3 CIVIL ENGINEERING

3.1 INTRODUCTION

This chapter provides additional information on the civil engineering design rationale and works for the various elements of the proposed Drumnahough Wind energy project. The following items are described in this chapter:

- Site Entrance Sightlines
- Internal Site Service Roads Design, Engineering and Rationale
- Turbine, Hardstand and Wind Farm Infrastructure Siting
- Internal Site Cable system
- Watercourse Crossing design
- Substation, Permanent Met Mast, Temporary Construction Compounds
- Borrow pits and Peat Storage design
- Site drainage systems design
- Sediment and Erosion Plan

3.2 SITE ENTRANCE

Access to the site during the construction phase will be from an existing forestry entrance off the L-10142 local road to the east of the site (Access Junction A), and from an existing forestry entrance off the L1622 local road to the west of the site (Access Junction B). The western access onto the L1622 is proposed as a temporary access to be used during the early construction phase only. The eastern entrance is proposed as the main access point to the wind farm until decommisioning.

The site entrances on the L-10142 (Junction A) and L1622 (Junction B) Local roads will require appropriate sight distance in both directions.

The requirements for junction sight distance are set out in Transport Infrastructure Ireland (TII) "DN-GEO-03060: Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade separated and compact grade separated junctions)". Sight distance is measured from a point 3.0m from the near edge of the major road along the centre of the minor approach road. This distance is referred to as the 'x-distance'. The visibility distance along the major road is referred to as the 'y-distance' and is measured to the near edge of the major road in both directions. The required sight distance in the vertical plane is based on eye and object heights of 1.05m. The 'y-distance' requirement depends on the design speed of the major road. This is the 85th percentile speed which is the speed below which 85% of vehicles travel.

The statutory speed limit on the local roads listed above is 80km/h but the design speed is likely to be somewhat lower. Based on observations on site, a design speed of 60km/h has been taken as being appropriate at these locations with a sight distance of the order of 90m due to the restricted horizontal alignment of these local roads.

The sightline distance will be achieved by installing of a timber post and rail fence and keeping an area outside the fence free of vegetation or other obstructions. The sight distance splays in both directions with the modifications in place are shown in **Chapter 2** and **Planning Drawing 19715-5419.** These improvements will remain in place permanently and will benefit users of the wind farm when exiting the site onto the public road. A photograph of a typical wind farm entrance with sightlines improved is given in **Figure 3-1**.

Drainage will be provided, as appropriate to prevent water from the site entrance, internal access road and visitor compound junctions flowing onto the public roads. Each junction will be designed to facilitate access for all vehicles associated with the construction and subsequent maintenance of the wind farm.

Figure 3-1 Typical Wind Farm Entrance

3.3 INTERNAL WIND FARM SITE SERVICE ROADS DESIGN, ENGINEERING AND RATIONALE

The internal site access road design objectives and design rationale for the proposed wind farm development are outlined below. The access road drawings are presented in A1 format in the planning application pack. These include:

- Proposed Internal Access Road Layout including identification of existing roads to be upgraded and widened and new roads to be constructed (refer to **Planning Drawing 19715-5005**);
- Proposed Internal Access Road Typical Details (refer to **Planning Drawing 19715-5403**);
- Junction Sight Distances (refer to **Planning Drawings 19715-5419**); and
- Proposed areas of clear fell associated with access roads infrastructure (refer to **Planning Drawing 19715-5021**).

Internal access roads are required in order to interconnect elements of the site and allow access to all wind turbines and wind farm infrastructure. The primary objectives when designing the new internal access roads was to utilise existing tracks where possible and to locate infrastructure where ground conditions are suitable. Maximum use has been made of existing roads, however the proposed development, will require new service roads to the majority of the turbines.

The proposed project will use 3.1km of existing forestry and existing wind farm tracks and 8.9km of new roads will be constructed within the proposed development site.

The new access roads will have a running width of 5.0m along straight sections of road with localised wider areas at bends to accommodate the efficient transport of the wind turbine components (See **Planning Drawings 19715-MWP-00-00-DR-C-5005 to 5015**). These roads will be constructed using excavated and floating road techniques depending on the ground conditions. These methods of construction are outlined in the following sections.

The existing routes were identified initially from high resolution aerial photography and thereafter from site visits, where the existing roads were assessed in terms of their width, gradient and associated drainage. The 3.2km of existing forestry and wind farm tracks used to access the wind farm accounts for approximately 26% of the total road length required to service the wind farm. The remaining roads will be a combination of floated and excavated roads in various parts of the site to suit the local peat depths.

The following outlines the internal access roads design rationale:

- The access road design was based on the necessity to deliver wind turbines with a maximum blade length of 71m.
- Road gradients throughout the majority of the site are 12% or less which is sufficient for turbine delivery.
- The maximum camber and crossfall gradient on the access roads is 2.5%.
- As turbines are normally grouped and linked in electrical circuits, consideration was given to cable circuit layouts in the internal access roads route selection process. It is planned to run all cables along the internal access roads; it is important to ensure that access routes facilitate efficient cabling.
- The construction of turbines immediately adjacent to the main site roads was avoided because of the potential conflict with construction traffic and the associated safety issues. These turbines will be accessed from short spur roads linked to the main access roads.
- Avoid stream crossings and water bodies, where possible.
- New sections of access roads should avoid deep peat or steep ground and natural drainage features.
- Road alignments were selected that will have adequate turning radii for delivery of turbines; and
- Aerial photography, Ordnance Survey Ireland (OSI) contour data and LiDAR data were used to inform the internal road design.

The following constraints were taken into account in the final design of the internal access road layout within the site:

I. Site topography (OSI contour data and LiDAR data) to avoid steep slopes for turbine delivery vehicles;
II. Hydrology buffer maps where streams were buffered, except where crossings are required
III. Avoidance of ecologically sensitive areas;
IV. Avoidance, where possible, of risk areas as identified in the Peat Stability Report (**Volume 3, Appendix E-1 of EIAR**);
V. Take account of existing public and forest road junctions where the wind farm access roads will interface.

The design of any particular length of site access road will depend on local geotechnical, topographical and hydrological conditions. Both excavated and floating road construction methods will be employed so as to achieve an access road structure appropriate to the site conditions.

The transition between the floated section and excavated section will be in accordance with the Scottish Natural Heritage / Forestry Commission Scotland (Forestry Civil Engineering - FCE) method illustrated below in **Figure 3-2**.

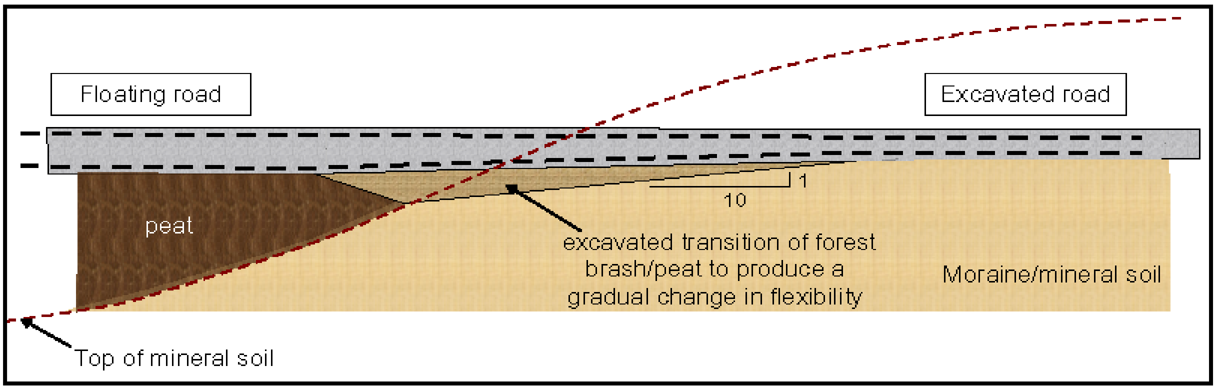


Figure 3-2 FCE method of transition from floated to excavated road

The stone required for the construction of the internal access roads will be sourced from four proposed on-site borrow pits. Once the access roads are constructed, the top surface will then receive a surface layer of imported limestone from local quarries to give a clean hardwearing running surface for the delivery of turbines. Where materials are required from off site, it is expected they will be sourced from local quarries. These are likely to include, but are not limited to, Letterkenny Concrete and Quarry, located on the N14 approximately 18km east of the site, Churchill Stone, located on the R251 north of the site and Bonar's Quarry, located off the N56, approximately 5km north of Letterkenny and other existing quarries in the surrounding area. Construction materials' delivery vehicles routes are likely to include the Regional Roads R250, R251 and Local Roads L-2744, L-1622-1, L-1114, L-1044, L-1034, L-1014 and L-10142.

The drainage network associated with the access roads will also be inspected and maintained throughout the works period.

Overall, the internal site layout design is an optimal one in terms of its minimal impact on the existing public road network in the vicinity of the site, the low risk in terms of peat stability and associated environmental impacts, the use of a well developed existing drainage network, good access and connectivity to the public road network and the ease of construction in this location.

3.3.1 Upgrading and Widening of Existing Forestry and Wind Farm Access Tracks

Existing forestry and wind farm tracks will be widened by removing organic material and soft subsoil to formation level and constructing a road on a layer of geogrid or geotextile as required by site conditions. The location of proposed new and upgraded roads is given in **Planning Drawing 19715-MWP-00-00-DR-C-5005**. This road construction will be similar in build up to the excavated road construction which is outlined in detail in **Section 3.3.2** below. The new width of road and the existing road surface, where required, will be capped with a 150mm layer of hard wearing Class 6F or similar stone see typical Wind Farm access road in **Figure 3-3**.

This road type will have a crossfall of 2.5% from one edge to the other. The existing roadside drains on the lower side of the road will be used as part of the dirty water drainage system for the site. The existing roadside drains on the higher side of the road will be retained as clean water drains.

Typically the sequence for upgrading and widening existing access roads will comprise the following:

I. The appointed contractor will survey the area for any unforeseen hazards prior to the commencement of works and set up warning signage as appropriate.

II. The material required for widening and upgrading the existing site roads will be sourced from a combination of the four proposed on-site borrow pits and external quarries. Sufficient passing bays will need to be constructed to allow for the safe movement of site traffic along the existing roads

III. The extraction of stone aggregate from the proposed borrow pits will be undertaken by 30-60 Ton 360° excavators and loaded onto articulated dumper trucks that will deliver the aggregate to the required road widening / upgrading locations.

IV. Widening works will begin with the use of excavators that will first remove any topsoil / vegetative layer which may be present. This material will be transported to an agreed temporary storage area and maintained for re-use during the restoration phase of the wind farm construction. Topsoil / vegetative removal will be kept to a minimum in order to prevent any runoff of silt during heavy rainfall.

V. Excavators will continue to strip and excavate the soft subsoil / peat underneath which will be temporarily stored adjacent to the access roads in accordance with approved methods with the use of an articulated dumper truck. Excavated material will only be temporarily stored on slopes under 5° and to a maximum height of under 1.0m until they are transported to the selected deposition areas where they will be permanently stored.

VI. Once a section of the widened access road is exposed to suitable formation; a layer of geogrid or geotextile material may be placed along its formation depending on ground conditions.

VII. The stone to be used for the widening works will be delivered to the required work area and spread out locally with the use of excavators on top of the geogrid / geotextile material. This will be compacted with the use of a roller which will roll the stone aggregate in maximum 250mm layers in order to achieve the required design strength.

VIII. The road upgrading works will involve the use of a roller compacting the site won stone aggregate in maximum 250mm layers laid over the existing road pavement. A layer of geogrid or geotextile material may be placed along the existing road pavement prior to the placement of the stone aggregate in order to achieve the required design strength.

IX. All upgraded / widened access roads will be constructed to a minimum drivable width of 5.0m with a maximum crossfall of 2.5% in order that water can flow off the roads and reduce the risk of rutting / potholes occurring.

X. Roadside drains (as per Section **3.16**) will be constructed to manage clean and dirty water runoff along widened and upgraded access roads.

XI. The final running surface of the new widened / upgraded access roads will be capped with a minimum 150mm layer of hard wearing Class 6F stone or similar using a road grader.

XII. Any surplus spoil material generated from the road widening works will be transported to the borrow pits to aid final reinstatement. Excavated topsoil and subsoil will be kept separate at the excavation and storage areas.

XIII. All excavations to be carried out will be battered back to a safe angle of repose (minimum slope angle of 45°) and comply with the Construction and Environmental Management Plan (CEMP) (See EIAR Volume 3 Appendix B-2).

XIV. Where drop offs greater than 1.0m in height occur alongside road edges; physical edge protection will be constructed in order to reduce the risk of vehicles overturning. Roadside marker posts will also be erected to delineate road edges in poor weather.

XV. The appointed contractor will ensure that all on-site personnel are aware of environmental constraints / sensitive areas within the wind farm site in which works are to be avoided.

Figure 3-3 Typical upgraded forestry road on a wind farm

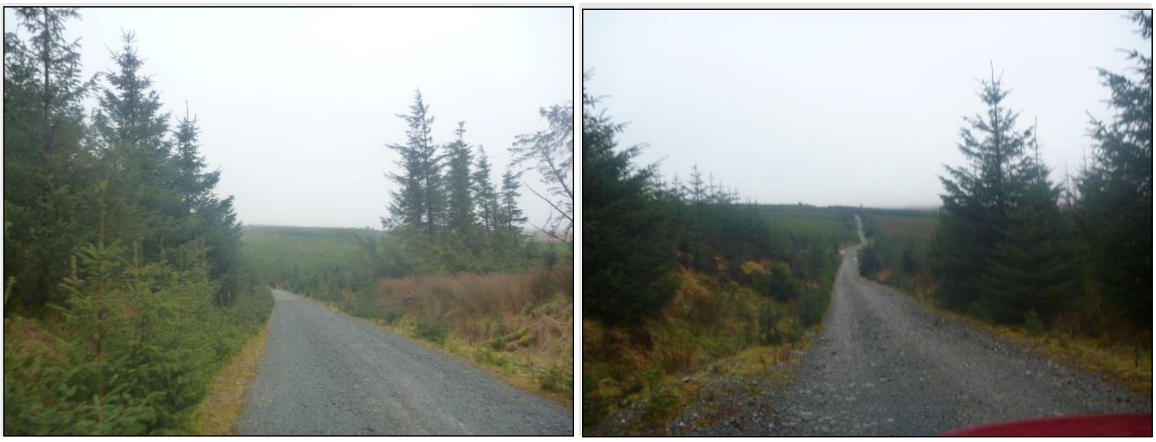


Figure 3-4 Existing Forestry Tracks in Drumnahough

3.3.2 New Excavated Roads

New excavated roads will be constructed using site won stone aggregate obtained from the proposed on-site borrow pits and placed over a layer of geogrid, where required, after all organic and soft subsoil material is excavated to formation level. Geotextile material, used to separate the road building material from the subsoil, may also be laid at formation level.

I. The appointed contractor will liaise with the wind turbine supplier prior to the commencement of the works to ensure that the design of the new excavated roads conforms with the wind turbine supplier's specifications.
II. The appointed contractor will survey the area for any unforeseen hazards prior to the commencement of works and set up warning signage as appropriate.
III. Excavators will first remove any topsoil / vegetative layer which may be present. This material will be transported to an agreed temporary storage area and maintained for re-use during the restoration phase of the wind farm construction. Topsoil / vegetative removal will be kept to a minimum in order to prevent any runoff of silt during heavy rainfall.
IV. Excavators will continue to strip and excavate the soft subsoil / peat underneath which will be temporarily stored adjacent to the access roads in accordance with approved methods with the use of an articulated dumper truck. Excavated material will only be temporarily stored on slopes under 5° and to a maximum height of under 1.0m until they are transported to the selected deposition areas where they will be permanently stored.
V. All excavations to be carried out will be battered back to a safe angle of repose (minimum slope angle of 45°) and comply with comply with the Construction and Environmental Management Plan (CEMP) (See EIAR Volume 3 Appendix B-2).
VI. Once a section of the excavated access road is exposed to suitable formation; a layer of geogrid or geotextile material may be placed along its formation depending on ground conditions which will be covered with site won aggregate stone as required compacted in maximum 250mm layers.
VII. The material required for construction of new excavated roads will be sourced from a combination of the four proposed on-site borrow pits and external quarries. The extraction of stone aggregate from the proposed borrow pits will be undertaken by 30-60 Ton 360° excavators and loaded onto articulated dumper trucks that will deliver the stone aggregate to the required excavated access road locations.
VIII. The stone will be delivered to the required work area and spread out locally with the use of excavators and compacted with the use of a roller which will roll the stone aggregate in maximum 250mm layers on top of the geogrid / geotextile material in order to achieve the required design strength.
IX. All new excavated access roads will be constructed to a minimum drivable width of 5.0m with a maximum crossfall of 2.5% in order that water can flow off the roads and reduce the risk of rutting / potholes occurring.
X. Roadside drains (as per Section **3.16**) will be constructed to manage clean and dirty water runoff along excavated access roads.
XI. The final running surface of the new excavated access roads will be capped with a minimum 150mm layer of hard wearing Class 6F stone or similar using a road grader.
XII. Any surplus spoil material generated from the excavated access road works will be transported to the borrow pits to aid final reinstatement. Excavated topsoil and subsoil will be kept separate at the excavation and storage areas.
XIII. Where drop offs greater than 1.0m in height occur alongside road edges; physical edge protection will be constructed in order to reduce the risk of vehicles overturning. Roadside marker posts will also be erected to delineate road edges in poor weather.
XIV. The appointed contractor will ensure that on site personnel will be aware of environmental constraints / sensitive areas within the wind farm site in which works are to be avoided.

Figure 3-5 Typical new excavated road on a wind farm

3.3.3 New Floated Roads

Floating road will be required in areas of deep peat that could not be avoided in the design of the access road layout. Where gradient and topographical conditions permit, floated road will also be utilised in areas of prime habitat such as the PB2 blanket bog habitat. The use of floating road methods will minimize the excavation of peat and reduce interference with the existing drainage regime in these areas of the site. A combination of geogrid and geotextile will be placed over the vegetation on the existing surface to be traversed with the floating road. A minimum thickness of 450mm of site won stone will be placed over the bottom layer of geogrid / geotextile. This will be overlain with a 150mm surface layer of Class 6F or similar material.

Where new access tracks will be constructed through forested areas, the felled trees may be used in the construction of the floating roads. This construction method involves layering the brash from the felling process on the existing ground surface and knocking the trees perpendicular to the direction of travel. A combination of geogrid and geotextile will be placed on top of the felled trees and the road construction completed using the same construction method as that outlined above.

Typically the sequence of constructing floating roads will comprise the following as per guidance from the Scottish Natural Heritage / Forestry Commission Scotland (Forestry Civil Engineering - FCE) on the construction of floated roads over peat:

I. The appointed contractor will mark out the line of the proposed floated road using a GPS / total station;
II. The intended floating road area is cleared of major protrusions such as rocks, trees, bushes etc down to ground level but residual stumps and roots are left in place.
III. The local surface vegetation and soils are left in place where possible as the existing vegetation and root mat may be the strongest layer in the system and care should be taken to preserve this layer if at all possible.
IV. Any local hollows and depressions are filled in with a suitable local lightweight fill such as tree brash, logs, or geogrid / geotextile material with stone aggregate.
V. A formation, 7 to 8m, wide is prepared where a layer of geogrid / geotextile is laid out by hand along the line of the proposed floated road.
VI. The specification for geotextiles will be finalised by the design engineer at construction stage but past empirical experience on previous constructed wind farms within Ireland and Scotland has proven the suitability of floated road construction over peat.
VII. Where there is a drainage requirement, suitably sized HDPE drainage pipes shall be laid on top of the installed geogrid / geotextile prior to the placement of stone aggregate. Cross drains will be laid at appropriate intervals to maintain the existing drainage regime on the site.
VIII. The material required for construction of new floated roads will be sourced from a combination of the four proposed on-site borrow pits and external quarries. The extraction of stone aggregate from the proposed borrow pits will be undertaken by 30-60 Ton 360° excavators and loaded onto articulated dumper trucks that will deliver the stone aggregate to the work face of required floated access roads.
IX. Wide tracked 360° excavators will be used for constructing the floated roads by cascading a minimum 450mm thickness of site won stone aggregate over the geogrid / geotextile. The suitable site won stone aggregate should be suitably sized in order to achieve a sound interlock with the geogrid / geotextile material. It is common practice for floated road construction on wind farms that the compaction of the stone aggregate is done by the wheels and tracks of construction plant alone.
X. An additional layer of geogrid / geotextile may be placed over the stone aggregate if necessary before a minimum capping layer of 150mm of Class 6F or similar material is laid out with excavators.
XI. All floated access roads will be constructed to a minimum drivable width of 5.0m with a maximum crossfall of 2.5% in order that water can flow off the roads and reduce the risk of rutting / potholes occurring.
XII. Roadside drains as per Section **3.16** will be constructed to manage clean and dirty water runoff along floated roads.
XIII. Where drop offs greater than 1.0m in height occur alongside road edges; physical edge protection will be constructed in order to reduce the risk of vehicles overturning. Roadside marker posts will also be erected to delineate road edges in poor weather.
XIV. To allow for the safe movement of site traffic during the construction of floated roads; a site traffic management plan will be prepared by the appointed contractor. Care will be taken when reversing vehicles on floating roads to ensure that they do not run along the edge of the road but stay within the delineated safe running zone.
XV. The appointed contractor will ensure that on site personnel will be aware of environmental constraints / sensitive areas within the wind farm site in which works are to be avoided.

Figure 3-6 Typical floated road on a wind farm

3.4 TURBINE LOCATIONS

A key step in the positioning turbines was to minimise the volume of excavated peat and to achieve a balance of cut and fill of the underlying strata at each turbine location. This was achieved by orientating the turbine base and crane hardstanding area with its long axis parallel to the ground contours as much as possible while taking account of access criteria for delivery of turbine components. This generally required some adjustment to the position of the access road on the approach to the turbine site. **Table 3-1** gives information of the site, ground slope and peat depth at and in the vicinity of each of the proposed turbines.

Table 3-1 Summary of ground parameters at Turbines

Turbine	Land use category	Slope	Peat depth
T1	Blanket bog and conifer forestry	0.7°	1.6m
T2	Coniferous forestry adjacent to an existing road	5.2°	1.7m
T3	Coniferous forestry	3.0°	1.9m
T4	Coniferous forestry adjacent to an existing road	6.0°	1.3m
T5	Coniferous forestry adjacent to an existing road	2.3°	2.4m
T6	Coniferous forestry	5.9°	2.2m
T7	Coniferous forestry	2.3°	2.0m
T8	Coniferous forestry	7.0°	2.2m
T9	Eroded blanket bog	10.3°	2.8m
T10	Eroded blanket bog	9.8°	2.1m
T11	Eroded blanket bog and coniferous forestry	9.1°	2.6m
T12	Coniferous forestry	4.3°	1.4m

3.5 TURBINE CRANE HARDSTANDS

The layout of the crane hardstand is designed to accommodate the delivery of the turbine components prior to their erection and to support the cranes during erection. Hardstands are also used for maintenance during the operation of the turbine. The hardstands will be approximately rectangular in shape with additional minor hardstand areas to accommodate lay down of the turbine blades and assist cranes. The area of a single hardstand is approximately 50m long by 35m wide. Refer to **Planning Drawing 19715-5401** for further details. Due to the significant loads that will be imposed by the outriggers of the main lifting crane during the turbine erection process; it is intended that the hardstands will be constructed using excavation methods to solid formation stratum over the footprint of the hardstand area / turbine base. A typical layout hardstand is shown in **Figure 3-7**.

The proposed works will be restricted to the turbine locations and will comprise the following:

I. Each crane hardstand will be formed on competent subgrade of the underlying subsoil / rock which will comprise of site won stone aggregate, obtained from the on-site borrow pits, laid on a geotextile filter membrane. The top layers of the crane hardstanding will be formed from imported Class 6F2 fill.
II. The stone aggregate will be compacted in 250mm layers and will vary in depth depending on the depth of peat and gradient of the underlying subgrade. Turbine locations have been selected to minimise the impact on peatlands which will minimise the volumes of peat to be excavated at each crane hardstand.
III. Temporary set down areas will be formed to facilitate the storage of the turbine components at each crane hardstand (e.g. the rotor hub assembly, the turbine blades, the turbine towers and nacelle). The temporary lay down areas will be cleared of vegetation, graded and generally left unfinished. Some sections of the lay down area will be surfaced using compacted stone aggregate. These sections will be recovered with soil after all turbines have been erected. The areas where stone aggregate will be required are shown on **Figure 3-8**.
IV. Plate bearing test results will be undertaken on the finished hardstand surface to check if ground bearing strengths are to the wind supplier's specifications. Once complete the assembly cranes will be set up on the hardstand and erect the wind turbine into place.

Figure 3-7 Typical finished hardstand on a wind farm

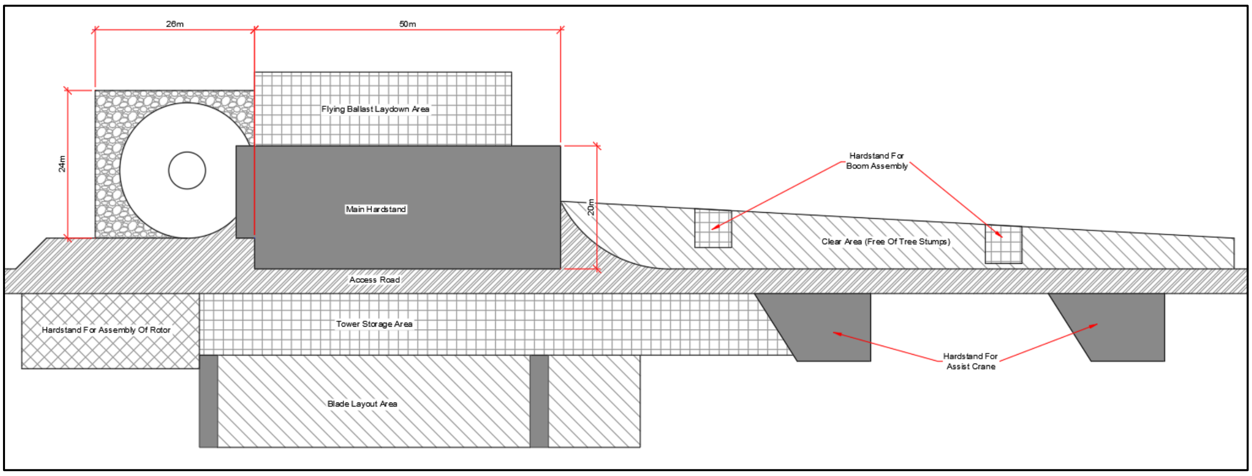


Figure 3-8 Typical hardstand dimensions and layout

3.6 TURBINE BASES

It is proposed that the 12 No. wind turbines will have a reinforced concrete base with a central pedestal above the base that will in turn support the wind turbine tower. The concrete base will bear onto rock, imported 6N fill to a suitable depth using a spread foundation or sit on a piled foundation. Site visits and peat probing have been carried out at each of the proposed turbine locations. Based on observations of rock outcrops during site visits and peat probes at turbine locations, it is likely that at least 6 of the turbines will have spread foundations. Further ground investigation will be required prior to detailed design to inform the foundation design. A worst case of 6m excavation for spread turbine bases has been assessed. Piled foundations have also been assessed to cater for situations where spread foundations cannot be used. Details of peat depths are provided in the Peat Stability Risk Assessment included in Volume 3 Appendix E-1 of the EIAR.

A typical spread foundation will be approximately 28m in diameter and will generally be installed to a depth of approximately 3.0m below grade. Approximately 900m^3 of concrete and 100 tonnes of steel will be used in the construction of each turbine base.

A typical piled foundation consists of a ring of piles around the edge of the base. Piles are typically auger bored, 750mm in diameter, made from reinforced concrete. The depth of the piles is dictated by the depth to a solid stratum. The final dimensions of the turbine bases will be determined as part of detailed engineering design at pre-construction stage following confirmation of the turbine supplier and from using detailed geotechnical data (including boreholes) that will be conducted at each turbine location. A conservative base size of 28m diameter has been assessed to capture a worst-case.

The proposed works will be restricted to the turbine locations and will comprise the following:

I. The extent of the excavation will be marked out and will include an allowance for trimming the sides of the excavation to provide a safe working area and slope batter;

II. Any existing peat found within the footprint of the turbine base will be excavated out during the course of formation works at the adjacent crane hardstand area. The excavation works will be carried out using hydraulic excavators where surplus peat / subsoil material will be transported to the on-site deposition areas via articulated dumper trucks or tractor and trailer for subsequent reuse in the permanent reinstatement of the borrow pits;

III. Blasting at turbine locations and hardstands may be necessary to enable excavation of the rock if encountered at less than 3m depth. Any blasting will be carried out by a suitably qualified specialist under licence with a suite of mitigation measures in place. Blasting, and mitigation measures associated with the process, is discussed in further detail in the Land and Soils Chapter of this EIAR.

IV. Standing water in turbine base excavations is likely to contain an increased concentration of suspended solids. Dewatering of turbine base excavations can result in significant flow rates to the drainage and settlement system if high capacity pumps are used. In order to avoid the need for pumping it is proposed to provide drainage channels from the excavations so as to prevent a build up of water. Where this is not feasible, temporary storage will be provided within the excavations and dewatering carried out at a flow rate that is within the capacity of the settlement ponds. Sediment control measures will be provided to prevent siltation of watercourses (See Section 3.17 for further details);

V. The excavated surface will be levelled and adequate drainage measures will be put in place along with suitable set back areas to facilitate placing of stone and ultimately the erection of shuttering for the turbine base;

VI. In the event that poor ground conditions are encountered during confirmatory ground investigations and a significant depth to sub-formation is required, a piled foundation may be considered. A piled foundation requires the use of specialist piling equipment which typically uses an auger drilling technique. A number of holes are drilled around the area of the turbine base to the suitable sub-formation depth determined at detailed design stage. The piles typically extend 2 to 4 m into competent rock. Once all the holes have been bored, reinforcement steel is inserted into each with concrete poured afterwards.

VII. Suitable stone aggregate will be used to form a solid level working foundation surface. The stone will be rolled and compacted to a suitable formation level;

VIII. Shutters and steel reinforcement will then be put in place and the foundation of the turbine will be prepared for pouring of concrete;

IX. A layer of concrete blinding approximately 75mm thick will be laid directly on top of the newly exposed formation, tamped and finished with a screed board to leave a flat level surface. The concrete will be protected from rainfall during curing and all surface water runoff from the curing concrete will be prevented from entering surface water drainage directly;

X. High tensile steel reinforcement will be fixed in accordance with the design drawings and schedules. The foundation anchorage system will be installed, levelled and secured to the blinding;

XI. Ductwork will be installed as required, and formwork erected around the steel cage and propped from the backside as required;

XII. The foundation anchorage system will be checked both for level and line prior to the concrete being poured in the base. These checks will be passed to the turbine supplier for their approval;

XIII. Ready-mix concrete will be delivered to each turbine base by a fleet of ready-mix concrete trucks via the internal access roads. Concrete will placed into each base by means of a concrete pump where vibrating pokers will be used to ensure that full and proper compaction of the concrete around the reinforcement in the turbine base has been made. Upon completion of the concreting works the foundation base will be covered and allowed to cure;

XIV. Steel shutters will be used to pour the circular chimney section;

XV. Following curing, the shuttering around the turbine base will be struck and removed;

XVI. Earth wires will be placed around the base; and,

XVII. The foundation will be backfilled using material arising during the excavation where possible and the surrounding area landscaped using the vegetated soil set aside during the excavation. A gravel access track will be formed from the main access track and hardstand to the turbine door and around the turbine for maintenance.

Figure 3-9 Typical construction of a wind turbine base

3.7 INTERNAL SITE CABLES

A network of underground cabling serving each turbine with electrical power and signal transmission will be installed within the site. The distribution system will electrically connect the wind turbines to the grid connection point. In this case two grid potential connection points have been considered, namely Connection to the permitted 110kv substation at Lenalea or alternatively to a new 110kv substation compound within the proposed development site. Cable jointing bays will be required to allow cables to be jointed from the turbines to the selected grid connection point.

Cabling on site is likely to consist of single or twin cable trenches for open ground sections and for trenches within internal access roads. A cable marker post will typically be installed on top in order to protect and identify the cable trench underneath. The typical build up for the internal site cable trenches will consist of selected excavated backfill on top of bedding material. The minimum cover depth over the ducts will be 750mm which is measured from the top of the cable duct to existing ground level. Where ducting is within internal access roads; the cable trench will be backfilled with lean-mix concrete in order to protect ducting from being damaged by heavy axle loads that will pass above. The excavated material generated from the trenches will be reused as backfill where possible or alternatively it will be deposited within the proposed on-site borrow pits as part of their reinstatement.

Where an open drain or watercourse is encountered during the installation of the internal site cable trenches; the cable trenches will cross the open drain or watercourse within the road carriageway via new or existing road crossings points to minimise the requirement for in-stream works. Marker tapes of non-corrodible material in bright red and yellow colour will be placed within the trench after backfilling for identification and safety purposes in accordance with ESB Networks guidelines. An earth berm will be placed over the cable trench with a marker post installed on top in a secure and robust manner so as to prevent the post from being damaged by animals or prevailing ground conditions. Cable marker posts will either be made of concrete, recycled plastic or timber material. Each marker post will contain appropriately worded warning signage highlighting to persons the presence of high voltage electricity cables underneath. Refer to **Planning Drawing 19715-5406** for further details.

3.8 DESCRIPTION OF GRID CONNECTION OPTIONS

Two potential grid connection points and their associated connection routes from the wind farm have been considered as part of this EIAR.

Connection to the permitted 110Kv Lenalea Substation

This connection consists of an underground 33kV collection cabling system from the proposed wind farm then travelling east and northeast to the permitted 110kV Lenalea substation located in Killymasny townland. This connection route option transverses transitional woodland scrub, commercial forestry, land principally occupied by agriculture, significant areas of natural vegetation and peat bogs and a section of public road (approximately 750m) from the entrance of the proposed development site to the entrance of the existing Cark Extension wind farm. The cable will then be laid within existing or permitted access track to the permitted Lenalea substation.

This connection options involves a total of 7 water crossings including 2 no. within the proposed development site (1 existing and 1 new), 1 No. water crossing adjacent to the public road (existing) and 4 No. within the Cark Extension and Lenalea sites along the existing or permitted access tracks.

This route will travel along the same alignment as the existing forestry/wind farm access tracks and proposed wind farm access tracks. Existing access track water crossings points will be used for the cable.

Cable trenching along the section of public road between T1 and the existing entrance to Cark Extension Wind Farm will be carried out in the road edge or in the grass area immediately south of the road where possible. This will depend on the space available in the verge and offset requirements from the existing cable. Where there is insufficient space at the edge of the road or in the grass area to the south of the road, the cable will be placed in the roadway. The cable will cross the public road on two occasions, between T1 and T2 and near the entrance to the existing Cark Extension Wind Farm. The public road crossing will be achieved by either open trenching or horizontal directional drilling. This will be done under the terms of road opening licences from Donegal County Council. The extent of works on the public road is relative small in scale at approximately 750m in length. The road will be reinstated to the required standard following the works. Road closure applications may also be required. All works will be planned and undertaken in full consultation with Donegal County Council, in particular the Roads Department/Roads Engineer for the area.

Alternative Connection to new 110Kv Substation

This connection consists of an underground 33kv collection cabling system within the proposed development site travelling north to a proposed 110kV substation in Trenkeel townland. From the substation, a loop in to an existing 110kV overhead line will be installed. Two new pylons will be installed to facilitate the connection.

This option entails the collection cable crossing under the public road between T1 and T2 then continuing along the same alignment as the existing forestry/wind farm access tracks and proposed wind farm access tracks to the proposed substation. The section involving the public road crossing will be achieved by either open trenching or horizontal directional drilling. This connection route option transverses commercial forestry, peat bog and transitional woodland scrub and involves 3 No. water crossings (1 existing crossing within existing on-site forestry tracks and 2 new crossings).

3.8.1 Excavation and Duct Installation – Along Public Roads

The proposed connection cabling system to the grid connection point in sections along the public road will be carried within a single cable trench which will be approximately 1.25m in depth and 0.6m in width. The installation will involve the following process:

- Prior to works commencing the area where excavations are planned will be surveyed and all existing services will be confirmed. A road opening licence will be obtained where required from Donegal County Council for the relevant road sections. All plant operators and general operatives will be inducted and informed as to the location of any services.
- Prior to works commencing a dilapidation survey will be carried out photographing and noting any existing damage or defects to structures or road surfaces. A copy of this survey will be submitted to Donegal County Council prior to works commencing.

- Prior to works commencing the route will be inspected and marked out on the ground. Standard good practice preparatory measures are then put in place along the extent of the route. This will include any required warning notices, temporary barriers, etc.
- Prior to works commencing a traffic management plan will be prepared by the appointed contractor and agreed with Donegal County Council. A traffic management plan is included in **Volume 3 Appendix H-2 of the EIAR.**
- During construction works, the trench will be excavated down through the existing stone in the road using an excavator machine. As stone fill is removed it is temporarily stockpiled adjacent to the trench for re-use in backfilling. In some instances some soil or unsuitable material may be encountered in the trench and this is removed from site and brought to an appropriately licensed facility for disposal.
- The trench is then prepared to receive concrete bedding and surround for the ducts. The ducts are surrounded by concrete with adequate cover over the duct.
- Once the concrete is suitability set, appropriate imported stone material is placed over the concrete surround and filled back up to the top of trench. Suitable warning tapes will also be installed in the trench. Once the trench is filled, the trenching and ducting process will move along the road in planned stages.
- The trench surface receives a temporary surface dressing of either spray and chip or macadam. Once the overall scheme is completed, the grid connection route and associated road areas will receive a new permanent macadam finish as agreed with Donegal County Council.
- Joint bays are to be installed where required along the connection route in the public road or along the grass margin of the public road. Once installed they are temporarily reinstated until they are opened again to allow for pulling cables through the ducts and jointing the cables afterwards. The joint bays will then be permanently backfilled and reinstated to the satisfaction of Donegal County Council.
- Directional drilling will be used where there is insufficient cover on a bridge or culvert crossing to allow the grid connection route pass over the crossing in a standard trefoil formation. The launch and reception pits to be made in the public road or grass margin will be permanently backfilled and reinstated to the satisfaction of Donegal County Council.
- The as-built location of the ducting will be surveyed using a total station / GPS. Marker posts will be installed along the grid connection route to also denote the location of ducting on the ground.
- A condition survey will be carried out on the roads impacted by the connection route, both pre and post construction. This will include a video survey of the road extent with any significant dilapidations further recorded by photography and local surveying as required.

Figure 3-10 Typical excavation works for a grid connection cable trench on public road

Figure 3-11 Typical ducting installation works for a grid connection cable trench on public road

Figure 3-12 Typical permanent reinstatement works for a grid connection cable trench on public road

3.8.2 Excavation and Duct Installation – Along Wind Farm and Forestry Access Tracks

The cable trench will either be located in the existing forestry or wind farm tracks or immediately adjacent to it depending on space available at each section of track. For new wind farm tracks the cable trench will be located immediately adjacent to the track.

The proposed connection cable system will be carried within a single cable trench which will be approximately 1.25m in depth and 0.6m in width. The installation of the connection cable system along the forestry and wind farm roads involve the following process:

- Prior to works commencing the area where excavations are planned will be surveyed and all existing services will be confirmed. All relevant bodies i.e. ESB Networks, EirGrid, Gas Networks Ireland, Eir, Donegal County Council etc. will be contacted and drawings for all existing services sought. All plant operators and general operatives will be inducted and informed as to the location of any services.
- Prior to works commencing the route will be inspected and marked out on the ground. Standard good practice preparatory measures are then put in place along the extent of the route. This will include any required warning notices, temporary barriers, etc.
- During construction works, the trench will be excavated down through the existing stone in the forestry or wind farm track using an excavator machine. As stone fill is removed it is temporarily stockpiled adjacent to the trench for re-use in backfilling. In some instances some soil or unsuitable material may be encountered in the trench and will be removed to the nearest material storage area.
- The trench is then prepared to receive concrete bedding and surround for the ducts. The ducts are surrounded by concrete with adequate cover over the duct.
- Once the concrete is suitability set, appropriate imported stone material is placed over the concrete surround and filled back up to the top of trench. Where the trench is adjacent to the access track, subsoil and topsoil will be placed over it. Suitable warning tapes will also be installed in the trench and marker posts will be installed at the surface.
- Once the trench is filled, the trenching and ducting process will move along the access track in planned stages.
- The as-built location of the ducting will be surveyed using a total station / GPS. Marker posts will be installed along the grid connection route to also denote the location of ducting on the ground.

Figure 3-13 Typical excavation works for a grid connection cable trench within wind farm

3.8.3 Existing Underground Services – along Connection Route

Any underground services encountered will initially be surveyed for levels in order to determine if there is adequate cover available for ducting to pass over these services. A minimum clearance of 300mm is required from the bottom of the ducting to the top of any underground service as per ESB Networks requirements. If this clearance cannot be achieved, the ducting will pass below the service with a minimum 300mm clearance maintained from the top of the ducting to the bottom of the service. All excavations will be kept within the public roadway boundaries i.e. in road or grass margins.

3.8.4 Joint Bays and Communication Chambers – along Connection Route

Joint bays are pre-cast concrete chambers that will be required along the connection route to the grid connection point over its entire length. They are required to join cables together to form one continuous cable. They will be located at various points along the connection route approximately every 500 - 1,000 metres depending on gradients, bends etc. It is proposed to install approximately 3 No. joint bays and communication chambers along the proposed connection route from the wind farm to grid connection point at the permitted 110kv Lenalea substation. Two of the joint bays are likely to be placed at the widened areas just off the public roadway at the entrance to Drumnahough and Cark wind farms with the third joint bay located in the public roadway between the entrances. No joint bays are proposed for the alternative grid option to a new 110kv substation within the site. The joint bays will remain within the existing/permitted corridor of the road network. The final locations will be agreed in advance with Donegal County Council.

Where possible, joint bays will be located in areas where there is a natural widening / wide grass margin on the road in order to accommodate easier construction, cable installation and create less traffic disruption. During construction, the joint bay locations will be completely fenced off. Any joint bays along the section of the public road network will be incorporated into the traffic management plan. A traffic management plan is included in **Volume 3 Appendix H-2 of the EIAR.** In the event An Bord Pleanála (the Board) decides to grant approval for the proposed development, the final TMP will address the requirements of any relevant planning conditions, including any additional mitigation measures which are conditioned by the Board. The final traffic management plan will be agreed with Donegal County Council prior to the commencement of works. Once the joint bays have been constructed they will be temporarily backfilled until they are re-excavated later to allow for the pulling and jointing of cables at each joint bay. Once cable pulling is complete, the joint bays will be fully backfilled again and permanently reinstated to the satisfaction of Donegal County Council.

The joint bays, communication chambers and sheath link boxes will be either precast or cast *in situ*. In order to place the boxes, the area of excavation will first be marked out on the ground and any necessary preparatory protection measures put in place to avoid any run off or loss of soil materials. These will include appropriate siltation measures along road side drainage (silt fences, check dams etc.).

The materials excavated from the joint bay chambers from within the wind farm site will be removed to the onsite borrow pits as part of the reinstatement. Any material excavated from joint bay chambers outside out the main wind farm site will be brought to a suitably licensed or permitted

facility depending on the material classification. Prior to the chamber being installed in a compacted layer of suitable stone or lean mix concrete, appropriate material will be placed in the excavation to a level surface. The boxes are then positioned *in situ* and backfilled around them with imported crushed stone material. The precast concrete joint bay chamber cover is then put in place at a suitable level to allow for a new road surface and chamber cover over.
Figure 3-14 shows a typical joint bay installation.

Figure 3-14 Typical joint bay construction

3.8.5 Duration of Construction of Connection Route to Grid Connection Point

Overall the works for the connection route to the grid connection point are estimated to take approximately 6 months. During the first 3 months the cable trenches will be constructed. The second 3 months will involve sequentially opening up all joint bays (these are pre-cast concrete chambers that will be required along the grid connection route over its entire length) and pulling electrical cables pulled through ducts and then joining each cable together.

For the grid connection option to the permitted 110kv Lenalea substation, works will be required on or adjacent to the public roadway for a short section (approximately 740m) between the eastern site entrance and the existing entrance to Cark Extension Wind Farm. The active construction area will generally be only along a 100-200m stretch of any roadway at any one time. There are anticipated to be up to 3 No. joint bays in the local roadway for grid option B with 2-3 days' work involved at each. Overall it is anticipated that these works on the public roadway for connection route option B are anticipated to take 1 month. Works on the public road for the alternative grid connection option to a new onsite substation are anticipated to take 2 weeks.

3.9 WATERCOURSE CROSSINGS

3.9.1 New Access Roads construction at Watercourse Crossings

Within the proposed wind farm site, up to 3 No. watercourses require crossing. It is proposed that these watercourses will be crossed using clear span pre-cast concrete culvert crossings such as a bottomless arch or bottomless box culvert. Clear span pre-cast concrete culverts are advantageous in several manners for this type of installation. As spans increase, the height can increase accordingly, allowing significant light penetration under the culvert which is advantageous from an ecological perspective. The increase in height is complimentary to the vertical alignment requirements for access road design.

The selection criteria for crossing natural streams and rivers within the site were:

- Avoid crossing streams or rivers at acute angles;
- Avoid meanders at the crossing location;
- Cross where foundations could be constructed without excess excavation;
- Consider vertical alignment requirements;

The design of a clear span pre-cast concrete culvert crossing will ensure that:

- The existing channel profile within the watercourse is maintained;
- Gradients within the watercourse are not altered;
- There is unrestricted passage for all size classes of fish by retaining the natural watercourse stream / river bed;
- There are no blockages within the watercourse. The large size of a clear span culvert allows for the passage of debris in the event of flood flow conditions;
- The watercourse velocity is not changed;
- The clear span of a culvert will ensure that the existing stream / river bank is maintained during construction which will in turn avoid the occurrence of in-stream works or limitation for movement of animals (e.g. otter) along banks;

Construction of the clear span crossings will be supervised by the Construction Manager, a suitably qualified engineer, the project manager and the Environmental Manager in accordance with Inland Fisheries Ireland *"Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters, 2016"* and Office of Public Works *"Construction, Replacement or Alteration of Bridges and Culverts, 2013"*.

Typically the proposed installation works for a clear span pre-cast concrete culvert will comprise the following:

I. Prior to the commencement of works, the design of the culvert will be submitted for approval to the Office of Public Works (OPW) under Section 50 of the Arterial Drainage Act, 1945 and to Inland Fisheries Ireland (IFI);
II. Upon design approval the extent of the excavations required for the culvert foundations at either side of the watercourse will be marked out. The foundations are to be set to an agreed minimum distance by IFI from the existing watercourse so as not to impact on the riparian habitat. Health and safety measures such as lifebuoys on stakes will be installed and where appropriate life jackets will be provided to persons working near the watercourse;
III. Appropriate environmental control measures such as silt curtains, silt traps, mats etc. will be erected on both sides of the watercourse. All necessary environmental and ecological checks will be carried out. These environmental control measures will reduce the potential for sedimentation of the watercourse;

IV. Excavators will begin to excavate the foundations to formation level where all excavations will be battered back to a safe angle of repose (minimum slope angle of 45°) and comply with the final Construction and Environmental Management Plan (CEMP) to be produced by the appointed contractor for the proposed development (See EIAR Volume 3 Appendix B-2). All excavation works will stop in the event of heavy rainfall.

V. All excavated material will be transported to the on-site deposition areas located outside of the hydrology buffer zone at the proposed borrow pits. Some of the excavated material will subsequently be reused as backfill around the culvert abutments and structure upon installation. Bare ground will be minimised.

VI. Once formation is reached at suitable ground conditions; steel reinforcement and shuttering will be installed. The culvert abutments will be prepared for the pouring of concrete by dewatering standing water within the excavations, which is likely to contain suspended solids, via a pump to an adequately sized settlement pond located outside of the hydrology buffer zone. The standing water will be treated through the settlement pond and clean filtration stone prior to outfall over vegetation away from the watercourse;

VII. Ready-mix concrete will be delivered to the culvert abutments by ready-mix concrete trucks and placed into each abutment by means of excavators. Upon completion the abutments will be covered and allowed to cure;

VIII. Following curing, the shuttering around the abutments will be struck and removed. A small temporary hardstand will be constructed so that a lifting crane, which will install the pre-cast concrete culvert components onto the abutments, can be set up;

IX. Deliveries of the pre-cast concrete culvert components will arrive to site. These components will be individually fitted and manoeuvred into position by the lifting crane onto the concrete abutments. The components will be inspected to ensure that each unit is level and secure;

X. Backfilling on either side of the culvert will commence in accordance with the culvert supplier's specifications using excavated material;

XI. The access road surface will be laid over the culvert structure using site won stone aggregate and compacted in maximum 250mm layers with the use of 10-20 Ton rollers. An internal cable trench will be installed within the carriageway of the culvert so that it can cross over the watercourse;

XII. Bunds will be installed to divert dirty water generated on the section of road over the culvert crossing into the dirty water system outside of the hydrology buffer zone. This will ensure that dirty water will not enter the clean watercourse;

XIII. If required, steel parapet railings and timber post and rail fencing will be installed at the sides and on the approaches to the culvert. This will prevent persons or vehicles falling into the watercourse while travelling across the culvert;

Figure 3-15 Typical Rectangular Box Bottomless Culvert

3.9.2 New Access Roads construction at Drainage / Stream Channel Crossings

Where the crossing of an existing natural or artificial drainage / stream channel is unavoidable, a suitable crossing will be designed. Typically this will be in the form of precast concrete or HDPE pipes. All crossings will be designed for a minimum 1 in 200 year return rainfall event. The invert of the pipe is typically submerged approximately $^1/_4$ of its diameter below the original drainage bed. Where natural gradients allow, a nominal back fall in the pipe will be incorporated to prevent scour and promote the settling of natural material along the invert of the pipe. An example of a permanent drain crossing is illustrated in **Figure 3-16**. New turbine service roads will be required to cross several minor drains / streams within the site. All such crossings and widening will be agreed with Inland Fisheries Ireland prior to construction. All construction method statements for crossings will be approved by Inland Fisheries Ireland.

Figure 3-16 Typical drainage channel crossing

Figure 3-17 shows a typical measure to be put in place at drainage and watercourse crossings in order to ensure dirty water does not enter clean watercourses. For the proposed development, the proposal is to use vegetated soil bunds to divert dirty water generated on the section of road over the crossings to the dirty water system. Alternatively temporary silt curtains, as shown in **Figure 3-18**, can be placed along the existing roads within the hydrology buffer zone. These silt curtains can run longitudinal to watercourses with a layer of stone placed along the bottom to prevent any seepage if there is a risk of silted runoff.

Figure 3-17 Dirty water containment at watercourse crossings

Figure 3-18 Silt curtain containment along existing roads near watercourses

3.9.3 Route to grid connection points construction at Major Watercourse Crossings

There are no major watercourse crossings along / adjacent to public roads required for the alternative grid connection option to a new 110kv substation within the site.

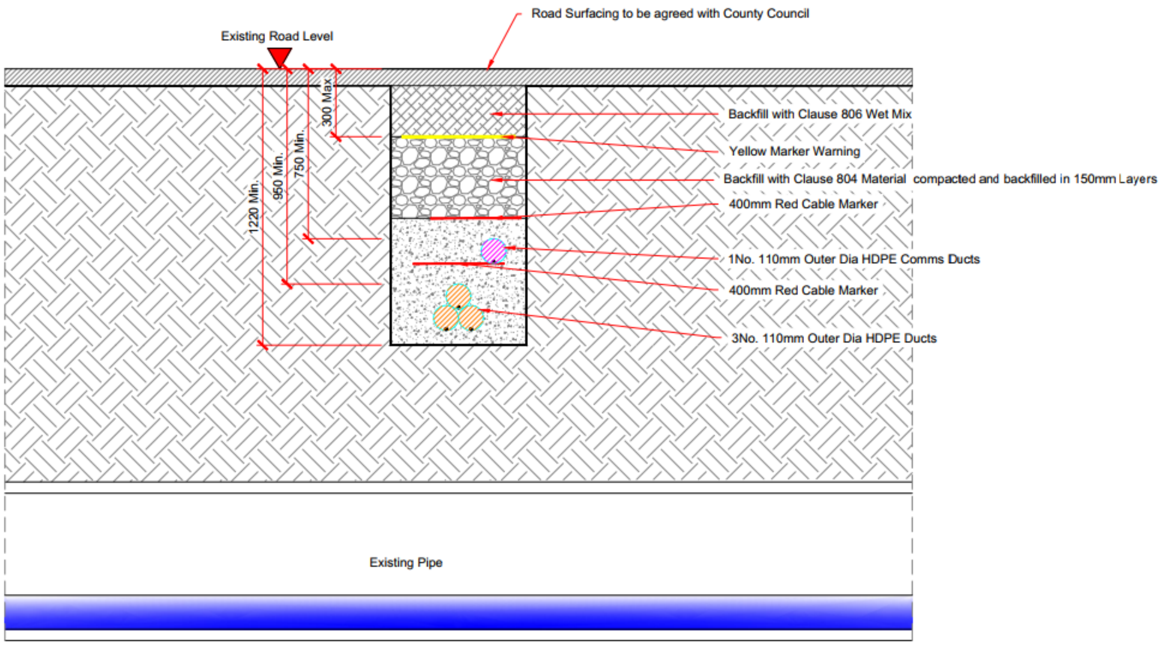
There is a total of 1 No. watercourse crossing on the local public road along the proposed connection route for grid connection to the permitted 110kv Lenalea substation.

The crossing options described below will also be used at existing bridges/culverts along sections of existing forestry/wind farm roads.

A description of the proposed crossing options is provided below. In-stream works are not required along the proposed connection route. Watercourse crossings within the existing and proposed wind farms will be installed adjacent to the access tracks and use the same watercourse crossing structure as the access track.

Option 1 - Crossings over Bridges/Culverts using Standard Trefoil Formation

Watercourses will not be directly impacted as no in-stream works or bridge alterations are proposed. Where adequate cover exists above a bridge, a standard trefoil arrangement will be used where the ducts will pass over the bridge without any contact with the top of the bridge or watercourse. The ducts will pass over the bridge in a standard cable trench as outlined in **Planning Drawing 19715-MWP-00-00-DR-C-5407.**



Option 1 - Cable Bridge Crossing (Ducts in Trefoil Formation) - Section A-A Scale 1:20

Figure 3-19 Typical Trefoil Arrangement at Bridge/Culvert Crossing

Option 2 - Flatbed Formation over Bridges/Culverts

Where cable ducts are to be installed over an existing bridge/culvert and sufficient cover cannot be achieved by installing a standard trefoil arrangement, the ducts will be laid in a much shallower trench. The ducts will be laid in a flatbed formation over the existing bridge and encased with galvanized steel plates in a concrete surround. This method of duct installation is further detailed in **Planning Drawing 19715-MWP-00-00-DR-C-5407.**

Where a bridge/culvert has insufficient cover within its deck to fully accommodate the required ducts, the ducts can be laid in a flatbed formation partially within the existing road where they will be encased with galvanized steel plates in a concrete surround. It may be necessary to locally raise the level of the existing road in order to achieve the required cover over the ducts. The increased road level will be achieved by overlaying the existing road with a new wearing course as required where any addition of new pavement will be tied back onto the existing road. Any works to locally raise the level of the existing road and potentially the bridge parapets will be agreed with Donegal County Council prior to commencement with all works and reinstatement carried out to their satisfaction. Once the ducts have crossed the bridge the ducts will resume to the standard trefoil arrangement.

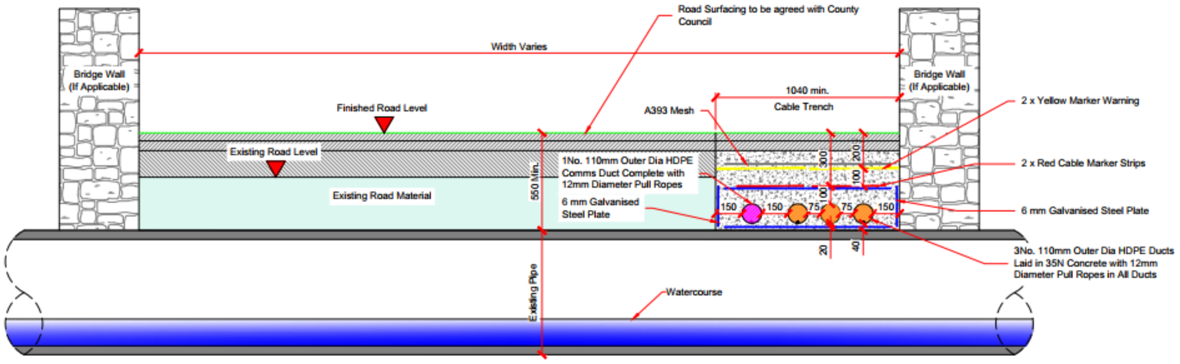


Figure 3-20 Typical Flatbed Arrangement at Bridge/Culvert Crossing

Option 3 - Directional Drilling under Bridges, Culverts and Watercourses

In the event that none of the above methods are appropriate, directional drilling will be utilised, which will require a service trench (launch pit) for the drill in the road either side of the watercourse. The directional drill process will require that the depth of the service trench will deepen in a defined slope as it approaches the watercourse crossing on either side, as to have sufficient passing depth under the watercourse.

The direction drill will be carried out as follows:

- The directional drilling machine will set up at a launch and reception pit (an enlarged portion of on-road trench, i.e. a service trench on either side of the crossing point at an appropriate distance back from the watercourse). The drill will then bore in an arc under the watercourse feature.
- The drilling head of the boring tool has a series of nozzles that feed a liquid bentonite mix along the bore direction, which provides both lubrication and also seals the cut face of the bore.
- Once the bore reaches the far side, the duct is then attached to the drill head and the duct is pulled back along the route of the bore to the original drilling point.

- Any bentonite mix is deposited within the bore shaft and spillage is collected at either end of the bore with dedicated sump; all excavated material and excess bentonite will be removed from site and brought to an authorised waste facility.
- Once the duct is in place under the watercourse, the normal process of road trenching can continue from either side of the watercourse structure.
- The launch and reception pits will be backfilled in accordance with normal specification for backfilling excavated trenches and to the satisfaction of Donegal County Council.

The directional drilling methodology is further detailed in **Planning Drawing 19715-MWP-00-00-DR-C-5408**

Table 3-2 Summary of proposed crossing methodology

Crossing No.	Crossing Type	Cover from Road Level to top of pipe	Description	Watercourse Crossing Option	Extent of In-stream works
1 (public road)	300 to 450mm Concrete Pipe	Approx 600mm	Accurate survey of cover over existing pipe not currently available. This information will be sought at detailed design stage. No contact will be made with the watercourse during the works. All available crossing options have been assessed to ensure that a worst-case has been assessed	Option 1, 2 or 3	None. No in-stream works required

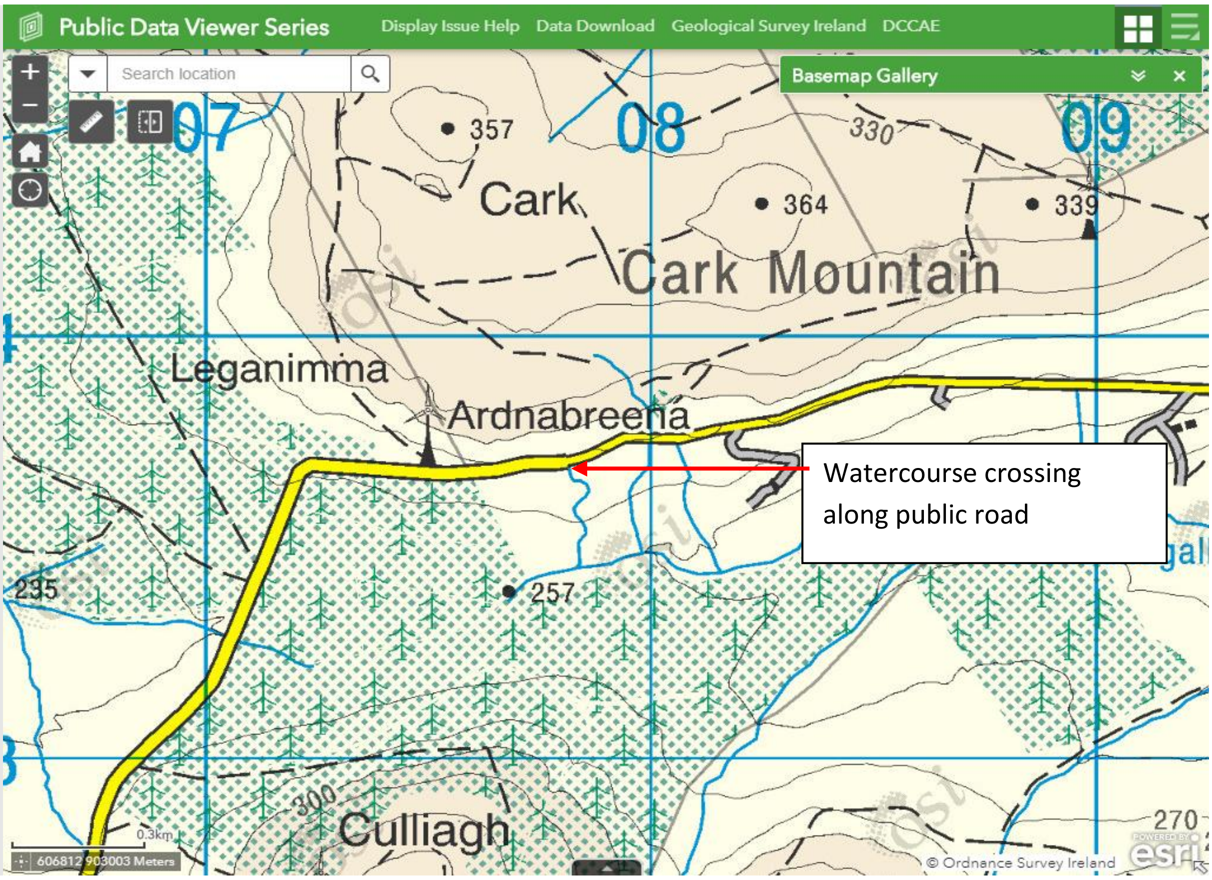


Figure 3-21 OSI Map at connection cable route in local roadway for connection Option to permitted 110kv Lenalea Substation

Figure 3-22 Existing culvert under local road along connection cable route for connection Option to permitted 110kv Lenalea Substation

Figure 3-23 View downstream of existing culvert in local road along connection cable route for connection Option to permitted 110kv Lenalea Substation

Figure 3-24 Typical directional drilling rig and launch pit

3.9.4 Route to Grid Connection point construction at Land Drainage Ditches

Where land drains are encountered on the proposed connection route to the grid connection point there are two scenarios, as follows:

I. In the event that there is adequate cover over the drain crossing, then the new ducts and trench will pass over the drain without interruption to the drain. No works will be required within the drain at these locations. The trench at these locations will be installed in the existing public / access road.

II. In the event where there is insufficient cover over a drain crossing point, the new grid connection route will have to be installed underneath the existing drain crossing. In order to do this the following approach is adopted:

- The drain is blocked upslope of the crossing and a sump is formed using sandbagging and stable clay soil material. This sump will accumulate water flow in the drain (if it exists) and will facilitate the use of a 50mm or 100mm submersible pump to over pump (fluming) the drain water across the road and back into the drain on the down flow section below the road.
- Two silt fences and filters will be put in place on the downslope of the crossing point to prevent siltation/sedimentation. Once the sump and over-pumping mechanism is in place, then the service trench excavation will progress.
- A section of drain crossing (pipe or stone culvert) is temporarily removed to allow the trench and duct to continue. The duct will pass under the drain and once in place it will be surrounded with lean mix concrete and then the trench will be backfilled with suitable stone from excavations, or imported.
- The drain will then be put back in place, surrounded with stone/lean mix concrete and the track restored to its finished level. The over-pumping measure can then be removed and normal drain flow resumes. The duct/trench work can then progress over the remaining length of the public / access road.

3.10 DIVERSION OF EXISTING 38KV OVERHEAD LINE AT T1

An existing 38kV overhead line passes through the proposed location of T1. This line will require diversion. The diversion will consist of either;

1. Undergrounding the line along its current alignment, or;
2. Keeping the line overhead following a new alignment.

Undergrounding the line will require the same construction steps as those detailed in 3.8.2.

Diverting the line will require the installation of new poles to carry the 38kV line. These poles are typically timber poles founded on concrete bases. A diagram of the proposed re-routed cable is given in **Figure 3-25** and photograph of the existing line is given in **Figure 3-26**.

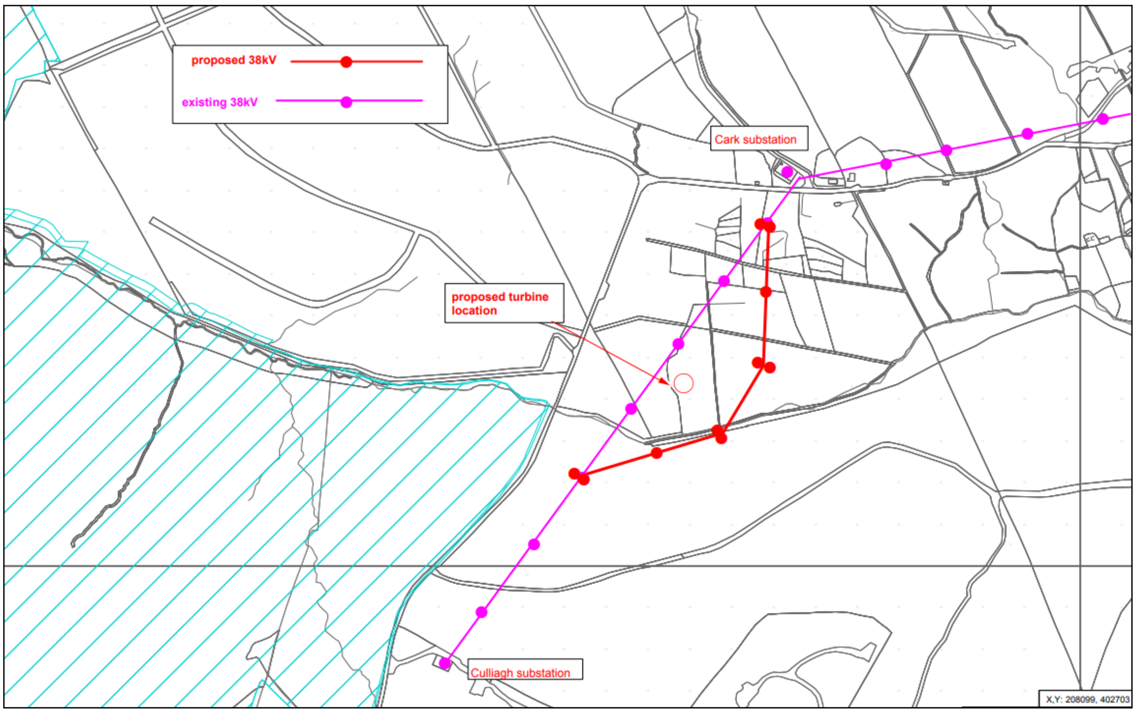


Figure 3-25 Diversion Route of Existing 38kV Cable

Figure 3-26 Photograph of Existing 38kV Overhead Line (From Google Maps)

3.11 SUBSTATION COMPOUND AND BUILDINGS AND BESS (ALTERNATIVE GRID CONNECTION OPTION)

If the grid connection option to the consented 110kv Lenalea substation is not progressed, a new substation would need to be constructed for the alternative grid connection option.

This section describes the construction methodologies that will be used for both the EirGrid and Independent Power Provider (IPP) substation buildings and the battery storage facility (BESS) as well as the substation compound associated with this alternative grid connection option. The proposed substation is located adjacent to an existing 110kV OHL. It will be a loop-in substation configuration. This will be achieved by installing two new end masts from which the existing 110kV line will be connected into and out of the new substation. .

The proposed works will be restricted to the site construction area and will comprise the following:

- Prior to construction, interception ditches will be installed upslope of the proposed substation compound to intercept any existing overland flows (clean water) and convey it downslope in order to limit the extent of surface water coming into contact with the works. The clean water conveyed will be discharged via a level spreader downslope of the works over existing vegetation.
- The area of the substation compound will be marked out using ranging rods or wooden posts and the soil stripped and removed to a temporary storage area for later use in landscaping. All remaining excavated material will be brought to the on-site borrow pits for final deposition. The area will be surveyed and all existing services will be identified. All plant operators and general operatives will be inducted and informed as to the location of any services.
- Perimeter drains will be installed or upgraded to collect surface water run-off from the substation compound which will include the installation of check dams, silt traps, oil interceptor and level spreaders to cater for surface run-off.
- All soils/peat on the substation site will be removed and replaced with site won compacted crushed rock or granular fill;
- Formation of the substation compound will be achieved where the compound will be constructed with compacted layers of suitable hardcore;
- The foundations for both substation buildings will be excavated down to the level indicated by the designer and appropriately shuttered. Reinforced concrete will be laid over it.
- The blockwork walls for each building will be built up from the footings to damp-proof course (DPC) level and the floor slab constructed, having first located any ducts or trenches required by the follow on mechanical and electrical contractors;
- The blockwork will then be raised to wall plate level and the gables and internal partition walls formed. Scaffold will be erected around the outside of the two buildings for this operation;
- The concrete roof slabs will be lifted into position using an adequately sized mobile crane;
- The construction and components of the substation buildings will be to EirGrid and ESB Networks specifications;
- The timber roof trusses at each building will then be lifted into position using a telescopic loader or mobile crane depending on site conditions. The roof trusses will then be felted, battened, tiled and sealed against the weather.
- Installation of a domestic wastewater holding tank to hold effluent from the toilets within the substation buildings.
- Installation of a Class 1 full retention oil separator to collect and treat oil spills within the substation compound.
- Installation of a rainwater harvesting tank to collect rainwater from the roofs of the substation buildings for toilet flushing and hand washing.

- Commencement of civil works associated with the construction of the transformer bund, equipment plinths etc. within the substation compound.
- Commencement of civil works associated with construction of underground cable ducts and trenches within the substation compound.
- Installation of electrical equipment within the substation compound and buildings including transformers, busbars, circuit breakers, cable supports, switchgear, panels etc. and all associated cabling.
- Installation of palisade fencing and associated gates to perimeter of the substation compound.

3.12 PERMANENT METEOROLOGICAL MAST

A permanent meteorological mast is proposed for the site to monitor the wind regime while the wind farm is in operation. The mast will be located in the same area of the site as T12. The mast is proposed in an area of the site where existing forestry roads and turning heads can be utilised, hence minimising the amount of new infrastructure required to erect and access the mast. The meteorological mast will be installed to a height of up to 110m which will be representative of the hub height of the turbines. The meteorological mast will be surrounded by a galvanised steel palisade fence, 2.4m in height. Details of the meteorological mast are shown in **Planning Drawing 19715-5402**. Excavated material will be reused for backfill/adjacent landscaping or will be relocated to the on-site deposition areas.

3.13 TEMPORARY SITE CONSTRUCTION COMPOUNDS

The 2 No. temporary site construction compounds will be used for the construction phase of the wind farm. The 2 No. compounds will have dimensions of approximately 100m x 50m and 55m x 25m respectively as shown on **Planning Drawings 19715-5417 and 19715-5418**. Site investigations indicate that the peat depth at the compound locations is less than 0.5m in depth. The peat will be excavated down to the underlying stratum. The peat and excavated materials will be stored locally on a temporary basis and will be used for reinstatement following completion of the works. This is discussed in more detail in Section 3.15.

The exposed surface will be levelled out by cutting and filling and will then be overlain with a layer of geotextile and crushed stone from the proposed on-site borrow pits. The finished surface will be formed with a layer of Class 6F or similar aggregate imported from local quarries. Each of the 2 No. site compounds will be graded and compacted out before the welfare container facilities are installed.

The compounds will be constructed early in the project in order to provide site offices and accommodation for staff and for the delivery of materials. Any surface water management, bunding, waste management measures etc. will also be put in place at the outset. Site security will have to be put in place adjacent to the entrance and will have to be maintained throughout all phases of the work. The compounds will be in place for the duration of the construction phase and will be removed once commissioning is complete.

Areas within the compounds will be constructed as access roads and used as vehicle hardstandings during deliveries and for parking. Typical requirements for temporary site compounds are listed below:

I. A bunded, impermeable and if necessary roofed containment area will be provided within the compounds for the storage of lubricants, oils and site generators etc.;
II. If necessary the compound will be fenced and secured with locked gates,
III. During the construction phase, a self-contained toilet/welfare facility with an integrated waste holding tank will be used on site for toilet facilities. This will be maintained by the service contractor on a regular basis and will be removed from the site on completion of the construction phase.
IV. Upon completion of the project the compounds will be decommissioned by backfilling the area with the material / peat arising during excavation, landscaped with topsoil as required.

Figure 3-27 Typical temporary site construction compound on a wind farm

3.14 BORROW PITS

There are 4 No. borrow pits proposed within the site which will be used to obtain site won stone aggregate. These borrow pits are located within the central, eastern, western and northern areas of the site where they will be used as sources of hardcore for the construction of access roads, crane hardstands and construction compounds.

Prior to felling of trees and the stripping of peat overburden over the area of the proposed borrow pits; an interceptor drain will first be excavated upslope in order to intercept existing overland flows and divert them around the borrow pits prior to discharge via a buffer zone on the downslope side. The shallow peat overburden will then be stripped and temporarily stockpiled, vegetated side upwards adjacent to the borrow-pit in order for it to be re-used in its reinstatement on completion. Any subsoil material overlying the rock will then be excavated and stockpiled separately from the peat. The stockpile will be sealed and a perimeter drain installed to intercept any run-off so that it can be discharged through an appropriately designed silt trap.

Standing water, any surface water runoff or water pumped from within the borrow pits is likely to contain an increased concentration of suspended solids. Runoff or pumped water from the borrow pits will be isolated from the clean catchment runoff by means of a series of open drains that will be constructed within the area. These drains will be of check dams that will attenuate the flow and provide storage for the increased runoff from exceptional rainfall events. The settlement ponds have been designed to a modular size where if larger areas of runoff have to be catered for at a single discharge point the size of the settlement pond will be increased pro rata.

Inspections of the borrow pits will be made by a geotechnical engineer through regular monitoring of the opening works.

Excavators will extract the stone using buckets and a ripper attachment or rock-breaker attachments may be utilised in the borrow pit locations. It is expected that 30-60 Ton 360° excavators will be utilised in tandem in the extraction of rock from the borrow pits. The larger excavators will extract rock from the face and floor of the excavation using digging buckets and rock rippers and will be assisted by smaller excavators, removing rock as it is broken, stockpiling locally within the excavation as well as loading articulated dumper trucks removing rock as required for distribution within the wind farm site. The sides of the excavations will be battered back to a suitable angle of repose to be determined by the nature of the rock present. Regular examination of these batters will be carried out by a geotechnical engineer to assess the stability of the rock face and slopes on an ongoing basis. There will be no public access permitted to or within the borrow pits. Secure edge protection and fencing will be erected around the borrow pits with warning signage erected. A berm will be constructed as required, at the leading edge to ensure that articulated dumper trucks are stopped at a safe distance from the edge of the borrow pit during loading of extracted stone aggregate.

Blasting at borrow pits may be necessary to enable excavation of the rock in the borrow pits and increase production rates to match the construction programme. Any blasting will be carried out by a suitably qualified specialist under licence. Blasting, and mitigation measures associated with the process, is discussed in further detail in the Land and Soils Chapter 9 and Chapter 11 Noise of this EIAR.

On completion of extraction activities at the borrow pits; these areas will be used for the permanent storage of some of the excavated peat and material from the turbine bases, crane hardstands, internal access road construction and other associated infrastructure. The borrow pits will also be suitably landscaped following reinstatement. This is outlined further in Section 3.15.2.

3.15 PEAT AND SPOIL STORAGE

3.15.1 Excavated Peat and Spoil Storage

The Peat and Spoil Management Plan for this development is discussed in the following section.

Excavated peat and spoil will be reused for the backfilling, landscaping and restoration around wind farm infrastructure such as turbines and hardstands. Peat will be deposited only within the buildable areas around the turbines to a maximum height of 1m. The felled areas around the turbines have been identified as a potential additional area that will be used to store peat, however, priority will be given to restoration of the borrow pits. The proposed locations for the peat and spoil storage are shown on **Planning Drawings 19715-MWP-00-00-DR-C-5005**.

Berms will be formed along sections of floated access roads in order to store an additional volume of excavated peat. These berms will also act as a physical edge protection measure to prevent vehicles falling off the raised floated road edge. This form of storage will be provided on both sides of the internal floated roads where the overall dimensions of the berms will be 1m high by 2.5m wide.

The remainder of the surplus excavated peat and spoil material will be stored within the 4 No. material storage areas at the proposed on-site borrow pits or in the key-hole felled areas.

Drainage and siltation control measures will be put in place in all peat storage areas. This will include a dedicated drainage network, temporary silt fences and settlement ponds designed to cater for the size of each storage area. Further details of the drainage philosophy that will be applied as well as siltation control systems and attenuations systems is give **in Section 3.16** of this report.

3.15.2 Restoration of Peat Deposition Areas

Peat is characterised by two distinct layers, the lower *catotelm* layer of highly humified peat and the upper *acrotelm* layer of fibrous peat which contains the live seed bank. The *acrotelm* layer should be regarded as an ecological resource that can be used for habitat restoration rather than simply as surplus excavated material.

As peat is excavated the *acrotelm* layer will be stripped first and set aside temporarily for re-use. As the peat deposition areas are filled they will be covered over with the *acrotelm* layer. This includes the outer faces of the containing berm(s). The peat deposition areas need to be completed and restored in a continuous cycle so as to minimise the length of time the *acrotelm* is stored and to allow the vegetation to be re-established as quickly as possible. It is important that the *acrotelm* is handled carefully and that it is not allowed to dry out while it is being stored. Regular watering may be necessary during dry weather periods. This will be carried out by the appointed Contractor.

3.16 SITE DRAINAGE

3.16.1 Design principles

The site drainage system was designed integrally with the wind farm layout as a measure to ensure that the proposal will not change the existing flow regime across the site, will not deteriorate water quality and will safeguard existing water quality status of the catchments from wind farm related sediment runoff.

A fundamental principle of the drainage design is that clean water flowing in the upstream catchment, including overland flow and flow in existing drains, is allowed to bypass the works areas without being contaminated by silt from the works. This will be achieved by intercepting the clean water and conveying it to the downstream side of the works areas either by piping it or diverting it by means of new drains or earth mounds.

This process will cause the normally dispersed flow to be concentrated at specific discharge points downstream of the works. In order to disperse this flow, each clean water drain will be terminated in a discharge channel running parallel to the ground contours that will function as a weir to disperse the flow over a wider area of vegetation. An alternative method is to allow the water to discharge through perforated pipes running parallel to the ground contours. Both of these methods will prevent erosion of the ground surface and will attenuate the flow rate to the downstream receiving waters. The specific drainage measures to be used at each location are shown on the drainage drawings included with the planning application. The clean water interceptor drains or earth mounds are all positioned upslope to prevent any mixing of the clean and dirty water. The outflow from these drains is then piped under the road at suitable intervals and at low points depending on the site topography.

Separating the clean and dirty water will minimise the volume of water requiring treatment. The dirty water from the works areas will be collected in a separate drainage system and treated by removing the suspended solids before discharging it to the downstream watercourse over vegetated ground. Dirty water drains will be provided on both sides of the access roads and along the periphery of the turbines, crane hardstands, substation compound and the temporary site construction compounds.

The treatment system will consist of a series of settlement ponds at designated locations throughout the site. (Refer to **Section 3.17** below). The treated outflow from the treatment system will be dispersed over vegetation in the same manner as the clean water dispersion, and will become diluted through contact with the clean water runoff in the buffer areas before entering the downstream watercourses.

The site drainage layout is presented in **Planning Drawings 19715-MWP-00-00-DR-C-5016** with drainage details presented in **Planning Drawing 19715-MWP-00-00-DR-C-5404 and 5405**. The drainage layout is overlaid on background OSI mapping in the A1 drawings that accompany the planning application.

3.16.2 Flood Attenuation

The creation of impermeable areas within a development site has the effect of increasing rates of runoff into the downstream drainage system and this may increase flood risk and flood severity downstream. This applies particularly to urban areas that drain to closed pipe systems which do not have the capacity to cater for increased hydraulic loads. The proposed development is located within a large rural catchment with an open drainage system. The footprint of the impermeable areas and the associated increase in runoff rate is minimal in the context of the catchment size and therefore represents a negligible increase in downstream flood risk. This can be seen by comparing the area of infrastructure to the area of the catchments in **Figure 3-28**. However, it is proposed to provide some attenuation in order to limit the flow rate into the settlement ponds during high intensity storm events so that they do not become overloaded. This will also attenuate the flow to the downstream watercourses.

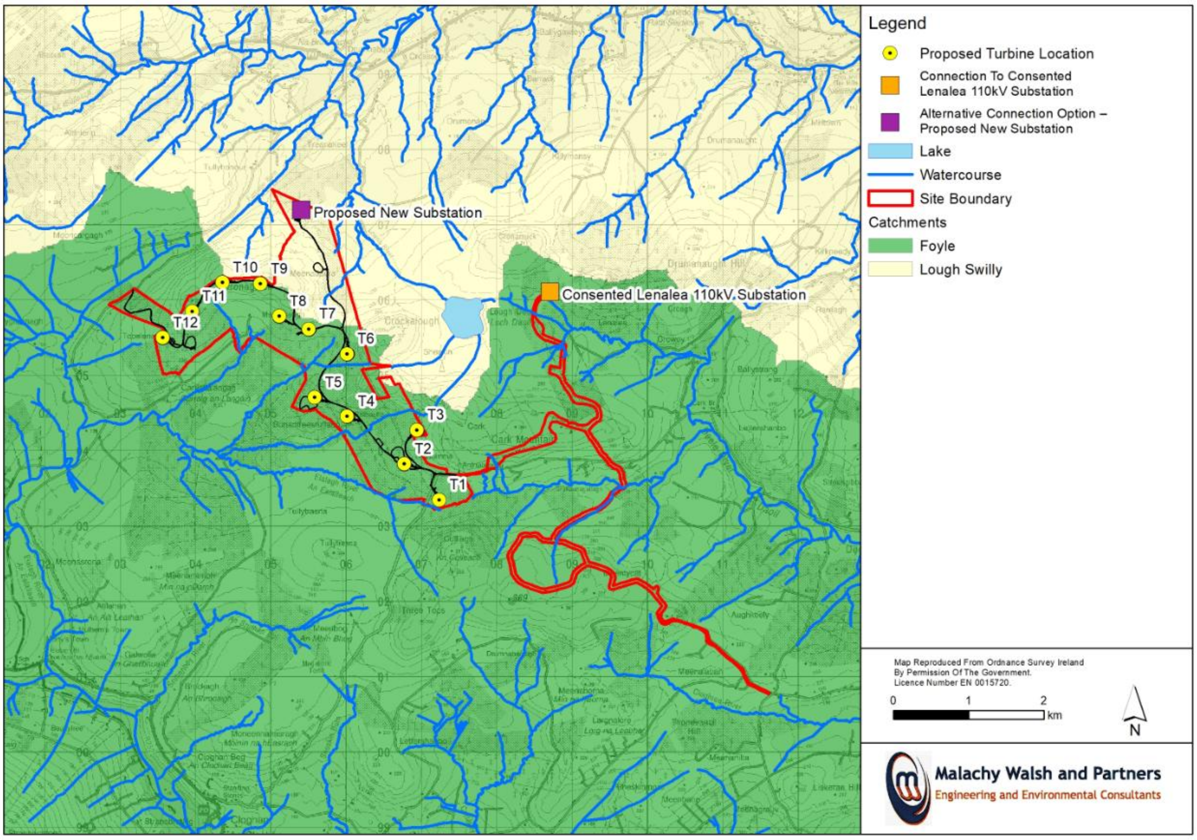


Figure 3-28 Proposed Infrastructure Overlaid on Catchments

The volume of water requiring attenuation relates to direct precipitation on the roads and other infrastructure footprint only. Due to their predominant unbound nature, the developed surfaces have some permeability and this reduces the attenuation requirement. Conventional attenuation systems use proprietary flow control units but these can become blocked with debris and vegetation and require regular maintenance. They are, therefore, not appropriate for use within a forestry environment or where long-term routine maintenance would not be practical.

It is proposed to provide the temporary storage within the drainage channels by creating stone dams at regular intervals within the channels. The spacing of the dams is typically 100 metres but will depend on the channel slope, with steeper channels requiring shorter intervals. The dams, which are constructed with small sized aggregate held in place by large aggregate, also reduce the flow rate through the drainage system and are an effective means of providing flow control. Temporary silt fences will also provide storage and flow control.

3.17 SURFACE WATER MANAGEMENT SYSTEMS

3.17.1 General

If not controlled, sediment such as peat, clay, or silt can cause significant pollution during the construction phase of a civil engineering project due to the erosion of exposed soil by surface water runoff. The surface water quality management system and plan has been prepared in order to control erosion and prevent sediment runoff during the construction phase of the proposed development. The implementation of sediment and erosion control measures is essential in preventing sediment pollution (See **Planning Drawing 19715-MWP-00-00-DR-C-5404 and 5405**). The system was designed having regard to:

- Knowledge of the site's environmental conditions;
- Numerous site visits and walkovers
- Previous construction experience of wind farm developments in similar peat environments;
- Previous experience of environmental constraints and issues from construction of wind farms in similar environmental conditions;
- Technical guidance and best management practice manuals. A list of best practice documents is given below and within the CEMP;

– CIRIA (2000), Sustainable Urban Drainage Systems Design Manual for Scotland and Northern Ireland
– CIRIA (2001) Control of water pollution from construction sites. Guidance for consultants and contractors (C532)
– CIRIA (2004) Interim Code of Practice for Sustainable Urban Drainage Techniques
– CIRIA (2005) "Environmental good practice on site" 145
– CIRIA (2006) Control of water pollution from linear construction projects. Technical guidance (C648)
– COFORD, 2004, Forest Road Manual, Guidelines for the design, construction and management of forest roads
– Department of Agriculture, Food and the Marine, Standards for Felling and Reforestation (Oct 2019)
– Department of the Marine and Natural Resources (1998), Fisheries Guidelines for Local Authority Works. Department of the Marine and Natural Resources, Dublin
– Department of Environment Heritage and Local Government (2006), Wind Farm Planning Guidelines
– Department of Housing, Local Government and Heritage, Draft Revised Wind Energy Development Guidelines (2019)
– Department of Marine and Natural Resources (DMNR) (1998), Fisheries Guidelines for Local Authority Works. Department of Marine and Natural Resources, Dublin
– Eastern Regional Fisheries Board. (Year Unknown). Fisheries Protection Guidelines. Eastern Regional Fisheries Board, Dublin
– Enterprise Ireland, Best Practice Guide BPGCS005 Oil Storage Guidelines
– Environment Protection Agency (EPA), http://www.epa.ie/pubs/advice/
– Forest Service and Department of Agriculture, Fisheries and Food, 2000a, Forest Harvesting and the Environment Guidelines.
– Forest Service and Department of Agriculture, Fisheries and Food, 2000b, Forest and Water Quality Guidelines
– Forestry Civil Engineering and Scottish Natural Heritage, 2010, Floating Roads on Peat
– Forestry Commission Scotland, 2004, Forests and Water Guidelines 4th Edition
– Forests and Water, 2011, UK Forestry Standard Guidelines
– Forestry and Water Quality Guidelines (Forest Service, Department of the Marine and Natural Resources, July 2000);
– Forest Harvesting and Environmental Guidelines (Forest Service, Department of the Marine and Natural Resources, July 2000).
– Inland Fisheries Ireland (2016) Guidance on Protection of Fisheries during Construction in and adjacent to Water
– Irish Wind Energy Association and Sustainable Energy Ireland (2008), Best Practice Guidelines for the Irish Wind Energy Industry
– MacCulloch 'Guidelines for the risk management of peat slips on the construction of low volume/low cost roads over peat' (2006)

- National Roads Authority (2004), Guidelines for the treatment of badgers prior to the construction of national road schemes, NRA, Dublin
- National Roads Authority, (2008), Guidelines for the crossing or watercourses, during the construction of national road schemes
- Scottish Natural Heritage (2015) Constructed tracks in the Scottish Uplands. 2nd Edition
- Office of Public Works "Construction, Replacement or Alteration of Bridges and Culverts, 2013".

UK Pollution Prevention Guidelines (PPG):

- GPP 2 (2018): Above ground oil storage tanks
- GPP 4 (2017): Treatment and disposal of wastewater where there is no connection to the public foul sewer
- GPP 5 (2017): Works and maintenance in or near water
- PPG6 (2012): Working at construction and demolition sites
- GPP08 (2017): Safe Storage and Disposal of Used Oils;
- GPP 21 (2017): Pollution incident response planning
- PPG 22 (2011): Incident response - dealing with spills
- PPG 26 (2011) Safe storage - drums and intermediate bulk containers

The following site-specific information was used in the design of the drainage and treatment system:

- High resolution aerial photography;
- Topographical survey information;
- Review of existing Coillte Forestry drainage networks;
- Wind farm infrastructure layout (turbines, service roads and ancillary development);
- Hydrology maps (watercourses and buffer zones);
- Soil and land use maps;
- Baseline water quality assessments; and
- Met Éireann extreme rainfall data.

The settlement ponds and check dams described in the following subsections provide the essential mechanism for the removal of silt from construction related runoff and the controlled return of the treated runoff to the downstream watercourses.

The drainage and treatment system will ensure that the proposed development will not create adverse effects on the aquatic environment that could compromise the ability to meet Water Framework Directive objectives or to fulfil compliance with basic measures required including the Nitrates Directive, the Habitats and Birds Directives and the Drinking Water Directive.

3.17.2 Constructions Works Areas

Runoff from the internal roadways, hardstands and other wind farm infrastructure will be isolated from the clean catchment runoff by means of a series of open drains that will be constructed within the works areas. These drains will be directed to settlement ponds that will be constructed throughout the site, downhill from the works areas. Each drain will incorporate a series of check dams that will attenuate the flow and provide storage for the increased runoff from exceptional rainfall events. The ponds have been designed to a modular size to cater for a single turbine and hardstand area or a 1,200m^2 area of internal access road. Where larger areas of runoff have to be catered for at a single discharge point the size of the settlement pond will be increased pro rata.

Dewatering of turbine base excavations can result in significant flow rates to the drainage and settlement system if high capacity pumps are used. In order to avoid the need for pumping it is proposed to provide drainage channels from the excavations so as to prevent a build up of water. Where this is not feasible, temporary storage will be provided within the excavations and dewatering carried out at a flow rate that is within the capacity of the settlement ponds.

3.17.3 Treatment Process

Contaminated runoff can be generated on the site access roads, construction compound, sub-station sites, battery storage area and turbine hard standing areas and is mainly due to excavation for the infrastructure or movement of delivery vehicles and on-site traffic. Drains carrying construction site runoff will be diverted into settlement ponds that reduce flow velocities, allowing silt to settle and reducing the sediment loading. A modular approach has been adopted for the design of the settlement ponds which have been sized to cater for a catchment area of 1,200m^2 works area. This is equivalent to a road length of 240m or the area of a typical turbine base and crane hardstand.

The settlement ponds have been designed as a three-stage tiered system as described in the bullet point below. The three-stage system also facilitates effective cleaning with minimal contamination of water exiting the pond.

The design of the drainage and settlement pond system for the site is detailed in the **Planning Drawing Planning Drawing 19715-MWP-00-00-DR-C-5404 and 5405.** The hydraulic design of the settlement ponds is outlined in **Section 3.17.4**.

The settlement ponds have been designed with regard to the following:

- Runoff flow rate for the localised catchment area;
- Met Éireann Extreme Rainfall Data (statistical rainfall intensity / duration table);
- Character of the impermeable areas (runoff coefficients); and
- Design particle size and density.

The treatment process consists of primary, secondary and tertiary treatment as follows:

- The *primary treatment* consists of a three stage settlement pond with an over-topping weir at each stage. The first chamber will remove most of the sediment load, while the remaining two chambers will remove most of the remaining load.
- Before the water is released onto the existing ground surface, it passes through a *secondary treatment* system in the form of a graded gravel filter bed which removes a further degree of siltation.
- The outflow from each interceptor is dispersed across a wide area of vegetation so that the velocity is minimised and the vegetation can filter out the residual sediment. This is the final or *tertiary* stage of the treatment process. Existing rills and collector drains within the tertiary treatment area are blocked off to prevent concentration of the flow.

Each sediment treatment pond at Drumnahough has been micro-sited and uniquely designed using the contour maps and aerial photos to avail of any locally level areas and to ensure that the outflow is spread over as much vegetation as possible before entering an aquatic buffer zone. See planning drawings included in planning pack.

Settlement ponds will require inspection and cleaning when necessary. This will be carried out by the appointed contractor under low or zero flow conditions so as not to contaminate the clean effluent from the pond. The water level would first be lowered to a minimum level by pumping without disturbing the settled sediment. The sediment would then be removed by mechanical excavator and disposed of in areas designated for deposition of spoil. Settlement ponds will require perimeter fencing and signage to ensure that there are no health and safety risks.

Figure 3-29 below shows a well constructed and maintained tiered settlement pond. This example is located in an upland environment with significant ground surface slope and operates efficiently provided that it is well maintained. The design has been developed in conjunction with Inland Fisheries Ireland personnel and Local Authority engineers.

Figure 3-29 Multi-tiered settlement pond with stone filter

The effluent from each settlement pond will discharge to an open channel, 8 to 10 metres in length, running parallel to the ground contours. This will form a weir that will overflow on its downhill side and disperse the flow across the existing vegetation. Buffer widths are designed in line with *Forests and Water, UK Forestry Standard Guidelines (Forestry Commission, 2011)* on protection of watercourses during forestry operations and management. This method buffers the larger volumes of run-off discharging from the drainage system during periods of high precipitation, further reducing suspended sediment load to surface watercourses. Existing rills and drains within the dispersion zone will be blocked off where necessary to prevent concentration of the flow.

3.17.4 Settlement Pond Design

3.17.4.1 Pond surface area (roads and hardstands)

Generally, high intensity rainfall events have a short duration and lower intensity rainfall events tend to have a longer duration. The Met Éireann Extreme Rainfall Data for the area demonstrate that the chance of occurrence of a storm event of a given duration decreases (higher return period) as intensity increases. **Table 3-4** shows the Point Rainfall Frequency, the total rainfall for each duration, and return period in millimetres. **Table 3-5** shows the same data converted to a rainfall rate in mm/hour. For a given return period the total depth of rainfall increases with storm duration but the actual rainfall rate over that period of time decreases. For the operation of the settlement ponds it is the rate of flow rather than the total rainfall that is relevant. The return period is a measure of the likelihood that a storm of a particular intensity will occur in a given year. However, it is important to note that the chances of occurrence of a storm event with a particular return period are the same in each year but should on average occur once in that time period. For instance, a storm event with an intensity of 170 mm/hour and 5-minute duration would be expected to occur once in a 100-year period (first row of **Table 3-5**). This is more appropriately expressed as an annual exceedance probability (AEP) of 1%; that is, it has a 1% chance of being equalled or exceeded in any year.

The runoff control measures for the wind farm site have been designed in the context of storm events of varying duration and intensity. The settlement ponds have been designed to cater for a maximum continuous flow rate associated with a medium-intensity rainfall event. Higher intensity runoff will be attenuated by the open drain collection system which provides temporary storage and limits the rate at which it enters the settlement ponds. This is achieved by the use of check dams within the open drains as described in Section 3.17.6. Longer duration storms of 24 hours or more generally have very low intensity and are not critical in terms of the runoff rates that they generate.

The modular settlement ponds at Drumnahough are designed to operate effectively for the runoff rate associated with a continuous high rainfall rate of 20 mm/hour. This is approximately equivalent to a 60-minute duration storm event with a 10-year return period (M10-60) or a 15 minute duration storm event with a 100-year return (M100-15). These rates are taken from the Met Éireann Point Rainfall Frequency table close to the site location. **Refer Table 3-4** for further detail.

The design runoff rate, used for the planning stage drainage design, is calculated using the formula:

Q = $c\,i\,A$

where c is the runoff coefficient,

i is the rainfall intensity in m/sec, and

A is the catchment surface area in m^2.

A runoff coefficient of 0.70 is assumed for the hardcore surface. For a rainfall intensity of 20mm/hour and an area of 1,200m^2 (which represents approximately the 240m of access road) runoff rate is:

Q = 0.70 x (0.02/3600) x 1,200 m^3/sec

= 0.0047 m^3/sec (4.70 litres/sec)

The main design parameter for the settlement pond is the water surface area. The required surface area is the design flow rate in m^3/sec divided by the particle settlement velocity (V_s) in m/sec (Area = Q/V_s m^2).

The particle settlement velocity is determined using the formula derived by Stokes as follows:

V_s = 2 r^2 (D_p – D_f) / (9 n)

where V_s is the particle settlement velocity (m/sec),

r is the radius of the particle (metres),

D_p is the density of the particles (kg/m^3),

D_f is the density of the fluid (kg/m^3), and

n is the viscosity of the fluid (0.000133 kg sec/m^2 @ 10°C).

For a particle density of 2,400kg/m^3, water density of 1,000kg/m^3 and particle diameter of 20 microns (radius 10^{-5} metres) the settlement velocity, V_s, is:

V_s = 2 x $(10^{-5})^2$ x (2,400 - 1,000) / (9 x 0.000133)

= 2 x 10^{-10} x 1,400 / 0.001197

= 0.000234 m/sec.

The required settlement pond surface area is

A_p = Q/V_s

= 0.0047/0.000234

= 19.95m^2

Theoretically the pond depth is not relevant but in practice a minimum depth is required to ensure laminar flow and to allow temporary storage of settled silt. The modular settlement pond system at Drumnahough has been designed with a surface area of 24m^2 (12m x 2m) and a depth of 1.25m (i.e. greater than the minimum above). This is divided into three chambers of equal length and in practice it has been found that most of the settlement occurs in the first chamber with very low turbidity levels being achieved in the final effluent. The design is conservative and therefore has sufficient redundancy to cater for occasional higher runoff rates or sediment loads.

3.17.4.2 Attenuation Design

For rainfall intensities above the design value of 20mm/hour the excess runoff needs to be temporarily stored. The storage can be provided in the drainage channels by installing check dams at intervals along the channel as described below.

The storage volumes required for 10-year storm events of various durations are shown in **Table 3-3**. The volumes are based on a catchment area of 1,200m^2 which represents approximately 240m of access track) and a runoff coefficient of 0.70. The maximum storage volume required is 6.18m^3 for 15 minutes storm duration. This is equivalent to approximately 25 minutes of flow through the settlement pond at the design through flow rate of 4.70 litres/second. The stored water will drain off gradually as runoff from the works area. The storage volume represents an average depth of 0.05m in a 206m long, 0.60m wide open drain and can therefore be easily accommodated in the drainage system.

Table 3-3 Calculated storage volumes

Storm Event	Duration (minutes)	Rainfall rate (mm/hour)	Excess (mm/hour)	Runoff Coefficient	Storage Volume (m^3)
M10-60min	60	20.50	0.0	0.70	0.00
M10-30min	30	30.40	9.9	0.70	4.95
M10-15min	15	45.20	24.7	0.70	**6.18**
M10-10min	10	57.60	37.1	0.70	6.18
M10-5min	5	93.60	73.1	0.70	6.09

The ability to limit flow rates is fundamental to the control of sediment during extreme storm events. It is not proposed to use any proprietary mechanical devices for this purpose but instead to rely on the check dams to effectively limit flow rates to the required values. The check dams will be constructed with gravel or other suitable material and will be of sufficient length and height to provide the required attenuation rates.

Table 3-4 Met Éireann point rainfall frequency table (rainfall depth in mm)

Storm Duration	Return Period (years)							
	0.5	1	2	5	10	20	50	100
5 min	3	3.9	4.4	5.8	6.9	8	9.8	11.3
10 min	4.2	5.5	6.1	8.1	9.6	11.2	13.6	15.7
15 min	5	6.5	7.2	9.6	11.3	13.2	16	18.5
30 min	6.7	8.7	9.7	12.9	15.2	17.7	21.5	24.9
60 min	9	11.7	13.1	17.4	20.5	23.9	29	33.5
2 hours	12.1	15.8	17.7	23.4	27.7	32.2	39.1	45.1
3 hours	14.5	18.8	21	27.9	32.9	38.4	46.5	53.7
4 hours	16.4	21.3	23.8	31.6	37.3	43.4	52.7	60.8
6 hours	19.5	25.3	28.3	37.6	44.4	51.7	62.7	72.4
9 hours	23.2	30.2	33.7	44.7	52.8	61.5	74.6	86.2
12 hours	26.2	34.1	38.1	50.6	598	69.6	84.5	97.5
18 hours	31.2	40.6	45.4	60.3	71.1	82.9	100.6	116.1
24 hours	35.3	46	51.4	68.2	80.5	93.8	113.8	131.4

Table 3-5 Met Éireann point rainfall frequency table (rainfall rate in mm per hour)

Storm Duration	Return Period (years)							
	0.5	1	2	5	10	20	50	100
5 min	36.0	46.8	52.8	69.6	82.8	96.0	117.6	135.6
10 min	25.2	33.0	36.6	48.6	57.6	67.2	81.6	94.2
15 min	20.0	26.0	28.8	38.4	45.2	52.8	64.0	74.0
30 min	13.4	17.4	19.4	25.8	30.4	35.4	43.0	49.8
60 min	9.0	11.7	13.1	17.4	20.5	23.9	29.0	33.5
2 hours	6.1	7.9	8.9	11.7	13.9	16.1	19.6	22.6
3 hours	4.8	6.3	7.0	9.3	11.0	12.8	15.5	17.9
4 hours	4.1	5.3	6.0	7.9	9.3	10.9	13.2	15.2
6 hours	3.3	4.2	4.7	6.3	7.4	8.6	10.5	12.1
9 hours	2.6	3.4	3.7	5.0	5.9	6.8	8.3	9.6
12 hours	2.2	2.8	3.2	4.2	4.8	5.8	7.0	8.1
18 hours	1.7	2.3	2.5	3.4	4.0	4.6	5.6	6.5
24 hours	1.5	1.9	2.1	2.8	3.4	3.9	4.7	5.5

3.17.5 Road construction

On-site experience in wind farm construction and forestry development across the country has shown that the single most effective method of reducing the volume of sediment created by construction is the immediate surfacing of all service roads with high quality, hard wearing crushed aggregate such as basalt, granite, schist limestone, laid to a transverse grade. When storm water drains transversely across a road constructed from hard wearing aggregate, as opposed to low class aggregate, the level of suspended solids is reduced significantly. This mitigation measure is fundamental to effective water quality management and will form part of the Construction Contract. In the case of road construction in areas of peat, imported limestone is normally used where the site won rock is not suitable. This can have the added benefit of contributing a balancing pH to help protect water quality from acidic runoff. The proposed development area can be serviced by several quarries which are within relatively short distance from the site. These can be used as a source of hard-wearing aggregate for road construction where necessary.

3.17.6 Check dams

Check dams will be placed at regular intervals, based on gradient, along all drains to provide flow attenuation, slow down runoff to promote settlement and to reduce scour and ditch erosion. Check dams are relatively small and constructed with gravel, straw bales or other suitable material. They will be placed at appropriate intervals and heights, depending on the drain gradient, to allow small pools to develop behind them. Examples of check dam or swales are shown below in **Figure 3-30**.

Figure 3-30 Examples of check dams along roadside drainage channels

3.17.7 Silt Fences

Silt fences placed temporarily along drains are an alternative method of reducing the volume of suspended sediment. They will be placed at the end of any locally steep section of drain. They have the double benefit of effectively producing a localised swale to reduce scour effects and also attenuating and filtering the discharge. An example of a typical silt fence installation is shown in **Figure 3-31**.

Figure 3-31 Example of a silt fence used in conjunction with check dams along roadside drainage channels

3.17.8 Operational Phase

The measures for control of runoff and sediment relate to the construction phase of the project when there is continuous movement of site vehicles and delivery vehicles moving around the wind farm site. Following construction, the amount of on-site traffic will be negligible and there will be no particular risk of sediment runoff. Silt ponds constructed for water quality protection, will remain in place and maintained for six months post construction phase. Where necessary, ponds will be partly filled with stone so that they will not present a long-term safety risk. The remaining ponds will be left to fill in and re-vegetate naturally or retained as ponds for biodiversity as outlined in **Chapter 6 Biodiversity** section 6.9.6 Ponds. Runoff from the roads, hard-standings, and other works areas will continue to be directed to these ponds and from there to the outfall weirs. Check dams within the drainage channels will also remain in place. The retention of this drainage infrastructure will ensure that runoff continues to be attenuated and dispersed across existing vegetation before reaching the downstream receiving waters.

3.18 REFERENCES

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