

Appendix H – Climate Change Pre-Screening

Pre-Screening Climate Change Risk Assessment

Wyong Town Centre

19-Nov-2023
Wyong Town Centre CRA Pre-Screening
Doc No. WTCPWD-AECM-NWW-SB-RPT-000001

Pre-Screening Climate Change Risk Assessment

Wyong Town Centre

Client: Transport for NSW

ABN: 18 804 239 602

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Quality Information

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Verified by Adam Davis

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Acronyms and Glossary

Table 1 Acronyms

Acronym	Definition
AR5	IPCC's Fifth Assessment Report
AR6	IPCC's Sixth Assessment Report
AQI	Air Quality Index
BoM	Bureau of Meteorology
CEMP	Construction environmental management plans
CSIRO	Commonwealth Scientific and Industrial Research Organisation
IPCC	Intergovernmental Panel on Climate Change
LGA	Local Government Area
NARClIM	NSW and Australian Regional Climate Modelling
RCP	Representative Concentration Pathways
REF	Review of Environmental Factors
SSPs	Shared Socio-economic Pathways
TERM	TfNSW Enterprise Risk Management
TfNSW	Transport for NSW

Table 2 Glossary

Key Term	Definition
Adaptation (to climate change)	Actions undertaken to manage or reduce the adverse consequences of climate change, as well as to harness any beneficial opportunities. Adaptation actions may include physical changes to an asset to achieve or facilitate adaptation including changes/upgrades to technology and equipment or design standards for particular project elements. Adaptation actions may also include scheduling regular reviews or inspections, development of an emergency management plan, and development of design guidelines.
Climate change	Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.
Climate hazards	'Hazard' is defined by the Intergovernmental Panel on Climate Change (IPCC) as: <i>"The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources."</i> ¹
Climate projections	Scientifically derived estimations of how different variables (such as temperature, precipitation, wind, solar radiation, sea level rise) in our climate and weather will be affected by increases in greenhouse gasses in the Earth's atmosphere.
Consequence	The consequence of a risk is based on the outcome of an event affecting objectives. It can be positive or negative. This has been assessed in line with TfNSW's risk management framework.
Likelihood	The likelihood of a risk is based on the chance that it will occur. This has been assessed in line with TfNSW's risk management framework.
Physical risk	Physical risk is the risk of direct damage to TfNSW's assets and services, supply chains, or liability due to failure to foresee losses from physical impacts of climate change. Physical risks can be: <ul style="list-style-type: none"> • Acute risks – event driven (shocks) • Chronic risks – longer-term shifts in climate patterns (stresses)

¹ Intergovernmental Panel on Climate Change, 2014. Climate Change 2014: Impacts, Adaptation and Vulnerability. Page 5.
https://www.ipcc.ch/site/assets/uploads/2018/03/ar5_wgII_spm_en-1.pdf

Executive Summary

Transport for New South Wales (TfNSW) is committed to building the climate resilience of its current and future projects. TfNSW propose to upgrade the Pacific Highway through Wyong Town Centre (the Project). The Project covers a length of about 2.4 km between Johnson Road and Cutler Drive intersections and is centred around the Wyong train station. In line with the Transport for New South Wales *Climate Risk Assessment Guidelines* Version 4.1, this report provides a climate risk assessment pre-screening for the Project.² This assessment provides guidance for a full climate risk assessment that will be undertaken by the Project contractor.

Through an analysis of historical events and climate projection, the climate effects relevant to the Project scope of works are listed in Table 3.

Table 3 Primary and Secondary Climate Effects Relevant to the Project

Primary Climate Effects	Secondary Climate Effects
Mean temperature	Extreme temperature and heatwaves
Average annual rainfall	Bushfire weather
Extreme rainfall	Storm events
	Flooding
	Drought
	Sea Level rise and coastal flooding

The pre-screening assessment identified the climate effects relevant to the construction and operational phases of the Project for two future time periods: the short-term time period of 2030; and a longer-term time period of 2090. Climate change risks for key climate hazards (Table 3) include:

- For the construction phase a total of 21 risks were identified, 13 of which were rated as medium risk which was the highest risk identified (see Table 4)
- For the operational phase, 28 risks were identified. For the 2030 time period, 13 risks were rated as medium and two were rated high. For the 2090 time period, 16 risks were rated medium and two were rated high. There were no extreme risks identified in this assessment (See Table 5)

The key climate hazards identified through the risk assessment included an increase in extreme temperatures and extreme rainfall and flooding.

Table 4 Summary of Construction Risk Assessment

Risk rating	2030
Low	8
Medium	13
High	0
Very high	0
Total risks	21

Table 5 Summary of Operational Risk Assessment

Risk rating	2030	2090
Low	13	10
Medium	13	16

² Transport for NSW 2021, Transport for New South Wales Climate Risk Assessment Guidelines version 4.1

Risk rating	2030	2090
High	2	2
Very high	0	0
Total risks	28	28

It is recommended that risk management and adaptation actions identified in this report through engagement with the design team are carried forward into the detailed design and construction phases of the Project. Per the Transport for New South Wales *Climate Risk Assessment Guidelines* Version 4.1 it is recommended a complete Climate Risk Assessment is undertaken as early as possible in the project life cycle, for this Project it should be undertaken during the detailed design phase.³ The CRA includes a facilitated risk assessment workshop to refine and finalise risks and actions. The following is a list of recommended CRA stakeholders and participants as per the Transport for New South Wales *Climate Risk Assessment Guidelines* Version 4.1 relevant to road projects⁴:

Table 6 Recommended CRA stakeholders and participants

TfNSW	Discipline leads (where available and part of the project team)
Sustainability Manager	Architecture & Services (including urban design and landscaping)
Project Sustainability Officer	Civil & Structures (including stormwater)
Project Design Manager	Construction/maintenance
Project Engineer	Drainage
Technical Manager	Electrical
Asset management team representative	Environment
	Operations
	People

³ Transport for NSW 2021, Transport for New South Wales Climate Risk Assessment Guidelines version 4.1

⁴ Transport for NSW 2021, Transport for New South Wales Climate Risk Assessment Guidelines version 4.1 pg. 46-47

1.0 Introduction

Transport for New South Wales (TfNSW) is committed to building the climate resilience of its current and future projects. This Climate Risk Assessment (CRA) Pre-Screening has been prepared in accordance with the TfNSW *Climate Risk Assessment Guidelines* Version 4.1⁵. These CRA Guidelines provide a common methodology for the preparation of climate risk and resilience assessments in line with the TfNSW *Sustainable Design Guidelines* (SDG) Version 4.0 requirements.⁶

1.1 Project Overview

TfNSW propose to upgrade the Pacific Highway through Wyong Town Centre (the Project). The Pacific Highway is the main thoroughfare through Wyong town Centre and a major arterial road connecting to the northern suburbs of the Central Coast, Sydney and further north through to Brisbane. The Project covers a length of about 2.4 km between Johnson Road and Cutler Drive intersections and is centred around the Wyong train station. Wyong is a coastal centre located 3 km north of Tuggerah and approximately 50km southwest of Newcastle.

The key project benefits include:

- Improve safety for all road users, including cyclists and pedestrians
- Improve traffic flow and provide reliable road access to and through Wyong town centre
- Provide a road environment that maintains as far as practicable the town's identity while providing opportunity for future revitalization and growth
- Ensure the highway upgrade is compatible with current and future public transport services
- Provide improved facilities for pedestrians and cyclists.

Key features of the Project will include:

- Widening of about 2.4 kilometres of the Pacific Highway between Johnson Road, Tuggerah and just north of Cutler Drive, Wyong to two lanes in each direction with a central median to separate northbound and southbound traffic
- Replacement of the existing Pacific Highway Road bridge over the Wyong River with a new road bridge for northbound and southbound traffic
- Footpath generally along the western side of the highway
- Off-road cycle path generally along the eastern side of the highway
- Reconfiguration of car parking including provision of a dedicated rail commuter car park east of Wyong railway station
- Upgrading Highway intersections with McPherson Road, Church Street, Rose Street, Anzac Avenue, North Road, and Cutler Drive
- Intersection adjustments at River Road, Alison Road, Robley Lane and Apex Park
- Replacement of the Rose Street Bridge over the rail line with a new longer and wider bridge
- Upgrade of Howarth Street intersections at Rose Street, Warner Avenue and Panonia Road
- Dedicated bus stops along the Highway in both directions and relocation of bus layover facilities to the east of the railway station
- Improved disabled parking and taxi spaces east of the railway station located close to access lifts and stairs

⁵ Transport for NSW 2021, TfNSW Climate Risk Assessment Guidelines version 4.1

⁶ Transport for NSW 2017, TfNSW Sustainable Design Guidelines Version 4.0

- Improvements to River Road, Panonia Road and South Tacoma Road which include pedestrian footpaths, kerbing, and guttering
- Demolition and removal of the locally heritage listed former Station Master's Cottage and Warner Shops
- Urban design improvements and landscaping throughout the proposal area, including relocation of existing palm trees along the highway where feasible
- Retaining walls of various heights and locations
- Property adjustment.

Additional features of the Proposal would include the following:

- Vegetation clearing
- Ancillary sites
- Utility adjustment or relocation, including electricity
- Provision of permanent access roads for maintenance activities
- Earthworks, including construction of embankments and existing fill embankment stabilisation measures
- Urban design improvements and landscaping works, including relocation of existing palm trees along the highway
- Demolition and removal of heritage listed former Station Master's Cottage and Warner Shops.
- Finishing roadworks including pavement, kerb and gutter, signage, lighting and line marking works
- Temporary ancillary facilities during construction including site offices, site compounds, laydown areas, and temporary access tracks
- Demobilisation of ancillary facilities following the completion of the construction of the Proposal
- Active travel routes (including bike lanes).

The regional context and key features of the design are presented in Figure 1 and Figure 2 respectively.

The design life requirement of major elements, as stipulated in Table PS201.1 of the brief, are listed below in Table 7.

Legend

- Proposal area
- Railway
- Motorway
- Main road
- National park/reserve
- Watercourse

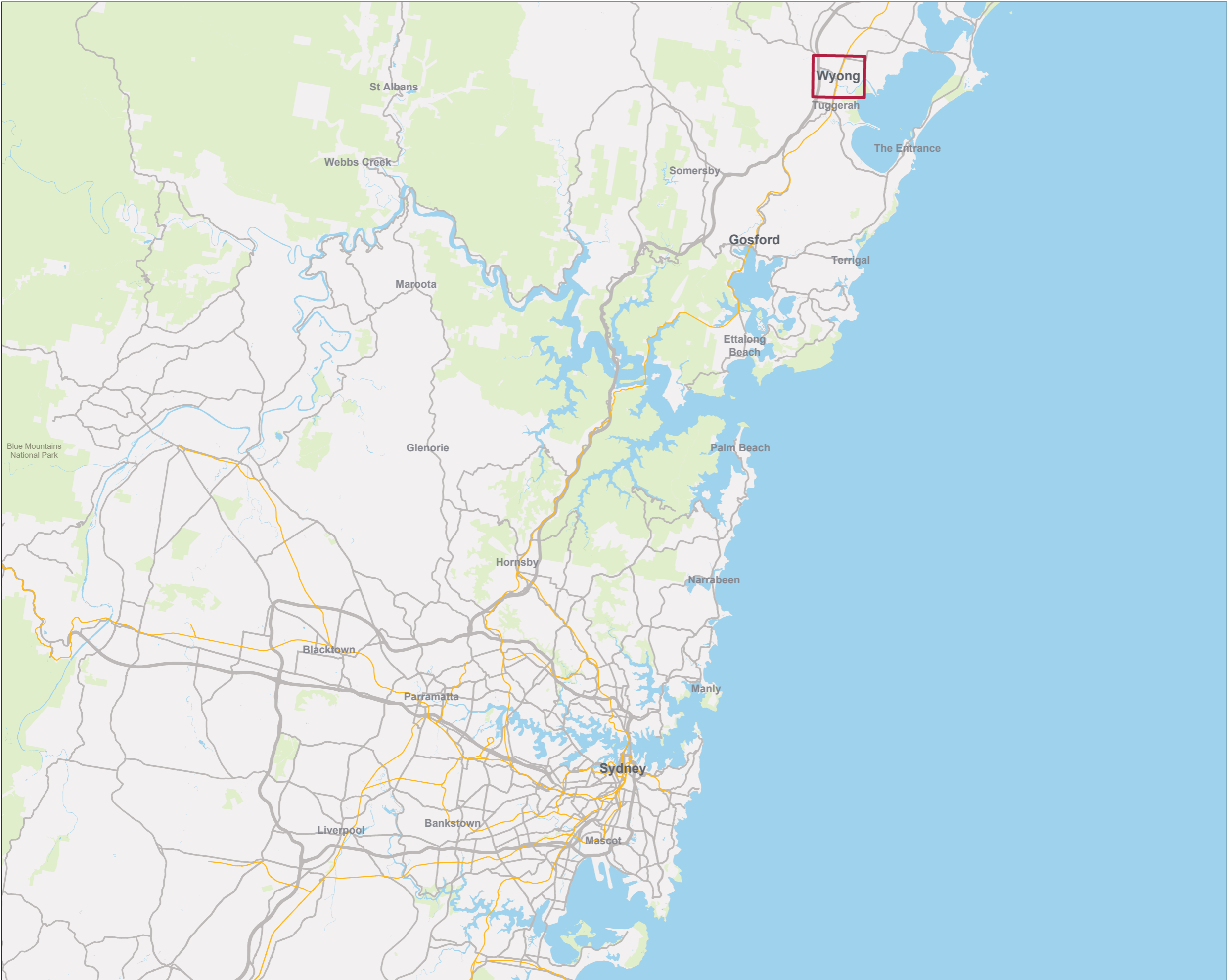
FIGURE 1: LOCATION OF
THE PROPOSED MODIFICATION

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0 200 400 m

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CREATED BY:
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COORDINATE SYSTEM:
GDA 1994 MGA ZONE 56

Legend

Proposal area

Railway

Motorway

Main road

Watercourse

**FIGURE 2:
PROPOSED MODIFICATION**

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Table 7 Design life of assets

Asset	Minimum Design life (years)
Inaccessible drainage elements	100
Drainage elements that are accessible for refurbishment and maintenance including sedimentation and detention basins	40
Sign faces	10
Sign support structures and other roadside furniture	50
Fences including fauna fences	20
Lighting and electrical equipment	20
Bridge and Tunnel structures, including underpasses, overpasses and wildlife tunnels	100
Retaining Walls including reinforced soil walls	100
Noise barriers, noise attenuation devices and headlight screens	50
Pavements <ul style="list-style-type: none"> Main carriageway including ramps Local roads 	40 20
Local Road embankment and support structures	100
Embankments, including reinforced embankments	100
Cut batters, including batter treatments	100
Timber furniture	30
Assets not detailed above	Typical industry values for similar Assets of a high standard and quality
Intersection capacity improvements	10

1.2 Purpose of this report

The purpose of this report is to provide a climate change pre-screening risk assessment for the upgrade of the Pacific Highway through Wyong Town Centre.

This report aims to analyse the potential impacts of climate change on the Project's objectives and deliverables. By conducting a pre-screening risk assessment, the report seeks to identify whether a comprehensive climate change risk assessment is necessary to ensure the Project's long-resilience to climate-related hazards. The findings presented will serve as a foundation for decision-making, guiding the inclusion of appropriate adaptation actions throughout the entire lifecycle of the Project.

1.3 Approach

This report is structured as follows:

- **Section 2** outlines the relevant guidelines and methodology used for the climate resilience assessment.
- **Section 3** provides the climate change context for the local area and the current climate change projections for the region.
- **Section 4** presents the climate risk and resilience assessment.
- **Section 5** presents high level climate change adaptation actions for the Project.
- **Section 6** provides a summary of the assessment and next steps.

2.0 Method

2.1 Risk assessment guidelines

The climate change pre-screening risk assessment provided in this report has been undertaken in line with the following relevant standards and guidelines:

- The climate change projections used in this assessment have been derived and collated in accordance with AS 5334:2013 *Climate change adaptation for settlements and infrastructure*.
- The climate change risks to the works have been assessed in line with TfNSW *Climate Risk Assessment Guidelines* Version 4.1⁵.

2.2 Risk assessment methodology

This assessment methodology followed Steps 1 through 5 of the CRA step by step process outlined within the TfNSW *Climate Risk Assessment Guidelines*, see Figure 3.

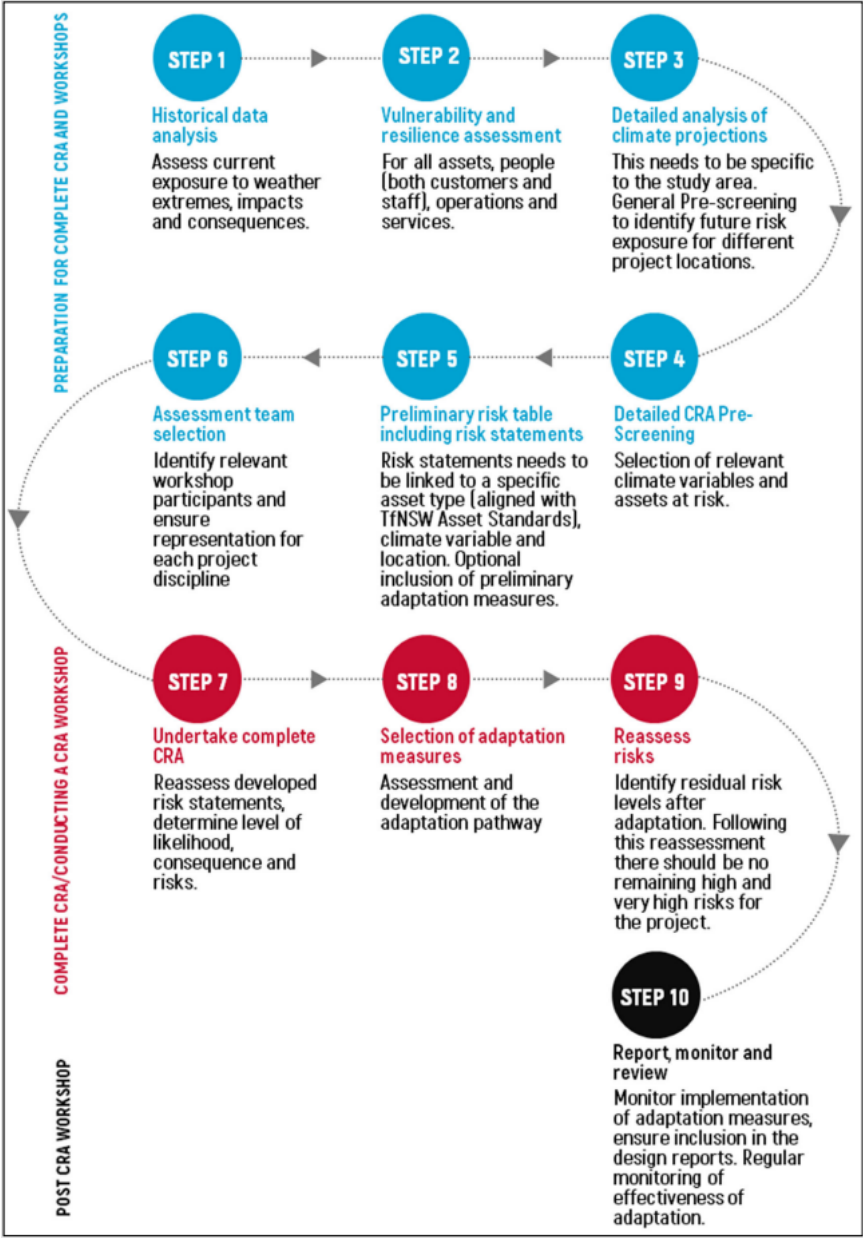


Figure 3 Climate Risk Assessment Step by Step process (TfNSW, 2022)

3.0 Climate change context

The *State of the Climate 2022*⁷ presents the latest climate research, analysis, and projections. It shows the long-term warming trend over Australia's land and oceans, showing that Australia's climate has warmed by 1.47°C since 1910. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6)⁸ states with high confidence that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. Other observed trends include an increase in record hot days, a decrease in record cold days, ocean warming, sea-level rise and increases in global greenhouse gas concentrations.

3.1 Local climate context

The current and historical local climate of the Hunter Region of NSW provides an indication of the exposure of the upgrade the Pacific Highway through Wyong Town Centre to future climate risks. Where feasible, this report will focus on climate projections for the Central Coast region.

Located 77 km North North East of Sydney, the Central Coast region extends over an area of 1,681 km².

Recently, extreme weather events have been occurring on a more frequent basis, with events in Wyong and the greater Central Coast region demonstrating the magnitude and potential consequences of extreme events. Recent impacts have included bushfire smoke and poor air quality from 2019/2020 bushfire season, extreme rainfall and storm events of 2022 and January 2023 thunderstorms.

3.1.1 Bushfire

The 2019–20 bushfire season was the worst NSW has ever recorded. Higher than average temperatures and low moisture levels in bushfire fuels following several years of drought enabled devastating fires to burn across much of the state. Although not directly impacted by bushfire, Wyong experienced secondary impacts of bushfire smoke and poor air quality.

The NSW Government declared the Central Coast an 'area of disaster' due to the surrounding bushfires from August 2019 onwards⁹. The Gospers Mountain fire burned nearby within Wollemi National Park in October till December 2019 and destroyed 90 homes across the Hawkesbury, Blue Mountains, Lithgow, Singleton Local Government Areas (LGAs)¹⁰ (Australian Institute for Disaster Resilience, 2020). The air quality index (AQI) in November spiked to 102 in Wyong, a rating of unhealthy for sensitive groups. High AQI ratings in Wyong can pose great concerns due to a higher than average portion of the population being older than 65 years of age.

On 31 December 2019 a bushfire burned at Charmhaven on the Central Coast, burning 418ha. As a result of the fire the Pacific Highway was closed between Gooramba Ave at Blue Haven through to the roundabout at Lake Haven Drive and the train line were closed between Morisset and Wyong¹¹.

Figure 4 presents the extent of bushfire prone land surrounding the Project and the Wyong region. As shown in Figure 4, most of the site is not located upon bushfire prone land however there is a large portion of land categorised as high bushfire risk land within the vicinity. High risk bushfire prone lands extends to the west at Wong and Ourimbah State Forests and further west to Yengo National Park. This presents risks related to access and egress and secondary impacts to bushfires such as smoke to the Wyong community.

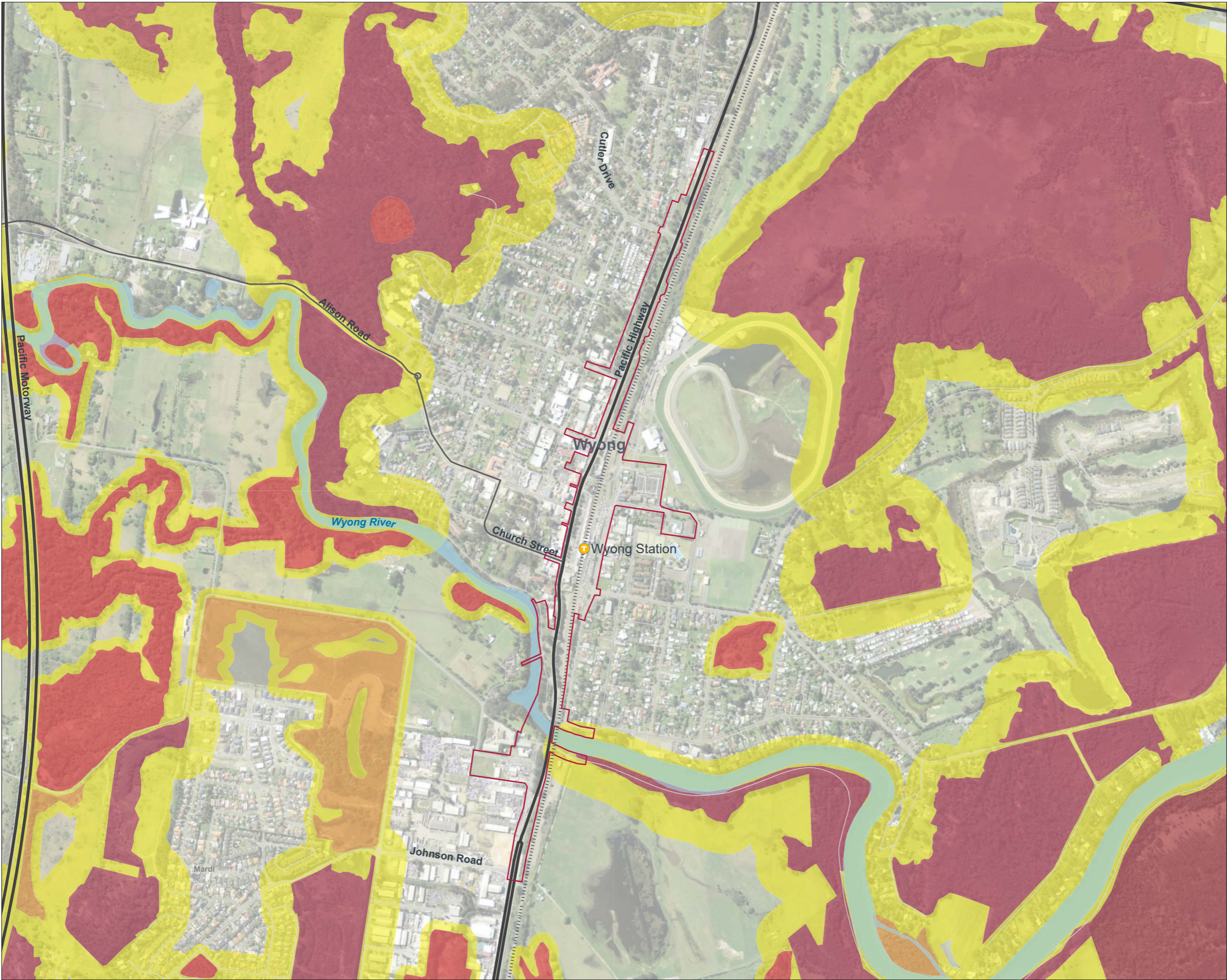
⁷ CSIRO and the Bureau of Meteorology (BOM) 2022, *The State of the Climate*, available at: <https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate>, accessed 17 October 2023

⁸ IPCC, 2023, Sixth Assessment Report (AR6), Working Group I: The Physical Science Basis.

⁹ NSW Government 2023, Natural Disaster Declarations, available at: <https://www.nsw.gov.au/disaster-recovery/natural-disaster-declarations>, accessed 18 October 2023

¹⁰ Australian Government National Emergency Management Agency, *Bushfires – Black Summer*, available at <https://knowledge.aidr.org.au/resources/black-summer-bushfires-nsw-2019-20/>, accessed 18 October 2023

¹¹ Coast news 2023, Charmhaven fire destroys property and closes highways and railway station, available at: <https://coastcommunitynews.com.au/central-coast/news/2020/01/charmhaven-fire-destroys-property-and-closes-highways-and-railway-station/>, accessed 18 October 2023



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Legend

Proposal area

Railway

Motorway

Main road

Watercourse

Bushfire Prone Land

Category 1

Category 2

Category 3

Vegetation buffer

**FIGURE 4:
BUSHFIRE PRONE LAND**

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Note: NSW RFS Bushfire vegetation categories

0 Vegetation buffer. 100m buffer for vegetation category 1 and 20m for vegetation category 2 and 3.

1 Highest risk of bushfire. Areas of forest, woodlands, heaths (tall and shot), forested wetlands and timber plantations.

2 Considered to be lower bushfire risk than Category 1 and Category 3. Rainforests. >Lower risk vegetation parcels with ongoing land management practices that actively reduces bush fire risk.

3 Considered to be of medium bushfire risk. Grasslands, freshwater wetlands, semi-arid woodlands, alpine complex and arid shrublands. *Buffers are created based on the bushfire vegetation, with buffering distance being 100 metres for vegetation category 1 and 30 metres for vegetation category 2 and 3.

3.1.2 Extreme Heat

The Central Coast region does not have an extended history of extreme heat and heat waves. The nearby township of Norah Head (Site ID: 061366) experiences mean maximum temperature of 25.9°C over summer and an average of 2.6 days over 35°C and 0.5 days over 40°C annually.¹²

Recent extreme heat events include:

- On average, the Central Coast experiences fewer than 10 hot days per year (maximum daily temperatures greater than 35°C)
- History of heatwaves including in November 2015, February 2017 and December 2019
- Eleven people were taken to hospital after suffering severe heat stress in January 2013, temperatures reach 44.8°C¹³
- November 2015, nearby township of Gosford experienced 40.8°C¹⁴.

3.1.3 Extreme rainfall and flooding

The Central Coast region is prone to flooding, the NSW Government declared the Central Coast an area of disaster during the following flood events¹⁵:

- December 2018
- January 2020
- October 2020 (Storms and flooding)
- March 2021
- February 2022
- June 2022
- September 2022.

During the March 2021 floods the Tuggerah Lake, located within 4kms of the Project, peaked at 1.5m leading to minor flooding of the surrounding area¹⁶. Tuggerah Lakes flooding again during the July 2022 floods. On this occasion, major flooding occurred where water levels exceeded the major flood level by 0.07m. The Central Coast region experienced consistent extreme rainfall during the week of the 3 to 9 March, leading to widespread flooding.

¹²Bureau of Meteorology 2023, Norah Head, available at: http://www.bom.gov.au/climate/averages/tables/cw_061366_All.shtml, accessed 18 October 2023

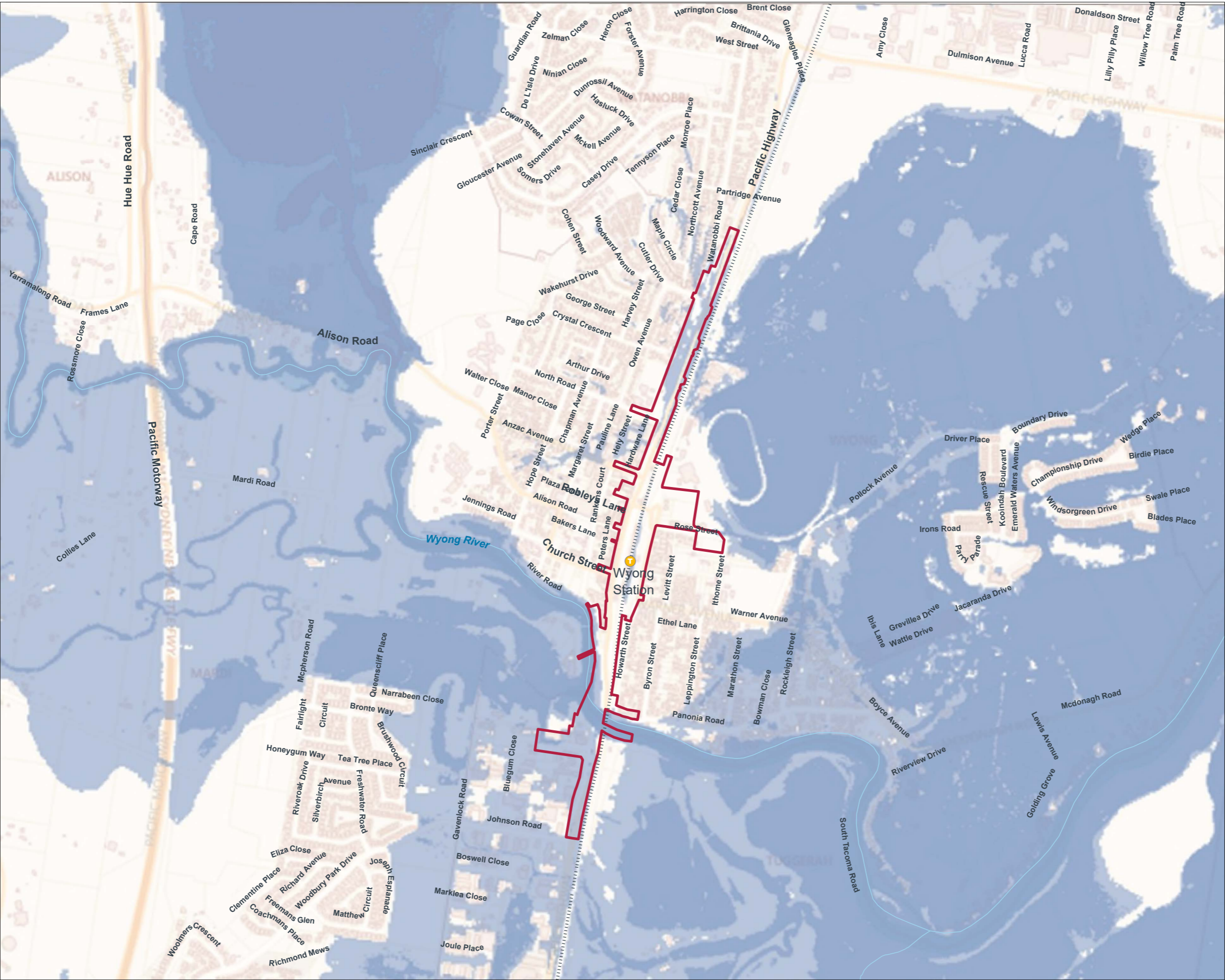
¹³ Source: <https://www.newcastleherald.com.au/story/1244827/scorcher-melts-away-the-records/>

¹⁴ ABC News 2015, NSW heatwave: Sydney reaches second hottest November day on record, available at: <https://www.abc.net.au/news/2015-11-20/parts-of-sydney-hit-40c-as-nsw-swelters-through-heatwave/6958014>, accessed 18 October 2023

¹⁵ NSW Government 2023, Natural Disaster Declarations, available at: <https://www.nsw.gov.au/disaster-recovery/natural-disaster-declarations>, accessed 18 October 2023

¹⁶ Coast News 2021, Coast cops a drenching, available at: <https://coastcommunitynews.com.au/central-coast/news/2021/03/coast-cops-a-drenching/>, accessed 18 October 2023

Figure 5 and Figure 6 highlight the risk of flooding to the current site in a 1 in 100 year flood event. Flood mapping and historical events show the Wyong River which flows into the Tuggerah Lake, is prone to flooding.



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Legend

- Proposal area
- 1 in 100 Flood Extent
- T Train Station
- Railway
- Watercourse

FIGURE 5:
1 IN 100 YEAR FLOOD EXTENT

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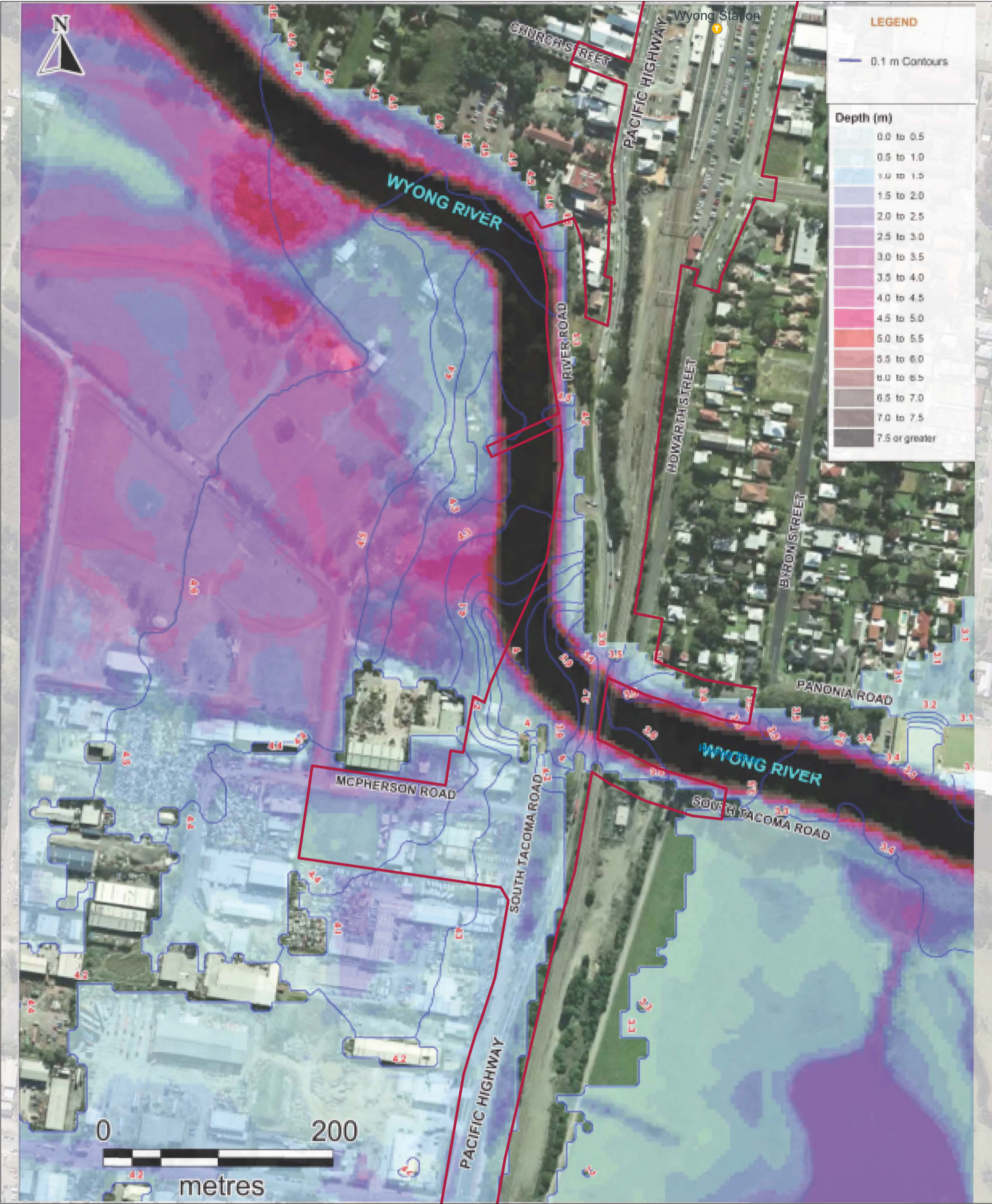


FIGURE 6:
WYONG RIVER EXISTING WATER SURFACE LEVEL AND 100-YEAR ARI FLOOD EXTENT

Legend

Proposal area

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3.1.4 Storms

The Central Coast region is prone to East Coast Lows with “more than 78% of extreme rain events on the central coast of NSW were attributed to East Coast Lows”¹⁷. Recent extreme events include:

- A severe thunderstorm warning was issued on 22 February 2022 for the Central Coast area, resulting in flash flooding and extreme weather. On the 8 and 9 March 2022, the development of an East Coast Low off the NSW Central Coast resulted in the region experiencing heaving rainfall¹⁸. The extreme rainfall promoted evacuation orders for nearby residents in low-lying areas round Tuggerah Lake, Wyong and Yarramalong¹⁹.
- In January 2023, intense thunderstorms swept across the Central Coast and Newcastle area. As the thunderstorm travelled towards Tuggerah Lake it gained in strength, producing extreme rainfall and large hail stones upon reaching Wyong²⁰.

3.1.5 Sea Level Rise

The Project is not currently impacted by sea level rise, see Figure 7, however the impact of sea level rise and increased rainfall should be considered within the design as it spans over Wyong River which is connected to the tidal Tuggerah Lake. Figure 8 presents the projected sea level rise in 2100 at the highest tide, the mapping utilises projections from the IPCC Sixth Assessment Report of 0.84m increase in sea level.

¹⁷ Adapt NSW 2016, Eastern Seaboard Climate Change Initiative East Coast Lows Research Program Synthesis for NRM Stakeholders

¹⁸ BOM April 2022, New South Wales in March 2022: Very wet along most of the coast, available at <http://www.bom.gov.au/climate/current/month/nsw/archive/202203.summary.shtml>, accessed 3 November 2023

¹⁹ Coast News March 2022, And still the rain comes, available at: <https://coastcommunitynews.com.au/central-coast/news/2022/03/and-still-the-rain-comes/>, accessed 3 November 2023

²⁰ Weather zone 2023, Lightning, hail hit NSW Central Coast and Newcastle, available at: <https://www.weatherzone.com.au/news/lightning-hail-hit-nsw-central-coast-and-newcastle/1292706>, accessed 18 October 2023



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DATE EXPORTED:
17/02/2025

CREATED BY:
AUSTINM3

COORDINATE SYSTEM:
GDA 1994 MGA ZONE 56

Legend

Proposal area

Sea Level Rise

Train Station

Railway

Watercourse

**FIGURE 7:
CURRENT DAY IMPACTS FROM
SEA LEVEL RISE**

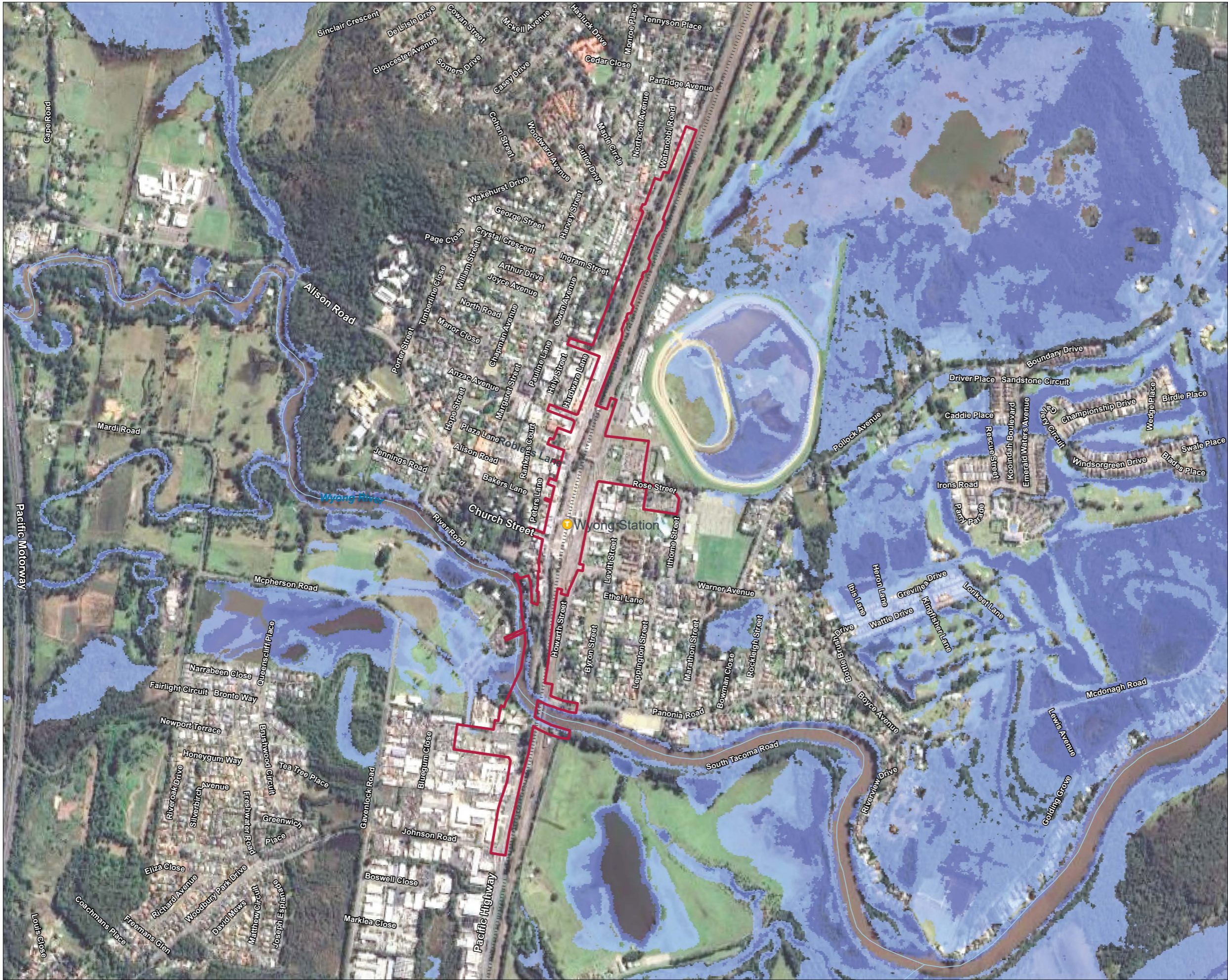
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Proposal area

Sea Level Rise

Train Station

Railway

Watercourse

FIGURE 8:
IMPACTS FROM SEA LEVEL RISE
IN 2100 (+0.84 M)

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Source: Imagery @ Sixmaps, 2023
Department of Customer Services, 2023

3.2 Climate change data

In order to assess climate change-related risks to the Project, the current climate science and model projections have been investigated for the following parameters based on available data sources.

Data sources used to inform this climate risk and resilience assessment have been chosen in accordance with the hierarchy presented in the TfNSW *Climate Risk Assessment Guidelines*, as follows:

- Adapt NSW and NSW and Australian Regional Climate Modelling (NARClIM) developed by the NSW Office of Environment and Heritage²¹ (OEH, 2014 & 2015)
- CSIRO and Bureau of Meteorology (BOM) Climate Futures²².

It is important to note the integrity of each climate data set as a whole, as the projections presented by each source represent a range of climate futures based on specific modelling parameters, scenarios and assumptions as described in the following sections. Care has been taken to consider each set of climate projections, to ensure an 'internally consistent climate future' approach. Preference has been given to the NARClIM climate data in accordance with the hierarchy outlined above.

3.3 Emissions Scenarios

The following emission scenarios were adopted for this project:

NARClIM

The Special Report on Emissions Scenarios (SRES) A2 scenario represents a high emissions pathway driven by economic growth and is projected to result in warming by approximately 3.4°C by 2100. The SRES A2 emission scenario was selected for use in the NARClIM climate projections as a review of the global emissions trajectory suggests that we are tracking along the higher end of the A2 scenario (OEH, 2014 & 2015).

Climate Futures

Projections are presented for two emission scenarios or possible pathways, referred to as 'representative concentration pathways' (RCPs), each of which reflects a different concentration of global greenhouse gas emissions. The two RCPs reported here are intermediate emissions (RCP4.5) and high emissions (RCP8.5). The RCP8.5 pathway, which arises from little effort to reduce emissions and represents a failure to prevent warming by 2100, is similar to the highest SRES scenario.

In 2021, IPCC released the first of several Working Group outcomes making up the Sixth Assessment Report (AR6), which included an update to global climate projections aligning to updated climate scenarios. These scenarios are known as Shared Socioeconomic Pathways (SSPs) and offer a broader view of a "business as usual" world without future climate policy. AR6 projection data has not yet been downscaled to the region and thus it is preferred to use the downscaled, higher resolution data of AR5 produced by the CSIRO and Bureau of Meteorology.

3.4 Time Scales

The expected design life of elements within the design varies. The project has been assessed against the 2090 timeframe given the design life of some elements including the bridge structures is 100 years.

Climate change projections for 2030 were identified as appropriate for assessment during the construction period and for short-term impacts of climate change on the Project.

Climate projections for the selected time scales represent averages over a 20-year period²³:

²¹ NSW Government 2015, Interactive climate change projections map, available at <https://www.climatechange.environment.nsw.gov.au/projections-map/>, accessed 18 October 2023

²² Dowdy, A. et al. 2015, East Coast Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia.

²³ Near future and far future are terms noted in AdaptNSW and NARClIM materials to describe the periods between 2020-2039 and 2060-2079, respectively.

- Projections for 2030 represent the average for the 20-year period between 2020 - 2039 (near future).
- Projections for 2090 represent the average for the 20-year period between 2080 - 2099 (far future).

3.5 Climate Variables

Climate differs from region to region due to changes in influencing factors such as geographical location, latitude, physical characteristics, variable patterns of atmosphere, ocean circulation and in some cases, human interaction²⁴. Consequently, climate change and the associated impacts can be expected to vary from region to region. The climate risk and resilience assessment provided in this report is based on projections for the Hunter region. Broader projections for the East Coast South Cluster are provided where data specific to the Central Coast region was unavailable. Detailed climate projections are presented in Table 8.

²⁴ IPCC, 2007, Fourth Assessment Report (AR4), Working Group I: The Physical Science Basis.

Table 8 Detailed climate projections

Climate Variable	Baseline Data Adapt NSW (OEI) ²⁵	Adapt NSW (OEI) ²⁶		CSIRO & BOM			
		NARCIIM		Climate Futures ²⁷			
		2030	2070	2030		2090	
	Central Coast	SRES A2 (High emissions)	SRES A2 (High emissions)	RCP 4.5 (Intermediate emissions)	RCP 8.5 (High emissions)	RCP 4.5 (Intermediate emissions)	RCP 8.5 (High emissions)
		Change relative to 1990 - 2009 (base)		East Coast South Region; Change relative to 1986 - 2005			
Mean temperature change (°C)	Summer 20–22°C Winter 12–14°C	+0.66 (+0.66 to +0.69)	+1.95 (+1.89 to +2.06)	+0.88 (+0.59 to +1.1)	+0.98 (+0.74 to +1.30)	+1.80 (+1.27 to +2.47)	+3.67 (+2.94 to +4.60)
Extreme heat (days over 35°C)	Fewer than 10 hot days% per year	+2.50	+7.10	6.92 (6.13 to 7.63)	7.40 (6.43 to 9.03)	10.63 (8.67 to 13.07)	19.44 (13.70 to 29.53)
Extreme heat (days over 40°C)	NA	NA	NA	0.62 (0.53 to 0.70)	0.70 (0.53 to 0.93)	1.13 (0.73 to 1.57)	2.80 (1.57 to 5.20)
Bushfire weather (Cumulative Forest Fire Danger Index (FFDI)) The FFDI combines observations of temperature, humidity and wind speed Fire weather is classified as severe when the FFDI is above 50.	Number annual severe (FFDI>50) fire weather days 1.4 (Williamtown weather station).	+0.1	+0.5	Increase by 20%	Increase by 45%	Increase by 45%	Increase by 130%
Mean annual rainfall change (%)	High variability from year to year. Rainfall varies considerably over the region, with average annual rainfall ranging from 1200–1600 mm near the coast to between 800–1200 mm further inland.	+1.50	+8.20	-2.56 (-10.43 to +6.48)	-0.87 (-10.84 to +6.20)	-2.33 (-16.28 to +8.52)	-3.22 (-20.21 to +16.11)
Wind speed (%)	NA	NA	NA	-1.07 (-2.91 to +0.5)	-0.51 (-2.31 to +1.86)	-0.99 (-4.24 to +0.22)	-1.10 (-6.88 to +4.22)
Sea Level Rise (Sydney) (m)	NA	NA	NA	+0.13 (+0.09 to +0.18)	+0.14 (+0.10 to +0.19)	+0.47 (+0.30 to +0.65)	+0.66 (+0.45 to +0.88)

Notes:

- Climate projections for 2030 represent the average for the 20-year period between 2020 - 2039 (near future)
- Climate projections for 2070 represent the average for the 20-year period between 2060 - 2079 (far future)
- SRES A2 represents a high emissions pathway driven by economic growth and is projected to result in warming by approximately 3.4°C (likely range 2.0-5.4) by the end of the 21 century
- RCP4.5 represents an emissions pathway consistent with low levels emissions, with global carbon dioxide concentration stabilised at about 540ppm by the end of the 21 century
- RCP8.5 represents a high emissions pathway, with global carbon dioxide concentrations reaching around 940 ppm by the end of the 21 century
- Quantitative results presented as model median (50th percentile) value, with 10 to 90 percentile range in bracket below
- Qualitative results have been discussed in the report where specific quantitative projections were unavailable (i.e. cells containing "NA")
- Climate Futures climate projections for the East Coast South sub-cluster gathered from the East Coast Cluster Report
- Extreme temperature greater than 30 and 40 degrees from the CSIRO threshold calculator tool.

²⁵ NSW Government 2014, Central Coast Climate Change snapshot.²⁶ NSW Government, Adapt NSW, 2023, Interactive climate change projections map near future and far future, available at: <https://www.climatechange.environment.nsw.gov.au/projections-map>, accessed 17 October 2023²⁷ Dowdy, A. et al. 2015, East Coast Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, eds.Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia.

In conjunction with climate change projection data listed in Table 9 and an analysis of historical events and hazard mapping. The following climate hazards were considered relevant to the Project.

Table 9 Primary and Secondary Climate Effects Relevant to the Project

Primary Climate Effects	Secondary Climate Effects
Mean temperature	Extreme temperature and heatwaves
Average annual rainfall	Bushfire weather
Extreme rainfall	Storm events
	Flooding
	Drought
	Sea Level rise and coastal flooding

4.0 Climate risk and resilience assessment

Due to previous events and observed and projected trends, risks to bypass and commuter car park infrastructure are likely through potential for physical damage, reduced operational capacity, accelerated deterioration of assets and potential risks to human health and safety. The increased frequency and intensity of extreme weather events, increased rainfall, flooding, bushfires and rising temperatures are already causing strain on road infrastructure and road users.

The CRA pre-screening was conducted using TfNSW *Climate Risk Assessment Guidelines* Version 4.1²⁸, provided in Appendix A which includes assessment criteria to determine the consequence and likelihood of each risk. These risks were assessed and rated as part of the Climate Change Pre-Screening Workshop held on 25 October 2023.

4.1 Construction pre-screening impact assessment

This section provides an assessment of construction impacts for the Project in terms of climate change. Climate change projections for the near future (2030) are considered relevant to the construction timeframe.

Table 10 Construction risk register

Risk ID	Risk Statement	Consequence Criteria	Potential Impacts	Likelihood	Consequence	Risk Rating
Increasing temperatures and number of hot days						
C-T1	Extreme heat events leading to health and safety concerns for construction staff	Safety	Construction staff	Likely	Minor	Medium
C-T2	Extreme heat events leading to reduced effectiveness and poor establishment of plantings	Environment	Plantings and landscaping	Likely	Moderate	Medium
C-T3	Extreme heat impacting the integrity of concrete during concrete pours	Project Delivery	Pavements, retaining walls	Unlikely	Moderate	Medium
Extreme rainfall and flooding						
C-P1	Extreme rainfall and wind events leading to construction interruption	Project Delivery	All assets	Likely	Moderate	Medium
C-P2	Extreme rainfall and flooding leading to overflow of sediment basins and increased risk of pollution to nearby waterway and the adjacent wetlands	Environment	Sediment basins	Likely	Moderate	Medium

²⁸ Transport for NSW 2021, TfNSW Climate Risk Assessment Guidelines version 4.1

Risk ID	Risk Statement	Consequence Criteria	Potential Impacts	Likelihood	Consequence	Risk Rating
C-P3	Extreme rainfall and flooding leading to lack of access to the site impacting supply chain.	Project Delivery	All assets	Likely	Moderate	Medium
C-P4	Extreme rainfall leading to damage to infrastructure during construction	Financial Sustainability	All assets	Likely	Minor	Medium
C-P5	Extreme rainfall and flooding impacting the ability to store materials onsite without concern of erosion of materials washing away	Everyday Service Delivery	All assets	Unlikely	Minor	Low
C-P6	Extreme rainfall leading to increased potential for stormwater runoff to impact surrounding sites, in particular the nearby wetlands	Environment	Wetlands	Unlikely	Moderate	Medium
Bushfire						
C-B1	Increasing bushfire frequency and intensity resulting in poor air quality and reduced visibility on construction sites causing delays in construction	Safety	Construction staff	Likely	Minor	Medium
C-B2	Increasing bushfire frequency and intensity leading to increased frequency of road closures and reduced access within the region causing delays in construction	Everyday Service Delivery	All Assets Construction staff	Unlikely	Minor	Low
C-B3	Increasing bushfire frequency and intensity impacting supply chain routes	Project Delivery	All assets	Likely	Moderate	Medium
C-B4	Increasing bushfire conditions leading to increased risk of grassfires within the vicinity of the site	Financial Sustainability	Plantings and landscaping	Unlikely	Insignificant	Low
C-B5	Increased bushfire frequency leading to increased delays in construction e.g. no hot works allowed during total fire bans	Project Delivery	All Assets	Likely	Insignificant	Low
Drought						
C-D1	Decreased availability of water for dust suppression leading to environment impacts and negative community perception	Reputation and integrity	Community	Unlikely	Insignificant	Low
C-D2	Failure of landscaping due to planting in dry and hot conditions.	Environment	Batter plantings Exotic species plants	Unlikely	Insignificant	Low

Risk ID	Risk Statement	Consequence Criteria	Potential Impacts	Likelihood	Consequence	Risk Rating
C-D3	Decreased availability of water impacting concrete pour as a high quantity of drinking quality water is required for concrete mixes and water restrictions could mean bore licenses are required	Financial Sustainability	Pavements, retaining walls	Unlikely	Minor	Low
C-D4	Severe lack of water resulting in impacts to construction and increased associated costs	Financial Sustainability	All Assets	Unlikely	Insignificant	Low
Storm Events						
C-S1	Extreme storms leading to construction interruption	Project Delivery	All assets	Likely	Minor	Medium
C-S2	Extreme storms leading to damage to infrastructure during construction	Financial Sustainability	All assets	Unlikely	Minor	Medium
C-S3	Extreme wind lifting dust from site impacting air quality	Safety	Community	Likely	Insignificant	Medium

4.2 Operational pre-screening impact assessment

Direct risks to the Project during operation and indirect risks from interdependencies with other infrastructure systems and organisations, as a result of climate change, are identified in Table 11.

Table 11 Operational risk assessment

Climate Variable	Risk Statement		Consequence Criteria	Potential Impacts	2030			2090		
					Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
Extreme rainfall and flood events	Direct Risks									
	F1	Extreme rainfall and flooding leading to increased maintenance requirements	Financial Sustainability	Pavements, bridge and culverts, retaining walls, embankments, fences	Unlikely	Minor	Low	Likely	Minor	Low
	F2	Extreme rainfall exceeding the capacity of the stormwater drainage network	Everyday Service Delivery	Pavements, bridge, and culvert, retaining walls, embankments, drainage elements	Unlikely	Moderate	Medium	Unlikely	Moderate	Medium
	F3	Extreme rainfall and flooding leading to a loss of access and egress to the commuter car park and surrounding region	Everyday Service Delivery	Pacific Highway, commuter car park	Likely	Major	High	Very Likely	Major	High
	F4	Extreme rainfall leading to an increase in road accidents	Safety	Community	Likely	Minor	Medium	Very Likely	Minor	Medium
	F5	Erosion of embankments and bridge piers impacting the integrity of the asset	Financial Sustainability	Bridge and culverts	Unlikely	Major	Medium	Unlikely	Major	Medium
	F6	Extreme rainfall impacting plant health leading to risk of erosion and invasive species threat	Environment	Landscaping	Likely	Moderate	Medium	Likely	Moderate	Medium
	F7	Increased rainfall intensity leading to a higher frequency of floods causing damage to infrastructure	Financial Sustainability	Pavements, bridge, and culverts, retaining walls, embankments	Likely	Moderate	Medium	Likely	Moderate	Medium
	Indirect Risks									
	F8	Extreme rainfall leading to faults/failure of power infrastructure resulting in interruptions to power supply	Everyday Service Delivery	Lighting and electrical equipment	Unlikely	Insignificant	Low	Unlikely	Insignificant	Low
F9	Extreme rainfall leading to accelerated soil movement	Financial Sustainability	Pavements, bridge, and culverts, retaining walls, embankments	Unlikely	Major	Medium	Unlikely	Major	Medium	
Storm events (including wind and hail)	Direct Risks									
	S1	Extreme weather events leading to damage and disruption to lighting and overhead power towers	Everyday Service Delivery	Lighting and electrical equipment	Unlikely	Insignificant	Low	Unlikely	Insignificant	Low
	S2	Extreme storms and winds leading to increased instances of debris on the carriageway impacting the health and safety of road users	Safety	Community	Likely	Minor	Medium	Very Likely	Minor	Medium
	S3	Extreme storms and winds leading accelerated degradation of materials and reduced life of structures	Financial Sustainability	Pavements, bridge, and culverts, embankments, fences	Unlikely	Moderate	Medium	Likely	Moderate	Medium
	S4	Extreme storm events leading to hail damage to the asset	Financial Sustainability	Signage	Unlikely	Minor	Low	Likely	Minor	Medium
	Indirect Risks									
	S6	Storm events leading to damage to power supply infrastructure	Everyday Service Delivery	Lighting and electrical equipment	Unlikely	Insignificant	Low	Unlikely	Insignificant	Low
	S7	Extreme wind and hail causing damage to vehicles	Everyday Service Delivery (Customer Satisfaction)	Vehicles	Unlikely	Moderate	Medium	Unlikely	Moderate	Medium
	Direct Risks									

Mean rainfall change	R1	Change in mean rainfall leading to increased soil erosion	Environment	Pavements, bridge, and culverts, retaining walls, embankments	Very unlikely	Minor	Low	Very unlikely	Minor	Low
Sea Level Rise	Indirect Risks									
	SLR1	Sea level rise leading to reduced access to the Project and reduced customer satisfaction	Everyday Service Delivery (Customer Satisfaction)	Community & personnel	Unlikely	Minor	Low	Unlikely	Minor	Low
Mean temperature change and Extreme heat (days over 35°C)	Direct Risks									
	T1	Extreme heat events leading to health and safety concerns for community members	Safety	Community & personnel	Likely	Insignificant	Low	Likely	Insignificant	Low
	T2	Extreme temperatures causing thermal expansion beyond design tolerances leading to increased stress of carriageway to bridge connections	Financial Sustainability	Pavements, bridge, and culverts	Very unlikely	Major	High	Very unlikely	Major	High
	T3	Increased failure of landscaping leading to risk of erosion and limb drop	Environment	Pavement, bridge, embankments,	Unlikely	Minor	Low	Likely	Minor	Medium
	T4	Increased risk of asphalt failure	Financial Sustainability	Pavements	Likely	Moderate	Medium	Likely	Moderate	Medium
	T5	Increased risk of median trips buckling	Financial Sustainability	Pavements	Unlikely	Insignificant	Low	Likely	Insignificant	Low
	Indirect Risks									
	T6	Extreme heat leading to increased power demand and/or failure of power infrastructure	Everyday Service Delivery	Lighting and electrical equipment	Unlikely	Insignificant	Low	Unlikely	Insignificant	Low
Bushfire events	Direct Risks									
	B1	Increasing bushfire frequency and intensity resulting in damage of structures	Financial Sustainability	Pavements, bridge, and culverts, retaining walls, embankments, fences	Unlikely	Moderate	Medium	Likely	Moderate	Medium
	Indirect Risks									
	B2	Bushfire events leading to damage to power supply infrastructure	Everyday Service Delivery	Lighting and electrical equipment	Unlikely	Minor	Low	Likely	Minor	Medium
	B3	Bushfires leading to damage to signage resulting in potential impacts to the health and safety of road users	Safety	Signposts, community	Likely	Minor	Medium	Likely	Minor	Medium
Drought	Direct Risks									
	D1	Increased instances of drought leading to vegetation loss leading to erosion and weed invasion	Environment	Embankments	Unlikely	Insignificant	Low	Unlikely	Insignificant	Low

5.0 Climate adaptation

Risk mitigation and climate change adaptation measures are proposed to reduce the impact of climate risks on the Project or increase the capacity of the Project to respond to changes in climate. The following adaptation actions are to be considered for the Project. Adaptation actions noted in green are considered to be business as usual.

Table 12 Adaptation actions

Adaptation ID	Adaptation Actions Proposed	Owner	Implementation Phase	Applicable risk statements	Status
Common					
AA-C1	Contingency incorporated into the works program to respond to extreme events.	Operator	Construction	C-T3, C-P1, C-P3, C-P5, C-B1, C-B2, C-B3, C-B5, C-S1	Existing
AA-C3	Design sheltered walkways between the carpark and the town centre to assist with extreme heat and rainfall	Designer	Detailed Design	F3, T1	Proposed
AA-C3	Emergency procedures in place to respond to extreme weather events and training provided to construction staff on how to respond.	Operator	Construction	C-T1, C-P2, C-P4, C-P5, C-P6, C-B1, C-B4, C-S2, C-S3	Existing
AA-C4	Provision of bus shelters at bus stops	Designer	Detailed Design	F3, T1	Existing
AA-C5	Review bridge abutment type against climate change flooding assessments	Designer	Concept Design and Detailed Design	C-P4,F5, F7,SLR1	Proposed
Extreme rainfall, storm and flood events					
AA-ER1	Ensure modelling of materials for suitable scour protection.	Designer	Detailed Design	C-P1,C-P4	Existing
AA-ER2	Drainage system to account for 10% blockage factor on bridges and major culverts	Designer	Detailed Design	F2,F3	Existing
AA-ER3	Climate sensitivity conducted accounting for a 15% increase in annual rainfall	Designer	Concept Design	F2,F5,F7	Existing

Adaptation ID	Adaptation Actions Proposed	Owner	Implementation Phase	Applicable risk statements	Status
AA-ER4	Use of high friction pavement	Designer	Detailed Design	F4	Existing
AA-ER5	Consider the selection of materials to account for an increase in the intensity of rainfall events / flooding/ storm events.	Designer	Detailed Design	F1,F4,F7,S4,S7	Proposed
AA-ER6	Consider the undergrounding of utilities to reduce the impacts to transmission lines from storm events	Designer	Detailed Design	F7,F8,S6,T6	Proposed
AA-ER7	Precautionary shut down periods during extreme storm events	Contractor	Construction	C-P1,C-S2, C-S3	Existing
AA-ER8	Construction methodology to meet the requirements constraints of the EPL and NSW Fisheries requirements	Contractor	Construction	C-P1,C-P2, C-P6	Existing
AA-ER9	Conduct further flood modelling to ensure temporary buildings are located above the 1 in 20 year flood level.	Designer	Detailed Design	C-P1,C-P3, C-P4,C-P5	Proposed
AA-ER10	Inclusion of permeable pavements in flood prone areas such as to the north of Wyong River to ensure the road is trafficable immediately following flooding	Designer	Detailed Design	F3,F4	Proposed
AA-ER11	Sediment basins designed in accordance with the <i>Blue Book</i> ¹⁶	Designer	Detailed Design	C-P2,C-P6	Existing
AA-ER12	Drainage systems to account for 1 in 100-year flood event with an additional allowance for increased rainfall intensity.	Designer	Detailed Design	F2,F3,F6	Existing
AA-ER13	Design to account for 50mm/hr rainfall events to improve driver safety during heavy rain events and reduce the risk of aquaplaning,	Designer	Detailed Design	F4	Existing
AA-ER14	AS/NZS 1170.2-2021 Wind design code includes climate change considerations to accommodate increased wind speeds	Designer	Detailed Design	S1,S3	Existing
AA-ER15	Spill containment provided to improve the water quality of runoff during extreme rainfall events. Location of sediment basins subject to detail design.	Contractor	Construction	C-P2,C-P6	Existing
AA-ER16	Develop Erosion and Sediment Control Plan to reduce sediment loaded runoff from leaving the site.	Contractor	Construction	C-P2	Existing
AA-ER17	Standard vegetation clearance zones to minimise vegetation debris on carriageway.	Operator	Operation	S2,S3	Existing
AA-ER18	Batters treated with hydro mulch and seed mix to reduce the possibility of erosion.	Contractor	Construction	R1	Existing

Adaptation ID	Adaptation Actions Proposed	Owner	Implementation Phase	Applicable risk statements	Status
AA-ER19	A flood response management plan will be prepared as part of the construction environmental management plans (CEMP). CEMP to detail how to approach works during wet periods and how to respond to flood warnings. Consider completing limiting materials within the laydown areas during wet weather periods	Operator	Construction	C-P5	Existing
AA-ER20	Laydown areas to be identified outside of the floodplain areas to reduce the risk of erosion of materials and/or contamination of surrounding land and waterways.	Contractor	Construction	C-P5	Existing
AA-ER21	Assess alternative drainage to ensure they have capacity to capture 1/100 year flood events	Designer	Detailed Design	F2	Existing
Mean temperature change and extreme heat (days over 35°C) and drought					
AA-T1	Consider the selection of materials to account for an increase in temperatures and extreme heat days. Asphalt mix to be developed specific to the region	Designer	Detailed Design	T2,T4,B3	Proposed
AA-T2	Infrastructure to allow for expansion and contraction of materials	Designer	Detailed Design	T2	Existing
AA-T3	Construction management plans to include a high temperature stop-work threshold.	Contractor	Construction	C-T1	Proposed
AA-T4	Consider the inclusion of solar panels to provide redundancy to lighting infrastructure	Operator	Detailed Design	T6	Proposed
AA-T5	Consider using recycled water in concrete mixes / other construction materials (specifications require drinking quality water) to reduce potable water use	Contractor	Construction	C-D1,C-D3	Proposed
AA-T6	Consider shading options for the commuter car park	Designer	Detailed Design	T1	Proposed
AA-T7	TfNSW construction specifications (QA B80) include limitations on temperatures for when concrete can be placed	Contractor	Construction	C-T3	Existing
AA-T8	Conduct thermal modelling of large concrete sections to determine the required controls during construction	Designer	Detailed Design	C-T3	Proposed
AA-T9	Pavement selection to consider pavement types, colouring and solar absorption levels	Designer	Detailed Design	T1,T4	Proposed
AA-T10	Where median strip is wide enough, and council regulations allow, include trees to increase the canopy cover	Designer	Detailed Design	T1,T5	Proposed
AA-T11	Inclusion of landscaping beds within the construction compound to reduce ambient heat impacts to construction workers	Designer	Detailed Design	C-T1	Proposed

Adaptation ID	Adaptation Actions Proposed	Owner	Implementation Phase	Applicable risk statements	Status
AA-T12	Include water storage facilities within site compounds to improve community perception of water use	Contractor	Construction	C-T3,C-D1, C-D2,C-D3,C-D4	Proposed
AA-T13	Assess the impact of groundwater draw down and consider utilising/installing groundwater bores onsite for construction operations	Designer	Construction and Detailed design	C-T3,C-D1, C-D2,C-D3,C-D4	Proposed
AA-T15	Utilise water trucks to provide increased irrigation to encourage plant uptake	Contractor	Construction	C-T2,C-D2, T1,D1	Existing
AA-T16	Selection of drought tolerant and native vegetation species for landscaping. Vegetation to be sourced locally where possible. Low maintenance planting selected for median strip	Contractor	Construction	C-T2,F9,T1, T3,T5,D1	Existing
Bushfire					
AA-B1	Ensure planting of vegetation as occurred prior to operation to enable adequate watering and improved vegetation uptake	Contractor	Construction	D1	Proposed
AA-B2	Maintain vegetation buffer along the northern portion of the site	TfNSW	Operation	B1,C-B4	Proposed
AA-B3	Grass alongside corridor to be maintained to reduce grassfires	Operator	Construction and operation	B1,B3,B4, C-B4,C-B5	Proposed
AA-B4	TfNSW to prepare a bushfire management plan for operation/ maintenance activities	Operator	Operation	B1,B2,B3,B4	Existing
Sea Level Rise					
AA-SLR1	Flood modelling to consider sea level rise	Designer	Detailed Design	SLR1	Proposed

6.0 Conclusion

6.1 Summary

The risk assessment identified a total of 21 climate risks during construction (see Table 13) and 28 climate risk risks (both direct and indirect risks) during the operational phase of the project (Table 14), responding to each of the climate variables identified for the Project. Based on the initial risk there were two operational high risks identified for 2030 and 2090. No very high risks identified as part of the assessment.

Table 13 Summary of Construction Risk Assessment

Risk rating	2030
Low	8
Medium	13
High	0
Very high	0
Total risks	21

Table 14 Summary of Operational Risk Assessment

Risk rating	2030	2090
Low	13	10
Medium	13	16
High	2	2
Very high	0	0
Total risks	28	28

The key hazards identified through the risk assessment were extreme rainfall and flooding leading to a loss of access and egress to the surrounding region and the impact of extreme heat leading to thermal expansion beyond design tolerances. The following priority actions should be considered for adoption to assist in mitigating the high risks:

- AA-T1 Consider the selection of materials to account for an increase in temperatures and extreme heat days. Asphalt mix to be developed specific to the region.
- AA-T2 Infrastructure to allow for expansion and contraction of materials.
- AA-T15 Utilise water trucks to provide increased irrigation to encourage plant uptake.
- AA-T16 Selection of drought tolerant and native vegetation species for landscaping. Vegetation to be sourced locally where possible. Low maintenance planting selected for median strip.

6.2 Next steps

This report fulfills the requirements of the detailed CRA, with the exception of residual risk ratings, in accordance with TfNSW CRA Guidelines. As a priority, TfNSW should focus on implementing the four priority actions prior to implementing the additional proposed adaptation actions listed in Table 12.

Appendix A

Risk Assessment Framework

Appendix A Risk Assessment Framework

The following tables are from the TfNSW *Climate Risk Assessment Guidelines* Version 4.1²⁹

Table 15 Transport risk likelihood table

Risk Likelihood Table						
Rating	L6	L5	L4	L3	L2	L1
Descriptor / Definition	Almost Unprecedented	Very Unlikely	Unlikely	Likely	Very Likely	Almost Certain
Qualitative Expectation	Not expected to ever occur during time of activity or project	Not expected to occur during the time of activity or project	More likely not to occur than occur during time of activity or project	More likely to occur than not occur during time of activity or project	Expected to occur occasionally during time of activity or project	Expected to occur frequently during time of activity or project
Quantitative Frequency	Less than once every 100 years	Once every 10 to 100 years	Once every 1 to 10 years	Once each year	1-10 times every year	10 times or more every year

Table 16 Transport combined consequence table

Consequence Table						
Rating	C6	C5	C4	C3	C2	C1
Description	Insignificant	Minor	Moderate	Major	Severe	Catastrophic
Safety	-Incident and/or injury/illness to staff/customer/community, not requiring first aid or medical treatment -No lost time	-Injury or illness to staff/customer/community, requiring first aid or medical treatment (non-hospitalisation) -No lost time post medical treatment -Single event	-Minor injuries or illnesses to staff/customer/community, requiring professional medical treatment (i.e. Doctor, nurse, and paramedic) or hospitalisation resulting in lost time -Injuries to customer/community requiring hospitalisation	-1 to 10 serious injuries or illnesses to staff/customer/community, as defined under S36 of the WHS Act (Work Health and Safety Act 2011 No 10) resulting in hospitalisation, lost time and/or potential permanent impairment -Multiple injuries to customer/community requiring hospitalisation -Single event and/or multiple locations -Co-ordinated emergency response required	-Single fatality and/or 10 to 20 serious injuries or illnesses to staff/customer/community, as defined under S36 of the WHS Act (Work Health and Safety Act 2011 No 10) resulting in hospitalisation, lost time and/or potential permanent impairment -Could impact safety across the network -Co-ordinated emergency response required	-Multiple fatalities and/or more than 20 serious injuries or illnesses to staff/customer/community, as defined under S36 of the WHS Act (Work Health and Safety Act 2011 No 10) resulting in hospitalisation, lost time and/or potential permanent impairment. (Permanent disabilities/chronic diseases) -Transport unable to assure community and network safety -Co-ordinated emergency response required
Everyday Service Delivery (Customer Satisfaction)	-Isolated written complaints -No impact to overall customer satisfaction index or customer ratings (Core customer satisfaction drivers). -Typical levels of complaints per 100K boardings benchmark	-Uninterrupted complaints at an increased volume for more than 3 months, resulting in a material increase in the rate of customer complaints for the mode or service (but less than 33% of the normal background level), increased ministerial and potentially ombudsman complaints -No impact to the overall customer satisfaction index. -Relatively small reduction (<5%) in the satisfaction level on one of the core	-Continuous complaints at an increased volume for more than a year, and/or an increase in the rate of customer complaints for the mode or service of >33% of the normal background level (per 100,000 boardings). Increased ministerial and ombudsman complaints and some media coverage. -Reduction in the overall customer satisfaction index for one mode by no more than 2%; Relatively small reduction (<5%) in the satisfaction level in 2 or 3 core drivers of customer satisfaction.	-A substantial and sustained uplift in the rate of customer complaints (per 100,000 boardings) with a backlog that can be cleared within 30 days, depending on resources. Repeat complaints associated with a failure to respond in a timely manner. Increased ministerial and Ombudsman complaints, along with intensified media coverage. NB: major changes in services tend to generate customer complaints (e.g. NorthWest Bus Service changes in Jul 19). In some instances this may present a risk while in others it may represent an adjustment period for customers. -Reduction in the overall customer satisfaction index for any mode by no more than 2% and can be recovered within 12 months. -Small reduction (<5%) in the satisfaction level for more than 3 core drivers of customer satisfaction or more than 5% on any one driver	-Increased customer complaints for up to 6 months, with normal background rates for the mode or service increasing by a factor of 3 or more, and a persistent backlog in responses – allowing for typical seasonal variation in complaints volume throughout the year -Backlog of complaints not readily cleared within 30 days, and repeat complaints associated with delayed responses to complaints. -Increased ministerial and Ombudsman complaints, accompanied by persistently negative media coverage. -The overall customer satisfaction index for one major mode only dropping by 3% or more and can be recovered within 12 months. -Larger reduction (5% or more) in the satisfaction level for more than 3 core drivers of customer satisfaction or more than 10% on any one driver.	A prolonged increase in customer complaints for greater than 6 months, with normal background rates for the mode or service increasing by a factor of 10 or more, and a persistent backlog in responses – allowing for typical seasonal variation in complaints volume throughout the year. -Substantial backlog of complaints. -Ministerial and Ombudsman complaints. - Persistent media and political scrutiny. -A prolonged material reduction in overall customer satisfaction across the board (5% or more) for one or more major transport modes. -A prolonged reduction (10% or more) in the satisfaction levels of the core drivers of customer satisfaction on more than one mode.
Everyday Service Delivery	-Antisocial behaviour on service or resulting in minor delays -Minor traffic incident resulting in minor delays -Passenger(s) unable to disembark due to technical asset failure for more than 5 minutes -BAU service delays	-BAU cancellations of service due to various causes including asset failure -Partial or full closure of a line/route/area or incidents resulting in minor to moderate delays e.g. track failure. -Access and operation compromised (e.g. closed entry and exits) for >30 minutes	-Police Operation on a transport asset (e.g. threat, suspicious package, security incident, civil unrest) -Incident requiring investigation by statutory authorities (WorkSafe, EPA, ONRSR/OTSI, NSW Police Force, RMS etc.)	-Police Operation on a transport asset (e.g. threat, suspicious package, security incident, civil unrest) resulting in a significant delay for a prolonged period of time and, likely to attract significant media attention e.g. no services during peak periods -Incidents resulting in a significant detrimental impact to a mode or multiple modes of transport for a prolonged period of time in excess of an hour, or likely to attract significant media attention e.g. derailment, overcrowding at stations,	-Serious injury or fatality to member of staff -Fatality on a service or asset / station/ interchange (not self-harm)	-Multiple injuries or fatality due to asset failure / derailment / or significant ongoing threat

²⁹ Transport for NSW 2021, TfNSW Climate Risk Assessment Guidelines version 4.1

				significant delays or no services during peak periods, injury to school children, multiple injuries, person overboard, fire on a service -Evacuation or unplanned closure, caused by flood, fire, smoke, or hazardous substance spill, and suspicious substance		
Financial Sustainability	- Capex (above P50 capital budget) < \$10 million - Non-infrastructure Capex <\$100K - Opex (including accounting adjustments) <\$1 million - Revenue (including fines, penalties, compensation etc) <\$100K	- Capex (above P50 capital budget) \$10 million to \$25 million - Non-infrastructure Capex \$100K to \$1 million - Opex (including accounting adjustments) \$1 million to \$10 million - Revenue (including fines, penalties, compensation etc) \$100K to \$1 million	- Capex (above P50 capital budget) \$25 million to \$50 million - Non-infrastructure Capex \$1 million to \$5 million - Opex (including accounting adjustments) \$10 million to \$25 million - Revenue (including fines, penalties, compensation etc) \$1 million to \$5 million	- Capex (above P50 capital budget) \$50 million to \$150 million - Non-infrastructure Capex \$5 million to \$25 million - Opex (including accounting adjustments) \$25 million to \$75 million - Revenue (including fines, penalties, compensation etc) \$5 million to \$25 million	- Capex (above P50 capital budget) \$150 million to \$250 million - Non-infrastructure Capex \$25 million to \$50 million - Opex (including accounting adjustments) \$75 million to \$150 million - Revenue (including fines, penalties, compensation etc) \$25 million to \$50 million	- Capex (above P50 capital budget) >\$250 million - Non-infrastructure Capex >\$50 million - Opex (including accounting adjustments) >\$150 million - Revenue (including fines, penalties, compensation etc) >\$50 million
Reputation and Integrity	-Single negative article in local media -Limited social media commentary -Goodwill, confidence and trust retained -Confined to the Branch -Local council may want to discuss	-Series of negative articles in local media (District / electorate based adverse media) -Some social media commentary -Confidence remains - minor loss of goodwill. Confined to Branch but requiring notification to Division -Council requires written explanation -Recoverable with little effort or cost. Some continuing scrutiny/attention	-Extended local media coverage with some broader Regional media coverage -Extended negative social media coverage -Confidence and trust of stakeholders denied (recoverable at modest cost within existing budget and resources) -Division formal response needed to State - Government/Regulator	-State media coverage, short term negative national media coverage -Widespread social media coverage -Confidence/trust impaired -Project/activity credibility under question -TNSW and/or Ministers Department requires update	-Sustained negative State media coverage -Regular 'talk-back' programs questioning credibility and capability -Confidence and trust are severely damaged -Widespread negative social media coverage -Regular updates demanded by Minister -Stakeholders withdraw their support recoverable at considerable cost, time and staff effort.	-Sustained, high profile media attention at National level -Material change in the public perception of the Agency -Extensive negative social media coverage -Confidence and trust non-existing. Government forced to reverse decision -Stakeholders are actively campaigning against the organisation
People	-Little employee interest/impact -Confidence and trust of employees retained -Confined to small number of people < 5 -No performance impairment -Little or no impact on workload, employee numbers, work/life balance -No cultural impact -No noticeable excess stress or excessive absenteeism of key staff during/after workload peaks -Union activity/correspondence without staff pickup	-Impacts employees at a specific location and/or of a specific discipline (e.g. accountants) (<50) -Employees concerned as to their wellbeing and future -Employees frustrated but still willing to proactively contribute to meeting objectives -Isolated incidence of excess stress or excessive absenteeism of key staff during/after workload peaks -Unions are being called upon to take up employee cause -IR tension is high	-Impacts large numbers of employees (<500) -Employee's wellbeing and future is at risk -Employees frustrated and are largely only doing what needs to be done -Culture and morale dropping -People are actively looking to leave -Noticeable incidence of excess stress or excessive absenteeism of key staff during/after workload peaks -Pockets of staff support for union agitation	-Majority of employees potentially impacted (50%). Employee morale is low -Employees not willing to proactively engage – lack of commitment -Key people are actively looking to leave -Widespread staff support for union agitation -Widespread incidence of excess stress or excessive absenteeism of key staff	-All employees potentially impacted -Employee morale is poor -Employees not willing to proactively engage -Key people are leaving, workforce churn rates increase (loss of IP) -Unions action – work to rule, stop work, short time but significant action -Stress and other work related injuries/health issues increasing -High incidence of excessive absenteeism of staff	-Employee brand significantly impaired -All employees potentially impacted -No confidence and trust of employees -Transport wide dissatisfaction – bad, dysfunctional morale. -Performance significantly impaired – little or no immediate sign of improvement -High staff turnover – poor corporate culture -Doubling of workload, stress levels dangerously high -Long-term (months) of ongoing rolling industrial action which significantly impacts on service delivery
Project Delivery	-Insignificant delay (1 – 2 days) -No reduction in functionality/scope -No discernible impact, benefit realisation may have a slight decrease but largely intact -No time delay with initiative or project but it will incur a slight decrease in the benefits realised -<2 month project delay	-Insignificant delay (1 – 2 days) -No reduction in functionality/scope -No discernible impact -Benefit realisation partially impaired but still adds value and economically sound -No public impacts -2-3 month project delay	-Minor delay (<1% to max of 1 week) -< 1% reduction in functionality/scope -Benefit realisation partially impaired but still adds value and economically sound -No public impacts -3-6 month project delay	-Major delay (< 10% to max of 5 months) -< 15% reduction in functionality/scope -Cost/benefit analysis may not have supported the Program go ahead -Publicly announced portion/milestone missed or final completion date missed with demonstrable mitigating external circumstances. -6-9 month project delay	-Severe delay (< 15% to max of 8 months) -< 15% reduction in functionality/scope -Cost/benefit analysis would not justify program -Publicly announced portion/milestone missed or final completion date missed on critical path project -9-12 month project delay.	-Total blow out in time (> 9 months or > 15%). -> 15% reduction in functionality/scope -Will probably require a major project in the foreseeable future to either rectify or complete the results of this project -Publicly announced portion/ milestone significantly missed or final completion date significantly missed on critical path project ->12 mth project delay -Failure to realise benefits of the initiative
Regulations and Compliance	-Low-level/Technical non-compliance with legal and/or regulatory requirement or duty by individuals or TNSW- not reportable -Minor non-compliance to a low impact contract clause – little or no interest by either party to pursue or rectify	-Non-compliance with whole or significant aspects of Government policy not reportable but requiring internal activity to put in place -Formal investigation and/or formal notification to regulator -Minor breach of contract by either party rectified through local management discussion	-Non-compliance with key Government policy - reportable and/or explanation required – need to put in place as soon as possible -Non-compliance – key obligation -Formal notification to regulator -Agency on notice -Breach of contract by either party rectified at Branch level management discussion -Small fine and no disruption to services.	-Technical non-compliance with a minor Government Policy - not reportable -< 10% reduction in non-compliance -Technical non-conformance -Minor non-compliance to a low impact contract clause – little or no interest by either party to pursue or rectify -Substantial fine and no disruption to services	-Non-compliance with high profile Government policy or Ministerial decree - immediately reportable to Government body (e.g. Treasury) and action to put in place required immediately (high priority) -Continuous breach resulting in prohibition notices -Breach of significant, key aspects of contract by either party leading to lodgement (threat) to sue and recompense at severe financial levels -Cessation of contract may occur -Large fines as a result of non-compliance -Licence or accreditation restricted or conditional affecting ability to operate	-Non-compliance with high profile Government policy or Ministerial decree - immediately reportable to Ministerial level requiring actions to put in place immediately (high priority) and progress to be reported to the Minister on an agreed and appropriate schedule -Litigation and potentially imprisonment -Loss of Operating licenses -Continued breach cannot be tolerated -Major contract breach by either party leading to significant litigation and financial costs -Total breakdown and cessation of contract -Criminal prosecution as a result of non-compliance
Environment	-No appreciable changes to environment	-Change from existing conditions that can be rectified immediately (< 1 day) with available resources	-Short-term (< 1 year) and/or well-contained environmental impact -Minor remedial actions probably required	-Short to medium term (between 1 and <5 years) environmental impact -Considerable remedial actions probably required	-Medium-term (>5 years) environmental impact -Extensive remedial actions probably required	-Long-term (>10 years) large-scale environmental impact -Extensive and ongoing remedial actions probably required

Table 17 Transport Risk matrix

Risk Matrix Evaluation Table								
Risk Ratings			Consequence					
A – Very High B – High C – Medium D – Low			Insignificant	Minor	Mode	Major	Severe	Catastrophic
			C6	C5	C4	C3	C2	C1
Likelihood	Almost certain	L1	C	B	B	A	A	A
	Very likely	L2	C	C	B	B	A	A
	Likely	L3	D	C	C	B	B	A
	Unlikely	L4	D	D	C	C	B	B
	Very unlikely	L5	D	D	D	C	C	B
	Almost unprecedented	L6	D	D	D	D	C	C

Appendix B

Climate Risk Pre-Screening Workshop

Appendix B Climate Risk Pre-Screening Workshop

The Climate Pre-Screening Workshop for Wyong Town Centre was conducted on 25 October 2023. Attendees are presented below in Table 18

Table 18 Initial workshop attendees

Name	Company	Role
Jesse Sounness	AECOM	Facilitator – Sustainability and resilience
Rebekah Panozzo	AECOM	Facilitator – Sustainability and resilience
Ian Leach	AECOM	Associate Director – Civil & Design Manager
Daniel Scott	AECOM	Senior Engineer – Civil and Structures
James Jentz	AECOM	Technical Director – Civil & Project Manager
Niel Standen	AECOM	Environmental Manager
Giulia Vignaroli	AECOM	Principal Urban Designer – Urbanism and Planning
Jeremy Durward	TfNSW	Planning and Environment Lead
Janene Flick	TfNSW	Senior Manager Sustainability
Andrew Levett	TfNSW	Project Delivery Manager

A summary of hazards and implications to the project were presented to workshop attendees for discussion.