Appendix AA

EMF assessment

aurecon

Project: City East Zone Substation and Integrated Commercial Development

EMF Assessment

Prepared for: Ausgrid

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1. Introduction

1.1 Background, site and project description

It is understood that Ausgrid is proposing to establish an indoor 132/11kV Zone Substation (City East Zone Substation) on the site of an existing thirteen-storey building at 33 Bligh Street in the Sydney CBD. The site has street frontages to both Bligh & O'Connell Streets and the overall development will incorporate commercial office floors above the substation levels. An aerial view of the project site (highlighted in red) and adjacent properties are shown in Figure 1.1. It can be seen that the neighbouring properties include

- On the southern side: several commercial/office buildings of similar height to the existing Ausgrid building.
- On the northern side, O'Connell Street frontage: a commercial office building of similar height to the existing Ausgrid building.
- On the northern side, mid-way between O'Connell and Bligh Streets: a high rise office tower.
- On the northern side, Bligh Street frontage: a small sandstone building, 3-4 storeys high.

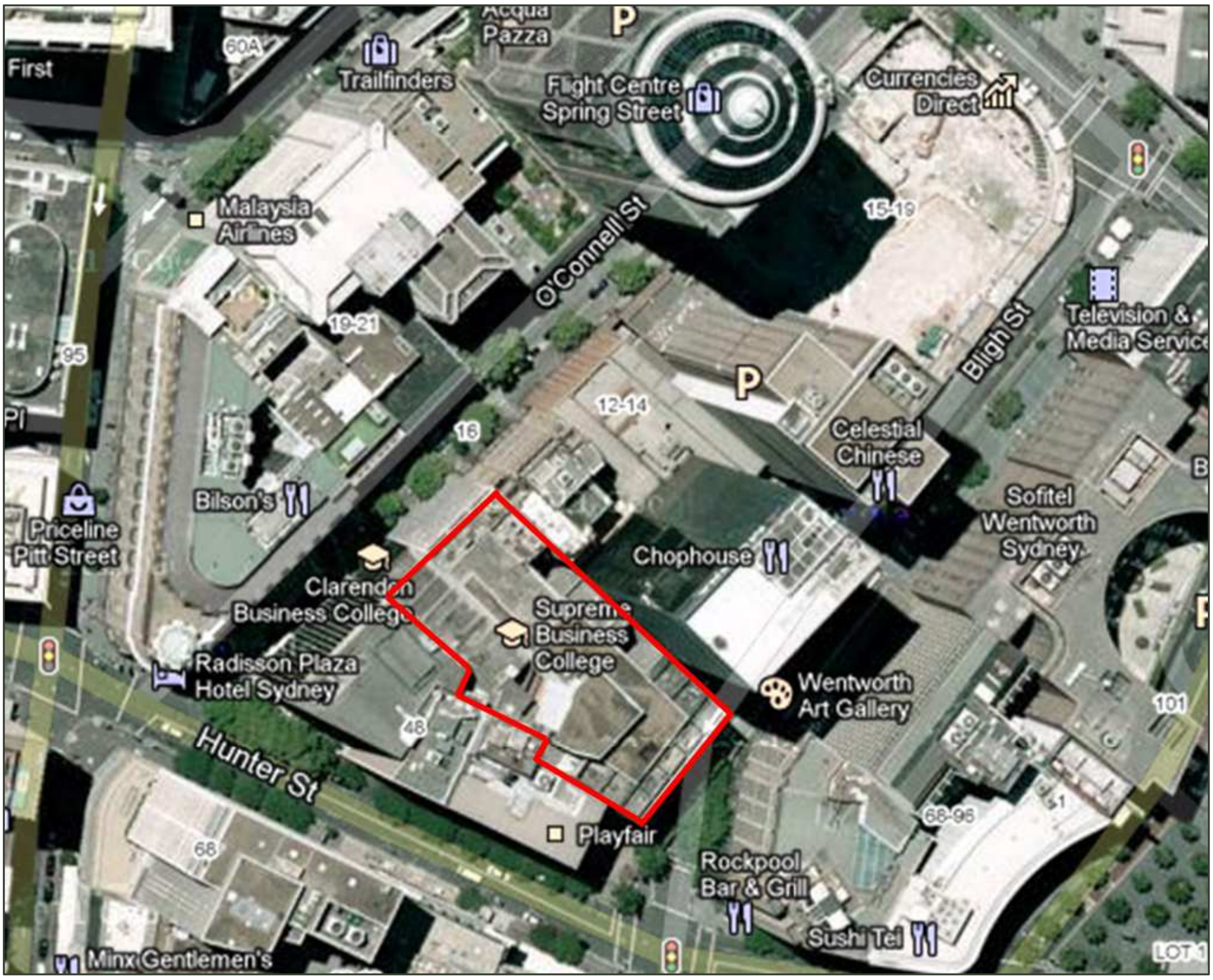

Figure 1.1 – Aerial View of Proposed Works Location

The substation equipment and connections, together with two levels of car parking will occupy the lower and basement levels of the new building and the commercial office will sit over it, with two levels of building plant in between. Vehicular access to the transformer roadway and car park will be provided from O'Connell St and the main pedestrian access to the office levels (through the lower lift foyer) will be from Bligh St, which is approx. 6 metres higher than O'Connell Street. A section through the substation, viewed from the Bligh Street end, is shown in Figure 1.2

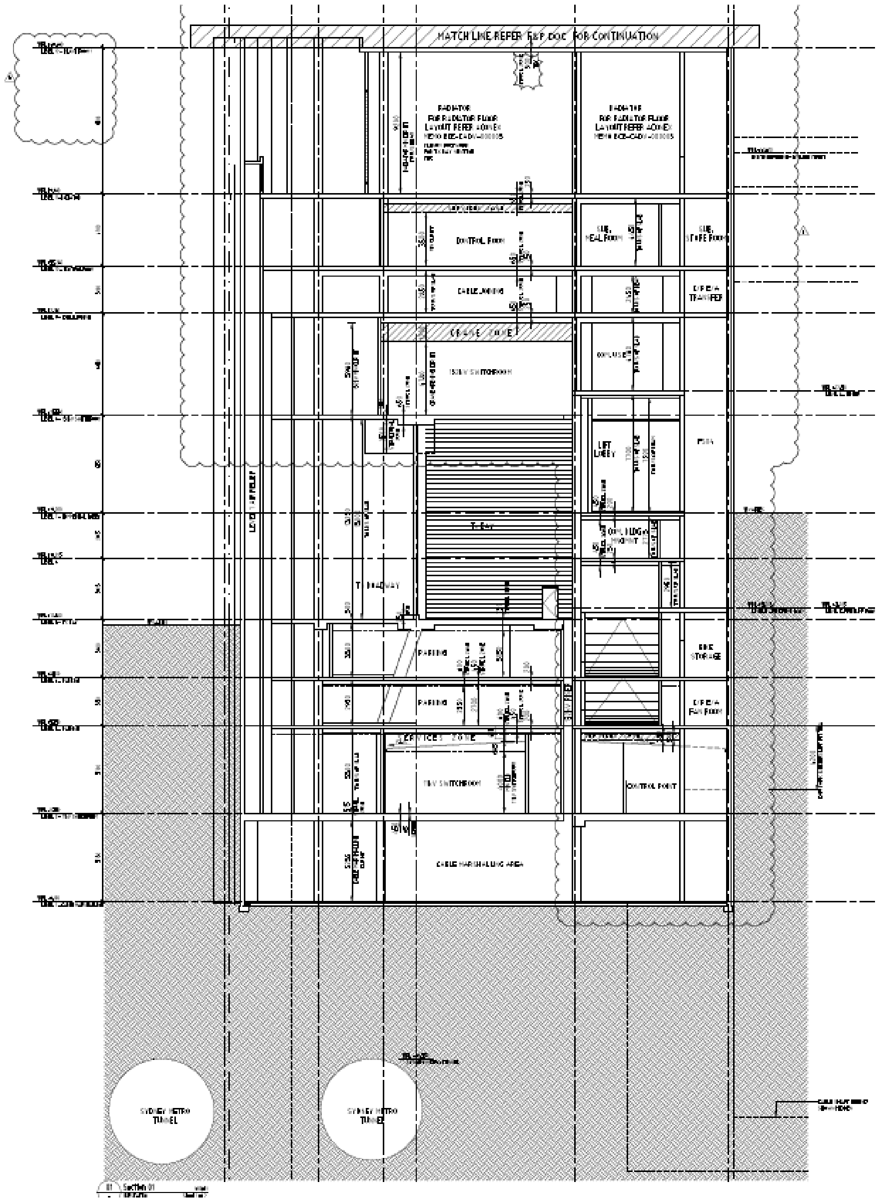

Figure 1.2 – Cross section viewed from Bligh Street end

In more detail:

- The 132kV feeders will enter from a cable tunnel some distance below the O’Connell Street level.
- The cable marshalling area will be 4 levels below the O’Connell Street level.
- The 11kV switchgear will be 3 levels below the O’Connell Street level.
- The two parking levels will be immediately below the O’Connell Street level.
- The transformers will be at the O’Connell Street level with the transformer void area occupying three levels
- The Bligh Street level, two floors above O’Connell Street will contain a lift lobby providing access to lifts connecting to the main entrance foyer of the commercial building some 45 metres above
- the level above Bligh Street will contain the 132kV switchgear
- The next three levels will contain cabling, control room and capacitors, and cooling radiators respectively

Layouts of the O'Connell and Bligh Street levels are shown in Figures 1.3 and 1.4 respectively

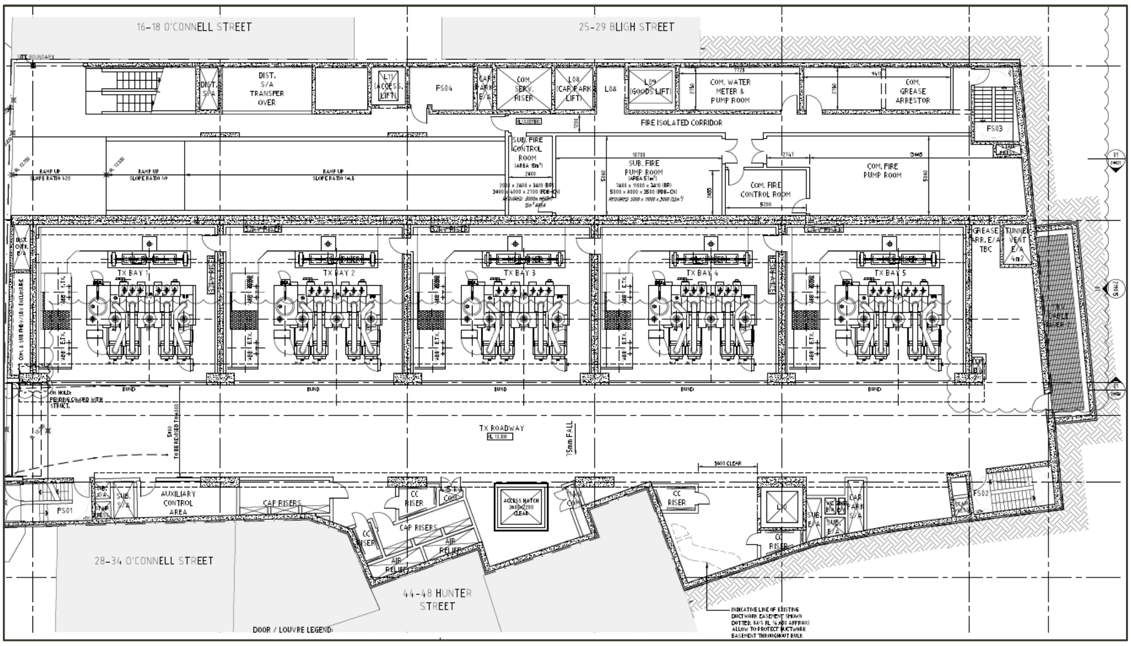

Figure 1.3 – City East ZS Plant Layout Level 5 (O'Connell Street)

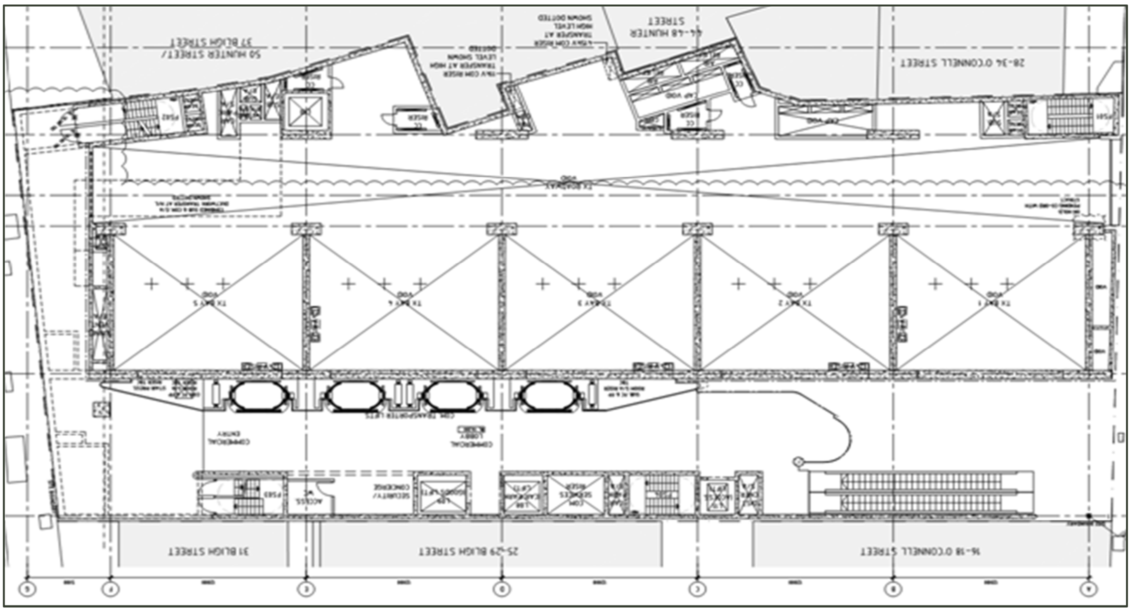

Figure 1.4 – City East ZS Plant Layout Level 7 (Bligh Street)

The proposed electrical works relevant to this assignment include:

- Installation of five 50MVA 132/11kV gas-insulated transformers;
- Installation of 132kV cabling from underground cable tunnels, via the 132 kV switchroom to the transformers;
- Installation of indoor 132kV gas-insulated switchgear;
- Installation of transformer tails to the 11kV switchroom;
- Installation of indoor 11kV switchgear;
- Installation of 24 x 4MVAR capacitor banks and associated cabling
- Installation of 72 outgoing 11kV underground feeders;

1.2 Scope of Assignment

In connection with the above works, Ausgrid has engaged Aurecon to undertake the following:

- Measurement of existing magnetic fields along the boundaries of the site.
- Perform calculations to make reasonable predictions of the electric and magnetic field levels to be associated with the proposed substation, under ultimate loading conditions.
- An assessment of the compliance of the proposed works with relevant national and international EMF guidelines.
- An assessment of the proposed design against precautionary and prudent avoidance principles as defined in the relevant guidelines.
- Advice regarding further magnetic field mitigation options if appropriate.

It is understood that the results of the above work will be used to assist Ausgrid with their environmental assessment of the proposed works.

1.3 Structure of Report

The remainder of Section 1 provides background information, including a brief overview of the EMF and human health issue and our modelling is presented in Sections 2 and 3. Section 4 addresses Ausgrid's design in the context of compliance with EMF standards and precautionary/prudent avoidance principles. Conclusions are presented in Section 5 and a list of reference documents is contained in Section 6.

1.4 General Description of Electric and Magnetic Fields

The electric and magnetic fields associated with electrical equipment are essentially independent of one another. The electric field is associated with the voltage of the equipment and the magnetic field is associated with the current (amperage). In combination, these fields cause energy to be transferred along electric wires.

An **electric field** is a region where electric charges experience an invisible force. The strength of this force is related to the voltage, or pressure, which forces electricity along wires. Electric fields are strongest close to their source, and their strength diminishes rapidly with distance from the source, in much the same way as the warmth of a fire decreases with distance. Many common materials - such as brickwork or metal - block electric fields, so they are readily shielded and, for all practical purposes, do not penetrate buildings. They are also shielded by human skin, such that the electric field inside a human body will be at least 100,000 times less than the external field (Ref 1).

Being related to voltage, the electric fields associated with transmission lines and electrical equipment in substations remain relatively constant over time, except where the operating voltage changes.

A **magnetic field** is a region where magnetic materials experience an invisible force produced by the flow of electricity (known as the electric current and measured in Amperes or amps). As magnetic fields are related to the current rather than the voltage, high voltage equipment is not the only source of magnetic fields encountered in everyday life. Modern life involves frequent contact with magnetic fields from a variety of sources such as appliances in the home and workplace and electrical machinery.

The strength of a magnetic field depends on the size of the current (measured in amps), and decreases with distance from the source. While electric fields are blocked by many common materials, this is not the case with magnetic fields. This is why locating equipment in enclosures or underground will eliminate any external electric field but not the magnetic fields.

The magnetic field strength resulting from an electrical installation varies continually with time and is affected by a number of factors including:

- The total electrical load
- The size and nature of the equipment
- The design of the equipment
- The layout and electrical configuration of the equipment and its interaction with other equipment.

1.5 Overview of EMF and Human Health

The possibility of adverse health effects due to the EMFs associated with electrical equipment has been the subject of extensive research throughout the world. To date, adverse health effects have not been established, but the possibility remains that they may exist.

While EMFs involve both electric and magnetic components, electric fields are relatively constant over time, are readily shielded and, in the health context, are generally no longer associated with the same level of interest as magnetic fields. Accordingly, the major focus of the remainder of this report is on magnetic fields.

Research into EMFs and health is a complex area involving many scientific disciplines - from biology, physics and chemistry to medicine, biophysics and epidemiology. Many of the health issues of interest to researchers are quite rare. In this context, it is well accepted by scientists that no study considered in isolation will provide a meaningful answer to the question of whether or not EMFs 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. Over the years, governments and regulatory agencies around the world have commissioned independent scientific review panels to provide such overall assessments.

The most recent scientific reviews by authoritative bodies are reassuring for most potential health issues. However, statistical associations[1] between prolonged exposure to elevated magnetic fields and childhood leukaemia have persisted. This led the International Agency for Research on Cancer (IARC) (Ref 2) in 2001 to classify magnetic fields as a "possible carcinogen".[2]

The fact that, despite over 20 years' laboratory research, no mechanism for an effect has been established, lends weight to the possibility that the observed statistical associations reflect some factor other than a causal relationship. This point is made in the 2001 report of the UK National Radiological

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[1] *It should be noted that a statistical association does not necessarily reflect a cause and effect relationship.*

[2] *IARC publishes authoritative independent assessment by international experts of the carcinogenic risks posed to humans by a variety of agents, mixtures and exposures. These agents, mixtures and exposures are categorised into 5 groups, namely:*

- *Group 1 -the agent is carcinogenic to humans-107 agents are included in the group, including asbestos, tobacco and ultra violet radiation;*
- *Group 2A - the agent is probably carcinogenic - 59 agents have been included in this group, including diesel engine exhaust, creosotes and PCBs;*
- *Group 2B - the agent is possibly carcinogenic to humans - 267 agents have been included in this group, including coffee, gasoline, lead, nickel, petrol engine exhaust and extremely low frequency magnetic fields;*
- *Group 3 - the agent is not classifiable as to carcinogenicity - 508 agents have been included in this group, including caffeine, coal dust and extremely low frequency electric fields;*
- *Group 4 - the agent is probably not carcinogenic to humans - only 1 agent (caprolactam) has been included in this group.*

Protection Board's (NRPB) Advisory Group, chaired by eminent epidemiologist, the late Sir Richard Doll (Ref 3).

> *"in the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children"* (page 164).

1.6 Health Standards

Until a few years ago, the relevant Australian health standard was the document called 'Interim Guidelines on Exposure to 50/60 Hz Electric and Magnetic Fields' (1989) (Ref 4), issued by the National Health and Medical Research Council (NHMRC) and based on international guidelines[3]. As the NHMRC has not updated its guidelines since their original issue, they have lapsed and the relevant Australian regulator (now ARPANSA) has been developing a new standard for several years. In December, 2006, ARPANSA issued a Draft Standard on "Exposure Limits for Electric and Magnetic Fields (0Hz to 3kHz)" for public comment (Ref 5). The Draft Standard proposed a magnetic field exposure limit (Reference Level) for the general public of 1000 milligauss (mG), which is numerically identical[4] to the previous (Australian) NHMRC Guidelines but only 50% of the current (2010) version of the international (ICNIRP) guidelines (Ref 6), upon which they were based. It is understood that, as a result of submissions received in response to the 2006 Draft, the Australian Government Radiation Health Committee, at its meeting of 18th July, 2007 (Ref 7), resolved, inter alia, to revise the magnetic field limit for the general public upwards to 3000mG.

In the absence of a current Australian standard, while noting the possible adoption of a 3000mG limit in the new ARPANSA Standard, we have favoured the current international (ICNIRP) guideline level of 2000mG[5] for this assessment.

In applying the ICNIRP Guideline, it is important to recognise that the numerical limits, e.g. 2000mG, are based on established health effects. In ICNIRP's fact sheet on the guidelines (Ref 8), it notes that:

> *"It is the view of ICNIRP that the currently existing scientific evidence that prolonged exposure to low frequency magnetic fields is causally related with an increased risk of childhood leukaemia is too weak to form the basis for exposure guidelines. Thus, the perception of surface electric charge, the direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes are the only well established adverse effects and serve as the basis for guidance."*

Being based on established biological effects (which occur at field levels much higher than those normally encountered in the vicinity of electrical equipment), the (numerical) exposure limits in the guidelines and standards cannot be said to define safe limits for possible health effects, should these exist, from fields at levels normally encountered in the vicinity of electrical equipment. Nevertheless, in the Foreword to the ARPANSA Draft Standard, the CEO of ARPANSA, Dr John Loy notes that "the incorporation of arbitrary additional safety factors beyond the limits of the Standard is not supported". It is in this context that precautionary measures such as "Prudent Avoidance" have arisen.

1.7 Prudent Avoidance

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[3] *The relevant international guidelines are those issued by the International Commission on Non-ionising radiation Protection (ICNIRP). These were first issued in 1988, have been regularly updated since, and were most recently re-issued in 2010.*

[4] *In line with the international guidelines, this limit is now independent of duration of exposure. Previous relaxations for shorter term exposures no longer apply.*

[5] *The corresponding occupational guideline level is 10000mG.*

With regard to the potential health effects from magnetic fields, while compliance with the relevant guideline is important in addressing established health effects, it does not necessarily address possible health effects, should they exist, from fields at levels normally encountered in the vicinity of electrical equipment. The possibility of such effects has been comprehensively studied over several decades worldwide but, to this day, there is no clear understanding of whether or not electric or magnetic fields at low levels can pose a threat to human health.

Since the late 1980s, many reviews of the scientific literature have been published by authoritative bodies. There have also been a number of Inquiries such as those by Sir Harry Gibbs in NSW (Ref 9) and Professor Hedley Peach in Victoria (Ref 10). These reviews and inquiries have consistently found that:

- Adverse health effects have not been established.
- The possibility cannot be ruled out.
- If there is a risk, it is more likely to be associated with the magnetic field than the electric field.

Both Sir Harry Gibbs and Professor Peach recommended a policy of prudence or prudent avoidance, which Sir Harry Gibbs described in the following terms:

> *"…. [doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk …"*

In 1999, the (US) National Institute of Environmental and Health Sciences (NIEHS) (Ref 11) found:

> *"In summary, the NIEHS believes that there is weak evidence for possible health effects from ELF-EMF exposures, and until stronger evidence changes this opinion, inexpensive and safe reductions in exposure should be encouraged." (page 38)*

The practice of 'prudent avoidance' has been adopted by the (Australian) Energy Networks Association (ENA) and most Australian power utilities, including Ausgrid.

In the Australian context, the Draft ARPANSA Standard addresses the matter of prudent avoidance in an Annex entitled *"A Public Health Precautionary Approach to ELF Fields".* The Annex states:

> *[Prudent avoidance] "does not imply setting exposure limits at an arbitrarily low level, and requiring that they be achieved regardless of cost, but rather adopting measures to reduce public exposure to ELF fields at modest cost."*

Section 5.7 of the Draft addresses "Protection of the General Public" and relevantly stipulates:

> *"Measures for the protection of the general public who may be exposed to ELF and/or static fields due to their proximity to high ELF and/or static sources must include the following: …… Minimising, as appropriate, ELF and/or static electric and magnetic field exposure, provided this can be readily achieved without undue inconvenience and at reasonable expense. Any such precautionary measures should follow good engineering and risk minimisation practice. ……………The incorporation of arbitrary additional prescriptive safety factors beyond the exposure limits of this Standard is not supported."*

Internationally, the World Health Organisation has also addressed the notion of prudence or precaution on several occasions, including in its 2007 publication Extremely low frequency fields. Environmental Health Criteria , Vol 238 (Ref 1), which states:

> *"…..the use of precautionary approaches is warranted. However, it is not recommended that the limit values in exposure guidelines be reduced to some arbitrary level in the name of precaution. Such practice undermines the scientific foundation on which the limits are based and is likely to be an expensive and not necessarily effective way of providing protection."*

It also states:

> ***"**Provided that the health, social and economic benefits of electric power are not compromised, implementing very low-cost precautionary procedures to reduce exposure is reasonable and warranted."*

Given the inconclusive nature of the science, it is considered that a prudent approach continues to be the most appropriate response in the circumstances. Under this approach, subject to modest cost and reasonable convenience, power utilities should design their facilities to reduce the intensity of the fields they generate, and locate them to minimise the fields that people, especially children, encounter over prolonged periods. While these measures are prudent, it cannot be said that they are essential or that they will result in any benefit.

1.8 Australian Standard 2067:2008 Substations and High Voltage Installations Exceeding 1kV AC

Australian Standard AS2067-2008 provides common rules for the design and the erection of high voltage electrical installations. This standard provides brief informative[6] guidance on EMF in Appendix D: EMF AND SAFETY ISSUES.

In relation to EMF, the Appendix provides the following guidance:

> *The designer must ensure that the installation design is, so far as is reasonable and practicable, carried out in such a way as to−*
>
> *(a) provide for the safety of persons, including employees of and contractors to the operator;*
> *(b) reduce the exposure of persons, including employees of and contractors to the operator and the public, to electric and magnetic field effects; and*
> *(c) reduce any damage, inconvenience or other detriment as a result of the activity.*
>
> *There are five basic techniques that should be used in the design and installation processes to reduce EMF:*
> *(i) Reduce electrical current by using more energy efficient equipment for large electrical loads such as lift motors, air conditioning equipment, industrial motors and manufacturing equipment.*
> *(ii) Balance circuits to minimize net magnetic fields.*
> *(iii) Reduce magnetic fields by circuit installation arrangements that reduce distance between, or coordinate the relative placement of, all conductors in the same circuit.*
> *(iv) Maximize distance between EMF sources and sensitive areas where the level, duration, affected persons or other consequences of exposure may warrant attention.*
> *(v) Shield sources by containment or dispersal behind specialized barriers.*
>
> *NOTES:*
> *1 Further information on the wiring matters and EMF and health issue is available at Energy Networks Association EMF web page www.ena.asn.au/emg.*

[6] The terms 'normative' and 'informative' are used in AS2067-2008 to define the application of the appendices to which they apply. A normative appendix is an integral part of a standard, whereas an informative appendix is only for information and guidance.

2 Further information on the EMF and health issue is available at the Australian Radiation Protection and Nuclear Safety Council (ARPANSA) web site (www.arpansa.gov.au).

In considering the practical application of Appendix D, it should be recognised that AS 2067 is a technical standard, not a medical one and that Appendix D is provided for information. It should also be noted that AS2067 (appropriately) refers designers to both ARPANSA and ENA for further information. Accordingly, it is to be interpreted as providing practical guidance to the adoption of precautionary measures as recommended by both WHO and ARPANSA rather than as proposing actions which go beyond such precaution. The terms “reasonable” and “practicable” should be interpreted as being consistent with the precautionary guidance of WHO and ARPANSA and the notion of “prudence” as espoused by ENA (Ref 15) to whom designers are referred for further information.

In the above context, it is relevant to consider the extent to which the five techniques mentioned in Appendix D have been applied in the design of the proposed substation. This is addressed in Section 4.3.

2. Aspects of Field Predictions and Input Information

2.1 Magnetic field dependence on load

The magnetic fields from substation equipment depend on the loadings at that particular time. Accordingly, in characterising the magnetic fields, it is necessary to make practical assumptions regarding the substation and feeder loadings.

During a typical day, the amount of load current passing through a substation will vary substantially between a daily minimum, generally in the early hours of the morning and a daily maximum at times of peak demand. Loadings also vary seasonally during the year, generally reaching a peak in either summer or winter.

In the EMF/health context, it is customary to look at two loading conditions as follows:

- Given that the epidemiological associations which underpin community interest regarding magnetic fields tend to relate to elevated "*average*" magnetic fields, it is necessary to characterise an “average” condition. This is achieved by making a conservative estimate of the long term average load and linking it to reasonable assumptions regarding other factors. The magnetic fields derived under these conditions are the most appropriate for consideration in the context of the magnetic field/health literature, rather than the maximum capacity of the substation, which may only be required for very short periods, on relatively few occasions, over the service life of the substation.

- As the “Reference Levels” in the relevant health guidelines are independent of time, it is also necessary to check the magnetic fields under peak load conditions to confirm that the “Reference Levels” have not been exceeded.

This approach has been followed in our modelling calculations, with the substation loading assumed to be at the 85th percentile level i.e. that level which is exceeded for only 15% of the year in accordance with the relevant industry guideline (Ref 12), provided that the “Reference Levels” are not exceeded under peak load conditions.

For the purpose of this EMF assessment, we have been advised that it is reasonable to share the total 85th percentile loadings of the proposed zone substation equally between all 72 outgoing 11kV feeders. It should be noted that, following completion of the proposed works, the magnetic fields would be dependent on the actual loadings rather than those used for calculation purposes.

2.2 Information provided by Ausgrid

Ausgrid has provided the following information to serve as a basis for the assessment:

- Proposed City East 132kV Zone Substation arrangement drawings.
- 11kV and 132kV cable tray and conduit penetration drawings for each substation floor in the proposed building.
- A sketch showing the routing of 11kV tails from the transformers to the switchgear.
- Typical cable cross sections, including the spacing between cables (or groups of cables), as well as between cores, to be assumed for each different section of cable.
- Plan and elevation drawings for key electrical infrastructure including the 132/11kV Transformers, 132kV Switchgear, 11kV Switchgear and Capacitor Banks.
- Load duration curves for the proposed 132kV feeders, showing the forecast peak and 85th percentile loads, upon commissioning and ultimately. The 85th percentile loads are set out in Table 2.1 below.
- For magnetic field calculation purposes, the contribution of the 132kV cables to the zone 11kV current is to be calculated as 10.08 times the total 132kV current.
- 72 11kV feeders will exit the substation, 36 each to O’Connell and Bligh Streets, with 18 heading north and 18 south in each case.

- Phasing of the 132kV cables within the substation is to match the corresponding transformer phasings
- A total of 24x4MVAR capacitor banks are to be installed, each equipped with an air-cored reactor. Design details as per drawing supplied.
- The transformer nearest Bligh St will serve as a spare and will not normally be loaded.

	85th% Load upon commissioning	**85th% Ultimate Load**
132kV incoming A	71.7 Amps	197.5 Amps
132kV incoming B	71.7 Amps	197.5 Amps
132kV incoming C	71.7 Amps	197.5 Amps
132kV incoming D	Normally Open	197.5 Amps
132kV incoming E	Normally Open	Normally Open
132kV outgoing F	Normally Open	Normally Open
132kV outgoing G	Normally Open	Normally Open
132kV outgoing H	Normally Open	Normally Open
132kV outgoing I	Normally Open	Normally Open

Table 2.1 – City East ZS 132kV Loadings

3. Field Characterisation

3.1 Existing magnetic field environment

In order to characterise and understand the existing magnetic field environment, Aurecon visited the site on 23rd February 2011 to undertake magnetic field measurements and to view the project area. The site comprises two buildings, a larger northern one (12 – 37 Bligh Street and a smaller southern one with frontage on 26 O'Connell Street). The northern, eastern and western boundaries of the site are straight but the southern boundary is quite irregular.

At the time of the measurements, both buildings were empty and, accordingly the normal magnetic field sources one would expect in a commercial building were absent and this was reflected in the generally low fields measured.

The measurements were undertaken with an Emdex 2 magnetic field meter, where practicable in conjunction with an Enertech linear data acquisition system, at a height of 0.9[7] metres above ground, as dictated by the (US) equipment used. Where access restrictions inside the building prevented the use of the linear data acquisition system, spot measurements were made with the same meter, hand held at a height of approximately 1 metre.

External measurements were undertaken along the Bligh and O'Connell Street frontages and internal measurements were taken along the northern and southern walls at several levels.

In interpreting all of the above measurements, it is important to recognise that they represent a snapshot in time and that, at other times, fields could be either higher or lower than those measured.

3.1.1 Magnetic fields at street frontages

The magnetic fields at both street frontages were measured in north-south traverses and the results are shown in Figures 3.1 and 3.2 below.

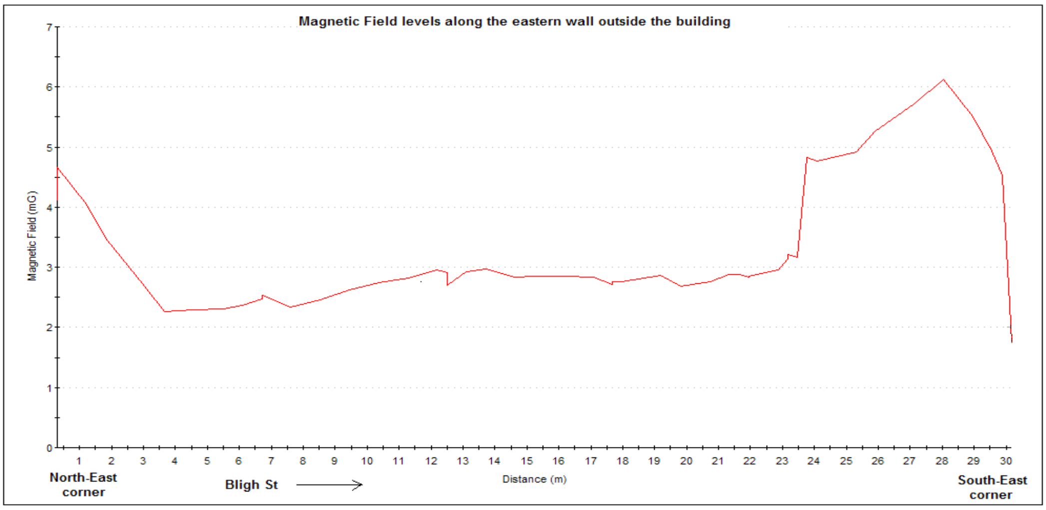

Figure 3.1: Magnetic fields along the eastern (Bligh Street) frontage

For about two-thirds of the traverse, the magnetic field levels were between 2 and 3mG. For the remainder of the traverse, the magnetic field level was in the range from 3mG to just over 6mG. The principal source of these fields appeared to be the 11kV cables which are located under the footpath.

[7] Internationally, a measurement height of 1 metre is more common but differences, if any, between the two measurement heights would not be material.

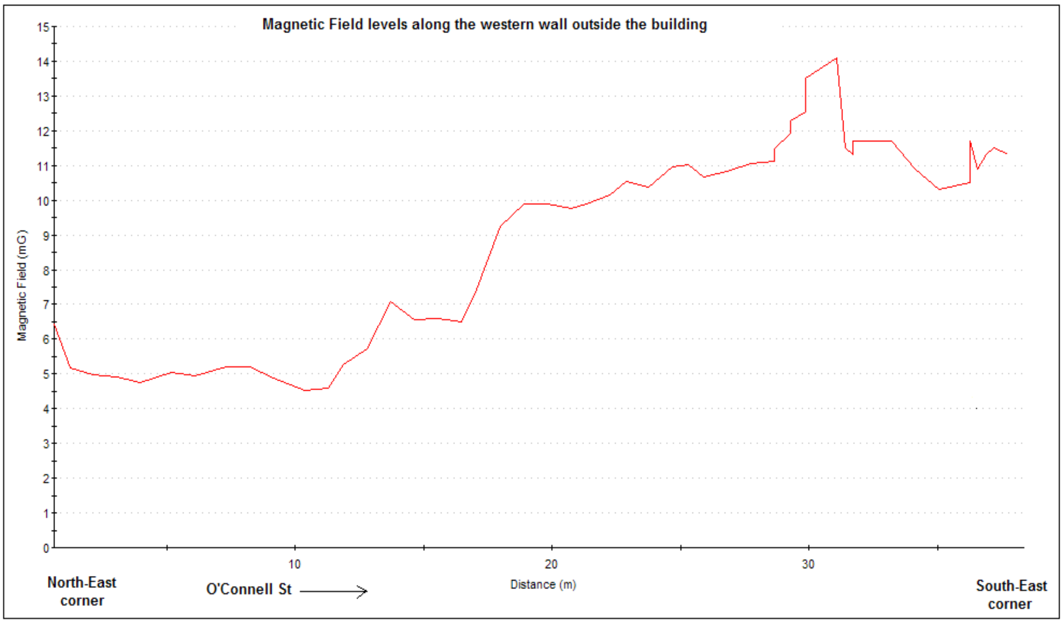

Figure 3.2: Magnetic fields along the western (O'Connell Street) frontage

For the first half of the traverse, the magnetic field ranged from 4 to 7mG but then increased progressively to about 14mG. Although the principal source of the magnetic fields was not identified, underground services in O'Connell Street are likely to have been the principal contributor.

3.1.2 Magnetic fields within the building

As noted above, both portions of the building are currently unoccupied and very little power is being consumed within it. Measurements were taken as close as practicable to the northern and southern walls, although access was somewhat restricted in places, due to the presence of internal walls and partitioning, particularly on Level 4.

The measurements taken were:

- Northern Wall – Level 3/2[8]: Traverse made with linear data acquisition system
- Northern Wall – Levels 4 (Bligh Street), 5 and 6: Spot measurements were made at frequent intervals along the length of the wall
- Southern Wall – Level 4: Spot measurements were made at convenient points along the wall which contained numerous irregular angles.

Northern Wall - Level 3/2

The magnetic field levels measured inside the building, along the northern wall, are shown in Figure 3.3.

8 Level 3 ends about 2/3 of the way through the building from the Bligh Street end, dropping away to level 2 from there to O'Connell Street

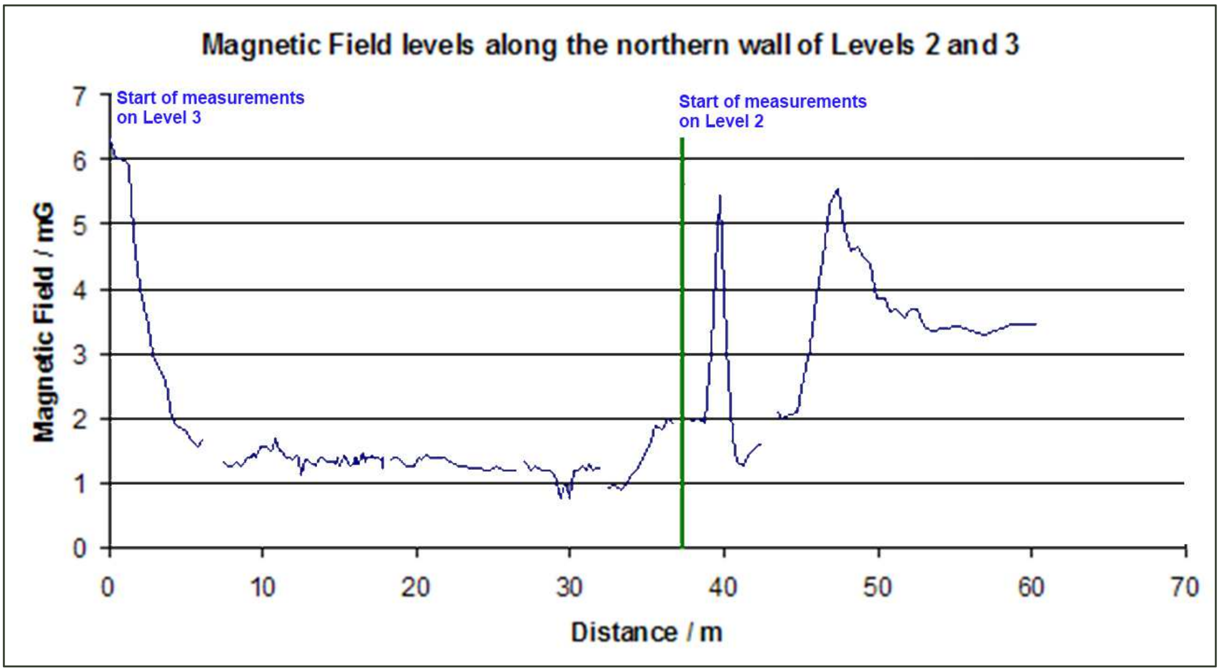

Figure 3.3: Magnetic fields along the northern wall inside the building on Level 3/2

Note: *The breaks in the graphed results in Figure 3.3 indicate locations where the instrument was physically moved around obstacles.*

On Level 3, the magnetic field level was about 6 mG at the Bligh Street end but dropped to less than 2mG within 5 metres and remained between 1 and 2mG up to the point where the floor dropped away to Level 2 (denoted by the green line in Figure 3.3). The traverse was continued on Level 2 and the field increased progressively to around 4 mG towards O'Connell St. There were also two "peaks" of around 5.5mG along this section, presumably due to cabling or services within the wall, or on the other side of it.

Northern Wall Level 4

The magnetic field levels recorded along the northern wall on Level 4 ranged from 0.7 to 3.7mG. The magnetic field level was below 1mG for most of the traverse, increasing towards the Bligh Street end.

Northern Wall Level 5

The magnetic field levels recorded generally ranged from 1.4 to 5.2mG, with a localised peak of 13.7mG, about 7m east of the north-western corner. At a height of 2m, the magnetic field value at that same spot increased to 18.2mG. The field source appeared to be inside the wall or outside the building.

Northern Wall Level 6

The magnetic field levels recorded generally ranged from 0.7 to 5.9mG, with a localised peak of 12.6mG observed in a similar location to that on Level 5.

Southern Wall Level 4

Along the southern side of the building, the magnetic field level varied from 1.3 to 10.4mG and was below 3mG for most of the traverse. The maximum value occurred in the vicinity of a bathroom mid-way along.

3.1.3 Summary of Site Measurements

In general, the fields were quite low and unremarkable for an empty office building. No significant magnetic field sources were identified during the survey. This was not unexpected.

The most notable point sources were near the bathroom on the southern wall of Level 4 and about 7m east of the north-western corner of Levels 5 and 6. All of these sources were very localised and the fields decreased rapidly as one moved away from the source.

Fields at the street frontages were dominated by external sources, notably, underground 11kV cables which run along both Bligh and O'Connell Streets.

In interpreting these measurements, it is important to recognise that they represent a snapshot in time and that, at other times, fields could be either higher or lower than those measured

3.2 Modelling of the magnetic field contribution of the proposed substation

Based on the available design and loading information, provided by Ausgrid, the magnetic field contribution expected from the proposed substation and associated underground feeder entries has been modelled using the CDEGS software package.

CDEGS is an internationally recognised software package pioneered by Safe Engineering Services & Technologies (SES) to provide grounding and electromagnetic and conductive interference analysis involving electrical networks. The software has undergone extensive scientific validation using field tests and comparisons with analytical or published results for over twenty years (Ref.13).

The magnetic field levels were calculated for the 85th percentile of the forecast initial and ultimate load levels, provided by Ausgrid as described in Section 2.2. It should be noted that, following completion of the proposed works, the magnetic fields would be dependent on the actual loading rather than that used for calculation purposes.

Fields have been calculated at a height of 1 metre above the various street and floor levels in accordance with international practice.

Calculations covering the following parts of the site have been performed:

- Carpark Level 3 – contour map produced
- Carpark Level 4 – contour map produced
- O'Connell St Level – contour map produced
- Building Management Office Level 6 – contour map produced
- Bligh St Level – contour map produced
- Capacitor bank level:– contour map produced
- First commercial floor (RL65) Level – contour map produced
- Northern wall (Notional internal wall of adjoining building) - Vertical contour map produced
- 3 x vertical contours along various sections of the southern wall

- Back wall of lifts from Bligh Street level to office foyer: - Vertical contour map produced
- Front wall of lifts from Bligh Street level to office foyer. - Vertical contour map produced

As with any high rise building, the proposed development will have its own electrical plant, cabling and internal wiring. As design details are not available at this stage, it has not been possible to include them in our model. In any case, being unrelated to the substation, we consider that these sources are beyond the scope of our brief.

The total magnetic field level at any point will be the vector sum of all of the magnetic field contributions of the various underground and above ground sources, including external ones. Our calculations relate to the contribution of the proposed substation and its associated feeders only.

Plan and 3D view screenshots of the CDEGS model of the proposed works are shown in Figure 3.4. Approximate street levels can be discerned from the 3D view, where groups of parallel cables exit north and south at the eastern and western sides of the model. This, in turn, highlights the extent to which the designers have managed to locate much of the cabling below street level.

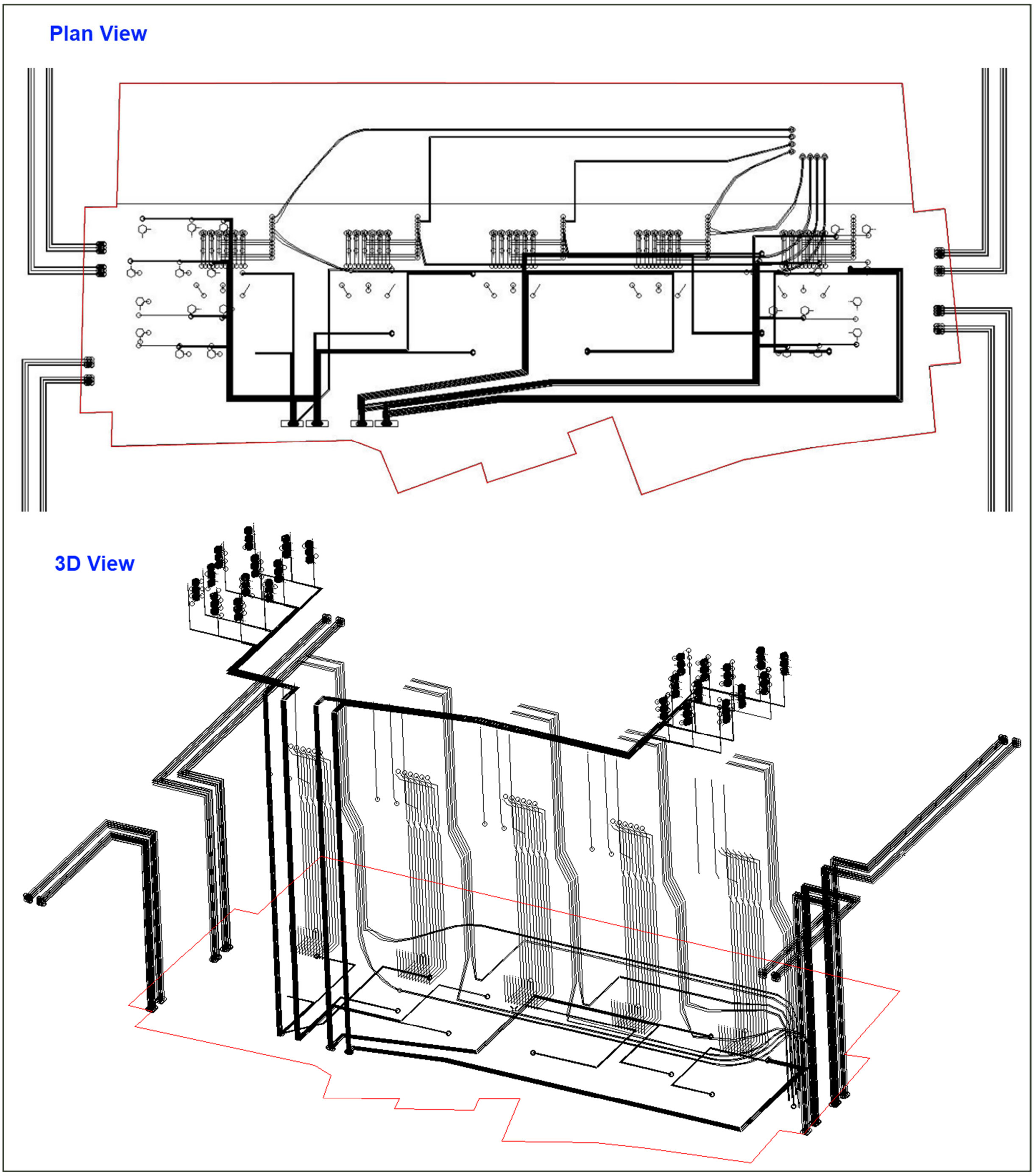

Figure 3.4 – CDEGS Model of proposed substation

The results obtained from the magnetic field modelling are shown below in Figures 3.5 to 3.18 and take the form of horizontal and vertical contour plots as applicable, with profiles along the street frontages.

Our calculations relating to the car park floors predicted localised exceedances of the guideline "Reference Levels". As the "Reference Levels" are independent of time (refer Section 2.1), Figures 3.5, 3.6 and 3.6a, which relate to the car parking levels, are based upon peak loads.

The remainder, where the guideline "Reference Levels" are not even approached, are based on the 85th percentile loading scenario, at a future time when the substation load has reached its long term maximum. The fields occurring shortly after commissioning of the substation will be considerably less. All of the plots were calculated at 1m above the relevant floor or street level.

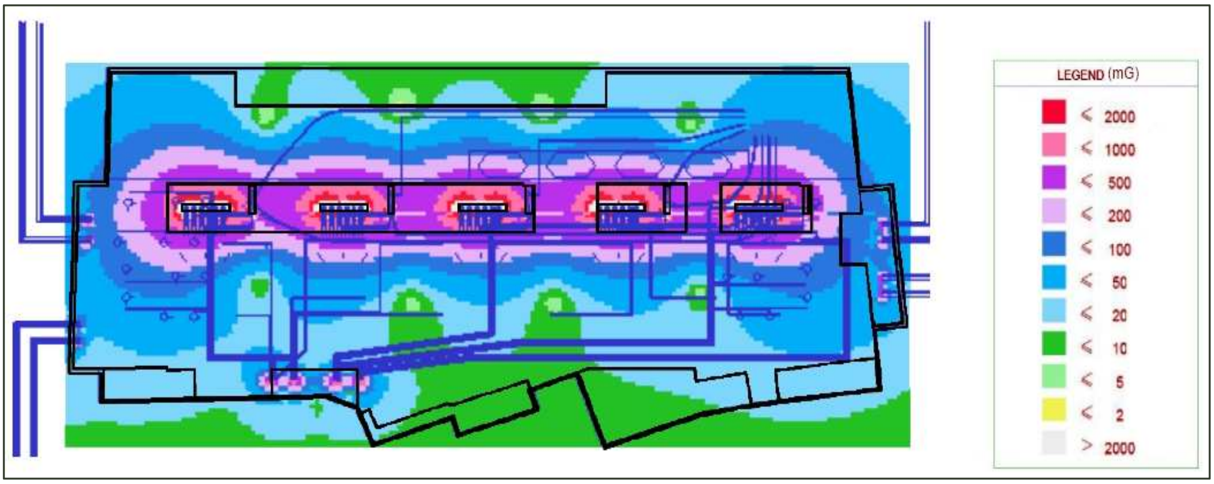

Figure 3.5: Predicted magnetic field contribution associated with the proposed substation - Carpark Level 3 (RL 6.35)

It can be seen from Figure 3.5 that the principal magnetic field source at this level is the 11kV transformer tails which pass through the floor in vertical risers. As Level 3 is a car parking level, parts of it will be accessible to the general public, although their occupation will be transitory. Under peak loads, fields across the bulk of the floor are in the range of 10-50mG. The field in the public space nearest the No 1 Transformer tails exceeds 2000mG (up to 5000mG) in a localised area at the edge of the access ramp.

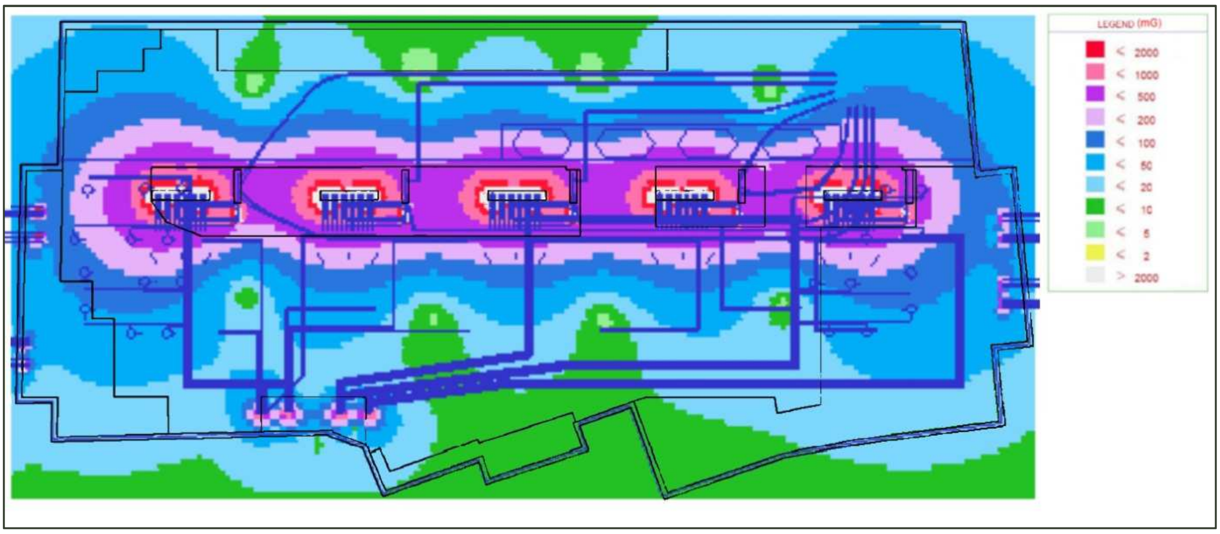

Figure 3.6: Predicted magnetic field contribution associated with the proposed substation - Carpark Level 4 (RL 9.5)

As with Level 3, it can be seen from Figure 3.6 that the principal magnetic field source on level 4 is also the 11kV transformer tails which pass through the floor in vertical risers. As Level 4 is a car parking level, parts of it will be accessible to the general public, although their occupation will be transitory. Under peak loads, fields across the bulk of the floor are in the range of 10-50mG. The field in the public spaces nearest the No 1 and No 4 Transformer tails exceeds 2000mG (up to 5000mG) in localised areas at the edge of the access ramp.

In order to provide a more precise indication of the areas where 2000 mG is exceeded, Figure 3.6a shows an enlarged contour map around the No 4 11kV transformer riser.

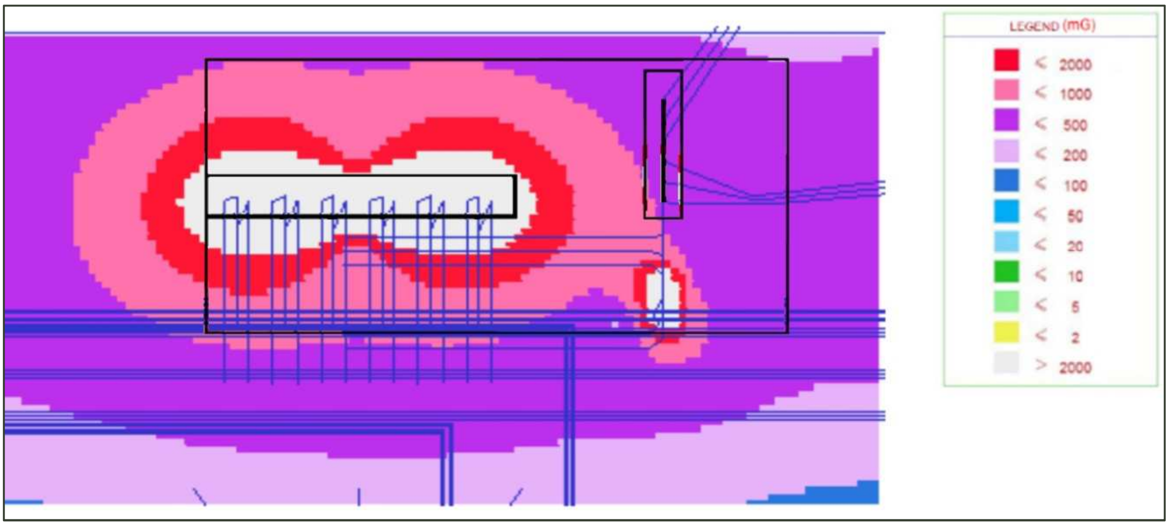

Figure 3.6a: Predicted magnetic field contribution associated with No 4 11kV riser - Carpark Level 4 (RL 9.5)

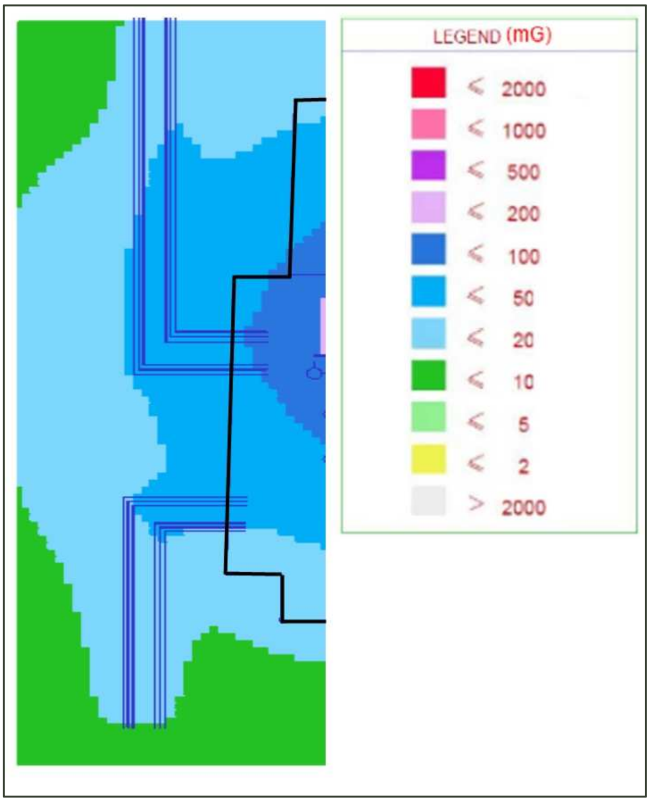

Figure 3.7: Predicted magnetic field contribution associated with the proposed substation - O'Connell St Level near the street frontage (RL 13.3)

The principal magnetic field source at the O'Connell Street level is also the 11kV transformer tails. Figure 3.7 is focussed on the O'Connell Street end with the building frontage shown as a stepped black line. The influence of the outgoing 11kV feeders can also be seen here. The only areas accessible to the general public at this level are the street outside the building, where the fields are in the range of 20 to 50 mG for most of the length of the frontage and less than 20 for the remainder. The only internal space accessible to the public is the entrance ramp to the car park, where the fields are in the range of 50 to 200 mG.

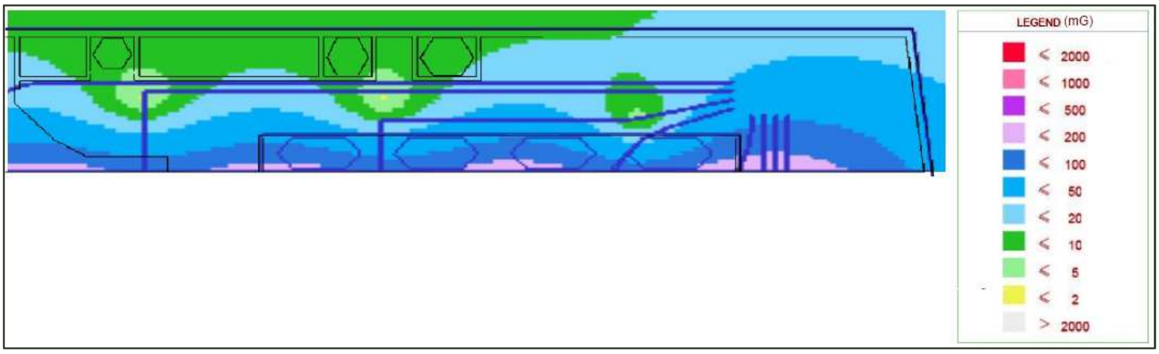

Figure 3.8: Predicted magnetic field contribution associated with the proposed substation - Commercial Building Management Office (RL 17.2)

The only publicly accessible area on Level 6 is the building management office. The principal magnetic field source at this level is the 11kV transformer connections. Under ultimate loading conditions, the fields in the publically accessible areas are predicted to be up to 50mG, but generally between 5 and 20mG.

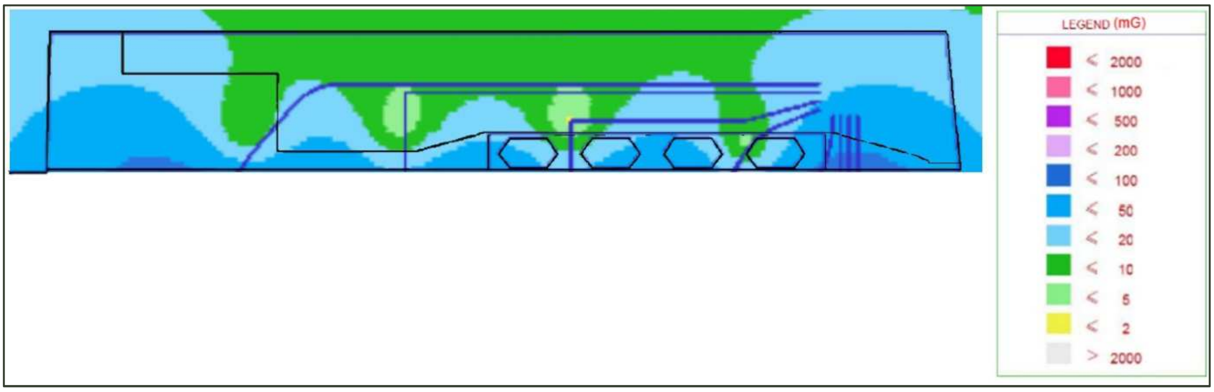

Figure 3.9: Predicted magnetic field contribution associated with the proposed substation – lift lobby on Bligh St Level (RL 20.2)

The only publicly accessible part of the Bligh Street level is the lift lobby. The principal magnetic field source at this level is the 132kV cabling and transformer connections. Under ultimate loading conditions, the fields in the lift lobby are predicted to be up to 40mG, but generally between 5 and 20mG.

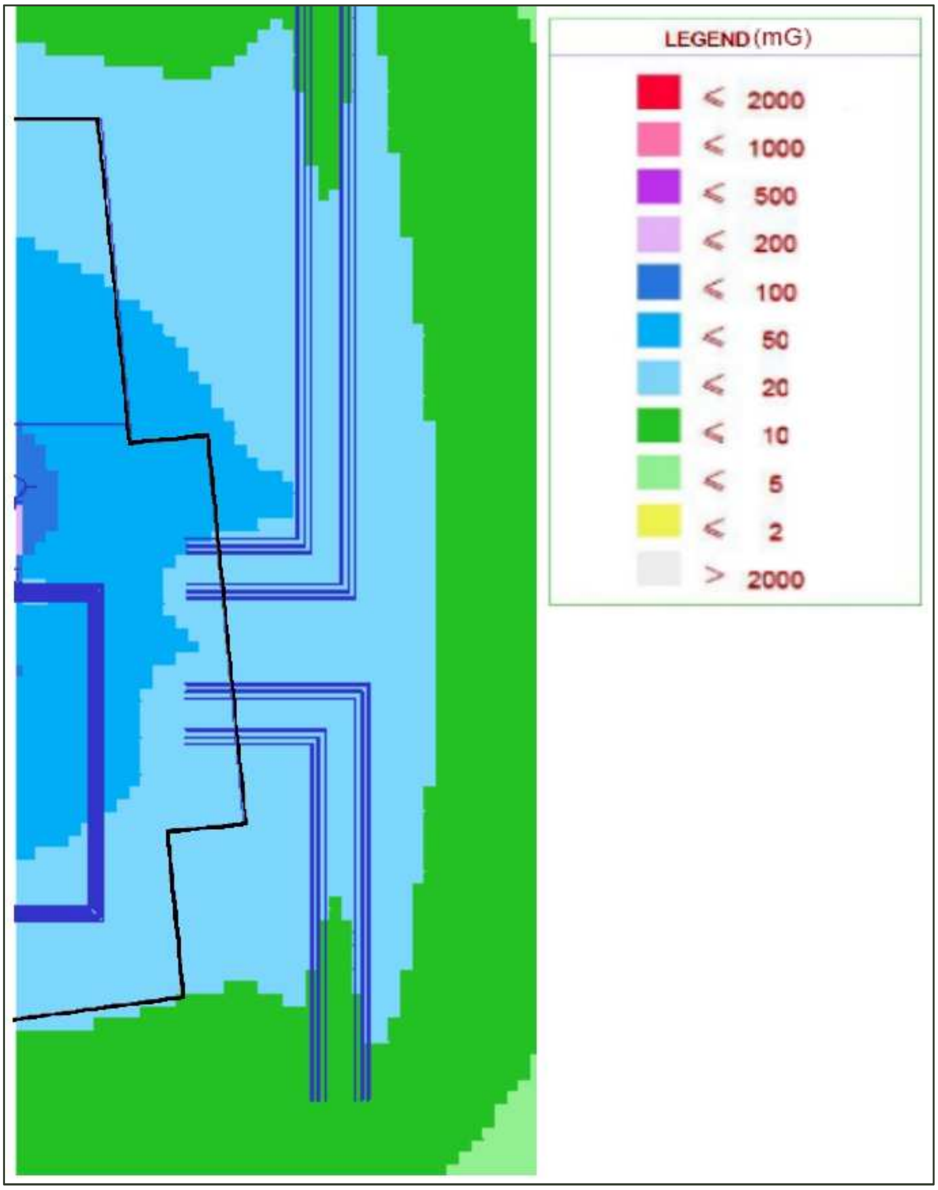

Figure 3.10: Predicted magnetic field contribution associated with the proposed substation including outgoing 11kV feeders - external footpath: Bligh Street level (RL 20.2)

The influence of the outgoing 11kV feeders in Bligh Street can be seen in Figure 3.10. It should be noted however, that the modelling was based on a notional allocation of cable locations and loadings and the contours should be regarded as indicative only. It should also be noted that, due to software limitations, the actual fields are likely to decrease more rapidly than indicated, as one moves away from the cables. The fields above the cables will be up to 20 mG but will decrease to less than 10 within a few metres

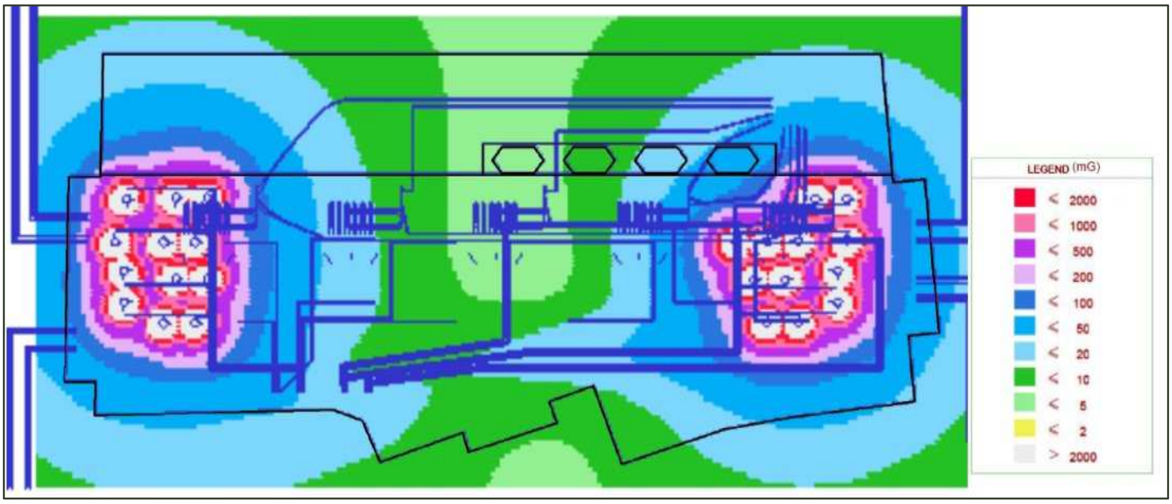

Figure 3.11: Predicted magnetic field contribution associated with the proposed substation - Capacitor bank level (RL 36.3)

It can be seen from Figure 3.11 that the principal magnetic field source at this level is the 24 air-cored reactors associated with the capacitor banks. The only part of this floor accessible to the public is the low rise lifts which pass through it. With all the capacitor banks operating at their rated current, the fields in the lift nearest Bligh Street are predicted to be in the range 20 to 50mG. The fields in the other lifts will range from less than 5, up to 20mG. The fields in the adjacent buildings at this level will generally be less than 10 mG, with an area towards the O'Connell Street end approaching 20 mG.

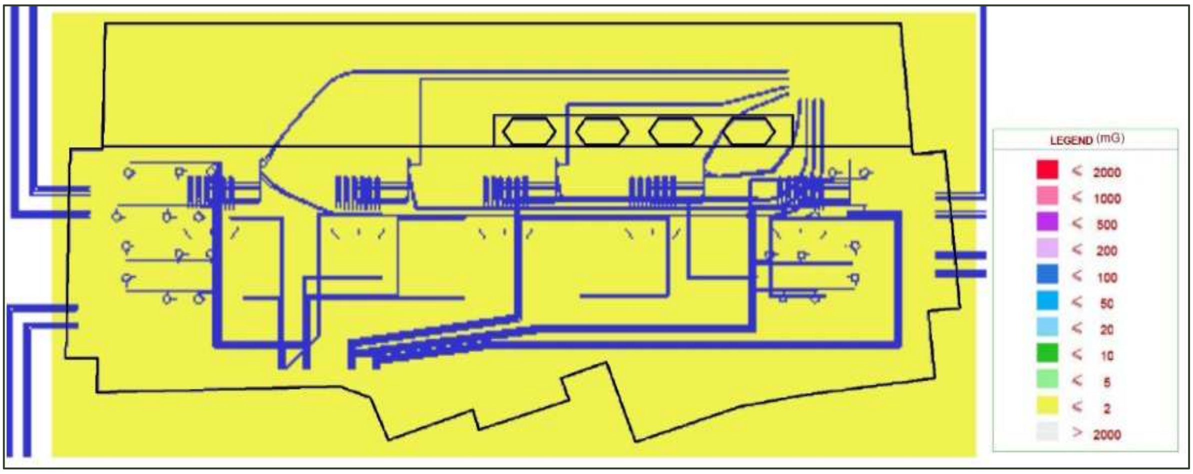

Figure 3.12: Predicted magnetic field contribution associated with the proposed substation – lowest level of commercial building (RL65.9)

It can be seen from Figure 3.12 that the contribution of the substation to the magnetic fields at this level is minor, being less than 2mG, even under the ultimate loading condition. The actual fields on this floor are likely to be dominated by internal wiring and, possibly, the building plant to be located on the two floors below.

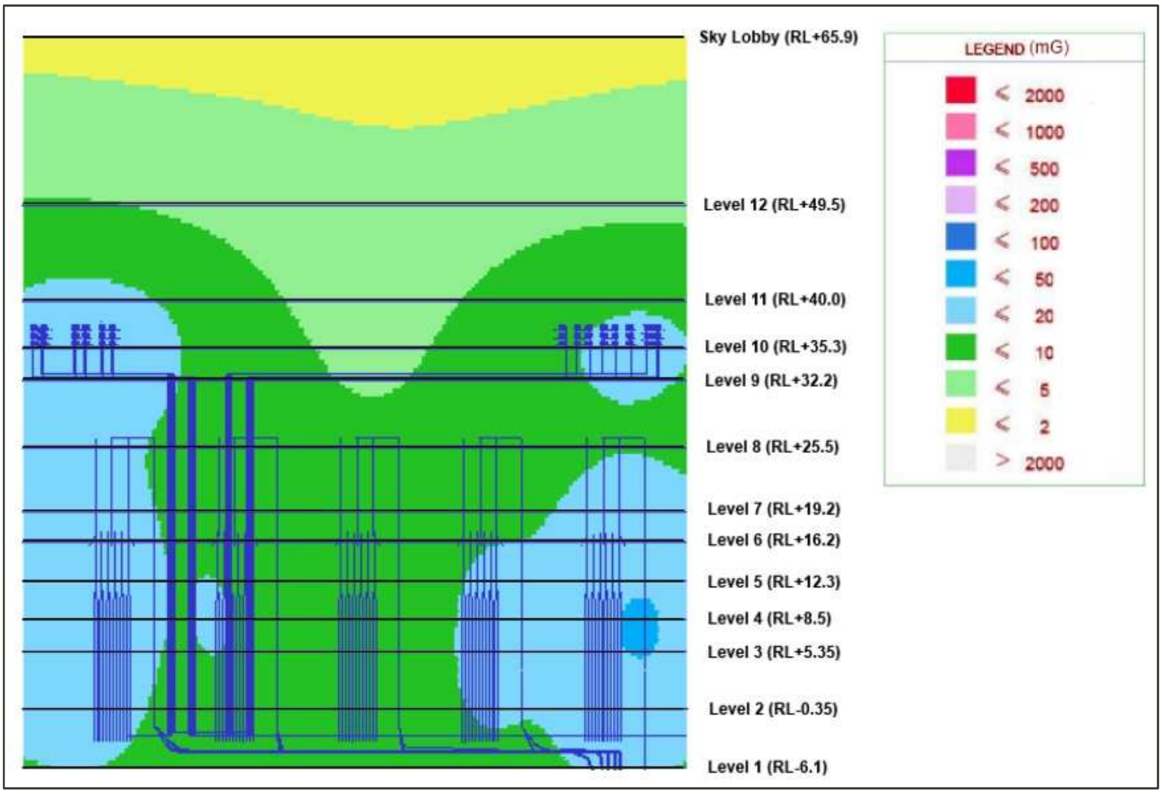

Figure 3.13: Predicted magnetic field contribution associated with the proposed substation - Northern wall (Notional internal wall of adjoining building) (RL -6.1 to 66)

Figure 3.13 is a vertical contour map covering the northern wall from level 1 to level 14, looking in a northerly direction. The magnetic field contribution of the substation above Level 12 is expected to be less than 5 mG. The contribution on Levels 9 and 10 is predicted to be in the range 10 to 20 mG in the vicinity of the capacitors but less than 10 mG elsewhere. The contribution between Levels 1 and 8 is predicted to be in the range 5 to 20 mG, with the highest fields towards the O'Connell Street end, and mid-way along the building towards Bligh Street.

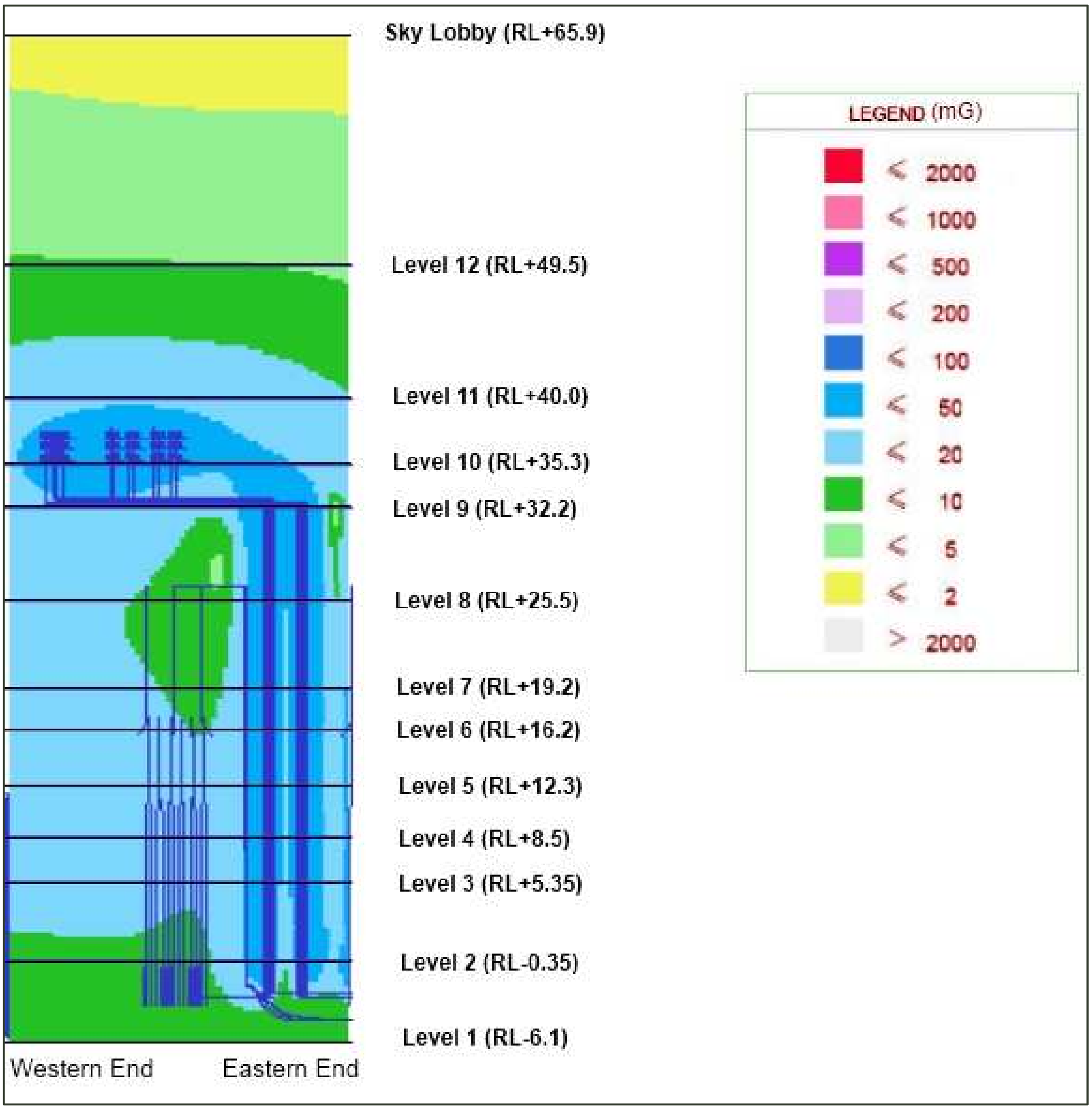

Figure 3.14: Predicted magnetic field contribution associated with the proposed substation - Southern wall, section A (the approx 1/3 of the wall towards the western end)

Figure 3.14 is a vertical contour map covering Section A of the southern wall from level 1 to level 14, looking in a northerly direction. The magnetic field contribution of the substation above Level 12 is expected to be less than 5 mG. The contribution on Levels 11 and 12 is predicted to be in the range 5 to 20 mG. The contribution on Levels 9 and 10 is predicted to be in the range 20 to 50 mG in the vicinity of the capacitors but less than 20 mG elsewhere. The contribution between Levels 1 and 8 is predicted to be generally in the range 5 to 20 mG, with the exception of the areas near the capacitor cabling, where fields are expected to be in the range of 20 to 50 mG.

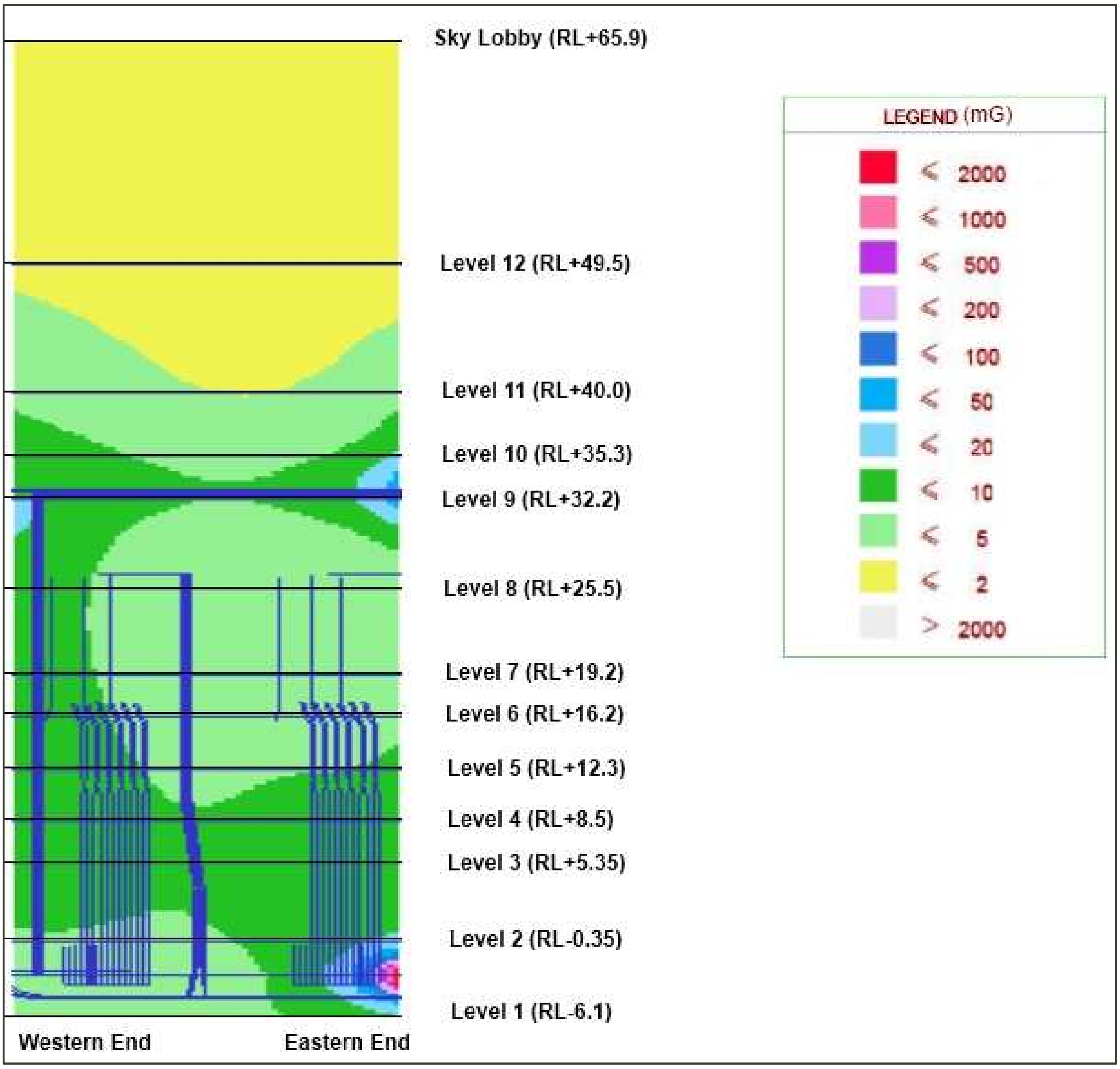

Figure 3.15: Predicted magnetic field contribution associated with the proposed substation - Southern wall, section B (the approx middle 1/3 of the wall)

Figure 3.15 is a vertical contour map covering Section B of the southern wall from level 1 to level 14, looking in a northerly direction. The magnetic field contribution of the substation above Level 12 is expected to be less than 5 mG, with much of the remaining levels being less than 10mG and nowhere exceeding 20 mG.

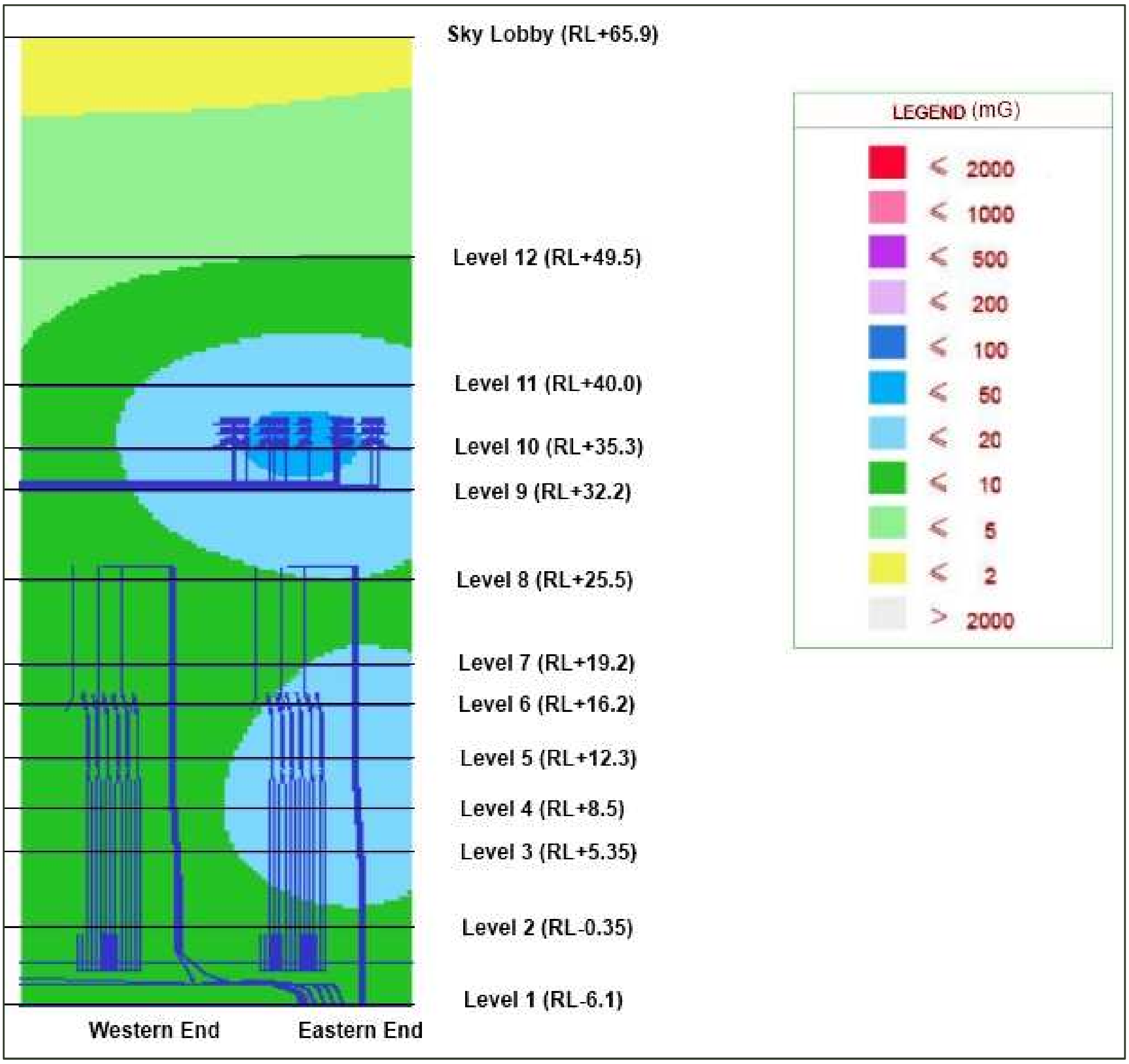

Figure 3.16: Predicted magnetic field contribution associated with the proposed substation - Southern wall, section C (the approx 1/3 of the wall towards the eastern end)

Figure 3.16 is a vertical contour map covering Section C of the southern wall from level 1 to level 14, looking in a northerly direction. The magnetic field contribution of the substation above Level 12 is expected to be less than 5 mG, with most of the remaining levels being less than 10mG, with the exception of an area, centred near the capacitors on level 10, where fields in the range 10 to 50 mG are predicted.

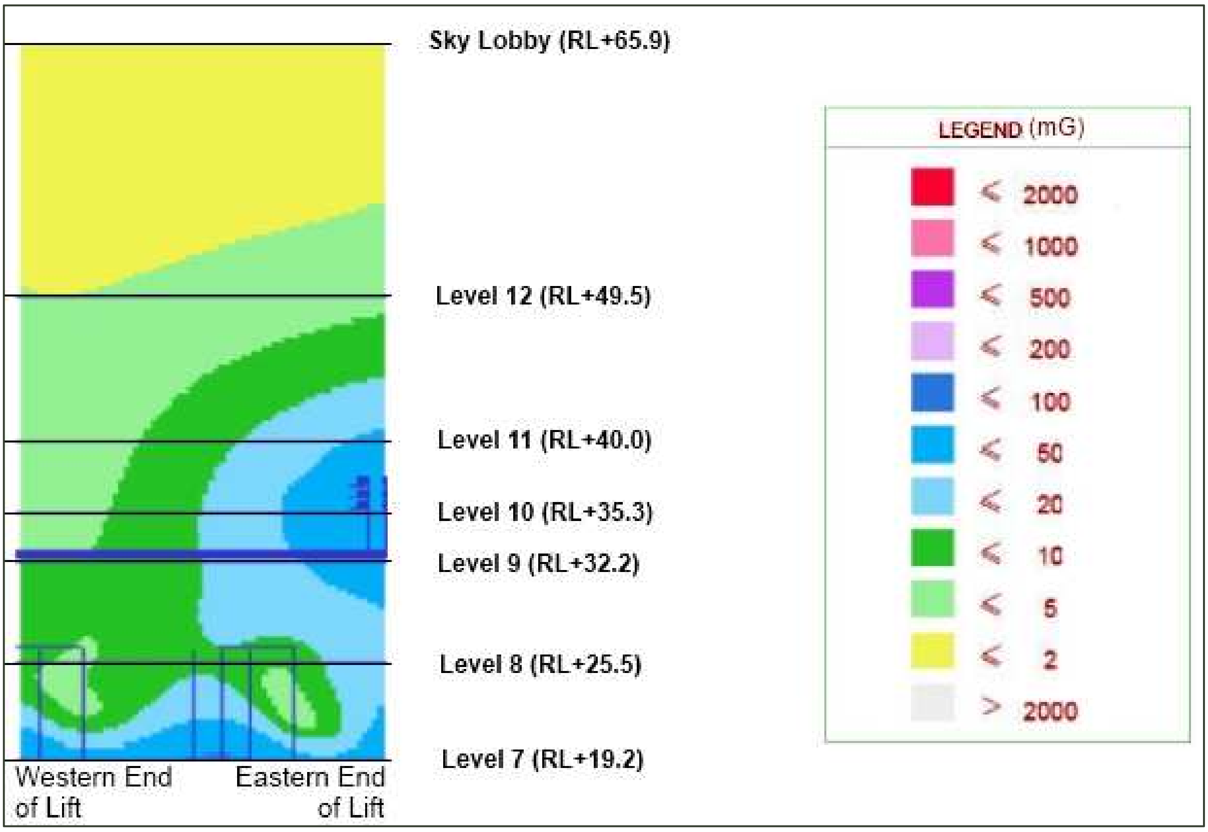

Figure 3.17: Predicted magnetic field - Back wall of lifts and lift lobby from Bligh Street level to office foyer (RL -6.1 to 66)

Figure 3.17 is a vertical contour map covering the back wall of the lifts from level 1 to level 14. The magnetic field contribution of the substation is predicted to be generally in the range 2 to 20 mG, reaching a maximum of up to 50 mG in the eastern lift at Level 10 where it passes the capacitors.

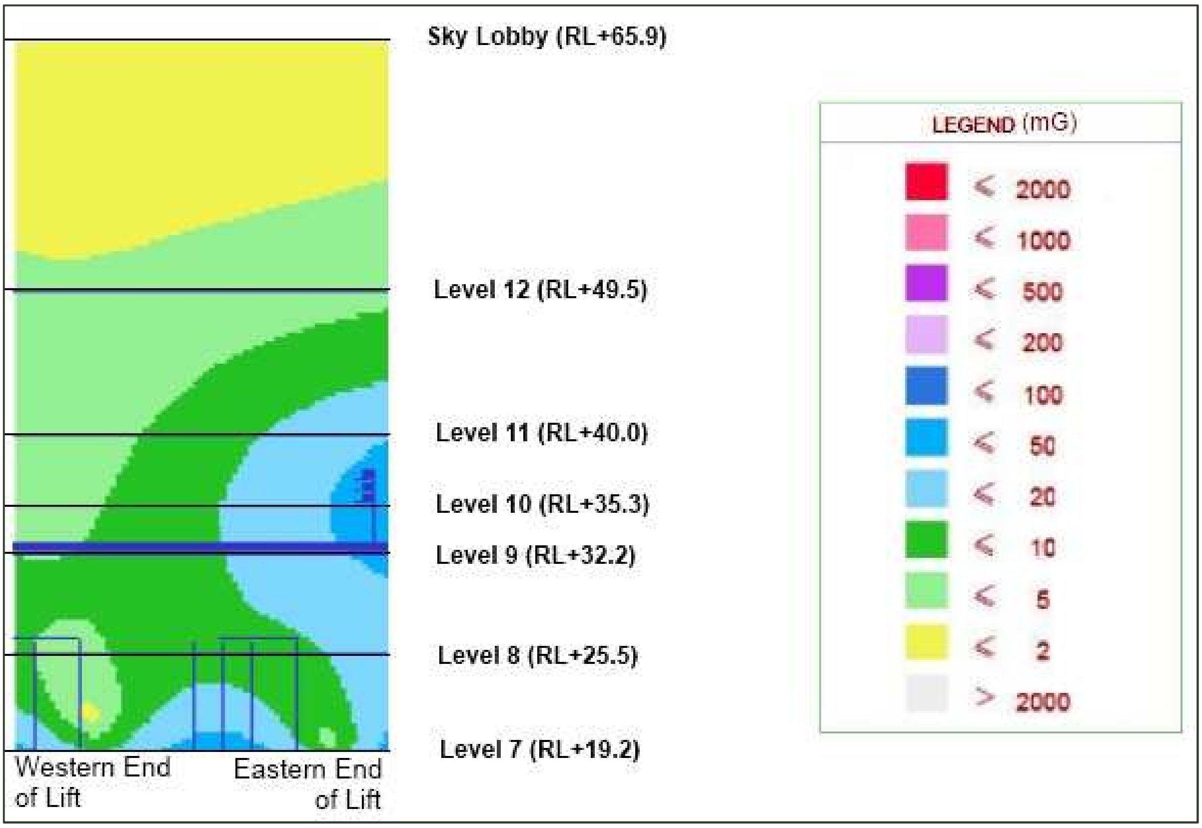

Figure 3.18: Predicted magnetic field - Front wall of lifts from Bligh Street level to office foyer (RL -6.1 to 66)

Figure 3.18 is a vertical contour map covering the front wall of the lifts from level 1 to level 14. The magnetic field contribution of the substation is predicted to be generally in the range 2 to 20 mG, reaching a maximum of up to 50 mG in the eastern lift at Level 10 where it passes the capacitors.

3.3 General observations re modelling results

The following observations are made with regard to the forecast magnetic field contribution from the proposed substation:

- Within the substation, the highest magnetic fields, which appear to be strongly influenced by the capacitors and the transformer connections, are expected to be in excess of 2000mG[10] but would reduce to less than 100mG within 5 metres of the connections.
- The fields across the bulk of the remainder of the substation itself would be less than 50mG, except for the areas in proximity to the transformer connections and capacitors and those areas directly above or beside underground cables or cable risers.
- The fields in areas accessible to the general public are predicted to be generally in the range of 2 to 20 mG. Localised peaks, which may exceed 2000 mG in areas accessible to the public, are predicted to occur as follows:
  - Near 11kV Risers on Level 3

[10] *The relevant occupational exposure limit, which applies within the substation, is 10000mG.*

- Near 11kV Risers on Level 4

- In the ultimate condition, the substation's contribution to the magnetic fields in adjoining buildings on the northern side would be less than 2 mG above Level 12, the contribution on Levels 9 and 10 is predicted to be in the range 10 to 20 mG in the vicinity of the capacitors but less than 10 mG elsewhere. The contribution between Levels 1 and 8 is predicted to be in the range 5 to 20 mG, with the highest fields towards the O'Connell Street end, and mid-way along the building towards Bligh Street.

- The highest magnetic field contribution from the substation to the adjoining small building at No. 31 Bligh Street is predicted to be generally less than 10 mG but possibly a little above this in the vicinity of the capacitors near the top of the building. Once the design and operating configurations of the substation have been finalised, it may be necessary to re-examine the fields in this area, with No. 5 Transformer in service.

- The substation's contribution to the magnetic fields in adjoining buildings on the southern side would be less than 5 mG above Level 12, and generally between 5 and 20 mG between levels 1 and 12, with localised peaks up to 50 mG between levels 1 and 9, in the vicinity of the capacitor bank risers midway along the southern side.

- The magnetic field levels along the street frontages are expected to be dominated by the outgoing underground feeders. Our modelling predicts magnetic fields directly above the cables of up to 20mG but, as noted above, the precise locations and loadings of the cables is not fully determined at this stage.

- As noted in Section 2.2, the transformer nearest Bligh St will serve as a spare and will not normally be loaded. In the event that it were to be loaded, the fields towards the Bligh St end would increase and become comparable to those at the O'Connell St end and the highest fields around whichever of the other four transformers had become the "spare" would decrease.

3.4 Electric fields

As most of the electrical equipment associated with the substation would be of the indoor variety, it would produce little or no electric field external to the equipment enclosure. It is understood that the only unenclosed high voltage connections within the substation would be short sections within the transformer enclosures. These enclosures would only be accessible to authorised persons. On this basis, the electric fields in these areas, directly under the connections, based on typical equipment characteristics, have been estimated to be within the relevant occupational limits.

No major source of electric field is expected beyond the live areas of the substation.

3.5 Magnetic fields experienced intermittently

As shown in section 3.2 there would be localised areas of elevated magnetic field levels in some areas accessible to the public in the vicinity of the substation and associated electrical infrastructure. In considering these localised higher fields, it is important to recognise that these intermittent fields, which may be experienced for short periods of time, are of a similar category to those we experience in everyday life. To put this into perspective, the Energy Networks Association (Ref 14) has published a series of typical magnetic field levels associated with particular appliances at normal user distance. These are set out in Table 2 below:

Appliance	Typical Measurement (mG)	Range of Measurements (mG)
Stove	6	2-30
Computer	5	2-20
TV	1	0.2-2
Electric Blanket	20	5-30
Hair Dryer	25	10-70
Refrigerator	2	2-5
Toaster	3	2-10
Kettle	3	2-10
Fan	1	0.2-2

Table 2: Magnetic Field Levels Associated with Appliances

From the above range of fields, it can be seen that the fields in most of the public areas would be within the range normally encountered in everyday life. In a few places, including the level 3 car park and level 4 car park near the 11kV and 132kV risers, the commercial lifts as they pass the capacitor banks and the southern side in the vicinity of the capacitor bank cable risers, the highest calculated fields are predicted to be higher than this range. However, on the basis that public access is restricted to no closer than 1.5m to the 11kV riser cables and 0.5m to the 132kV riser cables, these levels will still be within the relevant health limit.

4. Compliance with EMF Standards and Prudent Avoidance / Precautionary Principles

4.1 Compliance with Health Standards

4.1.1 Occupational Standards

In addressing Ausgrid's brief, we have interpreted compliance with health standards as relating to the general public rather than to the occupational exposures. Occupational exposures are subject to different (higher) limits than general public exposure and are influenced by work practices etc, as well as the design and operation of equipment. While not addressing occupational limits, we have no reason to expect that Ausgrid would not comply with them in operating the substation.

4.1.2 85th Percentile Loads

As noted in Section 3.3, the predicted magnetic field contribution of the proposed substation to areas in its vicinity that are accessible to the general public is expected to be generally less than 40mG under ultimate loading conditions. Its contribution to the magnetic fields in occupied spaces in adjacent buildings is expected to be generally less than 20mG under ultimate loading conditions. This contribution would be confined to levels 1 to 10 and would decrease as one moves away from the substation wall.

The highest of the above fields is 5% of the relevant health guideline (reference level) for the general public.

The substation's contribution to the magnetic fields at its Bligh Street frontage would be up to 20mG and would be dominated by the outgoing feeders. At the O'Connell Street frontage the magnetic fields would be up to 50mG with the main contributor being the nearby transformer connections.

4.1.3 Long Term (Ultimate) Peak Load Condition

During a typical day, the loading on the substation will vary substantially between a daily minimum, generally in the early hours of the morning and a daily maximum at times of peak demand. Loadings also vary seasonally during the year, generally reaching a peak in summer or winter. Finally, due to general load growth, the loadings on substations tend to grow over time until the substation's "ultimate capacity" is reached. For this reason, if they occur at all, the loadings corresponding to the maximum capacity of a substation are only likely to occur infrequently and for relatively short periods. We have examined a scenario with the substation loaded to its capacity and, in the vicinity of the 11kV risers in the level 3 car park and level 4 car park, in an area potentially accessible to the public, the fields may exceed 2000mG. Accordingly, the public car parking areas on Levels 3 and 4 should be examined and consideration given to field reduction measures or the installation of barriers to maximise users' separation from high field sources without impinging on their requirements for access and egress.

4.1.4 Electric Fields

As most of the electrical equipment associated with the substation would be of the indoor variety, it would produce little or no electric field external to the equipment enclosure. It is understood that the only unenclosed high voltage connections within the substation would be short sections within the transformer enclosures. These enclosures would only be accessible to authorised persons. On this basis, the electric fields in these areas, directly under the connections, based on typical equipment characteristics, have been estimated to be within the relevant occupational limits.

No major source of electric field is expected beyond the substation boundary as all of the incoming and outgoing feeders are to be underground.

4.2 Assessment against Prudent Avoidance Principles

As noted in Section 1.7, given the inconclusive nature of the science, it is considered that a prudent avoidance approach continues to be the most appropriate response in the circumstances. Under this approach, subject to modest cost and reasonable convenience, power utilities should design their facilities to reduce the intensity of the fields they generate, and locate them to minimise the fields that people, especially children, encounter over prolonged periods, provided this can be readily achieved without undue inconvenience and at reasonable expense, and be consistent with good engineering and risk minimisation practice.

It is understood that, along with other members of ENA, Ausgrid has adopted the policy of prudent avoidance and is applying it to this project. In this context, Ausgrid, in accordance with Ausgrid's policy of prudent avoidance, advises that it has:

- Openly shared information regarding the EMF/health issue and the proposed facility.
- Incorporated compact, indoor switchgear into the design, resulting in reduced magnetic fields when compared with a larger outdoor facility.
- Located the transformers centrally, thereby minimizing the influence of the transformer connections on the field levels at the boundary.
- Located the 11kV switchgear below street level, thereby minimizing the influence of the 11kV transformer tails on areas accessible to the public.
- Re-designed/relocated the 11kVand 132kV risers associated with the transformers and the 11kV capacitor cabling.

Nevertheless, due to the inherent difficulties in incorporating a large substation into a CBD site, the fields in some locations on level 3 and level 4, the commercial lifts, and the southern wall, in areas accessible to the public, are predicted to be higher than those normally encountered in everyday life.

Consistent with the principles of prudent avoidance, and to the extent feasible, it would seem prudent to further review the design, configuration and phasing of the 11kV and 132kV transformer connections and the 11kV capacitor cabling and examine the feasibility of configuring the 11kV air cored reactors to achieve a degree of field cancellation.

It would also be prudent, in finalising the design of the substation, for the designers to identify all practicable measures to reduce the magnetic fields which might be encountered by members of the public over prolonged periods and, consistent with the principles of prudent avoidance, adopt those which can be implemented at modest cost and without undue inconvenience.

4.3 Commentary on the Application of AS 2067 Appendix D

As noted in Section 1.8, Appendix D of AS 2067 provides practical guidance to the adoption of precautionary measures as recommended by both WHO and ARPANSA and, in particular, lists five generic techniques which may be applied by designers.

Commentary on the extent to which the five techniques mentioned in Appendix D have been applied in the design of the proposed substation is provided below.

> *(i) Reduce electrical current by using more energy efficient equipment for large electrical loads such as lift motors, air conditioning equipment, industrial motors and manufacturing equipment.*

This technique is directed more towards buildings than to utility substations and is not addressed further. In the case of utility substations the electrical current is fixed by the load and the voltages, which are standardised throughout the network. There is no option to change the load or the voltages to reduce the current.

(ii) Balance circuits to minimize net magnetic fields.

This technique is also more relevant to buildings and industrial installations than to utility substations. Nevertheless, it should be noted that, as a matter of course, utilities seek to balance circuit loadings on an ongoing basis.

(iii) Reduce magnetic fields by circuit installation arrangements that reduce distance between, or coordinate the relative placement of, all conductors in the same circuit.

This technique refers to the orientation, spacing and phasing of conductors to minimise magnetic fields. At this stage of the design process these aspects have not been finalised and our modelling to date reflects preliminary design information. Nevertheless, as noted in Section 4.2, a number of opportunities to reduce magnetic fields by optimising the orientation, spacing and phasing of conductors have been identified and suggested to the designers for further consideration in the detailed design stage. It is understood from numerous discussions with Ausgrid that all of these opportunities are currently under active consideration for adoption in the final design.

(iv) Maximize distance between EMF sources and sensitive areas where the level, duration, affected persons or other consequences of exposure may warrant attention.

In establishing the basic layout parameters for the proposed substation, Ausgrid has already gone to significant lengths to apply this technique. Most notably, major items of plant such as power transformers, transformer cable risers passing through the building and high voltage switches are located centrally, as far as possible from building boundaries. Additionally, much of the 11kV cabling, which is one of the major potential magnetic field sources, is located in a deep excavation, well below street level, thereby reducing the magnetic field contribution to neighbouring premises.

(v) Shield sources by containment or dispersal behind specialized barriers.

Although not ruled out at this stage, it is not appropriate to give detailed consideration to the application of this technique until other aspects of the design have been finalised. Furthermore, shielding has inherent disadvantages which make it less attractive than techniques which actually reduce the fields at the source. These disadvantages include:

- It may not be practical to install shielding in some locations
- It can result in de-rating of cables and equipment
- It can create noise and vibration issues
- It can be very expensive

Depending on the level of success the designers have in reducing magnetic fields through the application of mitigation techniques, including those mentioned in AS 2067, the possibility of applying shielding should remain as an option. However, consistent with the precautionary guidance provided by WHO and ARPANSA and the principles of reasonableness and practicability noted in AS 2067 shielding would only be warranted if the other more direct measures already adopted and being investigated do not achieve an acceptable outcome and if the shielding could achieve a material reduction to magnetic fields in frequented[11] areas in a practicable manner and at reasonable cost.

[11] Frequented areas are defined in this context as locations where people, especially children, may spend a prolonged period of time.

5. Conclusions and Recommendations

The design and layout of the proposed City East ZS has been reviewed and modelled to calculate the predicted electric and magnetic fields associated with it under both ultimate peak, and initial and ultimate 85th percentile, loading conditions. These predicted calculations have been assessed against the relevant health guidelines and the principles of prudent avoidance. In summary, our findings are:

- The predicted magnetic field contribution of the proposed substation in internal locations accessible to the general public is expected to be generally less than 40mG under ultimate (85th percentile) loading conditions.
- The substation's contribution to the magnetic fields in occupied spaces in adjacent buildings is expected to be generally less than 20mG under ultimate (85th percentile) loading conditions. This contribution would be confined to levels 1 to 10 and would decrease as one moves away from the substation wall. There are however predicted to be localised peaks of up to 50mG midway along the southern wall in the vicinity of the capacitor bank risers.
- The substation's contribution to the magnetic fields at its Bligh Street frontage is predicted to be up to 20mG and would be dominated by the outgoing 11kV feeders. At the O'Connell Street frontage the magnetic fields are predicted to be up to 50mG with the main contributor being the nearby transformer connections.
- Under ultimate peak loading conditions, localised peaks exceeding 2000mG are predicted near the 11kV Risers on Levels 3 and 4 which, in some areas, may be accessible to the public. Within 1.5m of the 11kV riser cables and 0.5m of the 132kV riser cables, the fields are expected to decrease to less than 1000mG.
- With the exception of localised peaks near the 11kV and 132kV Risers on Levels 3 and 4, the highest fields in areas accessible to the public are predicted to be 5% of the relevant health guideline (reference level) for the general public.
- The electric fields associated with the substation in areas accessible to the public are predicted to be negligible.
- The public car parking areas on Levels 3 and 4 should be examined and consideration given to field reduction measures or the installation of barriers to maximise users' separation from high field sources without impinging on their requirements for access and egress.
- Consistent with the principles of prudent avoidance, and to the extent feasible, it would seem prudent to further review the design, configuration and phasing of the 11kV and 132kV transformer connections and the 11kV capacitor cabling and examine the feasibility of configuring the 11kV air cored reactors to achieve a degree of field cancellation.
- In finalising the design of the substation, it would be prudent for the designers to identify all reasonable and practicable measures, including the relevant techniques outlined in AS2067, to reduce the magnetic fields which might be encountered to an acceptable level and adopting those measures which can be implemented at reasonable cost and without undue inconvenience. It is our understanding that based on the information provided by this report Ausgrid are currently undertaking a detailed review to identify such measures.

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