HUMAN HEALTH RISK ASSESSMENT

Enfield Intermodal - SSD 05_0147 MOD14

Prepared for: Goodman Property Services (Aust) Pty Ltd

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Goodman Property Services (Aust) Pty Ltd. Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
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EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) was commissioned by Goodman Property Services (Aust) Pty Ltd (the Proponent) to perform a Human Health Risk Assessment (HHRA) for a proposed modification (MOD 14) to the Enfield Intermodal Logistics Centre (the Enfield ILC).

The development approval for the Enfield ILC was granted on 5 September 2007 (the Approval). The Enfield ILC includes the active Enfield Intermodal Terminal (IMT) currently operated by Aurizon, proposed empty container storage parks, an existing warehouse and tarp shed, dedicated ecological areas and 30 hectares (ha) of remaining developable industrial zoned land. The Approval included construction of seven (7) warehouses with a total footprint area 109,300 square meters (m^2). To date, only one warehouse has been erected on site (URBIS, 2017). MOD 14 seeks to modify the Approval to modify built form parameters, including modifications to the site layout and approved building footprints to enable the construction of fourteen (14) warehouses and nineteen (19) strata units, encompassing 125,630 m^2, as well as approval to increase the building heights to a maximum of 13.7 metres (m). MOD 14 also seeks to modify the operational parameters to provide greater flexibility, such as extension of operating hours, permit warehouse and distributions uses and allow truck-to-truck freight movements for smaller sites with no direct interface with rail sidings.

This report presents the methodology and findings of the Health Risk Assessment completed for the application to modify the development consent for Enfield ILC.

Risk assessments of the nature performed here do not provide definitive assessments of the acceptability of risk for specific individuals. Risk assessments should only be applied on a probabilistic basis to a population of exposed persons.

SLR assessed the potential exposure pathways for human health from contamination during the operations of Enfield ILC. The assessment was based on a desktop review of available documents including air quality reports.

Taking available information sources into account and considering the nature and scope of the proposed works, it is considered that the proposed works are sufficiently characterised to enable an assessment of risks.

From the information available, it was concluded that:

- The communities who may be exposed to any Contaminants of Potential Concern (COPCs) associated with the operations of Enfield ILC were identified as the residents in residential areas closest to Enfield ILC. This took in surrounding residential areas in Strathfield, Enfield, Belfield, Lakemba and Greenacre.
- The COPC associated with the operations of Enfield ILC were identified as fine particulates (TSP, PM_{10}, $PM_{2.5}$), SO_2, NO_X, CO, and VOCs. Of which data was available for fine particulates (TSP, PM_{10}, $PM_{2.5}$) and NO_X.
- Comparisons of predicted COPC concentrations at receptor sites with relevant air quality assessment criteria or health based benchmarks determined that none of the identified COPCs were likely to be present at concentrations likely to impact on the health risks to receptors in the surrounding communities.

Therefore it is concluded the proposed modification for the operation of Enfield ILC is unlikely to lead to an increase in any existing potential health risks to the identified communities.

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) was commissioned by Goodman Property Services (Aust) Pty Ltd (the Proponent) to perform a Human Health Risk Assessment (HHRA) for a proposed modification (MOD 14) to the Enfield Intermodal Logistics Centre (the Enfield ILC).

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MOD 14 seeks to modify the Approval to modify built form parameters, including modifications to the site layout and approved building footprints to enable the construction of fourteen (14) warehouses and nineteen (19) strata units, encompassing 125,630 m^2, as well as approval to increase the building heights to a maximum of 13.7 metres (m). MOD 14 also seeks to modify the operational parameters to provide greater flexibility, such as extension of operating hours, permit warehouse and distributions uses and allow truck-to-truck freight movements for smaller sites with no direct interface with rail sidings.

This report presents the methodology and findings of the Health Risk Assessment completed for the proposed application to modify the development consent for a proposed modification (MOD 14) to the Enfield Intermodal Logistics Centre (Enfield ILC), undertaken by SLR Consulting on behalf of Goodmans Property Services (Aust) Pty Ltd.

The Health Risk Assessment was conducted as per the recommendations contained in *Environmental Health Risk Assessment. Guidelines for assessing human health risks from environmental hazards* (enHealth, 2012).

1.1 What is a Risk Assessment

1.1.1 What is Risk Assessment

Risk assessments have been defined in many ways but all share the concept of a process for estimating and characterising the potential risks associated with various agents or activities.

The National Research Council (1983) definition is:

Risk assessment is the systematic scientific characterisation of potential adverse health effects resulting from human exposures to hazardous agents or situations.

The underlying concept to risk assessment is the Conceptual Site Model (CSM) whereby risk is assessed using the concept of the links between source – pathway – receptor. This can include the source of Contaminants of Potential Concern (COPC) which may impact on the communities in question and transport mechanisms whereby COPC can be moved to exposure points (human receptors). If any of these links are missing then an exposure pathway in incomplete and human exposure will not occur. If the exposure pathway is potentially complete then likely impact on the receptor may need to be assessed.

The exposure pathway describes the course a COPC takes from the source to an exposed receptor. This pathway is unique for specific situations involving particular COPC and specific communities or individuals.

Once a COPC has travelled along the exposure pathway to the receptor, it may then be exposed to the COPC through a number of exposure routes. The basis of these routes are:

- Inhalation of contaminants, either as gases, mists, fumes or airborne particulates,
- Ingestion of contaminants, through food, drink or through secondary transfer from skin to mouth through poor hygiene practices, and
- Direct contact leading to absorption through skin (dermal absorption).

The exposure pathway and exposure route through which contaminants exposure can potentially occur will depend on the chemical characteristics of a contaminant and how the contaminant behaves in the environment. If the normal form of a chemical in the environment is a gas then the likely exposure route will be through inhalation. In contrast if the contaminant usually binds to particulate matter such as dust, soils or sediments, then the exposure routes may be inhalation of contaminated dusts, ingestions of soils or possible direct contact with contaminated soils.

The most common approach to risk assessment is a simple comparison of site specific data on COPC concentrations against relevant guidelines such as regulatory limits, investigation levels or screening levels. In most cases if the COPC meets the adopted guidelines, then the risk is considered low and acceptable. If the COPC exceeds the adopted guidelines then further evaluation is usually required.

1.2 Risk Assessment Approach

The methodology adopted in the conduct of the Human Health Risk Assessment is consistent with that used to evaluate risks to human health associated with a population’s exposure to a hazardous agent. The current study pertains to the application for the proposed modification (MOD 14) to the Enfield Intermodal Logistics Centre (Enfield ILC). Therefore this health risk assessment is focused on potential by-products associated with activities in the Logistics Centre.

The approach to the assessment of risk to human health is based on the protocols/guidelines recommended by the enHealth Council. These are detailed in the document “*Guidelines for assessing human health risks from environmental hazards. June, 2012*.”

Identification and assessment of the potential risks to human health within the site have been undertaken by implementing four prime tasks. These tasks are:

1. **Issue Identification** – This involves an evaluation of the available information on the key issues amenable to risk characterisation relating to activities in Enfield ILC.

2. **Hazard Assessment** – This task provides a review of the current understanding of the toxicity issues to humans associated with activities in Enfield ILC and identifies hazards associated with exposure to by-products activities in Enfield ILC.

3. **Exposure Assessment** – This task draws on the evaluation undertaken as part of the “Issue Identification” stage identifying the groups of people in surrounding communities who may be exposed to by-products associated with the activities in Enfield ILC and quantifying exposure concentrations.

4. **Risk Characterisation** – This task provides the qualitative evaluation of potential risks to human health. The characterisation of risk is based on the review of toxicity of by-products associated with the activities in Enfield ILC and assessment of the magnitude of exposure.

1.3 Objectives

The objective of the Human Health Risk Assessment is to provide an assessment of the risk associated with the proposed modification (MOD 14) to the Enfield Intermodal Logistics Centre (the Enfield ILC) to surrounding communities.

The risk assessment aims to:

- Identify the any COPC associated with the activities in Enfield ILC,
- Identify the groups of people who may be exposed to any COPC associated with the activities in Enfield ILC,
- Compare exposure concentrations with contemporary health standards (where available),
- Identify the health risks associated with exposure should it occur; and
- Assess and communicate the identified risks.

Risk assessments of the nature performed here do not provide definitive assessments of the acceptability of risk for specific individuals. Risk assessments should only be applied on a probabilistic basis to a population of exposed persons.

2 PROJECT OVERVIEW

2.1 Regional Setting

The Enfield ILC is approximately 15 kilometres from the Sydney Central Business District by road and 18 kilometres (km) from Port Botany by rail.

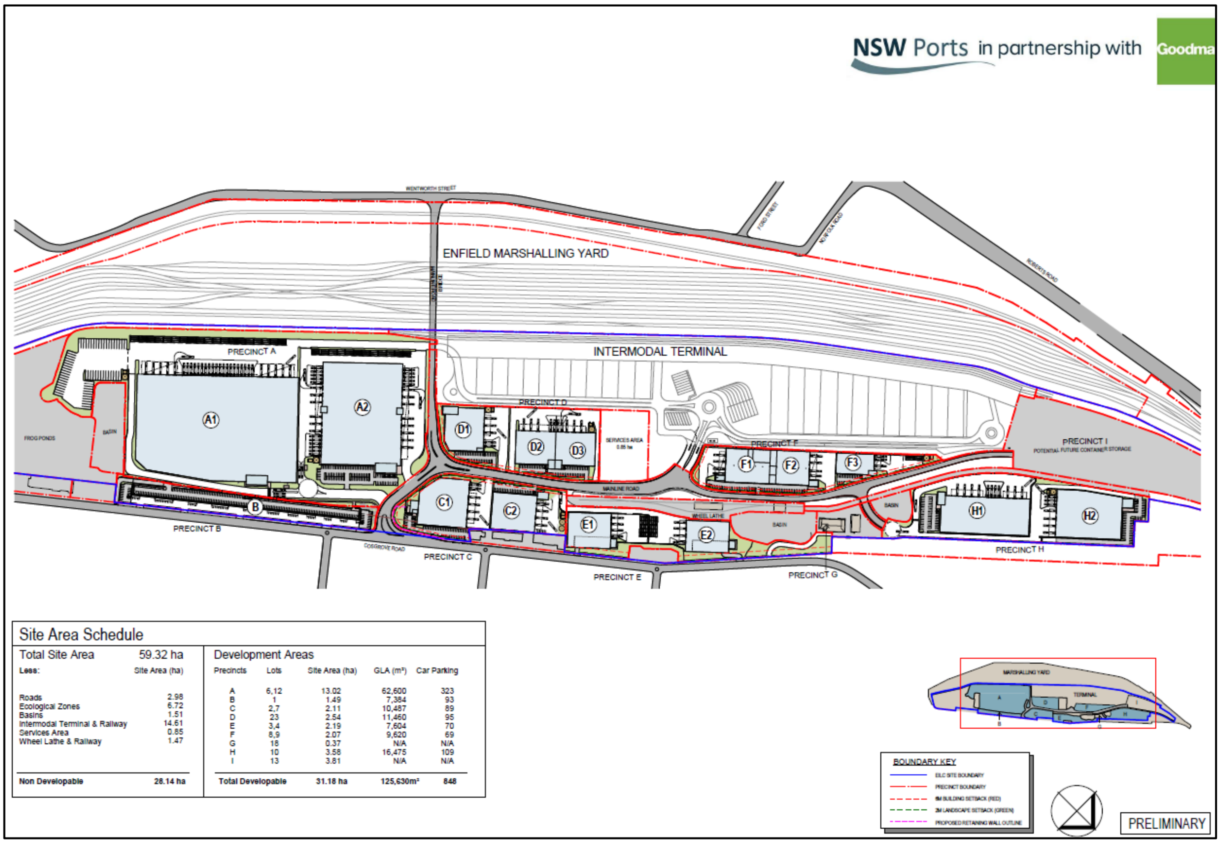
The Enfield ILC site is located within South Strathfield on the land generally bound by Cosgrove Road to the east, Punchbowl Road to the south, the Port Botany Freight Rail Line to the west and Roberts Road to the north (see **Figure 1**). It covers an area of approximately 60 hectares and is approximately 0.5 km in width and over 2 km in length. The Enfield ILC has the legal description Lots 1 - 23 DP 1183316. The main entrance to the Enfield ILC is via Cosgrove Road.

Figure 1 Regional Setting of the Enfield Intermodal Logistics Centre

2.2 Local Setting

The Development Application is seeking to modify the Approval to develop warehouse distribution centres within nine precincts as shown in **Figure 2** and outlined in **Table 1**.

Figure 2 Detailed Site Plan – Enfield Intermodal Logistics Centre



Source: SBA Architects, Enfield Intermodal Logistics Centre – Masterplan; EILC DA01 (P3), 22 January 2018

Table 1 Precinct Development Description - Enfield Intermodal Logistics Centre

Description		Area	
Non Developable Land		28.14ha	
Development Areas		31.18ha	
	Precinct A		13.02ha
	Precinct B		1.49ha
	Precinct C		2.11ha
	Precinct D		2.54ha
	Precinct E		2.19ha
	Precinct F		2.07ha
	Precinct G		0.37ha
	Precinct H		3.58ha
	Precinct I		3.81ha
Total Site Area		59.32ha	

Source: SBA Architects, Enfield Intermodal Logistics Centre – Masterplan; EILC DA01 (P3), 22 January 2018

2.3 Approved Development Activities

The Approval for the Enfield ILC includes the following activities:

- Demolition, relocation or removal of former railway buildings and structures;
- Earthworks and drainage including the levelling of the site, formation of landscape mounds and detention basins and removal of unsuitable materials, as required;
- Construction and operation of:
  - An intermodal terminal for the loading and unloading of containers between road and rail and the short-term storage of containers, with a capacity to handle 300,000 twenty-foot equivalent unit (TEU) per annum;
  - Rail sidings, railway lines and associated works to connect to the existing freight line;
  - Warehousing for the packing and unpacking of containers and the short-term storage of cargo;
  - Empty container storage facilities, for the storage of empty containers to be later packed or transferred back to the port by rail;
  - Light industrial/commercial area fronting Cosgrove Road complementary to operations at the site;
  - Access works including the construction of a road bridge over the new marshalling yards for access to Wentworth Street and an upgrade of the entrance to the site from Cosgrove Road; and
  - Internal roads, administration buildings, diesel and LPG storage and fuelling facilities, container wash down area, vehicle maintenance shed, and installation of site services (all utilities, stormwater and sewerage).

The Enfield ILC is currently operating well below its approved throughput capacity of 300,000 TEU per annum, with the current annual throughput estimated to be approximately 50,000 TEU per annum (URBIS 2017).

2.4 Proposed Development Activities (MOD 14)

2.4.1 Construction Activities

MOD 14 seeks to modify the approved masterplan to increase the number of buildings to fourteen (14) warehouses and nineteen (19) small strata units (compared to seven (7) warehouses allowed for in the Approval). This will include additional earthworks, encompassing approximately 50,430 m^3 of cut material that will be utilised within the Enfield ILC as fill and importing an additional 31,770 m^3 of fill material.

The construction assessment aims to assess construction impacts related to the additional earthworks and construction of the warehouses and strata units only. Construction of the intermodal terminal, rail sidings etc is not addressed as these facilities have already been approved and partially constructed.

2.4.2 Operational Activities

MOD 14 seeks to modify the operational parameters to provide greater flexibility and enable the Enfield ILC to service Greater Sydney's 24/7 port supply chain. Specifically, the proposed changes are:

- Extend the operating hours to 24/7;
- Allow for warehouse and distribution uses; and

- Allow truck-to-truck freight movements for smaller sites with no direct interface with the rail sidings.

The operational assessment aims to quantify air quality impacts related to road traffic emissions, especially those associated with idling truck engines while the truck-to-truck freight movements are taking place.

2.5 Surrounding Land Use & Sensitive Receivers

Figure 3 shows the surrounding land uses, light industry, rail corridor, residential dwellings and sensitive Receptors used in the air quality modelling study of SLR, (2018).

The closest residential areas are approximately 30 m from the Enfield ILC boundary (R1). Surrounding sensitive receptors identified for consideration in this assessment are listed in **Table 2** and presented in **Figure 3**.

Table 2 List of Identified Sensitive Receptors

Receptor ID	Easting (m)	Northing (m)	Distance to Closest Boundary (m)
R1[a]	322,244	6,246,913	30
R2[a]	322,308	6,246,713	30
R3[a]	324,873	6,246,255	360
R4[a]	321,760	6,246,437	285
R5[a]	321,249	6,248,585	100
R6	322,229	6,247,885	400
R7	322,137	6,248,159	450
R8	322,125	6,248,528	600
R9	321,745	6,248,791	340
R10	321,186	6,248,214	110
R11	321,185	6,247,944	120
R12	321,104	6,247,425	350
R13	321,038	6,247,042	560

Source: SLR (2018); Receptors 1 to 5 are the same as were assessed in the 2005 SKM Report (SKM 2005).

Figure 3 Surrounding Setting of the Enfield Intermodal Logistics Centre & Sensitive Receptors

3 RISK ASSESSMENT

3.1 Issue Identification

3.1.1 Community Chosen for Assessment

The communities chosen for the purposes of this assessment were the occupants in residential areas closest to Enfield ILC. The Sensitive Receptor at the greatest distance from the boundary was 600m from the site (see **Figure 3**). Accordingly this distance of 600m was used to define the areas chosen for assessment. This took in surrounding residential areas in Strathfield, Enfield, Belfield, Lakemba and Greenacre.

3.1.2 Potential Contaminant Emission Sources at the Enfield ILC

The Air Quality Impact Assessment by SLR (2018) identified the following emission sources during operations at the Enfield ILC.

- Traffic movements on paved roads inside the Enfield ILC & offsite on roads accessing the Enfield ILC.
- Vehicles exhaust emissions from trucks, locomotives and fork lifts.

3.1.3 Emissions from Operation at Enfield ILC

The Air Quality Impact Assessment (SLR, 2018) stated that:

"The main emissions to air during the construction phase will be emissions of particulate matter (dust), from minor excavation activities and material handling activities. Dust from the construction activities will be controlled using the best management practices."

SLR (2018) provided information on mitigation measures to be included in Construction Environment Management Plan (CEMP) to reduce airborne emissions during the construction phase.

On the proviso that an adequate CEMP be developed and implemented during the construction phase, then it is likely that effects of construction on air quality will be minimal and of short duration.

Regarding emissions during the future operations of Enfield ILC, the Air Quality Impact Assessment (SLR, 2018) stated that:

"*During the operational phase, the key emission sources and pollutants of interest have been identified as follows:*

- *Particulate emissions (as Total Suspended Particulate (TSP), particulate matter less than 10 microns (PM_{10}) and particulate matter less than 2.5 microns ($PM_{2.5}$)) resulting from traffic movements on paved roads;*
- *Truck exhaust emissions within the Enfield ILC, namely oxides of nitrogen (NO_X), carbon monoxide (CO), particulate matter (as TSP, PM_{10} and $PM_{2.5}$), sulphur dioxide (SO_2) and volatile organic compounds (VOCs);*
- *Locomotive idling emissions, namely NO_X, CO, TSP, PM_{10} and $PM_{2.5}$, SO_2 and VOCs;*
- *Emissions due to combustion of LPG in on-site forklifts, namely NO_X and CO, and*

Off-site air emissions associated with truck movements on the road network accessing the Enfield ILC. "

Based on the above information, the air quality impact assessment by SLR (2018) chose the following parameters to model air quality changes:

- Airborne particulates (TSP, PM_{10} & $PM_{2.5}$)
- Nitrogen dioxide

Emissions from diesels exhausts of truck and locomotives form a large component of the emissions during operations of the Enfield ILC. Diesel exhaust is a complex mixture of combustion products of diesel fuel, and the exact composition of the mixture depends on the nature of the engine, operating conditions, lubricating oil, additives, emission control system, and fuel composition (OSHA, 2011 citing Obert 1973 & Ullman 1989). The diesel particulate matter component in the exhausts are of particular concern as carriers of chemicals formed in combustion and unburnt fuel. Diesel particulate matter is typically less than 1µm in diameter (CDC, 2011). In the Enfield ILC air quality assessments diesel particulate matter formed part of the $PM_{2.5}$ assessment.

The previous air quality impact assessment by SKM (2005) concluded that increased truck movements on the road network accessing Enfield ILC would lead to insignificant increases in emissions of NO_2 and PM_{10}. Based on this both air quality impact assessments (SKM, 2005; SLR, 2018) did not consider these emission sources further in their assessments. Accordingly there is no data relating to emissions of NO_2 and PM_{10} from increased truck movements on the road network accessing Enfield ILC.

Furthermore, SKM (2005) concluded that emission of CO, SO_2 and VOCs, were likely to be low impact pollutants based to their low background concentrations. Based on this conclusion both air quality impact assessments (SKM, 2005; SLR, 2018) did not consider the emissions of CO, SO_2 and VOCs further in their assessments. Accordingly there is no data relating to emissions of CO, SO_2 and VOCs from operations of Enfield ILC. Further comment on this can be found in **Appendix B**.

3.1.4 Conceptual Site Model

Conceptual Site Model (CSM) uses the concept of the links between source – pathway – receptor to assess risk. This can include the source of Contaminants of Potential Concern (COPC) which may impact on the communities in question and transport mechanisms whereby COPC can be moved to exposure points (human receptors). If any of these links are missing then an exposure pathway in incomplete and human exposure will not occur. If the exposure pathway is potentially complete then likely impact on the receptor may need to be assessed.

The CSM development indicated that following factors:

- Potential COPCs
- The release mechanism whereby the COPCs may be released into the environment
- The transport pathways moving the COPCs through the environment
- Exposure pathways
- Exposure Routes whereby the a person takes in the COPC
- Location of potential receptors
- Significant pathways by which exposure may occur
- Minimal exposure pathways, considered as less likely to led to human exposure

- Primary exposure pathways considered to be the pathway by which the largest quantities of emissions of a identified COPC move
- Secondary exposure pathways considered to be the pathway by which lessor quantities (compared to the Primary exposure pathway) of the emissions of a identified COPC move

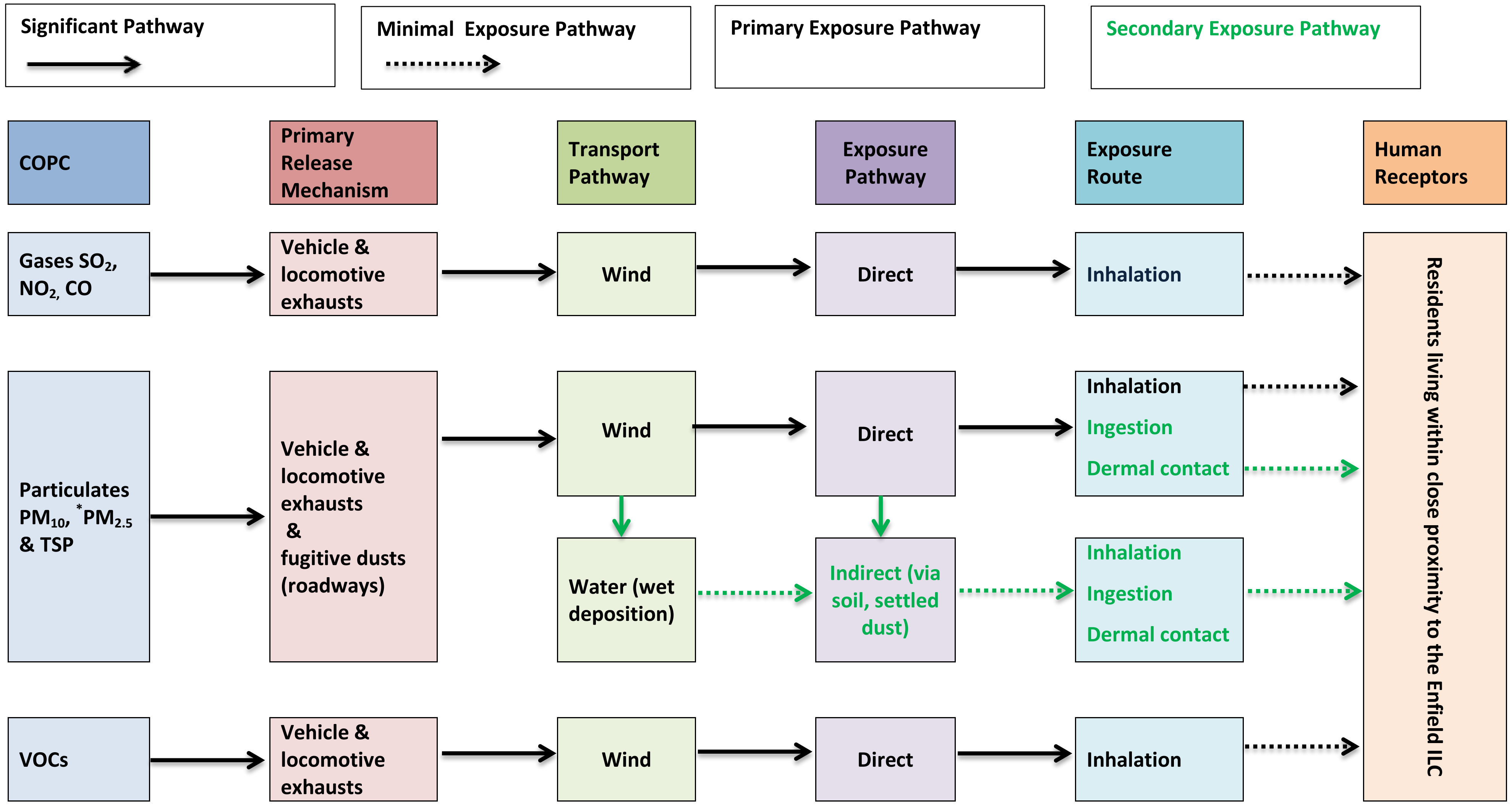
The Primary exposure pathway relating to the operations of the Enfield ILC were determined to be via the airborne pathway. This was due to the anticipated airborne COPC emissions being the dominate source for both point sources, such as vehicle exhausts and locomotive exhausts, and fugitive sources. The Secondary exposure pathway was considered to be the indirect pathway in which COPC emissions are transported off site through environmental forces such as wind, the COPC then settle into dusts or soils and are subsequently remobilised when the soil or dusts are disturbed, at which point human exposure may take place.

The Primary exposure pathway can be relatively easily quantified through the combination of site specific data such as both background measurements, coupled with COPC concentration estimates derived from the air quality modelling. Thus any increase in risk associated with the proposed modifications may be quantified.

In contrast, there is a lack of data relevant to the Secondary exposure pathways. Accordingly quantifying Secondary exposure pathways is not possible. What can be said about Secondary exposure pathways is that if the proposed modifications do not led to significant changes in the emission of particulate associated COPCs compared to emissions from the existing processes then there should be no increase in risk from Secondary exposure pathways to the local communities associated with the proposed modifications.

The CSM diagram has been set out in **Figure 4**.

Figure 4 Conceptual Site Model – Enfield ILC



Note * Includes diesel particulate matter

3.1.5 Contaminants of Potential Concern (COPC)

The groups of substances relevant to the operation of the Enfield ILC were detailed in the Air Quality Assessment (SLR, 2018). These groups of substances form the COPC for the health risk assessment and have been set out below in **Table 3**

Table 3 Contaminants of Potential Concern (COPC), Sources and Potential Exposure Pathways

COPC	Source	Exposure Transport Pathways or Environmental Sink	Exposure Routes*
Fine Particulates PM_{10} and $PM_{2.5}$	Vehicle exhausts Locomotive exhausts Fugitive dusts (from vehicle movement on roads)	Airborne	Inhalation Ingestion
Nitrogen oxides	Vehicle exhausts Locomotive exhausts	Airborne	Inhalation
Sulphur dioxide	Vehicle exhausts Locomotive exhausts	Airborne	Inhalation
Carbon monoxide	Vehicle exhausts Locomotive exhausts	Airborne	Inhalation
Volatile organic compounds VOCs	Vehicle exhausts Locomotive exhausts	Airborne	Inhalation

Note * Examples of these exposure Pathways and Routes are listed below:

Inhalation – Inhalation of airborne gases and particulates from point sources like vehicle exhausts or fugitive sources. This is a primary route of potential exposure highlighted in **Table 3**.

Ingestion – Ingestion of particulate matter, from point sources like vehicle exhausts or fugitive sources, either travelling directly from the source to the receptor or indirectly where the particulates have settled into settled dust or soils then are ingested through contamination of food, drink or through poor hygiene practices. This is the secondary route of potential exposure highlighted in **Table 3**.

3.1.6 Exposure Concepts

To assess the potential health impact of a COPC on a population the exposure can be assessed in two broad concepts, acute exposure and chronic exposure.

Acute exposure refers to short term exposures of up to 14 days, often with immediate effects on the exposed individuals. This may be due to the inherent toxicity of a contaminant or the physiological response the contaminant elicits such as irritation to an individual's airways.

Examples of parameters used to assess acute exposure can include peak concentrations of a contaminant, predicted 24 hour average concentrations and the like.

Chronic exposure refers to long term exposures based on exposure all day every day for a lifetime. An example of a parameter used to assess chronic exposure is the annual average concentrations of air pollutants.

3.1.7 Fine Particulates

Fine particulates refer to any particles likely to be potentially airborne. In terms of human health risk, the issues may arise from physical damage to the respiratory system from inhaled particles. Total Suspended Particulates (TSP) includes particles with an approximate aerodynamic diameter of 50µm and less. Particles at the larger end of this size range may be inhaled but do not as a rule penetrate far into the respiratory system. Accordingly the larger particulates may have little role in health impacts associated with inhaled particulates. The smaller particles such as PM_{10} and $PM_{2.5}$ are more of a health hazard as their size allows the particle to penetrate deeply into the respiratory system. Aside from physical damage, the particulates may also act as carriers of chemical contaminants, bound to the particulates, transporting the chemical into the lungs where absorption of the chemical into the body is more likely or into the gut if contaminated particulates are ingested.

The current study will focus on the potential health impacts associated with the smaller particles (PM_{10} and $PM_{2.5}$) that can potentially penetrate deep in to the lungs and therefore have the greatest potential for adverse health impacts.

These size fractions can be summarised as:

- Total Suspended Particulates (TSP), less than 50µm in diameter.
- PM_{10}, that is the fraction of TSP less than 10µm in diameter
- $PM_{2.5}$, that is the fraction of TSP less than 2.5µm in diameter

3.1.7.1 National Airborne Particulates Air Quality Goals and Health Based Criteria.

The current national air quality goals for particulates were set with a view to be protective of health and achievable for industry, based on the scientific evidence available at the time of setting the goals. With the advancement of scientific knowledge, there has been some debate as to whether the national goals need to be revised and on the adequacy of current national air quality goals for particulate matter for health risk assessments. The review by NEPC (2011) reported current national air standards were not meeting the requirements for adequate protection of human health. The review further commented that there was substantial new evidence on both short-term and long-term effects for particles (PM_{10} and $PM_{2.5}$) associated with increases in mortality and morbidity, with much stronger evidence now for cardiovascular outcomes. Therefore it is likely that future revision of the goals may lead to a lowering of the acceptable concentrations for PM_{10} and $PM_{2.5}$.

It is widely considered there is no lower threshold concentrations for the health effects of air pollution. That is to say there is no known lower limit threshold concentrations below which health impacts will definitely not occur in sensitive individuals. This does not mean that health impacts will definitely occur rather it indicates there may be a risk to health and that the risk of an incidence of adverse health impact will decrease as the concentrations of PM_{10} and $PM_{2.5}$ decrease. Therefore there may be some residual health risk associated with national air quality standards (NEPC, 2010). The question then becomes what is an acceptable level of health risk? This will be discussed below.

The current national air quality goals for airborne particulates have been set out below in **Table 4.**

Table 4 Particulate Matter Air Quality Goals

Particulate Class	Averaging Period	Goal (µg/m$_3$)
TSP	Annual	90#
PM_{10}	24 hours Annual	50* (maximum of 5 days exceedances per year) 30*
$PM_{2.5}$	24 hours Annual	25* 8*

* NEPC (2003), # DEC (2005)

The current national air quality goals are set as total airborne particulates concentrations (referred to as cumulative airborne particulate concentrations in air quality modelling predictions). Comparison of total airborne particulate concentrations, over the relevant averaging periods such as 24 hours or annual averages, to standards or goals can demonstrate potential for health risks. However, the natural fluctuations in background concentrations can make it difficult to determine the extent of potential risks associated with particulate emissions from a proposed development. That is, the additional contribution locally to the already existing health risks from airborne particulates in a particular geographical area.

The accepted method to investigate additional contribution to health risk from airborne particulates, as PM_{10} and $PM_{2.5}$, is to determine the increase in risk associated with the increase in airborne particulates (PM_{10} and $PM_{2.5}$) predicted from a proposed development. In this, the predicted incremental airborne particulates concentrations from modelling, that is the likely change in local concentrations caused by the proposed development are utilised rather than the predicted total concentrations. Established risk calculations are used to determine the potential increase in health risk to a community. The basis of these risk calculations have been set out in **Appendix A.**

The quantification of risk is an imprecise practise, based on available evidence, estimating level of risk within generally accepted ranges rather that absolute risk. The level of negligible / acceptable risk is generally considered to be less than 1 in 1,000,000 (i.e 1 x 10^{-6}) for contaminates with health effects considered to non-threshold in nature or carcinogenic chemicals (enHealth, 2012). At this level of risk, it is considered essentially non-existent. The level of risk is considered unacceptable at greater than 1 in 10,000 (1 x 10^{-4}). Tolerable risk occurs in the range between 1 x 10^{-6} and 1 x 10^{-4} (DEC, 2005). Tolerable risks are considered acceptable when best practise for minimising air toxics has been utilised.

3.1.7.2 TSP

As previously stated, it is the finer particles in TSP (PM_{10} and $PM_{2.5}$) that are associated with health impacts. Accordingly the current health risk assessment will focus on the PM_{10} and $PM_{2.5}$ size particles in the next sections.

However with regards to the TSP it was noted that the predicted cumulative annual average concentration was 40.6 µg/m^3, which was below the Approved Methods assessment criteria of 90 µg/m^3 (SLR, 2018).

3.1.7.3 PM_{10} & $PM_{2.5}$

Cumulative Concentrations PM_{10} & $PM_{2.5}$

The modelling of SLR (2018) concluded that during operation of Enfield ILC predicted annual PM_{10} concentrations would be within the current national air quality. The predicted annual $PM_{2.5}$ concentrations would exceed the current national air quality goal (9.5 µg/m^3 against a goal of 8 µg/m^3). However this exceedance was largely due to the current background concentrations (9 µg/m^3) which already exceeds the national air quality goal (8 µg/m^3).

The predicted annual average PM_{10} concentrations compared with current national air quality goal have been set out below in **Table 5**.

Table 5 Predicted Annual Average PM_{10} Concentrations at Sensitive Receptors & Particulate Matter Air Quality Goals

Particulate Class	Background (µg/m^3)	Average (µg/m^3) (cumulative impact)	Goal (µg/m_3)
PM_{10}	18.0	19.7	30*
$PM_{2.5}$	9.0	9.5	8

* NEPC (2003), # DEC (2005)

3.1.7.4 Health Risk Assessment of Changes in PM_{10} & $PM_{2.5}$ Concentrations

As discussed above in **3.1.7.1** while the current NEPC (2003) air quality goals for PM_{10} and $PM_{2.5}$ were established to be protective of health it is widely recognised concentrations below these levels may impact on health. Moreover the natural background fluctuations unrelated to a Project also may impact on health outcomes in the community. Therefore to determine if the Project will generate changes in PM_{10} and $PM_{2.5}$ community exposure that may impact on community health, risk assessments were undertaken based on the incremental changes predicted at the Receptors identified in the air quality report.

The quantified risk assessment of predicted incremental increases in annual average PM_{10} and $PM_{2.5}$ concentrations were in the negligible (risk = $\leq 1 \times 10^{-6}$) to tolerable risks (risk = $\leq 1 \times 10^{-4}$ to $\geq 1 \times 10^{-6}$) range. That is, risks may be considered acceptable when best practise for minimising air toxics have been utilised. The calculations have been set out in **Appendix A**.

Based on this, the Primary Exposure pathway was considered unlikely to lead to receptor exposure at concentrations likely to increase the receptors health risk. Therefore airborne particulate matter in the PM_{10} and $PM_{2.5}$ size range will not require further risk assessment.

3.1.8 Nitrogen Oxide (NO_x)

Oxides of nitrogen are a group of chemical compounds produced during the combustion process. The gaseous compounds produced by combustion include a range of oxides of nitrogen. Making up the majority of nitrogen oxides is the compound nitrogen oxide (NO) which accounts for roughly 90-95% of nitrogen oxides released with combustion of fossil fuels. The second most prolific combustion compound is nitrogen dioxide (NO_2) accounting for 5 -10% of nitrogen oxides. However, nitrogen dioxide concentrations rise over time as atmospheric reactions convert NO in to NO_2 in the time frame of several hours after emission into the environment.

Amongst this group, the main compounds of concern for human health are NO and NO_2. Only the concentration of NO_2 is regulated in ambient air.

The primary route of exposure to nitrogen oxides is by inhalation; however exposure by any route can cause systemic effects. Low levels of nitrogen oxides in the air are irritating to the eyes, skin, mucous membranes and respiratory tract (ATDSR 2002).

Populations that may be particularly sensitive to nitrogen oxides include asthmatics and those with chronic obstructive pulmonary disease or airway disease (ATSDR 2002).

NEPC (2003) set air quality guidelines for nitrogen dioxide considered to be protective of adverse health impacts for acute exposure and chronic exposure. The acute guideline has been set at 246 µg/m^3. Based on the lowest observed adverse effect level (LOAEL) of 409 to 613 µg/m^3 derived from statistical reviews of epidemiological data suggesting an increased incidence of lower respiratory tract symptoms in children and aggravation of asthma with an uncertainty factor of two added to protect susceptible individuals (EnRiskS, 2014).

The chronic guideline has been set at 62 µg/m^3. Based on the lowest observed adverse effect level (LOAEL) of 75 to 150 µg/m^3 during early and middle childhood which may lead to recurrent upper respiratory tract symptoms, with an uncertainty factor of two added to protect susceptible individuals (EnRiskS, 2014).

The air quality modelling of the operation of Enfield ILC predicted the offsite maximum NO_2 concentrations, as 1 hour maximum and mean annual concentrations, for discrete receptors.

The results have been set out below in **Table 6**.

Table 6 Mean Predicted Cumulative NO_2 Concentrations at Sensitive Receptors (SLR, 2018)

Guideline	Mean Predicted 1 Hour Maximum Concentration (µg/m^3)	Mean Predicted Annual Concentration (µg/m^3)
	126	24.1
Acute Health Based Guideline	**246**	N/A
Chronic Health Based Guideline	N/A	**62**

N/A = not applicable

The predicted concentrations of NO_2 are below both acute and chronic health based criteria. Therefore it is concluded the NO_2 from the operations are unlikely to increase the health risks to the local communities. Accordingly NO_2 can be excluded from further risk assessment.

Based on this, the Primary Exposure pathway was considered unlikely to lead to receptor exposure at concentrations likely to increase the receptors health risk. Therefore NO_2 will not require further risk assessment.

3.1.9 Carbon Monoxide (CO), Sulphur Dioxide (SO_2) & Volatile Organic Compounds (VOCs)

Both air quality impact assessments (SKM, 2005; SLR, 2018) did not model the emissions of CO, SO_2 and VOCs in their assessments. The basis of this was that SKM (2005) concluded that emission of CO, SO_2 and VOCs, were likely to be low impact pollutants due to their low background concentrations.

Accordingly these compounds cannot be assessed as part of the current health risk assessment. This data gap was noted in **Appendix B** Uncertainties and Limitations.

3.2 Issue Identification Summary

Based on the air quality modelling, this document indicated that the emissions from the proposed operation of the Enfield ILC would be within the relevant regulatory and health based criteria.

3.3 Toxicity Assessment

All other COPCs were eliminated in the preceding Hazard Identification stage. Accordingly there was no need for further toxicity assessment.

3.4 Exposure Assessment

In general, an exposure assessment aims to provide the magnitude, frequency, extent, character and duration of exposures to a chemical or material of concern. An exposure assessment also aims to identify human populations or groups who may be exposed and potential exposure pathways, which in this case is inhalation.

3.4.1 Exposure Pathways and Receptors

An exposure pathway describes the mechanism by which persons may be exposed to a COPC. Each exposure pathway must include a source, and a transport mechanism for a COPC to reach persons, for example environmental air movement. The exposure pathway is incomplete if any of these factors are not present, and therefore no additional risks are associated with that activity as the COPC does not reach the receptor.

3.4.1.1 Receptors

Receptors are similar groups of people from the defined communities. In this assessment, receptors are considered to be individuals who usually reside in the residential areas within close proximity to the Enfield ILC.

3.4.1.2 Assessment of Exposure Concentration

The exposure concentration used for the current study was based on results of air quality modelling as previously mentioned. All COPCs were within regulatory and health based criteria.

3.5 Risk Characterisation

Risk characterisation involves the incorporation of the exposure assessment and the hazard assessment to provide an overall evaluation and assessment of risk. Risk assessment is used extensively in Australia and overseas to assist decision making on project acceptability and chemical use. Risk is the probability of an unwanted event happening and is often expressed as a multiple of its consequences and frequency. Risks can be defined to be acceptable or tolerable if the population will bear them without undue concern. The quantification of risk is an imprecise practise, based on available evidence, estimating level of risk within generally accepted ranges rather that absolute risk. The level of negligible / acceptable risk is generally considered to be less than 1 in 1,000,000 (i.e 1×10^{-6}) for contaminates with health effects considered to non-threshold in nature or carcinogenic chemicals (enHealth, 2012). At this level of risk it is considered essentially non-existent. The level of risk is considered unacceptable at greater than 1 in 10,000 (1×10^{-4}). Tolerable risk occurs in the range between 1×10^{-6} and 1×10^{-4} (DEC, 2005). Tolerable risks are considered acceptable when best practise for minimising air toxics has been utilised.

Regulatory limits are set at points deemed ‘acceptable’ by the regulator, taking into account objective evidence of harm and the general views of society. However in some cases, health based guidelines from reputable sources may be more appropriate in determining risk.

As with any risk assessment there is always a degree of uncertainty associated with the assessment. The factors involved in this uncertainty and the implications are discussed in **Appendix B**

Negligible risks are those so small that there is no cause for concern, or so unlikely that there is no valid reason to take action to reduce them. Humans continually expose themselves to, or have imposed upon them, the risk of injury or fatality. Self-imposed risk is known as voluntary risk and includes everyday events such as smoking, swimming and driving. Each has an associated risk that people voluntarily accept when weighed against the perceived benefits.

A simple comparison of an air measurement and a health benchmark can be thought of as a “screening” exercise, that is, the risk assessor is screening for possible problems. If the majority of samples are much less than the benchmark, then in a majority of cases it would be appropriate to conclude that a health impact is unlikely.

The COPCs identified in the Issue Identification stage of the risk assessment were assessed as unlikely to be present at concentrations likely to impact on the health risks to receptors in the surrounding communities. This was based on comparisons of predicted COPC concentrations at or near receptor sites with relevant air quality assessment criteria, such as NSW EPA criteria or health based benchmarks. This group of COPCs included fine particulates (TSP, PM_{10}, $PM_{2.5}$) and NO_X.

4 CONCLUSIONS

SLR assessed the potential exposure pathways for human health from contamination during the operations of Enfield ILC. The assessment was based on a desktop review of available documents including air quality report as set out in section 3. 5?

A desktop evaluation is considered appropriate given the limited scope of the proposed works.

As this project involves only minor physical changes in process, the potential impact on the surrounding communities is limited.

Taking available information sources into account and considering the nature and scope of the proposed works, it is considered that the proposed works are sufficiently characterised to enable an assessment of risks.

From the information available, it was concluded that:

- The communities who may be exposed to any COPCs associated with the operations of Enfield ILC were identified as the residents in residential areas closest to Enfield ILC. This took in surrounding residential areas in Strathfield, Enfield, Belfield, Lakemba and Greenacre.
- The COPC associated with the operations of Enfield ILC were identified as fine particulates (TSP, PM_{10}, $PM_{2.5}$), SO_2, NO_X, CO, and VOCs. Of which data was available for fine particulates (TSP, PM_{10}, $PM_{2.5}$) and NO_X.
- Comparisons of predicted COPC concentrations at receptor sites with relevant air quality assessment criteria or health based benchmarks determined that none of the identified COPCs were likely to be present at concentrations likely to impact on the health risks to receptors in the surrounding communities.

Therefore it is concluded the proposed modification for the operation of Enfield ILC is unlikely to lead to an increase in any existing potential health risks to the identified communities.

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APPENDIX A

QUANTIFICATION OF RISK ASSOCIATED WITH AIRBORNE PARTICULATES AS PM_{10} & $PM_{2.5}$

The methodology regrading quantification of risk followed that outlined by the WHO (Ostro, 2004).

In the WestConnex M4 East and NorthConnex reports EnRiskS (2014 & 2015) provided extensive and detailed background to the use and development of the risk quantification methodology as well as the chosen health endpoints associated with the risk. Furthermore those projects required agreement with the NSW Department of Health with regards to the appropriateness of methodology. An example of this can be seen in NorthConnex reports (EnRiskS, 2014) which states "*The health impact functions presented in this table* (referring to Table 5-1) *have been discussed and agreed with NSW Health as the most current and appropriate for the quantification of potential health effects for the health endpoints considered in this assessment.*" This indicates a level of robustness in the methodology and functions chosen.

Based on this acceptance health impact functions in those previous reports, it was decided the current report would use the same health impact functions.

(EnRiskS, 2014) succinctly summarised the adopted health impact functions and exposure response relationships used in the risk assessment. As such the table has been quoted in full below as **Table 7**.

The risk equation utilised in the WestConnex M4 East and NorthConnex reports to calculate annual risk for individuals exposed to increased PM emission from the project has been set out below (EnRiskS, 2014).

The baseline health incidence data utilised in the current report was for NSW from NSW Health data sets from either 2005-2007 or 2009-2011 (see annotations **Table 6**) as used in the NorthConnex report (EnRiskS, 2014).

Risk = $\beta \times \Delta X \times B$

Where

β = slope coefficient relevant to the per cent change in response to a 1 $\mu g/m^3$ change in particulate matter exposure (as per Table B-1)

ΔX = change (increment) in PM10 or PM2.5 exposure concentration in $\mu g/m^3$ relevant to the project at the point of exposure

B = baseline incidence of a given health effect per person (eg annual mortality rate)

Table 7 Adopted Health Impact Functions and Exposure Response Relationships (source: EnRiskS, 2014)

Health endpoint	Exposure period	Age Group	Published relative risk (95% confidence interval) per 10 µg/m³	Adopted β coefficient (as %) for 1 µg/m³ increase in PM	Reference
Primary assessment health endpoints					
$PM_{2.5}$: Mortality, all causes	Long Term	≥30yrs	1.06 [1.04-1.08]	0.0058 (0.58%)	Relationship derived for all follow-up time periods to the year 2000 (for approx. 500 000 participants in the US) with adjustment for seven ecologic (neighbourhood level) covariates (Krewski et al. 2009). This study is an extension (additional follow-up and exposure data) of the work undertaken by Pope (2002), is consistent with the findings from California (19992002) (Ostro et al. 2006) and is more conservative than the relationships identified in a more recent Australian and New Zealand study (EPHC 2010).
$PM_{2.5}$: Cardiovascular hospital admissions	Short term	≥65yrs	1.008 [1.0059-1.011]	0.0008 (0.08%)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 0 (exposure on same-day)(strongest effect identified) (Bell, M. L. 2012; Bell, Michelle L. et al. 2008)
$PM_{2.5}$: Respiratory hospital admissions	Short Term	≥65yrs	1.0041 [1.0009-1.0074]	0.00041 (0.041%)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 2 (exposure 2 days previous)(strongest effect identified) (Bell, M. L. 2012; Bell, Michelle L. et al. 2008)
Secondary assessment health endpoints					
PM_{10}: Mortality, all causes	Short Term	All ages*	1.006 [1.004-1.008]	0.0006 (0.06%)	Based on analysis of data from European studies from 33 cities and includes panel studies of symptomatic children (asthmatics, chronic respiratory conditions) (Anderson et al. 2004)
$PM_{2.5}$: Mortality, all causes	Short Term	All ages*	1.0094 [1.0065-1.0122]	0.00094 (0.094%)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)
$PM_{2.5}$: Cardiopulmonary Mortality	Long Term	≥30yrs	1.14 [1.11-1.17]	0.013 (1.3%)	Relationship derived for all followup time periods to the year 2000 (for approx. 500 000 participants in the US) with adjustment for seven ecologic (neighbourhood level) covariates (Krewski et al. 2009).
$PM_{2.5}$: Cardiovascular mortality	Short Term	All ages*	1.0097 [1.0051-1.0143]	0.00097 (0.097%)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)
$PM_{2.5}$: Respiratory mortality (including lung cancer)	Short Term	All ages*	1.0192 [1.0108-1.0278]	0.0019 (0.19%)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)

* Relationships established for all ages, including young children and the elderly

Regarding the current project, the calculated changes in health risk from incremental changes in both PM_{10} and $PM_{2.5}$ have been set out below in **Table 8**. To err on the conservative side, increased risks were calculated using the 95% percentile as well as the 95% upper confidence limit for the mean.

The risks were found to be within the range considered to be negligible to tolerable risk as set out in DEC (2005).

Table 8 Health Risks Associated With Calculated 95% Percentile & 95% Upper Confidence Limit for The Mean Annual Average Change In PM_{10} & $PM_{2.5}$ Concentrations

			Primary Assessment Health Endpoints			Secondary Assessment Health Endpoints				
	Change in annual average PM_{10} (µg/m^3)	Change in annual average $PM_{2.5}$ (µg/m^3)	PM2.5	PM2.5	PM2.5	PM10	PM2.5	PM2.5	PM2.5	PM2.5
			Mortality - All causes Long Term ≥ 30 years	Hospitalisations - Cardiovascular Short Term ≥ 65 years	Hospitalisations - Respiratory Short Term ≥ 65 years	Mortality - All causes Short Term all ages	Mortality - All causes Short Term all ages	Mortality - Cardiopulmonary Long Term ≥ 30 years	Mortality - Cardiovascular Short Term all ages	Mortality - Respiratory Short Term all ages
			Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk
95% Percentile	3.4	1	6×10^{-5}	2×10^{-5}	4×10^{-5}	1×10^{-5}	6×10^{-6}	6×10^{-5}	2×10^{-6}	1×10^{-6}
95% Upper Confidence Limit for Mean	2.23	0.65	4×10^{-5}	1×10^{-5}	2×10^{-5}	9×10^{-6}	4×10^{-6}	4×10^{-5}	1×10^{-6}	7×10^{-7}

APPENDIX B

UNCERTAINTIES & LIMITATIONS

UNCERTAINTIES AND LIMITATIONS

Uncertainties are present in all risk assessments and this reinforces the need for a systematic and rigorous approach. The enHealth human health risk assessment process attempts to estimate risk as accurately as possible, however there are various sources of uncertainty in the process that should be examined. Understanding these uncertainties places the risk estimates in a proper perspective allowing them to be applied in practice with an appropriate level of confidence.

In general, the uncertainties and limitations of human health risk assessment can be classified into the following categories:

- Personnel exposure assessment.
- Toxicological assessment.
- Risk characterisation.

Various sources of uncertainty are briefly discussed below.

Uncertainty related to Exposure Assessment

The uncertainties that may exist in exposure assessment include the estimation of concentrations in the air:

- Uncertainties relating to air modelling.
- Models are generally conservative and overestimate concentrations

Uncertainty related to Toxicity Assessment

In general, the available scientific literature is insufficient to provide a thorough understanding of all of the potential toxic properties of chemicals or materials to which humans may be exposed. It is necessary therefore, to extrapolate these properties from data obtained under other conditions of exposure and involving experimental laboratory animals. This may introduce two types of uncertainties into the risk assessment, as follows:

- Those related to extrapolation from one species to another
- Those related to extrapolating from high exposure doses, usually in experimental animal studies, to the lower doses usually estimated for human exposure situations

Safety factors are introduced to compensate for these uncertainties. The use of safety factors and extrapolating from high exposure concentrations typically leads to a conservative over-estimation of dose response relationships.

Uncertainties in Site Specific Data and Modelling

Much of the data relied upon in this report was based on predicted COPC concentrations from the air quality modelling outlined by SLR (2018) and SKM (2005). The uncertainty associated with the air quality modelling predictions is more directed as the modelling deliberately chooses conservative parameters which are more likely to overestimate COPC concentrations. Therefore the predicted data used for exposure assessments in the risk assessment were likely to be much higher than what the actual concentrations will be when the Enfield ILC is in operation.

Uncertainties Conclusion
While a number of parameters used within the risk assessment have a moderate degree of uncertainty associated with them, values used to define these parameters have been selected to be conservative. This has resulted in estimates of risk which tend towards a conservative overestimation.

Data Gaps

There is no data relating to emissions of NO_2 and PM_{10} from increased truck movements on the road network accessing Enfield ILC. The SKM (2005) conclusions and subsequent acceptance in SLR (2018), that increased truck movements on the road network accessing Enfield ILC would lead to insignificant increases in emissions of NO_2 and PM_{10} are expected to be accurate. This would justify the decision did not to consider these emission sources further in their assessments. However provision of modelling results to justify this omission would have been preferable.

In a similar manner, there is no data relating to emissions of CO, SO_2 and VOCs from operations of Enfield ILC. SKM (2005) concluded that emissions of CO, SO_2 and VOCs, were likely to be low impact pollutants based to their low background concentrations. Based on this conclusion both air quality impact assessments (SKM, 2005; SLR, 2018) did not consider the emissions of CO, SO_2 and VOCs further in their assessments. Given the importance of CO, SO_2 and VOCs in this assessment, it would have been preferable to model these emissions in the air quality impact reports so these compounds could have been fully considered in the health risk assessment.

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