

Appendix 9.1 Watercourse Crossing Schedule

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Appendix 9.1 Watercourse Crossing Schedule

Introduction

This Watercourse Crossing Schedule has been produced to highlight the presence of watercourses which are required to be intersected by the Proposed Development access tracks and to provide relevant information on the nature of the crossings, likely crossing type required and design recommendations. The locations of these watercourse crossings are provided in Figure 9.4.

The number of watercourse crossings required has been minimised as far as practicable possibly as part of the design evolution of the Site, through focussed liaison within the project team.

The basis of the Watercourse Crossing Schedule and recommendations is around the following design guidance:

- The Construction Industry Research and Information Association (CIRIA) Culvert, Screen and Operation Manual (CIRIA,2019);
- Scottish Environment Protection Agency (SEPA) Good Practice Guide, River Crossings, 2nd Edition (2010a); and
- SEPA Good Practice Guide, Bank Protection Rivers and Lochs, 1st Edition (2010b).

A hydrological site survey was conducted in July 2020 by an experienced Chartered Hydrologist of the Turbine Development Area (i.e. where all proposed turbines are to be sited and associated infrastructure) and coordinated with the engineering design team. During this survey, several areas of concern were identified where the proposed track route traversed very boggy ground with a networks of braided peat channels that are vital in providing drainage continuity within the catchment and maintaining healthy peatland habitats. Through coordination with the engineering design team the resulting design evolution was able to realign sections of track, where possible, to avoid these areas.

The local hydrology of the main body of the Site is governed by the undulating moorland with varying topography. The Site features numerous watercourses and water bodies. The largest water body is Loch a' Chrathaich adjacent to the western edge of the Site, into which the far western and southwestern Site area drains and is outwith the Turbine Development Area (refer to Figure 9.2). A series of smaller lochs and lochans are present across the rest of the Site, within complex topography meaning drainage will flow from various high points into these water bodies. A dam associated with the Livishie Hydro Scheme is located at outflow of Loch a' Chrathaich. Multiple intake locations associated with the Livishie Hydro Scheme are also found in close proximity to the Site.

The majority of the Site drainage, with the exception of the lower access track and the west of the Site, is anticipated to flow to Allt Saigh, either directly or via the Allt Carn Choire Rainich or smaller unnamed watercourses (refer to Figure 9.2). Allt Saigh discharges into Loch Ness.

Watercourse crossings identified on 1:50,000 Ordnance Survey (OS) mapping have been assessed during the Site walkover and the Watercourse Crossing Schedule below outlines the crossing type(s) most likely suitable for each. All crossings are required and unavoidable given the Site setting and other Site constraints. High-level indicative span distances for WCX01, WCX07 and WCX08 have been provided, however these are based on limited information and are not considered appropriate to progress to design stage without further assessment. The final designs will require specific surveys and further hydrological assessment.

The majority of the existing crossings beneath the existing hydro track in the south of the turbine development area are required for drainage continuity, allowing the upgradient areas south of the track to continue draining north to the Allt Saigh. This track will need to be upgraded to wind farm specification and given the expectant


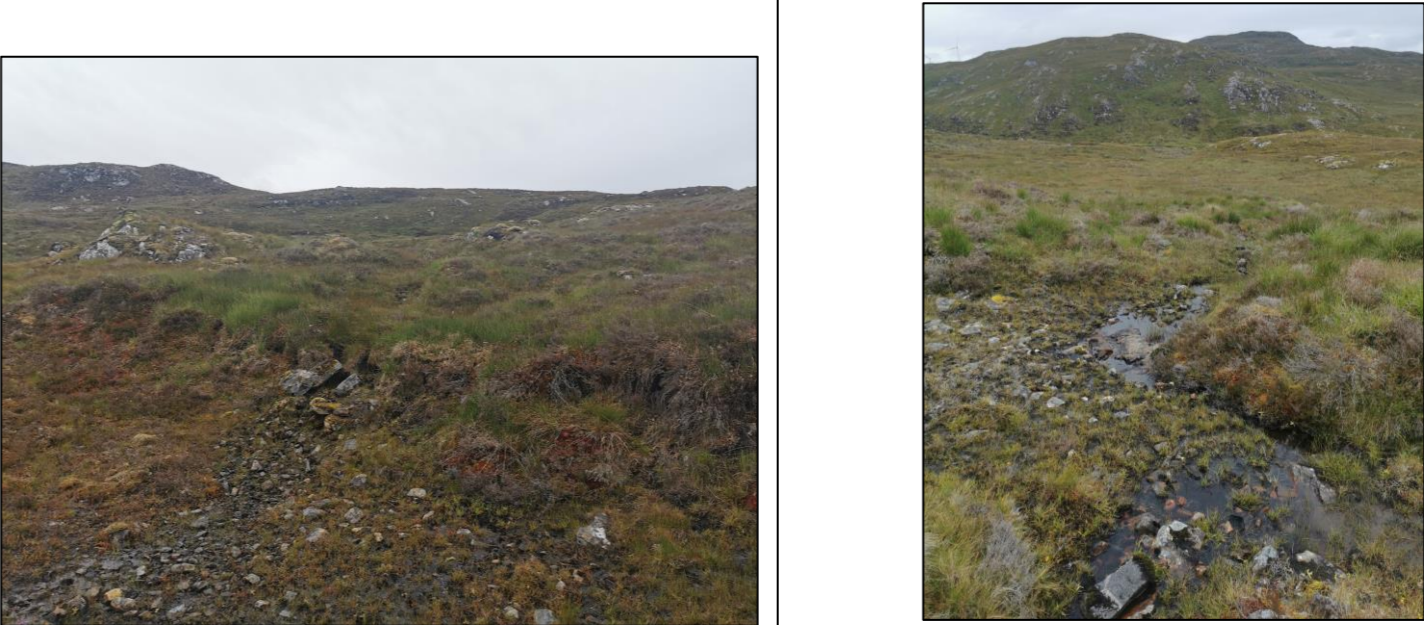
increased loading from construction traffic, the majority of these culverts will also need to be upgraded. The Watercourse Crossing Schedule below outlines the existing crossings identified during the Site survey.

Additional crossings have been identified along the proposed new track routes originating from minor watercourses (not shown on OS mapping) and discrete watershed pathways which are common in upland areas. The Watercourse Crossing Schedule below describes the solution for each additional crossing. For discrete drainage pathways, providing drainage continuity within the track drainage design will suffice in most instances, this is likely to be in the form of closed culverts. For more defined minor watercourses, a specific crossing would be required, some likely to be bottomless arched culverts.

Furthermore, all necessary measures to allow passage for fish and mammals will be incorporated into the detailed design of any bridge or culvert structures as described in SEPA's Good Practice Guide River Crossings (2010).

It should be noted that not all potential crossings relating to maintaining drainage continuity will have been identified, as the exact locations will be significantly dependent on the track micro-siting, local profile and extent of cut / fill. The precise locations and extent of these drainage continuity crossings will be identified at the detailed design and construction stage and implemented as required.

Watercourse Crossing Schedule





Significant Crossings ¹		
Watercourse Crossing 1 (WXC01) - Confirmed		
Location Description	<i>Located on proposed track between the Operational Development and Turbine 7 approximately 200m west of the turning head centre of Turbine 7.</i>	
Grid Co-ordinates	<i>238522, 820703</i>	
Watercourse Name	<i>Unnamed watercourse identified on OS 1:50k mapping</i>	
Watercourse Description	<i>Varying channel width with braided sections. Moderate Flows Observed. Channel width varies from c.2m - 10m. Steep right-hand overbank (looking downstream)</i>	
Principal Watercourse Catchment	<i>Drains to Loch Carn Tarsuinn Beag</i>	
Proposed Crossing Type(s)	<p><i>Open span crossing required to accommodate channel variability, steep right-hand overbank and conveyance within the likely flood plain extent.</i></p> <p><i>At this location the channel would not be capable of conveying the design flows. Therefore, an allowance within the span length to accommodate out of bank flows is required. Whilst flood plain extents are very difficult to determine at this stage it is predicted a minimum span distance of 10m would be required.</i></p>	
Watercourse Crossing 2 (WXC02) - Confirmed		
Location Description	<i>Located on existing track between Operational Development and Turbine 9. Crossing is located approximately 120m southwest of SSE LIDAR and approximately 480m southwest of Turbine 9.</i>	
Grid Co-ordinates	<i>238939, 819850</i>	
Watercourse Name	<i>Unnamed watercourse identified on OS 1:50k mapping</i>	
Watercourse Description	<i>Existing crossing on hydro track. 300mmØ clay pipe. Small catchment originating from Carn an Tuairneir upgradient, draining into a valley feature with discrete channel upgradient of track. Additional runoff within catchment collected in existing track side ditches.</i>	
Principal Watercourse Catchment	<i>Drains to Allt Saigh via Loch an Dubhair</i>	
Proposed Crossing Type(s)	<i>Pipe to be replaced to accommodate road widening. Diameter to be assessed relative to predicted design flows</i>	

Looking upstream. Note varying channel width and steep right-hand overbank


Looking downstream along short reach of uniform channel before braided section. Note wide potential floodplain extent

Looking upstream, valley feature draining to central discrete channel. Deposition of stones indicate potential of moderate to high flows


Looking downstream towards discharge location of connecting watercourse between loch Carn Tarsuinn Beag and Loch an Dubhair

Watercourse Crossing 3 (WXC03) - Confirmed			
Location Description	<i>Located on proposed track between Turbine 4 and Turbine 5 approximately 260m northeast of Turbine 4</i>		
Grid Co-ordinates	<i>239607, 821453</i>		
Watercourse Name	<i>Unnamed watercourse identified on OS 1:50k mapping</i>		
Watercourse Description	<i>Well-formed channel connecting Loch nam Brathain and Loch Liath</i>		
Principal Watercourse Catchment	<i>Watercourse eventually draining to Allt Saigh</i>		
Proposed Crossing Type(s)	<i>Bottomless Arch culvert likely required to accommodate channel and floodplain extent</i>		
		View upstream, note discarded brush on overbanks indicating out of bank flows	View downstream towards Loch Liath (not visible)
Watercourse Crossing 4 (WXC04) - Confirmed			
Location Description	<i>Located on proposed track leading to Turbine 15 and Turbine 12 approximately 355m southwest of Turbine 12.</i>		
Grid Co-ordinates	<i>239701, 821210</i>		
Watercourse Name	<i>Unnamed watercourse identified on OS 1:50k mapping</i>		
Watercourse Description	<i>Same channel as WXC03 approximately 260m further downstream. Well-formed straight section of channel, fast flowing</i>		
Principal Watercourse Catchment	<i>Watercourse eventually draining to Allt Saigh</i>		
Proposed Crossing Type(s)	<i>Bottomless Arch culvert likely required to accommodate channel and floodplain extent</i>		
		View upstream towards WXC03 (not visible)	View downstream towards Loch Liath

Watercourse Crossing 5 (WXC05) – Confirmed	
Location Description	<i>Located on proposed track leading to Turbine 15 and Turbine 12 approximately 250m southwest of Turbine 12.</i>
Grid Co-ordinates	<i>239842, 821234</i>
Watercourse Name	<i>Unnamed watercourse identified on OS 1:50k mapping</i>
Watercourse Description	<i>Similar channel to WXC03 and WXC04, slightly smaller, also discharging to Loch Liath. Well-formed meandering channel</i>
Principal Watercourse Catchment	<i>Watercourse eventually draining to Allt Saigh</i>
Proposed Crossing Type(s)	<i>Bottomless Arch culvert likely required to accommodate channel and floodplain extent</i>




View upstream







View downstream towards Loch Liath



Watercourse Crossing 6 (WXC06) – Confirmed	
Location Description	<i>Located on proposed track leading to Turbine 17, approximately 240m west of Turbine 17</i>
Grid Co-ordinates	<i>240132, 821246</i>
Watercourse Name	<i>Unnamed watercourse identified on OS 1:50k mapping</i>
Watercourse Description	<i>Incised, braided meandering channel at top of a well-defined valley feeding down to the Allt Saigh. Low channel capacities and evidence of wider regular flood plain extent</i>
Principal Watercourse Catchment	<i>Watercourse eventually draining to Allt Saigh</i>
Proposed Crossing Type(s)	<i>Provided the track keeps to the high ground, Bottomless Arch culvert will suffice</i>



View upstream (channels not discernible). Note discarded brush indicating flood plain extents. Track to stick to higher ground

Watercourse Crossing 7 (WXC07) - Confirmed			
Location Description	<i>Located on proposed track between Turbine 17 and Turbine 18, approximately 165m southeast of Turbine 17.</i>	 <p>View upstream in western channel, note steep gradient and discarded brush</p>	 <p>View downstream showing both parallel channels</p>
Grid Co-ordinates	<i>240529, 821123</i>		
Watercourse Name	<i>Unnamed watercourse identified on OS 1:50k mapping</i>		
Watercourse Description	<i>Outfall channel from upgradient loch in the form of two well-defined steep rocky channels, fast flowing</i>		
Principal Watercourse Catchment	<i>Watercourse eventually draining to Allt Saigh</i>		
Proposed Crossing Type(s)	<i>Open span crossing or double Bottomless Arch required to accommodate both channels and flood plain extent. This would be determined by more detailed analysis. Based on above dimensions and an assumed allowance for out of bank flows, it is estimated that a minimum span distance of 10m would be required.</i>		
Watercourse Crossing 8 (WXC08)			
Location Description	<i>Located on the proposed track between Turbine 16 and Turbine 14, approximately 230m south of Turbine 14</i>	 <p>View upstream</p>	 <p>View downstream</p>
Grid Co-ordinates	<i>240271, 820248</i>		
Watercourse Name	<i>Allt Saigh</i>		
Watercourse Description	<i>Main watercourse on site, Allt Saigh. Approximately 3.5m wide base, and 1.5m deep of channel</i>		
Principal Watercourse Catchment	<i>Allt Saigh</i>		
Proposed Crossing Type(s)	<i>Open span crossing required to accommodate large channel and likely significant floodplain extent given large upstream catchment area (c.7km²). Estimated suitable span distance would be 12-15m. The total channel width is between 6-8m and this suggested span length would ensure the bridge foundations would be suitably set back from the banks of the watercourse.</i>		
Notes: ¹ Significant defined as a watercourse identified in 1:50,000 OS mapping, requiring hydraulic analysis for crossing design			

Existing Crossings

Existing Crossings					General Comments
ID	X	Y	Rating ¹	Description	
WXC-A	240248	820131	Discrete	300Ø corrugated steel pipe	<p>The majority of existing crossings beneath the hydro track are for drainage continuity, allowing the upgradient areas south of the track to continue draining north to the Allt Saigh. This track will need to be upgraded to wind farm specification and given the expectant increased loading from construction traffic, the majority of these culverts will also need to be upgraded. Most requiring replacement due to condition (see images below).</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p><i>Example of existing pipe with insufficient cover and deformation</i></p> </div> <div style="text-align: center;">  <p><i>Example of partially blocked pipe</i></p> </div> </div> <p>The majority of existing crossings beneath the hydro track are for drainage continuity, allowing the upgradient areas south of the track to continue draining north to the Allt Saigh. This track will need to be upgraded to wind farm specification and</p>
WXC-B	240209	820139	Discrete	450Ø corrugated steel pipe	
WXC-C	240189	820136	Discrete	300Ø corrugated steel pipe	
WXC-D	240157	820109	Discrete	300Ø corrugated steel pipe	
WXC-E	240133	820091	Discrete	300Ø corrugated steel pipe	
WXC-F	240084	820109	Discrete	300Ø corrugated steel pipe	
WXC-G	240027	820113	Discrete	300Ø corrugated steel pipe	
WXC-H	239983	820115	Discrete	300Ø corrugated steel pipe	
WXC-I	239961	820098	Discrete	300Ø corrugated steel pipe	
WXC-J	239822	820091	Discrete	300Ø corrugated steel pipe	
WXC-K	239766	820076	Discrete	300Ø corrugated steel pipe	
WXC-L	239701	820061	Minor	500Ø corrugated steel pipe	
WXC-M	239658	820053	Minor	500Ø corrugated steel pipe	
WXC-N	239643	820054	Discrete	300Ø corrugated steel pipe	
WXC-O	239586	820059	Discrete	300Ø corrugated steel pipe	
WXC-P	239464	820076	Discrete	300Ø corrugated steel pipe	
WXC-Q	239343	820032	Discrete	300Ø corrugated steel pipe	
WXC-R	239287	819951	Minor	500Ø corrugated steel pipe	
WXC-S	239260	819946	Discrete	500Ø corrugated steel pipe	
WXC-T	239141	819879	Discrete	300Ø corrugated steel pipe	
WXC-U	239080	819858	Minor	500Ø corrugated steel pipe	
WXC-V	238835	819839	Minor	500Ø corrugated steel pipe	
WXC-W	238779	819833	Discrete	Culvert not visible, assumed buried but still some through-flow	



Example of existing pipe with insufficient cover and deformation



Example of partially blocked pipe

Existing Crossings					
ID	X	Y	Rating ¹	Description	General Comments
WXC-X	238691	819884	Discrete	300Ø corrugated steel pipe	given the expectant increased loading from construction traffic, the majority of these culverts will also need to be upgraded. Most requiring replacement due to condition.
WXC-Y	238554	819943	Minor	500Ø corrugated steel pipe	
WXC-Z	238436	819922	Discrete	300Ø corrugated steel pipe	
WXC-AA	238383	819912	Minor	Twin 300Ø clay pipes with concrete surround	
WXC-AB	238260	819776	Discrete	300Ø corrugated steel pipe	
WXC-AC	238219	819790	Minor	500Ø corrugated steel pipe	
WXC-AD	238176	819810	Minor	750Ø reinforced concrete pipe	
Notes: ¹ Minor rating defined as smaller channels not identified in OS 1:50,000 mapping, possible hydraulic analysis required. Discrete rating defined as discrete channels / drainage paths, requiring hydrological continuity crossings.					

Additional Crossings

Additional Crossings					
ID	X	Y	Rating ¹	Description	Proposed Crossing
WXC-AE	238451	820687	Discrete	Minor drainage path flowing west to east	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AF	238675	820707	Minor	Minor boggy braided channel in the vicinity of the track junction to T07	Dependent on final track locations and hardstanding, drainage continuity to be maintained
WXC-AG#	238684	820780	Minor	Original track alignment traversed heavily boggy section with numerous braided channels at X 238746, Y 820763. Revised crossing at WXC-AG#. Proposed realignment further west to avoid boggy section. Channel more defined at this point.	Bottomless Arch culvert likely required
WXC-AH#	238699	820871	Minor	Original track alignment crossed wide and steep valley section with boggy valley bed at X 238743 Y 820892. Revised crossing at WXC-AH#. Crossing proposed at head of watercourse identified on OS 1:50k mapping. Small channel at this location with small contributing catchment	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity. Re-alignment largely avoids valley feature
WXC-AI	238698	820984	Discrete	Discrete channel feature likely to convey flow during prolonged rainfall	Likely to be impacted / re-routed due to proposed borrow pit directly upgradient. Drainage continuity to maintained with cut-off ditches and piped culverts as above
WXC-AJ	238643	821009	Discrete	Minor braided channel in boggy area, steep upgradient catchment	Bottomless Arch culvert likely required and combined with cut-off ditches
WXC-AK	237997	822006	Minor	Boggy area in valley feature with 2 defined braided channels, likely subsurface flow	Bottomless Arch culverts over both channels
WXC-AL	238222	822132	Minor	50-100m stretch of boggy section with numerous minor/discrete channels	Drainage continuity to be maintained, upgradient flows to be redirected around infrastructure where required and discharged at a location matching the existing hydrological regime once clear of all infrastructure.
WXC-AM	238312	822090	Discrete	Discrete drainage path with narrow upgradient valley feature	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AN	238362	821842	Minor	Two separate braided meandering minor channels flowing predominantly east to west, spaced c.20m apart on proposed track alignment north/south	Bottomless Arch culverts over both channels
WXC-AO	238353	821741	Minor	Single braided meandering minor channel similar to WXC-AM	Drainage continuity to be maintained, upgradient flows to be redirected around infrastructure where required and discharged at a location matching the existing hydrological regime once clear of all infrastructure.
WXC-AP	238906	820955	Discrete	Discrete incised channels on steep slope	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AQ	239428	821316	Minor	Sluggish braided channel	Drainage continuity to be maintained, upgradient flows to be redirected around infrastructure where required and discharged at a location matching the existing hydrological regime once clear of all infrastructure.
WXC-AR	239565	821371	Minor	Very boggy and extensive braided channels	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity

Additional Crossings					
ID	X	Y	Rating ¹	Description	Proposed Crossing
WXC-AS	239590	821652	Discrete	Discrete braided drainage paths running northeast to south west on moderate slope down to Loch nam Brathain	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AT	239571	821889	Discrete	Discrete braided drainage paths running northeast to south west on moderate slope down to Loch nam Brathain	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AU	239506	822025	Minor	Minor braided channel downgradient of T05 location	Infrastructure cut-off drainage to discharge to this location to ensure upgradient catchment is not lost.
WXC-AW	240285	821238	Discrete	Discrete drainage paths flowing north to south	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AX	240415	821160	Discrete	Discrete drainage path flowing north to south	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AY	240588	821080	Discrete	Discrete drainage path flowing north to south	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-AZ	240770	821051	Minor	Network of braided boggy channels	Drainage continuity to be maintained, upgradient flows to be redirected around infrastructure where required and discharged at a location matching the existing hydrological regime once clear of all infrastructure.
WXC-BA	240871	821090	Minor	Track route proposed through localised valley feature, very boggy and multiple braided channels	Drainage continuity to be maintained, upgradient flows to be redirected around infrastructure where required and discharged at a location matching the existing hydrological regime once clear of all infrastructure.
WXC-BB	240884	821236	Minor	Well-formed incised valley feature, no visible flow but likely to flow after heavy rainfall	Bottomless Arch culvert
WXC-BC	239595	821176	Discrete	Discrete drainage path flowing north to south	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-BD	239228	821091	Minor	Multiple discrete drainage channels flowing north to south	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-BE*	238761	820393	Minor	Minor braided outflow channel from lochan, small contributing catchment	To be incorporated cut-off drainage design and piped beneath track to maintain drainage continuity
WXC-BF*	238914	821591	Minor	Final approach to T03 (c.200m) crossing numerous small channels	Drainage continuity to be maintained, upgradient flows to be redirected around infrastructure where required and discharged at a location matching the existing hydrological regime once clear of all infrastructure.
WXC-BG*	239510	821011	Minor	30m stretch of boggy section with multiple braided minor channels draining east to Loch Liath	Drainage continuity to be maintained, upgradient flows to be redirected around infrastructure where required and discharged at a location matching the existing hydrological regime once clear of all infrastructure.

Notes: ¹ *Minor* rating defined as smaller channels not identified in OS mapping, possible hydraulic analysis required. *Discrete* rating defined as discrete channels / drainage paths, requiring hydrological continuity crossings.
Denotes alternative crossing location as a result of survey findings
* Denotes crossing location based on review of satellite imagery

Conclusions and Recommendations

This Watercourse Crossing Schedule has been produced to highlight the presence of watercourses which are required to be intersected by the proposed wind farm tracks and to provide relevant information on the nature of the crossings, likely crossing type required and design recommendations.

Ultimately the recommendations set out in the Watercourse Crossing Schedule are compliant with best practice design guidance and proportionate to the hydrological regimes encountered during the site survey.

Following planning permission, the Watercourse Crossings will be subject to authorisation from SEPA under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (SEPA,2011). All watercourse crossings will be designed to ensure free passage for mammals and fish and to limit disturbance to the natural channel bed and embankment geomorphology and habitat as far as possible. All engineering activities authorised under CAR will be carried out in accordance with good practice and in compliance with environmental standards.

References

Construction Industry Research and Information Association (2019). Culvert, screen and outfall manual (C786). Available at: <https://www.thenbs.com/PublicationIndex/documents/details?Pub=CIRIA&DocID=328474>

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