Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Údarás Náisiúnta Iompair
National Transport Authority

Luas Finglas

Environmental Impact Assessment Report
2024

Chapter 16: Electromagnetic Compatibility and Interference

BARRY TRANSPORTATION egis GROUP

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Project Ireland 2040
Building Ireland's Future

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GLOSSARY OF FREQUENTLY USED TERMS

Acronym	Term
AC	Alternating Current
DC	Direct Current
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMC	Electromagnetic Compatibility
E-Field	Electric Field
EMI	Electromagnetic Interference
EMF	Electromagnetic Fields
EMR	Electromagnetic Radiation
HV	High Voltage
ICNIRP	International Commission on Non-Ionising Radiation Protection
IT	Information Technology
LRT	Light Rail Transit
LRV	Light Rail Vehicle
M-Field	Magnetic Field
OCS	Overhead Conductor System
OHL	Overhead Line
RED	Radio Equipment Directive
TII	Transport Infrastructure Ireland
TPSS	Traction Power Substation System

SECTION 16: ELECTROMAGNETIC COMPATIBILITY AND INTERFERENCE

16.1 Introduction

16.1.1 Purpose of this Report

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

In accordance with the requirements of Directive 2014/52/EU of the European Parliament and of the Council of April 16, 2014, amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (also known as the EIA Directive), this chapter describes and evaluates the likely direct and indirect significant effects of the proposed Scheme on electromagnetic compatibility and stray current. Additionally, this chapter describes the receiving environment, both within the boundaries of the proposed Scheme and a larger study area nearby.

The assessment is based on identifying and describing the likely significant effects arising from the proposed Scheme as described in Chapter 5 (Description of the proposed Scheme) and Chapter 6 (Construction Activities) of this EIAR. The proposed Scheme description is based on the reference design created to provide information about the proposed Scheme during the application stage for a Railway Order and to enable a thorough evaluation as part of the EIA Process.

16.1.2 Outline Scheme Description

The proposed Scheme comprises a high-capacity, high-frequency light rail running from Broombridge to Charlestown, connecting Finglas and the surrounding areas with Dublin's wider public transport network by providing a reliable, and efficient public transport service to the city centre via Broombridge.

As shown in Volume 4 – Map Figure 1-1, starting from Broombridge, the proposed Scheme travels northwards, crossing the Royal Canal and the Maynooth railway line adjacent to Broome Bridge. It then runs adjacent to the east of Broombridge Road and the Dublin Industrial Estate. It then crosses the Tolka Valley Park before reaching the proposed St Helena's Stop and then proceeds northwards towards the proposed Luas Finglas Village Stop. From here, the route passes through a new corridor created within the Finglas Garda Station car park, making its eastern turn onto Mellowes Road. The route then proceeds through Mellowes Park, crossing Finglas Road, towards the proposed St Margaret's Road Stop. Thereafter, the proposed line continues along St Margaret's Road before reaching the terminus Stop proposed at Charlestown.

The proposed Scheme has been designed to interchange with existing and future elements of the transport network including interchange opportunities with bus networks at all the new Stops and with mainline rail services at Broombridge. In addition, the proposed Scheme through the inclusion of integrated cycle lanes and cycling infrastructure sets out to facilitate multimodal "cycle-LRT trips" as a key aspect of the Luas Finglas scheme.

The proposed Scheme will comprise several principal elements as outlined in Table 16-1 and Table 16-2. A full description of the proposed Scheme is provided in the following chapters of this EIAR:

- Chapter 1 (Introduction);
- Chapter 5 (Description of the proposed Scheme); and
- Chapter 6 (Construction Activities).

Table 16-1: Overview of the Key Features of the proposed Scheme

Scheme Key Features	Outline Description
Permanent Scheme Elements	
Light Rail track	3.9km extension to the Luas Green Line track from Broombridge to Finglas (2.8km of grass track, 700m of embedded track and 360m of structure track).
Depot Stabling facility	A new stabling facility (with stabling for eight additional LRVs) will be located just south of the existing Broombridge terminus, as an extension of the Hamilton depot area.
Luas Stops	Four Stops located at: St Helena's, Finglas Village, St Margaret's Road, and Charlestown to maximise access from the catchment area including the recently re-zoned Jamestown Industrial Estate.
Main Structures	Two new Light Rail Transit (LRT) bridges will be constructed as part of the proposed Scheme: a bridge over the River Tolka within the Tolka Valley Park and a bridge over the Royal Canal and the Iarnród Éireann (IÉ) railway line at Broombridge. A number of existing non-residential buildings shall be demolished to facilitate the proposed Scheme. In addition, the existing overbridge at Mellowes Park will be demolished.
At Grade Signalised Junctions	10 at grade signalised junctions will be created at: Lagan Road, Ballyboggan Road, Tolka Valley Road, St. Helena’s Road, Wellmount Road, Cappagh Road, Mellowes Road, North Road (N2), McKee Avenue, Jamestown Business Park entrance. Note: The junction at Charlestown will be reconfigured but does not have an LRT crossing.
Uncontrolled Crossings	13 at grade uncontrolled crossings (11 pedestrian / cycle crossings and two local accesses located at: Tolka Valley Park, St Helena’s, Farnham pitches, Patrickswell Place, Cardiff Castle Road, Mellowes Park, St Margarets Road, and ESB Networks.
Cycle Facilities	Cycle lanes are a core part of the proposed Scheme in order to facilitate multimodal “cycle-LRV trips”. Approximately 3km of segregated cycle lanes and 100m of non-segregated cycle lanes along the route. Covered cycle storage facilities will be provided at Broombridge Terminus, Finglas Village Stop and St Margaret’s Stop and within the Park & Ride facility. “Sheffield” type cycle stands will be provided at all stop locations.
Power Substations	Two new traction power substations for the proposed Scheme will be located near Finglas Village Stop behind the existing Fire Station, and near the N2 junction before St Margaret’s Road Stop where the current spiral access ramp to the pedestrian overbridge is located. A third substation is required for the Park & Ride facility.
Park & Ride Facility	A new Park & Ride facility, with e-charging substation, located just off the M50 at St Margaret’s Stop will be provided with provision for 350 parking spaces and secure cycle storage. The building will feature photovoltaic (PV) panel roofing and is the location for an additional radio antenna. This strategic Park & Ride connecting the N2/M50 to the city centre will increase the catchment area of the proposed Scheme.
Temporary Scheme Elements	
Construction Compounds	There will be three principal construction compounds, two located west of Broombridge Road and one located at the northern extents of Mellowes Park. In addition, there are other secondary site compound locations for small works/storage. Details can be found in Chapter 6 (Construction Activities) of this EIAR.

Table 16-2: Summary of New Bridges of the proposed Scheme

Identity	Location	Description
Royal Canal and Rail Bridge	Approximately 10m east of the existing Broome Bridge and then continuing north, parallel with Broombridge Road on its east side	The proposed bridge is an eight-span structure consisting of two main parts: a variable depth weathering steel composite box girder followed by a constant depth solid concrete slab. The bridge has the following span arrangement: 35 + 47.5 + 30 + 17 + 3x22 + 17m. Steel superstructure extends over the first three spans. The bridge deck is continuous over the full length of 212.5m and has solid approach ramps at both ends.
Tolka Valley Park Bridge	Approximately 30m west of the existing Finglaswood Bridge	A three-span structure with buried end spans, thus appearing as a single span bridge. End spans as well as part of the main span consist of post-tensioned concrete variable depth girder, the central section of the main span is a suspended weathering steel composite box girder. The overall length of the bridge is 65m with spans 10m, 45m, 10m.

16.2 Overview of the Electromagnetic Spectrum

Radiation is referred to throughout this chapter by reference to several 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.

Electromagnetic radiation is a phenomenon that takes the form of self-propagating energy waves as it travels through space (vacuum or matter). It consists of both electric and magnetic field components. The energy waves oscillate in phase perpendicular to each other and perpendicular to the direction of energy propagation. It is observed that the longer the wavelength involved, the lower would be the frequency as well as the energy. Electromagnetic radiation is classified into several types according to the frequency of its wave. These types include (in order of decreasing frequency and increasing wavelength) cosmic radiation, gamma radiation, X-ray radiation, ultraviolet radiation, visible radiation, IR radiation, terahertz radiation, microwave radiation, and radio waves. A small and variable window of frequencies is sensed by the eyes of various organisms. This is known as the visible spectrum (λ 0.4–0.7 µm) or light. Electromagnetic radiation carries energy and momentum that may be imparted to matter with which it interacts.

The Electromagnetic Spectrum covers a very wide frequency range and there are many aspects of it with which people are familiar and are exposed to daily. Figure 16-1 illustrates some typical applications in the main frequency ranges.

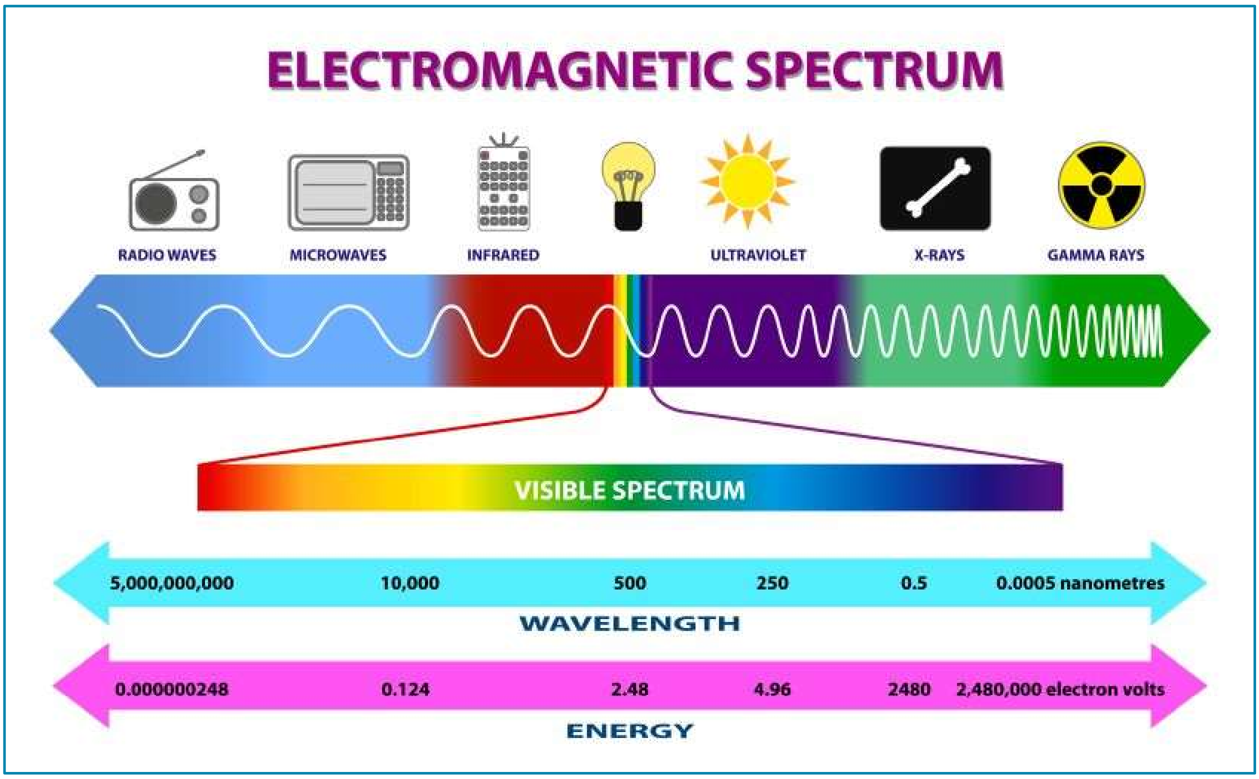

Figure 16-1: The Electromagnetic Spectrum (Source: istock image)

The electromagnetic spectrum is so called because it comprises electric and magnetic fields, hence the term “electromagnetic”. At the beginning of the electromagnetic spectrum, there are static fields. The most common static field is the earth’s magnetic field in which people are immersed at all times. Moving up the electromagnetic spectrum, the frequency used by electricity (50Hz) is reached and people are also surrounded by fields of this type as they are caused by household electrical wiring. At higher frequencies, the radiofrequency range is encountered. These are so called as they radiate and pass freely through the air. People 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 include 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 Scheme will generate electric and magnetic fields which can be categorised in three ranges:

- DC fields, generated by the traction system which powers the Luas LRVs;
- 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 Luas stops; 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 Luas LRV 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 on human beings. EMF comprise an electric field and a magnetic field and are emitted from both natural and human-made sources in the environment. All sources of EMF below 300GHz in the electromagnetic spectrum are considered to be 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 7 (Human Health) of this EIAR covers the broader impacts on human health considered for the proposed Scheme.

16.3 Methodology

The baseline environment is established as the existing conditions against which future changes, particularly those related to EMI and stray currents, will be evaluated.

This section outlines the methodology employed for assessing both the baseline environment and the anticipated impacts from an EMI and stray current perspective. It details the process for identifying potentially sensitive receptors and key stakeholders along the proposed Scheme alignment and describes the criteria used to evaluate the significance of EMI and stray current impacts. These criteria are based on the predicted electromagnetic radiation (EMR) from the proposed system and the known sensitivities of specific receptors in the receiving environment. The initial step involved defining the baseline radiation and stray current environment through a desktop study, stakeholder consultations, and field surveys.

The criteria detailed in section 16.3.4 has guided the categorization of the baseline environment and the assignment of baseline ratings. These ratings are crucial for quantifying the final predicted impact significance, ensuring a comprehensive understanding and mitigation of potential EMI and stray current effects on the environment and stakeholders.

16.3.1 Relevant Guidelines, Policy and Legislation

This assessment complies with the requirements of the European Directive on Electromagnetic Compatibility (2014/30/EU), and European Standards EN50121 (Parts 1-5) (CENELEC 2017), which addresses railway EMC. In addition, all electronics products placed on the market or taken into service in the EU must comply with all applicable directives. They include the above EMC Directive, the Low Voltage Directive (2014/35/EU) and the Radio Equipment Directive (2014/53/EU). 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 (as amended).

In addition to the above, the following 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 Council 1999), will be referenced:

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

The above directives do not cover emissions from DC and near DC fields, which are an interference risk also to particularly sensitive equipment such as scanning electron microscopes and magnetic resonance imaging equipment. However, an assessment of this type of EMI was included in the scope of this assessment.

16.3.2 Study Area

Luas Finglas is the proposed new northern extension of the Luas Green Line from its current terminus in Broombridge to a new terminus in Charlestown, near the N2-M50 interchange, it is approximately 4km long, with 4 new stops, two new substations, two main bridges, and a new extension to the Broombridge Hamilton depot. The general environment of the new line runs through a combination of industrial areas, residential areas, urban roads, green field areas and an interface with an existing railway line. An outline of the route for the Luas Finglas extension is presented in Figure 16-2.

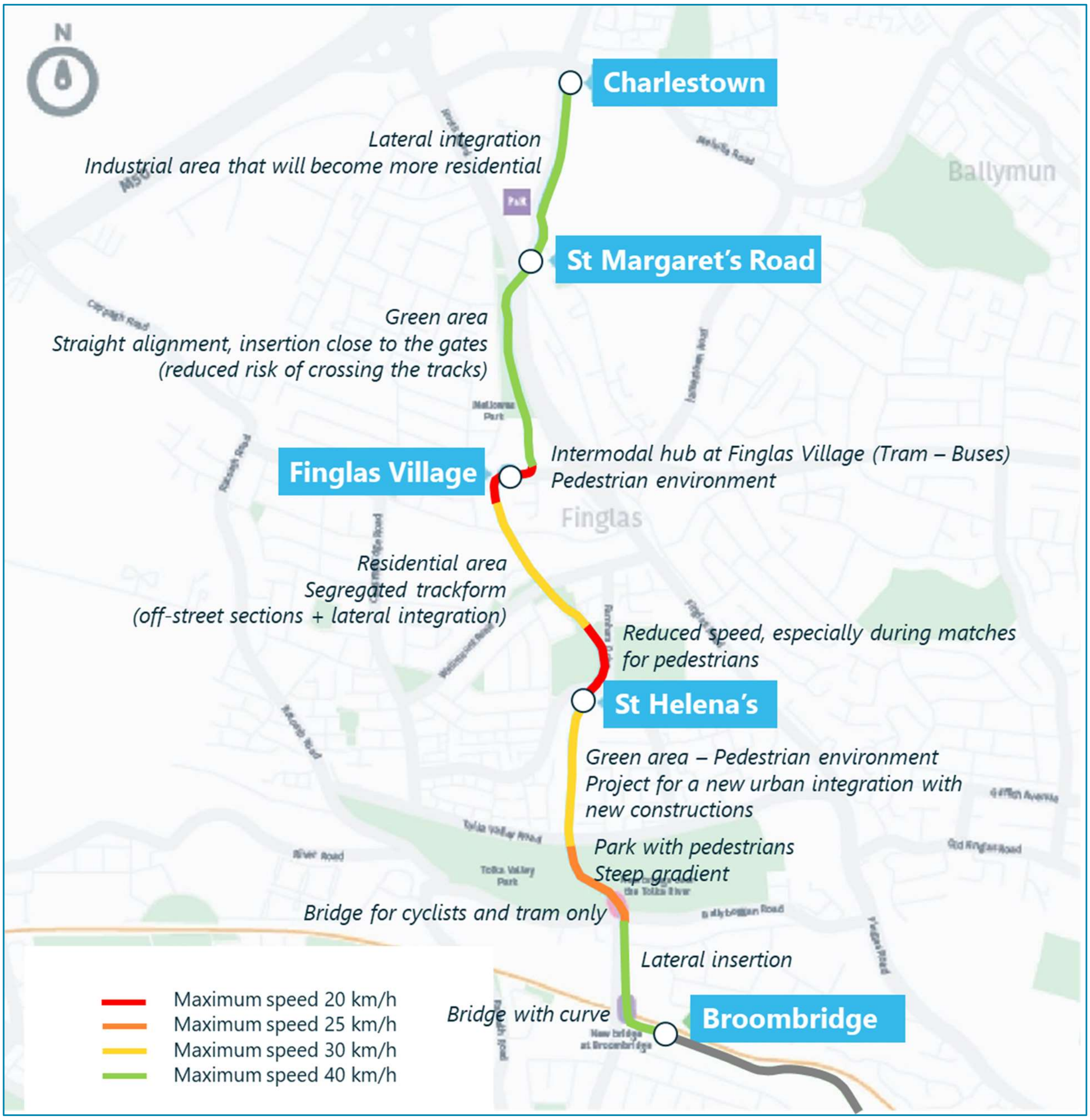

Figure 16-2: Luas Finglas Route Map

EMF 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 EMC Directive (2014/30/EU) is 10m and therefore all systems located 10m or greater from the track should not encounter radio frequency interference. However, due to the potential for extremely sensitive equipment to be used in some facilities such as medical, research and industrial, the corridor of influence was widened to 100m for the following receptor types:

- Hospitals, Clinics and Other Medical Establishments; and
- Recording and Film Studios.

A narrow corridor of 50m was used for the following receptor types:

- Educational Premises;
- Intentional and Unintentional Radio Transmitters;
- Other Commercial premises (retail unit, light industrial, heavy industrial, etc);

- Railway Interfaces; and
- LRT Depots and Signal Control Centres.

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 and is deemed best practice. 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 to be a risk to standard electrical equipment beyond 3m from the source. However, 100m is utilised for the 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 +50m in an urban or industrial environment, the levels anticipated would be reduced to background levels.

Table 16-3 provides a guide of the survey distances for the identification of key receptors.

Table 16-3: Critical Constructions and Relative Critical Distance (Source: HS2 - EMC Desktop Line of Route Survey, HS2-HS2-SY-REP-000-000023, Page 10)

Categories	Distance from Track (m)
Hospitals, Clinics and Other Medical Establishments	<100
Educational Premises	<50
Airports	<1000
Recording and Film Studios	<100
Military Establishments	<1000
Research Laboratories	<1000
Intentional and Unintentional Radio Transmitters;	<50
Other Commercial premises (retail unit, light industrial, heavy industrial, etc.)	<50
Radio Telescopes	<200
HV Tower Lines	<500
Railway Interfaces	<50 (Stray Current)
Depots and Signal Control Centres	<50

16.3.3 Data Collection and Collation

16.3.3.1 Desktop Survey Data Source

An initial high-level desktop survey was carried out to help identify the potential ‘hot spot’ and locations where EMI baseline measurements were to be carried out.

The data sources utilised for this first survey within the study area included the following:

- Proposed alignment drawings;
- Ordnance Survey Ireland (OSI[1]) maps;
- Google Maps™;

[1] Now Tailte Éireann

- A site visit along the proposed alignment and the wider study area; and
- Utilities' maps.

16.3.3.2 Baseline Survey Data Source

Based on the results of the abovementioned desktop survey, baseline surveys were carried out at the identified locations and also at the proposed location of the electrification substations for the proposed Scheme. On commissioning of the proposed Scheme, it is anticipated that the proposed site of the substations will generate the highest levels of EMR in the power frequency range of 50Hz.

Radiated emission measurements based on the requirements of EN50121-2 were carried out for the frequency range 9kHz to 6GHz at the locations below:

- Maynooth Railway Line, Broombridge Station and Hamilton Depot;
- Mobile Phone mast - south-western corner of Broombridge road and Royal Canal crossing;
- Finglas Garda Station;
- Finglas Fire Station (also the site of a proposed substation);
- Finglas Road / St Margaret's Road (site of a proposed substation); and
- Substation and HV Tower - south-western corner of Broombridge road and Royal Canal crossing.

EMF measurements were also carried out at the locations underneath and close to the 25kV 50Hz AC power lines.

16.3.4 Methodology for the Assessment of Impacts

The emissions from a LRV have the potential to affect close receptors. The emissions associated with an electric railway are characterised within the railway EMC emissions standard EN50121-2:2017 (between 150kHz and 1GHz). The limits for a LRV are the lowest limits in the standard (limit line C) and are therefore perceived as lower risk when compared with mainline electric railways. The emissions limit at 10m from the centreline of the closest track is defined in Figure 1 (limit line C) of that standard. Receptors closer than 10m from the track are in a harsher EMI environment than those outside of the 10m boundary. Receptors beyond 20m from the LRT fall into a typical residential and light industrial environment. Receptors greater than 20m away are unlikely to be affected by EMI from the LRT. Nevertheless, to follow due diligence, a boundary of 50m was considered in this survey for identification of receptors. EN50121-2 only addresses frequencies above 150kHz and there have been incidences on other projects of particularly sensitive measurement laboratories being affect by the DC magnetic fields from DC railways and LRTs at distances greater than 50m. For this reason, this survey has used the assessment distances defined in Table 16-4 to identify the primary receptors.

16.3.4.1 Desktop Survey - General Approach

An EMC desktop route survey has been conducted to identify and record potential sources or receptors of EMI within the study (defined in 16.3.2) area and sources or receptors have been identified and rated based on a Risk Scoring Matrix as shown below.

16.3.4.2 Desktop Survey - Rating

The scoring system for the receptors is presented in Table 16-4. This provides guidance as to those receptors that present a potentially high, medium or low risk.

Table 16-4: Risk Scoring Matrix for EMI (Source: HS2 - EMC Desktop Line of Route Survey, HS2-HS2-SY-REP-000-000023, Page 10)

Property Type		**Distance from Track Centreline (m)**		
		<20m	20m-50m	>50m
		3 – High probability of EMI impact	2 – Medium probability of EMI impact	1 – Low probability of EMI impact
Residential	1 – Low EMI Sensibility	4	3	2
Industrial	2 – Medium EMI sensibility	5	4	3
Highly sensitive (refer to Table 16-3)	3 – High EMI sensibility	6	5	4
EMI Risk = EMI Sensibility of the Receptor X Probability of EMI impact by the LRT System. With: From 1 to 3 – Low EMI Risk; 4 – Medium EMI Risk; and from 5 to 6 – High EMI Risk				

16.3.4.3 Site Walkover Survey

A site walkover survey was carried out on the 5th of September 2022 for the purpose of identifying suitable measurement locations, identifying access issues and identifying any hazards associated with the measurements. The site walkover survey covered the entire route from Broombridge to Charlestown (see Figure 16-2).

Details of the results of the site walkover survey are presented in the report titled "Preliminary Design Report – EMC Survey Plan" (Volume 5 - Appendix A16.1).

16.3.4.4 Baseline Survey - General Approach

Although the measurement methodology is driven by the requirements of EN50121-2:2017, some electrical or magnetic interference can prevent electrical or electronic equipment from working correctly. EMC is the ability of equipment or a system to function satisfactorily in its electromagnetic environment, without introducing intolerable electromagnetic disturbances to anything in that environment. The goal of EMC is the correct operation, in the same electromagnetic environment, of different equipment which use electromagnetic phenomena, and the avoidance of any interference effects. In order to achieve EMC, two aspects need to be considered:

- Emission issues are related to the generation of electromagnetic energy (either intended or unintended) by a source, and to the countermeasures which should be taken in order to reduce such generation or avoid the escape of any remaining energies into the external environment; and
- Susceptibility or immunity issues, in contrast, refer to the correct operation of electrical equipment in the presence of electromagnetic disturbances.

The importance of the EMC measurement survey is establishing the baseline EMI environment that the new LRT needs to operate within. This will highlight any particularly high sources of EMI emission in the environment that the LRT must be designed to be immune to. Further to this it identifies the baseline levels in the environment that are clearly attributable to outside sources. When the LRT is commissioned, it will be possible to identify those sources attributable to the LRT and those attributable to the outside sources. This is a key factor in demonstrating compliance of the new LRT to EN50121-2.

In addition to the standard radiated emission measurements to EN50121-2, electric and magnetic field measurements close to the 110kV HV lines (which run parallel to the proposed Scheme along Broombridge Road and over the route in Tolka Valley Park) were taken. This is important in identifying at an early stage if induced voltages from the HV lines into the LRT could be an issue either from an equipment reliability perspective or for a staff member or public touch potential safety issue.

In addition to EMC measurements detailed above, ground resistivity surveys were undertaken at electrical substation proposed locations to determine the optimum location for earth rods and earthing systems, and to determine that the earth rod resistance to earth value is sufficiently low enough to provide an effective safety earth. The measurement procedure used is the Wenner (four-rod) procedure that is given in BS 7430:2011.

In summary, the EMC measurement comprised in three types of measures:

- Radiated emission measurements;
- Electromagnetic Field measurements; and
- Ground resistivity measurements.

16.4 Baseline Environment

This section outlines the findings of the desktop studies and field surveys to provide a description of the current baseline based on the information gathered.

16.4.1 Desktop Survey

Based on the risk categorisation in Table 16-4, the baseline ratings are provided with respect to EM fields and stray current in Table 16-5 below.

Table 16-5: Current Baseline Ratings

Name	Description	Distance to the proposed Scheme	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
Maynooth Railway Line, Broombridge Station and Hamilton Depot	109m parallel running interface	<10m	High	Medium
Mobile Phone mast	Three, Meteor, Vodafone	23m	High	Low
Substation and HV Tower	Substation and HV Tower	24m	High	Low
HV Power Lines	Parallel HV Power lines for approx. 500m	50m	High	Low
HV Power Lines	Crossing over LRT	<10m	High	Low
Broombridge Business Centre	Other Commercial	35m	Low	Low
Colorman (Ireland)	Commercial Printer	18m	Medium	Low
Fashionflo Ltd.	Screen Printer	16m	Medium	Low
Vemar Transport Irlanda	Transport Services	22m	Low	Low
Chloe's Kitchen	Takeaway	16m	Medium	Low
West Rock	Commercial Printer	<10m	High	Low
TJ O'Mahony	DIY Superstore	18m	Medium	Low
Barnamore Grove	Residential	50m	Low	Low
Carrigallen Park	Residential	40m	Low	Low
Finglas Youth Service	Youth Organisation	42m	Low	Low

Name	Description	Distance to the proposed Scheme	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
St Helena's Resource Centre	Education	52m	Low	Low
St Helena's Childcare Centre	Education	20m	Medium	Low
Casement Road	Residential	30m	Low	Low
Farnham Crescent	Residential	24m	Low	Low
Wellmount Parade	Residential	29m	Low	Low
Patrickswell Place	Residential	<10m	Medium	Low
Gary's Computer Repair Service	Computer Repair	37m	Medium	Low
Little Sisters of the Assumption	Religious	33m	Low	Low
Kingdom Hall Jehovah's Witnesses	Religious	47m	Low	Low
St Fergal's Boys National School	Education	62m	Low	Low
Cardiff Castle Road	Residential	18m	Low	Low
Ravens Court	Residential	<10m	Medium	Low
BITACCRUAL	Investment	<10m	Medium	Low
Finglas Garda Station	State Police	10m	High	Low
Mellow Spring Childcare Development Centre	Childcare Agency	23m	Low	Low
Finglas Sport and Fitness Centre	Gym	20m	Low	Low
The Finglas Youth Resource Centre	Youth Organisation	17m	Low	Low
Finglas Fire Station	Fire Station	30m	High	Medium
North Road Motor Company	Used Car Dealer	<10m	High	Low
Pizza Hut Delivery	Takeaway	<10m	Medium	Low
North Road	Residential	<10m	Medium	Low
Lidl	Supermarket	53m	Low	Low
Murdock Builders Merchants, Finglas	Building Materials	<10m	High	Low
Atlas Autoservice and Tyres	Vehicle Repair	27m	Medium	Low
Industrial Estate	Miscellaneous Units	-	Medium	Low
Manhattan Peanuts Ltd.	Manufacturer	13m	Medium	Low
Aldi Stores	Supermarket	26m	Low	Low
Polonez, Finglas	Supermarket	19m	Low	Low
Auto Expert Garage	Mechanic	32m	Medium	Low

Name	Description	Distance to the proposed Scheme	Baseline Rating with Respect to EM Fields	Baseline Rating with Respect to Stray Current
Finglas Auto Parts	Auto Parts Store	<10m	High	Low
St Margaret's Road	Residential	25m	Low	Low
VanSigns Ltd	Corporate Office	17m	Medium	Low
ESB Networks	Electric Utility Company	40m	Medium	Low
McKelvey Celtic AFC	Football Club	50m	Low	Low
EVE Castleview	Disability Services Organisation	<10m	Medium	Low
Century Day Hospital	Hospital	<50m	Medium	Low
Connect Electronics Ltd	Industrial Equipment Supplier	12m	Medium	Low
Charlestown Shopping Centre	Shopping Centre	63m	Low	Low
Mobile Phone mast	Meteor, Vodafone, Three	126m	Medium	Low

The scoring of the identified receptors provides a guide as to where further survey work and potential mitigation measures are required. Using Table 16-5, some premises have been scored as a '5 or 6 – High EMI Risk' due to the close proximity to the LRT (<10m). However, due to the nature of the premises, it is likely that they contain nothing unusual or sensitive from an EMC perspective and these scores can be downgraded. The other High scores indicated where survey measurements should be carried out.

The remainder of the identified receptors which are scored '4 – Medium EMI Risk' and below will be managed by ensuring that the new LRT complies with the top-level EMC requirement for the proposed Scheme, which will include compliance with EN50121-2.

16.4.2 Substation Locations

The proposed HV substation locations are at or adjacent to the Finglas and St Margaret's Road Stops. These HV substations will be above ground and are considered significant in relation to EMR for the baseline environment. 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 as recorded in section 16.3.3.2.

16.4.3 Additional Substation at Park & Ride Facility

An additional substation is proposed at the Park & Ride facility, distinct from the HV substations associated with LRT operation. This facility is intended solely to supply car charging stations and is not a traction substation. Given its purpose and design, it is assessed that emissions from this substation will not be significant. This conclusion is based on preliminary assessments and the specific nature of the equipment to be used, which is tailored to minimize electromagnetic radiation (EMR) within the context of its operational environment.

16.4.4 Baseline Surveys

16.4.4.1 Radiated Emissions

This measurement survey, to determine the baseline electromagnetic environment in which the Luas Finglas LRT extension is required to operate, has been successfully completed, in accordance with the methodology and limits given in EN50121-2.

The background levels are below the limit lines with some exceedances that are attributable to narrow band emissions associated with known intentional transmitters in the environment.

The baseline survey results also provide an important benchmark against which the future LRT emissions characteristics can be compared as part of the assurance process to demonstrate compliance of the completed LRT with EN50121-2.

Detailed results of the Baseline survey are presented in the report titled "Preliminary Design Report - EMC Baseline Measurement Survey" (Volume 5 - Appendix A16.3).

16.4.4.2 Electric and Magnetic Fields

Measurements were also carried out of the 50Hz electric and magnetic field levels parallel and under the 100kV overhead lines where the new LRT will run. Detailed results of the Baseline survey are presented in the report titled "Preliminary Design Report - EMC Baseline Measurement Survey" (Volume 5 - Appendix A16.3).

The measured levels are compliant with exposure limits for people (based on Guidelines on Limiting Exposures to Electromagnetic Fields (ICNIRP) 1998).

16.4.4.3 Soil Resistivity Survey

The soil resistivity surveys carried out at the new substation proposed locations demonstrate that the site's ground conditions will be sufficient for an effective safety earth as each value decreases with depth.

The resistance values are also low enough to suggest that the Luas Finglas Stop substation proposed location is an ideal location to install and design an Earthing system for a traction power substation. These results also suggest that this site is unlikely to result in a 'hot site'[2], due to the acceptably low readings.

St Margaret's substation proposed location does show higher readings than the Luas Finglas substation location. However, the readings overall do show a decrease in value with a low resistance for each metre spacing. Test results at the gate entrance may suggest a defect such as metalwork under the ground at around 5 metres as the value does rise by 1ohm (Ω). Since the value is not registering as large or even in kilo-ohms (kΩ), it is still viable to suggest that this is a good site to locate a future substation. These readings also give evidence that it is unlikely to be classified as a 'hot site' despite the close proximity of residential properties.

Detailed results of the baseline survey are presented in the report titled "Preliminary Design Report - Soil Resistivity Survey" (Volume 5 - Appendix A16.4).

16.4.4.4 Stray Current

The existing TII Stray Current Standard (ref. PSD-PS-0003-01 Stray Current Protection Standards) will be followed and engagement with the Stray Current Working Group will be required at future stages to ensure that any asset in the vicinity of the proposed Scheme is not impacted or will not impact the proposed Scheme.

16.4.5 Appraisal Method for the Assessment of Impacts

16.4.5.1 Methodology for Evaluating Impacts and the Significance of Effects

The magnitude of the impacts and the significance of their effects on each identified receptor were assessed according to the EMR magnitudes outlined in Table 16-6. For the purpose of this appraisal the receptor

[2] A 'hot site' refers to a site where the installed earthing system results in an Earth Potential Rise of 430V or more under fault conditions, leading to safety issues such as dangerous Touch and Step Potentials.

types 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;
  - Housing for the Elderly;
  - Educational facilities (excluding universities and third level institutes);
  - Heritage buildings;
  - Churches;
  - Hospitality;
  - Opticians; and
  - Residential.
- Group 2; and
  - 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 Scheme beyond this distance. For Groups 2 and 3, a broader corridor was used to assess possible receptors in line with the distances identified as per Table 16-3.

Table 16-6 illustrates how these receptors were scored in relation to specific EMR levels. Associated with Table 16-4 is explanatory text as to 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 sensor's 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.

A further assessment is made in later tables where the quality of the effect is considered (see Table 16-8 to Table 16-12):

- Profound or significant effects are assessed as negative in terms of the quality of the effect.

- Imperceptible, slight, or moderate effects are assessed as neutral in terms of quality of effect.

Table 16-6: Impact Magnitude and Significance of Effect

Magnitude		Significance of Effect		
Field Type	**Limit**	**Group 1 Residential**	**Group 2 Industrial / Commercial**	**Group 3 Sensitive Research / 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
	>1.3	Slight	Moderate	Moderate
	>0.5	Imperceptible	Slight	Slight
	>0.05	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 (microtesla – an SI unit of magnetic flux density) 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.

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 European Directive on Electromagnetic Compatibility 2014/30/EU. The AC magnetic field immunity test levels for industrial equipment are 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.

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.

16.4.5.2 Other Criteria in the Assessment of Impacts

The study area for the EMR aspect of the EIAR is outlined in 16.3.2 along with the justification for the distance selected per type of radiation (DC, AC or RF).

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, its frequency of occurrence will also be outlined e.g. once, rarely, constantly or once a day.

16.5 Potential Impacts

In this section the magnitude of the predicted impacts and significance of the effects on receptors are identified in the baseline environment. The metrics used for determining impact magnitude and significance of the effects are outlined in Table 16-7.

From the desktop survey of the route, the main features identified that could be affected by EMC are:

- Interface with Maynooth Railway line and Luas Broombridge Hamilton depot;
- Parallel running with the overhead HV line. This could cause induced voltages into the LRV conductors;
- Crossing the overhead HV line. Depending on the separation distance between the LRV and overhead line, passengers and staff could be exposed to excessive EMFs from the HV line;
- Running close to the Finglas Garda Station and its associated radio equipment. The LRV could cause interference to the Garda radio systems and the Garda radio transmitters could cause interference to the LRV and wayside equipment;
- Running close to the Finglas Fire Station and its associated radio equipment. The LRV could cause interference to the Fire Station radio systems and the Fire Station radio transmitters could cause interference to the LRV and wayside equipment;
- One of the new substations is proposed to be located close to the Finglas Fire Station; and
- A new substation is proposed to be built near the junction of Finglas Road and St Margaret's Road.

In response to the ongoing DART+ West electrification of the Maynooth Line, the line adjacent to Luas may be electrified and, if so, a clear assessment of potential EMC issues, earthing and bonding strategy need to be carried out. As a result, a dialogue has been initiated with Iarnród Éireann and DART+ Project team to ensure that all relevant interface issues are addressed as both projects progress and particularly at the detailed design stage.

Detailed results of the desktop survey are presented in the report titled "Preliminary Design Report - EMC Desktop Survey' (Volume 5 - Appendix A16.2).

16.5.1 Construction Phase

No impacts from an EMI, EMF or stray current perspective are likely during the Construction Phase of the proposed Scheme and therefore, no detailed investigation was deemed necessary for this aspect of the Scheme. Electromagnetic emissions from the Construction Phase of the proposed Scheme 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. Levels will not exceed public exposure guideline limits outside of the construction works and neither are they expected to exceed limits for workers (which are five times higher than public limits) within the construction works. 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. DC field perturbations and AC fields from the on-site electrical equipment will not pose any impact to any of the identified receptors. Table 16-7 summarises the predicted significance of effects and quality of effects from the Construction Phase for EMR (DC, AC, RF and microwave) while Table 16-8 summarises stray current.

Table 16-7: Significance of Effects from Electromagnetic Emissions during the Construction Phase

Receptors	Significance of Effects	Quality of Effects
Public Exposure	Imperceptible	Neutral
Any facilities that may have highly sensitive equipment on the premises on a permanent basis. Public / private health hospitals Medical centres, dentists, 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 area e.g. containing medical equipment Industrial facilities with sensitive equipment Universities, colleges, schools without 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

Table 16-8: Significance of Effects from Stray Current during 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 Scheme. 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 16.3.2. The RF emissions may be detectable beyond 100m with tuned equipment.

16.5.2 Operational 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 Scheme 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. LRT 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 nearby 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 Scheme. The current will be gradual rather than a step change.

The potential EMI sources arising from the operation of the proposed Scheme 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.

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

- The power supply and distribution system;
- The LRVs draw current from the traction power station along the OCS which returns via the running rails 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 vehicle’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.

16.5.3 DC and Near DC Magnetic Field Impacts

The main forms of electromagnetic emissions from the proposed Scheme 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 cover 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 Scheme 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.

The only other concern is equipment particularly susceptible to DC magnetic fields – sensitive hospital equipment or research laboratories that may utilise magnetic resonance imaging, scanning electron microscopes and others that have very low DC immunity requirements. No such establishments or equipment were identified in the baseline surveys so there will be no significant impact from DC and DC magnetic fields to any receptors in the environment. This is nevertheless assessed in Table 16-9, showing any potential effects are only slight or imperceptible.

In addition to significance of effects, the quality of effects is also considered. This is important to inform the non-specialist reader whether an effect is positive, negative, or neutral. The following rationale is applied:

Positive Effects - A change which improves the quality of the environment (for example, by increasing species diversity, or improving the reproductive capacity of an ecosystem, or by removing nuisances or improving amenities).

Neutral Effects - No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error.

Negative / Adverse Effects - A change which reduces the quality of the environment (for example, lessening species diversity or diminishing the reproductive capacity of an ecosystem, or damaging health or property or by causing nuisance).

Table 16-9: Significance of Effects from DC Magnetic Fields during Operational Phase

Receptors	Significance of Effects	Quality of Effects
Any facilities that may have highly sensitive equipment on the premises on a permanent basis. Medical centres, dentists, vets. Signalling on rail networks.	Slight	Neutral
Telecommunications infrastructure.	Slight	Neutral
Public / private / research institutes. Sensitive equipment in universities, colleges, schools. Emergency Services mobile radio.	Slight	Neutral
Residential areas. Electricity Substations with earthing equipment. Educational institutions without sensitive equipment.	Imperceptible	Neutral
Public Exposure and Workers.	Imperceptible	Neutral

16.5.4 AC Field Impacts

16.5.4.1 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:

- Grid connection cables being laid and re-routed as part of the enabling works;
- MV 20kV cables powering substations at each proposed location;
- 110kV substations at Finglas Fire Station and St Margaret's Road; and
- 20kV substations at each proposed location.

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 the 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.

However, the advantage of AC feeds 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 LRVs 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 Guidelines on Limiting Exposures to Electromagnetic Fields (ICNIRP) EMF guidelines. Active implantable medical devices (AIMDs) which may be worn by the 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 Scheme 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.

16.5.4.2 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. 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. It is not required to be tested to these harmonic frequencies since the fields are not standard occurring fields in a typical office, industrial or domestic environment. They are a characteristic of the DC rectification and the 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 (20Hz – 20kHz). Predicted field strengths for these higher frequencies may approach immunity levels for such equipment under worst-case conditions at 5m, but under normal operation approved audio-visual systems should not experience an impact.

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.

Table 16-10 gives a summary of the significance of effects arising.

Table 16-10: Significance of Effects from AC Magnetic Fields during Operational Phase

Receptors	Significance of Effects	Quality of Effects
Public Exposure (including public with Active implantable medical devices (AIMDs) such as pacemakers and hearing aids (approved to EN 60118)).	Imperceptible	Neutral
Any facilities that may 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 / research institutes. Medical Centres including dentists and vets. Sensitive equipment in universities, colleges, schools. Emergency Services mobile radio.	Imperceptible	Neutral
Some residential areas containing medical equipment. Mixed units with a residential component. Industrial facilities with sensitive equipment. Universities, colleges, schools without sensitive equipment.	Imperceptible	Neutral
Electricity substations with earthing equipment. Educational institutions without sensitive equipment.	Imperceptible	Neutral
All other residential areas.	Imperceptible	Neutral

16.5.4.3 RF and Microwave Field Impacts

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

Radiofrequency fields from the proposed Scheme 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 which are referenced in section 16.3.1. 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. RF and microwave emissions attributed to the proposed Scheme 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 16-11 with a quality of effects classed as Neutral.

Table 16-11: Significance of Effects from RF and Microwave Fields during Operational Phase

Receptors	Significance of Effects	Quality of Effects
Public Exposure	Imperceptible	Neutral
Any facilities that may 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 equipment. Emergency services mobile radio.	Slight	Neutral
Some residential areas e.g. containing medical equipment. Industrial facilities with sensitive equipment. Universities, schools and colleges which do not have sensitive equipment.	Imperceptible	Neutral
All other residential areas. Mixed units with residential component. Electricity substations with earthing equipment. Educational institutions without sensitive equipment.	Imperceptible	Neutral

16.5.4.4 Stray Current Impacts

The proposed Scheme 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.

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. Mitigation measures are required to be applied during the installation of the proposed Scheme, 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, 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 DC 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. 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 Scheme 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.

A primary barrier for stray current will be the encapsulation of the rail, particularly in embedded sections such as road crossings or in green track section. This encapsulation is proposed as a crucial mitigation measure to protect both the LRT system and nearby buried utilities from the effects of stray currents, ensuring the integrity and safety of the infrastructure. Figure 16-3 shows examples of different encapsulation systems.

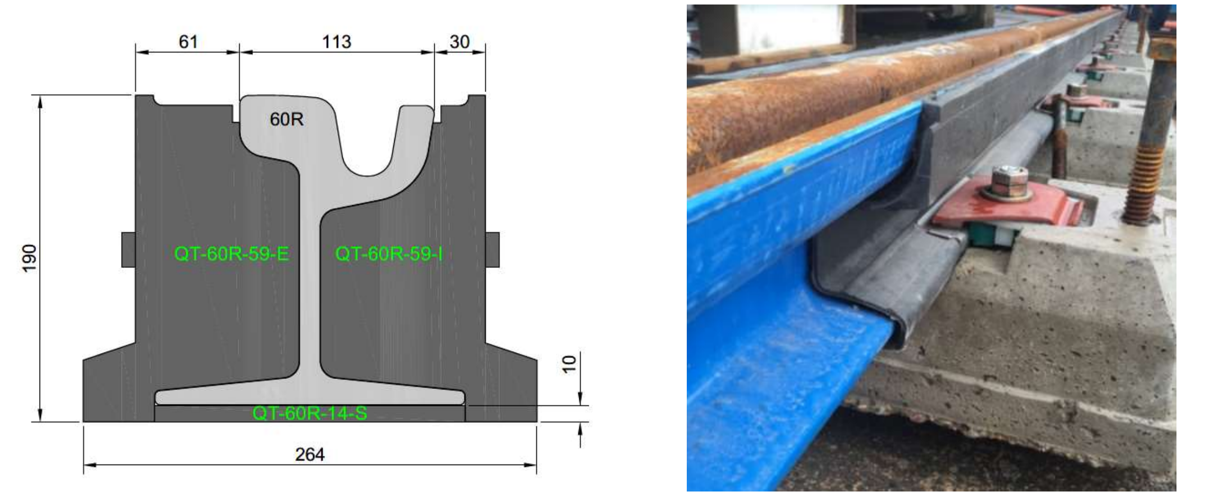

Figure 16-3: Pandrol Q-Track System (Source: Pandrol) and Trelleborg Encapsulation System (Source: Barry-Egis JV)

For all identified receptors, the significance of effects for stray currents has been rated as Slight or Imperceptible (Table 16-12). The quality of effects has been classed as Neutral in this instance. The proposed Scheme 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 16-12: 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 pipes, Steel gas mains and Telecommunications cables.	Slight	Neutral
Non-conductive buried utilities including: uPVC water pipes, Polyethylene gas pipes, Concrete pipes, and Fibre-optic cables.	Imperceptible	Neutral
Iarnród Éireann traction circuits.	Slight	Neutral

Receptors	Significance of Effects	Quality of Effects
Iarnród Éireann signalling and telecommunications circuits.	Slight	Neutral

16.5.5 Substation Locations

The proposed HV substation locations are at or adjacent to the Finglas and St Margaret's Road Stops. These HV substations will be above ground and are considered significant in relation to EMR for the baseline environment. This is on the basis that they handle significant AC and DC power and have the potential to impact the electromagnetic environment and require specific assessment. 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 as recorded in section 16.3.3.2.

16.5.6 Additional Substation at Park & Ride Facility

An additional substation is proposed at the Park & Ride facility, distinct from the HV substations associated with LRT operations. This facility is intended solely to supply car charging stations and is not a traction substation. Given its purpose and design, it is assessed that emissions from this substation will not be significant. This conclusion is based on preliminary assessments and the specific nature of the equipment to be used, which is tailored to minimize electromagnetic radiation (EMR) within the context of its operational environment.

16.6 Mitigation and Monitoring Measures

16.6.1 Top Level Hazards and Mitigations

The primary hazards and potential mitigations identified from the baseline surveys are given in Table 16-13.

Table 16-13: Top-Level Hazards Identified during Desktop Survey

No.	Hazard	Mitigation	Dependencies
1	Induced voltage from ESB HV overhead line to the LRV wayside conductors causing interference.	Carry out an induced voltage study to quantify the magnitude of induced voltage and determine the risk and if technical or operational mitigation measured are required.	Details of the ESB HV overhead lines (e.g. operating voltage, maximum load current, geometry of conductors).
2	Induced voltage from ESB HV overhead line to the LRV OHL causing touch voltage safety risk to personnel working on or near the OHL.	Review working procedures to ensure OHL is earthed when personnel are working near the line.	Details of the ESB HV overhead lines (e.g. operating voltage, maximum load current, geometry of conductors).
3	LRT crossing under the ESB HV overhead lines.	Carry out an assessment to determine the separation between the two systems and if there are any EMF risks to passengers or staff.	Details of the geometry of the LRV and overhead line at the crossing point.
4	Interference from the LRT to the Garda Station radio systems.	Review the radiated emission data for the LRVs to ensure emissions are low at the radio operating frequency. Review the OHL design to ensure it minimises arcing (e.g.	Details of the Garda radio operating frequencies.

No.	Hazard	Mitigation	Dependencies
		no gaps) in the area near the Garda station	
5	Interference from the Garda Station radio systems to the LRT.	Calculate the field strength from the radio systems at the LRV and wayside equipment. Review immunity levels for LRV and wayside equipment.	Details of the Garda radio transmitting power and antenna gain. Details of LRV and wayside equipment immunity levels.
6	Interference from the LRT to the Fire Station radio systems.	Review the radiated emission data for the LRVs to ensure emissions are low at the radio operating frequency. Review the OHL design to ensure it minimises arcing (e.g. no gaps) in the area near the Fire station	Details of the Fire station radio operating frequencies.
7	Interference from the Fire Station radio systems to the LRV line.	Calculate the field strength from the radio systems at the LRV and wayside equipment. Review immunity levels for LRV and wayside equipment.	Details of the Fire Station radio transmitting power and antenna gain. Details of LRV and wayside equipment immunity levels.
8	Interference from LRV line affecting nearby receptors	Ensure LRV meets emission limits in EN 50121-3-1. Ensure wayside equipment and LRV stop equipment meets appropriate emissions standard. Ensure the whole railway meets emissions limits in EN 50121-2. Ensure substations meets emissions limits in EN 50121-2.	
9	Interference from nearby emitters affecting LRVs, wayside equipment, LRVs stop equipment or substations.	Ensure LRV equipment meets EN 50121-3-2 immunity levels. Ensure wayside equipment and LRV stop equipment meets appropriate immunity standard. Ensure substation equipment meets immunity levels in EN 50121-5 or other appropriate immunity standard.	
10	Stray current affecting structures and utilities.	Liaise with utilities to determine potential assets that may be affected. Produce stray current management strategy in line with EN 50122-2 and best practice and addresses any identified utilities assets. Review design to ensure it is aligned with strategy and minimises stray current.	

No.	Hazard	Mitigation	Dependencies
		Inspect installation to ensure stray current mitigates are implemented.	
11	LRV line and associated power supply (substations) exceeding EMF limits	Ensure cable routing and substation design minimise EMF levels Ensure LRT meets the limits in the 'Low Action Levels' of the EMF Directive.	
12	High reading of Soil Resistivity at St Margaret's substation proposed location	To not bury spoil or contaminate the ground during the removal of the pedestrian fly-over	Removal of pedestrian fly-over. Construction methodology

16.6.2 Measures to Manage EMC throughout the Project Lifecycle

16.6.2.1 EMC Control Plan

The EMC Control Plan will set out how EMC will be managed and controlled throughout the life of the proposed Scheme. It will contain (but not limited to):

- Introduction;
- Scope, including relationship and boundary between EMC and EMC-related disciplines (e.g. earthing and bonding and stray current) in the Scheme;
- EMC Management structure and responsibilities;
- Electromagnetic Environment;
- EMC Standards to be met;
- Procedure for assessing equipment that does not meet the required standard (e.g. gap analysis, etc.);
- How EMC hazards will be identified mitigated and managed;
- EMF covering public, staff, and people at particular risk (e.g. pregnant or with active implantable medical devices);
- Tests and measurements required and at what stage of the Scheme they will be performed;
- Design reviews; and
- EMC deliverables and at what stage of the Scheme they will be delivered.

16.6.2.2 EMC Hazard Analysis & Risk Assessment

This document will either be a standalone piece of work or be part of the wider Scheme's Hazard and Risk Analysis. The approach taken will be detail in the EMC Control Plan.

Whatever the approach, the following will be addressed:

- Review the top-level hazards given in Table 16-13 and update as necessary;
- Consider EMI within systems used in the proposed Scheme (Intra EMI);
- Consider EMI between systems used in the proposed Scheme (Inter EMI);
- Consider EMI between the proposed Scheme, third parties and receptors (Extra EMI);
- Identify the EMC Hazards including safety aspects;
- Determine if the design can be changed to eliminate the hazard;
- If the design cannot be changed or a hazard still exists risk assess the hazard; and
- Identify the mitigations needed to reduce the risk to an acceptable level.

16.6.2.3 Stray Current Strategy or Management Plan

This document will give requirements to manage DC stray current that are specific to the proposed Scheme. It will include (but not limited to):

- Introduction;
- Scope;
- Stray current management structure and responsibilities;
- Liaising with affected stakeholders/receptors, particularly utilities with nearby assets;
- Requirements;
- Specific design techniques required for various sections;
- The need for and scope of any DC stray current modelling;
- Design review;
- Construction inspections;
- Final test and measurement; and
- Stray current deliverables and at what stage of the Scheme they will be delivered.

This document will follow the following Reference documents:

- PSD-PS-0003-01 Stray Current Protection Standards; and
- PSD-PS-0007-02 Luas Earthing and Bonding Design Standards.

16.6.2.4 EMC Simulation Studies

The measurement survey (see 16.4.4.2) shows that on the day of the measurements there was not any problem, but it cannot address the unbalanced load situation that can occur from time to time on a power system or the fault conditions on the power system.

Therefore, a computer simulation study of the overhead lines will be carried out as part of the detailed design stage, focusing on sections where they run parallel to or cross the new LRT. This will consider the overhead lines under typical load conditions as well as unbalanced and fault conditions, to predict the possible induced voltages and EMF fields that could be present on the LRT. This would identify if any unsafe voltages or EMF fields could be present on the LRT and any special mitigating measures that might be necessary in the LRT design, e.g. limiting the length of lineside cabling, limiting the length of metallic barriers, or using non-metallic barriers.

Additionally, considering the proximity and relevance of the DART+ West project, where the LRT alignment intersects with future electrified rail lines, this simulation study may be expanded to include interactions with the DART+ infrastructure. This extension will depend on the outcomes of Hazard Identification processes scheduled for a later stage.

16.6.2.5 EMC Test Plans

It is expected that the test organisation has an adequate level of experience and competence to carry out the EMC testing and can produce the detailed test plans in accordance with the proposed Scheme requirements. These test plans will need to be reviewed and agreed to ensure they align with the proposed Scheme requirements before the testing begins.

Test plans should include as a minimum:

- Reason for the measurements;
- Scope;
- Locations;
- Proposed time of measurements;
- Standards that are being used;
- If the standard has more than one way to carry out the measurements the test plan shall clearly state which method is being used;
- Any proposed deviations from the standard;
- List of proposed test equipment;
- Structure of the test report and presentation of the data; and
- Availability of electronic measurement data.

16.7 Residual Impacts

There are no significant residual impacts identified in this study.

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.

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.

16.8 Cumulative Impacts

The cumulative assessment of relevant plans and projects has been undertaken separately in Chapter 24 (Cumulative Impacts) of this EIAR.

16.9 Difficulties Encountered in Compiling Information

No difficulties were encountered in compiling information for this EMC Chapter due to effective data management and the collaborative effort to align with current EMC standards and stakeholder needs.

16.10 References

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