moray offshore renewables ltd

Environmental Statement

Technical Appendix 4.3 D - Electromagnetic Fields Modelling

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1.0 Introduction

The following report has been produced in support of the assessment of the potential effect of electro-magnetic fields (EMFs) on fish and shellfish ecology and includes an estimate of the magnetic fields expected to be produced by the cabling of the three wind farm sites and the offshore transmission infrastructure (OfTI) during the operational phase. The assessment of the likely effect of EMFs on fish and shellfish species is provided for the three wind farm sites and the OfTI in Chapter 7.2 and Chapter 10.2 respectively.

A number of species of conservation and commercial importance which are sensitive to EMFs are known to be present in the Moray Firth. Concerns were raised during consultation with relevant stakeholders in relation to the potential for EMFs to result in adverse effects on these species, particularly in the case of salmon and sea trout, for which little research in terms of the implications of potential behavioural EMF related effects has been undertaken to date. It should be noted that Marine Scotland Science (MSS) is currently undertaking research into the potential effects of EMF. An outline of the methodology of MSS current research is given in Annex 01 at the end of this document.

2.0 Methodology

Based on available reference information TNEI calculated and plotted both the HVDC and AC magnetic field magnitudes and the predicted compass deviation due to HVDC cables.

2.1 Assumptions

The calculations undertaken take account of the following assumptions:

- **DC Magnetic Fields (Export Cables)**
  - 2 x 750MW ±320kV HVDC links
  - Cables installed close-laid (touching)
  - Burial depth of 1m and 0.25m (under rock placement)
  - The two links are independent and thus do not impact on each other
  - The Earth's Magnetic field is excluded
- **Compass Deviation (Export Cables)**
  - The calculations assume the worst case condition of the cable running (Magnetic) North to South
  - The Earth's Magnetic field is assumed to be 50MicroTesla.
- **AC Magnetic Fields (Inter Array and OSPs Cables)**
  - AC cables are carrying rated power
    - 33kV AC cables are 630mm^2 and rated at 715A
    - 66kV AC cables are 630mm^2 and rated at 715A
    - 220KV 800mm^2 are rated at 775A
    - 220KV 300mm^2 are rated at 525A
  - Cable burial depth is 1m
  - AC Magnitude values are Peak not RMS

APPENDIX 4.3 D

2.2 Calculations

The electromagnetic field (B) generated by a single conductor was derived from Biot-Savarts Law as:

$$B = \frac{\mu I}{2\pi l}$$

Where l = the distance from the centre of the conductor

The magnetic field surrounding 2 core (DC) and 3 core (AC) was calculated by the superposition of fields due to single conductors.

2.3 References

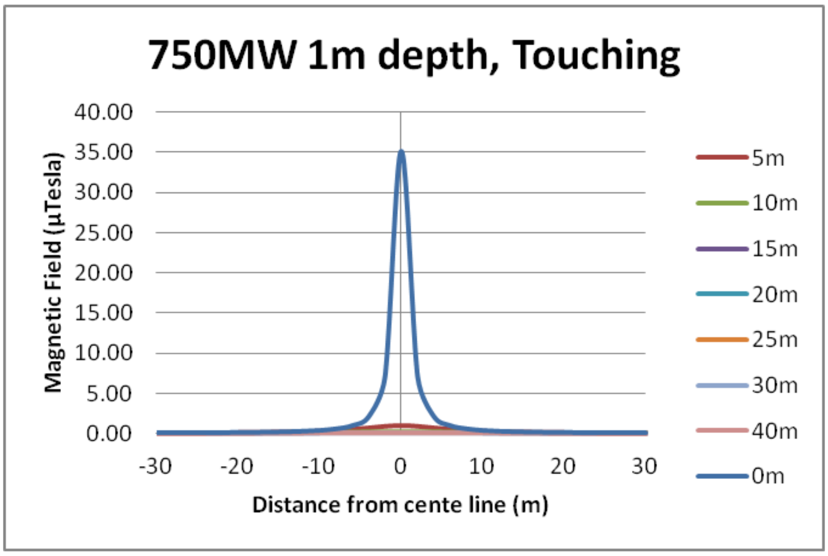
- Cowrie-EMF-01-2002 – A baseline assessment of electromagnetic fields generated by offshore windfarms (July 2003).
- Cowrie-EM FIELD – COWRIE 1.5 Electromagnetic fields review (July 2005).
- OWET – Electromagnetic field study. The study of electromagnetic fields generated by submarine power cables (September 2010).
- BOEMRE – Effects of EMFs from undersea power cables on elasmobranchs and other marine species (September 2011).

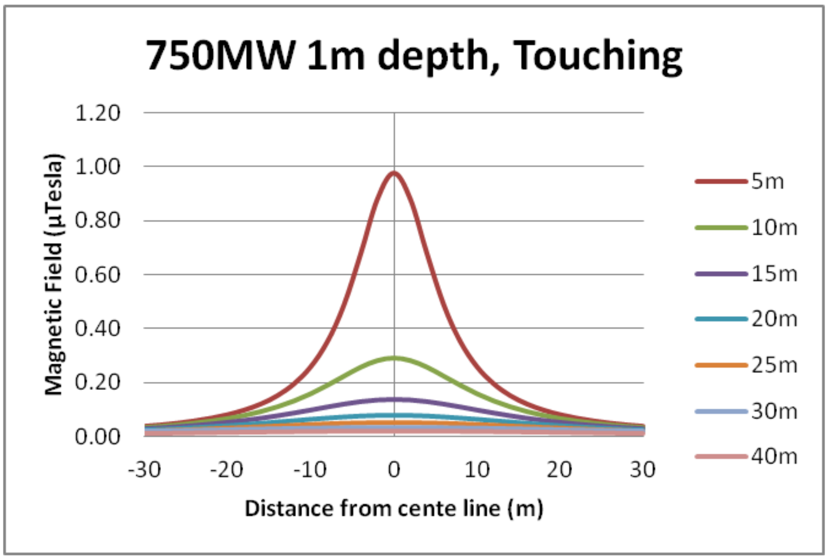
3.0 Modelling Results

The outputs of the modelling undertaken for HVDC export cables and AC inter-array and inter-platform cables are given below in Figure 3.1 to Figure 3.8:

- Figure 3.1 and Figure 3.2 show the predicted magnetic field produced by HVDC export cables assuming cable burial (1m) and protection (0.25 m under rock placement), respectively.
- Figure 3.3 and Figure 3.4 show the predicted compass deviation (degrees) expected from HVDC cables assuming cable burial (1m) and cable protection (0.25 m under rock placement).
- Figure 3.7 and Figure 3.8 show the predicted magnetic field produced by 33kV and 66kV AC inter-array cables assuming 1m burial.
- Figure 3.5 to Figure 3.6 show the predicted magnetic field produced by 800mm^2 and 300mm^2 220 kV AC inter-platform cables assuming 1m burial

In each of the figures below, the x axis indicates distance from the cable centre and the y axis Magnetic field strength in MicroTesla (10^{-6} Tesla) or compass deviation (degrees). Each plot shows multiple levels above the seabed (0, 5, 10, 15, 20, 25, 30 and 40m for DC cables and 0, 5, 10, 15, 20 and 25m for AC cables).





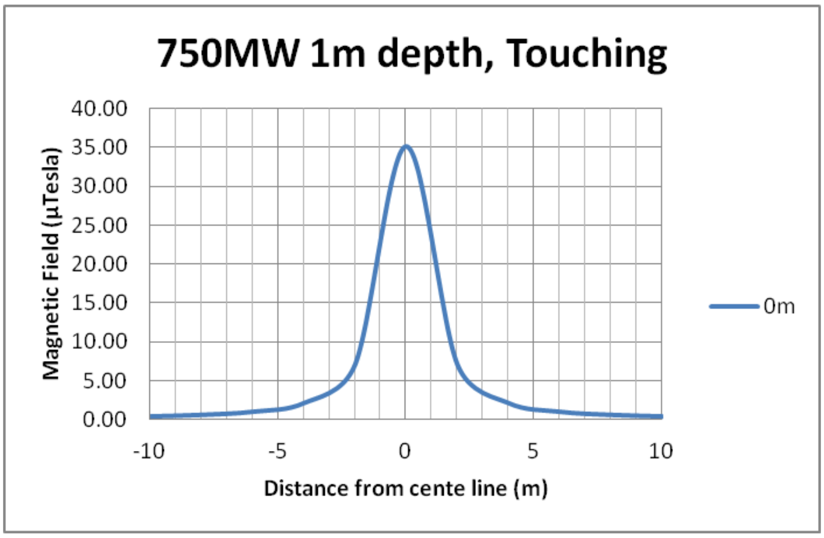


Figure 3.1 Magnetic field expected from HVDC Export Cables (bundled) assuming 1m burial

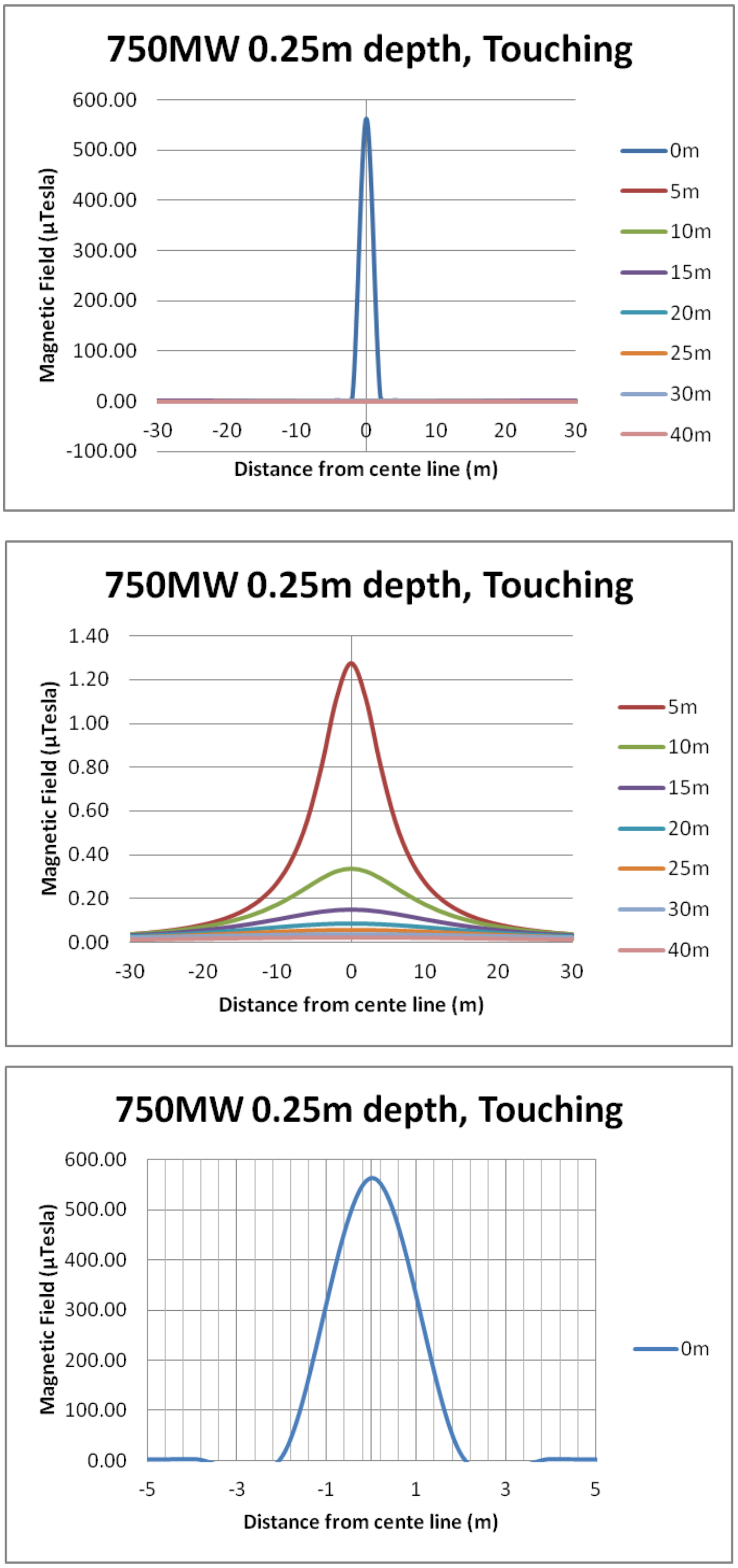


Figure 3.2 Magnetic field expected from HVDC Export Cables (bundled) cable protection (0.25 m under rock placement)

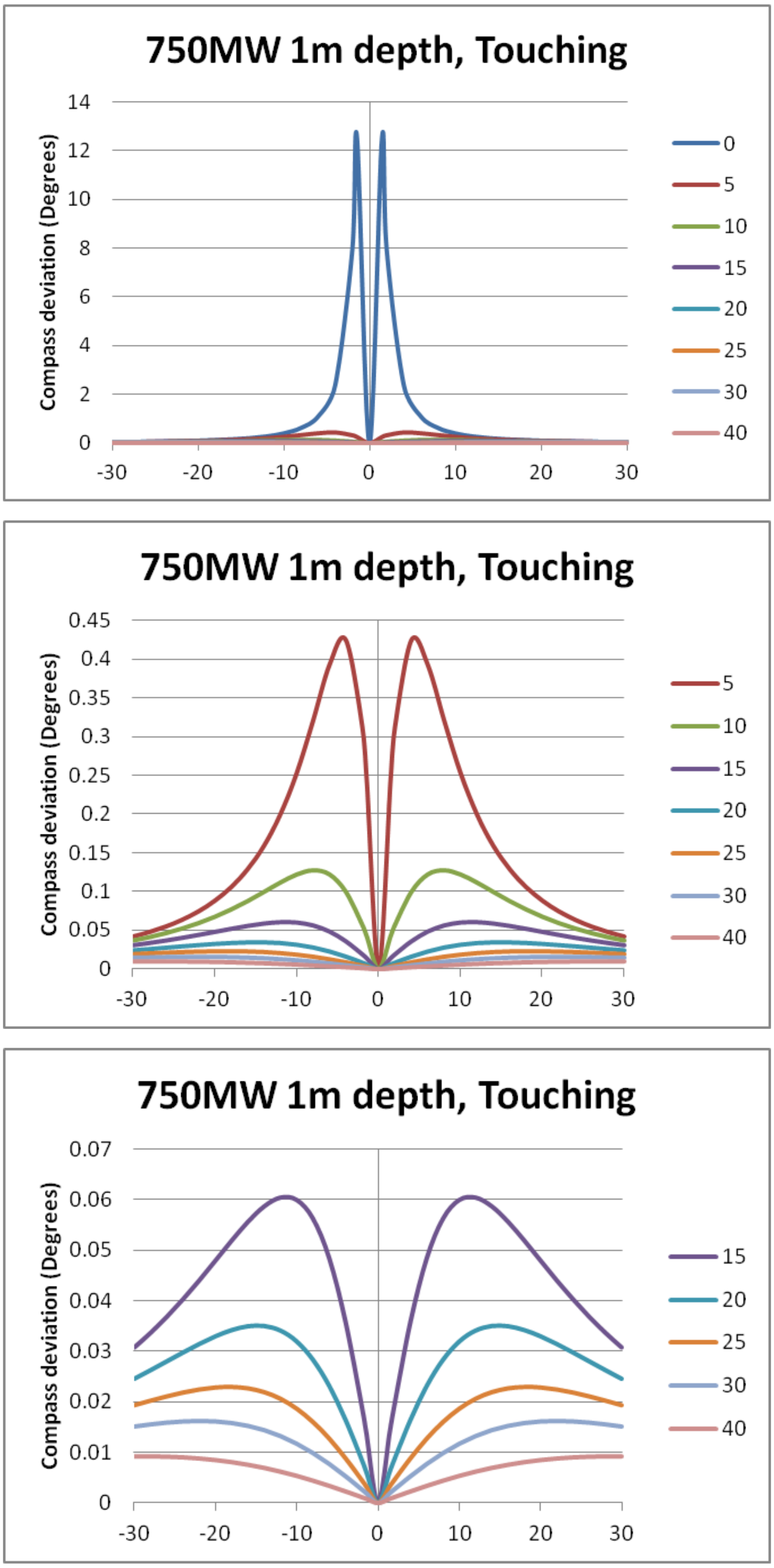


Figure 3.3 Compass Deviation calculated for HVDC Export Cables (bundled) assuming 1m burial

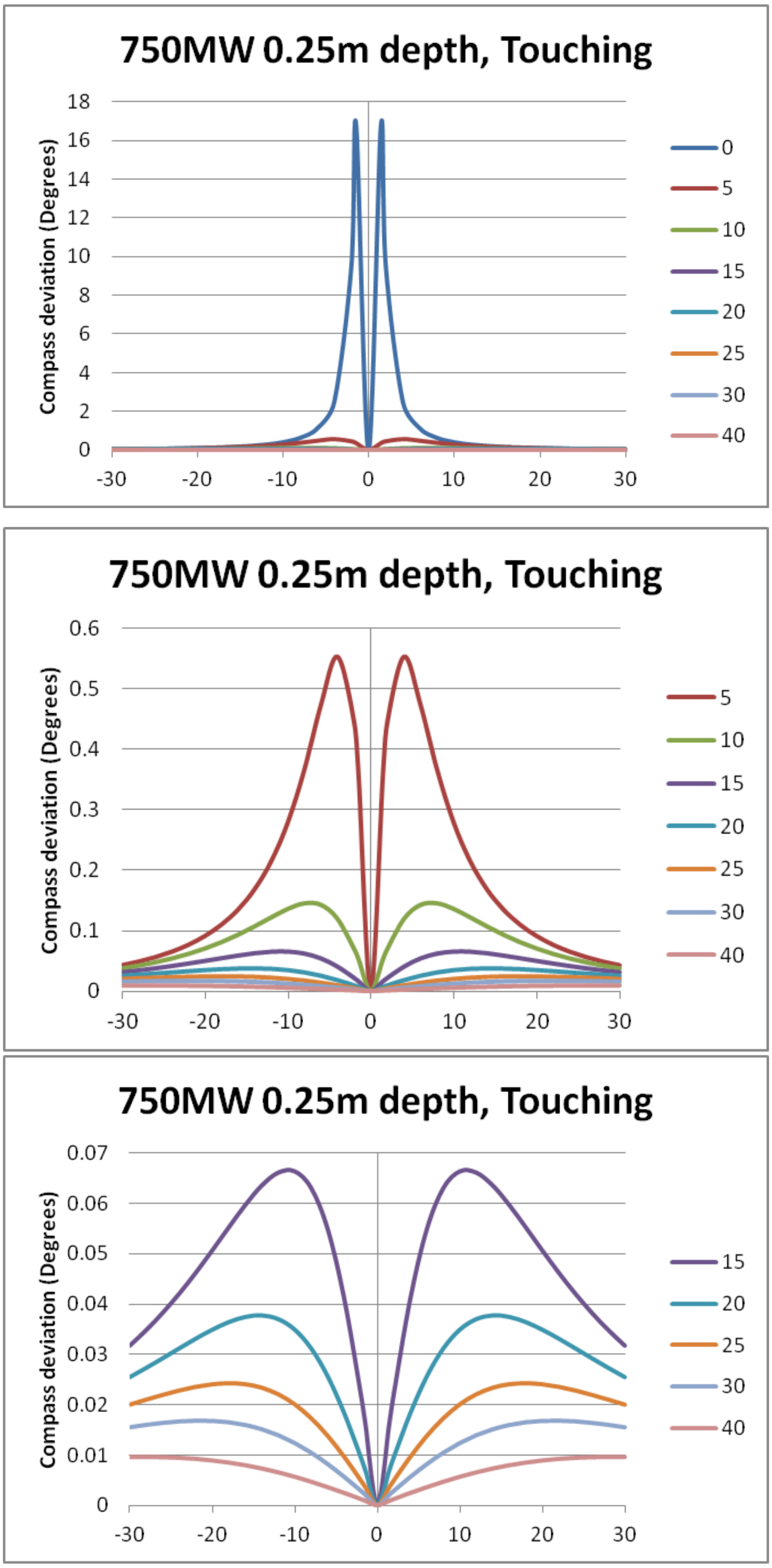


Figure 3.4 Compass Deviation calculated for HVDC Export Cables (bundled) cable protection (0.25m under rock placement)

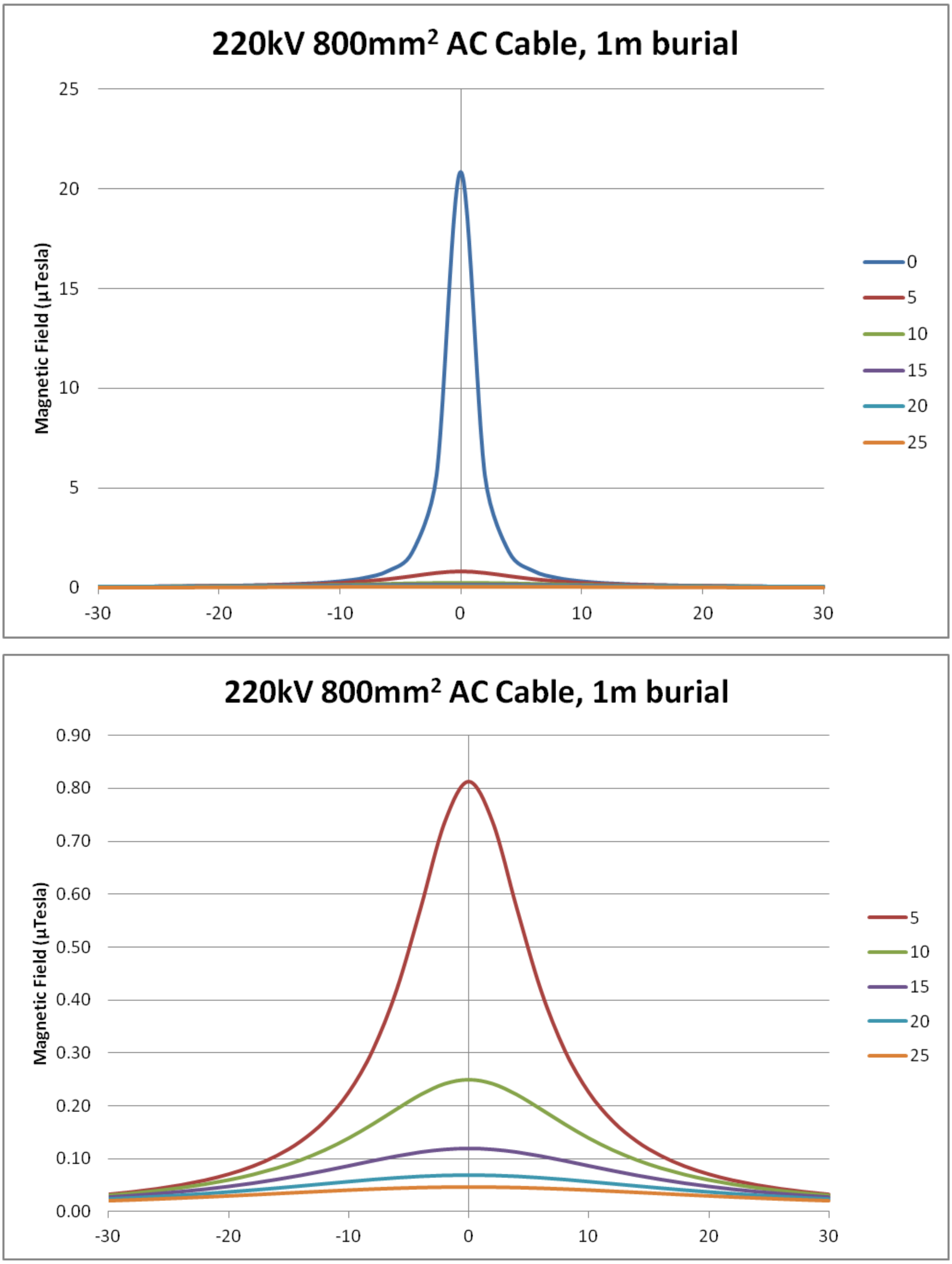
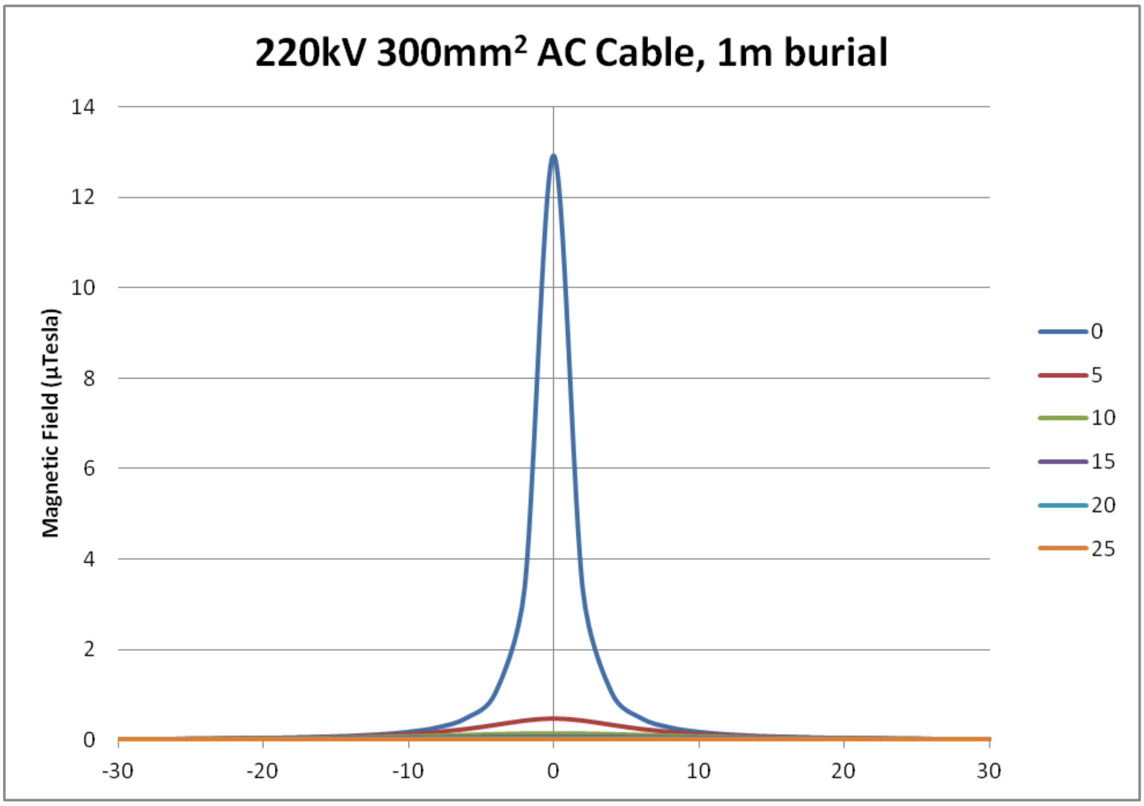


Figure 3.5 Magnetic field expected from 800mm² AC 220 kV inter-platform cables assuming 1m burial

APPENDIX 4.3 D



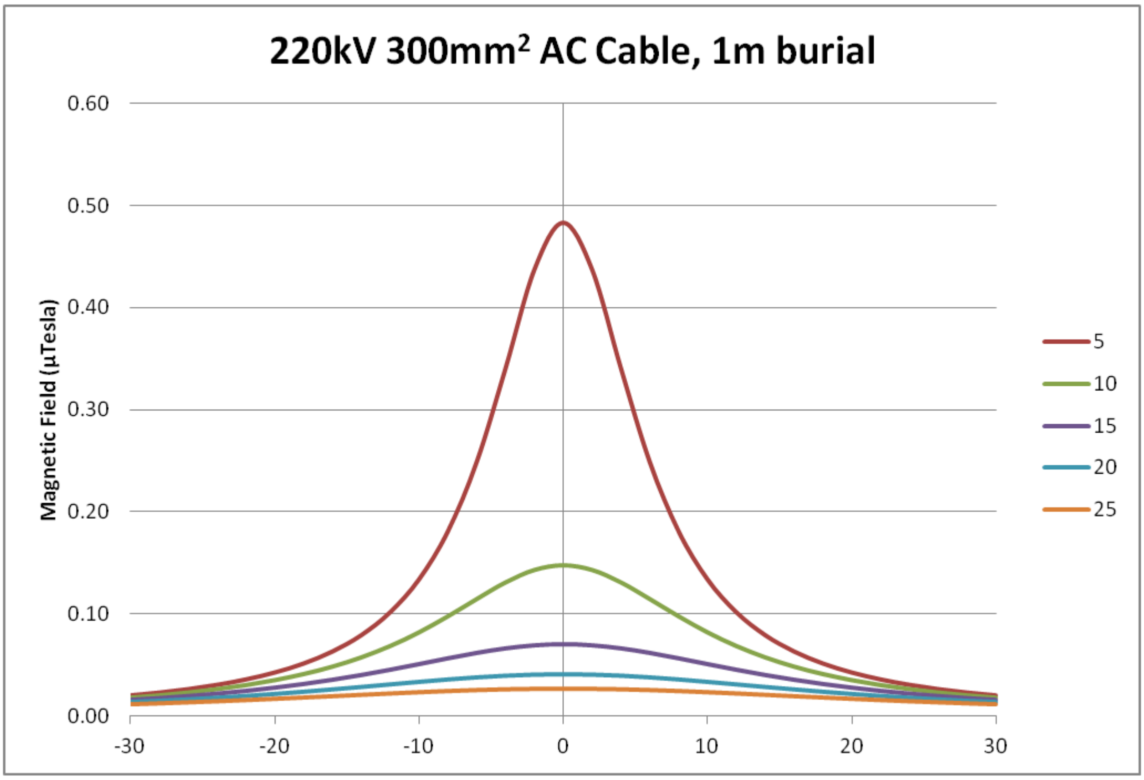
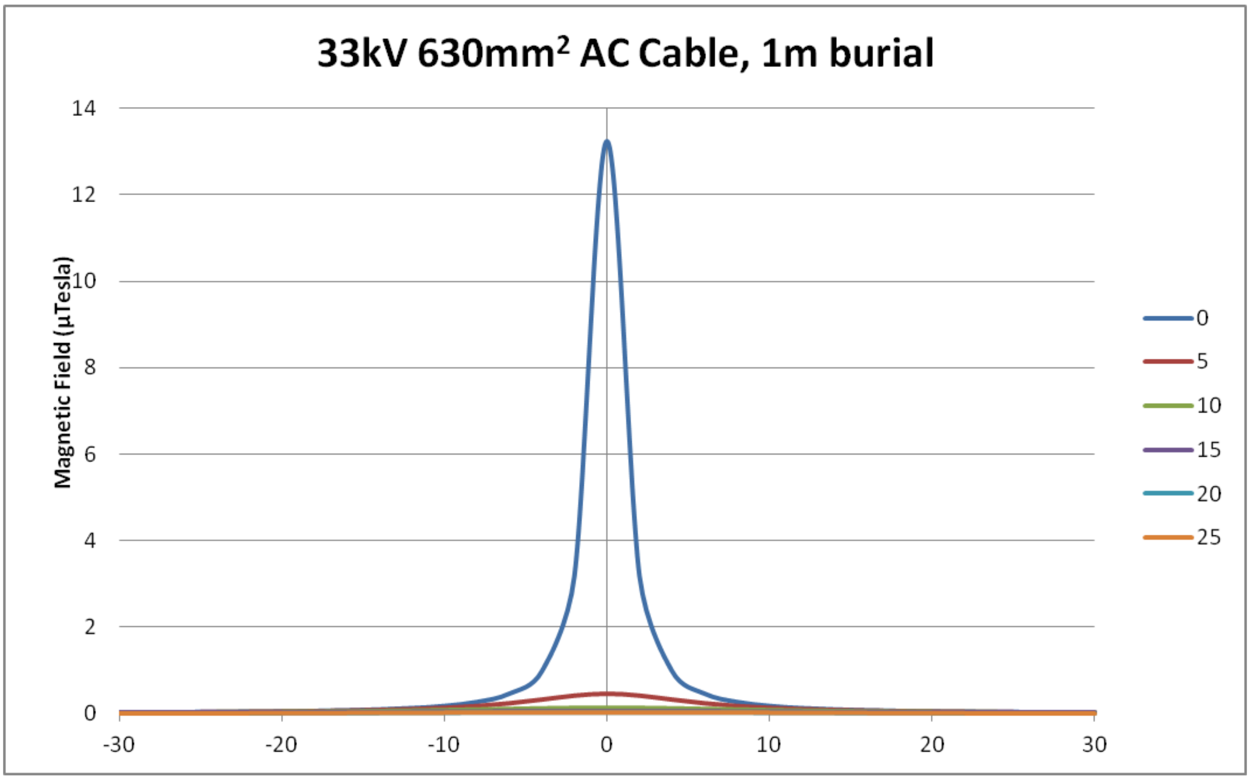


Figure 3.6 Magnetic field expected from 300mm² AC 220 kV OSP cables assuming 1m burial



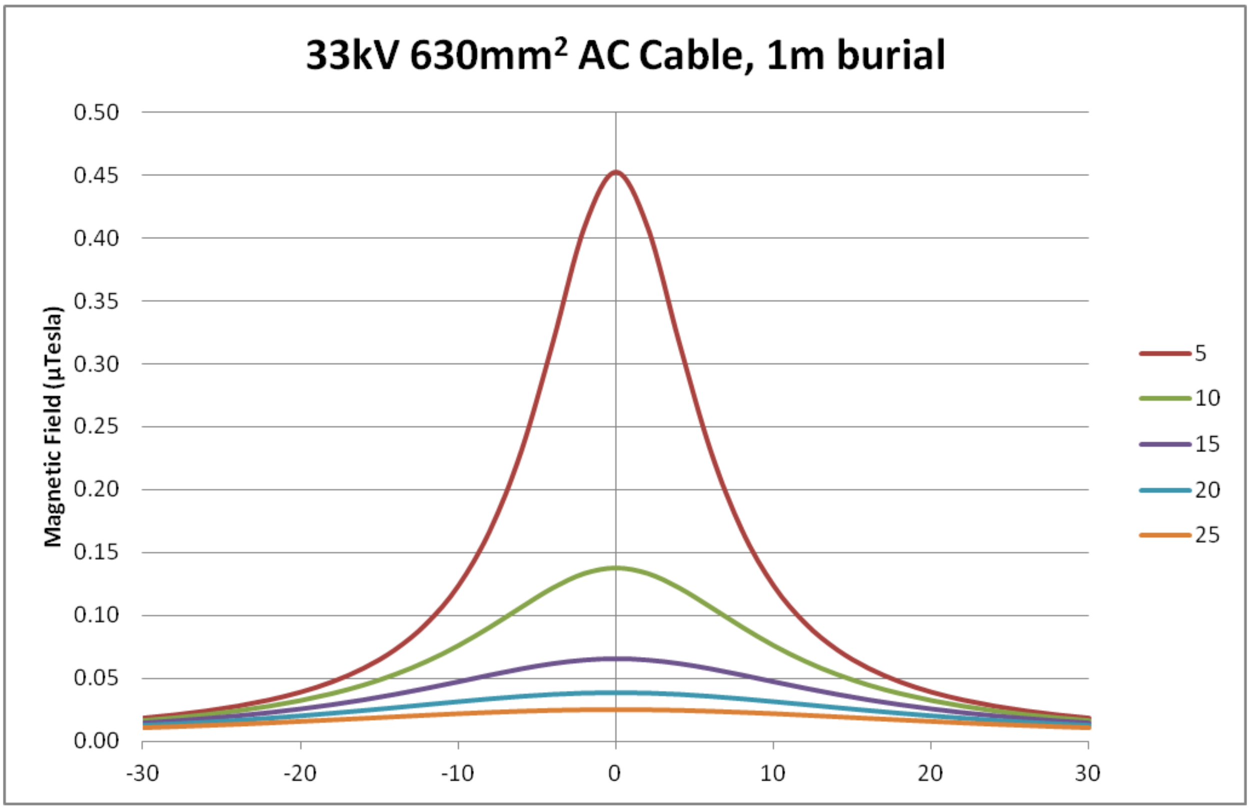
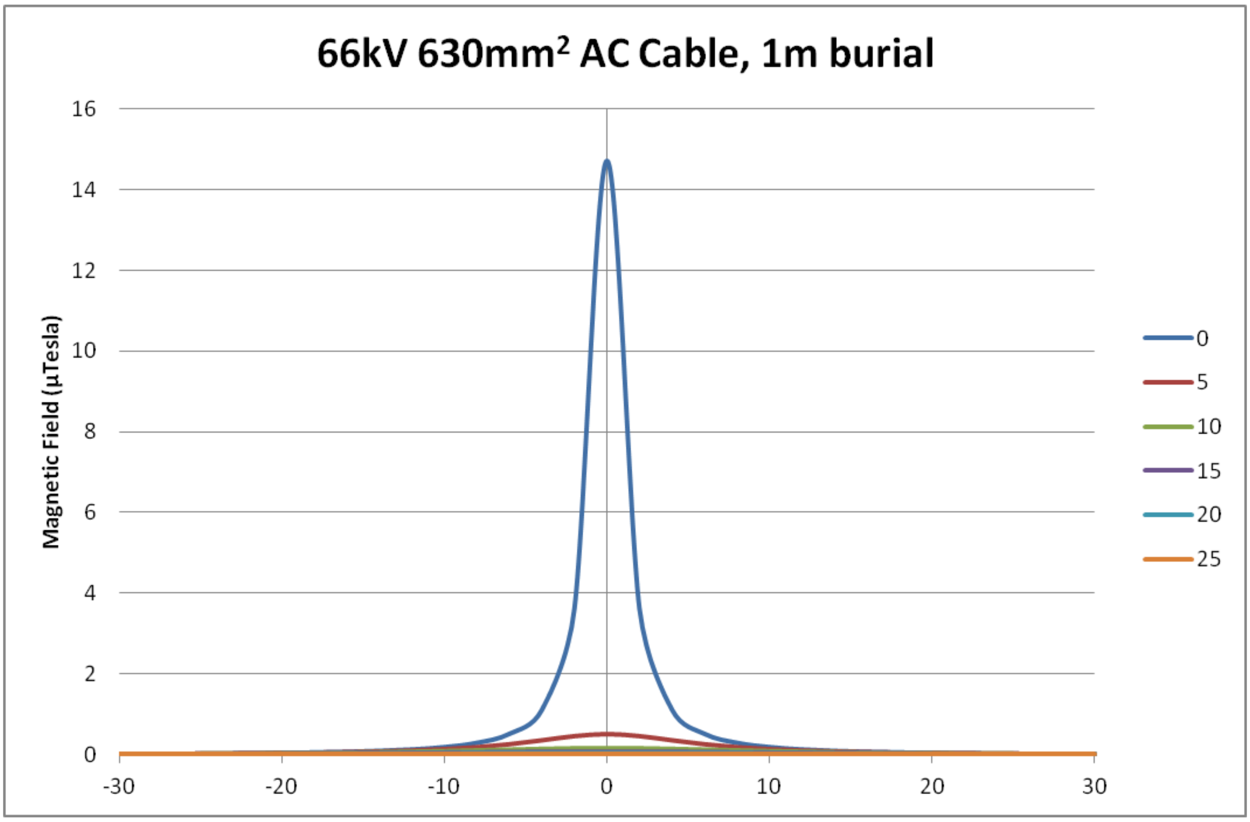


Figure 3.7 Magnetic field expected from 33kV inter-array cables assuming 1m burial



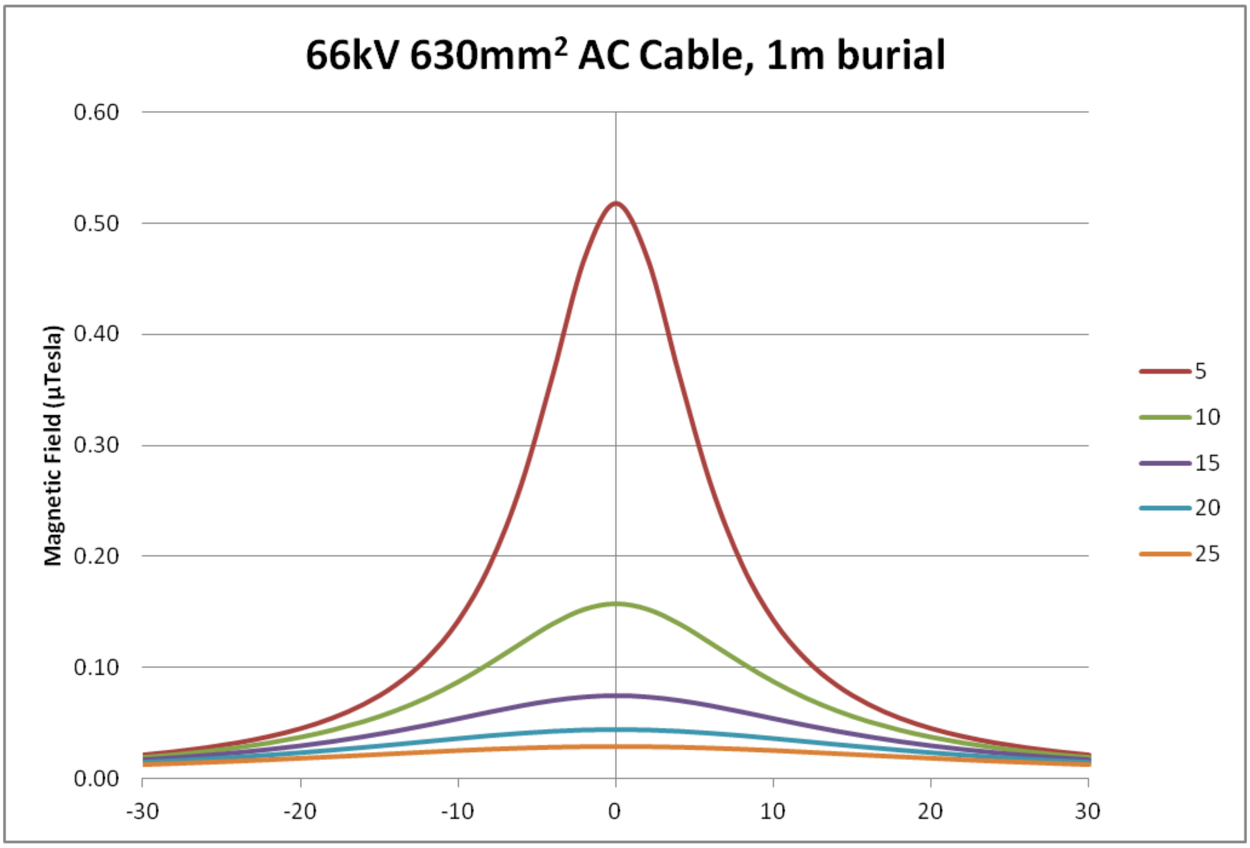


Figure 3.8 Magnetic field expected from 66 kV inter-array cables assuming 1m burial

4.0 Discussion

The highest magnetic fields are expected from the DC export cables. These will reach a maximum of approx. 35 μT at the seabed assuming 1 m burial (Figure 3.1 and Figure 3.2) and a maximum of approx. 560 μT at the seabed assuming cable protection (under 0.25 m of rock placement). As indicated in the Rochdale Envelope, it is planned to install a bundle of two export cables per trench. The two bundles would be separated by approximately 4 times water depth. For 80 km of the 105 km length of the offshore export cables route, it is expected that cables will be buried to a target depth of 1 m. As a result, the magnitude of the magnetic field associated to DC cables in approximately 80 km of the export cables route would be expected to be as shown in Figure 3.1 (where burial to 1 m has been assumed). The seabed in a 24 km section of the export cables route leading to shore contains areas of rock at, or close to, the surface, which is unsuitable for burial and cables will therefore have to be laid on the seabed. Where this is the case, cables will be protected by graded rock placement, concrete mattresses or other suitable protective coverings. Over this 24 km section, it is anticipated that only between 5 and 19 km may require such protection, the rest will be buried. It will be within this smaller section that the magnetic fields produced by export cables would be expected to be as shown in Figure 3.2 (where protection under 0.25 m of rock placement has been assumed).

For both buried and protected DC cables the magnetic field will decrease exponentially with vertical distance from the seabed (the magnetic field 5 m from the seabed is expected to be reduced to approx. 1 μT and 1.25 μT assuming cable burial and cable protection respectively). Similarly, the magnetic field will decrease rapidly with horizontal distance from the cables (within a few metres), whether cables are buried or protected.

As shown in Figure 3.3 and Figure 3.4 the compass deviation (degrees) expected from DC cables calculated assuming cable burial and protection respectively, will also decrease rapidly with vertical and horizontal distance from the cables (within a few metres).

Magnetic fields generated by inter-platform AC cables are expected to reach a maximum value at the seabed of approximately 21 μT for 800 mm^2 cables and 13 μT for 300 mm^2 cables (assuming cable burial to 1 m). As described above for DC cables, an exponential reduction in the strength of the magnetic field is also expected with distance from the seabed (reduced to approximately 0.80 μT and 0.50 μT within 5 m from the seabed for 800 mm^2 and 300 mm^2 respectively) and horizontally with distance from the cable (within a few metres).

Similarly, in the case of AC inter array cables., a significant reduction in the strength of the magnetic field is expected to occur within 5 m from the seabed for both 33 kV and 66 kV cables. The levels expected at the seabed are comparatively small (approximately 13 μT and 15 μT for 33 kV and 66 kV cables respectively) assuming cable burial to 1 m. As previously described for DC and inter-platform cables, in this case, the predicted magnetic fields are also expected to rapidly decrease horizontally with distance from the cable (within a few metres).

As shown above, the magnetic field produced by the proposed DC and AC cables will decrease rapidly both vertically and horizontally. In all cases, where cables are buried to 1 m depth, the predicted magnetic field is expected to be below the earth's magnetic field (assumed to be 50 μT). Where DC cables cannot be buried and are instead protected, the magnetic field is expected be below the earth's magnetic field within 5 m from the seabed.

Annex 01: Marine Scotland Science EMF Research

An EMF generating system as a tool for investigating the behavioural responses of migratory fishes to EMFs

An EMF generating system based on Helmholtz coils has been developed by Marine Scotland Science as a tool for investigating the behavioural responses of migratory fishes to magnetic fields associated with alternating currents. It consists of four pairs of Helmholtz coils used to create four channels through which fish can swim in a toroidal tank. The strength of the generated EMF emitted by the coils is varied by altering the input between 1/16 V AC and 8 V AC, generating an EMF strength which can range from < 1 μT to nearly 100 μT. The relative strength of the EMF according to position within the channel is made for calibration purposes at the time of installation. Fish behaviour is recorded using underwater and overhead video cameras. The system has been tested with a small number of European eels Anguilla anguilla. Trials will be conducted on Atlantic salmon Salmo salar smolts and eels during the coming year. No results are available yet.

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