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Moorebank Precinct East - Stage 2 Proposal

Greenhouse Gas and Climate Change Impact Assessment

SIMTA

SYDNEY INTERMODAL TERMINAL ALLIANCE

Part 4, Division 4.1, State Significant Development

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SYDNEY INTERMODAL TERMINAL ALLIANCE
MPE PROJECT STAGE 2

Greenhouse Gas and Climate Change Impact Assessment

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D	16/11/16	Final Greenhouse Gas and Climate Change Impact Assessment	CH	BS

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APPENDIX A

Summary of Greenhouse Gas and Climate Change Risk Management Strategies

APPENDIX B

Climate Change Risk Register

GLOSSARY OF TERMS

Term	Definition
ALCAS	Australian Life Cycle Assessment Society
AR5	Fifth Assessment Report
AS/NZ	AS/NZ 31000:2009: Risk Management – Principles and Guidelines
AS5334	Australian Standard - AS5334 - Climate Change Adaptation for Settlements and Infrastructure
AusLCI	National Database of Life Cycle Inventory
BAU	Business as Usual
BoM	Bureau of Meteorology
BPIC	Building Products Innovation Council
CEMP	Construction Environmental Management Plan
CH_2FCF_3	Refrigerants
CH_4	Methane
CO_2	Carbon Dioxide
CO_2-e	Carbon Dioxide Equivalent
COP21	United Nations Framework Convention on Climate Change (UNFCCC) at the 21st Conference of the Parties
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	Development Application
DoE	Department of Environment
DP&E	NSW Department of Planning and Environment
DSNDC	Defence National Storage and Distribution Centre
EA	Environmental Assessment
e.g.	For example
EIS	Environmental Impact Statement

Term	Definition
El Niño	Refers to the extensive warming of the central and eastern tropical Pacific Ocean – increased probability of dryer conditions.
La Niña	Refers to the extensive cooling of the central and eastern tropical Pacific Ocean – increased probability of wetter conditions.
LPG	Liquefied Petroleum Gas
EMS	Environmental Management Systems
EP&A Act	Environmental Planning and Assessment Act 1979
FFDI	McArthur Forest Fire Danger Index
GFA	Gross Floor Area
GHG	Greenhouse Gas
GWP	Global Warming Potential
ha	Hectares
HVAC	Heating, Ventilation and Air Conditioning
ID	Identity Document
IMT	Intermodal Terminal
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicators
Km/h	Kilo-metres per hour
kW	Kilowatt
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
m2	Meters squared
MAC	Marginal Abatement Cost
MJ/t	Mega-Joules per tonne
mm	Millimetres
MPE	Moorebank Precinct East

Term	Definition
Mt	Mega tonnes
N_2O	Nitrous Oxide
NGA	National Greenhouse Accounts
NGER	National Greenhouse and Energy Reporting Act 2007
NSW	New South Wales
OEMP	Operational Environmental Management Plan
OSD	On-site Detention
PAC	Planning Assessment Commission
PBP	Planning for Bushfire Protection
PMF	Probable Maximum Flood
PVC	Polyvinyl Chloride
SIMTA	Sydney Intermodal Terminal Alliance
SIMTA Project	Concept Plan Approval (MP 10_0193) for an intermodal terminal (IMT) facility at Moorebank
SoCs	Statement of Commitments
SSD	State Significant Development
SSFL	Southern Sydney Freight Line
t	tonnes
The Proposal	Stage 2 of the Moorebank Intermodal Terminal including warehouse and distribution facilities with ancillary offices, a freight village (ancillary site and operational services), stormwater, landscaping, servicing and associated works on the MPE site, together with a rail link connecting the MPE Project to the Southern Sydney Freight Line (SSFL).
UNFCC	United Nations Framework Convention on Climate Change
WRI/WBCSD	The World Resources Institute/World Business Council for Sustainable Development
WSUD	Water-Sensitive Urban Design

EXECUTIVE SUMMARY

The Moorebank Precinct East (MPE) Project involves the development of an Intermodal Terminal (IMT), warehouse and distribution facilities with ancillary offices, a freight village (ancillary site and operational services), stormwater, landscaping, servicing and associated works on the MPE site. The MPE Project is located on the eastern side of Moorebank Avenue, Moorebank, together with a rail link connecting the MPE Project to the Southern Sydney Freight Line (SSFL) within the Rail Corridor (the entire area, being the MPE site and Rail Corridor is herein referred to as the Project site).

The MPE Project would be developed in four key stages, including the IMT facility and rail link (Stage 1), construction of warehouse and distribution facilities (Stage 2), extension of the IMT facility (Stage 3), and completion of warehouse and distribution facilities (Stage 4). This assessment would address Stage 2 of the MPE Project (the Proposal) which includes the construction and operation of warehousing, distribution facilities and associated ancillary infrastructure.

Approval for the Proposal is being sought under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This report has been prepared as part of the environmental assessment process required under the EP&A Act, and includes greenhouse gas (GHG) emissions projections, mitigation measures, a marginal abatement cost (MAC) analysis and a climate change risk and adaptation assessment for the Proposal.

The total GHG emissions associated with the construction of the Proposal are expected to be approximately 8,884 tonnes of carbon dioxide equivalent (tCO_2-e) during the 24 month construction period, with the total embodied GHG emissions within the construction materials generating an additional 137,774 tCO_2-e. The annual operational GHG emissions would generate approximately 118,733 tCO_2-e per annum.

Annual GHG emissions from the Proposal represent approximately 0.02 per cent of Australia's total annual GHG emissions (523.3 Mega tonnes (Mt) CO_2-e). The transport sector contributes 92.9 MtCO_2-e each year to Australia's GHG emissions (DoE, 2016a). The Proposal is predicted to contribute 0.13 per cent to Australia's transport sector inventory and 0.46 per cent to the NSW inventory for the transport sector (of a total 26 MtCO_2-e). The commercial and institutional industries contributed just 1.31 per cent (5.3 MtCO_2-e) of the energy sector in Australia in 2014 (DoE, 2016a), of which the Proposal would account for approximately 2.24 per cent of the 5.3 MtCO_2-e.

A MAC analysis for the operation of the Proposal identified the theoretical costs associated with reducing GHG emissions generated. Marginal abatement means the cost to reduce or offset one unit of pollution; in this case one tonne of GHG emissions. An analysis of the GHG emissions reductions achievable by different energy efficiency measures for the Proposal identified theoretical costs associated with reducing emissions. This analysis then identified the theoretical cost per year to reduce GHG emissions by 27 per cent – to align with current Federal Government reduction targets.

The Marginal Abatement Cost (MAC) analysis for the operation of the Proposal indicates that an average saving of $8.75 million per year (if all costs are assumed to be averaged over the life of a technology) can be realised from achieving a 27 per cent reduction in GHG emissions. This equates to an average saving of $273 per t$CO_2$-e abated.

A climate change risk and adaptation assessment for the Proposal was undertaken to assess the risk posed by climate change and to identify adaptation strategies to mitigate these risks. The assessment identified a total of 13 climate change risks for the Proposal. If these risks are unmitigated the assessment found that there would be two high, ten medium, and one low uncontrolled risks by 2090 (the long-term risk year assessed based on the infrastructure design life) as a result of potential climate change impacts. A range of adaptive responses for treatment of the climate change risks identified would be incorporated into the design and operation of the Proposal to promote resilience to projected future climate change. Once implemented the engineering design and procedural responses for treatment of priority climate change risks would result in lower residual risk levels; such that no high risks remained. For the year 2090, following the implementation of adaptation measures the Proposal would not be subject to any high climate change risks, whereby six moderate risks and seven low risks remain.

1 INTRODUCTION

Arcadis has been commissioned by Sydney Intermodal Terminal Alliance (SIMTA) to prepare a Greenhouse Gas (GHG) Assessment, Climate Change Risk and Adaptation Assessment and a Marginal Abatement Cost Analysis (MAC) for Moorebank Precinct East (MPE) Stage 2 Proposal (the Proposal). The purpose of this reporting is to support a State Significant Development (SSD) Environmental Impact Statement (EIS) under Part 4, Davison 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.1 Background

Concept Plan Approval (MP 10_0193) for an intermodal terminal (IMT) facility at Moorebank, NSW (the Moorebank Precinct East Project (MPE Project) (formerly the SIMTA Project)) was received on 29 September 2014 from the NSW Department of Planning and Environment (DP&E). The Concept Plan for the MPE Project involves the development of an IMT, including a rail link to the Southern Sydney Freight Line (SSFL) within the Rail Corridor, warehouse and distribution facilities with ancillary offices, a freight village (ancillary site and operational services), stormwater, landscaping, servicing, associated works on the eastern side of Moorebank Avenue, Moorebank, and construction or operation of any part of the project, which is subject to separate approval(s) under the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Environmental Impact Statement (EIS) is seeking approval, under Part 4, Division 4.1 of the EP&A Act, for the construction and operation of Stage 2 of the MPE Project (herein referred to as the Proposal) under the Concept Plan Approval for the MPE Project, being the construction and operation of warehouse and distribution facilities.

The EIS has been prepared to address:

- The Secretary's Environmental Assessment Requirements (SEARs) (SSD 16-7628) for the Proposal, issued by NSW DP&E on 27 May 2016 (Appendix A).
- The relevant requirements of the Concept Plan Approval MP 10_0913 dated 29 September 2014 (as modified) (Appendix A).
- The relevant requirements of the approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (No. 2011/6229, granted in March 2014 by the Commonwealth Department of the Environment (DoE)) (as relevant) (Appendix A).

The EIS also gives consideration to the MPE Stage 1 Project (SSD 14-6766) including the mitigation measures and conditions of consent as relevant to this Proposal.

The EIS has been prepared to provide a complete assessment of the potential environmental impacts associated with the construction and operation of the Proposal. The EIS proposes measures to mitigate these issues and reduce any unreasonable impacts on the environment and surrounding community.

1.2 Purpose and scope of this assessment

This report supports the EIS for the Proposal (refer to Section 1.3 below for an overview of the Proposal) and has been prepared as part of a State Significant Development (SSD) Application for which approval is sought under Part 4, Division 4.1 of the EP&A Act.

This report has been prepared to address:

- The Secretary's Environmental Assessment Requirements (SEARs) (SSD 16-7628) for the Proposal, issued by NSW DP&E on 27 May 2016.

- The relevant requirements of Concept Plan Approval MP 10_0913 dated 29 September 2014 (as modified).
- The relevant requirements of the approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (No. 2011/6229, granted in March 2014 by the Commonwealth Department of the Environment (DoE)) (as relevant).

The SEARs relevant to this study, and the section of this report where they have been addressed are provided in Table 1-1

Table 1-1: Secretary's Environmental Assessment Requirements relevant to this study

Section	Environmental Assessment Requirement	Where addressed
3. Air Quality	c) A review of direct and indirect greenhouse gas emissions arising from this development and associated impact mitigation requirements, in reference to the Concept Plan greenhouse gas assessment	Section 4 – Section 8

This report has been prepared in accordance with the Statement of Commitments (SoCs) provided in the Concept Plan Environmental Assessment (EA). Table 1-2 provides a summary of the commitments and the section where they have been addressed in this report.

Table 1-2 Conditions of Approval compliance table

Section	SoCs	Where Addressed
Concept Plan Conditions of Approval	The Proponent commits to the preparation of a Greenhouse Gas Management Plan for the three major stages of the development in accordance with the provisions of the Greenhouse Gas Assessment.	The contents of this Report provide the context and analysis supporting the development of the Greenhouse Gas Management Plan. Mitigation and adaptation measures for GHG emissions and climate change risks are outlined in Sections 8 and Section 10.6 respectively. A summary of the proposed management strategies for the Proposal is provided in Appendix A.
	The Proponent would where applicable implement the controls and mitigation measures summarised in the *Climate Risk Assessment* report and including: • Incorporate climate change sensitivity analyses for 20 per cent increase in peak rainfall and storm volumes into flood modelling assessment to determine system performance	Climate change risks have been assessed in Section 10 and Appendix B of this Report. Recommended controls identified in the Concept Plan Climate Change Risk Assessment have been incorporated into the design of the Proposal. These measures have also been incorporated within the management strategy for the Proposal (Appendix A). Adaptation measures to promote resilience to projected climate
	• Incorporate appropriate flood mitigation measures, where practical within the design to limit the risk to acceptable levels	

Section	SoCs	Where Addressed
	• Consider the impacts of climate change on system performance, and where practical incorporate adaptive capacity measures within the design to limit the risk to acceptable levels	change are presented in Section 10.6.
	• Use of appropriate materials and engineering design capable of withstanding potential impacts posed by storm damage	
	• Incorporate appropriate strategic protection zones, including asset protection zones into design to limit bushfire risk to acceptable levels, where required	
	• Control of performance of hotworks on total fire ban days during construction and operation, particularly within any defined asset protection zones	
	• Maintain track stability through regular maintenance, use concrete sleepers in place of wooden ones and use preventative measures in the event of heatwaves (e.g speed restrictions, warehouse ventilation for improved heat removal)	
	• Consider further assessment of MAC Curves to assess commercial opportunities of reducing reliance on single energy source.	A MAC analysis for the Proposal is presented in Section 9.

1.3 Proposal overview

The Proposal involves the construction and operation of Stage 2 of the MPE Project, comprising warehousing and distribution facilities on the MPE site and upgrades to approximately 1.4 kilometres of Moorebank Avenue between the northern MPE site boundary and 120 metres south of the southern MPE site boundary.

Key components of the Proposal include:

- Warehousing comprising approximately 300,000m^2 GFA, additional ancillary offices and the ancillary freight village
- Establishment of an internal road network, and connection of the Proposal to the surrounding public road network

Ancillary supporting infrastructure within the Proposal site, including:

  - Stormwater, drainage and flooding infrastructure
  - Utilities relocation and installation
  - Vegetation clearing, remediation, earthworks, signage and landscaping

- Subdivision of the MPE Stage 2 site

The Moorebank Avenue upgrade would be comprised of the following key components:

  - Modifications to the existing lane configuration, including some widening
  - Earthworks, including construction of embankments and tie-ins to existing Moorebank Avenue road level at the Proposal's southern and northern extents
  - Raking of the existing pavement and installation of new road pavement
  - Establishment of temporary drainage infrastructure, including temporary basins and / or swales
  - Raising the vertical alignment by about two metres from the existing levels, including kerbs, gutters and a sealed shoulder
  - Signalling and intersection works
- Upgrading existing intersections along Moorebank Avenue, including:
  - Moorebank Avenue / MPE Stage 2 access
  - Moorebank Avenue / MPE Stage 1 northern access
  - Moorebank Avenue / MPE Stage 2 central access
  - MPW Northern Access / MPE Stage 2 southern emergency access

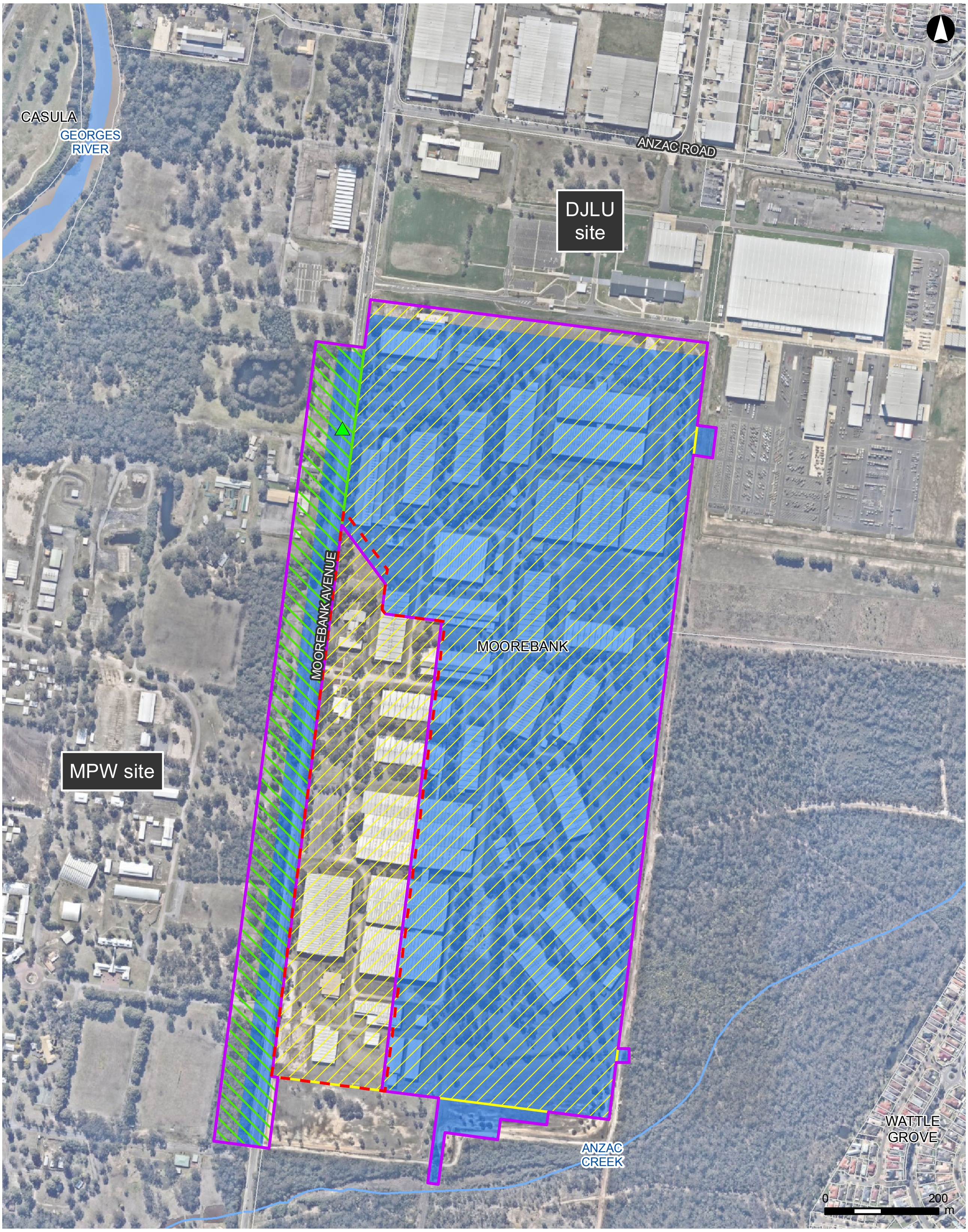
The Proposal would interact with the MPE Stage 1 Project (SSD_6766) via the transfer of containers between the MPE Stage 1 IMT and the Proposal's warehousing and distribution facilities. This transfer of freight would be via a fleet of heavy vehicles capable of being loaded with containers and owned by SIMTA. The fleet of vehicles would be stored and used on the MPE Stage 2 site, but registered and suitable for on-road use. The Proposal is expected to operate 24 hours a day, seven days per week.

An overview of the Proposal is shown in Figure 1-1. To facilitate operation of the Proposal, the following construction activities would be carried out across and surrounding the Proposal site (area on which the Proposal is to be developed):

- Vegetation clearance
- Remediation works
- Demolition of existing buildings and infrastructure on the Proposal site
- Earthworks and levelling of the Proposal site, including within the terminal hardstand
- Drainage and utilities installation
- Establishment of hardstand across the Proposal site, including the terminal hardstand
- Construction of a temporary diversion road to allow for traffic management along the Moorebank Avenue site during construction (including temporary signalised intersections adjacent to the existing intersections) (the Moorebank Avenue Diversion Road)
- Construction of warehouses and distribution facilities, ancillary offices and the ancillary freight village
- Construction works associated with signage, landscaping, stormwater and drainage works.

Construction works associated with signage, landscaping, stormwater and drainage works. The Proposal would operate 24 hours a day, 7 days a week.

The footprint and operational layout of the Proposal are shown on Figure 1-1. More information relating to the construction and operation of the Proposal is provided in Chapter 4 of the MPE Stage 2 EIS.



LEGEND

- MPE site
- MPE Stage 1 operational area
- MPE Stage 2 operational area
- MPE Stage 2 construction area
- Moorebank Avenue Upgrade
- Site access
- Lot boundary
- Watercourse

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1.4 Structure of report

This report is structured according to the following:

- Section 2 documents the GHG emissions estimation approach
- Section 3 provide a summary of the existing environment including an emissions profile for Australia and NSW within the transport and commercial sectors
- Section 4 assesses the expected emissions from construction activities for the Proposal
- Section 5 assesses the expected emissions from embodied energy within construction materials
- Section 6 assess the expect emissions from the Proposal's operational activities
- Section 7 provides a summary of the expected total emissions for the Proposal
- Section 8 documents a number of mitigation strategies to minimise GHG emissions at the Proposal site
- Section 9 describes the MAC analysis and results for the operational phase of the Proposal
- Section 10 outlines the climate change risks and adaptation strategies for the Proposal
- Section 11 concludes the assessment.

1.5 Key terms relevant to the Proposal

Table 1-3 provides a summary of the key terms relevant to the Proposal, which are included throughout this report.

Table 1-3 Summary of key terms used throughout this document

Term	Definition
General terms	
The Moorebank Precinct	Refers to the whole Moorebank intermodal precinct, i.e. the MPE site and the MPW site
Moorebank Precinct East (MPE) Concept Plan Approval (formerly the SIMTA Concept Plan Approval)	MPE Concept Plan Approval (SSD_0193) granted by the NSW Department of Planning and Environment on 29 September 2014 for the development of former defence land at Moorebank to be developed in three stages; a rail link connecting the site to the Southern Sydney Freight Line, an intermodal terminal, warehousing and distribution facilities and a freight village.
Moorebank Precinct East (MPE) Project (formerly the SIMTA Project)	The MPE Intermodal Terminal Facility, including a rail link and warehouse and distribution facilities at Moorebank (eastern side of Moorebank Avenue) as approved by the Concept Plan Approval (MP 10_0913) and the MPE Stage 1 Approval (14_6766).
Moorebank Precinct East (MPE) Site (formerly the SIMTA Site)	Including the former DSNDC site and the land owned by SIMTA which is subject to the Concept Plan Approval. The MPE site does not include the rail corridor, which relates to the land on which the rail link is to be constructed.

Term	Definition
Statement of Commitments (SoC)	Recommendations provided in the specialist consultant reports prepared as part of the MPE Concept Plan application to mitigate environmental impacts, monitor environmental performance and/or achieve a positive environmentally sustainable outcome in respect of the MPE Project. The Statement of Commitments have been proposed by SIMTA as the Proponent of the MPE Concept Plan Approval.
MPE Stage 2 specific terms	
MPE Stage 2 Proposal/ the Proposal	The subject of this EIS; being Stage 2 of the MPE Concept Plan Approval including the construction and operation of 300,000m^2 of warehousing and distribution facilities on the MPE site and the Moorebank Avenue upgrade within the Moorebank Precinct.
MPE Stage 2 site	The area within the MPE site which would be disturbed by the MPE Stage 2 Proposal (including the operational area and construction area). The MPE Stage 2 site includes the former DSNDC site and the land owned by SIMTA which is subject to the MPE Concept Plan Approval. The MPE site does not include the rail corridor, which relates to the land on which the rail link is to be constructed.
The Moorebank Avenue site	The extent of construction works to facilitate the construction of the Moorebank Avenue upgrade.
The Moorebank Avenue upgrade	Raising of the vertical alignment of Moorebank Avenue for 1.5 kilometres of its length by about two metres, from the northern boundary of the MPE site to approximately 120 metres south of the MPE site. The Moorebank Avenue upgrade also includes upgrades to intersections, ancillary works and the construction of an on-site detention basin to the west of Moorebank Avenue within the MPW site.
Construction area	Extent of construction works, namely areas to be disturbed during the construction of the MPE Stage 2 Proposal (the Proposal).
Operational area	Extent of operational activities for the operation of the MPE Stage 2 Proposal (the Proposal).

2 GHG EMISSIONS ESTIMATION APPROACH

This section outlines the GHG emissions estimation approach; policy framework, methodology and assessment boundary for the Proposal.

2.1 Policy Framework

In September 2013, the Intergovernmental Panel on Climate Change (IPCC) Working Group I released its Fifth Assessment Report (AR5) on climate change. The AR5 stated that warming of the climate system is unequivocal and, since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. Furthermore, the AR5 stated that it is extremely likely (95 to 100 per cent confidence) that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC 2014).

In Australia, there are a number of regulations, policies and targets which have been developed to manage and reduce GHG emissions. These include the following:

Table 2-1 Greenhouse gas emissions and climate change regulatory and policy context

Level	Type	Name	Description
Commonwealth Government	Regulation	*The National Greenhouse and Energy Reporting Act 2007*	Introduced in 2007 and requires corporations to register and report emissions, energy consumption or production that meets certain thresholds every year. In 2014 an amendment was passed which establishes a framework for the safeguard mechanism, a core element of the Emissions Reduction Fund. This would take effect from 1 July 2016.
	Target	Direct Action Plan	Targets set in the Direct Action Plan to cut emissions to five per cent below 2000 levels by 2020 and to 26 to 28 per cent below 2005 levels by 2030. It comprises an element to credit emissions reductions, a fund to purchase emissions reductions, and a safeguard mechanism.
	Inventory	State and Territory Greenhouse Gas Inventories for 2013/14.	This document provides an overview of the latest available estimates of GHG emissions for the Australian States and Territories based on a Kyoto accounting basis.
NSW Government	Target	*NSW Greenhouse Plan 2005*	The Plan sets emission reduction targets for NSW, including a 60 per cent reduction in greenhouse gas emissions by 2050 and a return to year 2000 levels by 2025.
	Legislation	*Environmental Planning & Assessment Act 1979*	The EP&A Act contains a general requirement to address environmentally sustainable principles, including climate

Level	Type	Name	Description
			change, within development applications.
	Target	NSW State Plan 2021	The NSW Plan 2021 has goals and targets towards climate change including: • 20 per cent renewable energy by 2020 • Assistance for businesses and households to realise annual energy savings of 16,000 gigawatt-hours by 2020 compared with 'business as usual' trends • Support for 220,000 low-income households to reduce their energy use by up to 20 per cent by June 2014 • An increase in the share of commuter trips made by public transport, including increasing the proportion of total journeys to work by public transport in the Sydney Metropolitan Region to 28 per cent by 2016 • Targets to increase walking and cycling • Planning policy to encourage job growth in centres close to where people live and to provide access by public transport.

2.2 Assessment methodology

The scoping process used for the assessment of GHG emissions for the Proposal are based on the following guidelines and regulations:

The scoping processes used for the assessment of GHG emissions for the Proposal are based on the following guidelines and regulations:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition (WRI/WBCSD, 2004)
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (DoE, 2014a)
- The Department of Environment (DoE) National Greenhouse and Energy Reporting System Measurement: Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia (DoE, 2014b)
- National Greenhouse Accounts (NGA) Factors (DoE, 2016a).

Under 'the Greenhouse Gas Protocol' (WRI/WBCSD, 2004), a Proposal's direct and indirect emissions sources can be delineated into three 'scopes' (Scope 1, Scope 2 and Scope 3) for GHG accounting and reporting purposes. These scopes are associated within an organisations operational boundaries (Figure 2-1).

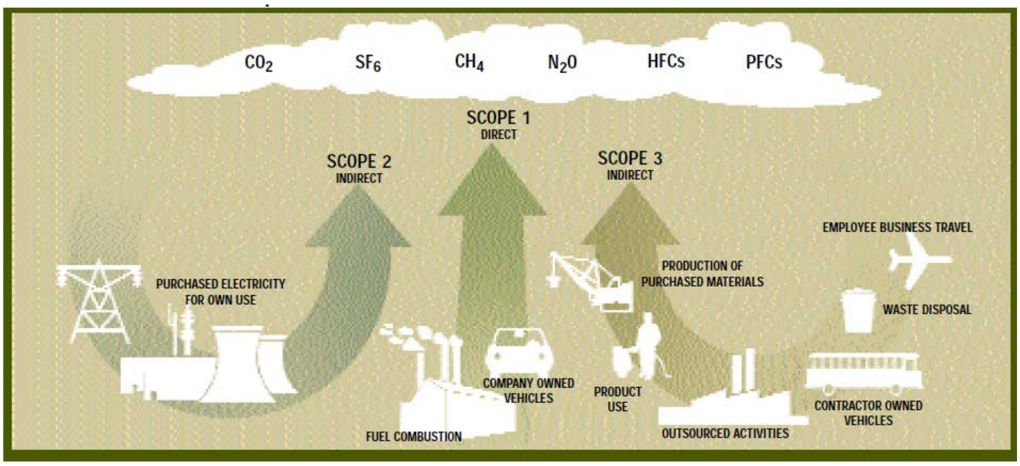

Figure 2-1 Overview of scopes and GHG emissions sources (WRI/WBCSD, 2004)

Further details of GHG operational scopes are outlined below:

- **Scope 1: Direct Greenhouse Gas Emissions -** Scope 1 emissions are direct GHG emissions from sources that are owned or controlled by SIMTA. Scope 1 can include direct emissions sources such as fuel consumption within machinery used during construction and operation.
- **Scope 2: Electricity Indirect Greenhouse Gas Emissions –** These account for GHG emissions arising from purchased electricity consumed on-site. Scope 2 emissions are considered indirect as they occur at an off-site facility where electricity is generated. Scope 2 emissions associated with the Proposal include the electricity that would be consumed within warehouses.
- **Scope 3: Other Indirect Greenhouse Gas Emissions –** Scope 3 emissions are those that are a consequence of SIMTA, but occur outside the site operational boundary and are not under SIMTA's control, such as construction vehicles and delivery of materials to the Proposal site. Scope 3 emissions also include the upstream and downstream emissions associated with the production of fuel, electricity and materials. Scope 3 emissions are an optional reporting category that allows for the treatment of all other indirect emissions.

Quantification of potential emissions from the Proposal has been undertaken in relation to carbon dioxide (CO_2) and other non-CO_2 GHG emissions, including methane (CH_4), nitrous oxide (N_2O), and refrigerant HFC-134a (CH_2FCF_3). To report these emissions, they are converted to carbon dioxide equivalents (CO_2-e) as specified under the Kyoto Protocol. The Global Warming Potential (GWP) adopted for each GHG is as follows: carbon dioxide GWP of 1; methane GWP of 25; nitrous oxide GWP of 298, and HFC-124a GWP of 1,430 as detailed in the NGA Factors (DoE, 2016a).

This assessment has been undertaken using the best available current and historical data. Assumptions have been outlined, where appropriate to maintain transparency.

2.3 Assessment boundary

A number of potential Scope 1, Scope 2 and Scope 3 emissions sources have been identified for the Proposal during the construction and operational phases. GHG emissions that would be generated during construction and operation are summarised in Section 4 and Section 6 respectively. The key sources of GHG emissions are provided below.

2.3.1 Construction

Construction of the Proposal is proposed to take between 24 and 36 months, commencing in the final quarter of 2017, with the completion of construction in the third quarter of 2019 (should construction take 24 months). The final construction program would depend on the market demand for warehouses to be constructed on the site.

The indicative construction program (based on a 24 month program) is shown in Table *2-2*. The construction works have been divided into seven ‘works periods’ which are interrelated and would potentially overlap. Subject to confirmation from the construction contractor, the order and staging of these construction works periods may change.

Table 2-2 Indicative construction program (based on a 24 month construction period)

Construction works period	2017				2018				2019			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Works Period A – Pre-construction activities												
Works Period B - Site Preparation activities												
Works Period C - Construction of the Moorebank Avenue diversion road												
Works Period D - Pavement and intersection works along Moorebank Avenue												
Works Period E – Bulk earthworks, drainage and utilities												
Works Period F - Construction and internal fit-out of warehousing												
Works Period G – Miscellaneous construction and finishing works												

A summary of the indicative construction works and activities which would be undertaken for construction of the Proposal during each of these works periods is provided in Table 2-3.

Table 2-3 - Construction activities to be undertaken within each works period

Construction Works Period	Activity
Works Period A – Pre-construction activities	• Establishment of site access points • Importation of fill for site preparation activities • Installation of site fencing • Remediation, where required.
Works Period B - Site preparation activities	• Demolition of existing structures • Clearing of vegetation • Raising and levelling of land (to final operational levels) within which the Main Warehousing Compound would be located • Temporary works, including installation of construction environmental management measures (e.g. erosion and sedimentation controls) • Establishment of construction compound fencing and hoardings • Installation of site offices and amenities • Construction of hardstands for staff parking and laydown areas • Establishment of temporary batch plant and materials crushing plant • Construction of access roads, site entry and exit points and security • Establishment of site haulage roads • Establishment of construction compound(s).
Works Period C: Construction of the Moorebank Avenue diversion road	• Stripping of topsoil within footprint of temporary diversion road • Installation of temporary drainage • Placement of fill and temporary road pavement (e.g. gravel) • Construction of interface between temporary diversion road and existing Moorebank Avenue • Installation of temporary road signage, street lighting and signalling • Transfer of traffic onto temporary diversion road from Moorebank Avenue.

Construction Works Period	Activity
Works Period D – Bulk earthworks, drainage and utilities	• Removal of existing pavement and stripping of topsoil within Moorebank Avenue • Importation, stockpiling and placement of approximately 600,000 m^3 of imported clean fill • Installation of on-site detention (OSD) and drainage infrastructure within the MPE site • Construction of retaining walls • Creation of a road formation by general earthworks (by constructing fill embankments) • Bulk earthworks and raising of the Proposal site to final level • Utilities relocation and installation • Establishment of hardstand areas. • Internal existing road network modifications to enable continued operations of the site during construction
Works Period E – Pavement works along Moorebank Avenue	• Placement of select layer of earthworks material on top of the road formation • Placing and compacting the pavement later (concrete, or concrete and asphalt) over the select layer (consisting of a sub-base and base) and potential sealing with bitumen • Traffic switching from diversion road onto final, raised Moorebank Avenue • Removal of construction traffic management and progressive opening of the internal road and warehouse access roads to traffic • Removal of road surface, road signage, street lighting and signalling from temporary diversion road • Commissioning of Moorebank Avenue.
Works Period F - Warehouse construction and internal fit-out	• Foundation and floor slab installation • Erection of framework and structural walls • Installation of roof • Internal fit-out of warehouses (racking and associated services).

Construction Works Period	Activity
Works Period G – Miscellaneous construction and finishing works	• Pavement construction (internal transfer roads and perimeter road), including forming of new kerbs, gutters, medians (where required) and other structures • Line marking, lighting and sign posting • Installation of road furniture, including traffic signs and pavement markers • Miscellaneous structural construction • Finishing works, including landscaping and general site rehabilitation, where required • Commissioning of the Proposal • Decommissioning/Demobilisation of the Proposal site, including removal of construction compound(s) and construction environmental controls.

2.3.2 Operation

The operation of the Proposal, which would be 24 hours per day, seven days a week, would generate emissions from:

- Transportation:
  - Movement of freight between the IMT and the warehousing
  - Distribution of freight to and from the warehousing
- Warehouse operation:
  - Electricity demand, including from lighting, heating, ventilation and air conditioning (HVAC), automated sortation systems and refrigeration
  - Fuel consumption within operational machinery (predominantly forklifts used within the warehousing)
  - Waste decomposition, from putrescible waste generated by onsite staff
  - Leakage of refrigerants within chilled commercial space.

2.3.3 Assessment boundary

Details of the assessment boundary for this assessment are illustrated below in Figure 2-2. The assumptions considered for the quantum of GHG emissions of the Proposal are explained in the following section.

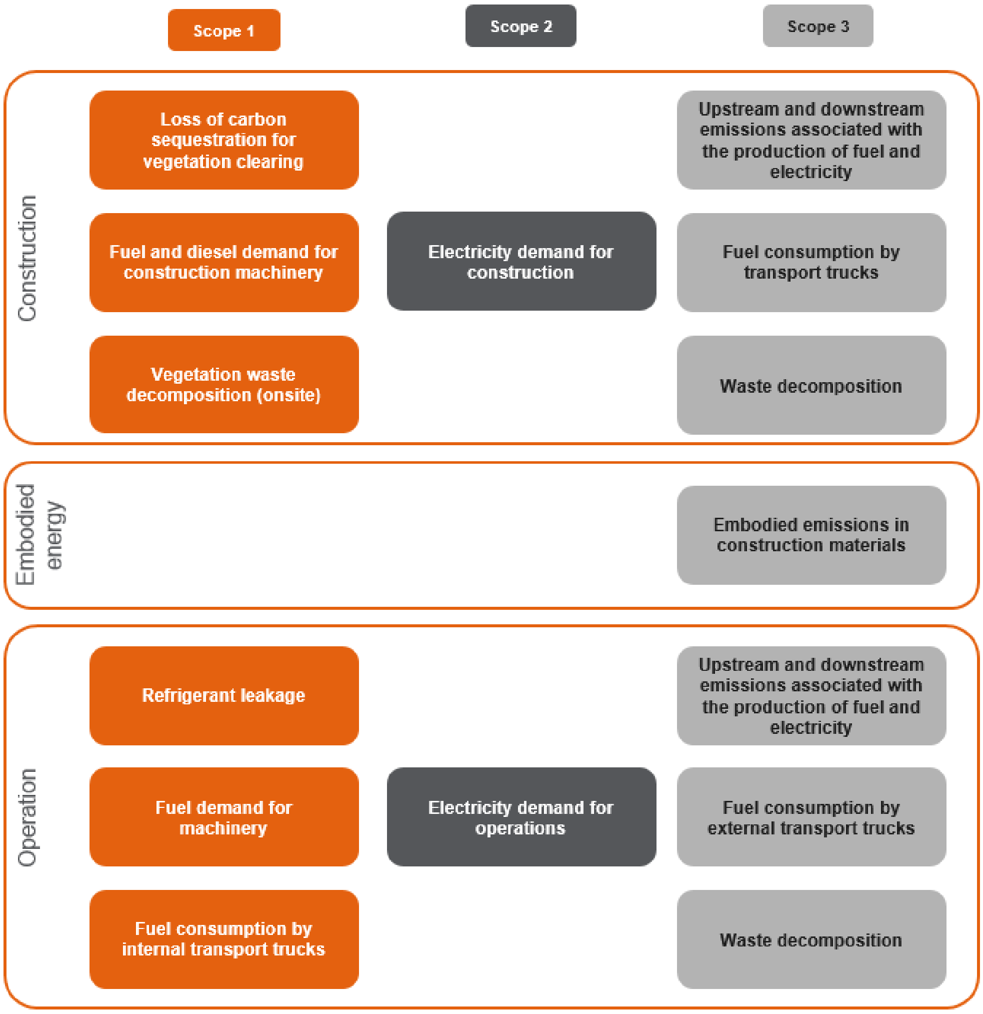

Figure 2-2 GHG assessment boundary

2.3.4 Assumptions for the assessment

This assessment has been undertaken using the best available data at the time of writing. Assumptions have been outlined, where appropriate, to maintain transparency.

Where specific assumptions have been made for the calculation of GHG emissions arising from an individual activity, they have been identified within the corresponding section of this report. The following provides a list of the general assumptions used throughout this report on the whole:

- Construction work hours were assumed to be 12 hours per day and 5.5 days per week
- The closest building material suppliers, recyclers and waste disposal facilities were identified by desktop searches, and associated distances used in the report calculations
- Only plant and machinery that would significantly contribute to CO_2-e emissions were considered in the assessment
- All cleared vegetation would be composted and used for landscaping purposes onsite.

3 EXISTING ENVIRONMENT

Existing accounts of greenhouse gases provided by the Commonwealth Department of the Environment (DoE) estimate that approximately 549.4 Mega tonnes (Mt) CO2-e were emitted in Australia during the 2012-13 financial year (DoE, 2016c). Table 3-1 presents a breakdown of the individual State and Territory GHG emissions contribution.

Table 3-1 Australia State and Territory GHG emissions (DoE, 2016c)

State or Territory	Total Emissions ($MtCO_2$-e)	Percentage of Total Australian Emissions
New South Wales	130.2	24.8
Victoria	118.1	22.5
Queensland	146.7	27.9
Western Australia	86.1	16.4
South Australia	27.6	5.3
Tasmania	15.6	3.0
Australian Capital Territory	1.5	0.3
Northern Territory	12.4	2.4
External Territories	0.04	<0.01
Total	**538.3**	**100**

*The difference between the national and the sum of the State and Territory emissions reflects the inclusion of military transport in the national inventory and a small balancing item.

As per the Intergovernmental Panel on Climate Change (IPCC), and reported within Australia's Greenhouse Gas Inventory, fuel combustion in transportation forms a sub-sector of the energy sector. The combined energy subsectors (including transport) were the largest source of GHG emissions in Australia in 2014, comprising 77 per cent of Australia's total emissions (405.6 Mt) (DoE, 2016b).

The transport sector accounted for around 70 per cent (92.9 $MtCO_2$-e) of Australia's GHG emissions in 2014 and 71.5 per cent of total GHG emissions in NSW (DoE, 2016b). Approximately 85 per cent of emissions produced by the transport sector are attributable to the road transport subsector. Commercial and institutional industries contributed just 1.31 per cent of the energy sector in Australia in 2014 (DoE, 2016b).

4 CONSTRUCTION BASED GHG EMISSIONS

Construction of the Proposal would be undertaken in seven key periods over a 24-36 month period. Primarily, construction would include the transport of materials on and off the Proposal site, civil works and construction of warehouses and buildings. These activities require the use of fuels and electricity which would result in associated GHG emissions.

Emissions were calculated by estimating fuel use and electricity consumption using available data. Emissions in tonnes CO_2-e were calculated using factors and methods from the *Australian Government National Greenhouse Accounts Factors – August 2016* (DoE, 2016a). Specific assumptions were made with regard to fuel use, electricity consumption, construction schedule, material quantities, material transport and waste decomposition.

Table 4-1 Indicative construction plant and equipment for the Proposal

Equipment	Construction Works Period						
	Works period A – Pre-construction activities	Works period B - Site Preparation activities	Works period C: Construction of the Moorebank Avenue diversion road	Works period E - Road and intersection works to facilitate the raising of Moorebank Avenue	Works period D – Bulk earthworks, drainage and utilities	Works period F - Construction and internal fit-out of warehousing	Works period G – Miscellaneous construction and finishing works
Loaders		✓			✓	✓	✓
Static and vibratory rollers, and high energy impact compaction	✓	✓	✓	✓	✓	✓	
Mobile cranes	✓	✓			✓	✓	
Excavators	✓	✓	✓	✓	✓	✓	
Excavators with hammers		✓			✓		
Backhoes		✓			✓	✓	✓
825 Compactor			✓	✓			
Crushing plant		✓			✓		
Batch plant					✓	✓	
Concrete agitators (or similar)		✓			✓	✓	✓
Concrete pumps		✓			✓	✓	✓

Equipment	Construction Works Period						
	Works period A – Pre-construction activities	Works period B - Site Preparation activities	Works period C: Construction of the Moorebank Avenue diversion road	Works period E - Road and intersection works to facilitate the raising of Moorebank Avenue	Works period D – Bulk earthworks, drainage and utilities	Works period F - Construction and internal fit-out of warehousing	Works period G – Miscellaneous construction and finishing works
Concrete saws					✓	✓	✓
Air compressors					✓	✓	✓
Jackhammers						✓	✓
Dozers		✓	✓	✓	✓		
Mulchers		✓					
20-40 tonne articulated tipper trucks	✓	✓			✓		
Scrapers		✓			✓		
Graders	✓	✓	✓	✓	✓	✓	
Water trucks	✓	✓	✓	✓	✓	✓	✓
Piling rigs					✓	✓	
Forklifts					✓	✓	✓
Small earthmoving equipment	✓				✓	✓	✓
Welder					✓	✓	✓
Road profiler			✓	✓			
Rubber Roller			✓	✓			

4.1 Works Period A – Pre Construction Stockpiling

Works Period A of construction would include the establishment of site access points, importation of fill for site preparation activities, installation of site fencing and any remediation where required.

Table 4-2 summarises the GHG emissions that would be generated as a result of the construction activities performed during works Period A. GHG emissions would be generated from the combustion of fuel within onsite machinery (Scope 1). Scope 3 emissions, those that occur outside the Proposal boundary and beyond the control of SIMTA, include the extraction, processing and transportation of fuel used within onsite machinery. Approximately 216 tCO_2-e would be generated as a result of Works Period A, including 201 tCO_2-e of Scope 1 emissions and 15 tCO_2-e of Scope 3 emissions.

Table 4-2 - Works Period A construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Establishment of site access points	67	-	5
Installation of fill for site preparation activities	130	-	10
Installation of site fencing	5	-	0.4
TOTAL	**201**	**-**	**15**

4.2 Works Period B – Site preparation activities

Works Period B of construction would include site preparation activities; such as the demolition of existing structures, clearance of vegetation, temporary works including installation of construction environmental management measures, establishment of haulage roads and establishment of construction compounds.

Vegetation clearing would generate emissions from a number of potential sources; including the loss of carbon sequestration, diesel consumption in machinery used for clearing and mulching, and vegetation decomposition.

Approximately 7.65 hectares (ha) of vegetation would need to be cleared to prepare the site for construction.

The loss of carbon sequestration, while not a true GHG emission, would result in less carbon dioxide being removed from the atmosphere. The net effect would therefore be that a greater amount of carbon dioxide would remain. Consequently, the loss of sequestration has been assessed as a Scope 1 source of emissions. Different vegetation types characteristically sequester carbon at different rates and to a different extent. Based on the vegetation types the likely tonnes of dry vegetation per hectare, and the average emissions factor have been used to determine the loss of sequestration (TAGG, 2013). Loss of sequestration has included all carbon pools including woody, non-woody, debris and soil. To provide a conservative estimate it has been assumed that all carbon removed is converted to carbon dioxide and released to the atmosphere.

Erosion and sediment control works to be undertaken for construction of the Proposal would involve the early establishment of operational water capture and treatment infrastructure, including swales, open concrete lined drainage channels and OSD's. Erosion and sediment control measures during construction of the Proposal along Moorebank Avenue would include the installation of sediment fences along the western perimeter of Moorebank Avenue, sedimentation ponds and hay bales around existing stormwater pit inlets.

Works Period B of construction would generate approximately 1,918 tCO_2-e, including 1,853 tCO_2-e of Scope 1 emissions and 66 tCO_2-e of Scope 3 emissions. The loss of vegetation sequestration would generate the largest portion of Scope 1 emissions (904 tCO_2-e) as shown in Table 4-3 and Figure 4-1

Table 4-3 Works Period B construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Demolition of existing structures	457	-	34
Clearance of remaining vegetation	10	-	1
Temporary works, including installation of construction environmental management	117	-	9
Establishment of site haulage roads	98		7
Establishment of construction compounds	174		13
Vegetation carbon sequestration loss	904		-
Vegetation decomposition	92		1
TOTAL	**1,853**	**-**	**66**

Figure 4-1 shows the total GHG emissions produced by Works Period B as attributable to the key activities undertaken during this works period of construction. The loss of vegetation carbon sequestration of existing structures would represent the largest generator of GHG emissions.

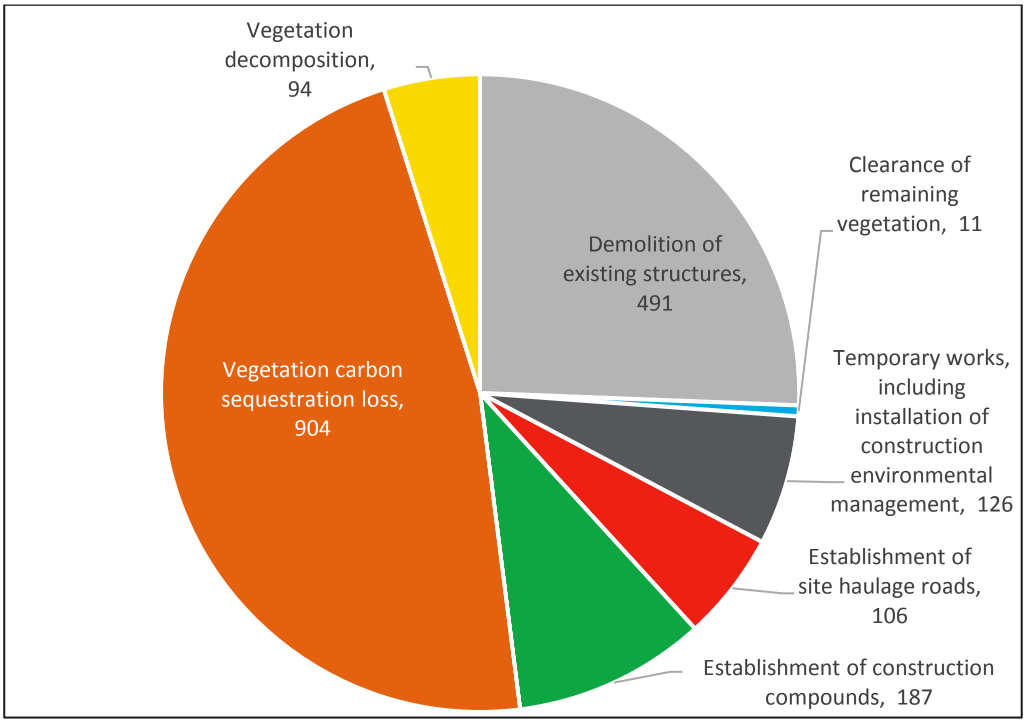

Figure 4-1 Summary of Works Period B GHG emissions (tCO_2-e)

4.3 Works Period C – Construction of Moorebank Avenue Diversion Road

Works Period C for construction would involve earthworks, drainage and sub-base activities for the Moorebank Avenue diversion road. Subsequent construction of a temporary road pavement would take place to divert vehicular traffic around the Proposal site.

The imported fill material would be placed within the Moorebank Avenue footprint for the construction of the road formation. Graders and/or bulldozers (or similar equipment) would be used to move the fill along Moorebank Avenue and the fill would be compacted to achieve the required geotechnical requirements for road construction. A water cart would be used at points where fill is unloaded to minimise dust generation, as and when required.

This delivery, compaction and conditioning of the imported fill for road formation, followed by the placement of the select layer of fill materials on top of the road formation, would continue until the surface level for laying pavement is achieved.

Works Period C of the Proposal would generate approximately 655 tCO_2-e which would be comprised of 609 tCO_2-e of Scope 1 emissions from fuel combustion within machinery and a further 46 tCO_2-e from Scope 3 emissions (refer Table 4-4).

Table 4-4 Works Period C construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Earthworks, drainage and sub-base	605	-	46
Construction of temporary road pavement	4	-	0.3
TOTAL	**609**	**-**	**46**

4.4 Works Period D – Bulk Earthworks

Works Period D of construction would involve bulk earthworks activities; such as the importation, stockpiling and placement of clean fill for the purposes of raising and levelling the proposal site, drainage and utilities relocation and installation, and establishment of hardstand areas.

Earthworks to facilitate construction of the Proposal would include the delivery of imported fill material via truck and/or semi-trailer from multiple sources within the Greater Sydney Metropolitan Area. It has estimated that approximately 600,000m^3 of fill would be imported to the Proposal site. It has been assumed that all excavated soil would be reused onsite for foundation preparation, levelling works and/or maintenance of construction haulage routes within the Proposal site.

Drainage, erosion and sediment control facilities would be constructed for the use of managing construction surface water runoff.

A concrete batching plant would be installed onsite for the delivery of concrete. The concrete batching plant would use a diesel oil powered generator which would contribute GHG emissions during works Period D of construction

The majority of emissions generated from Works Period D of construction would be from fuel combustion within machinery, and would consequently be characterised as

Scope 1. Works Period D of the Proposal would generate approximately 2,122 tCO_2-e as shown in Table 4-5.

Table 4-5 Works Period D construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Importation of general fill for raising and levelling of the proposal site	1,549	-	116
Drainage and utilities relocation and installation	353	-	27
Establishment of hardstand areas	71		5
TOTAL	**1,973**	**-**	**148**

4.5 Works Period E – Pavement works along Moorebank Ave

Works Period E of construction would involve the construction of pavement structures along Moorebank Avenue. Works Period E of construction would not be authorised to commence until Period C of construction (Moorebank Avenue diversion road) is completed and operational.

As per Works Period D earthworks to facilitate construction of the Proposal would include the delivery of imported fill material via truck and/or semi-trailer from multiple sources within the Greater Sydney Metropolitan Area. Once on-site the fill would be positioned, levelled and raised for the creation of the pavement sub-base. A concrete batching plant would be installed onsite for the delivery of concrete to finalise the pavement construction. The concrete batching plant would use a diesel oil powered generator which would contribute GHG emissions during works Period E of construction.

A pavement layer (concrete, or concrete and asphalt) would be paced and compacted over a select layer (sub-base and base) and would potentially be sealed with bitumen. Removal of redundant road surface, road signage and temporary diversion roads would also be required as part of Works Period E works.

The bulk of emissions for Works Period E of construction would be generated from the earthworks activities (approx. 707 tCO_2-e), as shown in Table 4-6. This would largely be a result of use of water trucks, soil compactors, bulldozers and excavators. A total of 740 tCO_2-e of emissions would be generated from Works Period E of construction, including 689 tCO_2-e of Scope 1 emissions and 52 tCO_2-e of Scope 3 emissions.

Table 4-6 Works Period E construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Earthworks and construction of pavement sub-base	657	-	49
Construction of pavement	31	-	2
TOTAL	**689**	**-**	**52**

4.6 Works Period F – Warehouse construction and internal fit out

Works Period F of construction would involve the installation of warehouse foundation and flooring slab, the erection of framework and structural walls and the installation of warehouse roofing and internal fit-out such as racking and associated services. A concrete batching plant would be used onsite for the delivery of concrete required within the warehouse construction.

Table 4-7 summarises the GHG emissions that would be generated as a result of the construction activities during Works Period F. Works Period F of construction would produce approximately 643 tCO_2-e of which nearly three quarters would be attributable to the construction of the warehouse.

Table 4-7 Works Period F construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Warehouse construction	423	-	32
Warehouse fit out	175	-	13
TOTAL	**598**	**-**	**45**

4.7 Works Period G – Miscellaneous construction and finishing works

Works Period G of construction would involve the finishing works, commissioning, demobilisation and miscellaneous construction activities not undertaken during Works Period A – F. Table 4-8 illustrates the GHG emissions produced from the various Works Period G activities. Figure 4-2 shows the total GHG emissions produced by Works Period G as attributable to the key activities undertaken during this works period of construction.

Table 4-8 Works Period G construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Pavement construction	204	-	15
Misc. structural construction	184	-	14

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Finishing works	130		10
Decommissioning	78		6
TOTAL	**597**	**-**	**45**

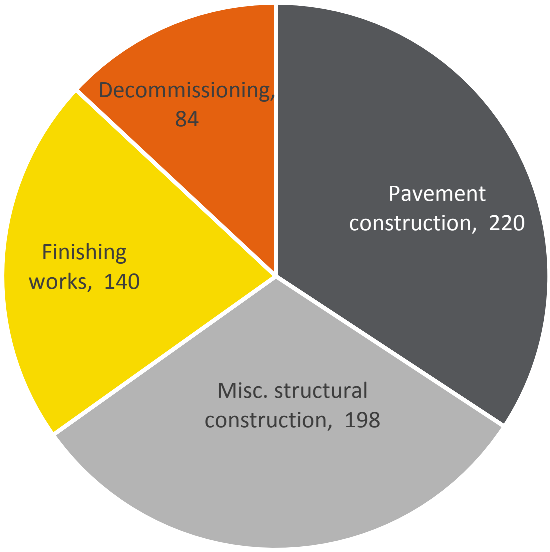

Figure 4-2 Summary of Works Period G GHG emissions (tCO_2-e)

4.8 Other construction activities

4.8.1 Site offices

Site offices would be required during the duration of construction activities. Construction compounds would be located within the Proposal site, containing varying number and sizes of site offices. An approximate average floor area of 2,400 m^2 has been assumed for the site offices that would be operational during construction. It has been assumed that site offices would be connected to the electrical grid, and would consequently largely generate Scope 2 emissions (rather than a scenario where they may be powered by diesel generators). Scope 3 emissions would also be generated as a result of the production of electricity, in the form of transmission and distribution loss. The use of electricity in the site offices would generate approximately 664 tCO_2-e of Scope 2 emissions across the 24 month construction period, as well as 95 tCO_2-e of Scope 3 emissions (refer Table 4-9).

4.8.2 Waste decomposition

In addition to vegetation, decomposition of putrescible waste (described in Section 4.1) would be generated by onsite workers during the construction period. Other construction and demolition waste would either be reused onsite, or has been assumed to be disposed of for recycling purposes. Given the inert nature of construction and demolition waste, and its likely reuse, no assessment of GHG emissions has been undertaken for these waste streams.

As shown in Table 4-9, based on the construction period and number of site works, approximately 732 tCO_2-e would be generated from the decomposition of mixed putrescible waste. It has been assumed that waste would be transported to the Lucas Heights Landfill for disposal, which captures 65 per cent of landfill gas. Waste decomposition is a source of Scope 3 GHG emissions.

4.8.3 Construction vehicle movements

The majority of construction vehicles accessing the Proposal site would be associated with the movement of construction materials, removal of waste from site, and delivery of fill. It has been assumed that materials would be supplied from the nearest available material supplier. Fuel combustion within construction vehicles represents a source of Scope 3 emissions. Approximately 457 tCO_2-e of Scope 3 emissions would be generated from heavy vehicles movements associated with the construction of the Proposal.

Table 4-9 Other construction activities GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Site offices	-	664	95
Waste decomposition	-	-	732
Transportation of materials and waste	-	-	457
TOTAL	**-**	**664**	**1,284**

4.9 Summary of Construction based GHG emissions

Construction of the Proposal would generate approximately 8,884 tCO_2-e over the 24 month construction period. Scope 1 emissions would generate 73 per cent of total emissions, with Works Period D generating the greatest proportion of emissions contributing 24 per cent (refer Figure 4-3 and Figure 4-4). Table 4-10 provides a summary of total GHG emissions generated by the construction of the Proposal.

Table 4-10 Total Construction GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Works Period A	201	-	15
Works Period B	1,853	-	66
Works Period C	609	-	46
Works Period D	1,973	-	148
Works Period E	689	-	52
Works Period F	598	-	45
Works Period G	597	-	45
Site offices	-	664	95
Waste decomposition	-	-	732
Materials and waste transportation			457
TOTAL	**6,519**	**664**	**1,700**

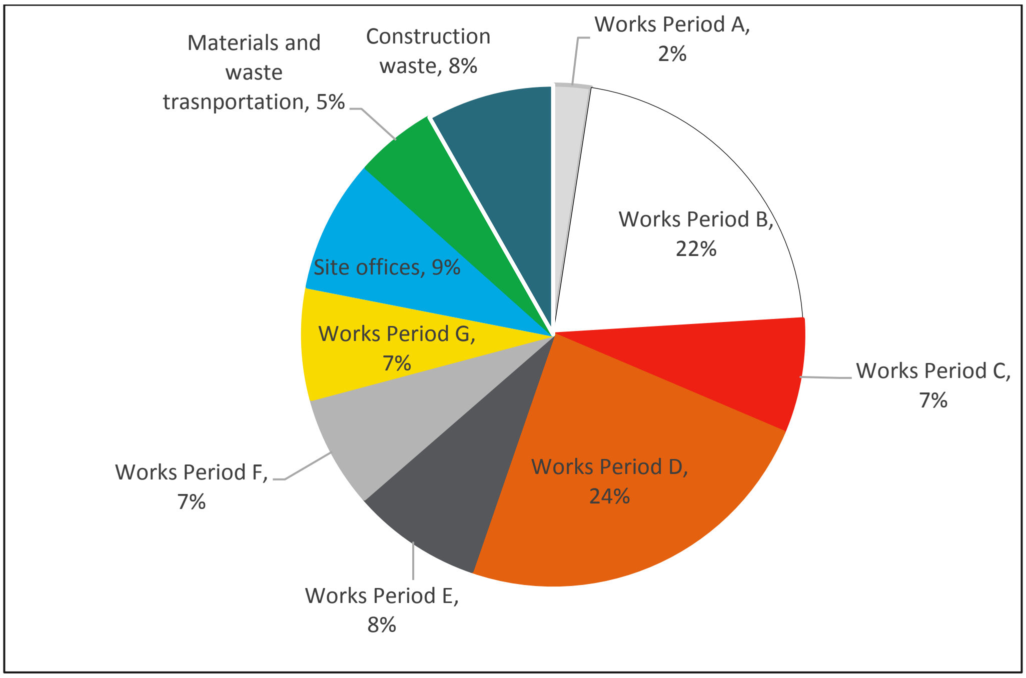

Figure 4-3 Summary of construction GHG emissions by Works Period (tCO_2-e)

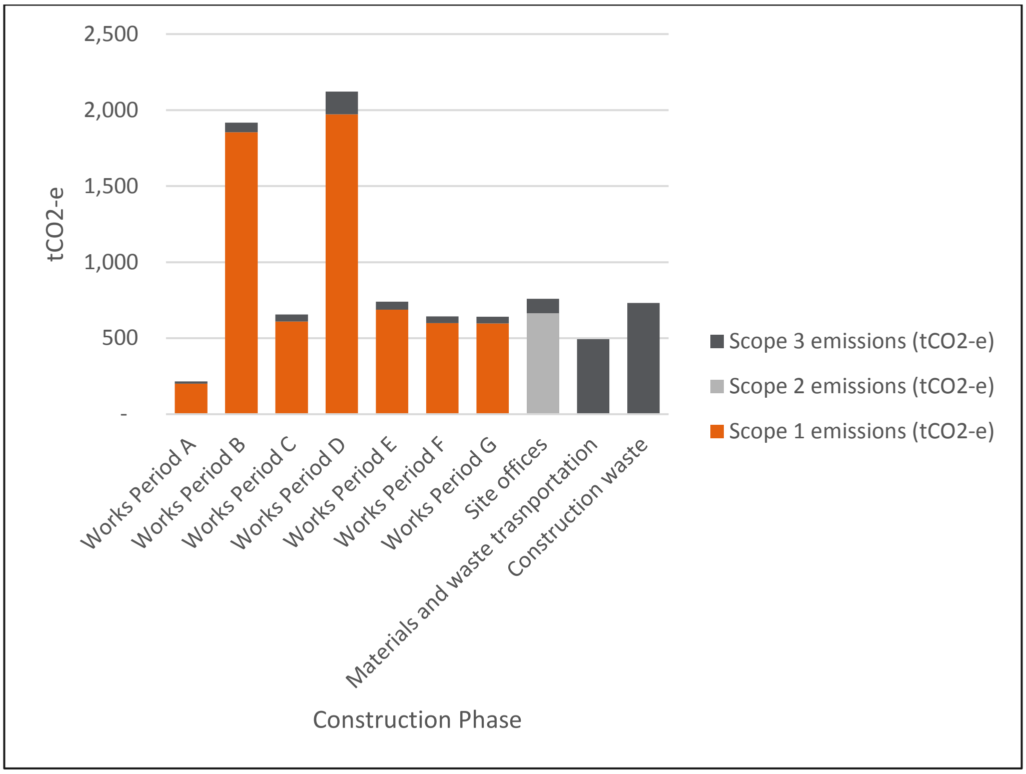

Figure 4-4 Summary of construction GHG emissions by emissions Scope (tCO_2-e)

5 MATERIALS EMISSIONS

To fully assess the potential environmental impacts of the Proposal throughout its lifecycle, consideration must be given to the materials used and their potential environmental, social and economic impacts. Internationally, life cycle (environmental) assessment (LCA) is acknowledged as the most complete and appropriate way to assess the environmental impacts of material and resource use. LCA considers the processes used to win raw materials, transport them, process them into usable materials and products, construct or assemble them and operate, maintain and refurbish them (ISCA, 2014).

Since 2006, the Australian Life Cycle Assessment Society (ALCAS) has been working with industry to compile Guidelines and a National Database of Life Cycle Inventory data (AusLCI) for every sector of the Australian economy. Further, the building and construction materials and products sector, represented by the Building Products Innovation Council (BPIC) have engaged the AusLCI to compile Life Cycle Inventory (LCI) data for all the major structural materials and products used in buildings and infrastructure. The method used to facilitate this outcome is based on a whole of life or full LCA methodology, as guided by international standards, and enables access to LCI data for the purposes of conducting LCAs.

Embodied energy in the construction materials used for the Proposal have been modelled in accordance with the *BPIC/ICIP Project's Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database*[1]. The assessment has focused on key materials that would be used in the construction process, including those that would represent the greatest volume and proportion of materials.

Embodied emissions are considered to be Scope 3 emissions source as they would occur offsite and are not under the operational control of SIMTA.

5.1 Embodied GHG emissions

A number of key pieces of infrastructure associated with the proposal have been identified as likely to embody the majority of emissions associated with materials used for the Proposal; these are:

- **Hardstand area/Precinct Infrastructure**: Including roads, car parking areas, onsite detention basins, stormwater pipes and culverts, water and sewer pipes, electrical cables, base pavements and bulk earthworks.
- **Warehouses**: Including concrete ground slabs and footings, structural steel, wall sheeting and reinforcing steel.

The materials that would be used for the construction of the above would be confirmed by the contractor prior to construction commencing. However, indicative construction materials have been identified for the purpose of this assessment. Where more than one material could potentially be used during construction, the material that would embody the greatest quantity of GHG emissions have been assessed in order to determine a 'worst case' scenario. Most notably, it has been assumed that where concrete slab would be required either a 40MPa (1:1:5:3) or 30MPa (1:2:4) would be used, roadworks would be paved with Hot Mix Asphalt (400 MJ/t), and steel would be 100 per cent virgin steel.

[1] GHG emissions from end of life of the Proposal have been excluded from the assessment due to large uncertainties in terms of degree of reuse of facilities and infrastructure, as well as degree of reuse, recycling and disposal of construction materials.

Based on the above, the following key material types have been identified for use in construction of the Proposal:

- Concrete:
  - Concrete (40MPa)
  - Concrete (30MPa)
  - Fibre-reinforced concrete
- Steel:
  - Structural steel (100 per cent virgin)
  - Steel sheet (100 per cent virgin)
  - Steel reinforcing mesh (100 per cent virgin)
  - Steel reinforcing bar (100 per cent virgin)
  - Steel girts and purlins (Galvanised steel and 100 per cent virgin)
- Asphalt (Hot Mix Asphalt)
- Polyvinyl chloride (PVC)
- Copper
- Aggregates

The total GHG emissions in construction materials were calculated to be 137,774 tCO_2-e, or approximately 15.5 times the estimated GHG emissions from the construction phase (excluding material impact).The embodied energy within construction materials amounts to the equivalent of less than two years of operation. Embodied energy emissions are presented in Table 5-1.

As evidenced by Table 5-1, concrete represents the greatest source of embodied GHG emissions, generating 87,913 tCO_2-e (refer Figure 5-1). As a result of the high volume of concrete and steel that could be used during the construction of the warehouses, this component of the Proposal would contribute 79 per cent of the embodied GHG emissions as shown in Figure 5-2.

Table 5-1 Embodied GHG emissions (tCO_2-e) from key construction materials)

Proposal element		Concrete 40MPa (1:1.5:3)	Concrete 30MPa (1:2:4)	Fibre-reinforced concrete	Polyvinyl Chloride (PVC)	Copper	Aggregates	Structural Steel	Steel Sheet	Steel reinforcing	Galvanised steel
Hardstand area / precinct infrastrtuce	Volume (m^3)	20,925	884	-	402	30	1,010,115	-	-	819	-
	Emissions (tCO_2-e)	9,144	258	-	872	1,346	5,127	-	-	10,124	-
Warehouse	Volume (m^3)	38,301	-	57,096	-	-	-	489	168	102	744
	Emissions (tCO_2-e)	16,738	-	61,773	-	-	-	4,057	2,904	1,400	21,892
TOTAL	**Volume (m^3)**	**59,226**	**884**	**57,096**	**402**	**30**	**1,010,115**	**489**	**168**	**921**	**744**
	Emissions (tCO_2-e)	**25,882**	**258**	**61,773**	**872**	**1,346**	**5,127**	**4,057**	**2,904**	**11,523**	**21,892**

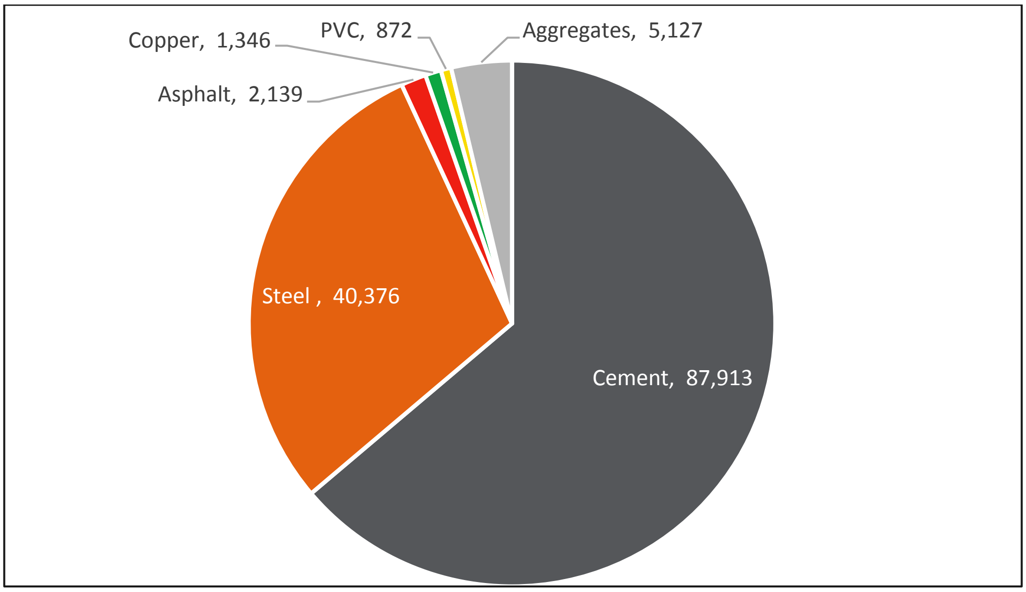

Figure 5-1 Embodied GHG emissions (tCO2-e) from key construction materials

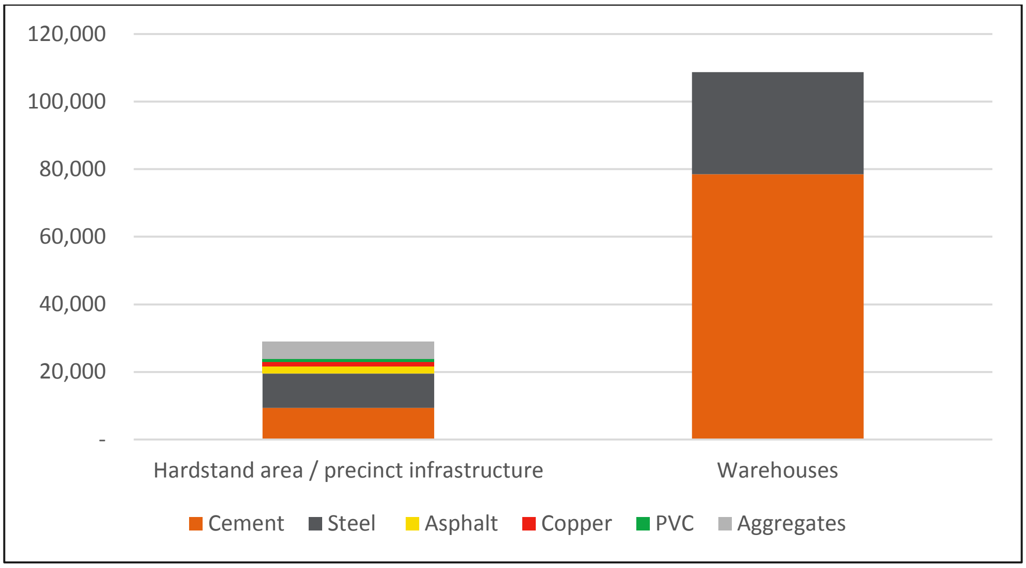

Figure 5-2 Embodied GHG emissions (tCO2-e) from key Proposal components

5.2 Concrete substitutions

As shown above, concrete contributes the majority of embodied GHG emissions associated with the construction of the Proposal. Under a worst case scenario concrete contributes 87,913 tCO_2-e from embodied energy, amounting to 64 per cent of the total embodied emissions from the key construction materials associated with the Proposal. This, however has been determined for a 40Mpa concrete with a 1:1.5:3 mix of cement, sand and aggregates or 30MPa (1:2:4). It has been assumed that a 'business as usual' cement mix would utilise 100 per cent Portland cement. Given the large volume of concrete required, and the high contribution to embodied GHG emissions, cementitious substitutions therefore may present an opportunity to significantly reduce embodied emissions.

A number of alternate materials may be used as substitutes to conventional concrete, such as asphalt, pavers or post-tension concrete. The use of any of these materials would reduce the embodied emissions associated with the pavement construction of the Proposal site. As concrete represents the worst case scenario further ways to potentially reduce embodied energy associated with the use of concrete are discussed below.

A significant opportunity to reduce GHG emissions from concrete consumption is to substitute Portland cement with materials such as local fly ash and blast furnace slag. In Portland cement manufacturing, almost one tonne of CO_2-e is released for every tonne of cement produced. The cement industry has reduced CO_2-e emissions significantly since the early 1980's and continues to develop methods that minimise the release of greenhouse gases, largely through the utilisation of supplementary cementitious materials such as fly ash, silica fume, ground granulated blast furnace slag and development of alternative binders to Portland cement (SCA, 2013).

Two cementitious substitution materials, slag and flyash have been considered as appropriate for possible use in concrete for the Proposal, should this material be used. Slag is produced in a blast furnace during the reduction of iron ore to iron. By processing blast furnace slag into slag cement or slag aggregate, the material is diverted from landfills. Consequently utilisation of slag cement in concrete not only lessens the burden on landfill, it also conserves virgin manufactured produced. In addition, slag cement requires nearly 90 per cent less energy to produce than an equivalent amount of Portland cement, and consequently reduces the embodied emissions (SCA, 2013).

Fly ash is a by-product of coal combustion in power stations. The use of fly ash in concrete can lead to many improvements in both environmental and overall concrete performance.

The level of substitution of fly ash and/or slag is largely governed by the concrete specifications including compressive strength required for a particular purpose. Two indicative concrete mix types have been identified as being suitable for substitutions with a 40Mpa mix (1:1.5:3) for the Proposal, as follows:

- Mix One: 320 kg/m^3 of General Purpose Cement (Portland) and 60 kg/m^3 of slag
- Mix Two: 255 kg/m3 of General Purpose Cement, 90 kg/m^3 of fly ash and 135 kg/m^3 of slag.

Based on the possible volume of concrete required as part of the Proposal the use of Mix One would generate approximately 21,674 tCO_2-e and Mix Two would generate 12,834 tCO_2-e, resulting in a 16 per cent and 50 per cent reduction in the concrete embodied emissions compared to the BAU scenario respectively, where concrete is used for the ground slabs across the entirety of the Proposal site. Figure 5-3 shows the total embodied GHG emissions for the volume of possible 40Mpa concrete required for the Proposal using alternate concrete mixes. It is noted that despite making up the majority of the embodied GHG emissions within concrete, cement comprises only a portion of the total materials used to make concrete. Little variance has been demonstrated within the other inputs into concrete (e.g. aggregate, sand and water) between the different concrete mixes.

In a worst case scenario, where concrete is selected for ground slab, the application of measures such as fly ash and/or slag mixes would result in a reduction of embodied GHG emissions. The final pavement type, when selected, would consider alternate mixes/types which may reduce the embodied energy of that application, where appropriate.

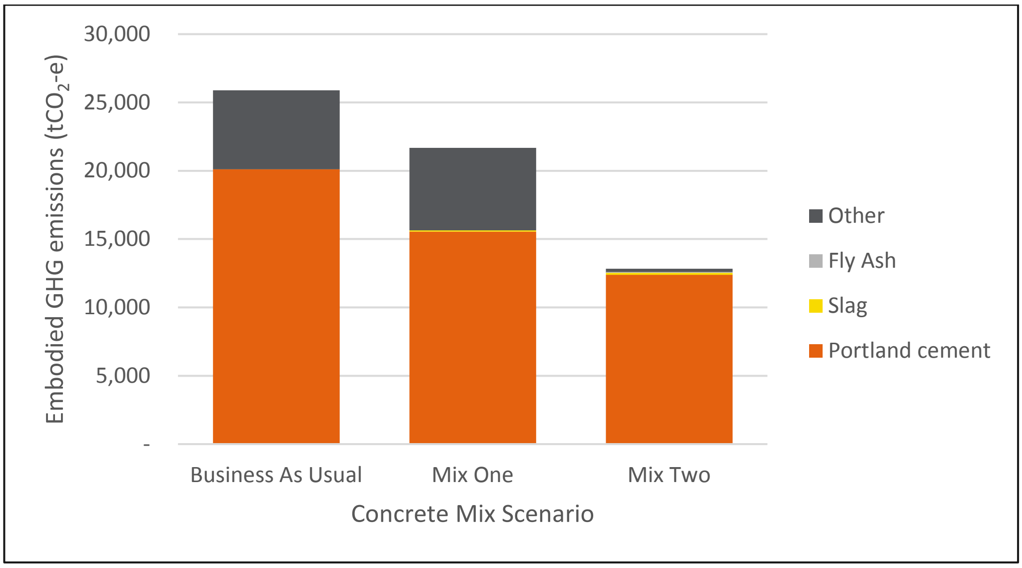

Figure 5-3 Embodied GHG emissions associated with different concrete mix types

5.3 Steel substitutions

Under a worst case scenario, where all steel used on site is 100 per cent virgin steel, the volume of steel required to construct the warehouses and the steel mesh within concrete would generate approximately 40,376 tCO_2-e**,** or 29 per cent of all the total embodied energy within construction materials (refer Figure 5-1). Consequently a review has been undertaken to identify potential opportunities to minimise GHG emissions embodied within steel.

Steel is an alloy of iron and carbon and much energy is required to produce heat during the production process. Steel is the most recycled material on the planet, is 100 per cent recyclable, and can be reused infinitely. Recycling steel uses 75 per cent less energy than making steel from raw materials.

Although two out of every three tons of new steel are produced from old steel, it is still necessary to continue to use some quantities of virgin materials. This is true because many steel products remain in service as durable goods for decades at a time and demand for steel around the world continues to grow. Supply of recycled steel is therefore likely to be a potentially limiting factor to the use of large volumes for the construction of the Proposal.

Two scenarios have been considered for the substitution of steel with recycled content. Firstly, assessing a most likely scenario whereby the steel used for the construction of the Proposal contains a portion of recycled steel content. The majority of steel produced in Australia already contains recycled steel, typically comprising 20 per cent (World Steel Association, 2016). Scenario One therefore considers the use of 20 per cent steel within all steel required for the construction of the Proposal.

The second scenario assesses the potential reduction in embodied energy from using complete recycled steel content for all wall and roof sheeting within the warehouses. It is noted that the structural steel beams, girts and purlins cannot be replaced with 100 per cent recycled steel content without potentially impacting the structural integrity of the warehouse structure. Therefore Scenario Two retains the 20 per cent recycled steel content assumption for all structural steel, and steel mesh.

The implementation of one of these two scenarios would be determined during construction and would be dependent on the availability of recycled steel and its structural properties. Figure 5-4 shows the embodied energy (tCO_2-e) from the replacement of virgin steel with recycled steel content, demonstrating that approximately 4,146 tCO_2-e would be saved from the use of 20 per cent recycled steel (most likely scenario) and up to 5,345 tCO_2-e**,** could be saved from the use of 100 per cent recycled steel in steel sheeting (subject to supply and structural feasibility).

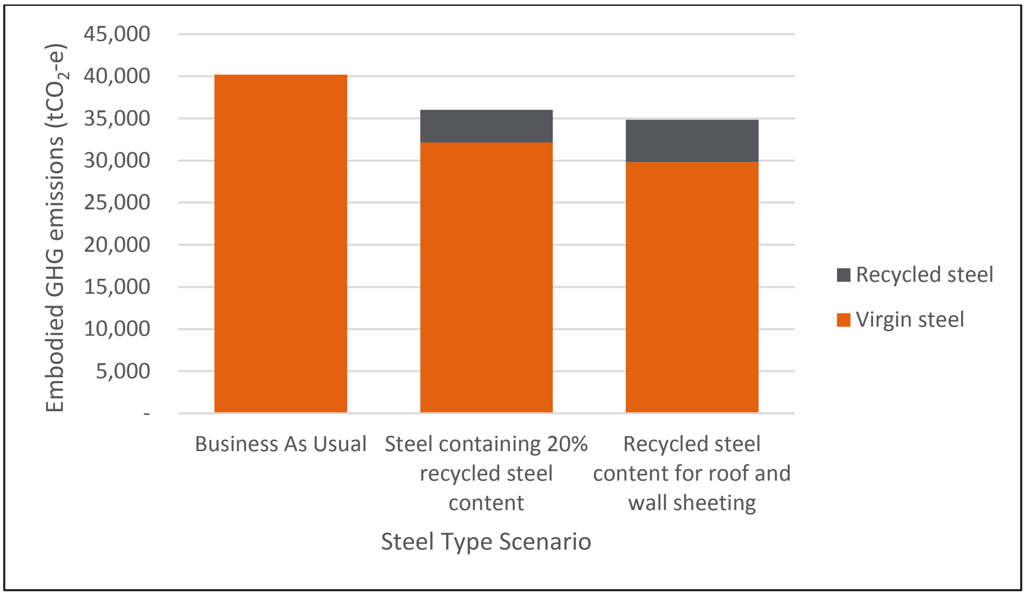

Figure 5-4 Embodied GHG emissions (tCO2-e) with different recycled steel content

6 OPERATION BASED GHG EMISSIONS

This section outlines the GHG emissions associated with the operation of the Proposal. The Proposal would involve the operation of the warehousing and distribution facilities, including a freight village and administration facilities. The warehousing would compromise approximately 300,000 m^2 GFA, additional ancillary offices, and an 8,000 m^2 GFA freight village. The Proposal is expected to operate 24 hours a day, seven days per week.

The key operational sources of GHG emissions would be from:

- Transportation of freight: Including between the MPE Stage 1 IMT and the warehouses, and to/from the warehouses externally
- Operation of the warehouses and freight village.

6.1 Transportation

6.1.1 Internal vehicle movements

The Proposal would interact with the MPE Stage 1 Project (SSD_6766) via the transfer of containers between the MPE Stage 1 IMT and the Proposal's warehousing and distribution facilities. The vehicle movements associated with the transfer of containers between the MPE Stage 1 IMT and the Proposal would be within the Proposal site only, and would not impact on the surrounding road network.

Movement of freight between the IMT and warehouses within the Proposal site would be undertaken 24 hours per day, seven days a week.

Internal vehicle movements would be within the operational control of SIMTA and are therefore a source of Scope 1 GHG emissions. Movements would be undertaken by a mix of heavy vehicles including semi-trailers and b-doubles. Approximately 582 trips (return) would be completed per day, resulting in the generation of 48 tCO_2-e annually.

6.1.2 External vehicle movements

Access to and from the Proposal site would be via the Proposal's access point on Moorebank Avenue, to the north of the MPE Stage 1 Project. Site access at this location would allow for vehicular access to warehouse and distribution facilities to enable the direct delivery and dispatch of goods to the warehouses.

The transportation of freight to/from the Proposal site would result in GHG emissions arising from fuel combustion. Transportation of freight externally to/from the Proposal site would represent a Scope 3 emissions source as it would occur outside the Proposal site operational boundary and would be outside of SIMTA's control. Transportation would be carried out by a mix of semi-trailers, rigids and b-doubles. Approximately 564 trips (return) would be complete per day, resulting in generation of 11,640 tCO2-e of Scope 3 emissions annually. To assess a 'worst-case' scenario it has been assumed that all trucks would travel to the furthest extremity of the freight catchment area, however in practice this is unlikely.

Table 6-1 Transportation GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Internal vehicle movements	44	-	3
External vehicle movements	-	-	11,640
TOTAL	**44**	**-**	**11,644**

6.2 Warehouse and freight village operation

The Proposal would provide up to 300,000 m^2 of warehousing across the Proposal site with ancillary offices attached. The Proposal would include eight warehouses, which would be up to 21 metres in height and of varying size and design. The Proposal would also include some internal fitout of the warehouses, namely the installation of racking and associated services. The Proposal would seek approval for the construction of these warehouses and also the operation of these warehouses by future tenants.

A freight village including amenities would be provided on the MPE site as part of the Proposal. The ancillary freight village would be located in the north-west of the Proposal site, directly north of Warehouse 1 and east of Moorebank Avenue. The freight village would include five buildings which would provide for a mixture of retail, commercial and light industrial land uses, with a combined GFA of approximately 8,000 m^2.

The warehouses would generally be operational for 24 hours a day, seven day per week.

6.2.1 Electricity consumption

The Proposal would have an on-site electricity demand associated with the warehousing and freight village operations. Electricity demand would comprise lighting, heating, ventilation, air conditioning and refrigeration. Electricity use represents a source of Scope 2 emissions. It is noted that once tenants commence occupation of the warehousing, electricity consumption would represent a Scope 3 emissions source for SIMTA or the warehouse tenant as appropriately delegated under the lease arrangements. However, for the purpose of this assessment and to fully quantify the GHG emissions generated from the operation of the warehouses, they have been assessed as a Scope 2 emissions source.

It has been assumed that warehousing would have an electricity demand 24 hours per day. Much of the electricity demand for warehousing (such as cooling) would likely be required both during all warehouse operational hours. However, lighting demand may be reduced outside of the operational hours of the warehousing. Consequently this assessment is likely to have overstated the electricity consumption associated with the operation of warehouse and freight villages. Some warehouses are likely to be fitted with automated sortation systems, and would consequently have a higher power demand.

Table 6-2 shows the total GHG emissions anticipated to be generated annually by the operation of the warehousing and freight village, indicating that approximately 83,199 tCO_2-e would be generated per annum. This would comprise 72,799 tCO_2-e of Scope 2 emissions from purchased electricity, and 10,400 tCO_2-e from transmission and distribution loss (Scope 3 emissions).

Table 6-2 Electricity consumption GHG emissions (tCO_2-e)

Emissions source		Kwh/day	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Warehouses	Warehouses (with automatic sortation systems)	146,376	44,879	6,411
	Warehouses (no automatic sortation system)	47,709	14,628	2,090
	Warehouse offices	14,121	4,330	619
	Chilled confectionary area	14,400	4,415	631
Freight village	Building A	1,231	377	54
	Building B1	2,614	801	115
	Building B2	585	179	26
	Building C	8,317	2,550	364
	Building D	2,085	639	91
TOTAL		**237,439**	**72,799**	**10,400**

6.2.2 Refrigerant leakage

In addition to electricity consumption, the chilled confectionary area proposed within one of the warehouses would require refrigeration. The operation of the warehouse and freight village would therefore result in the leakage of the refrigerant HFC-134a (CH_2FCF_3). HFC-134a has a global warming potential of 1,430. The leakage of refrigerant represents a source of Scope 1 emissions. Approximately 167 tCO_2-e would be generated as a result of leaked refrigerants used within the operation of the Proposal.

6.2.3 Fuel combustion

The use of machinery onsite would generate GHG emissions as a result of fuel combustion. The predominant machinery type that would be used within the warehouses and freight village would be forklifts and reach stackers used within the warehouses. The forklift fleet that would be used in the warehouse has been presumed to be comprised of Liquefied Petroleum Gas (LPG) forklifts. LPG forklifts have considerable environmental benefits when compared to diesel, reducing GHG emissions, noise and fumes. The assessment of LPG combustion in forklifts has assumed that the forklift fleet would be constantly operating the full 24 hours per day. This is therefore likely overstating the GHG emissions that would be produced, representing a worst case scenario.

The Scope 1 emissions that would be generated from LPG fuel combustion due to the use of machinery would be approximately 15,990 tCO_2-e per annum, as shown in Table 6-4. An additional 1,313 tCO_2-e per annum of Scope 3 emissions would be produced as a result of the production of the fuel required for operational machinery.

6.2.4 Waste decomposition

The warehouses and freight village would produce a range of waste types during operation, including food waste from operational staff and the freight village, paper and cardboard, and commercial and industrial waste. The warehouses would largely produce inert commercial and industrial waste, whereas the freight village would produce a mixed putrescible waste. Based on the nature of the waste produced, and anticipated volume, the operation of the Proposal would generate approximately 6,275 tCO_2-e as a result of waste generated from the Proposal annually. Approximately 102 tCO_2-e would be generated from the transportation of waste to its disposal destination.

Table 6-3 Waste decomposition GHG emissions (tCO_2-e)

Waste source		Waste produced (tpa)	Scope 3 emissions (tCO_2-e)
Warehouses	Warehouses	29,419	2,692
	Warehouses offices	5,590	2,582
Freight village	Building A	3,411	205
	Building B1	9,448	567
	Building B2	704	42
	Building C	513	148
	Building D	129	37
Waste transportation			102
TOTAL			**6,377**

6.3 Summary of operations based GHG emissions

The operation of the Proposal would generate approximately 118,733 tCO_2-e per annum, including 16,202 tCO_2-e of Scope 1 emissions, 72,799 tCO_2-e of Scope 2 emissions and 29,733 tCO_2-e of Scope 3 emissions. Table 6-4 shows a summary of the GHG emissions that would be generated as a result of the operation of the Proposal, indicating that electricity demand within the warehouses and freight village would be the single largest contributor to GHG emissions, accounting for 70 per cent of total operational emissions.

The Proposal would generate 0.02 per cent of Australia's total GHG emissions, and 0.1 per cent of NSW total emissions. This would equate to 0.13 per cent of the transport sector across Australia.

Table 6-4 GHG emissions generated from the operation of the warehousing and freight village (tCO_2-e per annum)

	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Transportation (internal)	44	-	3
Transportation external)	-	-	11,640
Warehouse electricity demand	-	68,251	9,750
Freight village electricity demand	-	4,548	650

	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Refrigerant leakage	167	-	-
Machinery use	15,990	-	1,313
Waste decomposition and transportation	-	-	6,275
TOTAL	**16,202**	**72,799**	**29,733**

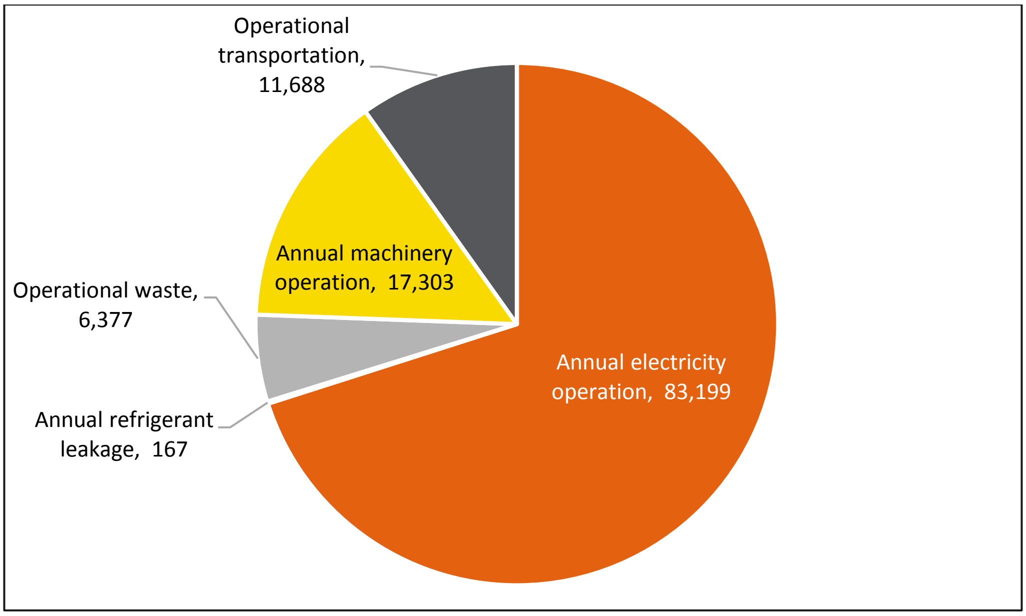

Figure 6-1 Annual operational GHG emissions (tCO_2-e/year)

Corporate emissions over 50,000 tCO_2-e/year would trigger reporting requirements under the *National Greenhouse and Energy Reporting (NGER) Act 2007.* The Proposal would generate over 50,000 tCO_2-e/year, however obligations under the NGER Act are based on which members have operational control over facilities, that meet a facility threshold or that contribute to meeting a corporate level threshed. Depending on the model applied to tenant occupation of warehouses, liability under the NGER Act may be apportioned between multiple controlling members.

The potential liabilities under the NGER Act would be identified by the proponent to determine any requirements for monitoring or reporting. If required, monitoring and reporting of GHG emissions would be carried out for the operation of the Proposal on an annual operational basis for incorporation into NGER reporting for the operationally controlling corporation.

7 SUMMARY OF GHG EMISSIONS FROM THE PROPOSAL

This section summarises the total GHG emissions that would be generated by the Proposal. The construction phase of the Proposal would generate approximately 8,884 tCO_2-e over a 24 month period, including 6,519 tCO_2-e of Scope 1 emissions. Embodied GHG emissions from the key construction materials would generate approximately 137,744 tCO_2-e Scope 3 emissions under a worst case scenario, or more than 15.5 times the emissions generated during the construction phase. Embodied GHG emissions, however, represent a full life cycle emission generation across the entire operational life of the Proposal. Operational GHG emissions would generate approximately 118,733 tCO_2-e, including 16,202 tCO_2-e Scope 1 GHG emissions, 72,799 tCO_2-e Scope 2 emissions and 29,733 tCO_2-e Scope 3 emissions (refer Table 7-1)

Table 7-1 Total GHG emissions generated by the Proposal

Proposal stage	Proposal component	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Construction (total – 24 months)	Works Period A	201	-	15
	Works Period B	1,853	-	66
	Works Period C	609	-	46
	Works Period D	1,973	-	148
	Works Period E	689	-	52
	Works Period F	598	-	45
	Works Period G	597	-	45
	Site offices	-	664	95
	Waste decomposition	-	-	732
	Materials and waste transportation			457
Total Construction GHG emissions		**6,519**	**664**	**1,700**
Total Embodied GHG emissions (lifetime)		**-**	**-**	**137,774**
Operations (total – annual)	Transportation	44	-	11,644
	Electricity consumption	-	72,799	10,400
	Refrigerant leakage	167	-	-

Proposal stage	Proposal component	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
	Onsite machinery	15,990	-	1,313
	Operational waste	-	-	6,377
Total Annual Operational GHG emissions		**16,202**	**72,799**	**29,733**

To provide a comparison of GHG emissions produced as a result of construction, materials and operation, total GHG emissions have been accumulated over a 20 year period[2]. Figure 7-1 shows the comparison of cumulative tCO_2-e generated as a result of construction, materials and operation. As evidenced by Figure 7-1 the construction phase would contribute a negligible amount when compared to the operational GHG emissions over the 20 year period. Similarly, operational GHG emissions would accumulate to over 17 times the total embodied GHG emissions over the period. This assessment is likely to overstate the materials cumulative impact, as it has apportioned the total embodied GHG emissions for the Proposal over the 20 year period, however it is likely that the materials would be in use for a longer period than this. It is also noted that, as discussed in Section 5, use of alternatives to steel (using recycled steel content) and concrete (such as asphalt, pavers of post-tension slabs), or alternate concrete mixes (such as slag and/or fly ash) may result in significantly lower embodied GHG emissions within materials.

[2] A 20 year period has been selected to conservatively apportion embodied energy across the operational life of the Proposal. That is, if total construction emissions, annual operation emissions and embodied emissions were directly compared, embodied energy would appear significantly higher than either emissions associated with construction or operation of the Proposal. This would be inconsistent with the whole of life assessment undertaken for materials. Instead, apportioning the embodied emissions over a 20 year period aims to demonstrate conservative whole of life embodied energy compared with operational and construction emissions over a single period. It is likely that the comparative 20 year period would overstate the materials cumulative impact, as materials would last for a longer period than this, however it provides indicative context for identifying GHG contributions as a result of the Proposal.

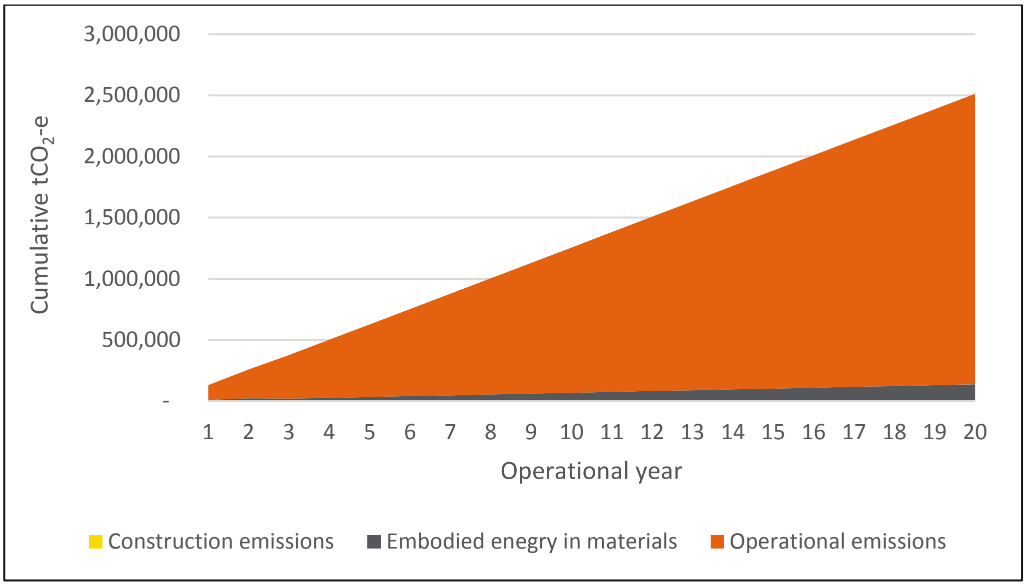

Figure 7-1 Cumulative total GHG emissions tCO_2-e)

8 GHG MITIGATION STRATEGIES

The carbon management principles (shown in Figure 8-1) provide a robust framework for the management and reduction of GHG emissions.

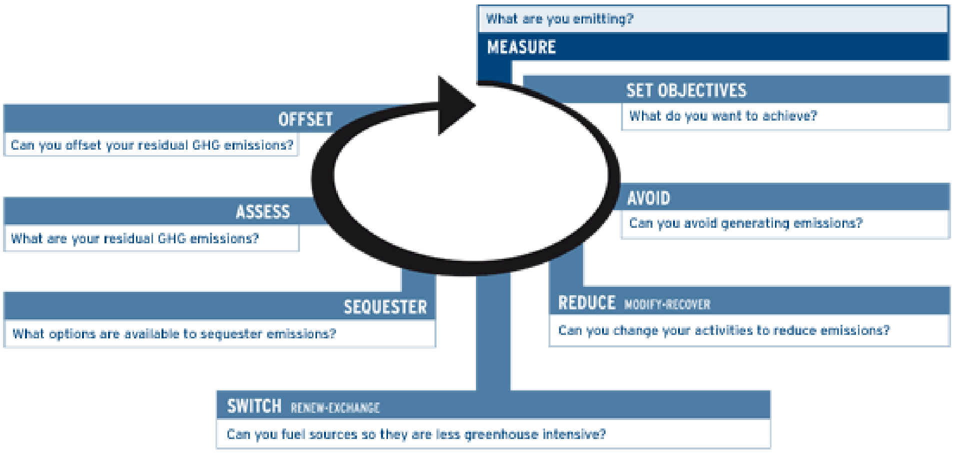

Figure 8-1 Carbon management principles for GHG emissions reduction (EPA Victorian, 2012)

The earlier sections in this assessment represent the GHG emissions measurement and setting objectives components of the carbon management principles. GHG emissions reduction actions should ideally be prioritised according to the carbon management principles as illustrated below in Table 8-1.

Table 8-1 Carbon management principles and a brief description of each

Management principle	Description
Avoid	Actions which avoid emissions, in the first instance, should be considered as a priority
Reduce	Actions which result in a reduction of emissions should be considered next
Switch	Actions which switch energy sources to reduce emissions should be the next considered
Sequester	Actions which sequester GHG emissions do not reduce emissions but store them
Offset	Offsetting of emissions through the purchase of offsets. This should be considered as a last resort.

8.1 GHG Management Plan

As per the conditions of the Concept Plan Approval, a Greenhouse Gas Management Plan will be prepared for each of the major stages of the SIMTA Project. Section 1-7 of this report provides the context and updated GHG assessment for the GHG Management Plan for Stage 2 (the Proposal). The mitigation measures and management strategies identified for the Proposal are provided in Section 8.2 below. In addition a number of additional potential abatement opportunities have been identified, including the marginal cost of abatement (refer Section 9). Furthermore climate change risks and adaptive measures are assessed in Section 10.6. A summary of the management strategy for GHGs and climate change risks is provided in Appendix A.

It is recommended that the mitigation measures, management strategies and abatement opportunities presented in this report are reviewed and updated as appropriate for incorporation into the Construction Environmental Management Plan (CEMP) and Operational Environmental Management Plan (OEMP), as required.

8.2 Mitigation Measures

8.2.1 Construction

The mitigation measures, management strategies and abatement opportunities presented in this report will be reviewed and considered where appropriate for incorporation into the CEMP. The following actions will be implemented, where reasonable and feasible, for mitigation of GHG emissions during construction:

- Where possible locally sourced materials will be used to reduce GHG emissions associated with transport
- Construction and demolition waste will be recovered and recycled where possible, and vegetation waste will be composted
- Construction works will be planned to minimise double handling of materials
- Demolition materials will be reused where possible to reduce GHG emissions associated with embodied energy
- Construction/transport plans will be incorporated within the CEMP to minimise the use of fuel during construction
- Fuel efficiency of the construction plant/equipment will be assessed prior to selection, and where practical, equipment with the highest fuel efficiency and which uses lower GHG intensive fuel (e.g. biodiesel) will be used
- On-site vehicles will be fitted with exhaust controls in accordance with the *Protection of the Environment Operations (Clean Air) Regulation 2010* as required
- Regular maintenance of equipment will be undertaken to maintain good optimum operations and fuel efficiency
- Where practicable, trucks removing waste from the site or bringing materials to the site will be filled to the maximum amount allowable, depending on the truck size and load weight, to reduce the number of traffic movements required
- Consideration will be given to material substitution where reasonable and feasible to reduce embodied energy of construction materials.

8.2.2 Operation

The mitigation measures, management strategies and abatement opportunities presented in this report will be reviewed and considered where appropriate for incorporation into the Operational Environmental Management Plan (OEMP). The following actions will be implemented, where reasonable and feasible, for mitigation of GHG emissions during the operation of the Proposal:

- Fuel efficiency of the operation plant/equipment will be assessed prior to selection, and where practical, equipment with the highest fuel efficiency and which uses lower GHG intensive fuel (e.g. biodiesel) will be used
- Energy-efficient guidelines for operational work will be considered and implemented where appropriate and regular maintenance of equipment will be undertaken to maintain fuel efficiency
- Energy efficiency design aspects will be incorporated wherever practicable to reduce energy demand.

- Consideration will be given to undertake further investigation and implementation of cost negative abatement opportunities.

9 MARGINAL ABATEMENT COST ANALYSIS

In addition to the mitigation measures outlined in Section 8 above, a Marginal Abatement Cost (MAC) analysis has been undertaken to determine the feasibility of implementing additional mitigation and abatement opportunities. MAC curves are one of the principle tools used to measure the relative economic impact of GHG emissions abatement mechanisms. Marginal abatement means the cost to reduce or offset one unit of pollution; in this case one tonne of GHG emissions. MAC curves generally show the cost, in $ per tonne CO_2-e, associated with the GHG emissions reductions achievable by different energy efficiency projects at a given point in time (CitySwitch, 2015).

9.1 Methodology

To produce the MAC curve, the abatement costs of technical reduction options have been calculated based on annual total costs and benefits. Construction and embodied energy have not been considered within the cost abatement analysis as operational GHG emissions would substantially contribute the majority of the GHG emissions over the Proposal life (refer Figure 7-1).

The methodology used to compile the MAC curve has been through the following key steps (described in detail below):

- Establish a BAU baseline and abatement target
- Identify and quantify potential emissions-reduction opportunities and their associated costs
- Combine costs and benefits to form the operational GHG abatement cost curve for the Proposal.

All cost and abatement potential estimates have been determined through a desktop analysis based on available market data and technical publications, to provide indicative MAC curves for the Proposal.

9.1.1 Determination of baseline

On 10 November 2016 Australia ratified the United Nations Framework Convention on Climate Change (UNFCCC) at the 21st Conference of the Parties (COP21) (the Paris Agreement), which commits signatory countries to work towards limiting global warming to two degrees and sets five-yearly targets for cutting emissions. Under the Paris Agreement Australia has committed to reduce emissions by 26-28 per cent below 2005 levels by 2030, which builds on the previous target of reducing emissions by five per cent by 2020 below 2000 levels.

The Australian Government has also committed to a long-term target to cut pollution by 80 per cent below 2000 levels by 2050.

The MAC curve prepared for the Proposal has been determined using the operational GHG inventory (Section 6) as the baseline, or BAU scenario. To align to the current federal emissions reduction targets, a 27 per cent target has been set for the MAC curve for the Proposal. Annually, the operation of the Proposal would produce approximately 118,733 tCO_2-e per annum. Consequently the MAC assessment aims to identify measures to reduce annual operational emissions by 32,058 tCO_2-e per annum in order to achieve a 27 per cent reduction.

9.2 Abatement technologies

A broad range of abatement technologies exist that could be employed as part of the Proposal. The MAC curve prepared as part of this report has not endeavoured to be exhaustive or prescriptive, and does not claim to cover every possible emission abatement measure worthy of consideration. Instead, it aims to contain a reasonable sample of abatement opportunities, as an indicative exercise in determining an abatement cost curve. Primarily the technologies assessed are those designed to abate emissions produced by the largest operational generation sources, and are those likely to have the largest abatement potential. For example, lighting systems within buildings have not been included as it is anticipated that, being a new development, a high level of energy efficiency will already be strived towards, and there will be little scope for significant efficiency improvements.

The assessment has also been limited to available technology today, and has not made any attempt to consider future technologies that may emerge. Each technology has been assessed in isolation, so that the cost and abatement potential reported should be considered on an individual merit basis. If abatement measures are employed in sequence this may have an impact on the total costs and benefits realised. For example the use of electric forklifts instead of LPG forklifts (described below) would increase total electricity demand, raising the cost associated with purchasing 20 per cent GreenPower.

The assessment has been prepared prioritising the *Carbon Management Principles for Emissions Reduction* (refer Section 8), such that offsetting has been considered as a last resort. The analysis indicated that the cost to abate through the purchase of offsets may present a more cost effective measure than implementation of some alternate technologies. However, each technology's use has been prioritised based on its hierarchical order under the *Carbon Management Principles for Emissions Reduction*, and offsetting has been modelled only to the extent required to achieve any gaps in the target reduction.

A brief description of the technologies analysed, and the methodology employed to determine the costs and benefits of each technology, is provided below.

9.2.1 Solar panels

Research and development associated with solar panels has resulted in rapid improvement in their efficiency and a subsequent reduction in GHG emissions payback period, such that the average GHG emissions payback period for photovoltaic panels is 0.5 to 3 years (Solaria, 2015). No consideration of the lifecycle assessment has therefore been incorporated due to the relatively small volume of embodied GHG emissions, and anticipating continued improvement, in solar panel efficiency.

A series of 100 kW solar panel systems capable of generating up to 500 kwh per day (in summer) have been modelled for potential installation on the warehouse roof space. Warehouses are typically a lightweight building structure, with limited potential to accommodate the weight of traditional photovoltaic cells. It is noted that additional structural could be provided as required to ensure adequate support for the placement of photovoltaic cells. However for the purpose of the assessment only 10 per cent of the warehouse roof space has been assumed as suitable for installation of solar panels. Panels would be strategically aligned with major structural elements to ensure their weight can be adequately supported on the warehouse structures. Emerging photovoltaic technologies, such as thin-film photovoltaics, are rapidly improving in their design and may be more suitable for installation on the warehouse roofs, however have not been considered further for the purpose of this assessment.

Costs have been determined based on the market value of 100 kW solar panel systems. No allowance has been made for the inclusion of rebates provided by the Government to offset these costs, such that the cost of abatement may be higher than what can potentially be achieved. A useful life for the system of 25 years has been assumed for the purpose of the assessment. The installation cost, and capital expenditure on the systems themselves, have been apportioned over the useful life of the systems to generate an average annual figure (while in reality, these expenses would be incurred in the year of installation, this allows for a comparison of average annual costs compared with operational savings. No discount factor or inflation rates have been applied). A nominal maintenance fee of 10 per cent per annum has also been applied.

The installation of solar panels would help to achieve SIMTA's commitment (as per the statement of commitments within the Concept plan Approval) to implementing on-site renewable energy generation where applicable.

Although the use of solar panels would result in a switch of energy sources it would be considered a management action to 'reduce' GHG emissions under the *Carbon Management Principles* as it would directly result in fewer emissions being produced. The use of this technology is therefore considered to be second on the *Carbon Management Principles* hierarchy.

9.2.2 Electric forklifts

Typically warehouse forklifts can be diesel, LPG or electric. Each forklift type has a range of advantages and disadvantages. The BAU scenario has assumed that the entire warehouse fleet would comprise LPG forklifts (assumed to be 5t forklifts). LPG forklifts typically have the cheapest initial upfront costs, however have the highest maintenance and fuel costs (compared to diesel and electric). LPG forklifts have considerable environmental benefits when compared to diesel, reducing GHG emissions, noise and fumes. Consequently the BAU scenario already has GHG emissions savings when compared to the use of diesel forklifts.

Electric forklifts typically have a higher initial capital expenditure requirement. This reflects the cost associated with the forklift itself as well as the battery and charger. Further, given that the Proposal allows for 24 hour operations, additional upfront cost would be required to purchase either a second battery for each forklift, or to include rapid charge technology. Current rapid charge technology allows one minute of charge to power a 5t forklift for 45 minutes (*pers comms. J.Ogata, Adaptalift Hyster, 14 Nov 2016*). Batteries could therefore be sporadically charged during down periods and staff change over times and still allow for almost continual 24 hour use. With the inclusion of rapid charge battery technology the upfront capital cost per forklift would be approximately 40% higher than that of an LPG forklift (*pers comms. J.Ogata, Adaptalift Hyster, 14 Nov 2016*).

Given the high use requirement for the forklifts to support 24 hour operations, neither a LPG nor electric forklift would be expected to have a useful operational life beyond five years. The upfront capital expenses for either type of forklift have therefore been apportioned over a five year period to identify an annual average cost. Annual maintenance costs have also been applied, noting that electric forklifts typically have maintenance cost 30% lower than LPG forklifts (Ferret, 2016).

The use of electric forklifts, instead of LPG forklifts, would be considered a 'reduce' GHG management action, and therefore second on the *Carbon Management Principles* hierarchy, and of equal priority to the installation of solar panels.

9.2.3 Alternate waste disposal

The operation of the MPE Project, including the warehouses and freight village, would produce mixed putrescible waste including food and organic waste. Commonly, and as assumed in the BAU scenario, mixed putrescible waste is sent to landfill where it is left to decompose generating methane and other GHGs. Under the BAU scenario it has been assumed that mixed putrescible waste produced during the operation of the

Proposal would be sent to the Lucas Heights Landfill, where approximately 65 per cent of the landfill gas produced would be captured.

Alternatively, mixed putrescible waste can be sent to another waste treatment facility for composting or biological treatment, such as at the Global Renewables' Eastern Creek UR-3R Facility. Alternate treatment of waste substantially reduces its GHG emissions generation potential. Further, if composted, organic waste can be used for crop and landscape plantings growth, contributing to carbon sequestration. An alternate scenario to BAU for the Proposal has been assessed where mixed putrescible waste is instead sent to the UR-3R Facility and is composted. Transportation costs, given the proximity of the Proposal site to both the UR-3R facility and the Lucas Heights Landfill have been considered to be comparable between the two scenarios. Although treatment at an alternate waste facility requires a greater processing cost, the waste is not subject to the landfill levy making composting the cheaper alternative. However the ability to compost waste from the Proposal would be contingent on capacity within existing alternate waste treatment facilities to accept waste from the Proposal.

The disposal of waste via composting instead of to land would be a GHG management principle that would 'reduce' GHG emissions. This would therefore be considered second on the *Carbon Management Principles* hierarchy, and would be considered equal priority to the use of electric forklifts and solar panels as a GHG reduction measure for the Proposal.

9.2.4 Biofuels

Biofuels in Australia are predominantly manufactured from used cooking oil and animal fats (tallow). The *National Greenhouse Gas Account Factors* (NGA Factors) indicate that the use of Biodiesel when compared with regular diesel fuel results in a reduction in GHG emissions of greater than 95 per cent. However, it should be noted that while on a tailpipe emission basis the opportunity for GHG emissions reduction is high, this does not take into consideration the complete life cycle assessment of biofuels, such as consideration of land clearing and the loss of carbon sequestration associated with the use of some biofuels.

CSIRO (2012) estimate that a mid-range abatement fraction for biodiesel, which allows for all upstream GHG emissions from the feedstock and fuel production stages, of 65 per cent abatement potential is a more realistic life cycle estimate than adopting a tailpipe emission reduction. Consequently an emission saving fraction of 0.65 has been adopted for the purpose of this assessment. B20 Biodiesel contains up to 20 per cent volume Biodiesel and is suitable for high speed diesel engines servicing wide load and speed variation and suitable for the transport automotive industry. Biodiesel B20 is suitable for use in modern engines fitted with exhaust after-treatment devices. Biodiesel has a slightly higher fuel efficiency rate than regular diesel, however is typically more expensive than regular diesel. The use of B20 has been assessed for all internal truck movements required for the operation of the Proposal.

The use of biofuels would be considered a 'reduce' GHG management action, and therefore second on the *Carbon Management Principles* hierarchy. This action would therefore have equal priority to the installation of electric forklifts, installation of solar panels and waste from landfill diversion.

9.2.5 Green energy

Currently coal and gas comprise of 73 per cent and 13 per cent of Australia's electricity mix respectively. Purchasing a percentage of GreenPower as part of the electricity mix replaces that proportion with electricity generated from a renewable source, including solar, wind, geothermal, biomass and low-impact hydropower. GreenPower is a national accreditation program for renewable energy, which sources energy that produces no net greenhouse gas emissions and has negligible impact on the environment. The potential purchase of green energy has been considered as a lower priority abatement opportunity as it would be considered a ‘switch’ management action under the *Carbon Management Principles* and therefore third on the priority hierarchy. A nominal allowance of 20 per cent green energy has been assumed for the assessment.

9.2.6 Carbon offsets

The purchase of carbon offsets has been considered as the lowest priority abatement opportunity for the Proposal with regard to the *Carbon Management Principles for Emissions Reduction.* An offset price of $20/t$CO_2$-e has been used for the assessment. The purchase of carbon offsets is at the bottom of the *Carbon Management Principles* hierarchy and would be used as the lowest priority abatement option.

9.3 Greenhouse gas emissions reduction opportunities and costs

For each opportunity analysis, the abatement cost is taken to be the additional cost of implementing the opportunity compared to the cost of the activity that would otherwise occur in the BAU scenario. The volume of each initiative is its potential to reduce GHG emissions.

The various abatement measures were ordered from lowest to highest cost. Aggregating these possible opportunities in the form of a cost curve allows for analysis of the potential for GHG emissions reduction for the proposal. The cost and potential volume of each opportunity is plotted left to right in order from lowest to highest cost.

Figure 9-1 shows the results of the MAC curve for a 27 per cent reduction in GHG emissions for the operation of the Proposal. As shown in Figure 9-1 the use of electric forklifts within the warehouse, diverting waste from landfill and the installation of solar panels represent negative cost opportunities, whereby their implementation leads to costs savings. Based on the technologies modelled, the total potential cost/savings of reducing GHG emissions by 27 per cent would be an average annual savings of approximately $8.7 million per year (if all costs are assumed to be averaged over the life of a technology), with an average saving of $273 per t$CO_2$-e abated. The analysis indicated that the implementation of the cost saving technologies alone (electric forklifts, waste diversion and solar panels) would achieve a saving in GHG emissions of 16,676 tCO_2-e or 14 per cent reduction in total annual operational emissions (118,733 tCO_2-e). Consequently these technologies alone achieve more than half of the targeted 27 per cent reduction. The use of electric forklifts alone would save approximately 9,230 tCO_2-e.

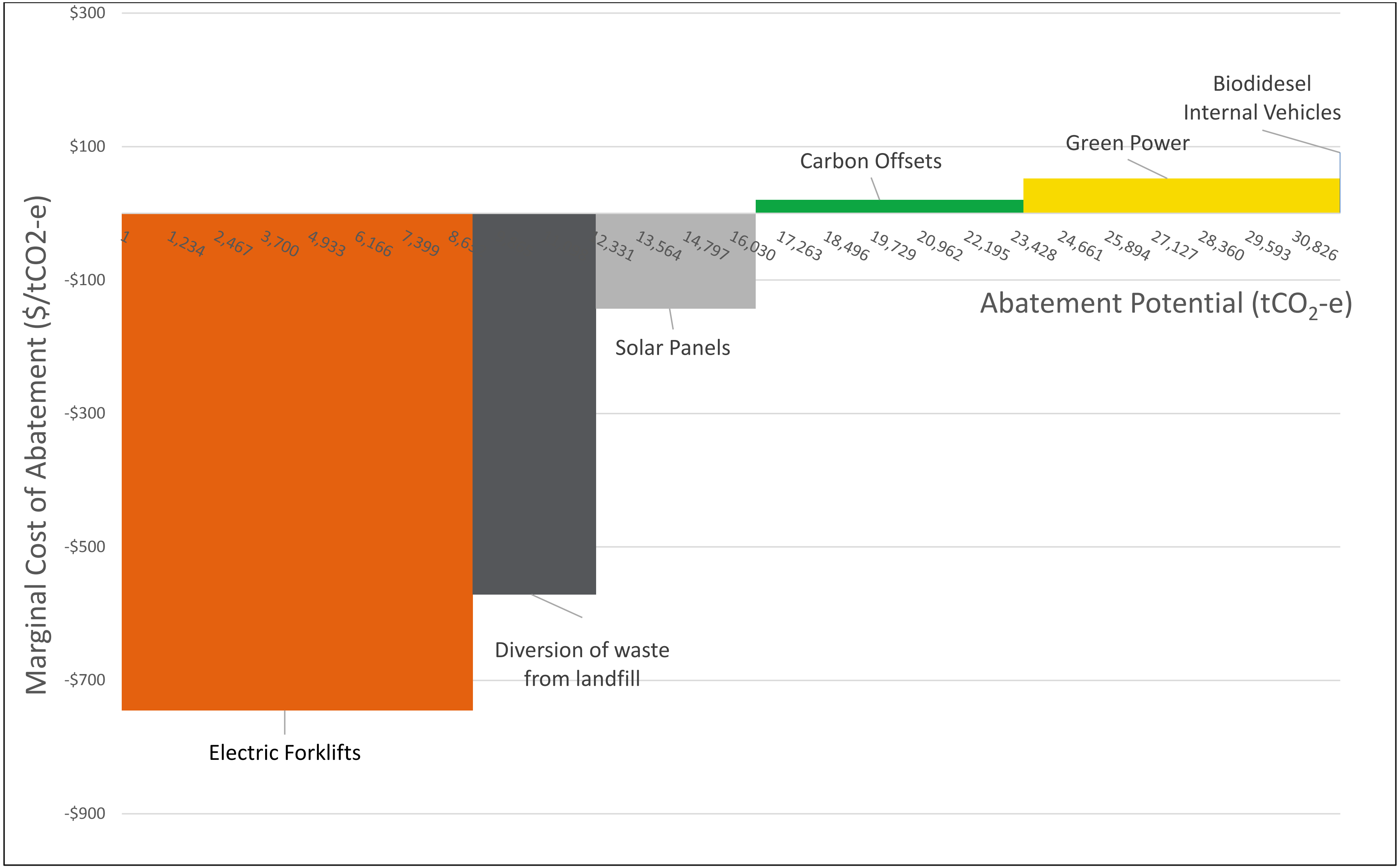

Figure 9-1 27 per cent marginal abatement cost curve for the operation of the Proposal

10 CLIMATE CHANGE RISK AND ADAPTAION ASSESSMENT

Climate change is likely to bring about changes in both average climate conditions and the frequency and severity of extreme events, In urban areas, climate change is projected to increase risks for people, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, inland and coastal flooding, water scarcity, sea-level rise, and storm surges. Building adaptive capacity into infrastructure projects is crucial for effective selection and implementation of adaptation options

There is a strong body of scientific evidence that climate change is occurring and that these changes are associated with release of GHG emissions from human activities. Future changes in climate have the potential to impact significantly on human and natural systems (IPCC, 2014). NSW is projected to experience the following climate changes:

- Most of the State is expected to become hotter, with higher maximum and minimum temperatures to be experienced across the State in all seasons
- Many parts of the State would experience a shift from winter-dominated to summer-dominated rainfall
- Higher evaporation is expected to impact much of NSW by 2050
- Increased risk of flooding due to increases in extreme rainfall.

Due to the inertia of the climate system, even if GHGs released in the atmosphere are dramatically reduced, the warming trend is likely to continue during the 21st century (DECCW, 2010).

The effects of climate change may pose a number of risks to the Proposal. These risks need to be understood and managed, where practicable to avoid impacts on customers, service reliability, environmental values, safety, project capital and operating costs. The purpose of assessing risks posed by climate change is to build adaptive capacity and resilience of the Proposal to potential hazards and risks associated with a changing climate.

This section of the report provides summary information on the existing environment, climate change context, an assessment of potential impacts and risks for the Proposal and adaptation options that can be implemented to reduce the likelihood or consequences of potential risks.

10.1 Assessment Objectives

The objectives of the climate change risk assessment are:

- Determine the current climate and climate change context for the Proposal
- Identify the potential impacts of climate change on the Proposal
- Assess the level of climate related risks for the Proposal
- Identify appropriate climate change adaptation responses.

10.2 Existing environment

10.2.1 Current climate regime

Most of the Sydney region has a warm temperate climate. Average annual rainfall in greater Sydney is between 1000 and 1500 mm. Rainfall throughout the region is greatest in summer and autumn, with a slightly higher proportion of winter rainfall on the coast than inland. Because evaporation and transpiration are lowest in autumn and winter, run-off is highest in autumn and winter and lowest in spring.

The Proposal area has a temperate climate with warm summers and cool winters. The warmest month is January and the coldest month is July. Rainfall fluctuates slightly through the year, but is marginally higher during the first half of the year, when easterly winds dominate. The El Niño Southern Oscillation plays an important role in determining the region's weather patterns. Drought and bushfire on the one hand, and storms and flooding on the other, are associated with the opposite phases of the oscillation. El Niño (dry) and La Niña (wet) episodes can often be detected through the Southern Oscillation Index. These events impact directly on climate variables.

Historic weather data was obtained for September 2016 from the Bureau of Meteorology (BoM) Bankstown Airport weather station (Station ID 066137) for rainfall, temperature, humidity and wind speed.

A review of these records found the following:

- Highest average rainfall month is February (103.6 millimetres (mm))
- The highest daily rainfall event was in February 1990 with 439.8 mm being recorded
- The lowest average rainfall month is September (43.6 mm)
- The average maximum temperature ranges between 17.2 °C (July) and 28.2 °C (January)
- The average minimum temperature ranges between 5.1 °C (July) and 18.1 °C (January)
- The highest recorded maximum at the weather station was 46.1 °C recorded on 18 January 2013
- Average wind speeds for any month range from 6.6 km/h (9am) to 22.6 km/h (3pm), with highest wind speeds recorded most frequently from the southwest to westerly direction
- The windiest months are generally January (20.9 km/h), October (20.9 km/h), November (21.6 km/h) and December (22.6km/h)
- Relative humidity in the area typically ranges between 44 per cent (3pm) and 80 per cent (9am).

The climate regime determined for the Proposal site, based on historical data (1968-2016) is presented in the sections below.

Rainfall

Figure 10-1 shows the historic monthly rainfall recorded at the Bankstown Airport weather station over the period 1968 to 2016. On average, the highest rainfall month is February (439.8 mm) with the lowest rainfall month being July (150.2 mm). The highest and lowest monthly average records for rainfall are also presented as an indication of the variability in monthly rainfall. As an indication of extreme rainfall events the highest daily rainfall is also presented. The data shows that there have been daily rainfall events recorded in every month that has exceeded the average rainfall for the entire month.

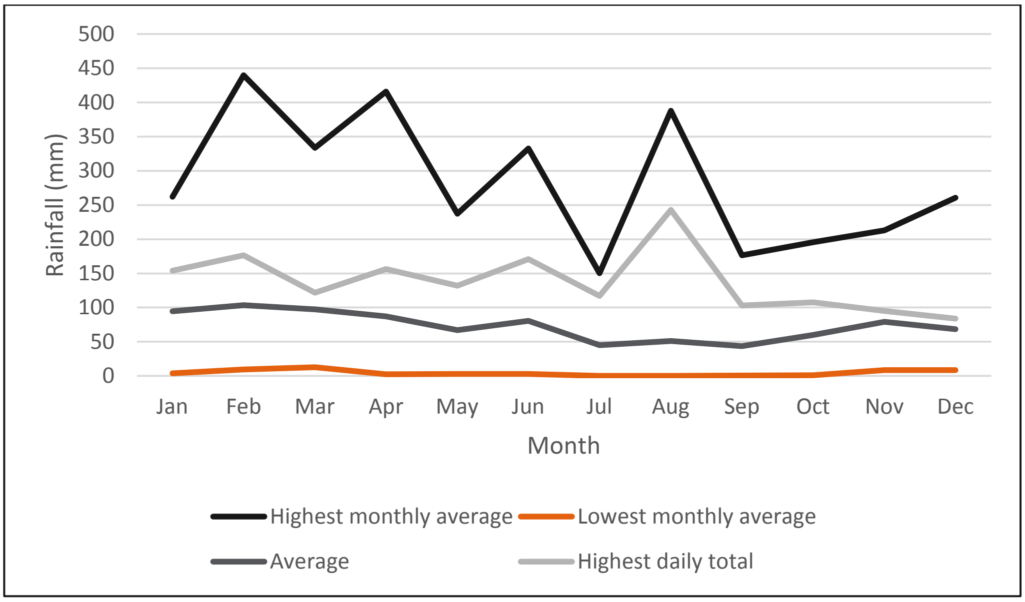

Figure 10-1 Average historic annual rainfall (BoM, 2016)

Temperature

Based on long-term (1910-2013) observations, temperatures in the Sydney Region have been increasing since about 1960, with higher temperatures experienced in recent decades (OEH, 2014). 2015 was Australia's fifth-warmest year since national temperature observations commenced in 1910. Following Australia's warmest year on record in 2015, both maximum and minimum temperatures remained well above average, with frequent periods of abnormally warm weather throughout the year.

Historic temperature data from the BoM was analysed for the period 1968–2014. Figure 10-2 shows the mean monthly maximum and minimum temperatures between 1968 and 2014. On average the hottest month is January (mean maximum 28.2°C and mean minimum 18.1°C) and the coolest is July (mean maximum 17.2°C and mean minimum 5.1°C). The highest and lowest recorded temperatures for each month since monitoring began in 1968 are also presented as an indication of the variability.

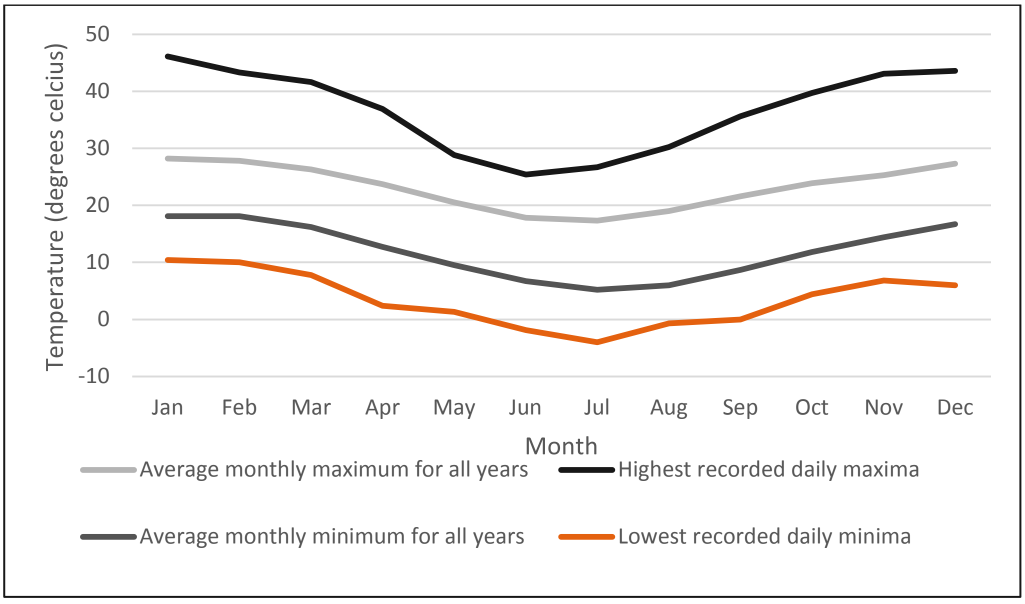

Figure 10-2 Historic average annual temperatures (BoM, 2016)

Figure 10-3 shows the number of days with temperatures greater than 30, 35 and 40 °C recorded for each month since 1968. January had the most number of days above 30 °C (11.6 days).

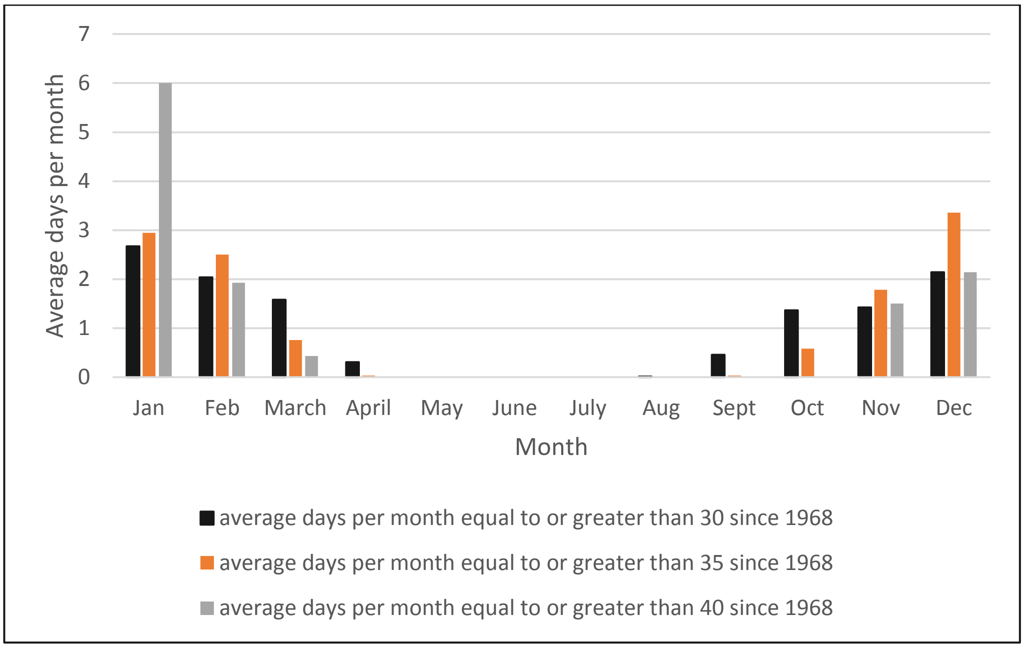

Figure 10-3 Average number of days above 30, 34 and 40ºC recorded at the Bankstown Airport weather station (BoM, 2016)

Wind speed

The mean wind speed recorded at 9am and 3pm at the Bankstown Airport weather station is shown in Figure 10-4. Mean wind speeds were generally lower in the morning and during the months March to July.

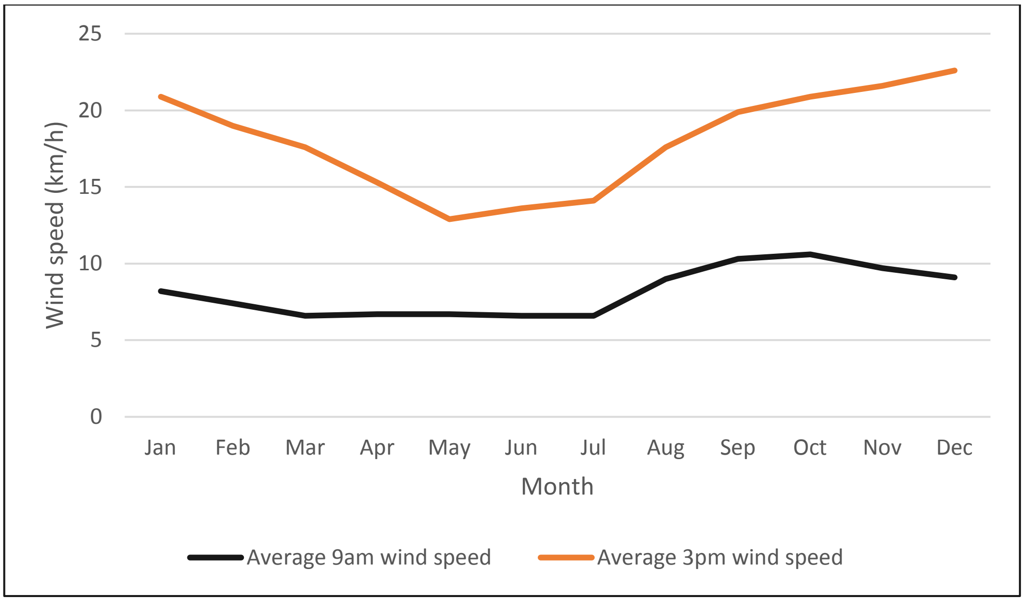

Figure 10-4 Mean 9am and 3pm wind speeds for each month (BoM, 2016)

Relative humidity

The mean relative humidity at the Bankstown Airport weather station is higher at 9am in the morning relative to 3pm in the afternoon for all months (refer to Figure 10-5) This is likely to be due to the lower wind speeds in the morning that increase in the afternoon, which have the effect of lowering the relative humidity.

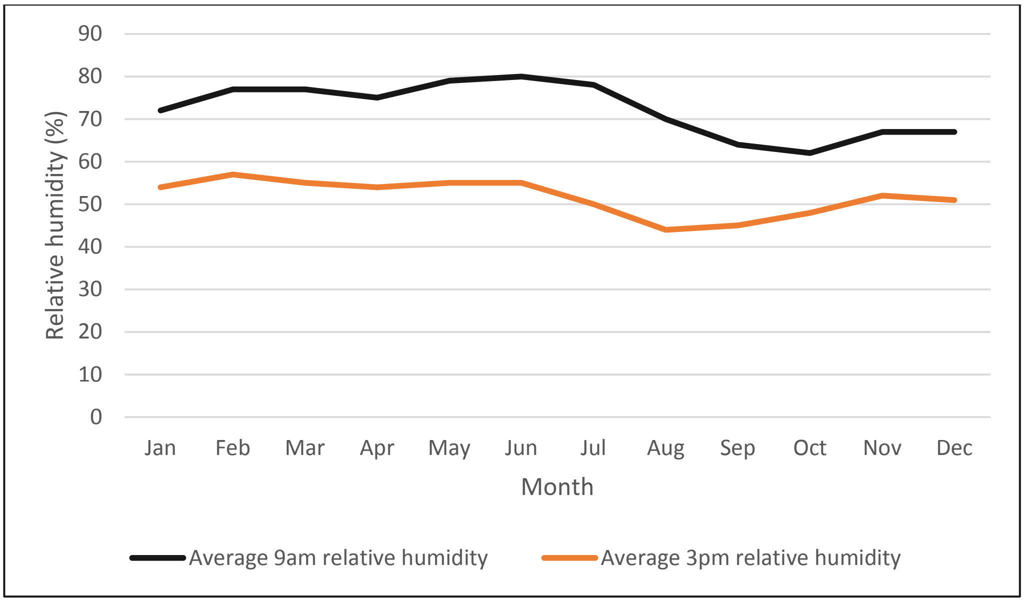

Figure 10-5 Mean 9am and 3pm relative humidity for each month (BoM, 2016)

10.2.2 Existing climate risks

It is likely that the Proposal site is predisposed to the following natural hazards as a result of the location's climate regime:

- Flooding
- Bushfire
- Hail, lightning and wind from severe thunderstorms
- Heat waves.

Flooding

The eastern portion of the Proposal site is adjacent to, and sits within the catchment of, Anzac Creek, a small tributary of the Georges River with a catchment area of some 10.6-squared-kilometres. The *Anzac Creek Flood Study* was completed in December 2005 (Bewsher Consulting, 2005), the outcome of which was the production of flood inundation and flood risk mapping generated from detailed hydrologic and hydraulic modelling of the catchment. The study established peak flood levels, flows and inundation extents for a range of probabilistic design event magnitudes up to the Probable Maximum Flood (PMF). The Flood Planning Level is the level below which planning controls are generally applied to development. The Flood Prone Land is PMF extent of inundation. The *Anzac Creek Floodplain Risk Management Study and Plan* was developed in 2008 (BMT WBM, 2008).

Figure 10-6, shows the extent of flooding relevant to the Proposal site, indicating that the Proposal site is subject to some inundation during a 100 year rainfall event.

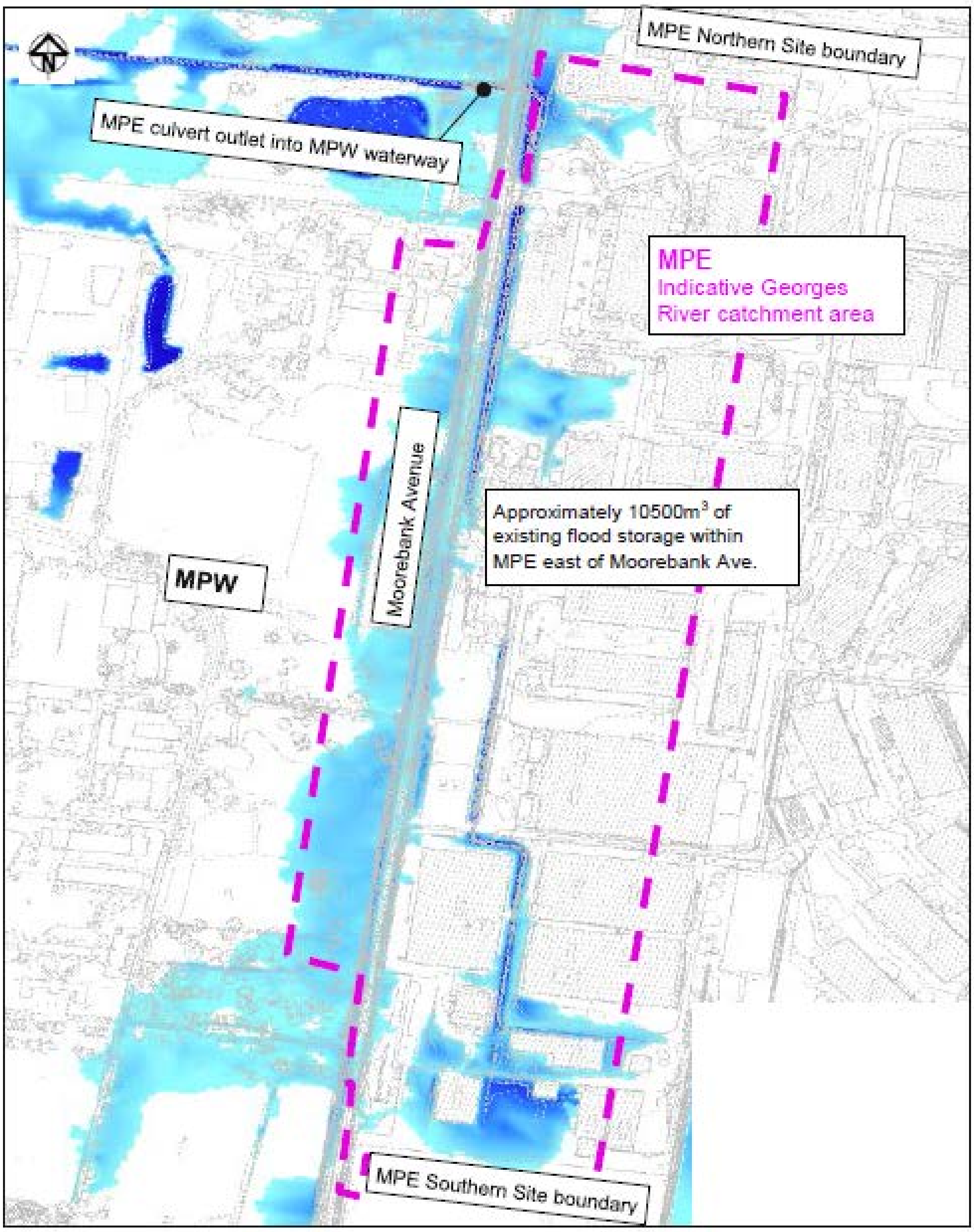

Figure 10-6 100 year ARI Flood extents and storage within MPE Georges River catchment area

Bushfire

The definition of bushfire vegetation categories is as follows:

- Category 1 (orange): forest, woodland, heath and wetlands
- Category 2 (yellow): moist rainforests, shrublands, open woodlands, mallee and grasslands.

Vegetation Category 1 bushfire prone land encroaches the Proposal site to the east, south and west (refer Figure 10-7).

The Proposal site also lies within nominated vegetation buffer areas for Category 1 bushfire vegetation. Areas mapped as Vegetation Category 1 bushfire prone land require consideration under *Planning for Bushfire Protection* (PBP) (NSW RFS, 2006). PBP outlines planning considerations for development and applies to all “development applications” on land that is classified as “bush fire prone land” (NSW RFS, 2006). PBP does not explicitly provide planning considerations with regard to industrial development. Instead, industrial development should comply with the broad aims and objectives of PBP.

Adequate defendable space is incorporated within the site boundary.

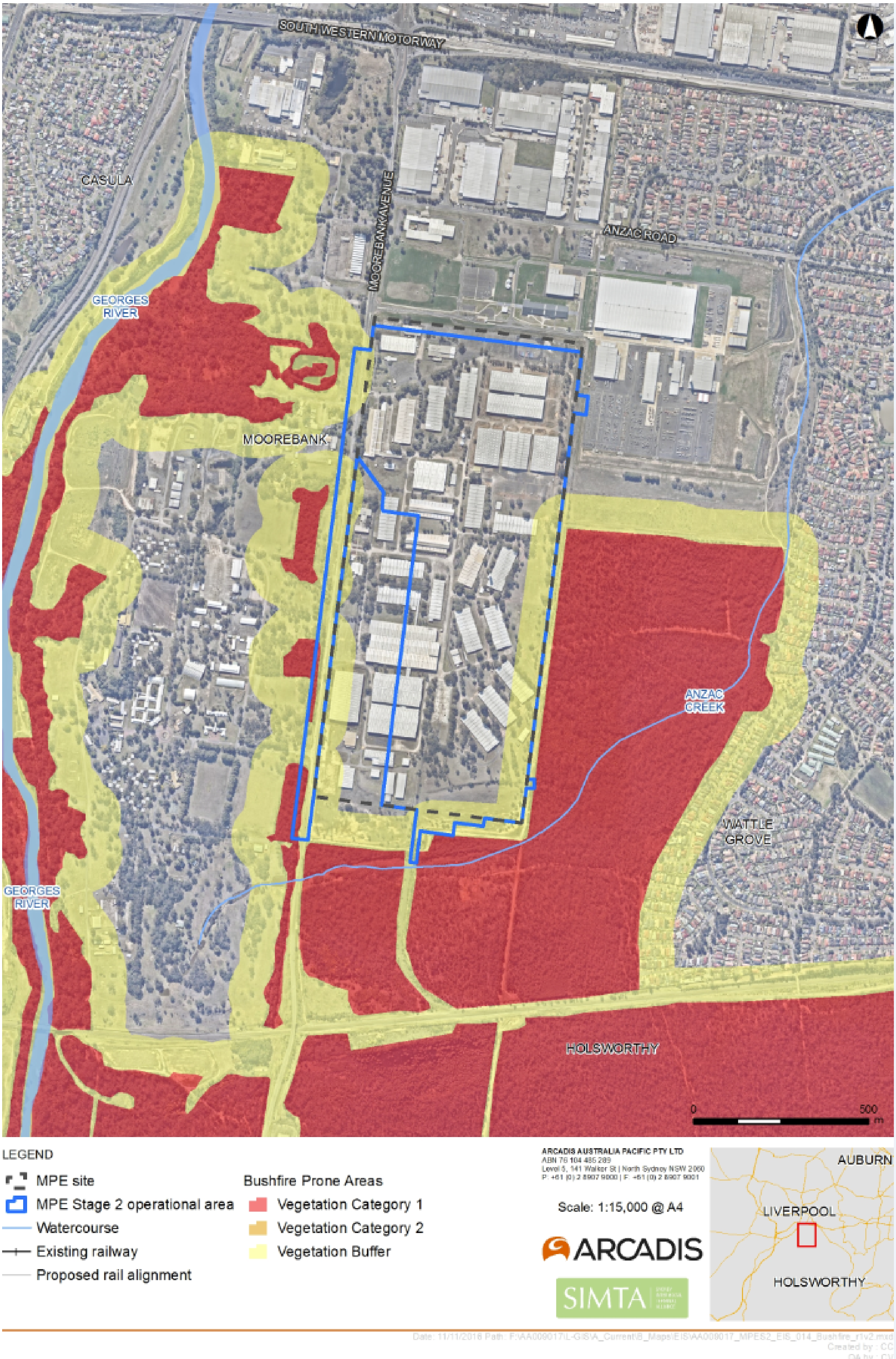

Figure 10-7 Extract of the Certified Liverpool Bushfire Prone Land Map showing the location of the MPE Stage 2 Site.

Hail, lightning and wind from severe thunderstorms

The BoM classifies a severe thunderstorm as an event that produces any of the following:

- Hailstones with a diameter of two centimetres or more at the ground
- Wind gusts of 90 kilometres per hour or greater at 10 metres above the ground
- Flash flooding
- A tornado.

From 20 April to 22 April 2015, the Sydney region experienced severe rain fall and 'cyclonic winds' gusting from 100 to 135 kilometres per hour from an east coast low resulting in many cases of flash flooding, and rivers breaking their banks due to sustained rain periods. 16 December 2015 a severe storm struck the east coast, with high rainfall, hailstones and unusually strong winds. Southern Sydney was particularly hard hit with homes and businesses un-roofed, sewerage and electricity cut and a wind gust of 213 kilometres per hour was recorded.

The Hunter, Central Coast, Sydney, Illawarra, South Coast, Southern Tablelands and Snowy Mountains regions were impacted by severe rainfall between 4 January and 6 January 2016. Peak rainfall over 24 hours were up to 255 millimetres (BoM, 2015b).

Current risks due to hail, lightning and wind are:

- Damage to structures
- Damage to machinery and construction materials
- Dust generated by wind erosion
- Damage to overhead power lines and signals
- Damage to electrical equipment on-site
- Occupational Health & Safety issues for site workers and employees.

Heat waves

A formal definition of a heat wave was developed in 2013. The BoM (2014) defines a heatwave as three days or more of high maximum and minimum temperatures that is unusual for that location.

Current risks to the Proposal from heat waves may include:

- Proposal delays due to Occupational Health & Safety issues
- Increased incidence of heat related illness on-site
- Overheating of machinery and equipment
- Degradation of building materials.

Summary

Existing risks associated with historical climate for the Proposal include:

- Bushfire impacts along the eastern, southern and western boundaries of the site
- Hail, lightning and wind associated with severe thunderstorms causing damage to infrastructure and structures
- Heatwaves causing Occupational Health & Safety issues as well as impacts on machinery and equipment.

10.3 Climate change projections

Climate change projection scenarios for the near future (2030) and far future (2070 to 2090), compared to the baseline climate (1986-2005) have been developed by the NSW Government and Commonwealth Scientific and Industrial Research Organisation (CSIRO) for the City of Sydney and south-eastern coast of NSW based on simulations form a suite of climate models (OEH, 2014 and CSIRO, 2015). Climate change projections have been ascertained for:

- Temperature
- Extreme temperatures
- Rainfall
- Fire weather.

Temperature

Temperature is the most reliable indicator of climate change. Across all the NSW models analysed to determine the climate change impacts for Sydney, all indicated that the average, minimum and maximum temperatures are all increasing. The implications of increased temperatures include increased incidence of illness and death (particularly among vulnerable populations groups), impacts on bushfire danger, infrastructure development and native species diversity. The projected changes in temperatures include (CSIRO 2015):

- Maximum daily temperatures in a high emissions scenario are projected to increase in the near future by 0.5-1.4ºC
- Maximum temperatures in a high emissions scenario are projected to increase in the far future by 2.9-4.8ºC
- Maximum temperatures in an intermediate emissions scenario are projected to increase in the far future by 1.3-2.7ºC
- There are projected to be more hot days and fewer cold nights.

The far future change in maximum and minimum temperatures for Metropolitan Sydney are shown in Figure 10-8 and Figure 10-9 respectively.

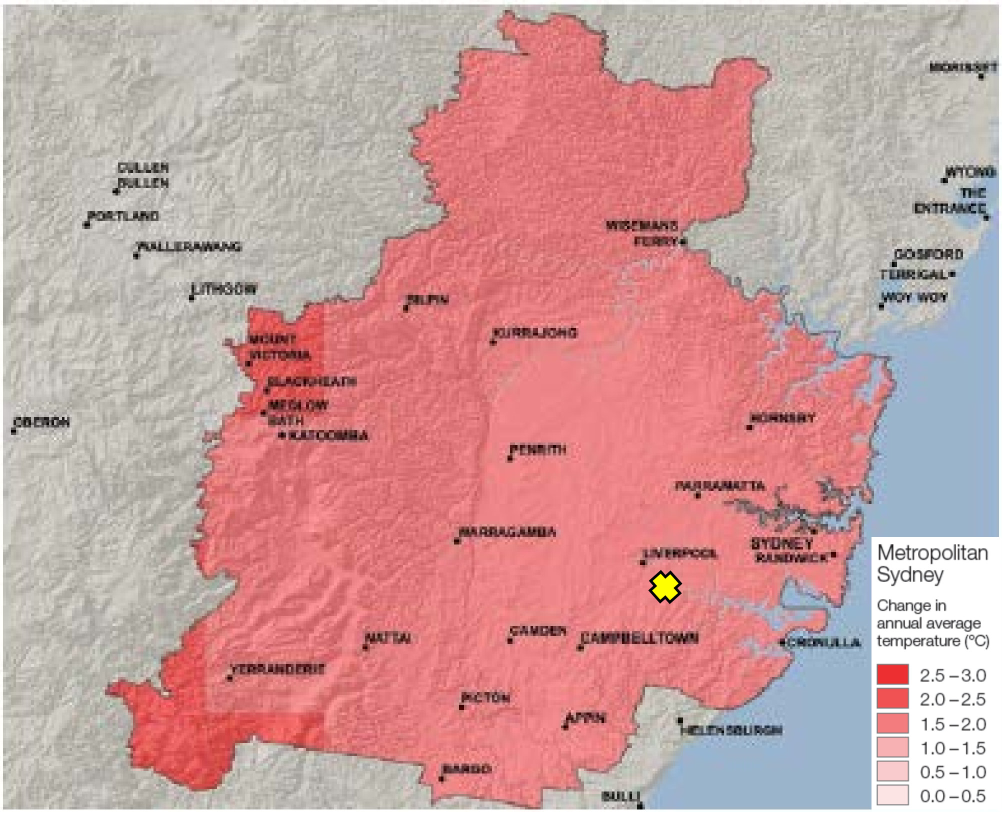

Figure 10-8 Far Future change in max temperatures (OEH, 2014)

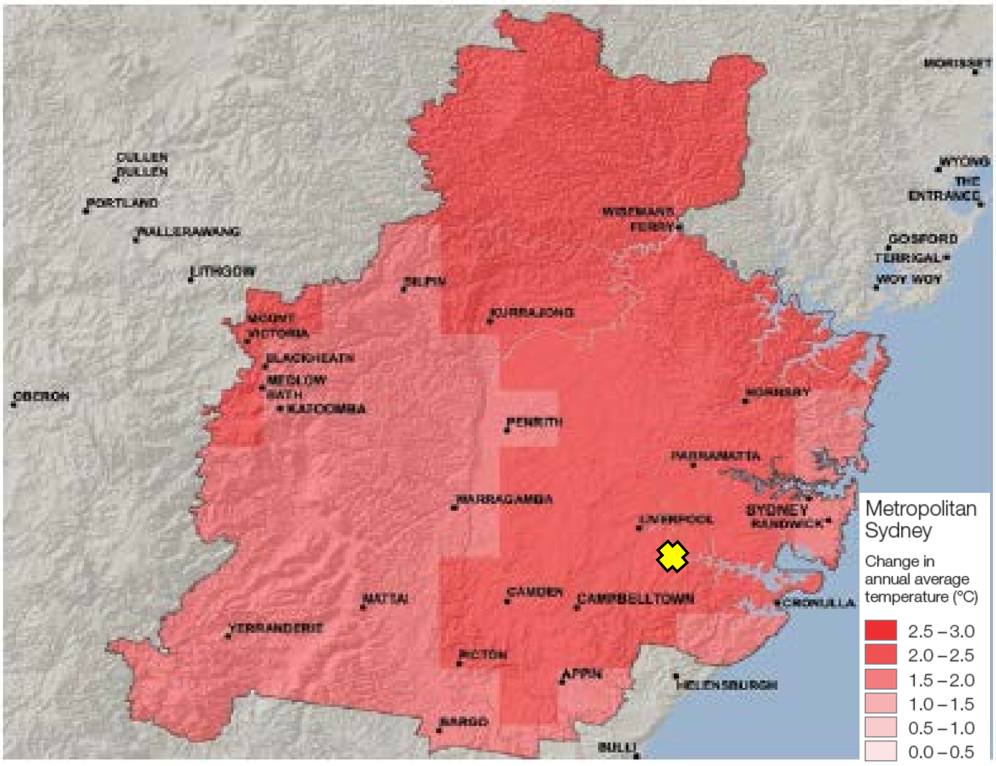

Figure 10-9 Far future-change in minimum temperature (OEH, 2014)

Extreme Temperatures

Extreme temperatures are projected to increase at a similar rate to mean temperature, with substantial increases in the temperature reached on hot days, the frequency of hot days, and the durations of warm spells. Frost risk days (minimum temperatures under 2 °C) are expected to decrease. Some areas could experience around two to three times the average number of days above 35 °C under intermediate emission scenarios by late in the century. (CSIRO, 2015). OEH (2014) have reported the following likely changes:

- The region, on average, is projected to experience an additional four hot days (with daily maximum temperature of above 35 ºC) in the near future and 11 more hot days in the far future
- The region, on average, would experience an average of five fewer cold nights per year in the near future and 12 fewer cold nights in the far future.

Table 10-1 Average annual number of hot days (CSIRO, 2015)

Parameter	1995	Current	2030 (Intermediate GHG emissions scenario)	2090 (Intermediate GHG emissions scenario)	2090 (High GHG emissions Scenario)
Over 35ºC	3.1 days	3.1 days	4.3 days	6.0 days	11 days
Over 40 ºC	0.3 days	0.03 days	0.5 days	0.9 days	2 days
Below 2 ºC	0.0 days	0.0 days	0.0 days	0.0 days	0.0 days

Rainfall

Changes in rainfall patterns have the potential for widespread impacts. Seasonal shifts can often impact native species' reproductive cycles as well as impacting agricultural productivity. Rainfall changes are also associated with changes in extremes, such as floods and droughts, as well as secondary impacts such as water quality and soil erosion that occur as a result of changes to rainfall (OEH, 2014).

Modelling results for projected changes in rainfall vary significantly, with some models indicating that rainfall would decrease, with others projecting increased rainfall patterns. Projections for the region's annual average rainfall range from decrease (drying) of 13 per cent to an increase (wetting) of 18 per cent by 2030 and continue to span both drying and wetting scenarios (-9 per cent to +24 per cent) by 2070 (OEH, 2014). Notwithstanding this the majority of models indicate that autumn rainfall would increase in the near and far future, while spring rainfall would decrease in the near future (with the far future projections less clear).

Understanding of the physical processes that cause extreme rainfall, coupled with modelled projections, indicate with high confidence a future increase in the intensity of extreme rainfall events (CSIRO, 2015). The level of magnitude of the increases, however, has not been confidently projected, with forecasts for 2090 under a high GHG emissions scenario ranging between a 10-40 per cent increases in the twenty year wettest day (CSIRO, 2015)

Fire Weather

Measuring and understanding fire weather patterns is usually accomplished through the use of the McArthur Forest Fire Danger Index (FFDI). The FFDI is a measure of the factors most strongly present during periods of high risk bushfire activity and is calculated as an 'exponential function of dryness, temperature, wind speed and humidity' (Clarke et al. 2011). The BoM issues fire weather warnings when the FFDI is projected to be over 50[3].

Similar to rainfall projections there are notable disparities between many studies and models regarding future fire behaviours in Australia. For example, Clarke et al (2011) predicted increase in FDI of between 30 per cent (for a low emissions scenario), and 300 per cent (under high emissions scenario) for NSW by 2050.

The OEH (2014) model results projected an increase in fire weather and severe fire weather days in the future. These increases are projected mainly in summer and spring. The results indicate that in the Liverpool Local Government Area, the projected changes in average annual days with an FFDI greater than 50, compared to the baseline period, would increase by 0.5-1 days in the far future. An FFDI above 40, predicts near-certain property loss should a fire occur, so that an increase of even one day per year in excess of this should be considered dangerous (Clarke et al. 2011).

There is high confidence that climate change would result in a harsher fire-weather climate in the future. However, there is low confidence in the magnitude of that change because of the significant uncertainties in the rainfall projection (CSIRO 2015).

The far future change in average daily FDI in summer and spring is shown in Figure 10-10 and Figure 10-11 respectively.

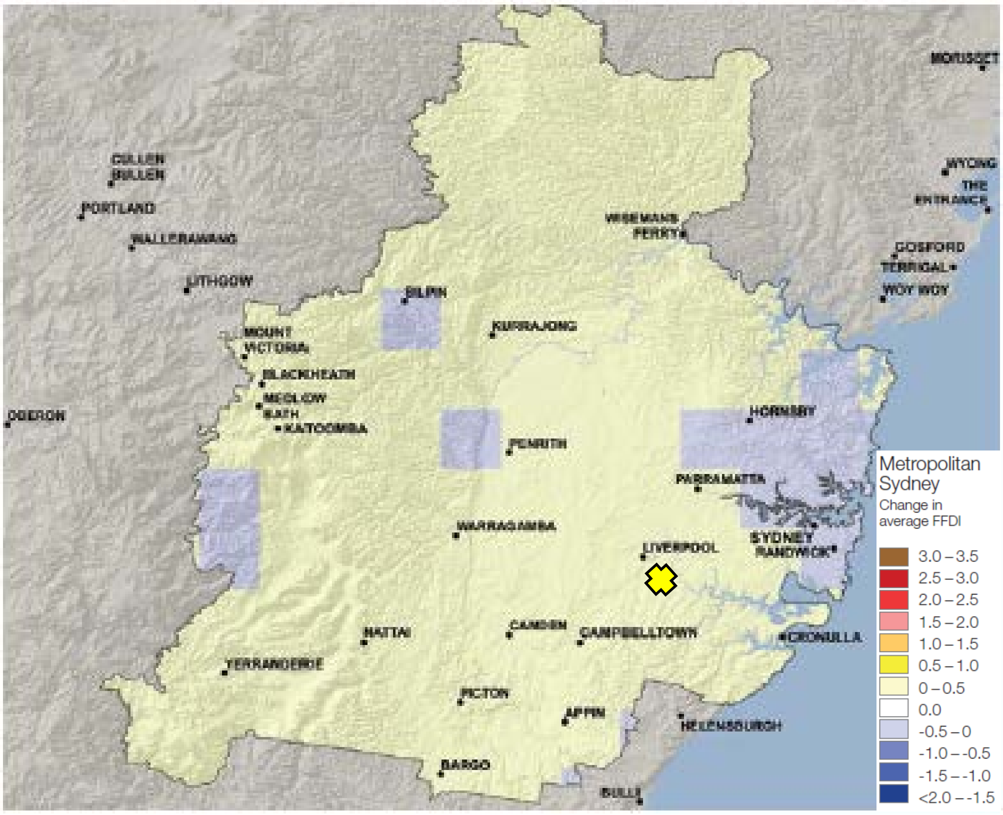

Figure 10-10 Far Future change in average daily FDI in Summer (OEH, 2014)

[3] Typically, but not exclusively, the McArthur scale has an upper limit of 100, with any ratings exceeding 50 indicating 'extreme' fire danger and the need for Total Fire Bans. On February 7 2009 in parts of Victoria, the FFDI readings were absolutely unprecedented, surpassing 300.

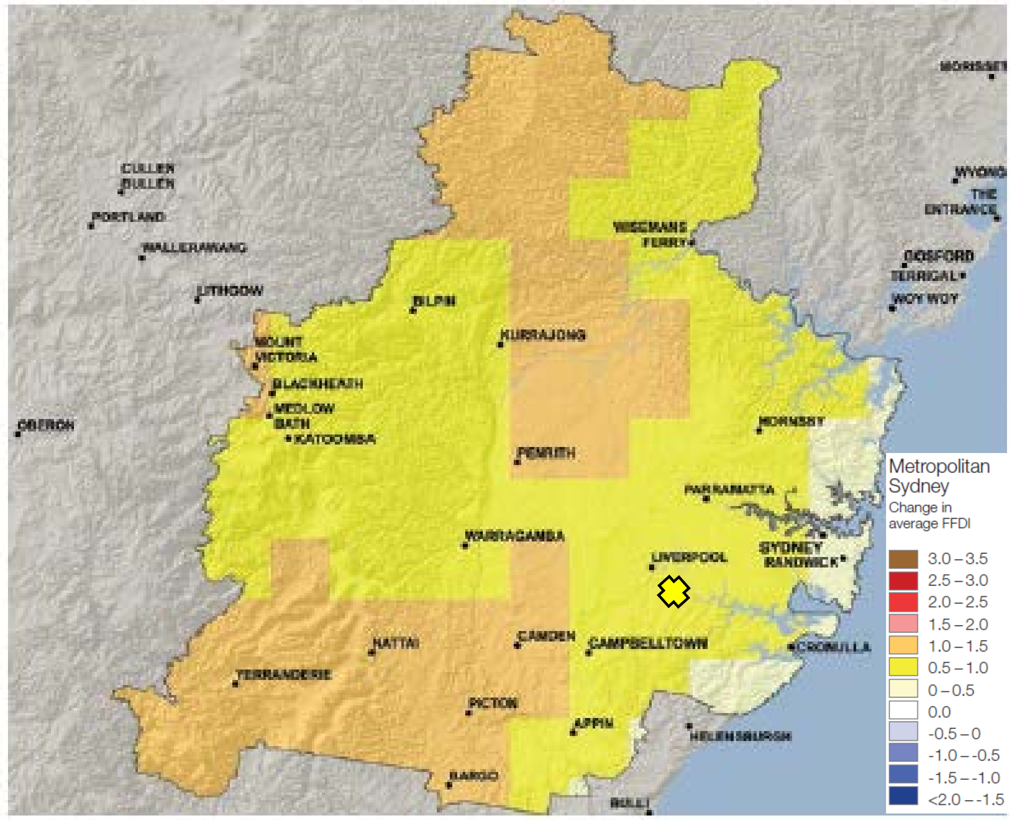

Figure 10-11 Far future change in average daily FDI in Spring (OEH 2014)

10.3.1 Summary of Climate Change Projections

Table 10-2 provides a summary of the projected changes in key climate parameters for the south-eastern coast of Australia and Sydney. The data shows the median (50th percentile) change as projected relative to the 1986-2005 period, with the 10th to 90th percentile change shown in brackets where applicable. The projections have been reported for the period 2030 and 2090 under intermediate and high emission scenarios.

Table 10-2 Summary of climate change projection data for the South-eastern coast of Australia and Sydney (CSIRO, 2015)

Variable	2030 (Intermediate GHG emissions scenario)	2030 (High GHG emissions scenario)	2090 (Intermediate GHG emissions scenario)	2090 (High GHG emissions scenario)
Temperature (ºC) Average	0.9 (0.6 to 1.2)	1 (0.6 to 1.3)	1.9 (1.3 to 2.5)	3.7 (2.7 to 4.7)
No. of days over 35 ºC*	1.2 (0.9 to1.9)	-	2.9 (1.8 to 5.1)	7.9 (5.1 to11.9)
No. of days over 40ºC*	0.2 (0.2 to0.5)	-	0.6 (0.5 to 1.0)	1.7 (1.3 to 3.0)
Rainfall (%)	-3 (-14 to 3)	-4 (-16 to 7)	-8 (-18 to 9)	-13 (-25 to 14)
Relative humidity (% absolute)	-0.5 (-1.9 to 1.1)	-0.7 (-1.8 to 0.1)	-1.1 (-3.5 to 0.5)	-1 (-3.5 to 1.9)
Wind speed (%)	-0.5 (-5.9 to 0.3)	-2.5 (-6.7 to 0.8)	-4.8 (-11.5 to 0.9)	-5.3 (-12.3 to 0.2)

Variable	2030 (Intermediate GHG emissions scenario)	2030 (High GHG emissions scenario)	2090 (Intermediate GHG emissions scenario)	2090 (High GHG emissions scenario)
Increase in No. of sever Fire Danger Days**	0.1 to 0.4	0.4 to 0.5	0.3 to 0.6	1.4 to 1.9

* Compared to 1981-2010 average

** Compared to 1995 Baseline

10.4 Risk and adaptation assessment methodology

The risks assessment was undertaken in accordance with:

- Risk management approach set out in AS/NZ 31000:2009 Risk Management – Principles and Guidelines
- Australian Standard AS5334 – Climate Change Adaptation for Settlements and Infrastructure

It is important to note that a preliminary climate change risk assessment (Hyder Consulting, 2013b) was undertaken as part of the Concept Approval EA for the SIMTA Project. The current climate risk assessment builds on the findings of this earlier study supported by current climate change projection data.

The following steps were undertaken to complete this risk assessment:

- Determine the climate change context in accordance with AS5334:
  - Define the GHG emission scenarios
  - Define future time horizons for the assessment
  - Define the climate variables
  - Select climate data for the assessment
  - Obtain past meteorological record
- Identify relevant climate risks and evaluate the likelihood and consequence of each risk
- Identify adaptation responses.

Different elements of the MPE Project would have different design life spans. Elements such as communications systems would have a relatively short design life (20 years), steel structures and operational equipment would have a moderate design life (30-40 years), while structural elements and embankments would have a long term design life (100 years). To identify short term and long term risks, two time periods (2030 and 2090) have been selected to facilitate the climate change risk and adaptation assessment.

Climate change risks were identified from a desktop assessment process based on the historic climate and projected changes to climate variables under a high emissions scenario for 2090. Risk statements were developed for the Proposal (based on predicted climate impacts), outlining the vulnerability of the site to the climate change impacts associated with the locality. Each climate impact was recorded in a risk register (see Appendix B).

Each risk statement was assessed using the following likelihood and consequence scales and was documented in a risk register (see Appendix B). Existing controls already in place for risk mitigation (e.g. environmental features, natural and man-made structures and mechanisms, procedures and factors) are considered in the analysis of risks.

Table 10-3 Likelihood ratings (Hyder Consulting, 2013a)

Rating	Recurrent risk	Single events
Almost certain	Could occur several times a year.	More likely than not – probability greater than 50 per cent.
Likely	May arise about once per year.	As likely as not – 50/50 chance.
Moderate	May arise once in ten years.	Less likely than not but still appreciable – probability less than 50 per cent but still quite high.
Unlikely	May arise once in ten years to 25 years.	Unlikely but not negligible – probability low but noticeably greater than zero.
Rare	Unlikely during the next 25 years.	Negligible – probability low, very close to zero.

Table 10-4 Consequence ratings (Hyder Consulting, 2013a)

Level	**Structural consequence**	**Environmental & sustainability consequence**
Insignificant	No structural damage.	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage.
Minor	Localised structural damage and slight service disruption. No permanent damage.	Severe loss of environmental amenity and a danger of continuing environmental damage.
Moderate	Widespread structural damage and loss of service. Damage recoverable by maintenance and minor repair.	Isolated but significant instances of environmental damage that may be reversed.
Major	Extensive damage requiring extensive repair.	Minor instances of environmental damage that could be reversed.
Catastrophic	Permanent structural damage to property and infrastructure.	No environmental damage.

Table 10-5 Risk matrix (Hyder Consulting, 2013a)

Likelihood \ Consequence	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Moderate	High	Extreme	Extreme
Likely	Low	Moderate	Moderate	High	Extreme
Moderate	Low	Low	Moderate	High	Extreme
Unlikely	Low	Low	Moderate	Moderate	High
Rare	Low	Low	Low	Moderate	Moderate

Once the priority risks were identified, using the matrices shown above, the level of treatment to reduce the risk to an acceptable level were identified. The risk accessibility and level of adaptation required is described in Table 10-6.

Table 10-6 Risk acceptability and level of adaptation required

Risk Rating	Adaptation required	Level of acceptance
Extreme	Requires immediate control or design measures to reduce risk level	Unacceptable level of risk without controls
High	High priority control measures required, or design measures to reduce risk	Unacceptable level of risk without controls
Moderate	Ongoing management measures or some design measures to reduce risk	Some controls required to reduce risks to lower levels. Risk level acceptable with appropriate controls in place
Low	Risk level kept under review	Risk level acceptable. Control not likely required

10.5 Potential impacts to development

Potential climate change hazards and risks were identified for the Proposal. Climate change risks are presented in Table 10-7. In summary, the unmitigated climate change risk assessment for the year 2090 found:

- No extreme risks
- Two high risks
- Ten medium risks
- One low risks

Table 10-7 Climate change risks for the Proposal for the year 2090

Risk Category	Risk Description	Uncontrolled Risk 2090
Temperature Increases		
Power outages	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to more frequent interruptions to mains power supply.	Moderate
Loss of structural component integrity	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to increased pressure on structural integrity causing movement/cracking/buckling of building structures.	Moderate
Failure of and reduced functionality of electrical systems	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to increased failure of air conditioning equipment on critical equipment resulting in reduced network capacity and increasing potential for major safety incidents.	Moderate
Stop work events	Increase in days over 35 °C would result in greater number of stop work days resulting in reduced operating hours for SIMTA	High
Increased rainfall intensity		
Flooding of site impacting asset lifecycle	Flood events within the site resulting in disrupted operations to the site resulting in impacts on costs and reduced asset lifecycle. Extreme rainfall by 2090 has the potential interrupt service and cause damage to infrastructure.	Moderate
Stormwater infrastructure failure	Overflows from on-site stormwater detention systems impacting on water quality in local creek systems such as Anzac Ck and Georges Rv.	Moderate
Appropriateness of design for flood mitigation structures	Flood mitigation structures such as culverts not appropriately designed to accommodate increased intense rainfall events resulting in reduced asset lifecycle and potential impacts on adjacent environmental values.	Moderate
Ground stability issues	Increased frequency and severity of extreme rainfall events leading to flooding or saturation of embankments and ground conditions.	Moderate
Off-site impacts on local watercourses	Increased run-off from hard surfaces due to inadequate controls for the provision of soft surfaces (landscaped areas) leading to increase in impacts (e.g. water quality, geomorphology) on natural creek systems	Moderate

Risk Category	Risk Description	Uncontrolled Risk 2090
Reduced annual rainfall		
Impacts on landscaping plant species	Changes in seasonal rainfall may result in dieback of site plantings increasing maintenance costs	Low
Storms, hail and wind events		
Storm, hail and wind events impacting site infrastructure	Increased frequency and severity of extreme storm, hail and wind events leading to debris, fallen trees and branches impacting infrastructure (structural, electrical and communications) and customers.	Moderate
Storm, hail and wind impacts on site operation	Increased frequency and severity of extreme storm, hail and wind events leading to operational service disruptions and delays.	Moderate
Increased frequency of bushfire		
Bushfire damage to site infrastructure, health and safety impacts	Increased frequency, severity and duration of bushfires damaging aboveground infrastructure and generating health and safety impacts on customers	High

10.6 Proposed adaptation measures and controls

Adaptation responses for treatment of the climate change risks identified above would be incorporated into the design and operation of the Proposal to promote resilience to projected future climate change, in accordance with Table 10-6. Table 10-8 presents a suite of engineering design and procedural responses for treatment of climate change risks, and the residual level of risk following their implementation. Importantly the assessment identified no extreme or high risks once adaptation responses have been implemented. The residual climate change risk assessment for the year 2090 identified six moderate risks and seven low risks.

Table 10-8 Adaptation responses for treatment of the Proposal's climate change risks

Risk Title	Adaptation Response	Mitigated Risk (2090)
Temperature Increases		
Power outages	High priority electrical systems would consider diversity and redundancy in the electrical systems design.	Moderate
Loss of structural component integrity	Areas most vulnerable to heat related impacts would be subject of regular inspection and maintenance.	Moderate
Failure of and reduced functionality of electrical systems	Any communications and safety management equipment rooms would be air-conditioned.	Low

Risk Title	Adaptation Response	Mitigated Risk (2090)
Stop work events	Develop heatwave response procedure for the Proposal for inclusion within the OEMP as required	Moderate
Increased rainfall intensity		
Flooding of site impacting asset lifecycle	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which would occur once every 100 years), plus an additional 20 per cent increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Low
Stormwater infrastructure failure		Low
Appropriateness of design for flood mitigation structures		Low
Ground stability issues		Low
Off-site impacts on local watercourses	Water-sensitive urban design (WSUD) controls (e.g. swales, biofiltration systems) have been incorporated into the Proposal stormwater system design and system performance has been found to meet water quality objectives.	Low
Reduced annual rainfall		
Impacts on landscaping plant species	Plant species selected for landscaping have been selected based on their ability to tolerate projected climate change	Low
Storms, hail and wind events		
Storm, hail and wind events impacting site infrastructure	Appropriate setback for trees and other vegetation would ensure vegetative debris would not disrupt services, whilst maintaining visual aesthetics and soil stability.	Moderate
Storm, hail and wind impacts on site operation	The Proposal has been designed through aspects such as incorporating intense rainfall projections into the design of stormwater infrastructure and the selection of appropriate materials to minimise potential impacts associated with storm damage.	Moderate
Increased frequency of bushfire		
Bushfire damage to site infrastructure,	Buildings and structures have been designed to be fire resistant in accordance with relevant standards.	Moderate

Risk Title	Adaptation Response	Mitigated Risk (2090)
health and safety impacts	Asset protection zones have been incorporated into the layout of the Proposal to limit bushfire risk to acceptable levels.	

11 CONCLUSION

Arcadis has been commissioned by Sydney Intermodal Terminal Alliance (SIMTA) to prepare a greenhouse gas (GHG) assessment, Climate Change Risk and Adaptation Assessment and Marginal Abatement Cost (MAC) Analysis to support a State Significant Development (SSD) Environmental Impact Statement (EIS) under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for Stage 2 of the Moorebank Precinct East (MPE) Project (the Proposal).

The total GHG emissions associated with the construction of the Proposal are expected to be approximately 8,884 tonnes of carbon dioxide equivalent (tCO_2-e) during the 24 month construction period, with the total embodied GHG emissions within the construction materials generating an additional 137,774 tCO_2-e. The annual operational GHG emissions would generate approximately 118,733 tCO_2-e per annum.

Annual GHG emissions from the Proposal represent approximately 0.02 per cent of Australia's total annual GHG emissions (523.3 Mega tonnes (Mt) CO_2-e). The transport sector contributes 92.9 $MtCO_2$-e each year to Australia's GHG emissions (DoE, 2016a). The Proposal is predicted to contribute 0.13 per cent to Australia's transport sector inventory and 0.46 per cent to the NSW inventory for the transport sector (of a total 26 $MtCO_2$-e). The commercial and institutional industries contributed just 1.31 per cent (5.3 $MtCO_2$-e) of the energy sector in Australia in 2014 (DoE, 2016b), of which the Proposal would account for approximately 2.24 per cent of the (5.3 $MtCO_2$-e).

A climate change risk and adaptation assessment for the Proposal was undertaken to assess the risk posed by climate change and to identify adaptation strategies to mitigate these risks. The assessment identified a total of 13 climate change risks for the Proposal. If these risks are unmitigated the assessment found that there would be two high, ten medium, and one low uncontrolled risks by 2090 as a result of potential climate change impacts. A range of adaptive responses for treatment of the climate change risks identified would be incorporated into the design and operation of the Proposal to promote resilience to projected future climate change. Once implemented the engineering design and procedural responses for treatment of climate change risks would result in lowered residual risks; such that no high risks remained. For the year 2090, following the implementation of adaptation measures the Proposal would not be subject to any high climate change risks, whereby six moderate risks and seven low risks remain.

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APPENDIX A

Summary of Greenhouse Gas and Climate Change Risk Management Strategies

Aspect /Risk	Mitigation/ Management measure	Status/ Timing
Risk of GHG emissions to the atmosphere; potential long term climate change impacts	Where possible locally sourced materials will be used to reduce GHG emissions associated with transport	Construction
	Construction and demolition waste will be recovered and recycled where possible, and vegetation waste will be composted	Construction
	Construction works will be planned to minimise double handling of materials	Pre-construction
	Demolition materials will be reused where possible to reduce GHG emissions associated with embodied energy	Construction
	Construction/transport plans will be incorporated within the CEMP to minimise the use of fuel during construction	Pre-construction and construction
	Fuel efficiency of the plant/equipment will be assessed prior to selection, and where practical, equipment with the highest fuel efficiency and which uses lower GHG intensive fuel (e.g. biodiesel) will be used	Pre-construction, construction and operation
	On-site vehicles will be fitted with exhaust controls in accordance with the Protection of the Environment Operations (Clean Air) Regulation 2010 as required	Construction and operation
	Regular maintenance of equipment will be undertaken to maintain good optimum operations and fuel efficiency	Construction and operation
	Where practicable, trucks removing waste from the site or bringing materials to the site will be filled to the maximum amount allowable, depending on the truck size and load weight, to reduce the number of traffic movements required	Construction and operation
	Consideration will be given to the embodied energy content of construction materials selected	Pre-construction and construction
	Energy efficiency design aspects will be incorporated wherever practicable to reduce energy demand	Detailed design,
	Energy-efficient guidelines for operational work will be considered and implemented where appropriate and regular maintenance of equipment will be undertaken to maintain fuel efficiency	Operation

Aspect /Risk	Mitigation/ Management measure	Status/ Timing
	Consideration will be given to undertake further investigation and implementation of cost negative abatement opportunities	Detailed design
Loss of structural component integrity	Areas most vulnerable to heat related impacts would be subject of regular inspection and maintenance.	Detailed design
Power outages	High priority electrical systems would consider diversity and redundancy in the electrical systems design.	Detailed design
Failure of and reduced functionality of electrical systems	Any communications and safety management equipment rooms would be air-conditioned.	Detailed design
Stop work events	Develop heatwave response procedure for the Proposal for inclusion within the OEMP as required	Operation
Flooding of site impacting asset lifecycle	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which would occur once every 100 years), plus an additional 20 per cent increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Detailed design
Stormwater infrastructure failure		
Appropriateness of design for flood mitigation structures		
Ground stability issues		
Off-site impacts on local watercourses	Water-sensitive urban design (WSUD) controls (e.g. swales, biofiltration systems) have been incorporated into the Proposal stormwater system design and system performance has been found to meet water quality objectives.	Detailed design
Impacts on landscaping plant species	Plant species selected for landscaping have been selected based on their ability to tolerate projected climate change	Detailed design
Storm, hail and wind events impacting site infrastructure and site operation	Appropriate setback for trees and other vegetation would ensure vegetative debris would not disrupt services, whilst maintaining visual aesthetics and soil stability.	Detailed design
	The Proposal has been designed through aspects such as incorporating intense rainfall projections into the design of stormwater infrastructure and the selection of appropriate materials to minimise potential impacts associated with storm damage.	Detailed design
Bushfire damage to site infrastructure, health and safety impacts	Buildings and structures have been designed to be fire resistant in accordance with relevant standards.	Detailed design

Aspect /Risk	Mitigation/ Management measure	Status/ Timing
	Asset protection zones have been incorporated into the layout of the Proposal to limit bushfire risk to acceptable levels.	

APPENDIX B

Climate Change Risk Register

Risk Code	Climate Impact	Risk Statement	Applicable year/s (choose more than one if applicable)	Direct or Indirect	Likelihood	Consequence	Level of Risk	Adaptation measure	Residual Likelihood	Residual Consequence	Residual Level of Risk
	Increase in extreme hot days	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to more frequent interruptions to mains power supply.	2030, 2090	Direct	Possible	Moderate	Moderate priority	High priority electrical systems would consider diversity and redundancy in the electrical systems design.	Possible	Minor	Moderate priority
	Increase in extreme hot days	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to increased pressure on structural integrity causing movement/cracking/buckling of building structures.	2030, 2090	Direct	Possible	Moderate	Moderate priority	Areas most vulnerable to heat related impacts would be subject of regular inspection and maintenance.	Possible	Minor	Moderate priority
	Increase in extreme hot days	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to increased failure of air conditioning equipment on critical equipment resulting in reduced network capacity and increasing potential for major safety incidents.	2030, 2090	Direct	Possible	Moderate	Moderate priority	Any communications and safety management equipment rooms would be air-conditioned.	Unlikely	Moderate	Low priority
	Increase in extreme hot days	Increase in days over 35 °C would result in greater number of stop work days resulting in reduced operating hours for SIMTA	2030, 2090	Direct	Likely	Moderate	High priority	Develop heatwave response procedure for the Proposal for inclusion within the OEMP as required	Possible	Moderate	Moderate priority
	Increase in extreme hot days	Flood events within the site resulting in disrupted operations to the site resulting in impacts on costs and reduced asset lifecycle. Extreme rainfall by 2090 has the potential interrupt service and cause damage to infrastructure.	2090	Direct	Possible	Moderate	Moderate priority	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which would occur once every 100 years), plus an additional 20 per cent increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Unlikely	Moderate	Low priority
	Increased extreme rainfall	Overflows from on-site stormwater detention systems impacting on water quality in local creek systems such as Anzac Ck and Georges Rv.	2030, 2090	Direct	Possible	Moderate	Moderate priority	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which would occur once every 100 years), plus an additional 20 per cent increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Unlikely	Moderate	Low priority
	Increased extreme rainfall	Flood mitigation structures such as culverts not appropriately designed to accommodate increased intense rainfall events resulting in reduced asset lifecycle and potential impacts on adjacent environmental values.	2030, 2090	Direct	Possible	Moderate	Moderate priority	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which would occur once every 100 years), plus an additional 20 per cent increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Unlikely	Moderate	Low priority
	Increased extreme rainfall	Increased frequency and severity of extreme rainfall events leading to flooding or saturation of embankments	2030, 2090	Direct	Possible	Minor	Moderate priority	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which would occur once every 100 years), plus an	Unlikely	Minor	Low priority

Risk Code	Climate Impact	Risk Statement	Applicable year/s (choose more than one if applicable)	Direct or Indirect	Likelihood	Consequence	Level of Risk	Adaptation measure	Residual Likelihood	Residual Consequence	Residual Level of Risk
		and ground conditions.						additional 20 per cent increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.			
	Increased extreme rainfall	Increased run-off from hard surfaces due to inadequate controls for the provision of soft surfaces (landscaped areas) leading to increase in impacts (e.g. water quality, geomorphology) on natural creek systems	2030, 2090	Indirect	Possible	Minor	Moderate priority	Water-sensitive urban design (WSUD) controls (e.g. swales, biofiltration systems) have been incorporated into the Proposal stormwater system design and system performance has been found to meet water quality objectives.	Unlikely	Minor	Low priority
	Increased extreme rainfall	Changes in seasonal rainfall may result in dieback of site plantings increasing maintenance costs	2030, 2090	Direct	Unlikely	Insignificant	Low priority	Plant species selected for landscaping have been selected based on their ability to tolerate projected climate change	Rare	Insignificant	Low priority
	Droughts	Increased frequency and severity of extreme storm, hail and wind events leading to debris, fallen trees and branches impacting infrastructure (structural, electrical and communications) and customers.	2030, 2090	Direct	Possible	Moderate	Moderate priority	Appropriate setback for trees and other vegetation would ensure vegetative debris would not disrupt services, whilst maintaining visual aesthetics and soil stability.	Possible	Minor	Moderate priority
	Increased severe storm events	Increased frequency and severity of extreme storm, hail and wind events leading to operational service disruptions and delays.	2030, 2090	Direct	Possible	Moderate	Moderate priority	The Proposal has been designed through aspects such as incorporating intense rainfall projections into the design of stormwater infrastructure and the selection of appropriate materials to minimise potential impacts associated with storm damage.	Possible	Minor	Moderate priority
	Increased severe storm events	Increased frequency, severity and duration of bushfires damaging aboveground infrastructure and generating health and safety impacts on customers	2030, 2090	Direct	Likely	Moderate	High priority	Buildings and structures have been designed to be fire resistant in accordance with relevant standards. Asset protection zones have been incorporated into the layout of the Proposal to limit bushfire risk to acceptable levels.	Possible	Moderate	Moderate priority

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