Climate Risk Assessment

SIMTA

SYDNEY INTERMODAL TERMINAL ALLIANCE

Part 3A Concept Plan Application

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SIMTA Moorebank Intermodal Terminal Facility

Climate Risk Assessment

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Executive summary

A desktop qualitative risk assessment was undertaken to determine risks posed by historical climate and projected climate change impacts for the SIMTA Moorebank Intermodal Terminal Facility (SIMTA proposal). The objective of the assessment was to assess the capability of the site to deliver required minimum levels of service throughout the entire design period, through the selection of appropriate materials and design of all structures.

An assessment of historical climate for the SIMTA proposal identified intense peak rainfall events, flooding and bushfire as the major risks. To mitigate current climate risks a number of recommendations were derived, including:

- Internal drainage design will take into account forecast average and peak rainfall events and identify water quantity and water quality measures, where appropriate.
- Assess impacts of development on flood conditions in Anzac Creek and Georges River.
- Determine bushfire planning controls consistent with *Planning for Bushfire Protection Guidelines 2006.*

A total of eight priority climate change risks, including those rated as 'extreme' and 'high' were identified from available climate change projection data for the SIMTA proposal. These risks were subject to a desktop review of applicable adaptation measures which could reduce the potential risk level over the life of the SIMTA proposal. Adaptation measures considered for risk reduction included existing and potential controls.

Recommended adaptation measures for control and mitigation of priority risks are shown following.

Glossary of terms

APZ	Asset Protection Zones
ESD	Environmentally and Ecologically Sustainable Development
DECCW	Department of Environment, Climate Change and Water
LEP	Liverpool Local Environmental Plan 2008
PBP	Planning for Bushfire Protection Guidelines 2006

Table 1: Adaption measures for control and mitigation of priority risks

Risk	Risk Rating	Adaptation Measure	Residual Risk*
Flooding of buildings and infrastructure causing higher maintenance costs and reduced asset lifecycle.	High	Incorporate climate change sensitivity analyses for 20 per cent increase in peak rainfall and storm volumes into flood modelling assessment to determine system performance.	Moderate
	High	Incorporate appropriate flood mitigation measures where practical within the design to limit the risk to acceptable levels.	Low
Flooding of rail infrastructure located within Anzac Creek sub-catchment causing declines in serviceability due to operational impacts.	High	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.	Low
Flood management structures are not designed to cope with future rainfall patterns leading to flood damage.	High		Low
Storm damage to structural enhancements/add-ons to buildings.	High	Use of appropriate materials and engineering design capable of withstanding potential impacts posed by storm damage.	Low
Increased bushfire frequency and intensity causing structural damage to buildings and infrastructure (including rail line) creating higher maintenance costs and reduced asset life.	High	Incorporate appropriate strategic protection zones, including asset protection zones into design to limit bushfire risk to acceptable levels.	Moderate
Increased heatwave frequency resulting in rail line buckling from sudden temperature rises causing higher maintenance costs and reduced asset life.	High	Maintain track stability through regular maintenance, use concrete sleepers in place of wooden ones and use preventative measures in the event of heatwaves eg speed restrictions.	Moderate
Increased operating costs due to higher carbon pricing.	High	Consider further assessment of marginal abatement cost curves to assess commercial opportunities of reducing reliance on single energy source.	Moderate

* **Residual risk rating** – Likelihood multiplied by the impact the risk happening **after** controls are in place. This rating cannot be calculated unless there are controls in place that have been inherently assessed.

The design of the SIMTA proposal will reflect these adaptation measures to mitigate potential risks posed by climate change, and result in the nominated level of residual risk.

Application of the measures identified above during detailed design would lead to the adoption of specific actions relating to climate change risks. These actions could include:

- Selection of building materials to withstand storm intensity.
- Structural design for increased wind intensities.
- Warehouse ventilation for improved heat removal.
- Provision of building/infrastructure setbacks and strategic fire management zones to the south and east of the site.
- Design of stormwater detention on-site to accommodate increased rainfall.
- Design of rail line to withstand flooding posed by increased frequency of extreme rainfall events.

The above residual risk analysis indicates that the SIMTA proposal, including appropriate adaptation safeguards as identified in this report, will give rise to low to moderate risk in relation to the identified climate change risks. Climate change risks are to be identified and appropriately considered across all stages of the life of the SIMTA proposal.

1. Introduction

1.1. Project background

The Sydney Intermodal Terminal Alliance (SIMTA) is a joint venture between Stockland, Qube Logistics and QR National.

The SIMTA Moorebank Intermodal Terminal Facility (SIMTA proposal) is proposed to be located on a land parcel currently occupied by the Defence National Storage and Distribution Centre (DNSDC) on Moorebank Avenue, Moorebank, south-west of Sydney. SIMTA proposes to develop the DNSDC occupied site into an intermodal terminal facility and warehouse/distribution facility, which will offer container storage and warehousing solutions with direct rail access.

The SIMTA proposal will be undertaken as a staged development and it is intended that an overall Master Plan, for the entire site, be undertaken for the purpose of applying for Concept Plan approval under Part 3A of the *Environmental Planning and Assessment Act 1979 (EPA Act 1979).*

Hyder Consulting have been commissioned to provide engineering, environmental and ecologically sustainable development (ESD) services for the SIMTA proposal, including this preliminary climate risk assessment report.

The design of new infrastructure is generally based on past climate history. Future climate change raises the potential that adjustments to the historical pattern of climate events (eg heavy rainfall intensity) or gradual changes (eg shifts in annual or seasonal temperature and/or rainfall) may contribute to premature deterioration of infrastructure assets. Incorporating climate change adaptation measures early in the design and planning phases of new developments assists in enabling the SIMTA proposal to withstand potential impacts posed by future climate.

When addressing climate change, two approaches can be implemented:

- Climate change mitigation which aims to reduce greenhouse gas (GHG) concentrations in the atmosphere in order to rate the overall magnitude of future climate change (this issue has been addressed in a separate Hyder Greenhouse Gas Assessment Report).
- Climate change adaptation which aims to adjust human and natural systems to cope with new climatic conditions and improve their resilience to cope with new climatic impacts.

1.2. Scope of works

This report has been developed to support an Environmental Assessment for a Concept Plan approval under Part 3A of the *Environmental Planning and Assessment Act 1979* for the redevelopment of the SIMTA site and rail corridor. This report is specific to the SIMTA proposal.

The report includes:

- An assessment of the current climate regime of the region to outline climate related risks to construction and operation. This includes an assessment of flood risk on-site in accordance with relevant provisions of the NSW Floodplain Development Manual (2005) including the potential effects of climate change, regarding potential for increased rainfall intensity. The Hyder Consulting (2011) Flood Study and Stormwater management report includes a climate change sensitivity assessment with regard to rainfall intensity. This assessment is applicable to the SIMTA site only.

- An initial qualitative climate change risk assessment to identify adaptation opportunities to mitigate longer term operational risks associated with future climate change projections applicable to the SIMTA proposal site.

In addition to the above, SIMTA are committed to addressing the emerging physical risks of climate change and exploring mechanisms of adaptation. The SIMTA proposal will deliver required minimum levels of service throughout the entire design period. This will be achieved through the selection of materials and design of all structures to consider both the current climate regime and projected impacts of climate change. The climate variables which are most likely to influence the selection of materials and design of structures at the SIMTA proposal site are:

- Rainfall (average and extreme events)
- Temperature (average and extreme events)
- Wind speed
- Evaporation

This report informs other documentation prepared to address the Director-General's Requirements (DGRs) relating to stormwater and flooding issued on the 24 December 2010 (Hyder stormwater and flooding report 2011) (Table 2):

Table 2: Director General's Requirements

Director General's requirements	Sections addressed
Changes to the site's hydrology and an assessment of the hydrological impacts of the SIMTA proposal and the effects on flood characteristics on and off the site.	Section 2.4 Section 3

1.3. Structure of this report

This report is structured as follows:

- Section 2 outlines the SIMTA proposal existing environment, including site description and the historical climate record for the site, compiled from Bureau of Meteorology (BOM) records.
- Section 3 details the findings of a climate change risk assessment for the site in relation to the scope identified above.
- Section 4 outlines recommended adaptation options for addressing impacts posed by current climate and future climate change.

2. Existing environment

2.1. Site description

The SIMTA proposal (refer to Figure 1) is located in the Liverpool Local Government Area. It is 27 kilometres west of the Sydney CBD, 16 kilometres south of the Parramatta CBD, five kilometres east of the M5/M7 Interchange, two kilometres from the main north-south rail line and future Southern Sydney Freight Line, and 0.6 kilometres from the M5 motorway.

The SIMTA site, approximately 83 hectares in area, is currently operating as a Defence storage and distribution centre. The SIMTA site is legally identified as Lot 1 in DP1048263 and zoned as General Industrial under Liverpool City Council LEP 2008. The parcels of land to the south and south west that would be utilised for the proposed rail corridor are referred to as the rail corridor. The proposed rail corridor covers approximately 65 hectares and adjoins the Main Southern Railway to the north.

Existing land use includes vacant land, golf course, extractive industries, and a waste disposal depot. Native vegetation includes woodland, forest and wetland communities in varying condition. Georges River and Anzac Creek intersect the proposed rail corridor. The supplementary lands area to the south of the SIMTA site to the north of the existing East Hills Rail Line are part of Lot 3001 DP1125930 and Lot 1 DP1125930. To the west of the Georges River, the Glenfield Waste Disposal site comprises several lots that are currently all used for the purposes of the waste facility.

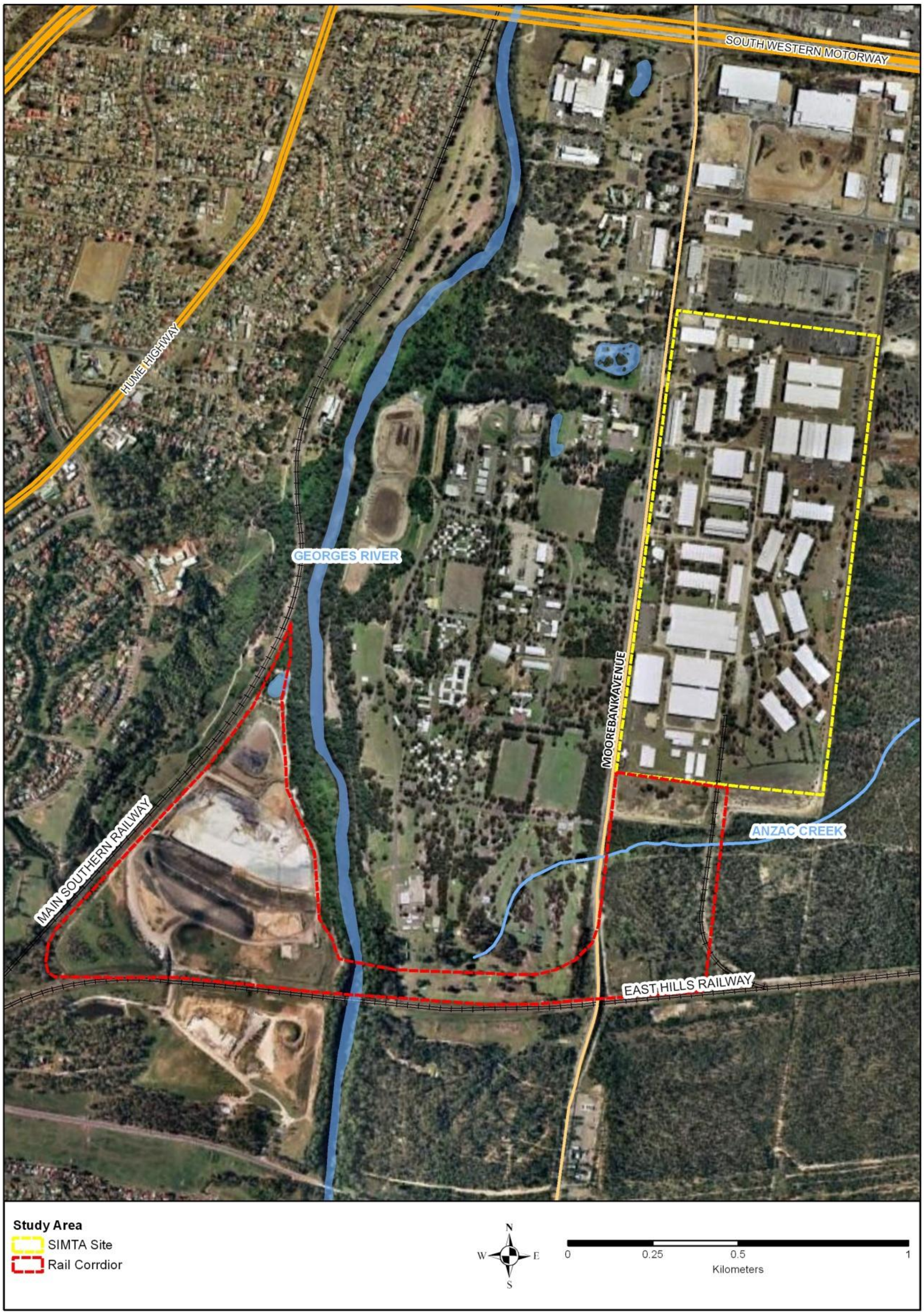

Figure 1: SIMTA proposal comprising of SIMTA site and rail corridor

2.2. Topography and natural drainage

The SIMTA site is relatively flat and lies at an elevation of between 14–16 metres AHD. A low hill on the eastern side of the site rises to about 22 metres AHD. There are no known creeks or rivers on the site, but some artificial surface drainage has been created in the south and north of the site, to channel waters to Anzac Creek.

The SIMTA proposal is within the catchment of Anzac Creek, a small tributary of the Georges River. A flood study of the area (BMT WBM 2008) indicated that the Anzac Creek catchment covered an area of 10.6 square kilometres. Anzac Creek is within the larger Georges River catchment, a sub-catchment of the Liverpool District catchment. Anzac Creek is four kilometres long and starts in the Department of Defence lands in Moorebank, flows north past the suburb of Wattle Grove and then underneath the M5 and Heathcote Road intersection. The creek then flows through Ernie Smith Recreation Reserve, flanked by the Moorebank Industrial Area to the west and the suburb of Moorebank to the east. The creek then flows under Newbridge Road, through McMillan Park and into Lake Moore at Chipping Norton.

The Georges River is adjacent to the SIMTA proposal, located within the Mid-Georges River catchment and the Liverpool District sub-catchment. It enters the Liverpool LGA from the south on the western side of the Defence Lands at Holsworthy and flows north, meeting with Glenfield Creek at Casula. From here the Georges River continues to flow north past the Liverpool City Centre, under Newbridge Road, past Lighthorse Park and over the Liverpool Weir. Downstream of the Liverpool Weir, the Georges River becomes slightly salty (estuarine) and is subject to tidal influences.

2.3. Current climate regime

The SIMTA proposal area has a temperate climate with warm summers and cool winters. The warmest month is January and the coldest month is July. Rainfall is fairly evenly spread through the year, but is slightly 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 (SOI). These events impact directly on climate variables.

Historic weather data was obtained from the Bureau of Meteorology (BOM) Bankstown Airport weather station (Station ID 066137) for rainfall, temperature, humidity and wind speed. The weather station is located at latitude 33.92 degrees south and longitude 150.99 degrees east which is about six kilometres north-east of the site. Records of weather data at the station commenced in 1968.

A review of these records found the following:

- Highest average rainfall is in February (439.8 millimetres).
- The highest daily rainfall event was in February 1990 with 439.8 millimetres being recorded.
- The lowest rainfall months being July and September (44.6 millimetres).
- The average maximum temperature ranges between 17.2 degrees Celsius and 28.1 degrees Celsius.
- The highest recorded maximum at the weather station was 44.8 degrees Celsius recorded on 18 January 2003.

- Mean wind speeds generally do not exceed 25 kilometres per hour at 9am or 3pm.
- Relative humidity in the area typically ranges between 45 per cent and 80 per cent.

2.3.1. Historic climate characteristics

Rainfall

Figure 2 shows the historic average monthly rainfall recorded at the Bankstown Airport weather station between the period 1968 to 2010. On average the highest rainfall month is February (439.8 millimetres) with the lowest rainfall months being July and September (44.6 millimetres). 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.

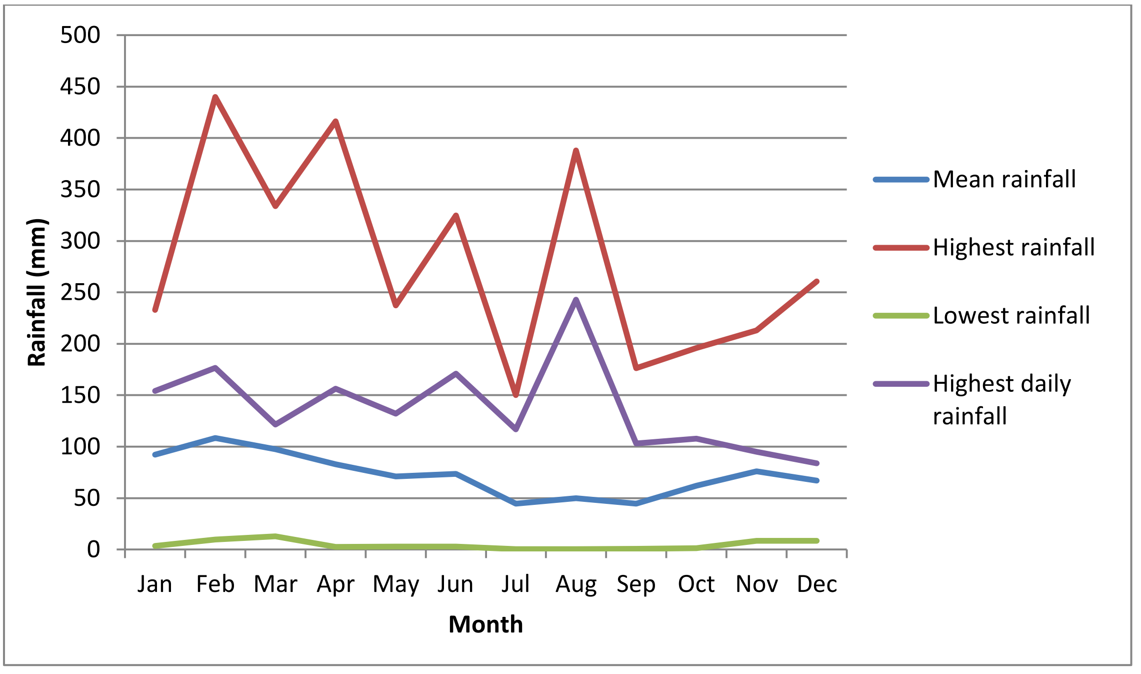

Figure 2: Average rainfall for the Bankstown Airport weather station (BOM 2010)

Temperature

Historic temperature data from the BOM was analysed for the period 1968–2010. Figure 3 shows the mean monthly maximum and minimum temperatures between 1968 and 2010. On average the hottest month is January (mean maximum 28.1 degrees Celsius) and the coolest is July (mean maximum 17.2 degrees Celsius). The highest and lowest recorded temperatures for each month during the 32 year monitoring period are also presented as an indication of the variability.

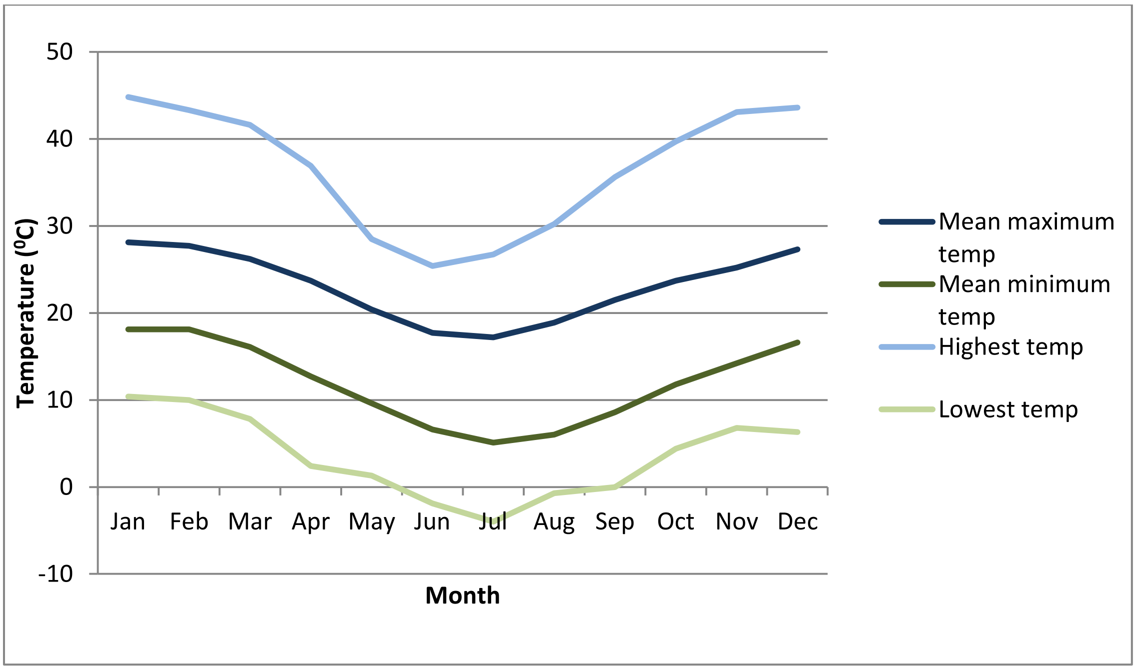

Figure 3: Average maximum and minimum temperatures recorded at the Bankstown Airport weather station (BOM 2010)

Figure 4 shows the mean number of days with temperatures greater than 30, 35 and 40 degrees Celsius recorded for each month since 1968. January had the most number of days above 30 degrees Celsius (8.8 days).

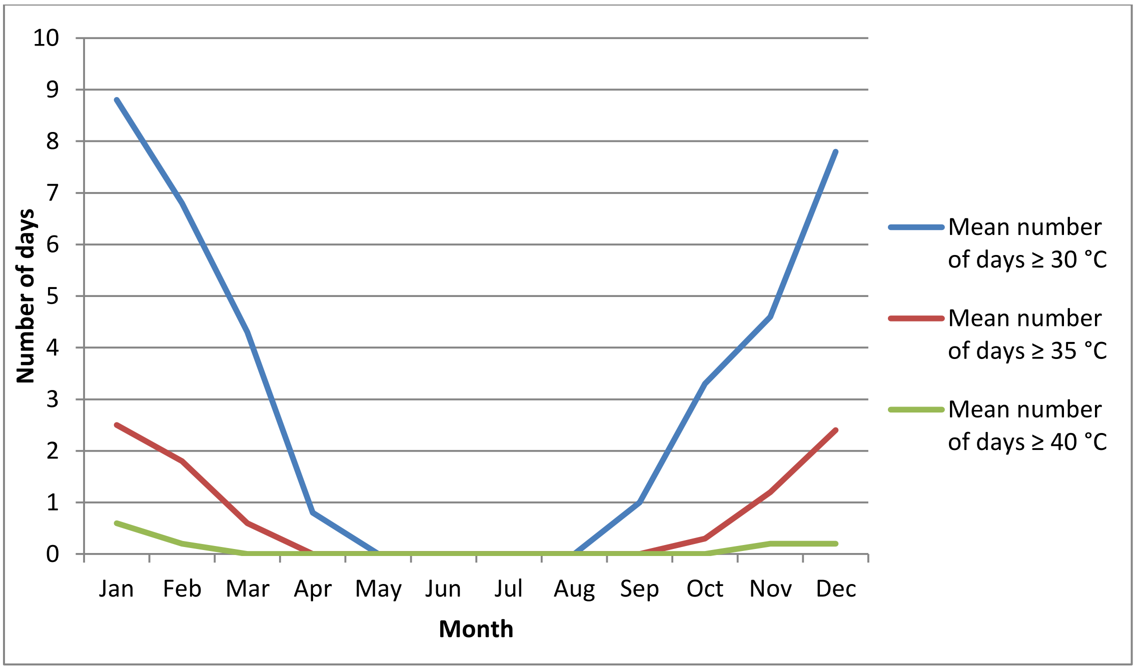

Figure 4: Mean number of days above 30, 35 and 40oC recorded at the Bankstown Airport weather station (BOM 2010)

Wind speed

The mean wind speed recorded at 9am and 3pm at the Bankstown Airport weather station is shown in Figure 5. Mean wind speeds were generally lower in the morning and during the months March to July.

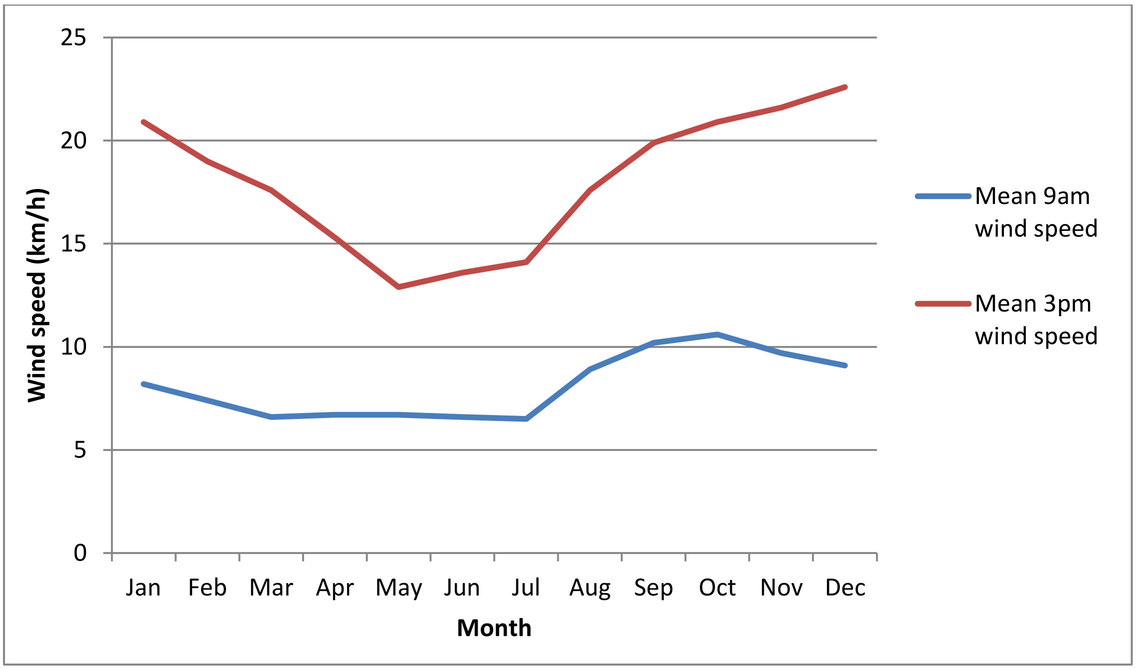

Figure 5: Mean 9am and 3pm wind speeds for each month (BOM 2010)

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 (Figure 6). This is likely to be due to the lower wind speeds in the morning that increase in the afternoon which has the effect of lowering the relative humidity.

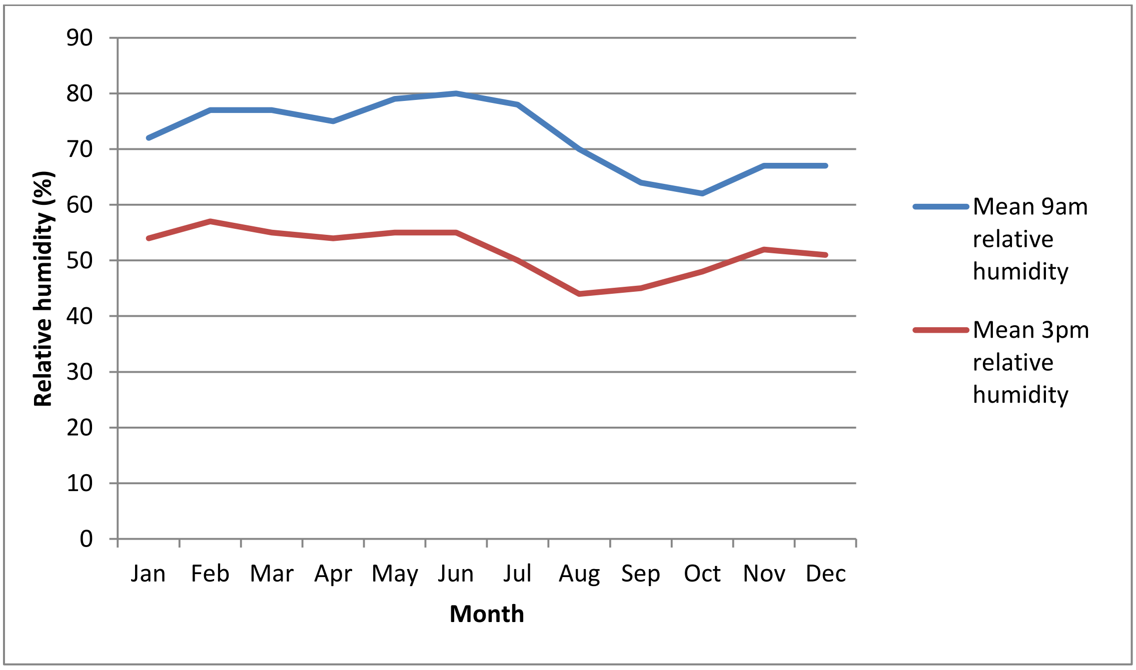

Figure 6: Mean 9am and 3pm relative humidity for each month (BOM 2010)

2.4. Existing climate risks

It is likely that the area is predisposed to the following natural hazards as a result of the climatic regime:

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

2.4.1. Flooding – SIMTA site

The eastern portion of the SIMTA 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 Probable Maximum Flood extent of inundation. The *Anzac Creek Floodplain Risk Management Study and Plan* was developed in 2008 (BMT WBM, 2008).

Figure 7, taken from the Liverpool Local Environment Plan 2008, shows the extent of flooding relevant to the SIMTA site. This indicates that although a small portion of the SIMTA site is on flood prone land, it is not part of a flood planning area.

2.4.2. Flooding - SIMTA rail corridor

The SIMTA rail corridor is intersected by the Anzac Creek catchment in the eastern section of the corridor, adjacent to the southern boundary of the SIMTA site. The Georges River dissects the central section of the rail corridor and flows almost parallel to the eastern boundary. Figure 7 shows that a significant proportion of the rail corridor is identified as flood prone land, particularly the eastern section, located south of the SIMTA site and in the Anzac Creek catchment and the central and western areas located in the Georges River catchment. The latter area of flood prone land is located within the Glenfield Waste Disposal facility (BMT WBM, 2008; Bewsher Consulting, 2005).

Figure 7: An excerpt from the Liverpool Local Environment Plan, with the SIMTA proposal shown in green (Liverpool City Council, 2008)

2.4.3. Bushfire

Figure 8 indicates the bushfire prone land in the area of the SIMTA proposal. The definition of bushfire vegetation categories is as follows:

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

Vegetation Category 1 bushfire prone land encroaches the SIMTA site to the east, south and west. For the rail corridor *Vegetation Category 1* accounts for a large portion of the eastern section as well as bordering the eastern boundary of the western segment (Figure 8).

Vegetation excluded from the bushfire vegetation categories are areas of vegetation less than one hectare, managed grasslands, managed botanical gardens, agricultural lands and mangroves. Areas of national parks and state forests estates are identified as bushfire vegetation Category 1.

The map was prepared under the *Rural Fires and Environmental Assessment Legislation Amendment Act 2002 (Amendment Act)*, which amends both the *Environmental Planning and Assessment Act 1979* and the *Rural Fires Act 1997*.

The SIMTA proposal also lies within nominated vegetation buffer areas for Category 1 bushfire vegetation. Areas mapped as Vegetation Category 1 bushfire prone land (Liverpool City Council 2010) require consideration under Planning for Bushfire Protection (PBP) (NSW RFS 2006b). PBP outlines planning considerations for development and applies to all “development applications” on land that is classified as “bush fire prone land” (NSW RFS 2006b). PBP does not explicitly provide planning considerations with regard to industrial development. Instead, industrial development should comply with the broad aims and objectives of Planning for Bushfire Protection (Shackleton C 2010, pers.comm., 29 July).

Asset Protection Zones (APZs) will be established and maintained, most likely along the eastern, southern and western boundaries of the proposal site and parallel to the rail link. Exact locations and widths of APZs for the SIMTA proposal will be defined by the Rural Fire Service Development Assessment and Planning division upon finalisation of development plans.

2.4.4. Hail, lightning and wind from severe thunderstorms

The Bureau of Meteorology 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.

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.

- OHS issues for site workers and employees.

2.4.5. Heat waves

There is no universal definition of a heat wave although according to BOM (2011) in a general sense it can be defined as a prolonged period of excessive heat.

Current risks to the SIMTA proposal from heat waves during construction and operation phase could include:

- Project delays due to occupational health and safety issues.
- Increased incidence of heat related illness on-site.
- Overheating of machinery and equipment.
- Degradation of building materials.

2.4.6. Summary

Existing risks associated with historical climate for the SIMTA proposal include:

- Flooding in the southern portion of the SIMTA site and within the rail corridor, particularly the eastern, central and western areas.
- Bushfire impacts along the eastern, southern and western boundaries of the proposal site and parallel to the rail corridor.
- Hail, lightening and wind associated with severe thunderstorms causing damage to infrastructure and structures.
- Heatwaves causing occupational health and safety issues as well impacts on machinery and equipment.

Consideration of the increase in frequency and magnitude of these impacts is addressed in Section 3.

Figure 8: Bushfire prone land (SIMTA proposal shown in green)

3. Potential climate change impacts

3.1. Introduction

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, 2007). 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 will 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 NSW Department of Planning does not have official guidelines in place for the assessment of climate change risk on major developments. In the absence of NSW Government guidelines the Australian Government's guidelines *Climate Change Impacts and Risk Management: A guide for business and government* have been applied for this assessment. The methods used within this assessment are also consistent with the Australian and New Zealand Standard for Risk management AS/NZS 31000-2009. The main objectives for this assessment are to:

- Identify risks from climate change impacts.
- Assess the risks.
- Identify adaptation options to mitigate the priority risks.

3.2. Climate change policy & planning instruments

Requirements for assessing potential risks associated with climate change on development projects and measures for adaptation are included in the following:

- ***Environmental Planning & Assessment Act 1979:*** contains a general requirement to address environmentally sustainable principles, including climate change.
- ***NSW State Plan:*** tackling climate change is identified as one of five 'Green State' priority areas and includes a Government commitment to a 60 per cent cut in greenhouse emissions by 2050.
- ***NSW Greenhouse Plan:*** Outlines a strategic approach to combating climate change in NSW for the period 2005-2008 and beyond. The plan includes goals and actions related to promotion of the likely impacts on NSW as well as the identification of appropriate adaptation strategies.

The only requirements relevant to inland sites are sited ie coastal planning documents accounting for sea level rise and flooding are not relevant to the current development site.

- ***NSW Climate Change Action Plan:*** NSW Government is currently in the process of finalising a draft *Climate Change Action Plan* which will replace the existing NSW Greenhouse Plan.

- ***NSW Floodplain Development Manual – management of flood liable land (2005):*** This manual indicates that responsibility for management of flood risk remains with local government. The Manual assists councils to balance the conflicting objectives of the floodplain through a risk management process. This process is likely to apply in the future when dealing with flooding risks posed by climate change.
- ***Floodplain Risk Management Guideline: Practical Consideration of Climate Change (2007):*** Provides advice on dealing with the impacts of climate change on existing development areas and discusses the potential changes to flood producing rainfall events caused by climate change.

3.3. Climate change projections

Climate change projection scenarios for the years 2030, 2050 and 2070 have been developed by the Intergovernmental Panel on Climate Change (IPCC, 2000) for various greenhouse gas emission scenarios. These emission scenarios combine a number of assumptions about demographic, economic and technological factors that are likely to influence future emissions. The emission scenarios were identified in the Special Report on Emissions Scenarios (SRES) and are referred to as the SRES scenarios (CSIRO, 2007).

Observed carbon dioxide concentrations, global mean temperatures and sea level rise have been tracking at the upper end of the IPCC scenario range from 1990 to 2006 (Raupach *et al*., 2007). As a result, CSIRO (2007) have advised that the mid and low projections are less likely than high projections. Furthermore, recent scientific research has found global emissions will most likely be higher than the IPCC's projections (Steffen, 2009). This is outlined in Figure 9.

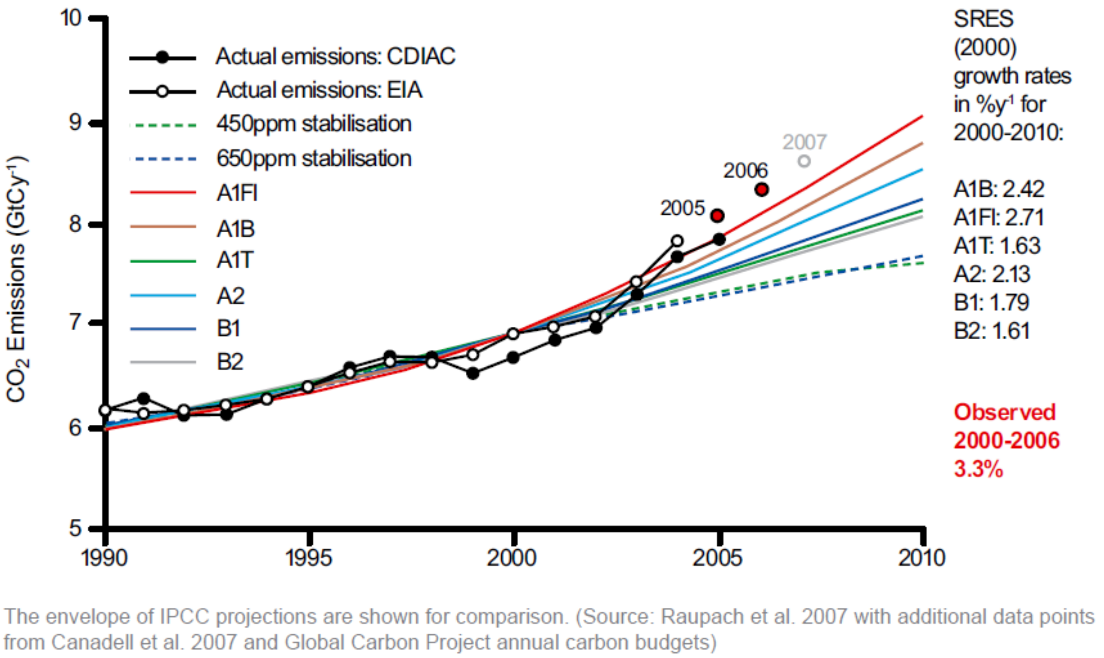

Figure 9: Observations of anthropogenic CO_2 emissions from 1990 to 2007 (Steffen, 2009)

The climate change projection data used to support the assessment of climate change risk has been obtained from the following sources:

- **NSW Climate Impact Profile (2010):** Department of Environment Water and Climate Change publication providing projected changes to temperature, rainfall and evaporation for the period 2050. The report also includes associated physical changes to runoff as a consequence of these climate variable changes. Note that these project changes are based on the A2 projections, potentially underestimating changes to climate variables.

- **Climate Change in NSW – Projected Changes in Climate Extremes (2004):** CSIRO publication providing projections for extreme temperature, extreme rainfall, extreme winds and extreme weather events for the period 2030 and 2070.
- **Analysis of future changes in extreme rainfall over Australia regions (2009):** CSIRO publication providing projections for extreme rainfall for the years 2055 and 2090 based on 12 global climate models and extreme value analysis.

Further detail on projected changes to climate variables is presented below.

3.3.1. Average temperature, precipitation and evaporation

Projected changes to mean daily minimum and maximum temperature, average seasonal precipitation and average seasonal evaporation are shown in Table 3.

Table 3: Summary of temperature and rainfall changes in the Sydney Region to 2050 projected under the A2 emissions scenario (DECCW, 2010)

Season	Minimum temperatures	Maximum temperatures	Precipitation	Evaporation
Spring	2.0-3.0^{o}C warmer	2.0-3.0^{o}C warmer	10-20% increase	10-20% increase
Summer	1.5-3.0^{o}C warmer	1.5-2.0^{o}C warmer	20-50% increase	10-20% increase
Autumn	1.5-3.0^{o}C warmer	1.5-3.0^{o}C warmer	No significant change	No clear pattern
Winter	1.5-3.0^{o}C warmer	2.0-3.0^{o}C warmer	10-20% decrease	No clear pattern

Regional projections for 2050 indicate that mean daily maximum and minimum temperatures are likely to increase in all seasons where the magnitude of projected increases ranges from 1.5 degrees Celsius to three degrees Celsius.

Rainfall projections for 2050 suggest that rainfall is likely to increase in all seasons except winter. Table 3 shows that summer rainfall is projected to increase by 20–50 per cent while winter rainfall is projected to decrease by 10-20 per cent.

Evaporation is likely to increase in spring and summer with projected increases of 10–20 per cent. However, no clear trend in projections is available for autumn and winter (DECCW, 2010).

3.3.2. Temperature and precipitation extremes

Extreme temperature

Climate change is expected to increase the annual frequencies of extreme daily temperatures (CSIRO, 2004). Days over 35 degrees Celsius are projected to increase from three in 2004 to four in 2030 and 2070 under low warming scenarios while the frequency of days over 35 degrees Celsius is expected to increase to six in 2030 and 18 in 2070 under high warming scenarios. Frequency of days exceeding 40 degrees Celsius are expected to increase from zero in 2004 to one in 2030 and four in 2070 under high warming scenarios (Table 4).

Table 4: Average number of days per year above 35°C and 40°C in Sydney 2004 and the years 2030 and 2070 under low and high warming scenarios (CSIRO 2004)

2004	2030	2070
Days exceeding 35°C		
3	4-6	4-18
Days exceeding 40°C		
0	0-1	0-4

Extreme rainfall

Global climate models and regional modelling studies indicate trends in increasing rainfall intensity. The median of the twelve climate models shows an 8.2 per cent mean increase in extreme rainfall intensity for the year 2055 and 19.75 per cent increase for the year 2090. However, it is important to note that there is high degree of variability across the twelve global climate models used for projecting changes in extreme rainfall as shown in Table 5.

Table 5: Percentage change in the 20 year return level for 1-day rainfall totals for the 2055 and 2090 IPCC A2 SRES scenarios relative to that of 1990 for eastern NSW (Rafter and Abbs, 2009)

	2055	2090
Extreme Rainfall (1 in 20 year event/24 hour duration), expressed as percentage intensity change compared to 1980 climate	8.2% (-3.2–39.9)	19.75% (-9.1–51.2)

*Figures in brackets indicate range of uncertainty across the Global Climate Models used for this study

3.3.3. Runoff

Modelled changes in runoff under climate change for the year 2050 are presented in Table 6. Climate change projections for the year 2050 indicate that redistribution of runoff across the seasons is likely with substantial increases in summer and minor decreases in winter in the Sydney region (DECCW, 2010).

Table 6: Modelled changes in runoff in Sydney Region under the A2 scenario for 2050 (adapted from DECCW, 2010)

Period	Runoff depths		
	Magnitude and direction of change	**Degree of agreement***	**Range of projected change**
Spring	Moderate decrease	Likely	-18% to +5%
Summer	Substantial increase	Very likely	0% to +34%
Autumn	Moderate increase	Likely	-5% to +23%
Winter	Minor decrease	Likely	-13% to +7%
Annual	Minor increase	About as likely as not	-7%-13%

*Degree of agreement based on the number of Global Climate Models (out of four) which agree with the direction of projected average change

3.3.4. Bushfire risk

More frequent high temperature days, increased evaporation rates and changes to rainfall patterns under climate change for the year 2050 are likely to increase fire frequency and intensity, although the return period of fires is considered likely to remain within the current domain of acceptable fire intervals of 10–30 years toward the year 2050. Intensification of fire dangers within the existing fire season (spring to early summer) is expected over most of the Sydney region. Under climate change the fire season will likely be longer, extending into late winter and lengthening into late summer. According to DECCW (2010) 'very high' to 'extreme' fire danger days are projected to increase by 10–50 per cent under the A2 climate change scenario for the year 2050.

3.3.5. Hail, lightning and wind from severe thunderstorms

CSIRO projections indicate that that hail risk may increase over the south east coast of Australia as outlined in Figure 10 (CSIRO 2007).

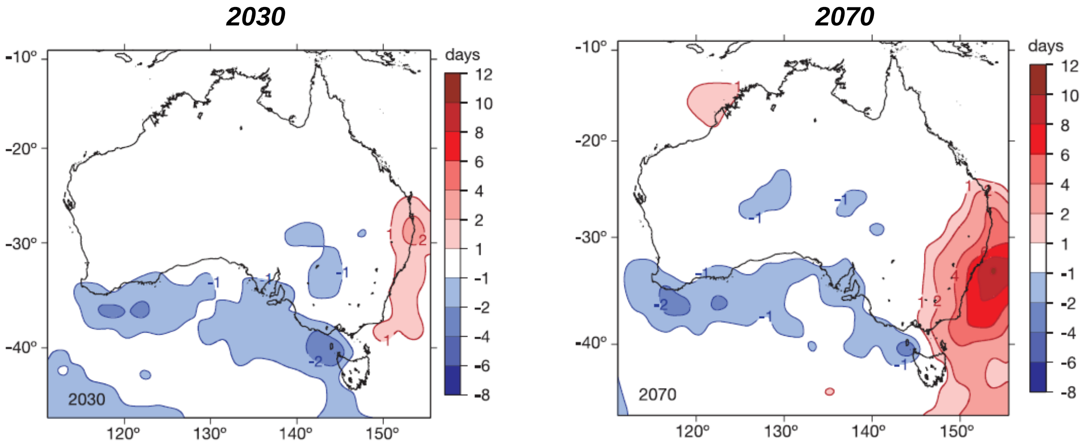

Figure 10: Projected changes in hail risk (hail-days per year) for 2030 and 2070. Blue regions indicate a decrease in hail risk and red regions indicate an increase in hail risk. The large-hail risk for this region is projected to almost double, increasing by between 4 to 6 days per year (CSIRO 2007).

Extreme monthly wind speed (strongest five per cent) is also projected to increase in summer and spring under the A2 projected climate change scenario in the Sydney region. In autumn and winter there is a tendency for decreases in extreme wind speed (CSIRO, 2004).

3.4. Potential impacts to development

Potential impacts to the SIMTA proposal arising from projected changes to climate variables are presented in Table 7. Note that hail, storms and fire are symptomatic outcomes from the interaction of each of the climate variables below.

Table 7: Potential impacts on development site

Climate variable	Potential impact
Rainfall/runoff	• Extended periods of inundation resulting from flood events. • Increased discharge events impacting on off-site creek and river catchment water quality. • Flooding of rail line impacting access to the SIMTA site. • Hydrology impacts on Georges River and Anzac Creek and catchment (including biodiversity). • Under-engineering of WSUD and flood mitigation structures.
Temperature and evaporation	• Asset deterioration and failure. • Increased brownouts. • Impacts on efficiency of building mechanical systems. • Dieback of plantings (WSUD and streetscape). • Increased frequency and intensity of bushfire events. • Reduced water availability. • Effects on WSUD design and engineering criteria.
Extreme winds	• Increase in number of extreme wind days during spring and summer. • Effects of extreme winds on design and engineering criteria.

3.5. Risk and adaptation assessment methodology

An overview of the climate change risk and adaptation assessment methodology is presented in Table 8.

Table 8: Overview of climate change risk and adaptation assessment methodology

Task	Activity
Context setting–climate change scenarios, scope of assessment, evaluation framework	• Identify appropriate climate change scenarios for Moorebank. • Determine projected climate changes for temperature, rainfall, and extreme events. • Establish the scope for the assessment and determine the evaluation framework to be used.
Desktop risk assessment–identify, evaluate and analyse the risks	• Conduct desktop based risk assessment. • Identify and analyse the risks to the SIMTA proposal from projected climate change impacts using agreed risk management framework.

Task	Activity
Adaptation assessment–adaptation actions to minimise priority risks	• Evaluate and rank preferred adaptation options (potential controls). • Review the initial assessment and place risks into priority categories.
Climate change adaptation report	• Deliver climate change report to be incorporated into EA.

3.5.1. Context setting

Climate change projections relevant to the SIMTA proposal have been described in Section 3.3.

A risk evaluation framework was developed and used to assign risk levels to impacts identified in the desktop assessment phase. Key elements of this framework are documented below in section 3.5.2.

3.5.2. Desktop based risk assessment

Risk identification

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 2070. Risk statements were developed for the SIMTA 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 A).

Risk analysis

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

Table 9: Likelihood ratings

Rating	Recurrent risks	Single events
Almost certain	Could occur several times a year.	More likely than not – probability greater than 50%.
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% 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: Consequence ratings

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.

A total of 30 risk statements were identified for the SIMTA proposal lifecycle, including construction, operation and decommissioning. Climate change risks apply to all phases, however, the majority of climate change risks identified are most applicable to the operational phase. Controls identified for the operational phase will equally apply to the other phases of the SIMTA proposal. These are presented in full in Appendix A and priority risks for the SIMTA proposal are summarised in Table 12. The likelihood and consequence for each risk statement was assessed and the risk rating was determined using the following matrix.

Table 11: Risk matrix

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

Prioritised risks

The initial suite of analysed risks was evaluated relative to one another to confirm the final risk ratings. Particular attention was paid to the high and moderate risks to prevent any inconsistency in assessment leading to a risk being inadvertently promoted or relegated as a priority risk (high and extreme).

Overall, a total of four priority risks (high or extreme) were identified as shown in Table 12 for the SIMTA proposal.

Table 12: Priority climate change risks applicable to SIMTA proposal

Climate Variable	Primary Impact	Risk statement	Risk rating
Rainfall	Extreme rainfall	Flooding of buildings and infrastructure causing higher maintenance costs and reduced asset life	High
		Onsite detention basins are not designed to cope with future rainfall patterns leading to flood damage	High
		Flooding of rail infrastructure located within Anzac Creek sub-catchment causing declines in serviceability due to operational impacts	High
Storms	Increased damage (including hail damage and thunderstorms)	Damage to structural enhancements/add-ons to buildings	High
Days over 35°C	Bushfire	Increased bushfire frequency and intensity causing structural damage to buildings and infrastructure creating higher maintenance costs and reduced asset life	High
		Reduced serviceability of rail line resulting in reduced asset life leading to operational impacts for intermodal facility	High
	Heatwaves	Rail line buckling from sudden temperature rises causing higher maintenance costs and reduced asset life	High
N/A	Increase in atmospheric CO_2 resulting in carbon pricing	Increased operating costs due to higher carbon pricing	High

3.5.3. Assumptions

Assumptions used in determining climate change risks include the following:

- This risk assessment is based on qualitative techniques to identify, analyse and evaluate risks. This is largely attributable to the subjectivity attributable to identification of likelihoods or consequences associated with climate change.
- Climate change projection data are not location sensitive or specific and are regionally generalised. As a result there may be subtle variations in applicability to the SIMTA proposal location. It is assumed that any local variability would not significantly alter the likelihood and consequence rating scales as assessed.

- Climate change risks were identified primarily via desktop review, informed by a site visit for understanding the local context.

4. Proposed mitigations and controls

The current climate regime for the SIMTA proposal will be considered during construction and appropriate actions adopted, where practical to mitigate risks to an appropriate level during construction and operation. Specific recommendations include:

- Undertake internal drainage design, accounting for average and peak rainfall events and identify water quantity and water quality measures, where appropriate.
- Assess impacts of development on flood conditions in Anzac Creek and Georges River (See SIMTA Moorebank Intermodal Terminal Facility: *Flood Study and Stormwater* ((2011)), Hyder Consulting, North Sydney.)
- Determine bushfire planning controls consistent with *Planning for Bushfire Protection.* (See SIMTA Moorebank Intermodal Terminal Facility: *Hazards and Risk Assessment* ((2011)), Section 5, prepared by Hyder Consulting, North Sydney.)

Priority climate change risks, including those rated as 'extreme' and 'high' were subject to a desktop review to determine applicable adaptation measures which could reduce the potential risk over the life of the SIMTA proposal. Adaptation measures considered for application included existing and potential controls.

Implementation of the recommended adaptation measures for control and mitigation of priority risks, as shown in Table 13, would mitigate potential risks posed by climate change, and result in the nominated level of residual risk.

Table 13: Adaptation actions for mitigation of priority climate change risks

Risk	Risk Rating	Adaptation Measure	Residual Risk*
Flooding of buildings and infrastructure causing higher maintenance costs and reduced asset lifecycle	High	Incorporate climate change sensitivity analyses for 20 per cent increase in peak rainfall and storm volumes into flood modelling assessment to determine system performance	Moderate
	High	Incorporate appropriate flood mitigation measures, where practical within the design to limit the risk to acceptable levels	Low
Flooding of rail infrastructure located within Anzac Creek sub-catchment causing declines in serviceability due to operational impacts	High	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.	Low
Flood management structures are not designed to cope with future rainfall patterns leading to flood damage	High		Low
Storm damage to structural enhancements/add-ons to buildings	High	Use of appropriate materials and engineering design capable of withstanding potential impacts posed by storm damage	Low
Increased bushfire	High	Incorporate appropriate strategic	Moderate

Risk	Risk Rating	Adaptation Measure	Residual Risk*
frequency and intensity causing structural damage to buildings and infrastructure (including rail line) creating higher maintenance costs and reduced asset life		protection zones, including asset protection zones into design to limit bushfire risk to acceptable levels Control of performance of hotworks on total fire ban days during construction and operation, particularly within any defined asset protection zones.	
Increased heatwave frequency resulting in rail line buckling from sudden temperature rises causing higher maintenance costs and reduced asset life	High	Maintain track stability through regular maintenance, use concrete sleepers in place of wooden ones and use preventative measures in the event of heatwaves (eg speed restrictions, warehouse ventilation for improved heat removal)	Moderate
Increased operating costs due to higher carbon pricing	High	Consider further assessment of Marginal Abatement Cost Curves to assess commercial opportunities of reducing reliance on single energy source	Moderate

* **Residual risk rating**– Likelihood multiplied by the impact the risk happening **after** controls are in place. This rating cannot be calculated unless there are controls in place that have been inherently assessed.

Application of the measures identified above during detailed design would lead to the adoption of specific actions relating to climate change risks.

The above residual risk analysis indicates that the SIMTA proposal, including appropriate adaptation safeguards as identified in this report, will give rise to low to moderate risk in relation to the identified climate change risks.

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Appendix A

Climate Change Risk Register

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Climate change impact		Risk statements	Likelihood	Consequence	Risk rating
Primary impact	**Secondary impact**				
Extreme wind speed	N/A	Structural damage to buildings and infrastructure creating higher maintenance costs and reduced asset lifecycle	Unlikely	Major	Moderate
		Structural damage to buildings and infrastructure creating higher insurance costs	Likely	Minor	Moderate
Extreme rainfall events		Increased runoff and sediment loads to waterways impacting water quality in local creeks and river systems	Likely	Moderate	Moderate
		Flooding of buildings and infrastructure causing higher maintenance costs and reduced asset life	Likely	Major	High
		Flooding of buildings and infrastructure causing higher maintenance costs and reduced asset life	Likely	Major	High
		Flooding of buildings and infrastructure causing higher insurance costs	Likely	Minor	Moderate
		Extended periods of inundation reduce serviceability of buildings and infrastructure causing operational impacts	Moderate	Moderate	Moderate

Climate change impact		Risk statements	Likelihood	Consequence	Risk rating
Primary impact	Secondary impact				
		Erosion of green space causing increased maintenance costs	Moderate	Insignificant	Low
		Rising groundwater level impacts on foundations/infrastructure leading to asset deterioration	Unlikely	Moderate	Moderate
		Flood management structures are not designed to cope with future rainfall patterns leading to flood damage	Moderate	Major	High
		Flooding of rail infrastructure located within Anzac Creek sub-catchment causing declines in serviceability due to operational impacts	Moderate	Major	High
Storm events (including hail and thunder storms)		Structural damage to buildings and infrastructure creating higher maintenance costs and reduced asset life	Unlikely	Minor	Low
		Structural damage to buildings and infrastructure creating higher insurance costs	Likely	Minor	Moderate
		Damage to structural enhancements/add-ons to buildings	Likely	Major	High

Climate change impact		Risk statements	Likelihood	Consequence	Risk rating
Primary impact	Secondary impact				
More days over 35 degrees	Brownout				
		Reduced serviceability of buildings and infrastructure causing closure/reduced operating hours for intermodal facility	Unlikely	Major	Moderate
		Reduced efficiency/failure of property mechanical services leading to reduced operating hours for intermodal facility	Unlikely	Major	Moderate
		Reduced serviceability of safety/security systems causing increased costs/loss of reputation	Unlikely	Major	Moderate
	Increased bushfire				
		Structural damage to buildings and infrastructure creating higher maintenance costs and reduced asset life	Moderate	Major	High
		Structural damage to buildings and infrastructure creating higher insurance costs	Likely	Minor	Moderate
		Reduced serviceability of rail line resulting in reduces asset lifecycle leading to operational impacts for intermodal facility	Likely	Major	High

Climate change impact		Risk statements	Likelihood	Consequence	Risk rating
Primary impact	Secondary impact				
		Reduced serviceability of buildings and infrastructure leading to reduced operating hours for intermodal facility	Moderate	Moderate	Moderate
			Likely	Major	Low
	Heatwave				
		Accelerated deterioration of materials causing reduced asset life and higher maintenance costs	Moderate	Minor	Low
		Reduced serviceability of buildings and infrastructure leading to reduced operating hours for intermodal facility	Moderate	Minor	Low
		Higher demand for air conditioning causing higher operating costs	Moderate	Minor	Low
		Rail line buckling from sudden temperature rises causing higher maintenance costs and reduced asset life	Moderate	Major	High

Climate change impact		Risk statements	Likelihood	Consequence	Risk rating
Primary impact	Secondary impact				
	Loss of working days				
		Loss of productivity leading to reduced operating hours for intermodal facility	Unlikely	Minor	Low
		Loss of productivity causing delays in project implementation	Unlikely	Minor	Low
Increase in average temperature	Deterioration of materials				
		Accelerated deterioration of materials causing higher maintenance costs	Likely	Minor	Moderate
Reduction of average rainfall	Reduced water supply				
		Higher water charges creating additional operating costs for intermodal facility operation	Likely	Minor	Moderate
		WSUD measures (onsite) do not meet performance requirements leading to increased retrofitting costs	Unlikely	Minor	Low
Increase in atmospheric CO2	Carbon pricing	Increased operating costs due to higher carbon pricing	Almost Certain	Moderate	High