



REPORT

AIR QUALITY ASSESSMENT FOR ENERGYAUSTRALIA'S SYDNEY CITYGRID PROJECT AND GREENHOUSE GAS ASSESSMENT FOR THE BELMORE PARK ZONE SUBSTATION

PlanCom Consulting Pty Ltd

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ES1 EXECUTIVE SUMMARY

PlanCom Consulting Pty Ltd (PlanCom) engaged PAEHolmes to provide an air quality assessment for the Sydney CityGrid Project including a greenhouse gas assessment for the Belmore Park Zone Substation. The work has been commissioned by EnergyAustralia as part of the contract for "Environmental Planning & Assessment Services for the Sydney CityGrid Project".

To meet licence obligations, cater for future demand and ensure timely replacement of older infrastructure, EnergyAustralia wishes to carry out various and staged new construction works as well as upgrading and refurbishing of existing infrastructure and assets within the Sydney Central Business District (CBD) (the "Project").

The Project will be assessed by the NSW Department of Planning under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). It will broadly include the following works:

- construction of up to three zone substations (including, if necessary, the demolition and/or refurbishment of existing zone substations and integrated commercial developments constructed on or in conjunction with the zone substations);
- replacement of and upgrades to high voltage cable network; and
- construction of tunnels for the installation of high voltage cables and associated communications infrastructure.

The Project components and required timeframes for delivery are described in Table ES1.1.

Table ES1.1: Project Components and Required Timeframes for Delivery

Project Component	Required Timeframe for Delivery ^a
Extension to the existing City South Cable Tunnel from Wade Place to Riley Street, Surry Hills (approximately 150m)	Mid 2012
Stub tunnel connection from the existing City South Cable Tunnel (nominally 20m below Campbell Street) to Belmore Park Zone Substation	Mid 2012
Belmore Park Zone Substation, encompassing commercial/retail development (at the corner of Pitt, Hay and Campbell Streets)	Mid 2012
City East Cable Tunnel (approximately 3.2km) from Riley Street, Surry Hills to Erskine Street, in the northern end of the CBD, inclusive of potential ventilation shaft and Services Control Room at an intermediate point along the alignment	Mid 2015
City East Zone Substation, potentially encompassing commercial/retail development (at a site yet to be determined)	Mid 2015
New Sub-transmission Switching Station (STSS) at Riley Street, Surry Hills, and potentially a tunnel services control and access to the City East Cable Tunnel (in the alternative the control and access would be located at a midway point along the tunnel alignment)	Mid 2015
Potential refurbishment or replacement of the existing Dalley Street Zone Substation or building at a nearby site	2018

^a pers comm J. Ardas, PlanCom Consulting Pty Ltd, 28/05/2008

Note: The commercial/retail development component of the Belmore Park Zone Substation Project will be constructed in a staged approach, potentially up to 5-10 years after completion of the zone substation component.

The objectives of this study are to consider the potential air quality impacts of the Project during construction and operation and assess whether mitigation is required. Where mitigation is required, appropriate measures are recommended. In addition, the greenhouse gas assessment is provided for the Belmore Park Zone Substation component of the Project.

Air quality was assessed based on an indicative construction activity plan and scheduling sequence, taking into account the location and the context of the surrounding area to determine the potential for exposure and or adverse impacts.

A review of construction equipment and vehicles and materials handling was conducted to identify emission sources from the works.

The main concern for air quality is the potential for emissions of dust and PM₁₀ during construction. However, air quality impacts are predicted to be insignificant if best practice dust management procedures are practised. Mitigation measures have been proposed to reduce emissions wherever possible and these recommendations could be included in a Construction Environmental Management Plan (CEMP) for the Project.

Potential for air quality impacts during operation of the Project have also been considered, however there are no predicted adverse impacts on air quality during the operation of the substations and high voltage tunnel.

Direct (Scope 1) greenhouse gas emissions are produced from sources within the boundary of an organisation and as a result of an organisation's activities. Scope 1 greenhouse gas emissions will be generated during construction of the Belmore Park Zone Substation from combustion engines of construction equipment.

During operation of the proposed Belmore Park Zone Substation there is potential for Scope 1 greenhouse gas emissions from leakage or spillage of sulfur hexafluoride (SF₆) insulating gas used in switchgear. It is noted that the transformers at Belmore Park Zone Substation will not use SF₆ insulating gas. They will instead operate on an alternative oil dielectric fluid, which does not constitute greenhouse gases. As such, only small quantities of SF₆ will be required at the Belmore Park site to operate switchgear. Other substations in the Sydney CityGrid network may use either SF₆ or other dielectric fluids in transformers. Where SF₆ is used, greenhouse gas emissions would be minimised by adhering to industry best practice procedures for handling and disposal.

Indirect greenhouse gas emissions (Scope 2 & 3) are generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation. The most important category of indirect emissions is from the consumption of electricity.

The greenhouse gas assessment only considers the Belmore Park Zone Substation. Scope 2 emissions from electricity consumption to operate the substation are addressed and emissions from Transmission and Distribution (T&D) losses will be reported by EnergyAustralia elsewhere.

Provided that the appropriate management and mitigation measures are followed the impacts on air quality from the Project and emissions of greenhouse gases from the Belmore Park Zone Substation are considered to be acceptable.

TABLE OF CONTENTS

1	INTRODUCTION	9
1.1	Project Summary	9
1.2	Project components	9
1.2.1	Sydney CityGrid Project Concept Application	9
1.2.2	Belmore Park Zone Substation Project Application	10
1.3	Study Objectives	12
2	STUDY APPROACH	13
2.1	Air Quality	13
2.2	Greenhouse Gases	13
3	EMISSIONS TO AIR	14
3.1	Sources of Emissions	14
3.2	Pollutants of Interest	14
4	EXISTING AIR QUALITY	15
4.1	Carbon monoxide	15
4.2	Lead	15
4.3	Nitrogen dioxide	16
4.4	Sulfur dioxide	16
4.5	Fine particles	16
5	ASSESSMENT	19
5.1	Air Quality	19
5.1.1	Construction	19
5.1.2	Operation	20
5.2	Greenhouse Gas	21
5.2.1	Combustion	21
5.2.2	Dielectric Medium to be used in Transformers	21
5.2.3	Electricity	24
6	MITIGATION MEASURES	25
6.1	Air Quality	25
6.1.1	Construction	25
6.1.2	Operation	26
6.2	Greenhouse Gases	26
7	CONCLUSIONS	27
8	REFERENCES	28
	APPENDIX A	A-1
A.1	Indicative Citygrid Project construction Program	A-2

ABBREVIATIONS AND GLOSSARY

Term	Definition
$\mu\text{g}/\text{m}^3$	Micrograms per cubic metre. A measure of particulate concentration in ambient air.
Air NEPM	National Environment Protection Measure for Ambient Air Quality
AIS	Insulation of air
CBD	Sydney Central Business District
CECT	City East Cable Tunnel
CEMP	Construction Environmental Management Plan
CO	Carbon monoxide
CO _{2-e}	Carbon dioxide equivalents
ENA	Energy Networks Australia
EP&A Act	NSW Department of Planning Environmental Planning and Assessment Act 1979
FR3	Ester based dielectric coolant specifically formulated for use in distribution transformers.
GIS	Insulation by SF ₆
GJ	Gigajoules or 1,000,000,000 Joules. A measure of energy.
GHG	Greenhouse gases i.e. carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, perfluorocarbons, hydrofluorocarbons.
GMR	Sydney Greater Metropolitan Region. Area that covers 57,330 km ² , which includes the greater Sydney, Newcastle and Wollongong regions.
GWP	Global warming potential relative to carbon dioxide over a 100 year period.
kg	Kilogram or 1,000 grams. A measure of mass.
kL	Kilolitres or 1,000 litres or cubic metre. A measure of volume.
kV	Kilovolts or 1,000 volts. A measure of the strength of an electrical source.
kWh	Kilowatt hours or 1,000 watt hours.
LCA	Life Cycle Assessment
m ²	Square metres. A measure of area.
m ³	Cubic metre or kilolitre or 1,000 litres. A measure of volume.
MVA	Megavolt amperes
n-2 licence conditions	Design, Reliability & Performance Licensing Conditions by the Minister for Energy for the Sydney CBD by 2014
NGA	National Greenhouse Accounts
NO ₂	Nitrogen dioxide
NO _x	Oxides of nitrogen i.e. nitric oxide (NO) and nitrogen dioxide (NO ₂)
NSW	New South Wales
NSW DECC	NSW Department of Environment and Climate Change
PlanCom	PlanCom Consulting Pty Ltd
PM ₁₀	Particulate matter with an aerodynamic diameter of less than 10 micrometres. Also referred to as fine particulate matter.
PM _{2.5}	Particulate matter with an aerodynamic diameter of less than 2.5 micrometres.
ppm	Parts per million (mass basis)
Riley Street STSS	Riley Street Sub Transmission Switching Station
Roadheader	Mechanical excavating machines that have a large rotating cutting head mounted on a moveable boom. They are able to turn tight corners during tunnel construction.
Scope 1 greenhouse gas emissions	Direct emissions produced from sources owned or controlled by the entity.
Scope 2 greenhouse gas emissions	Indirect emissions from the generation of purchased electricity consumed by the entity.
Scope 3 greenhouse gas	Indirect emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity (with the exception of electricity)

Term	Definition
emissions	generation).
SF ₆	Sulfur hexafluoride
SO ₂	Sulfur dioxide
STSS	A sub-transmission switching station – generally 132kV (without transformers)
Stub tunnel	A short section of tunnel which links to a main tunnel
t	Tonne or 1,000 kilograms. A measure of mass.
T&D	Transmission and Distribution
TBM	Tunnel Boring Machine
TEOM	Tapered-element oscillating microbalance. An instrument used to measure ambient concentrations of particulate matter.
TSP	Total suspended particulate

1 INTRODUCTION

PlanCom Consulting Pty Ltd (PlanCom) engaged PAEHolmes to provide an air quality assessment for the Sydney CityGrid Project including a greenhouse gas assessment for the Belmore Park Zone Substation. The work has been commissioned by EnergyAustralia as part of the contract for "Environmental Planning & Assessment Services for the Sydney CityGrid Project".

To meet licence obligations, cater for future demand and ensure timely replacement of older infrastructure, EnergyAustralia wishes to carry out various and staged new construction works as well as upgrading and refurbishing of existing infrastructure and assets within the Sydney Central Business District (CBD) (the "Project").

The Project will be assessed by the NSW Department of Planning under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act).

1.1 Project Summary

Peak electricity demand in the Sydney CBD is growing at an average rate of 1.7% per annum driven primarily by new residential, hotel and office developments.

EnergyAustralia, over the next 10 years, needs to construct new, or upgrade and refurbish existing, zone substations and replace high voltage cables supplying the substations in order to:

- meet n-2 licence conditions;
- cater for future demand and introduce new technologies that are likely to reduce electricity 'losses' by reducing the resistance of the electricity network; and
- ensure timely replacement of infrastructure which is due for retirement to maintain a reliable supply of electricity for the CBD.

Building works would include the construction of up to three zone substations (including, if necessary, the demolition and/or refurbishment of existing zone substations and would most likely include integrated commercial/retail developments on or in conjunction with the zone substations). The Project also involves the construction of up to three new tunnel sections in the Sydney CBD, and the city fringes, which would 'link' the existing tunnel networks and key zone substations servicing the city together.

1.2 Project components

1.2.1 Sydney CityGrid Project Concept Application

New and/or refurbished substations in the Sydney CBD and a tunnel network for 132 kV cables comprising:

1. Extension to the existing City South Cable Tunnel from Wade Place to Riley Street, Surry Hills (approximately 150 m);
2. Stub tunnel connection from the existing City South Cable Tunnel (nominally 20 m below Campbell Street) to Belmore Park Zone Substation;
3. Belmore Park Zone Substation, encompassing commercial/retail development (at the corner of Pitt, Hay and Campbell Streets);

4. City East Cable Tunnel (approximately 3.2 km) from Riley Street, Surry Hills to Erskine Street, in the northern end of the CBD, inclusive of potential ventilation shaft and Services Control Room at an intermediate point along the alignment;
5. City East Zone Substation, potentially encompassing commercial/retail development (at a site yet to be determined);
6. New Sub-transmission Switching Station (STSS) at Riley Street, Surry Hills, and potentially a tunnel services control and access to the City East Cable Tunnel (in the alternative the control and access would be located at a midway point along the tunnel alignment); and
7. Potential refurbishment or replacement of the existing Dalley Street Zone Substation.

1.2.2 Belmore Park Zone Substation Project Application

1. Belmore Park Zone Substation, encompassing commercial/retail development (at the corner of Pitt, Hay and Campbell Streets); and
2. Stub tunnel connection from the existing City South Cable Tunnel (nominally 20 m below Campbell Street) to Belmore Park Zone Substation.

Figure 1.1 provides an indicative plan showing the works for the proposed Project.

The Project components and required timeframes for delivery are described in Table 1.1.

Table 1.1: Project Components and Required Timeframes for Delivery

Project Component	Required Timeframe for Delivery ^a
Extension to the existing City South Cable Tunnel from Wade Place to Riley Street, Surry Hills (approximately 150m)	Mid 2012
Stub tunnel connection from the existing City South Cable Tunnel (nominally 20m below Campbell Street) to Belmore Park Zone Substation	Mid 2012
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City East Zone Substation, potentially encompassing commercial/retail development (at a site yet to be determined)	Mid 2015
New Sub-transmission Switching Station (STSS) at Riley Street, Surry Hills, and potentially a tunnel services control and access to the City East Cable Tunnel (in the alternative the control and access would be located at a midway point along the tunnel alignment)	Mid 2015
Potential refurbishment or replacement of the existing Dalley Street Zone Substation or building at a nearby site	2018

^a pers comm J. Ardas, PlanCom Consulting Pty Ltd, 28/05/2008

Note: The commercial/retail development component of the Belmore Park Zone Substation Project will be constructed in a staged approach, potentially up to 5-10 years after completion of the zone substation component.

1.3 Study Objectives

In terms of air quality the objectives of the study are to consider the potential impacts of the Project during construction and operation, including excavation works, and construction of substation structure and tunnels and assess whether mitigation is required. Where mitigation is required then appropriate measures are recommended.

The objective of this study with respect to greenhouse gases is to assess emissions from the Belmore Park Zone Substation component of the Project during the construction and operation of the substation and the stub tunnel. Where information is not yet available in detail, a qualitative assessment is provided.

2 STUDY APPROACH

2.1 Air Quality

Air quality was assessed based on an indicative construction activity plan and scheduling sequence, taking into account the location and the context of the surrounding area to determine the potential for exposure and or adverse impacts.

A review of construction equipment and vehicles and materials handling was conducted to identify emission sources from the works.

Mitigation measures were proposed to reduce emissions where possible and these recommendations could be included in a Construction Environmental Management Plan (CEMP) for the Project.

Potential for air quality impacts during operation of the Project have also been considered.

2.2 Greenhouse Gases

Direct (Scope 1) greenhouse gas emissions are produced from sources within the boundary of an organisation and as a result of an organisation's activities.

Scope 1 greenhouse gas emissions will be generated during construction of the Belmore Park Zone Substation from combustion engines of construction equipment.

During operation of the proposed Belmore Park Zone Substation there is potential for Scope 1 greenhouse gas emissions from leakage of SF₆ insulating gas from switch gear.

Indirect greenhouse gas emissions (Scope 2 & 3) are generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation. The most important category of indirect emissions is from the consumption of electricity. Scope 2 emissions are allocated to the organisation that owns or controls the plant or equipment where the electricity is consumed. Usually, the electricity consumer reports only the emissions from the electricity they use under Scope 2, and reports emissions associated with transmission and distribution (T&D) losses under Scope 3. However, companies that own or control T&D networks, i.e. EnergyAustralia, report emissions associated with all T&D losses on their networks under Scope 2.

This assessment only considers the Belmore Park Zone Substation. Scope 2 emissions from electricity consumption to operate the substation are addressed and emissions from T&D losses will be reported by EnergyAustralia elsewhere.

Where activity data are available, emissions are assessed using emission factors outlined by the *National Greenhouse Accounts (NGA) Factors (2008)*, which are published by the Australian Government Department of Climate Change. Activity data were provided by EnergyAustralia.

3 EMISSIONS TO AIR

3.1 Sources of Emissions

There is potential for emissions of combustion gases and dust to be generated during construction of the zone substation and integrated commercial developments as well as during excavation and tunnelling construction works and spoil handling activities.

During operation of the Belmore Park Zone substation, there is potential for Scope 1 greenhouse gas emissions of sulfur hexafluoride (SF_6) to be released via leakage from gas insulated switchgear and circuit breaker applications. If SF_6 is the chosen dielectric fluid in transformers located elsewhere in the Sydney CityGrid network, then potential for Scope 1 greenhouse gas emissions of SF_6 would also have to be considered.

During operation of the substation, emissions from electricity used to power the substation are considered as indirect (Scope 2) greenhouse gas emissions.

3.2 Pollutants of Interest

The main pollutants of interest are total suspended particulates (TSP) and particulate matter less than 10 micrometres in aerodynamic diameter (PM_{10}) that may be emitted due to the proposed demolition and construction works.

Combustion emissions, i.e. oxides of nitrogen (NO_x), fine particulate matter (PM_{10} and $\text{PM}_{2.5}$), carbon monoxide (CO) and sulfur dioxide (SO_2) from construction vehicles are also likely to be released.

During operation of the Belmore Park Zone Substation there is potential for emissions of SF_6 from gas insulated switchgear and circuit breaker applications. However, the transformers at Belmore Park Zone substation will operate using an oil based dielectric fluid. If mineral oils, FR3 or ester type oils are used, there would be no potential direct greenhouse gas emissions as these dielectric fluids do not constitute greenhouse gases. Transformers to be installed in other substations that are part of the Sydney CityGrid Project may operate on either SF_6 gas or the alternative oil based dielectric fluids. This assessment would be made during design development of those projects.

If SF_6 is used, it is noted that SF_6 is a highly potent greenhouse gas. Its global warming potential (GWP) is 23,900, which means that over a 100-year period, SF_6 is 23,900 times more effective at trapping infrared radiation than an equivalent amount of carbon dioxide. With an atmospheric lifetime of 3,200 years, SF_6 is also a very stable chemical. Therefore, due to its long lifespan and high potency, even a relatively small amount of SF_6 can have a significant impact on global climate change.

Apart from its use as an insulating medium in the electricity transmission industry, SF_6 is also used as a cover gas in the magnesium industry, for plasma etching in semiconductor manufacturing, as a reactive gas in aluminium recycling to reduce porosity, as thermal and sound insulation and in atmospheric tracer studies and medical applications.

4 EXISTING AIR QUALITY

This section provides an overview of existing air quality in Sydney. These summaries for pollutants are from a technical paper provided by the NSW DECC, providing a review of air quality in NSW to support the Clean Air Forum 2007 (NSW DECC, 2007).

Air quality has been monitored in Sydney since the early 1950s. The NSW DECC operates a comprehensive state-wide air quality monitoring network comprising sites throughout NSW, with particular focus on the main population centres of Sydney, the lower Hunter and the Illawarra. The information provided below is based on monitoring data from that network.

4.1 Carbon monoxide

Carbon monoxide (CO) is currently monitored at five stations in the Sydney region (Chullora, Liverpool, Macarthur, Prospect and Rozelle).

The Sydney CBD station was the longest established station, with over 20 years of data and was the only station where high levels of CO were detected. It was located on George Street at a height just above that of bus and truck exhaust pipes and within an urban canyon typified by poor dispersion. Thus, the station was considered a peak site, likely to record the greatest concentrations of CO in the Sydney region. It was closed in 2004 following six years without recording an exceedance.

During the 1980s, CO concentrations in the CBD exceeded the standard on up to 109 days per year and the maximum level of 26.7 parts per million (ppm) was almost three times the standard.

Since the introduction of unleaded petrol and catalytic converters in 1985, peak CO levels in the CBD have plummeted. The last exceedance of the CO standard in NSW was recorded there in 1998, and since 2002, maximum 8-hour concentrations have been half the standard.

Apart from at the CBD monitoring station, levels of CO at other stations have never exceeded the standard and have fallen considerably over the past 13 years. The maximum recorded values in these areas are now typically less than 30% of the standard.

The National Environment Protection Measure for Ambient Air Quality (Air NEPM) standard for CO is no longer exceeded anywhere within the monitoring network in NSW.

4.2 Lead

Lead was measured at three sites in Sydney (the CBD, Earlwood and Rozelle) for over 20 years, until 2004. DECC began phasing out ambient lead monitoring for the Air NEPM during 2004, and all lead monitoring ceased from 1 January 2005.

The introduction of unleaded petrol in 1985, the progressive reduction of the lead content of petrol and the subsequent ban on lead in petrol from 2002 have reduced ambient concentrations of atmospheric lead in Sydney. Lead levels today are well below the Air NEPM standard of 0.5 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$). Annual averages throughout NSW are now typically less than 0.03 $\mu\text{g}/\text{m}^3$ and many 24-hour average samples are below the minimum detection limit.

4.3 Nitrogen dioxide

In Sydney, the largest source of oxides of nitrogen (NO_x) emissions is on-road vehicles, which contribute over 71% of total NO_x emissions.

NO_x has been monitored continuously in NSW since the 1970s. NO_x is currently measured at 14 sites in Sydney.

During the 1980s, exceedances of the 1-hour nitrogen dioxide (NO_2) standard were common in Sydney, particularly during winter. Since then levels have fallen substantially, and the 1-hour standard has not been exceeded in Sydney since 1998. Maximum 1-hour concentrations are now well below the standard and annual average concentrations are typically less than 50% of the standard.

NSW has met the Air NEPM goal for NO_2 , which allows for one exceedance per year, since 1994. The last exceedance of the 1-hour standard was recorded during 1998. Current maximum NO_2 concentrations are well below both the 1-hour and annual standards.

NO_x emissions from motor vehicles have fallen as a result of improvements to fuel and vehicle emissions standards. Emissions of NO_x from individual motor vehicles are predicted to continue falling as stricter vehicle emissions standards are introduced. However, some of these gains are countered by the increasing number of vehicles and vehicle-kilometres travelled.

4.4 Sulfur dioxide

Sulfur dioxide (SO_2) is monitored at eight stations in the Sydney region (Bargo, Bringelly, Chullora, Macarthur, Prospect, Randwick, Richmond and Vineyard).

There has never been a recorded exceedance of the 24-hour or annual SO_2 standard in NSW. Typically, maximum 24-hour averages range between 8% and 12% of the standard, and maximum annual averages range between 5% and 10% of that standard.

In Sydney, no exceedances of the 1-hour SO_2 standard have ever been recorded. The maximum 1-hour concentrations are typically less than 20% and less than 30%, respectively, of the standard.

Historically, with the exception of stations located close to major industrial sources, SO_2 levels in NSW have been significantly below the Air NEPM standards.

SO_2 levels are well below the standards and are expected to remain low.

4.5 Fine particles

There are many sources of particles in the air, arising from both natural processes and human activity. The dominant source of PM_{10} from human activity in Sydney is industry (37%), but domestic sources and on-road mobile sources make up a greater proportion of PM_{10} emissions in Sydney than in the rest of NSW.

The annual domestic sector contribution to PM_{10} emissions in Sydney comes largely from wood heating (93%). Wood heating provides a good example of the seasonal variation in emissions. In Sydney, wood heaters account for 3% of total PM_{10} particle emissions in summer (January weekday), but 43% in winter (July weekday).

In rural areas, broadacre agricultural activities (e.g. stubble burning and cultivation) and the use of solid fuels for heating and cooking are the major anthropogenic sources of particles.

Emissions from natural events, such as bushfires and dust storms, also contribute significantly to fine particle levels in NSW. Almost 20% of PM₁₀ emissions in the Sydney Greater Metropolitan Region (GMR) come from agricultural burning, bushfires, prescribed burning and windborne dust.

Particles less than 10 µm in diameter (PM₁₀) and less than 2.5 µm in diameter (PM_{2.5}) are measured in NSW by using tapered-element oscillating microbalance (TEOM) instruments, which provide continuous, real-time particle mass measurement.

At present there is no Australian Standard method for measuring PM_{2.5}. A national program, the PM_{2.5} Equivalence Program, is assessing the accuracy and precision of various PM_{2.5} instruments. The Air NEPM PM_{2.5} advisory reporting standards of 25 and 8 µg/m³ for 24-hour and annual averages are not based on PM_{2.5} data measured by TEOM instruments.

In NSW, the highest exposure to fine particles occurs during severe bushfires and dust storms. During these events, peak PM₁₀ and PM_{2.5} levels can greatly exceed the relevant standards or goals. These events are also responsible for the greatest spatial extent (dust storms) and longest exposure to elevated levels (severe bushfires) of fine particles in NSW.

The highest ever recorded 24-hour average PM₁₀ level in NSW was 921.4 µg/m³, recorded at Albury during the severe dust storm of 19–20 March 2003. This was an extreme event that resulted in a peak concentration more than 18 times the Air NEPM standard. This same event also resulted in the highest PM₁₀ levels ever recorded in Sydney.

There is a strong seasonality to PM₁₀ levels. In Sydney, the majority of exceedances occur in spring and summer (81%).

The use of solid-fuel heaters, particularly older, inefficient models, during winter can be a significant source of fine particle emissions. However, winter exceedances in Sydney occur on average less than 1 day per year.

The few exceedances of the PM₁₀ standard in Sydney during winter are usually localised events. Of the ten winter exceedance days from 1994 to 2006, nine were days when an exceedance was recorded at a single monitoring station. In autumn, half of the exceedances were single-station events.

In contrast, during summer, more than two thirds of PM₁₀ exceedances in Sydney are multiple-station events, indicating that these events are more likely to be widespread or regional-scale. The events may be influenced by bushfires or dust storms, or they could be indicative of secondary particles produced during the formation of photochemical smog.

Exceedances of fine particle standards are common in NSW. Exceedances of the PM₁₀ standard have been recorded in all monitored regions. Levels above the PM_{2.5} Air NEPM standard are regularly recorded in the GMR. Since 1994 there has been no significant improvement in fine particle levels in the GMR.

There is significant seasonality to particle levels in NSW. PM₁₀ exceedances occur most often in the warmer months and days above the PM_{2.5} advisory reporting standard peak in winter and summer. The PM_{2.5} advisory reporting standard are exceeded more often than the PM₁₀ standard.

Although background levels of fine particles in Sydney increase during the cooler months, exceedances of fine particle standards in winter are primarily local events.

Exceedances of the PM_{10} standard are common in NSW during the warmer months. Extreme values, many times greater than the standard, have been recorded. These extreme levels are the result of natural events such as dust storms and bushfires. The severe drought conditions experienced across NSW over the past few years have contributed to an increased incidence of PM_{10} levels above the standard.

5 ASSESSMENT

5.1 Air Quality

5.1.1 Construction

Excavation of shafts (for access to tunnelling operations and to remove spoil material) is required at a number of locations at different phases throughout the proposed Project. Shaft excavations and spoil removal will involve surface earthworks and construction and materials handling activities, which have potential to generate dust emissions. However, disturbed surface areas around access shafts would be maintained to an area as small as possible and most likely between 20 m² and 50 m². Dust emissions from these areas are predicted to be negligible when managed appropriately and would have localised impacts only, if any. Exposed surface areas will be managed via dust mitigation measures such as those provided in Section 6.1.1 of this report.

Table 5.1 provides the proposed locations and estimated amounts of spoil to be removed during the Sydney CityGrid Project. Note that these items of work will be conducted in phases and mitigation measures will be focussed on each phase as it is conducted. An indicative construction program is further detailed in Appendix A.1.

Table 5.1: Locations of shafts and estimated amount of spoil material removed during the Project^a

Description	Location of Spoil Removal	Estimated Spoil Quantity (m ³) ^b
Belmore Park Zone Substation	Belmore Park Substation works	47,250
Belmore Park Commercial	Belmore Park Commercial works	23,250
Stub Tunnel to CSCT	Campbell Street	963
Riley Street STSS	Bulk excavation of entire site	42,000
CECT Launch Cavern	Riley Street Site	3,000
CSCT Extension	Riley Street Site	3,543
City East Cable Tunnel (CECT)	Riley Street Site	57,000
Potential Stub Tunnels (x3)	From shaft locations	5,670
Underwood St Shaft	Underwood Street (or potentially Gresham Street)	1,620
Yurong Street Shaft	Yurong St / Sir John Young Cres	3,240
City East Shaft	City East Zone Substation Location	3,240
Surface Works (General)	Around Dalley , Bent, Bridge and Gresham Streets	3,480
Contingency	Various	3,606
Total		197,862

^a Source: pers comm J. Ardas, PlanCom Consulting Pty Ltd, 28/05/2008 & 03/10/2008.

^b Allows for a 50% bulking factor.

Preparation of the site for construction of the Belmore Park Zone Substation and Riley Street Sub Transmission Switching Station (STSS) would also create disturbed surface areas with potential to cause dust emissions. However, if the construction site for the Belmore Park Zone Substation is managed using dust mitigation measures such as those provided in Section 6.1.1 of this report, it is expected to cause negligible dust impacts.

Excavation of the City East Cable Tunnel using a roadheader and a Tunnel Boring Machine (TBM) would generate dust at the working face and during handling and transport of spoil material. Both types of tunnelling machines use cutting or cooling fluid, predominantly water,

which would reduce the amount of dust generated. The tunnel would be mechanically ventilated to ensure that clean air is available to workers in the tunnel. During the construction period, dust laden air from the tunnel would be treated via a filtration system to remove dust particles before the air is exhausted from the tunnel. The design of the filtration system would meet the requirements of the *Protection of the Environment Operations (Clean Air) Regulation 2002* (as amended) and the filtration system would control any dust emissions at acceptable levels.

Spoil material would be stockpiled and loaded into trucks after being removed from the tunnel via the access shafts. The majority of the spoil would be removed via the Riley Street site. It should be noted that the Riley Street site has already been partially excavated as part of a previous development, where the low point of the site is approximately 10 metres deep. Further excavation would increase the depth of the site to approximately 20m below ground level. Loading of spoil into trucks for transport off-site will occur at the low point of the site, which will help to reduce potential dust impacts on nearby receptors. The depth of the site will help to protect the loading operations from wind and if dust emissions are generated, then a higher proportion is likely to resettle within the site than if the site was exposed. In addition, dust emissions from loading and transporting of spoil material would be minimised by adhering to management and mitigation procedures such as those outlined in Section 6.1.1 of this report.

Apart from dust emissions from earthworks, air quality impacts associated with construction of the substations and commercial development buildings for the Sydney CityGrid Project are expected to be negligible.

Combustion emissions will be emitted from the construction equipment and transport vehicles used during construction. Appendix A.1 provides further detail of the indicative vehicle and construction equipment to be used, as well as the approximate number of movements for spoil transport and the proposed construction schedule. At the peak of construction activity for the Project a TBM, general delivery vehicles, spoil trucks, semi-trailers (for concrete segment delivery), grout rig, gantry crane, front-end loader, excavator, dump truck and general tools and equipment may be operating simultaneously, which could include up to 20 truck movements a day. Combustion emissions from the proposed Project activities are considered to have insignificant impact on air quality when compared to emissions from existing sources in the area such as motor vehicles on nearby roads.

The main pollutants of concern during construction activities for the proposed Project are TSP and PM₁₀ from dust generating construction activities. These emissions are not expected to cause adverse impacts provided that management and mitigation practices are adhered to, as outlined in Section 6.1.1 of this report.

5.1.2 Operation

During operation, the high voltage cable tunnel would be ventilated through a tunnel air intake located at the Riley Street STSS or at some other location midway along the tunnel alignment. The preferred ventilation strategy is for the air intake to be located at Riley Street. The tunnel ventilation system will exhaust at the City North Substation.

Air emissions during operation of the tunnels would be clean air and adverse air quality impacts are not expected.

There are no adverse air quality impacts expected from the operation of substations and commercial development buildings for the Sydney CityGrid Project.

5.2 Greenhouse Gas

5.2.1 Combustion

During construction, greenhouse gases will be emitted from combustion of fuel in engines of construction equipment and vehicles. When the construction phase of the Project is conducted, EnergyAustralia will be required to report these emissions under the *National Greenhouse and Energy Reporting Act 2007* if they trigger the reporting requirements.

Emission factors and equations for calculating greenhouse gas emissions from automotive fuel use are provided in the *National Greenhouse Accounts (NGA) Factors (2008)*. The activity data required is the amount of fuels used. The following fuel combustion estimates were provided by EnergyAustralia (pers comm J. Ardas, PlanCom, 02/07/08):

- During the bulk excavation of the Belmore Park site approximately 300 litres of diesel per day for approximately 200 days (i.e. 60,000 litres).
- During the substation and commercial development building works approximately 50 litres of diesel per day for approximately 560 days (i.e. 28,000 litres).

Estimated greenhouse gas emissions from the combustion of diesel in construction equipment are as follows:

- Scope 1 GHG Emissions (t) = Activity (kL) x Energy Content of Fuel (GJ/kL) x EF (kg CO_{2-e}/GJ)/1000 = (88 x 38.6 x 69.5)/1000= 236 tonnes CO_{2-e}.
- Scope 3 GHG Emissions (t) = Activity (kL) x Energy Content of Fuel (GJ/t) x EF (kg CO_{2-e}/GJ) /1000 = (88 x 38.6 x 5.3)/1000= 18 tonnes CO_{2-e}.

It should be noted that the figures above relate to the overall quantities of GHG emissions generated as a result of the construction of both the substation and commercial development components of the Project, notwithstanding that these components will be constructed separately in a staged approach.

During operation of the commercial development at Belmore Park, the estimated gas consumption is approximately 860 GJ per annum (Waterman AHW, 2008). Therefore, estimated emissions from gas consumption are as follows:

- Scope 1 GHG Emissions (t CO_{2-e}) = (860 x 51.33 / 1000 = 44.1 tonnes per annum.
- Scope 3 GHG Emissions (t CO_{2-e}) = (860 x 14.8 / 1000 = 12.7 tonnes per annum.

5.2.2 Dielectric Medium to be used in Transformers

EnergyAustralia are investigating the use of the following dielectric fluids for use in transformers as part of the Sydney CityGrid project:

- Sulfur hexafluoride (SF₆);
- Mineral oil; or
- FR3^a or other ester type oils.

Each dielectric fluid in terms of air quality and greenhouse gas impacts is discussed in Table 5.2.

^a Ester based dielectric coolant specifically formulated for use in distribution transformers.

Table 5.2: Dielectric Mediums and Associated Air Quality and Greenhouse Gas Impacts

Dielectric Medium	Potential Air Quality Impacts	Potential Greenhouse Impacts
Sulfur hexafluoride (SF ₆)	No known air quality impacts from the use of SF ₆ as a dielectric medium	Direct emissions could arise from the leakage during commissioning /decommissioning or operation of SF ₆ filled transformers. Indirect greenhouse gas emissions would be associated with the manufacturing, transportation and disposal of SF ₆ .
Mineral oil ^a	No known air quality impacts from the use of mineral oils as a dielectric medium.	No direct emissions from the use of mineral oils. Indirect greenhouse gas emissions would be associated with the manufacturing, transportation and disposal of mineral oils.
FR3 or other ester type oils	No known air quality impacts from the use of FR3 or ester type oils as a dielectric medium.	No direct emissions from the use of FR3 or other ester type oils. Indirect greenhouse gas emissions would be associated with the manufacturing, transportation and disposal of FR3 or other ester type oils.

^a It is assumed that any mineral oil considered will not contain polychlorinated biphenyl's (PCBs).

Whilst SF₆ may be used as an insulation gas for transformers and other circuit breaker operations in the Sydney CityGrid network, it will not be used in the transformers at the Belmore Park Zone Substation. Alternatives being investigated by EnergyAustralia are the use of mineral oils, FR3 or other ester type oils. However, a small amount of SF₆ will be used in switchgear at the Belmore park site. EnergyAustralia has not made a decision on the type of dielectric fluid to be used in the transformers for the remaining components of the Sydney CityGrid project.

Potential greenhouse gas emissions from the use of SF₆ are evaluated in this assessment as this dielectric medium is the only medium with potential for direct emissions of greenhouse gas emissions. There are no known direct impacts on air quality from the use of any of the other potential dielectric mediums in transformers.

If either mineral oils or FR3 or other ester type oils are used, greenhouse gas emissions from operation of transformers are zero.

5.2.2.1 SF₆

Outlined in this section are estimated greenhouse gas emissions from the use of SF₆ in gas-insulated switchgear at the Belmore Park Zone Substation.

SF₆ gas which may be contained in gas insulated switchgear is non-toxic and typically held in relatively small quantities within the switch room. The switchgear is very reliable equipment and therefore the risk of gas leakage is extremely low. However, should a major leak occur, gas leakage alarms and an appropriately designed ventilation system would ensure the safety of personnel. As the gas is non-toxic, there is no exposure limit.

However, due to its high global warming potential (GWP) and its long atmospheric lifetime, SF₆ gas is included in the greenhouse gases of the Kyoto protocol.

During construction of the substation there would be no SF₆ onsite. SF₆ gas would be added to equipment during the commissioning stage (under strict handling procedures) and equipment is also emptied onsite for maintenance, recycling or destruction.

Therefore, since this greenhouse gas assessment is for the Belmore Park Zone Substation only, the potential for SF₆ emissions to atmosphere are:

- as spillage during filling or maintenance of insulation gas to switchgear;
- as leakage during operation; or
- as spillage during decommissioning of the equipment.

Emission factors and equations for calculating greenhouse gas emissions from gas insulated switchgear and circuit breaker applications are provided in the *National Greenhouse Accounts (NGA) Factors (2008)*.

Calculation of emissions from SF₆ leakage from the operation of switchgear

The Belmore Park Zone Substation will use 5 transformers (each using an oil based dielectric fluid) and 16 gas insulated circuit breakers (each using 120 kg SF₆). Therefore total amount of SF₆ in operation on site is 1,920 kg.

Applying the annual leakage rate of 0.005 (i.e. 0.5%) gives:

- An annual loss of SF₆ (kg) = 0.005 x 1,920 kg = 9.6 kg of SF₆.
- Multiplying the 9.6 kg of SF₆ by its GWP of 23,900 gives a total annual emission of approximately 229 tonnes of CO_{2-e}.

Emissions of any spills would be calculated using the same emission factors and equations. However, this should not be required if appropriate methods and procedures are followed to eliminate the risk of spills.

It should be noted that this assessment has identified only those emissions from the Belmore Park Zone Substation. A full environmental Life Cycle Assessment (LCA) of gas insulated switchgear would also take into account other factors such as energy losses across the network, longer operating life of gas insulated gear compared with air insulated gear as well as disposal methods and procedures of decommissioning equipment.

Literature on SF₆ emissions from the electricity transmission and distribution industry supports the idea that gas insulated switchgear has better overall environmental performance than air insulated systems, as outlined in the following extract from Bessede et al (2004).

[Bessede et al. (2004)] "The relative contribution of SF₆ to man-made global warming effect can be calculated by taking into account the SF₆ concentration in the atmosphere and its GWP. This value is approximately 0.1% (from all industries). When searching only the SF₆ gas coming from the world electrical industry, many people estimated it at 0.012%.

On another hand, many attempts have been done to evaluate the environmental impact of SF₆ from electrical equipment via environmental Life Cycle Assessment (LCA). For example, when considering the LCA of High Voltage Circuit Breakers, it has been proven that SF₆ losses due to leakage in service or during manufacturing and commissioning are not the major contributors to Global Warming. In fact, most of the global warming impact is due to the energy losses during the life of the apparatus. On a more global approach, full LCA of Medium Voltage networks has been done. For example, the impact of AIS (insulation by air) and GIS (insulation by SF₆) products included in rural or urban networks were studied. These studies showed that the total environmental impact of AIS is higher than for GIS equipment (using SF₆). Moreover, it was made clear that in such networks, the switchgear

represents less than 10% of the total networks Global Warming impact, which is again mostly due, to the energy losses within the network."

There is also much emphasis directed at maintenance of equipment and improving disposal methods of decommissioned equipment since leakage after disposal is considered to be by far the highest contributor to SF₆ emissions from gas insulated switchgear and transformers. These issues are highlighted by the following extracts from Weston (2007) and Bessede et al. (2006) below.

[Weston (2007)] "Any mass balance approach must consider the much higher contributions of emissions from decommissioned equipment that is no longer monitored for gas loss as with equipment in service. These emissions far exceed any estimates of industry emissions percentages based on manufacturer's leakage rates (default loss rate 0.5%). As with other pollutants, responsibility should rest with the owner of the equipment, regardless of its operational status, until such time as it has been appropriately reclaimed and recycled or destroyed and documented."

[Bessede et al. (2006)] "...some losses occur when the switchgear is filled and tested, but the primary source of SF₆ gas releases are leaks from aging SF₆ gas-insulated switchgear."

The peak industry body for the Australian electricity distribution and networks industry, Energy Networks Australia (ENA), currently estimates SF₆ emission levels for the whole Australian sector to be approximately 21.8 tonnes per annum (ENA, 2008).

5.2.3 Electricity

Electricity used to run the Belmore Park Zone Substation would be considered as Scope 2 and emissions attributable to upstream energy production are considered as Scope 3, indirect greenhouse gas emissions. Emission factors and equations for calculating greenhouse gas emissions from electricity from the grid are provided in the *National Greenhouse Accounts (NGA) Factors (2008)*. Note that transmission and distribution losses are reported by energy distributors elsewhere as Scope 2 emissions.

The estimated annual electricity consumption for the substation at Belmore Park is 14,000 kWh (pers comm J. Ardas, PlanCom, 02/07/08). The estimated annual electricity consumption for the commercial development at Belmore Park is approximately 2,148,000 kWh (Waterman AHW, 2008). Therefore, estimated emissions from electricity consumption are as follows:

- Scope 2 GHG Emissions (t CO_{2-e}) = ((14,000 + 2,148,000) x 0.89 / 1000 = 1,924 tonnes per annum.
- Scope 3 GHG Emissions (t CO_{2-e}) = ((14,000 + 2,148,000) x 0.17 / 1000 = 368 tonnes per annum.

6 MITIGATION MEASURES

6.1 Air Quality

6.1.1 Construction

An indicative construction program for the Sydney CityGrid Project is provided in Appendix A.1.

It should be noted that the construction phases of the Project will be staged over a timeframe of up to 10 years and potential impacts can be appropriately managed and mitigated.

It is not expected that any significant impacts will be experienced during construction. However, the following mitigation measures should be observed during demolition and construction, in order to minimise impacts as much as possible.

Demolition

- Sheet and screen buildings with suitable material and where possible strip inside buildings before demolition begins.
- Ensure that any asbestos is removed by a specialist contractor before demolition.
- Waste or materials for recycling should be removed from site as soon as possible. If stored, techniques to avoid emissions should be employed.
- Avoid explosive blasting where possible and consider using appropriate hand or mechanical alternatives.
- Bag and remove any biological debris or damp down before demolition.

Construction

- Access to construction sites would be via existing sealed roadways and the surface of trafficked areas within sites shall be sealed with bitumen or gravel.
- Wheels of all site plant and vehicles would be cleaned so that material with potential to generate dust is not spread on surrounding roads.
- Sealed roads around construction sites would be swept to remove deposited material with potential to generate dust, if necessary.
- Water shall be used to suppress particles potentially generated during the erection of boundary fences, barriers, screens and other ancillary structures.
- Areas of disturbed soils would be minimised during the construction period.
- Water may be used to suppress dust emissions during dry windy periods (as required).
- The height from which dust generating material is dropped would be minimised.
- Loaded trucks carrying spoil shall be covered at all times.
- The cutting/grinding of materials on site shall be kept to a minimum, but if necessary equipment and techniques to minimise dust will be used.
- Earthworks will be kept damp, as required, especially during dry weather.
- The tunnelling excavation face will be kept damp, as required, to minimise dust generation.

- Spoil stockpiles will be damped as necessary.
- Longer term spoil stockpiles would be treated with surface binding agents or sealed by seeding with vegetation or covered with secured tarpaulins.
- Potentially dusty materials will be handled as little as possible.
- Exhaust emissions will not discharge straight at the ground.
- Construction plant and vehicles will be well maintained and regularly serviced. Visible smoke from plant should be avoided. Defective plant will not be used.
- Engines will be switched off when vehicles are not in use and refuelling areas will be away from areas of public access.
- Loading and unloading will take place within the site.
- All waste will be removed from site and disposed to an appropriately licensed waste facility.
- A CEMP would also be prepared for the construction phase, specifically addressing measures to be implemented to minimise off-site dust emissions.

6.1.2 Operation

There are no adverse impacts on air quality predicted due to the operation of the proposed Project. Mitigation measures for air quality during operation of electricity substations and high voltage tunnels are therefore not required. The operation of the tunnel ventilation system is unlikely to adversely affect air quality in the vicinity of the City North Zone Substation, and as such, mitigation measures are not required.

6.2 Greenhouse Gases

Any measures to reduce fuel use or improve energy efficiency would reduce emissions of greenhouse gases due to combustion.

Methods for mitigating SF₆ gas emissions from the Belmore Park Zone Substation are based on best practice monitoring of leakage during operation, maintenance and end of life dismantling procedures.

Avoiding leakages during operation requires attention to the type of gaskets used in the equipment. Leakages during operations occur as gaskets age and harden with use, suffer from chemical attack and corrode. Equipment suppliers should fully evaluate the proposed environment and assess the appropriateness of gasket types for the operating life of the gas insulated switchgear.

Methods for improving leak detection monitoring and handling of SF₆ gas during operations and maintenance would also minimise emissions.

The management of the end of life gas insulated equipment should follow industry best practice guidelines. In particular, the treatment of SF₆ gas for recycling, i.e. 'cradle to cradle', or if the contamination due to arc switching is too high, from 'cradle to grave' should be managed.

The Energy Networks Association has recently developed a Guideline for the Management of SF₆. These management guidelines will assist the industry to reduce emissions of SF₆, by ensuring that all aspects of SF₆ management are addressed in a consistent manner by individual utilities.

7 CONCLUSIONS

This assessment has considered potential air quality impacts associated with EnergyAustralia's proposed Sydney CityGrid Project including a greenhouse gas assessment for the Belmore Park Zone Substation.

The main concern for air quality is the potential for emissions of dust and PM₁₀ during construction. However, air quality impacts are predicted to be insignificant if best practice dust management procedures are practised. No further air quality assessment is required.

There are no predicted adverse impacts on air quality during the operation of the substations, high voltage tunnel or the commercial development buildings.

There is potential for greenhouse gas emissions from the Belmore Park Zone Substation from combustion engines during construction, combustion of gas and electricity use during operation of the commercial development buildings and from leakage or spillage of SF₆ insulating gas (used in switchgear) during operation, maintenance and decommissioning of equipment. Emissions of greenhouse gases would be minimised by adhering to industry best practice procedures for handling and disposal of the insulation gas.

Provided that the appropriate management and mitigation measures are followed the impacts on air quality from the Project and emissions of greenhouse gases from the Belmore Park Zone Substation are considered to be acceptable.

8 REFERENCES

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APPENDIX A

Indicative CityGrid Project Construction Program

A.1 INDICATIVE CITYGRID PROJECT CONSTRUCTION PROGRAM

Construction Activity	Typical Equipment	Approximate Timing	Estimated Truck Movements (per day)
Establishment of Belmore Park Zone Substation	Mobile crane, trucks with work sheds, concrete trucks	Feb 2009	1-2 deliveries per day
Belmore Park Zone Substation site preparation (erect hoarding, service discon, site survey, services diversion)	Saw cutting concrete, bitumen, backhoe, 10 truck, concrete truck, traffic control, air compressors, jack hammers	Mar 2009	1-2 deliveries per day plus truck movements
Belmore Park Zone Substation bulk excavation	Drill rig, trucks to remove spoil, concrete pumps, D7 bulldozer, rock saws, rock hammers, semi trailer trucks to remove spoil, rock anchor drills, shot crete	Mar 2009 – Dec 2009	1-2 deliveries per day plus peak of 20 spoil truck movements per day
Belmore Park Zone Substation construction of 13 levels combined substation and commercial site, commencement of zone development	Crane, scaffolding, concrete pumps, concrete vibrators, concrete delivery trucks, placement of steel reinforcement, builders lift, builders hoist, scabbling, air compressor, jack hammers, concrete/bitumen saw cutting	Jan 2010 – April 2010	1-2 deliveries per day plus peak of 20 spoil truck movements per day
Establishment of Riley St site and Preliminary Construction Activities	Power tools, concrete saws, rock hammers, excavator, concrete agitator and pump, delivery vehicles, crane.	Jun 2010 – Sep 2010	General deliveries of the period, approximately 1 per day.
Excavate TBM entry cavern and CBD Cable Tunnel Extension	Roadheader, gantry crane, delivery vehicles, spoil trucks, excavator, dump truck, front-end loader, power tools, ventilation fan.	Sep 2010 – Mar 2011	1-2 deliveries per day. 4-5 spoil trucks per day.
Construct lining for CBD Cable Tunnel Extension and Tunnel fitout.	Delivery vehicles, concrete agitator and pump, power tools and general equipment, ventilation fan.	Mar 2011 – May 2011	1-2 concrete deliveries per day during Apr 2011.
Mobilise and assemble TBM	TBM, gantry crane, delivery vehicles, front-end loader.	Feb 2011 – Mar 2011	Included above.
Excavate TBM Tunnel between Riley Street and City North.	TBM, general delivery vehicles, spoil trucks, semi-trailers (concrete segment delivery), grout rig, gantry crane, ventilation fan, front-end loader, excavator, dump truck, general tools and equipment.	Apr 2011 – Jun 2012	Segment Delivery – 5 trucks/day for approx 200 days. Spoil removal – 10-15 trucks/day.
Remove TBM backup assembly and demobilise	Gantry crane, transport vehicles, general plant and equipment.	Jul 2012	General construction traffic only.
TBM Tunnel Fitout	Delivery vehicles, power tools, gantry crane, ventilation fan, general plant and equipment.	Aug 2012 – Jul 2013	1-2 trucks every 3 days.
Services Shaft and stub tunnel (if required)	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools, excavator, front-end loader, roadheader, dump truck and crane.	Aug 2011 – Nov 2011	2-3 trucks per day for spoil removal plus general deliveries.

Construction Activity	Typical Equipment	Approximate Timing	Estimated Truck Movements (per day)
City East Shaft and stub tunnel (if required)	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools, excavator, front-end loader, roadheader, dump truck and crane.	Dec 2011 – Mar 2012	2-3 trucks per day for spoil removal plus general deliveries.
Dalley Street Shaft and stub tunnel.	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools, excavator, front-end loader, roadheader, dump truck and crane.	Apr 2012 – Jul 2012	2-3 trucks per day for spoil removal plus general deliveries.
General Surface Works (cable trenching around Dalley, Gresham, Bent Streets)	Excavator, spoil truck, delivery vehicles, concrete agitator and pump, asphaltting.	Aug 2012 – Jan 2013	1-2 trucks / day.
Construct Riley Street Services Control Room and tunnel connections	Power tools, concrete agitator and pump, delivery vehicles.	Aug 2013 – Dec 2013	1-2 per day – general deliveries only.
Fitout Riley Street Services Control Room	Power tools, crane, delivery vehicles.	Jan 2014 – Apr 2014	1-2 per day – general deliveries only.
Reinstate Riley Street Site and Demobilise	Excavator, front-end loader, delivery vehicles, power tools.	May 2014 – Jun 2014	1 truck / day.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jun 2012 – Mar 2013	Semi trailer and crane (cable delivery) – once every 3 weeks. General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jan 2014 – Mar 2014	Semi trailer and crane (cable delivery) – once every 3 weeks. General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jan 2016 – Jun 2016	Semi trailer and crane (cable delivery) – once every 3 weeks. General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Oct 2016 – May 2016	Semi trailer and crane (cable delivery) – once every 3 weeks. General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jul 2016 – Jun 2018	Semi trailer and crane (cable delivery) – once every 4 weeks. General deliveries over the period.