Chapter 22
Electromagnetic Effects and Stray Current

CONTENTS

22. ELECTROMAGNETIC COMPATIBILITY AND STRAY CURRENT

22.1 Introduction

In this Chapter of the Environmental Impact Assessment Report (EIAR), the potential impacts of Electromagnetic Fields (EMFs) associated with the DART+ Coastal North project ("the Proposed Development") (in particular, the electrification works) are outlined and evaluated. Of particular relevance to this topic, the DART+ Coastal North project comprises circa 38km of electrification of the railway line from Malahide to Drogheda, in direct current, (DC) to cater for Battery Electric Multiple Units (BEMUs) and Electric Multiple Units (EMUs) as well as associated signalling and telecommunications works.

This project also interfaces with DART+ West, with the DART+ Coastal North package of work commencing at East Wall Junction (Tolka River) to the north of Connolly Station.

22.1.1 Basis of Electromagnetic Fields

EMFs are present in both natural geomagnetic fields and in areas where electricity is generated, distributed, or consumed. This includes railway traction systems, power lines, and electrical and electronic equipment. Additionally, intentional generation of EMFs occurs through radiocommunication systems. The implementation of the electrification programme for DART+ Coastal North trains and infrastructure will contribute to the existing levels of EMFs already generated by various man-made sources in the vicinity.

EMFs manifest as self-propagating waves in the air, comprising electric and magnetic field components that oscillate in perpendicular phases to each other and to the direction of energy propagation. These fields are commonly referred to as electromagnetic radiation and are categorized into different types based on their wave frequency. This classification, which forms the electromagnetic spectrum is depicted in Image 22-1.

The electromagnetic spectrum encompasses an extensive range of frequencies, and various aspects of it are encountered in everyday life. Ranging from lower to higher frequencies (and longer to shorter wavelengths), some familiar types of electromagnetic radiation include radio waves, microwaves, terahertz radiation, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. An EMF carries energy from its source, which can be transferred to another entity.

At lower frequencies, the electric and magnetic fields can be regarded as separate entities, each generated and functioning independently. The electric field is connected to the voltage of a source, while the magnetic field is associated with the flow of current (moving charges).

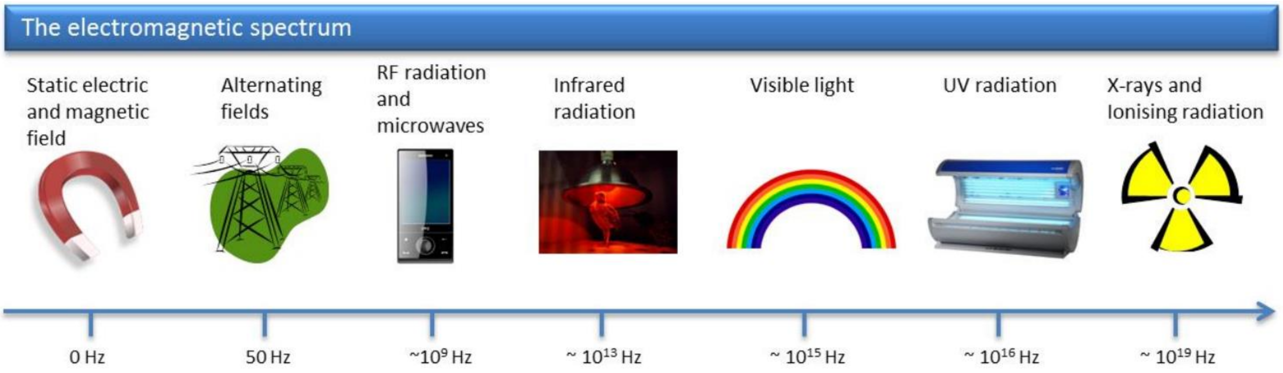

Image 22-1 The Electromagnetic Spectrum.

22.1.2 Electromagnetic Interference to Electrical Equipment

Electromagnetic Interference (EMI) refers to the undesired disruption caused by electromagnetic fields, such as magnetic fields, electric fields, or electromagnetic radiation. This interference can adversely affect the proper functioning of electrical systems and electronic equipment.

The existing environment contains various sources of electromagnetic fields (EMF), including but not limited to electrical equipment, power lines, telephone lines, signals from telecommunications masts (such as mobile phones and radio), underground communication cables, electrified trains, and broadcast transmitters. These emissions from different sources combine to create the current electromagnetic environment (EME) in a specific area or location.

The electromagnetic spectrum is utilized by numerous services such as television broadcasts, mobile phones, satellite communications, and radar systems. The allocation of spectrum segments to different services and the regulation of unintentional emissions are governed by EU Directives and National Regulations. Consequently, all equipment, including rail systems, that enters the EU market must adhere to strict emission and immunity limits.

Electromagnetic Compatibility (EMC) is an engineering discipline focused on ensuring that electrical and electronic equipment operates normally in its intended environment without causing intolerable electromagnetic disturbances or being adversely affected by existing levels of EMI. Achieving EMC requires considering three key aspects when modifying a system:

- Emissions: The generation of electromagnetic energy, whether intentional or unintentional, by a source is known as emissions. It may be necessary to implement countermeasures to minimize energy generation or prevent its escape into the external environment;
- Susceptibility or immunity: The ability of electrical equipment, referred to as receptors, to function as intended in the presence of a certain level of EMF is known as immunity or susceptibility. The equipment's immunity level must be considered to ensure proper operation;
- Coupling path considerations: The path through which EMFs propagate from their source to a receptor can be classified into different types:
  - Conductive: involves a direct electrical connection that allows the flow of current, potentially through the ground.
  - Capacitive/inductive: refers to localized interactions between the electric or magnetic fields of the source and the receptor at low frequencies.

- Radiative: involves long-range coupling through the propagation of electromagnetic waves (radiation).

The proposed DART+ Programme (of which the DART+ Coastal North project is part) aims to implement an electrified rail system operating on a 1500 V DC power supply. This system is designed to complement the existing DART network. Traction power for the trains will be supplied through Overhead Line Equipment (OHLE). It is important to note that the construction and operation of this new system has the potential to impact the existing electromagnetic environment (EME) and may cause disruptions to sensitive and safety-critical equipment across various frequency ranges. The potential sources of Electromagnetic Interference (EMI) from the Proposed Development include:

- Direct current (DC) fields and quasi-DC fields (considered frequencies below 1Hz) produced by the circulating current in the OHLE conductors;
- Alternating current (AC) fields generated by the electricity drawn from the Electricity Supply Board (ESB) to power the electrical equipment at stations, traction substations and other facilities (such as Signalling Equipment Buildings);
- Radiofrequency fields intentionally generated by communication systems and unintentionally produced as a by-product of the operation of electrical and electronic systems, such as train drive systems and signalling systems.

From an EMI perspective, however, the most crucial aspect of the traction supply is the current loading of the line as it tends to be the magnetic fields of these systems (as opposed to electric fields) that create the largest potential impacts.

It is important to consider stray DC currents that may deviate from their intended return path through the rails and instead flow through the ground and nearby metallic structures. These currents have the potential to cause corrosion in the structures and may result in damage or disruption to the operation of electrical equipment. Structures at risk typically include large conductive systems like utility pipes or cables that run in close proximity and parallel to the railway track.

22.1.3 Electromagnetic Exposure of People

Highly localised, strong electromagnetic fields (EMFs) can have short-term effects on human health. EMFs with frequencies below 300 GHz, found in the non-ionizing radiation range, lack sufficient energy to dislodge electrons from atomic structures like ionizing radiation such as gamma-rays and X-rays. Adverse health effects associated with non-ionizing EMFs are generally divided into two categories: non-thermal effects (below approximately 10 MHz) and thermal effects (above 100 kHz), with an intermediate range from 100 kHz to 10 MHz where both types of effects can occur. The impact of EMFs is predominantly observed in buildings and areas immediately adjacent to high voltage traction power distribution equipment, electricity substations, and transformers. These locations are at the highest risk of being influenced by EMF exposure.

22.1.4 Receptors of Electromagnetic Fields

The assessment took into account the following potentially sensitive receptors for EMFs:

- Local residents and the community;
- Domestic and industrial electrical equipment;
- Telecommunications infrastructure (including wireless radio services);

- Sensitive medical and research equipment;
- Utilities; and
- Mainline rail, suburban rail and light rail systems.

22.2 Legislation, Policy and Guidance

22.2.1 Legislation

The Transport (Railway Infrastructure) Act 2001 (as amended) provides for the making of a Railway Order application by Córas Iompair Éireann ("CIÉ") to An Bord Pleanála. The European Union (Railway Orders) (Environmental Impact Assessment) (Amendment) Regulations 2021 (S.I. No. 743 of 2021) gives further effect to the transposition of the EIA Directive (EU Directive 2011/92/EU as amended by Directive 2014/52/EU) on the assessment of the effects of certain public and private projects on the environment by amending the Transport (Railway Infrastructure) Act 2001 ('the 2001 Act'). The 2001 Act as amended (including by Statutory Instrument No. 743 of 2021) at Section 37 requires, inter alia, that the application be made in writing and be accompanied by:

- A draft of the proposed Railway Order;
- A plan of the proposed railway works;
- A book of reference to a plan describing the works which indicates the identity of the owners and of the occupiers of the lands described in the Plan; and
- A report on the likely effects on the environment of the proposed railway works.

A report of the likely effects on the environment of the proposed railway works is addressed by the preparation of this Environmental Impact Assessment Report (EIAR) (previously referred to as an Environmental Impact Statement in section 39 of the 2001 Act prior to the amendments effected by S.I. No. 743/2021). As mentioned, this EIAR is based on a coordinated approach in order to facilitate An Bord Pleanála carrying out a coordinated assessment with any assessment under Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora ("the Habitats Directive") or Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds ("the Birds Directive").

By virtue of Section 38 of the 2001 Act the development the subject matter of a Railway Order is deemed to be exempted development (under the Planning and Development Act 2000 (as amended)) and the provisions of Part IV of the Planning and Development Act 2000 are disapplied where the works involved are authorised by a Railway Order.

An examination, analysis and evaluation is carried out by An Bord Pleanála in order to identify, describe and assess, in the light of each individual case, the direct and indirect significant effects of the proposed railway works, including significant effects derived from the vulnerability of the activity to risks of major accidents and disasters relevant to it, on: population and human health; biodiversity, with particular attention to species and habitats protected under the Habitats and Birds Directives; land, soil, water, air and climate; material assets, cultural heritage and the landscape, and the interaction between the above factors.

In accordance inter alia with Section 39 of the 2001 Act and the provisions of the EIA Directive, CIÉ, as the Applicant for this Railway Order, has ensured that the EIAR is prepared by competent experts; contains a description of the proposed railway works comprising information on the site, design, size and other relevant features of the proposed works; contains a description of the likely significant effects of the proposed railway works on the environment; contains the data required to identify and assess the main effects which the proposed railway works are likely to have on the environment; contains a description of any features of the proposed railway works, and of any measures envisaged, to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment; contains a description of the reasonable alternatives studied by the Applicant – here CIÉ – which are relevant to the proposed railway works and their specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the railway works on the environment; contains a summary in non-technical language of the above information; takes into account the available results of other relevant assessments under European Union or national legislation with a view to avoiding duplication of assessments; in addition to and by way of explanation or amplification of the specified information referred above, the EIAR contains such additional information specified in Annex IV to the EIA Directive relevant to the specific characteristics of the particular railway works, or type of railway works, proposed and to the environmental features likely to be affected and in this regard Annex IV sets out the information which is referred to in Article 5(1) of the EIA Directive. Further the EIAR includes the information that may reasonably be required for reaching a reasoned conclusion in accordance with Section 42B of the 2001 Act on the significant effects of the proposed railway works on the environment, taking into account current knowledge and methods of assessment. This assessment has been undertaken in accordance with the above legislative and regulatory regime.

Additional legal measures that have contributed to this assessment include:

- European Directive on Electromagnetic Compatibility (2014/30/EU)
- Low Voltage Directive (2014/35/EU);
- Radio Equipment Directive (2014/53/EU);
- European Union (Radio Equipment) Regulations 2017 (S.I. No. 248 of 2017);
- European Union (Low Voltage Electrical Equipment) Regulations 2016 (S.I. No. 345 of 2016); and
- European Communities (Electromagnetic Compatibility) Regulations 2016 (S.I. No. 145 of 2016).

22.2.2 Standards

The following standards are relevant to the assessment, see Table 22-1 below.

Table 22-1 Standards.

Standard	Name/Description
EN 50121-1: 2017	Railway applications – Electromagnetic compatibility – Part 1: General.
EN 50121-2: 2017	Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world.
EN 50121-3-1: 2017	Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock - Train and complete vehicle.
EN 50121-3-2: 2017	Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus.
EN 50121-4: 2015	Railway applications – Electromagnetic compatibility – Part 4: Emission and immunity of the Signalling and Telecommunications Apparatus.
EN 50121-5: 2015	Railway applications – Electromagnetic compatibility – Part 5: Emission and immunity of railway fixed power supply installations.
EN 61000-6-1: 2007	Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments.
EN 61000-6-2: 2005	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments.
EN 61000-6-3: 2007	Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments.
EN 61000-6-4: 2019	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments.
EN 50122-1:2011	Railway applications - Fixed installations - Electrical safety, earthing and the return circuit -- Part 1: Protective provisions against electric shock.
EN 50122-2:2011	Railway applications - Fixed installations - Electrical safety, earthing and the return circuit -- Part 2: Provisions against the effects of stray currents caused by DC. traction systems.

22.2.3 Policy and Guidance

Regarding this chapter, there is no specific guidance available other than the broader Environmental Protection Agency (EPA) guidance referenced in Chapter 1 (Section 1.7.1) of this Environmental Impact Assessment Report (EIAR). However, the following guidelines, listed below, are relevant to the topic:

- ICNIRP. Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). Health Phys 118(5):483-524; 2020;
- ICNIRP Guidelines for limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz – 100 kHz). Health Phys 99(6):818-836; 2010.
- ICNIRP. Guidelines on limits of Exposure to Static Magnetic Fields. Health Phys 96(4): 504-514; 2009; and
- 1999/519/EC Council Recommendation of 12th July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz).

These guidelines provide recommendations and limitations for exposure to electromagnetic fields across different frequency ranges.

22.3 Methodology

The baseline environment refers to the existing environment that serves as a reference for evaluating future changes. This section describes the methodology used to assess the perceived impact of the Proposed Development on the baseline environment, taking into account relevant guidance on environmental impact. The assessment primarily focuses on the effects of electromagnetic fields (EMFs) on the public and the impact of electromagnetic interference (EMI) on third-party equipment. As part of the design process, a combined simulation of electromagnetic compatibility (EMC) and earthing and bonding (E&B) has been conducted for the entire route. A register has been created based on the survey results, which includes all equipment and assets identified as significant in terms of EMC and E&B along the railway line.

22.3.1 Limit Values

22.3.1.1 Human Exposure

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) publishes international guidelines that determine the limits of electromagnetic field (EMF) exposure necessary to safeguard the health of the general public and workers from recognized acute adverse effects. These guidelines establish fundamental restrictions on exposure based on a comprehensive review of all available scientific evidence concerning the health impacts of EMFs. Additionally, they provide reference levels for easily measurable or estimated EMF characteristics, ensuring compliance with the fundamental restrictions as long as these reference levels are not surpassed. Exposure assessments are typically conducted against these reference levels.

The ICNIRP limits have been adopted by the European Commission for public and occupational exposure, as outlined in the EU Recommendation 1999/519/EC and the EMF Directive, respectively. In Ireland, government policy falls under the purview of the Department of Environment, Climate and Communications (DECC), which continues to adhere to the guidelines formulated by the ICNIRP. In 2019, the Irish government issued a Statutory Instrument (S.I. No 190/2019), designating the Environmental Protection Agency (EPA) as the responsible entity for offering guidance to the government and the public on EMF exposure.

It is important to note that there is currently no consensus among scientists regarding potential long-term health effects resulting from exposure to low levels of EMFs. Therefore, this study exclusively addresses effects for which established assessment criteria have been identified.

22.3.1.2 Public Exposure

The table presented below, derived from EU Recommendation 1999/519/EC, presents the ICNIRP limits for public exposure reference levels across different frequency ranges. In the case of static magnetic fields up to 1Hz, the limit is set at 40 mT (0.04 T). These limits have been specifically selected for their rigorous nature, ensuring the highest level of compliance.

Table 22-2 Public exposure reference levels from Council Recommendation 1999/519/EC.

Frequency Range	Electric Field Strength (V/m)	Magnetic Field Intensity (A/m)	Magnetic Flux Density (μT)	Equivalent Plane Wave Power Density
up to 1 Hz	-	3.2×10^4	4×10^4	-
1 – 8 Hz	10000	$3.2 \times 10^4 / f^2$	$4 \times 10^4 / f^2$	-
8 – 25 Hz	10000	4000 / f	5000 / f	-
0.025 – 0.8 kHz	250 / f	4 / f	5 / f	-
0.8 – 3 kHz	250 / f	5	6.25	-
3 – 150 kHz	87	5	6.25	-
0.15 - 1 MHz	87	0.73 / f	0.92 / f	-
1 – 10 MHz	$87 / f^{1/2}$	0.73 / f	0.92 / f	
10 – 400 MHz	28	0.073	0.092	2
400 – 2000 MHz	$1.375 f^{1/2}$	$0.0037 f^{1/2}$	$0.0046 f^{1/2}$	f / 200
2 – 300 GHz	61	0.16	0.20	10

22.3.1.3 Limits for Trackside Equipment (Signalling & Telecoms)

For Signalling & Telecommunications apparatus installed inside the railway environment, the following requirements apply:

- Immunity requirements as per EN 50121-4 standard.

The immunity levels given in EN 50121-4 standard apply for:

- vital equipment such as interlocking or command and control;
- apparatus inside the 3 m zone;
- ports of apparatus inside the 10 m zone with connection inside the 3 m zone;
- ports of apparatus inside the 10 m zone with cable length > 30 m.

22.3.1.4 Limits for Power Supply Apparatus

For power supply apparatus including all electrical and electronic apparatus and systems intended for use in railway fixed installations associated with power supply, the following requirements apply:

- Immunity requirements as per EN 50121-5 standard.

Emission and immunity limits are given for items of apparatus which are situated:

a. within the boundary of a traction substation which delivers electric power to a railway;
b. beside the track for the purpose of controlling or regulating the railway power supply, including power factor correction;
c. along the track for the purpose of supplying electrical power to the railway other than by means of the conductors used for contact current collection, and associated return conductors. Included are high voltage feeder systems within the boundary of the railway which supply traction substations at which the voltage is reduced to the railway system voltage;
d. beside the track for controlling or regulating electric power supplies to ancillary railway uses. This category includes power supplies to marshalling yards, maintenance depots and stations;
e. various other non-traction power supplies from railway sources which are shared with railway traction.

The immunity levels given in EN 50121-5 standard apply for:

- vital equipment such as interlocking or command and control;
- apparatus inside the 3 m zone;
- ports of apparatus inside the 10 m zone with connection inside the 3 m zone;
- ports of apparatus inside the 10 m zone with cable length > 30 m.

22.3.1.5 Limits for Apparatus in Residential, Commercial, and Industrial Environments

For electrical and electronic apparatus intended for use in residential, commercial, and industrial environments, the following requirements apply:

- Immunity requirements as per generic EMC immunity standards EN 61000-6-1 and EN 61000-6-2.

The standard EN 61000-6-1 encompasses the residential, commercial and light-industrial environments, both indoor and outdoor, and applies to apparatus intended to be directly connected to a low-voltage public mains network or connected to a dedicated DC source which is intended to interface between the apparatus and the low-voltage public mains network. This standard applies also to any apparatus which is battery operated or is powered by a non-public, but non-industrial, low voltage power distribution system if this apparatus is intended to be used in, among others, the locations listed below:

- residential properties, for example houses, apartments;
- retail outlets, for example shops, supermarkets;
- business premises, for example offices, banks;
- areas of public entertainment, for example cinemas, public bars, dance halls;
- outdoor locations, for example petrol stations, car parks, amusement and sports centres;

- light-industrial locations, for example workshops, laboratories, service centres.

The standard EN 61000-6-2 encompasses the industrial environment, both indoor and outdoor, and applies to apparatus intended to be connected to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding manufacturing or similar plant and intended to operate in, or in proximity to, industrial locations. This standard applies also to apparatus which is battery operated and intended to be used in industrial locations including, among others, the ones listed below:

- industrial, scientific and medical (ISM) apparatus (as defined in CISPR 11);
- where heavy inductive or capacitive loads are frequently switched;
- where currents and associated magnetic fields are high.

22.3.1.6 Magnetic Field Limits for Equipment

All equipment surrounding a power line is subject to a steady magnetic field intensity that is proportional to the flowing current intensity, to the distance, to the conductor geometry, etc. The EN 50121 standard normalized the amplitude of the magnetic field level for the test of equipment immunity to particularly high levels for the trackside environment (EN 50121-4) and the traction substation environment (EN 50121-5) which was fixed at 100 A/m and 300 A/m for AC and DC systems, respectively. In the generic immunity standards these values are lower and equal to 30 and 3 A/m for the industrial and residential environments, respectively.

The magnetic fields caused by the currents from a power line are considered steady in the sense that it is subject normally only to small variations due to changes in the load demand. However, transients may be produced by short circuits and consequent protections triggering and the phenomenon may affect equipment located both trackside and at a traction substation. This phenomenon is considered relevant only for the EN 50121-4 environment and therefore is included into the standard, by means of a dedicated test for transient magnetic field, again at a 300 A/m intensity, based on the basic standard EN 61000-4-9.

Table 22-3 Magnetic Fields Immunity Levels for Trackside Equipment.

Reference	Summary of Scope	Maximum Magnetic Field (Immunity)
EN 50121-4	Magnetic field at 50 Hz (dc) applicable to signalling and telecommunication equipment (railway environment). (test according to EN 61000-4-8). Magnetic field at 0 Hz (dc) applicable to signalling and telecommunication equipment (railway environment). (test according to EN 61000-4-8). Magnetic field pulse in signalling and telecommunication equipment (railway environment). (test according to EN 61000-4-9).	100 A/m 300 A/m 300 A/m

Reference	Summary of Scope	Maximum Magnetic Field (Immunity)
EN 50121-5	Magnetic field at 50 Hz (dc) applicable to signalling and telecommunication equipment (railway environment). (test according to EN 61000-4-8). Magnetic field at 0 Hz (dc) applicable to fixed power supply installations and apparatus (railway environment). (test according to EN 61000-4-8).	100 A/m 300 A/m
ICE 61000-6-2	Magnetic field at 50 Hz (dc) applicable to apparatus intended to be connected to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding manufacturing or similar plant, and intended to operate in or in proximity to industrial locations (industrial environment). (test according to EN 61000-4-8).	30 A/m
ICE 61000-6-1	Magnetic field at 50 Hz (dc) applicable to apparatus intended to be directly connected to a low-voltage public mains network (residential environment). (test according to EN 61000-4-8).	3 A/m

22.3.2 Study Area

The EMI strength dissipates over distance. The precise distance at which EMI could be considered not an influence will very much depend on the sensitivity of individual receptors. In this order of ideas, the study area is determined by the Electromagnetic Environment around the railway line: railway EME first, followed predominantly by the residential and commercial EME (although it may as well be the industrial EME or the EME of a special premise where highly sensitive equipment is present).

Different study areas or zones that require assessment and management are identified:

- The railway boundary, which is defined as the area extending up to 10 meters from the centre of the nearest running line and 3 meters from the traction substation boundary. Equipment located within this boundary is assumed to meet the rail Electromagnetic Compatibility (EMC) standards.
- Since the immunity requirements for railway equipment are more stringent than those for residential and commercial applications, an additional buffer area of 10 meters is considered. Within this buffer area, the risk of Electromagnetic Interference (EMI) to safety-critical equipment and equipment that provides important services, but hasn't been tested to industrial EMC limits, needs to be assessed.
- Outside the buffer area, the existing EMC immunity limits for "light industrial," commercial, and residential settings are deemed sufficient to mitigate the risk of interference (Table 22-4), except for the most sensitive receptors as identified in the assessment.

The determination of these zones aligns with the recommendations outlined in the EN 50121 suite of standards. These standards serve as a basis for determining the extent of influence and study areas for Electromagnetic Interference (EMI) to and/or from the railway, guiding the assessment process.

Table 22-4 The study area either side of the alignment

Criteria	Width of Study Area
Potential impacts from Direct Current (DC) fields	100 m
Potential impacts from Alternating Current (AC) fields	10 m
Potential impacts from Radiofrequency (RF) and microwave fields	100 m
Potential impacts from stray currents	100 m

22.3.3 Surveys

Current knowledge of potentially sensitive receptors along the proposed route coupled with feedback from consultation with stakeholders and the results of the desktop study were used to identify those locations where baseline surveys of the electromagnetic spectrum were carried out:

- Survey on the electrified section (e.g., by the existing Malahide traction substation).
- Survey on the non-electrified section (e.g., by the future Gormanston traction substation).
- Survey at the crossing with the 400 kV DC link.

The survey results were also used to identify any electromagnetic signals present in the environment that may not be accounted for already and which may signify other equipment which needs to be considered from an EMI perspective.

22.3.4 Desktop Study

Apart for the surveys, a desktop study was conducted for the DART+ Coastal North project, whose aim was to assess the magnetic disturbances at power frequency (produced by the current-carrying conductors of the OHLE) that the equipment located in the vicinity of the railway line will be subject to.

In the desktop study, the magnetic field strength was calculated around the OHLE. For this, the intended OHLE configuration for the Proposed Development, as well as the calculated maximum currents through the OHLE conductors during normal operation (as per traction power simulations conducted for the Northern Line), were used.

22.3.5 Assessment Methodology

The approach for conducting the initial evaluation follows the recommendations outlined in the guidelines listed in Section 22.2.3 and takes into account the pertinent guidance provided by the EPA concerning Environmental Impact Assessment Reports (EIAR). The evaluation of the Proposed Development focuses on minimizing exposures to electromagnetic fields (EMFs) and stray currents.

The procedure for the assessment involves the following steps:

- Categorizing the initial environmental conditions, considering their significance and sensitivity;
- Establishing a baseline rating; and
- Appraising impacts and determining their level of significance.

22.3.5.1 Categorisation of the Baseline Environment

The evaluation requires an understanding of the prevailing baseline electromagnetic emissions (EME). A specific baseline rating is attributed to the baseline environment or sensitive receptor based on factors such as significance, sensitivity, and existing negative impacts. Each of these three concepts is elaborated upon within this section. Subsequently, this baseline rating is applied in the impact assessment (refer to Section 22.5) to ascertain the degree of importance for each sensitive receptor.

22.3.5.1.1 Importance of the Receptor

The significance of a receptor is contingent upon its inherent value and the potential severity of outcomes resulting from any alteration or malfunction in its operation. Receptors attain significance based on their value or rarity within a specific geographical scope, as well as whether the consequences of their loss or malfunction could lead to adverse effects.

Electromagnetic interference (EMI) has the potential to impact and disrupt critical and delicate equipment found in medical centres, data facilities, airports, and railway systems. Moreover, it could disrupt medical devices within households and influence the performance of regular household appliances. As a result, receptors of this nature hold importance due to the potential safety and medical ramifications they could give rise to.

Furthermore, EMI has the capability to affect broader infrastructural components, such as telecommunications apparatus, cabling, electrical systems (including substations), computer screens, communication devices, machinery, aircraft instrument landing systems, and sensitive instruments in commercial, industrial, pharmaceutical, and educational establishments. Hence, receptors of this kind are also accorded significance.

Concurrently, when considering the repercussions of EMI, stray currents have the potential to cause corrosion, ultimately leading to stability concerns in structures like breakage and leaks. They can also induce corrosion in metallic components and structures such as utility infrastructure, pipelines, and subterranean cabling. This situation becomes particularly significant in cases where metal functions as reinforcement material in structures such as bridges and buildings situated parallel and in proximity to the existing railway track. The potential safety implications and the possibility of infrastructure loss or damage could cause substantial disruption, thus marking them as important considerations as well.

22.3.5.1.2 Sensitivity of the Receptor

The susceptibility of a receptor hinges on its propensity to experience substantial effects when exposed to electromagnetic fields (EMFs).

When an important receptor encounters EMFs, it can result in the malfunction or failure of equipment. Equipment that malfunctions even in the presence of weak EMF fields is considered sensitive, whereas equipment that remains operational even in the presence of significantly stronger fields is regarded as non-sensitive.

Instances of equipment that use EMFs for their operation encompass telecommunications receivers, rail signalling systems, and common household appliances like radios and televisions. These entities are highly reliant on EMFs for their functioning, rendering them particularly susceptible to EMFs. Conversely, other equipment capable of functioning effectively even in the presence of significantly higher EMF levels, such as non-radio equipment and advanced medical and research apparatus, is considered to have lower sensitivity.

Particularly noteworthy in terms of stray currents are pipes and cable utilities. This is because stray currents can propagate a considerable distance away from the railway, and utilities are frequently positioned beneath and alongside railways. The evaluation of nearby utility lines must be conducted meticulously to assess the potential impact of stray currents. Utilities are recognized as a component of the baseline and are included as a sensitive receptor in this assessment.

22.3.5.1.3 Baseline Rating

The baseline assessment of the current electromagnetic and stray current environment is established by considering a variety of criteria that encompass its significance, susceptibility, and the current adverse impacts on the baseline environment. The specified baseline ratings for both EMF and stray current receptors are presented in Table 22-5 and Table 22-6, respectively.

Table 22-5 Criteria for Baseline Sensitivity Categorisation of Receptors with respect to EMF.

Sensitive locations/receptors	Baseline rating
• Facilities with highly sensitive equipment on the premises on a permanent basis; • Public/private health facilities; • Signalling on rail networks; and • Highly sensitive equipment in universities, colleges and schools	• Very High
• Telecommunications infrastructure; • Public/private scientific/research institutes; • Medical Centres including dentists and vets; • Universities, colleges and schools that may have potentially sensitive equipment; • Emergency services mobile radio; and • Locations with installations of custom audio-visual equipment.	• High
• Facilities that have sensitive equipment on the premises on a permanent basis; • Some residential areas, e.g. containing specific medical equipment; • Industrial facilities with potentially sensitive equipment; and • Universities, colleges, and schools which do not have sensitive equipment.	• Medium
• All other residential areas; • Mixed units with a residential component; • Electricity substations with earthing equipment; and • Educational institutions without sensitive equipment.	• Low
• All other areas.	• Very Low

Table 22-6 Criteria for Baseline Sensitivity Categorisation of Receptors with respect to Stray Current.

Sensitive locations/receptors	Baseline rating
• Any ground embedded metal shielded facility which has a high requirement for safety, e.g. high-pressure gas or water pipes; • Chemical industry installations; • Large ground embedded fuel tanks, e.g. fuel depot; and • Signalling on rail networks.	Very High
• Any ground embedded metal shielded facility which has a medium requirement of safety, e.g. low-pressure gas or water pipes, heating pipes	High
• Pre-stressed reinforcement of tunnels, bridges or port structures other than the project's proposed structures; • Metal shielded cables; • Other rail infrastructure, e.g. track; and • Small ground embedded fuel tanks, e.g. petrol stations.	Medium
• Other metal reinforced structures parallel to the alignment with a minimum length of 100 m, e.g. buildings.	Low
• Industrial facilities with large metal structures; and • All other areas.	Very Low

To contribute to the baseline assessment and in accordance with consultation outcomes, monitoring activities were carried out at specific locations to measure DC magnetic fields, AC electromagnetic fields, and RF electric fields.

In order to determine a baseline rating for stray current, the rating levels were chosen by considering a blend of factors, including the extent of buried structures and the recognized sensitivities associated with these structures.

22.3.6 Consultation

Consultation was undertaken with larger potentially affected stakeholders such as hospitals, universities, utility providers etc. to establish what particularly sensitive equipment they have, and where it is located on their campuses, to determine proximity to the Proposed Development. Based on these consultations, no additional baseline surveys or modelling were deemed required.

In accordance with the aforementioned criteria, the following locations were considered to potentially have sensitive equipment:

Table 22-7 Identified sensitive locations near the Northern Line.

Name	Address	Coordinates	Distance from railway (m)
BHU 259 GB TOBA TEK SINGH hospital	Toba Tek Singh, Hyacinth St, North Dock, Dublin, Ireland	53.35631, -6.24206	88

Name	Address	Coordinates	Distance from railway (m)
Clontarf Orthodontics	9 Clontarf Rd, Clontarf, Dublin 3, D03 XE16, Ireland	53.36382, -6.2239	74
Beautybox Clinic	Brookwood Rise, Harmonstown, Dublin, D05 P680, Ireland	53.37835, -6.19392	56
St. Joseph's Hospital Raheny	Springdale Rd, Edenmore, Dublin 5, D05 E261, Ireland	53.38155, -6.18122	99
Raheny Orthodontics	Raheny Shopping Centre, 4 Skillings House, Howth Rd, Clontarf East, Dublin 5, Co. Dublin, D05 R2N2, Ireland	53.38081, -6.17855	45
The Gallery Dental Practice	Marine Court, St James Terrace, Malahide, Co. Dublin, Ireland	53.45006, -6.15811	95
Elise O'Callaghan's Dental Practice Malahide	2, Ardán an Chaisleáin, An Tsráid Mhór, Malahide, Mullach Íde, Co. Contae Bhaile Átha Cliath, Ireland	53.45018, -6.15623	30
Malahide Vet Clinic	Railway Ave, Malahide, Dublin, K36 WY02, Ireland	53.45126, -6.15574	50
Gormanston Military Camp	Camp Rd, Irishtown, Co. Meath, Ireland	53.64695, -6.22966	30
Bon Secours hospital	Greenbatter, Dublin City, Co. Dublin, Ireland	53.7232, -6.33731	25

22.3.7 Difficulties Encountered / Limitations

This chapter of the EIAR has been formulated utilising the most reliable information and following the current standards and applicable guidelines. No technical challenges or difficulties were encountered during the development of this chapter in the EIAR.

22.4 Receiving Environment

The receiving environment is a combination of a standard urban and a sub-urban environment with intervening stretches through rural areas. There are residential, commercial, and industrial land uses, along with educational facilities, buried utilities and telecommunication equipment. Outside of the urban environment, the development passes mostly through farmland.

22.4.1 Description and Categorization of the Receiving Environment

The Proposed Development has been segmented into five discrete geographic areas spanning the corridor's length (referred to as Zones A to E), as described in Chapter 4 (Description of the Proposed Development). This division is summarised below, from south to north along the railway corridor:

- Zone A: North of Connolly Station to Howth Junction & Donaghmede Station
- Zone B: Howth Junction & Donaghmede Station (including Howth Branch) to Malahide Viaduct
- Zone C: Malahide Viaduct to south of Gormanston Station (Fingal border)
- Zone D: South of Gormanston Station (Fingal border) to Louth/Meath border

- Zone E: South of Gormanston Station (Fingal border) to Louth/Meath border

A description of the receiving environment concerning electromagnetic compatibility (EMC) and stray current has been provided on a geographic area basis. This method enables an in-depth examination of each specific area, rather than presenting a comprehensive overview of the entire study region.

22.4.1.1 Zone A: North of Connolly Station to Howth Junction & Donaghmede Station

The receptors located within a 100-meter radius of the railway centerline in Zone A have been identified in accordance with the details presented in Table 22-8 below. It is important to mention that in addition to the receptors listed below, there is residential development along the railway corridor, whose baseline rating with respect to EM and Stray Currents is diminishable.

Table 22-8 Zone A Sensitive Receptors.

Category	Receptor Type	Description		Distance from railway (m)	Baseline Rating with respect to EM fields	Baseline Rating with respect to Stray Current
Medical, Dental & Veterinary Clinics	Medical	BHU 259 GB TOBA TEK SINGH hospital	Toba Tek Singh, Hyacinth St, North Dock, Dublin, Ireland	88	High	Very Low
	Dental	Clontarf Orthodontics	9 Clontarf Rd, Clontarf, Dublin 3, D03 XE16, Ireland	74	Medium	Very Low
	Medical	Beautybox Clinic	Brookwood Rise, Harmonstown, Dublin, D05 P680, Ireland	56	High	Very Low
	Medical	St. Joseph's Hospital Raheny	Springdale Rd, Edenmore, Dublin 5, D05 E261, Ireland	99	High	Very Low
	Dental	Raheny Orthodontics	Raheny Shopping Centre, 4 Skillings House, Howth Rd, Clontarf East, Dublin 5, Co. Dublin, D05 R2N2, Ireland	45	Medium	Very Low

22.4.1.2 Zone B: Howth Junction & Donaghmede Station (including Howth Branch) to Malahide Viaduct

The receptors located within a 100-meter radius of the railway centerline in Zone B have been identified in accordance with the details presented in Table 22-9 below. It is important to mention that in addition to the receptors listed below, there is residential development along the railway corridor, whose baseline rating with respect to EM and Stray Currents is diminishable.

Table 22-9 Zone B Sensitive Receptors.

Category	Receptor Type	Description		Distance from railway (m)	Baseline Rating with respect to EM fields	Baseline Rating with respect to Stray Current
Medical, Dental & Veterinary Clinics	Dental	The Gallery Dental Practice	Marine Court, St James Terrace, Malahide, Co. Dublin, Ireland	95	Medium	Very Low
	Dental	Elise O'Callaghan's Dental Practice Malahide	2, Ardán an Chaisleáin, An Tsráid Mhór, Malahide, Mullach Íde, Co. Contae Bhaile Átha Cliath, Ireland	30	Medium	Very Low

22.4.1.3 Zone C: Malahide Viaduct to south of Gormanston Station (Fingal border)

The receptors located within a 100-meter radius of the railway centerline in Zone C have been identified in accordance with the details presented in Table 22-10 below. It is important to mention that in addition to the receptors listed below, there is residential development along the railway corridor, whose baseline rating with respect to EM and Stray Currents is diminishable.

Table 22-10 Zone C Sensitive Receptors.

Category	Receptor Type	Description		Distance from railway (m)	Baseline Rating with respect to EM fields	Baseline Rating with respect to Stray Current
Medical, Dental & Veterinary Clinics	Veterinary	Malahide Vet Clinic	Railway Ave, Malahide, Dublin, K36 WY02, Ireland	50	Medium	Very Low

22.4.1.4 Zone D: South of Gormanston Station (Fingal border) to Louth/Meath border

The receptors located within a 100-meter radius of the railway centerline in Zone D have been identified in accordance with the details presented in Table 22-11 below. It is important to mention that in addition to the receptors listed below, there is residential development along the railway corridor, whose baseline rating with respect to EM and Stray Currents is diminishable.

Table 22-11 Zone D Sensitive Receptors.

Category	Receptor Type	Description		Distance from railway (m)	Baseline Rating with respect to EM fields	Baseline Rating with respect to Stray Current
Defence	Military camp	Gormanston Military Camp	Camp Rd, Irishtown, Co. Meath, Ireland	30	Very High	Medium

22.4.1.5 Zone E: South of Gormanston Station (Fingal border) to Louth/Meath border

The receptors located within a 100-meter radius of the railway centerline in Zone E have been identified in accordance with the details presented in Table 22-12 below. It is important to mention that in addition to the receptors listed below, there is residential development along the railway corridor, whose baseline rating with respect to EM and Stray Currents is diminishable.

Table 22-12 Zone E Sensitive Receptors.

Category	Receptor Type	Description		Distance from railway (m)	Baseline Rating with respect to EM fields	Baseline Rating with respect to Stray Current
Medical, Dental & Veterinary Clinics	Medical	Bon Secours hospital	Greenbatter, Dublin City, Co. Dublin, Ireland	25	High	Very Low

22.4.2 Desktop Study Results

A calculation was made of the steady-state magnetic field produced by the DC-voltage-supplied OHLE at the point where traction currents are highest according to the traction power simulations conducted for the DART+ Coastal North project. This is presented in the images below for each of the relevant locations.

The magnetic field strength produced by the OHLE was calculated on a cross section and along an assessment line normal to the railway alignment, 1 m above ground, at different points of analysis of the railway (Image 22-2 to Image 22-32). The points of analysis chosen are the chainages (CH) corresponding to the different traction substations along the Northern Line. These points are of most interest when studying the magnetic field produced by the traction power supply system as they exhibit the greatest current through the OHLE and are therefore the points in which the magnetic fields with the highest magnitude will likely be present.

The magnitude of the magnetic field strength is shown in the units of µT. The equivalence between the units of µT and A/m (in free space conditions) is based on the following relationship: 100 µT = 1 Oe = 79.6 A/m. (IEC 10373-2, 2015 cl.3.15):

Table 22-13 Relation Between Magnetic Field Strength.

µT	0.4	1	15	20	30	100	300	376,9	500
A/m	0.3	0.8	11.9	15.9	23.9	79.6	239	300	398

22.4.2.1 Fairview Traction Substation

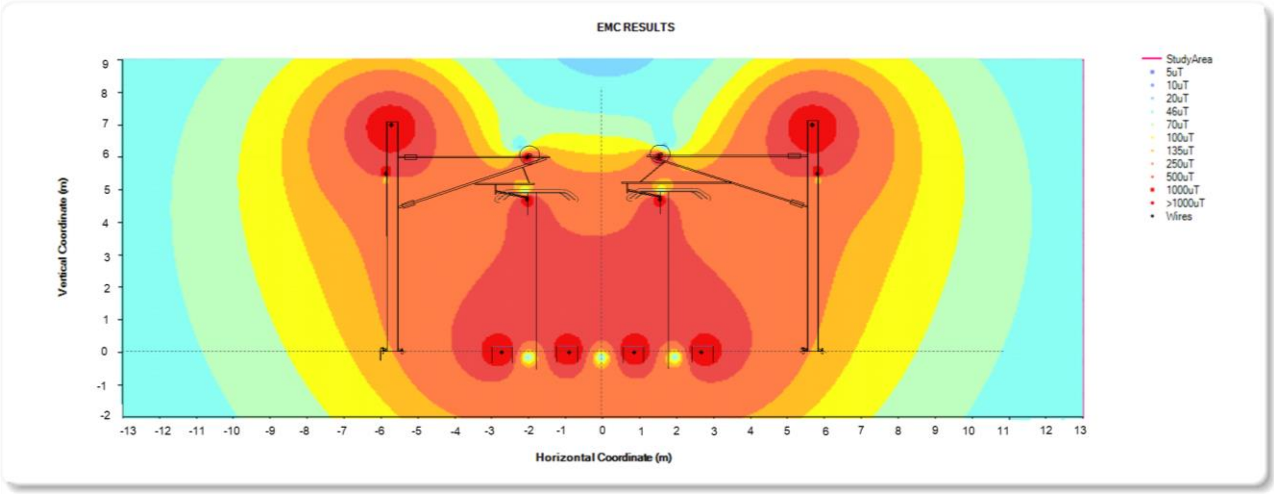

Image 22-2 Magnetic Field (Cross-Section) at 3+225.

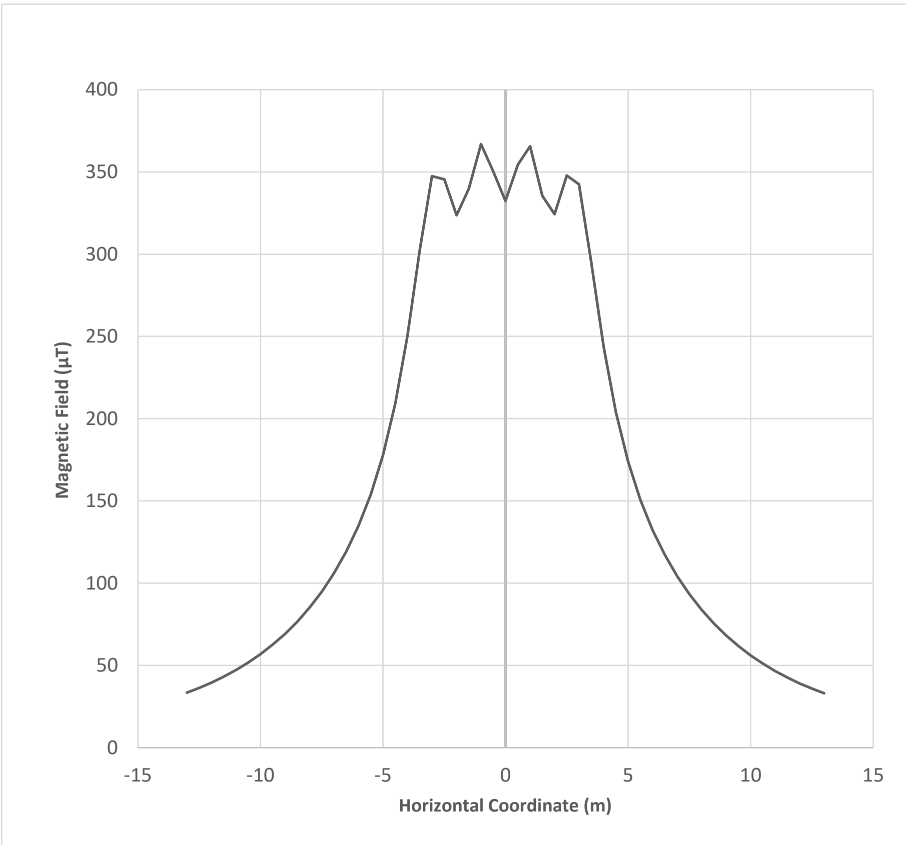

Image 22-3 Magnetic Field (Assesment Line at 1 Meter High) at 3+225.

22.4.2.2 Killester Track Paralleling Hut (TPH)

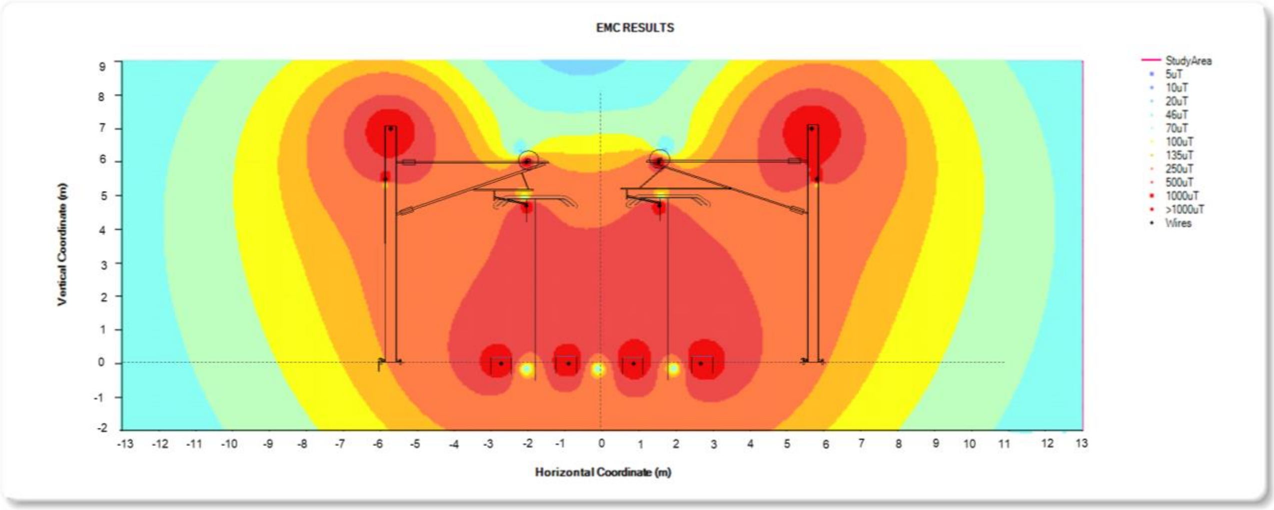

Image 22-4 Magnetic Field (Cross-Section) at 4+692

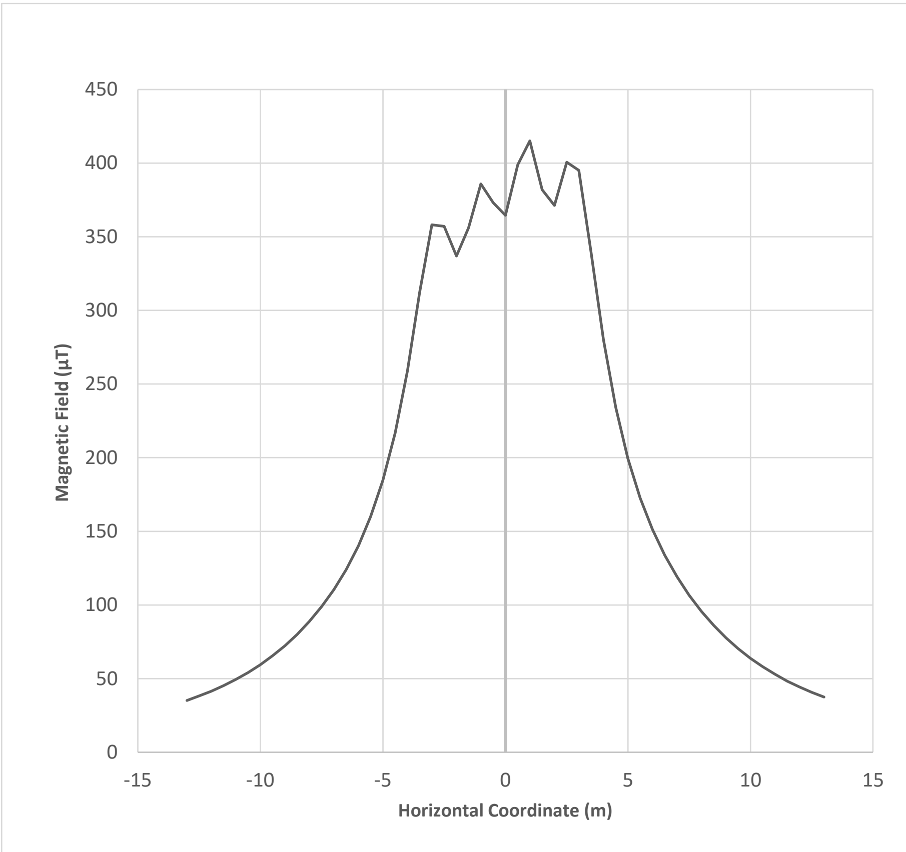

Image 22-5 Magnetic Field (Assesment Line at 1 Meter High) at 1 meter high at 4+692.

22.4.2.3 Raheny Traction Substation

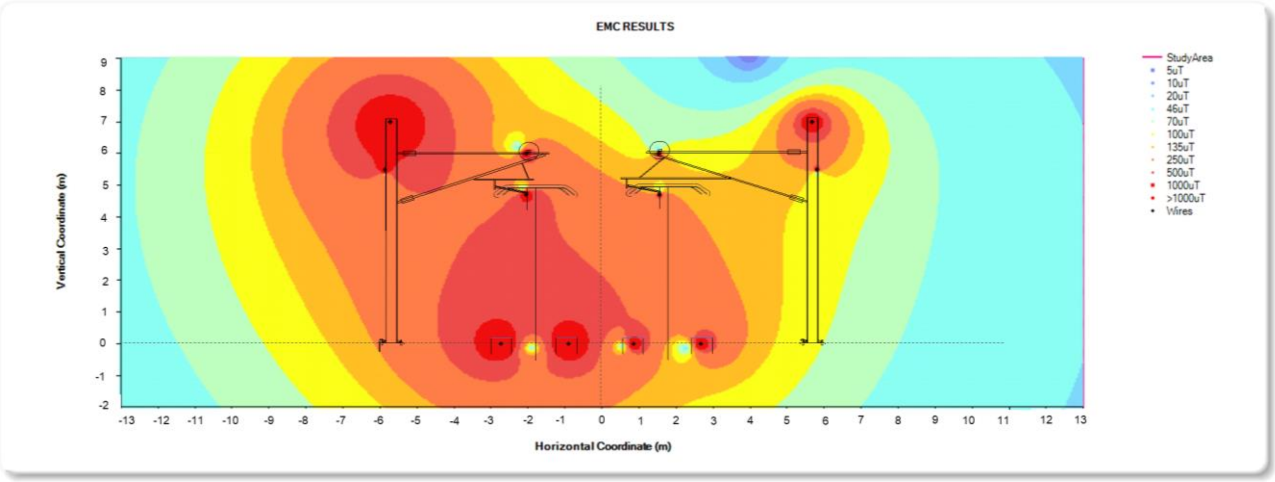

Image 22-6 Magnetic Field (Cross-Section) at 6+918.

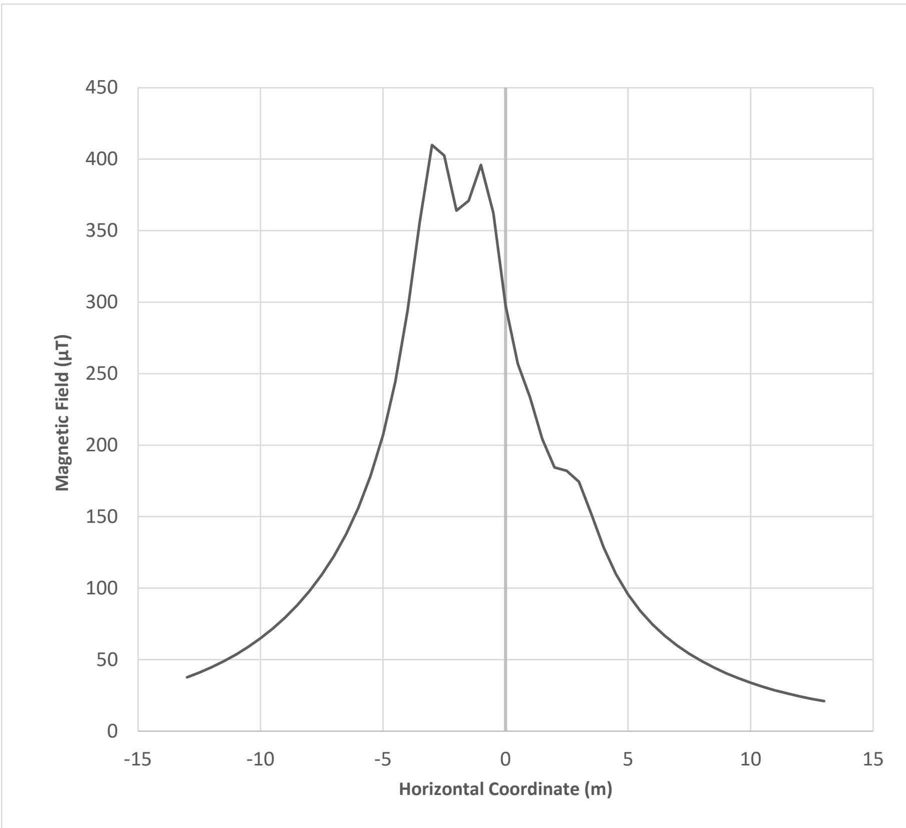

Image 22-7 Magnetic Field (Assesment Line at 1 Meter High) at 6+918.

22.4.2.4 Bayside Traction Substation

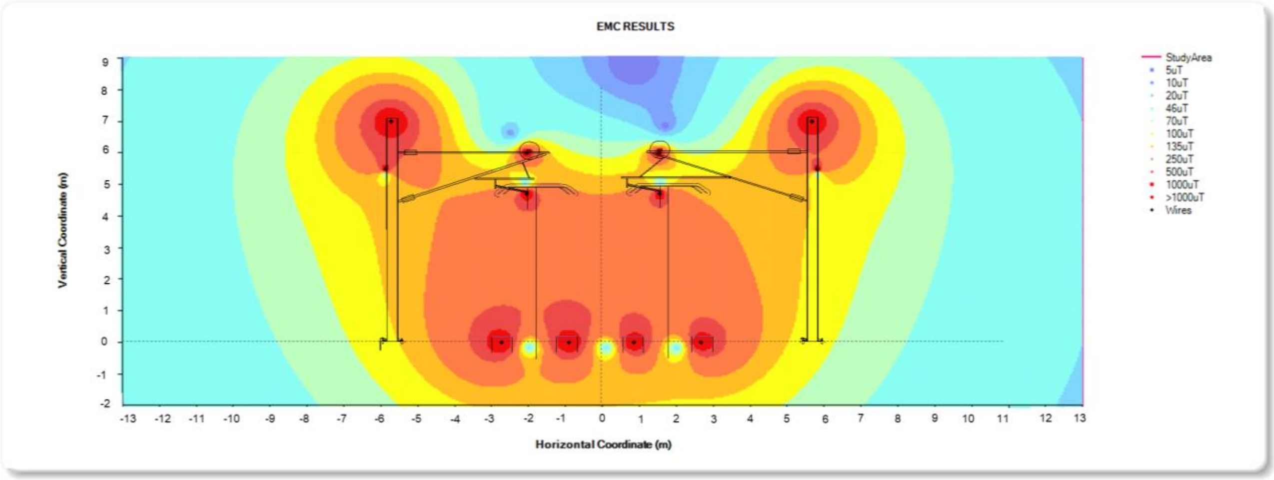

Image 22-8 Magnetic Field (Cross-Section) at 10+380.

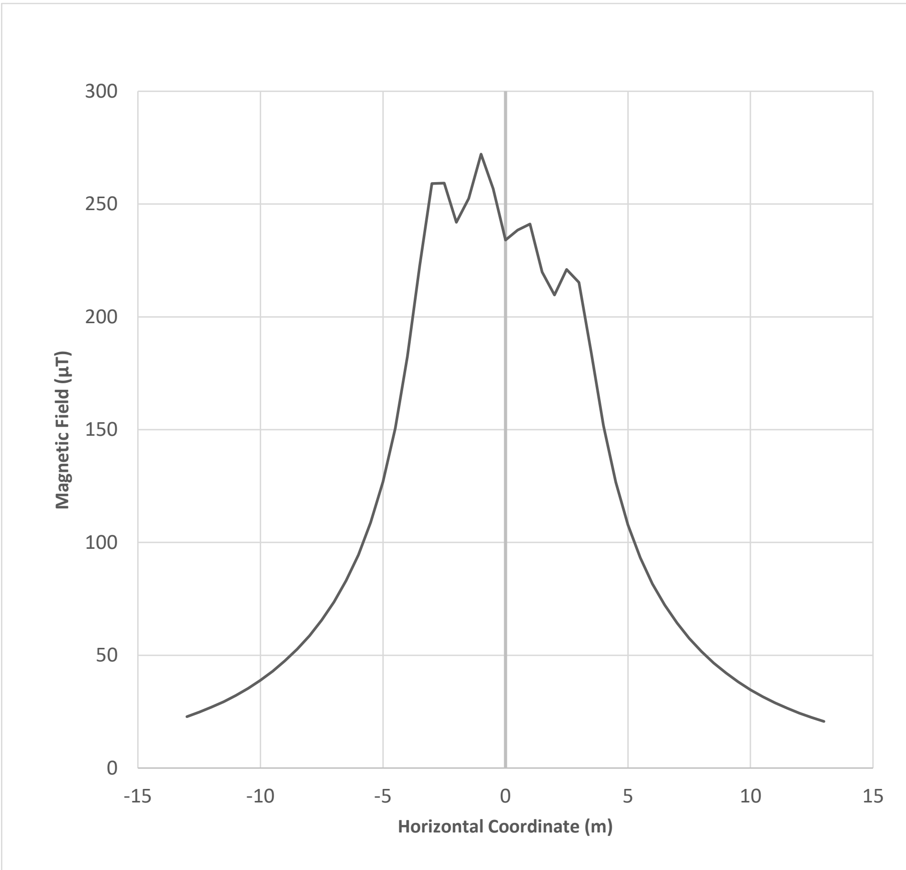

Image 22-9 Magnetic Field (Assesment Line at 1 Meter High) at 10 + 380.

22.4.2.5 Howth Traction Substation

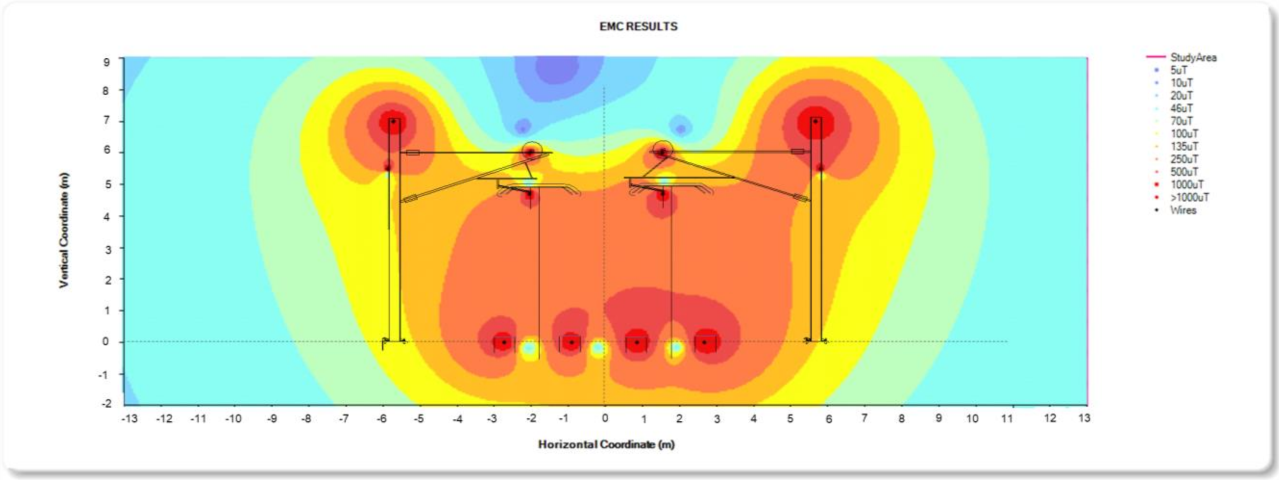

Image 22-10 Magnetic Field (Cross-Section) at 12+555.

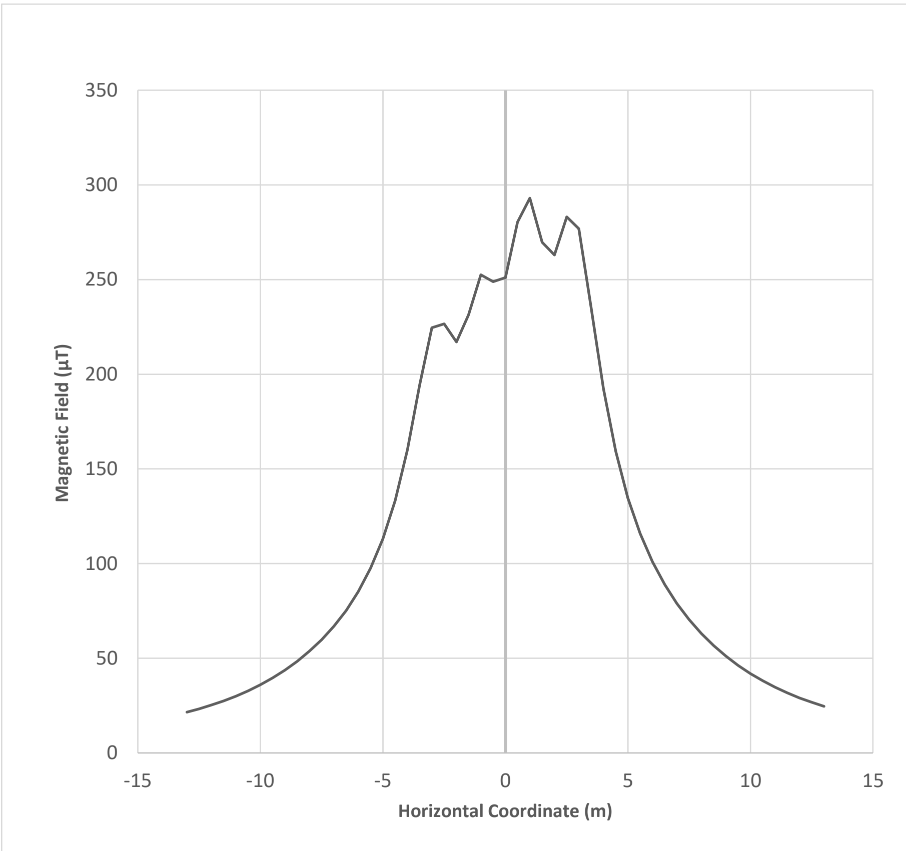

Image 22-11 Magnetic Field (Assesment Line at 1 Meter High) at 12+555.

22.4.2.6 Howth TPH

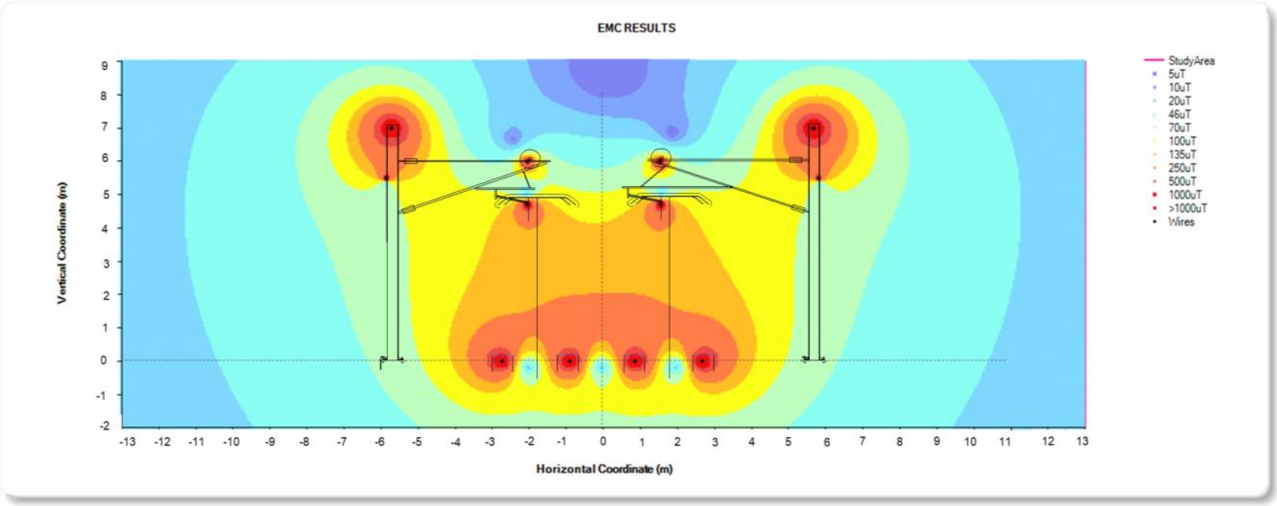

Image 22-12 Magnetic Field (Cross-Section) at 14+271.

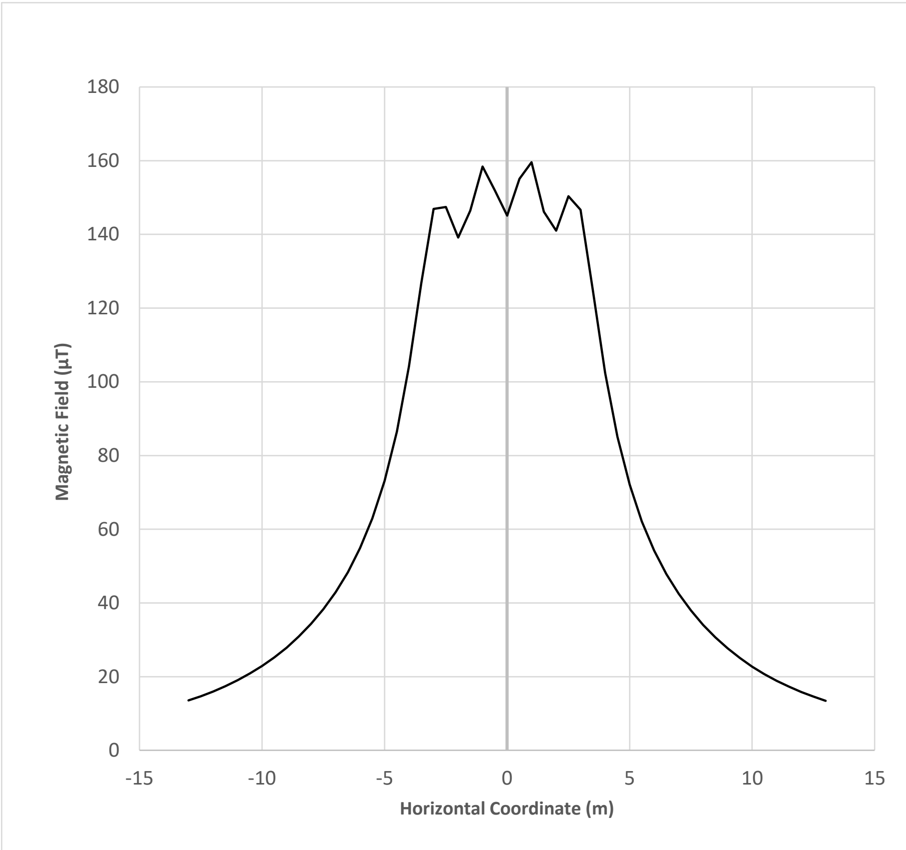

Image 22-13 Magnetic Field (Assesment Line at 1 Meter High) at 14+271.

22.4.2.7 Portmarnock Traction Substation

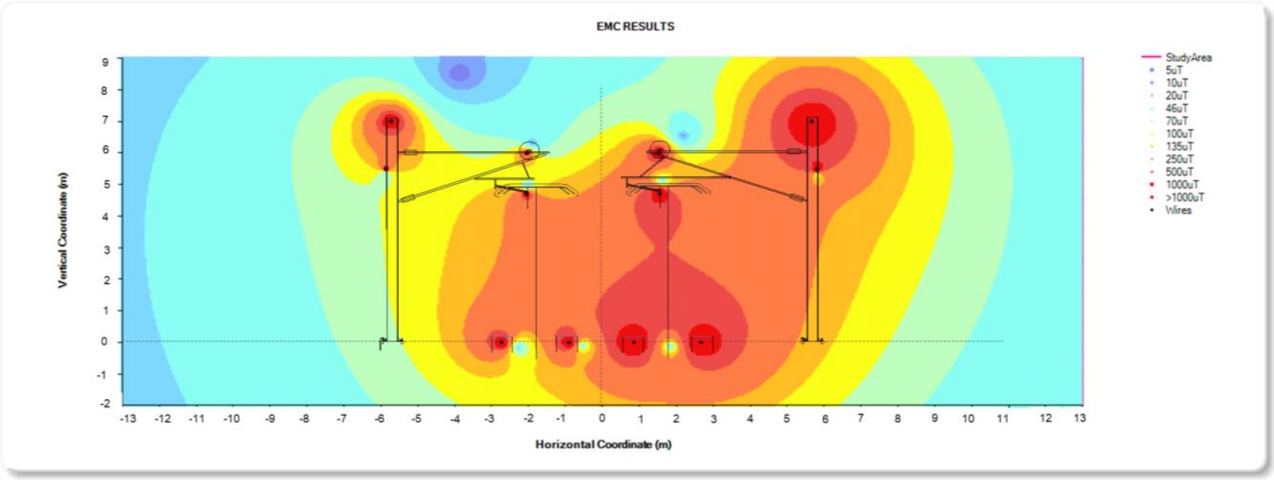

Image 22-14   Magnetic Field (Cross-Section) at 11+801.

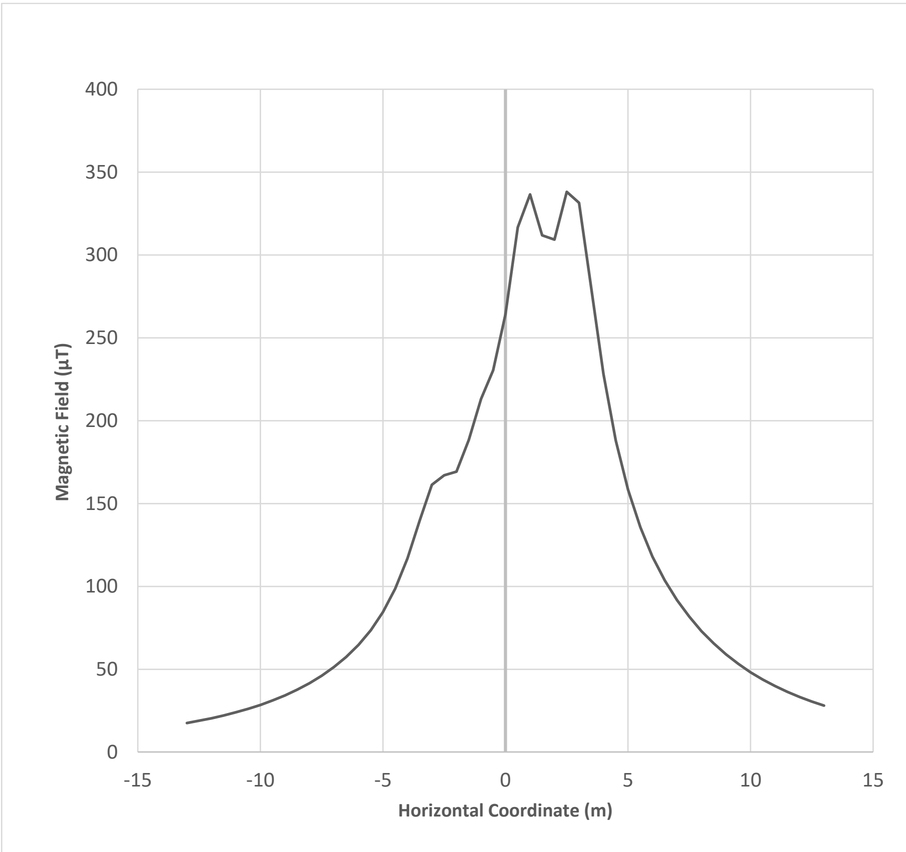

Image 22-15   Magnetic Field (Assesment Line at 1 Meter High) at 11+801.

22.4.2.8 Malahide Traction Substation

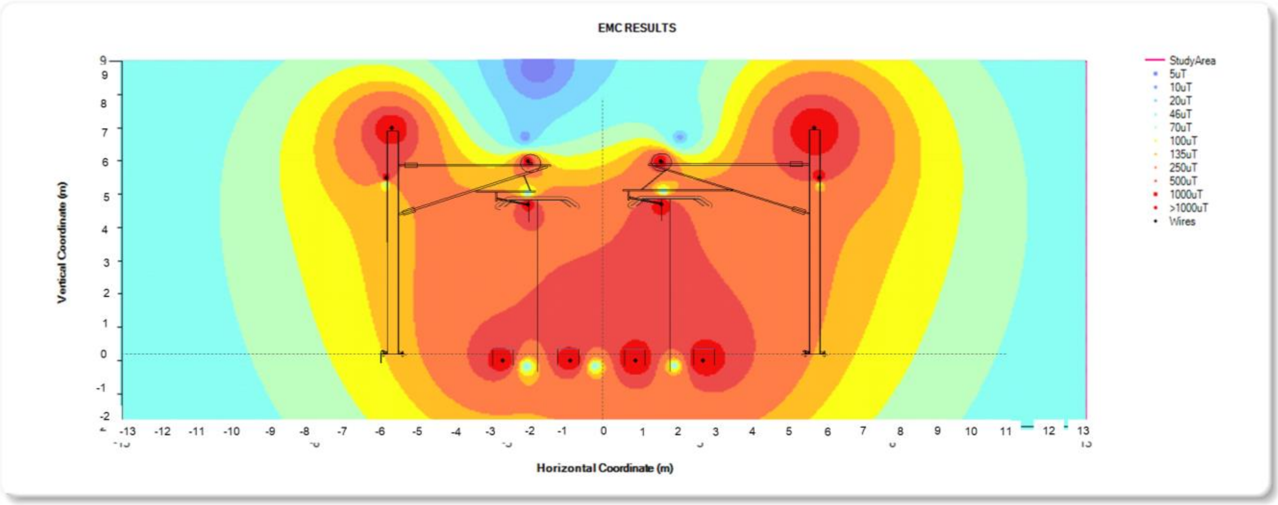

Image 22-16   Magnetic Field (Cross-Section) at 14+654.

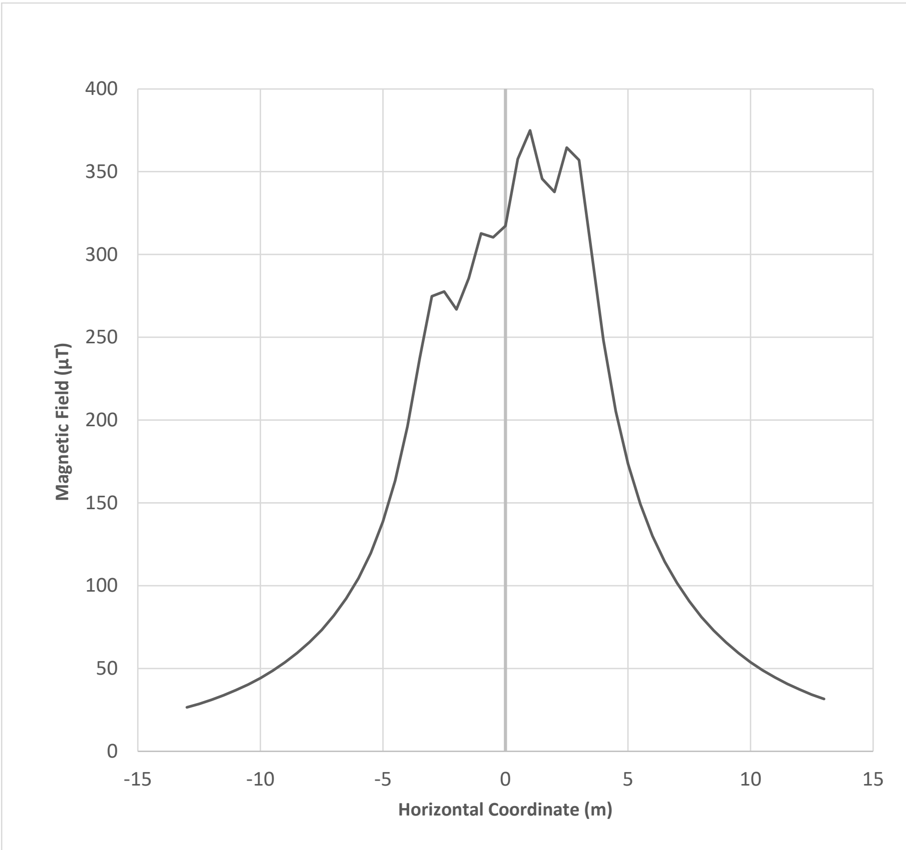

Image 22-17   Magnetic Field (Assesment Line at 1 Meter High) at 14+654.

22.4.2.9 Donabate Traction Substation

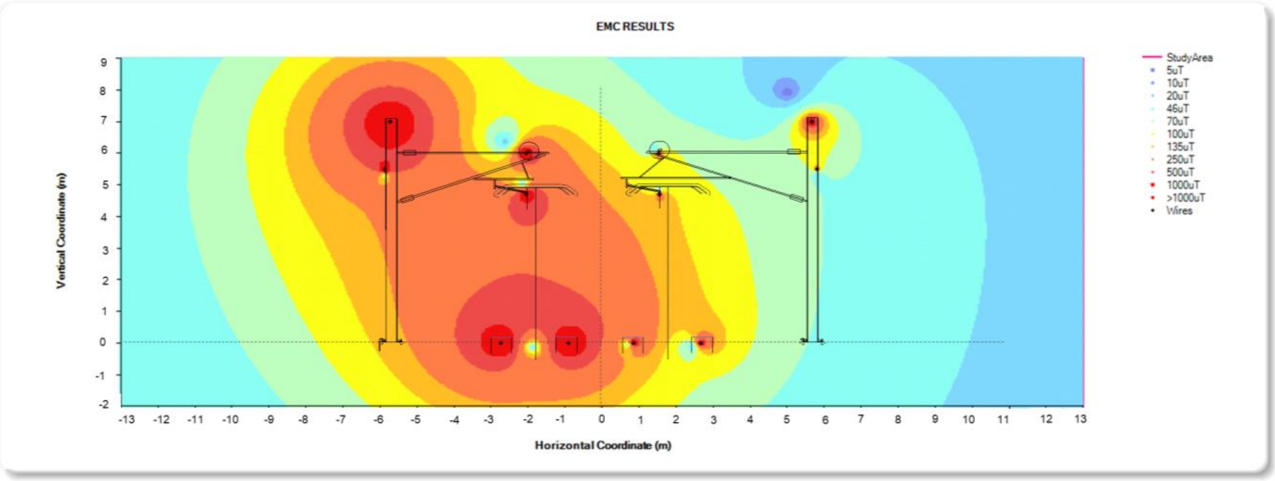

Image 22-18 Magnetic Field (Cross-Section) at 19+630.

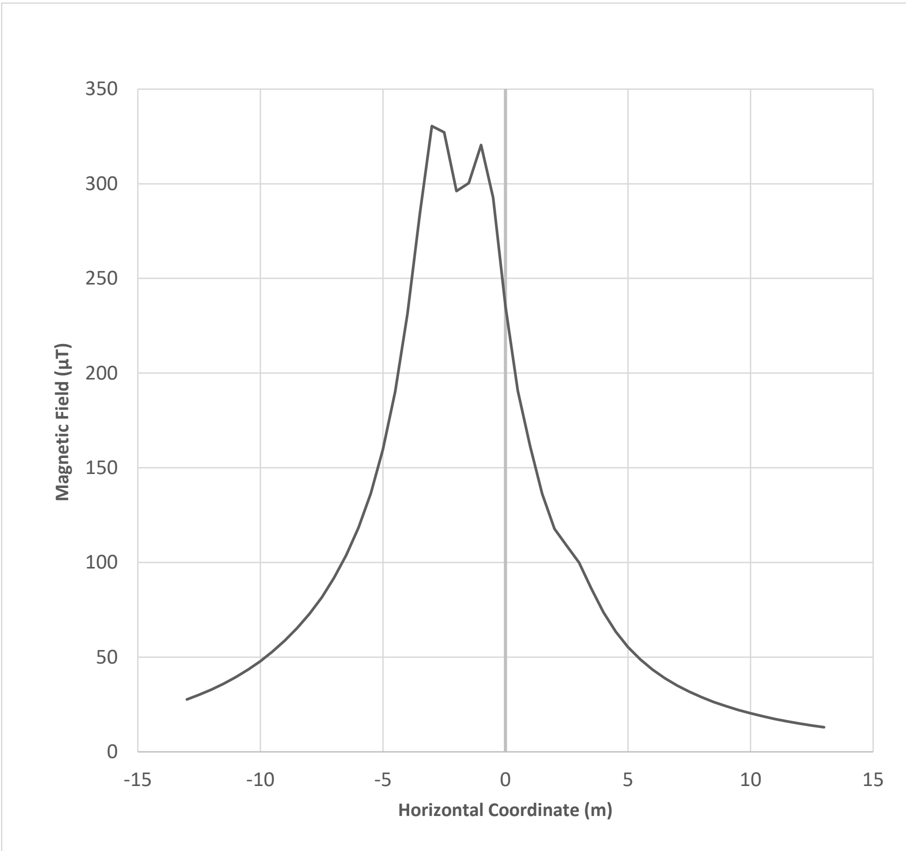

Image 22-19 Magnetic Field (Assesment Line at 1 Meter High) at 19+630.

22.4.2.10 Rush-Lusk Traction Substation

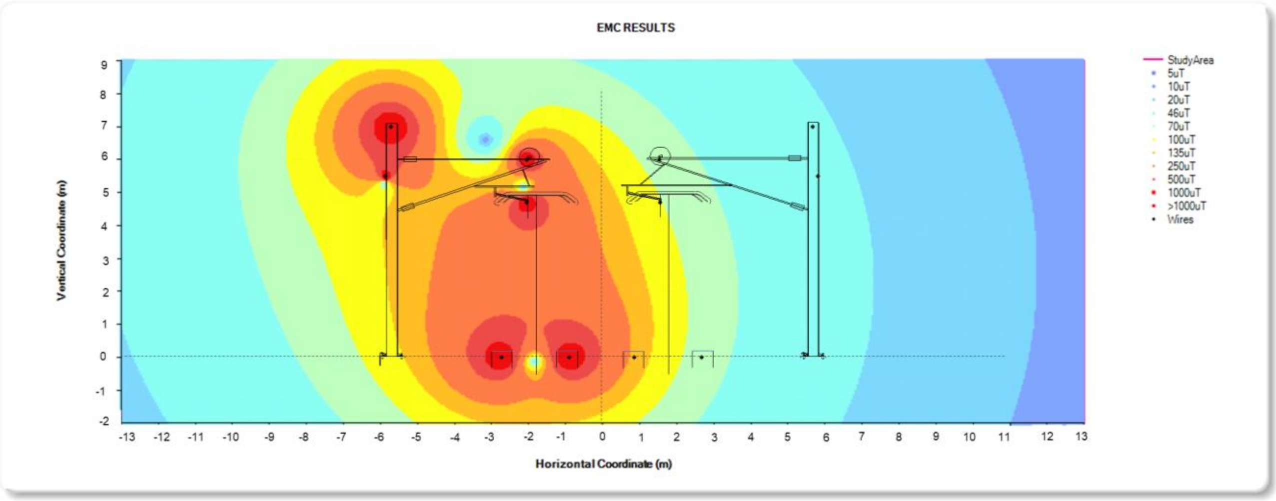

Image 22-20 Magnetic Field (Cross-Section) at 24+400.

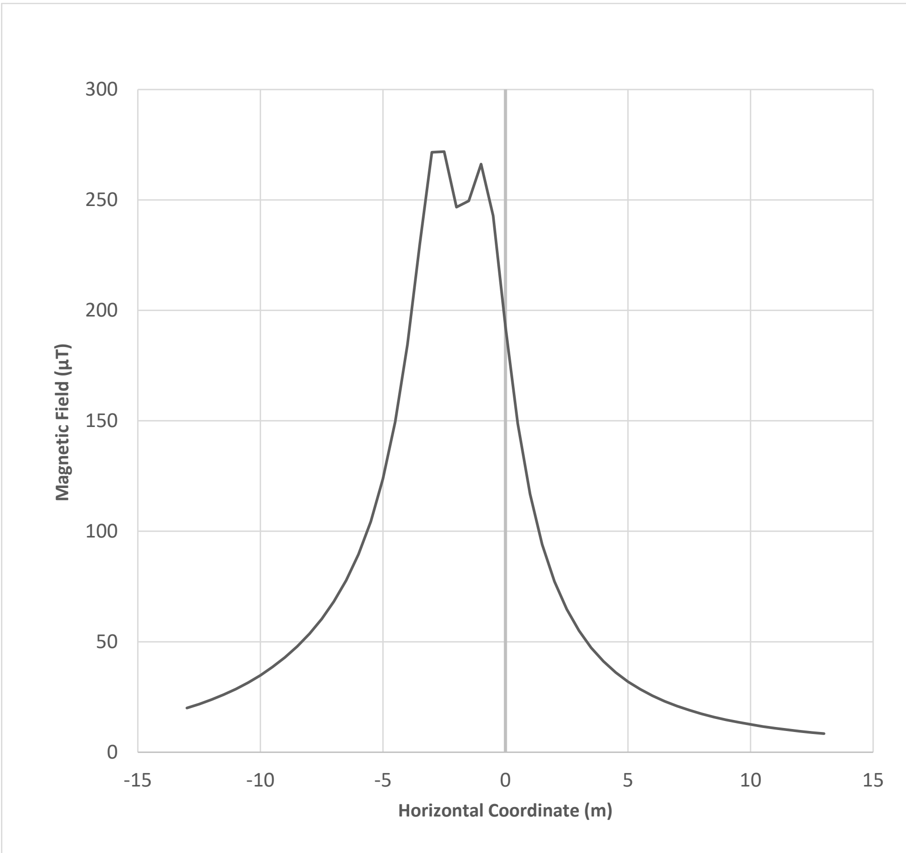

Image 22-21 Magnetic Field (Assesment Line at 1 Meter High) at 24+400.

22.4.2.11 Skerries South Traction Substation

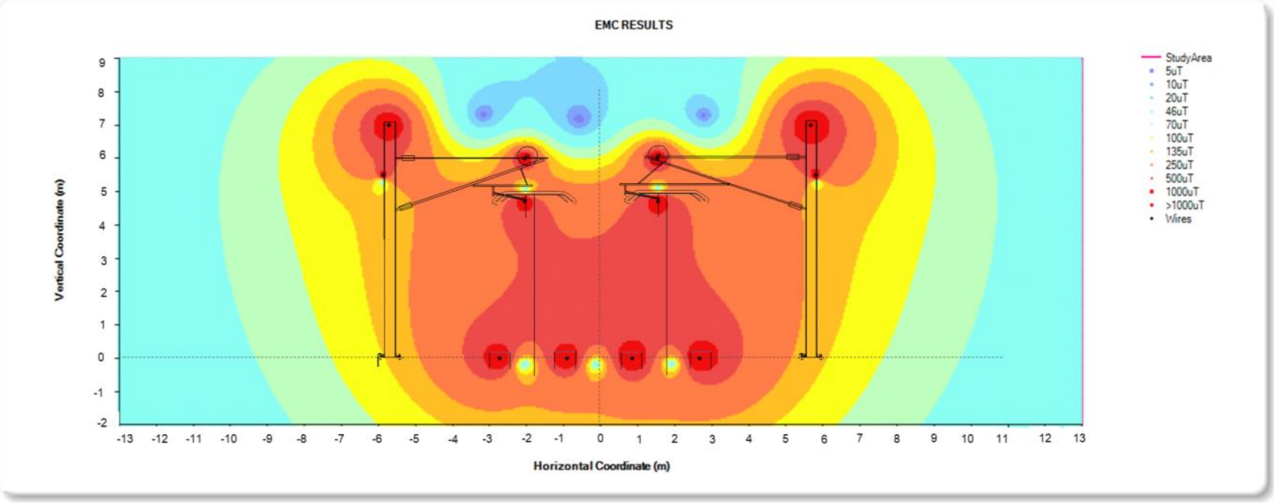

Image 22-22 Magnetic Field (Cross-Section) at 28+550.

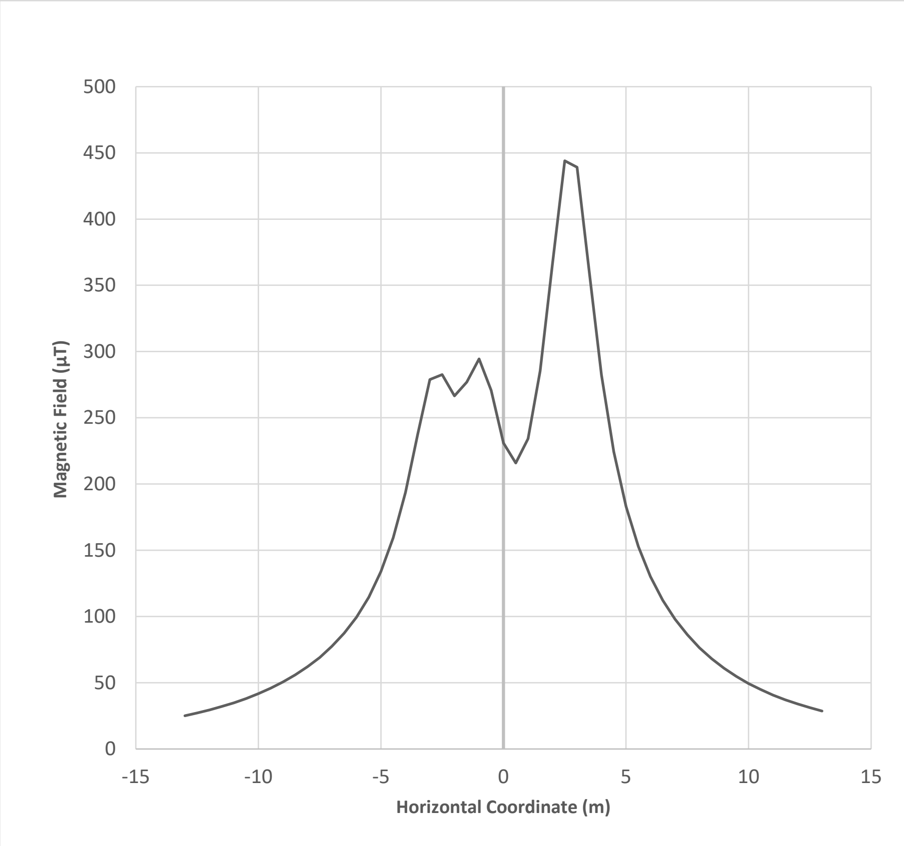

Image 22-23 Magnetic Field (Assesment Line at 1 Meter High) at 28+550.

22.4.2.12 *Skerries North (Ardgillan) Traction Substation*

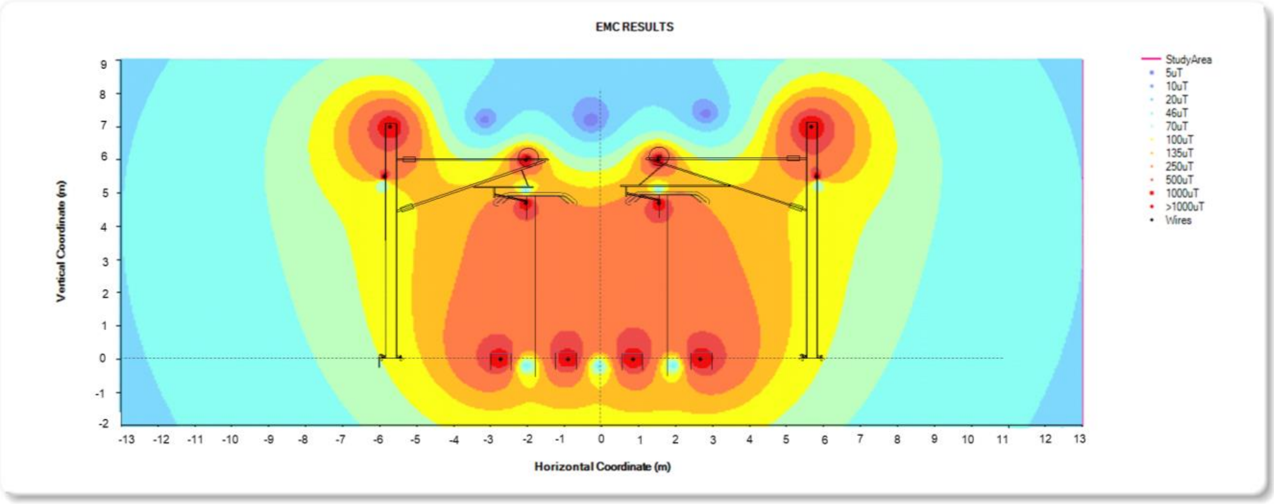

Image 22-24 Magnetic Field (Cross-Section) at 30+400.

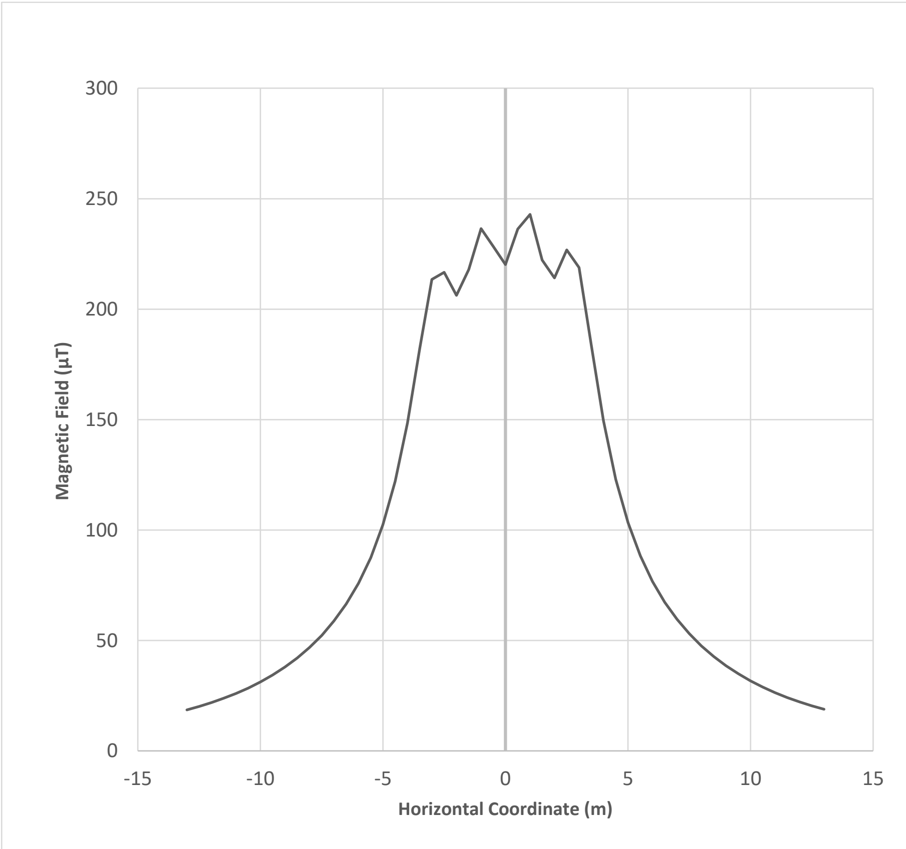

Image 22-25 Magnetic Field (Assesment Line at 1 Meter High) at 30+400.

22.4.2.13 Balbriggan Traction Substation

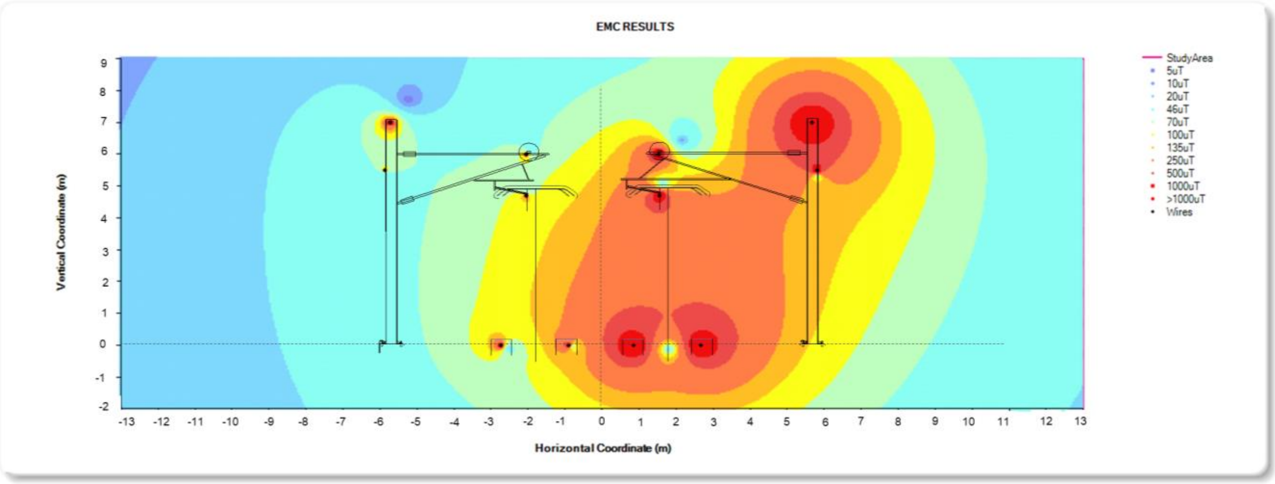

Image 22-1 Magnetic Field (Cross-Section) at 36+100.

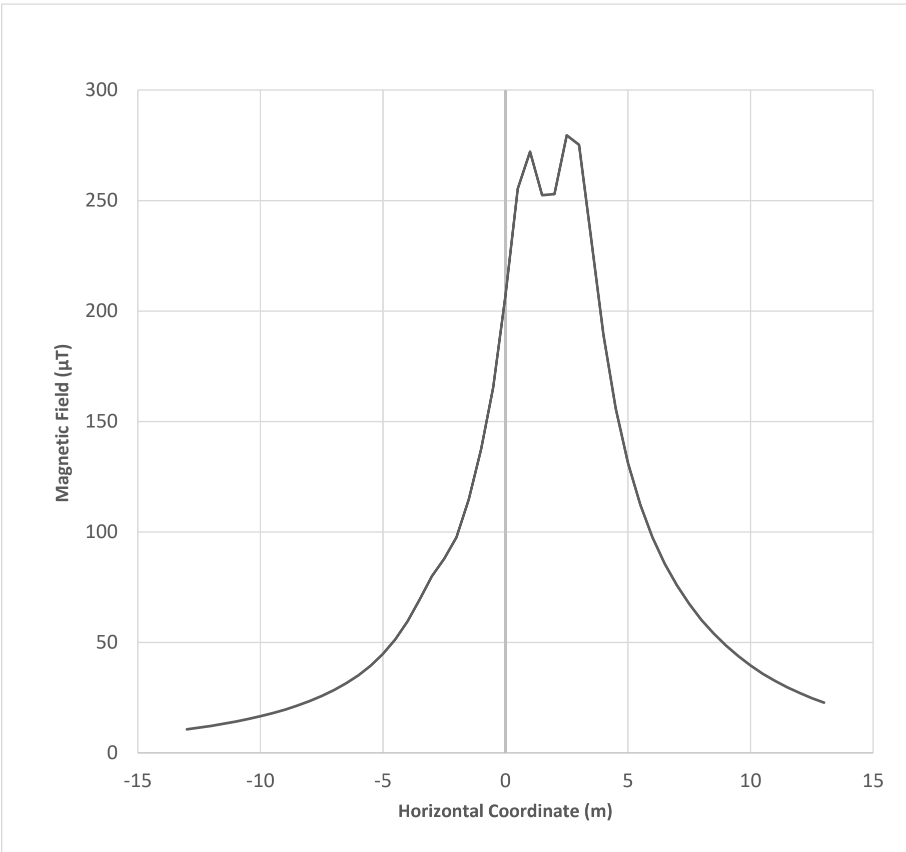

Image 22-26 Magnetic Field (Assesment Line at 1 Meter High) at 36+100.

22.4.2.14 Gormanston Traction Substation

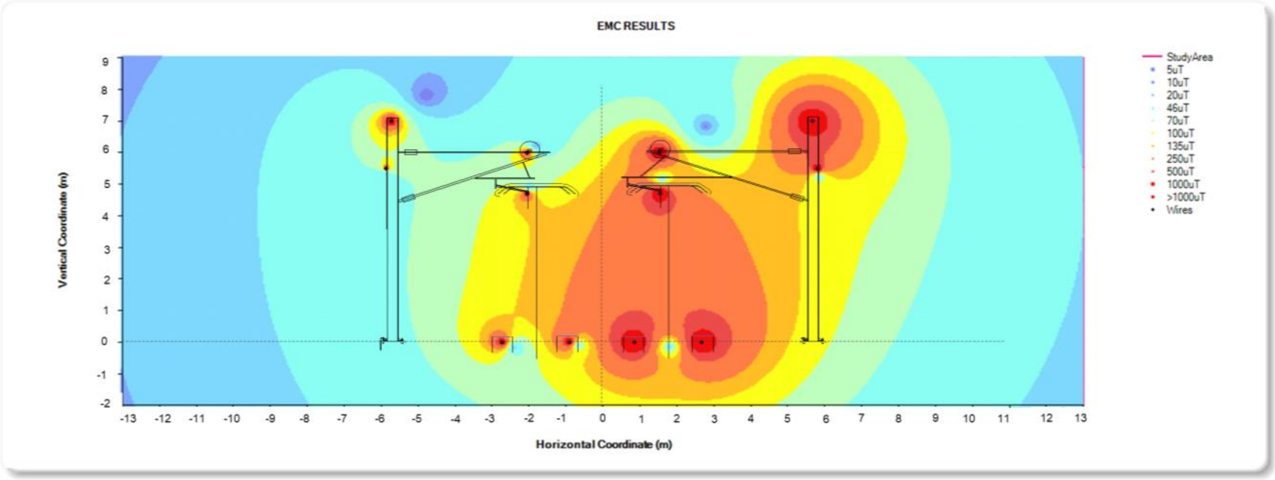

Image 22-27 Magnetic Field (Cross-Section) at 39 + 900.

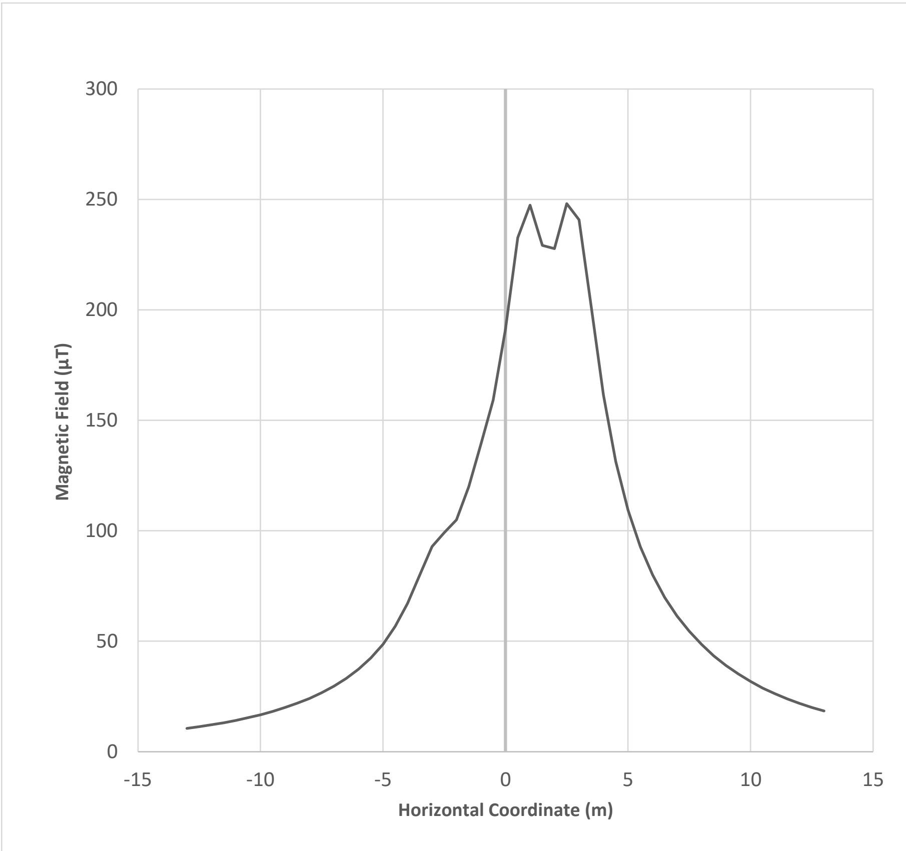

Image 22-28 Magnetic Field (Assesment Line at 1 Meter High) at 39+900.

22.4.2.15 Laytown Traction Substation

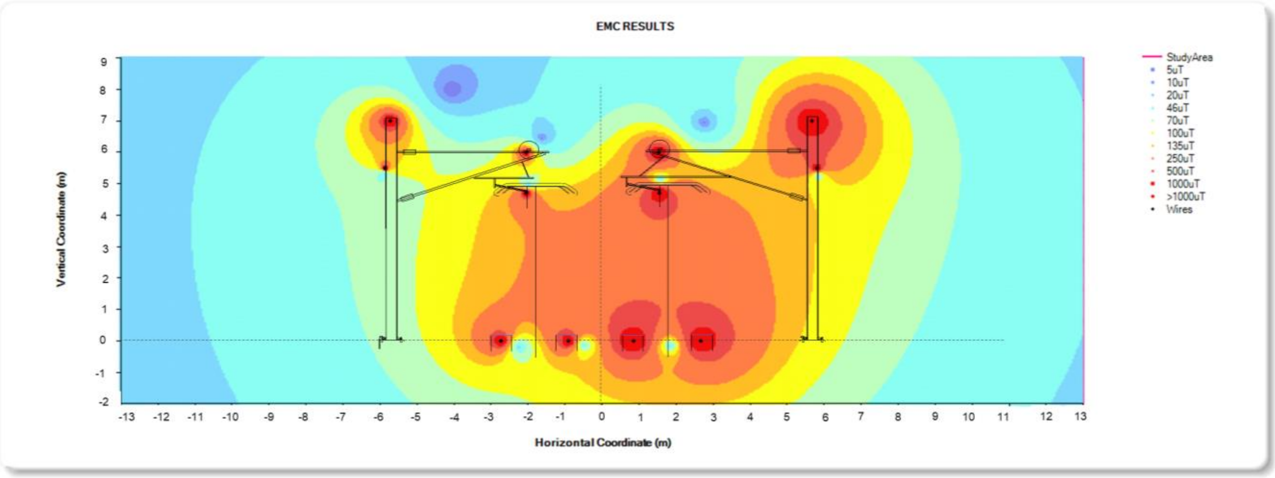

Image 22-29 Magnetic Field (Cross-Section) at 44 + 900.

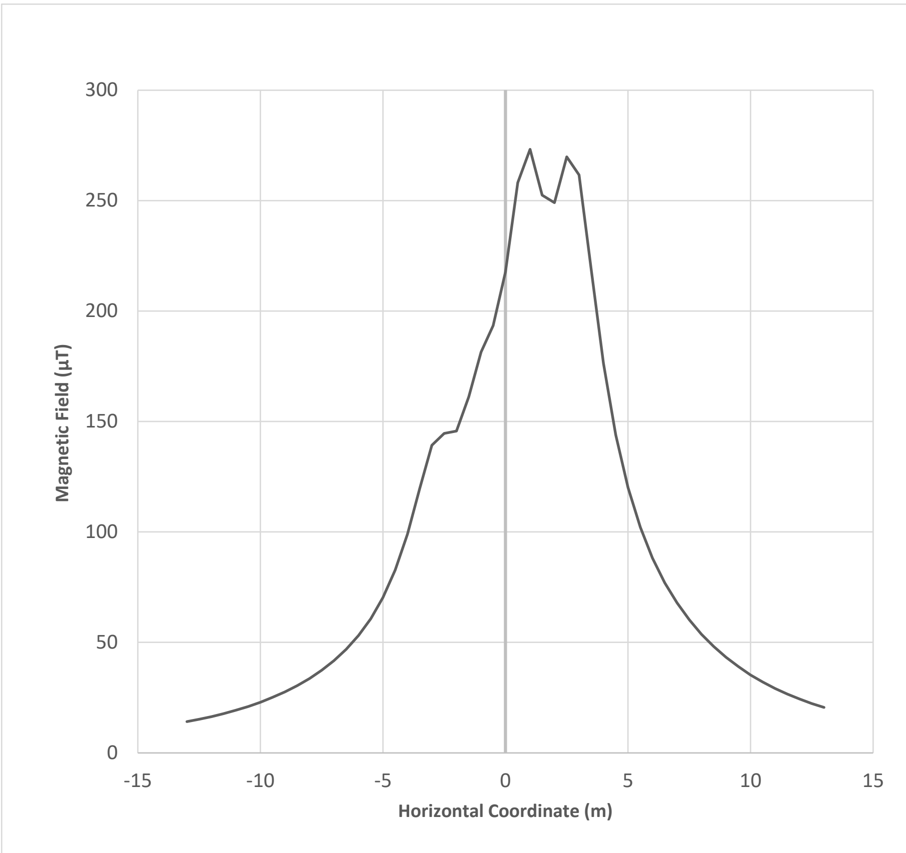

Image 22-30 Magnetic Field (Assesment Line at 1 Meter High) at 44+900.

22.4.2.16 Drogheda Traction Substation

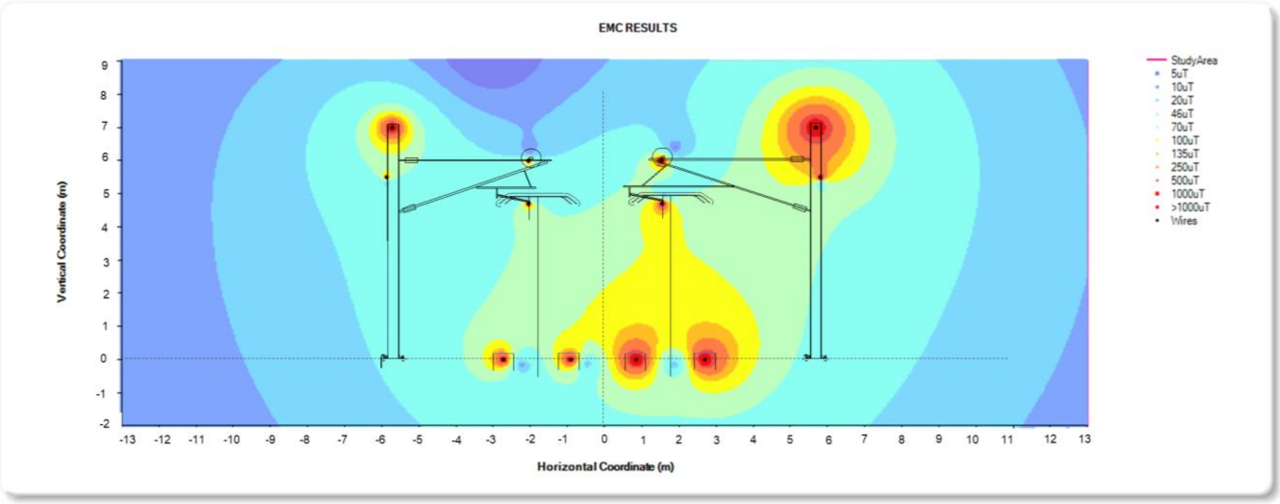

Image 22-31 Magnetic Field (Cross-Section) at 50+450.

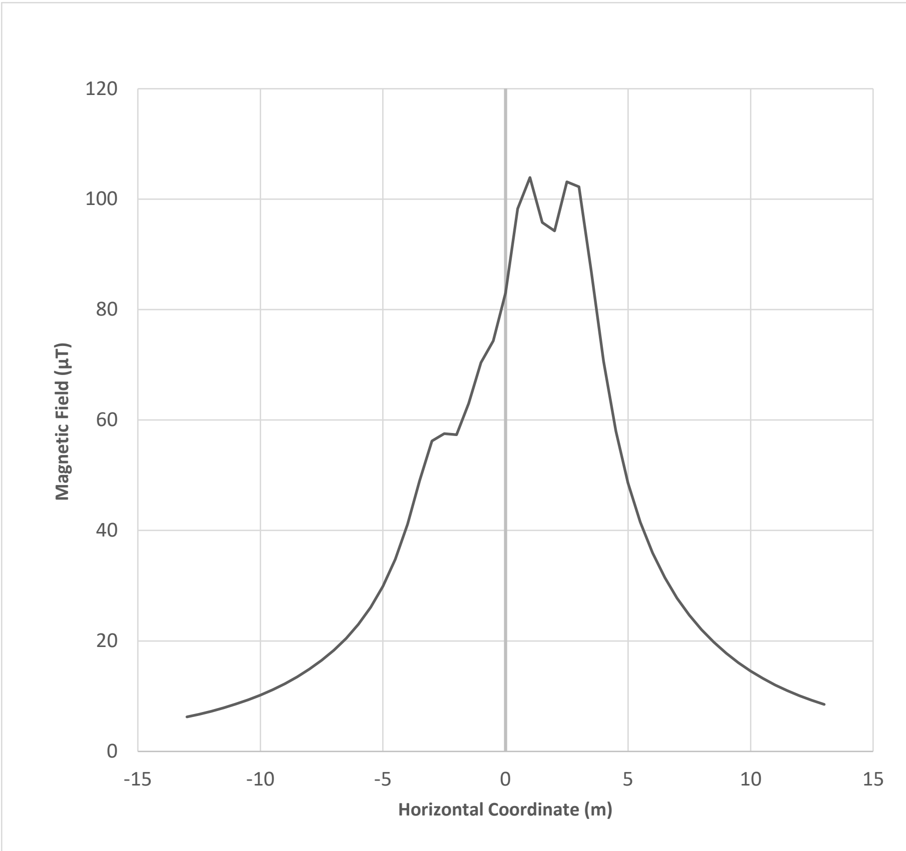

Image 22-32 Magnetic Field (Assesment Line at 1 Meter High) at 50+450.

22.4.3 Desktop Study Analysis

Image 22-2 to Image 22-32 indicate that the magnetic field decays sharply with distance from the OHLE. The magnitude of the magnetic field at 1 m height reaches maximum values at the points where the contact wires of the two tracks are located and then decreases in such way that at +/-6 m from the railway centreline (approximately where the OHLE poles are positioned) it is in all cases well below 377 µT (which in free space conditions is approximately equal to 300 A/m, the maximum immunity limit established for the railway environment as per EN 50121-4 and EN 50121-5). The magnetic field continues to decrease with distance from the OHLE, rapidly reaching values below 38 µT (which in free space conditions is approximately equal to 30 A/m, the maximum immunity limit established for the industrial environment as per IEC 61000-6-2), when a distance from the railway centreline of approximately 13m is reached.

It is clear therefore, in terms of steady-state magnetic field exposure for the railway equipment, that the expected levels are below the immunity levels specified for equipment located in both the trackside environment (EN 50121-4) and the traction substation environment (EN 50121-5); viz. 300 A/m, in those locations where the track-side S&T equipment is expected to be installed.

Likewise, the expected level is below the immunity limit specified for equipment located in an industrial environment (61000-6-2), viz. 30 A/m, when a distance from the railway centreline of approximately 13 m approx. is reached.

22.4.4 Baseline Survey Results

Frequencies from DC up to 18 GHz were monitored in each of the three locations listed in section 22.3.3.

For the DC magnetic field measurements, the results are presented firstly as the static field recorded over the measurement interval and also as the magnitude of the field fluctuations over that same period.

22.4.4.1 Gormanston EMR Survey

Measurements were performed at the bridge crossing the current rail line in proximity to the proposed traction substation, compound, and access road locations (marked with the square in Image 22-33 below).

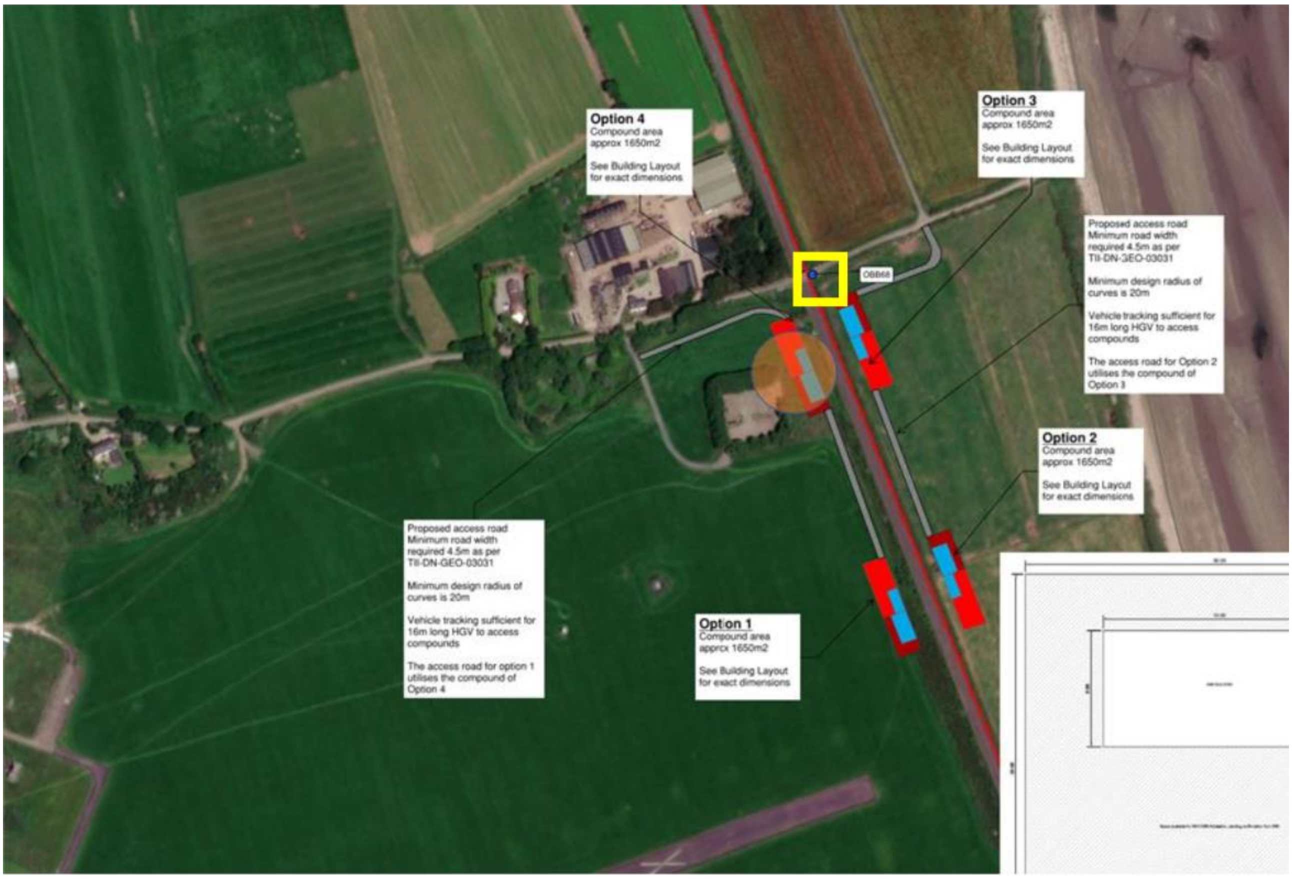

Image 22-33 Measurement Location at Gormanston

Image 22-34 Biconical Antenna at Gormanston.

Image 22-35 Loop Antenna at Gormanston.

DC Magnetic Field, Gormanston

The Earth's DC magnetic flux density (B) was measured for a period of 30 minutes. The average static field was approximately 44.4 μT. Three trains passed the measurement location over this time period, causing deviations of just over 1 μT. The largest deviations were caused however when two cars passed quite close to the measurement point (seen at 24 minutes) which created a deviation of almost 6 μT.

AC Electric and Magnetic Fields 1 Hz to 10 kHz, Gormanston

Image 22-38 gives a spectral plot of the magnetic field from DC to 100 Hz with Image 22-42 showing the equivalent electric field. The DC component can be seen to be much higher than any other frequency. A small spike at 50 Hz is evident, which is the transmission frequency for mains electricity but is barely above the normal background level. This would be typical of a more remote location with little in the way of mains lines nearby.

No unusually elevated electromagnetic field levels were detected in the range between 100 Hz to 10 kHz.

Radiofrequency Radiated Fields: 10 kHz to 18 GHz, Gormanston

There was no evidence, during the measurement and observation time of this study of any transient or intermittent events.

The RF emissions profile in this frequency range was well below the typical risk levels of 3 V/m.

At this site the strongest emissions were caused by Analog radio broadcasts (80 – 110 MHz), Digital Radio (147-223 MHz), Maritime Communications (160 MHz), Tetra Radio (390 MHz), Digital Television Broadcasting (470 – 790 MHz) and WiFi (2.4 GHz). In terms of mobile technology, the following signals were present, being mobile broadband, LTE (791-821 MHz and 925-960 MHz), GSM 900 and 1800 (900 MHz and 1.8 GHz), 3G (2.1 GHz) and 5G(3.6 GHz). Also detectable in the 8-18 GHz range were Maritime radionavigation signals.

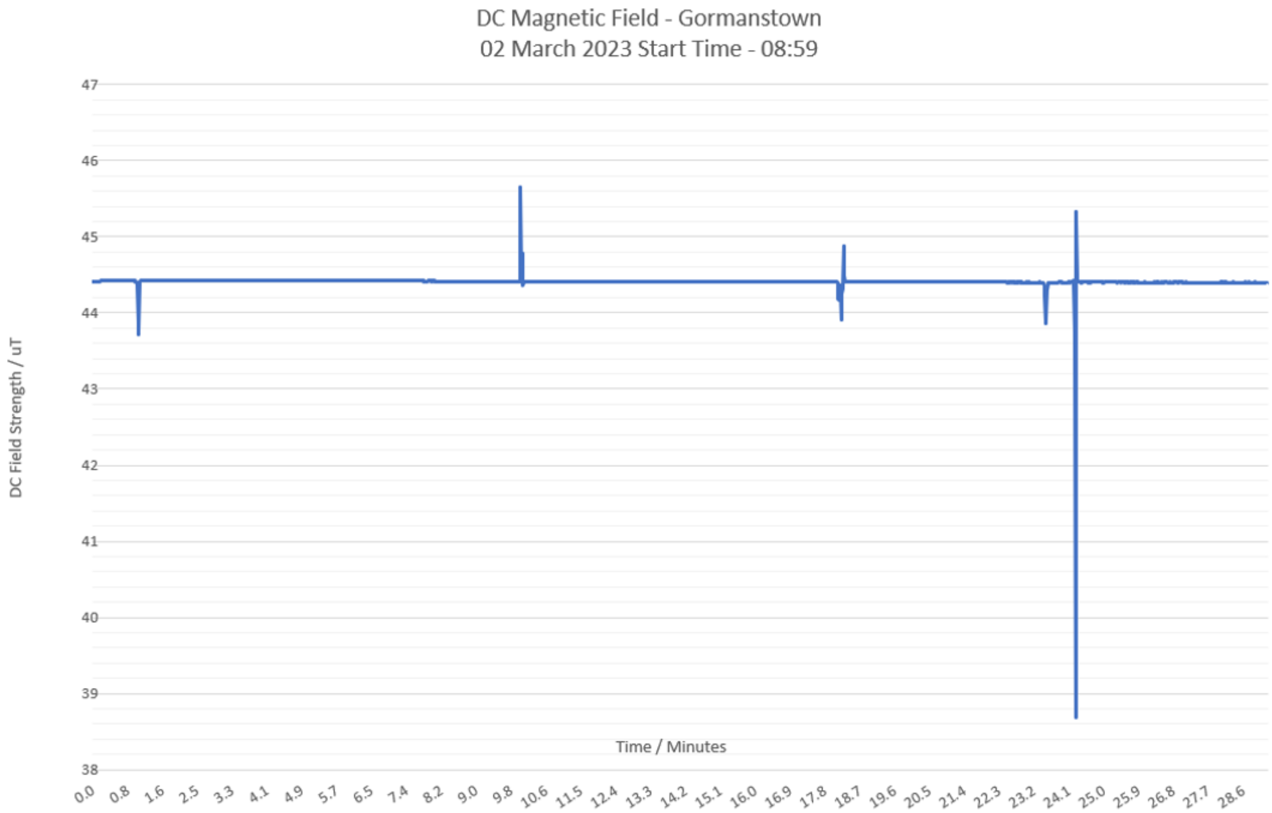

Image 22-36 Gormanston, DC Magnetic Field

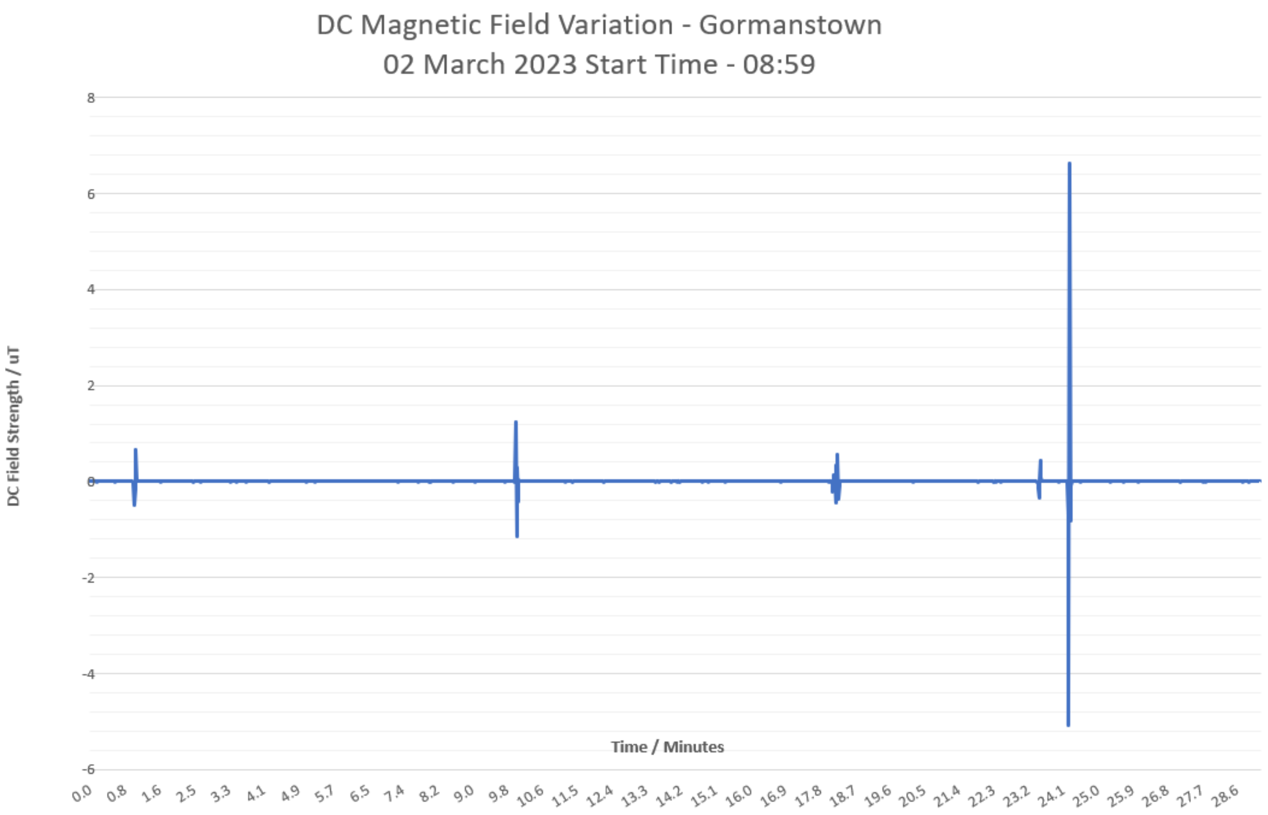

Image 22-37 Gormanston, DC Magnetic Field variations

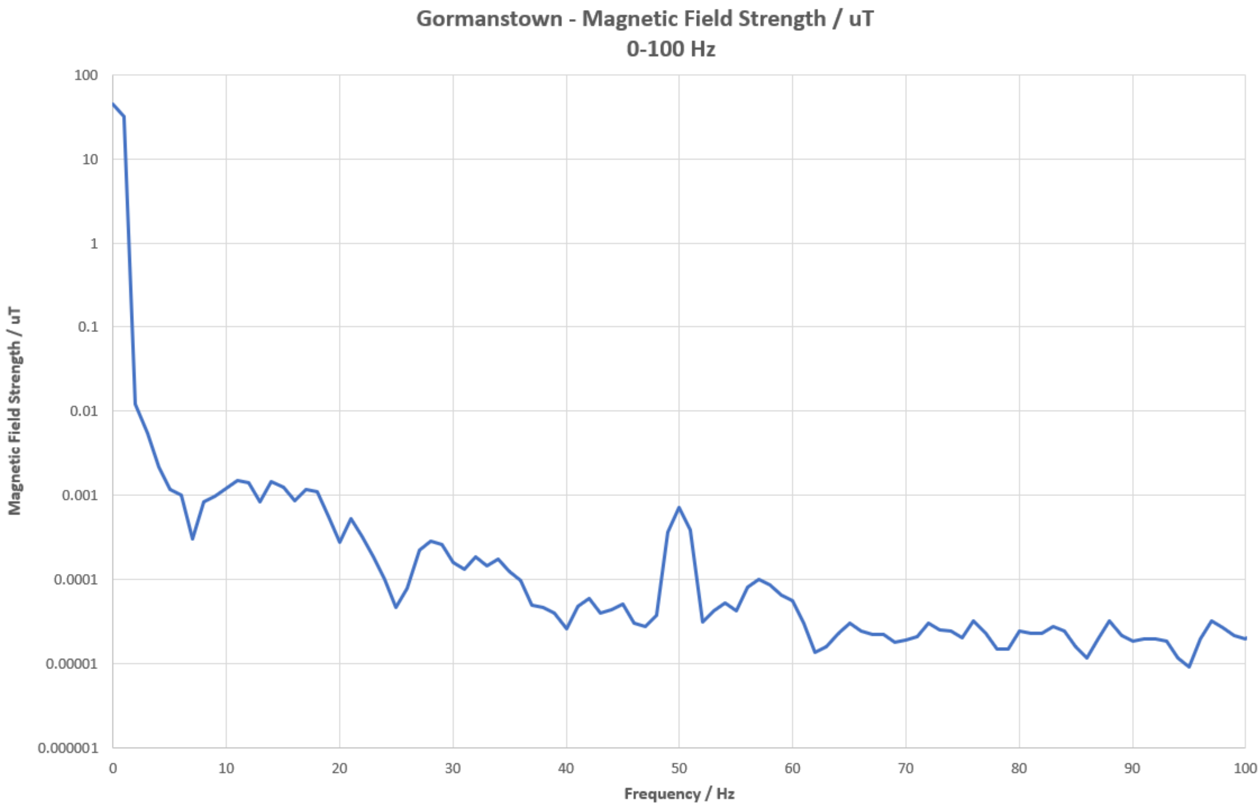

Image 22-38 Gormanston, 0 Hz to 100 Hz (Mag Field)

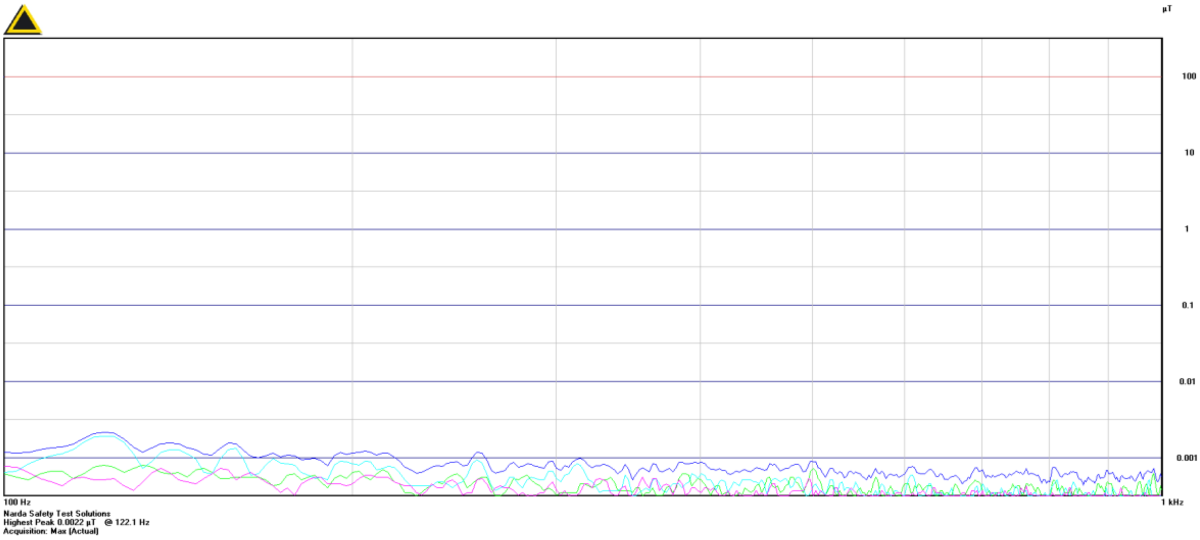

Image 22-39 Gormanston, 100 Hz to 1 kHz (Mag Field)

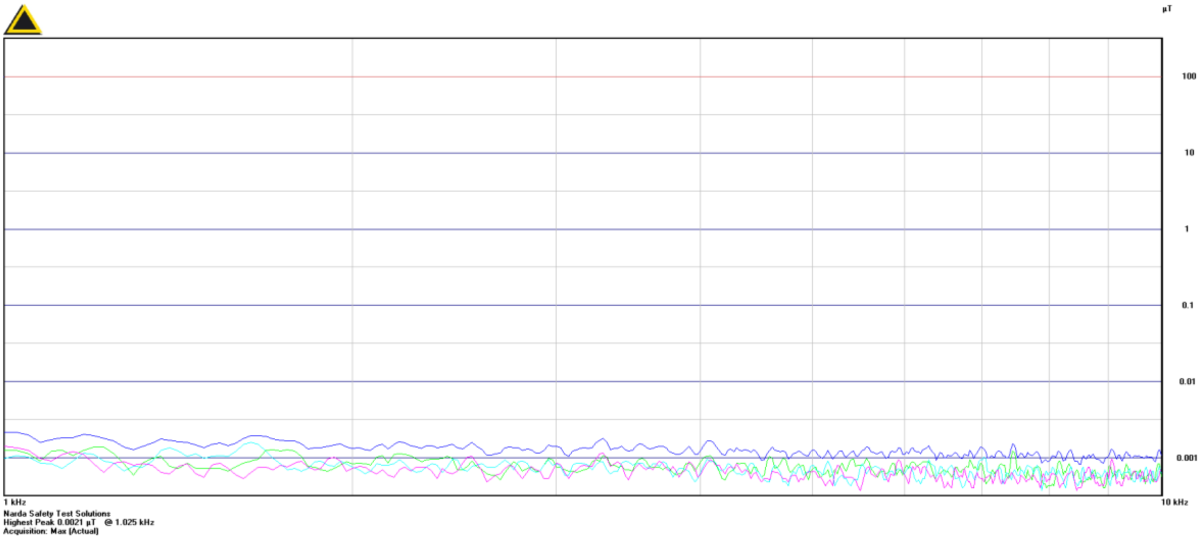

Image 22-40 Gormanston, 1 kHz to 10 kHz (Mag Field)

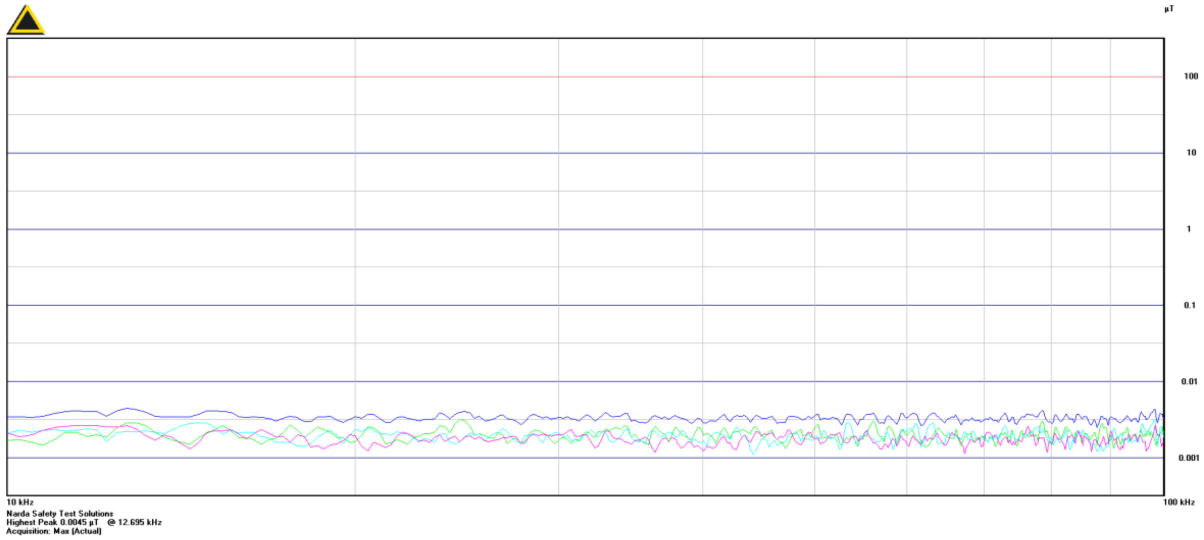

Image 22-41 Gormanston, 10 kHz to 100 kHz (Mag Field)

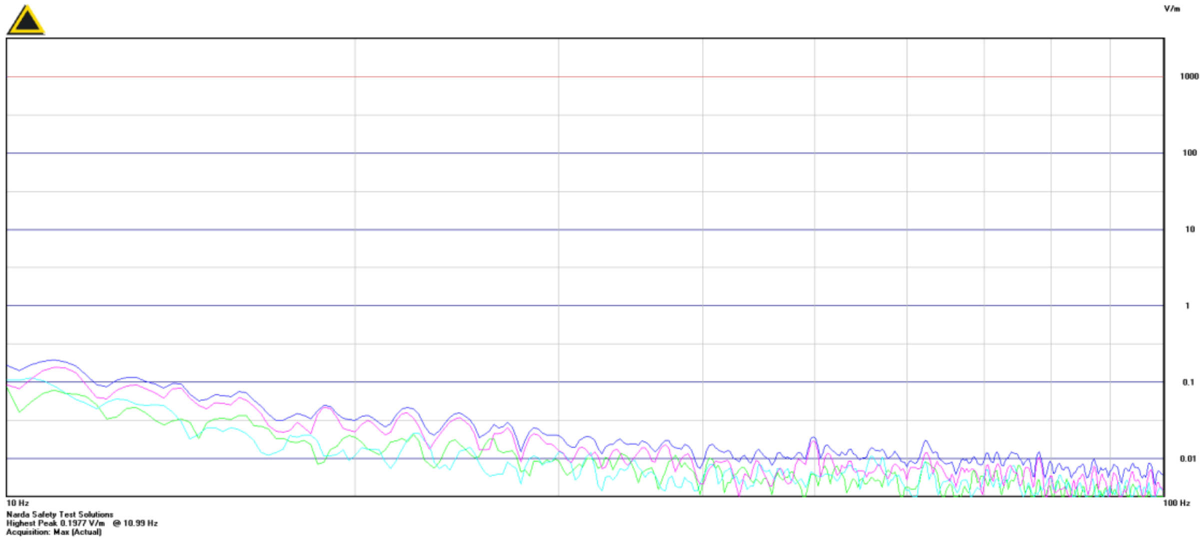

Image 22-42 Gormanston, 10 Hz to 100 Hz (E-Field)

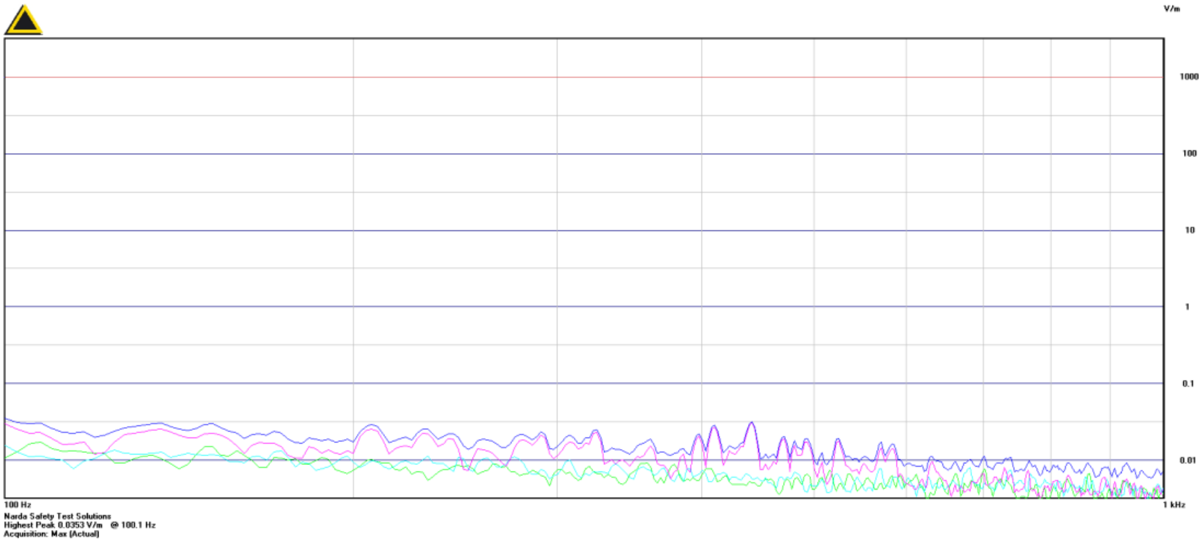

Image 22-43 Gormanston, 100 Hz to 1 kHz (E-Field)

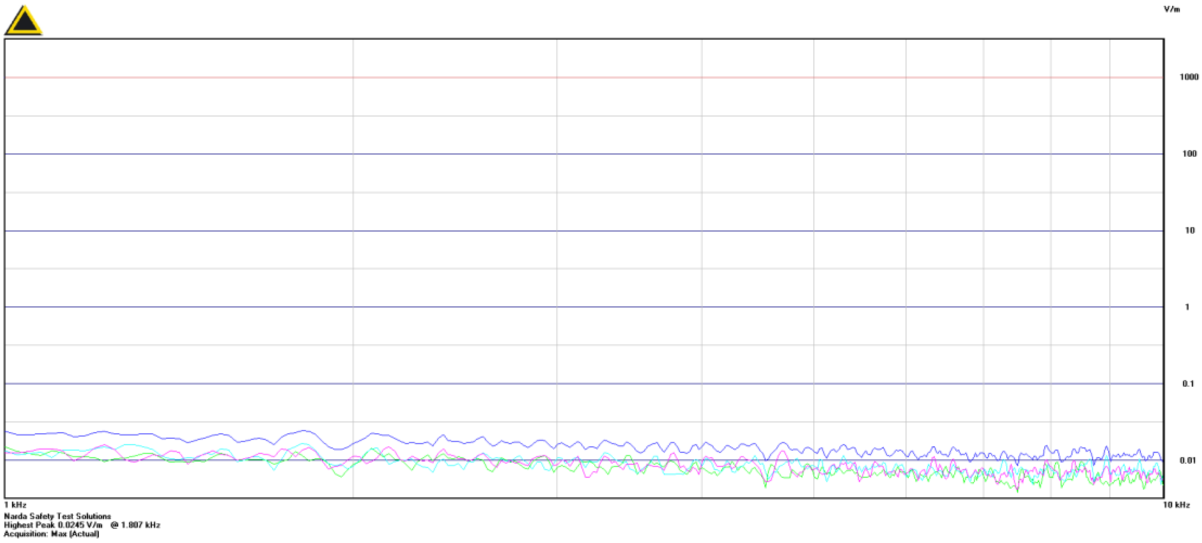

Image 22-44 Gormanston, 1 kHz to 10 kHz (E-Field)

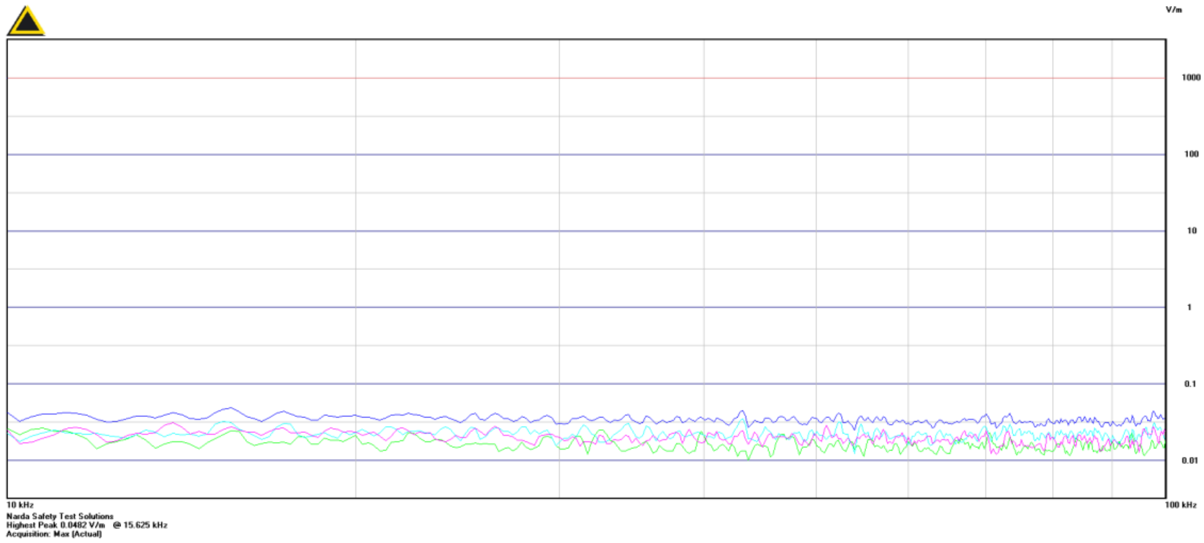

Image 22-45 Gormanston, 10 kHz to 100 kHz (E-Field)

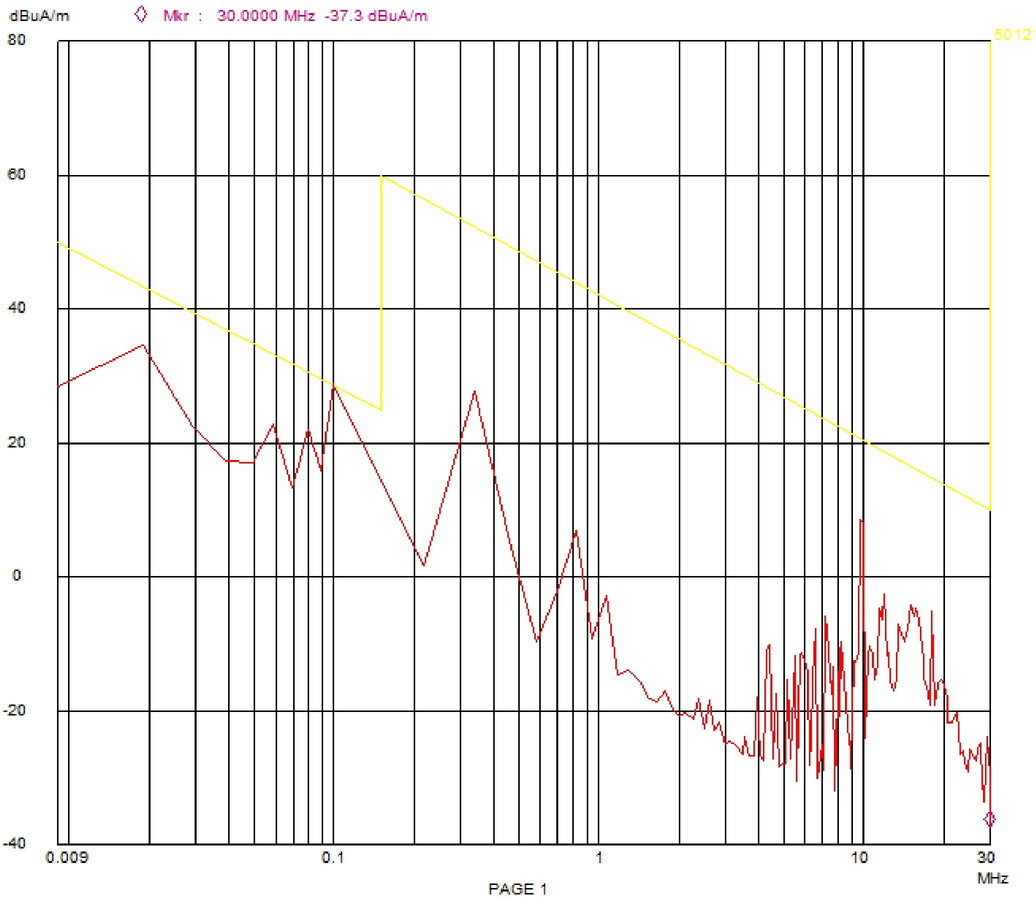

Image 22-46 Gormanston - 9 kHz to 30 MHz

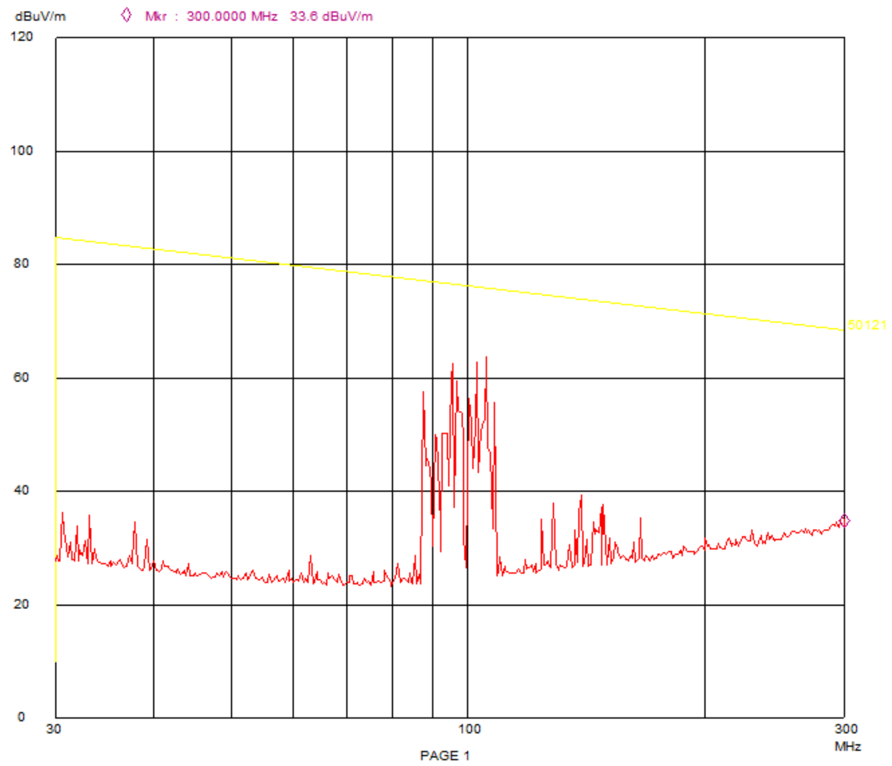

Image 22-47 Gormanston - 30 MHz to 300 MHz

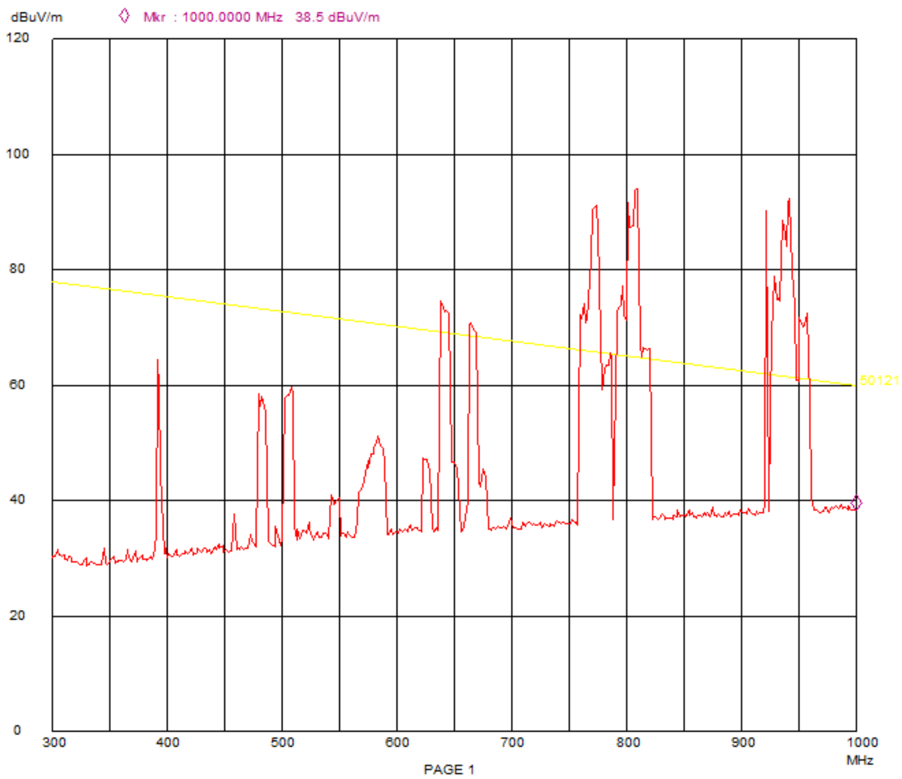

Image 22-48 Gormanston – 300 MHz - 1 GHz

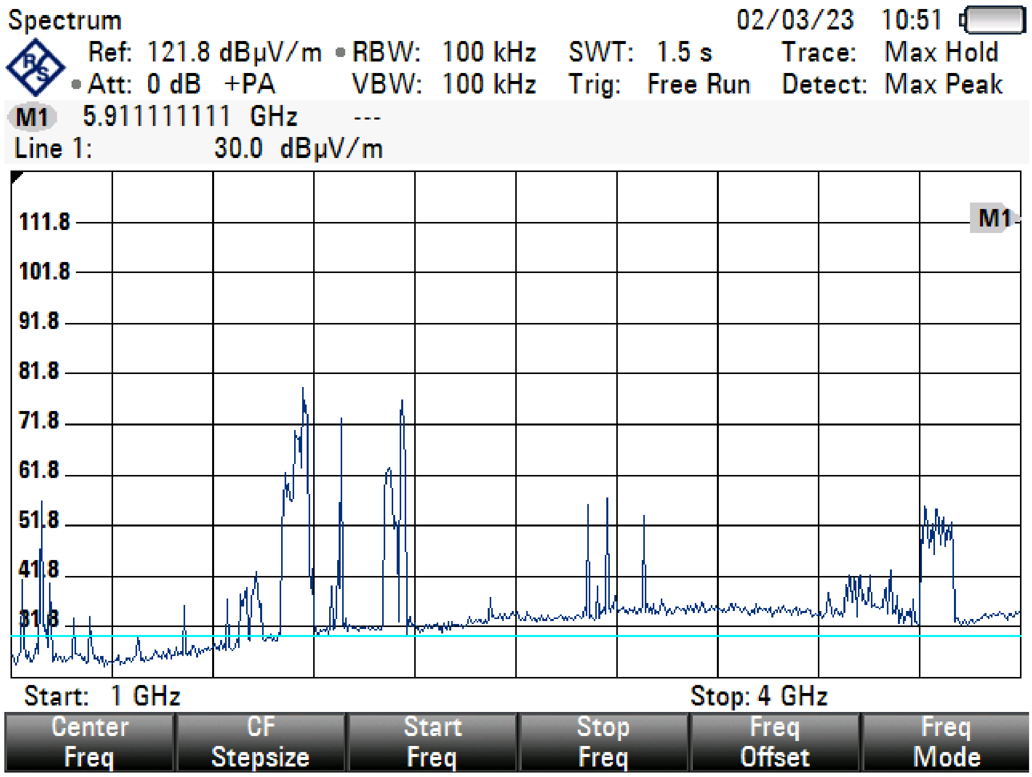

Image 22-49 Gormanston - 1 GHz to 4 GHz

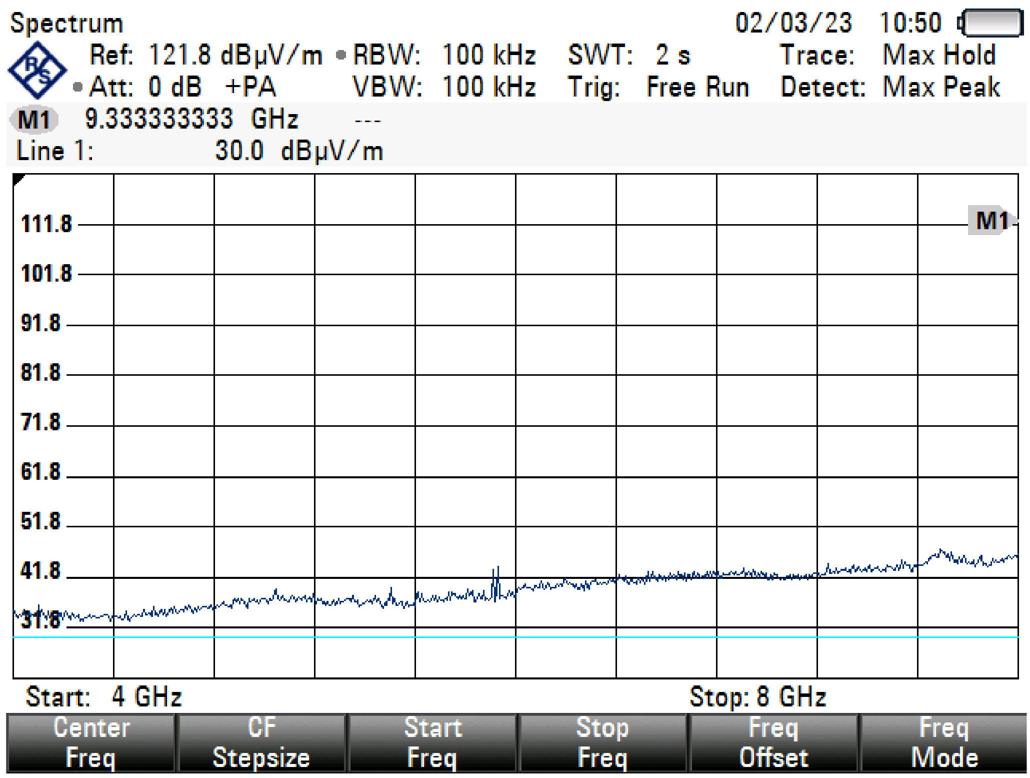

Image 22-50 Gormanston - 4 GHz to 8 GHz

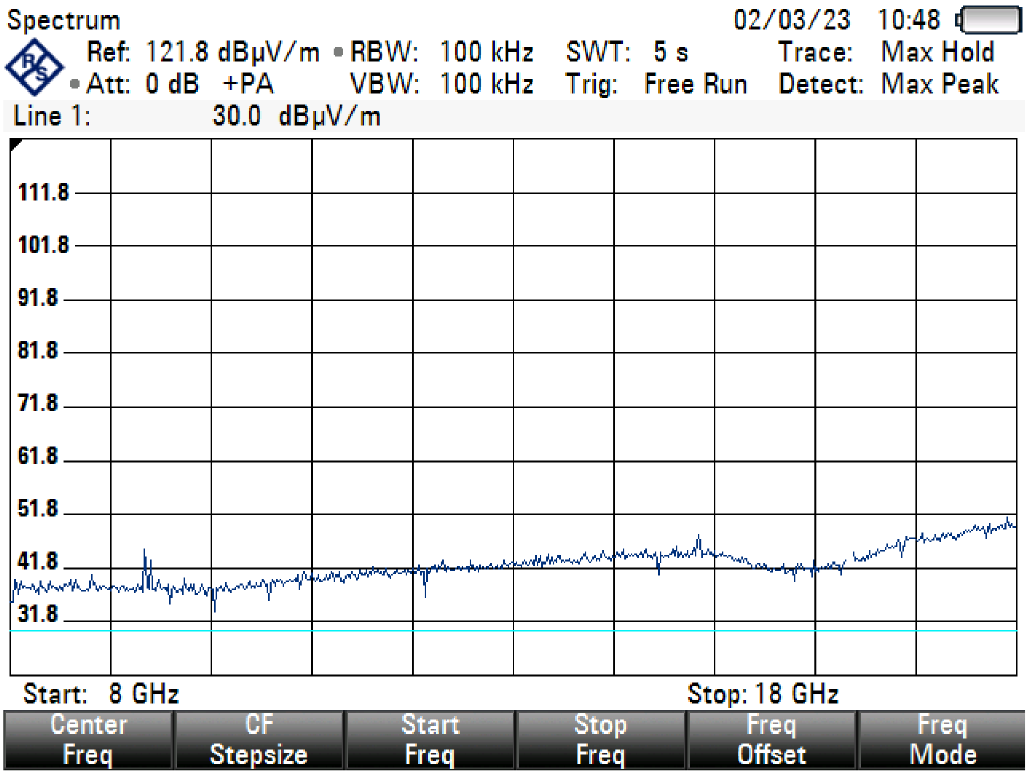

Image 22-51 Gormanston - 8 GHz to 18 GHz

22.4.4.2 Donabate EMR Survey

Measurements were requested to be performed at the location highlighted by the circle below which was the reported location of the intersection of the East West HVDC interconnector and the current rail line. Visiting the site however determined that the actual intersection location was approximately halfway between this reported location and the estuary. This latter location is where the DC and AC measurements were conducted (yellow square in Image 22-52).

Image 22-52   Measurement Location at Donabate (Source: Google Maps).

Image 22-53 Bartington magnetometer taking DC and near DC measurements at Donabate.

Image 22-54 Warning sign at intersection of rail line and HVDC transmission line

DC Magnetic Field, Donabate

The Earth's DC magnetic flux density (B) was measured for a period of 30 minutes. The most notable observation at this site from a DC field perspective was the 63 μT baseline reading. This is indicative of the nearby buried cable and its associated magnetic lines of flux as a result of the load current running through it. As this is a DC transmission line it would be expected to present a localised DC field effect. Three trains passed during the survey window, passing both North and South with the highest deviation recorded as 0.5 μT. The distance from the train line was approximately 12 metres.

AC Electric and Magnetic Fields 1 Hz to 10 kHz, Donabate

Image 22-57 gives a spectral plot of the magnetic field from DC to 100 Hz with Image 22-61 showing the equivalent electric field. The DC component can be seen to be much higher than any other frequency. An atypical observation noted was the magnitude of the 100 Hz field exceeding the 50 Hz field at this location. This would be attributable to the nearby interconnector. The converse of this is seen in the equivalent electric field plot in Image 22-61: Donabate, 10Hz to 100 Hz (E-Field) where the 50 Hz field is the strongest component. In Image 22-58 and Image 22-62 multiple harmonics can be seen as a result of the transmission line.

No other unusually elevated electromagnetic field levels were detected in the range between 100 Hz to 10 kHz.

Radiofrequency Radiated Fields: 10 kHz to 18 GHz, Donabate

There was no evidence, during the measurement and observation time of this study of any transient or intermittent events.

The RF emissions profile in this frequency range was well below the typical risk levels of 3 V/m.

At this site the strongest emissions were caused by Analog radio broadcasts (80 – 110 MHz), Digital Radio (147-223 MHz), Maritime Communications (160 MHz), Tetra Radio (390 MHz), Digital Television Broadcasting (470 – 790 MHz) and WiFi (2.4 GHz). In terms of mobile technology, the following signals were present, being mobile broadband, LTE (791-821 MHz and 925-960 MHz), GSM 900 and 1800 (900 MHz and 1.8 GHz), 3G (2.1 GHz) and 5G(3.6 GHz). Also detectable in the 8-18 GHz range was Maritime radionavigation signals for example at 9.3 GHz.

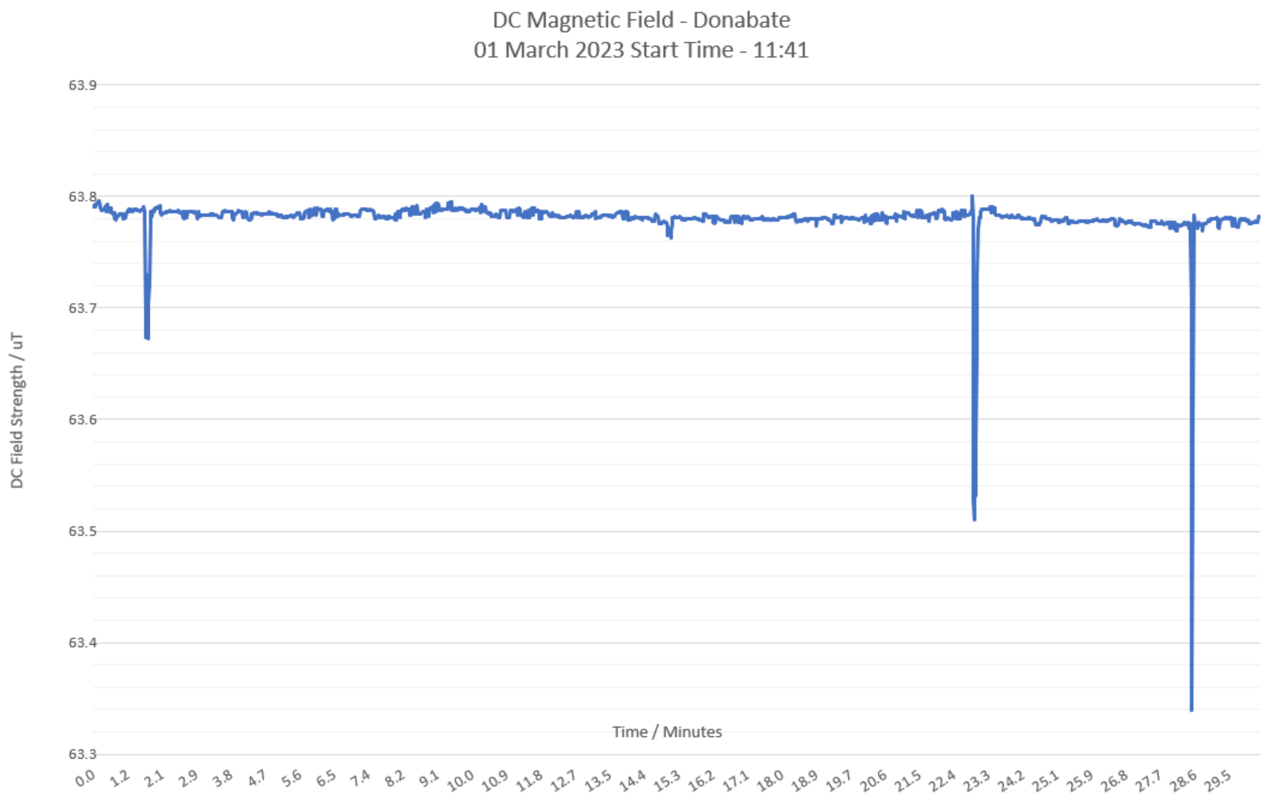

Image 22-55 Donabate, DC Magnetic Field

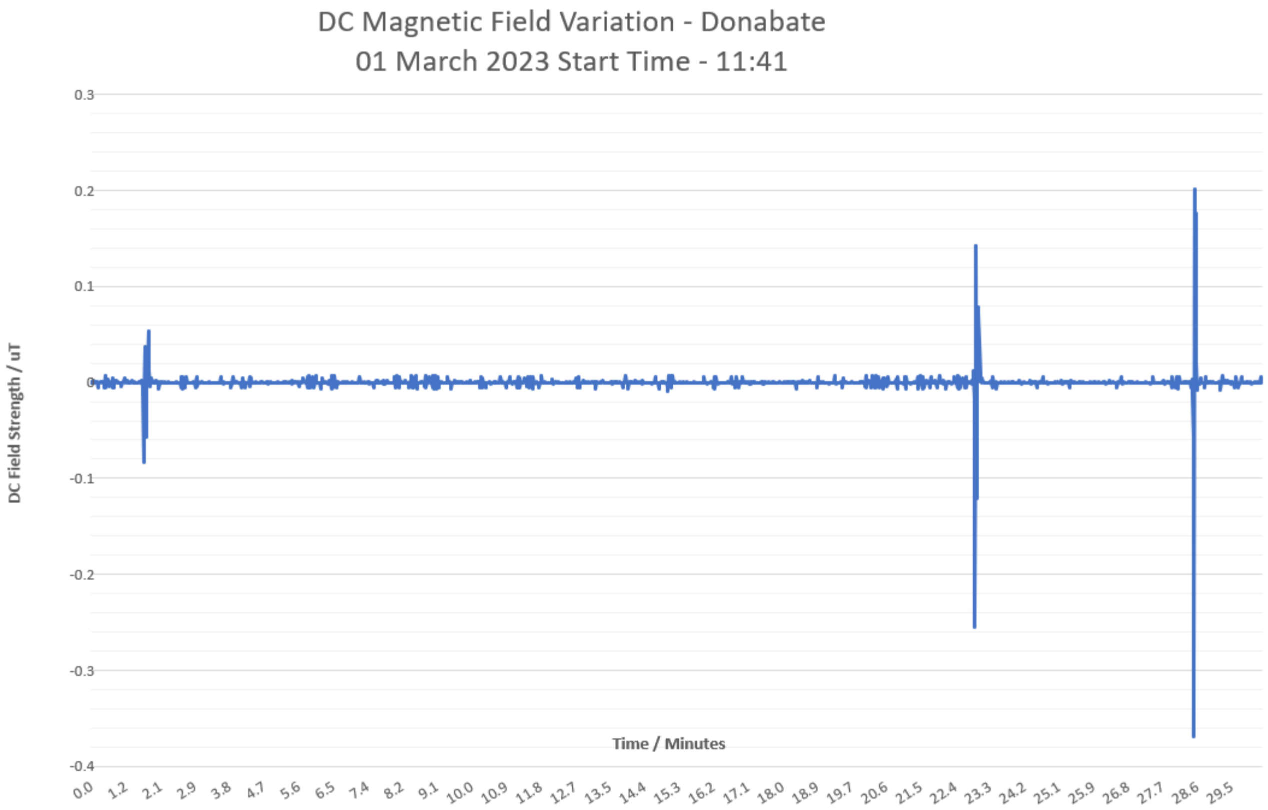

Image 22-56 Donabate, DC Magnetic Field variations

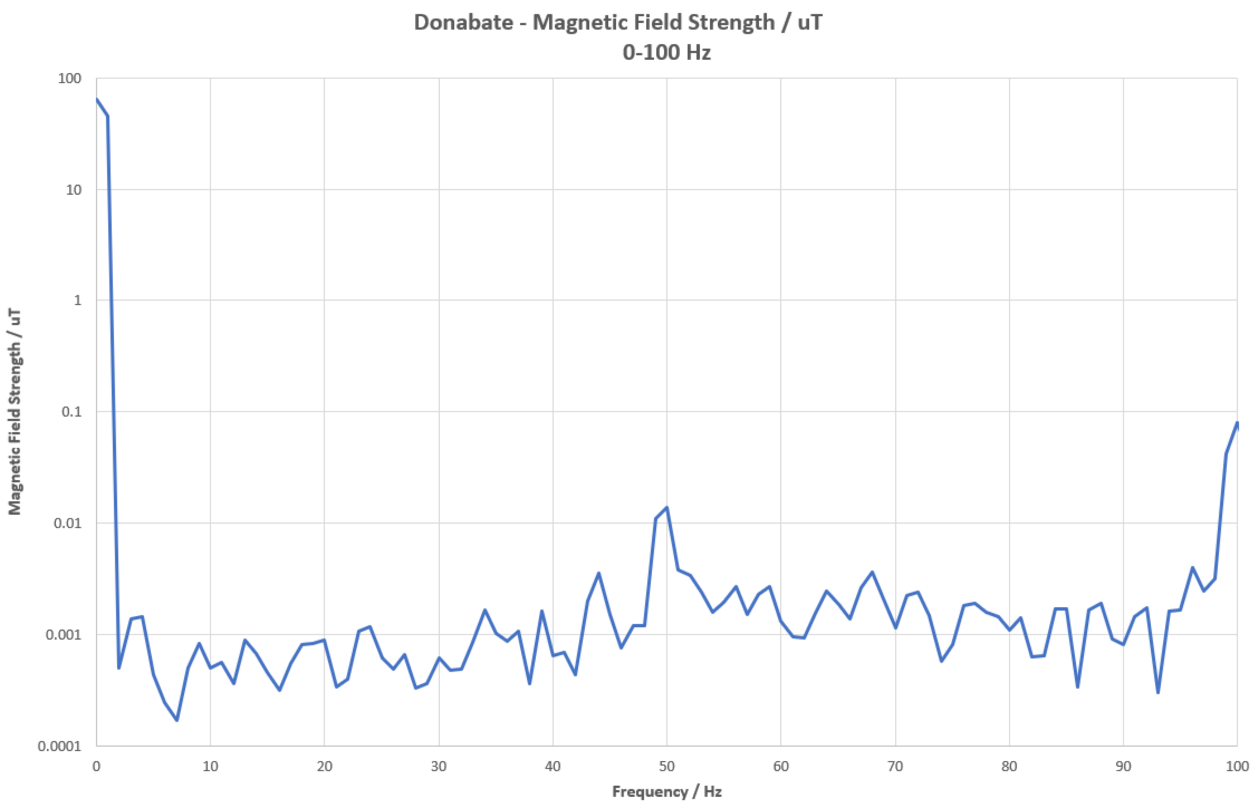

Image 22-57 Donabate, 0 Hz to 100 Hz (Mag Field)

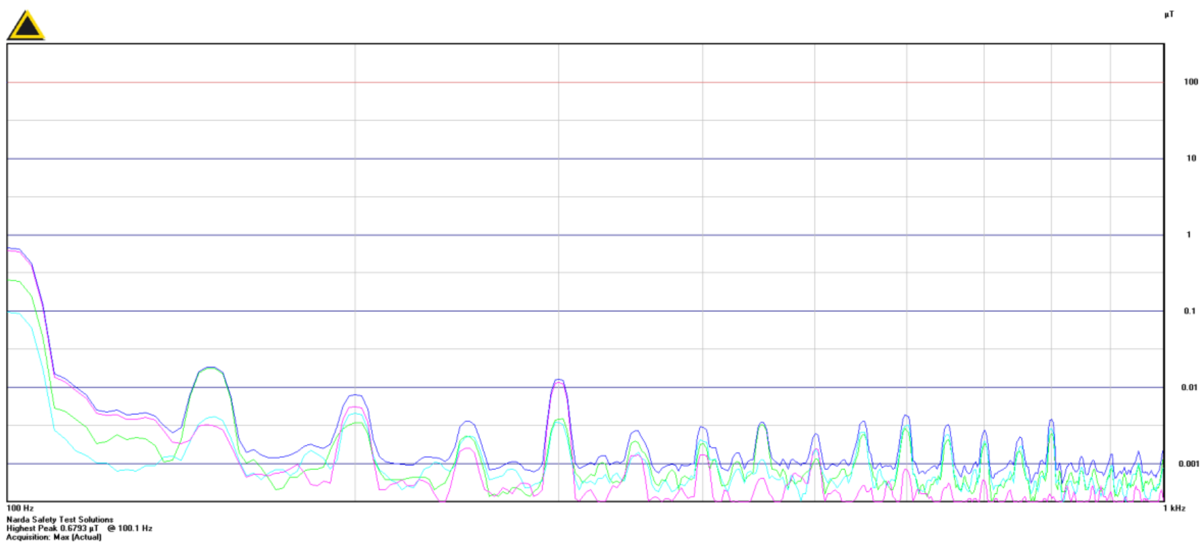

Image 22-58 Donabate, 100 Hz to 1 kHz (Mag Field)

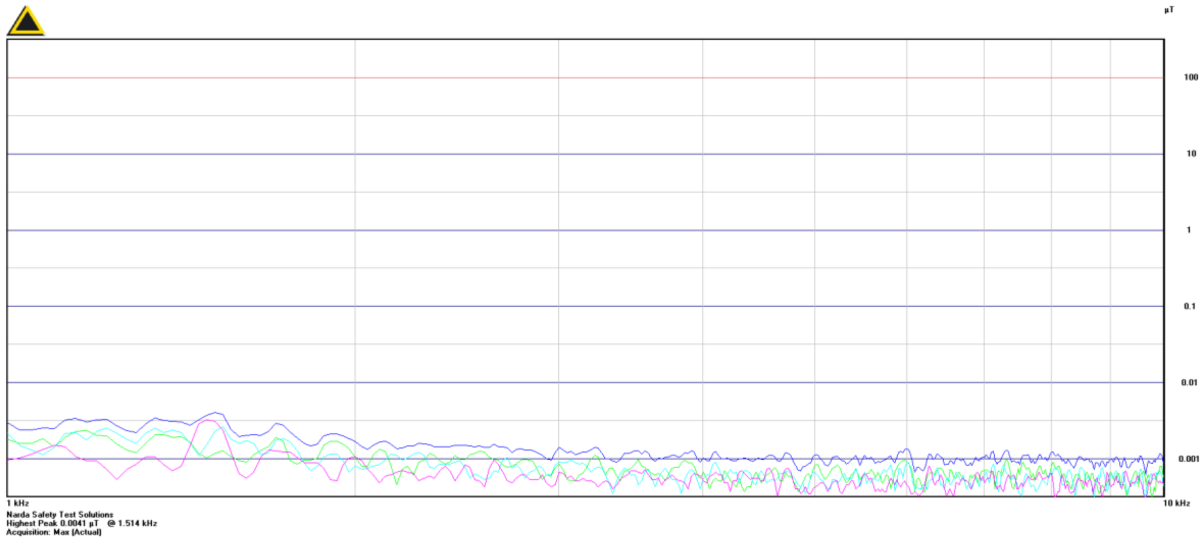

Image 22-59 Donabate, 1 kHz to 10 kHz (Mag Field)

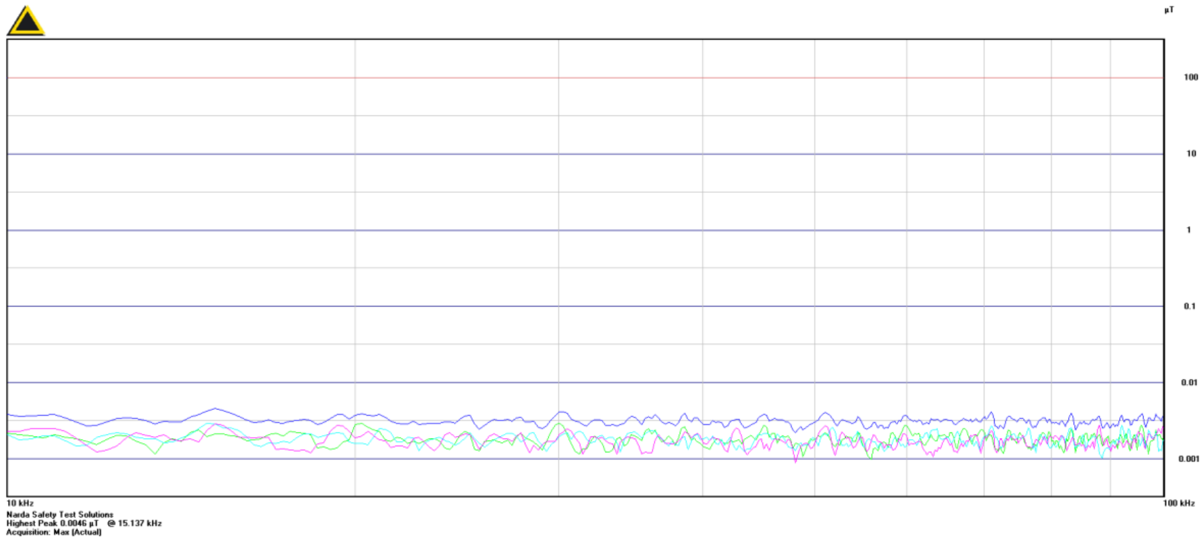

Image 22-60 Donabate, 10 kHz to 100 kHz (Mag Field)

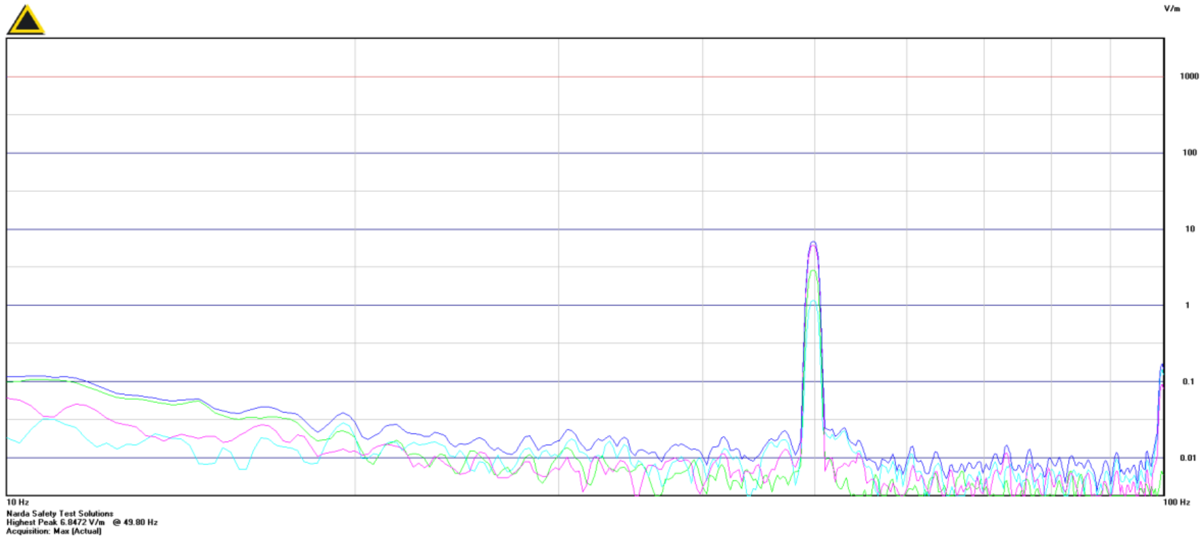

Image 22-61 Donabate, 10Hz to 100 Hz (E-Field)

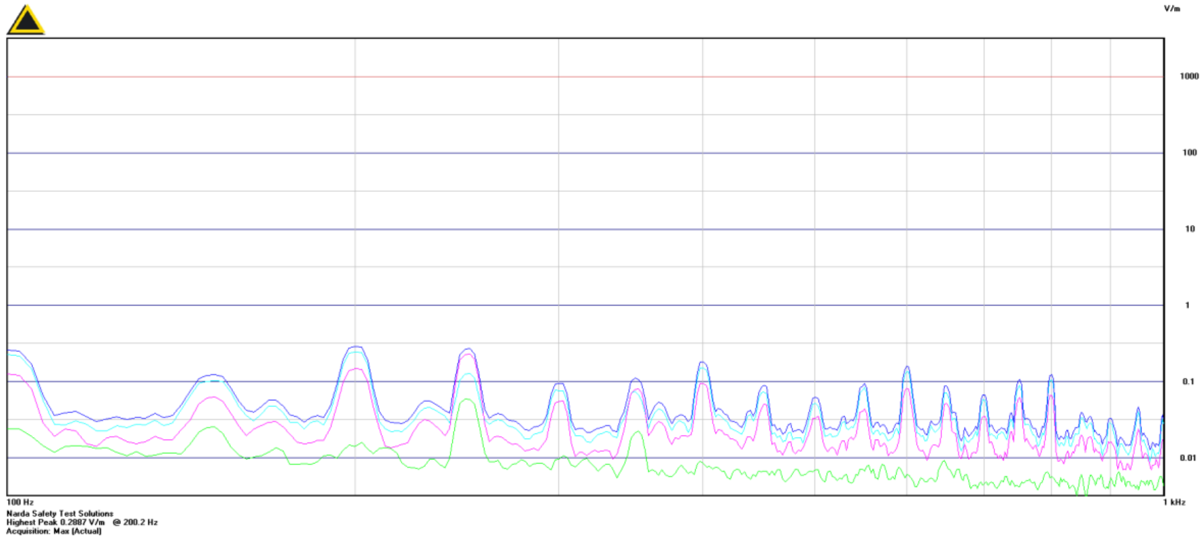

Image 22-62 Donabate, 100 Hz to 1 kHz (E-Field)

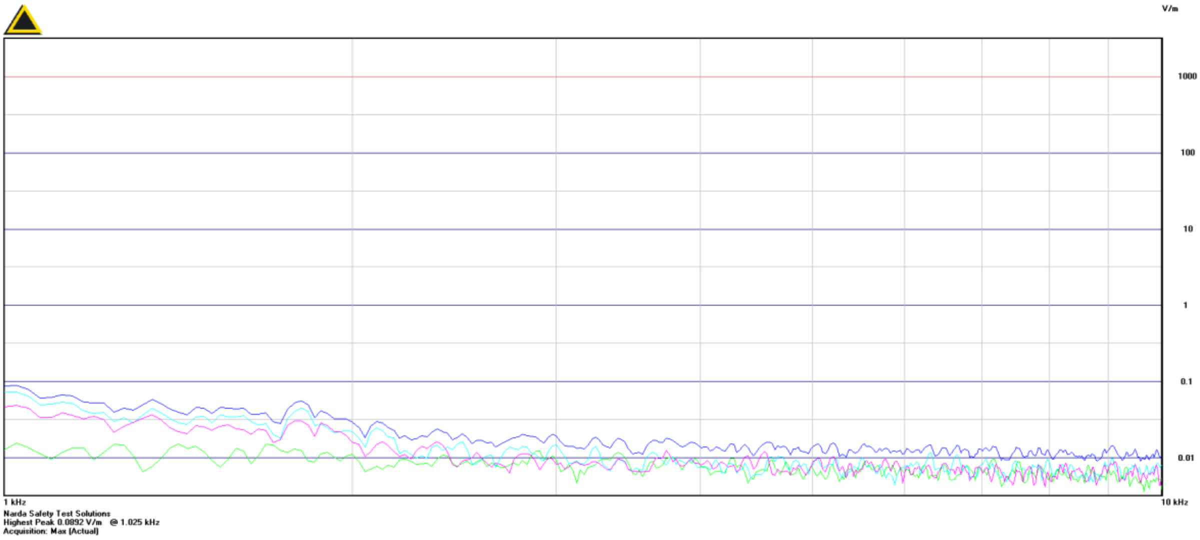

Image 22-63 Donabate, 1 kHz to 10 kHz (E-Field)

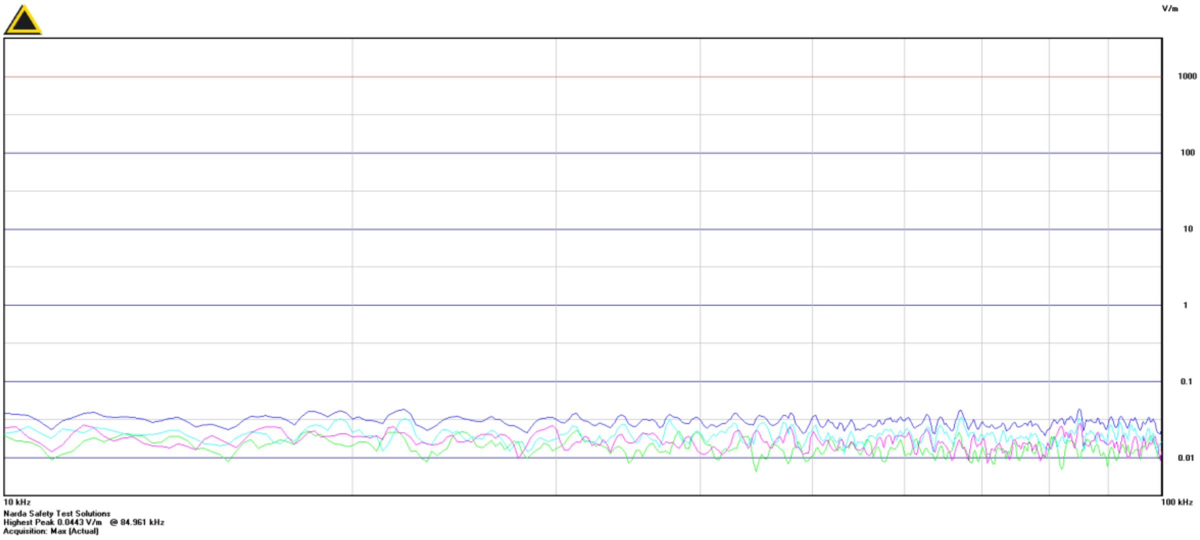

Image 22-64 Donabate, 10 kHz to 100 kHz (E-Field)

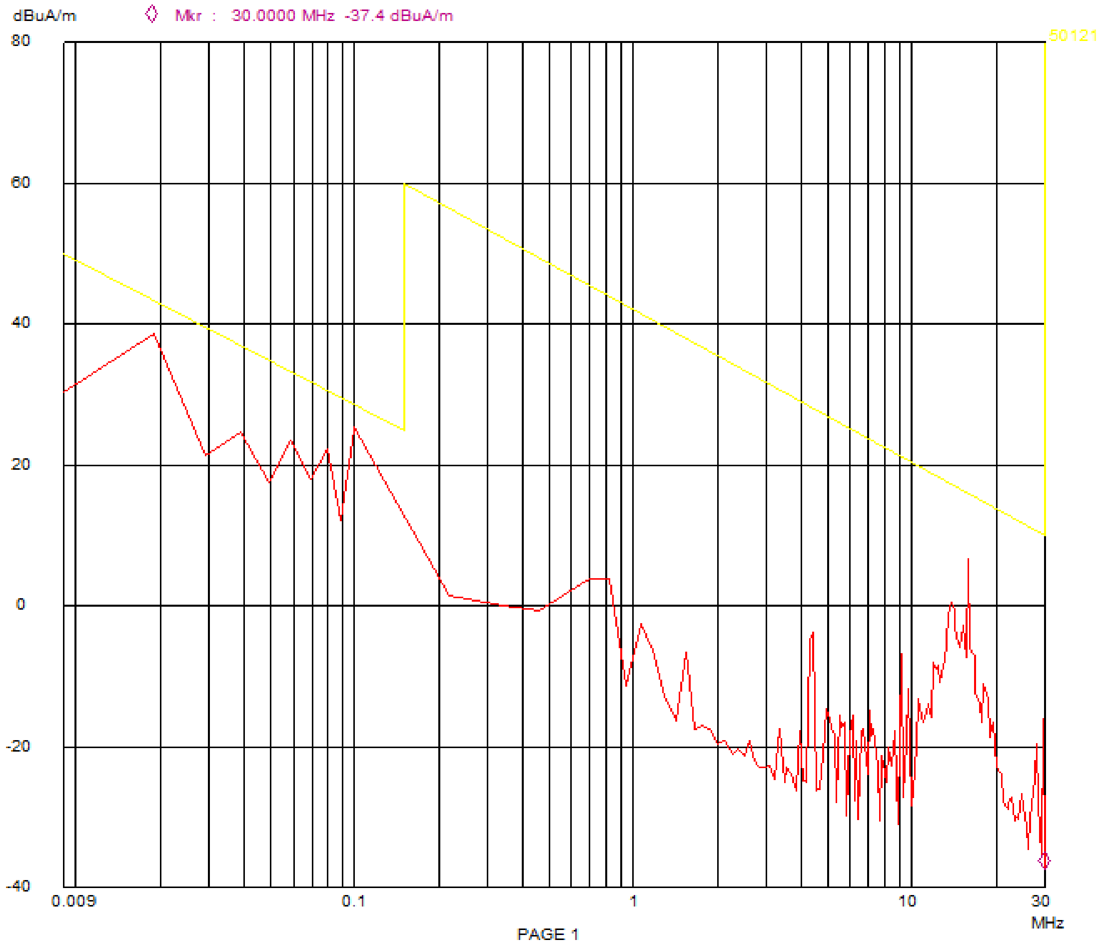

Image 22-65 Donabate - 9 kHz to 30 MHz

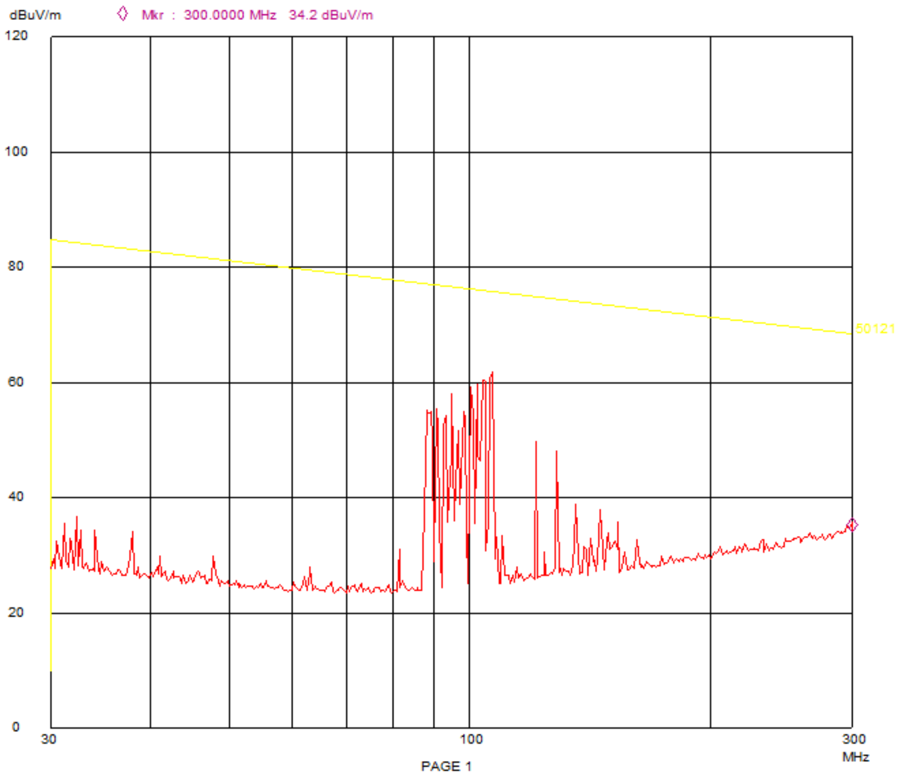

Image 22-66   Donabate - 30 MHz to 300 MHz

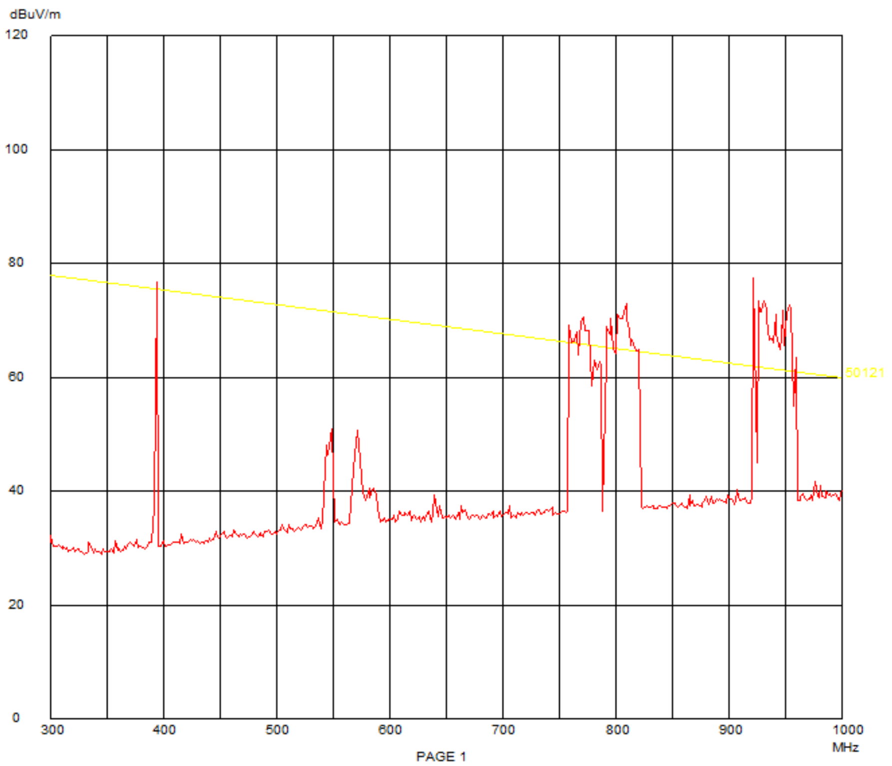

Image 22-67   Donabate – 300 MHz - 1 GHz

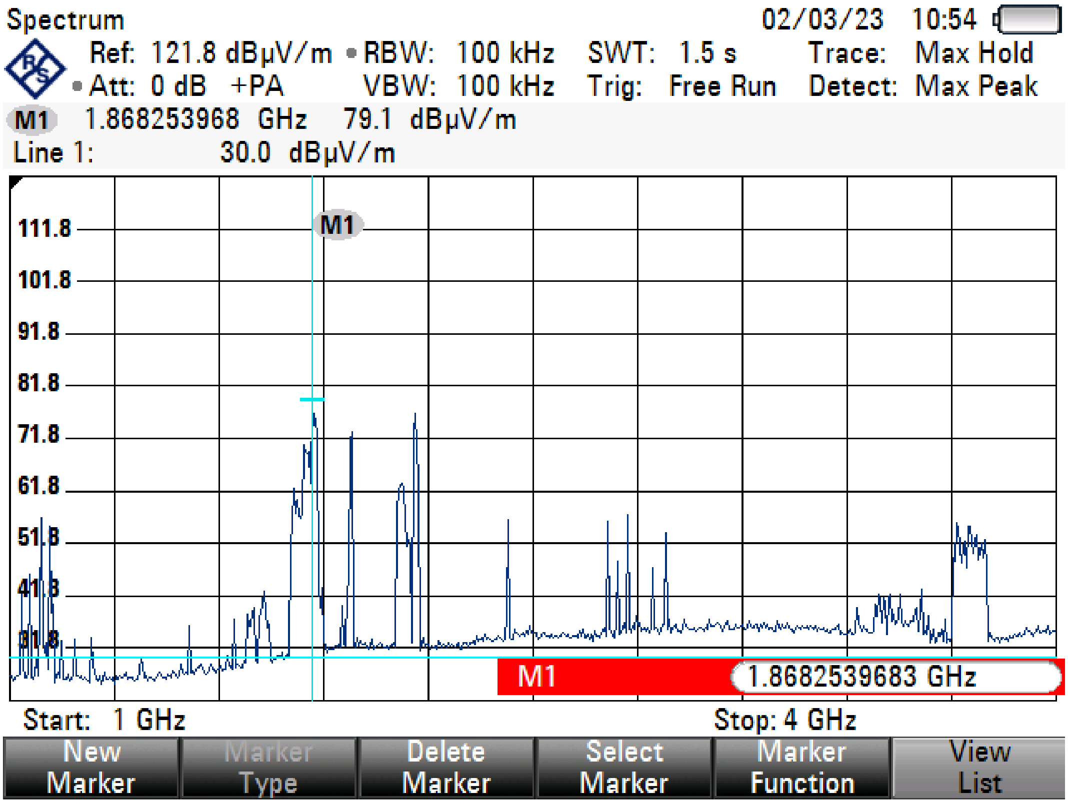

Image 22-68 Donabate - 1 GHz to 4 GHz

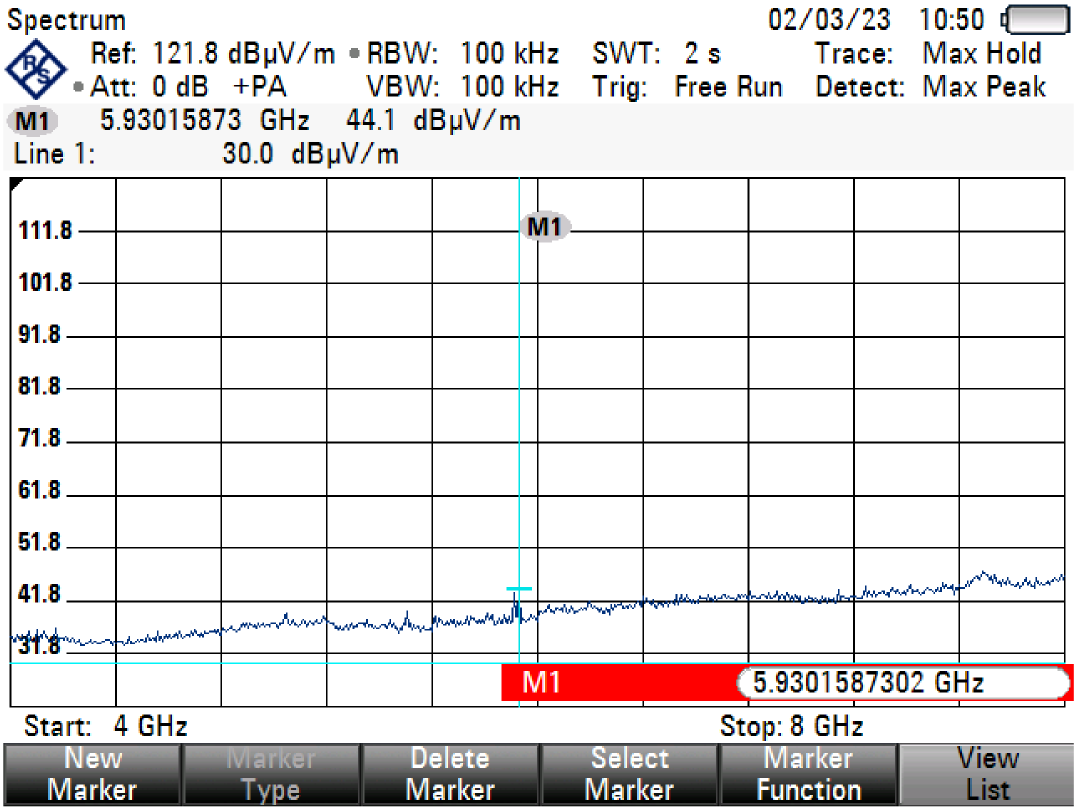

Image 22-69 Donabate - 4 GHz to 8 GHz

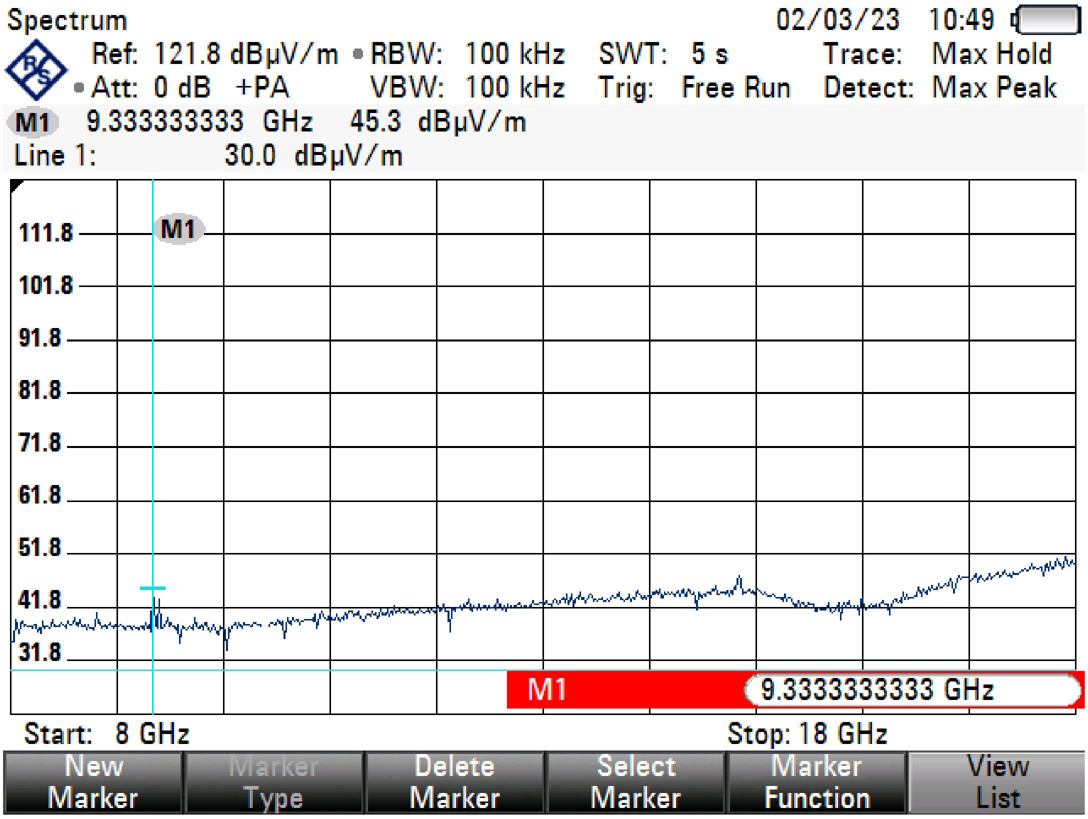

Image 22-70 Donabate - 8 GHz to 18 GHz

22.4.4.3 Malahide EMR Survey

Measurements were performed near the existing Malahide traction substation (highlighted area in Image 22-71) at the location of the yellow square in Image 22-71.

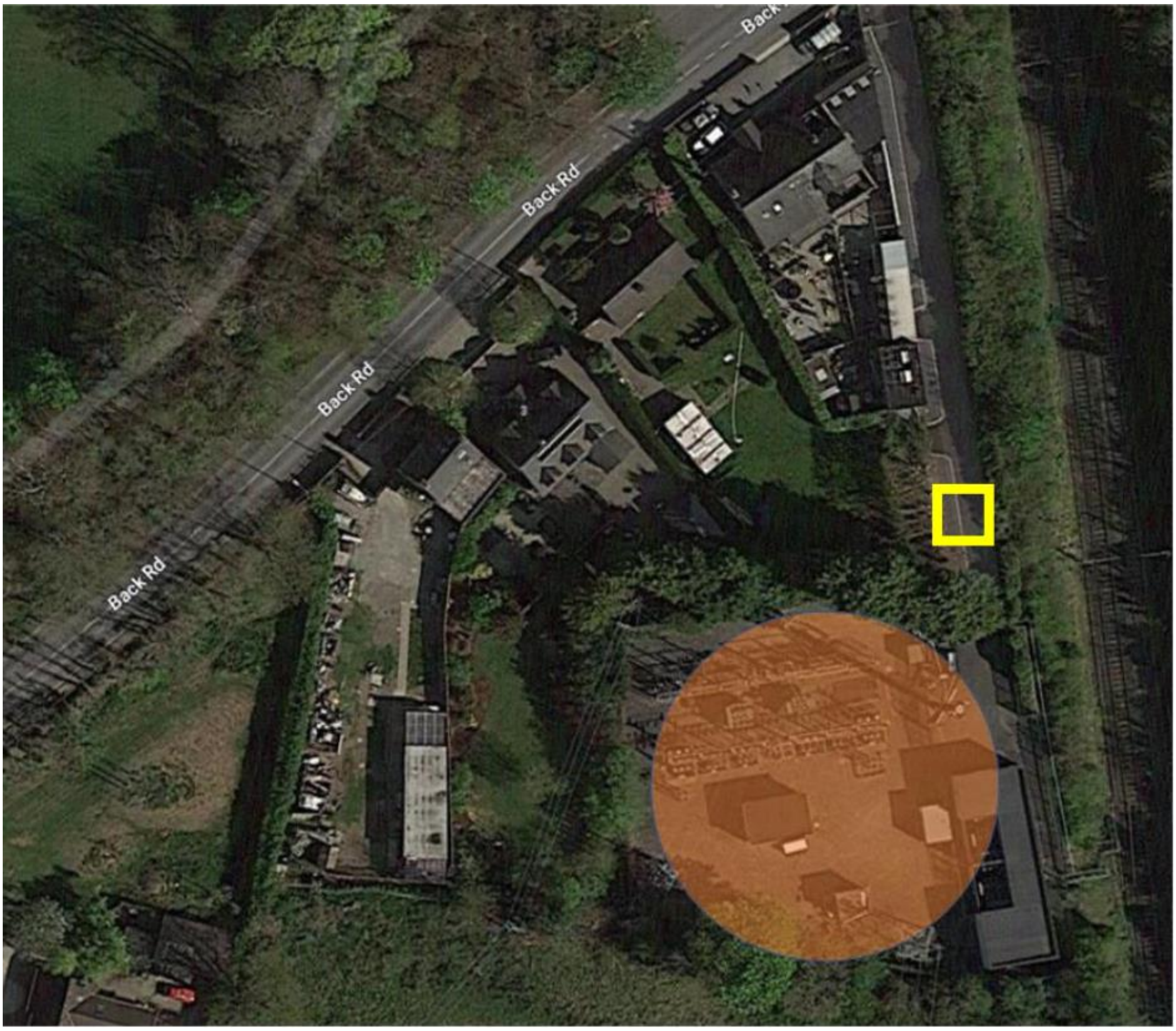

Image 22-71 Measurement Location at Malahide (Source: Google Maps)

Image 22-72 Malahide site.

Image 22-73 EHP cube measuring AC fields.

DC Magnetic Field, Malahide

The Earth's DC magnetic flux density (B) was measured for a period of 25 minutes at this location. The average static field was approximately 44.5 μT.

The location was approximately 11 m from the train line. At the commencement of measurements, a train was parked on the north bound rail line (closest to the measurement location). A south bound train passed before the north bound train moved on. A localised deflection can be seen until the first train moved on and settled ambient conditions resumed. Further trains passed during the measurement period. The electric trains (DART) caused the largest deviations (versus the diesel trains) due to the DC current load required to drive them e.g. the two largest field drifts of 3 μT and 2.8 μT were the result of a DART passing south (on the furthest line).

AC Electric and Magnetic Fields 1 Hz to 10 kHz, Malahide

Image 22-76: Malahide, 0 Hz to 100 Hz (Mag Field) gives a spectral plot of the magnetic field from DC to 100 Hz. The DC component can be seen to be much higher than any other frequency. A high magnitude 50 Hz field is also evident which would be expected as that is the operating frequency of the nearby traction substation and the surrounding electrical environment. Multiple harmonics are also evident in the 100 - 1 kHz frequency range.

No unusual elevated electromagnetic field levels were detected in the range between 1 Hz to 10 kHz.

Radiated Fields: 10 kHz to 18 GHz, Malahide

There was no evidence, during the measurement and observation time of this study of any transient or intermittent events. The RF emissions profile in this frequency range was well below the typical risk levels of 3 V/m.

At this site the strongest emissions were caused by Analog radio broadcasts (80 – 110 MHz), Digital Radio (147-223 MHz), Maritime Communications (160 MHz), Tetra Radio (390 MHz), Digital Television Broadcasting (470 – 790 MHz) and WiFi (2.4 and 5 GHz). In terms of mobile technology, the following signals were present, being mobile broadband, LTE (791-821 MHz and 925-960 MHz), GSM 900 and 1800 (900 MHz and 1.8 GHz), 3G (2.1 GHz) and 5G(3.6 GHz). Also detectable in the 4 and 7 GHz frequency range were primarily aeronautical radionavigation signals (Dublin airport is quite close by). Between 7-8 GHz were maritime communication and navigation signals.

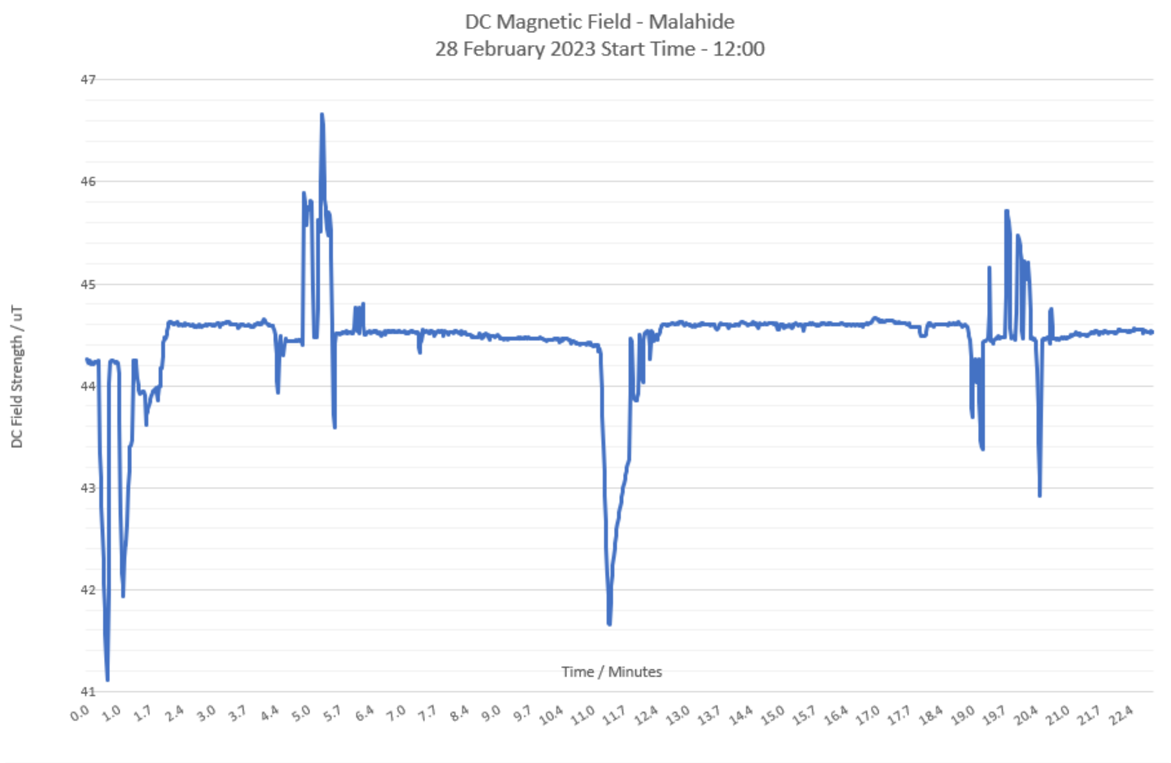

Image 22-74 Malahide, DC Magnetic Field

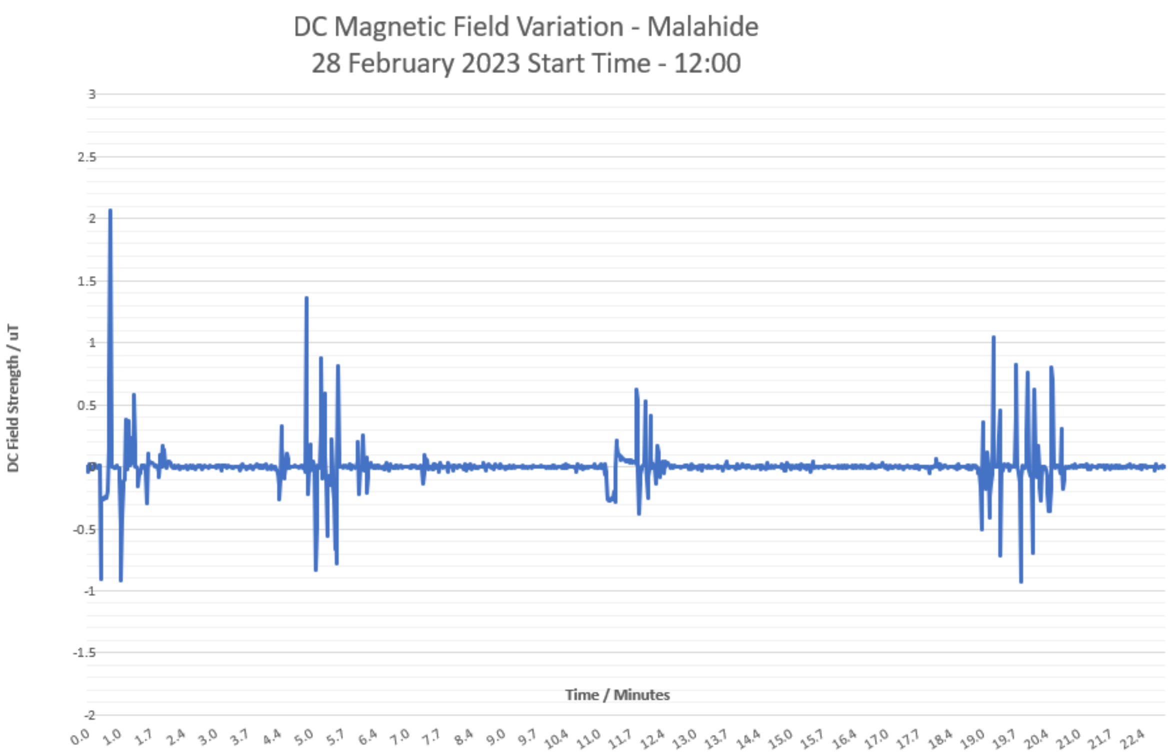

Image 22-75 Malahide, DC Magnetic Field variations

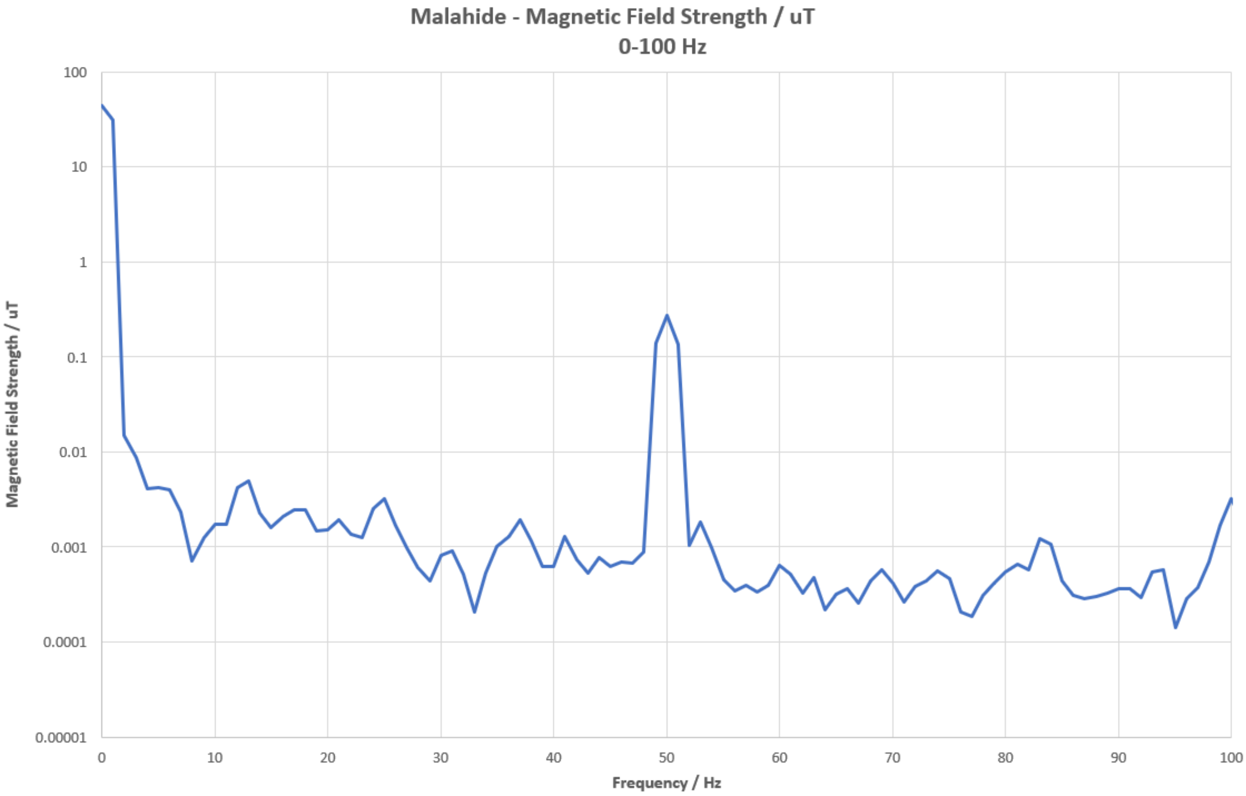

Image 22-76 Malahide, 0 Hz to 100 Hz (Mag Field)

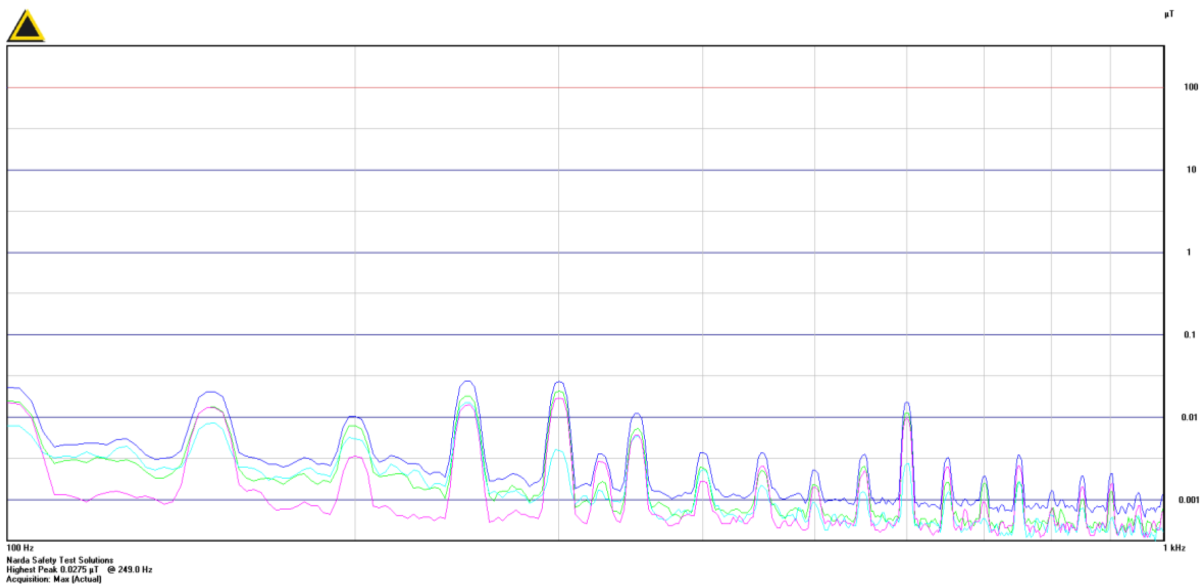

Image 22-77 Malahide, 100 Hz to 1 kHz (Mag Field)

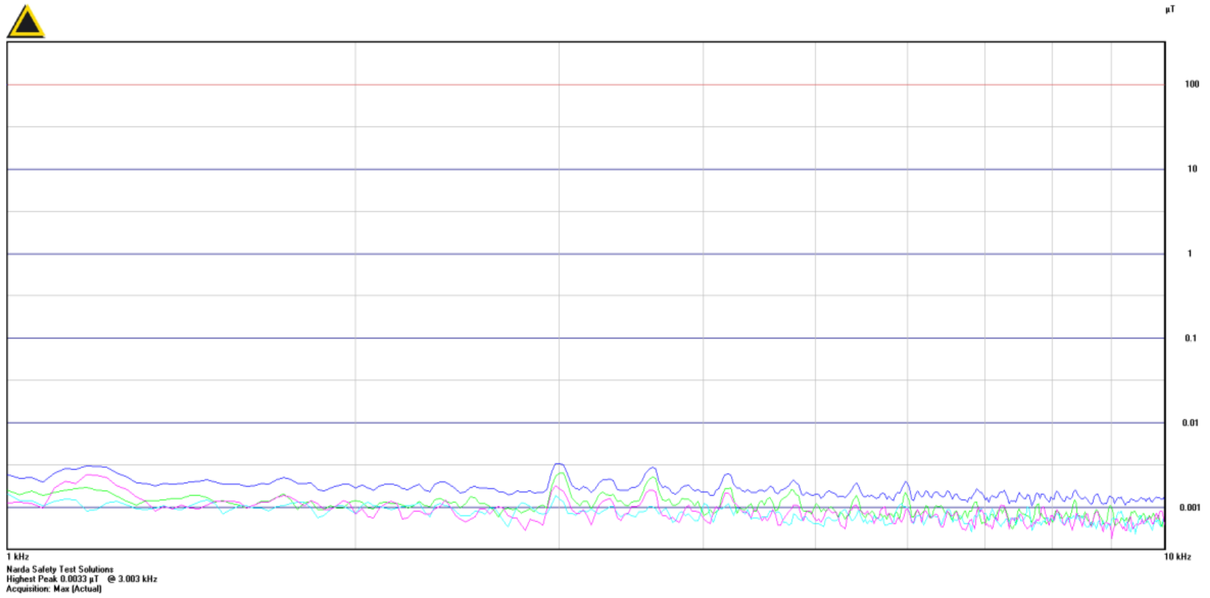

Image 22-78 Malahide, 1 kHz to 10 kHz (Mag Field)

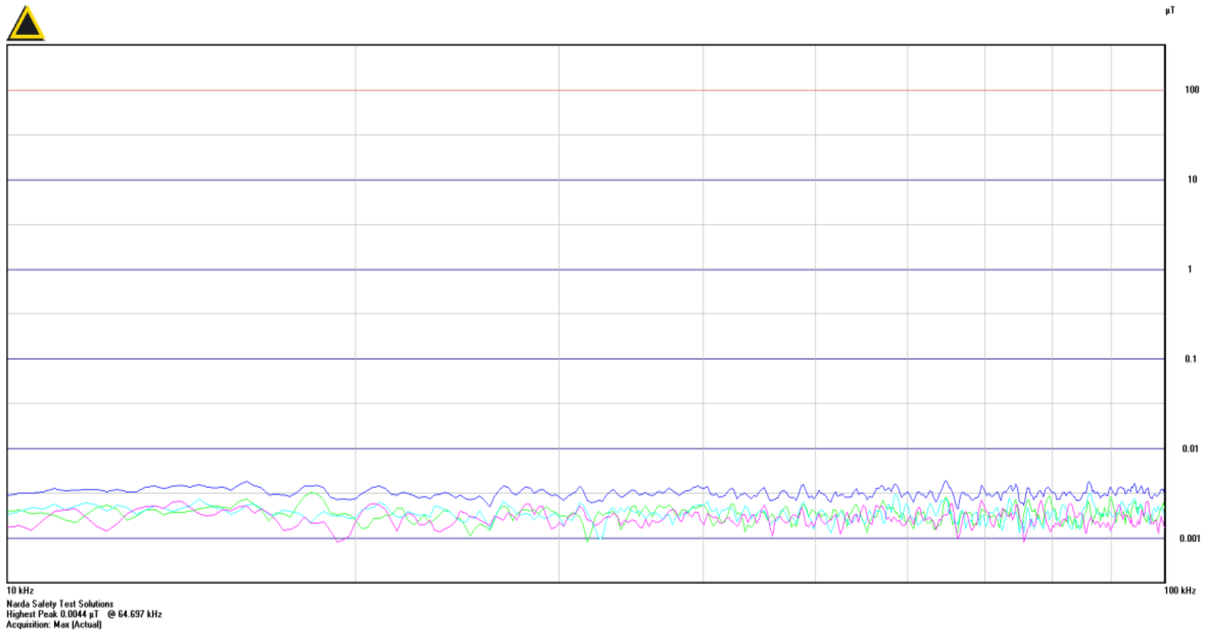

Image 22-79 Malahide, 10 kHz to 100 kHz (Mag Field)

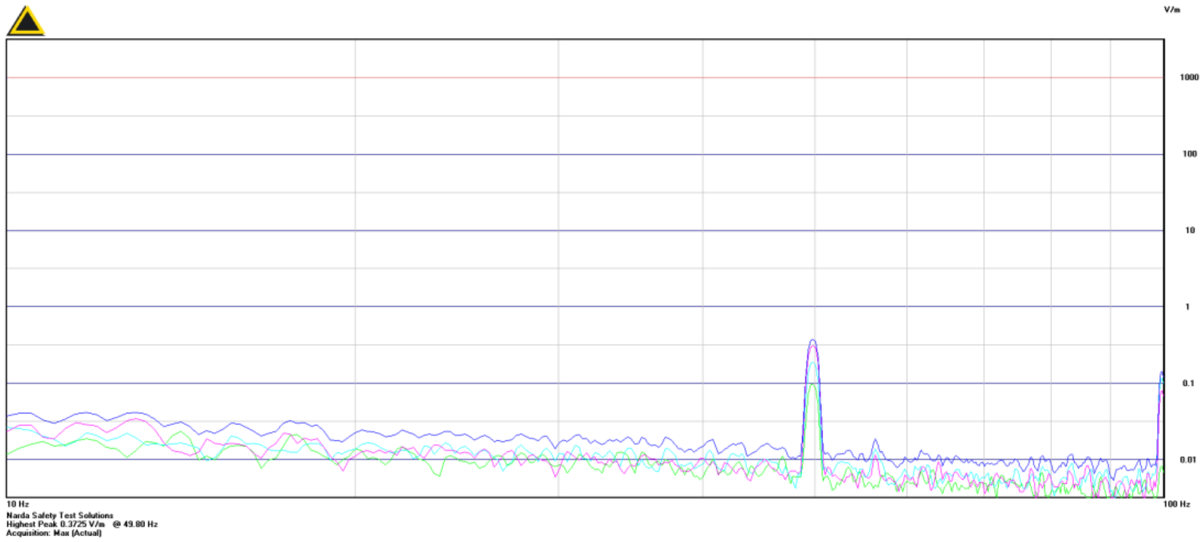

Image 22-80 Malahide, 10Hz to 100 Hz (E-Field)

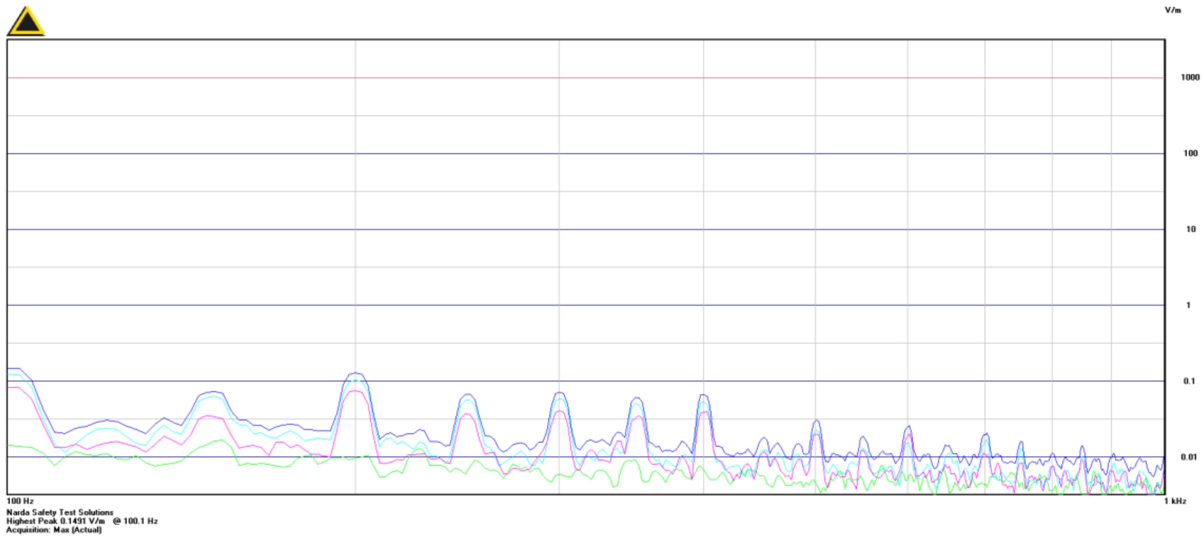

Image 22-81 Malahide, 100 Hz to 1 kHz (E-Field)

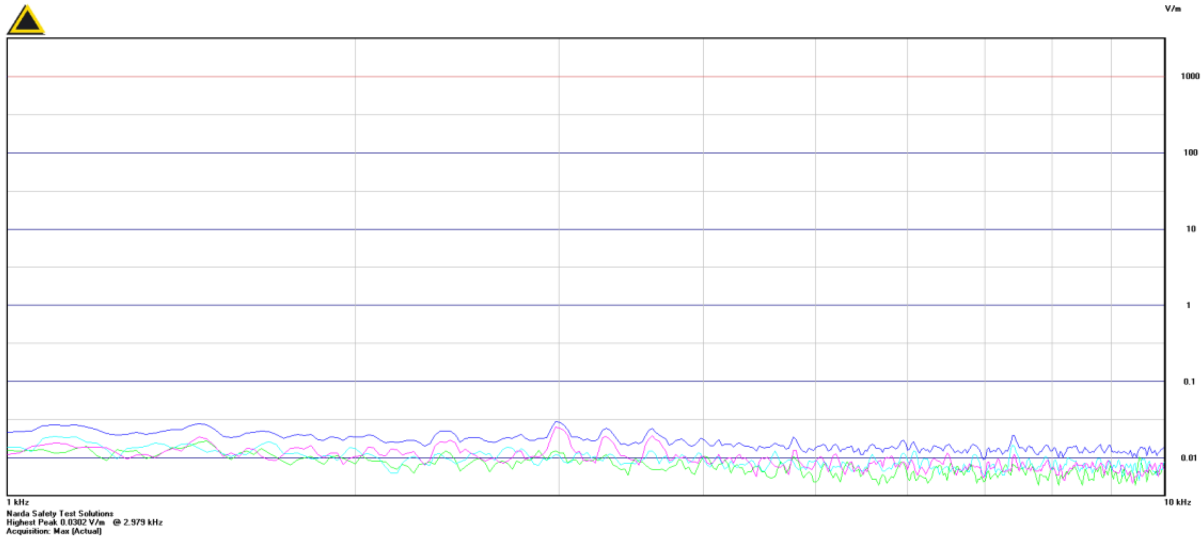

Image 22-82 Malahide, 1 kHz to 10 kHz (E-Field)

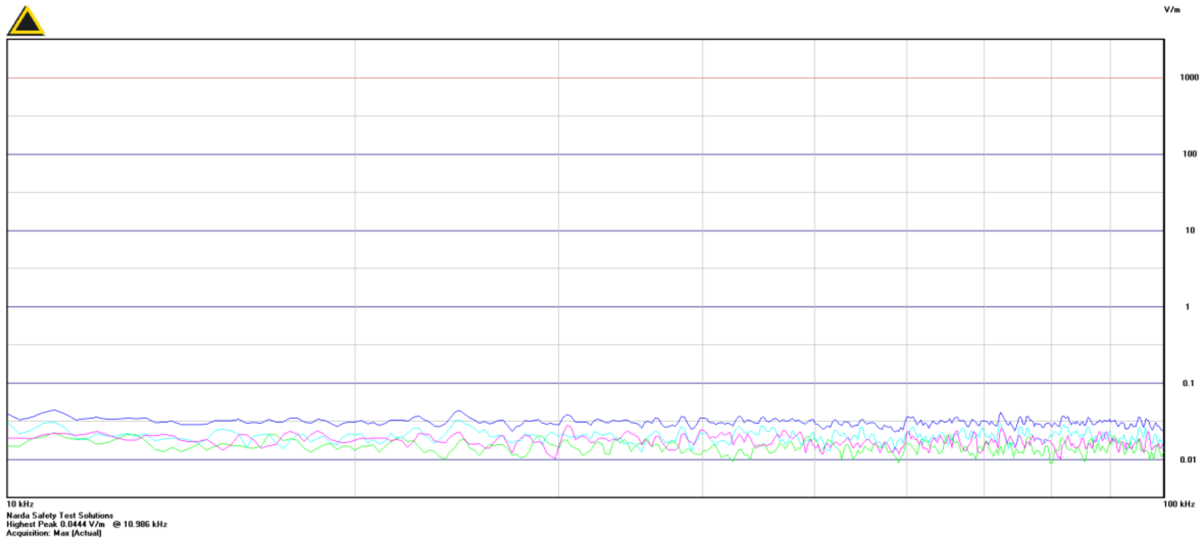

Image 22-83 Malahide, 10 kHz to 100 kHz (E-Field)

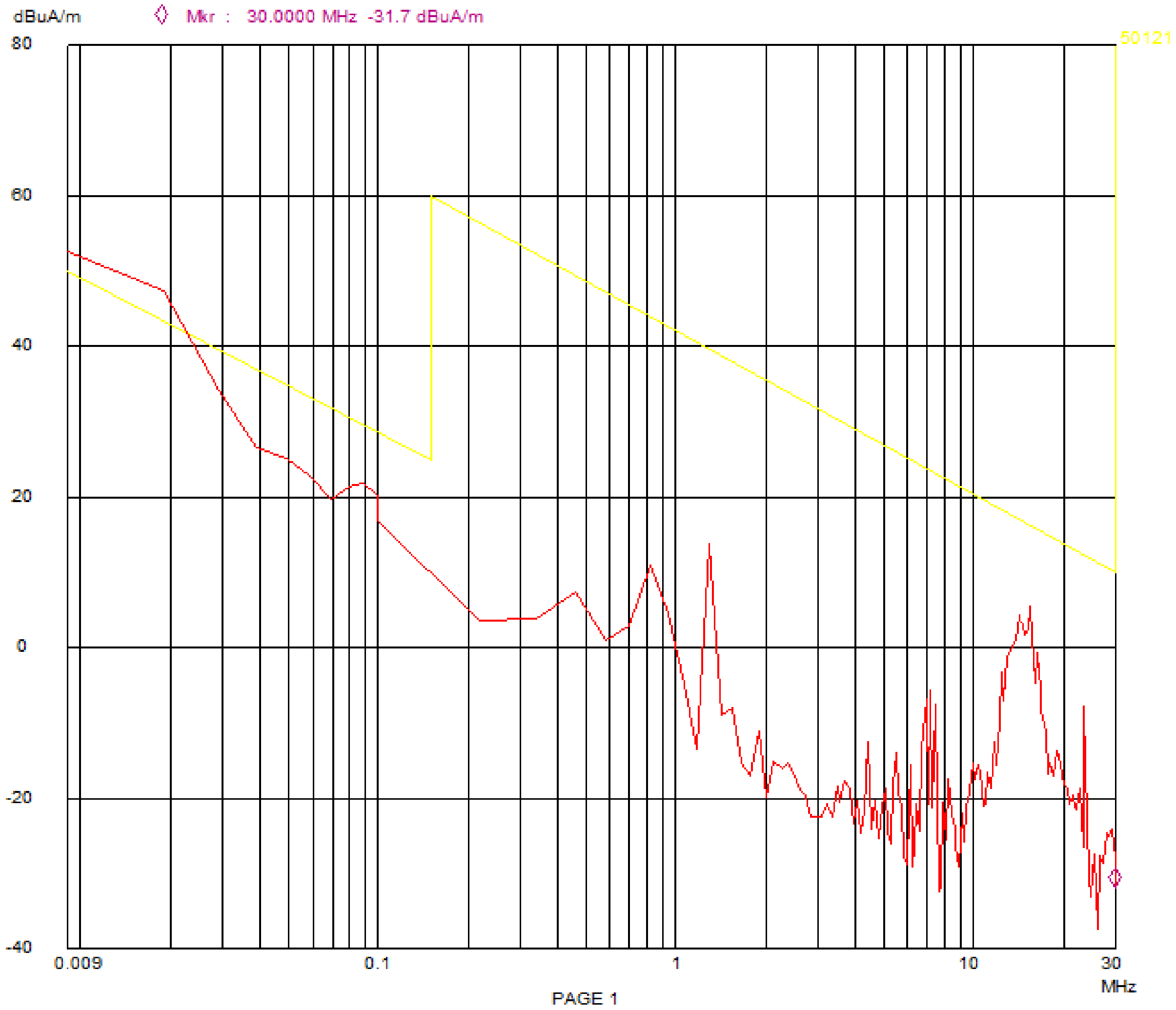

Image 22-84 Malahide – 9 kHz to 30 MHz

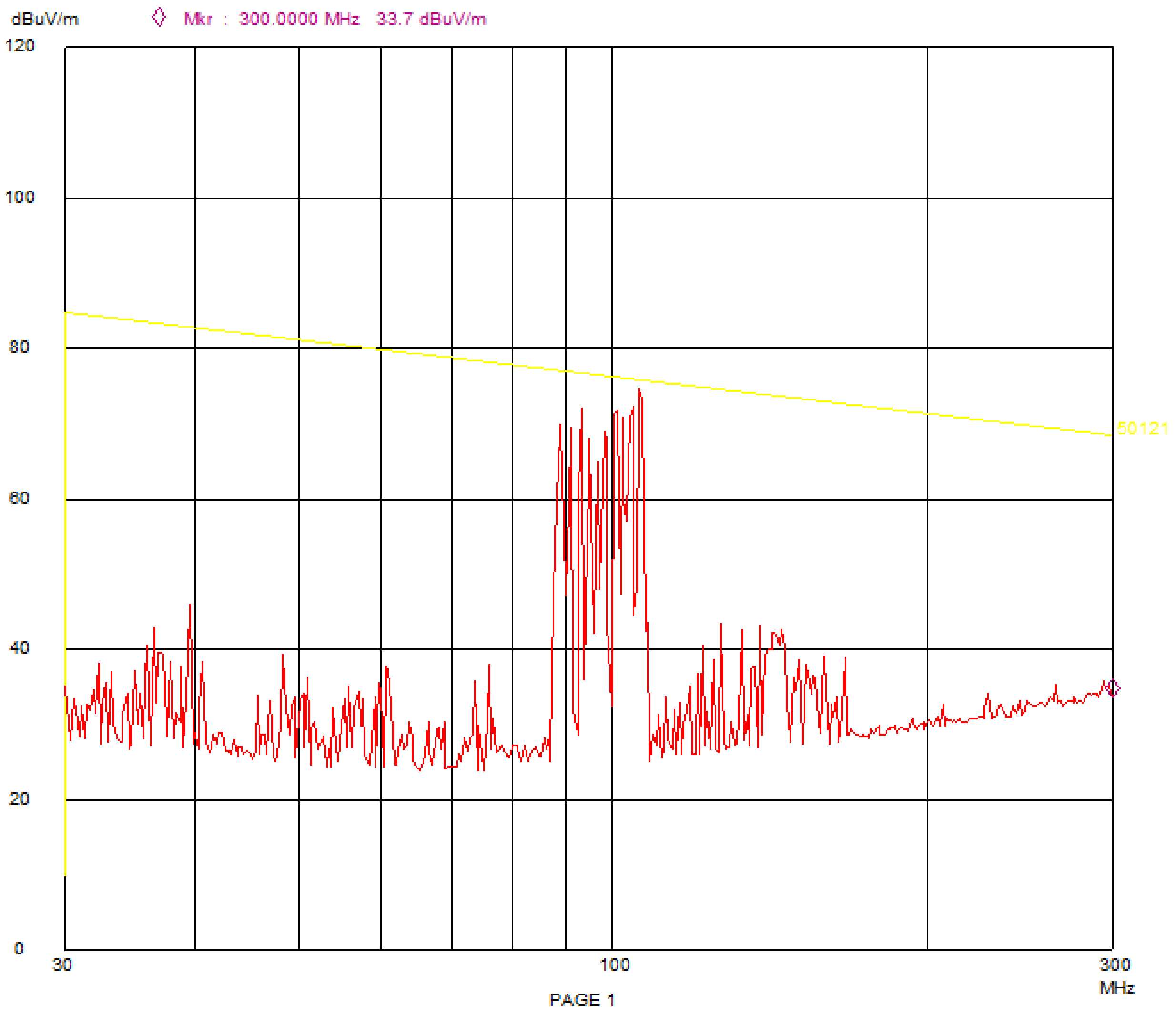

Image 22-85 Malahide – 30 MHz to 300 MHz

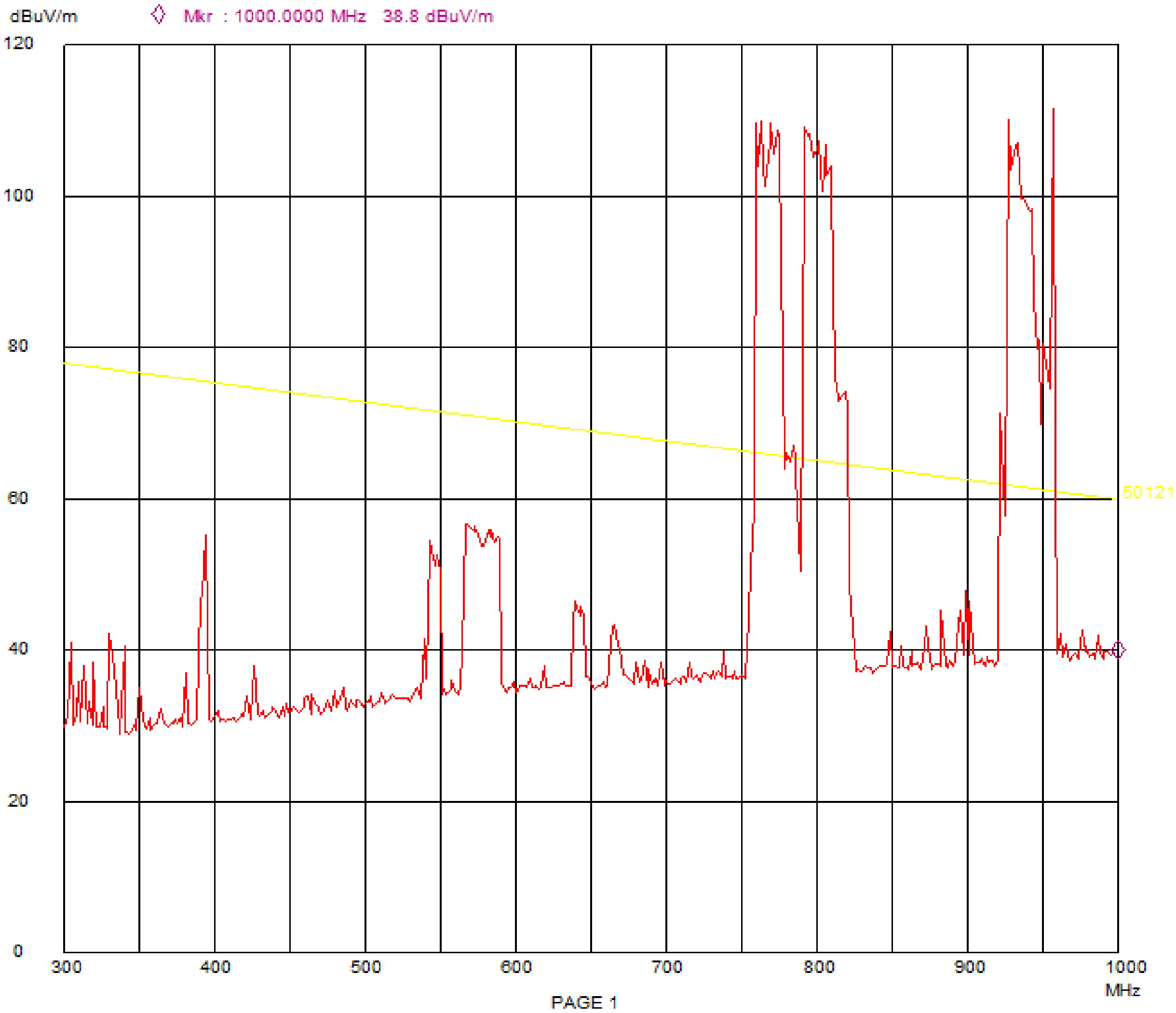

Image 22-86 Malahide – 300 MHz to 1 GHz

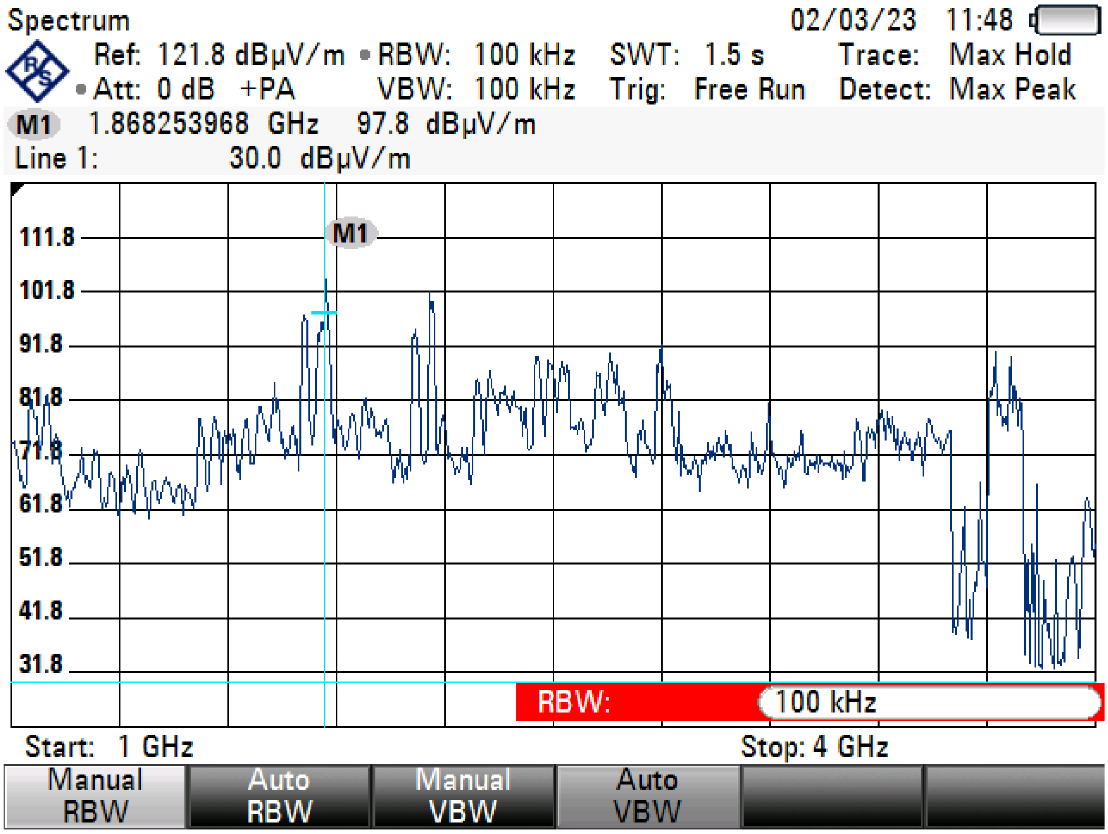

Image 22-87 Malahide - 1 GHz to 4 GHz

Image 22-88 Malahide - 4 GHz to 8 GHz

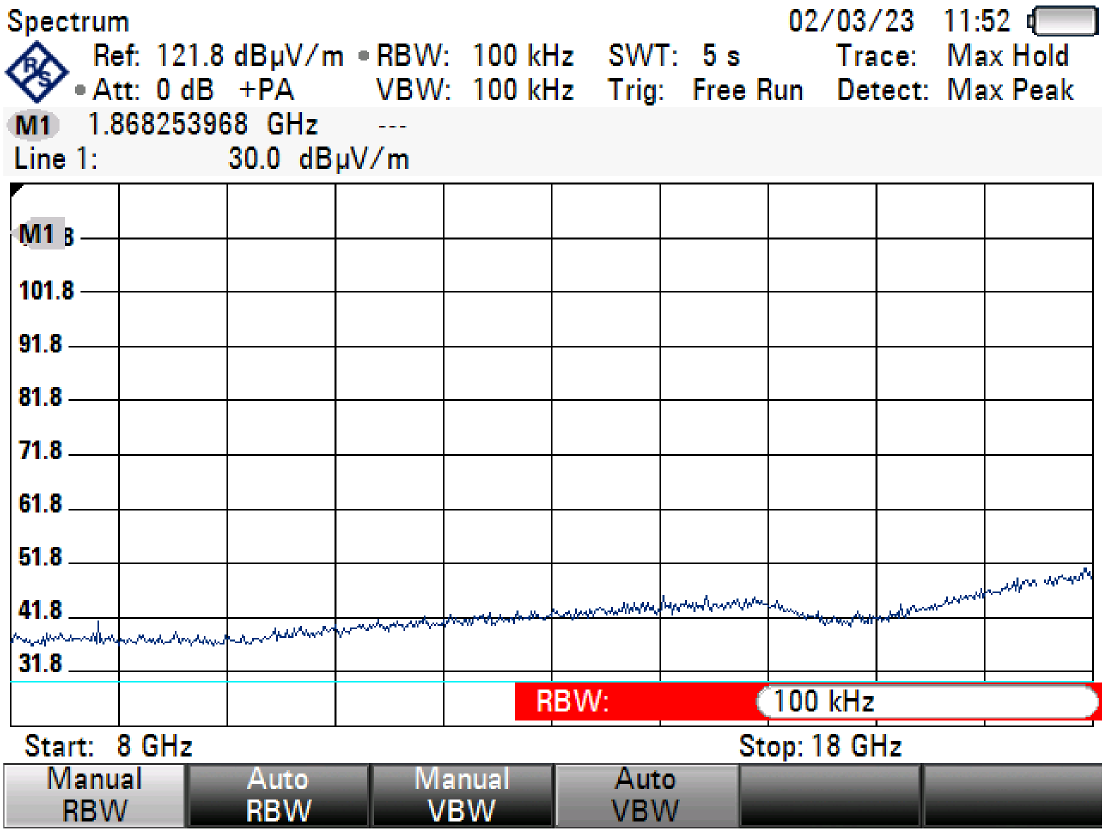

Image 22-89 Malahide - 8 GHz to 18 GHz

22.4.5 Baseline Survey Conclusions

DC Fields

DC magnetic field fluctuations measured throughout the surveys were, in general, low in frequency due to the measurement locations being predominantly away from passing vehicular traffic. The baseline DC levels measured at Gormanston and Malahide would be typical of what would be expected to be measured for the earth's magnetic flux density in Ireland allowing for localised deviations, such as those measured at the Donabate site where the buried HVDC line creates such a localised phenomenon and therefore baseline levels of 63 μT were recorded.

Deviation levels to this baseline (which are more critical for sensitive equipment) were generally attributed to passing diesel and electric trains with only a handful of instances of cars passing the measurement location at Gormanston.

The DC Magnetic fields measured at each site are a snapshot of the levels at a given time.

AC Fields

The pre-existing 50 Hz electric and magnetic levels were elevated in areas where mains transmission lines were in proximity including the electricity supply to the DART and the traction substation in Malahide. No non-mains attributable fields were noted in the AC domain at any of the survey sites.

RF fields

No unusual signals were noted to be present during the RF surveys carried out.

Electromagnetic fields and human health

The field strengths measured during these surveys also indicate that the existing environment was benign from a human health standpoint.

22.5 Description of Potential Impacts

22.5.1 Potential Construction Phase Impacts

During construction there are not expected to be any large-scale electrical installations that could generate significant levels of EMI such as traction substations or the operation of additional high voltage or high current carrying cables. Therefore, the construction phase of projects such as this tend to be quiescent from an electromagnetic perspective. No impacts on the public from an EMI, EMF or stray current perspective are envisaged during the construction phase of the Proposed Development.

Any future decommissioning is generally similar to but of even less impact than the construction effects.

22.5.2 Potential Operational Phase Impacts

Electromagnetic emissions may be generated by either the power supply system such as traction substations, the current supply system along the route, or the propulsion system onboard the rolling stock. The proposed project itself could also be susceptible to external electromagnetic fields that are generated by sources such as electricity cables and local radio-frequency (RF) transmitters.

Stray currents may occur at several potential receptors including buried tanks, water pipes and utilities running parallel to the system. The entry/exit points of these potential receptors for the stray current may experience corrosion over time without adequate mitigation measures.

Rail systems can generate transient emissions that are not controlled by EMC regulations. Such transients can pose a threat to the operation of neighbouring electrical and electronic equipment.

Large electrical installations can also cause voltage fluctuations on the public supply that can cause the phenomenon of flicker. Flicker is evident when lighting dims and can cause a nuisance to local residents and other sensitive receptors. This will be assessed and mitigated as appropriate, based on the profile of the current drawn from the distribution system (power grid) by the proposed railway electrification in the Northern Line. The current change will be gradual rather than a step change and will comply with the requirements set out in the connection agreement with the electricity distribution network operator.

The operation of the electrified line including the OHLE and support systems will be in-line with current best practices in relation to design and installation. Similar projects such as the existing DART and Luas currently operate well inside the guideline limits on human exposure to EMF. No impacts on public health from EMF are envisaged during the operational phase of the proposed project.

22.6 Mitigation Measures

During the ongoing design and construction phases of the proposed railway electrification project in the Northern Line, measures will be implemented to guarantee that the effects of EMI and EMF are within acceptable levels. This will be achieved by following relevant legislation, standards, and industry best practices. Furthermore, collaboration with third parties possessing sensitive equipment will take place to identify any potential risks related to EMI.

It is anticipated that in most cases, there will be no receptors specifically sensitive to EMI, or the risk to receptors from the new electrified railway will be sufficiently low, requiring no additional mitigation measures.

As part of the Project's design, a combined EMC and Earthing and Bonding (E&B) route-wide desktop survey has been conducted. This survey has identified specific assets that require consideration for the risk posed by DC stray current. The Project Design Team has compiled a comprehensive register of third-party assets. Below is a summary of the identified asset types and the general approach to mitigating stray current corrosion.

22.6.1 Overline Structures

During the ongoing design of the proposed railway electrification project in the Northern Line, the assessment is done to determine the need to bond overline structures to the traction return system using a Voltage Limiting Device (VLD) and/or utilize traction bonded flashover plates. The need for these measures mainly depends on the following factors:

- The material of the structure, such as stone, brick, steel, etc.
- The clearance planned between the bridge soffit and the contact wire.

22.6.2 Radio Transmitters

Earth mats for standalone transmitters will not have a direct galvanic connection to the traction return system. Therefore, any stray current flow through these mats will be incidental. The risk to these assets is considered to be sufficiently low.

22.6.3 Buried Services (Electrical Cables)

The presence of buried electrical cables that are typically insulated mitigates the risk of increased stray current flow. Insulation acts as a barrier, preventing the unwanted flow of current into the surrounding environment. As a result, the likelihood of stray current causing significant issues such as corrosion or damage to railway and third-party assets is reduced. The insulation effectively contains the electrical currents within the cables, minimizing their impact on nearby structures and underground metallic services. Therefore, the risk associated with increased stray current flow is considered to be low in this scenario.

22.6.4 Buried Services (Gas/Water/Sewage Mains)

The presence of underground metallic services may increase the occurrence of stray current flow from the DC traction return system, which can potentially cause corrosion or damage to railway and third-party assets. To mitigate this issue, the following measures have been taken into consideration in the ongoing design phase, as well as for the specification of construction requirements:

1. Renewing pads between tracks and sleepers to enhance the rail-to-earth resistance, if determined by an assessment of the conditions of the existing pads. This can help limit the flow of stray current through the rail system.
2. Whenever deemed appropriate, implementing collection mats, which are designed to collect and redirect stray current away from sensitive areas. These mats provide an alternative path for the current, reducing the risk of corrosion or damage to assets.
3. Whenever deemed appropriate, using sacrificial anodes, which are designed to corrode over time instead of the metallic assets they are protecting. These anodes can help divert stray current and protect vulnerable structures from corrosion.

It is also worth mentioning that the Proposed Development has set a requirement for the D&B Contractor to provide rail fasteners with a high insulation level that counteract as much as possible the loss over time of the insulation level of the rail fasteners due to mechanical, thermal, and chemical aging of materials, as well as the pollution due to intensive use of tracks. This does not translate into the replacement of the existing rail fasteners in the Coastal North unless there are measures showing that the original insulation level of the rail fasteners has decreased beyond one order of magnitude.

By employing these mitigations, the impact of stray current on the railway and third-party assets can be minimized, reducing the risk of corrosion or damage.

22.7 Monitoring

A stray current monitoring system will be implemented at each traction substation in the DART+ Coastal North project. This system will enable continuous monitoring of the rail-to-earth potential along the railway line. Dedicated monitoring locations, typically located at the traction substations, will be used to measure the rail potential (electrical potential of the rails with respect to earth). The purpose of this monitoring is twofold:

To ensure that the electrification system does not generate excessive levels of stray current that could cause issues or disruptions.

To verify that the mitigation measures implemented by the design and construction teams are functioning correctly and are compliant with the EN 50122-2 standard.

For the DART+ Coastal North project, a centralized data acquisition system is anticipated to be utilized for the stray current monitoring. This will facilitate the transfer of monitoring data to the IÉ SET (Signalling, Electrification and Telecommunications) Department for analysis and further evaluation.

22.8 Residual effects

Certain equipment, such as MRI machines, NMRs, SEMs, etc., has specific operational environmental requirements provided by their manufacturers. These requirements include factors such as temperature, humidity, and the recommended electromagnetic environment for optimal performance. End users of such equipment typically conduct surveys within their facilities to identify locations that are distant from electrical transformers, high current or high voltage cables, traffic, and ferromagnetic objects, as these can cause disturbances in DC magnetic fields. Following the construction and commissioning of the Proposed Development, installing equipment sensitive to DC and quasi-DC magnetic fields within 100 meters of the railway line may not be suitable unless appropriate mitigation measures are implemented.

In the case of future developments, such as extensions or new buildings near the railway line, including theatres, musical venues, stadiums, domestic or commercial premises, the introduction of unauthorized audio equipment within 20 meters of the lines could potentially experience interference in the audio frequency range due to AC fields.

While mitigation measures are applied to minimize the magnitude of stray current, it is important to note that stray current is an inherent phenomenon associated with DC rail systems. Therefore, ongoing monitoring of the traction circuit's performance, particularly in terms of current returns to the traction substation, will be necessary to ensure effective operation.

22.9 Cumulative effects

The cumulative assessment of relevant plans and projects is undertaken separately in Chapter 26 (Cumulative Effects) in Volume 2 of this EIAR.

The combined impact of electric and magnetic fields in the radiofrequency (RF) and microwave frequency ranges is considered to be negligible. Similarly, there are no expected significant cumulative effects in the range of alternating current (AC) fields.

Predicting cumulative impacts from stray current is challenging. As mentioned earlier, the underground environment in Dublin is already affected by stray currents, which can travel significant distances from their source. The primary contributors to stray currents are the DART system, along with smaller contributions from the various Luas lines. It is possible that cumulative effects may occur due to increased potential difference fluctuations on buried structures. If the exit point of stray current from a buried structure coincides with that of another source, it could lead to accelerated corrosion.

22.10 References

EN 50121-1: 2017. Railway applications – Electromagnetic compatibility – Part 1: General.

EN 50121-2: 2017. Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world.

EN 50121-3-1: 2017. Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock - Train and complete vehicle.

EN 50121-3-2: 2017. Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus.

EN 50121-4: 2015. Railway applications – Electromagnetic compatibility – Part 4: Emission and immunity of the Signalling and Telecommunications Apparatus.

EN 50121-5: 2015. Railway applications – Electromagnetic compatibility – Part 5: Emission and immunity of railway fixed power supply installations.

EN 61000-6-1: 2007. Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments.

EN 61000-6-2: 2005. Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments.

EN 61000-6-3: 2007. Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments.

EN 61000-6-4: 2019. Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments.

EN 50122-1:2011. Railway applications - Fixed installations - Electrical safety, earthing and the return circuit -- Part 1: Protective provisions against electric shock.

EN 50122-2:2011. Railway applications - Fixed installations - Electrical safety, earthing and the return circuit -- Part 2: Provisions against the effects of stray currents caused by DC. traction systems.

International Commission on Non-Ionizing Radiation Protection (ICNIRP) (2009). Guidelines on limits of Exposure to Static Magnetic Fields. Health Phys 96(4): 504-514; 2009.

ICNIRP (2010). Guidelines for limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz – 100 kHz). Health Phys 99(6):818-836; 2010

ICNIRP (2020). Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). Health Phys 118(5):483-524; 2020.

1999/519/EC Council Recommendation of 12th July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz).