year to 1:200-year return period, there is a 27% increase in flood. This is considered to be an adequate uplift for bridges or culverts where a small amount of transient upstream ponding would be of no consequence.
24. Furthermore, in terms of sizing rectangular culverts where there is a need to re-establish a natural stream bed, it is proposed that an additional 450mm is added to the vertical dimension so that the structure may be a depressed invert culvert, installed below natural bed level.

25. Note, however, that the digitised channel network is based on the watercourses visible on a 1:25,000 scale OS map. It may be that many of the smaller crossings in a particular development do not feature at this scale, nor would other features such as drainage ditches or moor grips. Thus, a pragmatic approach along with hydrological judgement may be required where definitive calculations are not practical. Thus, the range of options may comprise:
- comprehensive use of Flood Estimation Handbook (FEH) featuring the actual stream to be crossed;
  - utilise surrogate watercourse to calculate unit flow rates per hectare and then pro-rata to the specific crossing;
  - consider watercourse morphology to estimate 1-2-year return period flow based on bank full condition and then scale to design return period; and
  - consider channel morphology and 'match' conveyance capacity of existing channel so that crossing unlikely to form a restriction.
26. Although these may appear to be in decreasing order of sophistication it should be borne in mind that the regression equations for Mean Annual Flood (MAF) are not precise and may under or overestimate actual values. The error in the estimate does not improve when scaled up to the design return period. The channel morphology has been shaped by actual flow characteristics and recognising that may provide useful insight to past flood levels.
27. Where the crossing takes regard of migratory fish, the Scottish Executive issued guidelines (Scottish Executive, 2012) which provide important design criteria such a minimum width and depth of water, maximum velocity of flow and provision of rest pools. These parameters are species and culvert length dependent.

## A.7. Selection Process

28. The process of 'mapping' watercourse characteristics to a suitable form of crossing is conceptually simple. It is a case of matching several physical / ecological criteria to the most appropriate crossing type.
29. In practice, there are many permutations of watercourse, topography, bed materials etc. that can be considered. The number of categories of each attribute is set out in **Table A3**.

Type of Attribute	Options	Cases
Watercourse types	5	Stream, Ditch, Peat Hagg, Peat Pipe, Flush
Setting/Context	6	Incised, Broad, Road drain, Land drain, Buried, Surface
Size	3	Small, Medium, Large (predominantly as in width)
Ecological Provision	2	Yes, No

Table A3: Description of Watercourse Attributes

30. If every one of these attributes were permuted without regard to feasibility there would be 180 permutations; however, this reduces to 47 if anomalous physical combinations, such as buried streams or surface peat pipes, are discounted.
31. The number of options can be further reduced to 25 by considering only those that make environmental sense - thus fish migration within peat pipes is not a recognised phenomenon for which provision needs to be made. The reduction in numbers has been based on removing 22 hypothetical cases of Ecological



Provision where it is believed that the case for mammal ledges/passes and natural bed reinstatement either do not make sense or cannot be justified. Of these, seven relate to road side ditches or small land drains, eight to peat hags, four to peat pipes and four to flushes. In all of these cases, fish are neither present, nor mammals likely to be impeded.

32. The selection process can be reduced to a decision table, **Table A5**, whereby working from left to right across the columns a watercourse crossing type is determined. This table is also available as a spreadsheet and, with auto-filtering, allows a rapid check to be made of alternatives where a classification is marginal. A summary count of the options is given in **Table A4**.

Water feature	Number of options	Arch / Bridge	Culvert/ Pipe	Comments
Streams	12	4	8	All large streams crossed by bridge / arch
Ditches	5	-	5	Only large ditches would justify bridges
Peat Hags	4	-	4	None.
Peat Pipes	2	-	2	Pipes ensure continuity of subsurface flows
Flush	2	-	2	
<b>Total:</b>	<b>25</b>			

Table A4: Summary of Crossing Options

## A.8. Decision Rationale

33. In drawing up the choice of crossing type and the form of ecological provision a number of assumptions have been made. In effect these are embedded in the table and the rationale for making certain choices is explained below.

### A.8.1. Small, Medium and Large Crossings

34. Within the crossing type selection table, watercourse size is expressed in terms of small/medium/large but without actual dimensions being stated. In part this is because the table covers a range of features such as peat hags, ditches and streams where “large” in one context may not be “large” in another. However, within the category of streams and for the following dimensions are proposed:

- small - less than 1m;
- medium - between 1m and 3m; and
- large - greater than 3m.

35. For other features, such as hags, flushes etc., the size differentiation is not significant in determining crossing type; it merely governs the diameter or number of circular conduits to ensure drainage is unimpeded.

### A.8.2. Bridges

36. Where the watercourse is of significant width or the stream is within a deeply incised valley, a conventional abutment bridge may offer the best practical engineering solution whether or not ecological provision has to be made. In some cases, the bridge may be multi-span with one of more supports required within the watercourse. Where technically possible the abutments would be set back by at least

1m from the banks of the watercourse, if these are well defined. However, over the passage of time erosion/deposition could change this marginal strip between the abutment and watercourse, unless “hard” engineering is employed, which may not be desirable.

### A.8.3. Rectangular Culverts/Arches

37. Rectangular culverts and arches can be used where there are watercourses narrower than those appropriate for bridge construction, but which have a requirement to provide mammal and/or fish passage and ensure sufficient hydraulic capacity during peak flow periods. Rectangular culverts may incorporate mammal ledges and can be buried below stream bed level to enable the formation of a natural channel bed.

38. Arches minimise disruption to stream banks and base and enable mammal passage.

### A.8.4. Circular Culverts

39. In all cases where there are no ecological provisions to be made, it is assumed that neither natural bed material, water velocity nor depth are critical other than in the purely hydraulic sense. Thus, circular culverts provide an economic and viable solution.

### A.8.5. Multiple Culverts (Circular)

40. None of the multiple culverts have ecological implications, so the rationale above for singular circular culverts applies. Multiple (usually twin) culverts have been considered a viable option where the crossing is wide and the use of a single circular culvert would require a disproportionately large diameter which would also raise the height of the crossing.

41. In the case of deeply incised streams, culvert height may not be a major factor as it may be accommodated without the need to raise the road level. In such cases, it is recommended that the Contractor decides on the most appropriate design solution, in consultation with SEPA. A single circular culvert is typically preferred by SEPA as multiple culverts may become blocked easily, thus creating a fish barrier and preventing sediment from being transported downstream (SEPA, 2010).

### A.8.6. Multiple Culverts (Rectangular)

42. Multiple (usually twin) culverts have been considered a viable option where the crossing is wide. Although there is a reasonable range of width to depth ratios available for off-the-shelf precast units, there may be occasions where the topography and channel morphology would favour multiple culverts.

43. The decision table includes cases where ecological provision needs to be made and this can be designed into rectangular box culverts. The fact that there are multiple culverts means that there would be one or more piers within the watercourse, but the culvert sizing may be such as to ensure the original cross-sectional width is maintained. With twin culverts, it is also possible to set one at a lower elevation to act as a low flow channel.

44. ‘Flashy’ streams, particularly within incised channels, may lend themselves to rectangular culverts as a large height to width ratio can be employed to accommodate larger water level changes than would a circular culvert.

### A.8.7. Ecological Provision

45. The determination of ecological provision requirement is provided in **Chapter 7: Ecology and Biodiversity** of the EIAR. Where ecological provision is required for fish, the priority is that natural channel substrate is retained, which may be accomplished using depressed invert culverts. Where preservation of the bank is also deemed essential, the crossing type may be either a bridge or an arch to avoid impacts to the banks. Experience shows that in most cases the ground below a bridge or arch is unlikely to retain the former vegetation.
46. Where provision must be made for the passage of mammals, this may be accomplished by incorporating ledges at bank level within a rectangular culvert. Alternatively, a tunnel may be provided to one side of the watercourse.
47. The assumption has been made that wider crossings would be undertaken with a bridge resting on abutments which are clear of the stream edge. The smaller crossings may be constructed from segmental arches or similar – although small span bridges would be equally serviceable.
48. Inevitably, there would be some disturbance in the vicinity of the crossing during the construction period. The Construction Environmental Management Plan (CEMP) would address risk elimination and mitigation, particularly during the construction period. However, in addition to engineering, the reinstatement of vegetation must be integral to the design to provide 'rest/cover' areas.

### A.8.8. Construction

49. As a rule, the more in situ construction, the more complex the task and the longer the duration of activity in the vicinity of a watercourse crossing, the greater is the risk of a hazardous or pollution incident arising. Thus, "constructability" is a relevant factor to consider when selecting the type of stream crossing solution.
50. For example, it may be possible to span a 3m stream using either a rectangular culvert or conventional abutment bridge. A bridge may take weeks to construct and involve in-situ concrete pours and require a temporary crossing to facilitate work at both sides. A bridging culvert could be put in place within days and, with bed reinstatement, it would appear no different from the bridge option. Thus, where there are competing options it would be prudent to evaluate all forms of risk during the construction and operational phase of the structure and not just the status of the structure when completed.
51. In addition to the cross-sectional geometry of the watercourse, geotechnical factors also have an influence on constructability. The practicalities of excavation for foundations or bed preparation would depend upon the surrounding material being 'hard' and 'soft'. If the bed or banks would require heavy percussion hammering, drilling, blasting etc. then the material is 'hard'. Where the bed can be excavated by hand or excavator then the material is 'soft', which may include rock that is weathered or weak. In either case it is assumed that the bed rock can be broken out to a depth sufficient to allow the normal 200mm of granular bedding on which to lay precast concrete units where this is the chosen option.
52. In the schedule of individual stream crossings an indication has been given as to what is considered to be the most appropriate crossing type. This is generally based on the selection matrix in **Table A5**; however, this is intended as guidance only. On occasions specific channel characteristics or local morphology may suggest some variation on the selection table is more appropriate. For example, the table may suggest a single circular culvert, but due to topographic considerations multiple circular culverts may be more appropriate.

53. A particular issue that may arise with small/ephemeral watercourses is that the channel is ill-defined and on the day of the Site inspection an optimum position for the culvert is unclear. These conditions are most likely to arise on small headwater streams that are unmarked on the OS 1:50,000 scale maps or in areas containing peat hags. In these cases, it is anticipated that further observations would be made closer to the construction period. Also, some ditching or realignment immediately upstream may be necessary to convey flows towards the culvert to minimise ponding upstream of the crossing point.
54. A further issue to consider, in some instances, would be the provision of temporary crossings, perhaps to facilitate the construction of the permanent crossing or for some other purpose of limited duration. In these circumstances ecological provision to a lower standard may be inevitable although, as this would be temporary and perhaps seasonally phased, the actual impact may be negligible.

## A.9 Diagrams

55. A selection of schematic diagrams has been produced to illustrate some of the watercourse crossings that may arise. These are shown in **Table A6** and although not every permutation has been drawn, the selection attempts to cover the most frequent situations and at the same time show a variety of key design features.
56. In the majority of cases, these diagrams only show cross-sections of the crossings, however the length of culverts and arches would depend on the depth of the embankment material above the soffit of the pipe or crown of the arch and the arrangement of any entrance and exit structures. A single longitudinal section is given as a general illustration.
57. For example, if the face of the embankment is at 45° and the road width (W), the fill material height above the soffit is F and the height of the opening is H then the length of the culvert would be;  $W + 2 \times (F + H)$ , approximately. This excludes possible entrance and exit wing walls or pools.
58. Thus, for a 6m wide road with 1.5m of fill on top of a 2m high rectangular culvert the length would be approximately  $6 + 2 \times (1.5 + 2)$ ; giving 13m.
59. The situation is somewhat different for bridges as there is no fill placed above the stream, only the bridge deck which would be marginally wider than the road. However, the base of the abutments would be wider than the banks of the watercourse. This would depend on the height of the road embankment and the side slope.

---

## References

Centre for Ecology and Hydrology (2020). Flood Estimation Handbook Web Service.

CIRIA (2019). Culvert, screen and outfall manual (C786F), published by CIRIA.

Forestry Commission (2011). Forests and Water Guidelines, Fifth Edition, published by the Forestry Commission. [online]. Available from: <https://www.confor.org.uk/media/246145/forest-and-water-guidelines.pdf> [Accessed October 2021]

Institute of Hydrology (1993). Flood Studies Report.

Scottish Executive (2012). River Crossings and Migratory Fish: Design Guidance, published by the Scottish Executive. [online]. Available from: <https://www2.gov.scot/Topics/marine/science/Publications/publicationslatest/rivercrossings> [Accessed October 2021]

SEPA/Natural Scotland (2010). Engineering in the water environment: good practice guide. River Crossings. 2nd Edition. [online]. Available from: <https://www.sepa.org.uk/media/151036/wat-sg-25.pdf> [Accessed October 2021]

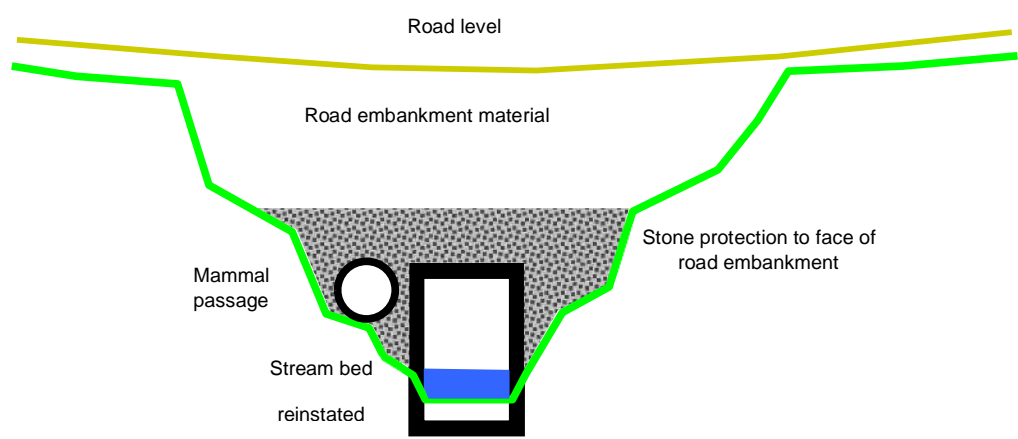
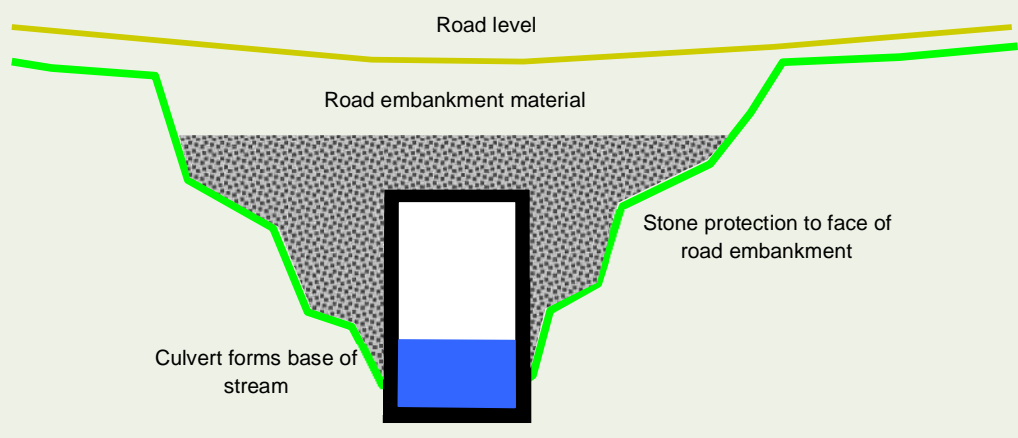
Code	Watercourse	CAR Applicable - Shown on OS 1:50,000 Mapping	Context	Size	Eco	Structure	Eco Provisions
WC01	Tairlaw Burn	Yes	Broad	Large	Yes	Existing crossing to be upgraded to open-base arch culvert.	The structure should permit the passing of mammals and fish.
WC02	Unnamed Tributary of Tairlaw Burn	Yes	Land drain	Medium	Yes	Existing culvert to be upgraded to oversized circular culvert.	The structure should permit the passing of mammals and fish.
WC03	Tairlaw Burn	Yes	Broad	Small	Yes	Existing culvert to be upgraded to oversized circular culvert.	The structure should permit the passing of mammals and fish.
WC04	Dalquhairn Burn	Yes	Broad	Medium	Yes	Existing culvert to be upgraded to oversized circular culvert.	The structure should permit the passing of mammals and fish.
WC05	Unnamed tributary of Palmullan Burn	Yes	Land drain	Small	Yes	New oversized circular culvert proposed for this crossing.	The structure should permit the passing of mammals and fish.
WC06	Unnamed Tributary of Linfern Loch	Yes	Land drain	Medium	Yes	Existing culvert to be upgraded to circular culvert.	The structure should permit the passing of mammals and fish.
WC07	Tairlaw Burn	Yes	Land drain	Medium	Yes	New oversized circular culvert proposed for this crossing.	The structure should permit the passing of mammals and fish.

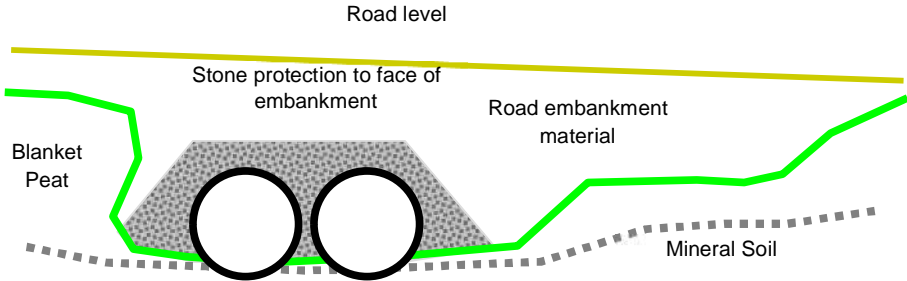
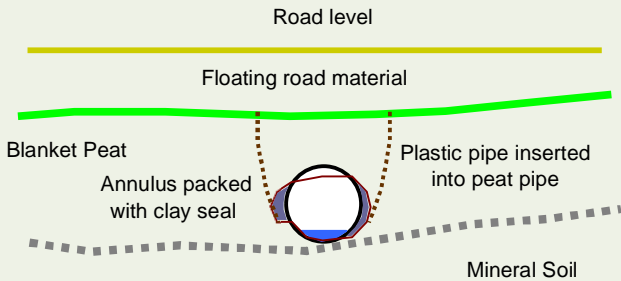
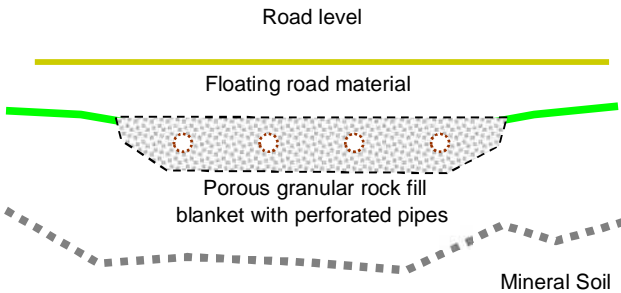
Table A5: Crossing Type Selection table

Sketch of Channel Cross-Section/Longitudinal Section	Comments
<p><b>Stream: Broad valley, Small channel, No Eco provision</b></p> <p>Road level Road embankment material Circular culvert set into soft bed</p>	<p>Typical of small headwater burns on rolling topography, perhaps before slopes become steeper and streams gather volume and energy and are more incised. Altitude or downstream topographic features exclude the possibility of fish being present.</p> <p>A circular precast concrete or plastic pipe would be placed on bedding material so that the invert is aligned with the original bed level. The pipe diameter would be sized by inspection of stream morphology because calculations alone may only provide the illusion of precision.</p>
<p><b>Stream: Broad valley, Small channel, Eco provision</b></p> <p>Road level Road embankment material Mammal Passage Circular culvert set into soft bed</p>	<p>Typical of small burns on rolling topography, similar to (1) but where there is a requirement for mammals to pass along the watercourse.</p> <p>A circular precast concrete or plastic pipe can be placed on bedding material so that the invert is aligned with the original bed level. The mammal passage would need to be at top of bank level and comply with minimum diameter requirements.</p>



Sketch of Channel Cross-Section/Longitudinal Section	Comments
<p style="text-align: center;"><b>Stream: Broad valley, Medium channel, Eco provision</b></p>	<p>Typical of mid reach 'Highland' streams with granular and cobbled beds. The habitat is well suited to resident and migratory fish. Aquatic mammals are present.</p> <p>The rectangular box culvert structure would contain a reinstated natural bed and the width would allow for the provision of mammal ledges aligned with the banks. The freeboard would provide passage for the design flood flows.</p>
<p style="text-align: center;"><b>Stream: Broad valley, Large channel, Eco provision (or not)</b></p>	<p>Typical of mid reach streams where superficial drift deposits are shallow. The stream has cut to the rock and the bed consists of boulders and intact rock.</p> <p>Placing rectangular box culvert(s) would require bedrock to be broken and excavated. An alternative to (5) using corrugated metal arch set into concrete footings which are clear of the stream banks. This would also allow passage for mammals. The height of the arch would pass the design flood without surcharging.</p>
<p style="text-align: center;"><b>Stream: Broad valley, Large channel, Eco provision (or not)</b></p>	<p>Typical of mid reach streams where superficial drift deposits are shallow. The stream has cut to the rock and the bed consists of boulders and intact rock.</p> <p>Placing rectangular box culvert(s) would require bedrock to be broken and excavated. An alternative to (4) using concrete abutments and steel / concrete composite decking. Passage for mammals where necessary. The height of the bridge soffit would pass the design flood without surcharging.</p>

Sketch of Channel Cross-Section/Longitudinal Section	Comments
<p><b>Stream: Incised valley, Medium channel, Eco provision</b></p>  <p>Labels in diagram: Road level, Road embankment material, Mammal passage, Stream bed reinstated, Stone protection to face of road embankment.</p>	<p>Typically found on energetic streams which have cut into deep clay or glacial deposits. As flood flows cannot spread laterally depth fluctuations may be considerable.</p> <p>The rectangular box culvert structure would contain a reinstated natural bed. As an alternative to mammal ledges a higher level circular pipe would allow mammal passage. This would act as a high flow relief if required, but be above the majority of minor floods.</p>
<p><b>Stream: Incised valley, Large channel, No Eco provision</b></p>  <p>Labels in diagram: Road level, Road embankment material, Stone protection to face of road embankment, Culvert forms base of stream.</p>	<p>Typically found on energetic streams which have cut through superficial deposits and into the rock formation. Depth fluctuations may be considerable, as flood flows cannot spread laterally.</p> <p>The bedrock would be broken out to facilitate the placing of large rectangular box culvert which would pass the design flow without surcharging.</p>

Sketch of Channel Cross-Section/Longitudinal Section	Comments
<p><b>Peat Hagg: Broad, Large (deep) channel, No Eco provision</b></p> 	<p>Typically found in deep blanket peat where the gully has bottomed out at the mineral soil / rock interface. Normally flows are small arising from seepage out of the peat, with intermittent large storm flows which may carry blocky peat fragments.</p> <p>The soil / bedrock would be excavated to allow for bedding and twin circular culverts set at a level which would avoid upstream ponding. The pipe diameter would be sized by inspection of the gully morphology because calculations alone may only provide the illusion of precision.</p>
<p><b>Peat Pipe: Buried, Large size</b></p> 	<p>These are encountered at random in blanket peat (and some may go un-noticed). Ensuring continuity of the bog hydrology is important.</p> <p>The section of peat pipe which would be below the road would need to be excavated and a 'best fit' plastic pipe would be inserted into the irregular ends. The space between the drainage pipe and the peat pipe would require to be sealed with natural material such as clay. The trench would be refilled with the excavated peat.</p>
<p><b>Flushes: Various widths</b></p> 	<p>Within the area of the flush there is no clearly defined channel, other than perhaps a broad concave area. Flow is predominantly by sub-surface interflow and it is important to ensure this continuity and avoid compaction of the flush by the road.</p> <p>A drainage blanket wrapped in geotextile placed below the road construction would provide flow continuity without concentrating the discharges into a narrow channel.</p>

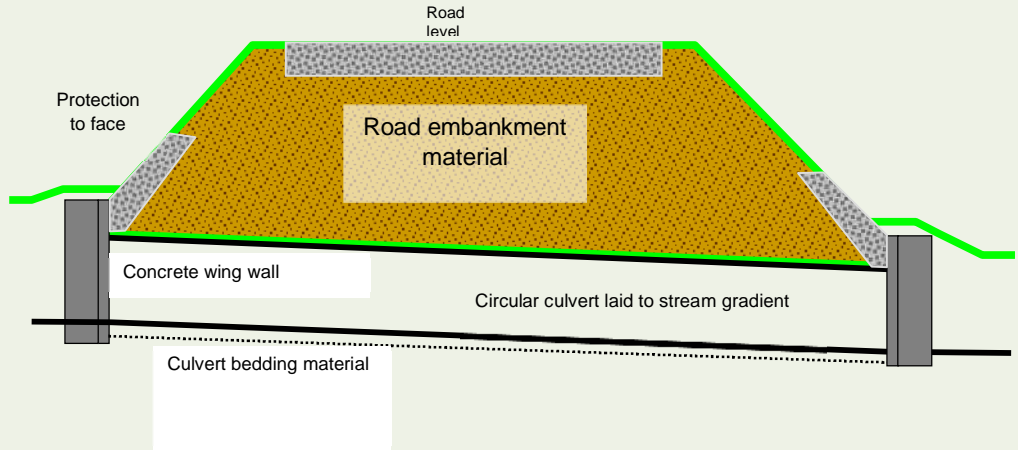
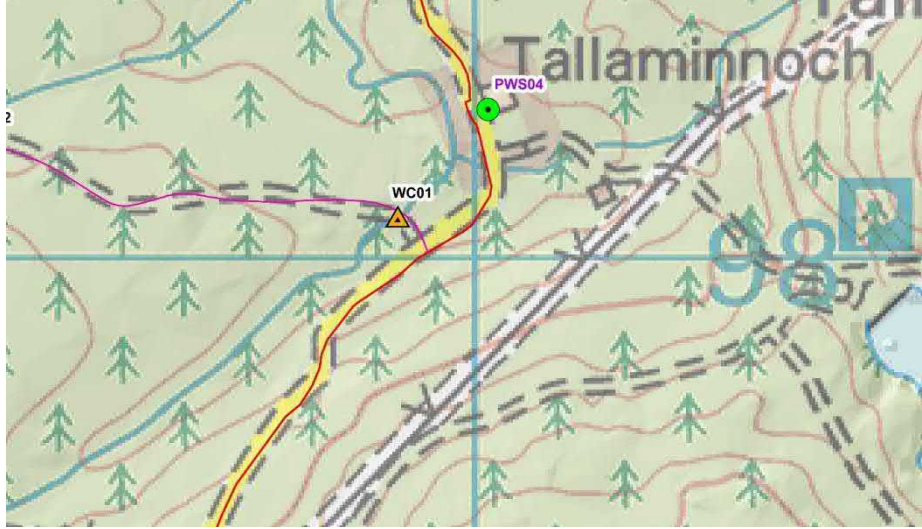



Sketch of Channel Cross-Section/Longitudinal Section	Comments
<p style="text-align: center;"><b>Longitudinal Section: Circular culvert, no Eco provision</b></p>  <p>The diagram illustrates a longitudinal section of a road crossing a stream. At the top, a horizontal line represents the 'Road level'. Below this is a cross-section of the 'Road embankment material'. On either side of the embankment, there are 'Concrete wing wall' structures. A 'Circular culvert laid to stream gradient' is shown passing through the embankment, supported by 'Culvert bedding material'. 'Protection to face' is indicated at the entrance and exit of the culvert.</p>	<p>In the case of crossings which have no need for particular ecological provision a circular culvert may be the preferred choice. This would generally be laid to the stream gradient on prepared bedding material. The entrance and exit to the culvert would require wing walls to locally stabilise the stream banks and the toe of the road embankment. Depending on the size of the opening various forms of wing wall construction may be used - concrete, gabions, stone. If there is a risk of surcharge then the embankment face may require protection.</p>




Table A6: Illustration of Watercourse Crossings







## Annex B - Description Sheets for CAR-Applicable Watercourse Crossings

<p><b>Crossing ID:</b> WC01</p> <p><b>Route:</b> Crossing approximately 50m from the northern site entrance on the existing northern forestry track and 1.5km east of wind turbine 12.</p> <p><b>Watercourse:</b> Tairlaw Burn, Tributary of the Water of Girvan</p> <p><b>Description:</b> Bed material consists of pebbles and gravel. No bedrock visible at bed layer. Bank material is peat. Flow downstream is constrained by fallen trees, causing pooling. The channel is approximately 4.0m wide and 0.3m deep, with the valley upstream 15.0m wide and 10.0m deep. The watercourse flows north east to the confluence with the Water of Girvan approximately 1.9km downstream of this crossing.</p>	<p><b>NGR:</b> NGR 239869, 598070</p>	
<p><b>Catchment Area:</b> Approximately 2.77km<sup>2</sup></p> <p><b>Peak Flows (m<sup>3</sup>/s):</b> Q<sub>5year</sub> = 6.45, Q<sub>25year</sub> = 9.81, Q<sub>200year</sub> = 15.69, Q<sub>200year + cc</sub> = 18.83</p> <p><b>Mean Flow (m<sup>3</sup>/s):</b> Q<sub>mean</sub> = 0.12</p> <p><b>Flood Risk:</b> Identified on SEPA Flood Risk Map: Yes, surface water flooding upstream of the crossing and river flooding downstream of the crossing.</p> <p><b>Ecology:</b> Suitable salmon habitat and sub-optimal Freshwater Pearl Mussel (FWPM) habitat was recorded in Tairlaw Burn. Fish surveys indicate the presence of trout. Mammal protected species were noted along the Tairlaw Burn. The habitat suitability assessment considered that Tairlaw Burn provides moderate habitat for these species.</p> <p><b>Crossing Type:</b> Open-base arch culvert proposed, retaining existing channel bed and banks. At the detailed design stage, a bridge without in-channel support may also be considered for this specific crossing location.</p> <p><b>CAR Application:</b> This would be anticipated as requiring a CAR Simple Licence, given 4.0m channel width for culvert. If a bridge was selected at the detailed design stage, assuming less than 20m of total bank was affected, this would require a CAR Registration.</p>		
 <p>Looking upstream from NGR 239869, 598070</p>	 <p>Looking downstream from NGR 239869, 598070</p>	 <p>View across channel from NGR 239869, 598070</p>

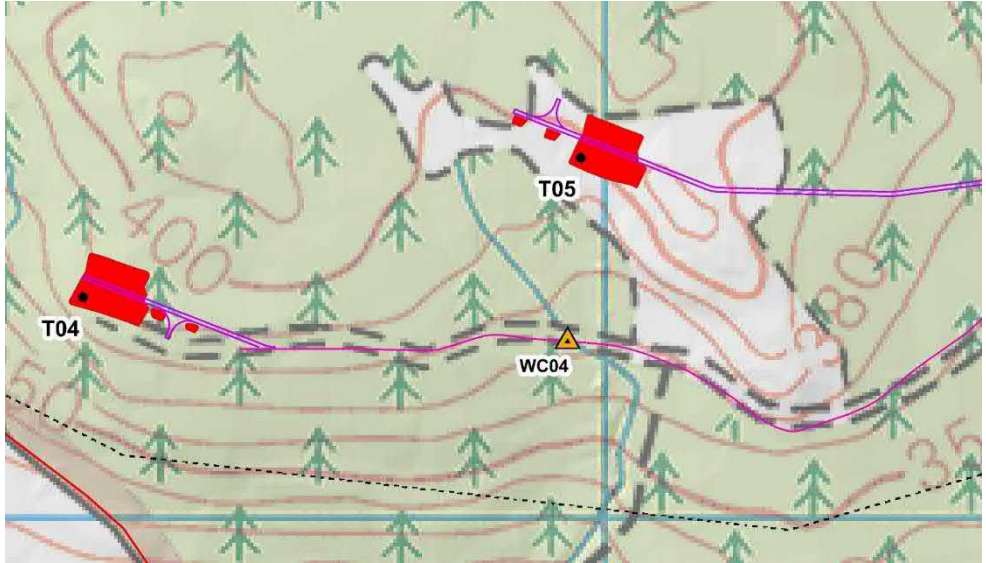





<p><b>Crossing ID:</b> WC02</p> <p><b>Route:</b> Crossing approximately 0.66km south east of wind turbine 10</p> <p><b>Watercourse:</b> Unnamed Tributary of Tairlaw Burn, Tributary of the Water of Girvan</p> <p><b>Description:</b> Bed material consists of boulders, pebbles, cobbles and gravel. No bedrock visible at bed layer. Bank material is vegetation and soil. The main channel is approximately 1.5m wide and 0.6m deep, with the valley 10m wide and 3m deep. The watercourse flows north east to the confluence with Water of Girvan approximately 3.9km downstream of this crossing.</p>	<p><b>NGR:</b> NGR 239134, 598209</p>	
<p><b>Catchment Area:</b> Approximately 0.21km<sup>2</sup></p> <p><b>Peak Flows (m<sup>3</sup>/s):</b> Not available for this sub-catchment. WC03 values are considered appropriate.</p> <p><b>Mean Flow (m<sup>3</sup>/s):</b> <math>Q_{mean} = 0.009</math></p> <p><b>Flood Risk:</b> Identified on SEPA Flood Risk Map: Yes, surface water flooding upstream of the crossing and river flooding downstream of the crossing.</p> <p><b>Ecology:</b> Suitable salmon habitat and sub-optimal FWPM habitat was recorded in Tairlaw Burn. Fish surveys indicate trout present in burn. Mammal protected species were noted along the Tairlaw Burn. The habitat suitability assessment considered that Tairlaw Burn provides moderate habitat for these species.</p> <p><b>Crossing Type:</b> Existing concrete pipe culvert (0.6m diameter) proposed to be replaced by oversized circular culvert for this crossing.</p> <p><b>CAR Application:</b> This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.</p>		
 <p>Looking upstream from NGR 239134, 598209</p>	 <p>Looking downstream from NGR 239134, 598209</p>	

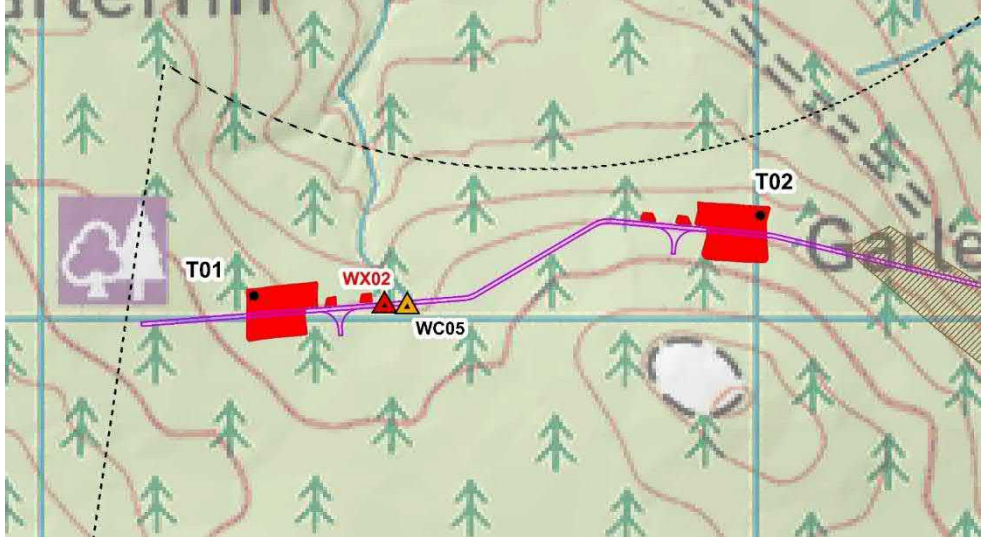





<p><b>Crossing ID:</b> WC03</p> <p><b>Route:</b> Crossing approximately 280m from the southern site entrance on the existing southern forestry track and approximately 1.15km north of wind turbine 13.</p> <p><b>Watercourse:</b> Tairlaw Burn, tributary of the Water of Girvan</p> <p><b>Description:</b> Bed material consists of cobbles, gravel and peddles. No bedrock visible at bed layer. Bank material is mainly soil and boulders. Small and fast flowing river set in a v-shaped valley. The main channel is approximately 0.2m wide and 0.5m deep, with the valley 10.0m wide and 3.0m deep. The watercourse flows north-east to the confluence with Water of Girvan approximately 4.8km downstream of this crossing.</p>	<p><b>NGR:</b> NGR 239189, 597349</p>	
<p><b>Catchment Area:</b> Approximately 0.92km<sup>2</sup></p> <p><b>Peak Flows (m<sup>3</sup>/s):</b> Q<sub>5year</sub> = 2.14, Q<sub>25year</sub> = 3.26, Q<sub>200year</sub> = 5.21, Q<sub>200year + cc</sub> = 6.25</p> <p><b>Mean Flow (m<sup>3</sup>/s):</b> Q<sub>mean</sub> = 0.041</p> <p><b>Flood Risk:</b> Identified on SEPA Flood Risk Map: Yes, surface water flooding upstream and downstream of watercourse.</p> <p><b>Ecology:</b> Suitable salmon habitat and sub-optimal FWPM habitat was recorded in Tairlaw Burn. Fish surveys indicate trout present in Tairlaw burn. Mammal protected species were noted along the Tairlaw Burn. The habitat suitability assessment considered that Tairlaw Burn provides moderate habitat for these species.</p> <p><b>Crossing Type:</b> Existing culvert to be replaced by oversized circular culvert for this crossing.</p> <p><b>CAR Application:</b> This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.</p>		
 <p>Looking upstream from NGR 239189, 597349</p>	 <p>Looking downstream from NGR 239189, 597349</p>	 <p>View across channel from NGR 239189, 597349</p>

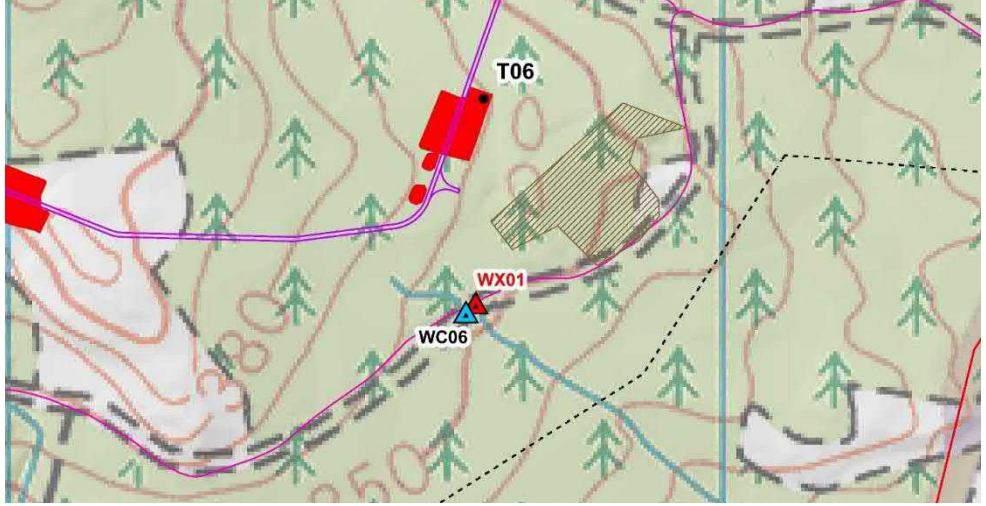





<p><b>Crossing ID:</b> WC04</p> <p><b>Route:</b> Crossing approximately 0.25km south of wind turbine 5.</p> <p><b>Watercourse:</b> Dalquhairn Burn, tributary of the River Stinchar</p> <p><b>Description:</b> Bed material consists of cobbles, pebbles. Bank material is peaty and is evident by the peat stained water. Watercourse situated in forested v-shaped valley. The main channel is approximately 2.5m wide and 0.35m deep, with the valley 5.0m wide and 3.0m deep. The watercourse flows south-west to the confluence with the River Stinchar approximately 4.79km downstream of this crossing.</p>	<p><b>NGR:</b> NGR 234948, 598251</p>	
<p><b>Catchment Area:</b> Approximately 0.33km<sup>2</sup></p> <p><b>Peak Flows (m<sup>3</sup>/s):</b> Not available for this sub-catchment. WC03 values are considered appropriate.</p> <p><b>Mean Flow (m<sup>3</sup>/s):</b> Q<sub>mean</sub> = 0.015</p> <p><b>Flood Risk:</b> Identified on SEPA Flood Risk Map: No.</p> <p><b>Ecology:</b> Ecological surveys indicate that salmon and trout are present in Dalquhairn Burn. The habitat suitability assessment found that the River Stinchar has moderate suitability for otters. However, no evidence was found within the Otter Survey Area.</p> <p><b>Crossing Type:</b> Existing culvert to be replaced by oversized circular culvert for this crossing.</p> <p><b>CAR Application:</b> This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.</p>		
 <p>Looking upstream from NGR 234948, 598251</p>	 <p>Looking downstream from NGR 234948, 598251</p>	 <p>View across channel from NGR 234948, 598251</p>

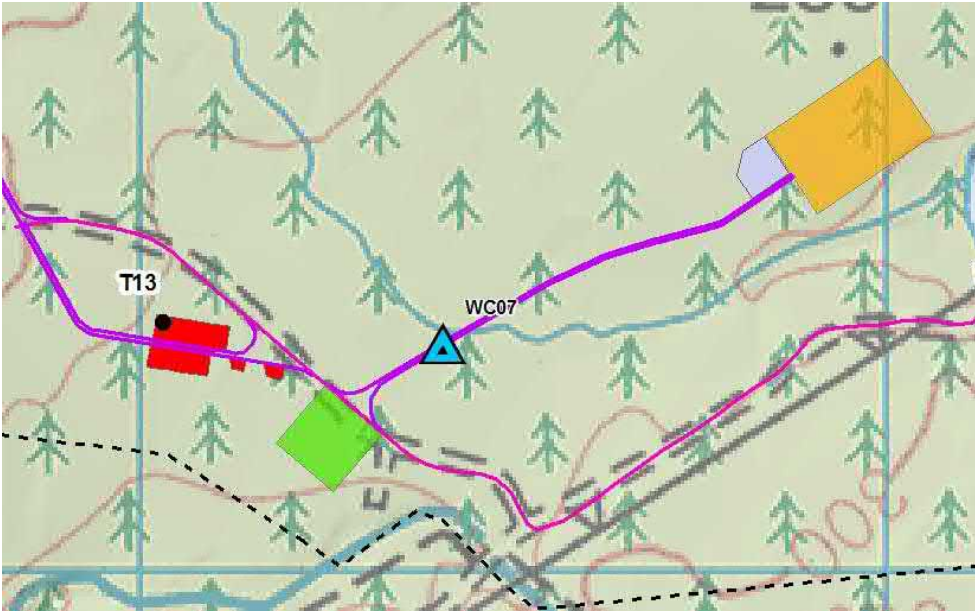





<p><b>Crossing ID:</b> WC05</p> <p><b>Route:</b> Crossing approximately 0.22km east of wind turbine 1.</p> <p><b>Watercourse:</b> Unnamed tributary of Palmullan Burn, tributary of Water of Girvan.</p> <p><b>Description:</b> Bed material consists of pebbles, cobbles, gravel and fine sediment. No bedrock visible at bed layer. Bank material is vegetation and peat. The main channel is approximately 0.5m wide and 0.2m deep with valley being The watercourse flows north to the confluence with the Water of Girvan approximately 1.20km downstream of this crossing.</p>	<p><b>NGR:</b> NGR 234512, 599022</p>	
<p><b>Catchment Area:</b> Approximately 1.07km<sup>2</sup></p> <p><b>Peak Flows (m<sup>3</sup>/s):</b> Not available for this sub-catchment. WC03 values are considered appropriate.</p> <p><b>Mean Flow (m<sup>3</sup>/s):</b> Q<sub>mean</sub> = 0.043</p> <p><b>Flood Risk:</b> Identified on SEPA Flood Risk Map: Yes. Surface water flooding downstream of watercourse.</p> <p><b>Ecology:</b> Ecological surveys indicate trout are present in the burn. Mammal protected species were noted along the Palmullan Burn, including otters. No evidence of water voles were found.</p> <p><b>Crossing Type:</b> No existing crossing. New oversized circular culvert proposed for this crossing.</p> <p><b>CAR Application:</b> This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.</p>		
 <p>Looking upstream from NGR 234520, 599024</p>	 <p>Looking downstream from NGR 234520, 599024</p>	 <p>View across from NGR 234520, 599024</p>



<p><b>Crossing ID:</b> WC06</p> <p><b>Route:</b> Crossing approximately 0.313km south west of wind turbine 6.</p> <p><b>Watercourse:</b> Linfern Loch tributary, tributary of the River Stinchar via Linfern Loch Burn.</p> <p><b>Description:</b> Bed material consists of pebbles, cobbles, gravel and fine sediment. No bedrock visible at bed layer. Bank material is vegetation and peat. The main channel is approximately 1.5m wide and 0.5m deep, with a valley width of 3m and valley depth of 1.5m. The watercourse flows south-east into Linfern Loch, approximately 1.1km downstream of this crossing.</p>	<p><b>NGR:</b> NGR 235641, 598350</p>	
<p><b>Catchment Area:</b> Approximately 0.22km<sup>2</sup></p> <p><b>Peak Flows (m<sup>3</sup>/s):</b> Not available for this sub-catchment. WC03 values are considered appropriate.</p> <p><b>Mean Flow (m<sup>3</sup>/s):</b> Q<sub>mean</sub> = 0.01</p> <p><b>Flood Risk:</b> Identified on SEPA Flood Risk Map: No.</p> <p><b>Ecology:</b> No evidence of salmon and trout recorded on watercourse. The Site access in the vicinity of Linfern Loch was restricted due to the presence of an active osprey nest south of Linfern Loch. No evidence of water vole or otters were recorded in the burn.</p> <p><b>Crossing Type:</b> Existing culvert to be replaced by oversized circular culvert for this crossing.</p> <p><b>CAR Application:</b> This would be anticipated to require a CAR Registration and constructed following the relevant General Binding Rules.</p>		
 <p>Looking upstream from NGR 235641, 598350</p>	 <p>Looking downstream from NGR 235641, 598350</p>	 <p>View across channel from NGR 235641, 598350</p>



<p><b>Crossing ID:</b> WC07</p> <p><b>Route:</b> Crossing approximately 150m north east of the temporary construction compound, on the proposed new access track to the Substation Compound, which is located approximately 500m north east.</p> <p><b>Watercourse:</b> Tairlaw Burn, Tributary of the Water of Girvan</p> <p><b>Description:</b> Bed material consists of pebbles, cobbles and gravel. No bedrock visible at bed layer. Bank material is grass and rush vegetation. The channel is located within relatively flat open ground with no distinct valley. The channel is approximately 1.0m wide and 1.0m deep. The watercourse flows north east to the confluence with the Water of Girvan approximately 5.5km downstream of this crossing.</p>	<p><b>NGR:</b> NGR 238407, 597303</p>	
<p><b>Catchment Area:</b> Approximately 0.33km<sup>2</sup></p> <p><b>Peak Flows (m<sup>3</sup>/s):</b> Not available for this sub-catchment. WC03 values are considered appropriate.</p> <p><b>Mean Flow (m<sup>3</sup>/s):</b> Q<sub>mean</sub> = 0.015</p> <p><b>Flood Risk:</b> Identified on SEPA Flood Risk Map: No, surface water flooding downstream of the crossing.</p> <p><b>Ecology:</b> Suitable salmon habitat and sub-optimal Freshwater Pearl Mussel (FWPM) habitat was recorded in Tairlaw Burn. Fish surveys indicate the presence of trout. Mammal protected species were noted along the Tairlaw Burn. The habitat suitability assessment considered that Tairlaw Burn provides moderate habitat for these species.</p> <p><b>Crossing Type:</b> No existing crossing. New oversized circular culvert proposed for this crossing.</p> <p><b>CAR Application:</b> This would be anticipated to require a CAR Registration and constructed following the relevant General Binding Rules.</p>		
 <p>Looking upstream from NGR 238407, 597303</p>	 <p>Looking downstream from NGR 238407, 597303</p>	 <p>View across channel from NGR 238407, 597303</p>



## Annex C – Minor Watercourse Crossings

Crossing ID	Grid Reference	Watercourse Type	Crossing Type	Comment
WX01	NGR 235654, 598362	Minor tributary channel	Circular culvert	New crossing
WX02	NGR 234480, 599023	Minor tributary channel	Circular culvert	New crossing
WX03	NGR 236488, 598763	Minor tributary channel	Circular culvert	New crossing
WX04	NGR 235699, 598835	Minor tributary channel	Circular culvert	New crossing

Table A6: Minor Watercourse Crossings

### Photographs

A selection of representative photographs of minor watercourse crossings is presented below.



Photograph A1: WX02, taken at NGR, 234480, 599024, looking upstream.



Photograph A2: WX03, taken at NGR 236488, 598764, looking upstream.



Photograph A3: WX04, taken at NGR I235699, 598836, looking upstream.



**Carrick Windfarm Project Team**

ScottishPower Renewables  
9th Floor ScottishPower Headquarters  
320 St Vincent Street  
Glasgow  
G2 5AD

**[CarrickWindfarm@scottishpower.com](mailto:CarrickWindfarm@scottishpower.com)**

