6.5 Effects to Pedestrians and Cyclists

The Project will provide dedicated footpaths and cycleways to improve pedestrian and cyclist amenity and safety. Further benefits of this infrastructure will be greater connectivity and accessibility not only across the network, but especially in proximity to the bus stations, resulting in increased catchment as well as the potential for mode shift to occur.

In the EB2 and EB3R project areas, a combination of bidirectional and unidirectional cycleways will be provided along Ti Rakau Drive between Pakuranga Road and Gossamer Drive. Unidirectional cycleways will also be provided on Pakuranga Road between Ti Rakau Drive and the RRF. The majority of the existing footpaths will be retained while new footpaths will be provided along sections of Ti Rakau Drive, William Roberts Road, Cortina Place and Mattson Road.

In the future, raised tables (raised pedestrian platforms) will be implemented across all priority-controlled side streets along the southern side of Ti Rakau Drive in the EB2 and EB3R project areas. These include:

- Palm Avenue and Aylesbury Street (raised intersection)
- Tiraumea Drive
- Roseburn Place
- Edgewater Drive west
- Wheatley Avenue
- Freemantle Place and Gossamer Drive (raised intersection)

Raised tables will also be implemented in the Pakuranga Town Centre area, the Reeves Road / Cortina Place intersection will be a raised intersection. **Figure 107** shows an example of a raised table in the proposed design at the Ti Rakau Drive / Edgewater west intersection.

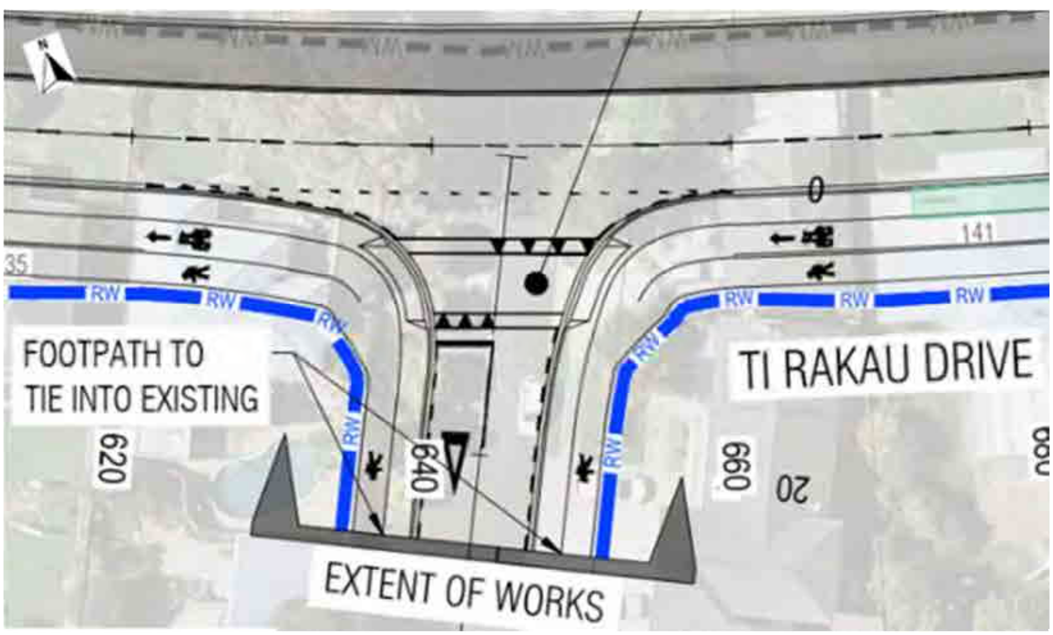

Figure 107: Example of raised tables in the proposed design

The presence of these crossing facilities will aid pedestrians and cyclists by simplifying the crossing task, increasing visibility by creating a visual cue for drivers to reduce their speed as they approach the intersections, and encourage courtesy between drivers and pedestrians. This will reduce the risk of potential conflict between vehicles and pedestrians. It should be noted that these raised tables will not be marked as formal pedestrian crossings. Compared to the existing environment, signalised pedestrian and/or cycle crossings will be provided more frequently along Ti Rakau Drive. Users will have safe and more direct travel routes, which will provide a connected network that encourages active modes. Signalised pedestrian crossings will be provided across all approaches of the following intersections:

- Pakuranga Road / Ti Rakau Drive (with a raised zebra crossing on the left-turn slip lane)
- Pakuranga Road / RRF (except northern approach)
- Reeves Road / Aylesbury Street (except eastern approach)
- Ti Rakau Drive / Aylesbury Street / Palm Avenue crossroads
- Ti Rakau Drive / Reeves Road / SEART
- William Roberts Road / Reeves Road
- Ti Rakau Drive / William Roberts Road / Mattson Road crossroads
- Ti Rakau Drive / Edgewater Drive east (except western approach)
- Ti Rakau Drive / Gossamer Drive

Additionally, a pedestrian crossing will also be provided at the Edgewater bus station. Lastly, the existing signalised pedestrian crossing on Pakuranga Road, constructed as part of EB1, will remain. The existing midblock pedestrian crossing on Reeves Road will be removed to avoid potential sightline issues. This is because the columns of the RRF will be located along the centre of Reeves Road, which may obstruct the view of pedestrians to vehicles.

Bidirectional cycleways will be provided along the northern side of Ti Rakau Drive, between Pakuranga Road and William Roberts Road. An eastbound unidirectional cycleway will be provided along the northern side of Ti Rakau Drive between William Roberts Road and Gossamer Drive, while a westbound unidirectional cycleway will be provided on the southern side of Ti Rakau Drive between Gossamer Drive and Reeves Road. Unidirectional cycleways will also be provided on both sides of Pakuranga Road between Ti Rakau Drive and the RRF. Together, these cycleways will tie into the existing cycleways provided on Pakuranga Road west of Ti Rakau Drive, as part of EB1.

Providing dedicated cycleways creates a physically separated and safe space that facilitates cycle movements through the network. This provides users with a more attractive mode of travel and supports the uptake of cycling. Furthermore, the cycleways will facilitate improved accessibility to the bus stations, increasing uptake of public transport across the network. Signalised shared pedestrian and cyclist crossings will be provided at the following intersections:

- Northern approach of Pakuranga Road / Ti Rakau Drive
- Northern approach of Ti Rakau Drive / Aylesbury Street / Pam Avenue
- Northern and Eastern approach of Ti Rakau Drive / Reeves Road / SEART
- All approaches of Ti Rakau Drive / William Roberts Road / Mattson Road
- Eastern and southern approaches of Ti Rakau Drive / Edgewater Drive east
- Northern and western approaches of Ti Rakau Drive / Gossamer Drive

Overall, pedestrian and cyclist amenity and safety will be improved. The Project will also provide greater accessibility and connectivity to public transport, increasing catchment and mode shift.

6.6 Effects to Property Access and Parking

6.6.1 EB2 – Reeves Road

The proposed design of Reeves Road in the EB2 project area does not provide any on-street parking. However, no on-street parking is provided in the existing environment. Therefore, the proposed design will have no effects on on-street parking.

6.6.1.1 3 Reeves Road (Gull Service Station)

Figure 108 shows the location and property boundary of 3 Reeves Road, as well as the Gull service station (red outline) developed on the site. Access to the property from Reeves Road will not be maintained in the proposed design as the section of Reeves Road between TI Rakau Drive and Cortina Place will be bus only. Discussions are ongoing with the owner regarding loss of direct road access onto Reeves Road.

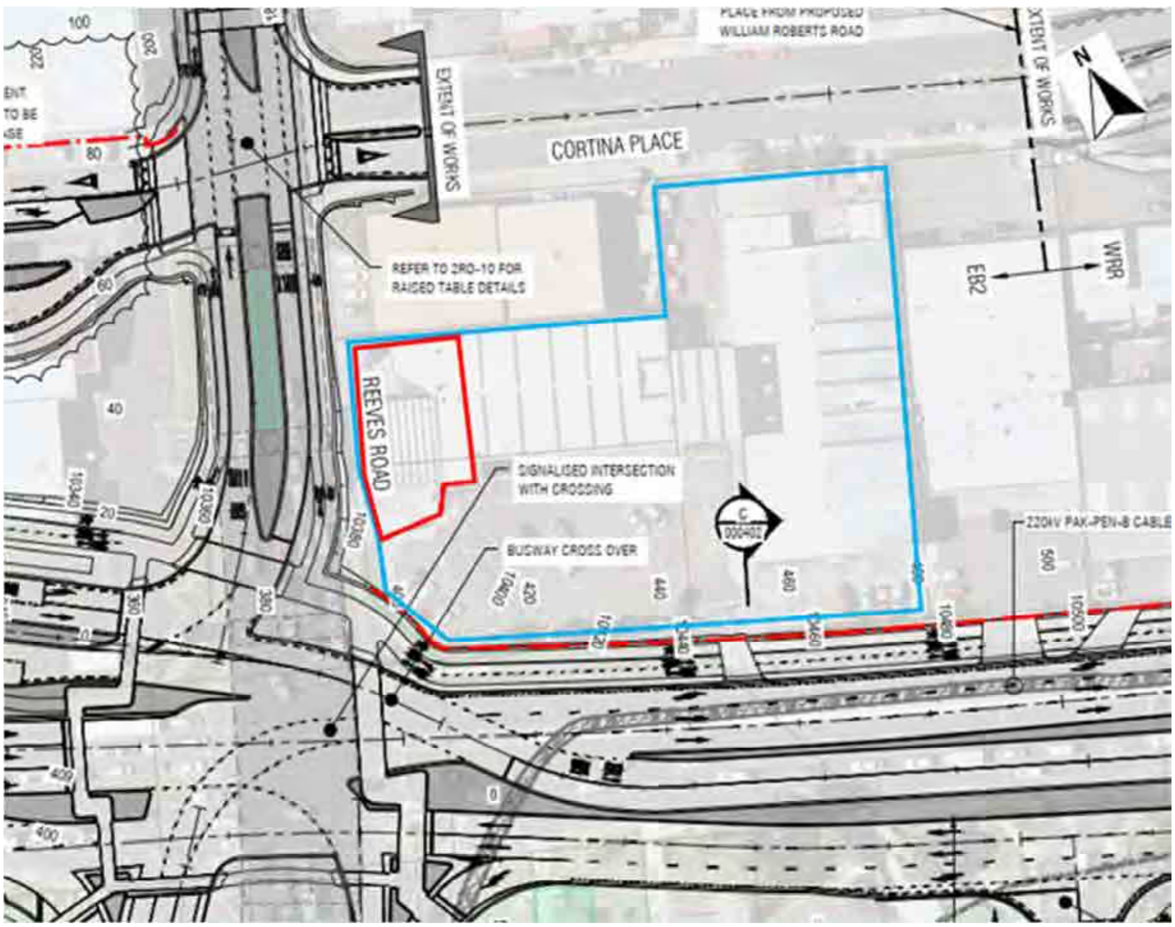

Figure 108: 3 Reeves Rd and Gull service station (red outline) upon completion

6.6.1.2 2 Cortina Place and 5 Reeves Road

As stated in **Section 5.1.1.1**, the properties at 2 Cortina Place and 5 Reeves Road have been acquired by AT and will be used as site offices during construction. Upon completion, these properties will be handed back or will be demolished for redevelopment in the future. **Figure 109** shows the location of 2 Cortina Place (yellow outline), 5 Reeves Road (blue outline) and the proposed design of the adjacent roads.

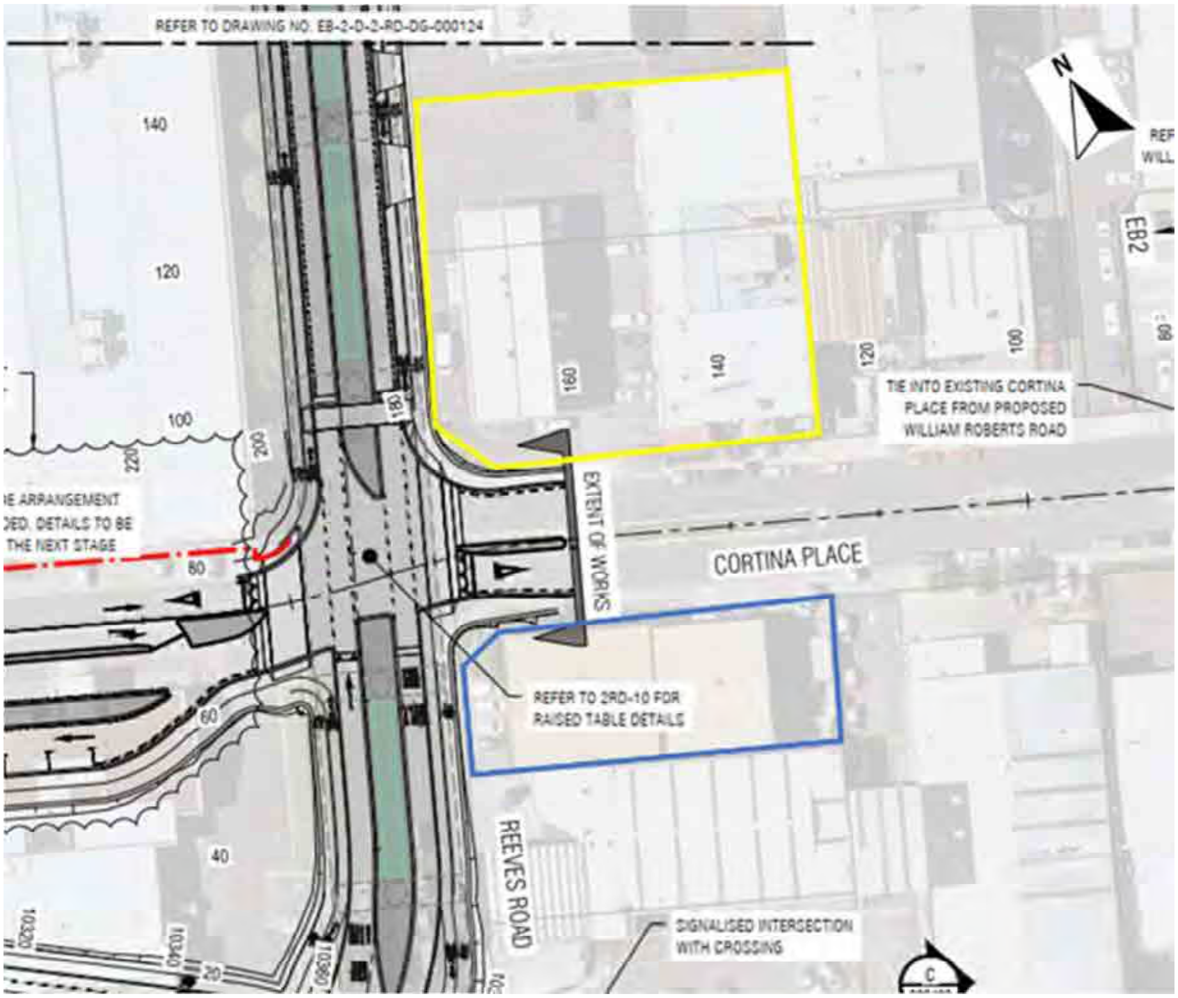

Figure 109: 2 Cortina Pl (yellow outline) and 5 Reeves Rd (blue outline) upon completion

The property at 5 Reeves Road will in future have no vehicle access from Reeves Road as the section of Reeves Road between Ti Rakau Drive and Cortina Place will be bus only. The property will however still be accessible via Cortina Place.

Upon completion, vehicle access from Reeves Road to the property at 2 Cortina Place will be reinstated. In future, the access from Reeves Road will be left-in/left-out only. However, this access will be in addition to the existing access off Cortina Place. Permanent effects to property access and parking at these properties are considered to be negligible.

6.6.1.3 11 Reeves Road (Eastside Pups Dog Grooming and Daycare)

Vehicle access from Reeves Road to the property at 11 Reeves Road will be reinstated once construction of the RRF and ground level works have been completed. The access will be left-in/left-out only due to the location of the columns of the RRF and potential sightline issues of opposing traffic. Although the access will be somewhat different compared to the existing environment, the permanent effects to property access are expected to be very low. **Figure 110** shows the location of 11 Reeves Road (blue outline) and the proposed design of Reeves Road.

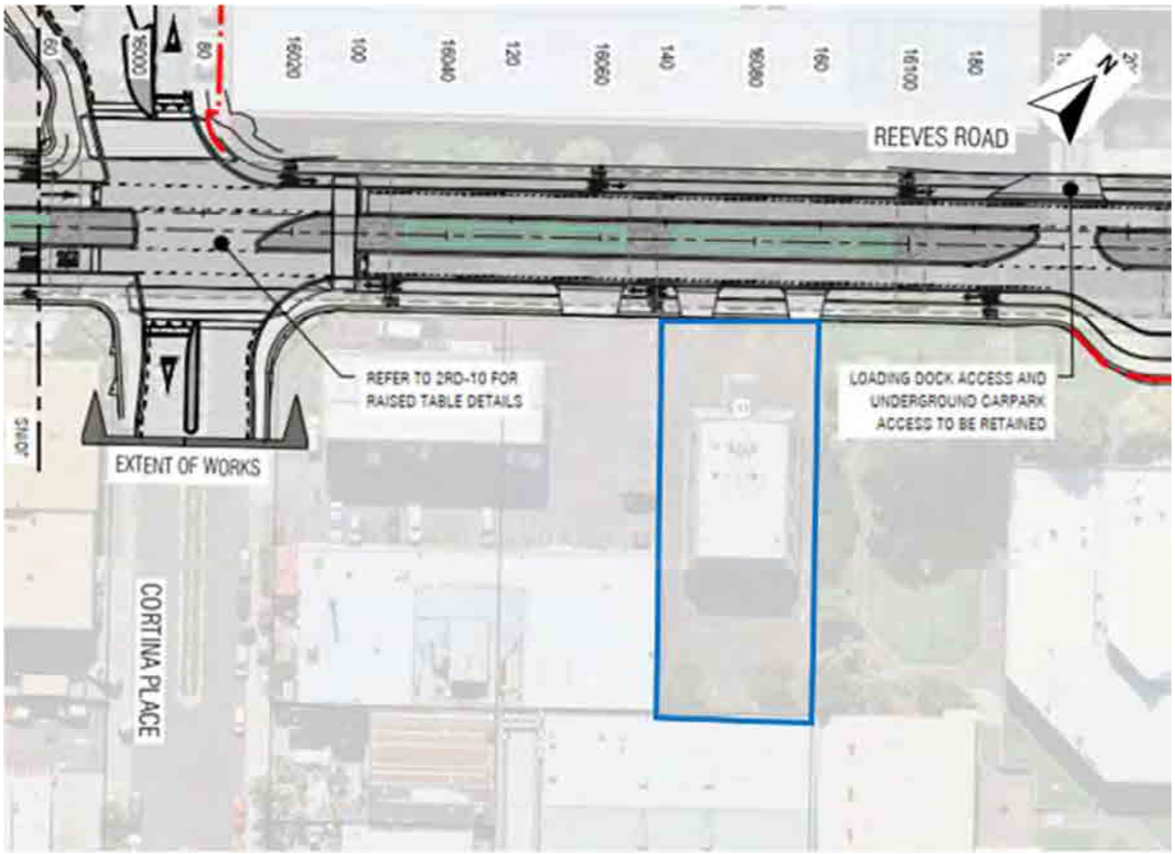

Figure 110: 11 Reeves Rd (blue outline) upon completion

6.6.1.4 13R Reeves Road (Te Tuhi)

Upon completion of the Reeves Road, access to the property at 13R Reeves Road (Pakuranga Community Centre) will be reinstated largely similar to the existing environment, and the temporary drop-off along William Roberts Road will be removed. Permanent effects to property access are expected to be negligible. **Figure 111** shows the location of the Te Tuhi development on 13R Reeves Road (blue outline) and the permanent access arrangement at the property.

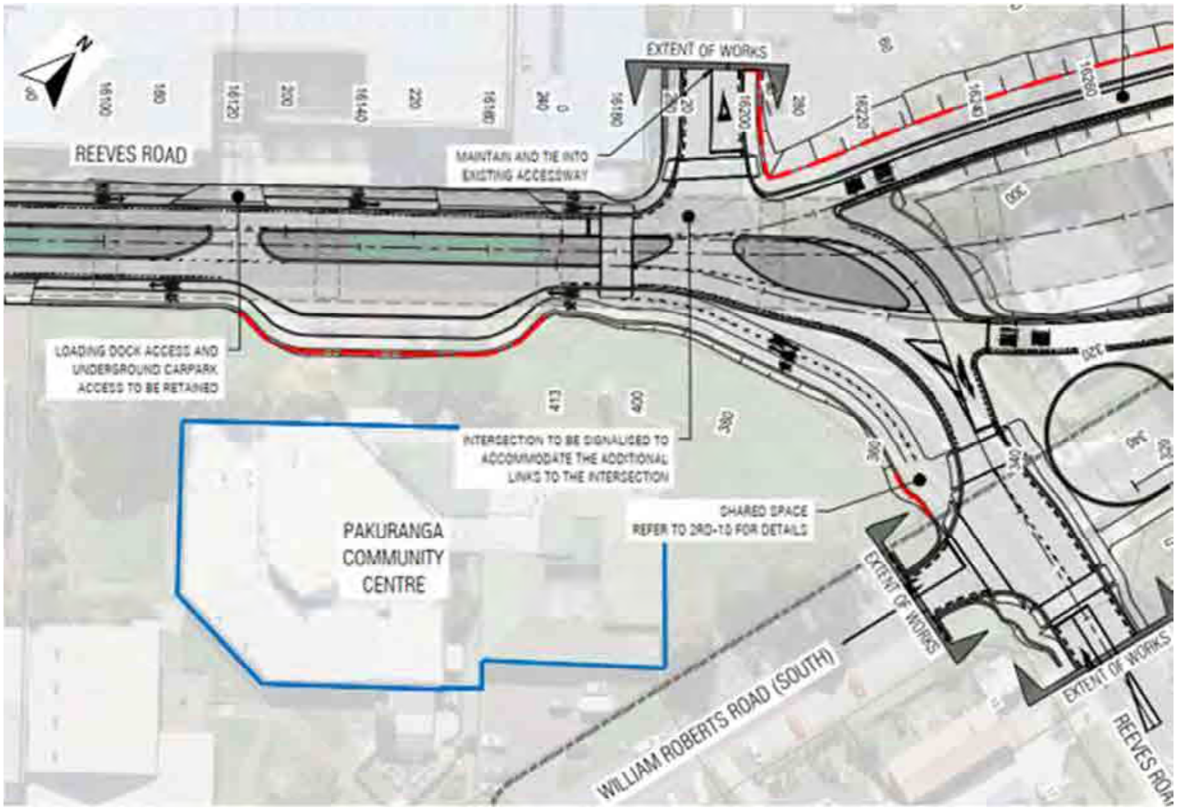

Figure 111: 13R Reeves Rd upon completion

6.6.1.5 7 Aylesbury Street and 2R Ti Rakau Drive (The Warehouse and Pakuranga Library)

Upon completion of Reeves Road, access to The Warehouse's goods access will be reinstated as per the existing environment (left-in left-out) with delivery vehicles approaching from the south via Cortina Place and exiting to the north on Reeves Road. A similar access arrangement will be provided to the Library service entrance. Access to the undercover carpark will be provided via Cortina Place to the south and Reeves Road to the north. **Figure 112** shows the permanent access arrangements at 7 Aylesbury Street (blue outline) and 2R Ti Rakau Drive (yellow outline) upon completion.

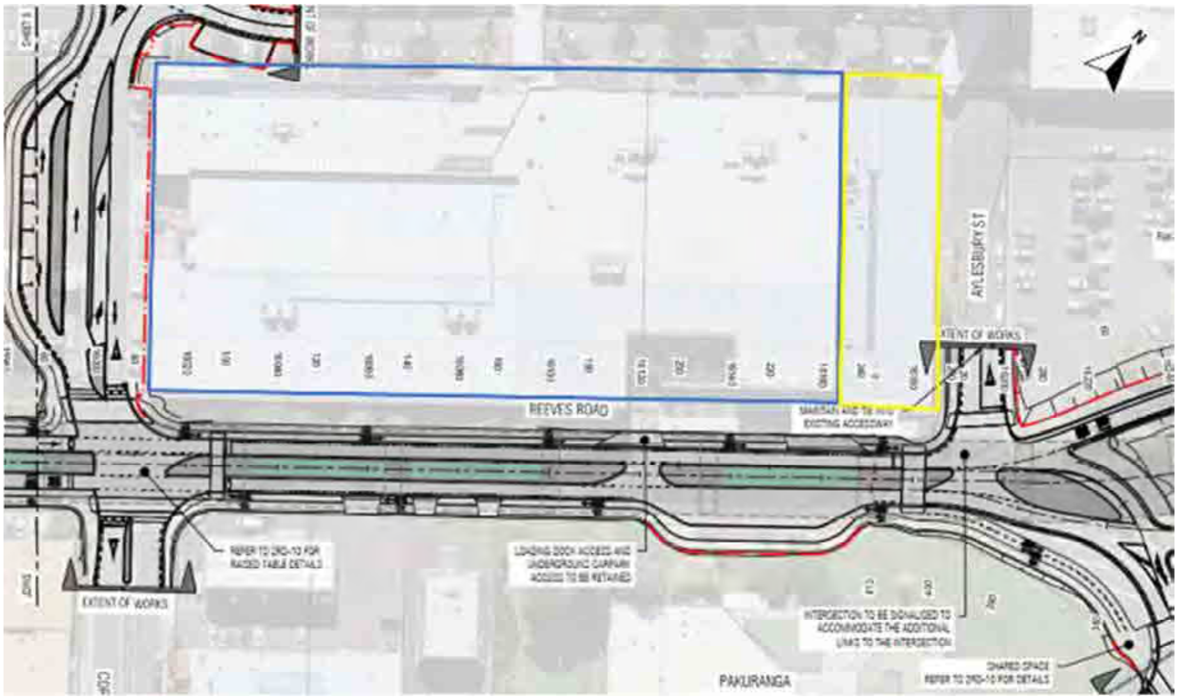

Figure 112: 7 Aylesbury St (blue outline) and 2R Ti Rakau Dr (yellow outline) upon completion

Permanent effects to property access, upon the completion of construction, are expected to be negligible as these access arrangements are largely similar to the existing environment and background traffic volumes on Reeves Road will be significantly reduced.

6.6.2 EB2 – William Roberts Road

6.6.2.1 William Roberts Road North

Upon completion, William Roberts Road north will no longer function as a through route between Reeves Road and Pakuranga Road, but rather as a local road to the surrounding residential properties. Each end of William Roberts Road north will be converted to a cul-de-sac with access off Ayr Road, and will provide ample on-street parking to the surrounding properties. Accesses to the remaining properties on the eastern side of the road will be maintained as per the existing environment. Overall, less through traffic will travel on William Roberts Road north, improving safety and the increased travel distance via Ayr Road to Lewis Road of roughly 300 m is considered to be negligible. Therefore, permanent effects to property access and parking are considered to be negligible.

6.6.2.2 William Roberts Road South

As stated in the WRRE ITA, the proposed WRRE design will result in the permanent loss of 12 parking spaces on William Roberts Road south, near the Pakuranga Leisure Centre and Ti Rakau Park.

Further north on William Roberts Road south, a total of 42 on-street parking spaces are provided at a 90˚ angle to the carriageway. To improve the safety of vehicles turning out from these parking spaces, and to avoid tracking curves passing over the road centre line, it is recommended that the angle of these parking spaces be adjusted (see **Figure 113**). The proposed design will provide 20 fewer on-street parking spaces.

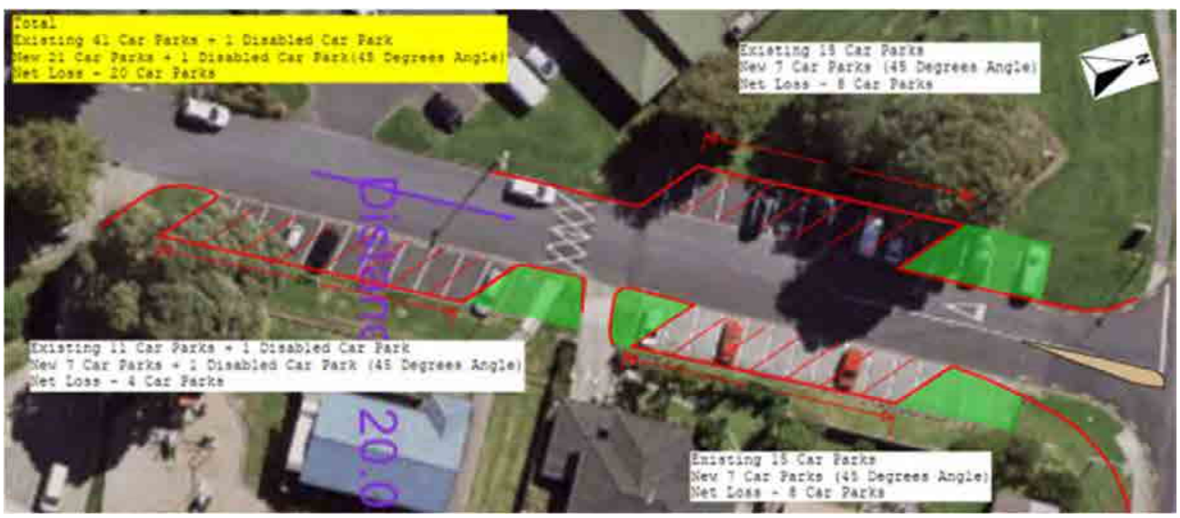

Figure 113: William Roberts Rd south parking adjustments

Therefore, the combined loss of on-street parking along William Roberts Road south due to the proposed design of WRRE and EB2, is 32 parking spaces.

Of the 32 parking spaces lost along William Roberts Road south, 16 parking spaces are located within Open Space zoned land (blue outline, see **Figure 114** below) and will require mitigation which is outlined below. The remaining 16 parking spaces are located within the road reserve (red outline below). As stated in **Section 3.7.3**, the average parking utilisation on William Roberts Road is not expected to exceed 49% on weekdays and 33% on weekends based on observations of current utilisation. Therefore, the permanent effects of the loss of these 16 parking spaces are considered to be very low.

Figure 114: William Roberts Rd south zoning and on-street parking

Nevertheless, it is proposed that a new off-street parking area will be constructed in Ti Rakau Park with access off William Roberts Road. The parking area will provide 21 additional parking spaces (24 in total, however three spaces are displaced). The proposed layout is shown in **Figure 115**.

Figure 115: William Roberts Rd south parking loss mitigation

The proposed parking area will be located near the new raised pedestrian crossing on William Roberts Road, connecting the proposed parking area with the existing footpaths on the western side of the carriageway. The proposed parking area will mitigate the effects on parking in Open Spaced zoned land along William Roberts Road south.

Stakeholder engagement is ongoing with Auckland Council to develop this option as well as relocating the existing playground to provide the necessary space for the proposed carpark.

6.6.3 EB2 – Pakuranga Road

In the proposed design, the kerbside lanes along Pakuranga Road between Ti Rakau Drive and the RRF will be converted to unidirectional cycleways. As such, no on-street parking will be provided along this section of Pakuranga Road in the future. Intermittent gaps will be provided in the buffer islands to allow for drainage to catchpits, but also to allow vehicular access to all properties with access off Pakuranga Road, similar to the existing environment (see **Figure 116** below).

As noted above, Pakuranga Road is largely similar to Ti Rakau Drive in the EB3R project area, in terms of traffic volumes and operating speeds, and so it is not unreasonable to assume that Pakuranga Road experiences the same low level of parking utilisation in the existing environment during weekdays and weekends. Based on this assumption, the permanent effects on on-street parking are expected to be negligible.

The majority of the clearway sections along Pakuranga Road, east of the existing William Roberts Road intersection (see **Section 5.5.4**), will be retained upon completion of the Pakuranga Road / RRF tie-in.

6.6.3.1 141 Pakuranga Road (GAS Service Station)

In the future, access from Pakuranga Road to the property at 141 Pakuranga Road will be largely similar to the existing environment. The proposed design will provide unidirectional cycleways in the kerbside lanes on Pakuranga Road, as well as buffer islands to separate the cycleways and the general traffic running lanes.

As above, intermittent gaps will be provided in the buffer islands to allow for drainage to catchpits, but also to allow vehicular access to this property, similar to the existing environment. **Figure 116** below shows the location of 141 Pakuranga Road (blue outline) and the proposed design along Pakuranga Road.

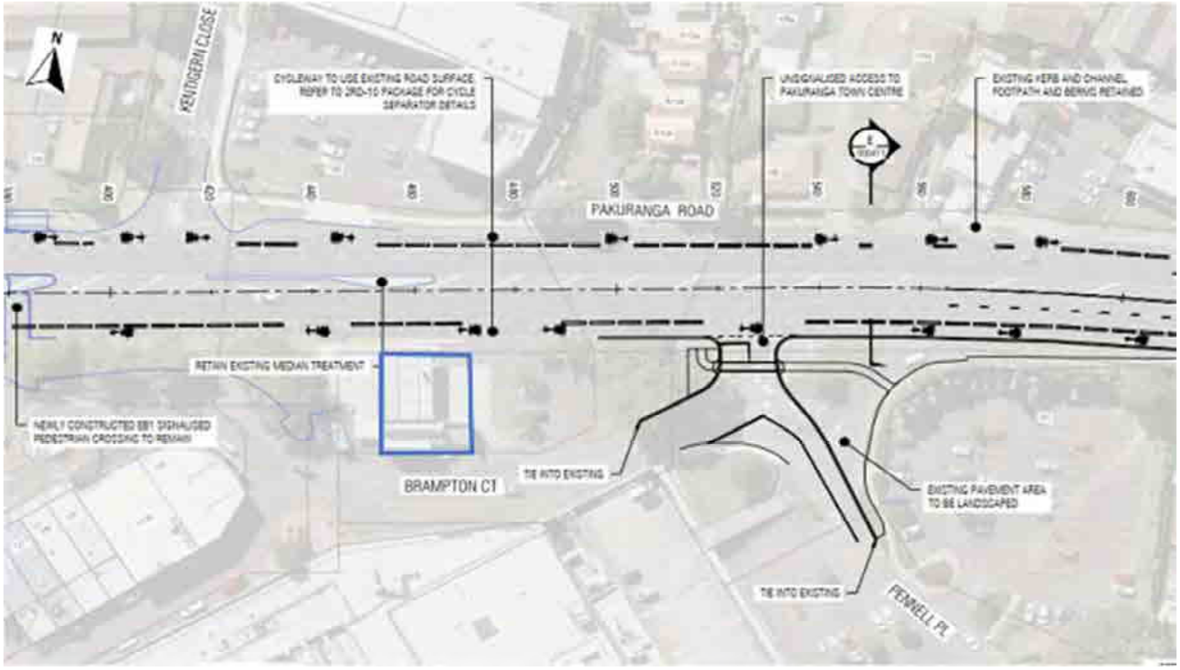

Figure 116: 141 Pakuranga Road (blue outline) upon completion

6.6.4 EB2 – Ti Rakau Drive, Side Roads and Properties

6.6.4.1 Ti Rakau Drive

The proposed design of Ti Rakau Drive in the EB2 project area, between Pakuranga Road and Reeves Road does not provide any on-street parking. However, no on-street parking is provided in the existing environment. Therefore, the proposed design will have no effects on on-street parking.

As per the existing environment, left-in/left-out access to the residential properties (3-27 Ti Rakau Drive) on the western side of the carriageway will be maintained. Upon completion, residents of these properties will no longer be able to use the existing U-turn facility on Ti Rakau Drive to head east. However, vehicles will still be able to turn right into Pakuranga Road and Brampton Court to execute a U-turn manoeuvre if required to head east along Ti Rakau Drive. Therefore, the permanent effects to these residential properties are considered to be very low.

6.6.4.2 Side Roads

Upon completion of the new Ti Rakau Drive / Aylesbury Street / Palm Avenue crossroads intersection, a raised intersection will be provided, with no effect on property access. No on-street parking is allowed on this section of Palm Avenue in the existing environment. Therefore, the final design will have no effects on on-street parking and property access along Palm Avenue.

6.6.4.3 Pakuranga Plaza

Property Access:

Upon completion of construction, the Plaza will be served by six access points in total including:

- Reeves Road / Cortina Place / Private Access Road intersection (unsignalised)
- The undercover carpark access off Reeves Road
- Reeves Road / Aylesbury Street intersection (signalised)
- Ti Rakau Drive / Aylesbury Street / Palm Avenue intersection (signalised)
- Pakuranga Road / Brampton Court intersection (unsignalised)
- The Pepler Street exit onto Pakuranga Road

The two existing Aylesbury Street accesses off Ti Rakau Drive will be combined into one crossroads intersection with Palm Avenue, the intersection will be raised and will be signalised. Furthermore, the Pakuranga Road / Brampton Court access will be realigned to provide improved access to vehicles turning right from Pakuranga Road eastbound. Although the total number of access points to the Plaza will be reduced by one compared to the existing environment, it is expected that the signalisation of two accesses will lead to an overall improvement in capacity and vehicle access to Pakuranga Plaza.

Parking:

Overall, the proposed design will result in the permanent loss of 257 of the 1,355 parking spaces at the Pakuranga Plaza. However, parking survey data showed that utilisation does not exceed 60% on an average weekday or weekend. As such, it is expected that the Plaza would still have 285 unoccupied parking spaces upon completion of construction. Therefore, the permanent effects of the proposed design on parking at the Pakuranga Plaza are considered to be negligible.

Figure 117 below shows the Pakuranga Plaza and the proposed design of the surrounding roads.

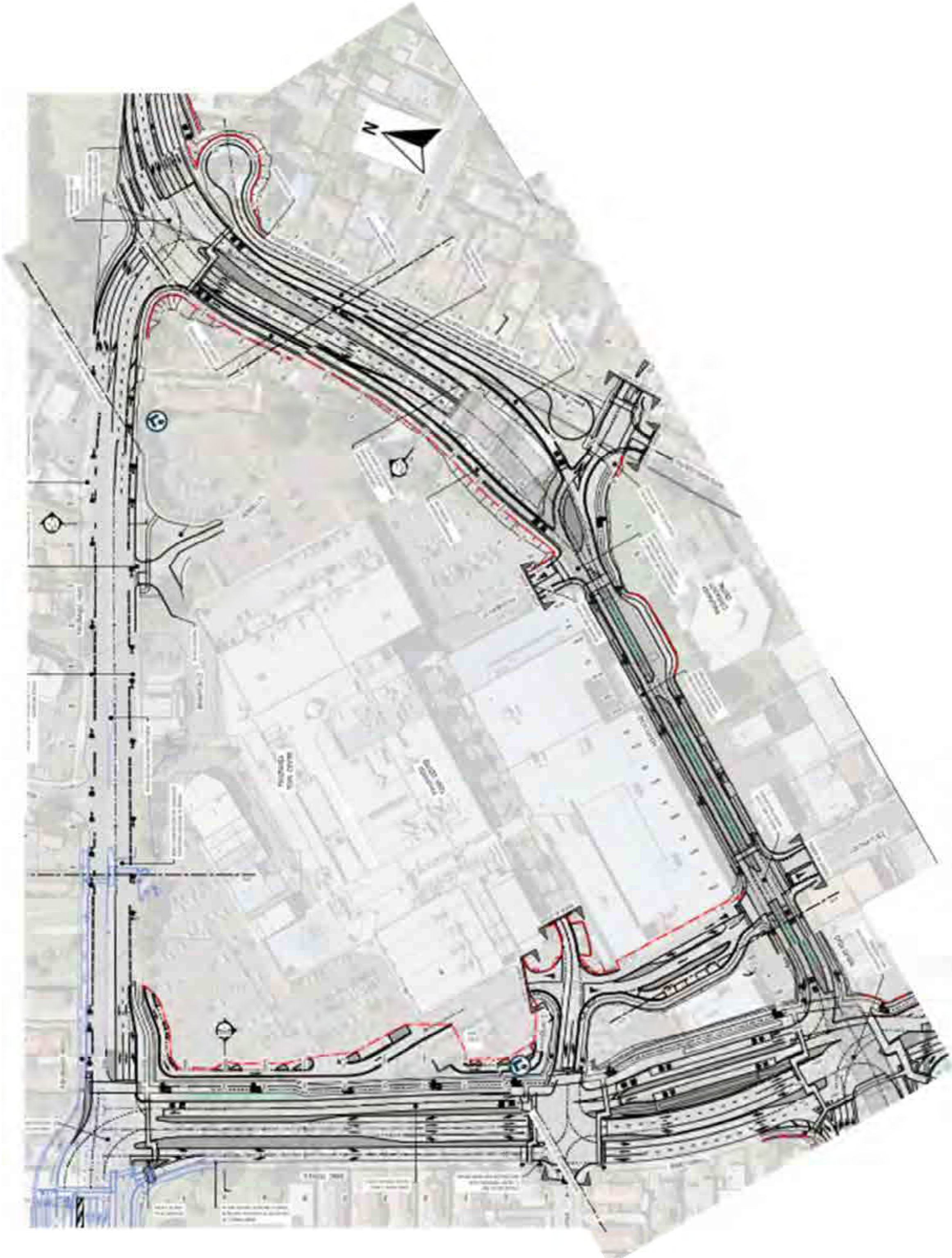

Figure 117: Pakuranga Plaza upon completion

6.6.4.4 26 Ti Rakau Drive

Upon completion of construction, 26 Ti Rakau Drive will be significantly redeveloped. A bus station will be provided between Aylesbury Street and Reeves Road, and a 'Kiss-and-Ride' facility will be provided on the private access road off Aylesbury Street that will consist of five parking spaces. Scooter and bike parking facilities will also be provided near the bus station. The remainder of 26 Ti Rakau Drive will be developed into open space, to improve amenity around the bus station (see **Figure 118**).

Figure 118: 26 Ti Rakau Dr artistic representation upon completion

6.6.5 EB3R – Ti Rakau Drive, Side Roads and Properties

6.6.5.1 Ti Rakau Drive

The proposed design of Ti Rakau Drive in the EB3R project area will provide online bus lanes along the centre of the carriageway, from Reeves Road to Gossamer Drive. In addition, unidirectional cycleways will be provided on both sides of Ti Rakau Drive. The cycleway on the northern side of the carriageway will be provided in the existing eastbound kerbside / parking lane and will be separated from the adjacent general traffic lanes by a buffer island. The cycleway on the southern side of Ti Rakau Drive will be separated from the general traffic running lanes by a grass berm. The proposed EB3R design of Ti Rakau Drive will provide no on-street parking between Reeves Road and Gossamer Drive.

However, as stated in **Section 3.7.4**, the average utilization of the existing on-street parking is poor with only 3% occupancy on weekdays and 8% on Saturdays. This is not unexpected as this high-volume road does not create an appealing location to park vehicles and is likely leading to a high perceived risk of crashes. Furthermore, the acquisition of the majority of the residential properties on the southern frontage of Ti Rakau Drive will remove the need for on-street parking along this section.

The current left-in/left-out access arrangements to the remaining properties on both sides of Ti Rakau Drive will be maintained upon completion. Access to these properties from the opposite side of Ti Rakau Drive will be facilitated by the new U-turn facility along the corridor as well as the U-turn manoeuvres provided at the Ti Rakau Drive / William Roberts Road / Mattson Road, Ti Rakau Drive / Edgewater Drive east and Ti Rakau Drive / Gossamer Drive intersections. Therefore, the permanent effects on property access and on-street parking are considered to be negligible.

6.6.5.2 Side Roads

Tiraumea Drive, Roseburn Place, Edgewater Drive and Wheatley Avenue:

Changes along the side roads of Tiraumea Drive, Roseburn Place, Edgewater Drive west, Wheatley Avenue and Edgewater Drive east as a result of the proposed design will be limited to the approaches of the intersections with Ti Rakau Drive. As such, permanent effects on on-street parking and property access along these side roads are considered to be negligible.

Marriott Road and Chevis Place:

No changes are proposed along Marriott Road and Chevis Place. Therefore, the proposed design will have no permanent effects on on-street parking and property access along these side roads.

Mattson Road:

The proposed design along Mattson Road is relatively more extensive. The Mattson Road approach will be set back approximately 27m south and 36m west of its current location where it intersects Ti Rakau Drive. This will provide space for the new westbound lanes on Ti Rakau Drive. However, the properties on the southern side of Ti Rakau Drive have been acquired, removing the need for on-street parking. Accesses to properties along Mattson Road not acquired by AT will be maintained and will interface with the new alignment of Mattson Road similar to the existing environment. Therefore, the permanent effects on on-street parking and property access along Mattson Road are considered to be negligible.

Gossamer Drive:

In the proposed design, the Gossamer Drive approach limit line will be set back approximately 15 m from its current location and the kerbside exit lane will be extended to 100 m. NSAAT line markings are currently provided on the eastern side of the road up to the bus stop near the intersection with Riverhills Avenue. These markings will be replicated on the western side of the road. This will result in the loss of on-street parking in front of 169, 171, 173 and 175 Gossamer Drive. It is likely that these properties have sufficient off-street parking, and that on-street parking is not occupied on a regular basis. Accesses to properties along Gossamer Drive not acquired by AT will be maintained and will interface with the roadway similar to the existing environment. Therefore, the permanent effects on on-street parking and property access along Gossamer Drive are considered to be negligible.

Freemantle Place:

The Freemantle Place approach will be set back approximately 11 m. NSAAT line markings are provided on the western side of the road for approximately 31 m from the limit line. The line markings will be reinstated upon completion and will result in the loss of one parking space in front of 3 Freemantle Place. The existing line markings on the eastern side of the road will be retained. Property access along Freemantle Place will be maintained as per the existing environment. Therefore, the permanent effects on on-street parking and property access along Freemantle Place are considered to be negligible.

6.6.5.3 Residential Properties on Southern Frontage of Ti Rakau Drive

Upon completion of the new westbound lanes on Ti Rakau Drive in EB3R, the temporary residential access tracks at 75A, 83, 83A-C, 87-91, 97, 103A, 129, 145, 175A, 177, 183-185 and 191 Ti Rakau Drive will be disestablished. Residents will be able to use their existing driveways off the new Ti Rakau Drive westbound lanes. The accesses will be left-in/left-out only, similar to the existing environment. Therefore, permanent effects to property access at these properties are considered to be negligible.

6.6.5.4 107 and 109 Ti Rakau Drive – Edgewater Shops

Upon completion, the temporary carpark at 105 Ti Rakau Drive will be made permanent. The carpark will provide 22 parking spaces. Access to and from the proposed carpark will be via Ti Rakau Drive, similar to the existing environment (see **Figure 119** below). Access to the refuse collection area to the rear of the property will be largely similar to the existing environment. Therefore, the effects of the proposed carpark on property access and parking are considered to be negligible.

Figure 119: Edgewater Shops proposed parking area upon completion

6.6.5.5 32 Edgewater Drive – Edgewater College

In the existing environment, Edgewater College is accessed from both the Edgewater Drive west and east intersections with Ti Rakau Drive, which provide for all movements in and out. The proposed design of the Ti Rakau Drive / Edgewater Drive west and east intersections is left-in left-out only.

As stated in **Section 4.2.2.2**, a U-turn facility will be provided between Edgewater Drive west and Wheatley Avenue which will enable eastbound traffic on Ti Rakau Drive to execute a U-turn manoeuvre and turn into Edgewater Drive west. Furthermore, a U-turn manoeuvre will also be provided on the western approach at the Ti Rakau Drive / Gossamer Drive intersection. This will enable eastbound traffic on Ti Rakau Drive to execute a U-turn and turn into Edgewater Drive east.

Overall, permanent effects to property access at Edgewater College are considered to be negligible. Permanent effects to school bus services to and from Edgewater College are assessed in **Section 6.4.8**.

6.6.5.6 207, 219 and 229 Ti Rakau Drive – Pakuranga Baptist Church

Access from Ti Rakau to the property at 207 Ti Rakau Drive (Pakuranga Counselling Centre) will be maintained in the future. Therefore, permanent effects to property access are considered to be very low. **Figure 120** below shows the location of 207 Ti Rakau Drive (blue outline) and the proposed design of the adjacent roads.

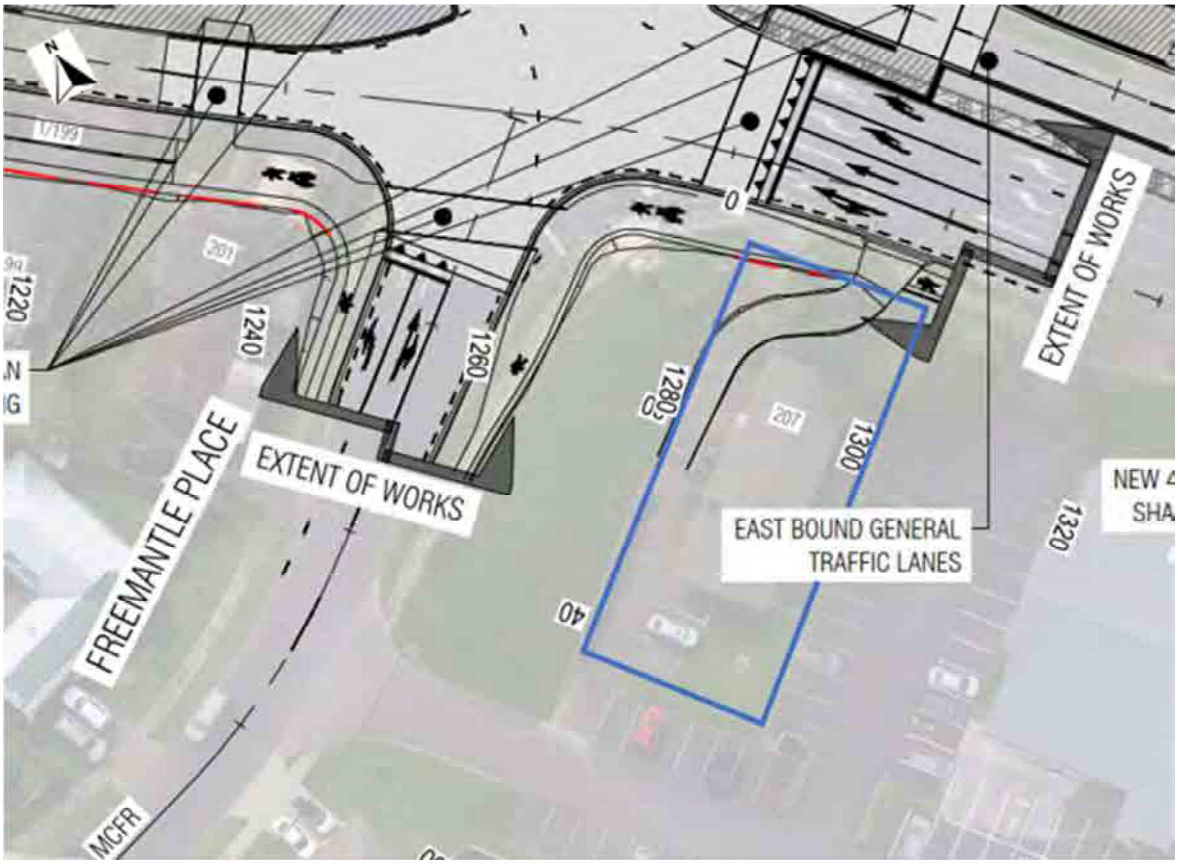

Figure 120: 207 Ti Rakau Drive (blue outline) upon completion

No changes to property access or parking are proposed at 209 and 229 Ti Rakau Drive in the proposed design. Access to these properties will be maintained as per the existing environment.

6.6.5.7 168R Gossamer Drive – River Hills Park

As stated in **Section 5.5.6.7**, a parcel of land along the southern boundary of 168R Ti Rakau Drive River Hills Park has been acquired to allow for the eastbound Gossamer Drive bus station. Discussions are ongoing with the Council as well as the Fencibles United Football Club on the rearrangement of the fields on the property as a result of the Project. **Figure 121** below shows the proposed field rearrangements at the River Hills Park.

Figure 121: 168R Gossamer Drive upon completion

However, from a transport perspective, the Project will have no permanent effects to property access and parking on-site.

6.7 Effects to Safety Performance

The sections below discuss the potential effects on safety performance in the context of EB2 and EB3R upon completion.

A Safe Systems Assessment (SSA) was undertaken of the proposed EB2 and EB3R design layouts. As stated in **Section 3.8.2**, the SSA was conducted in accordance with the Auckland Transport Safe System Assessment Guidelines which are based on the Austroads 2016, Research Report AP-R509-16, Safe System Assessment Framework. The above-mentioned report section also provides details on the types of crashes assessed as well as the SSA framework. A summary of the findings is presented below.

6.7.1 EB2

Table 45 provides an assessment summary and comparison of the SSA of the existing environment and the proposed design of EB2. Again, each crash type is scored based on exposure, likelihood and severity and a lower score corresponds with a safer system. It should be noted that Location C in EB2 indicates the location of the bus station upon completion of the Project.

Table 45: EB2 SSA – existing vs future environment

ZONE EB2 ASSESSMENT SUMMARY											
EXISTING LAYOUT	**R-O-R**	**H-O**	**INT**	**OTHER**	**M/C**	**P1**	**P2**	**P3**	**C1**	**C2**	**TOTAL**
A) TI RAKAU DR - MB	16	16	32	16	64	24	48	0	36	36	288
B) TI RAKAU DR - INT	16	16	32	16	48	24	0	48	36	36	272
C) TI RAKAU DR - MB	16	16	32	16	64	24	48	0	36	36	288
D) TI RAKAU DR - INT	16	16	24	16	48	18	0	24	36	27	225
E) TI RAKAU DR - MB	8	16	16	24	48	24	48	0	31.5	27	243
F) TI RAKAU DR - INT	16	16	24	24	48	18	48	36	31.5	27	289
G) TI RAKAU DR - MB	16	16	0	24	48	0	48	0	36	0	188
H) PAKURANGA RD - INT	16	16	24	16	48	12	0	24	36	36	228
I) PAKURANGA RD - MB	16	24	24	24	48	18	36	0	36	36	262
J) PAKURANGA RD - INT	16	24	32	16	64	18	0	48	36	36	290
K) REEVES RD - MB	9	13.5	15.75	13.5	36	18	36	0	31.5	36	209
L) REEVES RD - INT	15.75	13.5	18	13.5	36	21	0	48	36	36	238
M) WILLIAM ROBERTS RD - MB	NOT APPLICABLE										
N) CORTINA PL - MB	3	3	0	5.25	28	0	24	0	24	0	87
O) CORTINA PL - INT	9	13.5	18	15.75	42	21	0	48	27	36	230
P) PAKURANGA HWY - MB	24	0	0	24	32	0	0	0	0	0	80
Q) REEVES RD FLYOVER - MB	NOT APPLICABLE										
CDD LAYOUT	**R-O-R**	**H-O**	**INT**	**OTHER**	**M/C**	**P1**	**P2**	**P3**	**C1**	**C2**	**TOTAL**
A) TI RAKAU DR - MB	12	12	0	12	32	0	48	0	22.5	0	139
B) TI RAKAU DR - INT	0	0	0	0	36	8	0	12	30	20	106
C) TI RAKAU DR - MB	12	12	0	12	32	0	64	0	30	0	162
D) TI RAKAU DR - INT	12	12	24	12	48	24	0	48	25	30	235
E) TI RAKAU DR - MB	6	6	12	21	40	12	48	0	15	22.5	183
F) TI RAKAU DR - INT	12	6	15	18	48	12	0	24	15	15	165
G) TI RAKAU DR - MB	12	6	0	12	32	0	48	0	15	0	125
H) PAKURANGA RD - INT	12	12	18	12	48	15	0	24	15	15	171
I) PAKURANGA RD - MB	12	18	18	15	40	18	36	0	15	26.25	198
J) PAKURANGA RD - INT	18	12	12	12	32	15	0	30	36	36	203
K) REEVES RD - MB	0	0	0	0	18	6	18	0	12	12	66
L) REEVES RD - INT	0	0	0	0	15	6	0	12	15	15	63
M) WILLIAM ROBERTS RD - MB	0	0	0	0	12	7.5	15	0	24	24	83
N) CORTINA PL - MB	0	0	0	0	21	0	18	0	24	0	63
O) CORTINA PL - INT	0	0	0	0	12	8	0	16	16	16	68
P) PAKURANGA HWY - MB	16	0	0	16	16	0	0	0	0	0	48
Q) REEVES RD FLYOVER - MB	12	0	0	12	32	0	0	0	0	0	56

Apart from the product score for P2 type crashes (midblock crossings) remaining unchanged, the total score of Location A is significantly reduced. Due to the removal of one uncontrolled intersection into the Pakuranga Plaza, a reduced likelihood score for intersection and motorcycle crashes is expected. The C2 crash type is eliminated due to the removal of the unsignalised access into the Pakuranga Plaza.

Due to the new design providing a greater physical separation between carriageways and by replacing an unsignalised intersection (Palm Avenue) with traffic signals on all approaches, the total score for all general traffic type crashes for Location C has reduced.

The SSA shows that the product score for general traffic type crashes across all locations and for motorcycle crashes at most locations, are slightly reduced. This is due to a reduction in the posted speed limit from 60km/h to 50km/h, reducing the severity score.

Overall, the proposed design of EB2 is a balance between the competing modes of travel. The proposed design will provide staged crossings at various locations to reduce pedestrian delay, improve safety and discourage jaywalking. Overall, the product score of the proposed design is lower throughout EB2 compared to the existing environment.

6.7.2 EB3R

Table 46 below provides an assessment summary and comparison of the SSA of the existing environment and the proposed design of EB3R. It should be noted that Location F and H in EB3R indicate the locations of the bus stations upon completion of the Project.

Table 46: EB3R SSA – existing vs future environment

ZONE EB3R ASSESSMENT SUMMARY											
EXISTING LAYOUT	**R-O-R**	**H-O**	**INT**	**OTHER**	**M/C**	**P1**	**P2**	**P3**	**C1**	**C2**	**TOTAL**
A) ROSEBURN PL	8	16	32	24	64	24	48	0	27	36	279
B) MARRIOTT RD	8	16	32	24	64	24	48	0	27	36	279
C) EDGEWATER DR / CHEVIS PL	8	16	16	24	48	24	48	24	27	27	262
D) WHEATLY AVE	8	16	32	24	64	24	36	0	27	36	267
E) EDGEWATER DR	8	0	32	24	64	24	0	0	27	36	215
F) GOSSAMER STATION WB	8	0	0	24	32	0	0	0	27	18	109
G) GOSSAMER DR INTERSECTION	24	24	24	24	48	18	0	36	36	18	252
H) GOSSAMER STATION EB	8	16	0	8	16	0	32	0	36	0	116
CDD LAYOUT	**R-O-R**	**H-O**	**INT**	**OTHER**	**M/C**	**P1**	**P2**	**P3**	**C1**	**C2**	**TOTAL**
A) ROSEBURN PL	6	6	12	18	48	8	64	0	10	20	192
B) MARRIOTT RD	6	6	12	24	48	8	64	0	20	30	218
C) EDGEWATER DR / CHEVIS PL	4	4	8	16	24	8	20	0	16	24	124
D) WHEATLY AVE	6	6	12	18	48	8	48	0	10	20	176
E) EDGEWATER DR	6	0	12	18	48	8	0	0	10	20	122
F) GOSSAMER STATION WB	6	6	0	18	32	0	32	0	20	20	134
G) GOSSAMER DR INTERSECTION	8	10	10	12	24	8	0	24	20	24	140
H) GOSSAMER STATION EB	6	12	0	6	16	0	48	0	10	0	98

Although the total scores for Locations A, B and C are significantly reduced, the product score for P2 type crashes is slightly increased. This is due to the expected increase in pedestrian movements and slight increase in likelihood of pedestrians rushing to the bus station.

The total score of Location F is slightly increased, compared to the existing environment. Similar to the above, this is due to the expected increase in pedestrian movements and slight increase in likelihood of pedestrians rushing to the bus station.

A large improvement is observed in the product score for location G in the proposed design. This is due to a reduced product score in general traffic type crashes, including motorcycle crashes. Through the provision of a raised intersection, approach speeds of vehicles will reduce, causing severity and likelihood of general traffic type crashes to reduce.

A reduced product score is also observed for both pedestrian and cyclist crashes. Due to the reduced approach speed, the severity of pedestrian crashes is expected to reduce. The provision of a separate cycling facility will also reduce exposure and likelihood of cycling crashes.

As above, the proposed design will provide staged crossings at various locations in order to reduce pedestrian delay, improve safety and discourage jaywalking. Overall, the product score of the proposed design is lower throughout EB3R compared to the existing environment.

7 Mitigation Summary

The sections below provide a summary of the mitigation measures proposed in this ITA to mitigate the potential adverse effects of the Project both during construction and upon completion.

7.1 Mitigation Measures during Construction

The mitigation measures to be employed during construction will form part of the conditions of the CTMP.

7.1.1 Construction Support Areas

- The properties at 2 Cortina Place and 5 Reeves Road will serve as site offices for the Project. It is envisaged that, at least for the initial year of construction, site office staff will use public transport for commuter trips and will access the site offices on foot. A WTMP will be developed to reduce the number of private vehicles travelling to the worksites and to increase the accessibility of the worksites through more travel options. Following the initial year and as construction activities ramp up, a staff carpark will be provided at 26 Ti Rakau Drive.

- The operation and movement of the Gantry at the Pennell Place CSA will be under strict construction traffic management control. Advance notice and appropriate public communication of such infrequent activities will be undertaken prior to these being initiated. This will be achieved through the Construction Traffic Management Plan (CTMP).

- During the operation of the William Roberts Road north construction yard, it is proposed that the Pakuranga Road / William Roberts Road intersection will be signalised temporarily. This will improve the capacity of the right-turn movements into and out of William Roberts Road and improve the safety of turning across three lanes of through traffic.

7.1.2 Hours of Operation

- It is anticipated that some night works will be undertaken to minimise the disruption to the public, businesses and traffic. Night works will be intermittent, and will not be continuous in a single location or activity. These works will be controlled in part by the Project's consent conditions and management plans, including the Construction Noise and Vibration Management Plan (CNVMP).

7.1.3 Construction Vehicles and Routes

- Community engagement will be undertaken to raise awareness of the increase in construction vehicles that will pass through William Roberts Road south and Reeves Road due to the increase in exposure to some vulnerable users in the area. Construction vehicle drivers will also be briefed on these properties so that additional caution is employed when driving through these areas. This will be achieved through the CTMP.

7.1.4 General Traffic

- To mitigate the potential adverse effects to travel times during all Construction Scenarios, appropriate public engagement will be undertaken, and on-road messaging will be provided. This is expected to lead to changes in travel behaviour, such as peak spreading, flexible working and alternative route selection, that could lead to decreased traffic volumes. This in turn could lead to more manageable queues, lower delays and improved travel times on the network. This will be managed through the CTMP.
- It is expected that the effects of the Pakuranga Road drainage works (Construction Scenario 1.1) can be managed by utilising the flush median as a running lane in order to maintain three lanes westbound and two lanes eastbound during these works.
- The pedestrian crossing on the eastern arm of the Ti Rakau Drive / Reeves Road / SEART intersection will require removal for the duration of Construction Scenario 1.2 to 2 to allow for more efficient traffic signal phasing, which will assist in managing the increased demand on Ti Rakau Drive.
- In the PM peak, during Construction Scenario 1.1, it is recommended that Signal Phase D at the Pakuranga Road / St Kentigern College intersection be modified to a variable phase, only to be called when necessary. This will assist in managing the Pakuranga Road eastbound demand during the drainage works.
- During Construction Scenario 1.2 to 1.4, in the PM peak, it is recommended that fixed time cycles of 150sec and offsets be implemented at the following intersections to facilitate better coordination between closely spaced intersections:
    - Pakuranga Road / William Roberts Road (temporary traffic signal) – reference
    - Pakuranga Road / St Kentigern College – offset = 13sec
- In the PM peak, during Construction Scenario 2, it is recommended that fixed time cycles of 150sec and offsets be implemented at the following intersections:
    - Ti Rakau Drive / Reeves Road / SEART – reference
    - Ti Rakau Drive / Aylesbury Street / Palm Avenue – offset = 11sec
    - Pakuranga Road / Ti Rakau Drive – offset = 28sec
- Consultation with ATOC will be undertaken to implement these traffic signal adjustment measures.
- A temporary traffic signal will be provided at the Ti Rakau Drive / Edgewater Drive east intersection during the construction of the Ti Rakau Drive / Edgewater Drive west intersection. This will ensure that signalised movements for vehicles turning into and out of Edgewater Drive are maintained.

7.1.5 Bus Services and Facilities

- During the closure of Reeves Road, the 711 outbound (eastbound) service will be diverted temporarily to the newly completed WRRE.

- Once William Roberts Road north is closed, the 711 inbound (westbound) service will also be diverted to the WRRE and will utilise bus stop (ID 6127) to pick-up/drop-off passengers at the Pakuranga Plaza.

- Opportunities will be explored during the development of the CTMP to improve bus travel times during all Construction Scenarios, such as the provision of temporary bus priority or temporary bus lanes where feasible, along with measures to manage travel demand through the provisions of the SSTMPs.

- Appropriate public communication and advance warning of the planned works will be undertaken prior to the works being initiated. Public communication and signage will also be provided during construction informing motorists of the works and potential delays, which could lead to changes in travel behaviour such as travelling outside the peak periods or using alternative routes.

7.1.6 Pedestrians and Cyclists

- Pedestrian crossings and footpaths will be maintained at all times during construction. Should this be unachievable, temporary facilities will be provided to ensure pedestrian connectivity. This will be ensured through the CTMP.

7.1.7 Property Access and Parking

- Access from Reeves Road to the Gull Service Station at 3 Reeves Road will not be maintained during the Reeves Road closure. Discussions are ongoing with the owner regarding loss of direct road access onto Reeves Road.

- During the Reeves Road closure, a temporary two-way access will be provided from Cortina Place to the Eastside Pups Dog Grooming and Daycare at 11 Reeves Road.

- Access to The Warehouse's goods entrance at 7 Aylesbury Street and the service entrance to the Pakuranga Library and Citizens Advice Bureau at 2R Ti Rakau Drive will be maintained through the work site. Removable barriers will be installed in the median and the existing masonry wall on the property boundary will be removed, if required, and will be re-installed following construction.

- During the Reeves Road closure, the main access to Te Tuhi at 13R Reeves Road will be closed and a temporary drop-off area with a temporary walkway leading to the main entrance will be provided on William Roberts Road.

- Access to the GAS Service Station at 141 Pakuranga Road and the Pakuranga Plaza via Brampton Court will be maintained during the longitudinal drainage works on Pakuranga Road by completing the works in sections and via steel plating across the trenches. The construction team will also liaise with the operators of the service station to ensure sufficient access widths are provided, as and when required, for fuel delivery tankers.

- During Phase 1 of Ti Rakau Drive in EB3R, the remaining properties on the southern frontage will not have access to Ti Rakau Drive while the westbound lanes are constructed. Temporary residential access will therefore be provided during this phase via chip seal access tracks along the back of the acquired properties accessed through side streets. Properties that would use these access tracks include 75, 83, 83A-C, 87, 98, 91, 97, 103A, 129, 145, 175A, 177, 183, 185 and 191 Ti Rakau Drive.

- A temporary parking area, with 18 parking spaces, will be provided at 105 Ti Rakau Drive for the Edgewater Shops located at 107 and 109 Ti Rakau Drive during construction. The temporary carpark will be accessed via Edgewater Drive west and the access road to the rear of the commercial buildings. Temporary signage will be provided to direct customers.

- Drainage works at 207, 219 and 229 Ti Rakau Drive will be undertaken in sections to maintain vehicle access to all properties at all times. Furthermore, at the end of the work week, the work zone will be reduced in size, while maintaining safety, to free up as many occupied parking spaces as possible.

7.2 Mitigation Measures upon Completion

- Access to the Gull Service Station at 3 Reeves Road will not be maintained from Reeves Road. Discussions are ongoing with the owner regarding the loss of direct road access from Reeves Road.
- To mitigate the loss of 16 parking spaces located within the Open Space zoned land along William Roberts Road south an off-street parking area will be provided in Ti Rakau Park providing 21 additional parking spaces. Stakeholder engagement is ongoing with Auckland Council to develop this option as well as relocating the existing playground to provide the necessary space for the proposed carpark.
- To mitigate the removal of the parking spaces at the Edgewater Shops (107 and 109 Ti Rakau Drive), the temporary carpark at 105 Ti Rakau Drive will be made permanent and will provide 22 parking spaces.

- Discussions are ongoing with Council and Fencibles United Football Club to rearrange the fields on River Hills Park as a result of the parcel of land that has been acquired along the southern boundary of 168R Ti Rakau Drive to facilitate the eastbound Gossamer Drive bus station.

8 Conclusions

During the development of the updated construction methodology, based on an updated design, efforts have been made to add efficiencies to the overall construction programme and produce construction staging so as to minimise the adverse transport effects. This process has led to a more refined construction staging.

Overall, the temporary effects of the various CSAs as well as the construction traffic in the project areas will be mitigated appropriately and are considered to be negligible or very low. A WTMP will be developed to reduce private vehicle trips and to increase worksite accessibility through more travel options. CTMPs will be developed to avoid, remedy or mitigate the adverse effects of construction on transport, parking and property access so far as is reasonably practicable. The CTMPs will be developed in accordance with the conditions of consent and will include management strategies, controls and reporting protocols to achieve this. Hours of operation, especially night works, will be controlled in part by the Project's consent conditions and management plans, including the CNVMP.

Overall, the temporary effects on intersection performance during all construction scenarios across the network are considered to be negligible to low, with some mitigation measures in place. Appropriate measures have been proposed to support the operation of the construction yard, as well as during drainage works on Pakuranga Road, the RRF tie-in and works on the Edgewater Drive loop.

Although the temporary effects to intersection performance during construction are predicted to be negligible to low, some adverse effects to general traffic and bus travel times are expected, particularly during Construction Scenario 1.3[36]. These effects are not unexpected due to the number of additional intersections and ongoing construction activities. Various mitigation options were tested; however, it is expected that the only alternative to improve travel times would be to add more lanes, which would be expected to have significant implications on construction cost and programme. Furthermore, increases in travel times through the project area are inherent in the majority of transport projects of this scale, as are changes in travel behaviour that could be reasonably expected to reduce traffic volumes on the network, such as peak spreading, flexible working options and alternative route selection. With appropriate public engagement and on-road messaging, it is expected that these travel behaviour changes could occur This in turn could lead to more manageable queues, lower delays and improved travel times on the network. These will be managed through the CTMP process.

It should be noted that these effects are temporary, and once constructed, the RRF and EB2/EB3R as a whole will alleviate congestion, particularly around the Pakuranga Town Centre. Nevertheless, to mitigate these effects, appropriate public communication and advanced warning of the planned works will be undertaken prior to the works being initiated. Also, opportunities to improve bus travel times will be explored in the development of the CTMPs along with measures to manage travel demand through the provisions of the SSTMPs. Public communication and signage will also be provided during construction informing motorists of the works and potential delays, which would lead to changes in travel behaviour. Based on the above, the potential adverse effects to general traffic and bus travel times are considered to be mitigated as far as is reasonably practicable.

[36] Construction Scenario 1.3 simulates the closure of Reeves Road as well as the ongoing construction of the RRF (i.e., not constructed yet).

Temporary effects to pedestrian and cyclists during construction are considered to be negligible overall. Pedestrian crossings and footpaths will be maintained at all times during construction. Should this be unachievable, temporary facilities and diversions will be provided to ensure pedestrian connectivity.

Overall, the temporary effects during construction on property access and parking will be mitigated appropriately and are considered to be negligible or very low. Where existing vehicle access arrangements and parking provisions cannot be maintained, appropriate mitigation measures have been proposed to provide levels of access and parking commensurate with the existing environment as far as is reasonably practicable.

Engagement with property owners or operators will be undertaken during construction to communicate the planned works and duration, the potential disruption and proposed mitigation measures as well as to develop additional measures or improve upon proposed measures if required. Lastly, pedestrian access to properties will be maintained at all times. This will be ensured through the CTMPs.

Safety measures will be in place during construction, ensured by the CTMPs. The safety and protection of the public, traffic and construction team is paramount, and all site operations will be focused on zero harm to all involved, associated with and traveling through the project areas.

In the existing environment, Auckland's eastern suburbs are experiencing a range of transport related problems and challenges. The completion of EB2 and EB3R will improve upon these shortcomings through the following:

- Significantly improved travel options for all modes of transport
- Increased public transport patronage and mode share through increased catchment and dedicated bus lanes
- Reduced carbon emissions
- Improved walking and cycling amenity and safety through dedicated infrastructure
- Reduced congestion, particularly around the Pakuranga Town Centre, through the new Reeves Road flyover

The main elements of the proposed design of EB2 and EB3R include dedicated bus lanes along Ti Rakau Drive, connecting to the EB1 bus lanes at Pakuranga Road and terminating at Gossamer Drive, as well as three new bus stations along the corridor. A new link between Pakuranga Road and SEART in the form of the Reeves Road Flyover (RRF). Dedicated cycleways on Pakuranga Road, between Ti Rakau Drive and the RRF, and along Ti Rakau Drive from Pakuranga Road to Gossamer Drive.

In the future, the Ti Rakau Drive and Pakuranga Road corridors will have more strategic Place functions, in addition to the Movement of people and goods. The proposed Eastern Busway bus stations will also attract more people within the area as the activities served by these bus stations will become local attractions. Modal priority of pedestrians, cyclists and buses will be improved, and as a result modal priority of general traffic and parking will decrease across the project areas.

Overall, the proposed design of EB2 and EB3R is expected to lead to acceptable operations for general traffic across the network, and importantly, bus movements are predicted to operate at LOS C and with spare capacity. The RRF is expected to relieve congestion around the Pakuranga Town Centre by removing traffic from Ti Rakau Drive and providing a direct and faster link between Pakuranga Road and SEART. Furthermore, significant improvements in travel times are expected overall, especially from Botany towards Pakuranga and SEART.

Benefits of the new stations will be the ability to support significantly higher public transport patronage through increased catchment and higher service frequencies through increased capacity. These benefits, in combination with improved customer accessibility, amenity and safety, will lead to an increase in mode share of public transport. A particular benefit of the Pakuranga Town Centre bus station will be the integration of all bus services in the EB2 and EB3R project areas, which will provide an improved transfer experience for passengers. Another benefit of the stations will be improved safety for buses.

EB2 and EB3R are predicted to result in a significant increase in public transport patronage in the future. As such, bus station platforms and loading areas have been designed to provide appropriate levels of service and capacity to support this uptake in public transport. Along with this, bus service headways, reliability and efficiency will also be improved overall. The combination of these public transport upgrades is expected to significantly increase public transport mode share, which in turn will reduce congestion and reduce greenhouse gas emissions by way of a more sustainable movement of people through the network. Overall, the proposed design is predicted to improve bus travel times across the network. The combination of improved travel times and higher service frequencies will lead to faster and more reliable public transport trips.

The Project will provide dedicated footpaths and cycleways to improve pedestrian and cyclist amenity and safety. Providing dedicated cycleways will create a physically separated and safe space that facilitates cycle movements through the network, which will provide users with a more attractive mode of travel and supports the uptake of cycling. Furthermore, the cycleways will facilitate improved accessibility to the bus stations, resulting in increased catchment as well as the potential for mode shift to occur, increasing uptake of public transport across the network.

Lastly, the proposed design of EB2 and EB3R will provide an overall safer transport system for all modes of transport through the project areas with the aim to reduce fatal and serious injury crashes. The proposed design will provide staged crossings at various locations in order to reduce pedestrian delay, improve safety and discourage jaywalking. Raised pedestrian platforms will also be provided to create a low-speed environment, and to aid pedestrians and cyclists by simplifying the crossing task. Furthermore, these facilities will increase visibility by creating a visual cue for drivers to reduce their speed as they approach, and encourage courtesy between drivers and pedestrians.

In conclusion, with the proposed mitigation measures in place, the potential adverse effects during construction and upon completion of EB2 and EB3R are considered to be negligible to low overall. Furthermore, the proposed design is predicted to result in significant improvements and a range of benefits overall.

Appendix A

Reeves Road Closure Detour Assessment

Appendix B

EB2 General Arrangement Plans

Appendix C

EB3R General Arrangement Plans

Appendix D

Construction Scenario 1.1 – Phasing Diagrams

Appendix E

Construction Scenario 1.1 – Lane Performance Summaries

Appendix F

Construction Scenario 2 – Phasing Diagrams

Appendix G

Construction Scenario 2 – Lane Performance Summaries

Appendix H

EB2/EB3R Final Scenario – Phasing Diagrams

Appendix I

EB2/EB3R Final Scenario – Lane Performance Summaries

Appendix J

Base 2018 Model Update Report

Appendix K

EB2 – Indicative Construction Staging Diagrams

Appendix L

EB3R – Indicative Construction Staging Diagrams

Appendix M

Construction Scenario 1.2 – Phasing Diagrams

Appendix N

Construction Scenario 1.2 – Lane Performance Summaries

Appendix O

Construction Scenario 1.3 – Phasing Diagrams

Appendix P

Construction Scenario 1.3 – Lane Performance Summaries

Appendix Q

Construction Scenario 1.4 – Phasing Diagrams

Appendix R

Construction Scenario 1.4 – Lane Performance Summaries

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Appendix B

2018 Base Model Update Report

Beca

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Report

Auckland Model Refresh: Update and Validation Report

Prepared for Auckland Transport

Prepared by Beca Limited

In association with

Jacobs New Zealand

David Young Consulting

TDF Advisory Services PTY Ltd

9 July 2018

Revision History

Revision Nº	Prepared By	Description	Date
1.0	**Catherine Rochford/Nyan Lin/Soumya Subba**	Draft for Client Comment	25/5/18
2.0	Catherine Rochford/Nyan Lin/Soumya Subba	Draft Final addressing Client comments	29/06/2018
3.0	Nyan Lin	Include Jacobs' response to comments	9/07/2018

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Catherine Rochford/Nyan Lin/Soumya Subba**		29/06/2018
Reviewed by	**Andrew Murray**		29/06/2018
Approved by	**Andrew Murray**		29/06/2018
on behalf of	Beca Limited		

Executive Summary

This is the third of six reports documenting the refresh of the regional strategic demand and PT models operated by the Auckland Forecasting Centre (AFC). The suite of reports includes:

1. Auckland Transport Models Refresh 2017 – Model Specification
2. Auckland Transport Models Refresh 2017 – Phase 2 Specification
3. **Model Update and Validation Report (this report)**
4. Model Testing Report
5. User manuals
6. Model Guidance Note

Model Refresh

The two strategic models being updated are:

- The **Macro Strategic** model (**MSM**, previously called the Auckland Regional Transport model, ART3),
- The **Macro PT** model (**MPT**, previously called the Auckland Passenger Transport model, APT3)

A two-stage process has been adopted by the AFC for refreshing these two models:

Phase 1: Update the existing models to 2016 conditions with critical enhancements to MSM to support likely policy questions to be assessed from mid 2017; and

Phase 2 Longer-term upgrades such as the improved integration of the Macro Strategic model and Macro PT model and further enhanced functionality.

This report documents the research, processes and outcomes of the update and enhancement of the two models to a common 2016 base year. Testing of the models for future year forecasts are documented in the model testing report (report 4)

Phase 1 Purpose and Scope

The detailed specification for the Phase 1 tasks was developed through design workshops held between the AFC, their technical adviser and the consultant team in December 2016, and specified in the following report:

Auckland Transport Models Refresh 2017 – Model Specification, Beca Ltd, 26 January 2017

The key objectives for the Phase 1 Refresh identified by the AFC were:

- Update the models to reflect 2016 conditions
- Include PT crowding in the Macro Strategic model
- Enhance the Willingness to Pay (WTP) segmentation in the model to better respond to pricing schemes

The approach adopted to this refresh included some key principles, including:

- Provide technically robust updates/enhancements that retain the underlying integrity of the originally calibrated demand and distribution mode split (DMS) models
- Reflect the purpose of these models as designed for strategic planning purposes

- Improve the consistency and efficiency of coding and inputs to both models, where feasible
- Manage risks to have Phase 1 models available mid 2017

Model Enhancements

Enhanced functionality was successfully developed and implemented, including:

- Implementation of PT crowding in the Macro Strategic model, using the same function as adopted in the Macro PT model. This was implemented in a way that did not compromise model convergence and only marginally increased run times. It provided an expected response, with a slight reduction in overall PT demand and some switch from bus to rail on competing routes. The process was included in the calibrated 2016 model;
- Implementation of the WTP segmentation process, that includes the following key elements:
  - Segmentation of households into three groups (Low, Medium and High WTP) based on household income data;
  - Segmentation of the model trip demands into the three WTP segments using the household segment proportions;
  - Specified WTP parameters (including Value of Time) for each segment of each purpose. These values convert monetary costs into equivalent travel times. A relationship between income and VoT was identified and adopted however, as per previous research, the relationship is not strong;
  - An Incremental Mode Choice model (IMC), that modifies the mode share between the three segments, but retains the same overall mode share; and
  - A multi-class traffic assignment process that assigns 12 different vehicle segments, each with a different WTP value
- The process both improves the model response to pricing and allows a deeper analyses of the effects of pricing on different demographic groups. It was developed for both the base (2016) year and for forecasting. In the 2016 model, the only road pricing scheme is on the Northern Gateway Toll road, so results from the WTP process only materially differed from the normal model in this area. It provided a significantly improved match to observed traffic flows on the toll road;
- Representation of park and ride in the macro strategic model was enhanced to both include real car travel times and costs in the access function, and to include the park and ride car trips onto the road network;
- New truck demand matrices were used based on extensive commercial vehicle GPS data, which is significantly improved data set over that available in the original 2006 model. These were sourced from the AFC's DTA model development process;
- Although the structure of the two models was retained, significantly enhanced consistency of inputs and coding was achieved, to improve the efficiency and consistency of model operation and prediction. This included:
  - Common networks for all modes (previously only for buses)
  - Common mode codes, transit vehicle codes and travel time function numbers
  - Common park-and-ride stations and catchments
  - Common representation of bus lanes
  - Common Rail and ferry travel times
  - Consistent transfer penalties and unplanned/planned transfers
  - Common no-boarding-and-alighting nodes for PT services
- Refinement of the Macro Strategic model zones in greenfield areas to support more granular planning in those growth areas; and

- Adoption of a more efficient PT assignment algorithm

Model Update

The rebasing to 2016 models included the following:

- Updated 2016 land use inputs that reflect the recent higher-than-forecast growth;
- Updated 2016 networks and services;
- Updated car ownership model;
- Updated external, airport and trip-end models;
- Revised representation of road capacity to better reflect congestion;
- A review of the time of day model;
- Updated observed PT trip demands from HOP data. This is used to validate the synthetic predictions in the Macro Strategic Model and as direct input to the 2016 Macro PT model; and
- Updated interfaces between the two models, as well as with the ASP land use model.

Research Papers

Phase 1 also included a series of mini research papers that explored specific issues or opportunities. These papers generally relate to forecasting or potential Phase 2 enhancements, rather than base year model functionality. These topics included:

- Weekend models
- Trip frequency impacts
- Network resilience
- Active modes
- Behaviour change
- ITS
- Reliability of travel times
- Representation of couriers, taxis etc
- New disruptive technology
- Dealing with uncertainty
- Measure economic carry capacity of a corridor

Phase 2 Purpose and Scope

The following key issues were key issues identified with the existing and post-Phase 1 models:

1) Inconsistent structures and gaps in model inputs (e.g. periods modelled), which mean the two models are often run independently and with differing results
2) Lack of clarity about which model (Strategic or PT) should be used when and for what purpose
3) Different outputs from the two models (no “one source of truth”) with respect to:
   a) Total PT mode share
   b) Bus / rail split
   c) PT assigned volumes
4) Use of both the Strategic and the PT models can be time consuming, with logistical barriers to their consistent operation
5) A growing need to consider emerging and disruptive technologies or new modes.

Based on these identified issues, the following Objectives for Phase 2 were developed:

- Clarify the role of the two models and their intended use
- Remove or reduce remaining inconsistencies between the models so that they can be operated more seamlessly, within their designated purpose and with greater certainty on which forecasts are used
- Consider options to address new or disruptive modes or technology.

Detailed scoping workshops identified a range of options and sub-options to address these objectives. Some of those required additional investigation and testing to confirm the feasibility, benefits and appropriateness of some options, and to make decisions on which options to proceed with. As such, the Phase 2 study was recommended in two stages:

- An Investigation Stage (late 2017), that involves a series of testing and analysis to confirm the recommended option and specification
- An Implementation Stage, that implements the recommended scope through to mid 2018

The overall scope for the Phase 2 update was developed through technical workshops with the AFC, their technical adviser and the consultant team in September 2017. A key part of the Phase 2 work was targeted at obtaining greater consistency between the Macro Strategic Model and the Macro PT Model. That overall Scope is documented in the following **Phase 2 Specification** report:

Auckland Models refresh 2017 – Phase 2 Specification, Beca Ltd, October 2017

Model Enhancements

Work in Phase 2 was primarily concentrated around the Macro PT model, but did include some minor changes to the MSM. The following changes were adopted:

- Change of the growth factor method in MPT
- Creation of inter and PM peak models in MPT
- Improved efficiency of crowding implementation in MPT
- Review of the pivot model in MPT
- Review of the PT Sub-mode split and assignment in MPT
- Review of the auto-assignment methods in MSM
- Application of road perception factors in MSM

Overall Model Validation

For the Macro PT model, the AM peak model was updated and validated during Phase 1, with development of the inter and PM peak model being undertaken in Phase 2. For the Macro Strategic Model, the AM, interpeak and PM peak models were all updated and validated.

Overall, a very good validation was achieved for the macro strategic model. This is considered significantly enhanced over the 2016 forecast models, and in a number of aspects even improved over the 2006 model validation (especially in terms of car flows and travel times). The detailed validation of PT demands is considered very good for this type and age of model. Some data (such as comprehensive PT ticketing data) were not available in 2006 so a direct comparison to the historic model fit there is not possible for all data.

Residual issues include some under-estimation of ferry trips and under-estimation of some road travel times where extensive motorway queueing blocks back to the arterial network.

In the Macro PT model, the overall 2016 base year PT demands come directly from the observed data, but with sub-mode split between bus, rail and ferry (and walk versus park and ride access to each) calibrated via updated modal constants. Again, some elements of the high attraction to ferry were not able to be fully reflected in the models within the existing model structure or using parameters within accepted bounds.

Overall, it is considered that both models have successfully been updated and enhanced, with a level of validation suitable to this type of model. As such, it is considered that the 2016 base year models have met the key project objectives.

Contents

Appendices

1 Introduction

1.1 Background and Purpose

This report documents the updating and validation of the Base year (2016) strategic demand and public transport (PT) models operated by the Auckland Forecasting Centre (AFC). The current regional-scale models operated by AFC comprise three different, but integrated models:

- The **land use location** model (Auckland Strategic Planning model, ASP3)
- The **Macro Strategic** model (previously called the Auckland Regional Transport model, ART3)
- The **Macro PT** model (previously called the Auckland Passenger Transport model, APT3)

The Macro Strategic model is typically used to generate overall patterns of demand, in response to changes in networks, services, policies, land use or economic inputs. In this type of model theoretical representations of travel behaviour are calibrated and validated against past and current data[1].

The Macro PT model has a more detailed representation of the public transport system (especially a refined zone system), and makes use of an observed base year trip matrix. As such, its purpose is focussed on more detailed public transport analysis, especially in response to specific PT interventions.

In addition to the above models, AFC operate a series of more detailed ‘operational’ and ‘design-level’ models that represent elements of the transport system in greater detail. Those models generally use outputs from the regional models as their main demand inputs. AFC have separate work streams to rationalise and standardise those models, including through the development of the region-wide Dynamic Traffic Assignment (DTA) model. Apart from their interfaces, this work is focussed on the regional models rather than the operational models, acknowledging that further integration with the DTA model will be part of the future modelling system.

The original land use location and Macro Strategic models were developed and calibrated to 2006 data, whilst the Macro PT model was first developed circa 2001. Partial updates to all models were undertaken to 2013 census data. The three models have had minor refinements added over time, including enhancements to the interfaces between the models.

This update and validation report outlines the comprehensive rebasing to 2016 data of the macro strategic and macro PT models. In addition to the rebasing, AFC and their stakeholders have outlined various policy questions likely to be required of the models, some of which are not currently able to be readily answered using these tools. These questions have resulted in a number of enhancements to the models.

1.2 Scope of Model Update and Key Objectives

This project constitutes a ‘refresh’ of the Macro Strategic and Macro PT models, rather than a comprehensive rebuild of the models. This means that the model structures have been generally retained, with updates mostly to the input data and some input parameters. For the Macro Strategic model, this means that the structure and parameters of the calibrated demand model have not been altered. The 2006 model development had detailed census and household travel survey data to calibrate those underlying demand models. Similar data is not available for this update, which therefore requires retaining the existing structure.

[1] Only the HCV (truck) element in the Macro Strategic model and the PT matrix in the Macro PT models are fully based on observed data

As required by AFC, the recommended model updates have been undertaken in two phases:

- **Phase 1**:Required to be available for use in mid-2017 and comprising the rebasing of the regional models to 2016 and with key enhancements needed to support the likely policy questions (specifically PT crowding and WTP segmentation in the Macro Strategic model)
- **Phase 2**: Longer-term upgrades such as the improved integration of the Macro Strategic model and Macro PT model and further enhancements

The detailed scope and specifications for Phases 1 and 2 of the refresh were documented in the following report:

Auckland Transport Models Refresh 2017 – Model Specification, Beca Ltd, 26 January 2017

Auckland Transport Models Refresh 2017 – Phase 2 Model Specification, Beca Ltd, 13 October 2017

The starting points for this 'refresh' were the following models:

- The 2006 base and 2016 forecast Macro Strategic models
- The 2013 base Macro PT model (AM peak only)

The most critical objectives of the Phase 1 refresh identified by AFC were:

- Update the models to reflect 2016 data;
- Include PT crowding in the Macro Strategic model; and
- Enhance the Willingness to Pay (WTP) segmentation in the Macro Strategic model to better respond to pricing schemes.

For Phase 2 the key objectives were:

- Clarify the role of the two models and their intended use;
- Remove or reduce remaining inconsistencies between the models so that they can be operated more seamlessly, within their designated purpose and with greater certainty on which forecasts are used; and
- Functionality to consider new or disruptive modes or technology.

The approach adopted to this refresh included some key principles, including:

- Provide technically robust updates/enhancements that retain the underlying integrity of the originally calibrated demand and distribution mode split (DMS) models
- Reflect the purpose of these models as designed for strategic planning purposes
- Improve the consistency and efficiency of coding and inputs to both models, where feasible
- Manage risks to have Phase 1 models available mid 2017

1.3 Research Papers

The Phase 1 project included a series of mini research papers that explored specific issues or opportunities. These papers generally related to forecasting or potential Phase 2 enhancements, rather than base year model functionality. Topics explored included

- Weekend models
- Trip frequency impacts
- Network resilience
- Active modes
- Behaviour change

- ITS
- Reliability of travel times
- Representation of couriers, taxis etc.
- New disruptive technologies
- Dealing with uncertainty
- Measure economic carrying capacity of a corridor

The research papers can be found in **Appendix A.** Although none of these research papers resulted in additional functionality being implemented within the Phase 1 models, their findings help to interpret results and provide pointers for future enhancements.

1.4 Report Structure

The remainder of this report is structured as follows:

Chapter 2	Summarises the existing models
Chapter 3	Outlines the processes for the Refresh
Chapter 4	Describes the enhancements to the MSM undertaken in Phase 1
Chapter 5	Details the update to the MSM in Phase 1
Chapter 6	Describes the Phase 1 updates to the MPT
Chapter 7	Describes the further Updates to MSM in Phase 2
Chapter 8	Describes the changes and updates to MPT in Phase 2
Chapter 9	Describes tasks related to the consistency of the models and supplementary tasks.
Chapter 10	Describes the validation of the two models in Phase 2
Chapter 11	Provides brief conclusions to this report

Where appropriate, reference is made to specific **Tasks** defined in the Specification Reports.

2 Existing Models

2.1 Model Structure and Interface

The new Macro Strategic model (MSM) is an update of the previous Auckland Regional Transport (ART3) model, both of which use the EMME software platform. ART3 is a multimodal model that estimates travel demands based on the spatial land use patterns and quantities passed over from the land use location model. Outputs include vehicle and passenger demands and network flows, as well as accessibility levels by zone that are passed back to the land use model. Forecasting occurs from the base year to typically 2046. The land use model increments land use changes on an annual basis (that is, is run sequentially in every forecast year) with the transport model run in every fifth year, and transport accessibility updates are provided to the land use model every fifth year. This five year feedback provides an appropriate balance of practical model run times and robustness of data.

The Macro PT model (MPT) is an update of the previous Auckland Passenger Transport (APT) model which was first built in about 2003, based on 2001 data, and partially updated in 2006 with a further update to a 2013 base year. The updating to 2013 included extending the modelled area, and enhancing zonal and network consistency and other linkages with the Macro Strategic model.

The Auckland Strategic Planning (ASP3) model is a land use location model, the update of which is not included in this document.

The structure of this overall modelling system and its key components is indicated in the following **Figure 2-1-** to **Figure 2-5**:

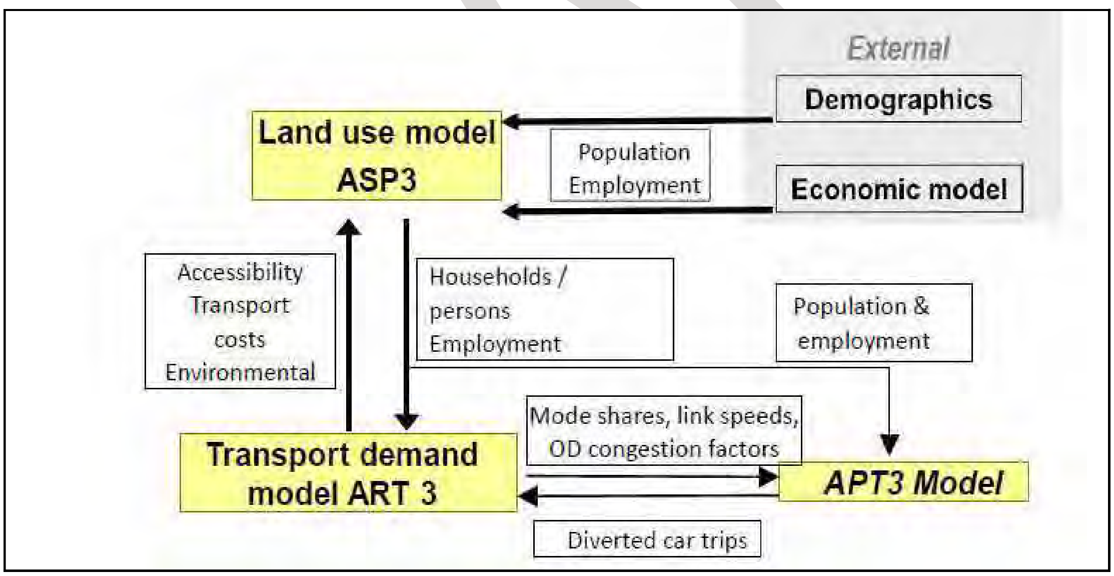

Figure 2-1 – Relationship of Main Regional Models

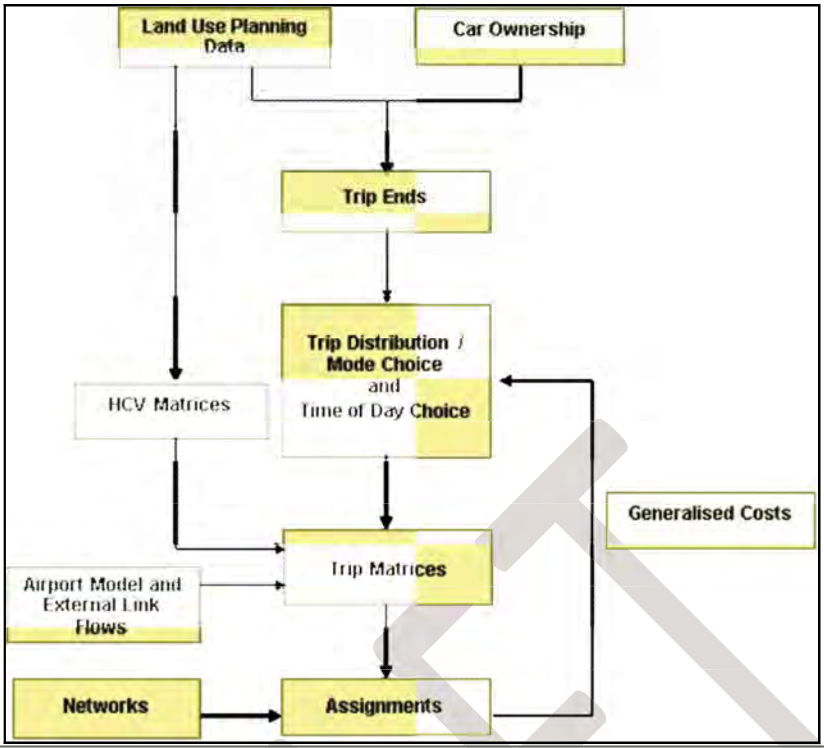

Figure 2-2 - Structure of the ART3 Model in Base Year

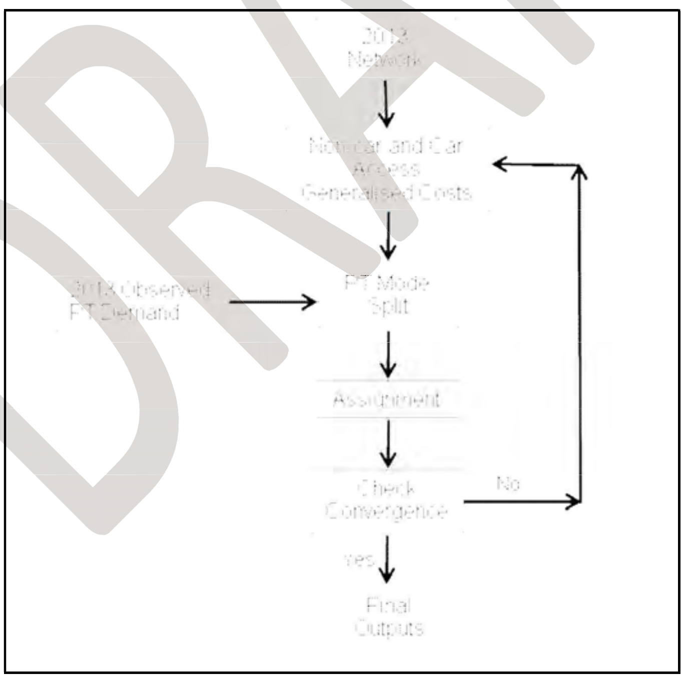

Figure 2-3 - Structure of the APT3 Model in Base Year

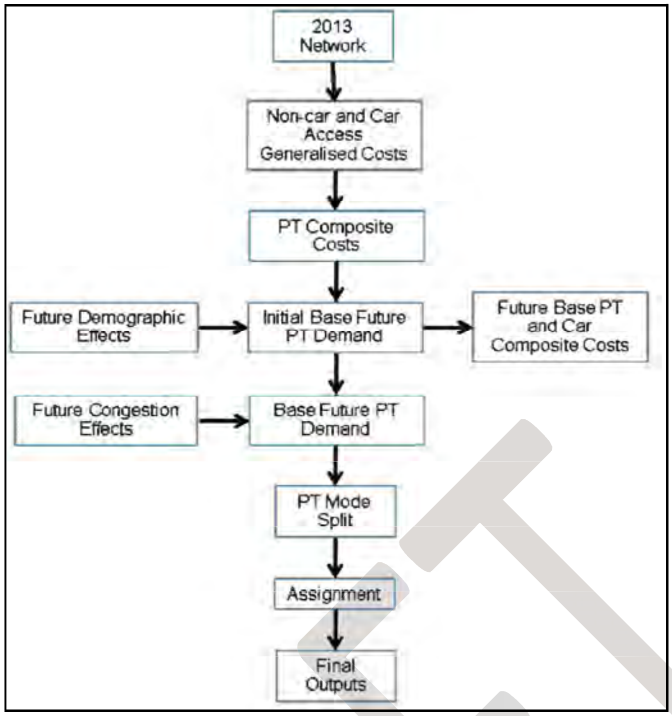

Figure 2-4 - Structure of the APT3 Model in Future Years –Reference/Base Mode

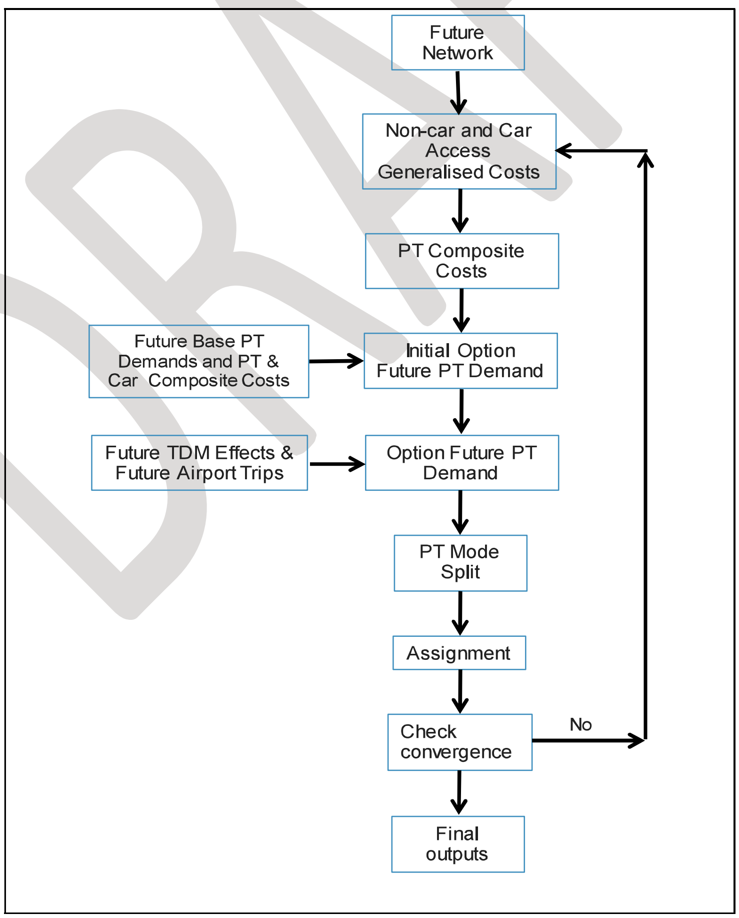

Figure 2-5 - Structure of the APT3 Model in Future Years –Option Mode

The model versions used at the start of this refresh project were ASP3.2 and ART3.2.

The models are run sequentially with information passed in both directions between them. ASP3 is run in each year beginning with year 2007, and ART3 is run in every fifth year beginning year 2011. Transport costs are passed from ART3 to ASP3 following each ART3 model run – and beginning with 2006 costs for 2007 ASP3 – and land use planning data (persons, households, employment, education rolls) are passed from ASP3 to ART3 prior to each ART3 model run.

Part of this sequence –forecasting from 2011 to 2016 - is shown diagrammatically in **Figure 2-6**.

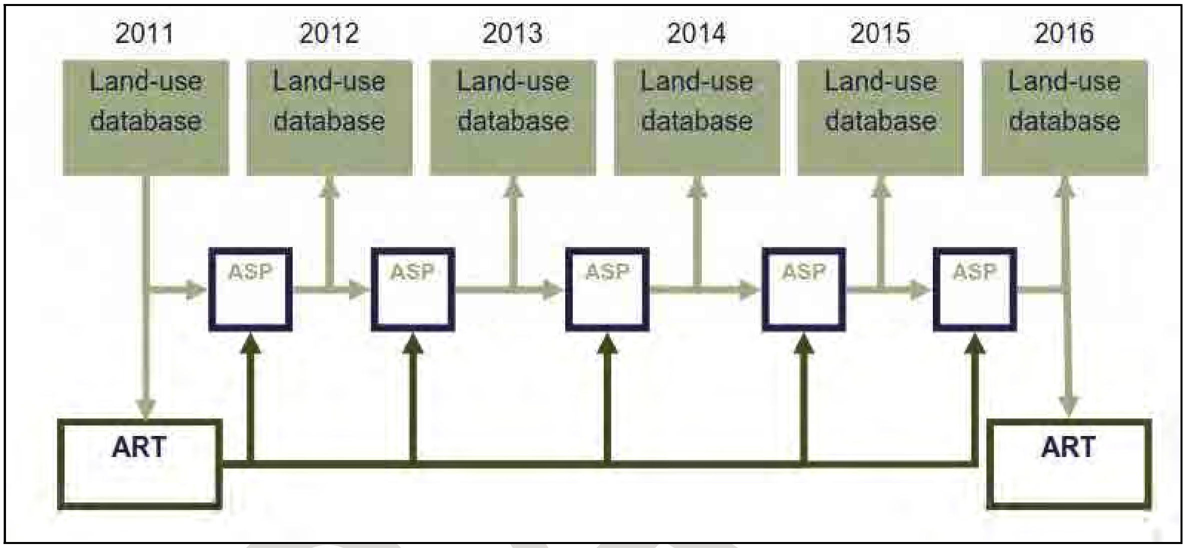

Figure 2-6 - ASP3-ART3 Sequence

In terms of the platforms, ASP3 operates in the DELTA software while the ART3 and APT3 models run in Emme.

2.2 2006 Auckland Regional Transport (ART3) model

In 2006, the Auckland Regional Council (ARC) commissioned Sinclair Knight Merz Ltd, in conjunction with Beca Infrastructure Ltd and David Simmonds Consultancy, to develop new regional transport and land use models for the Auckland Regional Council. This was known as the Auckland Transport Models (ATM2) project.

These models were:

- The Auckland Strategic Planning Model (ASP), a strategic integrated land-use model, for medium and long term planning, scenario development and evaluation, and for providing the necessary land use inputs for transport modelling, and
- The Auckland Regional Transport Model (ART), a conventional 4-stage and relatively detailed transport model for medium term project and policy planning and evaluation.

The models produced by this project were known as ASP3 and ART3 and replaced the previous versions of ASP and ART.

A range of reports are available for the ATM2 project, with only a brief summary provided here:

- *The Project Quality Plan (Hold Point 1 Report), October 2005;*
- *The Initial Model Specification and Data Requirements Report (Hold Point 2 Report), February*

2006 (first draft December 2005);
- *Hold Point 3A Report, April 2006;*
- *The ART3 Model Specification Report, November 2006; and the accompanying ART3 Data Processing Specification Report, November 2006;*
- *The ATM2 Survey Report, September 2006;*
- *The ART3 Data Processing Report, October 2007;*
- *The ART3 Preliminary Studies Report.*

The ART3 model estimation is documented in a series of reports:

- *The ART3 Zoning and Network Report*
- *The ART3 Car Ownership Report*
- *The ART3 Trip Ends Report*
- *The ART3Distribution and Mode Choice Report*
- *The ART3 Time of Day and Private Vehicle Factors Report*
- *The ART3 Commercial Vehicle Model Report*
- *The ART3 Model Testing and Validation Report*
- *The Model Forecasting Report*
- *The ART3 User Manual*

2.2.1 Overview of ART3

This section outlines the trip purposes, modes, time periods, and overall structure which is largely unchanged in the 2016 rebased model. Reference should be made to the reports on the sub-models for more detail.

Trip Purposes:

- Home-based work (HBW)
- Home-based education (HBE)
- Home-based shopping (HBSh)
- Home-based other (HBO)
- Employers business (EB)
- Non-home-based other (NHBO)

Modes:

- Light vehicles (called cars); persons in cars, that is, car driver and car passenger combined, in the demand models, converted into vehicles prior to assignment;
- Passenger transport; all PT modes combined in the demand models and assignment is used to split PT demands into bus and rail/ferry;
- Active modes; walk and cycle combined; trip productions only;
- Medium and heavy vehicles combined (called HCVs);
- Car and PT modes are referred to as mechanised modes in the demand models.

Modelled Periods:

- Trip ends and distribution-mode split are 24-hour models, and
- 24-hour demands are split into 5 periods by the time-of-day choice model:
  - AM peak: 7 am to 9am
  - Interpeak: 9am to 3pm
  - School peak: 3pm to 4pm
  - PM peak: 4pm to 6pm
  - Off peak: 6pm to 7am
- Assignment occurs in three of these periods: AM peak, Interpeak, PM peak.

Error! Reference source not found. shows an overview flow chart of the ART3 structure, including the demand-supply iterations, with generalised costs being fed back into the DMS-ToD sub-models. This can be summarised into the following steps and points:

Land Use Planning Data

- The land use planning data (persons in each zone by person and household type) from ASP3 is imported into Emme, and the person and employment data is adjusted to account for differences between the 2006 ASP data and the 2006 Census.
- Actual school rolls are used in 2006 and the differences between ASP 2006 and forecasts are added to these in forecasting.

Car Ownership

- Person numbers are input into the car ownership model to determine car ownership levels by zone based on household type.

Trip Ends

- Employment, households and rolls, and the person data (from car ownership) are used in the trip end models to determine the home-based (HB) zonal person trips (excluding HCVs) by purpose.
- Trip productions are by all-modes and active modes from which mechanised-mode productions are deduced, while trip attractions are for mechanised modes only. Any adjustments due to future changes in proportions working from home associated with non-pricing Travel Demand Management (TDM) are made.
- HBE trip ends are produced for all persons and with persons aged 13 and under removed; the latter is used in the HBE DMS-ToD model.
- NHB attractions (EB and NHBO) are estimated from HB trips ends and are by mode (car, PT), so occurs after the HB DMS-ToD models.
- The trip ends for external zones are adjusted to be only those for travel between the external area and the core study area. For 2006 the observed surveyed trip ends are used. In forecasting they are reduced by the same proportions as in 2006 and then additional growth factors applied to account for growth higher than that due to land use growth.

Distribution-mode split and Time-of-Day Choice

- The mechanised-mode home-based trip productions and attractions are input into the distribution-mode split (DMS) and time-of-day (ToD) choice models.
- DMS-ToD is undertaken separately for each HB purpose resulting in origin to destination (OD) trips by purpose, mode and time of day. Any adjustments due to the effects of future non-pricing TDM are then made. Person trips by car are converted into vehicles by applying vehicle occupancy rates.
- The NHB Distribution-ToD models are run separately for each purpose (EB and NHBO) and mode (car and PT) to give NHB OD trips by time of day.

HCV Matrices

- 24-hour HCV matrices were estimated from trip generation assumptions, a gravity-distribution calibrated to the average trip-length from a small sample of GPS surveys and matrix estimation to match traffic counts
- The 24-hour 2006 HCV matrix is imported into Emme and, in 2006, three time period matrices created using global factors.
- In forecasting, the ratio of future to 2006 synthetic trip ends are applied to the 2006 trip ends, and the time period HCV matrices are created.

Trip Matrices

- Car and PT matrices for the five periods are calculated, and under-reporting factors for LCVs in EB and cars for other purposes are applied to both persons in cars and car vehicles in all five periods,
- Vehicle trips for the three assigned periods are calculated from: car vehicles, HCVs, vehicle trips external to the region, vehicle trips to/from the airport associated with flights (the airport model has now been updated to a full multimodal model for flight-related trips).

Assignments and Generalised Costs

- Vehicle assignments are carried out for the three periods, skimming the costs, etc required. Vehicle assignments are done for only two segments, namely HCVs and light vehicles.
- PT assignments are carried out for four periods (including OP, in which the IP network is used with headways factored down by 3), and four purposes (HBW, HBE, EB and Other).
- Sub-mode split (between bus, rail and ferry) is done in the assignment, with Park and Ride assessed vis defined access links ("p-connectors")
- Generalised costs are calculated for each mode and period and purpose; for generalised costs the purposes reflect different values of time, operating costs, and fares; there are 3 for car (HBW, EB and Other) and 4 for PT (see above).
- Parking costs are included in the car costs for HBW (long-term) and Other (short term), and any tolls or pricing is also included in the car costs.
- The car costs are damped with those from the previous iteration, 70% previous and 30% new.
- Demand-supply convergence is tested as the maximum root mean square error (rmse) of the car and PT matrices by period between the current matrices and those from the previous iteration; convergence is achieved when the maximum rmse is less than 0.1 for two successive iterations.
- After converging, final assignments are carried out, prior to which school bus trips are removed from HBE PT trips.

A full description of the 2006 model validation can be found in "Auckland Transport Models Project (ATM2), ART3 Model Testing and Validation Report, August 2008". Key improvements to the 2016 validation as part of the model refresh are discussed in **Section 10**.

2.3 2013 Auckland Passenger Transport (APT3) model

The Auckland Passenger Transport (APT3) model was previously updated to a 2013 base and the level of validation documented in "APT3 Update 2013, Validation report, Auckland Transport Strategy and Planning, V2 August 2015". This change from a 2001 base year to a 2013 base year also included extending the modelled area and enhancing zonal and network consistency and other linkages with the Auckland Regional Transport (ART3) model. The updated model is known as APT3, which fits with the version of ART (ART3) to which it is linked.

3 Process for 2016 Update

3.1 Introduction

This section provides a brief overview of the process that was followed for the Phase 1 and Phase 2 update tasks

3.2 General Process

The model refresh was updated with close liaison between the AFC, their designated Technical Director and the consultant team. This involved a number of scoping and design-decision workshops, agreement of Specification Reports, fortnightly technical and progress meetings, technical documentation, provision of draft models for AFC 'shakedown testing' and liaison with the independent peer reviewer.

The focus of the Phase 1 tasks was primarily the update and enhancements to the MSM to provide a working model for AFC use. Only limited updates to the AM peak MPT model were undertaken at that time.

The focus of the Phase 2 work was primarily on update and development of the MPT model, with very limited change to the MSM. This work also further enhanced the consistency and efficient operation of the models.

3.3 Specific Tasks for each Phase

The specific tasks undertaken in each phase are summarised below:

Phase 1

- Development of project objectives
- Scoping Workshops (December 2016)
- Preparation and agreement of detailed Phase 1 Specification Report (January 2017)
- Rebasing and validation of the MSM to 2016 data, including:
  - Inclusion of enhanced WTP segmentation in MSM
  - Enhanced HCV model
  - Inclusion of PT crowding
  - Refinement of the zone system in greenfield growth areas
  - Enhanced representation of auto-access to PT stations
  - Updated representation of networks
  - Updated car-ownership, external, airport and trip-end models
- Rebasing and validation of the MPT AM peak model to 2016 data, including:
  - Development of 2016 matrices from HOP data
- Updated networks
- Rationalisation of network, mode and vehicle definitions between the two models

- Future-year model testing

Phase 2

- Scoping Workshops (March 2017)
- General Phase 2 Specification Report (October 2017)
- Technical Specification for MPT model update
- Minor changes and revalidation to 2016 MSM, including:
  - Change to path-based assignment algorithm
  - Inclusion of road perception factors
  - Minor change to validation factors and their caps
  - Change to interpeak auto-access to PT catchment
  - Change from link to segment-based PT time functions
  - Minor change to PT calibration parameters
- Change to the forecasting process in MPT
- Updated 2016 PT matrices from HOP data with revised park and ride catchment assumptions
- Development and calibration of interpeak and PM peak MPT models
- Future year testing

The need to enhance consistency between the two models meant some tasks undertaken in Phase 1 were revised in Phase 2. These were generally only minor changes in MSM.

4 Phase 1 Model Enhancements

This chapter describes the new or refined functionality added to the models in Phase 1 of the Refresh. These predominantly related to the Macro Strategic Model (MSM), however consistency with the Macro PT model (MPTM) was also enhanced.

The task numbers in brackets refer to tasks explained in the Phase 1 specification report previously referred to. Where further refinements were added in Phase 2, a reference is made to the relevant section in red text. Although both the MSM and MPT models were validated in Phase 1, this was updated in Phase 2. Only the final Phase 2 validation results are included in this report to avoid confusion.

4.1 Assignment Algorithms (Task 2.3.1[2])

Inro has introduced new assignment algorithms in recent years. The purpose of this task is to make use of the latest algorithm to improve efficiency and convergence. Three new or alternative EMME assignment methods were tested and assessed using the macro strategic model:

1. **Path based versus SOLA assignment algorithms**: Path based algorithms have been implemented (and SOLA has not been implemented) in the macro strategic model.
    a. The implementation of path based assignments provides the same functionality as in the historic macro strategic model but with faster assignment times and no adverse impacts.
    b. The implementation of SOLA would need to be scripted (via python) to enable all necessary skims to be saved as part of the assignment setup and would require additional analysis to get data on commonly used outputs such as select links and traversals. This additional level of scripting and processing would likely negate any benefits in tightly converged assignment times and functionality. It was therefore not implemented in Phase 1, but may be considered for Phase 2;
2. **Extended Transit Assignment**: Extended transit assignment has been implemented in the macro strategic model. This module has had no adverse impacts in implementation and improves both assignment run time and outputs analysis.
3. **Journey Levels**: Journey levels have not been implemented in Phase 1 of the macro strategic model refresh. Whilst journey level improves the flexibility to isolate boarding and transfer penalties, the implementation testing of journey levels without additional calibration of boarding and transfer penalties resulted in reasonable differences in the PT assignment. Full implementation would likely require recoding networks and recalibration. It is very new functionality so would likely require additional changes to address unforeseen issues. As such, it was agreed as being too high-risk for implementation in Phase 1. It should however be considered in Phase 2 of the macro strategic model, as it allows greater control and reporting of transfers.

[The path based assignment method was implemented in the demand and final assignments in Phase 2. This is further discussed in **Section 7.3**]

[2] Refer to the Phase 1 specification report

4.2 MSM Willingness to Pay (WTP) Segmentation (Task 3.1)

Segmented willilngness to pay is important when new pricing mechanisms are tested as we need to understand who changes mode and who changes routes. Therefore the macro strategic model demands were segmented by purpose, each of which has a different WTP response to monetary costs such as tolls. However, it's response to "smart pricing" strategies such as road tolling, cordon pricing or additional parking charges is limited by:

- The use of average values of time for each trip purpose, which means that there is no variability in response to pricing within a trip purpose
- The lack of WTP segmentation restricts the ability to analyse the effects of pricing on different
- market segments (including demographic and economic analyses)
- The private vehicle assignment uses a single vehicle class, hence with all purposes and segments using the same, average WTP response to road pricing. This provides an unrealistic assignment of vehicles to some pricing schemes.

Introducing WTP segmentation means that differential response to "smart" or other pricing for each WTP segment is now available in the model.

The specification of WTP segmentation was originally set out by AFC in a model update scoping note and then by the Project consultant team in ATM Refresh Project's model specification report:

- ART3 2016 Update, Initial Scoping Note, 15 November 2016, and
- Auckland Transport Models Refresh 2017 – Model Specification, 26 January 2017.

In this section the final specification and the linkage between WTP segmentation and household income are described.

Note: For simplicity, WTP is used in this specification interchangeably with VoT. Here VoT refers to value of time which is used to convert monetary costs to equivalent travel time in the model. Representation of pricing schemes and discussion of other WTP elements are described more in the Model Testing Report.

4.2.1 Final Specification

The WTP segmentation is an optional add-on to the model and follows a complete standard model run. The approach is generally as follows:

- Run the MSM as normal using the average VoT
- Segment the resulting demands into three WTP segments, (Low, Medium, High), based on household income data. This process was applied after the full model run, and then re-run the final vehicle assignment with 12 classes.
- Apply incremental mode-split models to reflect the distribution of WTP by OD
- Adjust the car/PT mode shares by OD across the three segments so that the overall mode shares from the main demand models by OD are retained
- Segment the vehicle assignment to reflect the distribution of WTP responses to travel costs and/or pricing

The OD demands resulting from a standard run of the MSM are car (persons) and PT for each main purpose (HBW HBE, HBSh, HBO, EB, NHBO) by 5 time periods (AM, IP, SP, PM, OP), and M/HCV trips, flight-related airport trips (car vehicles, PT), external trips (vehicles), and the car component of park-and-ride trips (vehicles) for the three assigned periods (AM, IP, PM).

The above demands are each split into three levels (Low, Medium, High) for the main MSM purposes using the zonal proportions of households as provided by Statistics NZ:

- for home-based purposes: using the segmented households and the from-home and to-home proportions,
- for non-home-based purposes (EB, NHBO): the segmented home-based trip ends, and
- for M/HCV, airport, external, and park-and-ride trips: splitting into three equal parts.

Incremental Mode Choice (IMC) models are run for each of the six main MSM purposes in each time period and at each segment level estimating new car persons and PT mode shares and demands in each case.

The IMC is defined as:

$$p_{car}^{new} = \frac{p_{car}^{0}\exp(\text{Ø}Price_{car}\Delta VT)}{p_{car}^{0}\exp(\text{Ø}Price_{car}\Delta VT) + p_{PT}^{0}\exp(\text{Ø}Price_{PT}\Delta VT)}$$

Where:

- the super index 0 indicates the mode share from the main MSM demand models
- Pricecar and PricePT are monetary costs: for car - vehicle operating costs, parking costs, tolls, and for PT - fares
- Ø are the scaling parameters used in the DMS models to multiply generalised costs
- $\Delta VT = \frac{1}{VTTS_{income}} - \frac{1}{VTTS_{average}}$
- The subscript Income indicates the VTTS for a particular Income Group (and purpose) and Average is the VTTS value used for that purpose in DMS.

Note that the implementation of the IMC allows for the non-toll components of the car and PT Prices to be varied from zero to their full value.

Following the estimation of new mode shares and demands in the IMC models, these demands are adjusted so that, for each time period, the sum of trips by mode and purpose and segment after the IMC is the same as the trips by mode and purpose resulting from the main MSM demand models. This is done at an OD level. Hence the IMC models effectively re-allocate trips by mode and purpose and period between the segment levels; they will not, for example, generate more HBW AM peak car trips in total for each OD.

This adjustment has been implemented as an option, so that the segmented WTPWTP can be run with or without the balancing adjustment.

The car person demands are converted into car vehicles using the same processes as used in the main MSM.

The vehicle demands for each WTPWTP segment are aggregated by trip purpose for assignment:

- HBW: includes park–and-ride trips in the AM peak and PM peak
- EB: includes business airport trips and external trips
- Other: the sum of HBE, HBSh, HBO and NHBO plus personal airport trips and, in the IP period, and park and-ride trips
- M/HCV

Hence with each of the above aggregated purposes at 3 WTP segment levels, there are 12 vehicle classes in the segmented assignment.

4.2.2 WTP Segmentation and Household Income

In order to provide a basis for vehicle WTP segmentation a linkage to household income has been introduced.

Two ways in which this linkage was considered were:

1) A direct linkage between household income and WTP so that for any particular income, a WTP could be derived.

2) An elasticity between variation in household income and variation in WTP.

There are four values of time (VoT) by trip purpose (Employers' Business (EB), Home Base Work (HBW), Other and HCV/MCV) and three household income segments.

Both New Zealand and international studies were considered, which include:

3) Urban Travel Time Value – Some New Zealand Findings (2000)

4) Stated Preference Surveys to Estimate Value of Time for New Zealand Toll Roads – Orewa Case Study (2004)

5) Stated Preference Surveys to Estimate Values of Time for New Zealand Toll Roads- Tauranga Residential Case Study (2004)

6) Assessment of Existing Behavioural Values of Travel Time Savings for Urban Project in New Zealand (2005)

7) NZ Traffic and Transport Modeller – Cars: LCV:HCV ratio determination (2005)

8) Auckland Road Pricing (2005)

9) Auckland Road Congestion Pricing – Application of VoT to RART Model (2005)

10) Tauranga Eastern Motorway Study - Behavioural Valuation of Travel Time Savings (2008)

11) Transmission Gully Toll Model Technical Specification (2008)

12) Synthesis of Research on Value of Time and Value of Reliability (2009)

13) TAG Unit 3.5.6 - Values of Time and Vehicle Operating Costs (2014)

14) Understanding and Valuing Impacts of Transport Investment – Values of travel time savings (2015)

15) Forthcoming Change to WebTAG (2016)

16) Economic Inputs Technical Note (2017)

17) UK Department for Transport – Updating appraisal values for travel time savings, Phase 1 study, (20 June 2010)

18) UK Department for Transport - Provision of market research for value of travel time savings and reliability, Phase 2 Report (14 August 2015)

Relationship between VoT and income

The US research papers generally concluded that income, while traditionally used as a proxy for VoT, was not an accurate measure of VoT. Marginal income was suggested as a better alternative, of which the data is usually not readily available.

The UK research suggests that there is significant variability in VoT elasticity with household income between the HBW and other trip purposes, with no consistent trend. For EB trips, the quoted elasticities are related to personal rather than household income. **It was considered that an appropriate compromise between the papers is to apply an elasticity of 0.5 to household income.** An adjustment was then required to the medium income group VoT such that the average VoT is consistent with the VoT in the DMS model. These values align well with the Tauranga Eastern Motorway values for both HBW and other trips. For EB trips, the average value within the macro strategic model aligns with the total employee and employer value of time. Without any research to justify an alternate elasticity **it was recommended that the elasticity of 0.5 also be used for EB.**

Both work and non-work values of time are assumed to increase with income with an elasticity of 1.0 in WebTAG which means that these same cross sectional elasticities can be used in the future forecasting as incomes change over time.

In order to apply the proposed elasticity of 0.5 to the high, medium and low income segmentation, the mean income values for each income category were taken from the outputs of the ASP model as:Table 4-1- Household Income segmentation levels

Income segment	Income	Difference from mean	Proportion of mean
Low	$27,944	-65%	35%
Medium	$67,276	-16%	84%
High	$143,770	80%	180%
MEAN	**$79,663**	-	

Applying the elasticity of 0.5, a final adjustment was required so that the average VoT of the three segments is equal to the VoT used in the distribution mode split model. This adjustment means that the medium income segment has an income that is 16% lower than the average income, and therefore a VoT that is 8% lower than the average VoT.

For calculating the future year WTP segments, the following steps were required:

- The average incomes for each segment were calculated and related to the difference from the overall mean
- An elasticity of 0.5 was applied to calculate adjustment factors for each segment relative to the overall mean.

Taking into consideration the mean household incomes for each income segment produced in ASP, and the elasticities resulting from a review of national and international evidence, the WTP for each income segment is provided below.

Table 4-2- VoT segmentation

		Average VoT ($/hr, 2016)			
Trip Purpose	**Average (DMS model)**	**Low income**	**Medium income**	**High income**	
Proportion of mean	100%	68%	92%	140%	
HBW	$13.11	$8.85	$12.09	$18.38	
EB	$41.73	$28.18	$38.49	$58.52	
Other	$10.97	$7.41	$10.12	$15.38	
M/HCV	$32.03	$21.63	$29.54	$44.92	

Statistics NZ information has been used to define the households by MSM zone in each income, and therefore WTP, category as shown in **Figure 4-1**. There is the opportunity to update the values of time to incorporate additional perception factors or Alternate Specific Constants (ASCs) which are commonly used in toll modelling to reflect responses to pricing which not related to travel time saving (such as quality of journey). These are discussed further in the Model Testing Report.

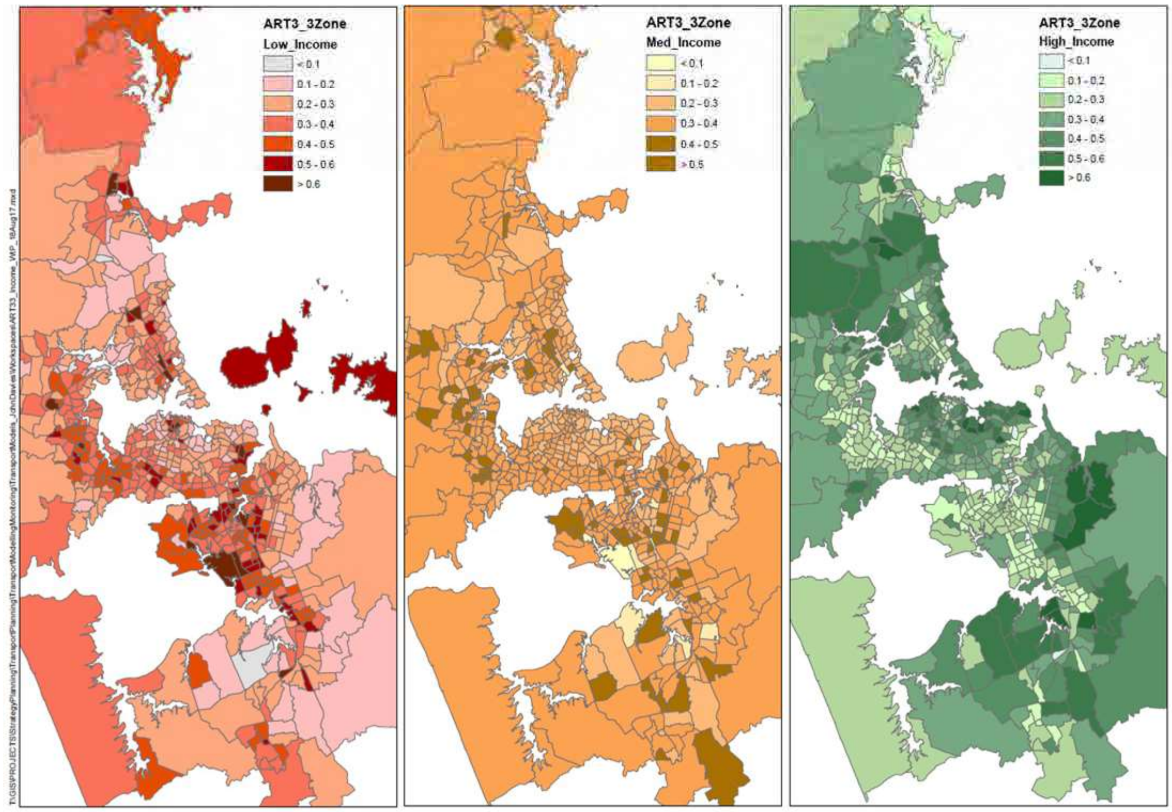

Figure 4-1- Willingness to Pay segments

4.3 MSM PT Crowding (Task 3.2)

Crowding on PT services increases the users perceived cost/difficulty of travel. Whilst a crowding function has been available in the APT3 model since 2013, there has previously been no PT crowding function in the macro strategic model. The APT3 model applied Crowding Factors (CF) to the in-vehicle travel time based on the average loading on the service.

Desirably the same function would be applied to the MSM, however implications on convergence and run times needed to be considered. A crowding function was therefore tested and implemented in the MSM as follows:

- Crowing factors (CF) were introduced into the transit travel time functions as per the MSM. The CFs are updated every demand-supply iteration in MSM using the demands at each iteration, but unlike MPTM there is no iterating to achieve convergence within a PT assignment
- A series of tests were carried out to understand the viability of introducing this simplified version of crowding, which identified that, with appropriate damping, convergence and run-times would remain manageable. The model response to adding crowding was also considered reasonable (and in line with observed effects), with both a general switch from bus to rail on some competing routes, and a small overall loss of PT demands.
- Following the ‘proof of concept’ testing, the crowding process was adopted in the MSM and activated during validation of the base model. The vehicle type codes and capacities were also rationalised between the two models to enhance consistency of coding and response.

The specification and testing are described further below.

4.3.1 Crowding Factors

The CF were calculated using the formulation given in the MPT crowding documentation:

Crowding Ratio, CR	= 1 + (V - Cs) / Ct	
Crowding Factor, CF	= 1	if CR <= 0.8
	= 1 + (0.07/0.2) * (CR - 0.8)	if 0.8 < CR <= 1.0
	= 1.07 + 1.8 * (CR - 1)	if CR > 1.0

The CF are calculated for each PT service segment in each of the three assigned time periods and then applied to the transit travel time functions (ttf) via the segment user element us2 in the same manner as was in MPTM at that time (note that the application of the CF has now changed in both models to apply to the time components only of the functions):

- bus: ul1=running time, ul2=stopped time, ul3=length part of fare
  - ft2 = (ul1+ul2+ul3)*(us2)
  - ft3 = (ul1+ul3)*(us2)
- ferry: ul1= time, ul3=length part of fare
  - ft5 = (ul1+ul3)*(us2)
- rail: ul1= time, ul3=length part of fare
  - ft7 = (ul1+ul3)*(us2)
  - ft8 = (ul1)*(us2)
  - ft9 = (ul1)*(us2)
  - ft10 = (ul1)*(us2)

[Note: PT travel time functions were updated from link to segment attribute in Phase 2. Please refer to **Section 9.2**.]

4.3.2 Tests Undertaken

The following tests were undertaken in a year 2026 test model to understand the crowding factor impact on run time and convergence:

- Test 1: CF calculated from reference model run (with no crowding) and applied as constants throughout the model run – this test would have no change in CF during the model iterations
- Test 2: CF calculated from the current model run from iteration 3 of the demand models and updated every iteration without any damping – this allows a change in CF during iterations
- Test 3: CF calculated from the current model run from iteration 2 of the demand models and updated every iteration with damping of the form:

CFnew =CFprevious * (1-1/N) + CFcurrent * (1/N)

Where N= iteration number

Additionally, a test was done with the 2026 land use inputs increased by 20% while retaining the same networks. This was done for a reference case (no CF), and then

- Test 4: CF calculated as for Test 3.

4.3.3 Test Results

Information is presented on demand-supply convergence, trips by mode, PT passenger-km by mode, and PT volume-to-capacity for the two reference cases and each of the above tests.

Convergence

All of the model runs converged except for Test 2, where the CF was calculated during the model run and not damped. The number of demand-supply iterations, including iteration 0, for those that did converge was:

- Reference (i.e. no crowding): 8 iterations
- Test 1: 10 iterations
- Test 3: 10 iterations
- Reference + 20%: 9 iterations
- Test 4: 11 iterations

Hence these tests indicate that introducing damped CF, Tests 3 and 4, increases the number of demand-supply iterations, in these cases by 2 iterations.

Trips by Mode

Table 4-3 provides car and PT trips by time period for the two reference cases and the percentage change from these in the tests.

The effect of CF in these tests was to reduce PT trips by up to 7% in the AM peak and increase car trips by around 1%; when the land use was increased by 20% the PT reduction was 10%. These changes in trips across modes and across time periods seem reasonable.

Table 4-3- Effects of crowding on 2026 peak period matrix totals

	Reference	Test 1	Test 3	Reference +20%	Test 4
AM Car Matrix (veh)	547,510	0.6%	0.5%	643,562	0.8%
IP Car Matrix (veh)	1,610,076	0.6%	0.5%	1,931,254	1.0%
SP Car Matrix (veh)	365,391	0.7%	0.5%	435,708	1.0%
PM Car Matrix (veh)	609,431	0.6%	0.5%	718,223	0.8%
OP Car Matrix (veh)	632,778	0.8%	0.6%	761,349	1.3%
AM PT Matrix (per)	89,962	-7.1%	-6.9%	113,635	-10.5%
IP PT Matrix (per)	107,944	-2.0%	-0.2%	136,093	-2.6%
SP PT Matrix (per)	47,303	-2.5%	-1.4%	59,283	-3.4%
PM PT Matrix (per)	75,250	-6.2%	-4.6%	95,455	-8.4%
OP PT Matrix (per)	32,426	-2.0%	-0.8%	41,048	-2.9%

Passenger-km

Table 4-4 gives the AM peak passenger km by mode for the two reference cases and the % change from these in the tests.

Rail travel reduces markedly in these tests, due to the low rail capacities in the models. This has the effect of increasing ferry travel and some small change in bus travel. These results are consistent with the volume-to-capacity information given below. The 2016 values are only provided for context.

Table 4-4- Effects of crowding on 2026 AM peak period matrix totals on passenger km

	2016 Model	Reference	Test 1	Test 3	Reference +20%	Test 4
Passenger-km						
Bus	422,002	603,683	11%	1%	727,167	-4%
Rail	275,992	374,709	-62%	-46%	504,307	-54%
Ferry	59,005	35,010	17%	20%	41,824	31%

PT Volume-to-Capacity

The numbers of line segments within intervals of PT volume/capacity for each PT mode have been extracted from the completed model runs. The AM peak results are given in **Table 4-5**.

The effect of CF in reducing the level of occupancy or crowding is clearly evident, more so with Tests 2 and 3 where the CF are generated during the model run and damped. The CF in Tests 3 and 4 are effective at reducing occupancy situations, particularly in light of the low rail capacities used in these tests.

Table 4-5- Effects of crowding on the number of segment with different levels of v/c ratio (2026 AM)

	Reference			Test 1			Test 3		
	Bus	Rail	Ferry	Bus	Rail	Ferry	Bus	Rail	Ferry
v/c<=0.8	15,658	957	132	15,546	1,218	132	15,888	1,031	132
0.8<v/c<=1.0	441	72	4	317	42	4	274	160	4
1.0>v/c<=1.2	28	32	0	130	16	0	45	182	0
1.2>v/c<=1.4	33	11	0	29	49	0	0	9	0
1.4>v/c<=1.6	47	22	0	56	0	0	0	0	0
v/c>1.6	0	288	0	129	57	0	0	0	0
	Reference+ 20%			**Test 4**					
	Bus	Rail	Ferry	Bus	Rail	Ferry			
v/c<=0.8	15245	865	132	15605	922	128			
0.8<v/c<=1.0	517	66	4	476	162	8			
1.0>v/c<=1.2	335	60	0	126	178	0			
1.2>v/c<=1.4	28	38	0	0	120	0			
1.4>v/c<=1.6	20	30	0	0	0	0			
v/c>1.6	62	323	0	0	0	0			

Conclusion and Recommendation from Testing

From the testing it was concluded that introducing CF into the PT travel time functions does not impact significantly on demand-supply convergence when damping is included. The effect of the CF is to balance demand by switching demand from overcrowded lines to other PT modes and to car.

Hence it was recommended that:

- CF be introduced into the MSM in Phase 1 of the Models Refresh Project using the same or similar processes to that used in Tests 3 and 4 above,
- The final CF at the end of the demand-supply iterations be included in the final assignments,
- The PT capacities used and calculation of CF be consistent with the MPTM,
- The convergence, specific capacities and CF function be monitored and reviewed during model validation.

4.3.4 Confirmation of Crowding Module

The crowding module was introduced into the 2016 MSM during its validation and a range of damping procedures were tested. The outcome of these tests was to confirm the preferred damping methodology from the initial tests, but to also apply a cap so that the proportion of current CF is no less than 25% of the damped CF value; that is:

$$CFnew = CFprevious * (1-1/N) + CFcurrent * (1/N)$$

Where N= iteration number, capped to a maximum of 4

4.4 MSM Enhanced HCV Model (Task 3.3)

The model includes a 'HCV' (truck) mode, which includes medium and heavy commercial vehicles. The original ART3 Model was based on an 'estimated' truck matrix created from limited travel data (mostly only traffic counts and a limited sample of truck trip-lengths). The calibrated demands were developed at a daily movement level, with simple global factoring to create demands for the AM, inter peak and PM periods.

This task involved using new truck matrices developed from a much larger sample of commercial vehicle GPS data, expanded and factored to match traffic counts. Matrices were estimated individually for each assignment period. The matrices were developed by the AFC in an interim version of regional 'DTA' model, then converted to the MSM zone system.

Task 2.4.6 (See **Section 5.4)** describes the process for the development of the 2016 base HCV matrices. The approach to growth forecasting was also reviewed, as described in the Forecasting Report.

4.5 MSM Enhanced Representation of 'Park-and-Ride'[3]

In the 2006 macro strategic model, car access to PT is represented using auxiliary transit links (called p-connectors) which connect directly between zone centroids and park-and-ride sites. Car times on these links are estimated and included in the generalised costs. This is a simplified representation of car access which has a few weaknesses:

- The travel times on p-connector links are based on functions derived from 2006 survey data and remain constant for forecasting (i.e. the travel costs do not reflect modelled vehicle travel times through the network, nor do they include costs such as tolls).
- The cars on p-connector links do not get included in the vehicle matrix and are not assigned to the road network (i.e. the car component of the park-and-ride trips are not reflected in traffic flows on the road network, and hence may also underestimate local and overall delays).
- The approach does not differentiate between park-and-ride and kiss-and-ride
- Many park-and-ride car parks are full prior to the AM modelled period (7am) and so historically the exclusion of park-and-ride vehicles on the network in the modelled period has not been considered of significance.
- Parking supply is not represented, nor any parking costs.
- The coding of park-and-ride stations and catchments in the macro strategic model differs from that in the macro PT model, resulting in coding inefficiencies and model inconsistencies.

In order to mitigate these weaknesses, the 2016 update has included:

[3] Although often referred to as 'park and ride', this element of the model includes other auto-access modes to PT stations (such as kiss and ride).