

12 June 2005

Report: Electromagnetic Field Mitigation in Childcare Centre at 481 Canning Street, North Carlton.

Client: Noel Arnold & Associates Pty. Ltd.

1. Introduction

North Carlton Childcare Centre is located adjacent to the CitiPower electricity substation known as Richardson – Canning Carlton Substation.

Following concerns raised by parents about exposure of children to the power frequency magnetic field emitted from the substation, Noel Arnold & Associates Pty. Ltd conducted preliminary electromagnetic field measurements (EMF) in the Childcare Centre

Preliminary results indicated elevated EMF levels in areas adjacent to the substation room and our firm was requested to carry out more detailed investigation and determine technically and economically viable measures for reduction of the magnetic field.

This report contains the results of detailed investigation with summary of relevant magnetic field and electrical measurements. Based on these results the most technically viable and cost-effective solutions are recommended for implementation.

2. EMF from Substation

The substation room is located within the land allocated for the Childcare Centre such that along its northern wall it is adjoining the Play Room 2 (currently known as the “3-5 years old Program Room”), the Toy Store is located across its western wall and the Carport is across its eastern wall (see the Ground Floor Plan of the Childcare Centre in Fig.1 below).

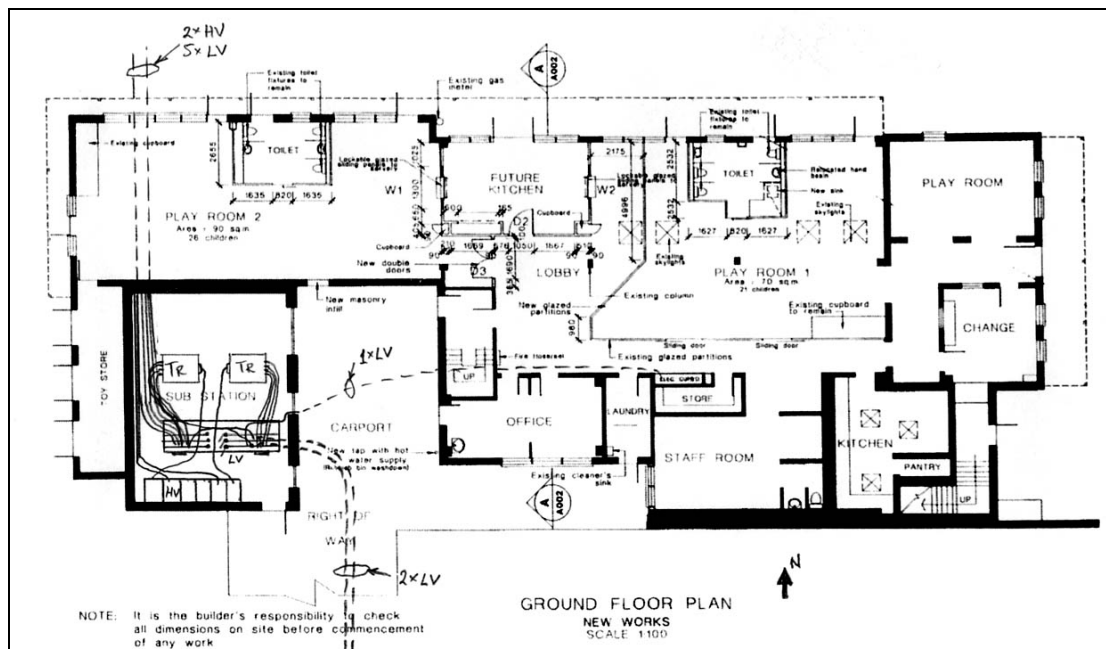


Fig.1 Ground Floor Plan of Childcare Centre (Substation Room is in the bottom left corner).

EMF measurements in the Centre were conducted at around 2.00 pm on Tuesday, the 17th of May 2005.

The electromagnetic field (EMF) meter used during the measurements was *HMI-1 EMF Magnetic Field Meter* with the following technical specification:

Number of axes	3
Measuring range	0.1-6000mG
Resolution	0.1mG
Accuracy Error	±(2% + 1 digit)
Frequency Response	50-1000Hz
Calibration Frequency	50Hz
Measurement type	true RMS

All the EMF measurements described below are given in units of milliGauss (mG).

The EMF was measured in the Play Room 2 along the substation wall and on the floor. Measurements revealed the following:

- The magnetic field along the substation wall at 1m above the floor was ranging from 6 mG at the eastern end to 10.5 mG. at the western end of the wall.
- The highest magnetic field on the floor was 27.1 mG and it was relatively similar in magnitude along a section of the floor which was approximately 1m wide and 6m long and extended from the substation wall (close to its western end) towards Richardson Street. EMF in the same area but at 1m height was around was 11mG. This indicated that the EMF source was below the floor.
- The highest magnetic field at the Eastern end of the Play Room 2 near the entrance door was 14mG at 1m above the floor, 8mG on the floor and 24mG at 2m above the floor. This indicated that the EMF source was in the ceiling space and as such would also affect some area on the 1st floor.

Inspection of the CitiPower substation revealed the following:

- The substation contained two 1000kVA, 11kV/415V oil-filled transformers located approximately 2.5m away from the northern wall, one low voltage (LV) switchboard located approximately 5.5m from the northern wall and the high voltage (HV) switchgear located along the south wall of the substation room (for details see Fig.1).
- The substation is fed by two 11kV underground cables that are buried in plastic conduits at approximately 1m depth below the Play Room 2.
- The substation is supplying LV current to external loads by the total of eight cables, seven of which are installed underground and, one that feeds the Childcare Centre, is installed above the ground. Six of the seven underground cables are of 4-core type, while the remaining eighth cable is made from four single-core cables. Five (all of them 4-core cables) out of seven cables were buried in plastic conduits at approximately 1m depth below the Play Room 2, while two remaining underground cables are buried in conduits under the Carport.

- At the time of the measurements the total substation load current on LV side was 700 A, which is approximately 25% of its rated capacity.

Usually the magnetic field from 3-core HV cables and 4-core LV cables is so small that it is hardly measurable at distances more than 1m away from cables. However, due to the multiple-earth-neutral (MEN) system of the neutral earthing in the LV networks, which is commonly used for electrical safety in Australia, the LV cables can emit strong EMF due to the residual current than might flow in the cables as a result of the MEN system.

The magnetic field measured on the floor of the Play Room 2 but at a distance from the substation wall strongly suggested that the magnetic field in that part of the room was mainly due to the residual current in the LV cables.

Measurements of the electric current in each of the outgoing LV cables showed that all eighth cables were carrying some residual current. Further electrical measurements revealed that combined residual current (sum of all residual currents) of five underground cables that are buried below the Play Room 2 was in the order of 18-23 A. The residual current in the other two u/g cables was 21-22 A in the 4-core cable and 5.0-5.2 A in the 4x1-core cable. The residual current in the LV cable that feeds the Childcare centre was 13.2 A.

Based on the above measurements it is clearly evident that the residual current in the LV cables buried below the Play Room 2 is the cause of the EMF on the floor in the western part of the room. However the western half of the room to a lesser extent is also affected by the EMF emitted from the LV cables of both transformers and from the substation LV switchboard.

In the eastern part of the room close to the entrance door the EMF was caused by flow of a.c. current in the water pipes. Several copper water pipes are located in the ceiling space and the combined electric current measured in all pipes together was 8.8 A.

It should also be noted that the LV cable that feeds the Childcare Centre is installed in the ceiling space adjacent to the Office, the Lobby and the Staff Room (see Fig.1). It is also located close to occupied areas on the 1st floor of the Centre. This cable, due to high residual current, causes strong EMF along its path.

3. EMF Mitigation Measures

The most common and most frequently used EMF mitigation measure is electromagnetic shielding which is made either from high permeability or high conductivity metal and which is usually installed around the EMF source, but occasionally also around EMF affected areas.

The effectiveness of shielding installation is depended on physical dimensions of the EMF source, its proximity to the affected area, the form and shape of the shielding structure and, to a larger degree, on the level of the residual current in cables and wires of the EMF source. The higher the residual current, the more technically difficult is to mitigate its EMF to within the acceptable limits.

Some practical physical obstacles such as doors, windows, brick or concrete walls, concrete floor and ceiling slabs, etc., prevent complete enclosing of the EMF source or the affected area by electromagnetic shielding metal and, as a result, affect the effectiveness of the shielding measure.

Therefore, in practical form the magnetic shielding metal can be installed on the floor above buried cables and on the wall that separated the Play Room 2 from the substation room.

Design and calculations of the EMF shielding installation on the floor above buried cables resulted in the following:

- The shielding plate on the floor should be extended to a minimum of 3.5m on either side of the cable path in one direction and for the entire width of the room from the substation wall to the windows in another direction. The thickness of the shielding cover on the floor, if made from our high permeability shielding metal “Magshield”, should be not less than 2mm. Such shielding cover on the floor will reduce the EMF on the floor in the areas away from the substation wall to the maximum level of 6 mG. It should be noted that no further reduction of the EMF on the floor above the cables is possible by application of electromagnetic shielding unless the residual current in the LV cables is substantially reduced.
- Shielding metal should also be installed above the LV cables buried in the play ground between the windows of the Play Room 2 and the fence along Richardson Street.
- Shielding metal should also be installed on the substation wall. However, for the best outcome the shielding should be installed on the wall inside the substation room such that the ends of the shielding structure are extended on adjacent walls and diverted away from the Play Room 2. The total thickness of the shielding cover on the wall should be not less than 1.2mm. Such shielding structure will reduce the highest EMF on the wall to less than 5mG when measured at 1m above the floor.

Other technical measures that should be applied for further EMF reduction in the Childcare Centre are as follows:

1. Elimination or substantial reduction of the residual current in five buried cables below the Play Room 2. This might be achievable by installation of neutral switches in two other underground cables at the locations where they can be connected to other LV feeders through normally open switches (at the overhead sections of the street services LV feeders).
2. Elimination of the residual current in the 4-core LV cable that feeds the Childcare Centre from the substation. This can be achieved by removal of the MEN link in the LV switchboard of the Childcare Centre. However, this measure should be accompanied by installation of additional Earth cable which should be routed along the 4-core power supply LV cable and connected to the Substation Earth at one end and the Earth Bar of the Childcare LV Switchboard at the other end.
3. In addition it may be necessary to insert a plastic pipe of at least 2m long into the existing copper water pipe for elimination of the electric current in the water pipe.

Application of this measure intrinsically related to the outcome of the measure described in Item 2 above and may not be necessary if the current in the water pipe will be eliminated as a result of removal of MEN link from the LV Switchboard.

The above recommended additional measures will result in substantial further reduction of the EMF in the Childcare centre, both on the Ground and the 1st floor to less than time-weighted average level of 4mG.

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