OUTLINE CONSTRUCTION METHODOLOGY

Dyrick Hill Wind Farm - 110kV Grid Connection

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1.0 Introduction

The purpose of this document is to outline and explain the construction techniques and methodologies which will be implemented during construction of the grid connection for the Dyrick Hill Wind Farm. It is proposed to connect the development via underground cable to the existing Dungarvan 110kV substation.

The 110kV grid connection will consist entirely of underground cabling (UGC) with the majority of the UGC to be installed within the public road network. There will also be short sections within the Dungarvan 110kV compound and within wind farm lands within to the Dyrick Hill Wind Farm. The UGC works will consist of the installation of 6 No. ducts in an excavated trench to accommodate 3 No. power cables, 1 No. fibre communications cable to allow communications between the Dyrick Hill Wind Farm and the existing Dungarvan 110kV substation, 1 No. spare communications duct and 1 No. earth continuity conductor duct.

This document is intended to be used as an aid to understand the methodologies to be employed during construction and should be read in conjunction with all other specialist reports which accompany the planning application. This document is in outline form only and will be revised and updated prior to the commencement of construction activities. Detailed method statements will be prepared in respect of each aspect of the development in advance of construction. The final construction methodology and method statements will be agreed with the Planning Authority in advance of commencement of construction.

2.0 Proposed 110kV Underground Cable Route

The proposed grid connection for the Dyrick Hill Wind Farm is approximately 16.01km in length and runs in a north-westerly direction from the existing Dungarvan 110kV Substation.

The proposed connection route utilizes sections of public road, existing access tracks, wind farm access tracks and some sections of private land.

The exact location of the UGC within the proposed site boundary is subject to minor modification following a further detailed assessment to be undertaken prior to construction and following consultation with Waterford County Council and all other relevant stakeholders, having regard to all environmental protection measures outlined in the planning application and accompanying technical reports.

Figure 1 below outlines the proposed UGC route in purple, with each section being formulated within Table 1.

This proposed grid connection route is shown as an Overall Site Location Plan in Drawing No. 05829-DR-100.

Figure 1 – Grid Connection Route Layout plan

Table 1 below summarises the route location features of the underground cable connection and route.

Table 1 – Approximate Route Location of Preliminary Design:		
Dungarvan Substation	**Public Roads**	**Private Land/Access Roads/WF**
115m	15,630m	268m

Table 1: Dungarvan 110kV Substation to the Dyrick Hill Wind Farm – UGC Route Location Summary

Table 2 below separates the UGC route into a number of sections and describes the specific construction requirements of each individual section.

Table 2 - Summary of 110kV Underground Cable Route
Description
Section 1 - UGC Route from Dungarvan 110kV Substation as far as the R672 Regional Road **For reference see Drawing No. 05829-DR-101.** The UGC will exit the Dungarvan Substation Compound to the south, passing a number of UGCs in the vicinity of the substation gate, and joins onto the national road (N72). Following the N72 in a west direction before meeting the Watercourse 1 (Colligan River) [Chainage – 500m] the first watercourse on this route. This watercourse is in the form of a precast concrete bridge with minimal cover, a Horizontal Direction Drill (HDD) will be utilised to cross this watercourse, within the road corridor. From here the UGC route follows the N72 west for approx. 1,110m as far as the R672. Section 1 Features: ▪ *Existing UGC Crossings* Third-party records show that the Dungarvan 110kV substation has a number of existing UGC routes exiting the substation within this section. The exact location, depth, and arrangement of the existing UGCs will need to be confirmed by detailed survey and site investigation works. A minimum separation distance between the cables will need to be adhered to in order to comply with EirGrid/ESB requirements. • *1 No. Joint Bays and associated chambers* The joint bays will be located below ground and finished/reinstated to the required Waterford County Council specification. All reinstatement works will be carried out in-line with the 'Guidelines for Managing Openings in Public Roads – 2017'. All Joint Bay infrastructure are to be installed within the corridor of the existing roadway. The link boxes and communication chambers will also be installed in the road corridor or verges where available. Road widening works may be required to facilitate the joint bays. The final position of the joint bay, link box and communication chamber will need to be agreed with ESB as part of the design approval process. • Joint Bay 01 (JB01) will be located at the entrance to the ESB Dungarvan 110kV Substation. • Joint Bay 02 (JB02) will be located West of JB01 within the N72. [Chainage – 800m] • *1 No. Bridge Crossings Colligan River*

Table 2 - Summary of 110kV Underground Cable Route

Description

There is one bridge crossings within this section, which requires Horizontal Directional Drilling (HDD) to cross it.

1. Bridge 1: WD-N72-007.00 This bridge is TII owned bridge, labelled 'WD-N72-007.00'. As this bridge is precast concrete, 500mm concrete slab, with the road surface sitting 100mm below the top of the concrete slab. There is a 500mm concrete base to support the bridge. This would indicate insufficient cover available to allow the ducts to be installed in the bridge deck, it is therefore recommended to utilise Horizontal Directional Drilling (HDD) to pass under the bridge and riverbed, within the road corridor.

1 No. HDD crossing will be carried out within the existing road corridor. The design and final location of the HDD launch/reception areas will need to be confirmed by a specialist drilling contractor following detailed site investigation works including bore holes. The total length of the proposed HDD will be approx. 75m – 100m. The HDD launch/reception pits will be reinstated with a transition coupler or transition chamber. All reinstatement works will be finished/reinstated to the required Waterford County Council specifications. All reinstatement works in the public road will be carried out in line with the 'Guidelines for Managing Openings in Public Roads – 2017'. The final position of each individual HDD and possible transition chambers will need prior agreement with ESB as part of the design approval process.

- *Service Crossings*

Initial studies show the UGC will cross at least 3 No. existing services within this section. These services will be crossed using an undercrossing or overcrossing method, which will be selected based on the cover available above the service. Service crossings have been designed in line with ESB specifications. All relevant stakeholders will be contacted to verify the existence of services prior to any construction works taking place.

Section 2 - UGC within the R672 Regional Road and the L5068 Local Road.

For reference see Drawing No. 05829-DR-101 through to 05829-DR-107

After exiting the N72 national road, the UGC continues north. This section begins in the R672 regional road. The UGC route follows the R672 for 3,600m. The R672 has several drainage crossings under the road, the majority of which are 350mm pipes. The UGC would run parallel to existing Irish Water infrastructure along this section of the route. The UGC carries predominantly north westerly converging onto local road (L5068). Along the L5068 the UGC encounters a cattle under cross which will require a HDD to pass under (Chainage – 8800m). The UGC follows the L5068 for approx. 568m, before turning west onto the L5068 for a further 1,409m before encountering the second watercourse crossing (Ballykerin Upper) [Chainage – 8800m] of the UGC route. This watercourse is in the form of a concrete slab bridge, situated on a bend on the road. It is proposed to cross this bridge utilising a HDD.
The UGC continues in this local road for a further 2,777m before meeting the third watercourse (Finisk River) [Chainage – 11600m] crossing of the route. This bridge is in the form of a historically listed structure. An offroad HDD will have to be used to cross this watercourse. The UGC continues in this road for a further 235m to the village of Millstreet. The UGC crosses the R671 regional road through Millstreet, before carrying onto an un-named local road.

Table 2 - Summary of 110kV Underground Cable Route
Description
The UGC then follows an un-named local road, north of Millstreet, for 3,987m, until it reaches the wind farm boundary. This road is a single lane road with a number of culvert/drainage crossing. <u>Section 2 Features:</u> ▪ *19 No. Joint Bays and associated chambers* The joint bays will be located below ground and finished/reinstated to the required Waterford County Council specification. All reinstatement works will be carried out in-line with the 'Guidelines for Managing Openings in Public Roads – 2017'. All Joint Bay infrastructure are to be installed within the corridor of the existing roadway. The link boxes and communication chambers will also be installed in the road corridor or verges where available. Road widening works may be required to facilitate the joint bays. The final position of the joint bay, link box and communication chamber will need to be agreed with ESB as part of the design approval process. • Joint Bay 03 (JB03) will be located West of the JB02 within the R672. [Chainage - 1600m] • Joint Bay 04 (JB04) will be located Northwest of JB03 within the R672. [Chainage – 2400m] • Joint Bay 05 (JB05) will be located Northwest of JB04 within the R672. [Chainage – 3150m] • Joint Bay 06 (JB06) will be located North of JB05 within the R672. [Chainage – 3900m] • Joint Bay 07 (JB07) will be located North of JB06 within the R672. [Chainage – 4700] • Joint Bay 08 (JB08) will be located North of JB07 within the L5068 local road. [Chainage -5450m] • Joint Bay 09 (JB09) will be located North of JB08 within the L5068 local road. [Chainage – 6200m] • Joint Bay 10 (JB10) will be located North of JB09 within the L5068 local road. [Chainage – 6950m] • Joint Bay 11 (JB11) will be located Northwest of JB010 within the L5068 local road. [Chainage – 7700m] • Joint Bay 12 (JB12) will be located Northwest of JB11 within the L5068 local road. [Chainage – 8400m] • Joint Bay 13 (JB13) will be located Northwest of JB12 within the L5068 local road. [Chainage – 9150m] • Joint Bay 14 (JB14) will be located West of JB13 within the L5068 local road. [Chainage – 9900m] • Joint Bay 15 (JB15) will be located West of JB14 within the L5068 local road. [Chainage – 10700m] • Joint Bay 16 (JB16) will be located West of JB15 within the L5068 local road. [Chainage – 11450m] • Joint Bay 17 (JB17) will be located North of JB16 within the unnamed local road. [Chainage – 12200m] • Joint Bay 18 (JB18) will be located North of JB17 within the unnamed local road. [Chainage – 12950m] • Joint Bay 19 (JB19) will be located North of JB18 within the unnamed local road. [Chainage – 13700m] • Joint Bay 20 (JB20) will be located North of JB19 within the unnamed local road. [Chainage – 14400m] • Joint Bay 21 (JB21) will be located North of JB19 within the unnamed local road. [Chainage – 15150m] • *3 No. HDD Crossings* There are 2 No. HDD crossings within this section. 1. Crossing 1: The first crossing in this section that will require a HDD to cross is an existing cattle concrete culvert under passing. There is approx. 500mm of cover between the road deck and the top of the concrete culvert. Due to the size and depth of the cattle underpass it is recommended to cross under the base of the culvert utilising a HDD. 2. Crossing 2: The second crossing that will require a HDD in this section is a river crossing. This river will be crossed entirely in private lands, this is due to a bridge with insufficient cover being located on a e

Table 2 - Summary of 110kV Underground Cable Route
Description
bend in the road. It may be achievable to complete a HDD bore within the road corridor, this will have to be confirmed by a drilling contractor. 3. Crossing 3: The third crossing that will require a HDD in this section is a historically listed structure in the form of a bridge. Mountain Castle Bridge – Reg. No. 22902211. It is proposed that this HDD crossing of the bridge will be within the road corridor. 1 No. HDD crossing will be carried out within private lands and 2 No. HDD crossing will be carried out I the road corridor. The design and final location of the HDD launch/reception areas will need to be confirmed by a specialist drilling contractor following detailed site investigation works including bore holes. The total length of the proposed HDD will be approx. 50m – 100m. The HDD launch/reception pits will be reinstated with a transition coupler or transition chamber. All reinstatement works will be finished/reinstated to the required Waterford County Council/Landowner specifications. All reinstatement works in the public road will be carried out in line with the 'Guidelines for Managing Openings in Public Roads – 2017'. The final position of each individual HDD and possible transition chambers will need prior agreement with ESB as part of the design approval process. • *Culvert Crossings/Drainage Crossings* The UGC will cross existing culverts within this section. The preferred crossing method is using a culvert undercrossing or overcrossing method which will be selected based on the cover available above the culvert. Culvert crossings have been designed in line with ESB specifications. Where it is not possible to cross under an existing culvert while maintaining the culvert in place, the culvert may be replaced. All reinstatement works will be carried out to the required Waterford County Council specification and in line with the 'Guidelines for Managing Openings in Public Roads – 2017'. • *Service Crossings* Initial studies show the UGC will cross at least 14 No. existing services within this section. These services will be crossed using an undercrossing or overcrossing method, which will be selected based on the cover available above the service. Service crossings have been designed in line with ESB specifications. All relevant stakeholders will be contacted to verify the existence of services prior to any construction works taking place.
Section 3 - UGC Route following Wind Farm Access tracks to the Proposed Wind Farm Substation. **For reference see Drawing No. 05829-DR-108 through to 05829-DR-109.** The UGC will exits the public road network and continues for the remainder of the route utilising private lands and the proposed wind farm access track.

Table 2 - Summary of 110kV Underground Cable Route
Description
Note: The precise location of the cable route may be subject to change as result of existing services/utility locations, ground conditions and any environmental constraints.

Table 2 - Summary of 110kV Underground Cable Route

3.0 Preliminary Site Investigations

It will be required to carry out preliminary site investigations along the cable route prior to construction to confirm design assumptions.

The following items may be carried out for the grid connection cable route:

- Slit trenches at locations of service crossings (full road/track width).
- Trial holes at all joint bay positions to ascertain ground conditions and thermal resistivity of the soil.
- Boreholes at HDD locations to ascertain ground conditions.

Traffic Management – Single Lane closure with Stop/Go system in place as required.

Equipment:

- 4x4 vehicle
- Concrete vibrator
- Wheeled dumper
- Soil compactor
- 360° tracked excavator (only rubber tracked machines will be allowed on public roads)

4.0 Access Routes to Work Area

The majority of the underground cable will be installed within the public road network and proposed access tracks and will therefore be accessed via the existing road network and the designated site access. Where the cable route is located on private lands, the contractor(s) will be required to utilise the local public road network in the vicinity of the work area.

A detailed Traffic Management Plan will be prepared and agreed with Waterford County Council prior to the commencement of construction. Some work areas will require a temporary road closure where it is not possible to safely implement a Stop/Go system. Where temporary road closures are necessary, a suitable diversion will be implemented using appropriate signage, following consultation and agreement with Waterford County Council.

Careful and considered local consultation will be carried out, to minimise the amount of disturbance caused during works. All plant and equipment employed during the works (e.g. diggers, tracked machines, footwear etc.) will be inspected prior to arrival and departure from site. Vehicles will be cleaned on access and egress to prevent the spread of invasive species.

5.0 Traffic Management

Traffic management and road signage will be in accordance with the Department of Transport: Traffic Signs Manual - Chapter 8: Temporary Traffic Measures and Signs for Road Works and in agreement with Waterford County Council. All work on public roads will be subject to the approval of a road opening license application. The contractor will prepare detailed traffic management plans for inclusion as part of the road opening applications. Where road widths allow, the UGC installation works will allow for one side of the road to be open to traffic at all times by means of a

'Stop/Go' type traffic management system, where a minimum 2.5m roadway will be maintained at all times. Where it is not possible to implement a 'Stop/Go' system a temporary road closure will be required. Temporary traffic signals will be implemented to allow road users safely pass through the works area by channelling them onto the open side of the road. The UGC will be usually installed in 100m sections, and no more than 100m will be excavated without the majority of the previous section being reinstated.

All construction vehicles will be parked within a designated works area so as not to cause additional obstruction or inconvenience to road users or residents. Temporary traffic signals will be in place prior to the works commencing and will remain in place until after the works are completed. The public road will be checked regularly and maintained free of mud and debris. Road sweeping will be carried out as appropriate to ensure construction traffic does not adversely affect the local road condition.

In the event of emergency, steel plates will be put in place across the excavation to allow traffic to flow on both sides of the road.

All traffic management measures will comply with those outlined in the accompanying Traffic Management Report (to be compiled prior to construction) and will be incorporated into a detailed Traffic Management Plan to be prepared in consultation with Waterford County Council prior to the commencement of UGC construction.

6.0 Road Opening Licence

The grid connection works will require a road opening licence under Section 254 of the Planning and Development Act 2000-2015 from Waterford County Council. A Traffic Management Plan (TMP) will be agreed with Waterford County Council prior to the commencement of the development. The TMP will outline the location of traffic management signage, together with the location of any necessary road closures and the routing of appropriate diversions. Where diversions are required, these will be agreed with Waterford County Council in advance of the preparation of the TMP.

7.0 Construction Hours

Standard working hours for construction will be 8.00am to 8.00pm Monday to Friday and 8.00am to 6.00pm on Saturday (if required), with no works on Sundays or Bank Holidays except in exceptional circumstances or in the event of an emergency. All site personnel will be required to wear project notification labelling on high visibility vests and head protection so that they can be easily identified by all workers on site.

8.0 UGC Construction Methodology

The UGC will consist of 3 No. 125mm diameter HDPE power cable ducts, 2 No. 125mm diameter HDPE communications ducts and 1 No. earth continuity conductor duct to be installed in an excavated trench. The trench will be typically 825mm wide by 1,315mm deep with variations on this design to adapt to bridge crossings, service crossings and watercourse crossings. The power cable ducts will accommodate 1 No. power cable per duct. One of the communications ducts will accommodate a fibre cable to allow communications between the Dyrick Hill Wind Farm and existing Dungarvan 110kV substation. The inclusion of 1 No. spare communications duct and 1 No. earth continuity conductor duct will also be required. The ducts will be installed, and the trench reinstated in accordance with landowner, EirGrid & Waterford County Council specifications. The electrical cabling/fibre cable will be pulled through the installed ducts in approximately 830 to 870m section lengths. Construction methodologies implemented and materials used will ensure that the UGC is installed in accordance with the requirements and specifications of EirGrid.

8.1 Trenching Methodology

The following section outlines the methodology to be followed during trenching works.

- The Contractor, and their appointed Site Manager, will prepare a targeted Method Statement concisely outlining the construction methodology and incorporating all mitigation and control measures as required by planning conditions where relevant;
- All existing underground services along the UGC route shall be confirmed prior to the commencement of construction works;
- At watercourse crossings, the contractor will be required to adhere to environmental control measures as described in the project Construction Environmental Management Plan (CEMP);
- Where the cable route intersects with culverts, the culvert will remain in place (where possible) and the ducting will be installed either above or below the culvert to provide minimum separation distances in accordance with EirGrid and Irish Water specifications;
- In the event that culverts require removal for ducting installation, a suitable method of damming the water source and pumping the water around the work area will be set out in a method statement and agreed with the relevant stakeholders. Once the ducts are installed the culvert will be reinstated to match existing levels and dimensions. If works of this nature are required, the contractor will liaise with Inland Fisheries Ireland in advance of works;
- A detailed Traffic Management Plan will be prepared and agreed with Waterford County Council;
- Excavated material will be temporarily stockpiled onsite for re-use during reinstatement. Stockpiles will be restricted to less than 2m in height. Stockpiles will be located a minimum of 50m from surface water features and all stockpiling locations will be subject to approval by the Site Manager and Project Ecological Clerk of Works (ECoW);
- Excavated material shall be employed to backfill the trench where appropriate and any surplus material will be transported off site and disposed of at a fully authorised soil recovery site;
- Any earthen (sod) banks to be excavated will be carefully opened with the surface sods being stored separately and maintained for use during reinstatement;
- The excavated trench will be dewatered if required, from a sump installed within the low section of the opened trench. Where dewatering is required, dirty water will be fully and appropriately attenuated, through silt bags, before being appropriately discharged to vegetation or surface water drainage feature;
- Where required, grass will be reinstated by either seeding or by replacing with grass turves;
- No more than a 50m section of trench will be opened at any one time. The second 50m will only be excavated once the majority of reinstatement has been completed on the first;
- The excavation, installation and reinstatement process will take approximately one day to complete a 100m section;
- Where the cable is being installed in a roadway, temporary reinstatement may be provided to allow larger sections of road to be permanently reinstated together;
- Following the installation of ducting, pulling the cable will take approximately one day between each joint bay, with the jointing of cables taking approximately 1 week per joint bay location.

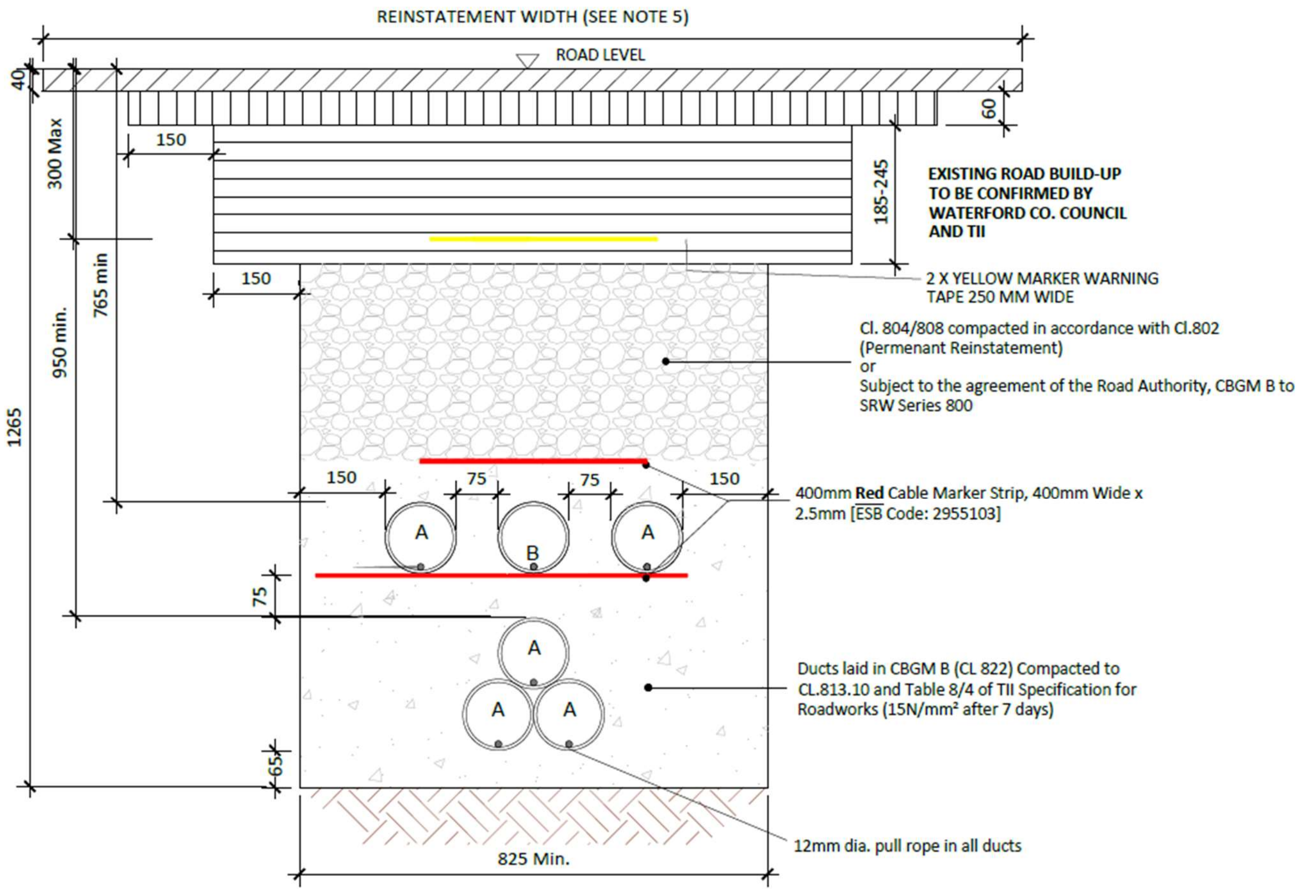
Figure 2 – Example of 110kV Underground Duct Installation

8.2 Ducting Installation Methodology

The trenching and ducting works will follow the step by step methodology below.

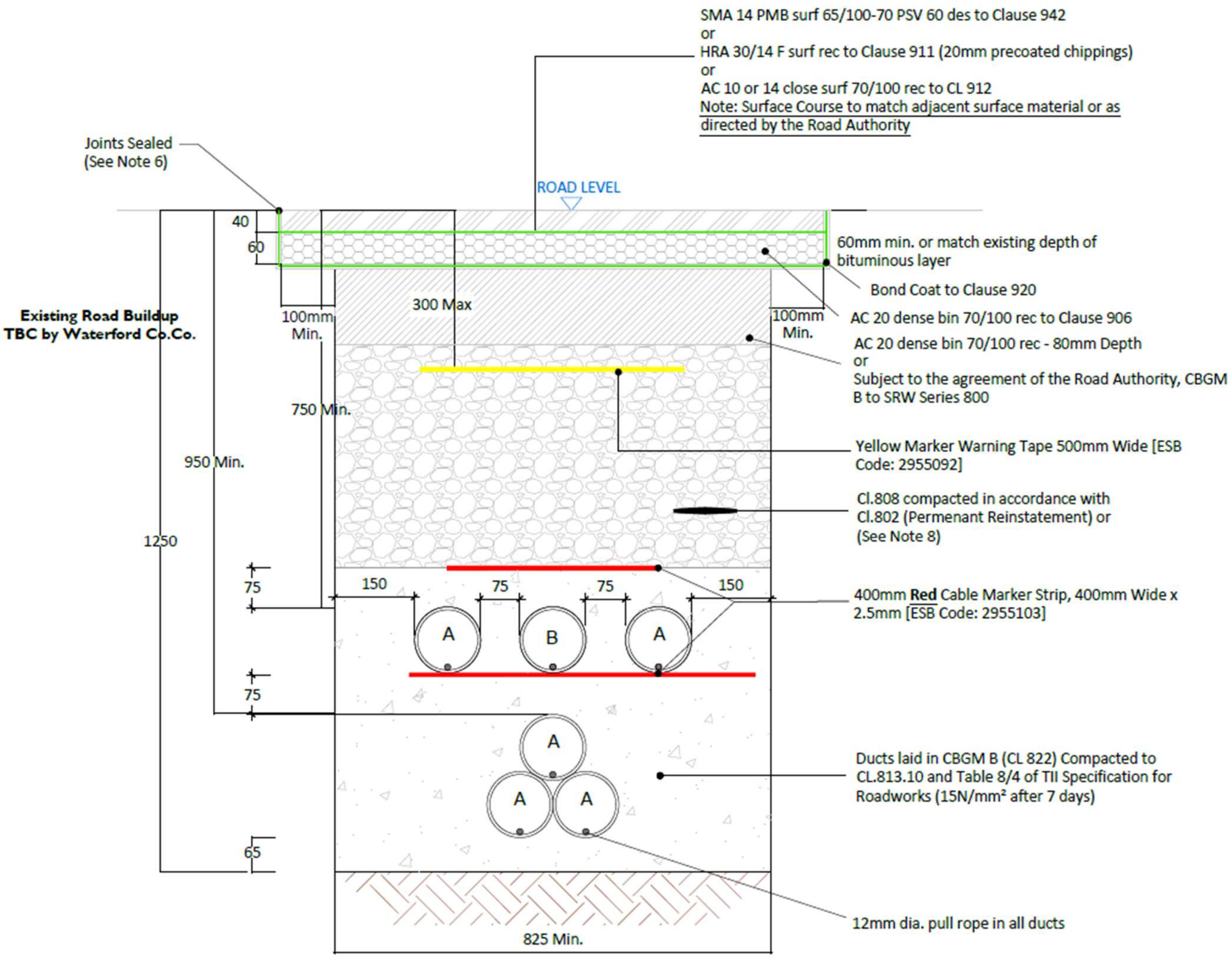
1. Grade, smooth and trim trench floor when the required 1,265mm depth and 825mm width have been obtained.
2. Place bedding layer of Cement Bound Granular Mixture B (CBGM B) material in accordance with its specification and compact it so that the compacted thickness is as per drawings.
3. Lay the bottom row of ducts in trefoil formation as detailed on design drawings. Use spacers as appropriate to establish horizontal duct spacing. Fit a secure cap / bung to the end of each duct run to prevent the ingress of dirt or water.
4. Carefully surround and cover ducts with CBGM B in accordance with the design drawings and specifications and thoroughly compact without damaging ducts.
5. Place cable protection strips on compacted CBGM B directly over the ducts.
6. Lay the top row of ducts onto the freshly compacted CBGM B including the cable protection strips above the bottom row of ducts. Place a secure cap at the end of each duct to prevent the ingress of dirt or water.
7. Carefully surround and cover ducts with CBGM B material in accordance with drawings and thoroughly compact without damaging ducts.
8. Place red cable protection strip on top of compacted CBGM B over each set of ducts as shown on the drawings.
9. Place and thoroughly compact CBGM B material or Clause 804 backfill, or soil backfill as specified and place warning tape at the depth shown on the drawings.
10. For concrete and asphalt/bitmac road sections, carry out immediate temporary/permanent reinstatement in accordance with the specification and to the approval of the local authority or landowner, unless otherwise agreed with local authorities *(Figure 3).*
11. For unsurfaced/grass sections, backfill with suitable excavated material to ground level leaving at least 100mm topsoil or match existing level at the top to allow for seeding or replace turves as per the specification of the local authority or landowner.

12. Clean and test the ducts in accordance with the specification by pulling through a brush and mandrel. Install 12mm polypropylene draw rope in each duct and seal all ducts using robust duct end seals fitted with rope attachment eyes in preparation for cable installation at a later date. All the works should be witnessed by an EirGrid Clerk of Works (CoW) as required.



A = 125mm: Outer Diameter HDPE Duct, SDR=17.6 (Power)
B = 125mm: Outer Diameter HDPE Duct, SDR=17.6 (Comms)

Figure 3 - 110kV Trefoil Trench in National Road



A = 125mm: Outer Diameter HDPE ESB Approved Duct, SDR=17.6 (Power) [ESB Code: 9317552]
B = 125mm: Outer Diameter HDPE ESB Approved Duct, SDR=17.6 (Comms) [ESB Code: 9317552]

Figure 4 – 110kV Trefoil Trench in Rural Roadway

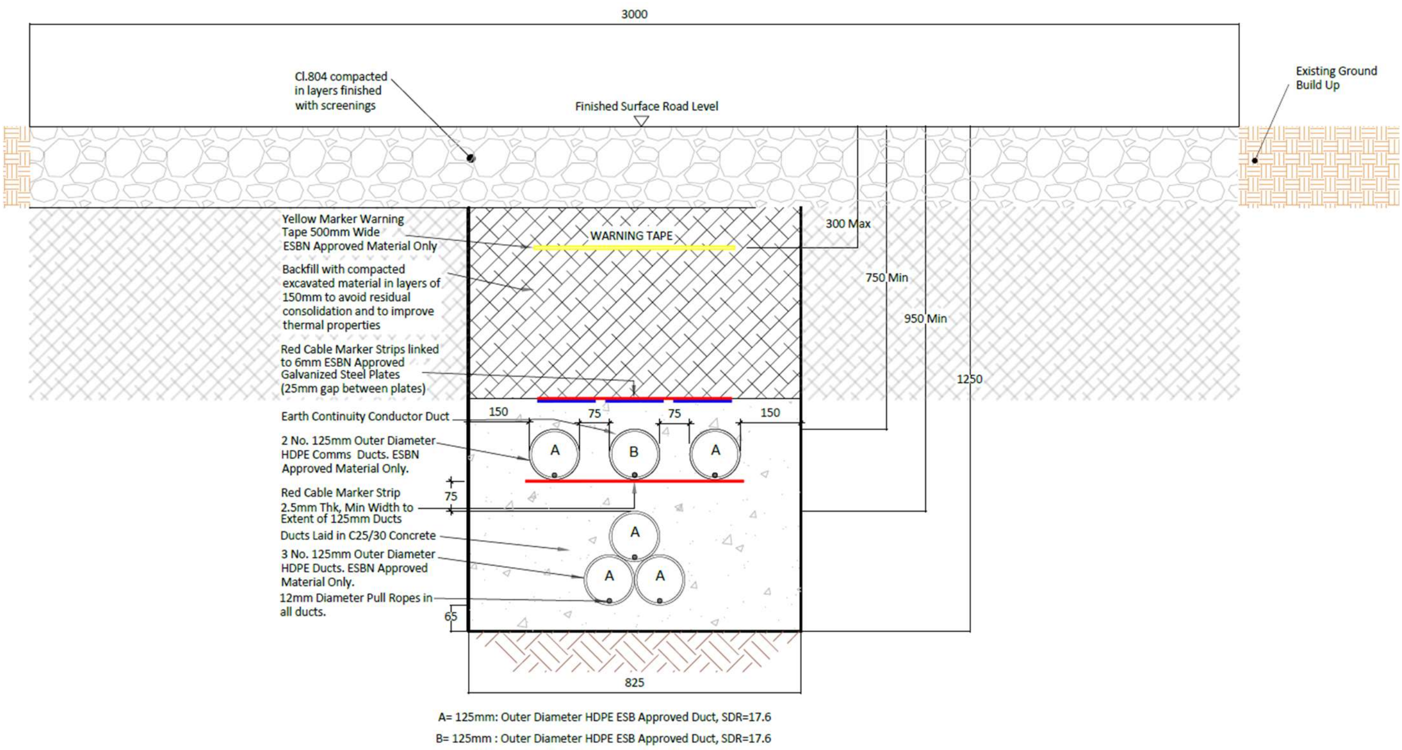


Figure 5 - Trench in Off Road Section

Equipment:

- 2-3 General Operatives;
- 1 Excavator Operator;
- 1 No. tracked excavator (only rubber tracked machines will be allowed on public roads);
- 1 No. dumper or tractor and trailer.

Materials:

- Sand for pipe bedding;
- Ready-mix Concrete where necessary (delivered to site);
- Trench backfilling material (excavated material and aggregates) to relevant specifications;
- 125mm diameter HDPE ducting;
- 125mm diameter HDPE ECC duct;
- Temporary Surface Reinstatement Materials;

8.2.1 UGC Installation within the public road

The majority of the 110kV route is located within public road and where applicable the trench will be installed in the non-trafficked strip between the typical vehicular wheel locations on the road. The cable will be micro-sited based on the presence of existing utilities and the nature of the road and the adjoining terrain. It is preferable to excavate a trench within the middle of the lane, or the middle of the roadway to reduce load on the cable.

8.3 Surface Cable Markers & Marker Posts

Surface cable markers will be placed along the route where the cable depth is unavoidably shallow due to constraints such as existing services. These cable markers will indicate the precise location of the UGC and will be metallic plates in accordance with ESBN and EirGrid standards.

Marker posts will be used on non-roadway routes to delineate the cable route and joint bay positions. Corrosion proof aluminium triangular danger sign, with a 700mm base, and with centred lightning symbol, on engineering grade fluorescent yellow background shall be installed in adequately sized concrete foundations. Marker post shall also be placed in the event that the cable burial depth is not standard. Siting of any marker posts will be agreed with EirGrid as part of the detailed design process *(Figure 5)*.

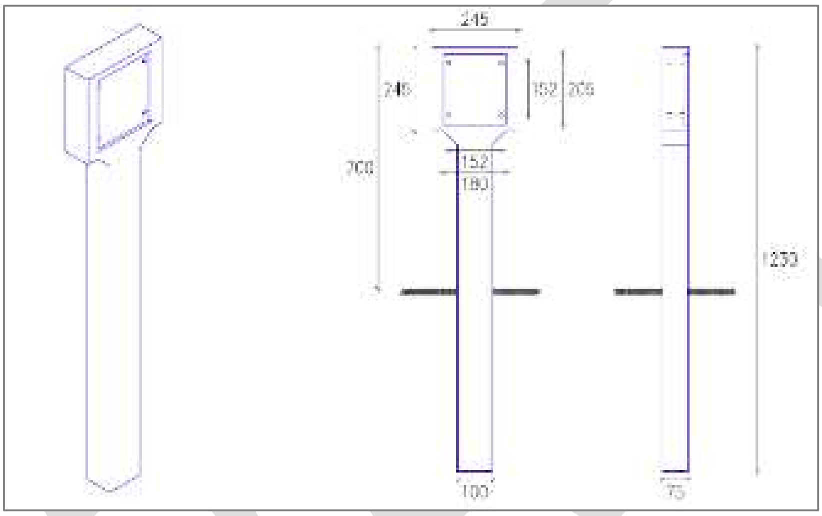


Figure 6 - EirGrid Marker Posts Example

8.4 Managing Excess Material from Trench

All excavated material will be temporarily stored adjacent to the trench prior to re-use in the trench reinstatement (where applicable). Stockpiles will be restricted to less than 2m in height. Excess material and excavated tar, etc. will be transported off site by an appropriately authorised waste collector and disposed of at an appropriately licenced waste facility.

8.5 Storage of Plant and Machinery

All plant, machinery and equipment will be stored on site within the UGC works area or within the temporary construction compound to be located at the proposed Dyrick Hill Wind Farm. Oils and fuels will be stored in an appropriately bunded area within the temporary construction compounds.

8.6 Joint Bays and Associated Chambers

Joints bays are to be installed approximately every 750m - 850m along the UGC route to facilitate the jointing of 3 No. lengths of UGC. Joint bays are approximately 2.5m x 6m x 1.75m pre-cast concrete structures installed below finished ground level. Joint bays will be located in the non-wheel bearing strip of roadways, however given the narrow profile of local roads this may not always be possible.

In association with joint bays, communication chambers are required at every joint bay location to facilitate communication links between the Dyrick Hill Wind Farm and the existing 110kV substation at Dungarvan. Earth sheath link chambers are only required at single point bonded sections along the cable route. Earth Sheath Links are used for earthing and bonding cable sheaths of underground power cables, so that the circulating currents and induced voltages are eliminated or reduced. Earth sheath link chambers and communication chambers are located in close proximity to joint bays. Earth sheath link chambers and communication chambers will be pre-cast concrete structures with an access cover at finished surface level.

The precise siting of all joint bays, earth sheath link chambers and communication chambers is subject to approval by EirGrid. Marker posts will be used on non-roadway routes to delineate the duct route and joint bay positions.

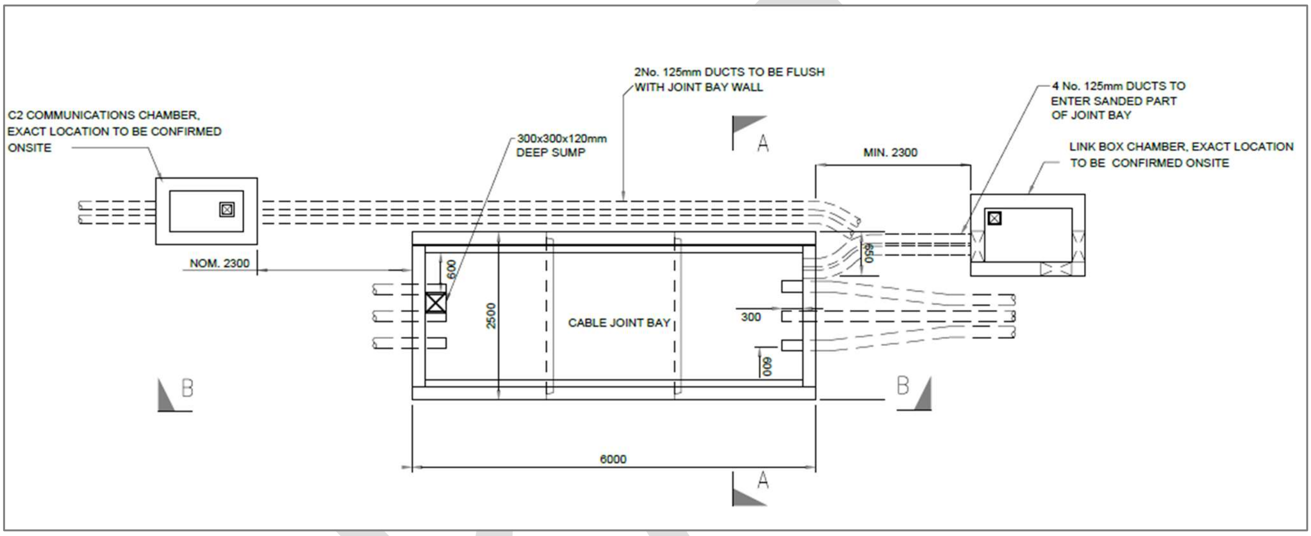


Figure 7 –110kV Joint Bay Plan Layout

8.7 Joint Bay Construction and Cable Installation

Before starting construction, the area around the edge of the joint bay which will be used by heavy vehicles will be surfaced with a terram cover (if required) and stone aggregate to minimise ground damage. Any roadside drains within the temporary works area will be culverted and check dams made from stone or sandbags covered with terram will be inserted upstream and downstream of these culverts to intercept any solids generated during the insertion or which wash out during the works. Silt fencing with straw bales will be interposed between the works area and any watercourses.

All excavated material will be stored near the excavations and reused for reinstatement works. Any soil required for reinstatement that will be temporarily stockpiled on site will be placed at least 15m back from the nearest watercourse on level ground and will be ringed at the base by silt fencing and be regularly monitored by a designated competent person for signs of solids escape. If necessary, an additional line of silt fencing with straw bales will be added in line with the relevant environmental control measures.

If the joint bay needs to be dewatered, this will be pumped to a percolation area if the soil is not saturated, otherwise a settlement tank will be used to remove any solids from the dewatering process to comply with the environmental control measures.

The following steps outline the methodology for joint bay construction and reinstatement:

1. The contractor will excavate a pit for joint bay construction, including for a sump in one corner.

2. Grade and smooth floor; then lay a 50mm depth of thick sand for pre-cast concrete construction on 200mm thick Clause 804 granular material.

3. Place pre-cast concrete sections on sand bedding. *(*Figure 8*)*

Figure 8 – Example of Joint Bay under construction (pre-cast)

4. Where joint bays are located under the road surface the joint bay will be backfilled with compacted layers of Clause 804 and the road surface temporarily reinstated as specified by the local authority.

5. For cable installation and jointing, the cable is supplied in pre-ordered lengths on large cable drums *(Figure 8).* Installing "one section" of cable normally involves pulling three individual conductors into three separate ducts. The cable pulling winch must be set at a predetermined cut off pulling tension as specified by the designer. The cable will be connected to the winch rope, using approved suitably sized and rated cable pulling stocking & swivel and a pulling head, fitted by the cable manufacturer**.** A sponge may also be secured to the winch rope to disperse lubricant through the duct. Lubrication is also applied to the cable in the joint bay before it enters the duct.

Figure 9 - HV cable pulling procedure (Drum set-up example)

6. Once the "two sections" of cable (total of 6 conductors) are pulled into the joint bay, a jointing container is positioned over the joint bay and the cable jointing procedure is carried out in this controlled environment. *(Figure 9)*

Figure 10 - HV cable jointing container

7. Following the completion of jointing and duct sealing works, place, and thoroughly compact cement-bound sand in the joint bay, in approximately 200mm layers to the level of the cable joint base to provide vertical support. Install additional layers of cement-bound sand and compact each layer until the cement-bound sand is level with the top of the joint. Install an additional 100mm cement-bound sand layer. Install cable protection strip. Backfill with cement-bound sand to a depth of 250mm below surface and carry out permanent reinstatement including placement of warning tape at 400mm depth below finished surface.

Equipment:

- 2-3 General Operatives
- 1 Excavator Operator
- 360˚ tracked excavator (13 ton normally, 22 ton for rock breaker)
- 1 No. tracked dumper or tractor and trailer

Materials:

- Sand for pipe bedding
- Clause 804 Material

- 160mm diameter HDPE ducting;
- 125mm diameter HDPE ducting;
- 63mm ECC Duct
- Precast Joint Bay Chamber Units
- Link Boxes & C2 Communication Chambers (precast)

9.0 Relocation of Existing Services

In order to facilitate the installation of the underground cable, it may be necessary to relocate existing underground services such as water mains or existing cables. In advance of any construction activity, the contractor will undertake detailed surveys and scans of the route to confirm the presence or otherwise of any services. If found to be present, the relevant service provider will be consulted in order to determine the requirement for specific excavation or relocation methods and to schedule a suitable time to carry out works.

9.1 HV Underground Cable (UGC) Crossings & Parallel Runs

As mentioned in Table 2 above there are a number of locations where the proposed UGC will have to cross other existing HV UGC routes. These crossing and parallel runs are most likely to occur in **Section 1** of the cable route surrounding the Dungarvan 110kV substation compound (see Table 2 for details)**.** Each individual crossing or parallel run will need to be individually assessed on a case-by-case basis. Site investigation works along with detailed surveying techniques and consultation with EirGrid/ESB will be required to determine the locations, depths, configurations, and ratings of any existing UGC routes.

A minimum separation distance between the cables will need to be adhered to in order to comply with EirGrid/ESB requirements. The EirGrid/ESB preferred undercrossing method will be used where possible. A crossing method can be seen in Figure 11 below. Where undercrossing of the existing UGC routes is not possible an overcrossing method will be used. All UGC crossings will need to be agreed with EirGrid/ESB as part of the design approval process. The UGC crossings have been designed in line with EirGrid/ESB specifications.

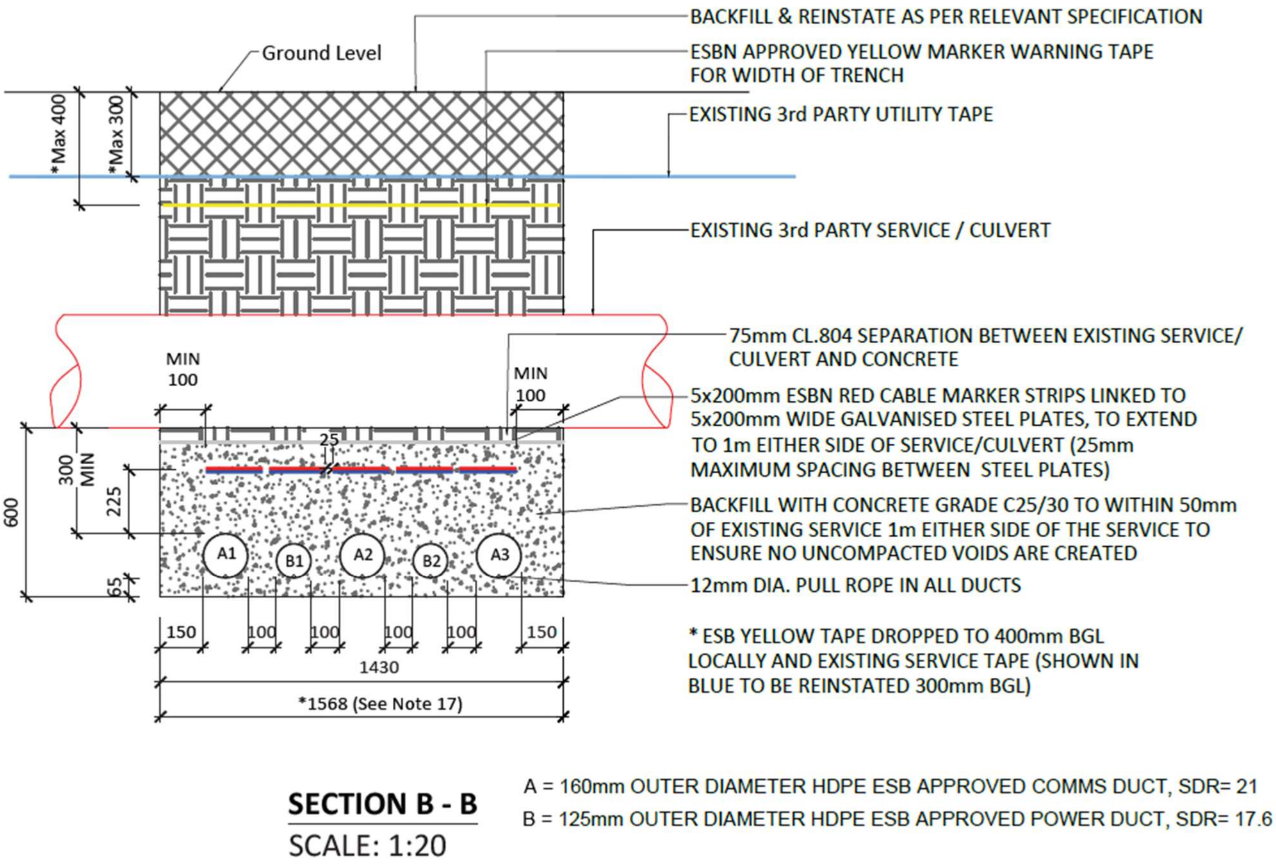


Figure 11 – Example of 110kV UGC Cable Undercrossing

9.2 Water Mains

Where conflict with existing watermains occurs, the water supply will be turned off by the utility so work can commence on diverting the service. The section of existing pipe will be removed and will be replaced with a new pipe along the new alignment of the service. The works will be carried out in accordance with the relevant utility standards.

10.0 Major Watercourse Crossings

The grid connection cable route includes 1 No. bridge crossings which will be completed using horizontal directional drilling (HDD) (refer to 11.0 below for further details). Where the cable route intersects with existing watercourses, a detailed construction method statement will need to be prepared by the Contractor prior to the commencement of construction and is to be approved by the Local Authority and relevant environmental agencies.

Minor watercourse crossing locations have been noted along the cable route in the form of culverts, pipe drains and minor field drains. Crossing of these existing culverts will be as per undercrossing or overcrossing methods, depending on the depth of the culvert or using open trenching. A detailed site survey of all culverts will need to be completed as part of the next phase of the project prior to construction. The culvert crossing methods are detailed in Figure 12 and Figure 13.

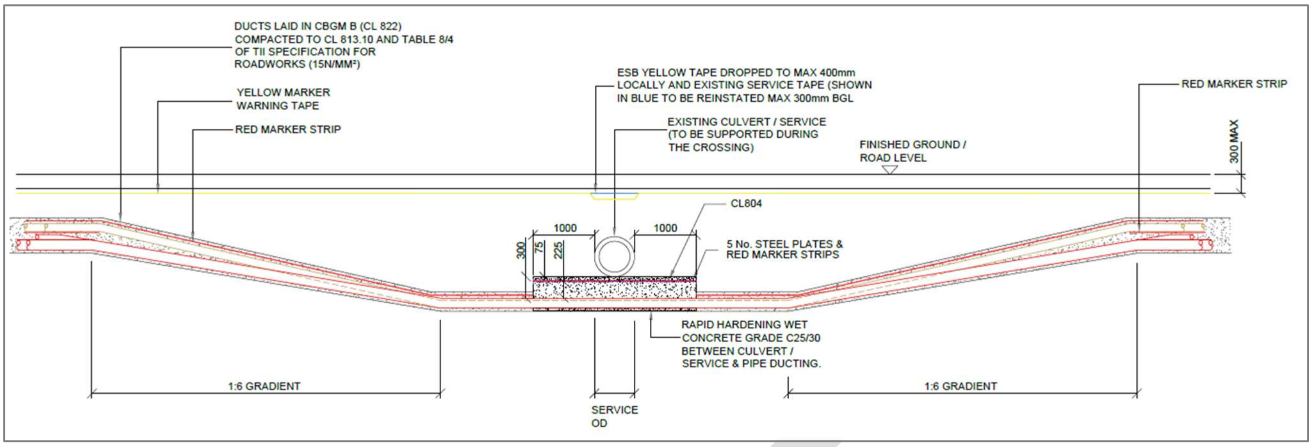


Figure 12 – 110kV UGC Culvert Undercrossing

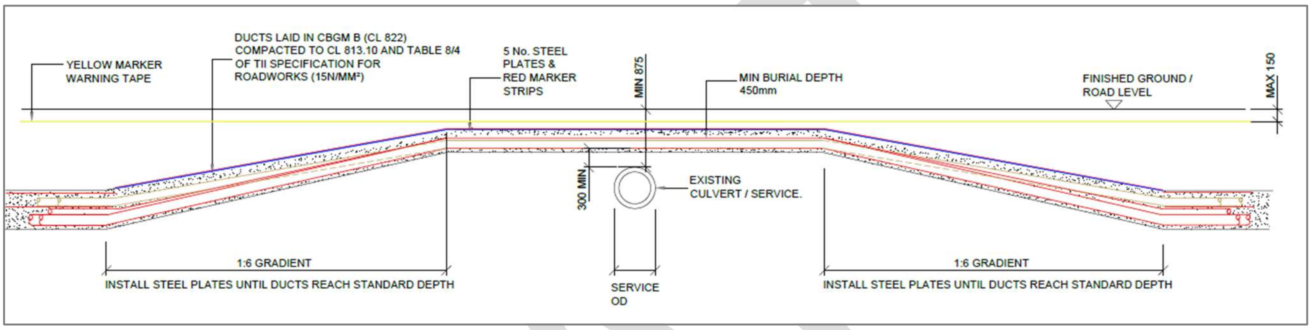


Figure 13 – 110kV UGC Culvert Overcrossing

Inland Fisheries Ireland have published guidelines relating to construction works along water bodies entitled 'Requirements for the Protection of Fisheries Habitats during Construction and Development Works at River Sites", and these guidelines will be adhered to during the construction of the development.

10.1 Watercourse 1 - Horizontal Directional Drilling (Colligan River)

ITM Coordinates: 623172.800, 595179.559

Bridge 1 has insufficient room to install the cable to ESB Networks and EirGrid specifications and the bridge is unsuitable to accommodate standard trenching. Horizontal directional drilling (HDD) will be implemented to bore approximately 1500mm beneath the waterway and bridge foundations. This depth is based on locating a suitable clay/silt formation for HDD and the required depth may increase subject to geotechnical investigations. Drilling will take place from the road carriageway**.** The methodology for HDD is outlined in Section 11.0 below. Transport Infrastructure Ireland engagements???

Figure 15 - Watercourse 1 Location within L7112

Figure 14 - Watercourse 1 superimposed on OSI

10.2 Watercourse 2 - Horizontal Directional Drilling (Ballykerin Stream)

ITM Coordinates: 619480.2853, 601537.8463

Watercourse 2 is a watercourse crossing located off road within private lands. Horizontal directional drilling (HDD) will be implemented to bore approximately 1500mm beneath the waterway. This depth is based on locating a suitable clay/silt formation for HDD and the required depth may increase subject to geotechnical investigations. Drilling will take place all within the privately owned lands**.** The methodology for HDD is outlined in Section 11.0 below.

Figure 16 - Watercourse 2 Crossing

Figure 17 - Watercourse 2 Crossing superimposed on OSI

10.3 Watercourse 3 - Horizontal Directional Drilling (Finisk River)

ITM Coordinates: 617224.7080, 601253.4596

Bridge 3 has insufficient room to install the cable to ESB Networks and EirGrid specifications and the bridge is unsuitable to accommodate standard trenching. Horizontal directional drilling (HDD) will be implemented to bore approximately 1500mm beneath the waterway to the north of the bridge structure. This depth is based on locating a suitable clay/silt formation for HDD and the required depth may increase subject to geotechnical investigations. Drilling will take place away from the road carriageway, utilising a corridor through private lands**.** The methodology for HDD is outlined in Section 11.0 below.

Figure 18 - Watercourse 3

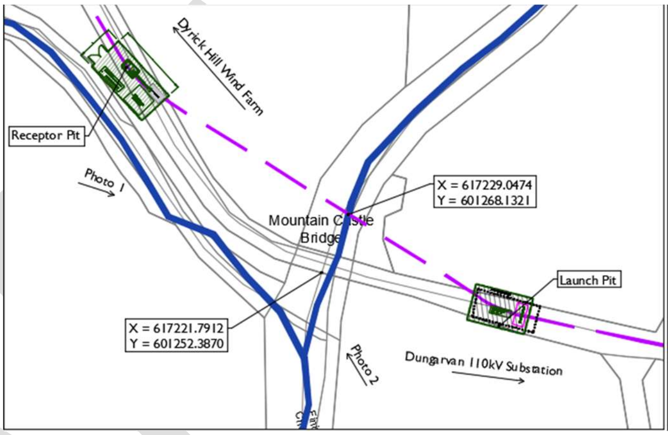


Figure 19 - Watercourse 3 superimposed on OSI

11.0 Horizontal Direction Drilling (HDD)

Horizontal Direction Drilling (HDD) is a method of drilling under obstacles such as bridges, railways, water courses, etc. in order to install cable ducts under the obstacle. This method is employed where installing the ducts using standard installation methods is not possible. There are two bridges on this UGC route which will require HDD due to insufficient cover and depth in the bridge to cross within the bridge deck.

The drilling methodology is as follows:

- A works area of circa. 150m^2 will be fenced on both sides of the river crossing, all within the road corridor.
- The drilling rig and fluid handling units will be located on one side of the bridge and will be stored on double bunded 0.5mm PVC bunds which will contain any fluid spills and storm water run-off.
- Entry and exit pits (1m x 1m x 2m) will be excavated using an excavator. The excavated material will be temporarily stored within the works area and used for reinstatement or disposed of to a licensed facility.
- A 1m x 1m x 2m steel box will be placed in each pit. This box will contain any drilling fluid returns from the borehole.
- The HDD pilot bore will be undertaken using a wireline guidance system. Assembly will be set up by the drilling team and steering engineer.
- The pilot bore will be drilled to the pre-determined profile and alignment under the watercourse crossings.
- The steering engineer and drill team will monitor the drilling works to ensure that modelled stresses and pressures are not exceeded.

- The drilled cuttings will be flushed back by drilling fluid to the entry and exist pits and re-cycled for re-use.
- Once the first pilot hole has been completed a hole-opener or back reamer will be fitted in the exit side which will then be pulled back to the entry side as part of the pre-reaming/hole opening process to enlarge the hole to the correct size.
- When the pre-reaming/hole opening/hole cleaning has been completed, a reamer of slightly smaller diameter than the final cut will be installed on the drill string to which the ducts will be attached for installation. The steel boxes will be removed, with the drilling fluid disposed of to a licensed facility.
- The ducts will be cleaned and proven, and their installed location surveyed.
- The entry and exit pits will be reinstated to the specification of ESB Networks, EirGrid and Waterford County Council.
- A joint bay/transition coupler/ transition chamber will be installed at either side of the bridge following the horizontal directional drilling as per EirGrid requirements, this will join the HDD ducts to the standard ducts.

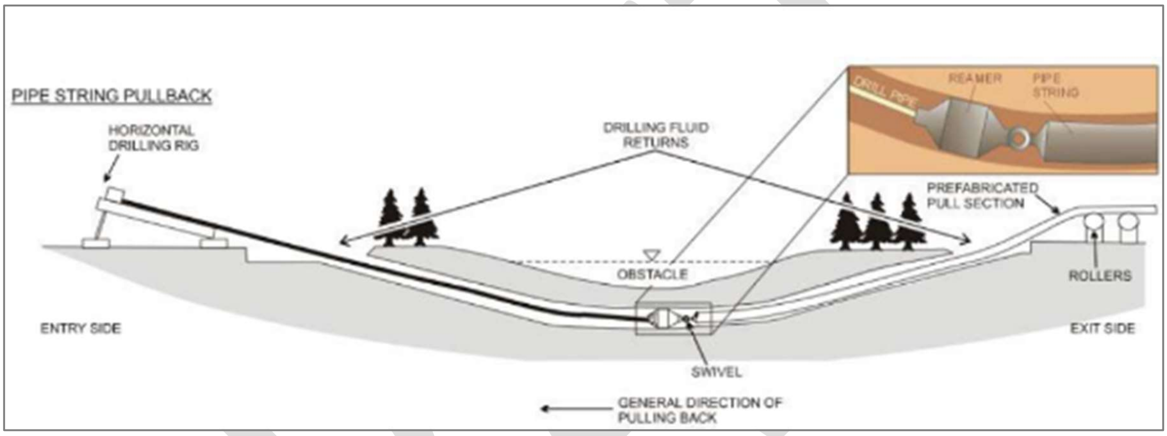


Figure 20 - Example of HDD Installation

12.0 Reinstatement of Private Land

Once all construction works are complete, the works areas on private lands will be reinstated with excavated soil and either seeded out with native species, allowed to vegetate naturally, or reinstated with excavated grass turves and will be restored to their original condition. This work will be carried out in consultation with the landowner and in line with any relevant measures outlined in the planning application, CEMP, and planning conditions.

13.0 Best Practice Design and Construction & Environmental Management Methodology

Prior to commencement of construction works the contractor will draw up detailed method statements which will be informed by this Outline Construction Methodology, environmental protection measures included within the planning application, measures within the CEMP, and the guidance documents and best practice measures listed below. This method statement will be adhered to by the contractors and will be overseen by the Project Manager, Environmental Manager and Ecological Clerk of Works (ECoW) where relevant.

The following documents will contribute to the preparation of the method statements in addition to those measures below: -

- Inland Fisheries Ireland (2016) *Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters*. Inland Fisheries Ireland*, Dublin,*
- National Roads Authority (2008) *Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes*. National Roads Authority, Dublin;
- E. Murnane, A. Heap and A. Swain. (2006) *Control of water pollution from linear construction projects.* Technical guidance (C648). CIRIA;
- E. Murnane et al., (2006) *Control of water pollution from linear construction projects*. Site guide (C649). CIRIA.
- Murphy, D. (2004) *Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites. Eastern Regional Fisheries Board, Dublin;*
- H. Masters-Williams et al (2001) *Control of water pollution from construction sites. Guidance for consultants and contractors* (C532);
- Enterprise Ireland (unknown). *Best Practice Guide (BPGCS005) Oil storage guidelines;*
- Law, C. and D'Aleo, S. (2016) *Environmental good practice on site pocket book*. (C762) 4th edition. CIRIA;
- CIRIA *Environmental Good Practice on Site (fourth edition) (C741) 2015*.

The works will be carried out by employing accepted best working practices during construction, including the environmental management measures listed below. Please note that the following measures will be supplemented by further specific environmental protection measures that will be included in method statements prepared for specific tasks during the works and will form part of the detailed CEMP.

- All materials shall be stored at the temporary compound within the Dyrick Hill Wind Farm site and transported to the works zone immediately prior to construction;
- Weather conditions will be considered when planning construction activities to minimise risk of run off from site;
- Provision of 50m exclusion zones and barriers (silt fences) between any excavated material and any surface water features to prevent sediment washing into the receiving water environment;
- If dewatering is required as part of the works e.g. in trenches for underground cabling or in wet areas, water must be treated prior to discharge;
- The contractor shall ensure that silt fences are regularly inspected and maintained during the construction phase;
- If very wet ground must be accessed during the construction process bog mats/aluminium panel tracks will be used to enable access to these areas by machinery. However, works will be scheduled to minimise access requirements during winter months;

- The contractor shall ensure that all personnel working on site are trained in pollution incident control response. A regular review of weather forecasts of heavy rainfall is required, with the Contractor required to prepare a contingency plan for before and after such events;
- The contractor will carry out visual examinations of local watercourses from the works during the construction phase to ensure that sediment is not above baseline conditions. In the unlikely event of water quality concerns, the Environmental Manager and ECoW will be consulted;
- Excavations will be left open for minimal periods to avoid acting as a conduit for surface water flows.
- Only emergency breakdown maintenance will be carried out on site. Emergency procedures and spillage kits will be available and construction staff will be familiar with emergency procedures.
- Appropriate containment facilities will be provided to ensure that any spills from vehicles are contained and removed off site. Adequate stocks of absorbent materials, such as sand or commercially available spill kits shall be available;
- Concrete or concrete contaminated water run-off will not be allowed to enter any watercourses. Any pouring of concrete (delivered to site ready mixed) will only be carried out in dry weather. Washout of concrete trucks shall be strictly confined to a designated and controlled wash-out area within the temporary construction compound at the substation site, remote from watercourses, drainage channels and other surface water features;
- A designated trained operator experienced in working with concrete will be employed during the concrete pouring phase;
- Concrete wastewater can be pumped into a skip to settle out; settled solids will need to be appropriately disposed of off-site;
- Wash-down water from exposed concrete surfaces will be trapped to allow sediment to settle out and reach neutral pH before clarified water is released to the drain system or allowed to percolate into the ground;
- Where dust suppression is considered to be required by the Contractor, such requirements and methodology shall be subject to the agreement with the Ecological Clerk of Works;
- Entry by plant equipment, machinery, vehicles and construction personnel into watercourses or wet drainage ditches shall not be permitted. All routes used for construction traffic shall be protected against migration of soil or waste water into watercourses;
- Cabins, containers, workshops, plant, materials storage, and storage tanks shall not be located near any surface water channels and will be located beyond the 50m hydrological buffer at all times.

The following mitigation measures will be undertaken specifically with regard to horizontal directional drilling:

- A geotechnical assessment shall be carried out prior to horizontal directional drilling and drilling shall only be carried out at locations where conditions are suitable for the control of drilling materials.
- All works will be supervised by a qualified environmental engineer.
- No works will be undertaken near the river corridor or river banks. Reception and launch pits for the directional drilling process shall be excavated a minimum of 20m from the stream banks.
- No construction activity will take place in riparian areas. Stockpiling of construction materials, refuelling of machinery and overnight parking will take place elsewhere in the temporary compound near the proposed substation. Concrete truck chute cleaning will take place in a separate appropriate location.
- The area around the bentonite batching, pumping, and recycling plants shall be bunded using terram and sandbags in order to contain any spillages.
- Silt fencing will be erected 5m from the reception and launch pits used for directional drilling.

- Horizontal directional drilling works shall not take place at periods of high rainfall and shall be scaled back or suspended if heavy rain is forecast.

14.0 Invasive Species Best Practice Measures

Invasive species can be introduced into a location by contaminated plant, machinery and equipment which were previously used in locations that contained invasive species. Good site organisation and hygiene management shall be maintained always on site, and best practice measures will be implemented, as follows:

- The contractor will prepare an Invasive Species Action Plan to be implemented during construction, and all personnel will be made aware of the requirements contained within;
- Plant and machinery will be inspected upon arrival and departure from site and cleaned/washed as necessary to prevent the spread of invasive aquatic / riparian species such as Japanese knotweed *Fallopia japonica* and Himalayan Balsam *Impatiens glandulifera*. A sign off sheet will be maintained by the contractor to confirm the implementation of measures;
- Site hygiene signage will be erected in relation to the management of non-native invasive material.

15.0 Waste Management

All waste arising during the construction phase will be managed and disposed of in a way that ensures the provisions of the Waste Management Act 1996 and associated amendments and regulations and the Waste Management Plan. Soil will be reinstated into trenches where possible. In the event there is excess material with no defined purpose, it will be transported to an authorised soil recovery site.

Instruction

Technical Lead:	Andrew Foley - TLI Group
Date of Writing:	02.09.22
Scope of Note:	110kV Cable Rating Check
Documents & Data Issued for Review:	n/a

Overview

TLI Group ("the Consultant") were engaged by EM Power ("the Client") on the development of Dyrick Hill Windfarm in Co. Waterford. The Consultant was engaged to assist the Client in selecting and preparing a planning application for the associated 110kV underground cable.

The grid connection will be a 110kV connection to the EirGrid 110kV Dungarvan Substation. The connected to the windfarm substation using a single circuit 110kV underground cable (UGC) circuit (approximate length 16.01km). The cable route and associated trench designs required for the cable route will be capable of achieving the required rating as required by the Dyrick Hill Wind Farm (74.4 MV Summer/Winter Rating). In order to meet the required maximum rating for this connection the developer may install 1000mm^2 Al XLPE cable or 1000mm^2 Cu XLPE cable for the cable circuit. The Client is currently working on the development of the windfarm and have indicated that the Maximum Export Capacity (MEC) of the windfarm will be 74.4MW.

This cable rating check was completed to assess the suitability of the cable size and cable trench designs for the 110kV UGC grid connection circuit.

The cable ratings check which have been completed as part of this study include:

- Standard Trefoil Trench Design
- Flat Formation Trench Design
- Horizontal Directional Drill Trench Design (3000mm depth)
- Flat Formation, Perpendicular (90°) Undercrossing Existing UGC Trench

Cable Study Parameters	
Cable Size:	1000mm² Al Cable /1000mm² Cu Cable
Nominal Voltage:	110kV *(Range 105kV to 120kV)*
Power:	68.8 *(As specified by Client)*
Power Factor:	0.95 assumed *(Range 0.85 lag to 0.93 lead)*
Avg. Cable Section Length:	750m *(trefoil), 50m (flat), 100m (HDD), 10m (flat, undercrossing)*
Cable Trench Design:	See Appendix A, B, C, & D
Ambient Temp (Soil)	20˚C /10 ˚C *(Summer/Winter rating)*
Soil Thermal Resistivity	1.2/1.0 Km/W *(Summer/Winter rating)*
Backfill Thermal Resistivity	1/0.85 Km/W *(Summer/Winter rating)*
Bentonite Thermal Resistivity	1.25 Km/W
Cable Screen Bonding:	Cross bonded
Power Duct Size:	125mm Standard

Table 1 - Cable Study General Parameters

Cable Rating Check Results

1000mm² Al Cable - 110kV Standard Trefoil Trench (Depth 950mm) Design:

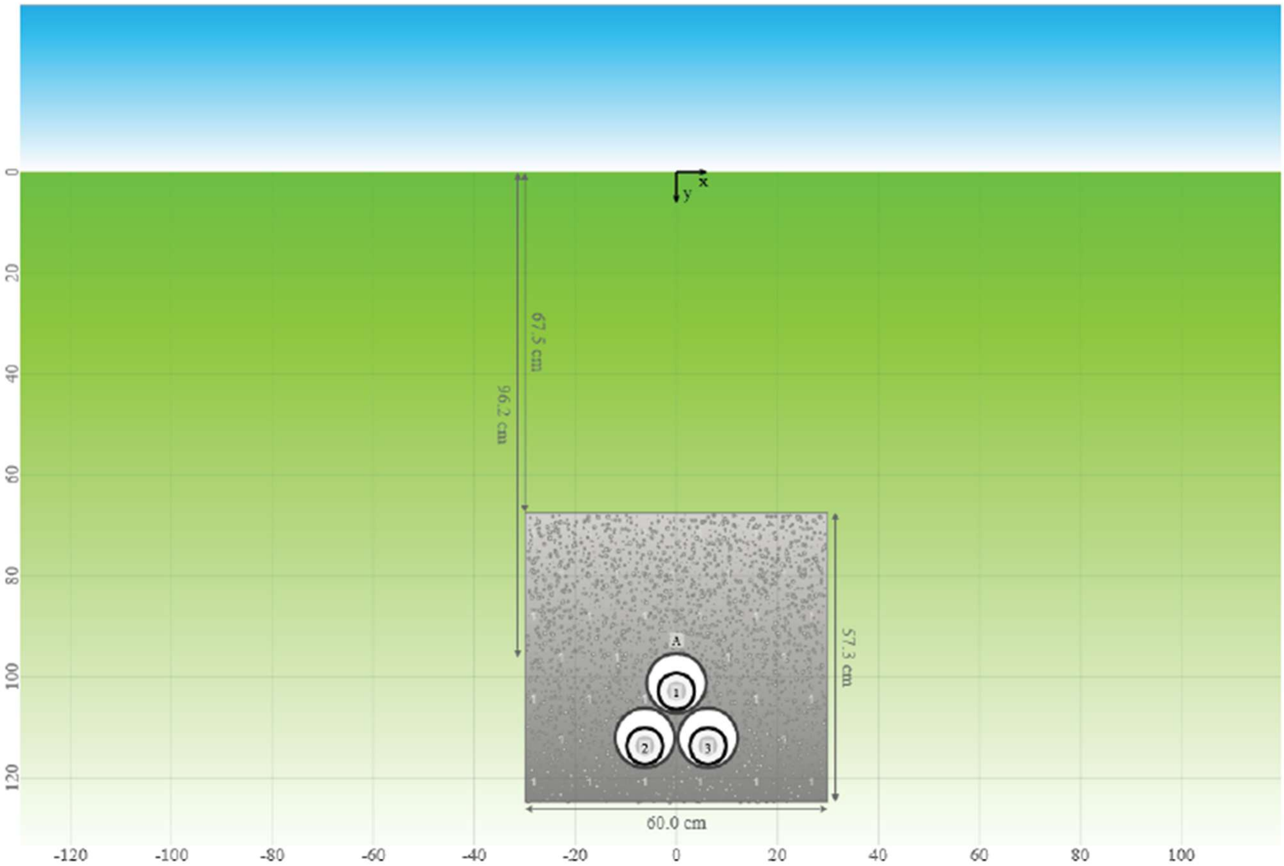
A cable rating study was completed for a **1000mm² Al XLPE (110kV) UGC** using the **standard trefoil trench design in 125mm ducts** as detailed in Appendix A. Using this arrangement, the cable circuit is capable of carrying a maximum full load current of **959A (153.20MW)**, see Table 2 below. Therefore, 1000mm² Al XLPE (110kV) UGC when installed using the standard trefoil trench design the circuit is capable of achieving the required summer maximum rating (74.4MW), see Table 2 below.

Rating Sheet Ref	Season	Ambient Temp (˚C)	Duct Spacing (mm)	Duct Depth (mm)	Rated MW	Rated Current	MW Loading	Loading Capacity
NKT 1000 Al - Standard Trefoil 125D-CB-Summer	Summer	20	-	950	153.20	847	68.8	45%
NKT 1000 Al - Standard Trefoil 125D-CB-Winter	Winter	10	-	950	173.50	959	74.4	43%

Table 2 - 1000mm² Al, Standard Trench Design

Statistics

Number of iterations of the solver	N_{calc}	5
Sum of currents from all systems	I_{sum}	846.6 A
Sum of average conductor temperatures from all systems	θ_{sum}	89.7 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	86.96 W/m



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. $\theta_c \mid \theta_e (\theta_{de})$ [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Al XLPE (110kV) - Copper Sheath -T1052	846.6	90.0 | 79.4 (67.8)	87.0

Figure 1 - Cable Rating Model, Standard Trench Design, 1000mm² Al

1000mm² Cu Cable - 110kV Standard Trefoil Trench (Depth 950mm) Design:

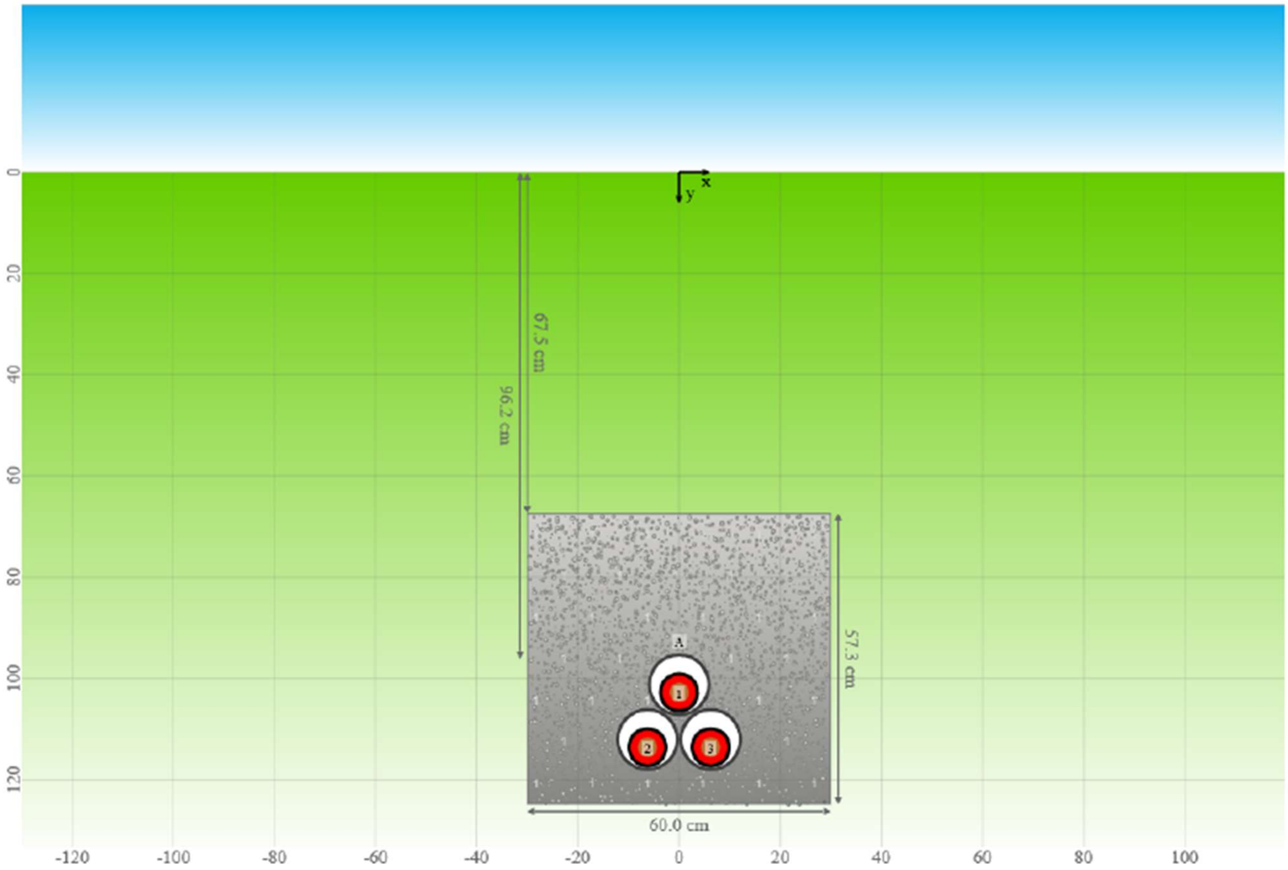
A cable rating study was completed for a **1000mm² Cu XLPE (110kV) UGC** using the **standard trefoil trench design in 125mm ducts** as detailed in Appendix A. Using this arrangement, the cable circuit is capable of carrying a maximum full load current of **1134A (205.20MW)**, see Table 2 below. Therefore, 1000mm² Cu XLPE (110kV) UGC when installed using the standard trefoil trench design the circuit is capable of achieving the required summer maximum rating (74.4MW), see Table 2 below.

Rating Sheet Ref	Season	Ambient Temp (°C)	Duct Spacing (mm)	Duct Depth (mm)	Rated MW	Rated Current	MW Loading	Loading Capacity
NKT 1000 Cu - Standard Trefoil 125D-CB-Summer	Summer	20	-	950	181.10	1001	74.4	41%
NKT 1000 Cu - Standard Trefoil 125D-CB-Winter	Winter	10	-	950	205.20	1134	74.4	36%

Table 3 - 1000mm² Al, Standard Trench Design

Statistics

Number of iterations of the solver	N_{calc}	5
Sum of currents from all systems	I_{sum}	1000.7 A
Sum of average conductor temperatures from all systems	θ_{sum}	89.7 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	87.901 W/m



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Cu XLPE (110kV) - TDE2056a	1000.7	90.0 | 79.8 (68.3)	87.9

Figure 2 - Cable Rating Model, Standard Trench Design, 1000mm2 Cu

1000mm² Al Cable - 110kV Flat Formation (450mm) Design*:*

A cable rating study was completed for **1000mm² AL XLPE (110kV) UGC** over a distance of 50m using the **flat formation trench design with 125mm ducts** as detailed in Appendix B, this arrangement uses a spacing of 325mm between power ducts. Using this arrangement, the cable circuit is capable is capable of achieving the required summer maximum rating (74.4MV), see Table 3 below.

Rating Sheet Ref	Season	Ambient Temp (˚C)	Duct Spacing (mm)	Duct Depth (mm)	Rated MW	Rated Current	MW Loading	Loading Capacity
NKT 1000 Al - Flat125D-CB-Summer	Summer	20	325	450	194.60	1075	74.4	38%
NKT 1000 Al - Flat 125D-CB-Winter	Winter	10	325	450	215.20	1189	74.4	35%

Table 4 - 1600mm² Al, Flat Formation Trench, 450mm depth, 325mm spacing

1000mm² Cu Cable - 110kV Flat Formation (450mm) Design*:*

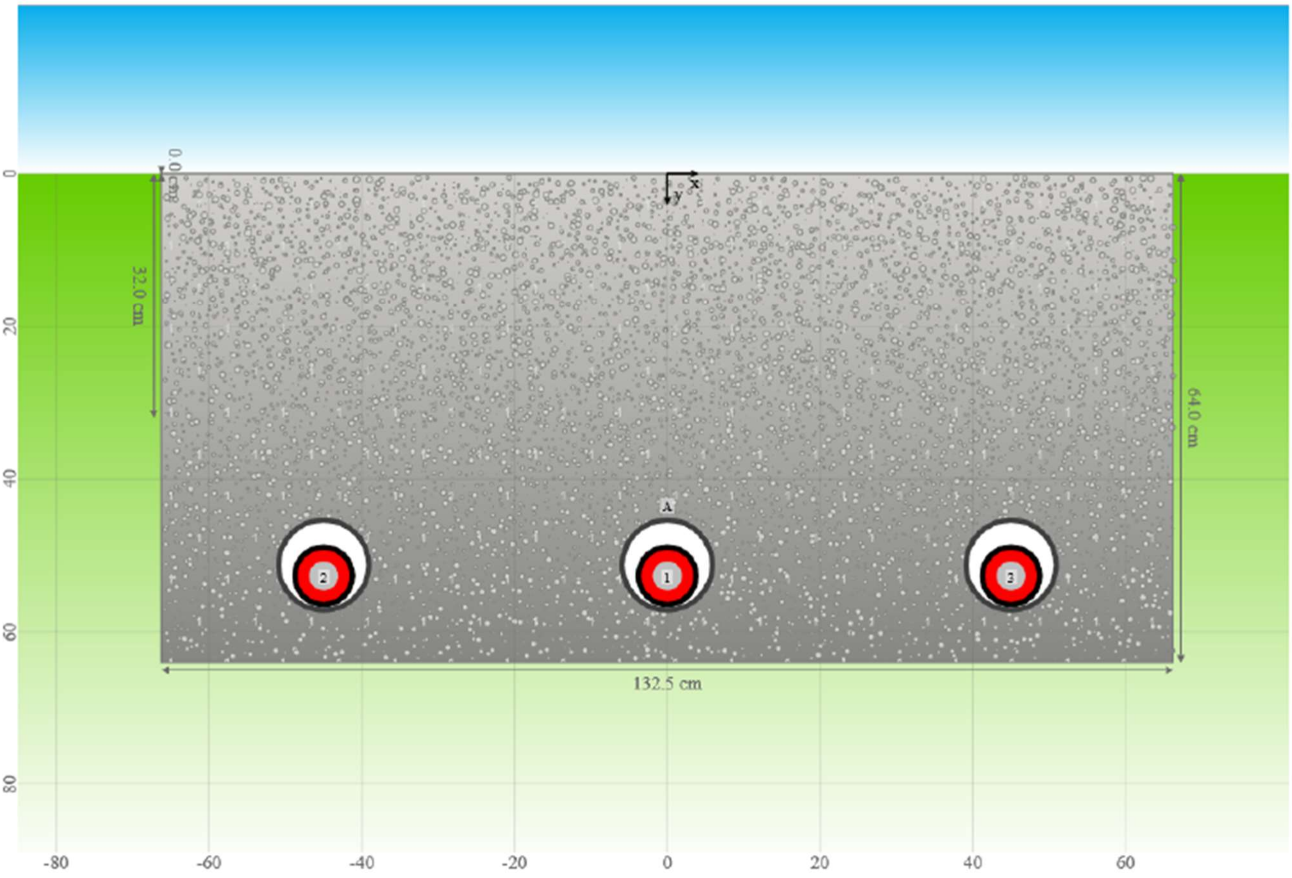
A cable rating study was completed for **1000mm² Cu XLPE (110kV) UGC** over a distance of 50m using the **flat formation trench design with 125mm ducts** as detailed in Appendix B, this arrangement uses a spacing of 325mm between power ducts. Using this arrangement, the cable circuit is capable is capable of achieving the required summer maximum rating (74.4MV), see Table 3 below.

Rating Sheet Ref	Season	Ambient Temp (˚C)	Duct Spacing (mm)	Duct Depth (mm)	Rated MW	Rated Current	MW Loading	Loading Capacity
NKT 1000 Cu - Flat 125D-CB-Summer	Summer	20	325	450	240.00	1326	74.4	31%
NKT 1000 Cu - Flat 125D-CB-Winter	Winter	10	325	450	265.50	1467	74.4	28%

Table 5 - 1000mm² Al, Flat Formation Trench, 450mm depth, 325mm spacing

Statistics

Number of iterations of the solver	N_{calc}	5
Sum of currents from all systems	I_{sum}	1075 A
Sum of average conductor temperatures from all systems	θ_{sum}	87.3 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	136.836 W/m



Systems

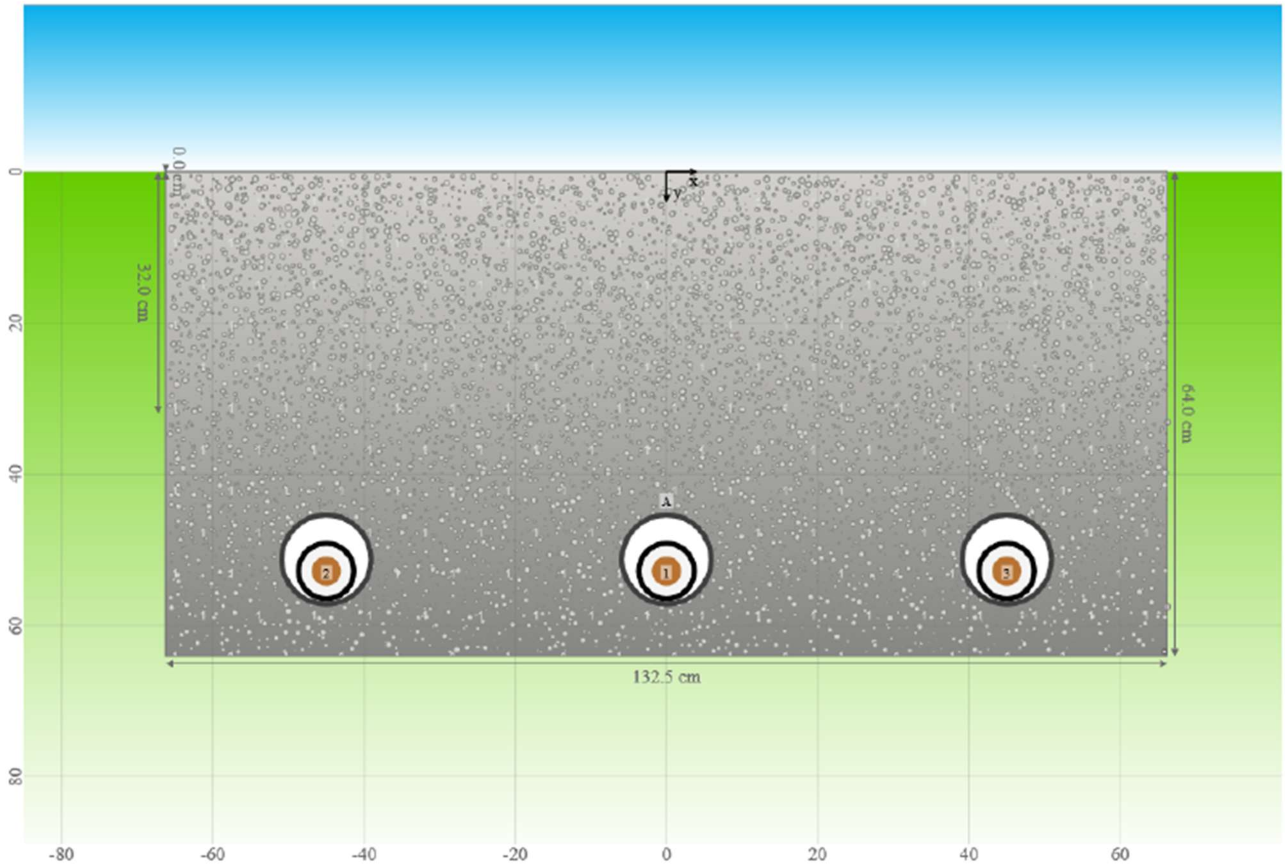
Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. $\theta_c \mid \theta_e$ (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Al XLPE (110kV) - Al Wire Scrn (2020)	1075.0	90.0 | 72.3 (53.8)	136.8

Figure 3 - Cable Rating Model, Flat Formation Trench, 1000mm^2 Al, 450mm depth, 325mm spacing, summer

Statistics

Number of iterations of the solver	N_{calc}	5
Sum of currents from all systems	I_{sum}	1325.9 A
Sum of average conductor temperatures from all systems	θ_{sum}	87 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	136.945 W/m



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Cu XLPE (110kV) - TDE2056a	1325.9	90.0 | 73.0 (54.0)	136.9

Figure 4-Cable Rating Model, Flat Formation Trench, 1000mm2 Cu, 450mm depth, 325mm spacing, summer

Horizontal Directional Drill (HDD) - Trefoil Formation (Depth 3000mm):

A cable rating study was completed for a **1000mm² AL XLPE (110kV) UGC** over a distance of 100m utilising a HDD in a trefoil formation, at a **depth of 3000mm.** It should be noted that the HDD crossings a larger duct size of 140mm was used. This can be seen from Table 4 below.

Rating Sheet Ref	Season	Ambient Temp (˚C)	Duct Spacing (mm)	Duct Depth (mm)	Rated MW	Rated Current	MW Loading	Loading Capacity
NKT 1000 Al - HDD Trefoil 3000mm 140D-CB-Summer	Summer	20	-	3000	135.10	747	74.4	55%

Table 6 – HDD Trefoil Options, Using 1000mm² Al Cable in 140mm Ducts

A cable rating study was completed for a **1000mm² Cu XLPE (110kV) UGC** over a distance of 100m utilising a HDD in a trefoil formation, at a **depth of 3000mm.** It should be noted that the HDD crossings a larger duct size of 140mm was used. This can be seen from Table 4 below.

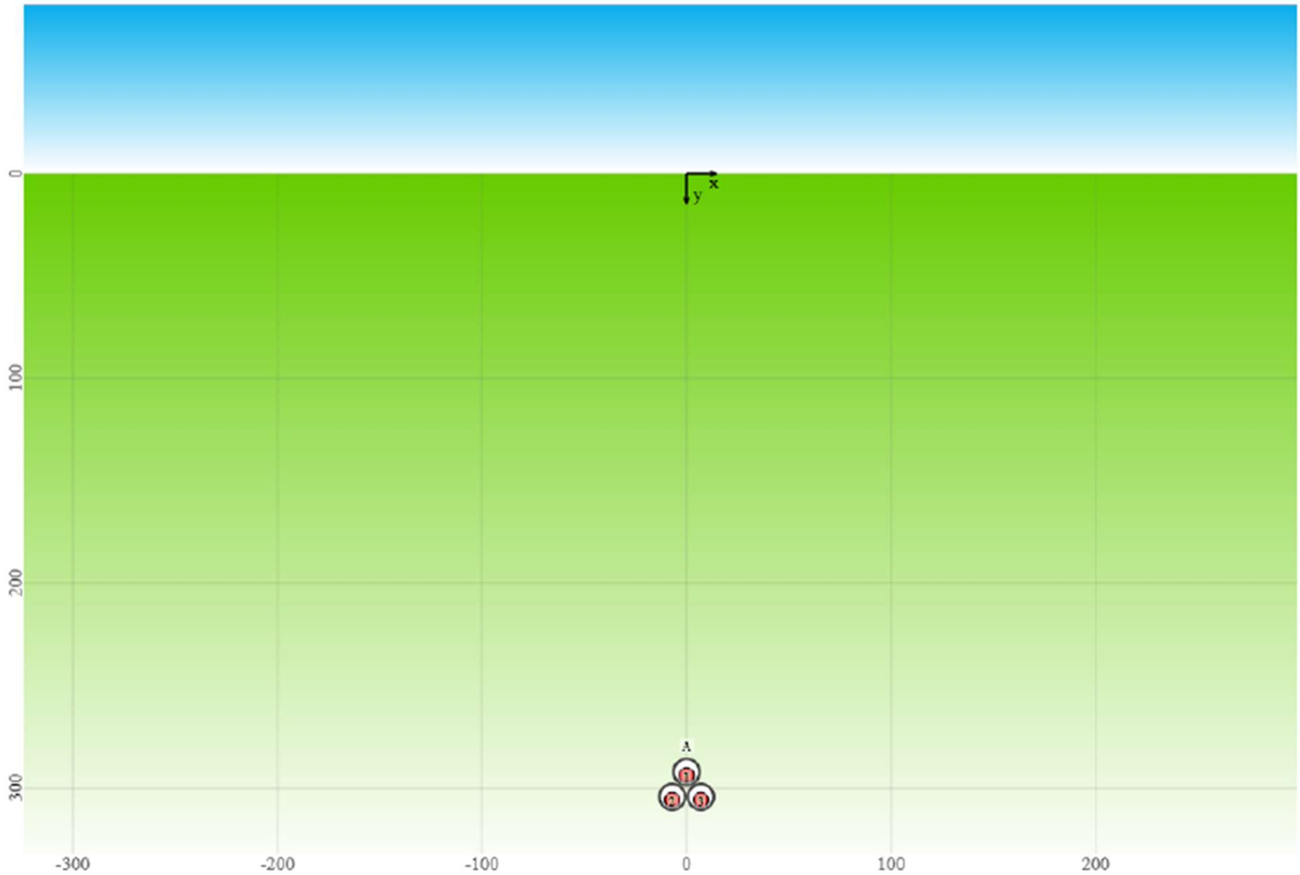
Rating Sheet Ref	Season	Ambient Temp (˚C)	Duct Spacing (mm)	Duct Depth (mm)	Rated MW	Rated Current	MW Loading	Loading Capacity
NKT 1000 Cu - HDD Trefoil 3000mm 140D-CB-Summer	Summer	20	-	3000	161.10	890	74.4	46%

Table 7 – HDD Trefoil Options, Using 1000mm² Cu Cable in 140mm Ducts

It can be seen that both the 1000mm² Al and the 100mm² Cu cables can achieve the required rating.

Statistics

Number of iterations of the solver	N_{calc}	5
Sum of currents from all systems	I_{sum}	889.8 A
Sum of average conductor temperatures from all systems	θ_{sum}	89.9 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	68.172 W/m



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Cu XLPE (110kV) - TDE2056a	889.8	90.0 | 82.0 (72.0)	68.2

Figure 5 - Cable Rating Model, HDD Trefoil, 1600mm^2 Cu, 3000mm depth, summer

Cable Study Results Summary

The results from the initial cable rating checks indicate that the use of either 1000mm^2 Al cable or 1000mm^2 Cu cable for the project is sufficient to carry the maximum 74.4MV maximum rating without exceeding the proposed recommended maximum conductor temperature of 90˚C.

Dyrick Hill WF - 110kV Grid Connection

Cable Rating Study Results

1000mm2 Al XLPE Cable - 1000mm2 Cu XLPE

Rev-00 (02.09.22)

Cable Rating Study Results

Rating Sheet Ref	Season	Ambient Temp (˚C)	Backfill Res. (K.m/W)	Soil Res. (K.m/W)	Duct Config.	Duct Spacing (mm)	Duct Depth (mm)	Rated MW	Rated Current (A)	Actual Current (A)	Loading MW (MEC)	Loading Capacity
NKT 1000 Al - Standard Trefoil 125D-CB-Summer	Summer	20	1	1.2	Trefoil 125mm	-	950	153.20	847	680	68.8	45%
NKT 1000 Al - Standard Trefoil 125D-CB-Winter	Winter	10	0.85	1	Trefoil 125mm	-	950	173.50	959	380	74.4	43%
NKT 1000 Cu - Standard Trefoil 125D-CB-Summer	Summer	20	1	1.2	Trefoil 125mm	-	950	181.10	1001	380	74.4	41%
NKT 1000 Cu - Standard Trefoil 125D-CB-Winter	Winter	10	0.85	1	Trefoil 125mm	-	950	205.20	1134	380	74.4	36%
NKT 1000 Al - Flat125D-CB-Summer	Summer	20	1	1.2	Flat 125mm	325	450	194.60	1075	380	74.4	38%
NKT 1000 Al - Flat 125D-CB-Winter	Winter	10	0.85	1	Flat 125mm	325	450	215.20	1189	380	74.4	35%
NKT 1000 Cu - Flat 125D-CB-Summer	Summer	20	1	1.2	Flat 125mm	325	450	240.00	1326	380	74.4	31%
NKT 1000 Cu - Flat 125D-CB-Winter	Winter	10	0.85	1	Flat 125mm	325	450	265.50	1467	380	74.4	28%
NKT 1000 Al-Flat_2500_325S-125D-Summer-CB	Summer	20	1	1.2	Flat 125mm	325	2500	151.20	835	380	74.4	49%
NKT 1000 Al-Flat_2500_325S-125D-Winter-CB	Winter	10	0.85	1	Flat 125mm	325	2500	160.70	888	380	74.4	46%
NKT 1000 Cu-Flat_2500_325S-125D-Summer-CB	Summer	20	1	1.2	Flat 125mm	325	2500	186.00	1028	380	74.4	40%
NKT 1000 Cu-Flat_2500_325S-125D-Winter-CB	Winter	10	0.85	1	Flat 125mm	325	2500	197.70	1093	380	74.4	38%
NKT 1000 Al - HDD Trefoil 3000mm 140D-CB-Summer	Summer	20	-	1.2	Trefoil 125mm	-	3000	135.10	747	380	74.4	55%
NKT 1000 Cu - HDD Trefoil 3000mm 140D-CB-Summer	Summer	20	-	1.2	Trefoil 125mm	-	3000	161.10	890	380	74.4	46%

Table 8 – Cable Rating Study Results Summary

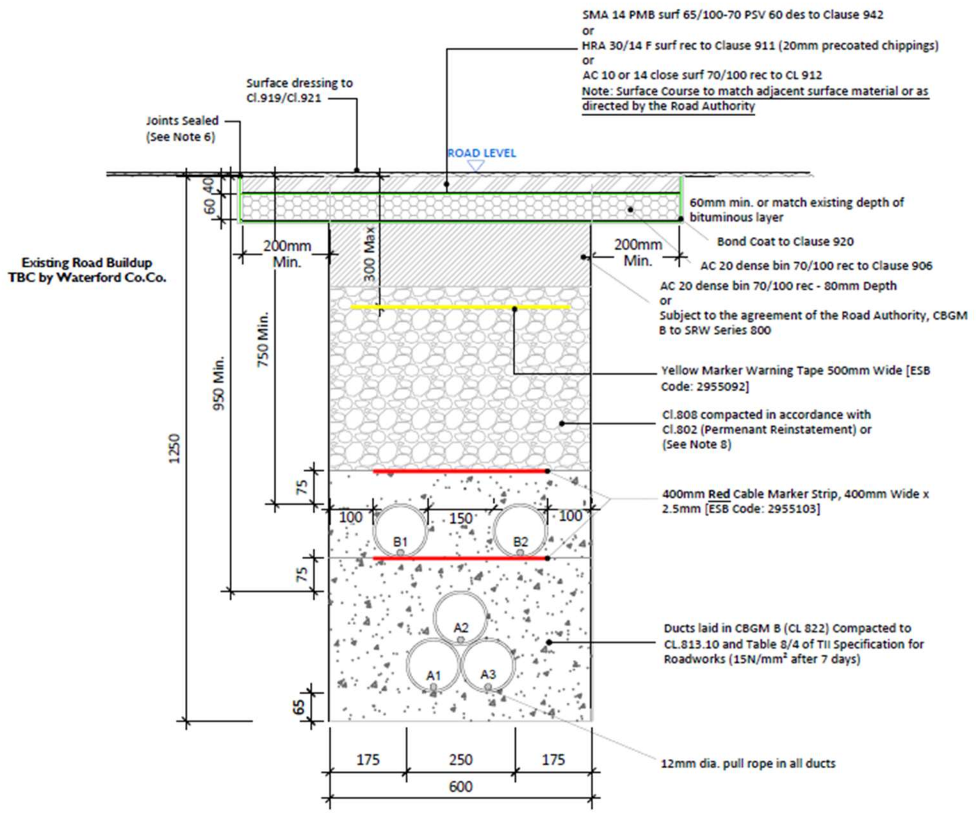
It can be seen from **Table *8*** above that both the 1000mm^2 Al XLPE cable and the 1000mm^2 Cu XLPE cable are capable of achieving the required maximum power capacity of **74.4MW** when installed in the standard trefoil trench design under summer conditions. All other trench designs are capable of achieving this 74.4MW rating.

As part of the planning process, a number of service crossings have been identified on the route. The exact number of service crossings will need to be confirmed following site investigation works and during construction as the service information provided by the utilities is indicative only. The size and depth of the services to be crossed is not known at this stage and will be confirmed during construction. The 110kV ducting will cross the existing services using either an undercrossing trench design or an overcrossing trench design as to be determined during construction. Other services may be encountered on the route during construction.

It should be noted that any crossings or parallel runs with other underground cable MV/HV circuits may result in a derating of the Dyrick Hill Windfarm 110kV UGC. This derating effect will decrease the available loading capacity of the cable, no major cable crossing points or parallel runs have been identified as part of the design stage.

Appendix A – Standard 110kV Trench Trefoil Design (125mm Ducts)

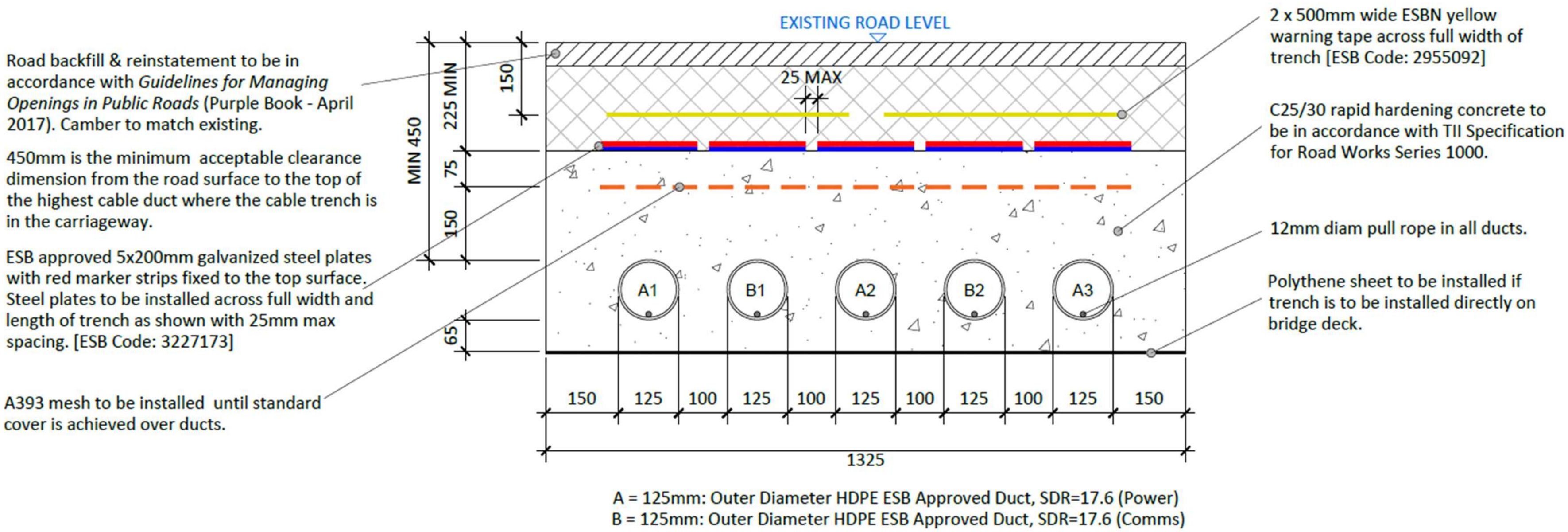
Reinstatement details based on Guidelines for Managing Openings in Public Roads - SD4



A = 125mm: Outer Diameter HDPE ESB Approved Duct, SDR=17.6 (Power) [ESB Code: 9317552]
B = 125mm: Outer Diameter HDPE ESB Approved Duct, SDR=17.6 (Comms) [ESB Code: 9317552]

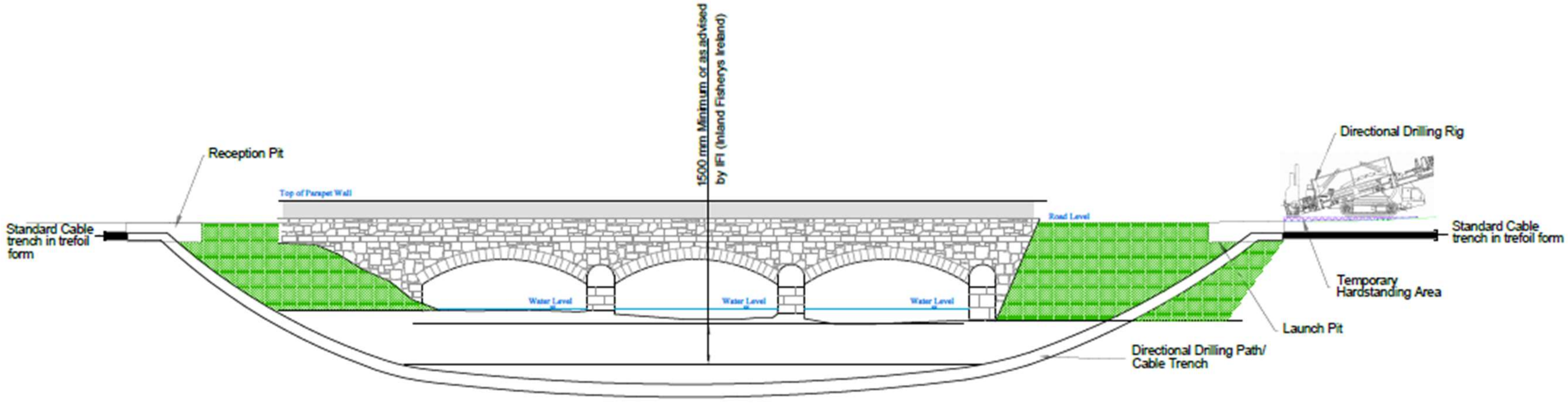
Typical Section Through Permanent Reinstatement of Longitudinal Opening in Roadway

Appendix B – Flat Formation 110kV Trench Design (125mm Ducts – 450mm Depth)

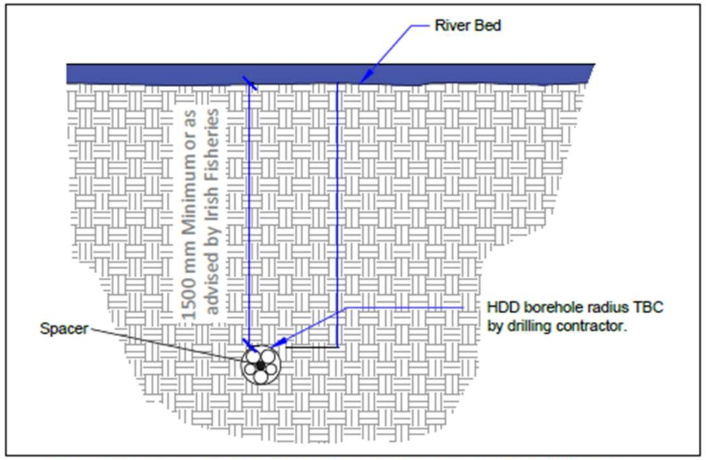


Typical Section Through Ducting in Flat Formation

Appendix C – HDD Trefoil Formation 110kV Trench Design (140mm Ducts – 3000mm Depth)



Typical Directional Drilling Bridge Crossing Detail - Cross Section



Typical Directional Drilling Water Crossing Detail-Longitudinal Section

Instruction:

Technical Lead: Ruairi Geary - TLI Group

Date of Writing: 02.09.2022

Scope of Note: Summary of cable pulling calculations check on pinch point sections within the UGC route.

Documents & Data Issued for Review: N/A

Details:

TLI Group (the Consultant) were engaged by EM Power (the Client) to identify and evaluate Cable Pulling Calculations from the proposed Dyrick Hill Windfarm Substation to the Dungarvan 110kV Substation for the proposed 110kV grid connection as part of the planning application process. The purpose of this Technical Note is to outline the calculations completed to ensure that the maximum pulling tension and side wall bearing pressure limits of the installed cable would not be exceeded during construction. These calculations were based on the current design, elevations and profile details for the UGC route recorded as part of the topographical survey.

The study area for these calculations were carried out between joint bays where potential pinch point sections could be encountered.

Coefficient of Friction considerations for Pulling of electroconductive cables have been incorporated in respect to cable manufactures parameters. These are as follows;

Material of Ducting:	*Greasing:*	*Outer Sheath PE*
HDPE	*Without*	*0.20*
	With	*0.15*

For the cable pulling calculations check it has been assumed that 110kV NKT 1000mm^2 Al XLPE Cable is to be installed for this project. The following pulling tension and side wall bearing pressure limits apply to this cable and have been used as part of the calculations:

Cable Type:	NKT 1000mm^2 AL XLPE (110kV)
Max Pulling Tension:	30 kN ≈ 30000 N ≈ 3059.15 kg (force)
Max Side Wall Bearing Pressure:	10 kN ≈ 10000 N ≈ 1001.97 kg (force) for Cables installed within ducts

These limits have been formulated, originating from cable manufacturers functional specifications **Appendix A, Mechanical Properties**. Max pulling tension and the max side wall bearing pressure can be derived from the unit conversion from kilo-newton meter (kN/m) to kilogram per meter units.

For calculation purposes applying the following: $\mathbf{1kN/m \approx 101.97\,kg/m}$

Section 1: *JB09 to JB10*

On review of the pinch point section highlighted between JB09 to JB10 section, the cable pulling study analysis found installing **NKT 1000mm² AL XLPE (110kV) UGC** from entry pit at JB09 and at JB10, the permissible pulling force exerted onto the cable for this prospective install resulted in approx. **5829.1N ≈ 5.8kN** which is within the manufactures specified limit of 30kN.

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **55.3N/m ≈ 0.553kN** and therefore within the specified manufactures limit of 10kN when pulled predominantly on an upward trajectory from JB09 to JB10.

On review of the section from entry at JB10 and exiting at JB09, the permissible pulling force exerted onto the cable was more efficient. The pulling tension value for this prospective install resulted in approx. **3973.2N ≈ 3.97kN**

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **3.4N/m ≈ 0.034kN** and therefore within the specified manufactures limit of 10kN when pulled from JB10 to JB09.

It is therefore recommended that this section of cable is pulled from Joint Bay 10 to JB09.

Section 2: *JB10 to JB11*

On review of the pinch point section highlighted within the JB10 to JB11, the cable pulling study analysis found installing **NKT 1000mm² AL XLPE (110kV) UGC** from entry pit at JB10 and exiting at JB11, the permissible pulling force exerted onto the cable for this prospective install resulted in approx. **3696N ≈ 3.7kN** which is within the manufactures specified limit of 30kN.

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **35.6N/m ≈ 0.36kN** and therefore within the specified manufactures limit of 10kN when pulled from JB10 to JB11.

On review of the section from entry at JB11 and exiting at JB10, the permissible pulling force exerted onto the cable was more efficient. The pulling tension value for this prospective install resulted in approx. **4082N/m ≈ 4.08kN**

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **73.4N/m ≈ 0.073kN** and therefore within the specified manufactures limit of 10kN when pulled from JB03 to JB02.

It is therefore recommended that this section of cable is pulled from Joint Bay 10 to Joint Bay 11.

Section 3: *JB12 to JB13*

On review of the pinch point section highlighted within JB12 to JB13 the cable pulling study analysis found installing **NKT 1000mm² AL XLPE (110kV) UGC** from entry pit at JB12 and exiting at JB13, the permissible pulling force exerted onto the cable for this prospective install resulted in approx. **5436.8N ≈ 5.4kN** which is within the manufactures specified limit of 30kN.

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **162.6 N/m ≈ 0.163kN** and therefore within the specified manufactures limit of 10kN when pulled from JB15 to JB16.

On review of the section from entry at JB16 and exiting at JB15, the permissible pulling force exerted onto the cable was more effective. The pulling tension value for this prospective install resulted in approx. **5332.4N ≈ 5.33kN**

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **69.2 N/m ≈ 0.07kN** and therefore within the specified manufactures limit of 10kN when pulled from JB16 to JB15.

It is therefore recommended that this section of cable is pulled from Joint Bay 12 to Joint Bay 13.

Section 4: *JB14 to JB15*

On review of the pinch point section highlighted within the JB14 to JB15 the cable pulling study analysis found installing **NKT 1000mm² AL XLPE (110kV) UGC** from entry pit at JB14 and exiting at JB15, the permissible pulling force exerted onto the cable for this prospective install resulted in approx. **2735.9N ≈ 2.74kN** which is within the manufactures specified limit of 30kN.

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **90.7 N/m ≈ 0.091kN** and therefore within the specified manufactures limit of 10kN when pulled from JB20 to JB21.

On review of the section from entry at JB15 and exiting at JB14, the permissible pulling force exerted onto the cable was less effective. The pulling tension value for this prospective install resulted in approx. **4075.2N ≈ 4.1kN**

The cable pulling study finding for the maximum permissible sidewall force allowable was found to be satisfactory with approx. **22.1 N/m ≈ 0.02kN** and therefore within the specified manufactures limit of 10kN when pulled from JB21 to JB20.

It is therefore recommended that this section of cable is pulled from Joint Bay 14 to Joint Bay 15.

Appendix A – Functional Cable Specification

Item	Query	Unit	Reply
1	Conductor: (a) Material (b) Type e.g. round, etc. (c) Design e.g. stranded, segmental etc. (d) Nominal diameter (e) Cross-sectional area (f) Method of water blocking	 mm mm^2	 aluminium round stranded, compacted 38,9 1000 swelling yarns and/or swelling tapes
2	Inner Semi-conducting Layer: (a) Material Grade (b) Nominal Thickness (c) Minimum Thickness	 mm mm	 XLPE 1,1 0,7
3	Insulation: (a) Material Grade (b) Nominal thickness ;12-13 mm required (c) Minimum thickness (d) Ovality of insulation layer ≤ 10%	 mm mm	 XLPE 12,0 10,8 less 10%
4	Outer Semi-conducting Layer: (a) Material Grade (b) Thickness (c) Minimum thickness	 mm mm	 0,9 0,7
5	Nominal diameter over cable core	mm	67
	Roundness of cable core ; maximum ovality < 0.7 mm	mm	max. 0,7
6	Radial thickness of insulation and semi-conducting layers (a) Nominal (b) Minimum	 mm mm	 14,0 12,2
7	Bedding Layer/Water Barrier (a) Material (b) Thickness (c) OD of bedding layer (d) Method of electrical connection between 4 and 8 (e) Method of water blocking	 mm mm	 semiconducting and swellable tapes 2,0 72 semiconducting and swellable tapes semiconducting and swellable tapes
8	Metallic Sheath: (a) Material (b) Type, corrugated or smooth (c) Nominal thickness (d) Mean diameter (e) Cross-sectional area (f) Diameter over crest of corrugations (g) OD of sheath if not corrugated (h) Diameter and no. of extra copper wires required to ensure short circuit performance of cable meets Specification 18080 (if needed)	 mm mm mm^2 mm mm	 aluminium smooth 1,6 74 393 n. a. 76 n. a.
9	Outer MDPE/HDPE Sheath (a) Material (b) Nominal thickness (c) Minimum thickness	 mm mm	 HD PE 3,6 2,96
	(d) Shore D hardness		appr. 58
	(e) Shrinkage %		max. 3%
10	Nominal diameter of completed cable including thickness of any conductive outer layer	mm	84
11	Conductive Outer Sheath Layer (a) Material Type (b) Thickness (c) Extruded Layer Surface resistivity (d) Graphite Layer Surface Resistivity (e) Coefficient of friction of cable based on sidewall force equal (a) for graphite layer (b) extruded outer conductive layer	 mm KOhm/m KOhm/m	 graphite max. 16 kOhm/m - (b): n.a. here (a): in PE tube: 0,2 in PE tube, greased: 0,1… 0,2
	Coefficient of Friction based on 5000N/m sidewall force at bends (static and dynamic) (a) for graphite layer (b) for extruded outer conductive layer		 (b): n.a. here (a): in PE tube: 0,2 in PE tube, greased: 0,1… 0,2
12	(a) Normal length per drum (b) Maximum length per drum	 m	1000 m at drum diameter 3,4 m x width 2,2 m (p. ex.) tbd
13	(a) Normal gross weight of loaded drum (b) Maximum gross weight of loaded drum	kg kg	9300 tbd
14	Maximum drum dimensions width/height Minimum drum barrel dimension	 m	3,7 m width x 4,3 m height

Item	Query	Unit	Reply
15	Minimum radius of bend around which cable can be pulled		
	(a) Laid Direct	m	2,1
	(b) In ducts	m	2,1
	(c) Cable placed in position with former	m	1,25
	(d) Cable placed in position without former	m	2,1
16	Permissible pulling force allowed on conductors during installation	kN	30
17	Maximum permissible sidewall forces	kN	10