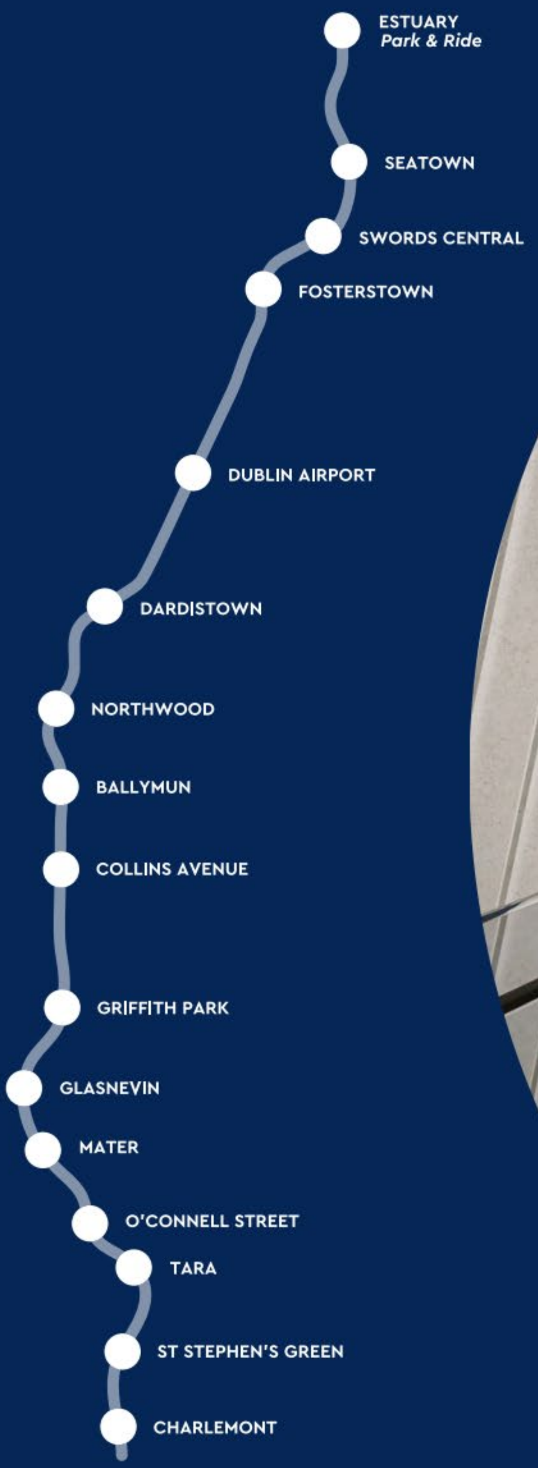

12 Electromagnetic Compatibility and Stray Current

Contents

Table of Abbreviations

Acronym	Meaning
AC	Alternating Current
AIMD	Active Implantable Medical Devices
AML	Advanced Microscopy Lab
AZ	Assessment Zone
CEI	Compliance Engineering Ireland
CRANN	Centre for Research on Adaptive Nanostructures and Nanodevices
CRT	Cathode Ray Tube
CT	Computed Tomography
DAA	Dublin Airport Authority
DANP	Dublin Airport North Portal
DART	Dublin Area Rapid Transit
DASP	Dublin Airport South Portal
DC	Direct Current
DFB	Dublin Fire Brigade
EIAR	Environmental Impact Assessment Report
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMF	Electromagnetic Fields (comprising Electric and Magnetic Fields)
EMI	Electromagnetic interference
EMR	Electromagnetic Radiation
E-Field	Electric Field
µT	Magnetic Fields are measured in micro-Tesla, µT
V/m or kV/m	Electric Fields are measured in Volts per metre, V/m or kiloVolts per metre, kV/m
EPA	Environmental Protection Agency
ESB	Electricity Supply Board
ESBN	Electricity Supply Board Networks Ltd
EU	European Union

Acronym	Meaning
HV	High Voltage
ICNIRP	International Commission on Non-Ionising Radiation Protection
iCRAG	Irish Centre for Research in Applied Geosciences
ILS	Instrument Landing System
LINAC	Linear Accelerator
MRI	Magnetic Resonance Imaging
MV	Medium Voltage
M-Field	Magnetic Field
NMR	Nuclear Magnetic Resonance
OCR	Overhead conductor rail
OCS	Overhead Contact System
OPW	Office of Public Works
OSI	Ordnance Survey Ireland
PBX	Private Branch Exchange
PET	Positron Emission Tomography
RADAR	Radio Detection and Ranging
RED	Radio Equipment Directive
RF	Radiofrequency
SEM	Scanning Electron Microscope
SNIAM	Sami Nasr Institute of Advanced Materials
SQUID	Superconducting Quantum Interference Device
STM	Scanning Tunnelling Microscope
TBM	Tunnel Boring Machine
TCD	Trinity College Dublin
TPSS	Traction Power Supply System
WHO	World Health Organisation
XLPE	Cross-linked Polyethylene

12. Electromagnetic Compatibility and Stray Current

12.1 Introduction

This Chapter of the Environmental Impact Assessment Report (EIAR) assesses the impact of the MetroLink Project (hereafter referred to as the proposed Project), on electromagnetic compatibility and stray current during the Construction Phase and Operational Phase.

This chapter describes and assesses the likely direct and indirect significant effects of the proposed Project on electromagnetic compatibility and stray current, in accordance with the requirements of Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (i.e. the EIA Directive) (European Union, 2014a). This Chapter also provides a characterisation of the receiving environment within the proposed Project and within a wider study area in the vicinity of the proposed Project.

The assessment is based on identifying and describing the likely significant effects arising from the proposed Project as described in Chapters 4 to 6 of this EIAR. The proposed Project description is based on the design prepared to inform the Railway Order application stage of the proposed Project and to allow for a robust assessment as part of the EIA Process.

Where it is required to make assumptions as the basis of the assessment presented here, these assumptions are based on advice from competent project designers and are clearly outlined within the Chapter.

12.2 Outline Project Description

A full description of the proposed Project is provided in the following chapters of this EIAR:

- Chapter 4 (Description of the MetroLink Project);
- Chapter 5 (MetroLink Construction Phase); and
- Chapter 6 (MetroLink Operations & Maintenance).

Limits of deviation have been set for the proposed Project and this is addressed in the Wider Effects Report annexed at Appendix A5.19.

Table 12.1 presents an outline description of the key elements of the proposed Project which are appraised in this chapter. Diagram 12.1 presents an outline of the main elements of the Construction Phase that are appraised in this chapter and Diagram 12.2 presents an outline of the main elements of the Operational Phase that are appraised in this chapter.

Table 12.1: Outline Description of the Principal Project Elements

Project Elements	Outline Description
Permanent Project Elements	
Tunnels	It is proposed to construct two geographically separate, single-bore tunnels, using a Tunnel Boring Machine (TBM). Each section of tunnel will have a 8.5m inside diameter and will contain both northbound and southbound rail lines within the same tunnel. These tunnels will be located as follows: ▪ The Airport Tunnel: running south from Dublin Airport North Portal (DANP) under Dublin Airport and surfacing south of the airport at Dublin Airport South Portal (DASP) and will be approximately 2.3km in length; and ▪ The City Tunnel: running for 9.4 km from Northwood Portal and terminating underground south of Charlemont Station.

Project Elements	Outline Description
Cut Sections	The northern section of the alignment is characterised by a shallow excavated alignment whereby the alignment runs below the existing ground level. Part of the cut sections are open at the top, with fences along the alignment for safety and security. While other sections are "cut and cover", whereby the alignment is covered.
Tunnel Portals	The openings at the end of the tunnel are referred to as portals. They are concrete and steel structures designed to provide the commencement or termination of a tunnelled section of route and provide a transition to adjacent lengths of the route which may be in retained structures or at the surface. There are three proposed portals, which are: ▪ DANP; ▪ DASP; and ▪ Northwood Portal. There will be no portal at the southern end of the proposed Project, as the southern termination and turnback will be underground.
Stations	There are three types of stations: surface stations, retained cut stations and underground stations: ▪ Estuary Station will be built at surface level, known as a 'surface station'; ▪ Seatown, Swords Central, Fosterstown Stations and the proposed Dardistown Station will be in retained cutting, known as 'retained cut stations'; and ▪ Dublin Airport Station and all 10 stations along the City Tunnel will be 'underground stations'.
Intervention Shaft	An intervention shaft will be required at Albert College Park to provide adequate emergency egress from the City Tunnel and to support tunnel ventilation. Following the European Standard for safety in railway tunnels TSI 1303/2014: Technical Specification for Interoperability relating to 'safety in railway tunnels' of the rail system of the European Union, it has been recommended that the maximum spacing between emergency exits is 1,000m. As the distance between Collins Avenue and Griffith Park is 1,494m, this intervention shaft is proposed to safely support evacuation/emergency service access in the event of an incident. This shaft will also function to provide ventilation to the tunnel. The shaft will require two 23m long connection tunnels extending from the shaft, connecting to the main tunnel. At other locations, emergency access will be incorporated into the stations and portals or intervention tunnels will be utilised at locations where there is no available space for a shaft to be constructed and located where required (see below).
Intervention Tunnels	In addition to the two main 'running' tunnels, there are three shorter, smaller diameter tunnels. These are the evacuation and ventilation tunnels (known as Intervention Tunnels): ▪ Airport Intervention Tunnels: parallel to the Airport Tunnel, there will also be two smaller diameter tunnels; on the west side, an evacuation tunnel running northwards from DASP for about 315m, and on the east side, a ventilation tunnel connected to the main tunnel and extending about 600m from DASP underneath Dublin Airport Lands. In the event of an incident in the main tunnel, the evacuation tunnel will enable passengers to walk out to a safe location outside the Dublin Airport Lands. ▪ Charlemont Intervention Tunnel: The City Tunnel will extend 360m south of Charlemont Station. A parallel evacuation and ventilation tunnel is required from the end of the City Tunnel back to Charlemont Station to support emergency evacuation of maintenance staff and ventilation for this section of tunnel.
Park and Ride Facility	The proposed Park and Ride Facility next to Estuary Station will include provision for up to 3,000 parking spaces.
Broadmeadow and Ward River Viaduct	A 260m long viaduct is proposed between Estuary and Seatown Stations, to cross the Broadmeadow and Ward Rivers and their floodplains.
Proposed Grid Connections	Grid connections will be provided via cable routes with the addition of new 110kV substations at DANP and Dardistown. (Approval for the proposed grid connections to be applied for separately, but are assessed in the EIAR).

Project Elements	Outline Description
Dardistown Depot	A maintenance depot will be located at Dardistown. It will include: ▪ Vehicle stabling; ▪ Maintenance workshops and pits; ▪ Automatic vehicle wash facilities; ▪ A test track; ▪ Sanding system for rolling stock; ▪ The Operations Control Centre for the proposed Project; ▪ A substation; ▪ A mast; and ▪ Other staff facilities and a carpark.
Operations Control Centre	The main Operations Control Centre (OCC) will be located at Dardistown Depot and a back-up OCC will be provided at Estuary.
M50 Viaduct	A 100m long viaduct to carry the proposed Project across the M50 between the Dardistown Depot and Northwood Station.
Temporary Project Elements	
Construction Compounds	There will be 34 Construction Compounds including 20 main Construction Compounds, 14 Satellite Construction Compounds required during the Construction Phase of the proposed Project. The main Construction Compounds will be located at each of the proposed station locations, the portal locations and the Dardistown Depot Location (also covering the Dardistown Station) with satellite compounds located at other locations along the alignment. Outside of the Construction Compounds there will be works areas and sites associated with the construction of all elements of the proposed Project, including an easement strip along the surface sections.
Logistics Sites	The main logistics sites will be located at Estuary, near Pinnock Hill east of the R132 Swords Bypass and north of Saint Margaret's Road at the Northwood Compound. (These areas are included within the 14 Satellite Construction Compounds).
Tunnel Boring Machine Launch Site	There will be two main tunnel boring machine (TBM) launch sites. One will be located at DASP which will serve the TBM boring the Airport Tunnel and the second will be located at the Northwood Construction Compound which will serve the TBM boring the City Tunnel.

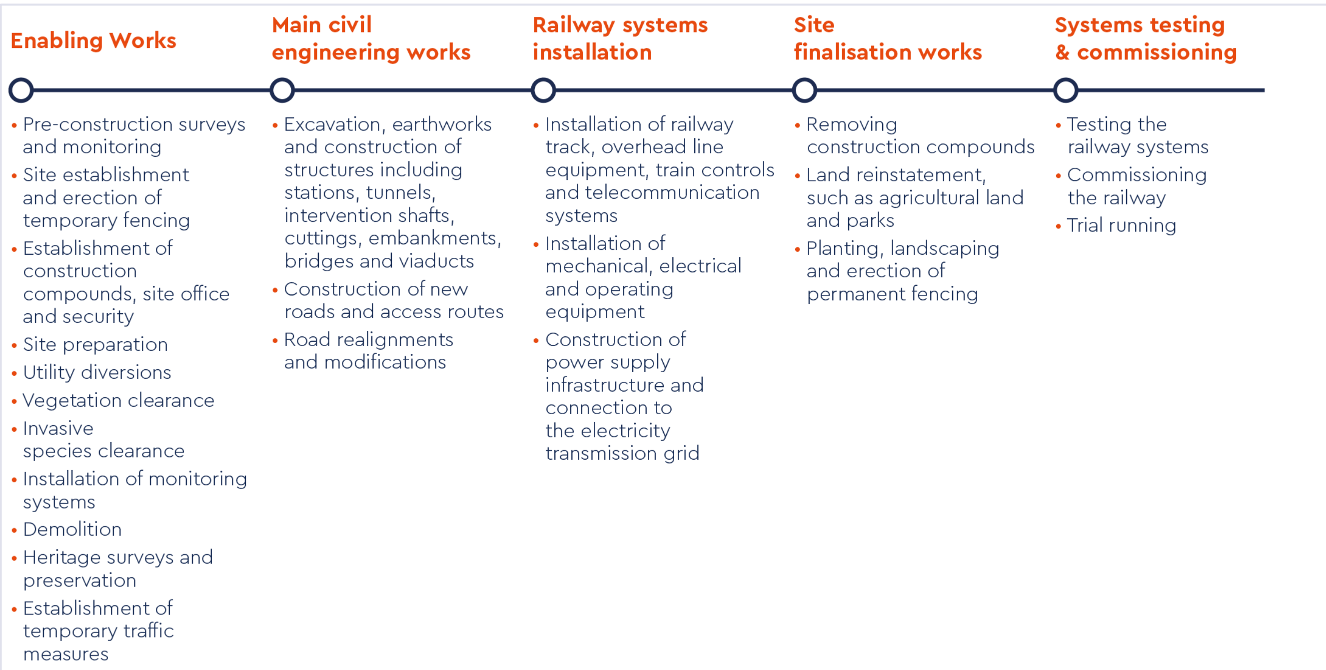

Diagram 12.1: Summary of Key Activities during the Construction Phase of the Proposed Project

Operational Strategy

- Fully Automated Rolling Stock
- Designed for a maximum of 20,000 passengers per hour per direction
- Minimum possible headway at 100 seconds
- Train will accommodate 500 passengers
- Operational Hours from 05:30 until 0:30

Operational Systems

- Operational Control Centre at Dardistown
- 40 High Floor Vehicles
- Power Systems to supply power to vehicles and stations
- Communication Systems including Radio, WiFi, CCTV, Public Address and Voice Alarm (PAVA), public mobile network and Emergency Telephones
- Ventilation and Air Conditioning Systems
- Emergency Evacuation and Fire Fighting Systems

Maintenance Systems

- Vehicle Maintenance at Dardistown Depot
- Maintenance of Operational Corridor outside of Operation Hours (0:30 until 5:30)
- Maintenance of Power systems, Communication Systems and Ventilation and Air Conditioning Systems

Station Operation

- Access via Escalators, Stairs and Lifts
- Signage
- Ticket Machines
- Lighting
- Back of House
- CCTV and Security

Diagram 12.2: Summary of Key Activities during the Operation Phase of the Proposed Project

12.3 Overview of the Electromagnetic Spectrum

Radiation is referred to throughout this chapter by reference to a number of terms including Electromagnetic Radiation (EMR), Electromagnetic Spectrum, electric and magnetic fields (e.g. Direct Current (DC) fields, Alternating Current (AC) fields and Radiofrequency fields), Electromagnetic Compatibility (EMC) and Electromagnetic Interference (EMI). A description of stray current is also provided.

EMR is a phenomenon that takes the form of self-propagating waves in air or in water. It consists of electric and magnetic field components which oscillate in phase perpendicular to each other and perpendicular to the direction of energy propagation. EMR is classified into several types according to the frequency of its wave; these include (in order of increasing frequency and decreasing wavelength) radio waves, microwaves, terahertz radiation, infra-red radiation, visible light, ultraviolet radiation, x-ray and gamma rays. A small and somewhat variable window of frequencies is sensed by the eyes of various organisms; this is what we call the visible spectrum or light. EMR carries energy and momentum that may be imparted into matter with which it interacts.

The Electromagnetic Spectrum covers a very wide frequency range and there are many aspects of it with which we are familiar and exposed to, on a daily basis. Diagram 12.3 illustrates some typical applications in the main frequency ranges.

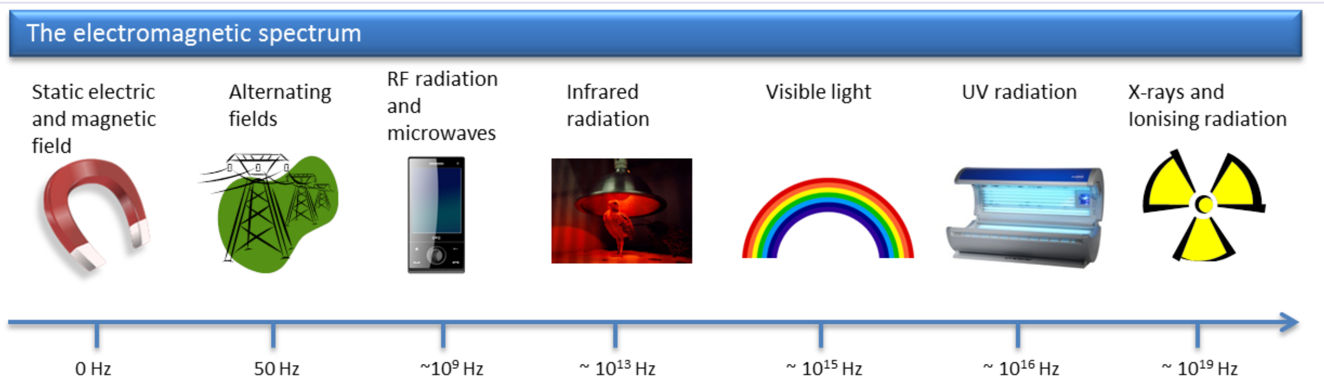

Diagram 12.3: The Electromagnetic Spectrum

The electromagnetic spectrum is so called because it comprises electric and magnetic fields, hence the term "electromagnetic". At the beginning of the electromagnetic spectrum we have static fields. The most common static field is the earth's magnetic field in which we are all immersed at all times. As we move up the electromagnetic spectrum, we reach the frequency used by electricity (50Hz) and we are also surrounded by fields of this type as they are caused by our house wiring. At higher frequencies we enter the radiofrequency range. These are so called as they radiate and pass freely through the air. We rely on radiofrequency waves to receive TV and radio. There are also many communications systems using these frequencies for mobile phones, air traffic control and Garda radio.

As the electromagnetic spectrum is a scarce resource and is used for safety critical applications it is carefully protected by European Union (EU) Directives. This means that all equipment placed on the EU market, including rail systems, must meet strict emissions limits. Sources of Electromagnetic Fields (EMF) in the existing environment includes items such as electrical equipment, power lines, telephone lines, signals from existing telecommunications masts (mobile phone and radio), underground communication cables, electrified trains, and broadcast transmitters. The emissions from these sources combine to make up the current electromagnetic baseline environment.

The proposed Project will generate electric and magnetic fields which can be categorised in three ranges:

- DC fields, generated by the traction system which powers the trains;
- AC fields, generated by the electricity drawn by the system from the Electricity Supply Board Networks (ESBN) and used to power the equipment at all the stations; and
- Radiofrequency fields generated by the radio systems used for communications and also as a by-product of every electrical and electronic system such as the train drive system.

EMC relates to the ability of different EM devices to function properly when they are situated in the same environment, i.e. it relates to the compatibility between different devices. EM devices can generate and propagate energy causing EMI. Devices can also receive and be interfered with by energy generated and propagated by other devices in the same environment. If an EM device is not compatible with other devices in the same environment, EMI can lead to the device not functioning properly. High levels of EMR can also cause adverse health effects in human beings. EMF comprise an electric field and a magnetic field and are emitted from both natural and manmade sources in the environment. All sources of EMF below 300GHz in the electromagnetic spectrum are considered Non-Ionising Radiation, which means the EMF do not carry enough energy to remove an electron from its atomic structure unlike what is classed as ionising radiation such as Gamma rays or X-rays.

EM fields are a combination of E-Fields and M-Fields which interact with each other. Both are discussed within this chapter. While both are associated with each other the simplest way to consider each is that the E-Field is related to the voltage of an EM source while the M-Field is related to the current (charges) flowing. Where the dominant or most applicable component of an EM field is the E-Field or the M-Field, they will be discussed as such. For clarification also, M-Field is used as the general term and can refer to either the Magnetic Field Strength (H-Field) or the Magnetic Flux Density (B-Field) which are two related vectors.

Stray current is a phenomenon associated with any electrified rail system and occurs when current leaks from the rails and passes through other nearby metallic structures. The current flowing into and out of the structure can result in corrosion. The structures potentially at risk are usually large electrically conductive systems such as utility pipes or cables running close to and parallel with the track.

While this chapter deals with EMR in relation to equipment and human health, Chapter 10 (Human Health) of this EIAR covers the broader impacts on human health considered for the proposed Project.

12.4 Methodology

The baseline environment is defined as the existing environment against which future changes can be measured.

This section describes the methods applied in assessing the baseline environment from an EMI and stray current perspective. It discusses how potentially sensitive receptors along the alignment were identified along with key stakeholders. It also details the criteria applied in assessing the significance of EMI and stray current impacts based on the predicted EMR from the system and the known sensitivities of specific receptors in the receiving environment.

The baseline radiation and stray current environment has been defined through a desktop study, consultation with relevant stakeholders and field surveys. The baseline environment is then categorised using the criteria outlined in Section 12.4.4.4 and baseline ratings are assigned. These baseline ratings are subsequently used in quantifying the final predicted impact significance.

12.4.1 Relevant Guidelines, Policy and Legislation

The proposed Project will be required to comply with the requirements of the European Directive on Electromagnetic Compatibility (2014/30/EU) (European Union, 2014b), and European Standards EN 50121 (Parts 1-5) (CENLEC, 2017), which address railway EMC. In addition, all electrical and electronic products placed on the market or taken into service in the EU must comply with all applicable directives which include the above EMC Directive, the Low Voltage Directive (2014/35/EU)(European Union, 2014e) and the Radio Equipment Directive (2014/53/EU) (European Union, 2014d). These directives have been transposed into Irish law under the following statutory instruments:

- S.I. No. 145/2016 - European Communities (Electromagnetic Compatibility) Regulations 2016;
- S.I. No. 248/2017 - European Union (Radio Equipment) Regulations 2017; and
- S.I. No. 345/2016 - European Union (Low Voltage Electrical Equipment) Regulations 2016.

The proposed Project's required compliance in accordance with the above directives and standards will be assessed in addition to guidelines on limiting exposures to EMF as published by the International Commission on Non-Ionising Radiation Protection (ICNIRP) and the European Council Recommendation (1999/519/EC) (European Union Council, 1999).

The Electromagnetic Compatibility Directive (2014/30/EU) (European Union, 2014b) and the Radio Equipment Directive (2014/53/EU) (European Union, 2014d) do not cover emissions from DC and near DC fields which are also an interference risk to particularly sensitive equipment such as Scanning Electron Microscopes (SEMs) and Magnetic Resonance Imaging (MRI) equipment. Nonetheless an assessment of this type of EMI will be included in the scope of the investigation.

Potential impacts from stray currents arising from the operation of the system will also be covered as per European Standard EN 50122-2 (CENLEC, 2010).

As well as considering the relevant Environmental Protection Agency (EPA) guidance with respect to EIARs (EPA, 2022), the scope and methodology for the baseline assessment has been devised in consideration of the following guidelines:

- EN 50121-2:2017 Railway applications - Electromagnetic compatibility Part 2: Emission of the whole railway system to the outside world (CENLEC, 2017);
- International Commission on Non-Ionising Radiation Protection (ICNIRP) Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (DC up to 300GHz). (ICNIRP, 1998);
- EU Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300GHz) 1999/519/EC (European Union Council, 1999);
- EU Electromagnetic Compatibility Directive 2014/30/EU on the approximation of the laws of the Member States relating to electromagnetic compatibility (European Union, 2014b); and
- EU Electromagnetic Fields Directive, 2013/35/EU (European Union, 2013).

12.4.2 Study Area

In determining the size of the study area, the following key aspects of the proposed Project were reviewed with the intent of identifying a corridor of influence (i.e. a specific distance) either side of the proposed alignment:

- Proposed electrification scheme, including:
  - 110kV HV substations;
  - HV feeder cables;

- 20kV MV traction substations;
- MV auxiliary substations; and
- 20kV MV ring distribution cables.

- Design features of the traction power feed systems including:

- Overhead line;
- Return rails; and
- Substation locations.

Electromagnetic Field strengths dissipate over distance. The precise distance at which EMI could be considered an influence will very much depend on the sensitivity of individual receptors. The protection distance provided in the European Directive on Electromagnetic Compatibility (2014/30/EU) (European Union, 2014b) is 10m and therefore all systems located 10m or greater from the rail system should not encounter radio frequency interference. However, due to the potential for extremely sensitive equipment used in some facilities such as medical, research and industrial, the corridor of influence was widened to 100m for the following receptor types:

- Research facilities (including universities and third level institutes);
- Medical Centres;
- Dental facilities;
- Hospitals;
- Scientific Institutions;
- Industry with potentially sensitive equipment;
- Mixed sensitive land uses;
- Buried utilities;
- Veterinary Clinics; and
- Theatre/Recording studios.

A narrow corridor of 10m was used for the following receptor types:

- Day-care facilities;
- Elderly Housing;
- Educational facilities (excluding universities and third level institutes);
- Heritage buildings;
- Churches;
- Hospitality;
- Opticians;
- Residential; and
- Offices and corporate land uses.

The rationale for the 100m area for DC and quasi-DC fields is based on study areas applied to similar electrified rail impact assessments performed in the past. Beyond 100m the simulated magnetic field perturbations tend to be of a magnitude that could be considered typical background levels in all but the most quiescent of locations. Realistically, RF signals would not be at intensity levels considered a risk to standard electrical equipment beyond 3m from the source. However, 100m is utilised for their study area by virtue of the fact that the signals could be detected and measured with specialised equipment at this distance and also to have some uniformity with the zone used for DC and quasi-DC fields. Finally, in relation to AC fields related to the power frequency; at a distance of +10m in an urban or industrial environment the levels anticipated would be reduced to background levels.

As well as housing pre-existing electrified rail services such as the DART and Luas, Dublin's subterranean environment is already heavily populated with many buried electricity and telecoms cables. The ability to detect and measure stray currents that could potentially be attributed to the proposed Project will be limited within the pre-existing environment the further from the development that measurements may be made. While theoretically faint evidence of stray current could be detected up to 1km away from the source (particularly for older unprotected electrified rail systems) a more realistic study area of 100m is chosen for what is a modern project that will be bound by state of the art standards and reduction techniques.

Table 12.2 lists the study area either side of the alignment highlighting but also distinguishes between the different impact sources of EMI and the maximum distance at which they may cause an impact.

Table 12.2: Study Area

Criteria	Width of Study Area (on both sides of the alignment) With respect to field types	
	Wide Corridor	Narrow Corridor
Potential impacts from Direct Current (DC) and Near DC fields	100m	10m
Potential impacts from Alternating Current (AC) fields	10m	10m
Potential impacts from Radiofrequency (RF) and microwave fields	100m	10m
Potential impacts from stray currents	100m	10m

12.4.3 Data Collection and Collation

Within the study area potentially sensitive land uses/receptors and stakeholders needed to be identified. The data sources utilised for this identification within the study area included the following:

- Land use maps provided by Jacobs Idom;
- Proposed alignment maps;
- Ordnance Survey Ireland (OSI) maps;
- Google Maps™;
- A tour along the proposed alignment; and
- Utilities maps.

These were all combined to create a database of stakeholders. This included medical centres, entertainment venues, domestic and commercial premises, hospitals, schools and universities.

All commercial stakeholders were presented with a questionnaire the purpose of which was to list any electrical equipment they were in possession of on their premises that they classed as being sensitive to EMI.

A subgroup of all these stakeholders were categorised as Major Stakeholders. These were organisations with either large campuses or networks (such as utilities and rail). The likelihood of these major stakeholders having equipment that is particularly sensitive to EMI from DC rail systems was considered to be higher. This included hospitals, universities, and rail operators. Due to the size and complexity of these organisations meetings and presentations were undertaken in order to present information about EMI, how it manifests itself, and to provide assistance in compiling their sensitive equipment lists. Chapter 8 (Consultation) details the process of stakeholder consultation that was undertaken.

As well as reviewing the equipment lists provided by all the stakeholders that engaged in the process, the sites of the Major Stakeholders were also chosen as the locations to perform EMR baseline surveys. It was key to establish the current EMR baseline environment within which these systems and equipment were being operated and whether any known issues already existed.

Baseline surveys were also performed at the locations of the electrification substations for the proposed Project. These sites were not chosen from the perspective of assessing impacts on potentially sensitive electronic or scientific equipment but from the perspective of the limits for public exposure to EMF (see also Chapter 10: Human Health). On commissioning of the proposed Project, it is likely that the site of the substations will generate the highest levels of EMR in the power frequency range (i.e. 50Hz). Therefore, these sites were chosen with respect to covering the guidelines for exposure to EMF.

In summary the data sources outlined in Table 12.3 were used in identifying and categorising the baseline environment.

Table 12.3: Data Sources

Information Acquired	Data Sources
Sensitive land uses/receptors	▪ Land use maps provided by Jacobs ▪ Proposed alignment maps ▪ Google maps™ ▪ OSI maps ▪ Physical tour of the alignment ▪ Stakeholder questionnaires ▪ Major Stakeholder meetings and presentations ▪ Utilities maps
Baseline EMR profile	Monitoring was conducted at the sites of identified major stakeholders using broadband radiation meters, spectrum analysers and appropriate antennas. The frequency range covered was from DC (0Hz) to 18GHz i.e. including DC, AC, RF and Microwave frequencies

12.4.4 Analysis Methods

12.4.4.1 Categorisation of the Baseline Environment

This section explains the categorisation of the baseline EMR and stray current environment. Identified receptors are assigned a baseline rating based on importance, sensitivity and existing adverse effects of the receiving environment. Each of these three terms is explained in detail in this section. The professional opinion of the specialist also plays an important role in assigning the baseline rating. The baseline rating will subsequently be used in the impact section (Section 12.10) to determine the likely significance of effects.

12.4.4.2 Importance of the Baseline Environment

The importance of a receptor is determined by how serious the consequences of its failure or malfunction would be. Receptors are considered to be important if their loss causes widespread disruption or if safety issues arise if they malfunction.

EMI can potentially affect equipment in medical centres, safety signalling and navigational equipment in railways and airports and certain medical equipment in the home. Such receptors are therefore important because of the potential safety issues that could arise.

EMI can also affect wider infrastructure facilities such as telecommunications equipment and cabling, electrical substations, computer screens and sensitive instruments in industrial, medical and research facilities. These receptors are therefore also considered to be important.

Stray current can cause corrosion in metal structures such as utility pipes and cables, reinforcing bars in bridges and buildings and underground fuel tanks, particularly where such infrastructure runs parallel and close to the alignment of the proposed Project (within 100m). Because of the safety implications of such corrosion and because loss of the infrastructure concerned may be potentially disruptive, such receptors are also considered to be important.

12.4.4.3 Sensitivity and Existing Adverse Effects

The sensitivity of a receptor is determined by how readily it will fail or malfunction in the presence of external EMR. Equipment which fails when exposed to even weak fields is considered to be sensitive, while equipment which continues to operate in much stronger fields is considered to be non-sensitive.

Equipment which relies on EM fields to operate, e.g. radio receivers, TV and telecommunications receivers and many types of rail signalling systems, is most sensitive to external radiation which happens to be at the same frequency as the equipment is designed to operate. Such equipment is considered to be sensitive at that frequency.

On the other hand, non-radio equipment continues to operate in much stronger fields and so is generally considered to be non-sensitive. However, certain types of medical and high-end research equipment, such as linear accelerators (LINACs) and SEMs are known to be susceptible to strong AC and DC fields and are therefore also classed as sensitive.

Some facilities already exist and operate in an adverse EM environment. The purpose of the stakeholder consultations was to identify pre-existing interference issues due to particularly sensitive equipment being in close proximity to high EM field generating sources.

In relation to buried utilities/structures and stray current, the most susceptible utilities are those that run close to (within 100m) and parallel to the alignment for long distances. And of those structures the most conductive of materials would be the most sensitive such as cast iron and steel pipework.

12.4.4.4 Baseline Rating

The baseline rating of the existing radiation and stray current environment is determined by having regard to the range of criteria reflecting its importance, sensitivity and existing adverse effects currently being experienced. The criteria that have been defined for EMR and stray current are shown in Table 12.4 and Table 12.5 respectively.

Table 12.4: Criteria for Baseline Categorisation with Respect to EMR

Criteria	Baseline Rating
Any facilities that have highly sensitive equipment on the premises on a permanent basis. Public/private hospital facilities. Signalling on rail networks. 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. Locations with installations of custom audio-visual equipment.	High
Any facilities that have potentially sensitive equipment on the premises on a permanent basis. Some residential areas e.g. containing medical equipment. Industrial facilities with potentially sensitive equipment. 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. Educational institutions without sensitive equipment.	Low
All other areas.	Very low

Table 12.5: Criteria for Baseline Categorisation with Respect to Stray Current

Criteria	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. 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 Proposed Project structures. Metal shielded cables. Other rail infrastructure e.g. tracks. Small ground embedded fuel tanks, e.g. a petrol station.	Medium
Other metal reinforced structures parallel to the alignment with a minimum length of 100m (e.g. buildings).	Low
Industrial facilities with large metal structures. All other areas.	Very low

By way of informing the baseline assessment, and following consultations, monitoring of DC magnetic fields, AC EMF and RF electric fields was conducted at a number of sites deemed to be sensitive to EMI.

For the purpose of assigning a baseline rating for stray current the rating levels were selected based on a combination of the length of the buried structures and known sensitivities of such structures.

12.4.5 Methodology for Predicting Theoretical Worst-Case EMR Levels

Once the baseline was defined and sensitive receptors identified and categorised following review of the data sources listed in Table 12.3, it was then necessary to predict anticipated levels of EMI for these locations. The purpose of this exercise was to inform the predicted impacts section of this chapter (Section 12.10) using the appraisal methods discussed in Section 12.6.

12.4.5.1 DC and Near DC Magnetic Fields

A combination of field acquired data from surveys conducted on similar electrified rail systems and modelling was used to determine the worst-case DC magnetic field perturbations that are likely to occur from the proposed Project once operational at various distances from the alignment.

Forecasted current loads were acquired from the traction system design team and the maximum operational currents were obtained. These maximum operational currents were then used for modelling using the Biot-Savart law which defines the relationship between the magnetic field contribution and its source current element in mathematical terms.

12.4.5.2 AC Fields

Again, field acquired data from similar developments was used to inform the predicted AC field levels from the proposed Project. This included not just the power frequency of 50Hz but also harmonics of the power frequency as a result of the rectification process to derive the DC supply for the traction system from an AC source. The locations of the various substations were also examined and their proximity to any potentially sensitive receptors.

The proposed routing and rerouting of voltage supply cables laid by the ESBN along with their constituent operation voltages and load currents were considered to establish the worst-case power frequency E-Field and M-Field levels derived from maximum voltage and current load levels.

12.4.5.3 RF and Microwave Fields

Any RF and microwave fields emanating from the proposed Project will be as a result of the installation of pre-approved communication and signalling systems. The specifications of these systems are required to meet the standards set out in the relevant EU Directives. Therefore, the worst-case levels that are likely to occur in this frequency range are exactly those limits as specified in the various product standards for both EMC and Radio.

In relation to equipment immunity to the high frequency and AC fields discussed in the section above, it is assumed that any potentially sensitive electromagnetic receptor identified as a result of questionnaires or consultations is immune to interference from the proposed Project in these frequency ranges by virtue of the fact that such equipment is required to meet the relevant EU standards for immunity. The immunity levels prescribed by the EMC and Radio Directives exceed the maximum permitted emission levels from the proposed Project. This is with the exception of bespoke equipment and highly sensitive scientific and research equipment.

The impacts from the different types of EMR are examined and discussed in more detail in Section 12.10.

12.5 Consultations

Consultations with stakeholders, where they occurred, are discussed in the respective sections for each stakeholder in the baseline description in Section 12.7 with further details provided in Chapter 8 (Consultation).

12.6 Appraisal Method for the Assessment of Impacts

12.6.1 EMR and Stray Current During Construction Phase

No impacts from an EMI, EMF or stray current perspective are likely during the Construction Phase of the proposed Project and therefore no detailed investigation was deemed necessary for this aspect of the Project. The EM profile of the Construction Phase will not differ significantly from that of a regular large scale construction site with emissions attributable to on site transformers, radio communications equipment and any construction tools utilising wireless technology that may be used. The main difference in emissions profile to that of a standard construction site will be that of the power feed for the TBM, which will be electrically powered.

12.6.2 EMR and Stray Current During Operation Phase

Electromagnetic emissions are generated by the power supply system such as electrical substations, the current supply system along the alignment and the propulsion systems onboard the rolling stock. The proposed Project itself could be susceptible to external EMF that are generated by sources such as electricity cables and local RF transmitters.

Stray currents could potentially occur on nearby 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 are also known to generate transient emissions that are not controlled by EMC regulations. These are primarily caused by the switching in and out of large electrical loads. 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 cause the phenomenon of flicker when not mitigated correctly. Flicker is evident when lighting dims causing a nuisance to local residents and other sensitive receptors. This will be mitigated by the power profile of the current draw from the proposed Project. The current will be gradual rather than a step change.

Electrical design details such as traction system voltages, load currents, distances between rails and overhead lines were all utilised and fed into models to ascertain predicted magnetic field levels (both

DC and AC) at different distances from the alignment. The highest specified working currents were utilised to inform these models as these would result in the highest field levels.

Modelling was not required for RF and Microwave field levels, as these are strictly governed by the limits contained in the European EMC Directive and Radio Equipment Directive.

12.6.3 Methodology for Evaluating Impacts and the Significance of Effects

The magnitude of the impacts and the significance of their effects on each identified receptor was assessed according to the EMR magnitudes outlined in Table 12.6. For the purpose of this appraisal the receptor types listed in Section 12.4.2 were categorised into three groups based on their perceived sensitivity to specific levels of EMR with Group 1 being classified as the least sensitive and Group 3 the most sensitive:

- Group 1:

- Day-care facilities;
- Elderly Housing;
- Educational facilities (excluding universities and third level institutes);
- Heritage buildings;
- Churches;
- Hospitality;
- Opticians; and
- Residential.

- Group 2:

- Offices and corporate premises (including state offices);
- Industry with potentially sensitive equipment;
- Mixed sensitive land uses;
- Theatre/Recording studios; and
- Dental facilities.

- Group 3:

- Research facilities (including universities and third level institutes);
- Scientific Institutions;
- Medical Centres; and
- Hospitals.

A narrow corridor of 10m was used for the following receptor types: Group 1. These receptors were not considered to be in possession of the type of equipment sensitive to the lower levels of EMR from the proposed Project beyond this distance.

Table 12.6 illustrates how these receptors were scored in relation to specific EMR levels. Below Table 12.6 is an explanation of why particular levels were chosen.

In terms of defining the significance of effects, the following rationale was applied:

- **Imperceptible** - There is no indication of any significant changes to the baseline electromagnetic environment;
- **Slight** - A localised change to the baseline that is measurable with specialised instrumentation but without affecting the operability of equipment;
- **Moderate** - Equipment operators are unlikely to notice additional noise affecting their equipment's performance. But some may experience noise effected performance at certain sensitivity levels of their equipment (e.g. higher resolution settings), where noise is defined as unwanted signals appearing within a sensors measurement range;
- **Significant** - Levels significant enough to cause a nuisance for the performance of routine tasks e.g. running a standard MRI scan; and

- **Profound** - Some equipment rendered inoperable. Potential safety limits for human exposure to EMR exceeded.

Table 12.6: Impact Magnitude and Significance of Effect

Magnitude		Significance of Effect		
Field Type	**Limit**	**Group 1 (Residential/Schools)**	**Group 2 (Industrial/Commercial)**	**Group 3 (Sensitive Research Centres/Hospitals)**
DC fields	> 500µT	Profound	Profound	Profound
	> 50µT	Moderate	Moderate	Significant
	> 10µT	Slight	Slight	Moderate
	> 1µT	Imperceptible	Slight	Slight
	> 0.1µT	Imperceptible	Imperceptible	Slight
	> 0.01µT	Imperceptible	Imperceptible	Slight
AC fields	> 38µT	Profound	Profound	Profound
	> 3.8µT	Moderate	Significant	Significant
	> 1.3µT	Slight	Moderate	Moderate
	> 0.5µT	Imperceptible	Slight	Slight
	> 0.05µT	Imperceptible	Imperceptible	Slight
RF and Microwave fields	> 10V/m	Profound	Profound	Profound
	> 3V/m	Profound	Moderate	Significant
	> 1V/m	Slight	Slight	Moderate
	> 0.1V/m	Imperceptible	Imperceptible	Slight
	> 0.01V/m	Imperceptible	Imperceptible	Imperceptible

The DC limit of 500µT is based on the standard EN 45502-2-1:2003 Active implantable medical devices Part 2-1: Particular requirements for active implantable medical devices intended to treat bradyarrhythmia (cardiac pacemakers), which requires units to comply with this exposure level.

The 50µT DC magnetic field limit is based on the typical immunity level of some sensitive hospital equipment. It should be noted that there may be particular items of equipment with lower immunity levels.

Testing carried out at the existing Luas Red Line during qualification testing has shown that Cathode Ray Tube (CRT) based televisions do not exhibit screen interference at 10m distance. As such, the effects of DC magnetic fields less than 10µT on residential and commercial locations are classified as slight to imperceptible, while the most sensitive of medical and scanning equipment is known to have manufacturer specified sensitivities of as low as 1µT and 0.1µT.

The AC and RF field limits are based on the immunity levels listed in harmonised standards under the EMC Directive 2014/30/EU (European Union (2014c)). The AC magnetic field immunity test levels for industrial equipment is 38µT while 3.8µT is used for residential equipment. Similarly, the levels of 10V/m, 3V/m and 1V/m are some of the different immunity test levels for industrial, domestic and Information Technology (IT) equipment.

Stray current levels cannot be modelled due to the quantity of buried structures and utilities in the urban environment that run parallel to the alignment and the existence of other stray currents already present from the likes of the DART and Luas systems. Accordingly, for the purpose of assessing the impact from stray currents, the significance of the effects has been derived from the original baseline rating for such structures.

Where the significance of effects for a specific parameter are evaluated to be Significant to Profound, they were determined to have a quality of effects classed as Negative. For an Imperceptible to Moderate significance of effects, these were determined to have a quality of effects classed as Neutral.

Projects that have yet to receive planning approval, such as Hammersons Dublin Central Site 2 Project, were not listed as potential receivers. It is worth noting however that whether or not such developments go ahead, they will not have any notable effect on how the proposed development will impact other existing receivers in their vicinity.

12.6.4 Methodology for Evaluating Impacts and the Significance of Effects for the General Public

As referenced in Chapter 10 (Human Health) the following discusses the EMR aspect of human health in relation to exposure guideline limits. The Irish Government establishes expert groups from time to time to advise on EMF or more specifically exposure to EMF. In Ireland Government policy is set by the Department of Communications, Climate Action and Environment which continues to adopt the guidelines developed by the ICNIRP. The ICNIRP guidelines are endorsed by the World Health Organisation (WHO) and the EU.

In 2019 the Government published a Statutory Instrument (S.I. No 190/2019) which assigns responsibility to the EPA for providing advice to the Government and the public on exposure to electromagnetic fields.

The values used in Table 12.6 are mostly derived in relation to equipment. The limit levels for human exposure are many times higher again.

Internationally the allowable exposure levels for EMF are published by ICNIRP, which are frequently updated. ICNIRP has issued guidelines for limiting exposure to static and time varying electric and magnetic fields up to 300GHz. The latest update on static fields is covered by:

- ICNIRP Guidelines on limits of exposure to Static Magnetic Fields (ICNIRP, 2009b)

The latest update on time-varying fields is covered by:

- ICNIRP Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300GHz) (ICNIRP, 2009a)

The ICNIRP limits have been adopted by the European Commission for both public and occupational application. For occupational purposes, a directive was published:

- Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields (European Union, 2013))

While for public application, the EU published a Council Recommendation:

- 1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0Hz to 300GHz) (European Union Council, 1999)

Note: For reference, that the earth's magnetic field is between 30 µT and 70µT (from equator to poles) and is a static field that is present everywhere on the earth. The level in Ireland is around 49µT. The ICNIRP limit for static magnetic fields, included in the Council Recommendation, is 40 milli Tesla (40,00µT).

In addition to the health limits outlined in the above Directives and Council Recommendations, there are also limits for EMC and potentially susceptible devices such as Active Implantable Medical Devices (AIMD). These include devices such as cardiac pacemakers, implanted defibrillators, cochlear implants and similar devices. Devices such as pacemakers have particular standards that they need to adhere to with respect to electromagnetic fields. One such example is EN 50527-2-1:2016 "Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices. Specific assessment for workers with cardiac pacemakers", which states that pacemakers are expected to work uninfluenced as long as the General Public Reference levels of Council Recommendation 1999/519/EC (European Union Council, 1999) are not exceeded. The ICNIRP notes that these levels can be as low as 500µT. The occupational EMF Directive 2013/35/EU (European Union, 2013) states an action level of 500µT for static magnetic fields reasoned by interference with the operation of AIMDs.

The ICNIRP limits for occupational exposure are an order of magnitude higher than for public exposure therefore the public guideline limits are chosen here since they are the most stringent to apply. These are the same limits that are outlined in the 1999/519/EC Council Recommendation (European Union Council, 1999). Table 12.7 shows the reference levels for public exposure to time-varying electric and magnetic fields.

Table 12.7: ICNIRP EMF Limits for general public exposure to time-varying electric and magnetic fields

Frequency Range	E-Field Strength (V/m)	H-Field (A/m)	B-Field (µT)	Equivalent plane wave power S (Wm^{-2})
up to 1Hz	-	3.2×10^4	4×10^4	-
1 – 8Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	-
8 – 25Hz	10,000	4,000/f	5000/f	-
0.025 – 0.8kHz	250/f	4/f	5/f	-
0.8 – 3kHz	250/f	5	6.25	-
3 – 150kHz	87	5	6.25	-
0.15 - 1MHz	87	0.73/f	0.92/f	-
1 – 10MHz	$87/f^{1/2}$	0.73/f	0.92/f	-
10 – 400MHz	28	0.16	0.092	2
400 – 2000MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	f/200
2 – 300GHz	61	0.16	0.20	10

To illustrate the difference between human exposure limits and that for electromechanical equipment the guideline limit for public exposure to DC magnetic fields is 40,000µT versus the 1µT limit used for sensitive medical equipment. This is the same for the exposure limits for humans versus equipment up through the frequency range.

Levels up to the limits contained in the ICNIRP EMF guidelines are considered safe for members of the public and, for the purpose of this assessment, are classed as having a significance of effects of Imperceptible with the quality of effects classed as Neutral. Any predicted levels in excess of the limits set out in Table 12.7 are classed as having a significant effect, with the quality of the effects classed as Negative.

12.6.5 Other Criteria in the Assessment of Impacts

The study area for the EMR aspect of the EIAR is outlined in Section 12.4.2 along with the justification for the distance selected per type of radiation (DC, AC or RF). Any deviations to these distances in relation to the extent of an impact on a particular receptor are highlighted in Section 12.10.

The likelihood of the occurrence of identified impacts is also discussed. Typical operational emissions that would be expected day to day and their associated impacts on the baseline would be classed as "likely", for example. In discussing potential impacts, worst-case conditions are also required to be considered. An example would be fault conditions that may result in higher (or lower) localised EM emissions than would persist during normal operation. A persistent overcurrent fault due to a faulty rail would be considered unlikely as such a fault would require prompt rectification.

When discussing the duration of effects the following rationale is applied.

- **Momentary effects -** Effects lasting from seconds to minutes;
- **Brief effects -** Effects lasting less than a day;
- **Temporary effects -** Effects lasting less than a year;
- **Short-term effects -** Effects lasting one to seven years;
- **Medium-term effects -** Effects lasting seven to fifteen years;
- **Long-term effects -** Effects lasting fifteen to sixty years; and
- **Permanent effects -** Effects lasting over sixty years.

Finally, when an effect is determined to be likely it's frequency of occurrence will also be outlined e.g. once, rarely, constantly or once a day.

12.7 Description and Categorisation of the Baseline Environment

This section outlines the findings of desktop studies, questionnaires, field surveys and information gained through stakeholder consultations carried out. It uses this information to provide a description of the current baseline based on all information gathered.

The baseline environment was broken into the four Assessment Zones (AZs). AZ1 starts at the Park and Ride Facility and runs to DANP, AZ2 which is the Dublin Airport Tunnel section, AZ3 from DASP to the Northwood Portal and AZ4 from Northwood Portal to Charlemont Station.

As outlined in the methodology, stakeholders were requested to complete equipment lists, with the aid of a questionnaire, detailing specific equipment that they had on site which they suspected may be susceptible to EMI. Examples were provided in the questionnaires by way of assisting the compilation of these lists (such as IT equipment and medical/research equipment). CEI used the information garnered from these questionnaires and consultation meetings along with maps of the proposed alignment to assign a baseline rating to each, recalling that the study area varied between 10m and 100m depending on the receptor type, as discussed in Section 12.4.2.

12.7.1 AZ1 - Northern Section Baseline

AZ1, which runs from Estuary to North of Dublin Airport, comprised the land uses within the study area outlined in Table 12.8.

Table 12.8: AZ1 Land Uses

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
AZ1	Commercial/Corporate areas: ▪ Bostick Industries Limited ▪ Woodies, Seatown ▪ Swords Business and Technology Park ▪ Hertz Europe Service Centre ▪ Airside Retail Park.	Low	Very Low
	Swords National Ambulance Service Base.	High	Very Low
	Fujitsu Ireland.	Medium	Very Low

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
	Utilities (pipes and cables) including: Cast iron water mains along Dublin Road, Swords.	Very Low	Medium
	Parklands and Sports fields. Fingallians GAA.	Very low	Very Low
	Residential and hospitality areas. Seatown residential area. Ashley Avenue.	Low	Very Low
	Siemens Healthcare.	Very High	Very Low
	Medical and Veterinary Hospitals: ▪ Tara Winthrop Private Clinic ▪ VHI Swiftcare Clinic ▪ Lissenhall Veterinary Hospital ▪ Swords Veterinary Hospital.	High	Very Low
	Fuel/Service Stations. Texaco Swords Road.	Low	Medium
	Agricultural Land.	Very Low	Very Low

Siemens was identified as a site with potentially sensitive research equipment on their premises and was assigned a baseline rating as Very High with respect to EM fields. A baseline survey was conducted at this location on 12 December 2018. These are discussed in Section 12.9.1.1.

With the exception of Siemens, no other particularly sensitive receptors were assigned a baseline rating of Very High which warranted further investigations or a baseline survey.

Medical, dental and veterinary facilities were classed as a high from an EM Field perspective. Equipment questionnaire sheets were examined but consultations were not deemed necessary.

12.7.2 AZ2 – Airport Section Baseline

AZ2, which was the Dublin Airport section of the study area, contained the land uses outlined in Table 12.9.

Table 12.9: AZ2 Land Uses

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
AZ2	Residential.	Low	Very Low
	Dublin Airport Authority (DAA) (Including Jet fuel pipeline within Dublin Airport).	Very High	Very High
	Utilities (pipes and cables).	Very Low	Medium
	Commercial/Corporate areas within Dublin Airport.	Low	Very Low

Dublin Airport was noted as a site with potentially sensitive equipment on their premises and, accordingly, was identified as a Major Stakeholder with whom consultations were held the details of which are covered in Chapter 8 (Consultation). A baseline survey was also conducted at this location on 3 May 2019 discussed in Section 12.9.2.1

With the exception of Dublin Airport, no other particularly sensitive receptors were identified that warranted further investigations or a baseline survey.

12.7.3 AZ3 – Dardistown to Northwood Baseline

AZ3, which runs from South of Dublin Airport to Northwood in Ballymun, comprised the land uses outlined in Table 12.10.

Table 12.10: AZ3 Land Uses

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
AZ3	Agricultural Land Uses.	Very Low	Very Low
	Industrial areas.	Medium	Very Low
	Utilities (pipes and cables) including: ▪ Ductile iron water main along Ballymun road ▪ 250mm steel gas main along St Margaret's Road to Carton Way.	Very low	Medium
	Parkland and Sports fields. Na Fianna GAA Collinstown playing field. Whitehall Rangers Football Club.	Very Low	Very Low
	Residential areas.	Low	Very Low
	Petrol Stations. Circle K (Northwood Service Station).	Low	Very Low

No potentially sensitive receptors were identified that warranted further investigation or a baseline survey.

12.7.4 AZ4 – Northwood to Charlemont Baseline

AZ4, which runs from the Northwood Portal to Charlemont, comprised the land uses outlined in Table 12.11.

Table 12.11: AZ4 Land Uses

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
AZ4	Commercial/Corporate areas: ▪ Ballymun plaza ▪ Ballymun Sports and Fitness ▪ Bank of Ireland Saint Mobhi Road ▪ Glasnevin Physical Therapy ▪ Commercial units on Finglas Road ▪ Commercial units on Prospect Road ▪ Commercial units on Phibsborough Road ▪ Commercial units on North Circular Road ▪ Commercial units on Goldsmith Street ▪ Commercial unit on Berkeley Road ▪ Commercial units on Berkeley Street ▪ Commercial units on Blessington Street ▪ Commercial units on Fredrick Street North ▪ Offices/Commercial units on Parnell Square East ▪ Offices/Commercial units on O'Connell Street ▪ Commercial units on Henry Street ▪ Offices/Commercial units on Abbey Street Lower (Including Amplifon) ▪ Commercial units on Eden Quay ▪ Commercial units on Burgh Quay	Low	Very Low

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
	▪ Offices/Commercial units on Poolbeg Street ▪ Commercial units on Townsend Street ▪ Commercial units on Spring Garden Lane ▪ Commercial units on Pearse Street ▪ Offices/Commercial units on Leinster Street South ▪ Offices/Commercial units on Merrion Row ▪ Offices on St Stephen's Green South ▪ Offices at the junction of Earlsford Terrance and Hatch Street ▪ Offices at Harcourt Terrace ▪ Offices at Grand Parade.		
	Utilities (pipes and cables) including: ▪ Ductile iron water main along Ballymun road ▪ Iron water main along St Mobhi Road and Botanic Road ▪ Cast iron pipes servicing multiple estates adjacent to water main line such as Dean Swift Estates, Clonmel Road Griffith Avenue, Land uses in Phibsboro and other city centre locations ▪ Cast iron water main continuing along Berkeley Road to O'Connell Street ▪ Ductile Iron water pipe along Kildare Street ▪ Cast Iron water pipe along St Stephen's Green continuing to Harcourt Terrace ▪ 500mm steel gas main along Harcourt Terrace ▪ 400mm steel gas main along Ballymun road to Glasnevin Hill and St Mobhi Road	Low	Medium
	Residential and hospitality areas: ▪ Gateway residential areas ▪ Residences at the junction of Ballymun road and Glasnevin Avenue ▪ St Mobhi Road ▪ Botanic Avenue ▪ Daneswell Road ▪ Fairfield Road ▪ Botanic Road ▪ Brian Boru public house ▪ Prospect Avenue ▪ De Courcy Square ▪ Dalcassian Downs ▪ Phibsborough Road ▪ Royal Canal Bank ▪ North Circular Road ▪ Goldsmith Street ▪ Berkeley Road ▪ Berkeley Street ▪ Nelson Street ▪ Blessington Street ▪ Fredrick Street North (including the Castle Hotel) ▪ Wynn's Hotel ▪ Grans Central Bar ▪ Eden Quay ▪ Burgh Quay ▪ Townsend Street ▪ Pearse Street Public House	Low	Very Low

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
	▪ Earl Court ▪ Harcourt Terrace ▪ Grand Parade.		
	Parkland and Sports fields: ▪ Balcurris Park ▪ Setanta GAA ▪ Albert College Park ▪ Hampstead College Park ▪ Na Fianna CLG ▪ Home Farm FC ▪ Garden of Remembrance.	Very Low	Very Low
	Saint Joseph's Church on Berkeley Road.	Medium	Very Low
	Fuel/Service Stations: ▪ Circle K Ballymun Road.	Low	Medium
	Schools and colleges: ▪ Scoil an tSeachtar Laoch Ballymun ▪ Ballymun Youthreach ▪ CDETB Adult Education Service Ballymun ▪ Ballymun Library ▪ National College of Arts and Design.	Low	Very Low
	DCU	High	Low
	Irish Rail Crossing at the Prospect Road.	Very High	Low
	Dental/Medical Facilities: ▪ Cahill Dental Clinic ▪ D11 Dental ▪ College Gate Clinic ▪ Glasnevin Family Practice ▪ O'Loughlin's Dental Surgery ▪ Prospect Medical Practice ▪ Freedom Dental, O'Connell Street ▪ CIE Occupational Health Unit on Marlborough Street ▪ St Peter's Square Dental Surgery ▪ The Fredrick Dental Clinic ▪ Smiles Dental, O'Connell Street ▪ Dublin Dental Hospital and School ▪ McNally Opticians on the Green.	High	Very Low
	Mater University Hospital	Very High	Low
	Rotunda Hospital	Very High	Low
	Rotunda IVF	Very High	Low
	Gate Theatre	High	Very Low
	Ambassador Theatre	High	Very Low
	GPO	Low	Very Low
	Abbey Theatre	Medium	Very Low
	Luas Red Line	Medium	Medium
	Luas Green Line	Medium	Medium
	Irish Rail at Tara Street Station	Very High	Low
	Dublin Fire Brigade	High	Very Low
	Trinity College Dublin	Very high	Low

Area	Summary Description	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
	Leinster House, Department of the Taoiseach, Other Government departments	High	Very Low
	National Gallery of Ireland and National Library of Ireland	Low	Very Low
	Museums (National Museum of Archaeology, Natural history Museum).	Low	Very Low
	National Concert Hall	Very High	Very Low
	Royal Victoria Eye and Ear Hospital	Very High	Very Low

Notable sites that fell outside the study area for AZ4 include - The Bon Secours Hospital, Whitehall College of Further Education, the National Metrology Labs, the Irish Meteorological Service, the Mater Private Hospital and Mountjoy Prison.

The majority of the DCU campus also fell outside the corridor, however due to a slight incursion within the 100m zone and the potential for the installation of sensitive receptors at some point in the future it was chosen as a location for a baseline survey, carried out on 12 December 2018 which is discussed in Section 12.9.4.1. The proposed Project crosses the Irish Rail network at Prospect Road (Maynooth Line) so this site was also chosen for a baseline survey with the survey performed on 3 May 2019 discussed in Section 12.9.4.2.

The Mater Hospital, Rotunda and Rotunda IVF were identified as Major Stakeholders with whom consultations were held. These are noted in Chapter 8 (Consultation). Baseline EMR surveys were carried out outside the Mater Hospital (Refer to Section 12.9.4.3) above the proposed alignment on 1 December 2018 and outside the Rotunda IVF clinic (Refer to Section 12.9.4.4) located within the main Rotunda Campus on 29 November 2018. The Ambassador and Gate Theatres were also given a High baseline rating (sensitivity of magnetic pickups to power frequency harmonics). Both of these sites were also within the Rotunda Campus and adjacent to the Rotunda IVF clinic. The one baseline survey within the Rotunda campus was deemed sufficient to cover these four stakeholders.

Irish Rail at Tara Street, the National Concert Hall and the Royal Victoria Eye and Ear Hospital were all identified as sites with Very High baseline ratings from an EM Field perspective and therefore chosen for baseline surveys which were carried out on 1 December 2018 (discussed in Section 12.9.4.5), 28 November 2018 (discussed in Section 12.9.4.7) and 28 November 2018 (discussed in Section 12.9.4.8) respectively.

Finally, baseline surveys were also carried out at TCD on 29 November 2018 at two locations. These are discussed in Section 12.9.4.6). Follow up DC surveys were then also carried out on 25 February 2019 and 19 March 2019 as part of consultations with the college. These are covered in the report titled 19E7900-1 TCD DC and Near DC EMI while the details of the consultations are covered Chapter 8 (Consultation).

Baseline surveys were not carried out at locations rated less than Very High. The following sites were rated as Medium to High from an EM Field perspective – Dental and Medical facilities, Dublin Fire Brigade, Luas Red Line, Luas Green Line, Abbey Theatre and Government Buildings. Consultations were undertaken with the facilities and operations team at Government Buildings.

No other sensitive receptors or stakeholders were identified that warranted further investigation or a baseline survey.

12.7.5 Substation Locations

Chapter 4 (Description of the MetroLink Project) details the proposed Project description, including electrification. MV substations are intended to be located at each project station interconnected by a 20kV MV ring. The proposed HV substation locations are the Naul Road and Dardistown fed by a 110kV electrical service. These HV substations will be above ground and are considered more significant in relation to EMR for the baseline environment than the MV substations. Therefore, in addition to the baseline surveys conducted at sensitive stakeholder locations, EMR baseline surveys were also conducted at the two proposed HV substation sites. Naul Road was surveyed on 13 April 2021 with the results discussed in Section 12.9.5.1. Meanwhile, the proposed Dardistown substation location was surveyed on 5 October 2020 with the results discussed in Section 12.9.5.2.

12.8 Baseline Receptors

As discussed in Section 12.4.3 information was gathered from a number of sources before arriving at the final ratings for each selected land use within the study area. Table 12.8, Table 12.9, Table 12.10, Table 12.11 depict the assigned ratings for the stakeholders within each zone. This section discusses in more detail the sensitive receptors identified by these stakeholders.

In relation to most of the land uses, similar equipment types were frequently listed by stakeholders, which comprised standard equipment types that would be encountered by the majority of the population on a regular basis. The following list is a summary of the typical equipment contained in stakeholder questionnaire responses:

- Televisions;
- IT equipment;
- Communications equipment;
- Radio systems;
- Security systems;
- Medical equipment such as ventilators and monitors;
- Scanning Medical equipment such as X-ray machines;
- Microscopes;
- Manufacturing equipment and machinery;
- Signalling systems;
- Audio/Visual equipment; and
- Laboratory equipment.

The potential operational impacts on such equipment are discussed in Section 12.10. With regards to the significant stakeholders identified (those rated with a Baseline rating of Very High) within each AZ, a summary of the discussions and consultations with respect to each follows. Some stakeholders from within the high rated category were also selected for further consultations.

12.8.1 AZ1 – Northern Section

12.8.1.1 Swords National Ambulance Service Base

No completed equipment questionnaire was received from this location. However, likely sensitive receptors on-site include IT, radio and communications and medical equipment.

12.8.1.2 Siemens

Siemens manufacture sensitive scanning medical equipment at their site and expressed concern of potential EMI from the proposed development on their equipment and systems within the plant. A baseline survey was also carried out at the Siemens site at a location on their premises that would be considered the closest to the proposed alignment on 12 December 2018.

12.8.1.3 Fujitsu Ireland

Fujitsu listed the following equipment types as being potentially sensitive to EMI - Large computer hard drives, sensitive electronic instruments, major computer installations and telecoms installations.

12.8.1.4 Hertz Europe Service Centre

The European operations centre for Hertz listed the following equipment as potentially sensitive receptors - Radio/Wireless dish antenna, server farms, storage disks, computer equipment, network switches and router device, telecoms and PBX Equipment, Fibrelink and ducts to outside, Server farms for Hertz Europe.

12.8.1.5 Medical and Veterinary Hospitals

The Tara Winthrop Private Clinic listed the following equipment with respect to potential sensitivity to EMI from the proposed Project - Optical equipment on site for eye and hearing tests and computer servers for IT systems.

At the Swords Veterinary Hospital, the following equipment was listed as a concern - surgical microscopes, bench microscopes, scanning systems sensitive to noise, vibration and electromagnetic interference, large computer hard drives, sensitive electronic instruments and telecommunications installations.

In discussions with this stakeholder, the Swords Veterinary Hospital also stated that there was a potential that at a future date their facility would house an MRI scanner.

The Veterinary Hospital in Lissenhall only listed a bench microscope on their equipment list. However, it was assumed that similar instrumentation to the Swords Veterinary Hospital could be present on the site.

No equipment survey response was received from the VHI Swiftcare clinic in Swords. The following equipment is likely to be present at such a facility – microscopes, IT equipment, Telecoms equipment and other medical equipment such as X-ray scanners.

12.8.2 AZ2 – Airport Section

12.8.2.1 Dublin Airport

Meetings and consultations were undertaken with DAA on several occasions, which included presentations and a site tour on 24 January 2019. These are recorded in Chapter 8 (Consultation). A baseline survey was performed on the site above the proposed Dublin Airport Station location on 3 May 2019. Correspondence and reports were also exchanged in relation to some of the maintenance and calibration practices performed in Hanger 5 beside the North Apron. The airlines that utilise the airport are considered customers by DAA and they were also consulted in relation to onboard systems that may have sensitivities to interference.

The following equipment was listed by DAA as being of potential concern - Scanning systems, passenger and baggage screening systems, optical microscopes, precision balances, Large computer hard drives, sensitive electronic Instruments, telecommunications installations, telescopes (possible), optical equipment (possible), equipment operated or controlled by laser, particle or optical beams e.g. linear particle accelerator (possible), Major Computer Installations, Broadcasting Requirements & Sound Recording Equipment.

Outside in the airfield are various RADAR, traffic control, navigation, and communications systems, along with the Instrument Landing System (ILS) and Electrical Lighting system (Above Ground Lighting). The Irish Aviation Authority were consulted with in relation to the ILS as the operation and upkeep of these systems fell within their remit.

In terms of onboard sensitive systems, the airlines primary interest was in relation to flux valve instrumentation utilised to give the aircrafts bearing based on the earth's magnetic field.

In terms of sensitivity to stray currents DAA cited an underground Jet fuel pipeline along with other utilities and pipework.

12.8.3 AZ3 – Dardistown to Northwood

No major stakeholders were identified within this zone that required further consultations.

12.8.4 AZ4 – Northwood to Charlemont

12.8.4.1 Dental/Medical Facilities

A number of dental and medical facilities were identified in the study area of the AZ4. These are listed in Table 12.11. The equipment questionnaire responses received did not highlight any atypical equipment to add to the list outlined at the start of Section 12.8, with the exception of the CIÉ (Coras Iompar Éireann) Occupational Health Unit on Marlborough Street that listed an audiometer unit used for testing hearing.

Amplifon is listed in Table 12.11 as a commercial unit but warrants a mention in this section due to the nature of its retail operation in hearing aids and its proximity of 2m from the proposed alignment. They listed standard IT and telecom equipment along with hearing aid test equipment as potentially sensitive to EMI.

12.8.4.2 DCU

A baseline survey was performed in DCU on 12 December 2018, due to the extreme west of the campus falling just inside the 100m study area for sensitive research facilities. However, no faculties or departments were within this area and therefore no potentially sensitive receptors identified.

12.8.4.3 Irish Rail Crossing at Prospect Road

The proposed Project crosses the Maynooth Line at Prospect Road. Irish Rail was considered a major stakeholder and therefore this site was chosen for a baseline survey which was conducted on 3 May 2019. Irish rail electromechanical systems include the following – Signalling, IT, radio, communications, track circuits/axle counters, control systems and CCTV. It is also proposed that the Maynooth Line will be upgraded to full electrification with the corresponding traction systems and Overhead Line Equipment to be installed.

12.8.4.4 Mater University Hospital

The Mater University Hospital was classed as a Major Stakeholder and consultations were undertaken with representatives of the hospital. A baseline survey was also conducted at the closest point the proposed alignment comes to the hospital on 1 December 2018.

Among the equipment listed by the hospital, as part of the equipment questionnaire, were the following types: Surgical microscopes, bench microscopes, MRI systems, scanning systems sensitive to noise vibration and electromagnetic interference. A large list was provided which included the following:

- Optical microscopes (and other optical instruments);
- Precision balances;
- Large computer hard drives;
- Sensitive electronic instruments;
- Telecommunications installations;
- A linear particle accelerator;
- Major computer installations;
- Broadcasting equipment; and
- Sound recording equipment.

Following discussions and consultations an updated list of medical equipment was supplied. This outlined the equipment type and location within the hospital. Among the equipment types listed were audiology equipment, MRI and CT scanners. Despite a linear accelerator being listed previously, one was not listed on the updated equipment list received. The MRI and CT scanners are in the Radiology department on the second floor of the Whitty Building while the audiology equipment is in the adult outpatient section on the first floor. A CT scanner was also listed as located in the A&E Department.

12.8.4.5 Rotunda Campus

The Rotunda Campus contained several stakeholders that were considered separate. Therefore, consultations were undertaken with the Rotunda IVF clinic, Rotunda Hospital and the Gate Theatre. These are recorded in Chapter 8 (Consultation). No consultations were undertaken with the Ambassador Theatre.

A baseline survey was conducted outside the Rotunda IVF Clinic above the proposed alignment on 29 November 2018. Baseline AC fields were also measured within the Gate Theatre on 5 July 2022.

12.8.4.5.1 Rotunda IVF Clinic

During discussions with the Rotunda IVF Clinic the following equipment was listed as being potentially sensitive to EMI - bench microscopes with attachments, embryo microscopes, incubators, ultrasound scanners and radio transmitters used to monitor/control gas levels.

It was also noted that all of the equipment was located on the ground floor of the building which was below street level. Therefore, the equipment would be closer to the alignment than the projected tunnel depth would illustrate. No equipment known to be sensitive to time varying DC magnetic fields such as MRIs, LINACs and SEMs were specified for this site.

Discussions with the stakeholder highlighted plans that were ongoing for the relocation of the Clinic to an alternative location away from the Rotunda Campus.

12.8.4.5.2 Rotunda Hospital

Consultations and meetings were undertaken with representatives of the Rotunda Hospital where equipment types with sensitivities to EMI from the proposed Project were discussed. CEI attended one of the Rotunda Hospital consultations on 4 October 2018. With the exception of an SEM located within the hospital, no other equipment was identified outside of the standard medical equipment found within such a hospital (microscopes, ultrasound scanners and monitors).

The SEM also had previously been examined with respect to EMI from the Luas Green Line and is discussed in Section 12.10 of this chapter.

12.8.4.5.3 Gate Theatre

A site visit was undertaken to meet stakeholders at the Gate Theatre and discuss possible EMI from the proposed development on 10 September 2019. It was revisited on 5 July 2022. This is referenced in Chapter 8 (Consultation). The equipment on-site included the following: audio-visual equipment, lighting equipment, communications installations, sound recording equipment and an induction loop for the hearing impaired. Temporary audio-visual and lighting equipment would also be brought to the site occasionally by various performers and removed again on completion of a show.

It was noted in 2019 that the site was sensitive to EMI particularly in the audible frequency range (20Hz to 20kHz). Specifically, a "mains hum" (50Hz) from a nearby ESBN feed was suspected to cause issues with the induction loop system on the site. A threshold for the levels at which this becomes problematic was not established. Occasionally during performances there would be a requirement for musical instruments to be used on stage, of a type that would use a magnetic pick-up for amplification purposes. On returning to the site in 2022 the induction loop had been damaged during works related to a show and was therefore out of use. The facilities team at the theatre were in the process of sourcing a replacement system, as opposed to carrying out a repair. The new system they were investigating was an infrared system that would remove the requirement for a perimeter loop around the floor of the theatre and would be much more robust against potential interference than the current system.

12.8.4.5.4 Ambassador Theatre

No correspondence in relation to EMI was received from the operators of the Ambassador Theatre. However, considering the nature of activities at this venue it was reasonable to assume that similar to the Gate Theatre (and likely more frequently), audio amplification utilising magnetic pick-ups such as those used on electric guitars would be used. Audio-visual and lighting equipment customised for each performing act would also be frequently installed and removed from the site.

12.8.4.6 Luas Red Line and Luas Green Line

The Luas systems include traction, signalling, lighting, ticketing, and communications equipment. This equipment, utilised in the running and powering of the Luas, is currently operating in an electromagnetic environment similar to that which would be produced by the proposed Project with a time varying DC magnetic field being a distinctive property of DC voltage driven transit systems.

12.8.4.7 Irish Rail at Tara Street

The alignment of the proposed Project comes into the proximity of the DART line at Tara Street Station (within 30m). As stated previously Irish Rail was considered a major stakeholder with a baseline rating of Very High and therefore this site was also chosen for a baseline survey which was conducted on 01 December 2018. Irish Rail electromechanical systems would include the following: DC traction system (including OCS), signalling, IT, radio, communications, track circuits/axle counters, control systems and CCTV.

12.8.4.8 Dublin Fire Brigade

The Dublin Fire Brigade Headquarters was rated as High from an EM Field perspective due to the safety critical nature of their operations. It is approximately 30m at ground level from the proposed alignment. From the equipment survey response, the following was listed as being potentially sensitive to EMI: Computer dispatch system for DFB (Dublin Fire Brigade) located in building, Tetra antennas on roof, microwave network mast, tape and recording devices and major computer installations.

12.8.4.9 Trinity College Dublin

Several discussions, presentations and meetings took place with stakeholders at Trinity College Dublin (TCD). Academics, facilities and administrative representatives were consulted. Equipment questionnaires were completed along with tours of the site. Notable dates include the following, with the details discussed in Chapter 8 (Consultation):

- 25 February 2019;
- 19 March 2019;
- 27 September 2019;
- 16 April 2020; and
- 10 February 2021.

A baseline survey was performed on the Trinity Campus on 29 November 2018 at two locations, the first being an outdoor location above the proposed alignment and the second being an indoor location on a subfloor in the SNIAM building above the proposed alignment.

The volume and range of equipment listed was significant. A process to refine the receptor list was undertaken in order to highlight specifically those types of equipment that were adjudged to be a potential risk to the type of EMI anticipated to be generated from the proposed development. The refined list comprised:

- A Superconducting Quantum Imaging Device (SQUID) in SNIAM building;
- Three Nuclear Magnetic Resonance (NMR) spectrometers in the Chemistry Department;
- Two MRI systems in the Lloyd Institute;
- Three SEMs in the Panoz Institute (Centre for Microscopy and Analysis); and

- Scanning Tunneling Microscopes (STM) in the Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN).

Further baseline surveys were performed at the locations of these equipment types on 25 February 2019 and 19 March 2019.

Discussions with the operator of the SQUID revealed that the equipment had, in the past, experienced occasional EMI from the operation of the nearby DART. An occurrence that seemed to have abated with the recent construction of the Trinity Business School. The operator of the NMR had similarly noted interference impacting on their scanning capability when a large transformer was being moved outside of the building. The residual magnetism of this equipment was sufficient to cause this interference from a distance of 4m or 5m away.

The SEMs and MRIs were located below ground level in their respective buildings. These locations were chosen when the equipment was installed due to the expected quiescent electromagnetic environment particularly in relation to DC and Quasi DC magnetic fields. Similarly, the STMs, which are more sensitive to vibration than EMI, were on the second sub-floor of the CRANN building. Proximity of the DART to the CRANN building appeared to have generated sensitivity issues with at least one of the STMs. According to the operator the nature of the sensitivity experienced was acoustic based and not electromagnetic in nature.

12.8.4.10 Leinster House and Other Government Buildings

Consultations were undertaken with both the Office of Public Works (OPW) and representatives from within Government Buildings and the Department of the Taoiseach to discuss the proposed Project and identify any potentially sensitive receptors to EMI. A presentation was given to the OPW on 18 January 2019 at Dublin Castle while the committee rooms of the Dáil were visited for a presentation on 21 October 2019. These are noted in Chapter 8 (Consultation).

Standard electrical equipment was listed as potentially sensitive such as large computer hard drives, sensitive electronic instruments, major computer installations, broadcasting equipment and sound recording equipment.

Equipment located below ground level will be closer to the proposed Project. In the basement of the Department of the Taoiseach is the main security operations unit and a press office, for example. In Government Buildings the committee rooms are housed 10m below ground level. This means that they will be as close as 5m to the crown of the proposed tunnel. Within these committee rooms is an induction loop system for assisted hearing.

12.8.4.11 National Concert Hall

There were consultations undertaken with representatives from the National Concert Hall at their site on 27 September 2019. This is recorded in Chapter 8 (Consultation). A baseline survey was performed at the location on the site that was closest to the proposed alignment on 28 November 2018. Among the equipment cited as being potentially sensitive to EMI were sound recording equipment, audio-visual equipment and systems, telecommunications equipment and broadcasting equipment.

12.8.4.12 Royal Victoria Eye and Ear Hospital

This location was classed as a major stakeholder with the potential to have extremely sensitive equipment located on their premises. A site survey was performed at a location on the campus that was the nearest point to the proposed alignment on 28 November 2018.

No equipment with a known sensitivity to DC and near DC magnetic field variations was identified at the hospital (such as MRIs and Linear Accelerators). However, the following equipment was listed by the hospital - Surgical microscopes, bench microscopes, scanning systems sensitives to noise, optical microscopes, large computer hard drives, sensitive electronic instruments, telecommunications installations, optical equipment, major computer installations and sound recording equipment.

12.9 Baseline Survey Results

EMR baseline surveys were performed at the following locations:

- Siemens (DC – 18GHz);
- Dublin Airport;
- DCU;
- Irish Rail Crossing at Prospect Road;
- Mater University Hospital;
- Rotunda Campus;
- Irish Rail at Tara Street Station;
- TCD;
- The National Concert Hall;
- Royal Victoria Eye and Ear Hospital;
- New 110 kV HV Substation Locations:

- Naul Road; and
- Dardistown.

The data and results of these surveys are presented in the report titled "19E7901-3 MetroLink EMR Baseline Survey" (Appendix A12.1). A summary of these surveys is presented within the following sections.

12.9.1 AZ1 – Northern Section Surveys

12.9.1.1 Siemens

At the measurement location, the Earth's DC magnetic flux density (B) was measured at an average of 47.3µT with the maximum deviations seen to be 0.02µT.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.2 AZ2 – Airport Section Surveys

12.9.2.1 Dublin Airport

At the measurement location, the Earth's DC magnetic flux density (B) was measured at an average of 47.3µT with the maximum deviations seen to be 0.15µT.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.3 AZ3 – Dardistown to Northwood Surveys

No surveys were undertaken in AZ3.

12.9.4 AZ4 – Northwood to Charlemont Surveys

12.9.4.1 DCU

At the measurement location, the Earth's DC magnetic flux density (B) was measured at an average of 48.2µT with the maximum deviations seen to be 0.01µT.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.4.2 Irish Rail Crossing at Prospect Road

At the measurement location, the Earth's DC magnetic flux density (B) was measured at an average of 44.5µT with the maximum deviations seen to be 6µT with the high fluctuation attributed to vehicular traffic passing quite close to our measurement location.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.4.3 Mater University Hospital

At the measurement location, the Earth's DC magnetic flux density (B) was recorded at an average of 47.5µT with the maximum fluctuations seen to be up to 2.25µT. The level of the fluctuations at this site were attributable to the traffic (including buses and large trucks) passing in proximity to the measurement point.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.4.4 Rotunda Campus

At the measurement location, the Earth's DC magnetic flux density (B) was recorded at an average of 41.9µT with the maximum fluctuations seen to be up to 0.03µT.

No unusually elevated electromagnetic field levels were detected in the range between 1Hz to 10kHz. Additional measurements of electric and magnetic fields within the Gate Theatre in the range 10Hz to 100kHz also did not highlight any unusual field levels.

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.4.5 Irish Rail at Tara Street

At the measurement location, the Earth's DC magnetic flux density (B) was recorded at an average of 55µT with the maximum fluctuations seen to be up to 3.5µT. Deviations of this magnitude and slightly higher would be expected near an electrified rail system such as the DART.

No unusually elevated electromagnetic field levels were detected in the range between 1Hz to 10kHz. The near DC fields (less than 10Hz) were typically of a magnitude of less than 0.01µT. With variations of electrical current drawn by the nearby DART line, the near DC fields were seen to increase to in excess of 0.01µT, again not atypical in proximity to an electrified rail system.

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.4.6 Trinity College Dublin

As part of the initial baseline data collection exercise two measurement locations in TCD were chosen initially that were above the proposed alignment route. The Earth's DC magnetic flux density (B) was recorded at averages of 45.2µT and 52.5µT respectively, noting the 52.5µT reading was attained below ground level inside a building. The maximum fluctuations noted were 0.5µT.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

After further consultations with TCD, it was decided to perform further baseline measurements in the DC and low frequency domain near identified sensitive equipment, the details of this investigation presented in report "19E8383-1 Trinity College Dublin DC and Near DC Electromagnetic Radiation Survey Report" (Appendix A12.2).

12.9.4.7 National Concert Hall

At the measurement location, the Earth's DC magnetic flux density (B) was recorded at an average of 44µT with the maximum fluctuations seen to be up to 0.15µT.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.4.8 Royal Victoria Eye and Ear Hospital

At the measurement location, the Earth's DC magnetic flux density (B) was recorded at an average of 47µT with the maximum fluctuations seen to be up to 0.1µT.

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

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.5 Substation Locations

12.9.5.1 Naul Road Substation Location

At the measurement location, the Earth's DC magnetic flux density (B) was recorded at an average of 49.9µT with the maximum fluctuations seen to be up to 0.03µT.

The 50Hz field was notable in the AC range (0.002µT magnetic field, 300V/m Electric Field) due to the close proximity of an overhead power line passing near the measurement location (10m approximately). Harmonics associated with the transmission line were evident at higher frequencies (100Hz and above).

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.9.5.2 Dardistown Substation Location

At the measurement location, the Earth's DC magnetic flux density (B) was recorded at an average of 47.5µT with the maximum fluctuations seen to be up to 0.01µT.

The 50Hz field was notable in the AC range (0.03µT magnetic field, 100V/m Electric Field) due to the close proximity of an overhead power line passing near the measurement location (5m approximately). Harmonics associated with the transmission line were evident at higher frequencies (10Hz and above).

There was no evidence during the measurement and observation time of the study of any transient or intermittent events in the frequency range 10kHz to 18GHz. The RF emissions profile in this frequency range was well below the typical risk levels of 3V/m.

12.10 Predicted Impacts

Within this section we outline the magnitude of the predicted impacts and the significance of the effects on the receptors identified in the baseline environment in Section 12.7, including human exposure. The metrics used for determining impact magnitude and significance of effects are outlined in Table 12.6. Where other metrics or limits are used, then the rationale for their use is explained.

The tables within this section group many receptors into general categories for conciseness where the significance of effects from the predicted impacts have been rated as imperceptible to slight. Therefore, any receptors listed in Section 12.7 that are not explicitly discussed in this section fall within these general groupings. For example, a medical practice explicitly listed in Section 12.7 such as *Glasnevin Family Practice* falls within the grouping *Medical Centres*.

12.10.1 Construction Phase Impacts

Electromagnetic emissions from the Construction Phase of the project will differ only slightly from a typical large-scale construction project. The significance of effects on all identified receptors will vary between imperceptible to slight. The largest sources of elevated baseline levels in the AC range will be in the immediate vicinity (within 5m) of on-site generators used to power electronic tools and lighting and most significantly the TBM. The TBM will be fed via a power feed cable from the south portal at Dublin Airport for the Dublin Airport tunnel and from the Northwood Compound for the city centre tunnel. This feed will emit localised AC fields around the feeder cables. Levels will not exceed public exposure guideline limits outside of the construction works. The TBM itself is so large (100m or slightly longer) that it will affect the earth's DC magnetic field creating a localised distortion to the lines of flux. The rate of movement of the machine is so slow however that any impact on potentially sensitive equipment would be difficult to detect. Some receptors are documented in Chapter 14 (Ground-borne Noise & Vibration) that are common to this chapter. As part of mitigation measures for noise and vibration some of these (particularly in TCD) will not be in operation as the TBM passes, reducing the likelihood of DC magnetic field interference to nil for those equipment types.

Temporary on-site communications and IT infrastructure will result in emissions in the RF range of frequencies. However, any emissions from such equipment are governed by the EMC and Radio Directives such that impacts on identified receptors in the study area are unlikely. As a result, the significance of effects for all receptors is classified as imperceptible, with the exception of receptors that may have specialised equipment, such as spectrum analysers, that can be tuned to detect the frequency content of these emissions. DC field perturbations and AC fields from the on-site electrical equipment will not pose any impact to any of the identified receptors. Table 12.12 summarises the predicted significance of effects and quality of effects from the Construction Phase for EMR (DC, AC, RF and microwave) while Table 12.13 summarises stray current.

Table 12.12: Significance of Effects from Electromagnetic Emissions during the Construction Phase

Receptors	Significance of Effects	Quality of Effects
Any facilities that have highly sensitive equipment on the premises on a permanent basis. Public/private health hospitals. Medical centres including dentists and vets. Signalling on rail networks.	Imperceptible	Neutral
Telecommunications infrastructure. Public/private scientific/research institutes. Sensitive equipment in universities, colleges, and schools. Emergency services mobile radio.	Slight	Neutral
Any facilities that have potentially sensitive equipment on the premises on a permanent basis. Some residential areas e.g. containing medical equipment. Industrial facilities with sensitive equipment. Universities, colleges and schools which do not have sensitive equipment.	Imperceptible	Neutral
All other residential areas. Mixed units with a residential component. Electricity substations with earthing equipment. Educational institutions without sensitive equipment.	Imperceptible	Neutral
All other areas.	Imperceptible	Neutral
Public exposure.	Imperceptible	Neutral

Table 12.13: Significance of Effects from Stray Current during the Construction Phase

Receptors	Significance of Effects	Quality of Effects
Buried pipes and cables.	Imperceptible	Neutral
All other land uses.	Imperceptible	Neutral

No likely significant effects have been identified for the Construction Phase of the proposed Project. A change to the baseline EM environment from RF emissions of on-site communications equipment or AC emissions from local power generators is likely and will be constant during the Construction Phase. However, the duration of these effects will be medium-term, disappearing once the site ceases its activity. The extent of the AC fields will be no more than outlined in Section 12.4.2. The RF emissions may be detectable beyond 100m with tuned equipment.

12.10.2 Operational Phase Impacts

The potential EMI sources arising from the operation of the proposed Project have been introduced in Section 12.3. Potential impacts include radiated interference from the DC magnetic fields, AC magnetic fields and radiofrequency electric fields. Conducted interference may be caused by stray currents from the traction system.

Note, two types of catenary system arrangements are proposed, these are:

- Overhead contact system (OCS), which consists of a single contact wire and a single catenary wire supported from a support structure; and
- Overhead conductor rail (OCR) which is a rigid aluminium contact rail incorporating a contact wire.

The OCS will be used on all above ground sections while OCR will be used in the tunnelled and covered sections. OCS is the term used for both throughout this chapter as the nature of the catenary system does not affect the electromagnetic field modelling, which is a product of the voltages and current loads.

Elements of the proposed Project that can potentially act as sources and propagators of EMI comprise:

- The power supply and distribution system;
- The trains draw current from the traction power station along the OCS which returns via the running rails back again to the substation. This traction current has the potential to generate EMF. The Traction Power Supply System (TPSS) includes substations, feeders, OCS, running rails (regarding return and stray current) and feeding/return current cables between the OCS and running rails to the substation;
- The rolling stock traction equipment, including inverters, traction motors and auxiliaries;
- Signalling systems; and
- Communication systems.

Finally, stray current is generated from the traction system. Current travels to the trains via the OCS, passes through the train's electric motors and returns to the substation via the rails. Due to the length of the rails and the magnitude of the drive currents involved small amounts of the return current may find alternative paths back to the substation via buried utilities running for long distances in parallel with the alignment.

12.10.2.1 DC and near DC Magnetic Field Impacts

The main forms of electromagnetic emissions from the proposed Project are controlled by the Radio Equipment Directive (RED) and EMC Directives. Standard electrical equipment sensitivity to DC and near DC magnetic field is not typically an issue and therefore there are no immunity standards for equipment such as IT or domestic equipment that covers this frequency range. Conversely there are no emissions standard limits for DC and near DC magnetic fields with respect to levels that could cause EMI which the development must meet.

However, there is the EMF Directive which specifies limits for human exposure. This level is set from 4,000µT at DC to 800µT at 5Hz. These levels will not be exceeded by the proposed Project at any location to which the public has access and therefore the significance of the effects arising from DC and near DC magnetic fields for members of the public, including staff, is classed as imperceptible with the quality of effects classed as Neutral. Low level DC and near DC fields well below the limits set out in the EMF Directive will persist permanently once the traction supply remains energised.

12.10.2.1.1 Modelling DC Magnetic Fields

The DC current flowing in the OCS to the trains causes a magnetic field. This current is returned in the rails to the substation which causes a magnetic field that is opposite in polarity and therefore acts to partly cancel the magnetic field resulting from the OCS. A planar view of a single rail line is shown in Diagram 12.4. For illustrative purposes only a single line is shown with a pair of rails and the OCS.

The field intensity (strength) at a given point (receptor) depends upon the magnitude of the current running in the conductors (sources – OCS and rails) and the distance between them and that point (receptor).

There is the additional effect of two or more lines operating in close proximity (not depicted) which acts to effect the magnetic lines of flux even further and therefore the resultant intensity at the receptor.

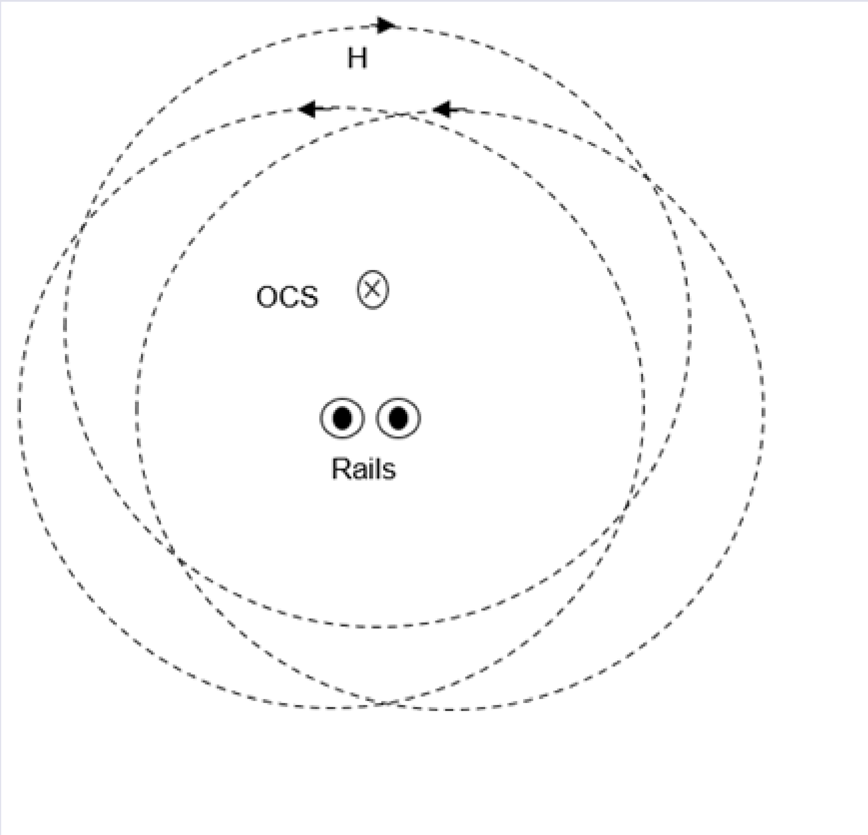

Diagram 12.4: DC Magnetic Fields around the Rails and OCS

The magnetic field from each conductor is defined by:

$H = I / (2 * \pi * r)$

where:

$\pi = 3.142$

H: magnetic field intensity [measured in amps per metre];

I: traction current (Amps A);

r: distance between source point and receptor

At any determined point in space, magnetic fields of various sources may interfere with each other which is what occurs with two overhead lines and four return rails. The resulting magnetic field may be amplified or compensated as a result of these interferences depending on the direction of current flow in each conductor.

The current flows in the OCR and returns via the rails split equally between the two. Therefore, the magnetic fields partially cancel.

The magnetic flux density is related to the magnetic field strength by the relationship:

$B = \mu 0 * \mu r * H$

Where:

B: magnetic flux density (measured in Tesla [T]);

$\mu 0$: absolute permeability (physical constant);

μr: relative permeability (coefficient of materials).

In air B (µT) = 1.26 x H (A/m).

The DC magnetic fields have been calculated for current flowing in the power supply system. The magnetic flux density was calculated for various distances from the alignment taking account of both vertical and horizontal distances. Worst-case load currents, provided by the electrical system designers, were utilised.

To further create a worst-case calculation the following operational scenarios were assumed:

- Two trains starting and accelerating (peak current) on the two tracks at the same time; and
- The traction power system is fed from only one substation (such a scenario could arise in the case of maintenance) such that the maximum current is flowing on a given section of track in the one direction.

During normal operation, the traction power supply is fed from two substations (one at each end of each section), which means that the current is split between two adjacent substations and magnetic fields strengths would be closer to half.

As previously stated, everyday electrical and IT equipment are not susceptible to DC and quasi-DC magnetic field perturbations. However, sensitive scanning equipment does exist in the medical and advanced scientific research industries such as MRIs and SEMs. The stakeholders that disclosed they possessed such equipment were TCD, the Mater University Hospital, and the Rotunda. Swords Veterinary Hospital stated that they had plans to install an MRI at their site.

A depiction of how this DC magnetic field perturbation presents itself in the time domain is depicted in Diagram 12.5. This graph shows the DC magnetic flux density for an accelerating electrified train at distances of 3m and 10m from the railway. The X-axis depicts time in hours:minutes:seconds. The figure acts to demonstrate the momentary nature of the larger perturbations which occur on acceleration and the reduction of magnitude with distance from the line.

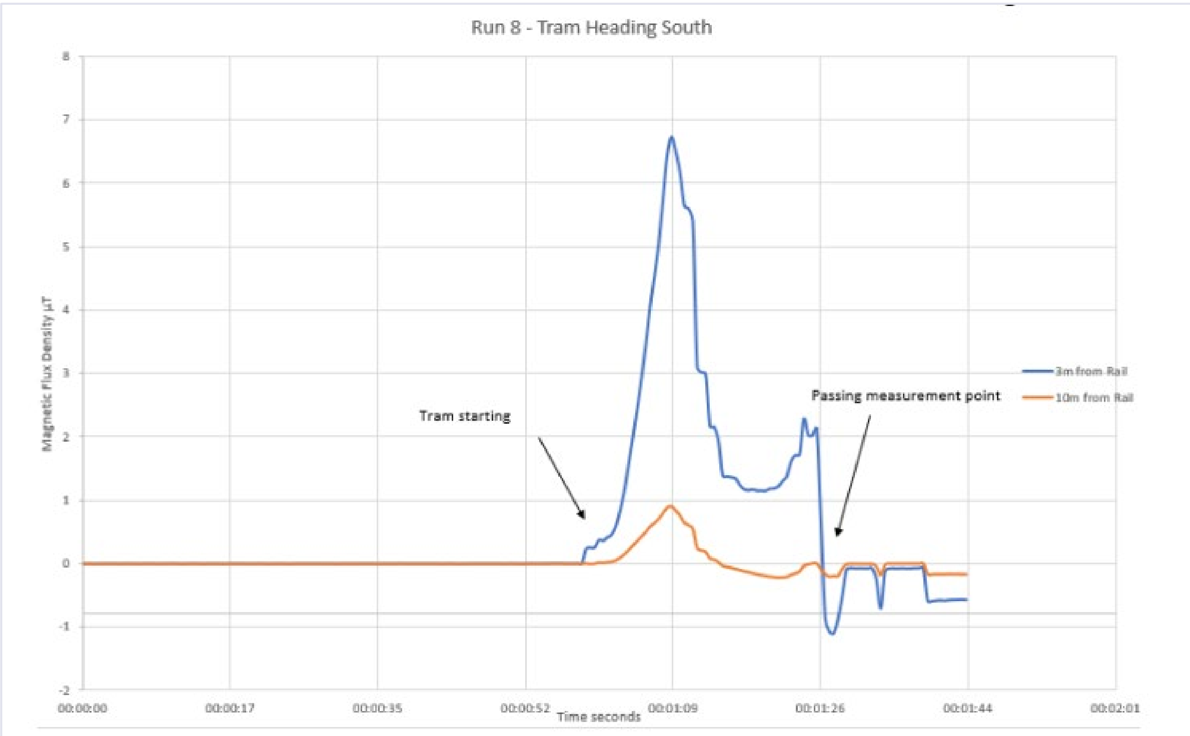

Diagram 12.5: Magnetic Flux Profile of Luas passing Measuring Point at 3m and 10m Distance

12.10.2.1.2 Impacts on Dublin Airport

In the initial questionnaire response from Dublin Airport, it was noted that there was the potential of equipment such as particle accelerators being present on site, which would have sensitivities to DC magnetic fields. No evidence of such equipment was provided by DAA during consultations carried out on 5 September 2018 and 24 January 2019.

The Irish Aviation Authority was consulted in relation to the ILS at Dublin Airport which included the North Runway development. An investigation was conducted with the findings presented in report "20E8833-1 ILS and EMF from MetroLink" (Appendix A12.3). The results of this investigation confirm that there will be no significant effects on the ILS.

Correspondence was exchanged with the DAA in relation to EMI emanating from the electrified scheme. It was concluded that there would be no significant effects on DAA equipment.

Discussions were undertaken with some of the main airlines that utilise Dublin Airport (Aer Lingus, Ryanair, Stobart Air, and City Jet) and Dublin Aerospace who perform maintenance operations. The DAA acted as an intermediary for the presentation of data in relation to EMF from the proposed Project to these stakeholders. There are no likely significant effects arising from AC and RF fields. Discussions then moved to DC magnetic fields. A technical note was presented outlining worst-case modelled DC magnetic field levels and the anticipated compass deflections resulting from such levels. See "20E1808-1 MetroLink DC Field Intensities at Dublin Airport", (see Appendix 12.4). Following presentation to the airlines, the effects of this impact were determined only to be of significance for users of aircraft manufactured by ATR that utilised Flux Valve Compasses.

Practical testing on an ATR aircraft was performed to verify the accuracy of the anticipated deflection predictions made. DC magnetic field was applied at varying strengths to discern its impact. In summary the anticipated deflection levels were verified. This is detailed in report "20E9047-2 Flux Valves and EMF from MetroLink" (Appendix A12.5). The magnitude of the deflections discussed (a worst-case maximum deflection of 7° is anticipated) would be comparable to other localised sources within the airport. For example, deflections are commonly noted that are attributable to passing fuel trucks, buildings and buried utilities and structures.

The 7° deflection level is unlikely to cause a triggering of on-board monitoring and warning systems. It is likely that the effects of this impact will only be identifiable if the pilot or first officer are monitoring that instrumentation at the exact time of traversing the tunnel. From discussions with the airlines, this effect is not an issue for some, while others requested the implementation of some mitigation measures. This is discussed in Section 12.11. Finally, it is unlikely that there will be any impacts on planes in flight or during take-off or landing.

The significance of the effects at Dublin Airport was determined to be Moderate with a quality of effects classed as Neutral. The probability of the effect (however small) is likely and predicted to be within a corridor of 20m either side of the proposed alignment.

As the DC perturbations discussed are at their highest when trains are accelerating the frequency of occurrence would be several times an hour during peak traffic. The duration of the effect would be momentary.

12.10.2.1.3 Impacts on Trinity College Dublin

Modelled DC magnetic field levels for the equipment within TCD, highlighted in Section 12.8.4.9, are depicted in Table 12.14 along with the equipment sensitivities which were ascertained from their respective datasheets.

Table 12.14: TCD – Equipment Sensitive to DC and near DC Magnetic Fields

Building Name	Equipment	Baseline DC Field fluctuations	Sensitivity	Modelled Levels
SNIAM	SQUID	± 0.7µT	0.01µT	1.2µT
Chemistry	Three NMRs	± 0.1µT	0.5µT	1.4 - 1.9µT (DC)
Lloyd	Two MRI systems	± 0.2µT	1µT*	0.7µT
Panoz (EE4)	Three SEMs	± 0.15µT	0.1µT	0.3µT
CRANN	STMs	± 2µT	None specified	0.1-0.2µT

* Estimated value

As part of investigations the modelled levels outlined in the table above were simulated at their installation locations of this equipment. The details of this testing can be seen in report "19E8382-1 TCD DC and Near DC Field Simulation Testing" (Appendix A12.6) but in summary the following was noted.

Of the equipment tested, effects arising from DC and near DC magnetic fields were noted at the following:

- SEMs in the Centre for Microscopy Analysis (PANOZ building);
- MRI machines in Lloyd building; and
- NMRs in Chemistry.

No impacts were noted at the STM in the CRANN building or the SQUID in SNIAM. The operator of the SQUID outlined that they believed their concerns were more around AC field sensitivities rather than DC, which was noted. The AC fields predicted at the distance of the SQUID from the proposed alignment are likely to be no more than at background radiation levels and therefore no impact is envisaged on the SQUID from the proposed Project.

In relation to the three systems that did experience an effect, the SEMs experienced the most interference at the highest magnification levels of the equipment. While these magnification levels are not used continually the problem would manifest itself occasionally when the required maximum sensitivities of the instrument are needed. The baseline DC magnetic field in the iCrag was previously measured and was shown to be experiencing DC magnetic fluctuations as high as 0.1 to 0.15µT, which are above the equipment's stated sensitivity of 0.1µT. Since the 0.3µT modelled is worst-case it is reasonable to assume that actual operational levels will be lower than this. Therefore, it is unlikely that the SEMs will experience any continual interference from the proposed Project.

The proximity of the MRIs and NMRs to the proposed alignment suggests that these are of the biggest concern to interference. In the case of the NMRs, it is likely that routine scans and measurements will be affected rendering some quantities unmeasurable due to a much-reduced resolution. While the duration of the effect may be only momentary, these momentary disruptions could occur several times an hour throughout the day during the operation of the proposed Project.

The effects of DC magnetic fields on the TCD campus have been determined as Significant with a quality of effects classed as Negative.

Mitigation measures will likely need to be employed within one building at least (the Chemistry Building). Details of these mitigation measures are set out in Section 12.11.

12.10.2.1.4 Impacts on Mater Hospital

The Radiology Department of the Mater hospital is located in the Whitty Wing on Level 2. It is more than 100m from the proposed alignment and therefore modelled levels at this distance are such that no significant effects are likely to be experienced in the operation of the on-site MRI, CT and PET-CT scanning equipment. Accordingly, the significance of effects on the Mater Hospital from DC magnetic fields has been determined as Slight with a quality of effects classed as Neutral.

12.10.2.1.5 Impacts on Rotunda Hospital

There were no specifications available for the sensitivity of the SEM located on this site. It is currently located equidistant from the Luas Green Line and the proposed alignment. Discussions with representatives from the Rotunda did not highlight any ongoing interference experienced by this equipment from the Luas Green Line.

Modelled worst-case DC magnetic field levels at the distance of this receptor (approximately 35m) are 2.5µT. Modern SEMs have a typical sensitivity of 0.1µT but the sensitivity of this older model is likely to be in excess of that value.

In the past this particular SEM was assessed for its sensitivity to differing DC magnetic field strengths up to and above what was the considered worst-case modelled DC fields from the Luas Green Line, which was 3.6µT. Table 12.15 outlines a summary of these tests.

Table 12.15: Results from DC Magnetic Field testing on JEM-100CXII SEM in Rotunda

DC Field Strength Applied	Effects Seen	Comments
±3.6µT	x4,800 Magnification: Beam centre moved as a result of applying the field x100,000 Magnification: Darkening seen on image. Focus affected	High magnification images show the focus at this level is affected.
± 2µT	x4,800 Magnification: Beam centre moved as a result of applying the field x100,000 Magnification: Darkening seen on image. Focus unaffected.	Whether the effect on high magnification images at this level is detrimental is subjective and dependent on how much of the image the operator wishes to focus on.
±1.2µT	x4,800 Magnification: Beam centre moved as a result of applying the field x100,000 Magnification: Darkening seen on image. Focus unaffected	The focus of the high magnification image may be affected around the sides, but the centre which the operator is concentrating on appears unaffected.

DC Field Strength Applied	Effects Seen	Comments
±0.8µT	x4,800 Magnification: Negligible movement on beam centre. x100,000 Magnification: No darkening seen on image. Focus unaffected	The focus of the high magnification image may be affected around the sides, but the centre which the operator is concentrating on appears unaffected.
±0.6µT	x4,800 Magnification: Beam centre movement as a result of applying the field difficult to detect x100,000 Magnification: No darkening seen on images. Focus unaffected	No detrimental effects seen at low or high magnification.

In summary, an effect may be seen in worst-case conditions. However, as has been discussed, the actual operational levels will be lower. Any such effects would be momentary in nature and expected to occur rarely. It is unlikely that the DC field levels will exceed those currently experienced from the nearby Luas Green Line, which is not causing operational issues. While there is a sensitivity with this type of equipment, the significance of effects of DC magnetic fields on the Rotunda has been determined as slight as per the criteria set out in Table 12.6 (i.e. modelled levels of 2.5µT less than 10µT) and also due to the fact that DC field perturbations exceeding those already experienced at the location of the SEM is unlikely. The quality of effects is classed as Neutral.

12.10.2.1.6 Impacts on Swords Veterinary Hospital

The list of equipment currently in situ at the Swords Veterinary Hospital does not have a sensitivity to DC magnetic fields at the modelled levels for the proposed Project. Momentary DC magnetic field fluctuations that would occur several times per hour during the operation of the proposed Project are unlikely to impact any of the equipment currently operated on the site. It was given a significance of effects of Slight with respect to DC magnetic fields and a quality of effects classed as Neutral.

12.10.2.2 Predicted DC Magnetic Field Significance of Effects

Table 12.16 provides a summary of the significance of effects from DC magnetic fields during the Operation Phase.

Table 12.16: Significance of Effects from DC Magnetic Fields during Operational Phase

Receptors	Significance of Effects	Quality of Effects
Any facilities that have highly sensitive equipment on the premises on a permanent basis. Medical centres including dentists and vets. Signalling on rail networks.	Slight	Neutral
Telecommunications infrastructure.	Slight	Neutral
Public/private scientific/research institutes. Sensitive equipment in universities, colleges and schools. Emergency services mobile radio.	Slight	Neutral
Any facilities that have potentially sensitive equipment on the premises on a permanent basis. Some residential areas e.g. containing medical equipment. Industrial facilities with sensitive equipment. Universities, colleges and schools which do not have sensitive equipment.	Slight	Neutral

Receptors	Significance of Effects	Quality of Effects
All other residential areas. Mixed units with a residential component. Electricity substations with earthing equipment. Educational institutions without sensitive equipment.	Imperceptible	Neutral
Dublin Airport.	Moderate	Neutral
Mater University Hospital.	Slight	Neutral
Rotunda Hospital.	Slight	Neutral
Swords Veterinary Hospital.	Slight	Neutral
TCD.	Significant	Negative
All other areas.	Imperceptible	Neutral
Public exposure.	Imperceptible	Neutral

12.10.3 AC Field Impacts

12.10.3.1 AC Fields at the Power Frequency

AC EMF will occur primarily at the power frequency of 50Hz. The main sources for these fields will be the following –

- 110kV and 220kV HV MetroLink Grid Connection cables being laid and re-routed as part of the enabling works;
- MV 20kV cables powering substations at each proposed station;
- 110kV substations at Naul Road and Dardistown; and
- 20kV substations at each proposed station.

Elevated levels of E-Fields can be expected at the substations. However, these are required to be within guideline limits for exposure, with intensity decreasing with distance due to inverse square law.

The E-Fields from the cables will be naturally shielded by the earth due to the cables being buried. The magnitude of the M-Field is related to the current load in the cables. The maximum current that can theoretically flow in the cables is dictated by the cross-sectional area of the cable.

The AC magnetic fields can be modelled using a similar methodology to that used for the DC field modelling above. The advantage of the AC feeds however is that the cables can be run close together and take advantage of cancellation. This works in three phase feeds where each feed is out of phase with the others, such that their associated fields act to cancel (or more accurately reduce) the fields associated with the other feeds, thereby reducing the emissions for the overall line. As the HV lines servicing the substations are to run underground, the phase conductors will be located closer together than they would be if they were installed in an overhead configuration. This means that cancellation of EM fields between the phases will be sizeable. Also, the proposed cable routes will be predominantly along public roads meaning that the highest source of AC fields within most locations adjacent to these feeds could be expected to be measured from building wiring and appliances as opposed to the proposed supply cables.

Due to the continued electrification required for operation of both the trains and ancillary systems, the AC fields at the power frequency are of a continuous duration with the magnitudes varying briefly based on the actual loading of the circuits at a given time, but the levels will not exceed the ICNIRP EMF guidelines.

AIMDs which may be worn by the general public, such as pacemakers, are tested to higher EMF Immunity levels than standard electrical equipment to safeguard operation according to EU regulations (CENELEC 50527-1:2010). A limit of 100µT applies to 50Hz magnetic fields and 5,000V/m to 50Hz electric fields. This is the same as the public exposure limits for Magnetic and Electric Fields also (again 100µT and 5,000V/m). These levels will not be exceeded by the proposed Project and, accordingly, the significance of effects for public exposure to AC fields has been determined to be Imperceptible with a quality of effects classed as Neutral.

12.10.3.2 AC Fields at Harmonic Frequencies

Due to the nature of the rectification of the power source to derive the DC voltage to drive the traction system, what are known as harmonics occur at multiples of the fundamental power frequency of 50Hz, i.e. 2 x 50Hz, 3 x 50Hz and so on. Therefore, these harmonics will appear at 100Hz, 150Hz, 200Hz, 250Hz and up with the magnitude of the odd harmonics larger than the even harmonics. For example, the 3rd harmonic at 150Hz will exceed the 2nd harmonic in magnitude. Along with the modelling carried out as part of the DC field modelling, these harmonic levels were estimated at different distances from the proposed alignment. Their magnitude is always below that of the 50Hz fundamental. As these harmonics are a by-product of the DC system their duration and frequency would be of a similar profile with the magnitude of the harmonics peaking when the DC current peaks. Therefore, their duration would again be momentary with a frequency of several times per hour.

Standard electrical equipment, before it is sold in the European marketplace, is tested for immunity to the magnetic field generated by the power frequency. They are not required to be tested to these harmonic frequencies since they are not standard occurring fields in a typical office, industrial or domestic environment. They are a characteristic of the DC rectification and high current used to drive the traction system.

Typical electrical equipment such as IT, industrial and domestic will not have any susceptibility to these harmonic frequencies, with the exception of audio-visual equipment. The reason being that these harmonics occur within the range of human hearing (20 – 20kHz). However, any standard audio-visual equipment sold on the European marketplace will likely have been assessed to the standard of EN 55103-2 (audio, video, audio-visual, and entertainment lighting control for professional use). This standard for professional audio equipment has immunity levels of 1 µT at 50Hz, decreasing linearly with the logarithm of the frequency to 0.01µT at 5kHz. The predicted maximum levels at 5m from the proposed alignment at the 300Hz and 600Hz harmonics are 0.4µT. Immunity requirements as per EN 55103-2 are calculated to be 0.6µT (for 300Hz) and 0.45µT (for 600Hz). Therefore, interference with systems more than 5m from the proposed alignment is unlikely. Immunity levels at higher frequencies such as 1,200Hz may be lower as per the standard with a requirement to withstand 0.12µT specified. Predicted field strengths for these higher frequencies may approach these levels under worst-case conditions at 5m but under normal operation approved audio-visual systems should not experience an impact. No third-party audio-visual equipment was identified closer than 5m from the proposed tunnel.

Hearing aids, as worn by members of the public, would be approved to EN 60118 under the Medical Device Directive. These would be tested to immunity levels slightly higher to those outlined above.

It is also worth discussing the induction loops encountered in both the Gate Theatre and the Dáil committee rooms. Again, these would be required to be immune to magnetic fields at levels in the audible range above what would be generated by the traction system at the distances involved. The underground location of the committee rooms means its approximate distance from the crown of the tunnel is 5m. The induction loop in the Gate Theatre, which is one floor above street level would be even further away. The induction loop in the Gate theatre already does experience some noise on their system, which is assumed to be at 50Hz, according to discussions with technicians on the site. The representatives of the Theatre maintain that this issue became much more noticeable after the rerouting of a nearby ESBN high voltage cable. The induction loop currently installed at the theatre was a Signet PDA1000/2 which bore a CE mark. The CE mark indicates that the manufacturer declares their equipment meets the EMC directive. Therefore, it should meet the current immunity requirements for such equipment. It would be expected that the more modern system in the Dáil committee rooms would have the required immunity level also. As it is for use with hearing aids it should be approved to EN 60118-4 which specifies an immunity to AC fields of 0.5µT.

Finally, equipment unlikely to have been assessed for immunity to magnetic field interference in the AC range are magnetic pickups, typically used on stringed instruments such as electric guitars and bespoke equipment. Lab testing of sensitivities for such an instrument suggested the following audible sensitivities:

- 300Hz – 0.02μT;
- 600Hz – 0.005μT; and
- 1,200Hz – 0.001μT.

What is noticeable in the dataset above is that the higher the frequency the more sensitive the relationship. As the test was subjective this would be what is expected due to the nonlinear sensitivity of the human ear to different frequencies. By way of comparison to data from another electrified DC system the equivalent frequency intensities was acquired from an operational Luas, at a distance of 10m and 20m.

- 10m distance:

- 300Hz – 0.034μT;
- 600Hz – 0.028μT; and
- 1,200Hz – 0.004μT.

- 20m distance:

- 300Hz – 0.004μT;
- 600Hz – 0.002μT; and
- 1,200Hz – 0.0002μT.

Although not worst-case levels as the Luas would have had to be operating at worst-case at the time, the levels at 20m were below the sensitivity established in the lab, while at 10m they were at levels that could possibly be perceived. But in the absence of formal standard limits perception based on one human observer is very much a subjective quantity.

A significance of effect of slight is given for the Ambassador Theatre and Gate Theatre with a quality of effects of Neutral. The Dáil was also rated as having a Slight significance of effects with a quality of effect classed as Neutral.

In relation to TCD, the equipment discussed previously in TCD is not known to have sensitivities at the predicted levels for harmonics at the distances involved, with the exception of the SQUID which has specifications for tolerances in this frequency range. Again however, at the distance of this equipment from the proposed alignment any impact is unlikely. TCD was given a significance of effects of Slight AC fields with a quality of effects classed as Neutral.

The proposed alignment does not bring the route directly below the National Concert Hall building but passing through the campus just adjacent to the north-eastern corner of the building. Deviation within the limits of the tunnelling operation may bring it just under this corner. The depth of the tunnel and distance from the National Concert Hall's main performance areas will ensure that any AC fields or Harmonics will be adequately reduced to levels so as not to cause any impact on approved audio-visual systems. Bespoke or non-standardised systems may have a perceptible impact if they were to be located away from these main performance areas (for example on the ground floor of the north-eastern corner of the building) and directly above the proposed alignment. This is a scenario that is less likely if the tunnelling does not deviate westward within its limits from its projected path. This National Concert Hall was given a significance of effects of Slight with a quality of effect classed as Neutral with respect to AC fields.

Finally, Dublin Airport was given a significance of effects of Imperceptible and quality of effects of Neutral with respect to AC fields.

12.10.3.3 Predicted AC Fields Significance of Effects

Table 12.17 provides a summary of the significance of effects from AC fields during the Operation Phase.

Table 12.17: Significance of Effects from AC Fields during Operational Phase

Receptors	Significance of Effects	Quality of Effects
Any facilities that have highly sensitive equipment on the premises on a permanent basis Public/private hospital facilities	Imperceptible	Neutral
Telecommunications infrastructure Signalling on rail networks	Slight	Neutral
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	Imperceptible	Neutral
Some residential areas e.g. containing medical equipment. Mixed units with a residential component. Industrial facilities with sensitive equipment. Universities, colleges and schools which do not have sensitive equipment.	Imperceptible	Neutral
Electricity substations with earthing equipment. Educational institutions without sensitive equipment.	Imperceptible	Neutral
All other residential areas	Imperceptible	Neutral
Dublin Airport	Imperceptible	Neutral
Gate Theatre	Slight	Neutral
Ambassador Theatre	Slight	Neutral
Dáil Eireann	Slight	Neutral
National Concert Hall	Slight	Neutral
TCD	Slight	Neutral
All other areas	Imperceptible	Neutral
Public exposure	Imperceptible	Neutral

12.10.4 RF and Microwave Field Impacts

The system contractor(s) will ensure that the electrical systems, communications and equipment associated with the proposed Project comply with the EMC Directive 2014/30/EU and the Radio Equipment Directive 2014/53/EU.

Radiofrequency fields from the proposed Project will emanate from the following sources;

- From the traction vehicle;
- Radio communication and IT systems;
- Microwave links; and
- Signalling systems.

The radiofrequency emissions from the vehicles and infrastructural equipment will be controlled by compliance with the mandatory application of the two previously mentioned directives, the EMC and RED. These are implemented in Ireland under Statutory Instruments. As such, the radiofrequency emissions levels will be controlled to levels that will ensure the absence of interference with radio, TV and telecommunications apparatus. The location of radio transmitters will be such to ensure that the levels of emissions do not cause interference with electrical and electronic equipment along the route. This will ensure that levels at possible receptors will not exceed 1V/m. Emissions above tunnelled sections of the alignment will be so as to be almost undetectable with specialised instrumentation due to the effect the earth has for attenuating electric fields. RF and microwave emissions attributed to the proposed Project will be permanent in nature once the systems remain online.

All receptors in the study area along the proposed route have been given a significance of effects rating of between Imperceptible to Slight according to Table 12.18 with a quality of effects classed as Neutral.

12.10.4.1 Predicted RF and Microwave Fields Significance of Effects

Table 12.18: Significance of Effects from RF and Microwave Fields during Operational Phase

Receptors	Significance of Effects	Quality of Effects
Any facilities that have highly sensitive equipment on the premises on a permanent basis Public/private hospital facilities Signalling on rail networks Highly sensitive equipment in universities, colleges and schools	Slight	Neutral
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 Locations with installations of custom audio-visual equipment	Slight	Neutral
Dublin Airport	Slight	Neutral
Some residential areas e.g. containing medical equipment. Industrial facilities with sensitive equipment. Universities, colleges and schools which do not have sensitive equipment.	Imperceptible	Neutral
All other residential areas. Mixed units with a residential component. Electricity substations with earthing equipment. Educational institutions without sensitive equipment.	Imperceptible	Neutral
Public Exposure	Imperceptible	Neutral

12.10.5 Stray Current Impacts

12.10.5.1 Predicted Stray Current Impacts and Significance of Effects

The proposed alignment intersects and runs parallel to dozens of buried pipes and cables of varying sizes and importance. These include electricity cables, sewage and water pipes, gas pipes and telecommunication cables. The more conductive the material used in the pipework, the more prone it is to stray currents. For example, cast iron pipes, the likes of which would have been installed during Victorian times.

Diagram 12.6 best illustrates the nature of stray current.

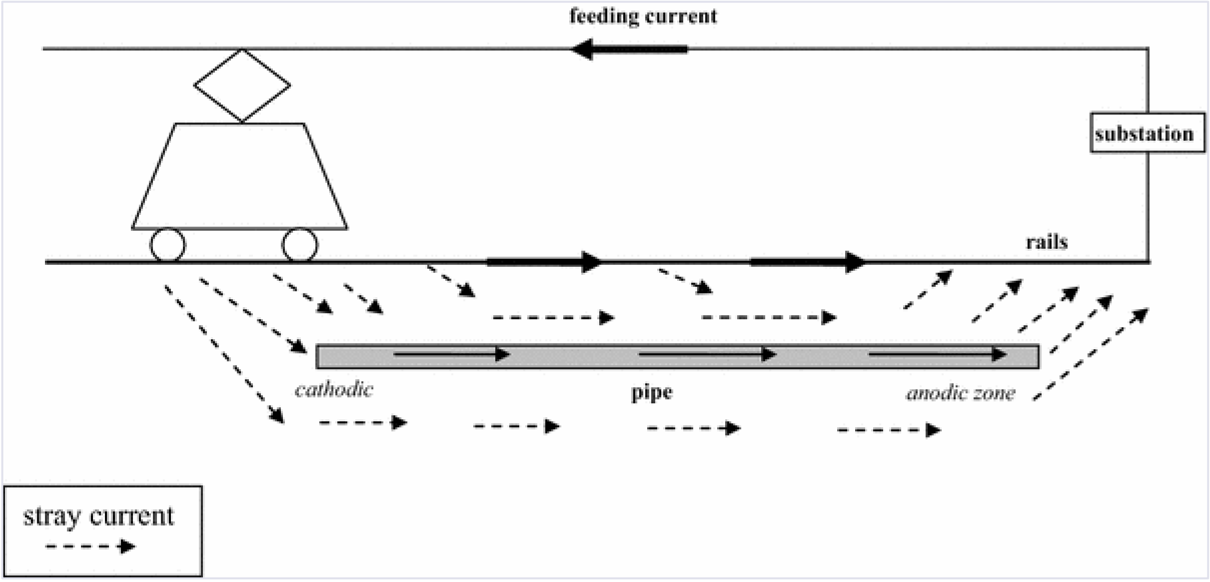

Diagram 12.6: Illustration of Stray Current in an Electrified Rail System

Corrosion is a naturally occurring feature of buried pipework also, which is not attributable to stray currents. The underground environment in Dublin is heavily populated with various types of these buried items and stray current is already a feature experienced by them. When the DART was installed stray current mitigation measures were not as advanced as they are today and as a result stray currents from the DART line have been observed on various utilities around Dublin and Wicklow, often at distances of several miles away from the lines.

Mitigation measures are required to be applied during the installation of the proposed Project, and are not optional, which will significantly reduce the potential impact of these stray currents on nearby buried utilities. These available measures include the use of a stray current collector system, adjustment of the power supply system, improvement of the return circuit (high conductivity in the rails) and isolation of the return circuit from ground (rail-to-earth resistance). The use of a slab track helps facilitate some of these measures e.g. cross-bonding the top layer of reinforcing steel of the slab helps improve the return circuits conductivity. Any measures performed need to comply with EN 50122-2:2010 (Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems). Once operational, monitoring of the earthing system and stray currents will be performed to ensure that potential faults in these mitigation measures or degradation over time is adequately detected.

Some utility owners themselves already apply their own mitigation measures in some instances to protect against corrosion and stray currents, replacing old metallic pipework with non-conductive equivalents for example, but also, in some instances, using cathodic protection such as that used by Dublin Airport on their buried jet fuel pipe. This method of protection utilises a sacrificial anode to help protect the main pipework which acts as the cathode in the electric circuit. The cathodic protection system may be passive or active. In the case of an active system an external power source is required to induce the necessary current to maintain the desired circuit polarity.

Stray currents from the proposed Project will be permanent in duration once the lines are electrified. The magnitude of these currents would be so small as to be indistinguishable from other ambient currents even with measurement equipment. There will be momentary increases in the magnitude of the currents when trains are pulling power from the lines with the magnitude of the currents being proportional to the load current on the track. At this point the currents are likely to be detectable on structures closest to the alignment in rural locations (100m away). Within the city it should be possible to again detect the presence of these currents but much closer to the alignment, for example within 10m to 20m. In this case the proposed Project could be more easily identified as the likely source and not the DART, Luas or other source for example. For all identified receptors the significance of effects for stray currents has been rated as Slight (Table 12.19).

The quality of effects has been classed as Neutral in this instance. The proposed Project itself will also act as a sink for the stray currents already present in the subterranean environment while having its own stray current emissions mitigated through its design.

Table 12.19: Significance of Effects from Stray Current during the Operational Phase

Receptors	Significance of Effects	Quality of Effects
Buried pipes and cables of conductive material including: ▪ Cast iron water mains along Dublin Road Swords ▪ Ductile iron water main along Ballymun Road ▪ 250mm steel gas main along St Margaret's Road to Carton Way ▪ Iron water main along St Mobhi Road and Botanic Road ▪ 500mm steel gas main along Harcourt Terrace ▪ 400mm steel gas main along Ballymun road to Glasnevin Hill and St Mobhi Road ▪ Cast iron water main continuing along Berkeley Road to O'Connell Street ▪ Ductile Iron water pipe along Kildare Street ▪ Cast Iron water pipe along St Stephen's Green continuing to Harcourt Terrace ▪ Cast iron pipes servicing multiple estates adjacent to water main lines such as Dean Swift Estates, Clonmel Road Griffith Avenue, Land uses in Phibsborough and other city centre locations ▪ Telecommunications Cables.	Slight	Neutral
Jet Fuel Pipe at Dublin Airport.	Slight	Neutral
Non-conductive buried utilities and cables including: ▪ PVC water pipes ▪ Polyethylene gas pipes ▪ Concrete pipes ▪ Asbestos pipes ▪ Fibre optic cables.	Imperceptible	Neutral
Luas and Irish Rail traction circuits.	Slight	Neutral
Luas and Irish Rail signalling and telecommunication circuits.	Slight	Neutral

12.11 Mitigation Measures

With regards to DC magnetic field impacts on sensitive medical and scanning equipment such as those located in TCD, the Rotunda and the Mater the following mitigation measures are available:

- Relocation of effected equipment;
- Installation of an active-cancellation system; and
- Shielding of the labs/rooms using specialised material designed to attenuate magnetic fields.

Active cancellation systems operate on the basis of responding to a changing magnetic field, whereby the system generates a counter field to cancel out fluctuations as they occur. The response time of such a system has been cited as a cause of concern by some of the technical experts at TCD, in previous meetings, so if such a system were to be adopted then the speed of cancellation versus the equipment acquisition rate would need to be scrutinised, to the point of field testing the application for effectiveness.

A final solution would be the installation of fixed shielding, a solution with which some of the departments and institutes at TCD are already familiar. The Scanning Transmission Microscope at the Advanced Microscopy Lab (AML), for example (not currently located on the main TCD campus) has a sensitivity of 6nT or 0.006µT and has already been installed in a double shielded room constructed from Mu-metal.

Any unexpected impacts in relation to AC fields can be addressed in a number of ways if necessary, including:

- Shielding; and
- Filtering.

For DC magnetic fields at Dublin Airport, while there will be no impact for some airlines, and it is unlikely to manifest itself to a notable level for others that utilise Flux Valve compass systems, it was agreed with the DAA that they would implement one of the following measures:

- Update their Aerodrome Notification Package; or
- Utilise another form of standard notification to the airlines.

The nature of this update or notification would be of a form that outlines the proposed Project alignment through the airport, with a corridor width of 20m, within which magnetic compass systems may experience momentary fluctuations as they pass through.

12.12 Residual Impacts

Locations within the TCD, Rotunda and Mater Campuses where DC and quasi-DC magnetic field perturbations are at elevated levels from the operation of the proposed Project may not be suitable for the installation or relocation of equipment with sensitivities to these types of fields. The potential installation of MRI technologies at Dublin Airport in the future will need to be cognisant of the new baseline environment against manufacturers' specifications for these systems.

Although unlikely, future developments such as extensions and new building at locations including theatres, musical venues, stadiums, domestic or commercial premises that bring unapproved audio equipment within 20m of the lines could potentially experience interference in the audio frequency range.

A future MRI installation at Swords Veterinary Hospital may have issues with DC magnetic field interference.

Despite applied mitigation measures to minimise the magnitude of stray current, it is an inevitable phenomenon associated with DC rail systems. Continued monitoring of the performance of the traction circuit with respect to current returns to the substation will be required.

12.13 Difficulties Encountered in Compiling Information

Issues that proved problematic at times, with the knock-on delays to completion of certain works, were:

- Datasheet requests for some equipment listed as being sensitive to EMI not being provided;
- Some requests for information were not responded to for example the Ambassador Theatre;
- Following the requested communication channels when dealing with stakeholders; and
- Gaining permits to access some sites to perform baseline surveys.

12.14 Glossary

Term	Meaning
Alignment	Alignment refers to the three-dimensional (3D) route of the railway, considering both the horizontal and vertical alignment.
Alternating current	An electric current that reverses its direction many times a second at regular intervals, typically used in power supplies
Brief effects	Effects that last less than a day
Construction Compound	An area occupied temporarily for construction-related activities. The main construction compounds will act as strategic hubs for core project management activities (ie engineering, planning and construction delivery) and for office-based construction personnel. The main construction compounds will include: offices and welfare facilities, workshops and stores, and storage and laydown areas for materials and equipment (e.g. aggregate, structural steel, and steel reinforcement).
Direct current	An electric current flowing in one direction only.
Electromagnetic compatibility (EMC)	The ability of electrical equipment and systems to function acceptably in their electromagnetic environment, by limiting the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects such as electromagnetic interference (EMI) or even physical damage in operational equipment.
Electromagnetic field	A property of space caused by the motion of an electric charge
Enabling Works	These are works to prepare a site in advance of the main construction works, for example, demolition, removal of vegetation, land levelling.
Intervention Shaft	A tunnel to provide emergency access between the railway tunnel and ????
Intervention Tunnel	A tunnel parallel to the railway tunnel to provide emergency access / egress
Long-term effects	Effects that last fifteen to sixty years
Magnetic field	A region around a magnetic material or a moving electric charge within which the force of magnetism acts
magnetic flux density	The amount of magnetic flux in an area taken perpendicular to the magnetic flux's direction.
Medium-term effects	Effects that last seven to fifteen years
Momentary effects	Effects that last from seconds to minutes
Overhead Conductor Rail	A rigid aluminium contact pole incorporating a contact wire to carry the current to power trains in the tunnelled sections
Overhead Contact System	A system to connect the trains with the source of electrical power consisting of a single contact wire and a single catenary wire supported from a support structure.
Park & Ride Facility	A location usually sited out of the main urban areas comprising a large car park and connected with a mass transit system, in the case of MetroLink an urban metro to attract potential travellers to drive and park at the facility and take the metro into the city centre and avoid driving into the city centre.
Permanent effects	Effects that last over sixty years
Radiofrequency field	An alternating current which, when put through an antenna, generates an electromagnetic field for wireless broadcasting or communication by sending a current through an antenna
Retained Cut Station	A railway station constructed primarily below ground level with vertical retaining walls either side of the alignment to reinforce the walls and no roof or enclosure overhead.
Short-term effects	Effects that last one to seven years
Surface Station	A railway station designed at ground level
Temporary effects	Effects that last less than a year

Term	Meaning
Underground Stations	A railway station located fully underground with a roof slab over the station to enclose it fully.

12.15 References

Environmental Protection Agency (2022) Guidelines on the information to be contained in Environmental Impact Assessment Reports

European Committee for Electrotechnical Standardization (CENELEC) (2009). Electromagnetic compatibility – Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use - - Part 2: Immunity (EN 55103-2:2009)

European Committee for Electrotechnical Standardization (CENELEC) (2010). Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems (European Standard: EN 50122-2:2010)

European Committee for Electrotechnical Standardization (CENELEC) (2017). Railway applications - Electromagnetic compatibility Part 2: Emission of the whole railway system to the outside world (European Standard: EN 50121-2:2017).

European Committee for Electrotechnical Standardization (CENELEC) (2019). Electroacoustics – Hearing aids – Part 4: Induction-loop systems for hearing aid purposes – System performance requirements (EN 60118-4:2015+A1:2018)

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

International Commission on Non-Ionising Radiation Protection (ICNIRP) (1998). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (DC up to 300GHz). Health Physics 74 (4): 494-522.

International Commission on Non-Ionizing Radiation Protection (ICNIRP) (2009a). Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz). HEALTH PHYSICS 97(3):257-258.

International Commission on Non-Ionizing Radiation Protection (ICNIRP) (2009b). Guidelines on limits of exposure to Static Magnetic Fields. HEALTH PHYSICS 96(4):504-514.

12.15.1 Directives

European Union (2013). Directive 2013/35/EU (Electromagnetic Fields Directive) of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields).

European Union (2014a). Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (i.e. the EIA Directive)

European Union (2014b). European Directive on Electromagnetic Compatibility (2014/30/EU)

European Union (2014c). Electromagnetic Compatibility Directive 2014/30/EU on the approximation of the laws of the Member States relating to electromagnetic compatibility.

European Union (2014d). Radio Equipment Directive (2014/53/EU).

European Union (2014e). Low Voltage Directive (2014/35/EU).

12.15.2 Regulations

Electromagnetic Compatibility Regulations 2016 - S.I. No. 145/2016.

Low Voltage Electrical Equipment Regulations 2016 - S.I. No. 345/2016.

Radio Equipment Regulations 2017 - S.I. No. 248/2017

Radiological Protection Act 1991 (Non-Ionising Radiation) Order 2019 - S.I. No 190/2019