SMEC
Member of the Surbana Jurong Group

local people
global experience

Artist's Impression

Environmental Impact Statement – Chapter 24: Traffic and transport

Warragamba Dam Raising

Reference No. 30012078
Prepared for WaterNSW
10 September 2021

SMEC INTERNAL REF. 30012078

Contents

List of Tables

List of Figures

24 Traffic and transport assessment

This chapter provides an assessment of traffic and transport impacts during construction and operation of the Warragamba Dam Raising Project. The relevant Secretary's Environmental Assessment Requirements (SEARs) are shown in Table 24-1.

Table 24-1. Secretary's Environmental Assessment Requirements: Traffic and transport assessment

Desired performance outcome	Secretary's Environmental Assessment Requirements[1]	Where addressed
17. Transport and traffic Network connectivity, safety, and efficiency of the transport system in the vicinity of the project are managed to minimise impacts. The safety of transport system customers is maintained. Impacts on network capacity and the level of service are effectively managed. Works are compatible with existing infrastructure and future transport corridors.	1. The Proponent must assess construction transport and traffic (vehicle, pedestrian, and cyclists) impacts. The assessment should consider existing and planned developments, as well as upgrades around the Wollondilly Shire area. Consideration should be made to the structure and suitability of proposed access routes.	Section 24.2 Section 24.3
	2. The Proponent must assess the operational transport impacts of the project.	Section 24.2 Section 24.4.4
	3. The Proponent must provide consideration of the effects of extended inundation of downstream transport infrastructure, and of the effects on the road network of any alternate routes required where that transport infrastructure is inundated for prolonged periods. This should include assets such as Yarramundi, Richmond and Windsor road bridges and vehicular ferries at Lower Portland, Sackville, and Wisemans Ferry.	Section 24.4
	4. The Proponent must consider contingency plans for management of traffic during construction in the event of: (a) emergency closures due to flood, fire, and road accidents (b) significant pavement failures due to some roads needing repair within the Wollondilly Shire area (c) load limits of bridges in the area.	Section 24.4 Section 24.5

1. This chapter specifically addresses SEAR 17 in addition to those general requirements of the SEARs applicable to all chapters and as identified as such in Chapter 1 (Section 1.5, Table 1-1).

The traffic and transport impact assessment (TTIA) is supported by detailed investigations, which are documented in the Traffic and transport assessment (Appendix O).

The proposed management and mitigation measures in this chapter are collated in Chapter 29 (EIS synthesis, Project justification and conclusion).

24.1 Project overview

24.1.1 Project description

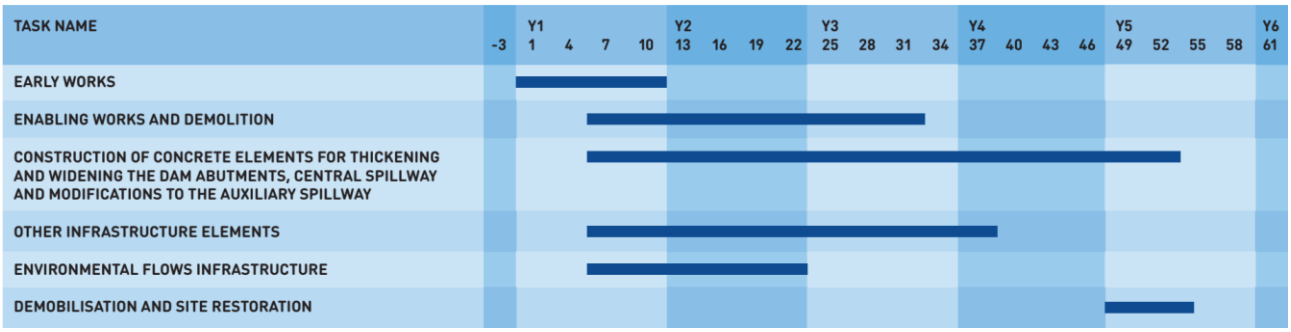
The Project is to provide additional capacity to facilitate flood mitigation (a flood mitigation zone or FMZ) by increasing the crest level of the central spillway by approximately 12 metres and the auxiliary spillway crest by around 14 metres above the existing full supply level for temporary storage of inflows. The spillway crest levels and outlets control the extent and duration of the temporary upstream inundation. There would be no change to the existing maximum volume

of water stored for water supply. The current design includes raising the dam side walls and roadway by 17 metres to enable adaptation to projected climate change. The Project includes the following main activities and elements:

- demolition or removal of parts of the existing Warragamba Dam, including the existing drum and radial gates,
- thickening and raising of the dam abutments
- thickening and raising of the central spillway
- new gates or slots to control discharge of water from the FMZ
- modifications to the auxiliary spillway
- operation of the dam for flood mitigation
- environmental flow infrastructure.

A preliminary construction program is presented in Figure 24-1 with construction anticipated to be completed within four to five years.

Figure 24-1. Preliminary construction program



The Project would delay downstream flooding, which would reduce current downstream flood peaks and increase the time taken for downstream water levels to recede. The dam would be subject to the following operational regimes, depending on the water level.

Normal operations

Normal operations would apply when the reservoir level is at or lower than the FSL, which is when the water level in the dam is at or below RL[1] 116.7 metres.

Flood operations

Flood operations would apply when the water level is higher than the FSL. The FMZ would have sufficient storage to accommodate a 1 in 20 to 1 in 40 chance in a year flood. For larger floods the FMZ would be filled and uncontrolled discharge would occur over the central spillway, and potentially, auxiliary spillway of the dam. Operational objectives are to:

- maintain the structural integrity of the dam
- minimise risk to life
- maintain Sydney's water supply
- minimise downstream impact of flooding to properties
- minimise environmental impact
- minimise social impact.

24.1.2 Project location and study area

The study area and regional road network is shown on Figure 24-2. Warragamba Dam is located approximately 65 kilometres west of Sydney in a narrow gorge on the lower section of the Warragamba River, 3.3 kilometres before it joins the Nepean River. The township of Warragamba is located approximately one kilometre east of the dam wall. The upstream environment includes the reservoir formed by Warragamba Dam (Lake Burragorang) and its tributaries,

[1] RL (reduced level) – metres above mean sea level or metres Australian Height Datum (mAHD)

and comprises approximately 5,280 hectares, broadly equating to the area between the existing dam full supply level (FSL) and the Project probable maximum flood (PMF) level. The downstream environment includes a short section of the Warragamba River, the Hawkesbury-Nepean River and its floodplain, and some of the tributaries of the Hawkesbury-Nepean River (such as South Creek) that experience backwater flooding affects.

The traffic and transport study area comprises:

- the dam construction area near the township of Warragamba, which broadly covers an area of about 105 hectares
- the operational area, which includes the roads and intersections around Warragamba and the region that would be used by light and heavy vehicles during Project construction (refer Figure 24-2)
- downstream flood affected areas up to the PMF (noting that the Project PMF would be less than the existing PMF)
- upstream flood affected areas up to the Project PMF. Upstream operational impacts of the Project on fire trails, walking tracks and private property access are assessed in Chapter 20 (Protected and sensitive lands).

24.1.3 Study methodology

The traffic and transport assessment addresses SEARs requirements (Table 24-1), as well as meeting the following outcomes:

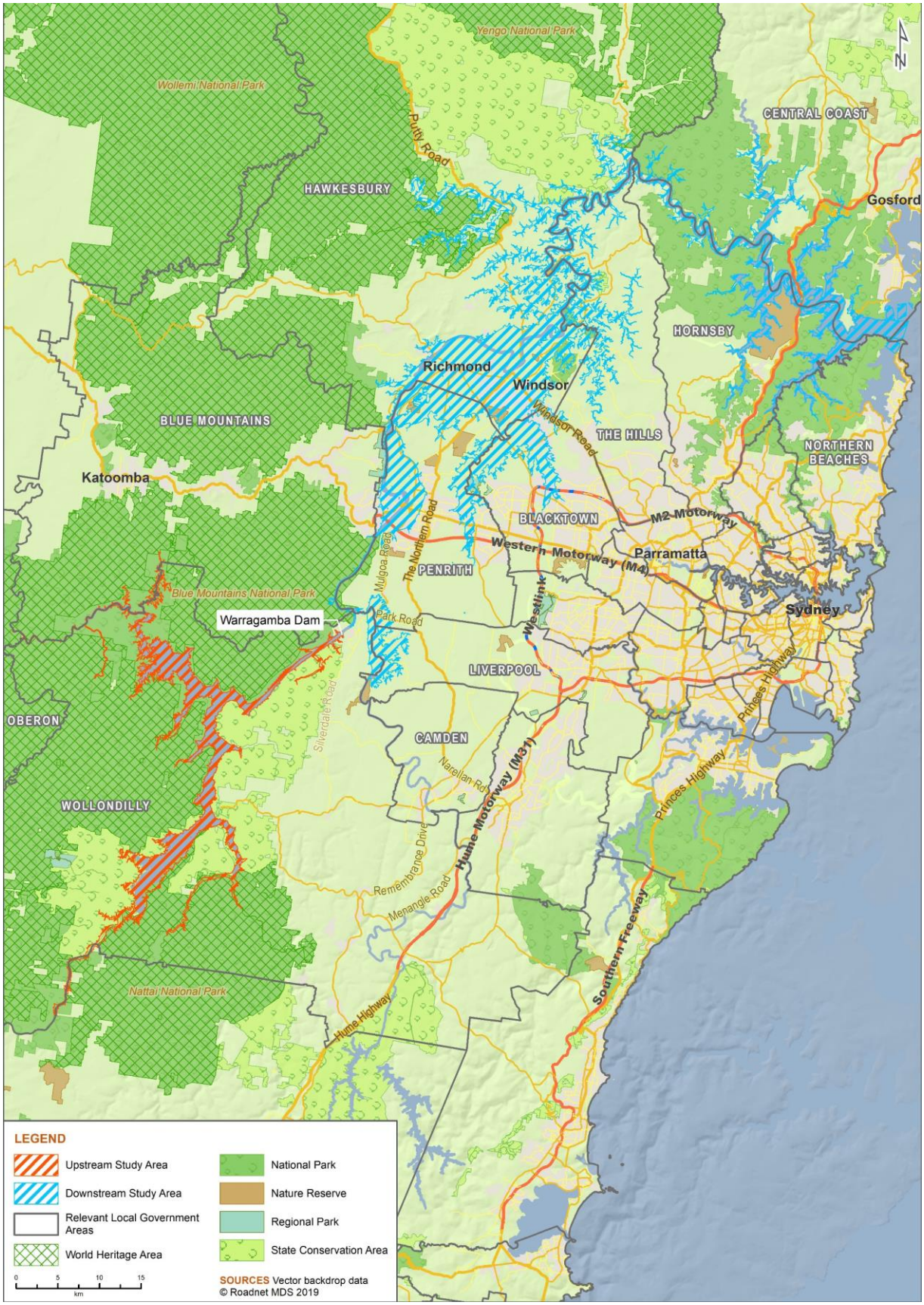
- network connectivity, safety, and efficiency of the transport system are managed to minimise impacts
- the safety of transport system users is maintained
- impacts on network capacity and the level of service are effectively managed
- works are compatible with existing infrastructure and future transport corridors.

Relevant assessment guidelines include:

- *Guide to Traffic Management – Part 3 Traffic Studies and Analysis* (Austroads 2007)
- *Guide to Traffic Generating Developments Version 2.2* (RTA 2002)
- *Cycling Aspects of Austroads Guides* (Austroads 2014)
- *NSW Bicycle Guidelines v 1.2* (RTA 2005)
- *Planning Guidelines for Walking and Cycling* (DIPNR 2004).

The SEARS also identify the NSW Sustainable Design Guidelines Version 3.0 (TfNSW 2013); these guidelines have since been superseded by the latest version, issued in March 2019.

Figure 24-2. Study area and regional road network



24.2 Existing environment

24.2.1 Road network

24.2.1.1 Regional road network

The regional road network is shown on Figure 24-2. The M4 Motorway, The Northern Road and Hume Motorway provide regional access to the proposed construction site.

The M4 Motorway is located to the north of Warragamba and connects the Warragamba Dam area to Western Sydney and other parts of Sydney via The Northern Road and Mulgoa Road.

The Northern Road and Mulgoa Road are located to the east of Warragamba and connect with Park Road and Silverdale Road respectively (refer Figure 24-2). Construction work is currently being undertaken to upgrade The Northern Road, which is anticipated to be completed before commencement of the Warragamba Dam construction works. The Northern Road is a key corridor and would be used to transport construction materials to the site from both the north and south.

The Hume Motorway is located to the south of the Warragamba and connects to Warragamba via Menangle Street, Remembrance Drive, Narrellan Road, The Northern Road, and Silverdale Road.

24.2.1.2 Local road network

The Warragamba road network is shown on Figure 24-3 and can be categorised into three basic types of roads:

- residential streets that make up most of the local roads
- local arterial roads, such as Farnsworth Avenue, that provide connections to the regional road network
- commercial or industrial roads that service light industry, recreational facilities, and commercial facilities in the southern part of Warragamba.

Production Avenue and Farnsworth Avenue provide access to the existing Warragamba Dam and visitor centre, and Haviland Park. Local roads, such as Twenty-Third Street and Twenty-Fourth Street connect with Production Avenue and Farnsworth Avenue within the proposed Project construction site. However, most of these roads have public access restrictions and are controlled with boom gates and other security measures. There are a number of designated parking areas located on Production Avenue and Farnsworth Avenue adjacent to Warragamba Dam. Parking located on Farnsworth Avenue (as shown in Figure 24-8) is designated for the Warragamba Dam staff only, however, other parking areas are open to visitors visiting Warragamba Dam and Haviland Park.

The surrounding road network is shown in Figure 24-4. Heavy vehicle access to the construction site is proposed from:

- the north – via The Northern Road, Park Road (through Wallacia), Silverdale Road, Farnsworth Avenue, and Production Avenue
- the south – via Silverdale Road, Warradale Road, and Production Avenue. Marsh Road in the south would provide more direct access to the construction site than Warradale Road, however, its pavement condition is in poor condition and there is an eight-tonne load limit.

The Blaxland Crossing Bridge is located on the west side of Wallacia and connects Park Road and Mulgoa Road with Silverdale Road. Currently, heavy trucks from Norton Basin quarry and Warragamba chlorination plant use this bridge. Heavy vehicles coming from the north would cross this bridge to access the construction site.

Figure 24-3. Local roads and parking areas in and around Warragamba Dam

Figure 24-4. Road network surrounding the Project

24.2.2 Major intersections and traffic count surveys

Seven key local intersections were identified for intersection capacity analysis and to identify potential Project impacts on the performance of these intersections. The selection of these intersections was based on the anticipated trip distribution and routes of construction light and heavy vehicles. The seven intersections are:

1. Mulgoa Road/Park Road intersection
2. Silverdale Road/Farnsworth Avenue intersection
3. Warradale Road/Production Avenue intersection
4. Warradale Road/Silverdale Road intersection
5. Silverdale Road/Marsh Road intersection
6. Farnsworth Avenue/Production Avenue intersection
7. Park Road/Northern Road intersection.

The Northern Road Upgrade project[2] includes recent traffic count data (carried out in 2017) of the Park Road/ Northern Road intersection. This data was used for assessing the capacity of thePark Road/Northern Road intersection. For the other six intersections, traffic count surveys were undertaken for both AM and PM peaks for 2- hour periods (AM peak – from 7.00 to 9.00 and PM peak – from 16.00 to 18.00). Directional traffic counts were also undertaken on three road segments, namely Silverdale Road, Park Road and Farnsworth Avenue.

Figure 24-5 to Figure 24-7 show the average daily traffic (ADT), AM peak two-hour period (7.00 to 9.00) and PM peak two-hour period (16.00 to 18.00) traffic over a one-week period for the three directional traffic count locations. Generally, weekend traffic volumes were lower than the weekday traffic volume at all three locations. Peak PM traffic volumes were higher than the AM peak period. Consequently, the traffic assessment and intersection capacity analysis were undertaken for a weekday only to assess the performance of the worst case scenario.

The current intersection traffic count data (total and heavy vehicle) for both AM and PM peak-hours (1-hour traffic count) at the seven intersections are shown in Figure 24-8 and Figure 24-9 respectively.

The turning patterns and volumes at the Park Road/Northern Road intersection were extracted from the Northern Road Upgrade Project report. An annual growth rate of 3.5 percent has been applied to the turning volume data to estimate the 2018 turning volume for the Park Road/Northern Road intersection. Details of the assumed annual growth rate are discussed in Section 24.2.4 below.

The turning volumes of future year 2022 with and without the developments for both AM and PM peak-hours are provided in Appendix O (Traffic and transport assessment report, Appendix A).

[2] The Northern Road Upgrade – Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park, Final Environmental Impact Statement, December 2017 (Jacobs Australia 2017)

Figure 24-5. Weekly traffic variation of Silverdale Road, south of Taylors Road

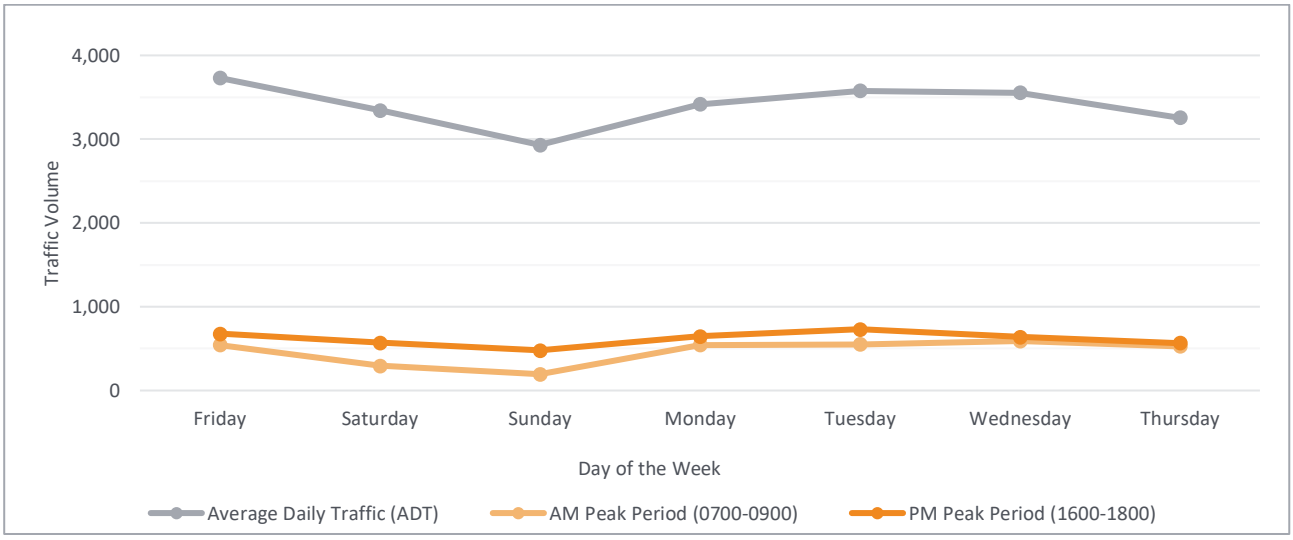


Figure 24-6. Weekly traffic variation of Park Road, east of James Street

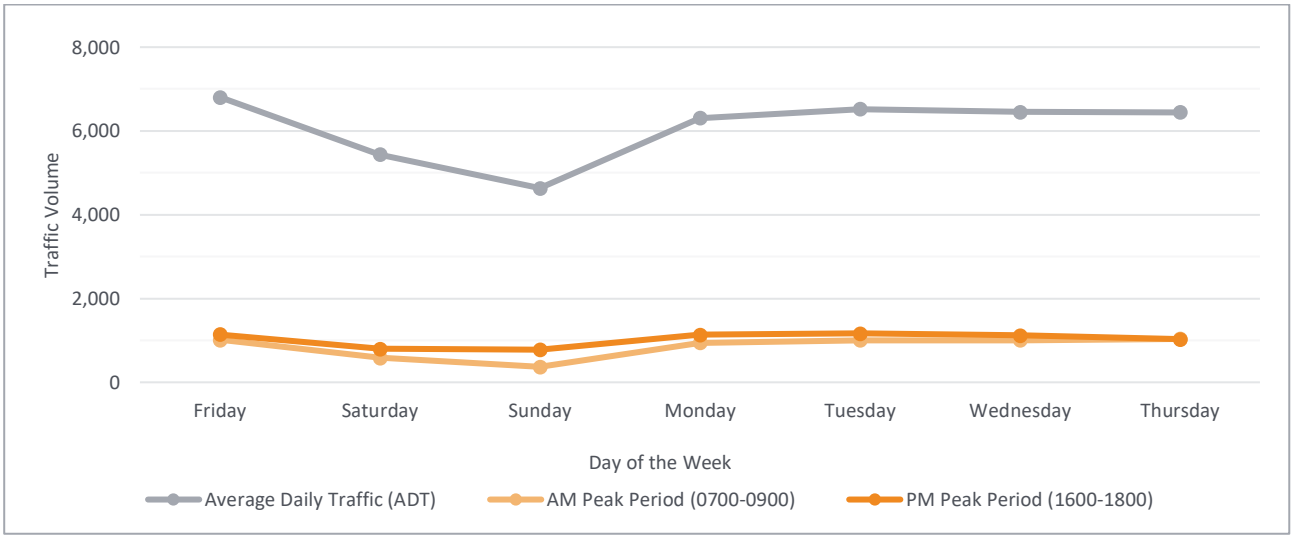


Figure 24-7. Weekly traffic variation of Farnsworth Avenue, north of Production Avenue

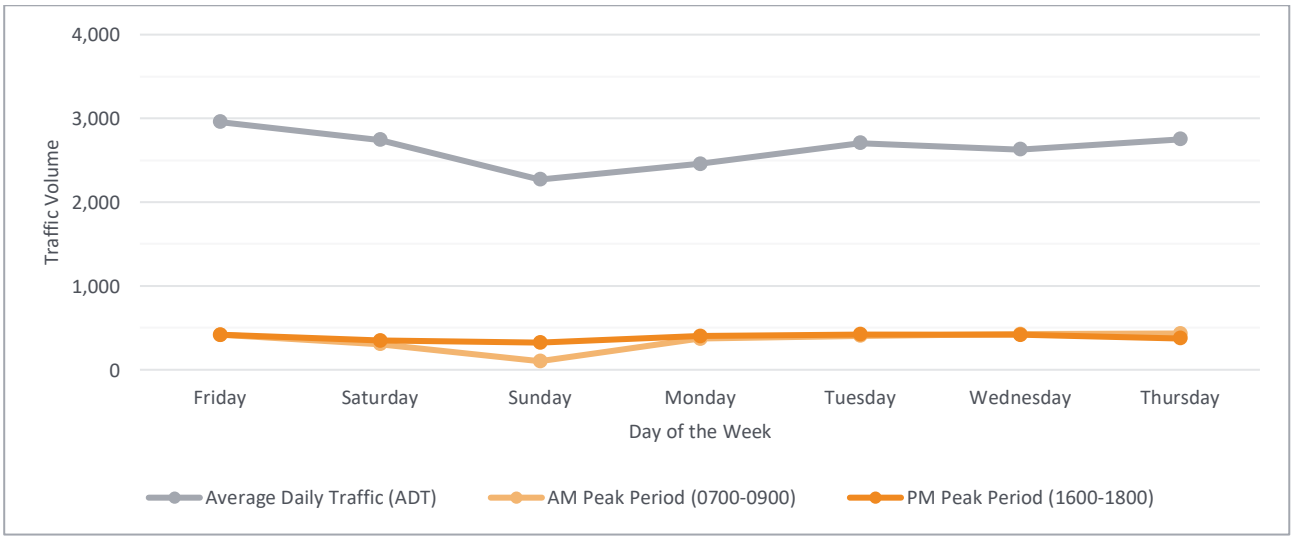


Figure 24-8. Existing intersection traffic count data in the AM peak-hour (1-hour period)

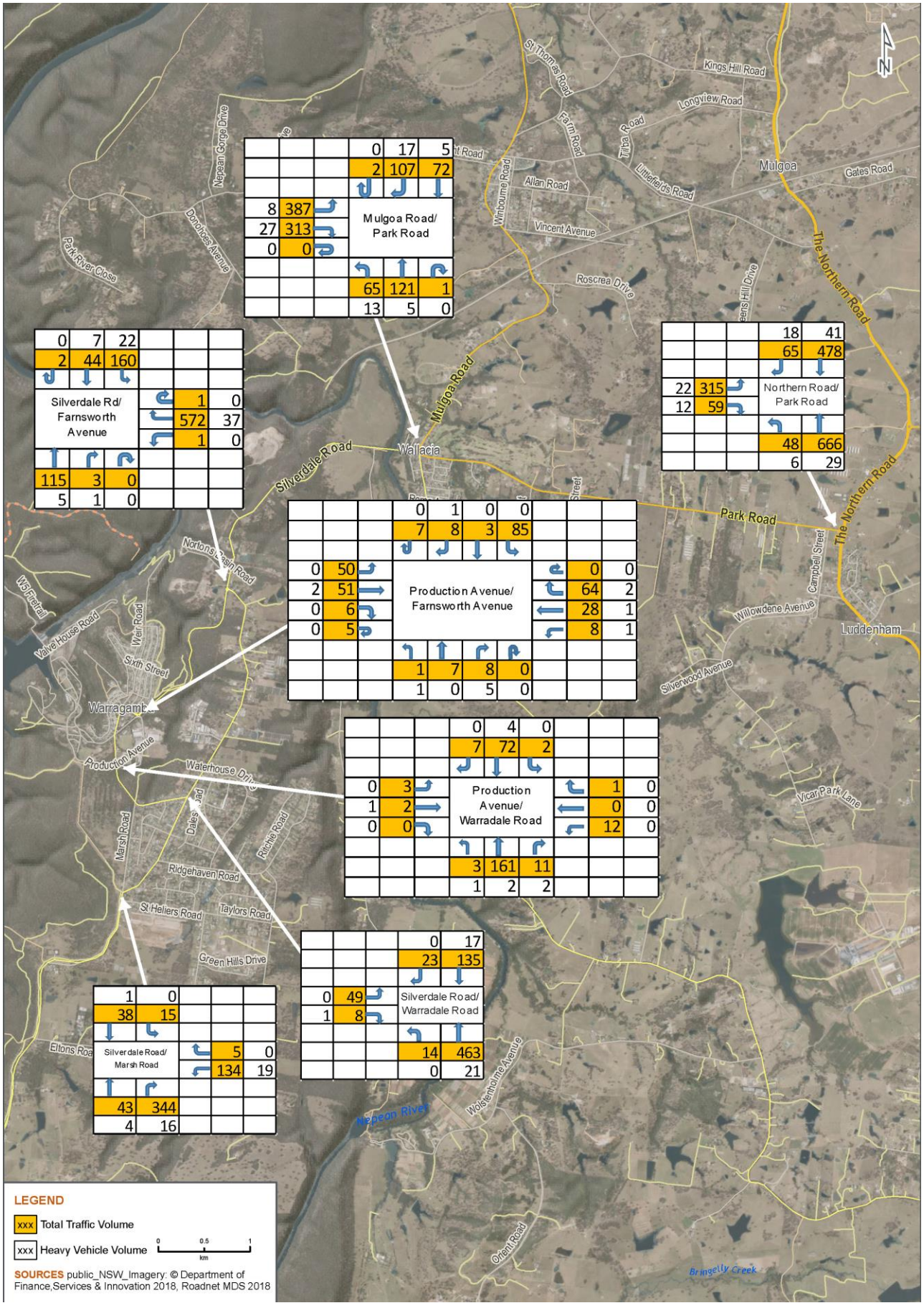
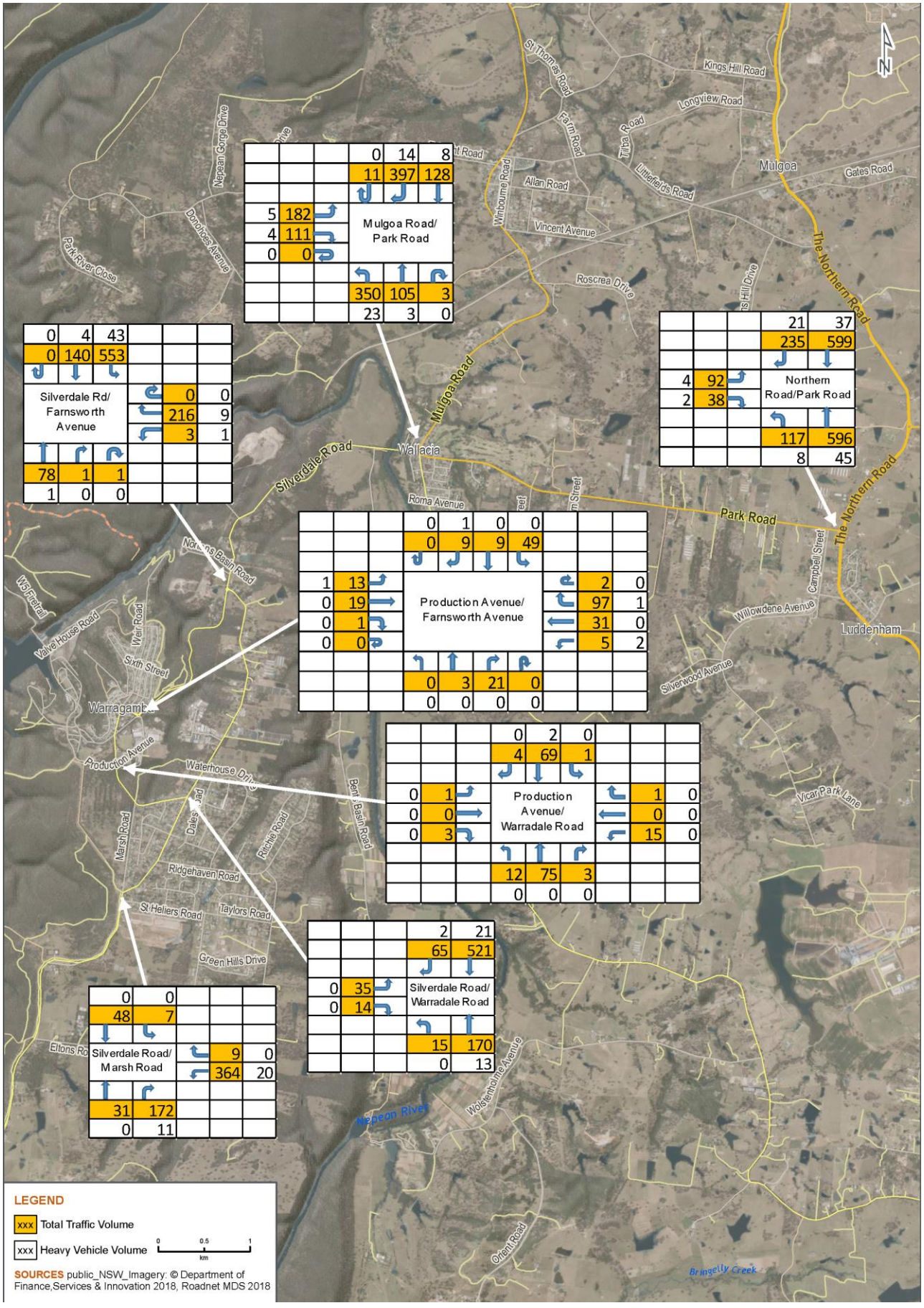


Figure 24-9. Existing intersection traffic count data in the PM peak-hour (1-hour period)



24.2.3 Roads and intersection capacity

The existing performance of the road network in the vicinity of the Project construction area was determined to provide a baseline to assess the impacts of additional construction traffic on the existing road network capacity. The performance of the road network is largely dependent on the operating performance of intersections that are the critical capacity control points. The level of service (LOS) is the standard measure used to assess the operational performance of the intersections. Level of service is ranked from LOS A to LOS F, with LOS A representing the best performance and LOS F the worst. SIDRA Intersection (version 7) modelling software was used to model and assess the performance of the identified intersections.

The criteria used to determine intersection level of service based on average delay is defined in the 2002 *Guide to Traffic Generating Developments* (RTA 2002)), and outlined in Table 24-2.

Table 24-2. RTA delay-based level of service criteria for intersections

Level of service	Average delay per vehicle (sec)	Traffic signals/roundabouts	Give way and stop signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; incidents would cause excessive delays at signals Roundabouts require other control modes	At capacity; requires other control mode
F	>70	Over capacity; unstable operation	Over capacity; unstable operation

Intersection capacity analysis was carried out for all seven intersections for the following scenarios:

- intersection capacity analysis of base year 2018
- intersection capacity analysis of future year 2022 without Project construction traffic
- intersection capacity analysis of future year 2022 with Project construction traffic (intersection capacity analysis of future year 2022 with Project construction traffic was carried out for two scenarios – Scenario 1 and Scenario 2 as illustrated in Section 24.3.1.2).

24.2.4 Planned developments, growth rate, and future year traffic estimation

Wollondilly Shire Council was consulted to obtain information on other planned developments expected to impact on the road network at the same time as construction of the Project. No specific developments were identified, however it was agreed to use a 3.5 percent annual traffic growth rate to estimate the construction year 2022 traffic, and to capture any additional traffic from future planned development. The assumed annual growth rate is high and conservative given that the NSW average is 1.6 percent annual growth rate[3].

24.2.5 Average travel speed

Travel speeds provide an additional means of assessing the functional performance of a road. The criteria for determining the level of service based on average travel speeds is defined by Austroads *Guide to Traffic Management, Part 3: Traffic Studies and Analysis* (Austroads 2017), and outlined in Table 24-3.

[3] Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/mf/3218.0 on 27 July 2018

Table 24-3. Austroads speed-based level of service criteria for urban roads

Average travel speed as a percentage of posted speed limit	Level of service (volume to capacity<1)
>85%	A
67-85%	B
50-67%	C
40-50%	D
30-40%	E
<30%	F

Table 24-4 shows the average travel speed on Park Road, Silverdale Road and Farnsworth Avenue.

Table 24-4. Current travel speed of various roads around the Project site

Location	Criterion	Posted speed limit (km/hr)	Average travel speed (km/hr)*	Speed ratio (travel speed/ posted speed)	LOS
Park Road					
Eastbound	24-hour average speed	80	82.4	103%	A
	AM peak average speed		82.8	104%	A
	PM peak average speed		81.4	102%	A
Westbound	24-hour average speed	80	83.5	104%	A
	AM peak average speed		82	103%	A
	PM peak average speed		83.1	104%	A
Silverdale Road					
Northbound	24-hour average speed	60	60.8	101%	A
	AM peak average speed		60.5	101%	A
	PM peak average speed		59.3	99%	A
Southbound	24-hour average speed	60	61.6	103%	A
	AM peak average speed		59.6	99%	A
	PM peak average speed		62	103%	A
Farnsworth Avenue					
Northbound	24-hour average speed	60	65.9	110%	A
	AM peak average speed		65.7	110%	A
	PM peak average speed		65.8	110%	A
Southbound	24-hour average speed	60	67.3	112%	A
	AM peak average speed		65.3	109%	A
	PM peak average speed		65.7	110%	A

** Directional Traffic Survey 2018*

All roads investigated performed with LOS A. However, all these roads are single lane divided road with a low proportion of heavy vehicles. It is anticipated that additional heavy trucks loaded with construction materials may drive at lower speeds, which may result in reducing the average travel speed of the roads.

24.2.6 Property access

Existing access to properties in Warragamba, Wallacia, and Silverdale areas were identified to assess potential access impacts during construction.

Currently, many properties in the Silverdale and Wallacia areas have direct access from Silverdale Road, Park Road, and Mulgoa Road. The properties are shown in Figure 24-10 and Figure 24-11 respectively. It is anticipated that additional construction traffic, especially heavy vehicles, may have impacts on these access locations along Silverdale Road, Warradale Road, Mulgoa Road, and Park Road.

The southern route also passes through the main activity centres (commercial, schools etc.) of Tahmoor, Picton, and The Oaks as shown in Figure 24-12 to Figure 24-14. Additional heavy vehicle movements in these areas may impact access and result in a reduction in pedestrian safety.

Many rural properties have direct access from Park Road, Silverdale Road, Montpelier Drive and Remembrance Drive along the northern and southern routes, which may be impacted by the additional construction traffic.

Figure 24-10. Property access from Park Road (northern route)

Figure 24-11. Property access from Silverdale Road and Warradale Road (southern route)

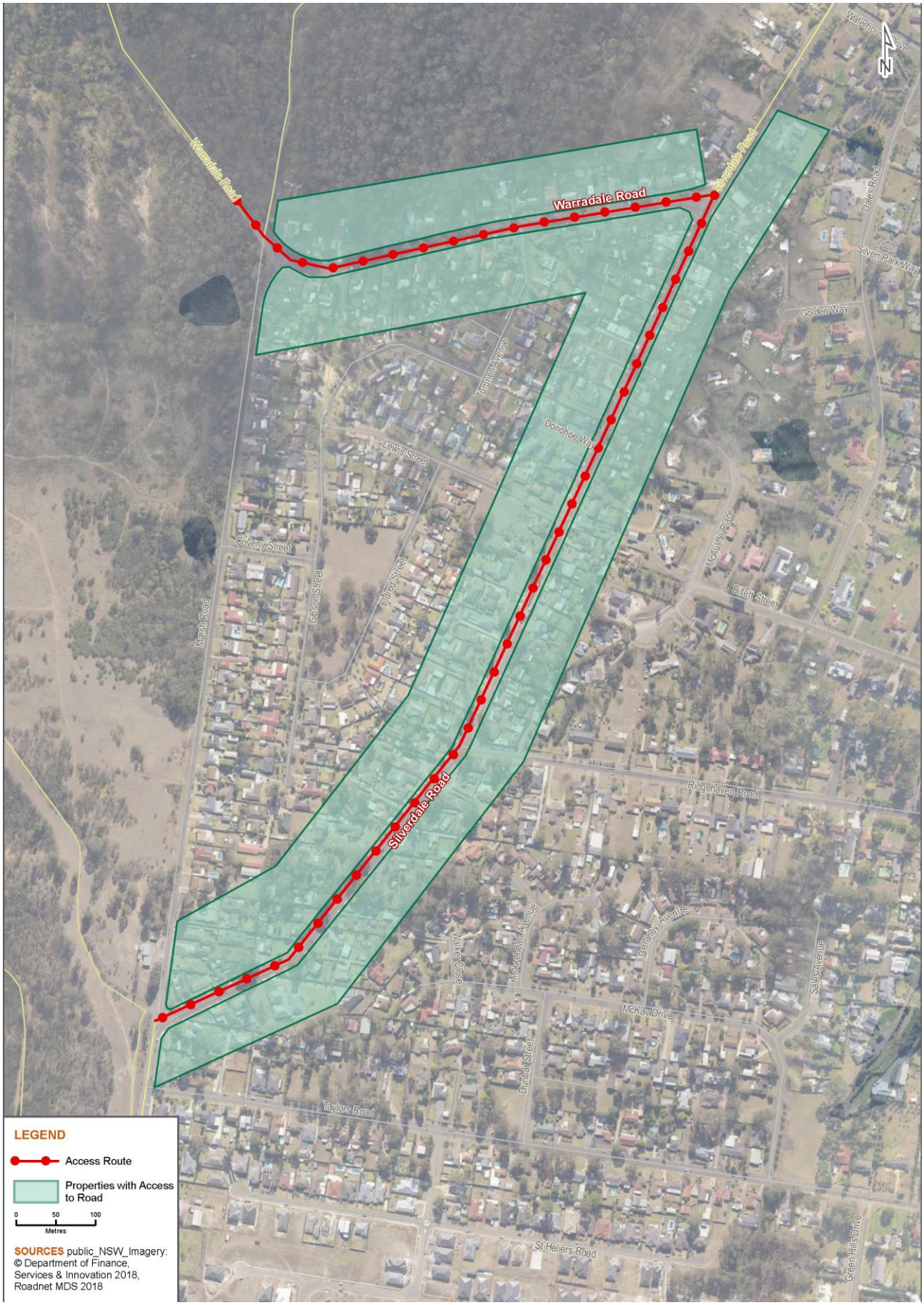


Figure 24-12. Property access from Montpelier Drive (southern route)

Figure 24-13. Property access from Argyle Street (southern route)

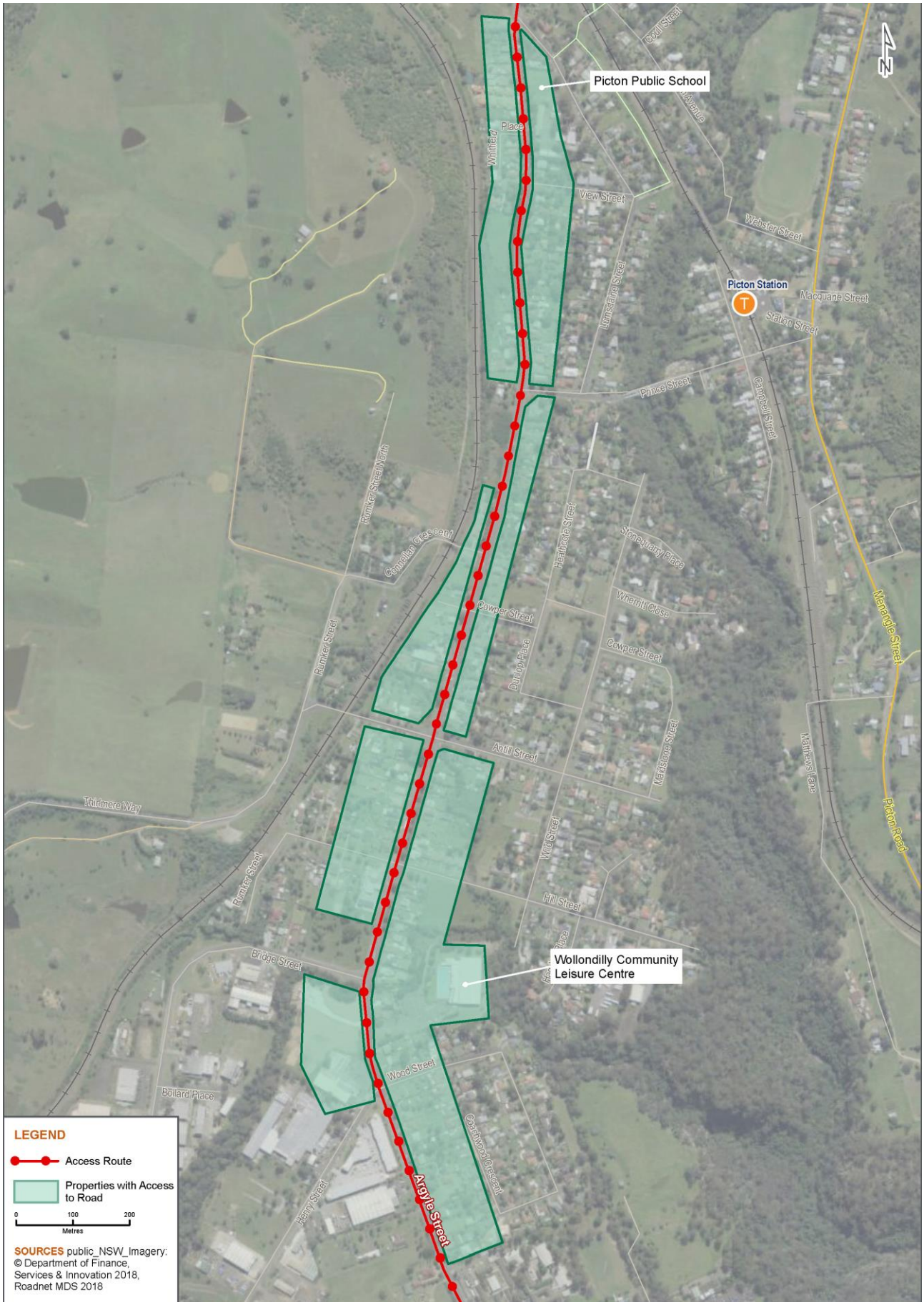
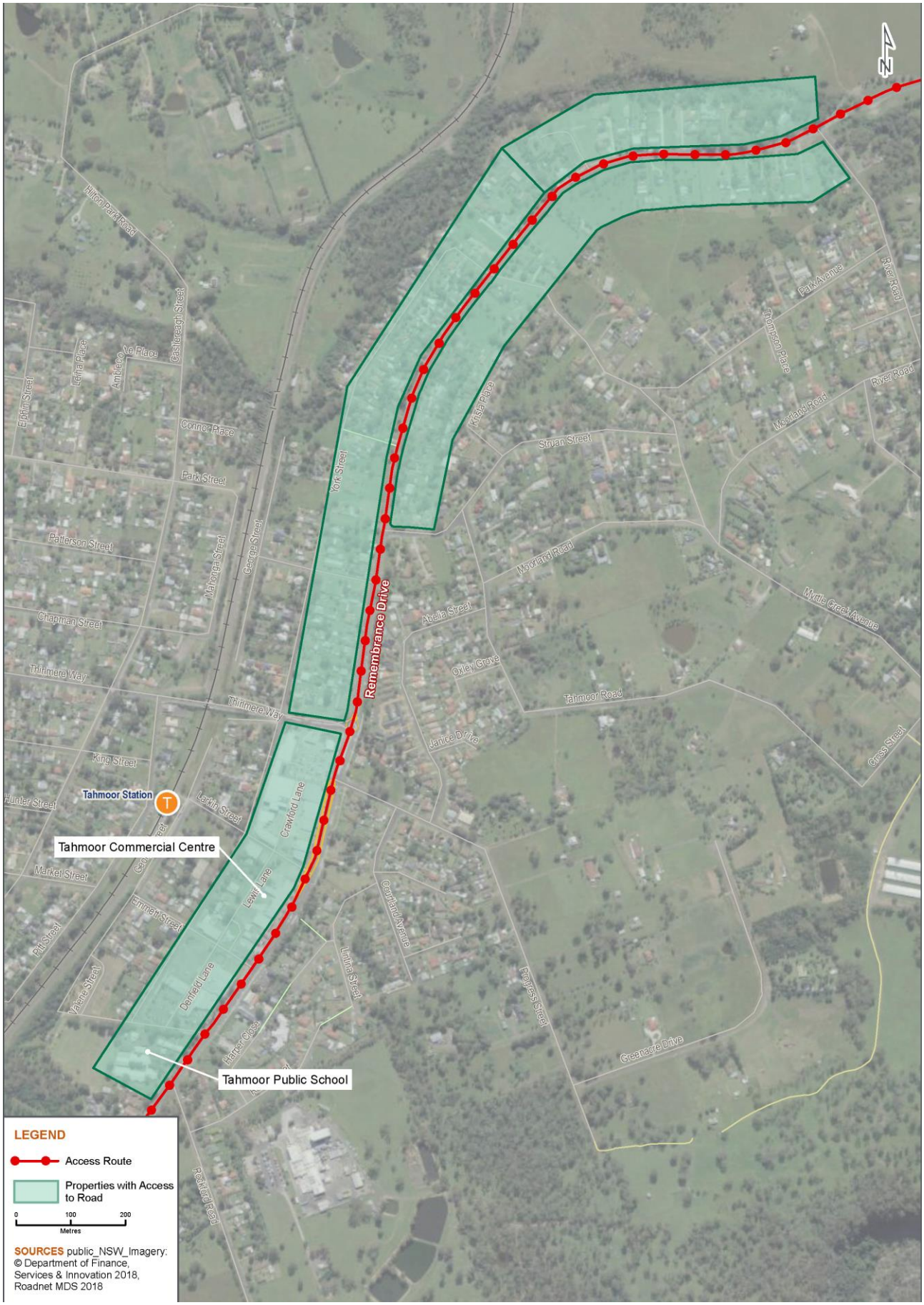


Figure 24-14. Property access from Remembrance Drive (southern route)



24.2.7 Pavement condition

Existing pavement condition of the road network was assessed based on the pavement condition index (PCI) data received from the Wollondilly Shire Council. The PCI levels are given in Table 24-5.

Table 24-5. Pavement condition index (PCI) level

Pavement Condition Index (PCI)	Road condition
10 to 8	Very good
5 to 8	Good
2.5 to 5	Fair
1 to 2.5	Poor
<1	Very poor

Source: Pavement Condition Index, Wollondilly Shire Council

The existing pavement condition of the surrounding road network is shown in Figure 24-15. Roads along the northern route (Silverdale Road, Farnsworth Avenue, and Production Avenue) have good pavement condition. However, roads along the Southern Route (Silverdale Road, Warradale Road) have poor pavement condition.

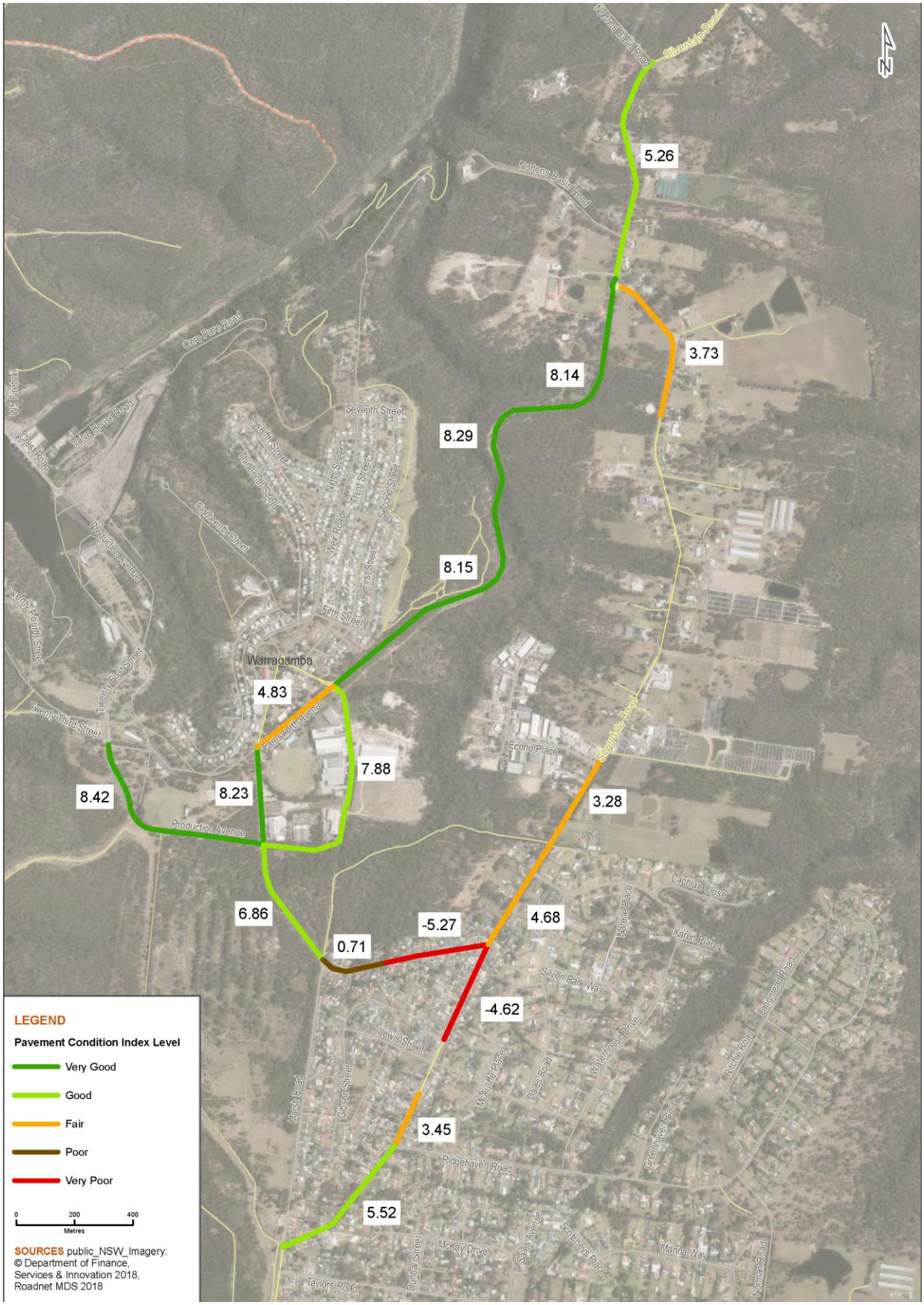
24.2.8 Pedestrians and cyclists

There are no designated cycle paths within the local road network. However, there are designated pedestrian walkways along some of the local roads as shown in Figure 24-16 to F*igure* 24-19. However, these walkways are not continuous and are concentrated around the main activity centres. Most of these walkways are narrow (1.25 metres) except for the walkways around Farnsworth Avenue and Weir Road (range from 2–2.8 metres).

Pedestrian and cyclist activities on local roads are indicatively shown on the Strava[4] heat map (Figure 24-20). Most activity occurs along Silverdale Road, Farnsworth Avenue, Warradale Road, Production Avenue, Weir Road and Marsh Road.

[4] Strava is an internet service for tracking human exercise: *https://medium.com/strava-engineering/the-global-heatmap-now-6x-hotter-23fc01d301de.*

Figure 24-15. Existing pavement condition of roads surrounding the Project site



Source: Pavement Condition Index, Wollondilly Shire Council (undated received on 5 June 2018)

Figure 24-16. Walkways along Park Road and Silverdale Road

Figure 24-17. Walkways along Farnsworth Avenue and Weir Road

Figure 24-18. Walkways along Production Avenue

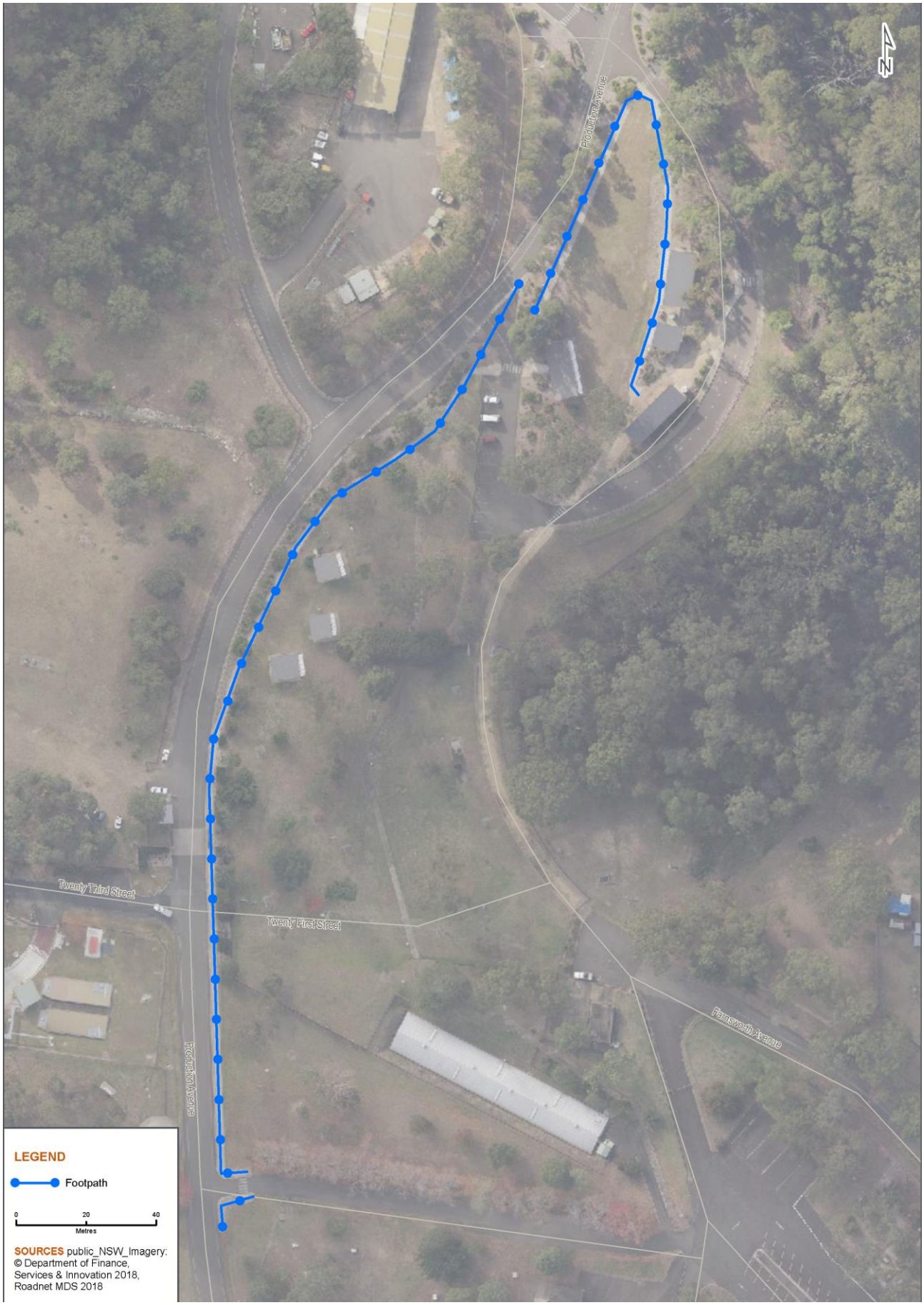


Figure 24-19. Walkways along Warradale Road

Figure 24-20. Active transport (pedestrian and cyclists) Strava heat map in Warragamba area

Source: https://www.strava.com/heatmap#12.81/151.01269/-33.88418/hot/all

24.2.9 Public transport and school bus service

There are no major transport interchanges or public transport hubs near the Project construction area. There are two bus routes, namely 795 and 32, serving the Warragamba area.

- Bus route 795 goes from Penrith to Warragamba via Mulgoa Road-Silverdale Road-Marsh Road-Warradale Road-Fourteenth Street-Weir Road. Bus route 795 has frequencies of one to two trips per hour (30-minute/60-minute headway) during both AM and PM peak periods, and three trips during off-peak period[5].
- Bus route 32 goes from Camden to Warragamba via Macquarie Grove Road-Cobbitty Road-Werombi Road-Silverdale Road-Marsh Road-Warradale Road. Bus route 32 has frequencies of one to two trips per hour (34-minute to 75-minute headway) during both AM and PM peak periods[6].

The Warragamba Public School is located on Farnsworth Avenue and has school bus access from Weir Road. Currently one school bus (Bus No. 4106) operates in the morning and uses Silverdale Road, Farnsworth Avenue, Marsh Road, Warradale Road, and other local roads to access the school.

24.2.10 Loading capacity of Blaxland Crossing Bridge

The normal loading capacity of Blaxland Crossing Bridge is approximately 57.5 tonnes. The bridge has undergone recent remedial works during which the loading capacity was reduced to 38 tonnes. However, the works on Blaxland Crossing Bridge have been completed and the normal loading capacity of the bridge has been reinstated.

[5] Derived from https://www.busways.com.au/travelling-with-us/route/795/route-795-penrith-warragamba-jamisontown-regentville/20180603-0 on 12 November 2018

[6] Derived from https://busabout.com.au/pdf/timetables/31-32.pdf on 12 November 2018

24.2.11 Existing downstream transport infrastracture and river crossings

The Hawkesbury-Nepean River, its floodplain and its flooding potential presents a major constraint to transport corridors, however many are key corridors enabling the movement of vehicles and trains across the river. Some of the crossings due to their location, low capacity and historical development are flood prone and below the 1 in 100 chance in a year flood level. There are also a number of important transport corridors that cross tributaries of the Hawkesbury-Nepean River and which are also evacuation routes. Key transport crossings are shown on Figure 24-21. Flood levels at which crossings are closed are given in Table 24-6.

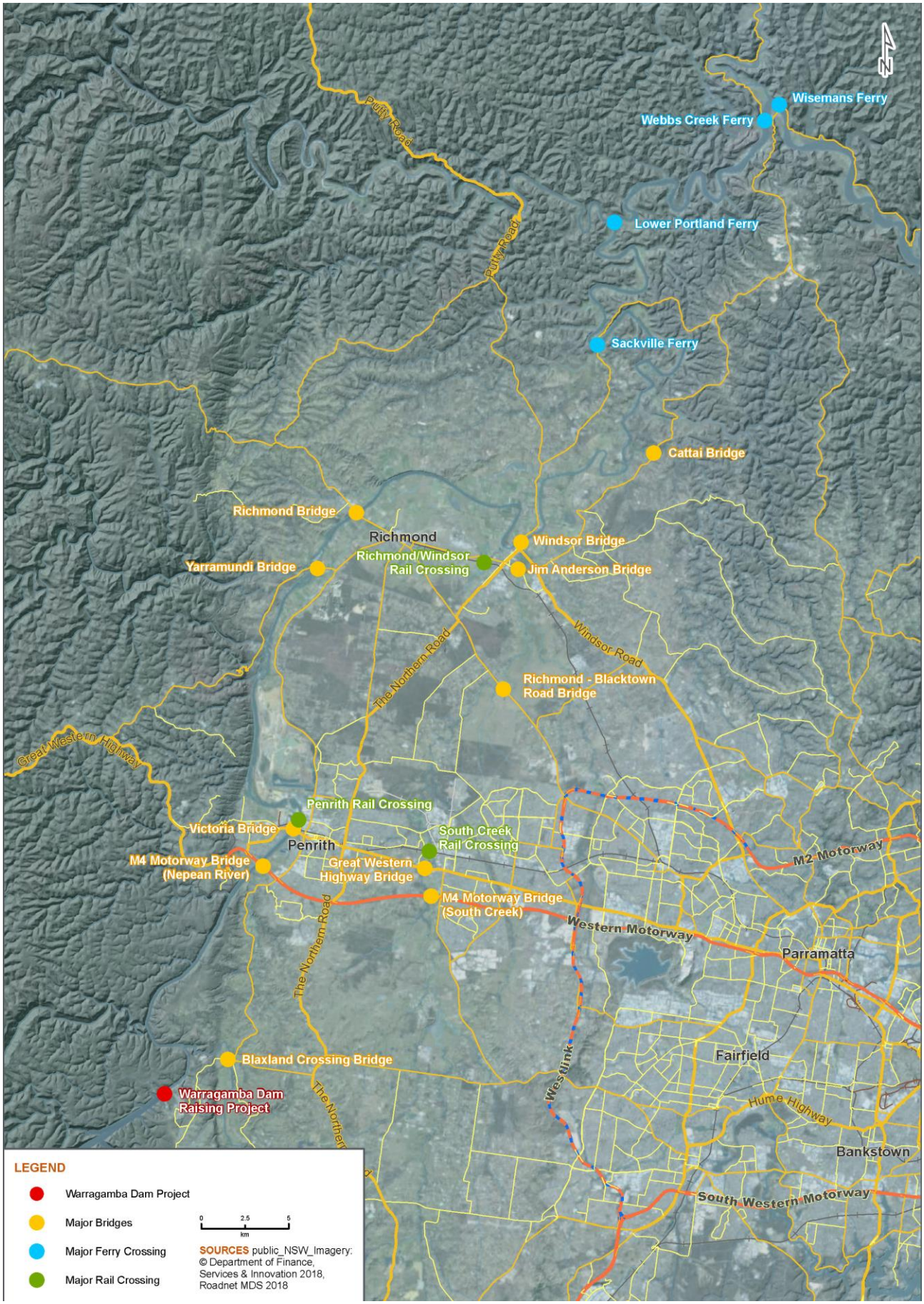
Table 24-6. Key waterway crossings in study area

Crossing	Maximum flood closure level[1] (mAHD)	Features
Road		
Cattai Creek Bridge at Cattai	1.99	Cattai Road/Wisemans Ferry Road crossing of Cattai Creek
Yarramundi Bridge	5.61	Crossing of the Hawkesbury-Nepean River north of Penrith and provides access to Yarramundi and Winmalee
Windsor Bridge (New)	9.8	New bridge crossing of the Hawkesbury River at Windsor was recently opened in May 2020.
Richmond Bridge	7.82	Crossing of Hawkesbury River - provides access to Bells Line of Road and North Richmond
Richmond- Blacktown Road Bridge	12.57	Crossing of Rickaby Creek – important evacuation route
Jim Anderson Bridge	14.16	Hawkesbury Valley Way crossing of South Creek – important evacuation route from Windsor
Victoria Road Bridge	28	Great Western Highway crossing of Nepean River at Penrith. Approaches to bridge are lower than bridge
M4 Motorway Bridge - Nepean River	30.4	Westbound M4 Motorway crossing of Nepean River
M4 Motorway Bridge - Nepean River	32.6	Eastbound M4 Motorway crossing of Nepean River
M4 Motorway Bridge - South Creek	26.1	M4 Motorway crossing of South Creek at St Marys
Great Western Highway Bridge - South Creek	24.56	Great Western Highway crossing of South Creek at St Marys
Blaxland Bridge (Wallacia)	33.8	Silverdale Road crossing of the Nepean River at Wallacia
Car ferry		
Sackville Ferry crossing	3 to 3.5	Car ferry crossing Hawkesbury River
Lower Portland Ferry crossing	3 to 3.5	Car ferry crossing Hawkesbury River
Webbs Creek Ferry crossing	3 to 3.5	Car ferry crossing Hawkesbury River
Wisemans Ferry crossing	3 to 3.5	Car ferry crossing Hawkesbury River

Crossing	Maximum flood closure level[1] (mAHD)	Features
River crossing (Rail)		
Penrith Rail Crossing (28 m height)	28	Main western line crossing of Nepean River. Approaches are lower than bridge
South Creek Rail Crossing (24.8 m height)	24.8	Main western line crossing of South Creek at St Marys
Richmond/Windsor Rail Crossing (12.65 m height)	12.65	Richmond line crossing of South Creek

Note 1: This is the maximum flood level before closure of these crossings. During flood events these crossings will close well before the flood reaches these levels based on a risk assessment by the road, rail or ferry operators in consultation with emergency services.

Figure 24-21. Major bridges and ferry crossings downstream of Warragamba Dam



24.3 Construction impacts

Potential impacts on the road network were assessed against the following criteria:

- roads and intersection capacity
- pavement condition
- average travel speed
- property access
- pedestrian and cyclist
- public transport
- local parking.

The number of heavy vehicles travelling to the dam site would be relatively low in comparison to the capacities of the major highways and arterial roads. The traffic assessment has therefore focussed on the local road network surrounding the Project construction site, which is described in Section 24.2.1 and Section 24.2.7 (refer Figure 24-3, Figure 24-4, and Figure 24-15).

24.3.1 Construction program, traffic generation, and travel routes

A large quantity of concrete would be produced at the dam site at one or two concrete batch plants, with materials sourced from off-site. Materials for concrete production include:

- cement
- fly ash
- fine aggregrates
- coarse aggregates.

Most of the heavy vehicle movements to and from the Project construction site would be trucks delivering materials for concrete production, with fine and coarse aggregrates generating the highest proportion of heavy vehicle movements. Sources of construction materials would be the responsibility of the construction contractor, however, quarries on the South Coast, Southern Highlands, Blue Mountains and immediately north of Sydney have been identified as producing aggregates suitable for the Project. Fly ash would most likely be sourced from a power station in the eastern states and cement from suppliers in the Sydney region. An allowance of 15 percent additional heavy vehicle movements has been made to account for deliveries of other materials and equipment to the construction site.

A preliminary construction program is presented in Section 24.1.1 (refer Figure 24-1) with construction expected to be completed within four to five years. Construction information is shown in Table 24-7.

Table 24-7. Project construction program

Aspect	Amount	Unit
Construction period – year	2022-2025	
Total number of peak delivery weeks	150	weeks
Construction working days per week	6	days
Construction working hours per weekday	10	hours
Construction working hours per Saturday	5	hours
Materials for concrete production	1,558,233	tonnes

Source: WaterNSW 2018

Based on the assumptions given in Table 24-8, it was estimated that there would be approximately 208 heavy vehicle movements per day (IN and OUT) for the period of main works. A breakdown of heavy truck movements is outlined in Table 24-9.

Table 24-8. Assumptions for heavy vehicle trip generation

Assumption	Criterion
Total allowable weight of each truck: *x*	42,500 kg
Weight of each truck: *y*	16,000 kg
Net weight: (*x*-*y*)	26,500 kg
Short loads factor	15%
Other truck movements factor	15%

Source: WaterNSW 2018

Table 24-9. Heavy vehicle movements during construction

Material	Total tonnes	Total heavy vehicles - construction period	Daily heavy vehicles accessing site (IN)	Daily heavy vehicle movements (IN and OUT)
Cement	75,123	2,835	3.8	7.6
Fly ash	89,580	3,380	4.5	9.0
Fine aggregate (Sand)	846,874	31,957	42.6	85.2
Coarse Aggregate	546,656	20,629	27.5	55.0
Steel	10,880	1,232	1.6	3.3
Short loads (See Note)		9,005	12.0	24.0
Other truck movements		8,820	11.8	23.5
Total	1,569,113	77,858	103.8	207.6

Note: Short loads assume that trucks are only loaded to 85 percent of total capacity, which is a conservative assessment

Vehicle generation was estimated as follows:

Heavy vehicles: The estimated 208 truck movements would generally be spread evenly through an effective ten-hour day and an average of about 21 heavy vehicle movements would occur in every hour (approximately 11 IN and 11 OUT).

Cars: It is estimated that up to 500 workers would be on site daily during the peak construction period. Using a conservative approach, it was assumed that heavy vehicle and worker trips would occur in the same hour and that all workers would travel to the site by car with an average car occupancy of two people per car. It was also assumed that all workers (250 cars) would travel to the site during the morning peak-hour (AM peak) and would leave the construction site during the PM peak. Based on this estimation, the Project would generate 250 car trips an hour (250 vehicles IN at AM peak-hour and 250 vehicles an hour OUT at PM peak-hour).

24.3.1.1 Heavy vehicle routes

Heavy vehicles would use northern and southern routes to deliver construction materials to the dam site.

The northern route is shown on Figure 24-22 and includes:

- The Northern Road
- Park Road from The Northern Road to Wallacia
- Silverdale Road from Wallacia to Farnsworth Avenue
- Farnsworth Avenue between intersections with Silverdale Road and Production Avenue

- Production Avenue between intersections with Silverdale Road and the construction access.

The southern route is shown on Figure 24-23 and includes:

- Silverdale Road from the Oaks to Warradale Road
- Warradale Road to Production Avenue
- Production Avenue between intersections with Warradale Road and the construction access.

A combination of the above two routes may also be used by heavy vehicles travelling to the site. Trip distributions are discussed in Section 24.3.1.2.

24.3.1.2 Traffic distribution and assignment

For the purpose of assessing the impacts of Project construction traffic, estimated worker journeys were distributed and assigned to different roads and intersections. It is assumed that majority of workers (75 percent) would travel to the site from the Greater Western Sydney region (Penrith, Liverpool, Campbelltown etc.) using Mulgoa Road and The Northern Road during the AM peak-hour. These two roads are the only convenient options to access the site from the Greater Western Sydney Region. Twenty percent of workers' journeys were assumed to orginate from the south using Silverdale Road and five percent of workers' journeys were assumed from the adjacent local Wallacia area as shown in Figure 24-24. In the PM peak, the same proportion of worker journeys would be in the opposite direction as shown in Figure 24-25.

Heavy vehicles would use the northern and southern routes to access the site. However, the southern route would only potentially be used by heavy vehicles if aggregates for concrete production were sourced from the Southern Highlands. If aggregates are sourced from other locations, all heavy vehicles would use the northern route to access the construction site. Other materials would generally be sourced from the Sydney region and therefore a proportion of heavy vehicles would always use the northern route. Considering this, two scenarios were assessed for assessing the impact on the road networks:

- Scenario 1 – 100 percent heavy vehicles using the northern route
- Scenario 2 – 50 percent heavy vehicles using the Northern Route and 50 percent using the southern route.

Figure 24-22. Northern construction access route

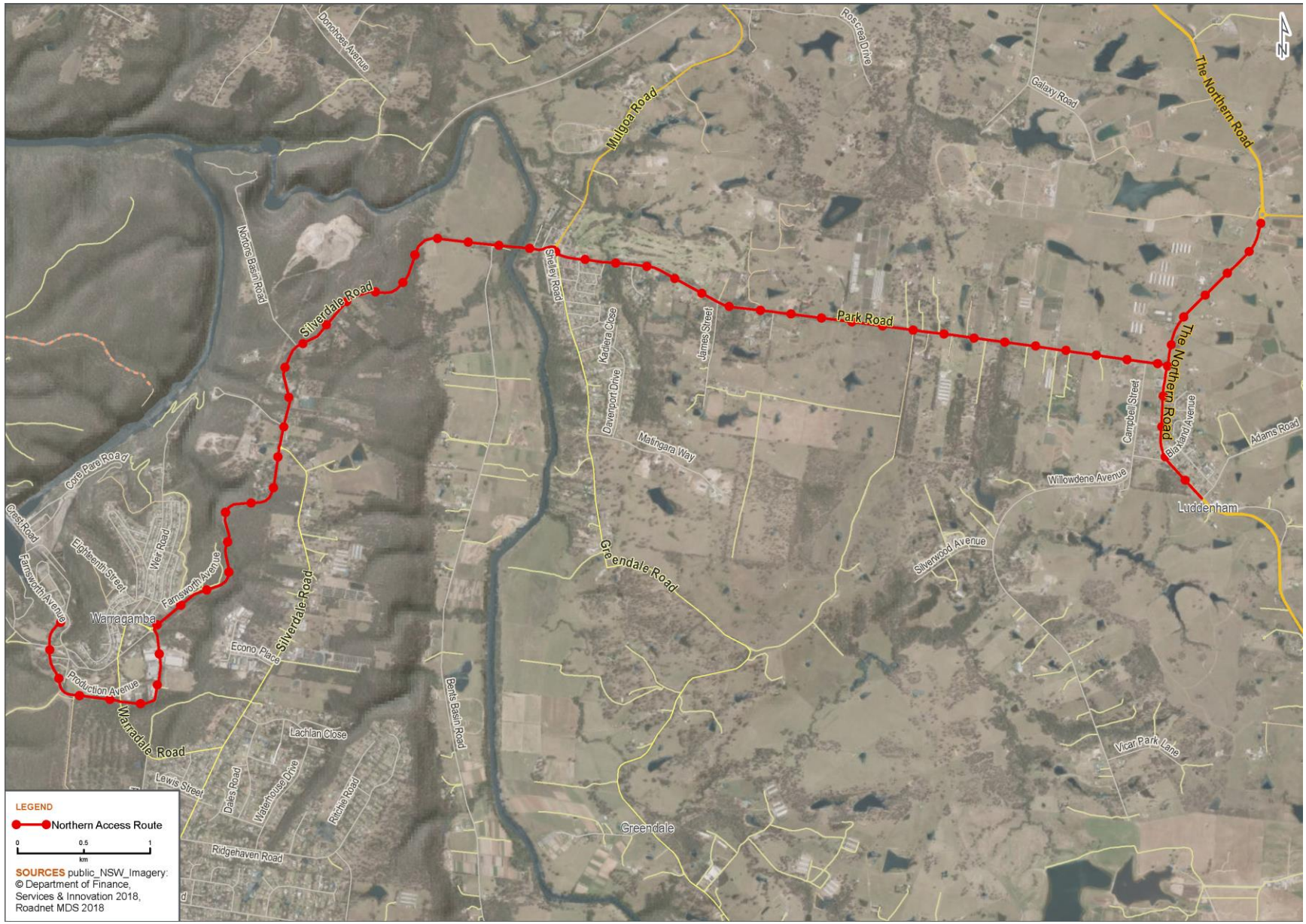


Figure 24-23. Southern truck route

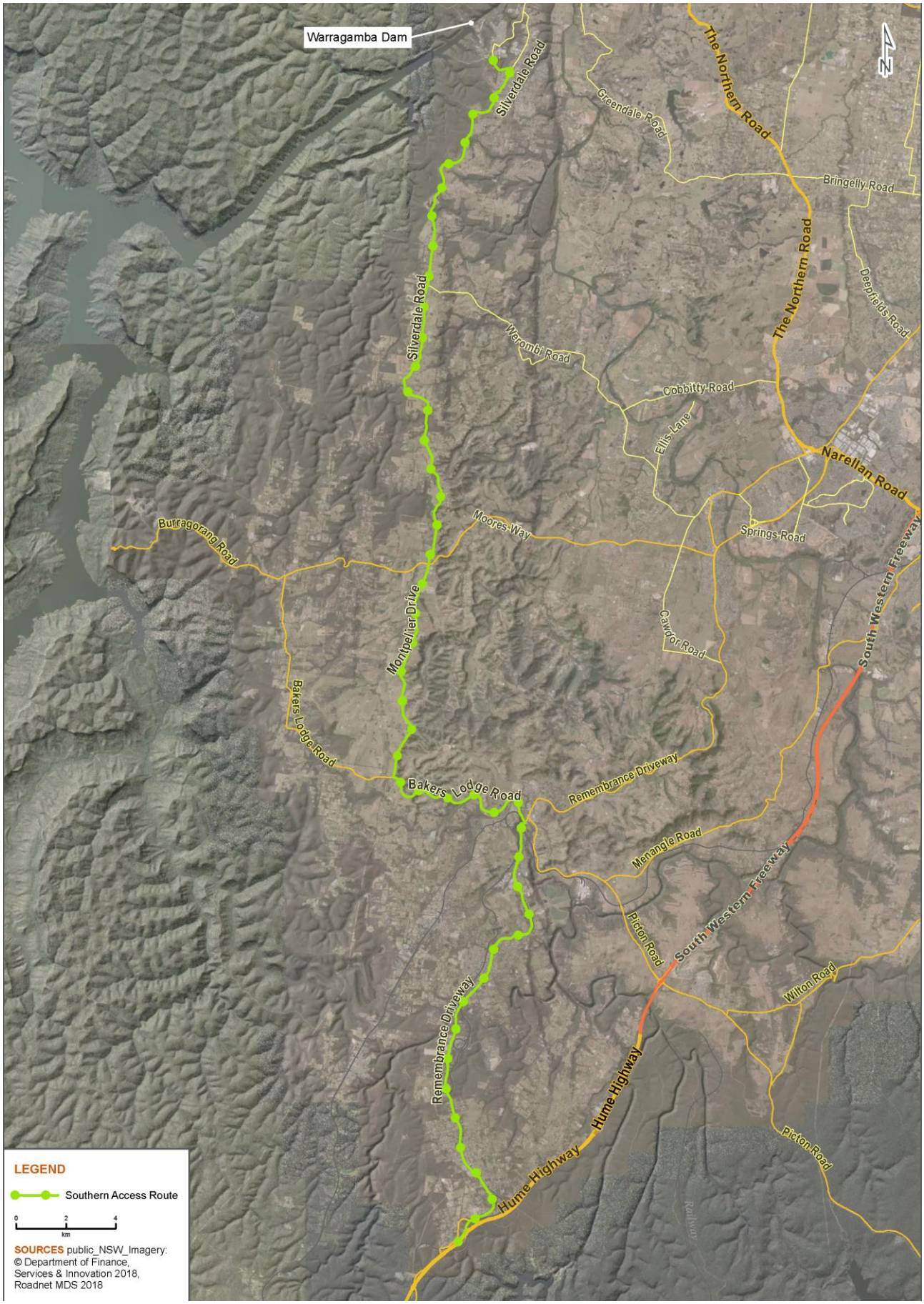


Figure 24-24. Trip distribution and assignment of worker journeys for AM peak

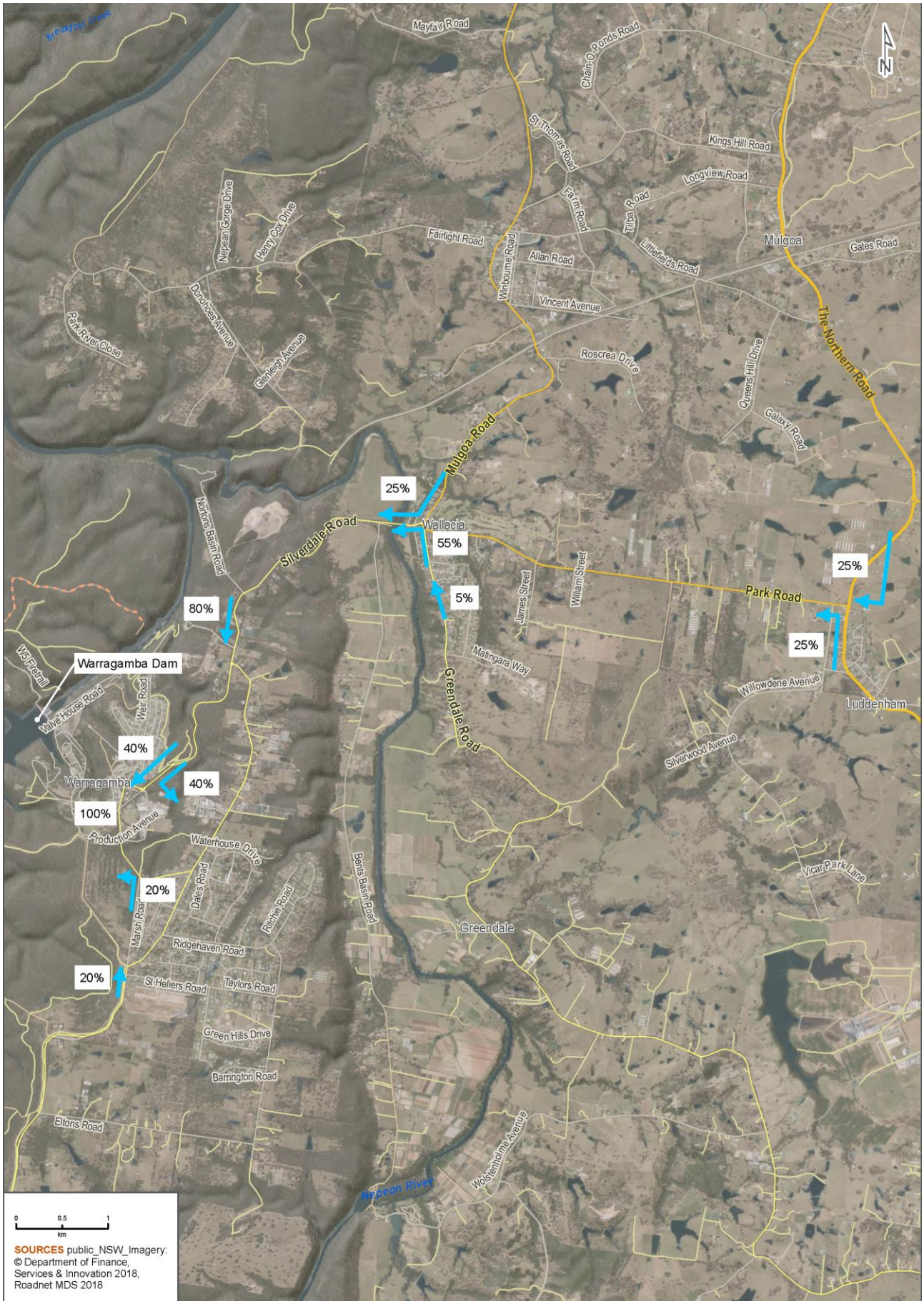
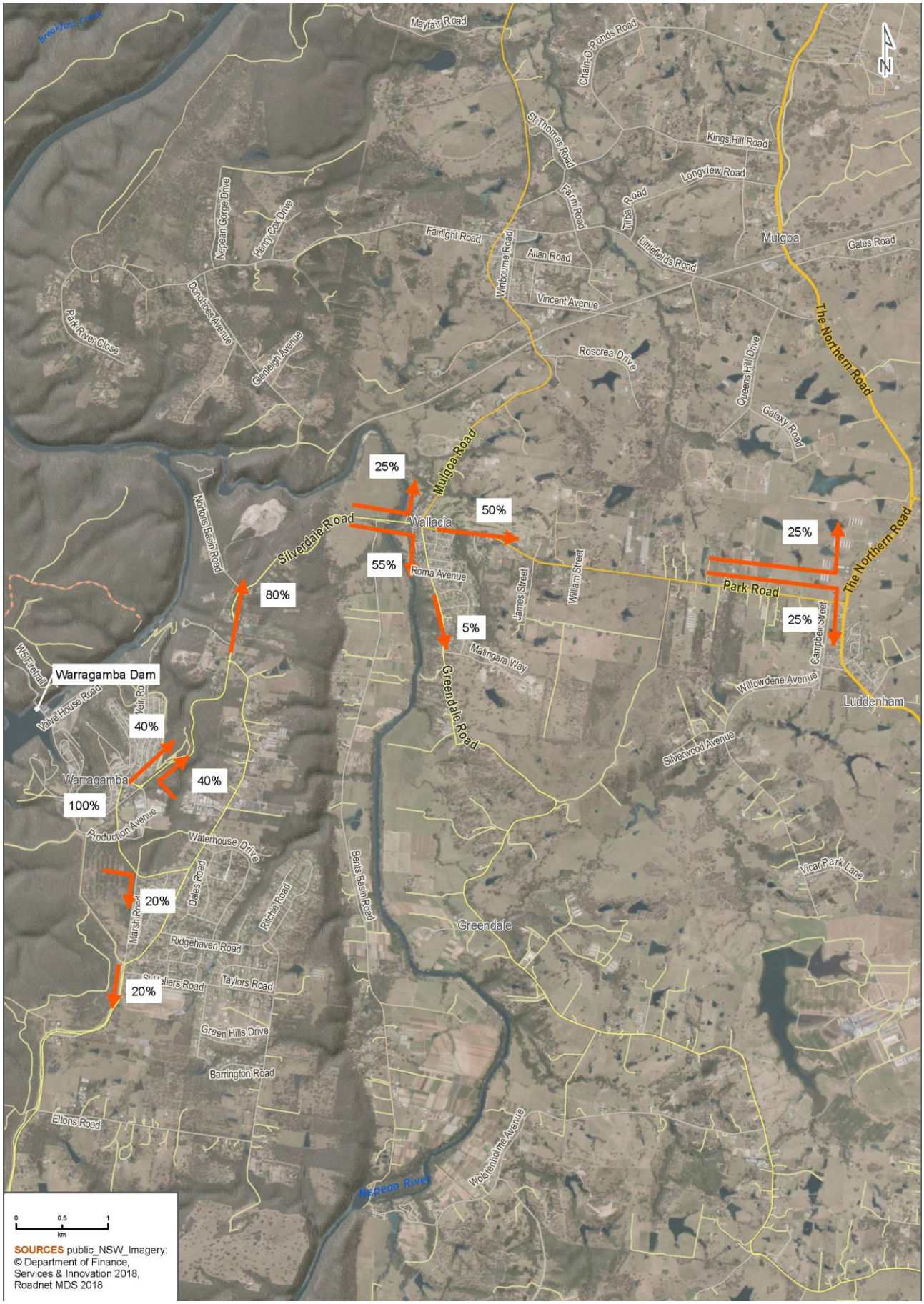


Figure 24-25. Trip distribution and assignment of worker journeys for PM peak



24.3.2 Road modifications

The following road network modification would occur during the construction period:

- removal of non-construction related accesses
- closure of public access to Production Avenue (northern part near the construction site) and Twenty-Third Street/Twenty Fourth Street for construction vehicles only
- closure of Farnsworth Avenue (northern part near the construction site) for all vehicles
- closure of visitors' parking area of the Warragamba Dam Visitor Centre
- installation of temporary traffic signal at Production Avenue/Warradale Road intersection to enhance the safety of vehicles/heavy trucks movements.

24.3.3 Impacts on intersections

It is anticipated that most of the future northbound and southbound through-traffic at the Park Road/Northern Road intersection would use the new link between the Elizabeth Drive/Existing Northern Road intersection and New Northern Road/Existing Northern Road intersection. For the purposes of this study, the northbound and southbound traffic of the Park Road/Northern Road intersection were reduced to 50 percent for future year 2022 analysis, assuming 50 percent of the existing Northern Road traffic would shift to the new link in future years. It should be noted that the majority of the north-south traffic at Park Road/Northern Road intersection is through traffic and the new link would provide a better and faster option. It is anticipated that in the future more traffic would use the new link for north-south movements. As such, adoption of a 50 percent shift of future traffic to the new link is conservative for assessing the Park Road/Northern Road intersection.

Table 24-10 shows the intersection capacity analysis of the seven intersections affected by the Project. All intersections except the Park Road/Northern Road intersection are predicted to perform at LOS A in future year scenarios in both AM and PM peaks, and with and without Project traffic. Detailed SIDRA modelling intersection analysis is provided in Appendix O (Traffic and transport assessment report).

Traffic count surveys were undertaken during the winter season and no traffic volume data is available for other seasons to understand the seasonal traffic variation in the study area. However, it is anticipated that seasonal variations in traffic volumes are likely to have minimal impact on road network capacity, as the road network currently operates with acceptable level of service and has sufficient levels of reserve capacity to accommodate any minor seasonal variations in traffic volumes.

Table 24-10. Performance analysis of intersections around the Project construction area

Intersection	Assessment scenario	Peak-hour	Delay (sec)	LOS	Degree of Saturation
Northern Road/Park Road intersection without Northern Road Upgrade - no reduction of traffic (stop-controlled intersection)	2018	AM	37.8*	C*	0.75
		PM	30.6*	C*	0.43
	2022 Without development	AM	174.6	F	1.12
		PM	48.3	D	0.56
	2022 Scenario 1	AM	373.9	F	1.35
		PM	899.1	F	1.96
	2022 Scenario 2	AM	321.4	F	1.29
		PM	840.8	F	1.9
Northern Road/Park Road intersection with Northern Road Upgrade - 50 percent traffic reduction on northbound and southbound approach (stop-controlled intersection)	2022 Without development	AM	18.1	B	0.49
		PM	16.5	B	0.30
	2022 Scenario 1	AM	21.9	B	0.55
		PM	23.9	B	0.69
	2022 Scenario 2	AM	21.1	B	0.53
		PM	23.2	B	0.68

Intersection	Assessment scenario	Peak-hour	Delay (sec)	LOS	Degree of Saturation
Park Road/Silverdale Road/Mulgoa Road intersection (Roundabout)	2018	AM	7.2	A	0.58
		PM	8.1	A	0.56
	2022 Without development	AM	7.5	A	0.67
		PM	9.3	A	0.69
	2022 Scenario 1	AM	7.6	A	0.69
		PM	10.6	A	0.73
	2022 Scenario 2	AM	7.6	A	0.68
		PM	10.4	A	0.72
Silverdale Road/Farnsworth Avenue intersection (Roundabout)	2018	AM	7.5	A	0.41
		PM	5.3	A	0.44
	2022 Without development	AM	7.6	A	0.47
		PM	5.3	A	0.51
	2022 Scenario 1	AM	7.8	A	0.58
		PM	5.3	A	0.51
	2022 Scenario 2	AM	7.7	A	0.58
		PM	5.3	A	0.51
Farnsworth Avenue/Production Avenue intersection (roundabout)	2018	AM	4.7	A	0.09
		PM	5.7	A	0.01
	2022 Without development	AM	4.7	A	0.11
		PM	5.8	A	0.11
	2022 Scenario 1	AM	4.7	A	0.24
		PM	6.1	A	0.13
	2022 Scenario 2	AM	4.7	A	0.23
		PM	6.1	A	0.13
Production Avenue/Warradale Road intersection (stop-controlled intersection)	2018	AM	10.2*	A*	0.1
		PM	7.6*	A*	0.05
	2022 Without development	AM	10.4*	A*	0.11
		PM	7.7*	A*	0.06
	2022 Scenario 1	AM	13.6*	A*	0.14
		PM	10.3*	A*	0.21
	2022 Scenario 2	AM	14.2*	A*	0.15
		PM	10.3*	A*	0.22
Silverdale Road/Warradale Road intersection (stop-controlled intersection)	2018	AM	10.0*	A*	0.26
		PM	9.9*	A*	0.32
	2022 Without development	AM	10.5*	A*	0.3
		PM	10.6*	A*	0.37
	2022 Scenario 1	AM	10.5*	A*	0.3
		PM	10.6*	A*	0.37

Intersection	Assessment scenario	Peak-hour	Delay (sec)	LOS	Degree of Saturation
	2022 Scenario 2	AM	12.8*	A*	0.31
		PM	12.7*	A*	0.37
Silverdale Road/Marsh Road Intersection (stop-controlled intersection)	2018	AM	9.6*	A*	0.13
		PM	9.6*	A*	0.23
	2022 Without development	AM	10.0*	A*	0.15
		PM	10.3*	A*	0.27
	2022 Scenario 1	AM	10.2*	A*	0.17
		PM	10.5*	A*	0.27
	2022 Scenario 2	AM	10.3*	A*	0.18
		PM	10.6*	A*	0.27

* Worst movement delays and LOS

24.3.3.1 Temporary traffic signals at Warradale Road/Production Avenue intersection

As requested by Wollondilly Shire Council, a temporary signalised intersection was considered at the Warradale Road/Production Avenue intersection to improve the safety of heavy vehicle movements. Temporary traffic signals were installed at this intersection during the construction of the auxiliary spillway project (1998-2002) and were removed upon completion of construction works.

Capacity analysis of the proposed temporary signalised intersection was carried out to assess the performance during construction starting year 2022 for both scenario 1 and 2 and for AM and PM peaks. Results are shown in Table 24-11.

Table 24-11. Capacity analysis of Warradale Road/Production Avenue traffic signals

Intersection	Analysis scenario	Peak-hour	Average delay (sec.)	LOS	Degree of saturation
Warradale Road/Production Avenue intersection (signalised)	Scenario 1	AM	28.3	B	0.68
		PM	26.0	B	0.51
	Scenario 2	AM	28.4	B	0.68
		PM	26.2	B	0.54

The proposed temporary signalised intersection would perform at acceptable LOS for both scenarios and for both peak-hours in year 2022.

Currently, vehicles more than six metres long are not permitted to perform the eastbound left turn due to the kerb alignment and sight distances. However, Wollondilly Shire Council requested that the intersection be modified to allow for the movement, and this was considered in the capacity analysis. A review of this intersection would be carried out pre-construction in accordance with latest Austroads guidelines to ensure this turning movement can be accommodated and traffic signals safely implemented.

24.3.4 Impacts on road capacity

Low traffic volumes were recorded on Park Road, Farnsworth Avenue and Silverdale Road (see Section 24.2.2). It is estimated that the Project would generate 250 car trips during morning and afternoon peak periods, which would have negligable impact on road capacities in the study area.

24.3.5 Impacts on pavement condition

Additional heavy vehicle movements from construction traffic on the two access routes would result in some deterioration in pavement condition. Pavements in poor condition are more prone to movement and further deterioration due to issues such as asphalt fatigue, water ingress permanent deformations, thermal stresses and

rutting. It is likely that the pavement condition of the Southern Route would be more affected than the Northern Route, which has a better existing pavement condition.

24.3.6 Impacts on pedestrians and cyclists

Heavy vehicle routes near the proposed construction area would include part of Silverdale Road and Production Avenue. The proposed heavy vehicle routes for the Project would avoid possible pedestrian and cyclist activity areas within the local Warragamba area except for part of Silverdale Road and Production Avenue as shown in Figure 24-20.

While there would generally be no direct impact on pedestrian or cyclist movements or paths, there may be an increased safety risk due to the increase in heavy vehicle movements. This is particularly the case where heavy vehicle routes pass by schools or commercial areas. Truck movements within Warragamba will be programed to avoid high transport activities, such as active school zones and sporting events.

The Project workforce would mostly involve workers living across the Sydney region, but site establishment should include limited secure bike parking to encourage cycling, particularly from the local area.

24.3.7 Impacts on access

The increased construction traffic would not result in any loss of access or any substantial delays in accessing roads from properties, businesses or other facilities. However, there is the potential for increased safety risks for vehicles accessing heavy vehicle routes, particularly in residential areas and commercial areas where existing heavy vehicle numbers are low.

24.3.8 Impacts on public transport and school bus service

The existing bus routes and operations in the Warragamba area would not be affected by the additional construction traffic as there is sufficient capacity on the existing local roads. It is also to be noted that due to the additional construction heavy truck movements in the Warragamba area, the bus travel time between the stops may increase. However, the bus routes (795 and 32) serving the Warragamba area have low frequencies. Considering the low heavy truck movements (21 truck movements an hour), it is anticipated that such impacts on the overall bus travel times would be low. Similarly, the impacts on the school bus service would be minimal provided that the school drop off continues to take place on Weir Road.

24.3.9 Impacts on parking

All Project vehicles including worker/staff cars would be parked inside the construction area, as shown on . It is also to be noted that WaterNSW staff would have access to the construction site and staff parking area for the purpose of operating the Dam. No additional external or on-street parking spaces would be required.

The Warragamba Dam visitors' parking area, parking around Haviland Park and the parking area near the corner of Farnsworth Avenue and Production Avenue would be closed during the construction period. The Warragamba Dam Visitor Centre may remain open during the construction period, however, this would only be for bus tours and there would be no car or pedestrian access to the visitor centre. The existing parking area located on Farnsworth Avenue (see Section 24.2.1.2), would be available for parking and access to the adjacent recreational area, subject to agreement with Council. The potential impact on local parking is anticipated to be moderate as there would be a loss of parking and access to recreational areas. A parking plan would be prepared as part of the construction traffic management plan.

Potential impacts on visitors during construction and management measures are discussed further in Chapter 25 (Visual amenity).

24.3.10 Impacts on Blaxland Crossing bridge

The allowable weight of each truck including contruction materials would be 42.5 tonnes, which is below the normal loading capacity (57.5 tonnes) of the bridge. As such, it is anticipated that there would be no adverse impacts on the Blaxland Crossing Bridge. However, it is recommended that the posted speed limit for heavy trucks be reduced during construction and bridge performance continuously monitored.

24.3.11 Summary of construction impacts

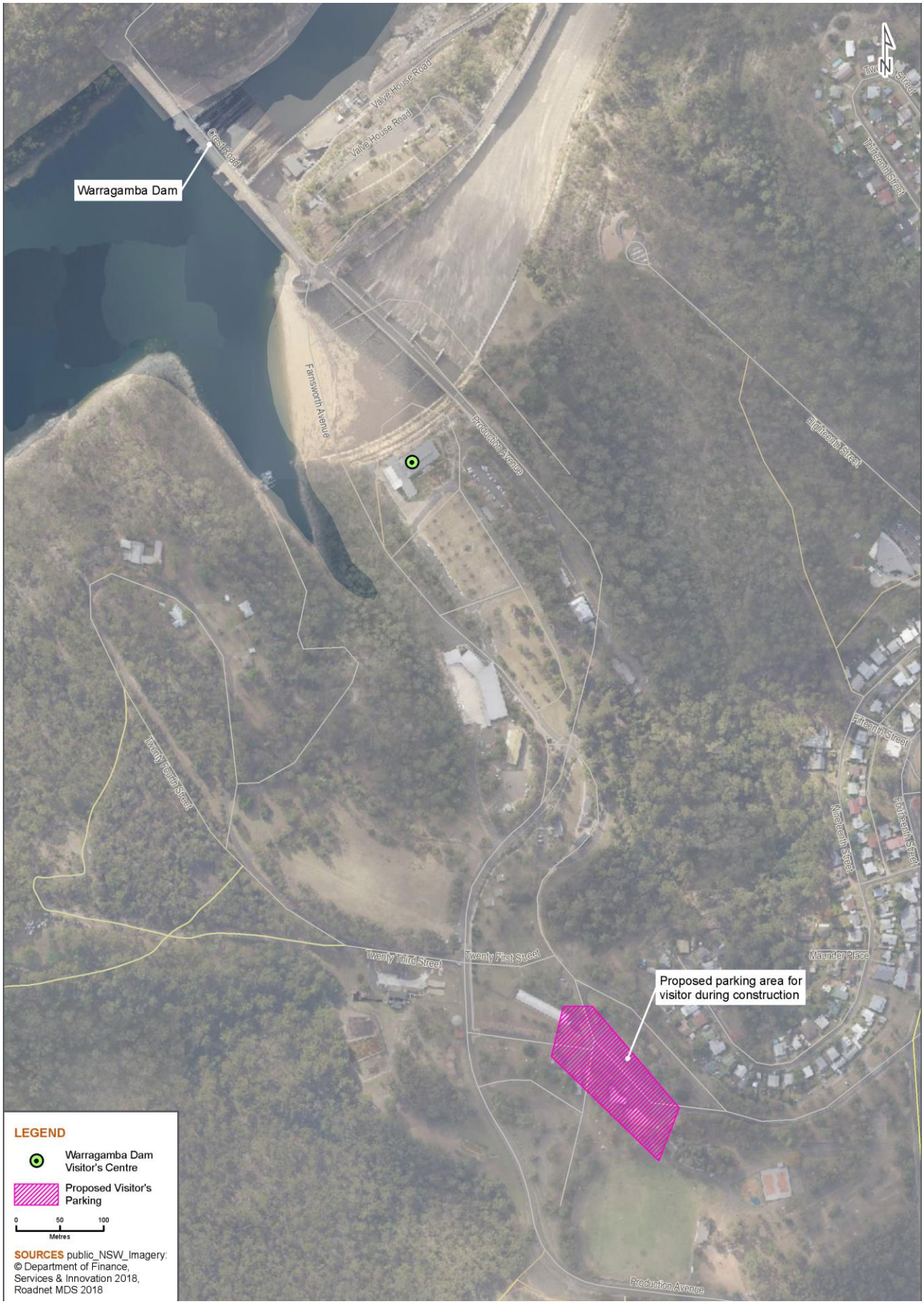
Potential construction impacts are summarised in Table 24-12.

Table 24-12. Summary of potential construction impacts

Impacts	Level	Assessment
Road and intersection capacity	**Minor**	All intersections are performing with good level of service with the additional construction traffic. All intersections have spare capacity to accommodate additional traffic.
Pavement condition	**Major**	Roads along the southern route have poor/very poor pavement condition. As such, additional heavy trucks along this route may have detrimental impacts on the surface condition
Average travel speed	**Moderate**	Additional slow-moving heavy trucks may reduce the network travel speeds.
Property access	**Moderate**	Proposed heavy vehicle routes would not result in a reduction in access however safety may be impacted in the existing residential and commercial access locations in Silverdale and Wallacia areas
Pedestrian and cyclist	**Moderate**	The southern route passes through the commercial areas and schools (pedestrian and cyclist active area) in Tahmoor, Picton and The Oaks and would increase safety risks in these areas. There would be potential for some interaction of construction related heavy vehicle movements with pedestrians and cyclists along part of Silverdale Road and Production Avenue, which would increase safety risks in these areas.
Public transport	**Minor**	All roads have spare capacity. There would be no impacts on the operation of existing public transport services.
Local parking	**Minor**	All construction vehicles would be parked inside the construction site. Some impacts would occur for the visitors' parking.
Blaxland Crossing Bridge	**Minor**	Allowable weight of construction trucks including the construction materials is less than the maximum loading capacity of Blaxland Crossing bridge. As such, no adverse impacts are anticipated on Blaxland Crossing bridge.

It should be noted that the level of impacts identified in Table 24-12 are qualitative based on the understanding of potential impacts of proposed construction activities and associated construction related vehicle movements on the surrounding road network.

Figure 24-26. Proposed temporary visitor parking



24.4 Operational impacts

24.4.1 Overview

Potential operational impacts of the Project on traffic and transport include:

- impacts in and around Warragamba Dam
- impacts and benefits of the Project on the closure of downstream key river crossings and low points due to flooding
- impacts and benefits of the Project on the delay in closure with the Project for the same modelled flood event (that is, period for evacuation)
- impacts of the Project on upstream traffic and transport routes.

A key objective of the Project is to delay peak flooding downstream to allow evacuation routes to remain open for longer and to provide increased opportunity and additional time for a greater number of people to self-evacuate via road. The following flood scenarios were considered:

- 1 in 5 chance in a year event
- 1 in 10 chance in a year event
- 1 in 20 chance in a year event
- 1 in 50 chance in a year event
- 1 in 100 chance in a year event
- 1 in 200 chance in a year event
- 1 in 500 chance in a year event
- 1 in 1000 chance in a year event
- probable maximum flood (PMF).

Evacuation planning is discussed in Chapter 15 (Flooding and hydrology). In summary:

- reducing risk to life is the key objective of the Project. The Project reduces the risk to life by reducing the flood peak level and the frequency of mass evacuations
- due to the populated flood islands and rapid, extensive and deep flooding of the valley, and the inclement weather associated with major flood events, shelter in place or rescue is not feasible and mass self-evacuation ahead of the flood event is the primary method of reducing risk to life from major flood events
- areas of the valley are modelled to take 20 hours to evacuate (SES Flood Plan 2015), but the BoM target forecast time is 15 hours in Richmond/Windsor and 8 hours at Penrith (BoM NSW Service Level Specification). The Hawkesbury-Nepean Valley Flood Risk Management Directorate (the Directorate), is working with BoM to extend this forecast time, but as forecasting the flood peak beyond 9 hours relies on rain yet to fall there are limits to the ability to extend the forecasts with accuracy.
- for those flood events that still trigger mass evacuation after the dam is raised, the dam raising delays the peak compared to the current dam. This means that the peak is later in the rainfall event causing the flood, so that more of the rain is on the ground and hence the accuracy of the forecast is improved.
- projected climate change is modelled to increase the intensity of rainfall during flood events, which then increase both the frequency and speed of flood events.

24.4.2 Impacts at Warragamba Dam

Operation of the Project would not generate any additional deliveries, workers or other traffic generating activities than is currently the case. Once construction is completed, traffic flows in the surrounding road network would return to their existing levels and there would be no additional traffic impacts on the road network surrounding Warragamba Dam from Project operations.

Parking and the dam road network would be returned to their pre-construction configuration.

24.4.3 Traffic and transport impacts - downstream

24.4.3.1 Potential impacts on transport and road corridors

The Project would result in changes to downstream flow patterns and flood extents, resulting in:

- a delay in the peak of the flooding event compared to the existing conditions
- a reduction in peak flood levels, extents and durations
- an increase in the duration of low-level flooding during the discharge of water temporarily captured in the flood mitigation zone
- a reduction in the velocity of flood flows; the reduction in velocity at some locations is significant whereas at other locations negligible.

Depending upon the location and relative height of the road or transport corridor, the changes in downstream flooding due to the Project would have different impacts. One of the key objectives of the Project is to delay peak flooding downstream to allow important evacuation routes to remain open for longer and to provide increased opportunities and additional time for a greater number of people to self-evacuate via road. Changes in the period a crossing is open is assessed in Appendix O (Traffic and transport assessment report, Section 5.2.1).

Management of the FMZ is discussed in Chapter 15 (Flooding and hydrology, Section 15.7.10). Once the peak of the flood event has passed and emptying of the FMZ has commenced, low level flooding would continue until the FMZ has been emptied. The majority of the flood mitigation zone would be emptied at a constant rate of about 100 gigalitres per day, for up to 12 days, which may result in the ongoing closure of low level crossings. For larger floods a higher rate of discharge of up to 230 gigalitres per day may be possible (termed piggy-backing releases) for a short period without any change to downstream flooding. Generally, these higher discharge rates would occur for about two days before the FMZ discharge is reduced to a constant 100 gigalitres per day.

The impacts on the major river crossings, including roads, rail and ferry crossings, during various flood scenarios with and without the Project were modelled for the five SEARs events as well the 1 in 50, 1 in 200, 1 in 500, and 1 in 1,000 chance in a year events. The assessment includes impacts on crossing closure time (in hours) and time to closure (in hours) during the flood scenarios for both with and without the Project. An assessment of the alternative routes for crossings where there is an increase in closure times during flood events is also presented.

24.4.3.2 Impacts on key river crossing low points and alternate routes during flood events

Table 24-13, Table 24-14 and Table 24-15 show the number of hours that major river crossings would be closed during flood events for existing conditions and with the Project. The results have been colour-coded with red indicating an increase in closure time and green indicating a decrease in closure time. These are the 50th percentile values based on a range of modelled flood scenarios. More detailed information on the range of closure times (10th, 50th and 90th percentiles) possible for each event at each crossing are provided in Appendix O (Traffic and transport assessment report, Appendix C). It was assumed that all major roads leading to river crossings have sufficient elevations and would remain open during flood events.

Figure 24-27 to Figure 24-34 show the operational status of the major roads and river crossings for the various flood events under existing conditions and with the Project.

Table 24-13. Major river crossing closure times (hours, 50th percentile) for existing conditions and with Project during different flood events

Description	Bridge name	Phase	Hours closed for a range of flood events Red shading = increase in closure time Green shading = decrease in closure time								
			1 in 5	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200	1 in 500	1 in 1000	PMF
Bridge on Cattai Road over Cattai Creek	Cattai Creek Bridge	Current	94	124	140	151	157	166	175	181	230
		Project	205	333	349	359	348	343	335	328	309
Bridge on Springwood Road over Hawkesbury River	Yarramundi Bridge	Current	72	105	119	131	138	147	154	160	198
		Project	81	304	322	344	329	316	309	305	284
Bridge on Bridge Street over Hawkesbury River	Windsor Bridge (New)	Current	59	88	105	116	125	135	145	149	182
		Project	209	328	356	369	358	352	343	338	265
Bridge on Bells Line of Road over Hawkesbury River	North Richmond Bridge	Current	49	80	94	108	115	126	136	140	171
		Project	0	42	70	128	152	166	179	186	244
Bridge on Richmond Road over South Creek		Current	0	0	0	41	54	64	75	81	108
		Project	0	0	0	0	0	28	61	72	112
Bridge on Hawkesbury Valley Way over South Creek	Jim Anderson Bridge	Current	0	0	0	0	0	30	45	52	84
		Project	0	0	0	0	0	0	0	29	83
Bridge on Great Western Hwy over Nepean River	Victoria Bridge	Current	0	0	0	0	0	0	0	0	51
		Project	0	0	0	0	0	0	0	0	44
Bridge on M4 Motorway over Nepean River		Current	0	0	0	0	0	0	0	0	46
		Project	0	0	0	0	0	0	0	0	36
Bridge on Great Western Hwy over South Creek	Penrith Valley Bridge	Current	0	0	0	0	0	0	0	0	40
		Project	0	0	0	0	0	0	0	0	16
Bridge on M4 Motorway over Ropes Creek		Current	0	0	0	0	0	0	0	0	18
		Project	0	0	0	0	0	0	0	0	0
Bridge on M4 Motorway over South Creek		Current	0	0	0	0	0	0	0	0	0
		Project	0	0	0	0	0	0	0	0	0
Bridge on Silverdale Road over Nepean River	Blaxland Crossing Bridge	Current	0	34	49	55	60	64	70	71	93
		Project	0	32	44	50	56	60	68	70	88

Table 24-14. Major rail river crossings closure time (hours, 50th percentile) during flood events for the existing conditions and with Project

Description	River/creek crossing	Phase	Hours closed for a range of flood events Red shading = increase in closure time Green shading = decrease in closure time								
			1 in 5	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200	1 in 500	1 in 1000	PMF
Penrith rail crossing	Nepean River	Current	0	0	0	0	0	0	0	0	51
		Project	0	0	0	0	0	0	0	0	44
South Creek rail crossing	South Creek	Current	0	0	0	0	0	0	0	0	35
		Project	0	0	0	0	0	0	0	0	17
Richmond/Windsor rail crossing	South Creek	Current	0	49	71	84	94	102	114	119	147
		Project	0	0	26	93	133	145	157	171	202

Table 24-15. Major ferry crossings closure time (hours, 50th percentile) during flood events for the existing conditions and with Project

Description	Phase	Hours closed for a range of flood events Red shading = increase in closure time Green shading = decrease in closure time								
		1 in 5	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200	1 in 500	1 in 1000	PMF
Sackville Ferry crossing	Current	66	97	109	123	131	141	149	154	189
	Project	61	108	147	194	208	216	229	239	276
Lower Portland Ferry crossing	Current	44	76	88	102	114	119	125	130	162
	Project	29	58	73	118	141	143	148	162	225
Webbs Creek ferry crossing	Current	0	5	45	66	75	81	86	92	124
	Project	0	0	15	40	59	70	74	79	136
Wisemans Ferry crossing	Current	0	5	45	66	75	81	86	92	124
	Project	0	0	15	40	59	70	74	79	136

Generally, the Project would result in a reduction or no change in closure times apart from low level crossings such as Yarramundi Bridge, the Cattai Creek bridge at Cattai, Windsor Bridge and some ferry crossings. Low-level crossings would experience an increase in closure times due to the emptying of the FMZ. Some crossings would experience a reduction in closure times for smaller events and an increase in closure time for larger events. Key findings for each of the crossings are summarised below.

- Cattai Creek Bridge at Cattai – This is the lowest level bridge considered in the assessment (about 2 mAHD) and is prone to flooding and closure during all modelled flood events. The number of hours that this bridge would be closed would approximately be double for all events except the PMF due to the Project. This is because the low-level flooding caused by the emptying of the FMZ would result in a longer closure time of the bridge. Although the bridge would be closed for longer there are nearby alternative routes that would remain open.
- Yarramundi Bridge – This is the second lowest level bridge considered in the assessment (about 5.61 mAHD) and is prone to flooding and closure during all modelled flood events. The number of hours that this bridge would be closed would increase by about two to three times for all events except the 1 in 5 chance in a year flood event and PMF due to the Project. There would still be an increase in closure time for these two events, however, the increase would not be as large as for other events. Increased closure times are due to the low-level flooding caused by the emptying of the FMZ. Although the bridge would be closed for longer there are alternative routes.
- Windsor Bridge (New) – The number of hours that this bridge would be closed would increase by about two to three times for all events except for the PMF due to the Project. There would still be an increase in closure time for the PMF, however, the increase would not be as large as for other events. Increased closure times are due to the low-level flooding caused by the emptying of the FMZ.
- North Richmond Bridge – The North Richmond Bridge is closed during all flood events under existing conditions. With the Project, the North Richmond Bridge would remain open during the 1 in 5 chance in a year event and would be closed for shorter periods during the 1 in 10 chance in a year flood event and the 1 in 20 chance in a year flood event. For the other events there would be a minor increase in the number of hours closed due to the Project.
- Jim Anderson Bridge – Under existing conditions, the Jim Anderson Bridge is closed during flood events greater than the 1 in in 100 chance in a year event. With the Project, the bridge would only be closed during events greater than the 1 in 500 chance in a year flood event and would be closed for shorter periods of time.
- Victoria Bridge, M4 Motorway Bridges (Nepean River), M4 Motorway Bridge (Ropes Creek) and Great Western Highway Bridge would remain open and operational during all flood events apart from the PMF under existing conditions and with the Project. All these bridges would be closed during a PMF event, however there would be a small reduction in the time that they are closed with the Project.
- Blaxland Crossing Bridge – Apart from the 1 in 5 chance in a year flood event the bridge would be closed during all flood events both under existing conditions and with the Project. However, there would be a small reduction in the time that the bridge was closed due to the Project.
- Sackville Ferry crossing – This ferry crossing is closed during all flood events and the period of closure would increase by about 50 percent due to the Project for all flood events apart from the 1 in 5 chance in a year flood event where it would decrease slightly.
- Portland Ferry crossing – This ferry crossing is closed during all flood events and the period of closure would increase by about 25 percent due to the Project for most flood events apart from the 1 in 5, 1 in 10 and 1 in 20 chance in a year flood events, where closure times would decrease slightly.
- The Webb Creek and Wisemans Ferry have identical closure patterns as they are adjacent to each other and results for both assessment criteria are relatively similar. The ferries remain open for the 1 in 5 chance in a year flood event and close for the remainder of events under existing conditions. With the Project, the ferries would also remain open for the 1 in 10 chance in a year flood event and there would be a decrease in the time the ferries are closed for all other flood events apart from the PMF. There would be a small increase in the number of the hours the ferries are closed during the PMF event due to the Project.
- The Penrith and South Creek rail crossings would remain open during all flood events under existing conditions and with the Project, except for the PMF event. There would be a small reduction in the number of hours the Penrith and South Creek rail crossings are closed with the Project during the PMF
- Windsor Richmond rail crossing would be closed under existing conditions during the 1 in 10 chance in a year flood event and all larger flood events. With the Project the Windsor Richmond rail line would remain open during the 1 in 10 chance in a year flood event – and there would a reduction in closure time during the 1 in 20 chance in a year. For all other flood events there would be an increase in closure times due to the Project

- Generally, the Project would result in a reduction or no change in closure times apart from low level crossings such as Yarramundi Bridge, the Cattai Creek bridge at Cattai, Windsor Bridge and some ferry crossings. The low-level crossings would experience an increase in closure times due to the emptying of the FMZ. Some crossings would experience a reduction in closure times for smaller events and an increase in closure time for larger events.

Figure 24-27. Operational status of major river crossings and roads: 1 in 5 chance in a year flood event

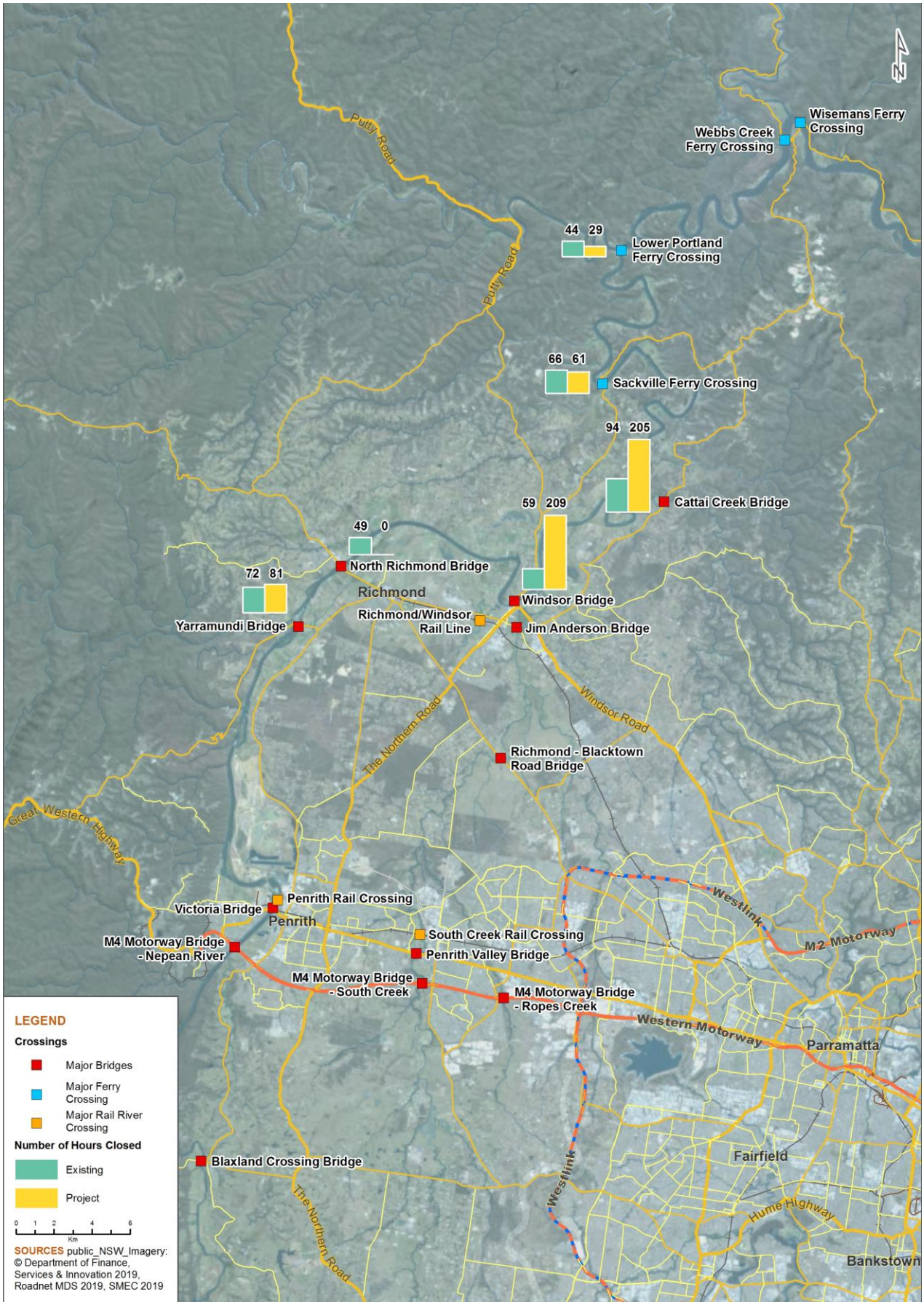


Figure 24-28. Operational status of major river crossings and roads: 1 in 10 chance in a year flood event

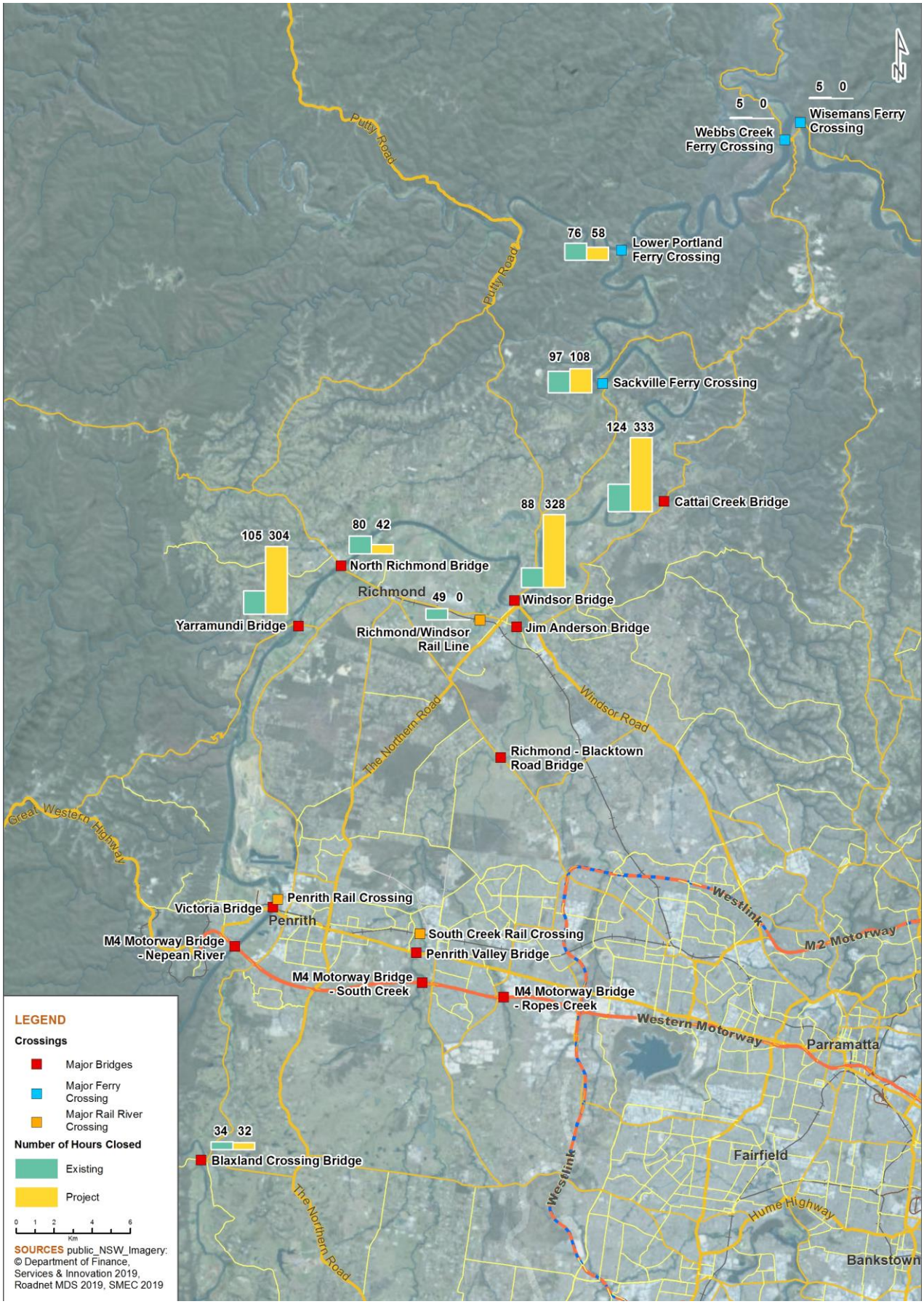


Figure 24-29. Operational status of major river crossings and roads: 1 in 20 chance in a year flood event

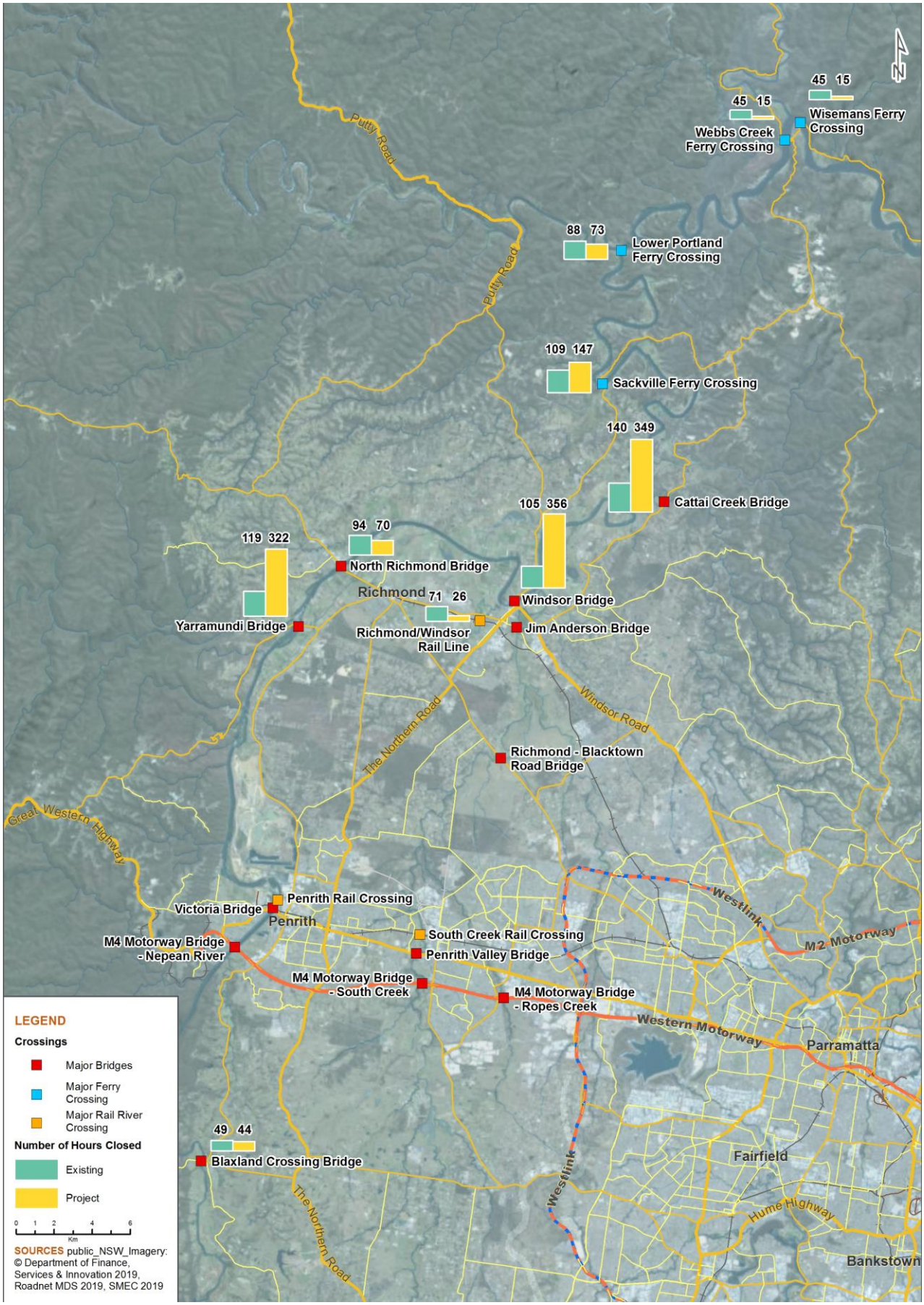


Figure 24-30. Operational status of major river crossings and roads: 1 in 100 chance in a year flood event

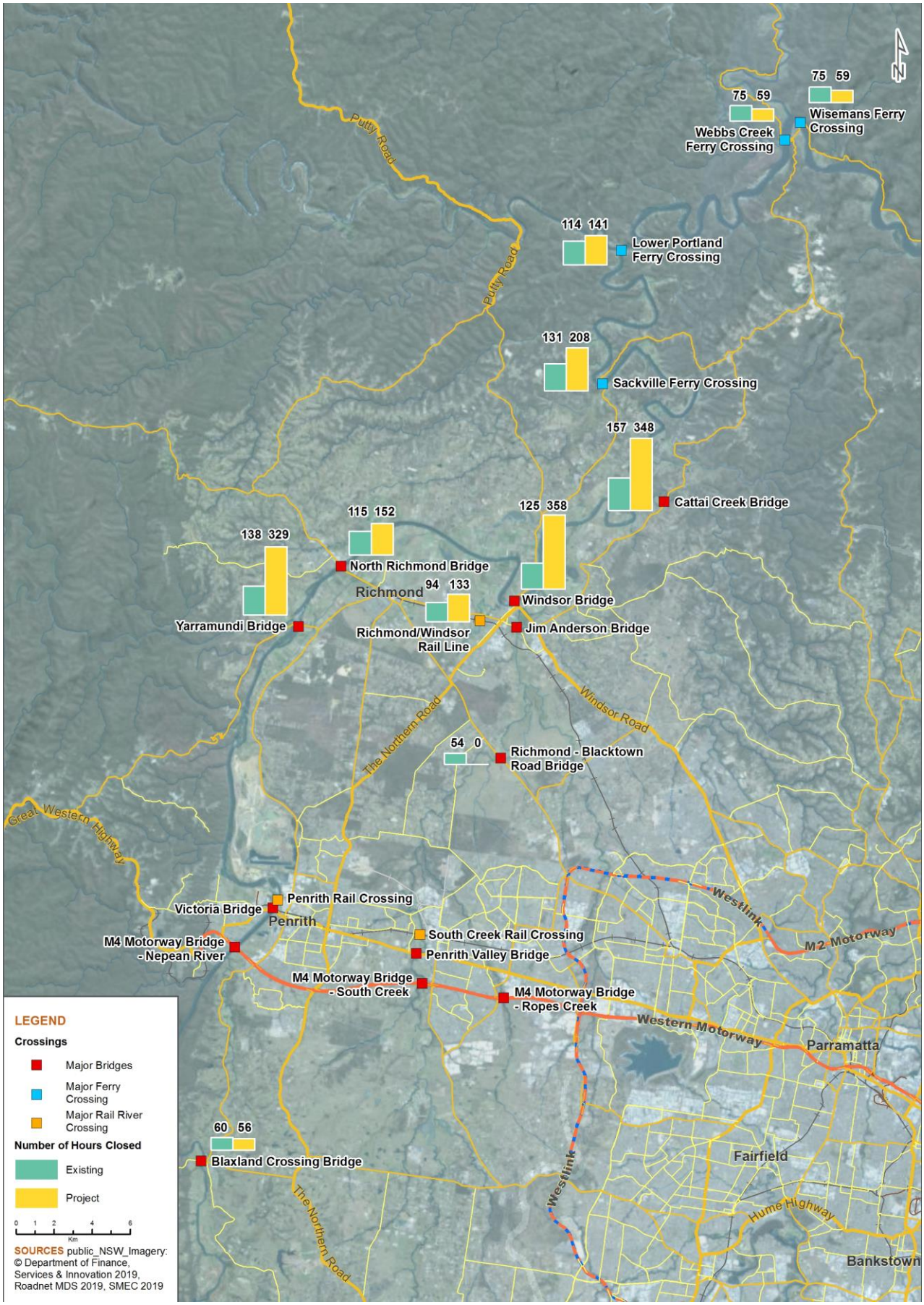


Figure 24-31. Operational status of major river crossings and roads: 1 in 200 chance in a year flood event

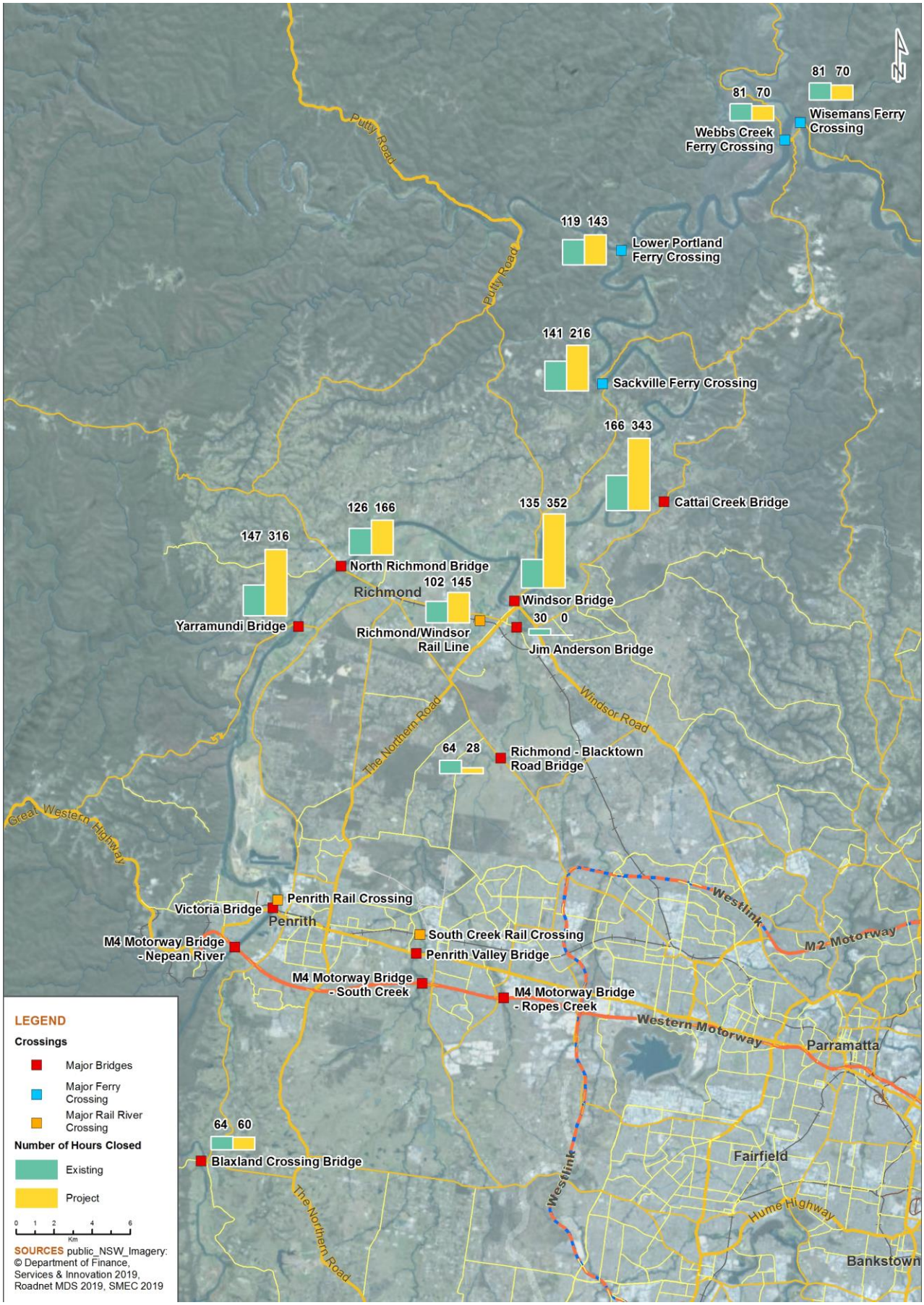


Figure 24-32. Operational status of major river crossings and roads: 1 in 500 chance in a year flood event

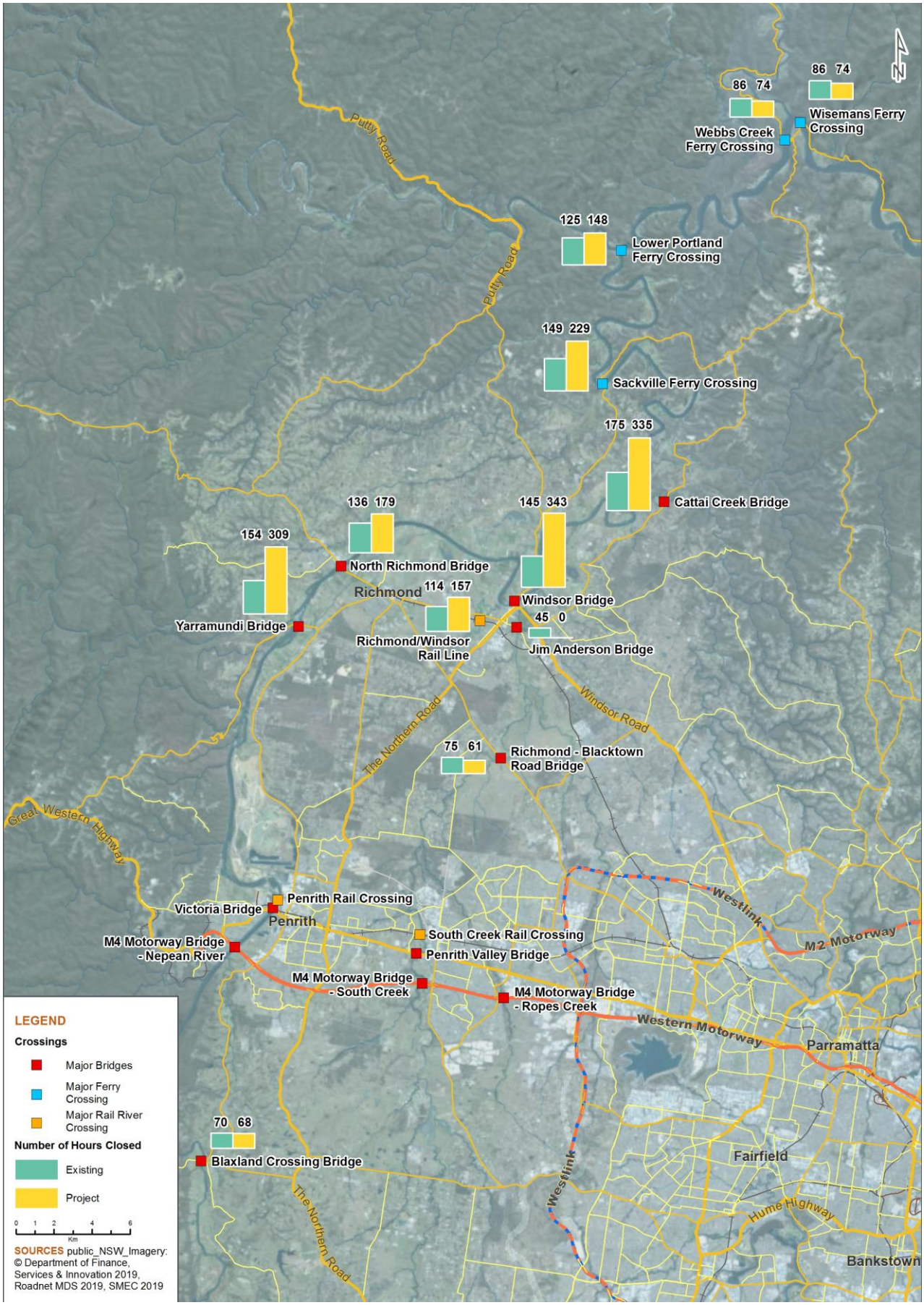


Figure 24-33. Operational status of major river crossings and roads: 1 in 1,000 chance in a year flood event

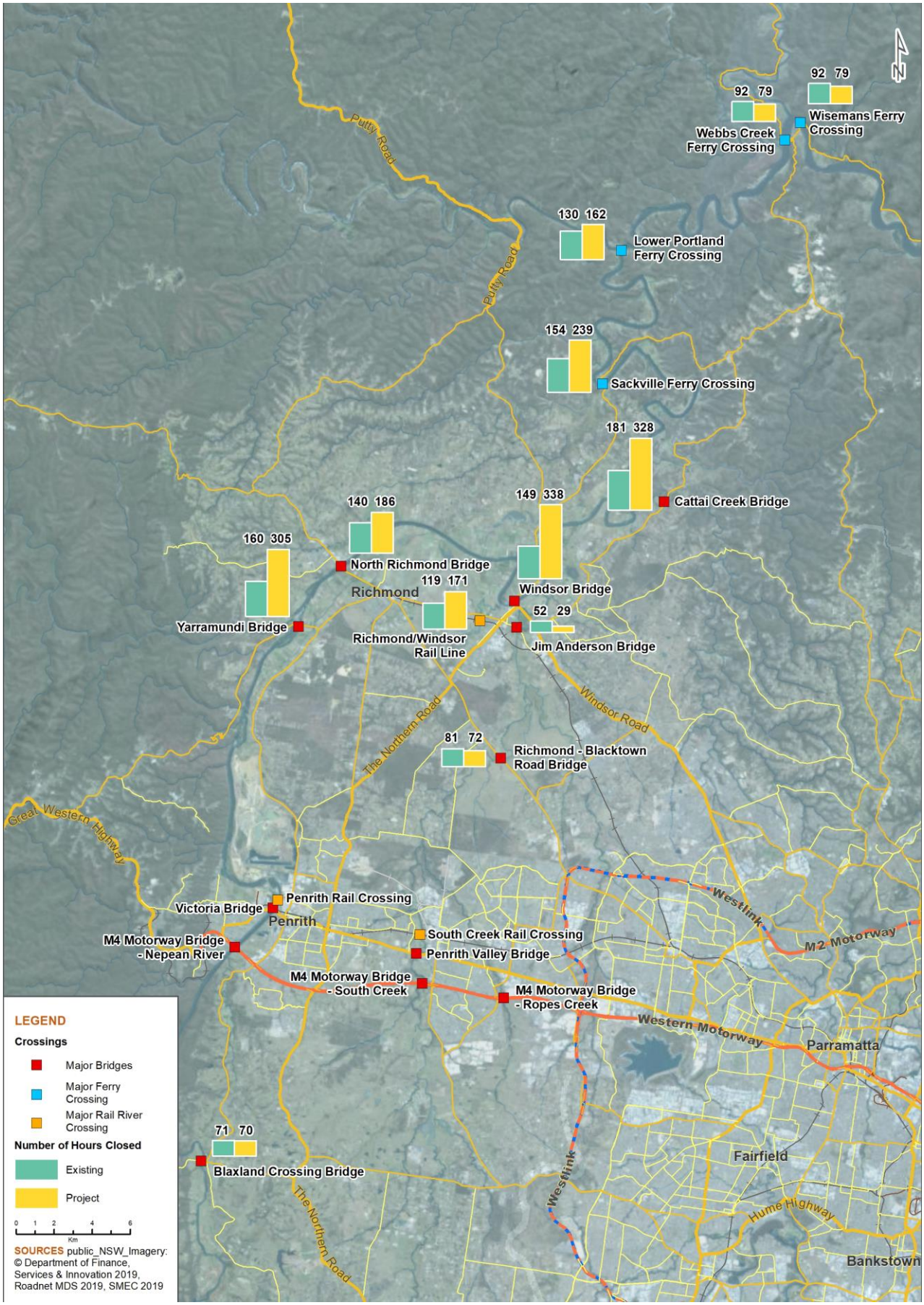
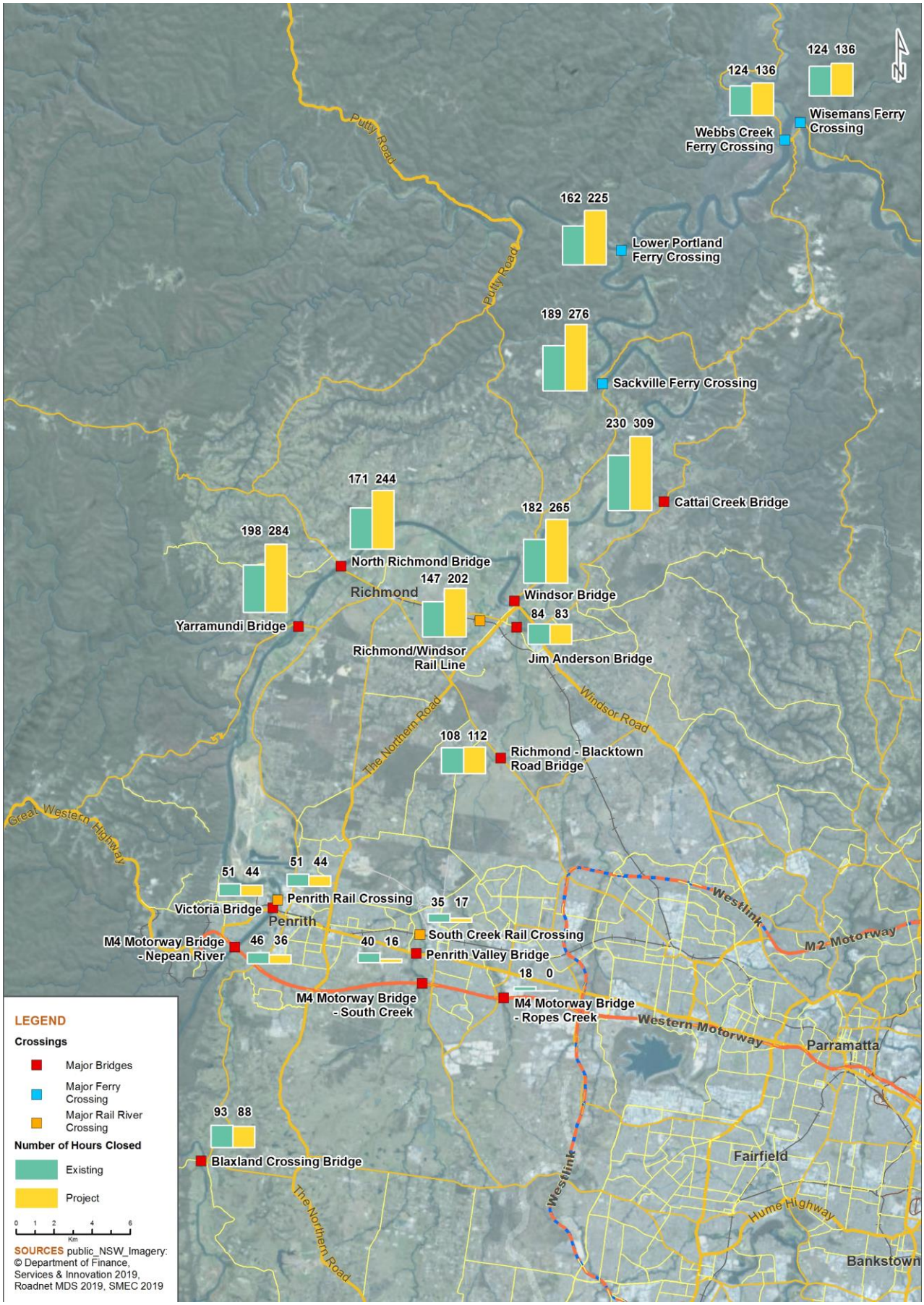


Figure 24-34. Operational status of major river crossings and roads: probable maximum flood (PMF) event



24.4.3.3 Alternative routes

It is beyond the scope of the assessment to determine alternative routes for all crossings and all flood events. Only those that would be impacted by the Project and would experience a significantly greater period of closure have been assessed. This includes the Yarramundi Bridge, the Cattai Creek bridge at Cattai and the Sackville Ferry. These crossings are low level and already experience extended periods of closure during flood events. However, with the Project they would experience increased closure periods. The capacity of the alternative routes when the FMZ is being discharged would not be affected by evacuations as the peak of the flood (and any resulting evacuations) would have passed.

Alternatives to Yarramundi Bridge

Yarramundi Bridge provides an east-west crossing of Nepean River between Yarramundi and Anges Bank. Estimated peak traffic volumes are about 1,000 vehicles per hour and the average daily traffic volume is estimated to be about 12,000 vehicles per day (Urban Research and Planning 2015). While there is no information on travel destinations for vehicles using the bridge, it is likely that movements would be predominately vehicles either from or wanting to access Winmalee and Yarramundi. There may also be some through traffic to/from the upper Blue Mountains to/from Windsor/Richmond.

There are also a number of current road and bridge upgrades that are relevant to potential alternative routes including:

- Grose River Bridge – a new bridge over the Grose River just north of the Yarramundi Bridge is in its final stages of development and approval. This would provide a road link from Yarramundi to North Richmond – which currently does not exist. Based upon the proposed development program, this bridge would be open by the time the Project is operational
- Richmond Bridge – there have been a number of recent upgrade programs for intersections and the approaches to the Richmond Bridge to reduce congestion. In May 2018, the NSW Government announced $25 million over four years for upgrades to the Richmond Road corridor between Richmond and North Richmond. This included funding to build improvements at the March Street and Bosworth Street intersection in Richmond and funding for planning for the duplication of Richmond Bridge to reduce congestion between Richmond and North Richmond. The duplication of Richmond Bridge would include a new higher-level bridge. At this stage there is no estimated time for the provision of the duplicated bridge
- Windsor Bridge – the new Windsor Bridge was opened for traffic in May 2020. It is higher than the existing bridge and would be open for longer than the existing bridge during floods.

The largest increases in closure times of the Yarramundi Bridge would be for events between the 1 in 10 chance in a year flood and the 1 in 100 chance in a year flood event when the bridge would be closed for about 200 additional hours on average – which is about 8.5 days. The smallest increase would be for the 1 in 5 chance in a year flood event where the bridge would be closed for an extra four days. The increased closure times relative to the time periods for the major floods events is small – for example the 8.5 extra days of closure for a 1 in 20 chance in a year flood would on average result in Yarramundi Bridge being closed an additional 0.1 percent of time over a 20-year period.

There are three potential alternative routes to cross the Hawkesbury-Nepean River and access or departure from Yarramundi and Winmalee. These are:

- Richmond Bridge – The alternative route would include (from west to east) Springwood Road, the new Grose River bridge, Ashtons Road, Grose River Road, Grose Vale Road and Bells Line of Road, Richmond Bridge and Kurrajong Road. For the 1 in 5 and 1 in 10 year chance in a year flood event, the Project would result in the Richmond Bridge being closed for shorter periods, however for larger flood events the bridge would be closed for one to two days longer
- M4 Motorway bridges – The alternative route would include (from west to east) Springwood Road, Hawkesbury Road, the Great Western Highway, M4 Motorway, and the M4 Motorway bridges. At least one of the two M4 bridges would be open during all modelled events including PMF
- Victoria Bridge Great Western Highway - The alternative route would include (from west to east) Springwood Road, Hawkesbury Road, M4 Motorway, the Great Western Highway, Victoria Bridge, and High Street. This route would be available for floods up to and including the 1 in 100 chance in a year flood event.

Given the small increase in closure times relative to the occurrence of major flood events and the temporary nature of any closure, network modelling was not warranted to assess impacts. However, the capacity of potential alternative routes to manage diverted traffic was assessed to identify any potential congestion issues resulting from the Project.

Two-hour peak period traffic data for alternative routes was sourced and a theoretical capacity calculated based upon a typical lane capacity of 1,750 vehicles per hour (Table 24-16). However, it should be noted that the lane capacity during an emergency evacuation condition could be affected by a number of factors and is typically lower than the lane capacity during a normal situation. Of potential alternative routes, locations where traffic volumes are approaching their theoretical capacity include Richmond Bridge, Victoria Bridge and the M4 Motorway. However, the predominate movement of traffic across Yarramundi Bridge in each of the peak periods is generally opposite to the typical peak traffic movement at the other locations. For example, the highest traffic movement in AM peak across Yarramundi Bridge is east to west, whereas at other locations is west to east.

Consequently, the relatively small potential increase in traffic on the alternative routes from the Yarramundi Bridge closure is unlikely to result in any increased congestion for the relatively short period diversions are required.

Table 24-16. Peak traffic numbers on alternatives routes for closure of the Yarramundi Bridge

Road	Year	Time period (2 hours)	Eastbound (vehicles)	Westbound (vehicles)	Theoretical capacity (vehicles)
Yarramundi Bridge	2013	AM Peak	623	1,344	3,500
		PM Peak	1,325	454	3,500
Great Western Highway at Falconbridge	2017	AM Peak	3,956	2,393	7,000
		PM Peak	3,885	3,855	7,000
Richmond Bridge	2013	AM Peak	3,030	1,433	3,500
		PM Peak	1,893	2,813	3,500
Windsor Bridge	2019	AM Peak	949	2,137	3,500
		PM Peak	2,343	1,127	3,500
High Street (near Victoria Bridge	2017	AM Peak	3,737	2,064	3,500
		PM Peak	2,661	3,786	3,500
M4 Motorway Penrith	2016	AM Peak	10,417	5,542	10,500
		PM Peak	7,053	11,343	10,500

Source: Urban Research and Planning (2015) and RMS Traffic Volume Viewer

Alternatives to Windsor Bridge (new) at Windsor

The new Windsor Bridge at Windsor provides a north-south crossing of the Hawkesbury River at Windsor.. Morning and evening peak traffic numbers over the old Windsor bridge in 2019 are presented in Table 24-17. The alternative route to cross the Hawkesbury River would by via Richmond Bridge which would be accessed via Wilberforce Road, Singleton Road, Kurmond Road, Maddens Road, Slopes Road, Crooked Lane, and Bells Line of Road. The Richmond Bridge is closed during all flood events under existing conditions. With the Project, the Richmond Bridge would remain open during the 1 in 5 chance in a year event and would be closed for shorter periods during the 1 in 10 chance in a year flood event and the 1 in 20 chance in a year flood event. For the other events there would be a minor increase in the number of hours closed due to the Project.

The alternative route if both bridges are closed would be via the proposed Grose River bridge to Yarramundi. The routes from Yarramundi are detailed in the section above.

Table 24-17. Peak traffic numbers using the Windsor Bridge

Road	Year	Time period (2 hours)	Eastbound (vehicles)	Westbound (vehicles)	Theoretical capacity (vehicles)
Windsor Bridge	2019	AM Peak	949	2,137	3,500
		PM Peak	2,343	1,127	3,500

Alternative to Cattai Creek bridge at Cattai

Cattai Creek bridge at Cattai provides a north-south crossing of Cattai Creek at Cattai. Estimated AM and PM peak traffic volumes are only available for Cattai Road north of Pitt Town and are low (Arcadis 2018) in both directions (Table 24-18).

For most events the Cattai Creek bridge at Cattai would be closed for an additional seven to eight days. The smallest increase would be for the 1 in 5 chance in a year flood event where the bridge would be closed for an extra 4.5 days. The increased closure times relative to the time periods for the major floods events is extremely small – for example the extra eight days of closure for a 1 in 10 chance in a year flood would on average result in Cattai Creek bridge at Cattai being closed an extra 0.2 percent of time over a 10-year period.

The alternative route from north to south would be Halcrows Road, Cattai Ridge Road, and Pitt Town Dural Road. There is no traffic volume information available for these roads, however, typically traffic volumes would be low as the area is not highly developed. Given the small number of vehicles that use Cattai Road in peak periods, there is not likely to be a congestion issue when the bridge is closed.

Table 24-18. Peak traffic numbers using the Cattai Creek Road

Road	Year	Time period (1 hour)	Northbound (vehicles)	Southbound (vehicles)	Theoretical capacity (vehicles)
Cattai Road -north of Pitt Town	2018	AM Peak	135	248	1,750
		PM Peak	175	154	1,750

Alternatives to major ferry crossings

The Sackville Ferry provides a north-south crossing of the Hawkesbury River at Sackville and has a capacity of about 200 to 300 vehicles a day. The alternative route if the ferry is closed (from south of the river to north), would be via Sackville Road, King Street, Wilberforce Road, Windsor Road, Bridge Street, Macquarie Street, Hawkesbury Valley Way, Groves Ave, Windsor Road, Pitt Town Road, Cattai Road, Wisemans Ferry Road, and Sackville Ferry Road.

The Lower Portland Ferry provides east-west crossing of the Hawkesbury River at Lower Portland. This is a cable ferry and operates on demand with a capacity of three small cars per trip. The alternative route if the ferry is closed (from west of the river to east), would be via West Portland Road, Sackville Road, King Street, Wilberforce Road, Windsor Road, Bridge Street, Macquarie Street, Hawkesbury Valley Way, Groves Ave, Windsor Road, Pitt Town Road, Cattai Road, Wisemans Ferry Road, Sackville Ferry Road, and River Road.

The Wisemans and Webbs Creek Ferries provide east-west crossings of the Hawkesbury River at Wisemans Ferry. The alternative route if the Wisemans Ferry is closed (from west of the river to east), would be via Old Northern Road, Mid Dural Road, Galston Road, Pacific Highway and, Wisemans Ferry Road. The alternative route if the Webbs Creek Ferry is closed (from East of the river to west), would be via Old Northern Road, Cattai Road, Pitt Town Road, Windsor Road, Groves Ave, Hawkesbury Valley Way, Macquarie Street, Bridge Street, Windsor Road, Wilberforce Road, King Street, Sackville Road, West Portland Road, Green Road, Bicentenary Road, and Chaseling Road North.

Given the relatively small number of vehicles that would be diverted due to the closure of these ferry crossings, there would be no capacity issues on any of these roads.

24.4.3.4 Impacts on time to closure of a crossing

The main benefit of the Project is the reduction of downstream flood peaks, which reduces both the number of people needing to evacuate and the likelihood that critical evacuation routes are cut. For those flood events that still cut evacuation routes with the Project, it is critical that these routes get cut no earlier than and preferably later than they would with the current dam. The number of hours after the beginning of an event that a major road crossing remains open is shown in Table 24-19. The railway is not considered to be a major means of evacuation, and the ferry crossings have low capacities and therefore would also not be considered to be major evacuation routes.

The delay in floods reaching critical levels downstream with the Project would vary for each modelled flood event, as it depends on the specific sequence of inflows for that event. For example, for all modelled flood events to reach the 1 in 100 chance per year flood planning level in the Richmond/Windsor area and cut the Jim Anderson Bridge (17.3 mAHD) with the current dam, with the Project 86 percent would no longer reach that level. For those modelled flood events that still reach 17.3 metres with the Project:

- 7.2 percent of flood events will be delayed reaching 17.3 metres by over 15 hours
- 4.6 percent of flood events will be delayed reaching 17.3 metres by 10 to 15 hours
- 2.1 percent of flood events will be delayed reaching 17.3 metres by 5 to 10 hours
- 0.2 percent of flood events will be delayed reaching 17.3 metres by less than 5 hours
- No flood events will reach 17.3 metres faster

The Project achieves similar delays for larger flood events. For example, for all the flood events that were modelled to cut the Castlereagh Road evacuation route (20.2 mAHD, approximately 1 in 700 chance per year) with the current dam, with the Project 80 percent would no longer reach that level. For those modelled flood events that still reach 20.1 metres with the Project:

- 5.9 percent of flood events will be delayed reaching 20.2 metres by over 15 hours
- 9.6 percent of flood events will be delayed reaching 20.2 metres by 10 to 15 hours
- 4.1 percent of flood events will be delayed reaching 20.2 metres by 5 to 10 hours
- No flood events will be delayed reaching 20.2 metres by less than 5 hours.

While some delays in closing time are relatively short, any extra time can be critical in evacuations as a single lane with traffic travelling at 40 kilometres an hour has a capacity of about 1,500-1,750 vehicles per hour. Assuming two people per vehicle, an extra hour for evacuation could allow approximately 3,000 to 3,500 extra people to be evacuated.

Table 24-19. Number of hours before a river crossing is closed for different flood events for the existing conditions and with the Project

Crossing	Hours before a river crossing is closed for different flood events Red shading = increase in time to closure Green shading = decrease in time to closure									
	1 in 5 chance in a year (hours to closure)		1 in 10 chance in a year (hours to closure)		1 in 20 chance in a year (hours to closure)		1 in 100 chance in a year (hours to closure)		PMF (hours to closure)	
	Existing	Project	Existing	Project	Existing	Project	Existing	Project	Existing	Project
Cattai Creek Road Bridge	8 (3-22)	10 (4-23)	8 (2-14)	8 (3-19)	6 (2-13)	7 (3-17)	5 (2-11)	6 (3-14)	6	3
Yarramundi Road Bridge	3 (1-17)	6 (3-21)	3 (1-9)	5 (3-17)	2 (1-5)	4 (2-14)	2 (1-4)	4 (2-10)	1	3
Windsor Road Bridge (New)	Not closed	Not closed	Not closed	Not closed	30 (21-45)	Not closed	21 (15-34)	39 (29-54)	8	14
North Richmond Road Bridge	4 (3-17)	17 (6-27)	5 (3-19)	11 (5-22)	3 (2-12)	9 (4-20)	3 (2-10)	6 (4-19)	2	5
Richmond - Blacktown Road Bridge	Not closed	Not closed	Not closed	Not closed	46 (35-64)	Not closed	38 (26-55)	59 (43-75)	20	28
Jim Anderson Bridge	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	29 (21-41)	Not closed	18	24
Victoria Road Bridge	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	53	64
M4 Motorway Bridge - Nepean River (west)	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed
M4 Motorway Bridge - Nepean River (east)	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	81	110
M4 Motorway - South Creek	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	69	93
Great Western Highway - South Creek	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	Not closed	7	8
Blaxland Crossing Road Bridge (Wallacia)	15 (11-29)	15 (12-29)	12 (8-26)	13 (9-26)	10 (5-19)	11 (8-20)	8 (3-15)	10 (7-18)	7	8

Note: Range is 10th to 90th percentile. Hours to closure indicated in brackets

24.4.3.5 Traffic and transport impacts – upstream

The upstream impacts of the Project are confined to the existing catchment special areas around Lake Burragorang and Warragamba Dam. Access to the special areas is restricted and generally the public is not permitted to access these areas without permission. There are no public roads or rail lines in the special areas that would be impacted by the Project.

Most of the special areas are owned by various departments of the NSW Government, with the National Parks and Wildlife Service generally responsible for their management. However, there are small areas of private landholdings within the special areas that are accessed via unsealed roads and fire trails. Private land holdings are located along the Wollondilly River and the upper Coxs River and Yerranderie. Only two private lots would be impacted by the Project and these would only be impacted in extreme flood events, that is, the PMF. The access road to these lots would experience some additional flooding, however, the increase in the period of flooding would be hours – and consequently minor. Other private landholdings and Yerranderie generally access their properties from the south or west, and these unsealed roads and fire trails would not be impacted by the Project and therefore there would be no change to the access.

Some fire trails, especially those adjacent to the dam and rivers, would experience greater extents and durations of flooding due to the Project. Only WaterNSW catchment staff and NPWS staff use the fire trails and the impact on fire trails is discussed in Chapter 20 (Protected and sensitive lands). It should also be noted that fire trails and access to the special areas are generally closed after substantial rainfall events and hence before any significant increase in dam storage levels to limit damage to the trails and prevent any incidents or emergencies.

24.4.4 Summary of operational impacts

24.4.4.1 Traffic impacts at Warragamba Dam

Once the Project is operational, there would be no additional activities at Warragamba Dam that would generate traffic. Consequently, there would be no change in the current traffic volumes associated with the dam operation, which are minimal and within the capacity of the current road network.

24.4.4.2 Traffic and transport impacts – downstream

Impact on closure times of key crossings

There would be both potential impacts and benefits from the Project on the closure times for downstream key crossings.

Low level crossings such as the Cattai Creek Bridge at Cattai, Yarramundi Bridge and the new Windsor Bridge would experience longer periods of closure under the Project scenario for all flood events. The Richmond Bridge crossing of the Nepean River and the new Windsor Bridge would also experience longer closure times for floods more severe than 1 in 50 chance in a year flood, however, there would be reduced closure times for other lesser flood events. The Sackville Ferry and potentially the Lower Portland Ferry would also experience longer closure times under the Project scenario. The key crossings would remain closed after the flood peak due to draining of the FMZ. There would be alternative routes to the areas that would use these crossings (for example, Yarramundi/Winmalee and McGraths Hill/Windsor), however, motorists would experience longer travel times.

Higher level key crossings would experience benefits, that is, a decrease or no change in the duration of closure times under the Project scenario. The extent of the benefits would be variable, depending on the level of the crossing and the size of the flood events, however some crossings would remain open during certain flood events under the Project scenario, when under existing conditions they would be closed.

Overall the benefits of the Project in reducing key crossing closure times outweigh the impacts of the Project on low level crossings.

Impact on time to closure of key crossings

The Project would result in a delay in the downstream flood level peak, which in turn may provide an increase in time before a key crossing is closed and allow more residents to evacuate.

Apart from Cattai Creek Bridge at Cattai during the PMF, the Project would delay the closure of key crossings or they would remain unchanged. The most significant benefits in delaying the closure of key crossings are predicted for the more severe flood events, where mass evacuations are more likely to be required.

Also, some key crossings would no longer close during specific flood events, which would allow them to maintain their flood evacuation function when under existing conditions they would be closed.

Overall the benefits of the Project in delaying the time to closure of downstream key crossings is substantial and would allow the evacuation of a greater number of people, especially during severe flood events.

Traffic and transport impacts – upstream

The Project would not impact any upstream public roads. There would be a minor loss of access to two remnant private lots in the Special Area during significant and rare flood events, however other access to private land holdings would remain unaffected. Impacts on fire trails and other assets in the special areas are assessed in Chapter 17 (Socio-economic, land use and property).

24.5 Environmental management measures

Transport for NSW is currently developing the Hawkesbury Nepean Valley Regional Flood Evacuation Road Master Plan, which will include a detailed investigation of the impacts of flood events on the road network of Hawkesbury-Nepean Valley floodplain and the preparation of an evacuation road network plan and suitable flood road design standards. This study will include a scenario that considers evacuation associated with raising of the Warragamba Dam wall.

The Project would largely result in benefits to downstream key crossings and management measures are generally focused on managing the FMZ discharge. However, specific management measures have been developed to avoid, minimise or manage potential risks identified in Section 24.3 and Section 24.4. Management measures have been incorporated in the Environmental Management measures in Chapter 29 (EIS synthesis, Project justification and conclusion).

As part of the construction traffic management plan (CTMP), a contingency plan will be developed to manage traffic during the construction period in the event of emergency road closures due to flood, fire, and/or road accidents; road repair works and bridge load limits. An outline of a contingency plan is shown in Table 24-20. More specific management measures are given in Table 24-21.

Table 24-20. Construction contingency plan

Event	Proposed contingency plan (Included in Table 24-21 **as TT1**)	When to be implemented	Responsibility
Flood and fire	All workers, sub-contractors and suppliers shall be provided with proper training on emergency evacuation plan during flood and/or fire	Throughout the construction period	Construction contractor
Flood, fire, road accidents, major pavement failure, loading capacity of Blaxland Crossing bridge	Feasibility of using alternate route (The Northern Road-Cobbitty Road-Werombi Road-South part of Silverdale Road) shall be checked to access the construction site in the event of road closure during development of construction traffic management plan	Before commencement of construction	Construction contractor
Major pavement failure and Loading capacity of Blaxland Crossing bridge	Reduced loading capacity of trucks shall be considered	During the emergency event scenarios	Construction contractor
Road breakdown, Road accident, Major pavement failure	Trained personnel shall be deployed to the event location to manage/control traffic movements in consultation with concerned authorities	During the emergency event scenarios	Construction contractor

Table 24-21. Management measures

Impact	ID	Environmental management measure	Timing	Responsibility
Impacts from construction traffic	TT1	A construction traffic management plan (CTMP) will be prepared which will detail processes to minimise delays and disruptions and identify and respond to changes in road safety due to Project construction works. The CTMP will be prepared in accordance with applicable guidelines and relevant standards, guides and manuals. The CTMP will: ▪ include a construction contingency plan to manage traffic in the event of emergency road closures due to flood, fire, and/or road accidents, road repair works and bridge load limits ▪ ensure all relevant stakeholders are considered during all stages of the Project ▪ provide safe routes for pedestrians and cyclists during construction ▪ comprehensively communicate changes in traffic conditions on roads or paths to community, emergency services, public transport operators, other road user groups and other affected stakeholders ▪ identify measures to manage the movements of construction-related traffic to minimise traffic and access disruptions in the public road network ▪ minimise the use of local roads by the Project's heavy vehicles and identify haulage routes ▪ propose a car parking strategy for construction staff ▪ consider truck telematics to assist the project managers and road network managers to ensure mass limits are adhere to and to reduce congestion/improve safety during peak construction periods ▪ speed management of construction related vehicles to cross Blaxland Crossing Bridge and continuous monitoring of bridge performance	Pre-construction	Construction Contractor
Worker vehicle impacts	TT2	Carpooling will be encouraged to minimise number of employee vehicles travelling to the site.	Construction	Construction Contractor
Off-site queuing of heavy vehicles	TT3	Queueing of heavy vehicles will be permitted only within the site perimeter.	Construction	Construction Contractor
Access to construction area	TT4	All construction traffic will use Production Avenue to access the site.	Construction	Construction Contractor
Safety of intersection	TT5	The Warradale Road/Production Avenue intersection will be reviewed against the latest relevant Austroads guidelines (for example, sight distances) and appropriate modifications made in consultation with Wollondilly Shire Council to ensure compliance.	Pre-construction	Construction Contractor
	TT6	Temporary traffic signals will be installed at Warradale Road/Production Avenue intersection.	Pre-construction	Construction Contractor

Impact	ID	Environmental management measure	Timing	Responsibility
Impacts on road condition	TT7	Regular inspection and maintenance will be carried out on Park Road, Silverdale Road, Farnsworth Avenue, Production Avenue and Warradale Road.	Construction	Construction Contractor
	TT8	A road dilapidation report will be prepared in consultation with the relevant road authority for the Park Road, Silverdale Road, Farnsworth Avenue, Production Avenue and Warradale Road.	Pre-construction	Construction Contractor
Out-of-hours heavy vehicle movements	TT9	Heavy vehicle site access will be restricted to the standard working hours only. No heavy vehicle access will be permitted for periods outside standard working hours unless required for an emergency, delivery of oversize plant or for other justifiable reason as detailed in the construction traffic management plan.	Construction	Construction Contractor
Road safety	TT10	A Stage 1 road safety audit (RSA) will be undertaken at the detailed construction traffic management plan development stage.	Pre-construction	Construction Contractor
Impacts on visitor parking	TT11	Provision of using existing car park facilities on Farnsworth Avenue for visitor centre and Haviland Park will be considered.	Construction	Construction Contractor
	TT12	Parking strategy will be developed to understand the demand and supply of parking spaces for the visitor centre and Haviland Park during the construction stage.	Construction	Construction Contractor
Safety of school buses	TT13	Consideration will be given to ensure that the operation of general construction traffic will be minimised during periods of school bus operations.	Construction	Construction Contractor
Bridge and road closures during flood mitigation zone discharge	TT14	WaterNSW will keep the Bureau of Meteorology (BoM) informed of the discharge volumes from the FMZ. BoM will then combine these releases with other inflows and rainfall forecasts and tell the SES, TfNSW and Councils what the forecast river levels are at agreed gauge locations according to the NSW Flood Warning Service Level Specification.	Operation	WaterNSW
Source of construction materials	TT15	Consideration shall be given for materials recovery and re-use opportunities from nearby construction sites such as Western Sydney Airport (WSA), metro or rail tunnels	Construction	Construction Contractor
Alternate mode to transfer construction materials	TT16	Consideration shall be given to use alternate modes such as rail, where possible, to transfer the construction materials from long distance to reduce number of constructions related heavy vehicle movements on roads	Construction	Construction Contractor

24.6 Risk assessment

An environmental risk assessment was carried out in accordance with the SEARs, using the methodology provided in Appendix C (Risk assessment procedure). A Project risk matrix was developed and risk ranking evaluated by considering:

- the likelihood (L) of an impact occurring
- the severity or consequence (C) of the impact in a biophysical and/or socio-economic context, with consideration of:
  - whether the impact will be in breach of regulatory or policy requirements
  - the sensitivity of receptors
  - duration of impact, that is, whether the impact is permanent or temporary
  - the areal extent of the impact and/or the magnitude of the impact on receptors.

The likelihood and consequence matrix is shown on Figure 24-35.

Once the consequence and likelihood of an impact are assessed, the risk matrix provides an associated ranking of risk significance: **Low**; **Medium**; **High** or **Extreme,** as shown in Table 24-22**.** The residual risk was determined after the application of proposed mitigation measures.

The risk analysis for potential traffic and transport impacts is provided in Table 24-23. This includes the residual risk of the potential impact after the implementation of mitigation measures.

Table 24-22. Risk ranking definitions

Risk definitions	
Extreme 21 – 25	Widespread and diverse primary and secondary impacts with significant long-term effects on the environment, livelihood and quality of life. Those affected will have irreparable impacts on livelihoods and quality of life.
High 15 – 20	Significant resources and/or Project modification would be required to manage potential environmental damage. These risks can be accommodated in a Project of this size, however comprehensive and effective monitoring measures would need to be employed such that Project activities are halted and/or appropriately moderated. Those impacted may be able to adapt to change and regain their livelihoods and quality of life with a degree of difficulty.
Medium 9 – 14	Risk is tolerable if mitigation measures are in place, however management procedures will need to ensure necessary actions are quickly taken in response to perceived or actual environmental damage. Those impacted will be able to adapt to changes.
Low 1 – 8	On-going monitoring is required however resources allocation and responses would have low priority compared to higher ranked risks. Those impacted will be able to adapt to change with relative ease.

Figure 24-35. Risk matrix

		Consequence				
		Negligible	Minor	Medium	Major	Extreme
	LEGAL	No legal consequences	No legal consequences	Incident potentially causing breach of licence conditions	Breach of licence conditions	Breach of licence conditions resulting in shutdown of Project operations.
	SOCIO-ECONOMIC	Impacts that are practically indistinguishable from the social baseline or consist of solely localised or temporary/short-term effects with no consequences on livelihoods and quality of life.	Short-term or temporary impacts with limited consequences on livelihoods and quality of life. Those affected will be able to adapt to the changes with relative ease and regain their pre-impact livelihoods and quality of life.	Primary and secondary impacts with moderate effects on livelihoods and quality of life. Will be able to adapt to the changes with some difficulty and regain their pre-impact livelihoods and quality of life.	Widespread and diverse primary and secondary impacts with significant long-term effects on livelihoods and quality of life. Those affected may be able to adapt to changes with a degree of difficulty and regain their pre-impact livelihoods and quality of life.	Widespread and diverse primary and secondary impacts with irreparable impacts on livelihoods and quality of life and no possibility to restore livelihoods.
	HEALTH	No health consequences	Accident or illness with little or no impact on ability to function. Medical treatment required is limited or unnecessary.	Accident or illness leading to mild to moderate functional impairment requiring medical treatment.	Accident or illness leading to permanent disability or requiring a high level of medical treatment or management.	Accident, serious illness or chronic exposure resulting in fatality.
	ENVIRONMENT	Localised (on-site), short-term impact on habitat, species or environmental media	Localised or widespread medium-term impact to habitat, species or environmental media	Localised degradation of sensitive habitat or widespread long-term impacts on habitat, species or environmental media. Possible contribution to cumulative impacts.	Widespread and long-term changes to sensitive habitat, species diversity or abundance or environmental media. Temporary loss of ecosystem function at landscape scale. Moderate contribution to cumulative impacts.	Loss of a nationally or internationally recognised threatened species or vegetation community. Permanent loss of ecosystem function on a landscape scale. Major contribution to cumulative effects
		A - negligible	**B** - minor	**C** - medium	**D** - major	**E** - extreme
Expected to occur during the Project or beyond the Project	**a** - expected	**13**	**14**	**20**	**24**	**25**
May occur during the Project or beyond the Project	**b** - may	**8**	**12**	**19**	**22**	**23**
Possible under exceptional circumstances	**c** - possible	**6**	**7**	**11**	**18**	**21**
Unlikely to occur during the Project	**d** - unlikely	**4**	**5**	**10**	**16**	**17**
Rare or previously unknown to occur	**e** - rare	**1**	**2**	**3**	**9**	**15**

Risk Definition (see Table 24-22)	**Low**	**Medium**	**High**	**Extreme**

Table 24-23. Traffic and transport risk assessment

Key impacts	Risk before mitigation			Mitigation and management	Risk after mitigation			Residual risk
	L	C	R		L	C	R	
Construction								
Traffic generation causing noise, dust, safety and road function impacts along access routes. ▪ Trucks: Up To 208 daily truck movements, evenly dispersed over a nominal 10-hour day. Major transport activities include heavy vehicle transport of concrete production materials (concrete aggregate, fly ash and cement), and other construction materials. ▪ Cars: Workforce generated traffic. Up to 250 daily car movements in AM peak and 250 daily car movements in PM peak	b	E	23	TT1, TT2, TT3, TT4, TT5, TT6, TT7, TT8, TT9, T10, TT11, TT12, TT13, TT14, TT16, TT17	d	E	17	Construction traffic may potentially disrupt local traffic and an Extreme risk is assessed due to the potential for accidents and potential fatalities. Other impacts such as noise and dust may create significant, but less severe risks. Mitigation will include a wide range of measures and their implementation will significantly reduce the likelihood that serious accidents would occur, although the consequences remain the same. Safety remains a concern and a High residual risk reflects the requirement for diligence and ongoing monitoring to ensure risk is properly managed and does not escalate.
Operation								
After construction is completed, traffic flows in the surrounding road network would return to their existing levels and there would be no additional traffic impacts on the surrounding road network.	c	B	7	None required	c	B	7	Low residual risk not requiring significant additional mitigation measures.
Low level bridges would experience longer times of closure during some flood events due to the emptying of the FMZ. This would result in longer travel times for some roads users.	b	C	19	TT14	B	B	12	Bridge closures would happen infrequently and provided sufficient information and planning of alternative routes is provided to road users, any additional impacts should be minimal.

local people
global experience

SMEC is recognised for providing technical excellence and consultancy expertise in urban, infrastructure and management advisory. From concept to completion, our core service offering covers the life-cycle of a project and maximises value to our clients and communities. We align global expertise with local knowledge and state-of-the-art processes and systems to a range of industry sectors.

www.smec.com