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Chapter 21

Electric and Magnetic Fields

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Genex Kidston Connection Project - Ministerial Infrastructure Designation Assessment Report

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21.0 Electric and Magnetic Fields

21.1 Background Information Regarding Electric and Magnetic Fields

Electric and magnetic fields occur almost everywhere, can exist independently of each other, and can result from both natural sources and human activity. Naturally occurring electric fields result from charged particles in the atmosphere and storm activity, and the electric field strength can vary quite quickly as a result of lightning discharges. The earth's natural magnetic field varies with latitude, and some rocks and minerals are also naturally magnetic.

Unlike most natural electric and magnetic fields, those relevant to transmission lines alternate at the frequency of the alternating current (AC) power transmission system. These fields alternate in magnitude and direction 50 times per second (50 Hz). Although they may occur simultaneously at the same place, the electric and magnetic fields exist independently of one another. These power–frequency fields are commonly referred to as extra low frequency electric and magnetic fields (ELF EMFs).

Household electrical wiring and common appliances (electric blankets, televisions, hair-dryers, computers, etc.) all produce ELF EMF. Background magnetic fields in the home are usually around 0.1 µT and background electric fields in the home can be up to 20 V/m (ARPANSA, 2018). The electric field produced by any source outside the home will be attenuated considerably by the structure of the home, as all common building materials are sufficiently conducting to screen fields (World Health Organization, 2007).

EMFs should not be confused with electromagnetic radiation. EMFs are fundamentally different in their physical nature and in the way they interact with the body (NZ Ministry of Health, 2013). Electromagnetic radiation is a term used to describe the movement of electromagnetic energy through the propagation of a wave (e.g. radio waves, microwaves). This wave is composed of electric and magnetic waves which oscillate (vibrate) in phase with, and perpendicular to, each other (Energy Networks Association, 2016). This is in contrast to EMF, where the electric and magnetic components are essentially independent of one another. EMFs around power lines and electrical appliances are not a form of radiation (NZ Ministry of Health, 2013).

21.2 Sources of Power Frequency Electric and Magnetic Fields

21.2.1 Electric fields

EMFs are produced by all transmission lines, distribution systems, wiring and equipment that use AC electricity. An electric field will exist around any conductor that is energised from the power supply, whether or not there is any load connected to it. The strength of power frequency electric fields depend primarily on the voltage of the system and also on the distances of the point of measurement from the energised conductor and from nearby earthed objects.

High voltage transmission lines may generate fields of several thousand volts per metre (V/m), whereas fields from lower voltage distribution lines will be in the order of hundreds of V/m, and home appliances several tens of V/m or less.

It is important to note that the electric field strength falls quickly with increasing distance from the voltage source. It is also relatively easy to shield electric fields. Trees, shrubs, buildings, human skin and even clothes will shield electric fields.

21.2.2 Magnetic fields

Magnetic fields are produced by, and proportional to, the flow of alternating electric current through conductors. The strength and direction of the field will change with the alternating current at 50 Hz. Transmission line magnetic fields are affected by variables such as line loading, line design, and wire height above ground (Energy Networks Association, 2006). The strength of the magnetic field also decreases rapidly with distance from the source, but it is not practical to provide shielding for magnetic fields (unlike the simple shielding that is possible for electric fields).

However, the magnetic fields generated by the individual conductors in an AC power system can partly cancel each other, depending on their configuration relative to each other. This cancelling effect is greater when the conductors are closer together. It is for this reason that the magnetic field directly

above an underground cable buried 1 to 1.5 m deep can be as high as or higher than the field directly below an equivalently loaded line some 10 m overhead. However, the field strength from the underground cable will usually fall off faster with increasing distance because of the closer proximity of the conductors to one another.

Magnetic fields are measured using a gaussmeter, in a unit of microtesla (μT) or milligauss (mG). 1 Microtesa (μT) equals 10 milligauss (mG).

Typical magnetic fields, measured at normal user distance from common household appliances, some overhead lines and associated infrastructure are outlined in Table 21-1. The data in Table 21-1, from the Energy Networks Association, shows that power frequency magnetic fields are not just associated with high voltage transmission lines but are found everywhere in modern society with its almost universal reliance on electricity.

Table 21-1 Typical magnetic field ranges (Energy Networks Association, 2016)

Item	Range of Measurements in μT
Electric stove	0.2 - 3
Refrigerator	0.2 - 0.5
Electric kettle	0.2 - 1
Toaster	0.2 - 1
Television	0.02 - 0.2
Personal computer	0.2 - 2
Electric blanket	0.5 - 3
Hair dryer	1 - 7
Pedestal fan	0.02 - 0.2
Switching Station (at fence)	0.1 - 0.8
Distribution Line	
Under line	0.2 - 3
10 away	0.05 - 1
Transmission Line	
Under line	1 - 20
Edge of easement	0.2 - 5

21.3 Existing Environment

21.3.1 Existing field strengths in and around the Preferred Alignment

The proposed transmission line will be co-located with Ergon Energy's Greenvale 66 kV line for approximately 90 km and with Ergon's Kidston 132 kV line for approximately 52 km. EMF generated from this infrastructure has been incorporated into the modelling undertaken by Powerlink described below.

There are no other material sources of 50 Hz EMF in close proximity of the Preferred Alignment.

21.3.2 Possible receptors in proximity to the Project

There is one sensitive receptor within 500 m of the Preferred Alignment (Figure 3-2, Chapter 3 Project Description). This has been identified as an old tin mine immediately on the northside of the Ergon 66kV line within 'Kilclooney' station. The mine is thought to have been established between 1900-1950 and is now used as a private campsite with several buildings that have services connected. The Preferred Alignment for the transmission line is located on the southern side of the 66 kV line and is approximately 100 m from the camp site.

It is not expected that any persons other than Powerlink employees or contractors would spend any significant periods of time close to the transmission infrastructure.

21.4 Potential Impacts

21.4.1 Estimated EMF associated with the Project

Powerlink has undertaken an EMF assessment for a proposed 275 kV double circuit transmission line co-located with Ergon Energy's Ross-Kidston 132 kV line. Both lines are modelled at full load.

EMF levels on Powerlink's proposed transmission line where it is co-located with Ergon Energy's Greenvale 66 kV line have not been shown as the EMF levels are reduced due to the lower voltage and line loading.

21.4.1.1 Electric field

Where the proposed transmission line is co-located with the 132 kV line, it was calculated that the maximum expected combined electric field would be approximately 2700 volts per metre (V/m). The electric field at the edge of the proposed 60 metre wide transmission line easement was estimated to be < 100 V/m (Figure 21-1). This is significantly below internationally recognised EMF guidelines for established health effects (Section 21.4.2.3).

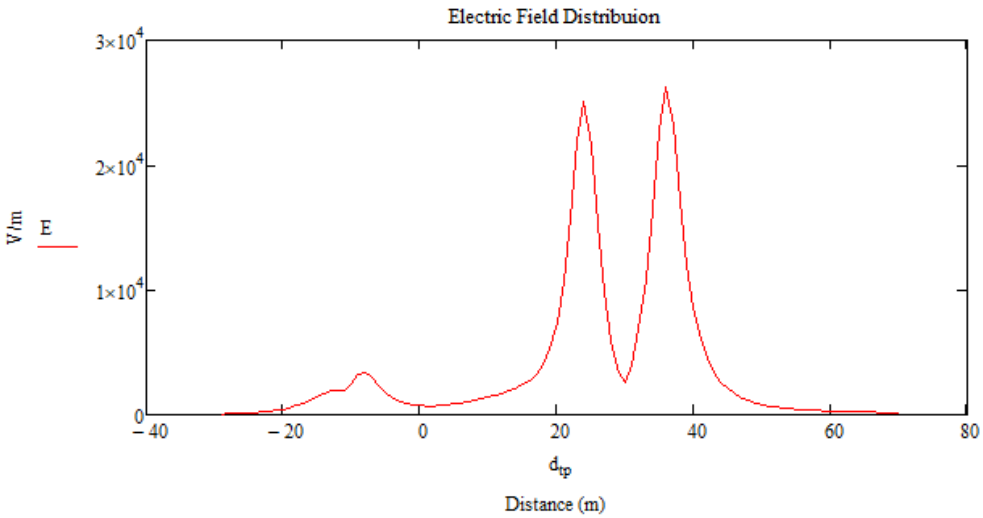

Figure 21-1 Estimated electrical field - co-located with the 132 kV line

21.4.1.2 Magnetic field

Where the proposed transmission line is co-located with the 132 kV line, it was calculated that the maximum expected combined magnetic field would be approximately 250 milligauss (mG). The magnetic field at the edge of the 60 m wide transmission line easement was estimated to be approximately 33 mG (Figure 21-2). This is significantly below internationally recognised EMF guidelines for established health effects (Section 21.4.2.3).

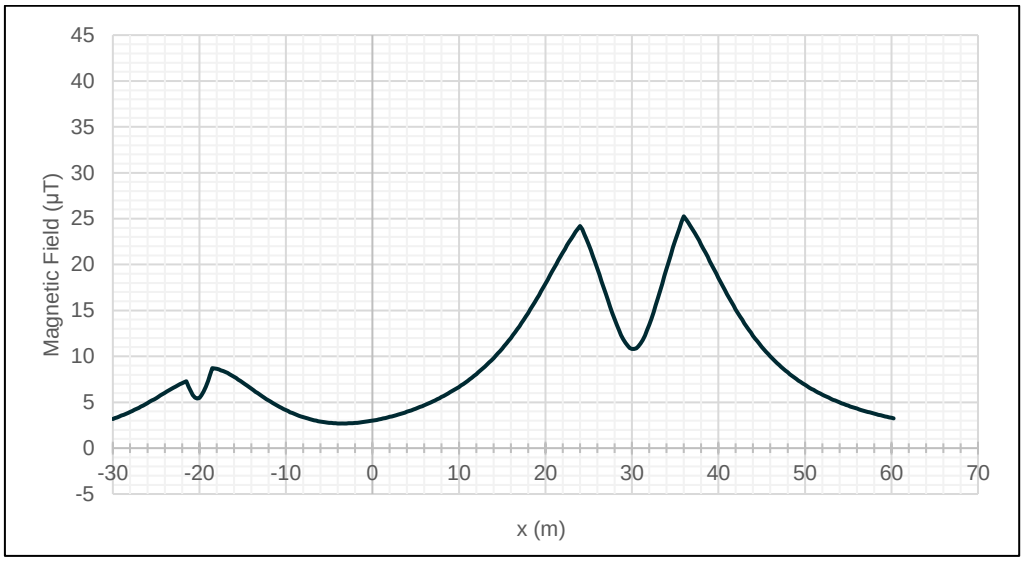

Figure 21-2 Estimated magnetic field – co-located with the 132kV line

21.4.2 Health

21.4.2.1 Research

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a Commonwealth Government agency charged with the responsibility for protecting the health and safety of people and the environment from EMF.

Research into EMF and health is a complex area involving many disciplines, from biology, physics and chemistry to medicine, biophysics and epidemiology. Research on EMFs and health has been conducted for over 40 years, including over 2,900 studies at a cost of more than $490 million internationally (Energy Networks Association, 2016).

The research has generally focused on the magnetic fields with two main areas of research, epidemiology and laboratory studies. Both areas would need to provide links between EMFs and adverse health effects for causality to be accepted by health authorities.

- **Epidemiology (population):** This research looks at statistics to see if there are patterns of disease in large groups of people. The difficulty with large statistical studies is that they take several years to produce meaningful results and even then, there are different opinions about how the results should be interpreted. There may be other factors in the study which could complicate the interpretation of the results. Scientists generally agree that epidemiological studies aren't strong enough by themselves to establish that adverse health effects exist.
- **Laboratory:** In the laboratory researchers have studied animal cells, as well as human volunteers under controlled circumstances to see if EMFs have any effects. There have been many hundreds of these studies, and scientists look for results which can be successfully repeated in different laboratories. In over 40 years of research there have been no such consistently reproducible results for exposures below the guidelines.

It is well accepted by scientists that no one study considered in isolation will provide a meaningful answer to the question of whether or not EMF can contribute to adverse health effects. In order to make an informed conclusion from all of the research, it is necessary to consider the science in its totality. All of the research is reviewed periodically by expert panels which are established by national or international bodies with the purpose of trying to determine whether or not human exposure to EMF is related to adverse health effects.

21.4.2.2 General research findings

There is no established evidence that exposure to magnetic fields from powerlines, switching station, transformers or other electrical sources, regardless of the proximity, causes any health effects (ARPANSA, 2015). Generally, homes that are more than 50 m from a high voltage powerline are not expected to have higher than typical magnetic fields. For switching stations and transformers, the magnetic fields at distances of 5-10m away are generally indistinguishable from typical background levels in the home (ARPANSA, 2015).

The following provides advice from credible public health authorities regarding the potential health impacts from EMF.

- ARPANSA: There is no established evidence that ELF EMF is associated with long term health effects. There is some epidemiological research indicating an association between prolonged exposure to higher than normal ELF magnetic fields (which can be associated with residential proximity to transmission lines or other electrical supply infrastructure, or by unusual domestic electrical wiring), and increased rates of childhood leukaemia. However, the epidemiological evidence is weakened by various methodological problems such as potential selection bias and confounding. Furthermore this association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed (ARPANSA, 2018).
- World Health Organisation: Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the World Health Organisation concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields (World Health Organization, 2018).
- US National Cancer Institute: Studies have examined associations of these cancers with living near power lines, with magnetic fields in the home, and with exposure of parents to high levels of

magnetic fields in the workplace. No consistent evidence for an association between any source of non-ionizing EMF and cancer has been found. There was no evidence that electrical utility workers who were exposed to pulsed electromagnetic fields produced by power lines were more likely to develop brain tumours or leukaemia than the general population (National Cancer Institute, 2016).

- Health Canada: There have been many studies on the possible health effects from exposure to EMFs at ELFs. While it is known that EMFs can cause weak electric currents to flow through the human body, the intensity of these currents is too low to cause any known health effects. Some studies have suggested a possible link between exposure to ELF magnetic fields and certain types of childhood cancer, but at present this association is not established (Government of Canada, 2016).

21.4.2.3 EMF Guidelines for established health effects

The two internationally recognised exposure guidelines are:

- International Commission in Non-Ionizing Radiation Protection (ICNIRP) 2010
- International Committee on Electromagnetic Safety, Institute of Electrical and Electronics Engineers (IEEE) 2002.

ARPANSA aligns with the ICNIRP guidelines for the protection of people from exposure to ELF EMF, which recommends a magnetic field public exposure limit is 200 microtesla (2,000 mG). The IEEE Standard recommends a magnetic field public exposure limit is 904 microtesla (9,004 mG).

Magnetic field exposure limits are intended to prevent the occurrence of synaptic effects perceived as magneto-phosphenes in the sensitive retinal tissue. While this phenomenon is not itself considered an adverse health effect, it is related to synaptic effects in specialised neural tissue, and since similar effects could possibly occur elsewhere in the central nervous system, particularly the brain, expert groups have advised that exposure involving the head should be below this level (Energy Networks Association, 2016).

Electric field exposure limits are intended to protect against synaptic effects (ICNIRP, 2010) and micro-shocks (IEEE, 2002), with both organisations reporting a public exposure limit of 5000 V/m. Micro-shocks may involve a spark discharge that occurs either immediately before making contact with a grounded conductor, or when a grounded person touches a charged isolated conductor. The public exposure level is similar to that experienced from spark discharges when touching, for example, a door handle after acquiring static from crossing a carpet or getting out of a car seat (Energy Networks Association, 2016).

The Powerlink technical assessment estimated that both the electric field and magnetic field strength for the co-located lines would be well below the relevant internationally recognised guidelines administered by the ICNIRP (Section 21.4.1).

21.4.2.4 Persons working on or under high voltage transmission lines

It is not expected that any persons other than Powerlink employees or contractors would spend any significant periods of time within or close to the transmission infrastructure. Powerlink employees and contractors working within the easement will do so in accordance with relevant health, safety and environmental guidelines and procedures, as will those working on the structures themselves.

As the Project traverses rural properties, it is likely that landholders engaged in land management or agricultural activities will spend time adjacent to or occasionally cross under the Powerlink transmission line. Such persons may be subjected temporarily to a higher ELF magnetic field than they might experience in their home, but such exposure will be well within the limits in current international health guidelines (Section 21.4.2.3).

21.4.2.5 Interference with implanted medical devices

There are no known instances of adverse effects on pacemaker users around power lines, or in other areas where exposure limits comply with the ICNIRP reference levels for the public (NZ Ministry of Health, 2013). A very small proportion of cardiac pacemakers have been found to be sensitive to 50/60 Hz electric and magnetic fields close to the ICNIRP limits for public exposure and it is most likely that they will revert to a fixed pacing mode, which poses no immediate threat to the wearer (NZ Ministry of Health, 2013).

Users of implanted medical devices such as pacemakers and defibrillators are typically issued with warnings regarding the effects of electric and magnetic fields including those from electric arc welders and magnetic resonance imaging (MRI) devices.

The United Kingdom's Department of Health's Medicines and Healthcare Products Regulatory Agency (MHRA) does not consider that transmission line EMFs constitute a significant hazard to the operation of pacemakers (Department of Energy and Climate Change, 2011).

21.4.2.6 Corona ion discharge

In addition to the 50 Hz electric fields themselves, there is a related phenomenon known as corona. Corona is a localised electrical discharge which can occur due to very high localised electric fields in the vicinity of sharp edges on energised conductors and fittings. Corona leads to the generation of ions in the air, as well as audible and radio frequency noise. Transmission lines are designed as far as possible to minimise corona but some level of corona generally remains in certain environmental conditions. In Australia most transmission and distribution lines are designed to have surface voltage gradients under normal operating conditions which are much less than the levels where an increased frequency of corona ions are formed (Energy Networks Association, 2009).

Some research studies suggested that generated ions attached to pollutants in the air and drifted away from the power line for distances possibly up to few kilometres. It has been postulated by physicist Denis Henshaw that these ions may be inhaled or deposited on the skin of a person nearby and could lead to enhanced pollutant absorption to people living near powerlines with possible health impacts.

Henshaw's theoretical mechanisms involving corona ions and pollutant particles have not been proven by health studies on real populations near transmission lines. The following provides a summary of the findings of relevant studies.

- National Radiological Protection Board (NRPB) UK (and subsequently confirmed by the World Health Organization): It seems unlikely that corona ions would have more than a small effect on the long-term health risks associated with particulate air pollutants, even in the individuals who are most affected (NPRB, 2004) (World Health Organization, 2007).
- Bracken Study: Based on this study, AC transmission lines appear to have a minor impact on potential long-term exposure to space charge (ions and/or charged aerosols) beyond the ROW (right of way) (Bracken, 2005).
- Queensland University of Technology: The research has shown that large sections of overhead high voltage transmission lines in South-East Queensland are essentially corona-free. The resulting ion concentrations are rarely high enough to be of any concern with regards to health effects. Both air ion and charged particle concentrations decrease rapidly with distance from the lines and merge with background values within a distance of about 200 m from the lines (Fatokun, 2208) (Jayaratne, 2008).

21.4.3 Potential exposure to Project EMF

The advice of recognised health authorities is that whilst a causal link has not been established between human health and exposure to power frequency electric and magnetic fields, prudent avoidance should be exercised in relation to EMF exposure.

Note that EMF retains an IARC (International Agency for Research on Cancer) classification of 2B - Possible Carcinogen. This category is used when there is limited evidence of carcinogenicity in humans and less than sufficient evidence in experimental animals. Whilst this terminology is quite strong and alarmist to the general reader, it should be noted that it retains this classification since the scientific evidence collated and peer reviewed over many years cannot categorically rule out a link between exposure and cancers. It should also be noted that many other day to day common exposure items are categorised in Category 2B including items like coffee, soaps, perfumes etc.

Powerlink has adopted the policy of prudent avoidance in response to this issue and this is consistent with the above advice. For the current Project, it has been possible to select a Preferred Alignment which is remote from frequented locations and this is entirely consistent with the application of prudent avoidance.

There is one sensitive receptor approximately 100 m from the proposed transmission line (Section 21.3.2). At this distance, no detectable EMF would exist as a result of the construction and operation

of the transmission line (Section 21.4.2.2). Detectable fields are likely to be present only as a result of local distribution lines and domestic wiring and appliances.

It is not expected that any persons other than Powerlink employees or contractors would spend any significant periods of time adjacent to or close to the transmission infrastructure. As the Project traverses rural properties, it is likely that landholders engaged in land management or agricultural activities will spend time in or occasionally cross under the Powerlink transmission line. Such persons may be subjected temporarily to a higher ELF magnetic field than they might experience in their home, but such exposure will be well within the limits in current international health guidelines.

21.4.4 Other potential impacts

21.4.4.1 Induction in adjacent metal objects

The electric field generated by a transmission line can induce a charge in a sufficiently large metal object that is insulated from the earth. A person touching it could discharge the object to earth and experience ‘microshock’. Powerlink will assess the potential for such situations and propose mitigation measures for any objects near the transmission line that may be affected.

There is also the possibility that a transmission line could cause induction on fences (including electric fences) running parallel to the line for a sufficient distance. The inductive coupling between the transmission line and the fence wire could induce currents and voltages in the fence wire. Powerlink will provide mitigation measures to assist the owner of any fence induction mitigations or assistance with electric fence installations that might be adversely affected.

Powerlink have prepared a short information sheet to assist with safe operation of electric fencing near electricity transmission line. The information sheet is included in Appendix G. The information sheet outlines recommended separation distances and fence hardware, and most importantly, it encourages landholder to contact Powerlink regarding their proposed electric fencing arrangement so that technical advice can be provided.

Coupling between the transmission lines and other conductive infrastructure running parallel to them could result in induced voltages and currents, especially in the event of fault conditions. Conductive infrastructure, such as pipelines and rail, are not known to be present in proximity to the Preferred Alignment (Chapter 24 Infrastructure). However, as the transmission line traverses through a number of agricultural properties, there is the potential for unmapped private infrastructure is present. Powerlink will provide mitigation measures to assist the owner of any conductive infrastructure that might be adversely affected.

21.4.4.2 Potential for impact on crops and livestock

In more than 50 years of operating high voltage transmission lines across Queensland, Powerlink and its predecessor have no known instance of detrimental effects on crops or livestock from exposure to EMF.

The United Kingdom’s National Policy Statement for Electricity Networks Infrastructure states that there is little evidence that exposure of crops, farm animals or natural ecosystems to transmission line EMFs has any agriculturally significant consequences (Department of Energy and Climate Change, 2011).

The Australian Government National Standard for Organic and Bio-Dynamic Produce (Edition 3.7, 2016) does not mention powerlines, electric or magnetic fields (Department of Agriculture and Water Resources, 2016). Section 1.25.2 of the Standard states that “Bio-dynamic Preparations are to be stored in a suitable container away from fumes, electricity, contamination sources.” The Project is not located within close proximity of any known storage areas and is therefore not considered to impact on organic or bio-dynamic certification.

21.4.4.3 Radio and television interference

The corona discharges from points of high local electric field strength on transmission lines, described in Section 21.4.2.6, can generate high–frequency fields in a broad band in the radio spectrum from a few hundred kilohertz (kHz) up to several megahertz (MHz). These radio frequency fields may cause interference with radio broadcast reception at locations near the transmission line. There should not be any significant problem if the correct line hardware design is used.

This form of interference is also subject to statutory limits imposed in accordance with Australian Standards. The proposed transmission line will be designed to meet these standards. In the event

that corona–induced interference becomes a problem, Powerlink will arrange to undertake any necessary remedial work.

Overhead transmission lines may also cause some degree of shielding of radio and television signals for receivers near the line, which may cause reception difficulties in areas of weak signal strength. Powerlink will assist people experiencing reception problems caused by the transmission line by providing advice and, if necessary, signal amplification equipment.

21.5 Mitigation and Management Measures

There is one sensitive receptor within 500 m of the Preferred Alignment. This has been identified as an old tin mine immediately on the northside of the Ergon 66kV line within ‘Kilclooney’ station, which is occasionally used as a private weekender. The Preferred Alignment is located on the southern side of the 66 kV line and is approximately 100 m from the camp site. At this distance there will be no measurable increase in EMF over typical background levels.

Powerlink has adopted the policy of prudent avoidance with regards to EMF, and the following mitigation measures are proposed to reflect this.

- Should radio or television interference be identified, Powerlink can assist people experiencing reception problems caused by transmission line by providing advice and, if required, signal amplification equipment.
- Powerlink will assess the potential for induced charge in proximal metal objects, and propose mitigation measures for any objects in or near the easement that may be affected.
- Where the possibility that a transmission line could cause interference with the operation of an electric fence running parallel to the line, Powerlink will provide mitigation measures to assist the owner of any electric fence installation that might be adversely affected. Powerlink have prepared a short information sheet (Appendix G) which outlines recommended separation distances and fence hardware, and most importantly, it encourages landholder to contact Powerlink regarding their proposed electric fencing arrangement so that technical advice can be provided.
- In the event that corona–induced interference becomes a problem, Powerlink will arrange to undertake any necessary remedial work.