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Queenstown Public Transport Business Case

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CONFIDENTIAL

Public Transport Hubs and Infrastructure

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3.1	Incorporating NZTA feedback for Five Mile Interchange

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Contract TCTB1 dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Executive Summary

This paper documents the public transport infrastructure that would be required to support the public transport services proposed as part of the Queenstown Public Transport Business Case, including interchanges, priority measures, road corridor constraints and bus depot. The key findings from the assessments are outlined below.

Kawarau Falls Bridge

One of the optional add-ons to each of the service pattern options is the provision of a new bridge over the Kawarau River which would connect Boyd Road to Red Oaks Drive. The proposal under this 'add-on' is to develop a combined public transport, walking and cycling bridge. The public transport bridge would reduce bus travel times and improve service reliability.

The benefits of a public transport bridge are:

- Reducing the travel time from Jacks Point to Frankton and Queenstown Town Centre, which would make public transport a more attractive and viable option. The travel time saving would be approximately two kilometres or about four minutes per trip.
- Enabling public transport vehicles to bypass the anticipated traffic congestion on the existing Kawarau Falls Bridge when the southern growth area is developed
- Avoiding the need to divert buses from Jacks Point off SH6 to Remarkables Park reducing public transport operating costs
- Simplifies the public transport network and avoids the need for the Frankton loop service because cross town connections could be made at Remarkables Park and Five Mile

The provision of bus lanes on SH6 could be used instead of, or as a staged approach to, the public transport bridge to enable buses to bypass the majority of queuing expected in the future. These bus lanes would be for the northbound direction only with the proposed extent of the bus lanes being from Boyd Road to the Kawarau Falls bridge with Peninsula Road likely being signalised.

Jack's Point Ferry

Another optional add-on to the proposed short list service patterns options is an electric ferry service running from Homestead Bay to Queenstown. This ferry service would serve the lower half of the southern growth area in Jacks Point and provide an alternative route for commuters to avoid traffic on SH6 when travelling to Queenstown.

Homestead Bay marina is one of the planned future development areas in the Southern Corridor. The form and intensity of development is still uncertain but is expected to be higher density residential around the lakefront, with lower density residential and open space on the outer edges.

The public transport facilities required for the ferry service to operate successfully are:

- Wharf
- Electric ferry charger
- Passenger shelter
- Walking/cycling/road access to and from Jack's Point and the proposed development located between Homestead Bay and SH6
- Bus stop (for southern growth corridor public bus service)
- Bus turnaround facility
- Bus driver facilities (which may be integrated with the marina)

Lucas Place Bus Lanes

Lucas Place is the primary route that connects the Airport and Remarkables Park with the state highway network. Lucas Place is expected to be increasingly congested in the future due to planned development along Hawthorne Drive. Bus lanes on Lucas Place have been proposed in order to enable buses to bypass the expected congestion and get to the state highway network quicker. Lucas Place is currently one lane in each direction but the road reserve is 20m wide so the road could be widened to accommodate either a bus lane in the inbound direction or bus lanes in both directions. A potential second stage of works could be to extend the bus lane to Hawthorne Drive which is currently two lanes in each direction. This would involve marking the kerbside lane as a bus lane. Extending the bus lane to Hawthorne Drive may require the signalisation of Lucas Place / Hawthorne Drive / Roberston Street / Riverside Road to provide bus priority through the intersection.

Intersection Modifications

Three intersections in Lake Hayes were identified as being a constraint for bus operations which are Sylvan Street/ Howards Drive/ Luna Place, Sylvan Street/ Hope Avenue and Rere Road/ Hope Avenue/ Acheron Place. In these locations intersection modifications are proposed so that they are able to accommodate planned bus movements.

Stanley Street Bus Hub

An assessment of options to modify the Stanley Street Bus Hub to accommodate articulated buses was completed. It was found that minor modifications to the Queenstown arterials design could be made which includes lengthening bus stop boxes. The location of bus layover and turnaround is dependent on the Queenstown arterials project. An interim bus layover on Memorial Street should be investigated with buses turning around via Shotover Street, Camp Street and Memorial Street. If the Malaghans Road add on is used, then the preferred way for buses to turn around is via Frankton Rd and Coronation Drive. The preference would be to extend the Jack's Point bus route to One Mile once stage 3 of the Queenstown arterials is complete.

Frankton Bus Hub

As part of the New Zealand Upgrade Programme (NZUP) the Frankton bus hub will be improved with more bus stops and an enhanced passenger waiting area. As part of this advisory paper options to modify the NZUP design to accommodate articulated buses were considered. It was found that relatively simple design changes could be made to lengthen the bus stop boxes to accommodate articulated buses. Further changes to the NZUP layout were considered and discounted with an off-road bus interchange not being required unless an off-line public transport route is built.

Five Mile

Consideration was also given to providing a bus hub at Five Mile which reflects the importance of the area as a retail and services destination. The preferred location for a bus hub is SH6 near the intersection with Grant Road. This location makes best use of the NZUP investment in bus lanes on SH6 and the intersection upgrade at SH6 / Grant Road. This location also enhances journey reliability and offers a more direct service, avoiding potential constraints associated with navigating through the Five Mile development, including constraints related to design vehicle widths on Shearers Drive.

Remarkables Park

For service patterns that include a Kawarau River bridge the Remarkables Park bus service would become a linear route rather than the current loop. Therefore options which place the Remarkables Park bus stops on a more direct route between the proposed bridge and Lucas Place were considered. The preferred location the Remarkables Park interchange is Hawthorne Drive near Tex Smith Lane which places the stops close to the supermarket but also stays on the main road. If the Kawau River bridge is not included in the preferred service pattern then the current stops in Remarkables Park Town Centre could be retained.

Depot

The existing bus depot is too small to accommodate the increase in peak vehicle requirement that would result from increased service levels and is not in the optimal location for a high voltage power connection that is needed for electric bus charging.

A scoping assessment has been undertaken at a suburb level of detail. This assumes that the new bus depot would be publicly owned, as enabled by the Sustainable Public Transport Framework, rather than being owned by the bus operator.

A total estimated land parcel size of approximately 10,000sqm is required to accommodate the depot, including bus parking, vehicle parking, offices and space for electrical charging. This is considerably larger than the existing Ritchie's bus depot on Glenda Drive in Frankton, which is about 3,800m^2.

Key findings from the location assessment are:

- Frankton and Coneburn were shortlisted as locations for further consideration of an electric bus depot
- Frankton north of the airport and Coneburn have zoning that would be straightforward to establish a depot
- The zoning in Frankton south of the airport prohibits service activities. A bus depot has been considered a service activity for this assessment
- Driver accommodation on the depot site would be challenging as it is prohibited for both Coneburn and parts of Frankton north
- Coneburn has ecological restrictions and only serviced with bore water so might need on site water storage for fire fighting

Once the business case has been endorsed by partners and the preferred ownership for the Queenstown bus depot confirmed the next steps to identify a preferred location would be:

- Engage with Aurora early in the process to confirm electric grid capacity and plan high voltage power connection
- Engage with landowners in Frankton and Coneburn on timeframes for subdivision and willingness to sell. Consider lease of land only if long term lease can be secured as a large investment in site improvements would be required to develop a depot
- Undertake due diligence on preferred sites that investigates cost of development and consenting risks

Off-line solution

This paper has identified that there is sufficient theoretical capacity within the Stanley Street bus hub and SH6A to accommodate the forecast number of buses until 2053. However, if traffic is not throttled back at Frankton as per the planned operation of the BP roundabout then buses could experience excessive delays in the town centre. Therefore, a potential trigger for investigating an off-line public transport solution would be when it is no longer feasible to hold traffic back in Frankton. This could be due to excessive queuing which delays buses in Frankton. An off-line solution would avoid the limitations of the road network and make crossing hills and water bodies easier. It is recommended that an offline solution is integrated into the design of the public transport network to avoid forced transfers where possible.

1 Introduction

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess, and develop service pattern and decarbonisation options, and explore funding and operational models.

This Public Transport Hubs and Infrastructure Advisory Paper is part of the Project's suite of advisory papers. It documents the public transport infrastructure that would be required to support the public transport services proposed as part of the Queenstown Public Transport Business Case. The types of public transport infrastructure that have been considered in this paper include interchanges, priority measures, road corridor constraints and bus depot.

The paper is structured as follows:

- Chapter 2 discusses the public transport priority infrastructure that has been identified to support the service pattern options.
- Chapter 3 discusses the public transport infrastructure required to support a Homestead Bay ferry at a high-level including wharf, bus facilities and park n ride.
- Chapter 4 documents the findings from the tracking of buses on the current and proposed routes along the current road network.
- Chapter 5 covers the public transport interchange concepts for Stanley Street, Frankton Hub, Five Mile and Remarkables Park.
- Chapter 6 investigates locations for a new electric bus depot at a suburb level of detail to identify the most feasible locations from public transport operations, power availability and urban planning perspectives.

The recommendations of this paper will help shape the investment proposal for the Queenstown Public Transport Business Case. Please refer to Advisory Paper 6 for information on potential park n ride locations.

1.1 Service Pattern Options

At the time of writing this paper, an emerging preferred service pattern had yet to be confirmed. Therefore, the public transport infrastructure required for the two shortlisted options is considered by this paper. Table 1 shows the fleet requirements for both a 15-year and 30-year outlook.

Table 1: Forecast fleet requirements for the two short list service pattern options

Option	15-year outlook	30-year outlook
Bus Max	20 standard buses 10 articulated buses	6 standard buses 47 articulated buses
Jack's Point Spine	16 standard buses 14 articulated buses	18 standard buses 26 articulated buses

1.1.1 Bus Max

The Bus Max network consists of multiple high frequency bus routes running along SH6A between Queenstown and Frankton before branching off to serve outer towns and suburbs. The frequent bus routes at Arthurs Point to Arrowtown, Fernhill to Lake Hayes and Queenstown to Jack's Point. The Queenstown to Jack's Point service diverts into Remarkables Park and Queenstown Airport. The standard frequency bus routes are Kelvin Heights to Quail Rise via Frankton Hub and a

Frankton loop service that connects the airport, Remarkables Park and Five Mile. The bus network is supported but a Frankton Arm ferry service that follows the current route but with a 30-minute frequency.

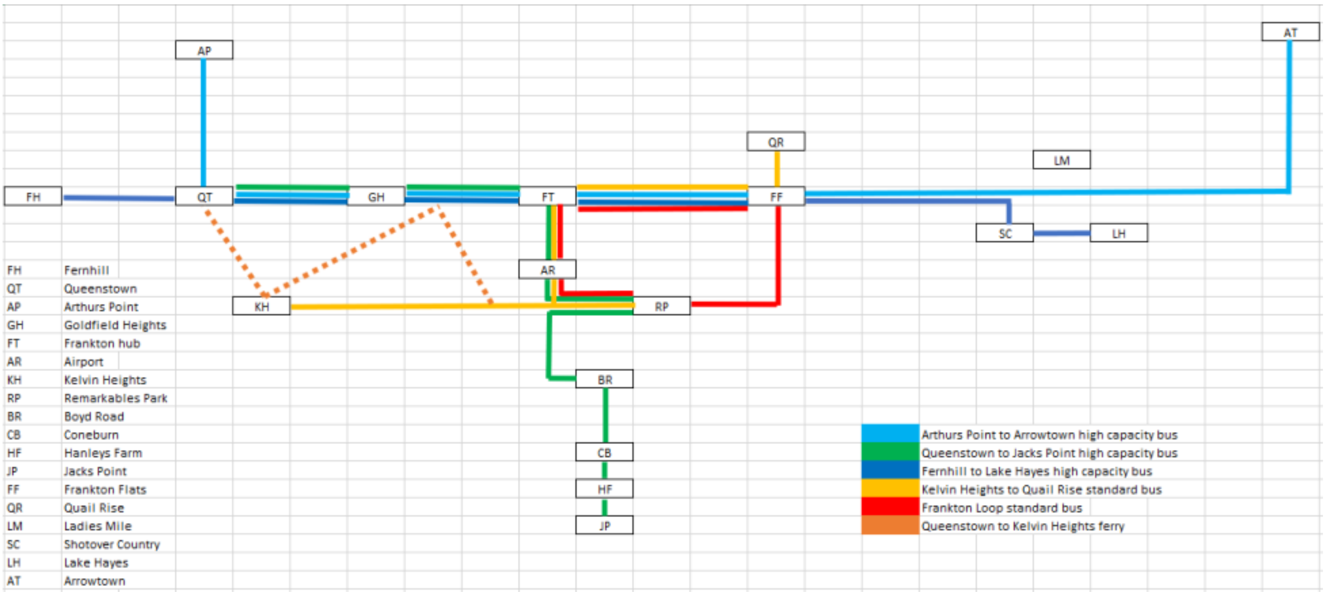


Figure 1: Schematic bus network diagram of Bus Max option

1.1.2 Jack's Point Spine

The Jack's Point Spine is built around a single high frequency bus route on SH6A that runs from Queenstown to Jack's Point via Remarkables Park and the Airport. Services from Arrowtown and Lake Hayes hub into the spine service at Frankton with Fernhill to Arthurs Point service connecting at Stanley Street. The Kelvin Heights to Quail Rise service runs along Hawthorne Drive between Remarkables Park and Five Mile in order to pick up the expected development in that area. The same Frankton Arm ferry service is used which stops at Queenstown, Bayview, Marina and Hilton.

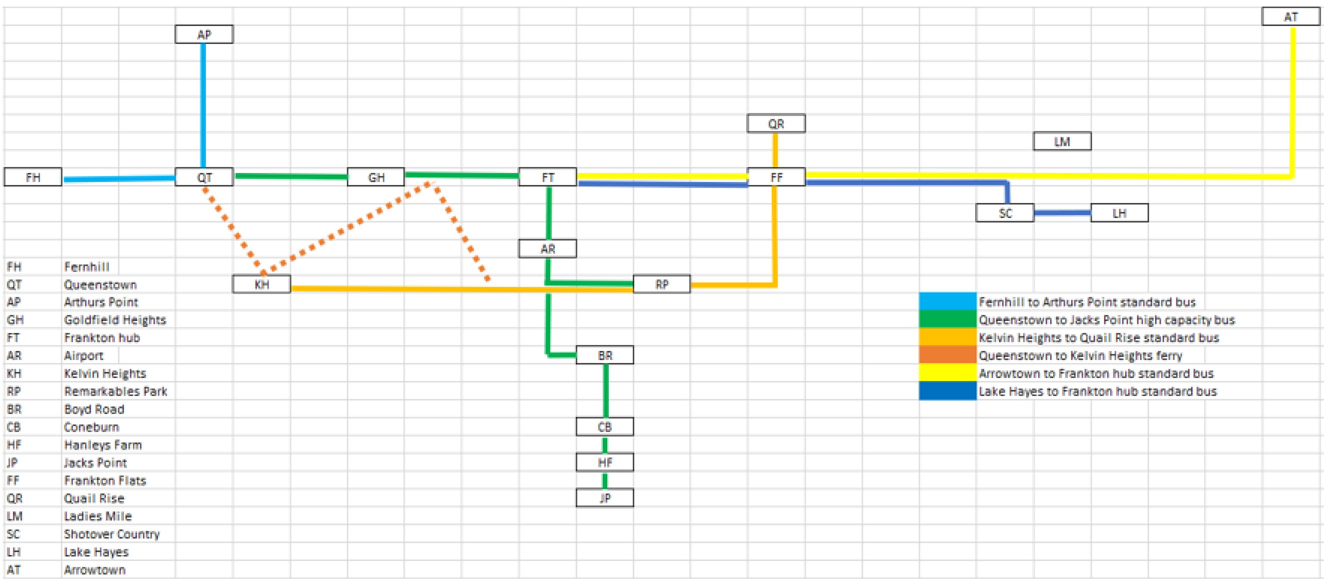


Figure 2: Schematic bus network diagram of Jack's Point Spine option

1.1.3 Option Add-ons

There are three 'add-ons' being considered for the base service pattern options, including:

- A new public transport, walking and cycling bridge over the Kawarau River in order to make Remarkables Park on the way from the Southern Growth Area and thereby avoid a detour
- A ferry service from Homestead Bay to Queenstown that would serve the lower half of the Southern Growth Area
- Route change to have the Queenstown to Arrowtown service go via Mallaghans Road and a second Arrowtown to Frankton Hub via Five Mile service for those travelling to Frankton.

1.2 Technology requirements

Intelligent Transport Systems (ITS) is not specifically required for public transport operations as bus drivers have radios. These can be used for communicating disruptions without the need for variable message signs. All buses are tracked using GPS so do not need loops or cameras to monitor buses.

Real-time information boards at bus stops have not been considered for this Business Case. ORC currently make use of smartphone applications to provide real-time information to customers.

1.3 Do minimum Infrastructure

The do minimum infrastructure is the New Zealand Upgrade Programme Queenstown Package which includes bus lanes on SH6 south and east, an upgraded Frankton bus hub, signalising the BP roundabout and signalised intersections and pedestrian crossings along SH6A. The Queenstown Package has committed funding in the current National Land Transport Programme and is included in the National Parties transport policy.

Other infrastructure included in the do minimum is the town centre improvements which includes the pedestrianisation of the streets within the town centre and stage 1 of the Queenstown arterials project. A new Arthurs Point bridge to replace the existing Edith Cavell Bridge is also included in the do minimum. Stages 2 and 3 of the Queenstown arterials project are not included in the do minimum due to funding uncertainty.

2 Public Transport Priority Infrastructure

This section discusses the public transport priority infrastructure required to support the short-listed service pattern options. These include the Kawarau River public transport bridge, bus lanes on SH6 south of Kawarau Falls and Lucas Place bus lanes.

2.1 Public Transport Bridge

One of the optional add-ons to each of the service pattern options is the provision of a new bridge over the Kawarau River which would connect Boyd Road to Red Oaks Drive (Figure 3). A new cycling bridge in this location is envisaged as part of the Wakatipu Active Travel Network Business Case. The proposal under this 'add-on' is to develop a combined public transport, walking and cycling bridge.

The purpose of the public transport bridge is to enable Remarkables Park to be served directly by a bus route from the Southern Growth Area (Figure 4). The public transport bridge would reduce bus travel times and improve service reliability.

The benefits of a public transport bridge are:

- Reducing the travel time from Jacks Point to Frankton and Queenstown Town Centre, which would make public transport a more attractive and viable option. The travel time saving would be approximately two kilometres or about four minutes per trip.
- Enabling public transport vehicles to bypass the anticipated traffic congestion on the existing Kawarau Falls Bridge when the southern growth area is developed
- Avoiding the need to divert buses from Jacks Point off SH6 to Remarkables Park reducing public transport operating costs
- Simplifies the public transport network and avoids the need for the Frankton loop service because cross town connections could be made at Remarkables Park and Five Mile

Figure 3: Suggested public transport only link road with a bridge connecting Boyd Road and Red Oaks Drive

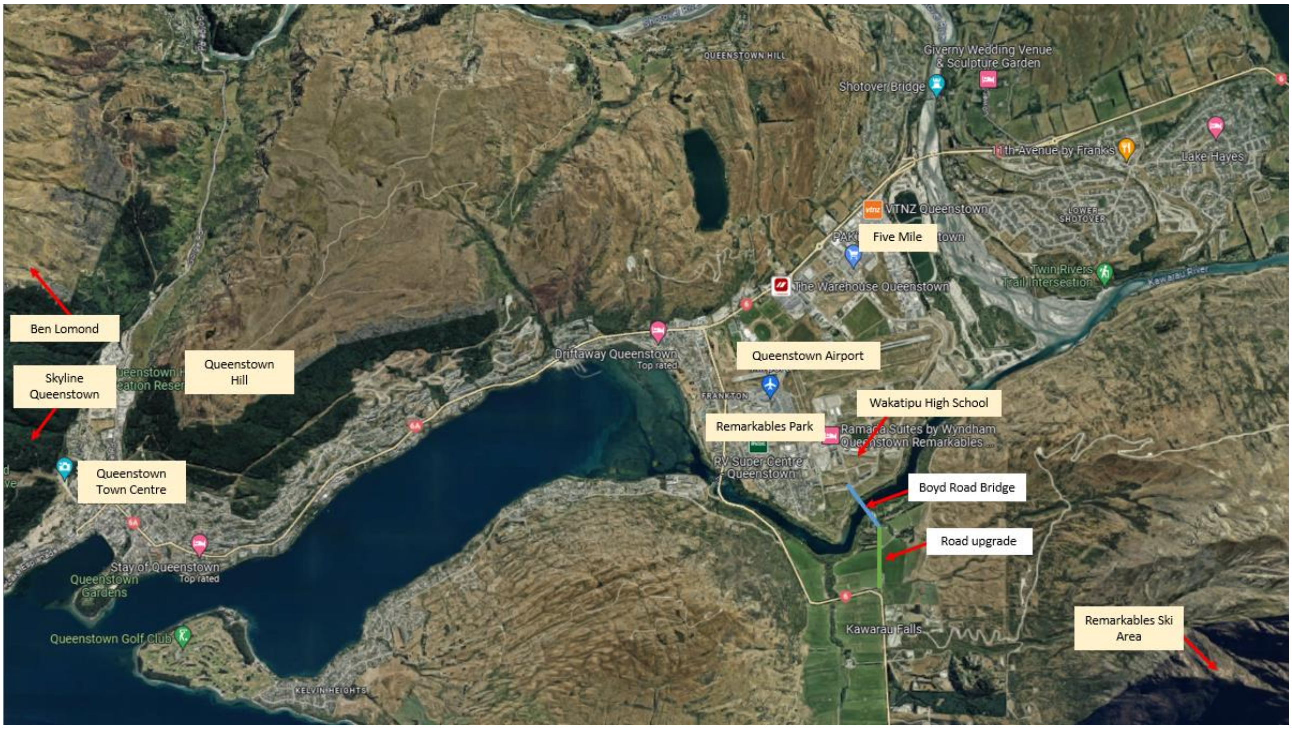


Figure 4: Proposed Boyd Road bridge relative to destinations in Queenstown and Frankton

2.2 Bus Lanes on State Highway 6

The provision of bus lanes on SH6 could be used instead of, or as a staged approach to, the public transport bridge to enable buses to bypass most of the queuing expected in the future. These bus lanes would be for the northbound direction only with the proposed extent of the bus lanes being from Boyd Road to the Kawarau Falls bridge (Figure 5) with Peninsula Road likely being signalised.

As a significant increase in public transport mode share will be needed to prevent the Kawarau Falls bridge from being over capacity, implementing bus lanes would be beneficial to support this mode shift. This is because bus lanes would provide a queue jump for buses that improves journey times and reliability for commuters which helps to make public transport a more attractive mode. The bus lanes south of the bridge would be a continuation of the bus lanes proposed as part of the New Zealand Upgrade Queenstown package that are show in Figure 6.

Note that installing bus lanes on SH6 would not address the geographical challenge of accessing Remarkables Park as it is not enroute to Queenstown for buses departing from Jack's Point. Serving Remarkables Park with the existing road network would therefore require a detour of the bus route, a transfer for passengers or using two routes that overlap in Jack's Point. All the network design options with the existing road network are a compromise in terms of either travel time or operating costs.

Figure 5: Extent of proposed bus lanes south of Kawarau Falls Bridge

Figure 6: Extent of NZUP proposed SH6 bus lanes – Frankton Marina, Frankton and Five Mile

2.3 Lucas Place Bus Lanes

Lucas Place is the primary route that connects the Airport and Remarkables Park with the state highway network. Lucas Place is expected to be increasingly congested in the future due to planned development along Hawthorne Drive. Bus lanes on Lucas Place have been proposed to enable buses to bypass the expected congestion and get to the state highway network quicker (Figure 7). Lucas Place is currently one lane in each direction but the road reserve is 20m wide so the road could be widened to accommodate either a bus lane in the inbound direction or bus lanes in both directions. A potential second stage of works could be to extend the bus lane to Hawthorne Drive which is currently two lanes in each direction. This would involve marking the kerbside lane as a bus lane. Extending the bus lane to Hawthorne Drive may require the signalisation of Lucas Pl / Hawthorne Dr / Roberston St / Riverside Rd to provide bus priority through the intersection.

Figure 7: Proposed bus lanes on Lucas Place and option to extend bus lanes along Hawthorne Drive

3 Jack's Point Ferry

Another optional add-on to the proposed short list service patterns options is an electric ferry service running from Homestead Bay to Queenstown. This ferry service would serve the lower half of the southern growth area in Jacks Point and provide an alternative route for commuters to avoid traffic on SH6 when travelling to Queenstown. Figure 8 shows the indicative location of the new marina or wharf that would be situated at the end of Homestead Bay Road.

Figure 8. Indicative marina/wharf location for proposed Homestead Bay – Queenstown ferry service.

Homestead Bay marina is one of the planned future development areas in the Southern Corridor. At the time of writing, the area was mostly undeveloped with the landowner undertaking a structure plan exercise. The form and intensity of development is still uncertain but is expected to be higher density residential around the lakefront, with lower density residential and open space on the outer edges.

The public transport facilities required for the ferry service to operate successfully are:

- Wharf
- Electric ferry charger
- Passenger shelter
- Walking/cycling/road access to and from Jack's Point and the proposed development located between Homestead Bay and SH6
- Bus stop (for southern growth corridor public bus service)
- Bus turnaround facility
- Bus driver facilities (which may be integrated with the marina)

Other infrastructure to develop a marina at Homestead Bay has not been investigated.

4 Bus Tracking

4.1 Introduction

To understand any road network constraints on the operation of buses across the proposed public transport network, vehicle tracking was completed using AutoCAD. The types of buses that were tracked are the Auckland Transport 19m articulated bus and 12.6m long rigid large bus. These buses are larger than the current bus fleet in Queenstown which is 10m rigid buses. It is anticipated that larger buses would be required on the Queenstown public transport network in the future in order to accommodate growth. The tracking was based on aerial photos with the aim being to keep the buses within the traffic lane and not cross the centre line or encroach into adjacent lanes.

The 19.0m articulated bus generally tracked better than the 12.6m rigid bus as the articulation point enabled a smaller turning radius for the articulated bus. No tracking problems were encountered on the state highway network (SH6 and SH6A). In some parts of the local road network tracking problems were encountered which included intersections and mid-block sections were parking was permitted. These areas are discussed further below.

4.2 Fernhill

Fernhill currently has a frequent bus route which travels down Fernhill Road and uses Arawata Terrace to turn around. However, the narrowness of Arawata Terrace (approximately 7.5m kerb to kerb) presents a challenge for buses as they must drive down the centre of the road where there are parked cars on both sides. This is a problem for all types of buses which have a similar width. To accommodate bus movements, it is proposed that either parking be removed on one side of Arawata Terrace to provide effectively a 5.5m carriageway. This is still narrower than ideal but would be an improvement over the existing condition. Another option would be to build a bus turn around at the end of Fernhill Road which avoids the need to use Arawata Terrace. However, the disadvantage of using a bus turn around is that it would likely involve removing a section of reserve land.

Figure 9: Bus tracking on Arawata Terrace

No tracking issues were found for Fernhill Road.

4.3 Hanley's Farm

Hanley Farm is currently served by route 4 which does a loop inside Hanley Farm via Jack Hanley Dr, Howden Dr and Bannister St. Tracking issues were encountered at all three of the intersections within the loop where buses would need to claim the whole road in order to make it around the 90 degree turns, as illustrated in Figure 10.

As the southern growth area develops it is envisaged that Howden Drive would be the primary north-south bus corridor from Homestead Bay and through the centre of Hanley Farm. North-south bus movements on Howden Drive do not present tracking issues as the road is wider and mostly straight. Therefore, in the interim period whilst the Southern Growth Area's road network is being built, medium sized buses may need to continue to be used. An interim route once Homestead Bay is built could be Māori Jack Rd – Howden Dr – Jack Hanley Dr once the road between Jack's Point and Hanley Farm is built.

Figure 10: Bus tracking through typical Hanley's Farm intersection

4.4 Jack's Point

The current bus route in Jack's Point goes via Māori Jack Road and Jack's Point Rise. Tracking issues were encountered on Jack's Point Rise which is a narrow road (approximately 6.5m wide) which involves a tight 90 degree turn to join the road. The narrowness of the road makes it difficult for buses to traverse if there is parked cars or vehicles travelling in the other direction. Furthermore, the narrowness of the road would make it infeasible to operate buses in both directions in the future instead of the one-way loop.

Figure 11: Bus tracking along Jack's Point Rise

A nuance of Queenstown's road network is that the roads within Jack's Point are private but public buses operate on some of these roads. Therefore, any modifications to the roads within Jack's Point to better accommodate buses would require the consent of the developer. However, as the Southern Growth corridor develops the primary bus corridor may shift to Homestead Bay therefore modifying the Jack's Point roads may not be required. Instead, it may be appropriate to operate medium sized buses (equivalent to the current bus fleet) as a secondary bus route that may serve Jack's Point.

4.5 Lake Hayes and Shotover Country

The suburbs of Lake Hayes and Shotover Country are served by bus route 5. Tracking of the roads used from the existing bus route identified that Onslow Road, Rere Road, Hope Avenue and Sylvan Street are narrower than desired for bus operations. These roads are approximately 9m wide which means that if cars are parked on both sides of the road that section of road is not wide enough for two-way traffic. Therefore, as bus frequencies increase in the future it may be necessary to manage on street parking through the use of broken yellow lines.

Furthermore, three intersections in Lake Hayes were identified as being a constraint for bus operations which are Sylvan St/ Howards Dr/ Luna Pl, Sylvan St/ Hope Ave and Rere Rd/ Hope Ave/ Acheron Pl. In these locations intersection modifications are proposed which could include widening the intersection and making the central island fully mountable.

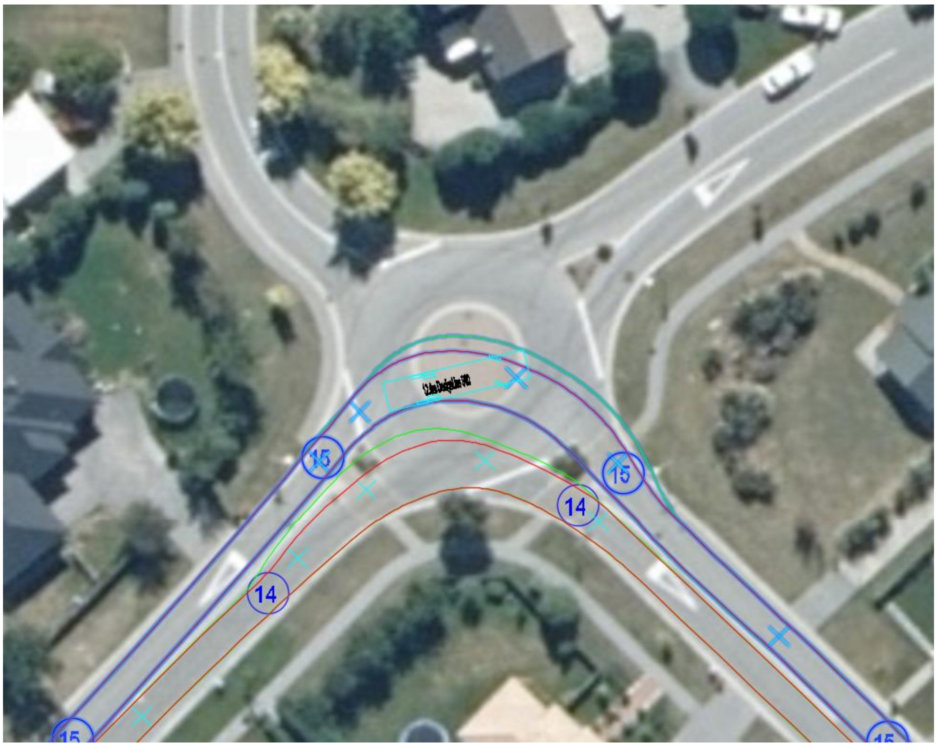


Figure 12: Bus tracking for Howards Dr/ Sylvan St/ Luna Pl

5 Public Transport Interchanges

5.1 Introduction

The scope of this section includes:

- Discussion of what a bus interchange is and what facilities may be required
- Determining the appropriate size of interchanges for Queenstown
- Identify potential the preferred interchange layout for Five Mile and Remarkables Park
- Explore options to amend the Frankton Hub and Stanley Street interchanges to accommodate articulated buses

The Queenstown Airport bus stop is also an interchange in the sense that passengers are transferring between transport modes (bus to plane). However, the airport stop has not been included in the scope of the Infrastructure Advisory paper as passengers would not transfer between public transport modes at this location. An interchange is also envisaged for Homestead Bay to enable passengers to transfer between bus and ferry. However, at the time of writing this advisory paper the Jack's Point ferry had not been confirmed and the location of the wharf unclear, therefore a Homestead Bay interchange was not explored further.

5.2 Interchanges

A public transport interchange is a location where passengers transfer between services to access destinations that are not directly on their bus route. Interchanges provide a comfortable space for passengers to wait between services and may also include customer information, retail and ticket kiosks. Interchanges have an important function in a connected public transport network as they can reduce the inconvenience of transferring between services. Interchanges can also have an important service delivery function as they may also include bus layovers and driver facilities.

Frankton Hub and Stanley Street are the primary interchanges in the current public transport network. The Frankton Hub is proposed to be expanded as part of the New Zealand Upgrade programme with more stopping points and improved facilities. The Stanley Street interchange is proposed to be upgraded as part of the town centre improvements with the changes including consolidating the bus stops, improved shelters and enhanced landscaping.

The proposed service patterns move away from a pulse timetable at Frankton Hub to a frequent connected network with multiple interchanges. The advantage of the connected network is that it enables more direct journeys and means that a smaller interchange at Frankton Hub is required. Five Mile and Remarkables Park were identified as suitable locations for interchanges as they are places where customers are wanting to access, they offer passive surveillance and are where bus services cross over. The Remarkables Park interchange becomes more important with the proposed Boyd Road Bridge as this would place Remarkables Park directly on the primary bus route for the Southern Growth corridor.

Figure 13: Current and proposed interchange locations

5.3 Interchange Layout Options

The type of interchange layout has implications for space requirements, attractiveness of the interchange for customers, operational efficiency and safety. The typical types of the interchange layouts are as follows:

- Sawtooth
- Angle
- Drive through
- Linear (parallel)

These are discussed further below.

5.3.1 Sawtooth (drive-in, drive-out)

A sawtooth platform design is when the kerb is angled to make it easier for buses to pull into the stopping point and to depart without needing to reverse. Sawtooth designs are more space efficient than linear platforms because they reduce the length of pull in and out space required. Sawtooth designs can be used for both standard and articulated buses with the length of the platform needing to be longer for articulated buses.

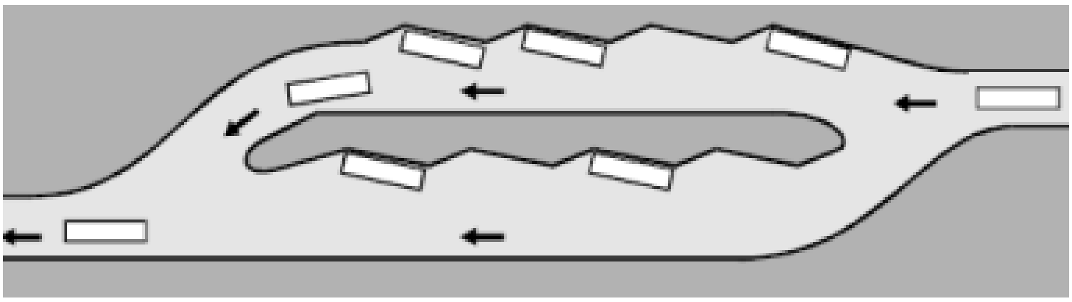


Figure 14: Typical off-street saw-tooth platform layout

5.3.2 Angle (drive-in, drive-out)

Angled platform design is when a bus drives into a parking space which is typically angled at 45 to 60 degrees with the bus then needing to reverse to leave the interchange. An example of an angled interchange design is the Christchurch Bus Interchange which is an off-road facility with an interchange building. Angled platform design is best suited to when buses are dwelling for long periods of time such as at a terminus as manoeuvring into and out of the stopping points is more difficult. It is typically necessary to exclude pedestrians, cyclists and other vehicles from the manoeuvring area for safety reasons.

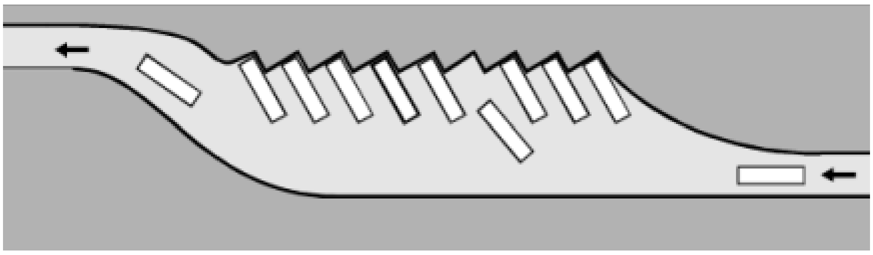


Figure 15: Typical off-street angle platform layout

5.3.3 Drive Through (platform island)

Drive through platform design places waiting passengers on islands with buses being able to drive up to the island and out the interchange without reversing. The advantages of island design are that it is more space efficient and spreads waiting passengers across a greater area. The disadvantages of island design are that it can create greater bus vs crossing pedestrian conflicts and often results in narrow waiting areas for passengers. An example of drive through design is Palmerston North central city interchange.

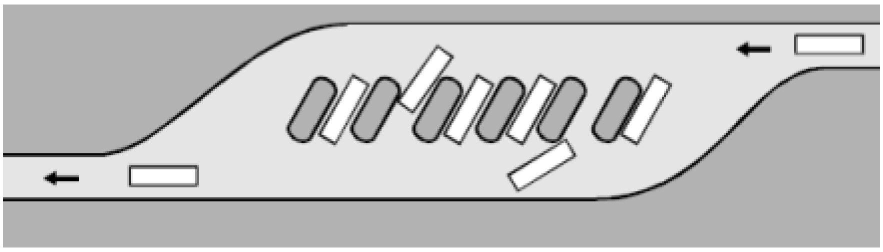


Figure 16: Typical drive-through platform layout

5.3.4 Linear (parallel platform)

A linear platform is when a bus pulls up to a straight kerb with passengers waiting on a single large platform. Linear platform design is the most common layout in New Zealand with examples being the Wellington bus interchange and bus stations on the Northern Busway in Auckland. The advantage of linear design is that it can be used on street and provides a kerbside platform that can be part of the footpath. A disadvantage of linear design is the longer pull in / pull out distances required which places stopping points further apart requiring a greater walk for passengers. If insufficient pull in / pull out space is provided, then buses would not be able to pull up parallel with the kerb which reduces the accessibility of the service.

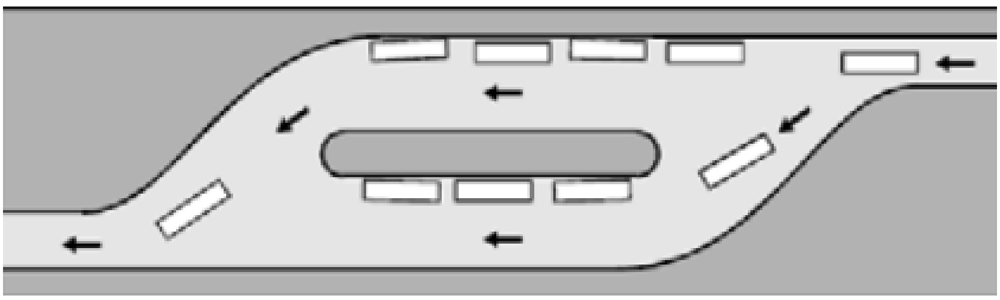


Figure 17: Typical off-street linear platform layout

5.4 Bus Stop Capacity

Bus stop capacity determines the overall capacity and efficiency of a bus route. If a bus stop does not have sufficient capacity to serve the volume of scheduled buses, this negatively impacts travel times and passenger experience. The capacity of a bus stop is determined by a variety of factors including:

- Dwell time which is the length of time the bus occupies a stop
- Presence and timing of nearby traffic signals
- Design of the bus stop and whether buses can overtake each other
- Number of bus bays provided

Figure 18 shows the capacity of bus stops away from traffic signals and Figure 19 shows that capacity of stops affected by nearby traffic signals. There are two ways to increase the capacity of a bus interchange which is to either increase the number of stops or reduce the dwell time.

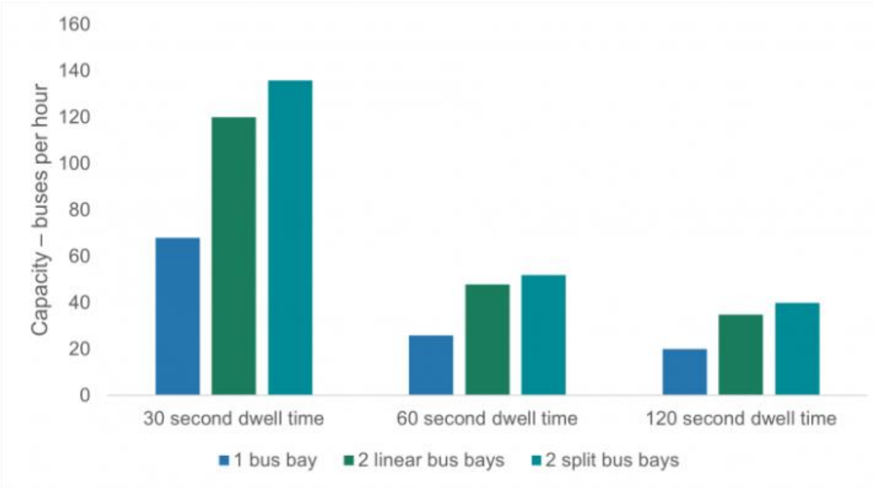


Figure 18: Capacity of bus stops away from traffic signals[1]

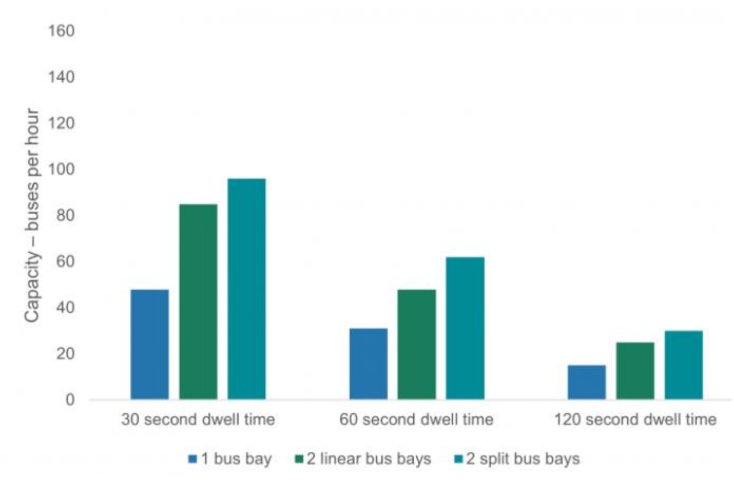


Figure 19: Capacity of near-side bus stops near traffic signals

[1] https://www.nzta.govt.nz/walking-cycling-and-public-transport/public-transport/public-transport-design-guidance/bus-stop/bus-stop-capacity/

5.5 Interchange Hierarchy

In order to provide an indication of the types of facilities required for the current and proposed interchanges in Queenstown, the following interchange hierarchy has been developed. This hierarchy draws on the Auckland Transport Public Transport Interchange Design Guidelines and has been amended to suit the Queenstown context. The table below provides a general classification of interchange types based on public transport services and surrounding land uses.

Table 2: Hierarchy of public transport interchanges

Classification	Services	Land use	Examples
Major interchange	• Several frequent services terminate or pass through • Inter-regional services may terminate	City centre or metropolitan centre	Britomart Station and New Lynn Station
Intermediate interchange	• One or more frequent services terminate or pass through • Standard frequency services terminate	Town centre	Otara Interchange and Constellation Station
Minor interchange	• A frequent service may pass through • Standard frequency services terminate or pass through	Local centres	

The typical facilities found at each class of the interchange are listed in Table 3. Reflecting the greater importance to the network, major interchanges have the highest level of facilities and may be contained within a landmark building. At the other end of the hierarchy minor interchange are enhanced paired bus stops which are often on road with standard bus shelters.

Table 3: Typical features of public transport interchanges based on hierarchy

Features	Major interchange	Intermediate interchange	Minor interchange
Shelter	Typically fully enclosed station building	Custom shelters which covers whole platform area	Standard bus stop shelters
Seating	Seating for at least 10 people per platform / stop	Seating for at least 10 people per platform / stop	Seating for at least 6 people per platform / stop
Security	High level of security required including on-site security	CCTV, lighting, emergency help point required	Lighting required; CCTV and emergency help point desirable
Service information	Staffed kiosk, ticket machines, real-time display, maps, and timetables required	Ticketing machines, real-time display, maps, timetables, required, possible staffed at peak times	Ticketing machines desirable; real-time display, maps and timetables required
Facilities	Toilets, baby change facilities, driver facilities required. Café and retail desirable	Toilets and drivers room required but could be adjacent to interchange	Toilets nearby desirable. Ideally close to other facilities

Accessibility	Fully accessible with station building with lifts if over multiple levels	Same platform boarding/ alighting where possible and pedestrian priority	On-street with pedestrian crossing aids

5.6 Queenstown Interchange Classification

Using the classification system above, the service levels and land use for each of the current and future interchange locations were assessed. It was found that the interchanges in Queenstown best fit into the intermediate interchange classification. Stanley Street would be at the upper end of an intermediate interchange as it serves a nationally important tourist destination. Whereas Frankton hub would be at the lower end of an intermediate interchange classification due to the poorer surrounding land use being a golf course and low density residential.

It is considered that high quality on street interchanges are appropriate for the interchanges within Queenstown and that an offline interchanges with station building would not be warranted. Because the interchanges would be on street it is considered that linear and sawtooth layout designs are most suitable. This is because linear and sawtooth can be used in mixed traffic situations and do not require the exclusion of pedestrians and cyclists from the manoeuvring area.

Table 4: Queenstown public transport interchange classification

Interchange location	Services	Land use	Classification
Stanley Street	• Multiple frequent bus routes passing through or terminating	• Town centre which is major tourist destination	Intermediate interchange
Frankton hub	• Multiple frequent bus routes passing through or terminating	• Local centre with nearby shops	Intermediate/ minor interchange
Five Mile	• Frequent bus route passing through • Standard frequency routes passing through	• Town centre which is major retail destination	Intermediate interchange
Remarkables Park	• Frequent bus route passing through • Standard frequency routes passing through	• Town centre with nearby high school	Intermediate interchange

5.7 Stanley Street

5.7.1 Current Situation

Stanley Street is the main bus interchange for Queenstown town centre. It is located on State Highway 6A and is 300m walk to the lake front. Three bus routes travel through or terminate at Stanley Street which are:

- Route 1 Sunshine Bay – Remarkables Shops (green route)
- Route 2 Arthurs Point – Arrowtown (blue route)
- Route 5 Queenstown – Lake Hayes (purple route)

Figure 20: Current Queenstown bus network through Stanley Street

Figure 21 shows that the stopping points within the Stanley Street interchange are spread out with stops A and B being paired and bus stop C is the next block over. Stop C is used by route 5 which terminates at Stanley Street and uses Camp Street to turn around. The current interchange has limited facilities (shelters, bike parking and rubbish bins) and has limited passive surveillance due to the frontage being a liquor centre and a play centre.

Regional and inter-city bus routes (serving locations including Wānaka, Dunedin, and Invercargill) use Athol Street for passenger drop-off and pick-up. Currently passengers must walk around the block to connect between regional and local services.

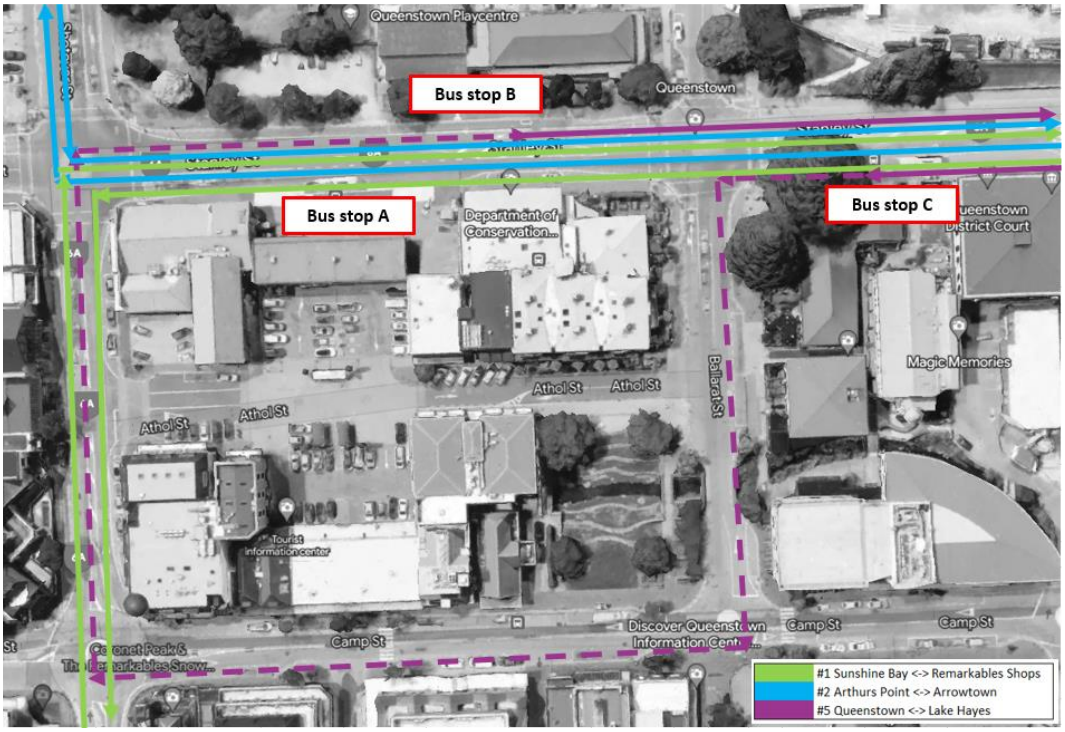


Figure 21: Current bus network operations through Stanley Street

5.7.2 Town Centre Upgrade

As part of the Queenstown arterials project there will be changes to the way in which buses and general traffic move around the town centre. The changes that are relevant to bus operations are that the stage 1 arterials project is expected to reduce (but not remove) general traffic volumes on

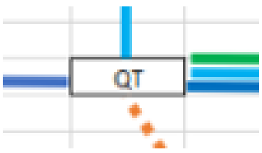
Stanley Street. Other changes are consolidating Stanley Street stopping points in a single block and widening Stanley Street to have a bus lane in each direction. There would also be a plaza between Athol Street and Stanley Street with new bus shelters and footpaths. The intersection of Camp Street and Ballarat Street would be closed to traffic and therefore terminating buses would need to turn around using Stanley Street.

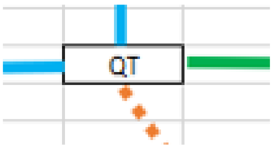
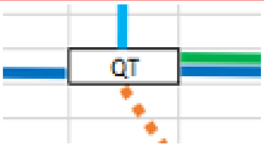
Figure 22: Early concept designs for Stanley Street and around

5.7.3 Service Patterns Town Centre Routing

Table 5 shows the different routing configurations for the short-listed service pattern options. The dashed line in the small network diagrams refers to the ferry service from Kelvin Heights. The Malaghans Road add-on affects the route that Arrowtown buses would take with buses entering the town centre from Gorge Road rather than Stanley Street.

Table 5: Bus network options through Stanley Street in 2039

Option	Services	No. peak buses (one-way)	Type of buses
Bus Max	Queenstown <-> Jack's Point	12	Articulated
	Arthurs Point <-> Arrowtown	6	Articulated
	Fernhill <-> Lake Hayes	6	Articulated
		24 Total	24 Articulated
Jack's Point Spine	Queenstown <-> Jack's Point	12	Articulated
	Fernhill <-> Arthur's Point	12	Standard

		24 Total	12 Articulated 12 Standard
Malaghans Road	Queenstown <-> Jack's Point	12	Articulated
	Arthurs Point <-> Arrowtown (via Malaghans Road)	4	Standard
	Fernhill <-> Lake Hayes	6	Articulated
		22 Total	18 Articulated 4 Standard

The following maps show the routes of buses which travel through the Stanley Street interchange in more detail. For the Bus Max option, buses from Arrowtown run through to Arthur's Point and buses from Lake Hayes run through to Fernhill. Only the buses from Jack's Point terminate at Stanley Street and would need to turn around in the town centre.

Figure 23: Bus network operations through Stanley Street for Bus Max option

For the Jack's Point Spine option, buses travelling from Arthur's Point to Fernhill must detour into Stanley Street via either Athol Street (which is currently one way) or Camp Street. This is demonstrated in Figure 24.

Figure 24: Bus network operations through Stanley Street for Jack's Point Spine option

With the Malaghans Road add-on buses would need to turn around via Frankton Road and Coronation Drive which is a 1km loop. This is due to the topography of the town centre which means that there are not roads suitable for buses closer to the interchange. At off peak times when the additional capacity bus articulated buses were not required then the Arrowtown to Queenstown bus could interline with the Queenstown to Jack's Point bus.

Figure 25: Bus network operations through Stanley Street for Malaghans Road option

5.7.4 Hub capacity

A maximum of 30 buses per hour on SH6A has been applied for the design of the service pattern options in order to avoid potential delays for buses. 30 buses per hour using articulated buses is sufficient to accommodate the forecast demand in 2053 with the target public transport mode share of 40%. With two bus stops in each direction the Stanley Street hub would have a theoretical capacity of 60 buses per hour per direction. Therefore, the capacity of the bus hub is unlikely to be exceeded based on the required number of buses along. However, this relies upon the town centre not being congested by general traffic. The proposed operation of the Queenstown strategic road network is that traffic would be held back at Frankton to enable SH6A and the town centre to operate with an acceptable level of service. Furthermore it is expected that parking prices in Queenstown town centre will continue to rise in the future which provides a strong disincentive to driving into the town centre.

5.7.5 Off-line solution

There is sufficient capacity both in terms of the public transport fleet and the bus hubs to accommodate the forecast number of passengers until 2053. However, this relies upon public transport receiving priority both within the town centre and in Frankton. It is not feasible to continue to hold back traffic in Frankton due to excessive queuing which impacts local access and buses within Frankton then an off-line public transport solution should be investigated. This could involve replacing a bus route with an off-line service so that there are fewer buses in the town centre.

5.7.6 Stanley Street Options

The starting point of the concepts is the town centre streetscape improvements designs. Two options were developed which are do minimum (option 1) and do more (option 2).

The key features of Option 1 are:

- Mid-block kerb build-out to enable shorter crossing distance for pedestrians at mid-block crossing and improve the visibility of the traffic signals
- Removal of left-turn lane from Stanley Street to Shotover Street, and building out the kerb to shorten the crossing distance for pedestrians
- Longer bus bay to allow for articulated buses
- Adjustments to kerbs to allow for bus tracking out of Ballarat Street

Figure 26: Stanley Street interchange, Design Option 1

Design Option 2 has a realigned kerbline to make it easier for buses to pull into and out of the bus stops. The alignment of the kerb was also changed to widen the footpath on the southern side of Stanley Street where there are more active building frontages.

Figure 27: Stanley Street interchange, Design Option 2

5.7.1 Bus Turn-around Options

Under all bus network options, the Queenstown / Jack's Point service terminates at Stanley Street. With the Malaghans Road option, the Queenstown / Arrowtown service also terminates at Stanley Street. Buses that have terminated must turn around to get to the starting bus stop on the other side of the road. With the consolidation of bus stops within a single block and the streetscapes improvement project it will no longer be possible to use Ballarat St – Camp St – Shotover St to turn around. There are a range of options to be considered to address this, as described in Table 6.

Table 6: Options for enabling Frankton buses to turn around at Stanley Street

Option	Advantages	Disadvantages
Extend terminus of Jack's Point bus route to One Mile	Serves western half of town centre and brings buses closer to Skyline Queenstown One Mile provides plenty of space for bus layover and driver facilities	Only feasible for the Jack's Point and Lake Hayes bus routes when arterials stage 3 in place to avoid buses being stuck in traffic on Shotover St and Beach St
Jack's Point buses turn around via Shotover St, Camp St and Memorial St and layover on Memorial St	Could be implemented during arterials stage 1 Places bus layover out of the interchange and in a location with no building frontages	Would require a reconfiguration of Memorial Street including potentially one-waying the street

5.7.2 Stanley Street Interchange Recommendations

The recommendations for the Stanley Street interchange are:

- Option 1 is the preferred concept as there will be a need for wider footpaths on the northern side of Stanley Street once Project Manawa is complete
- The location of the bus layover and turnaround are dependent on the Queenstown arterials project and would need an interim location until stage 3 of the project is complete
- An interim bus layover on Memorial Street should be investigated with buses turning around via Shotover St, Camp St and Memorial St
- If the Malaghans Road add on is used then the preferred way for buses to turn around is via Frankton Rd and Coronation Dr
- The preference would be to extend the Jack's Point bus route to One Mile once stage 3 of the Queenstown arterials is complete

5.8 Stanley Street Interim Layout

At the time of writing this report there was some uncertainty on the timing of the Queenstown town centre improvements of which the Stanley Street bus hub changes are a part of. Therefore, consideration was also given to interim layout that would enable the articulated buses to operate and provide an improved level of amenity for public transport customers. The starting point for the interim layout is the current bus stops on Stanley Street, buses would turn around using the existing route of Ballarat Street and Camp Street.

The recommended interim changes to the Stanley Street bus hub are as follows, drawings of the interim layout can be found in the appendix.

Stop A:

- Negotiate with the Super Liquor to close the western driveway and lengthen the bus stop box to 20m
- Relocate the bus shelter to the head of the stop
- Realign the kerb to have a in lane stop rather than a half indented bus stop

Stop B

- Lengthening the bus stop box to 40m to accommodate two buses
- Removing the kiosk, lengthening the hard stand area and installing additional shelters at the head of the stop
- Locating a layover space over the former playcentre driveway as the playcentre as relocated the Queenstown Primary School and the site is owned by QLDC
- Installed a portacom for driver facilities within the former playcentre parking lot

Stop C:

- Lengthening the bus stop box to 20m and shorten the coach parking stop outside the courthouse

5.9 Frankton Hub

In this section, we describe the Frankton bus hub and future plans. Only public services are considered. Tourist and commercial services are not considered but are acknowledged as users of this facility.

5.9.1 Current Situation

The current Frankton Hub is located on State Highway 6A with inbound (to Queenstown town centre) stops being off road and outbound stops being on the state highway. The current timetables are timed to have a pulse at Frankton where all bus routes arrive at the same time to facilitate transfers. Bus route 2 (Arthurs Point to Arrowtown) and route 5 (Lake Hayes to Queenstown) divert into the Frankton hub and use the off-road side of the interchange. Whereas bus routes which are travelling to Remarkables Park, Kelvin Heights and Jack's Point use the golf club side of the interchange. Customers wanting to transfer from Quail Rise to Queenstown, Jack's Point to Airport and Lake Hayes to Airport need to cross the state highway. There is a signalised pedestrian crossing south of the interchange however walking between the two halves of the interchange requires a 120m walk.

Figure 28: Current services using Frankton Hub

5.9.2 New Zealand Upgrade Programme planned changes

As part of the New Zealand Upgrade Programme (NZUP) Queenstown package the Frankton Hub is planned to be upgraded and expanded. The features from the proposed designs are:

- Increased number of bus bays with mixed sawtooth and linear layout
- Dedicated tourist operator bays
- Dedicated taxi stands
- Signalised access to the bus hub from SH6A
- New bus shelters and increased seating
- Facilities for bus drivers

Figure 29: Designs for Frankton Hub improvements

Because the New Zealand Upgrade Queenstown designs did not envisage articulated buses this advisory paper will investigate options to either amend the proposed design and or investigate alternative designs.

5.9.3 Proposed Off Road Frankton Hub

The long-term plan for the Frankton Hub is an off-road facility with station building on golf course land using an angled platform design. The existing bus hub would be converted to tour coach use with public buses using the new facility. The difficulties with an off-road interchange for Frankton Hub are as follows:

- Most buses would be travelling through and not terminating at the interchange which means that buses would be dwelling for a short period of time
- The detour required to access the interchange and manoeuvre required to access the platform would add delay to bus services
- Surrounding land uses would not warrant a major interchange unless significant redevelopment was to occur

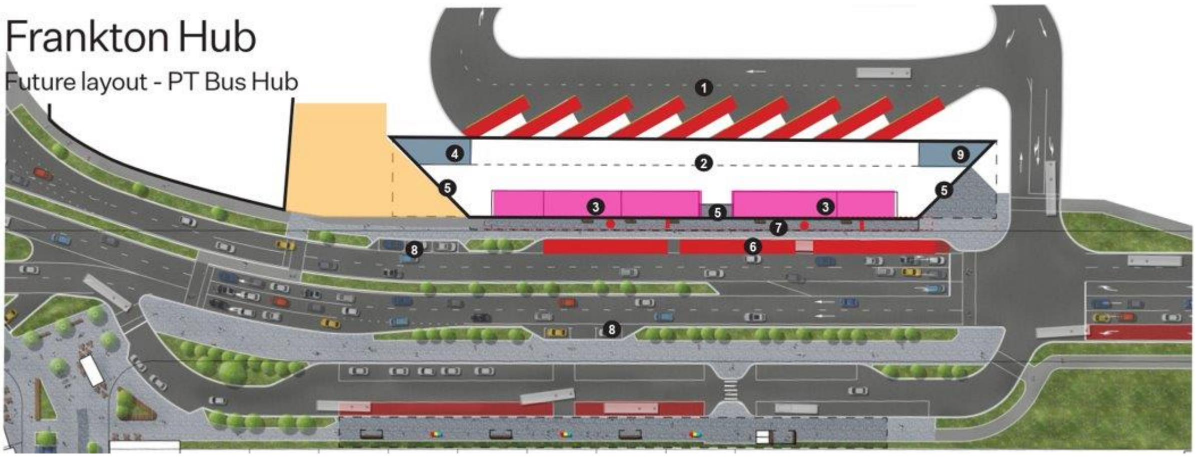
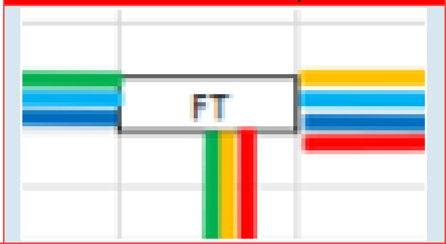


Figure 30: Concept for long term layout of Frankton Hub

5.9.4 Proposed Service Levels

The number of buses that would travel through the Frankton bus hub in the future and the direction which they are travelling in depends on the service pattern option which is chosen. Table 7 below summarises the frequency in 2053 and type of buses for each of the short-listed service pattern options. Bus Max has the highest frequency of services through the Frankton Hub due to the addition of the Frankton loop service. Jack's Point spine which results in services from Lake Hayes terminating at Frankton Hub and would not have the Frankton loop service.

Table 7: Bus network options through Frankton Hub

Option	Services	No. peak buses (one-way)	Type of buses
Bus Max	Kelvin Heights <-> Quail Rise	4	Standard
	Arthurs Point <-> Arrowtown	8	Articulated
	Fernhill <-> Lake Hayes	6	Articulated
	Queenstown <-> Jack's Point	15	Articulated
	Frankton Loop	4	Standard
		**37 Total**	**36 Articulated 8 Standard**
Jack's Point Spine	Queenstown <-> Jack's Point	20	Articulated
	Frankton <-> Arrowtown	6	Standard
	Frankton <-> Lake Hayes	6	Standard
		**32 Total**	**12 Articulated 20 Standard**

The estimated number of bus stops required to accommodate the future service levels at Frankton Hub is two stopping points per direction. The proposed designs have three stopping points per direction and therefore one of the stopping points could be used a layover for terminating services.

The routing for the Bus Max and Jack's Point Spine service pattern options are shown in the diagrams below. The Arrowtown and Lake Hayes buses would divert into Frankton Hub as they currently do. Services going to Jack's Point and Remarkables Park would continue to stop at the golf course side of the interchange.

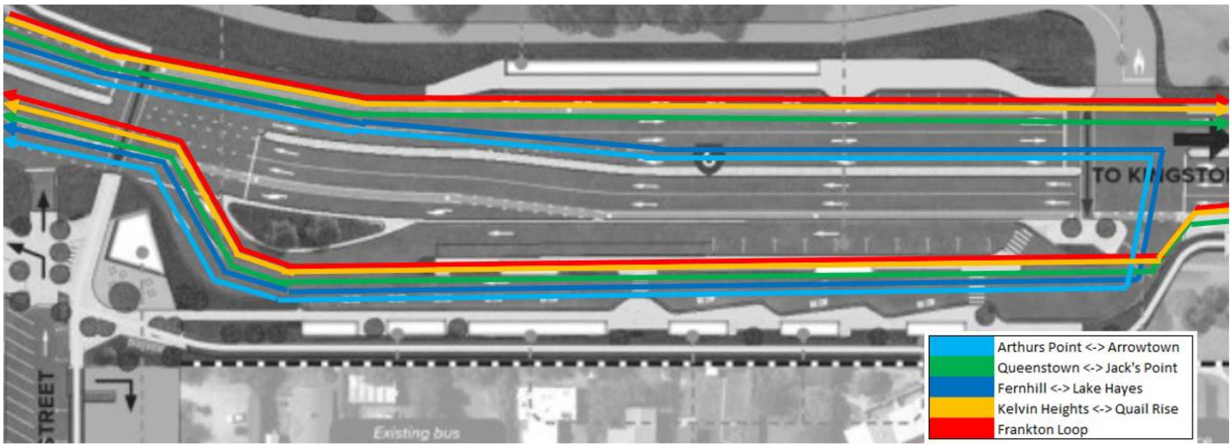


Figure 31: Bus Max network through Frankton Hub

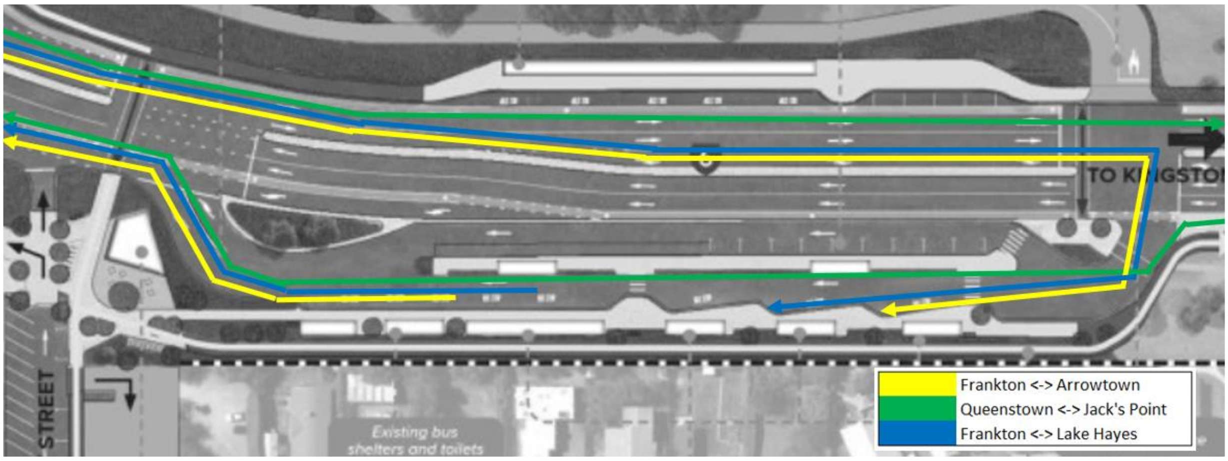


Figure 32: Bus network through Frankton Hub for other options

5.9.4.1 Design Option 1

Design option 1 is the minimum changes required to accommodate articulated buses and some simple improvements to the design. The proposed changes are:

- Moving the southbound bus stop closer to the pedestrian crossing by relocating car parking thereby shortening the walk distance for transferring passengers
- Sawtooth bus stop designs altered to be 20m long platforms that would be sufficient to accommodate articulated buses
- Separate access with bus only access to the bus hub, and public access to the drop-off car parks. This will avoid conflict between buses and general traffic and shortens the pedestrian crossing distance.

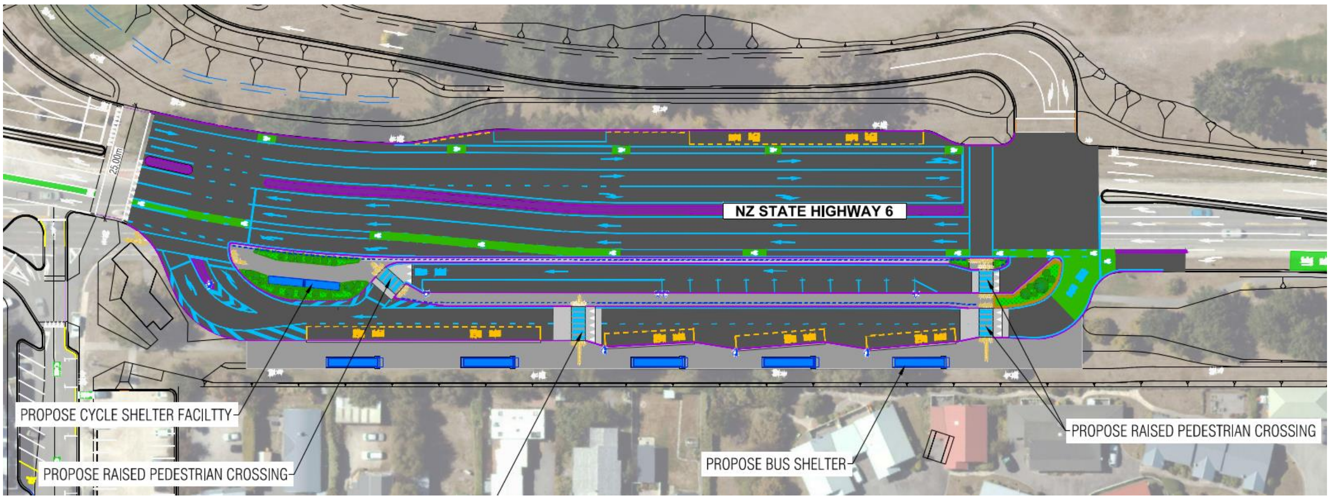


Figure 33: Frankton bus hub design Option 1

5.9.4.2 Design Option 2

Design Option 2 includes the following changes from the notice of requirement design:

- Switching the bus stops to the island and the pickup/ drop off parking to the kerbside to reduce conflicts between waiting pedestrians and cyclists using the shared path
- Changing all the bus stops to 20m long sawtooth platforms that would be more accessible for tour coaches
- Removal of the on-road cycle lanes to provide a right-turn bus lane into the bus hub.

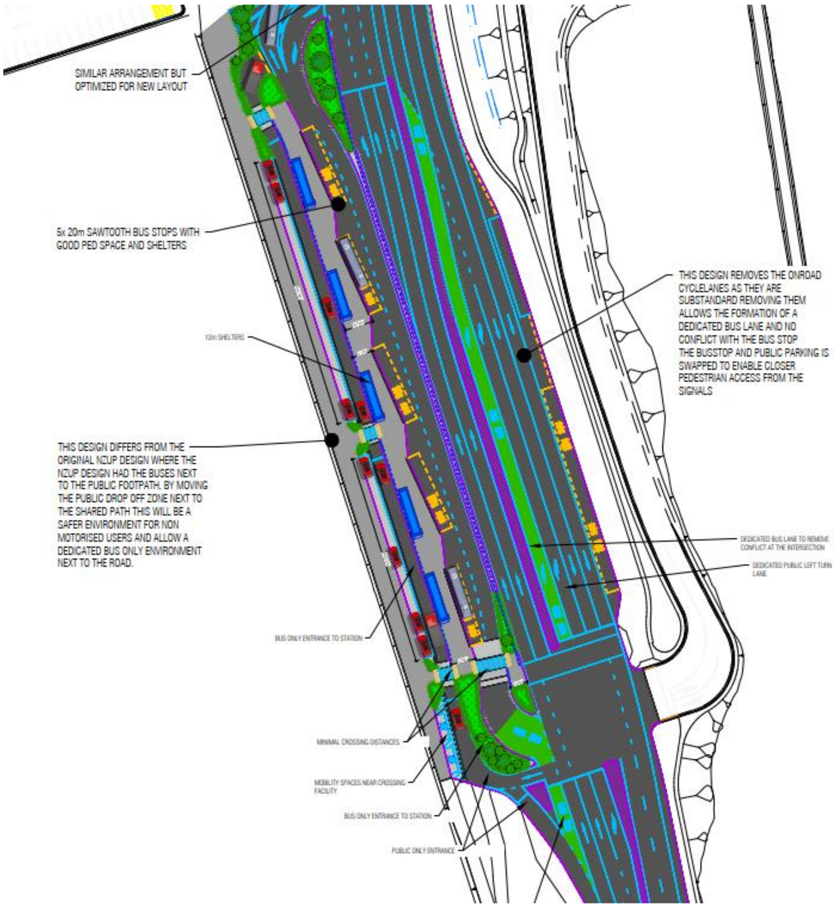


Figure 34: Frankton bus hub design Option 2

5.9.4.3 Design Option 3

Design option 3 is the greatest change from the New Zealand Upgrade design as the platform layout would change to an island. The features of the design option 3 are:

- Buses circle around the island platform in the counterclockwise direction
- Six stopping points within the interchange each long enough for an articulated bus
- Buses travelling to Remarkables Park and Jack's Point would go into the interchange rather than stop on the state highway
- A single signalised intersection on the state highway for buses to enter and egress, vehicles departing the drop off area would be required to turn left

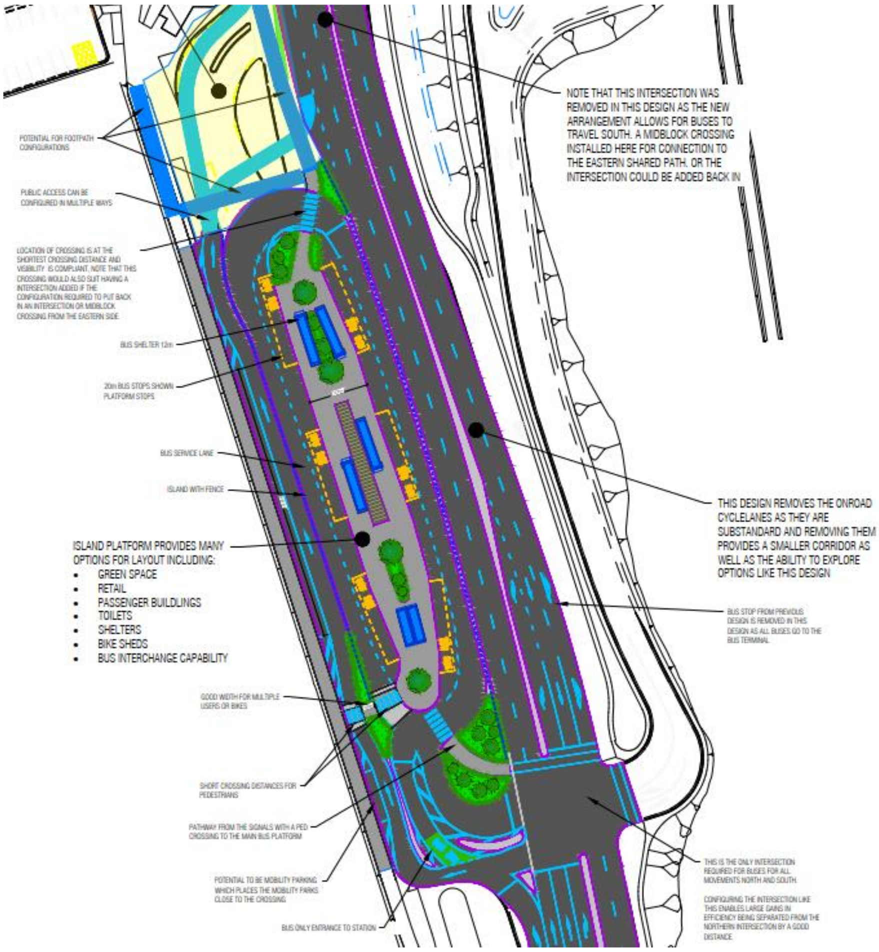


Figure 35: Frankton bus hub design Option 3

5.9.5 Frankton Hub Recommendations

The following recommendations for Frankton bus hub have been informed by discussions with Way to Go:

- That design option 1 (do minimum changes from New Zealand Upgrade) is preferred. This is because keeping the bus shelters along the property line is desirable to reduce noise for neighbouring properties.
- That the bus stops on State Highway 6 are moved closer to the pedestrian crossing to reduce the walking distance
- That an off-line bus interchange is not required in the foreseeable future because the interim design has enough capacity until 2053

The design modifications to accommodate articulated buses are relatively minor. They should be incorporated into the NZUP designs now rather than waiting until a later date.

5.9.6 Tourist coaches

As part of the NZUP design tourist coaches would use the front five stops within the interchange with the back three stops being for public buses. The proposed modifications to the NZUP design keeps this proposal unchanged and therefore there would be designated space within the interchange for tourist coaches. An assessment of future tourist coach demand has not been completed so at some point in the future it may be necessary to find additional space for tourist coaches elsewhere within the road network.

5.10 Five Mile and Remarkables Park Interchange Locations

Five Mile and Remarkables Park are identified as natural interchange points within the service pattern options. This is because both Five Mile and Remarkables Park are important destinations with retail, services, hotels and a high school. Further, transfers at these locations would be used by passengers wanting to travel around Frankton and for passengers from Quail Rise and Kelvin Heights to travel to Queenstown.

Because the current bus stops at these locations are not suitable for the proposed service pattern options, the first step in the interchange assessment was to identify the preferred location for an interchange. In order to inform the location assessment the following nine criteria have been developed which includes customer considerations, proximity to destinations and project feasibility.

Table 8: MCA criteria description

Criteria	Description	Relevant Investment Objectives (IO) or Critical Success Factors (CSF)
Distance between bus stops	The longest distance between bus stops for transferring bus stop passengers. Scoring is based on passengers crossing at signalised crossings, pedestrian crossings, or pedestrian refuges.	IO1: Increase public transport patronage IO3: Improve access to economic and social destinations
Maximum number of lanes to cross	The maximum number of lanes that transferring passengers must cross to get from one bus stop to another.	IO1: Increase public transport patronage IO3: Improve access to economic and social destinations
Traffic volume of roads to cross	The total traffic volume of roads that transferring passengers must cross to get from one bus stop to another.	IO1: Increase public transport patronage IO3: Improve access to economic and social destinations
Distance to nearest facility	Measure of accessibility to nearby services and facilities. Facility is any public facility such as a shop/mall, café, library, service provider, etc. Of all the interchange bus stops, the bus stop with the furthest distance between it and its nearest facility is the one used for scoring.	IO1: Increase public transport patronage IO3: Improve access to economic and social destinations

Availability of kerbside space for bus to stop	Length of space available for kerbside stop requiring space for an articulated bus, a standard-length bus, and entry/exit tapers as per Tables 1 and 2. Entry/exit tapers can be over driveways. In some locations, on multi-lane corridors, an in-lane bus stop is recommended, which does not require the length for entry/exit tapers. Score reflects the bus stop with least amount of space.	CSF2: Technical feasibility
Availability of space to provide shelter	The physical space available to provide a 2-3m deep shelter clear of the footpath. Score reflects the bus stop with least amount of space.	CSF2: Technical feasibility
Property purchase or encroachment requirements	Degree to which property purchase or encroachment agreements are required to provide sufficient space for shelters.	CSF2: Technical feasibility
Complexity of delivering civil works	Degree to which civil works are required to implement interchanges bus stops.	CSF2: Technical feasibility

The scoring matrix for these criteria are in the following table. A seven-point scoring matrix has been used.

Table 9: Scoring matrix for multi-criteria assessment

Criteria	-3	-2	-1	0	1	2	3
Distance between interchange stops	>200m	150-200m	100-150m	75-100m	50-75m	25-50m	<25 metres
Max no lanes to cross	>5	5	4	3	2	1	None
Total traffic volume of roads to cross	>12,000 vpd	9-12,000 vpd	7-9,000 vpd	5-7,000 vpd	3-5,000 vpd	1-3,000vpd	<1,000vpd
Distance to nearest facility (café, shop, library, etc) for furthest away bus stop	>200m	150-200m	100-150m	75-100m	50-75m	25-50m	<25 metres
Availability of kerb-side space for bus to stop (at shortest bus stop)	<15m kerb-side space available	15-20m kerb-side space for standard bus (no tapers)	20-39m kerb-side space for articulated (no tapers)	39-44m kerb-side space for standard + tapers	44-54m kerb-side space for articulated + tapers	54-59m kerb-side space for standard + standard + tapers	>59m kerb-side space available for articulated + standard + tapers
Availability of space to provide shelter (at stop with least amount of space)	Insufficient space to provide space without demolishing buildings		<2m width clear of footpath		2-2.5m width clear of footpath	2.5-3m width (clear of footpath)	>3m width (clear of footpath), ample space available at bus stop
Property purchase or encroachment agreement required	Major project purchase or encroachment required			Some property purchase or encroachment required			No property purchase or encroachment required for any bus stops
Complexity of delivering works / amount of civil works required (new shelter exempted)	Highly complex - requires relocating services and realigning road		Higher degree of complexity. Kerb and channel realignment + other works required.	Some degree of complexity. Kerb and channel realignment required.	Simple project which could be delivered with limited civil works	Simple project which could be delivered with no civil works, lines and markings only	Lines and markings already in place

5.11 Five Mile Interchange

5.11.1 Current Situation

Two bus routes currently serve Five Mile which are route 3 Quail Rise to Kelvin Heights and route 5 Lake Hayes to Queenstown. Both of these buses divert off SH6 via Hawthorne Dr, Shearers Drive and Grant Road. Route 2 Arrowtown to Arthur's Point stays on SH6 and runs past Five Mile but there are no bus stops on the state highway.

The current bus stops in Five Mile are split stops with the inbound stop being near the intersection of SH6 / Grant Rd and the outbound stop being near Grant Rd / Central St. A challenge with the current layout is the distance between the stops which makes it more difficult for those less familiar with the network to navigate. Due to the narrow footpath the bus shelter for the inbound stop is at the tail of the stop instead of the head which means that passengers tend to wait under the shop canopy.

5.11.2 Proposed Service Changes

Table 10 shows how route changes through Five Mile vary depending on each short-listed service pattern option. It is proposed the Kelvin Heights – Quail Rise, Fernhill – Lake Hayes, Frankton Loop and Frankton – Arrowtown bus routes would divert into Five Mile. The Arrowtown to Arthur's Point bus is proposed to continue to run direct via SH6 and not stop at Five Mile as this bus route is longer and more prone to delays.

Table 10: Bus routes serving Five Mile under different network options

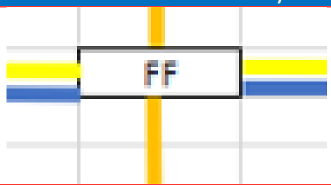
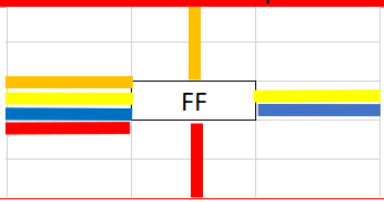
Option	Services	No. peak buses (one-way)	Type of buses
Bus Max	Kelvin Heights <-> Quail Rise	4	Standard
	Fernhill <-> Lake Hayes	6	Articulated
	Frankton Loop	4	Standard
		14 Total	**6 Articulated 8 Standard**
Jack's Point Spine	Kelvin Heights <-> Quail Rise	4	Standard
	Frankton <-> Arrowtown	6	Standard
	Frankton <-> Lake Hayes	6	Standard
		16 Total	**16 Standard**
Bus Max with Malaghans Road	Kelvin Heights <-> Quail Rise	4	Standard
	Frankton <-> Arrowtown	6	Standard
	Fernhill <-> Lake Hayes	6	Articulated
	Frankton Loop	4	Standard
		20 Total	**6 Articulated 14 Standard**

Figure 36 to Figure 38 show the proposed routes through Five Mile in more detail. All routes that go into Five Mile use Shearers Drive because Central Street is not suitable for bus services.

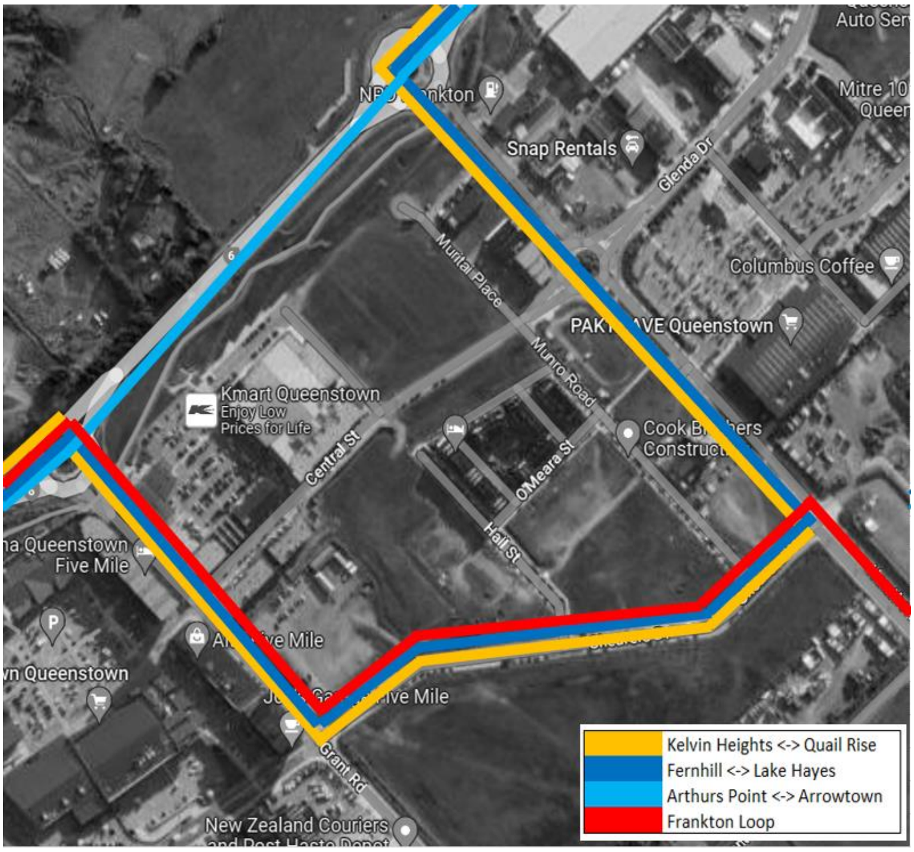


Figure 36: Proposed bus routes through Five Mile – Bus Max option

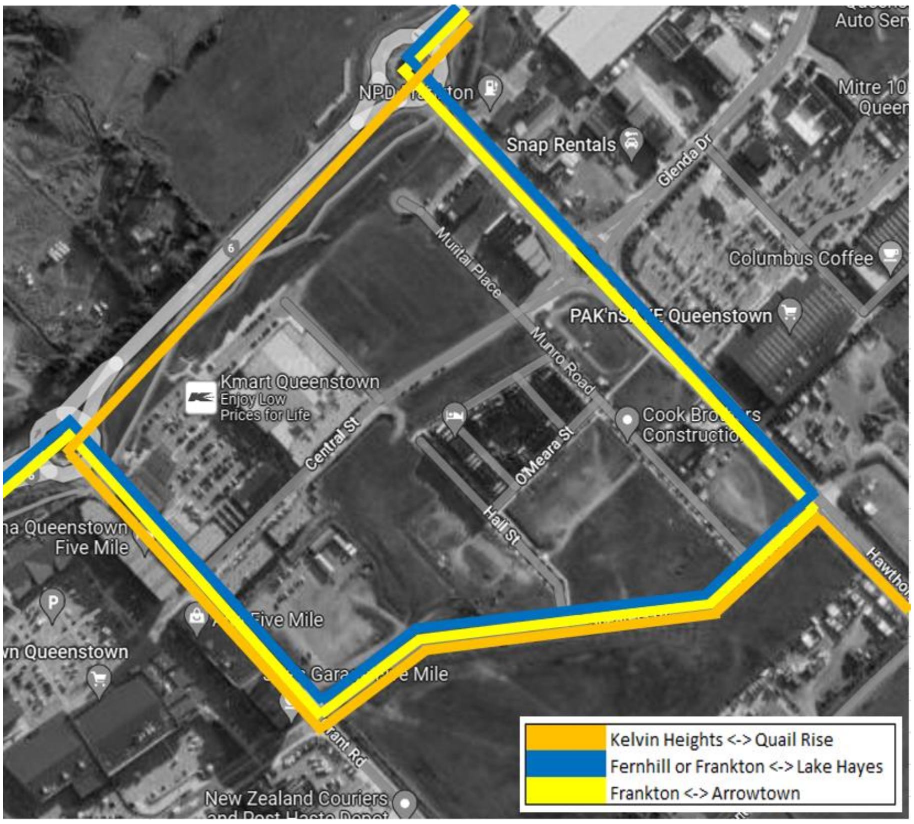


Figure 37: Proposed bus routes through Five Mile – Jack's Point Spine option

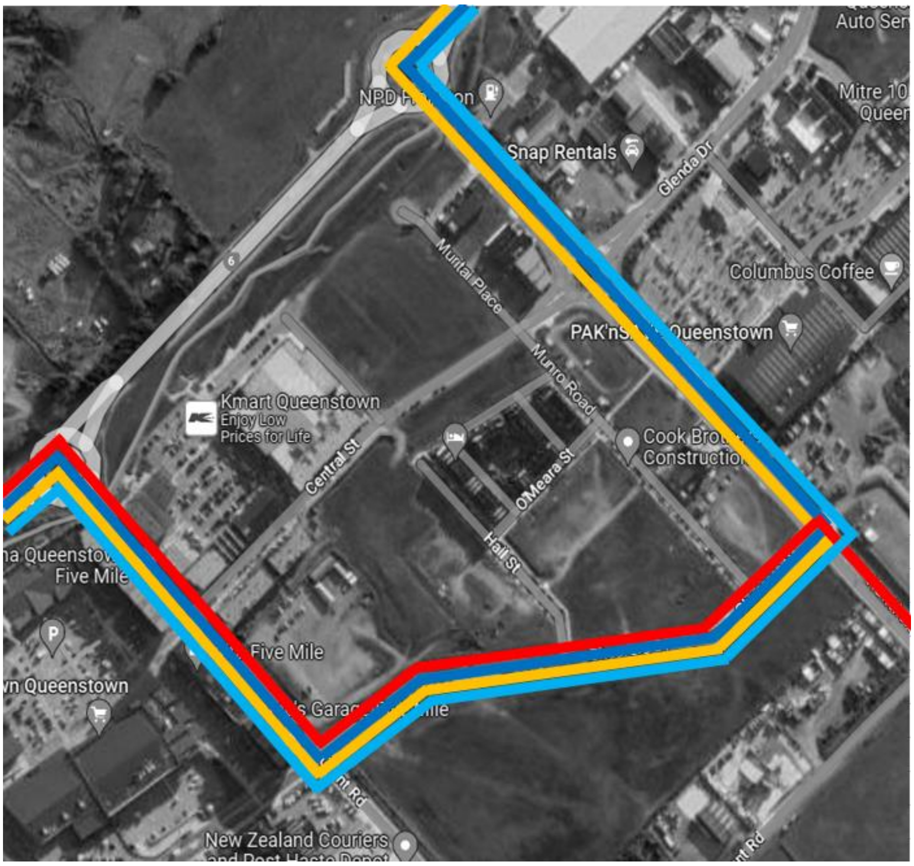


Figure 38: Proposed bus routes through Five Mile – Bus Max with Malaghans Road

5.11.1 Interchange Requirements

The requirements for a Five Mile bus interchange are as follows:

- Pairing of bus stops so that passengers can easily change between buses
- Bus stops being close to the shopping centre so that customers with bags do not need to walk far
- Bus shelters in both directions which are located near the head of the stop
- Enough footpath space for bus customers to wait without blocking people walking around the shopping centre
- Lighting of the bus shelter and stop
- Bus stops long enough to accommodate articulated buses

Assuming an average 60 second dwell time and the bus stop being located near-side to traffic signals the capacity of one stop is 30 buses per hour. Therefore, one bus stop per direction would have enough capacity for the planned frequency of services in 2039. No bus routes would terminate at this location and therefore no bus layover or driver facilities are required.

5.11.2 Layout options

There are four options for interchange bus stop locations for Five Mile with this assessment assumes that the land parcels along Shearers Drive are developed:

- Option 1: State Highway 6, near Grant Road
- Option 2: Grant Road
    - Option 2a: Northbound bus stop between Central Street and Shearers Drive
    - Option 2b: Northbound bus stop between SH6 and Central Street
- Option 3: Shearers Drive
- Option 4: Hawthorne Drive

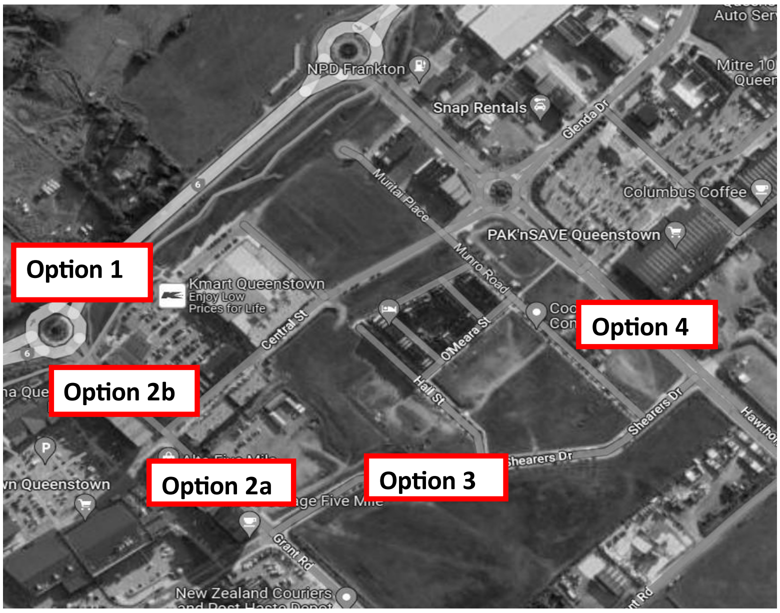


Figure 39: Five Mile interchange bus stop location options

5.11.2.1 Option 1: SH6

As part of the NZUP Queenstown Package the intersections along SH6 are to be signalised with a bus lane installed in both directions. This would provide the opportunity to implement bus stops on SH6 with passengers crossing at the lights. Indicative bus stop locations are shown below, the final location would be determined by the design for the intersection upgrade to achieve the best level of connectivity and operation efficiency.

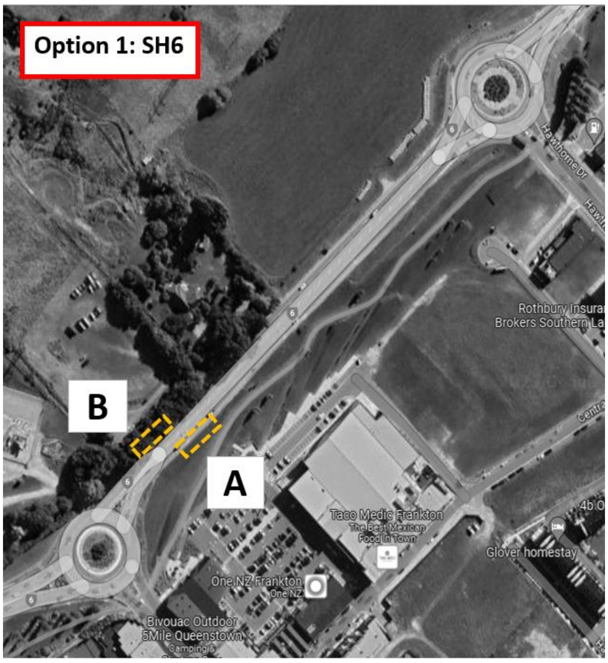


Figure 40: Five Mile bus interchange location Option 1

Table 11: Five Mile Option 1 bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	None	Bus stops in bus lane	Hawthorne Drive shops	Provision of shelter and connecting footpath Installed intersections by others
B	None	Bus stops in bus lane	Hawthorne Drive shops	Provision of shelter and connecting footpath Installed intersections by others

Advantages

- Ample space to physically provide shelters and waiting area
- Enables the Arrowtown and Lake Hayes bus routes to operate more efficiently and enhances journey reliability by avoiding circuitous route through Five Mile.
- Utilises NZUP bus lanes on SH6
- Within approximately 200-300m walking distance to key activities
- Accessible to the planned mixed use development north of the highway

Disadvantages

- Probable long wait times (>60 seconds) at signalised intersection
- Safety issue if passengers cross directly, away from traffic lights to access bus stop on other side
- Unpleasant waiting area along the side of a state highway, however could be improved with urban design

5.11.2.2 Option 2: Grant Road

This option involves pairing the bus stops on Grant Road and upgrading the facilities in order to form an on-road interchange. The recently installed outbound bus stop on Grant Road is considered to be in a good location as it is close to the centre of the shopping area. The outbound bus stop also has amble space for a bus shelter with 7m from kerb to boundary and no current building frontages.

There are two locations for the northbound bus stop in order to pair it with the outbound bus stop which have considered as sub-options. The first option is to locate the stop nearside on Grant Road south of Central St immediately across from the outbound stop. This would involve removing on-street parking and shortening the left turn lane. The second option is to locate the stop on the far-side of Central Street 25m further south than its current location. This would involve switching the parking and the bus bay so that the bus stop is closer to the supermarket. There are existing shop verandas so a bus shelter may not be required and instead seating could be provided between the shop entrances.

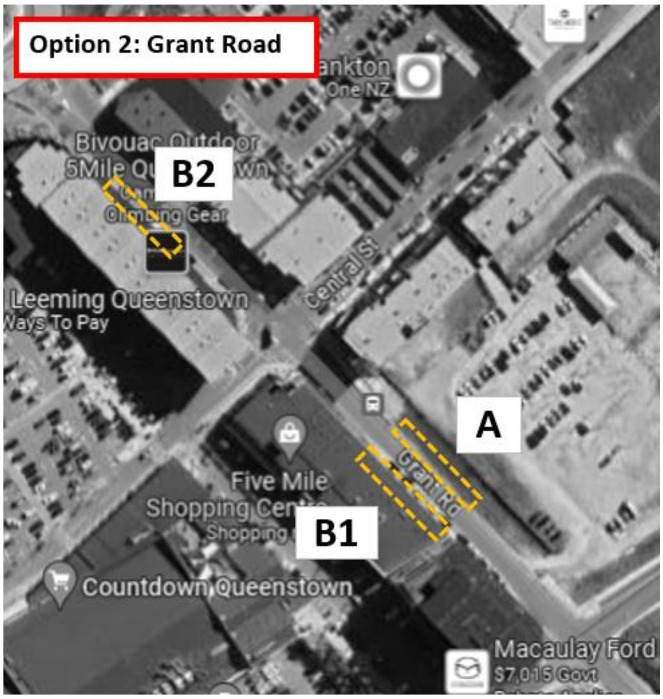


Figure 41: Five Mile bus interchange location Options 2a and 2b, Grant Road

Table 12: Five Mile Option 2a and 2b bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	In lane	12m	In the middle of the shopping centre	Provision of shelter Lengthened bus stop for articulated buses
B1	None	NA	In the middle of the shopping centre	Removal of parking to provide space for bus stop. Shelter to come from existing verandas Seats and bus stop information
B2	Kerbside	50m (exit taper leads into the intersection)	In the middle of the shopping centre	Benches and bus stop information under veranda. Removal of parking to allowing lengthening of bus stop

Advantages

- Short walking distances to the Countdown, Warehouse and Rebel Sport
- Pedestrian friendly environment for transferring passengers
- Able to use intersection for pull in taper
- Places public transport in a more prominent location

Disadvantages

- Insufficient space for bus shelter and may instead use shop verandas and seating
- Requires changes to on-street parking although the net reduction in parking for a stop far side of Central Street is minimal

5.11.2.3 Option 3: Shearers Drive

This option would involve upgrading the existing bus stops on Shearers Drive with bus shelters and a pedestrian crossing. The area along Shearers Drive is currently undeveloped and the zoning is mixed commercial and residential. At the time of writing this paper it was unclear what type of businesses would locate to Shearers Drive and whether they would provide active building frontages.

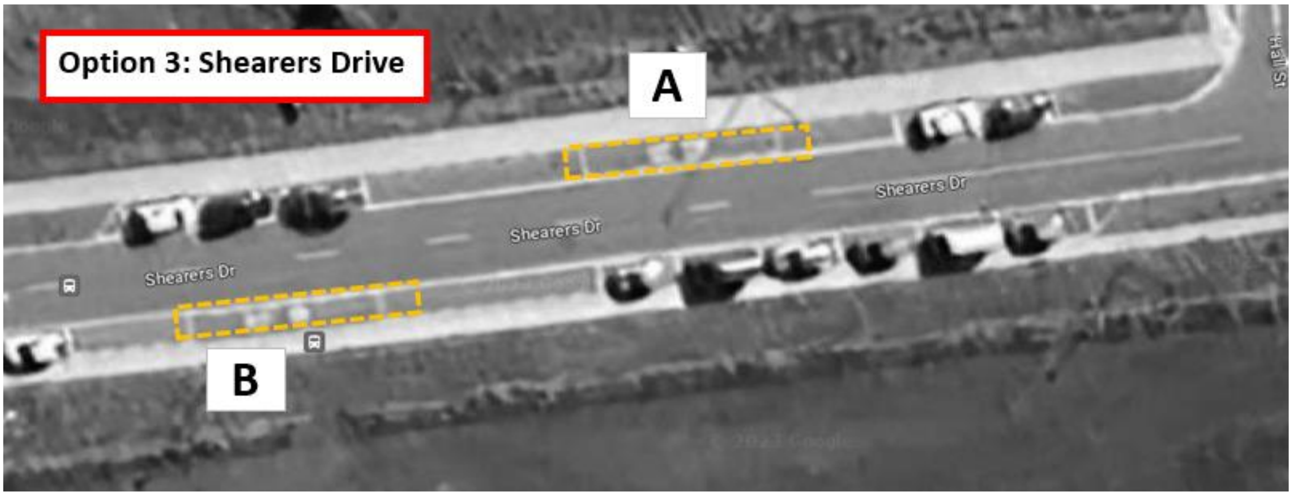


Figure 42: Five Mile bus interchange location Option 3, Shearers Drive

Table 13: Five Mile Option 5 bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	Kerbside	39m	Undeveloped sites	Provision of shelter Parking removal to allow lengthening of kerbside bus stops Pedestrian crossing
B	Kerbside	39m	Undeveloped sites	Provision of shelter Parking removal to allow lengthening of kerbside bus stops Pedestrian crossing

Advantages

- Sufficient room for bus stops and shelters
- Currently a low-traffic road, so relatively easy for passengers to cross the road

Disadvantages

- A long distance from shops or services
- Unclear what form the development along Shearers Road would take

5.11.2.4 Option 4: Hawthorne Drive

This option makes use of existing indented bus bays on Hawthorne Drive and would add bus shelters and upgrade the pedestrian crossing. Since this location is further north of Shearers Drive buses from Kelvin Heights and the Frankton loop would not be able to access Five Mile.

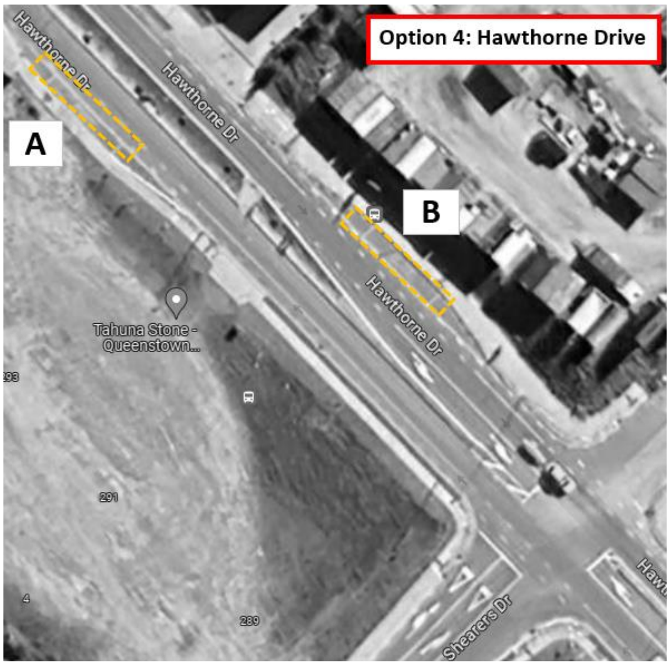


Figure 43: Five Mile bus interchange location Option 4, Hawthorne Drive

Table 14: Five Mile Option 4 bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	Indented	33m	Low-density retail including Pak n Save supermarket	Provision of shelter. Lengthen bus bays to accommodate articulated buses Upgrade pedestrian crossing.
B	Indented	31m	Low-density retail including Pak n Save supermarket	Provision of shelter. Lengthen bus bays to accommodate articulated buses

Advantages

- Makes use of existing bus stops

Disadvantages

- Busy road for passengers to cross
- Low-density retail with limited facilities within easy walking distance
- Is located on a shared path which presents a challenge for cycle/pedestrian interactions
- Buses from Kelvin Heights and the Frankton loop would not be able to access Five Mile

5.11.3 MCA and preferred option

The preferred location for a bus hub is SH6 near the intersection with Grant Road. This location makes best use of the NZUP investment in bus lanes on SH6 and the intersection upgrade at SH6 / Grant Road. This location also enhances journey reliability and offers a more direct service, avoiding potential constraints associated with navigating through the Five Mile development, including constraints related to design vehicle widths on Shearers Drive.

A secondary option if SH6 is not feasible is Option 2b (Grant Road far side of the intersection with Central St). This is because Grant Road has a central location close to shops and services and would make use of existing infrastructure.

Table 15: MCA scoring for Five Mile interchange locations

Criteria	Option 1. SH6 near Grant Road	Option 2a. Grant Rd nearside of intersection	Option 2b. Grant Rd far side of intersection	Option 3. Shearer's Drive	Option 4. Hawthorne Drive
Distance b/w interchange stops	1	3	3	1	0
Max no lanes to cross	1	1	1	1	1
Total traffic volume of roads to cross	-2	-1	-1	2	-3
Distance to nearest facility (café, shop, library, etc) for furthest away bus stop	2	3	3	-3	-1
Availability of kerb-side space for bus to stop (at shortest bus stop)	3	3	3	3	0
Availability of space to provide shelter (at stop with least amount of space)	3	-1	-1	1	1
Property purchase or encroachment agreement required	3	3	3	3	3
Complexity of delivering works / amount of civil works required (new shelter exempted)	2	-1	1	1	0
Unweighted score	13	10	12	9	1
Unweighted ranking	1	3	2	4	5

5.12 Remarkables Park Interchange

5.12.1 Current Situation

Two bus routes currently serve Remarkables Park retail precinct which are route 1 Sunshine Bay to Remarkables Shops and route 3 Kelvin Heights to Frankton. Both routes arrive at Remarkables Park shops by doing a one-way loop along Hawthorne Drive, Red Oaks Drive, and Golden Elm Lane. The destinations in Remarkables Park are reasonably spread out with a high school, library and hotels being around 400m from the supermarket, medical centre and retail stores.

Figure 44: Current bus network through Remarkables Park

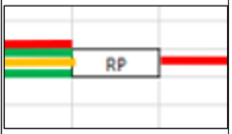
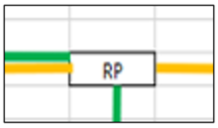
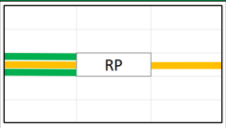
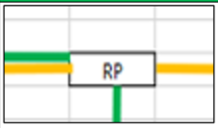
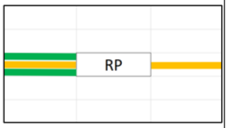
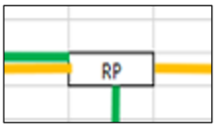
An advantage of the current way one loop is that buses are able to stop in the middle of the town centre which reduces walking distances. However, the one-way loop will make it harder to serve the rest of Hawthorne Drive as the lots along this road develop in the future.

Figure 45: Current bus stop at Remarkables Park where route 1 route terminates

5.12.2 Possible Changes

Table 16 documents the frequency and direction of travel for the bus services in each of the short-listed service pattern options. The inclusion of the public transport bridge would mean that buses from the Southern Growth area would travel along Red Oaks Drive. Another change is that all the options include a bus route around the back of Hawthorne Drive which is either the Kelvin Heights to Quail Rise or Frankton loop service.

Table 16: Bus network through Remarkables Park for each option

	No Bridge	New Bridge	No. peak buses (one-way)	Type of buses	Difference between bridge & no bridge sub-options
Bus Max	Kelvin Heights <-> Quail Rise	Kelvin Heights <-> Quail Rise	4	Standard	With a new bridge, Frankton Loop service not required. Kelvin Heights <-> Quail Rise changes alignment to go behind airport
	Queenstown <-> Jack's Point	Queenstown <-> Jack's Point	12	Articulated	
	Frankton Loop		4	Standard	
			20	12 Articulated 8 Standard (only 4 with bridge option)	
Jack's Point Spine	Kelvin Heights <-> Quail Rise	Kelvin Heights <-> Quail Rise	4	Standard	Queenstown <-> Jack's Point service re-aligned to be along Red Oaks Drive
	Queenstown <-> Jack's Point	Queenstown <-> Jack's Point	12	Articulated	
			16	12 Articulated 4 Standard	
Malaghans	Kelvin Heights <-> Quail Rise	Kelvin Heights <-> Quail Rise	4	Standard	Queenstown <-> Jack's Point service re-aligned to be along Red Oaks Drive
	Queenstown <-> Jack's Point	Queenstown <-> Jack's Point	10	Articulated	
			14	10 Articulated 4 Standard	

5.12.3 Interchange Function and Requirements

Remarkables Park is envisaged as an interchange as it is the point where passengers from Kelvin Heights could transfer to get to Queenstown and southern growth area passengers transfer to travel to Five Mile.

Assuming an average 60 second dwell time, one bus-bay will be enough to serve the planned 14 to 20 buses per hour in the peak. However, two bus bays would provide the flexibility to have a regulation point (where buses wait if they are early) at Remarkables Park.

5.12.4 Options for Remarkables Park Interchange

Four options have been identified for the Remarkables Park interchange location which are:

- Option 1: Hawthorne Drive/ Red Oaks Drive
- Option 2: Hawthorne Drive between Red Oaks Drive and Cherry Blossom Avenue
- Option 3: Hawthorne Drive between Cherry Blossom Avenue and Riverside Road
- Option 4: Remarkables Park Town Centre

Figure 46: Remarkables Park interchange bus stop options

At the time of writing this paper the planned upgrades along Hawthorne Drive include signalised intersections at Red Oaks Dr and Cherry Blossom Ave with raised pedestrian crossings on Red Oaks Dr and Hawthorne Dr[2]. These changes will make it easier and safer for pedestrians to cross Hawthorne Dr and Red Oaks Dr.

Figure 47: Planned safety improvements in Remarkables Park

5.12.4.1 Option 1: Hawthorne Drive / Red Oaks Drive

There are three existing bus stops at this interchange, which could be upgraded to form an interchange. Under this option buses would stop on Hawthorne Drive on either side of Red Oaks Dr with pedestrians using the signalised intersection to cross between stops. With the addition of the public transport bridge buses from the southern growth area would stop at the Remarkables Park school stop and potentially another stop on the other side of the road.

[2] https://www.qldc.govt.nz/your-council/major-projects/hawthorne-drive-intersection-improvements

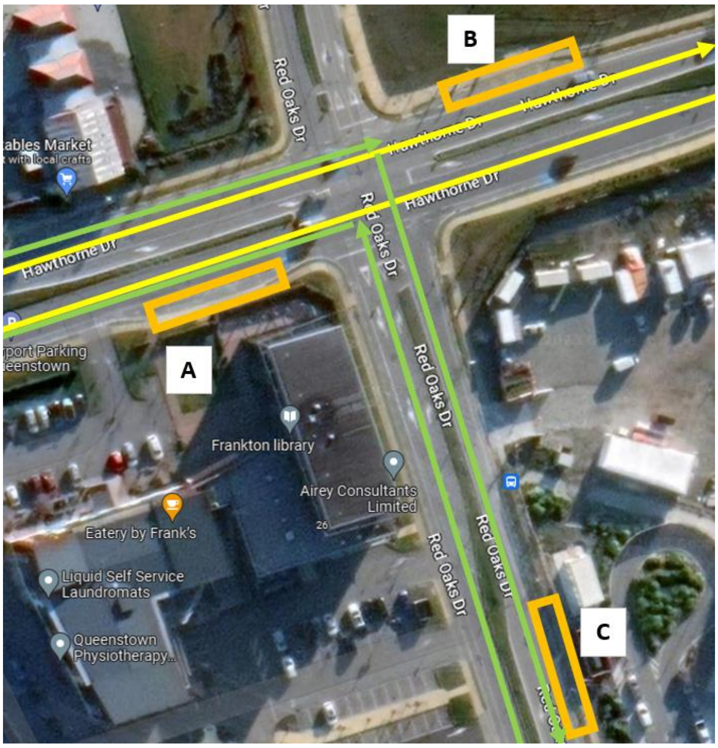


Figure 48: Remarkables Park Option 1, Hawthorne Drive / Red Oaks Drive

Table 17: Remarkable Park Option 1 bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	Indented	33m	Library Shops and services Hotel	Provision of shelter Potentially lengthen stop to accommodate two buses
B	Indented	29m	Nothing without crossing road	Provision of shelter Potentially lengthen stop to accommodate two buses
C	Kerbside	39m	Wakatipu High School	Provision of shelter

Advantages

- Makes use of existing bus stops
- Enough space to physically provide shelters

Disadvantages

- Long distances between bus stops to transfer (100m)
- Some transfers require crossing of two multi-lane arterial road
- Bus stops spread across two roads

5.12.4.2 Option 2: Hawthorne Drive between Red Oaks Drive and Cherry Blossom Drive

This option retains Bus Stop A from the Hawthorne / Red Oaks intersection option with a new bus stop (B) added to the opposite side of the road, near the Remarkables Market. To enable bus passengers to cross Hawthorne Drive to access shops / services and to transfer between buses a new crossing would be required. This crossing would be reasonably close to the signalised

Hawthorne Dr/ Red Oaks Dr intersection (75m) so there may be some resistance to installing an addition crossing.

Figure 49: Remarkables Park Option 2, Hawthorne Drive

Table 18: Remarkable Park Option 2 bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	Indented	33m	Library Shops and services Hotel	Provision of shelter Potentially lengthen stop to accommodate two buses
B	None	NA	Remarkables Market	Provision of shelter and waiting area Improved crossing between bus stops

Advantages

- Makes use of one existing bus stop
- Enough space to physically provide shelters
- Reasonable access to high school, library and hotels

Disadvantages

- Requires crossing of four lanes of traffic on arterial road
- Remarkables Park market side of the road does not have active building frontages

5.12.4.3 Option 3: Hawthorne Drive between Cherry Blossom Avenue and Riverside Road

This option is for the bus stop interchange to be between Cherry Blossom Avenue and Riverside Road. This option could make use of the planned raised pedestrian crossing to enable people to cross Hawthorne Drive to transfer and access the town centre. Two new bus stops would be required at this location that would replace a grass verge.

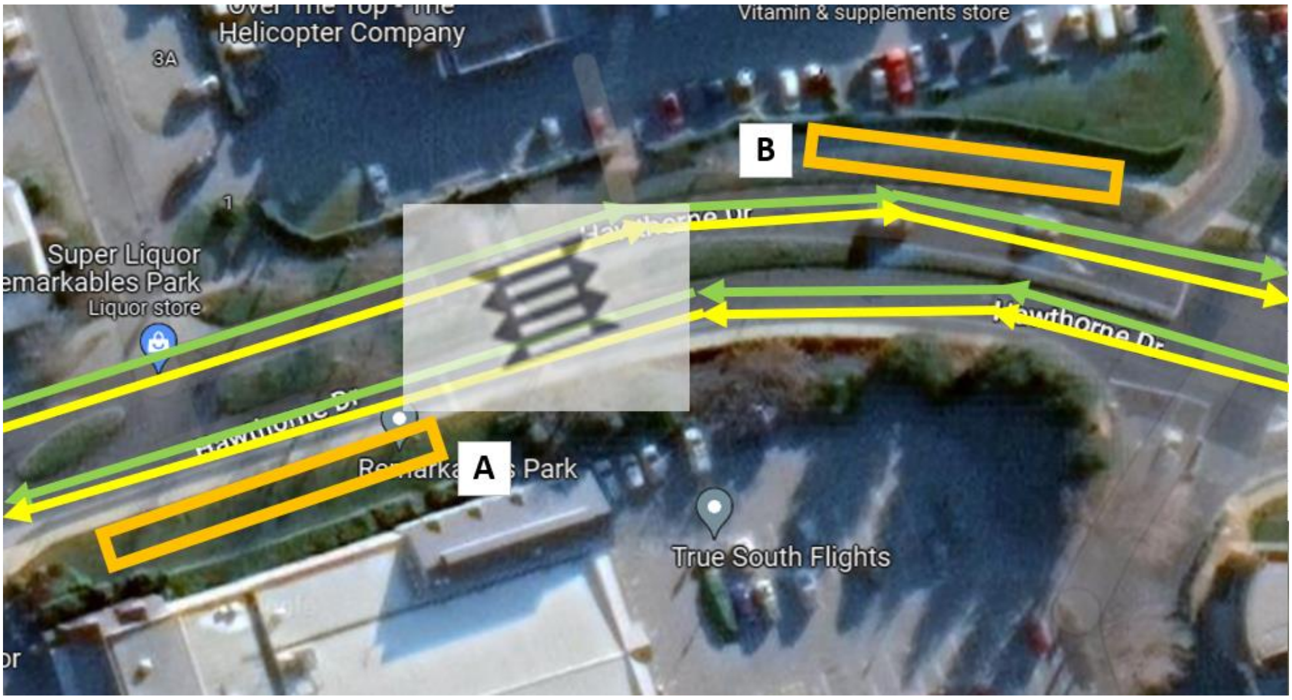


Figure 50: Remarkables Park Option 3, Hawthorne Drive with indicative location of raised pedestrian crossing

Table 19: Remarkable Park Option 3 bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	None	NA	Remarkables Park town centre	Provision of shelter Indented bus stop in current grassed area
B	None	NA	Retail area	Provision of shelter Indented bus stop in current grassed area

Advantages

- Enough road space to provide shelters
- Central location close to supermarket
- Ability to integrate with planned crossing facility
- Only two lanes of traffic to cross

Disadvantages

- Requires completely new bus stops
- Bus Stop B on a bend which are awkward for buses
- Insufficient length for two bus stops

5.12.4.4 Option 4: Remarkables Park Town Centre

This option would involve installing bus stops within the Remarkables Park Town Centre opposite the existing bus stops. This would allow buses to travel through the town Centre in both directions thus avoiding the need for a one-way loop. Buses travelling towards Five Mile would be able to use Golden Elm Lane and Red Oaks Dr to join back on Hawthorne Drive. The infrastructure required to implement the interchange are bus shelters and seating in both directions, kerbline changes on one side of the road and bus stop markings. Space for the bus stop could be created by removing one of the traffic lanes and having one lane in each direction instead of 2+1 lanes. The Remarkables Park bus stops are on private roads and therefore any changes would require the agreement of the landowner.

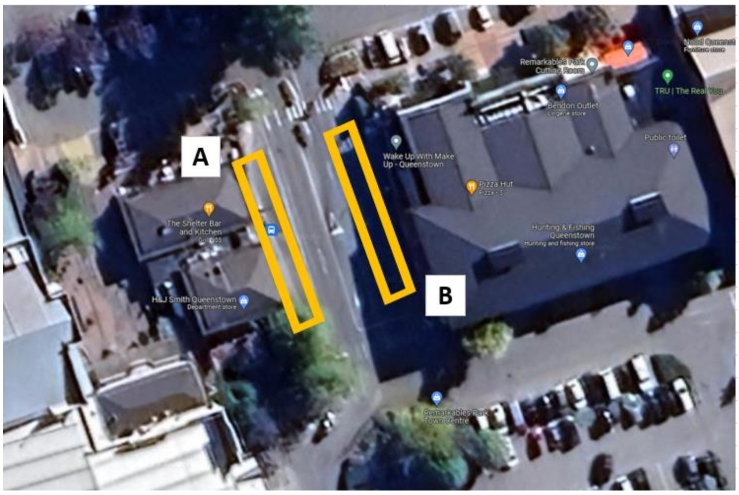


Figure 51: Remarkables Park interchange option 4, town centre stops upgrade

Table 20: Remarkable Park Option 3 bus stops

Bus Stop	Current bus stop type	Current length (incl tapers)	Closest facilities	What's required to make an interchange
A	Indented	33m	Remarkables Park town centre	Provision of shelter
B	None	NA	town centre	Provision of shelter Bus stop markings Modifications to road network

Advantages

- Minimises walking distances as places bus stops in the middle of the town centre
- Attractive waiting environment due to high pedestrian volumes
- Enables buses to also service the planned development along Golden Elm Lane and Wakatipu High School

Disadvantages

- Requires consent of the landowner
- Requires changes to internal road layout

5.12.5 MCA and Preferred Option

The table below shows the location assessment scoring for the Remarkables Park interchange options.

Table 21: MCA scores of each option

Criteria	Option 1. Hawthorne/ Red Oaks	Option 2. Hawthorne near Red Oaks	Option 3. Hawthorne near Tex Smith Lane	Option 4. Remarkables Park
Distance between interchange stops	-2	-2	-1	1
Max no lanes to cross	-3	-2	-2	1
Total traffic volume of roads to cross	-1	-1	-1	1
Distance to nearest facility (café, shop, library, etc) for furthest away bus stop	-2	-2	2	2
Availability of kerb-side space for bus to stop (at shortest bus stop)	1	1	0	-2
Availability of space to provide shelter (at stop with least amount of space)	1	1	1	1
Property purchase or encroachment agreement required	3	3	3	-3
Complexity of delivering works / amount of civil works required (new shelter exempted)	1	1	-1	-1
Unweighted score	**-2**	**-1**	**1**	**0**
Unweighted ranking	**4**	**2**	**1**	**3**

The highest scoring option for the Remarkables Park interchange is Hawthorne Drive near Tex Smith Lane. An interchange in this location is close to Remarkables Park town centre (particularly the supermarket) and would provide the most direct route for buses. The next best option is Remarkables Park town centre that places buses off the main road, in the middle of the town centre and in location with active frontages. Hawthorne Drive near Red Oaks Drive is not preferred because it is away from the shops and services of the town centre and the Remarkables Market side of the road does not have active frontages.

Figure 52: Preferred interchange location in red and backup option in orange

6 Bus Depot

6.1 Introduction

This section documents the scoping exercise for an electric bus depot in Queenstown. The location assessment is at a suburb level of detail rather than evaluating individual sites therefore the outcome of the paper will a narrow list of sites rather than a preferred site. This assumes that the new bus depot would be publicly owned, as enabled by the Sustainable Public Transport Framework, rather than being owned by the bus operator. No design has been undertaken as part of this assessment.

The existing bus depot is too small to accommodate the increase in peak vehicle requirement that would result from increased service levels and is not in the optimal location for a high voltage power connection that is needed for electric bus charging.

The process that was followed to identify feasible locations for a new bus depot included:

- estimating the size of the bus depot that would be required for the proposed bus network. A long-term view was taken by basing the calculation on the number of buses forecast to be needed in 30 years' time.
- considering commercial land parcels that would be of a size large enough to accommodate the bus depot.

Several other factors were also included in the location assessment which are proximity to termini of bus routes and the availability of high voltage power connections.

6.2 Role of Bus Depots

At its most simple function, a bus depot is a place to store buses when they are not in service. However, bus depots typically have additional functions including charging facilities for electric buses, office space for the bus company and providing maintenance, repairs and cleaning facilities. In some cities there may be satellite bus depots which are smaller and may not provide office or maintenance facilities. Satellite bus depots have the advantage of placing buses closer to the service termini. However, they can make management of staff and fleet across multiple locations more difficult.

For Queenstown it is considered that a single depot serving the whole network would be most suitable. This is because of the limited availability of commercial land and the relatively small scale of the public transport network.

6.3 Bus Depot Size Estimation

To implement the Bus Max network option, a fleet of up to 56 articulated buses and up to seven standard-sized buses would be needed. To meet government policy all these buses would need to be zero emission which is likely to be battery electric at least in the short and medium term. The size of the bus fleet is for 2053 and is based on demand forecasts from the public transport model. The approach taken to the assessment is to identify locations with enough space for the 2053 demands. However, in practice the development of the bus depot may be staged.

The components that have been included in the bus depot size calculations are:

- Bus parking
- Space for bus movements, avoiding the need for reversing
- Bus charging facilities
- Bus maintenance and washing facilities
- An office for bus depot staff and drivers
- Car, motorcycle, and cycle parking for staff

To estimate the probable size for a bus depot, the Institute for Transportation and Development Policy's Bus Rapid Transit planning guide[3] was used. For information on space requirements for car parking, mobility parking, and cycle parking, the Auckland Transport Parking Design Guide[4] and Queenstown-Lakes District Council's district plan[5] were referred to.

6.3.1 Number of Buses Required

Using the Bus Max option, the following estimates have been made for the number of buses required by 2053. The number of buses is similar between the other short-listed service pattern options.

These estimates are based on indicative timetables which assumes an average speed of 30km/hr in urban areas and a two-minute minimum layover between trips. The number of spare buses is calculated by taking 10% of the in-service buses.

Table 22: Number of Buses Required by 2053

Bus type	In service	Spares	Total
Articulated	47	5	52
Standard	6	1	7

6.3.2 Bus Parking Space Requirements

To estimate the size of a depot, the following formulas from the Bus Rapid Transit planning guide have been applied:

- Area occupied by a vehicle, VA:

[3] https://brtguide.itdp.org/branch/master/guide/
[4] https://at.govt.nz/media/1982226/engineering-design-code-parking_compressed.pdf
[5] https://www.qldc.govt.nz/media/nlib0txc/14-transport-rules-jun-2022.pdf

  - Articulated bus: 45 m^2
  - Standard 10m long bus: 25m^2

- Access area, AP = 4 * VA
- Area for visual inspection and cleaning, VI = 6 * VA
- Bus parking area PAR = 2 * VA * N, where N = number of buses
- Maintenance area MA = 0.2 * PAR

Table 23: Space required for 52 articulated buses and seven standard buses

	Articulated buses	Standard buses	Total Area
Number of articulated buses required	52	7	
Area occupied by vehicle, VA	45m^2	25m^2	
Access area, AP	4 * 45 = 180m^2	NA, use same space as articulated buses	180m^2
Area for visual inspection & cleaning, VI	6 * 45 = 270m^2	NA, use same space as articulated buses	270m^2
Bus parking area, PAR	2 * 45 * 52 = 4,680m^2	2 * 25 * 7 = 350m^2	5,030m^2
Maintenance area, MA	0.2 * 4680 = 936m^2	NA, use same space as articulated buses	936m^2
Total			6,416m^2

6.3.2.1 Parking

The Queenstown Lakes District Council's District Plan[6] and Auckland Transport's Parking Design Guide[7] were used for guidance on space requirements for car parking, mobility parking, motorcycle and cycle parking.

A maximum of 53 buses are required to be in service, meaning 53 drivers. Assuming one office staff member per 10 drivers, it is estimated that there will be five office-based staff. Assuming one car parking space per staff member, 58 car parks will be required. The space required to provide parking for drivers and office staff in accordance with the district plan is shown in the following table.

Table 24: Parking Requirements, QLDC District Plan Rules

Vehicle type	Rule	Recommendation	Space Requirement
Car	Parking maximum: 3.5m^2 per 100m^2 of area used for maintaining etc, plus 1 per 100m^2 storage space ~98 spaces	One space per bus driver, office staff and mechanics = 63 car parks	29.9m^2 per car park = 1,884m^2

[6] https://www.qldc.govt.nz/media/nlib0txc/14-transport-rules-jun-2022.pdf
[7] https://at.govt.nz/media/1982226/engineering-design-code-parking_compressed.pdf

Mobility parking	Up to 10,000m² floor area used for storage, and up to 2,500 m² used for other industrial uses = Two spaces	Two mobility parking spaces	40.3m² per car park = 80.5m²
Bicycle	One bike space per 10 on-site workers	Equivalent of one car parking space to provide enough space for 8-10 bicycles	29.9m²
Motorcycle / scooter	None	Equivalent of one car parking space to provide space for ~5 motorcycles or scooters	29.9m²
Total			2,025m²

It is assumed that car parking arrangements will be at 90° angles and considers manoeuvring space, and space between vehicles. There is an opportunity to potentially reduce car parking space with different angles or a lower number of car parks.

There are no district plan requirements for visitor parking and bus depots do not tend to attract high numbers of visitors. Therefore, it is expected that parking space provided will be sufficient for any visitors to the site.

Given the high cost of living in Queenstown and surrounding suburbs, it is expected that many staff will drive to the depot from outer towns such as Cromwell and Kingston.

6.3.2.2 Office Space

Office space includes offices for depot-based staff, as well as common areas for drivers when on breaks or between shifts. For the purposes of estimating size requirements, it is assumed that office space will be on a second storey, above the maintenance area. This is common practice for bus depot design with examples being Kaiwharawhara depot in Wellington and Maces Road Depot in Christchurch. Therefore, the additional footprint for office space is assumed to be zero.

6.3.2.3 Electrical Charging Facilities

Because diesel buses are being phased out across New Zealand, the new Queenstown bus depot has been planned to accommodate an all battery electric bus fleet. For electric bus depots charging would occur where the buses are parked whereas for diesel bus depots refuelling occurs at a centralised point. Therefore, the space required for electric bus depots tends to be larger than that of the equivalent diesel bus depot due to the chargers and associated electrical equipment. The exception to this if the bus depot uses overhead structures to place the charger unit above the bus rather than to the side or back. However, these overhead structures tend to be more expensive therefore for this assessment chargers located on the ground have been assumed.

New Zealand's first fully electric bus depot, in Panmure, Auckland, opened in January 2023[8]. The number of buses it was able to hold reduced from 44 to 35, a reduction of 20%. Based on this example, an extra 20% space to account for electric bus charging to the estimated space required from the BRT formula was applied.

$$6{,}416m^2 * 20\% = 1{,}283m^2$$

[8] https://www.stuff.co.nz/auckland/local-news/300791939/new-zealands-first-electric-bus-depot-unveiled

6.3.2.4 Estimated Total Space Requirements

By combining the area required for bus depot facilities (including electrical charging), and space for staff vehicle parking, the estimated total parcel size required to accommodate a bus depot is summarised in the table below.

Table 25: Estimated Area Required for Bus Depot

Depot element	Area Required
Bus parking, maintenance, cleaning, access, etc	6,416m^2
Vehicle parking	2,025m^2
Office space (2nd floor)	0m^2
Space for electrical charging	1,283m^2
Total estimated bus depot space	**9,724m^2**

As summarised above, just under 10,000m^2 is required to accommodate the future electric bus depot. This is considerably larger than the existing Ritchie's bus depot on Glenda Drive in Frankton, which is about 3,800m^2. It should be noted that the vehicle requirement increases from approximately 18 buses current to 59 buses for the new network in 2053, hence the increase in depot space required.

Figure 53: Existing Ritchie's bus depot on Glenda Drive, Frankton

6.3.3 On Site Driver Accommodation

Queenstown, like many other tourism centres, is experiencing a challenge in housing affordability and availability which affects all residents including essential workers. One option to alleviate housing costs for bus drivers could be to provide accommodation on the bus depot site. It is envisaged that this would be used for short stays by bus drivers who commute from centres outside the district such as Christchurch and Invercargill. This would be formalising expected practice by the current bus operator who owns and rents properties in Queenstown for bus drivers. However, no allowance has been made in the depot size calculations for driver accommodation.

Consideration has been given to district planning rules as in this scenario the bus depot would become mixed use commercial.

6.4 Initial Location Assessment

The initial assessment of potential depot locations considered land-use, parcel size, proximity to termini and topography. The merits of all areas of Queenstown and nearby towns were assessed. However only a few areas have large flat and undeveloped land parcels.

Table 26: Initial Assessment of Potential Bus Depot Locations

Area	Availability of suitable commercial / industrial land?	Location?	Pass / Fail?
Fernhill	None on flat land.	At start/end of one high-capacity route and not far from Queenstown for other high-capacity routes.	Fail
Arthurs Point	None on flat land.	At start point for high-capacity bus service and 10-15 mins from Queenstown or Fernhill for two high-capacity routes.	Fail
Queenstown	Industrial activity on Gorge Rd – could be suitable if enough land becomes available for purchase.	At or near start/end of three high-capacity bus services. 15-20mins from the standard service between Quail Rise and Kelvin Heights.	Pass
Frankton	Appears to be available parcels, particularly near the Airport. Other sites around Frankton that could be suitable if available.	Centrally located to access all bus route start/end points. However, only two standard bus routes start nearby (Quail Rise and Frankton Loop). Also centrally located for bus drivers to get to.	Pass
Southern Corridor (Coneburn)	Industrial zone identified at Coneburn	Jack's Point is start/end of high-capacity route. Further from other termini – 20 mins from Arthurs Point / Arrowtown and 15 mins from Lake Hayes.	Pass
Kelvin Heights	No practical space. Would require subdivision of public recreational land.	At start/end of one standard route. At least 15 mins from other termini.	Fail
Quail Rise	None on flat land.	At start/end of one standard route. Close to Lake Hayes for start/end of high-capacity route.	Fail
Shotover Country / Lake Hayes / Ladies Mile	No practical space. Would require subdivision of public recreational land or lifestyle blocks.	At start/end of high-capacity route. 10 mins from Arrowtown and 15-20 from Jack's Point/Queenstown.	Fail
Arrowtown	Industrial sites in northwest of town which could be suitable.	Start/end of one high-cap route but over 20 minutes from other termini.	Fail

Arrow Junction	In rural area. Would require subdivision of farms or lifestyle blocks.	Close to start/end of Lake Hayes and Arrowtown routes.	Fail

Based on this assessment, Fernhill, Arthurs Point, Kelvin Heights, Quail Rise, and Shotover / Lake Hayes / Ladies Mile, and Arrow Junction failed the basic initial assessment based on lack of suitable or practical locations. Arrowtown fails based on being too far from the start / end of other high frequency services.

6.4.1 Preliminary Assessment of Potential Options

Following the initial assessment described above, there are three location options considered for a more detailed assessment:

- Gorge Road
- Frankton
- Coneburn

The three locations considered for further assessment are also the current and planned industrial areas of Queenstown as shown in the Spatial Plan. This is because industrial areas tend to have larger land parcels and have relatively flat topography. Another advantage of locating a bus depot in an industrial area is lower sensitivity to noise and visual impacts as there is generally not residential land use nearby.

6.4.1.1 GIS Analysis

GIS analysis was then used to better understand the suitability of land parcels within the three areas identified. This exercise replied upon publicly available information and more detailed assessment would be required of land parcels at a later point.

Professional judgement was then applied to determine whether a site might be suitable. Sites were ruled out based on:

- **Shape**: for maximum usability, sites should be reasonably square
- **Topography**: flat land is necessary for bus storage and movement
- **Current land use**: there are developed were ruled out to avoid cost and disruption to businesses
- **Environmental features**, such as streams or wetlands that would limit development
- **Road connections** from the depot to the State Highway network

Given the fast pace at which Queenstown is developing, aerial imagery may be out of date and therefore local knowledge was used to sense check the GIS analysis. No investigation into the willingness of landowners to sell or lease land has been made for this assessment.

It is assumed that access to a bus depot will be via an arterial or collector road to accommodate bus movements.

Option 1: Gorge Road, Queenstown

This area is largely already developed, so providing a site here would require purchase and redevelopment of an existing site. Access to this area is either along the often-congested SH6A corridor or around the back via Malaghans Road.

Advantages

- Close to the start/end points of multiple bus routes (Queenstown, Fernhill and Arthur's Point)

Disadvantages

- Few undeveloped sites, so would have to remove existing buildings
- Sites tend to be too small to meet space requirements
- Difficulty in providing a suitable power connection
- Difficult to access between peak periods due to traffic on SH6A
- Less attractive for staff and drivers from out of Queenstown to access, due to congestion on SH6A and through the town centre

Figure 54 shows the GIS output of sites of 8,000m^2 to 100,000m^2 along Gorge Road. Most of these are unsuitable due to being on public parks, schools, or with environmental features which make a bus depot impractical.

Figure 54: Land parcels 8,000-100,000m^2 along Gorge Rd, Queenstown

Option 2: Frankton Industrial Area

Frankton is the most centrally located bus depot location option. There appears to be multiple sites of sufficient size north and east of the Airport in Frankton. Many sites have been developed, but there remain empty lots based on the most recent aerial imagery to hand.

Advantages

- Central location, within 15 minutes of all start/end points of bus routes
- Available space
- Closer for staff commuting from out of town

Disadvantages

- Only close to two low frequency route termini (Quail Rise and Frankton Loop)

The Frankton Master Plan[9], endorsed in 2020, sets the spatial planning framework for Frankton. The purple blocks indicate light industrial activities and light red indicates commercial activities. The industrial and commercial areas are where residential activities are excluded so could be easier to accommodate a bus depot from an urban planning perspective. Both of these areas are served by Hawthorne Drive which is an arterial road that connects to the state highway network in both the north and west.

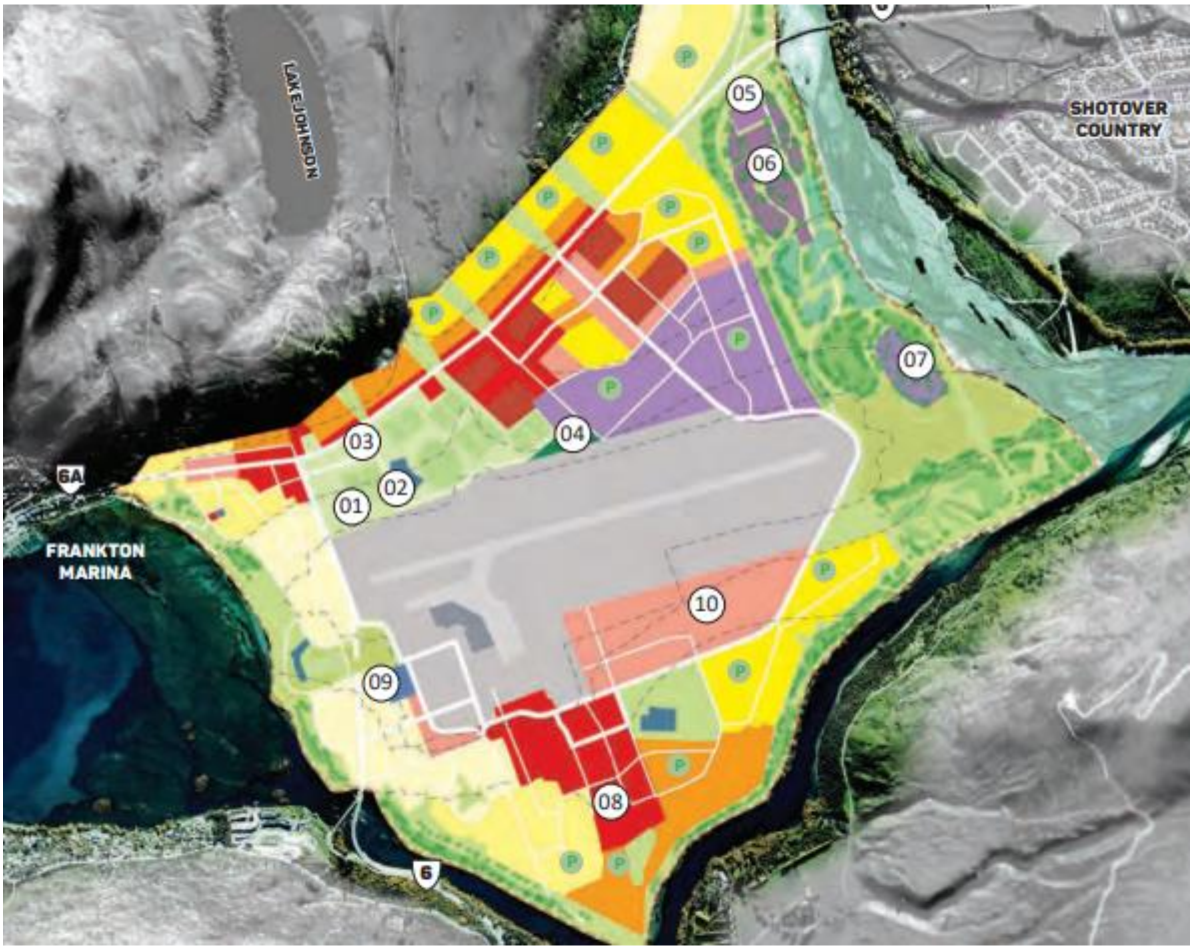


Figure 55: Frankton Master Plan (industrial zone in purple)

Figure 56 shows land parcels with an 8,000m^2-100,000m^2 area in Frankton. The most promising parcels are those north of the airport which are large enough and have an industrial zoning. Parcels to the south of the airport did not come through in the GIS analysis because they had not been subdivided from the airport. Therefore, discussions with the airport would be needed to understand if and when the southern parcels would be available. Some of parcels identified in the GIS map are not suitable due to existing land uses (schools and parks) and residential zoning.

[9] https://www.qldc.govt.nz/services/transport-and-parking/way-to-go/frankton-masterplan

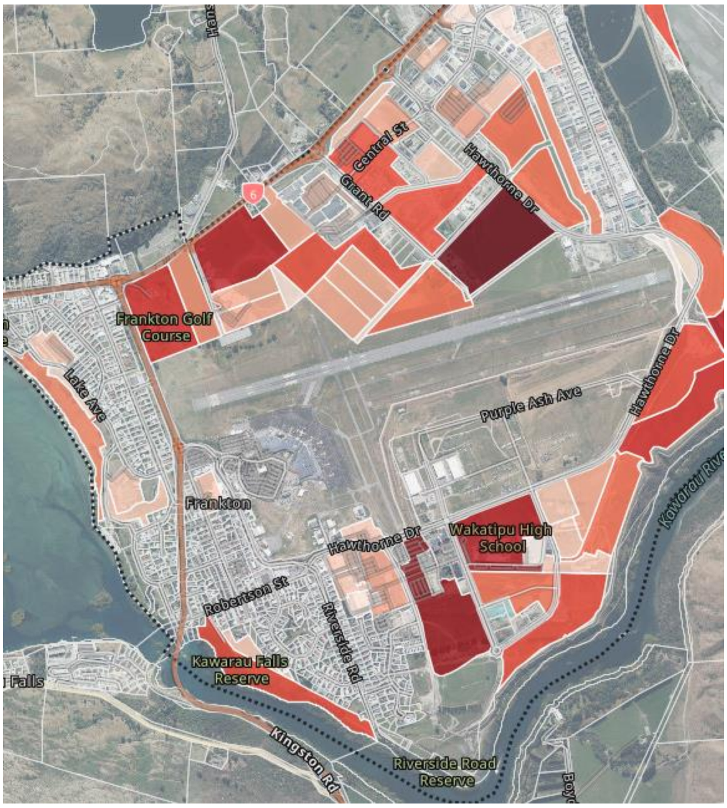


Figure 56: Land Parcels 8,000m²-100,000m² in Frankton

Option 3: Coneburn Industrial Development[10]

An industrial zone is proposed south of Queenstown on the east side of SH6. This zone is known as Coneburn Industrial Development and at the time of writing this paper is in the process of being developed.

Figure 57: Location of proposed Coneburn Industrial Development (Source: GeoSolve Geotechnical Report)

[10] https://www.qldc.govt.nz/your-council/district-plan/variation-to-coneburn-industrial-zone

Advantages

- Presumed willingness to sell sites
- Potential to provide high voltage power connection during land development
- Potential to negotiate with developer on parcel boundaries

Disadvantages

- Not yet subdivided so greater uncertainty
- Located far from termini of Arrowtown and Lake Hayes bus route termini
- Expected congestion on Kawarau Falls bridge in the future
- Less centrally located which may result in longer commutes for staff

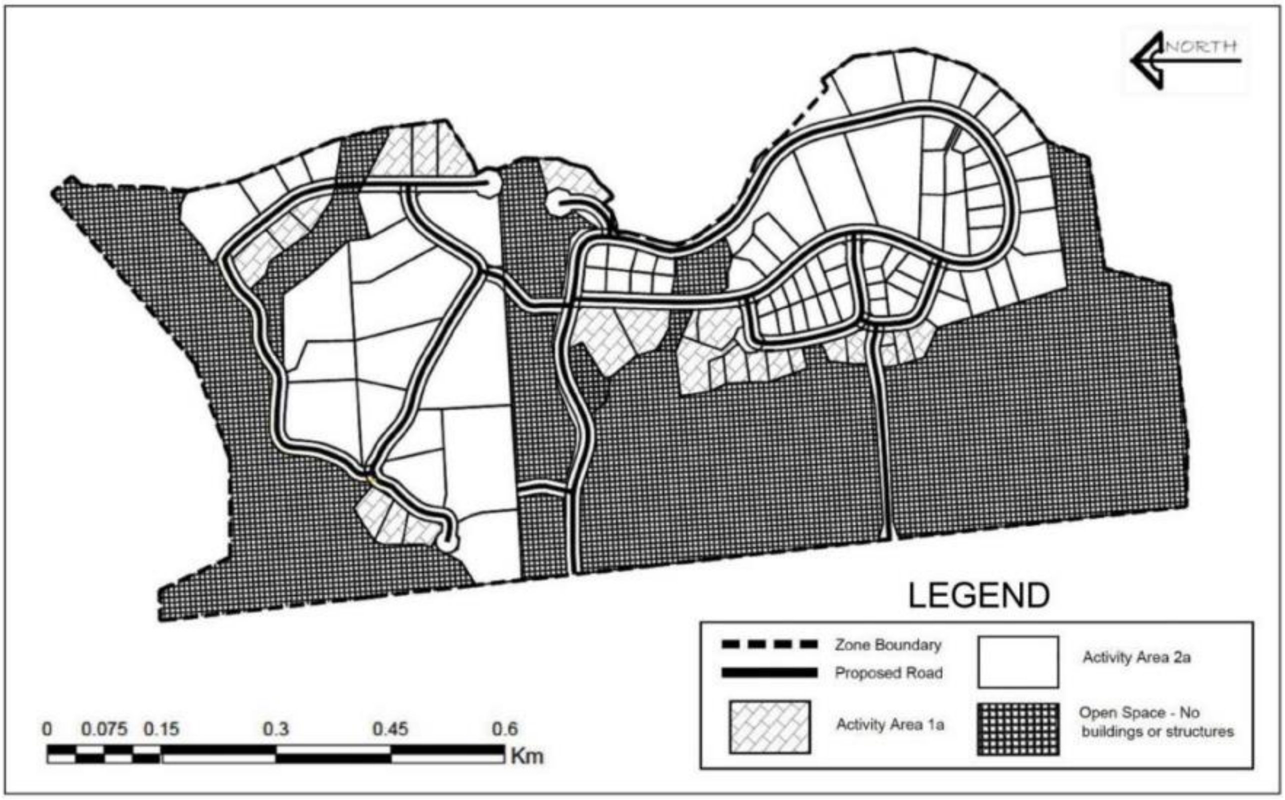


Figure 58: Coneburn Structure Plan (Source: QLDC)

Due to Coneburn not being subdivided it was not possible to complete a GIS analysis as had been undertaken for other areas. However, from the structure plan there appears to be sites of suitable size and shape for a bus depot.

A consideration for travel times from a bus depot located in Coneburn is the potential for public transport priority infrastructure in the southern corridor. As part of this business case northbound bus lanes on SH6 between Boyd Road and Kawarau Falls bridge and a public transport bridge from Boyd Road to Red Oaks Drive are being considered. Public transport priority for the southern growth corridor would help to reduce bus travel times for both in service and repositioning trips.

6.5 Detailed Location Assessment

Following the initial assessment, a multi-criteria analysis (MCA) was completed for Gorge Road, Frankton and Coneburn. The purpose of the MCA was to consider the multiple factors that go into determining an optimal location that include ease of development, operational considerations and urban planning considerations. There is often not a perfect location for a depot. Trade-offs are often made between these factors for the sites which are available at the time of procuring a depot. The purpose of this assessment is to narrow down the list of potential sites rather than to identify a single preferred site. This is to provide some flexibility during negotiations with landowners and to reflect the reality that some information only becomes available during detailed due diligence.

6.5.1 Description of Criteria

This section describes the criteria that have been used for the bus depot location MCA. A scoring system of -3 to +3 was used for each criteria.

Flat, square sites >8,000m^2

GIS was used to identify sites that are between 8,000m^2 and 100,000m^2. While the estimate for the bus depot was just over 10,000m^2, assessing sites from 8,000m^2 allows for some margin of error. It is assumed that sites much larger than 10,000m^2 would be sub-divided.

Sites need to be relatively flat and of a generally square shape to be suitable as it is easier to design for parking, manoeuvring and buildings for regular shaped sites. Assessment of whether a site was suitably flat, or square was based on professional judgement.

Table 27: Scoring guidance for 'flat, square site >8,000m^2' Criterion

-3	-2	-1	0	1	2	3
No sites >8,000m^2 (fatally flawed)				1-2 flat, square sites >8,000m^2	3-4 flat, square sites >8,000m^2	>5 flat, square sites >8,000m^2

Presence of Undeveloped Sites

Aerial imagery from GIS and Google Streetview, along with local knowledge, was used to determine the level of improvements that had been made to the site. This criteria reflects that sites which have already been developed are more expensive to purchase so are less economical than undeveloped sites.

Table 28: Scoring Guidance for 'development potential of sites' Criterion

-3	-2	-1	0	1	2	3
Already fully developed. Large-scale demolition required or environmentally sensitive			Developed land but with few buildings (e.g. a car yard)			Undeveloped land

Complexity in Providing Sufficient Power Connection

It is estimated that 4MW high voltage electrical connection would be required for the bus depot to enable all buses to be charged overnight. Since most commercial and industrial sites are connected to the low voltage network a new connection and transformer are likely to be needed.

This estimate assumes 48x80Kw chargers and two 60kW chargers for the workshop are required. Most buses will be charged at night (between 10pm and 6am). This equates to 3,900 kW which requires 4MW of installed capacity.

The MCA assesses the difficulty or ease of providing this amount of power to the area based on the current electrical grid and planned upgrades. The availability of electrical grid capacity is not guaranteed but rather based on existing demands, the capacity of the local network and whether the utility provider as planned upgrades. Therefore, it is recommended that ORC engages early with the utility provider to confirm availability of capacity and schedule in works to connect to the high voltage power grid.

Table 29: Scoring guidance for 'complexity in providing power' Criterion

-3	-2	-1	0	1	2	3
Extremely complex to provide 4MW power to site			Complex to provide 4MW power to site			Low complexity providing 4MW power to site

Distance to Bus Route Termini

The closer the bus depot is to the start / end of a bus service, the lower the operating costs. This is because when the bus is travelling between the depot to the start/ end of the route the operator needs to pay for the time and distance travelled but the bus is not generating any revenue.

The scoring for this criterion was calculated by taking an approximate travel time from Google Maps from the depot to each of the route termini. The travel times were then averaged in order to have one figure to compare between locations.

Table 30: Scoring guidance for distance to bus route termini Criterion

-3	-2	-1	0	1	2	3
>20 min average travel time to termini	17-20 min average travel time to termini	14-16 min average travel time to termini	11-13 min average travel time to termini	8-10 min average travel time to termini	5-7 min average travel time to termini	<5 min average travel time to termini

Distance from Cromwell to Bus Depot

Anecdotally it is known that some bus drivers live in Cromwell and commute to work in Queenstown. This is because Cromwell has lower housing costs. However, Cromwell is a 45-minute drive from Frankton not accounting for traffic. Therefore, a bus depot that is located on the eastern side of Queenstown would be more accessible for staff travelling from Cromwell.

Table 31: Scoring guidance for 'distance from Cromwell to bus depot' Criterion

-3	-2	-1	0	1	2	3
>60 min drive from Cromwell	51-60 min drive from Cromwell	46-50 min drive from Cromwell	41-45 min drive from Cromwell	36-40 min drive from Cromwell	30-35 min drive from Cromwell	<30 min drive from Cromwell

6.5.2 Assessment Results

Table 32 below shows the draft MCA scoring for the potential bus depot locations. Frankton and Coneburn both have flat undeveloped sites whereas the sites in Gorge Road are smaller, more developed and are often irregular shapes. Frankton and Coneburn would also be easier to connect to the high voltage power network due to the local grid around Queenstown town centre being near capacity. Frankton has the most central location both in terms of proximity to bus route termini and to Cromwell whilst Gorge Road and Coneburn as more out of the way.

Table 32: MCA for Bus Depot location

Criteria	Gorge Rd	Frankton	Coneburn
Flat, square sites >8,000m^2	1	3	3
Presence of undeveloped sites	0	3	3
Complexity in providing sufficient power connection	-3	2	2
Distance between bus depot and bus route termini	1	2	0
Distance between bus depot and Cromwell	-2	0	-2
Unweighted score	**-3**	**10**	**6**

Based on this assessment, a bus depot in Frankton would be the preferred location with Coneburn being a second choice should sites not be available in Frankton or Coneburn land prices be significantly cheaper. Gorge Road is not considered to be feasible for the electric bus depot due to lack of available sites of the required estimated size and challenges with providing the power connection. Frankton has two distinct areas that may suit a bus depot which are south of the airport in commercially zoned land and north of the airport in industrial zoned land.

6.6 Planning Analysis

The below analysis discusses zoning provisions and activity status of the areas shortlisted in for a potential Bus Depot. The analysis is high level and focusses on the activity status of the Bus Depot, including offices and potential driver accommodation. The analysis does not go into a high level of detail regarding the various performance standards that would apply to each location (height limits, setbacks, earthworks limits etc). These are matters than can be worked through once individual sites are earmarked for further due diligence. This analysis does identify 'show stoppers' from a zoning perspective, along with other limitations we are aware of that further narrow the potential locations.

This assessment does not assess other provisions, such as any Regional Plans or National Environmental Standards. Again, these would be part of a second stage analysis.

6.6.1 Plan Structure and Status

The Queenstown Lakes District Currently has two district plans:

- The Operative Queenstown Lakes District Plan (ODP); and
- Proposed Queenstown Lakes District Plan (PDP)

With respect to some of the Zones assessed in this report, it should be noted Council resolved to exclude the Frankton Flats B Zone and the Remarkables Park Special Zone from the PDP. Therefore, the activity status in these zones is governed by the ODP.

6.6.1.1 Definitions

Unsurprisingly, the activity of a Bus Depot does not fit neatly into the definitions in the ODP / PDP due to it being a relatively bespoke activity. This assessment considers that the 'best fit' for a Bus Depot is as a service activity:

<u>Service Activity</u> (ODP and PDP)

Means the use of land and buildings for the primary purpose of the transport, storage, maintenance or repair of goods.

Buses (as goods) would be stored, maintained and repaired on the site.

The definition of Public Transport Facility was also considered:

<u>Public Transport Facility</u> (PDP)

A facility for passenger movements on/off and between public transport services, including:

- Passenger waiting areas
- Shelters
- Public ferry terminals
- Ticketing and other passenger facilities
- Bus interchanges

This definition covers the various pieces of infrastructure needed to support the operation of the network, apart from the start / end of day facilities (i.e. the depot) – so it is not particularly helpful in terms of the bus depot.

<u>Residential Activity</u> (ODP/PDP)

Means the use of land and buildings by people for the purpose of permanent residential accommodation, including all associated accessory buildings, recreational activities and the keeping of domestic livestock. For the purposes of this definition, residential activity shall include Community Housing, emergency refuge accommodation and the non-commercial use of holiday homes. Excludes visitor accommodation, residential visitor accommodation[11].

The driver accommodation component of the bus depot would be considered a residential activity.

Activity Sensitive To Aircraft Noise (ASAN) / Activity Sensitive to Road Noise (ODP/PDP)

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[11] The reference to residential visitor accommodation is in the PDP only.

Means any residential activity, visitor accommodation activity, residential visitor accommodation activity, homestay activity, community activity and day care facility activity as defined in this District Plan including all outdoor spaces associated with any education activity, but excludes activity in police stations, fire stations, courthouses, probation and detention centres, government and local government offices.

The driver accommodation component of the Bus Depot would be considered an ASAN.

Outer Control Boundary (ODP):

Means a boundary, the location of which is based on predicted day/night sound levels of Ldn 55 dBA from future airport operations. The location of the boundary is shown in Figure 31a.

Outer Control Boundary (PDP):

Means a boundary, as shown on the District Plan web mapping application, the location of which is based on the predicted day/night sound levels of 55 dBA Ldn from airport operations in 2036 for Wānaka Airport and 2037 for Queenstown Airport.

In other words, land within the Outer Control Boundary (OCB) is subject to higher levels of noise. On this basis, ASAN are discouraged from being undertaken within the OCB.

6.6.2 Potential Approvals Pathways Under the RMA

Broadly speaking, there are three ways for an activity to be authorised under the Resource Management Act (RMA):

6.6.2.1 Permitted Activities

Permitted activities do not require resource consent.

6.6.2.2 Resource Consent

A resource consent is an authorization to undertake an activity that is not permitted.

The various types of activity status are as follows (the abbreviations are those used in the tables below in sections 6.6.4.1 to 6.6.4.4:

- Controlled (CON) – Council must grant consent and can impose conditions.
- Restricted Discretionary (RDA) – Council can grant or decline consent but can only consider those matters over which discretion is reserved.
- Discretionary (DIS) - Council can grant or decline consent.
- Non-Complying (N-C) - Council can grant or decline consent, but is subject to additional policy and effects tests before approval can be contemplated.
- Prohibited (PRO) – Consent cannot be applied for.

As a general principle as one moves down the list from a controlled activity to a non-complying activity, obtaining a consent becomes more complex and the level of risk increases.

6.6.2.3 Designation

Designation is a tool available to Requiring Authorities. The Otago Regional Council as a local authority is a requiring authority as per Section 166 of the RMA and could use these powers to designate a site (as opposed to obtaining resource consent) for a bus depot. This would mean the provisions of the Operative or Proposed Plan would not apply to the Activity, and in theory Council could seek to designate an activity on a site where it is prohibited. This is discussed below in Section 6.6.6.

6.6.3 District Wide Activities - PDP

6.6.3.1 Transportation

The below transportation rule applies across the district:

Table 33- PDP Transportation Rules

29.4 Rules - Activities		
29.4.6	Off-site and non-accessory parking used exclusively for the parking of coaches and buses in the General Industrial Zone, Coneburn Industrial Zone, Business Mixed Use Zone and Local Shopping Centre Zone. Control is reserved over: a. Design, external appearance, and landscaping and the resultant potential effects on visual amenity and the quality of the streetscape; b. Effects on the amenity of adjoining sites' compatibility with surrounding activities; and c. The size and layout of parking spaces and associated manoeuvring areas	CON

Buses could be parked (only) in the Coneburn Industrial Zone as a controlled activity (i.e. consent must be granted).

6.6.4 Zone Provisions

6.6.4.1 Coneburn Industrial Zone

Chapter 44 of the Proposed Queenstown District Lakes Plan (PDP) is the Coneburn Industrial Zone. This zone has as of 28 September 2023 had some recent changes made to its provisions by way of a Variation to the PDP. In the PDP the Coneburn Industrial Zone's purpose is identified as:

"The Coneburn Industrial Zone provides for industrial and service activities. Conversely, standalone offices, residential and almost all retail uses are excluded within the zone in order to ensure that it does not become a mixed use zone where reverse sensitivity issues and land values make industrial and service activities unviable within the zone."

6.6.4.1.1 Coneburn Industrial Zone - Policy Framework

The relevant Objective and Policies of the Coneburn Industrial Zone are listed below (emphasis added):

*Objective 44.2.1 – A **dedicated industrial and service zone** with a mix of compatible activities that excludes residential, standalone offices, and most retail*

*Policy 44.2.1.1 **Enable a wide variety of industrial and service activities** ranging from lighter industrial activities to those of a yard based nature through the use of the Structure Plan limiting development to Activity Areas 1a and 2a.*

*44.2.1.3 **Exclude offices (not ancillary to a permitted activity)** to avoid reverse sensitivity effects and to avoid the use of industrial land for non-industrial purposes.*

*44.2.1.6 **Restrict residential activities** in the zone to only custodial units for people whose duties require them to live on site.*

As can be seen from the above policy direction an activity like a Bus Depot aligns with the outcomes the PDP seeks for the Zone.

6.6.4.1.2 Coneburn Industrial Zone – Activity Status

The table in Rule 44.4 lists the activity status for activities in the Coneburn Industrial Zone. Table 33 below is an excerpt of the key activities as they relate to a Bus Depot.

Table 34 - Coneburn Industrial Zone Activity Status

Rule	Activities located in the Coneburn Industrial Zone	Activity Status
44.4.1	Industrial and Service Activities	PER
44.4.2	Offices ancillary to any permitted activity	PER
44.4.7	Buildings a. Landscaping; The extent to which landscaping will improve the visual appearance of the site, buildings, outdoor storage areas, and carparking areas, taking account of: i. The nature of planting or materials to be used; ii. The ease of maintenance; and iii. The size of the plans and/or the time it will take for the plants to mature. b. External appearance (including signage, the colour of the buildings and, in particular, the extent of corporate colours used); c. The ability to service the building(s), in terms of roading, water supply, stormwater and waste water; d. Waste and recycling storage space; e. Natural Hazards (if not addressed at the time of subdivision); f. Fencing adjacent to the open space area.	CON
44.4.9	Custodial Unit A single Residential Unit providing for the custodial management of an Industrial or Service activity and which complies with all of the following requirements: a. It is located above or behind an Industrial or Service Activity; b. It is maintained in the same ownership as the Industrial or Service Activity; c. It is not subdivided, unit titled or otherwise separated, including by lease from the Industrial or Service activity it is attached to; d. It is not over 50m^2 and no more than 20% of the GFA of the building in which it is contained; e. It is only occupied by persons working in the Industrial or Service activity to which the unit is attached and whose duties require them to live on site.	DIS
44.4.19	Residential Activities (other than those that meet 44.4.9 above)	PR

44.5	Rules - Standards	
44.5.1	Standards for activities located in the Coneburn Industrial Zone	Non-compliance Status
44.5.1	Development of Land Uses No land use activity may be consented in advance of landscaping the Open Space Area as shown on the Structure Plan based on the following triggers: a. No more than 10% of the Activity Areas can be consented unless work required under the Ecological Management Plan has been completed on no less than 25% of the open space area; b. No more than 25% of the Activity Areas can be consented unless work required under the Ecological Management Plan has been completed on no less than 50% of the open space area; c. No more than 50% of the Activity Areas can be consented unless work required under the Ecological Management Plan has been completed on no less than 100% of the open space area.	N-C

6.6.4.1.3 Activity Status - Discussion

Based on the above, the activity status a Bus Depot would be permitted in the Coneburn Industrial Zone, subject to meeting the other controls, and noting other aspects to a Bus Depot – such as building and a custodial unit would require resource consent. There are a number of other standards applying to the site that are not assessed here for brevity, relating to building size and location etc.

The provisions of Rule 44.5.1 also need to be understood in terms of whether the work required under the ecological management plan has been completed (as identified in (a-c) – as this is a precursor to consenting activities in the Activity Areas.

Finally, some discussion with Council as to whether the driver accommodation would fit within what is envisaged as a custodial unit requires some discussion with Council (and the landowner). It is suggested that a custodial unit is something different to driver accommodation (residential activity – which is prohibited).

6.6.4.1.4 Coneburn – Other Commentary

At present, the Coneburn site is only serviced with water (from an on-site bore) and there are no reticulated wastewater and stormwater services currently available.

The site is also on the outer limits of the existing public transport network and it is not clear how a driver could get to work for an early start (or home from work) without having a private motor vehicle unless they live nearby e.g. Jacks Point or Hanley Farm.

6.6.4.2 Frankton – Zoning

Figure 62 below is an excerpt from the PDP Planning Maps showing the Frankton Area. Zoning-wise Frankton[12] can be broken into five Key Zones:

- Airport Zone
- Community Purposes Zone (Queenstown Events Centre including Frankton Golf Course)

[12] For the purposes of this assessment, this is the area bounded by SH6 to the north and west, the Kawarau River to the South and the Shotover River to the east

- Frankton Flats B Zone
- General Industrial and Service Zone
- Remarkables Park Special Zone

As discussed above, both the Frankton Flats B Zone and Remarkables Park Special Zone were excluded from the PDP – these are shown as the 'greyed out' areas on the planning map except below.

The other significant planning control in Frankton is the Queenstown Airport Outer Control Boundary (OCB). Activities sensitive to aircraft noise are prohibited within this area. This has implications in terms of the potential driver accommodation aspect of the Bus Depot.

In terms of the analysis below, both the Airport Zone and Open Space and Recreation Zone, Airport Zone and Industrial and Service Zone have been excluded from the planning analysis due to them being outside of the shortlisted areas. It is noted the Frankton Masterplan does show a Transport Hub on part of the current golf course site.

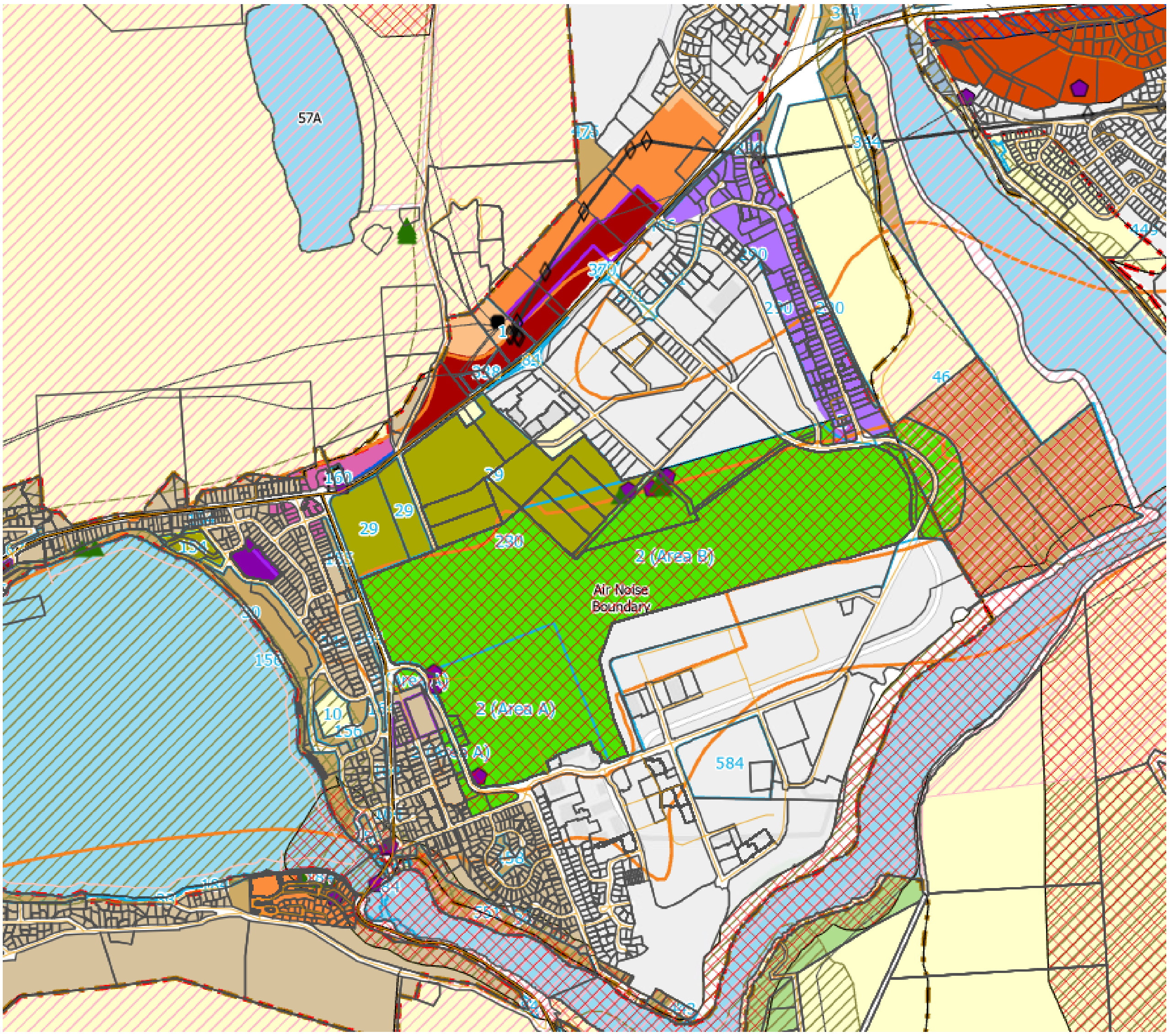

Figure 59 - Frankton - Zoning

6.6.4.3 Frankton Flats B Zone (Frankton - North of Airport)

The figure below shows the Structure Plan layout for the Frankton Flats B Zone. The zone provisions further detail what activities are envisaged in each of the activity areas.

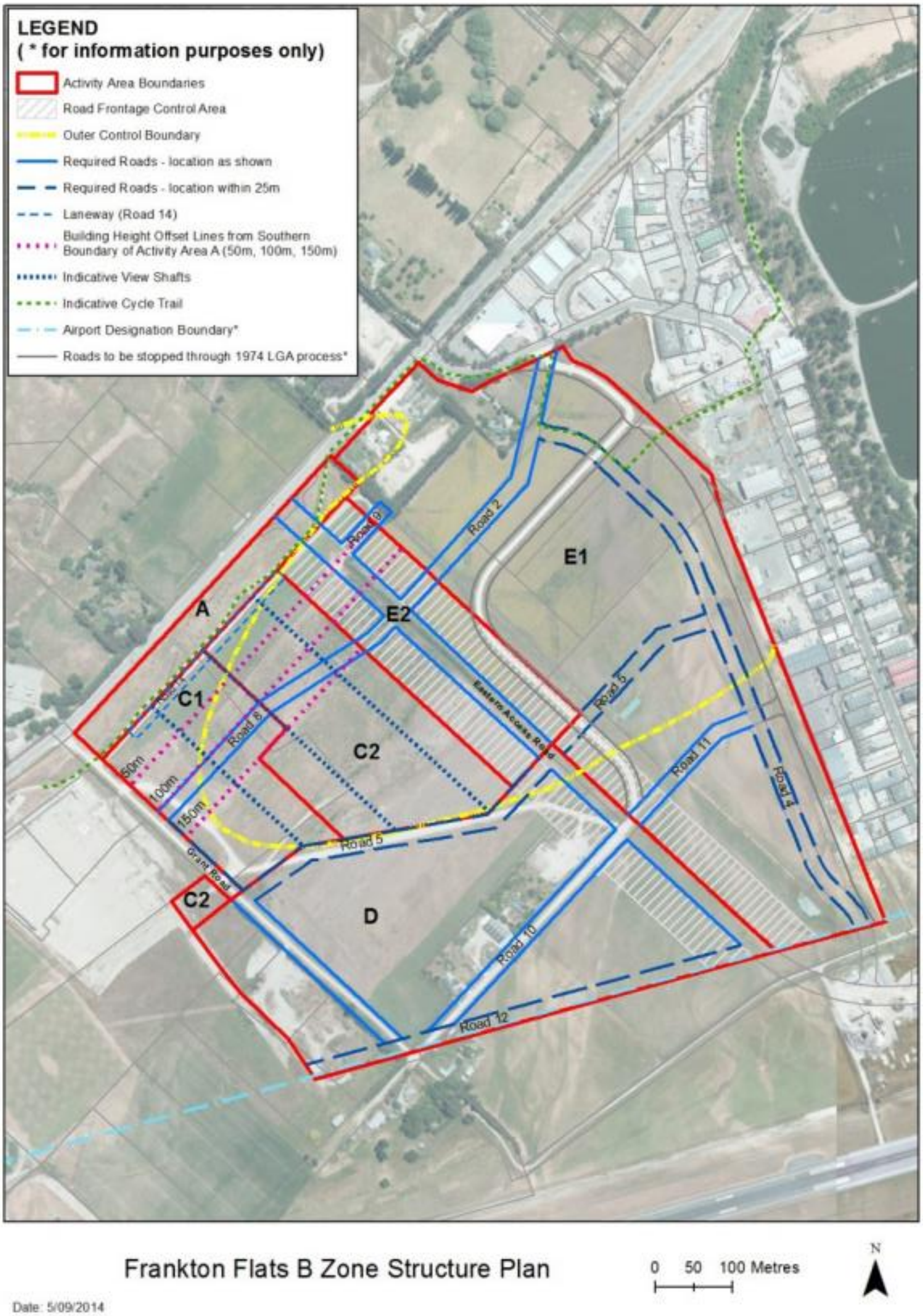

Figure 60 - Frankton Flats B Zone Structure Plan

6.6.4.3.1 Frankton Flats B Zone – Policy Framework

The relevant Objective and Policies of the Frankton Flats B Zone are listed below (emphasis added):

Activity Area E1

Objective 10 Activity Area E1 (Industrial) ***An area for industrial and service activities****, which has a standard of amenity that is appropriate to the function of the Activity Area*

Policy 10.1 To ***enable a wide variety of industrial activities and service activities*** *ranging from lighter industrial activities through to those of a yard based nature.*

Policy 10.2 To ***ensure that any office space is ancillary to the use of the site*** *for industrial and service activities.*

Policy 10.5 To ***ensure that Activities Sensitive to Aircraft Noise are not*** *located within the Outer Control Boundary*

Activity Area D

Objective 11 Activity Area D (Yard Based Industry) An area ***dedicated to yard based industrial and service activities*** *where there is a predominance of outdoor storage of goods, equipment and materials.*

Policy 11.1 To ***enable industrial and service activities*** *which require larger land areas with a smaller proportion of building coverage.*

Policy 11.2 To ***ensure that any office space is ancillary to the use of the site*** *for yard based industrial and service activities.*

Policy 11.4 To ***exclude activities that conflict with the intended function of this Activity Area*** *such as those involving a high percentage of building coverage, small lot sizes, generate reverse sensitivity effects or which would* ***otherwise not be appropriate in close proximity to the Airport (including residential*** *and visitor accommodation).*

In terms of the policy direction above, both Activity Areas D and E1 are favorable to the establishment of a bus depot. Note both Activity Areas seek to exclude activities sensitive to aircraft noise (10.5) or those that would generate reverse sensitivity effects (11.4) an example of which is the driver's accommodation as a residential activity.

6.6.4.3.2 Frankton Flats B Zone – Activity Status

As shown above in Figure 63 the Frankton Flats B Zone is split into six Activity Areas. Table 34 below is an excerpt from Table 1 of Rule 12.20.3.7 of the Operative District Plan, identifying the key activities associated with the bus depot and the respective activity status of these.

Table 35 - Frankton Flats B Zone - Activity Status

Activity	Activity Area					
	A	C1	C2	D	E1	E2
Industrial Activities, Service Activities (including ancillary retail activities)	PRO	N-C	N-C	PER	PER	N-C
Offices Ancillary to and Permitted or Controlled Activity	PRO	PER	PER	PER	PER	PER
Residential Activities and Home Occupations located at ground floor*	PRO	NC where adjoining road 8, otherwise PER	PER	PRO	PRO	PRO

Residential Activities and Home Occupations located on levels other than ground floor	PRO	PER	PER	PRO	N-C	N-C
Activities Sensitive to Aircraft Noise within the Outer Control Boundary (OCB) as shown on the Structure Plan	PRO	PRO	PRO	PRO	PRO	PRO
PER= permitted; N-C = noncomplying; PRO - prohibited						

Areas D and E1 are the most promising in term of the underlying zoning as the Bus Depot would be a permitted activity, including attached offices. However due to a large portion of Activity Area D being within the OCB, there is very limited scope for the driver accommodation facility to be located within Area D apart from a small triangular piece on the corner of Grant Road and Hawthorne Drive. It should also be noted that elsewhere in the Frankton Flats B Zone residential activity is permitted (e.g. Activity Area C) which makes it potentially an attractive proposition for a nearby residential driver accommodation (noting both the proximity of the residential activity areas to both Areas D and E1, and also to retail, supermarkets and other services (e.g. medical) within the Frankton Flats B Zone).

6.6.4.4 Remarkables Park Special Zone (Frankton - South of Airport)

The Remarkables Park Special Zone occupies the area shown in the figure below. Similar to the Frankton Flats B Zone, the zone provisions further detail what activities are envisaged in each of the activity areas.

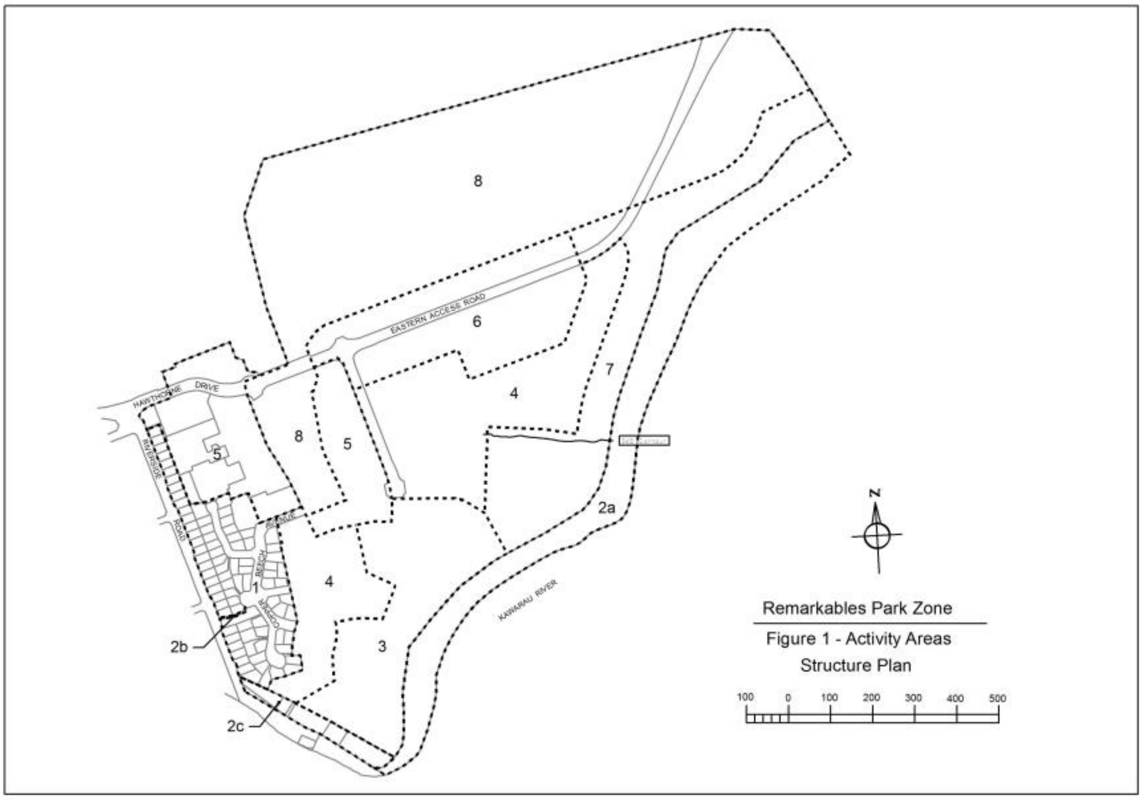

Figure 61 - Remarkables Park Special Zone - Structure Plan

6.6.4.4.1 Remarkables Park Special Zone – Policy Framework

The relevant objective and policies of the Remarkables Park Special Zone are listed below (emphasis added):

<u>Objective 1</u>: Integrated management of the effects of ***residential, recreation, commercial, community, visitor accommodation, educational and Queenstown Airport activities***

<u>Policy 8</u>: To ensure that the activity areas of the Remarkables Park Zone collectively enable a town to be established including a variety of ***commercial, retail, community, education, recreation, residential and visitor accommodation activities*** *and pedestrian and transport connectivity, to serve the local, district and regional populations.*

The policy framework for the zone does not provide for service activity.

6.6.4.4.2 Remarkables Park Special Zone - Activity Status

As shown above the Remarkables Park Special Zone is split into 10 Activity Areas. Table 35 below is an excerpt from Table 1 of Rule 12.11.3.6 of the Operative District Plan, identifying the key activities associated with the bus depot and the respective activity status of these.

Table 36 - Remarkables Park Special Zone - Activity Status

Activity	Activity Area									
	1	2a	2b	2c	3	4	5	6	7	8
Residential Activity	PER	N-C	N-C	N-C	PER	PER	CON	PER	PER	CON
Service Activities	PRO	PRO	PRO	PRO	PRO	PRO	PRO	PRO	PRO	PRO

Both Industrial and Service activities are Prohibited Activities within the Zone. As identified above in Section 6.6.2.2 a prohibited activity means resource consent cannot be applied for.

6.6.5 Other Constraints

6.6.5.1 Natural Hazards

Noting all of the sites have been recently rezoned, natural hazards would have been a consideration at that time. A review of the Otago Regional Council's Natural Hazards Database indicates:

The Frankton sites are shown to have:

- Ground Classification D – Deep or Soft Soil
- Liquefaction – A Domain – Liquefaction potential is Low to none

Coneburn is shown to have:

- Ground Classification D – Deep or Soft Soil
- Liquefaction – A Domain – Liquefaction potential is Low to none
- Alluvial Fan – Active, debris dominated

The presence of these does not trigger any additional consenting requirements in terms of the ODP/PDP. As with any building project, geotechnical due diligence is recommended.

6.6.5.2 Noise Limits

The Coneburn Industrial Zone and Frankton Flats B Zones have different noise regimes.

The Coneburn Industrial Zone does not have one specific noise limit. The limit depends on the zone in which the noise is received outside of the Coneburn Industrial Zone (Rule 36.5.18). This would require a site-specific assessment as a lot of factors would be at play in determining compliance.

Noise in Frankton Flats B, within Activity Areas D & E1 must not exceed the following limits at the boundary with Activity Area C2:

Table 37 - Frankton Flats B Zone - Noise Limits

Noise Limit	Frankton Flats B Zone (Activity Areas D & E1)
Daytime (0800 – 2000)	65dBA L_{10}
Night-time (2000 – 0800)	65dBA L_{10} and 70dBA L_{max}

Similar to above, this would require a site by site assessment.

6.6.5.3 Hours of Operation

There is nothing in the zoning provisions that limit the hours of operation. Noise limits are likely to be the limiting factor in this regard (if at all).

6.6.6 Discussion

Based on the above the following observations are made:

- Both Frankton Flats B and Coneburn have zonings that would provide for the establishment of a bus depot and ancillary offices as a reasonably straightforward proposition due to the activity status. There will still likely be resource consent in some form required (e.g. for the buildings). However, as the activity is permitted any consenting risk is considered comparatively low. The plans specifically identified these zones as an appropriate location for service activities.
- At the Coneburn Industrial Zone a limiting factor for driver accommodation is the activity status of residential activity (prohibited). Therefore, any associated driver accommodation would need to be located off-site.
- At the Coneburn Industrial Zone another limiting factor is the ecological work required as a precursor to development. The status/timing of this would need to be established with the owner.
- The Coneburn site is currently only serviced with water.
- The Coneburn site is relatively remote from the current urban form and services of Frankton, noting the residential neighborhoods of Hanley Farm and Jacks Point to the south-west.
- At the Frankton Flats B Zone a limiting factor for driver accommodation is the OCB which limits the potential sites (noting there are nearby areas zoned for residential activity and the area is well serviced with retail, supermarkets and other professional services).
- The Frankton Flats B Zone is well serviced with 3 waters infrastructure.
- The Frankton Flats B Zone is located in close proximity to the existing Frankton Bus Hub (and preferred[13] location for an expanded Frankton Bus Hub).
- The Remarkables Park Special Zone is not available for service activity due to it being a prohibited activity.

On this basis the suggested preference for further investigation is the Frankton Flats B Zone. However, it is noted that other considerations (land cost) will mean that the Coneburn Zone should not be dismissed in its entirety but does not offer all of the advantages the Frankton Flats B Zone does. The Remarkables Park Special Zone is considered a 'non-starter'.

[13] Queenstown Business Case Options Assessment Section 4.1.3

As discussed above, should the ORC have financial responsibility for the Bus Depot, the option is available to designate the site by way of the process set out in Part 8 of the RMA. In theory, this process can be used regardless of the activity status of an activity in the zone - in other words to 'get around' the prohibited activity status in the Remarkables Park Special Zone for the Activity, or the residential component being prohibited in the OCB or at Coneburn. This would bring with it a high degree of planning risk as the activity would be contrary to the policy direction set for the Zone. Designating a site for the Bus Depot and Offices alone would be similar to a resource consent in complexity but does offer the advantages of flexibility provided by the 'two stage' process of designating the site then submitting an outline plan for the built form on the site.

The advantages and disadvantages of resource consent vs designation is something that should be traversed as part of a finer-grained site selection / due diligence process.

6.7 Recommended Next Steps

Once the business case has been endorsed by partners and the preferred ownership for the Queenstown bus depot confirmed the next steps to identify a preferred location would be:

- Engage with Aurora early in the process to confirm electric grid capacity and plan high voltage power connection
- Engage with landowners in Frankton and Coneburn on timeframes for subdivision and willingness to sell. Consider lease of land only if long term lease can be secured as a large investment in site improvements would be required to develop a depot
- Engage with current and potential bus operators on their requirements for a depot and whether on-site driver accommodation would assist in recruiting more drivers
- Undertake due diligence on preferred sites that investigates cost of development and consenting risks

6.8 Land availability

A desktop assessment of land availability for a new bus depot in the Gorge Road, Frankton and Coneburn areas was completed. The results of the assessment found a chronic lack of available 10,000m2 industrial sites in these areas due to the prevailing small lot size. Industrial land would be most straightforward from a consenting point of view due to the there being low sensitivity of surrounding land uses. Other approaches include using a commercially zoned site and applying for resource consent, amalgamating adjoining industrial sites or purchasing a site from the Coneburn industrial park which is currently unsubdivided. Consideration was given to sites owned by QLDC however this are predominately used for recreation (golf course and sports fields) so are considered unfeasible to use for a bus depot.

With regards to the Coneburn industrial area discussions with local property valuers found that there will be 75 sites within the development that will be available within the next 12 months. The expected price for the sites is in the range of $1,000 to 1,500m2 which is less than the typical price for sites in Frankton. It is understood that a further industrial area is planned south of Coneburn which is in the early planning stages and has been through the plan change process.

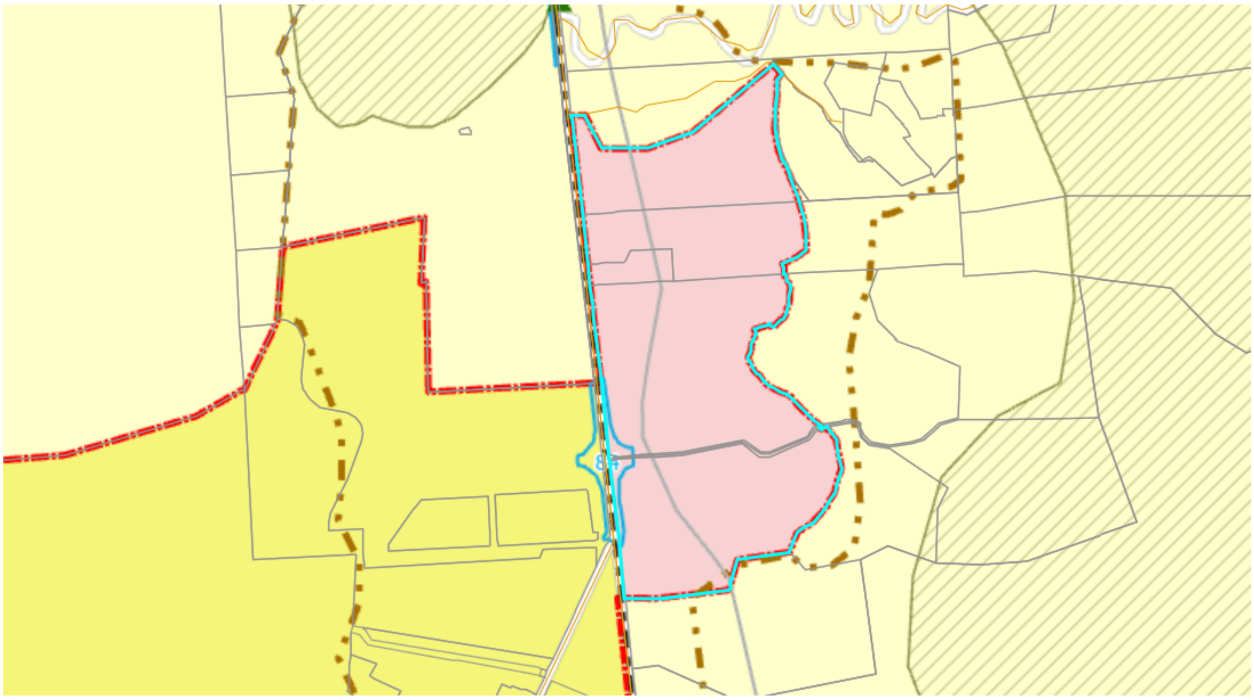

Table 38: Zoning map showing location of Coneburn Industrial Area in pink

For Frankton a large proportion of the sites are owned by Queenstown Airport Limited including the runway itself and some large undeveloped sites along Hawthorne Drive. Discussions with the airport have found a willingness to lease a site north of the runway for use as a bus depot. A lease arrangement would reduce up front costs for developing a bus depot but the terms of the lease would need to be favorable due to the significant investment required in site improvements.

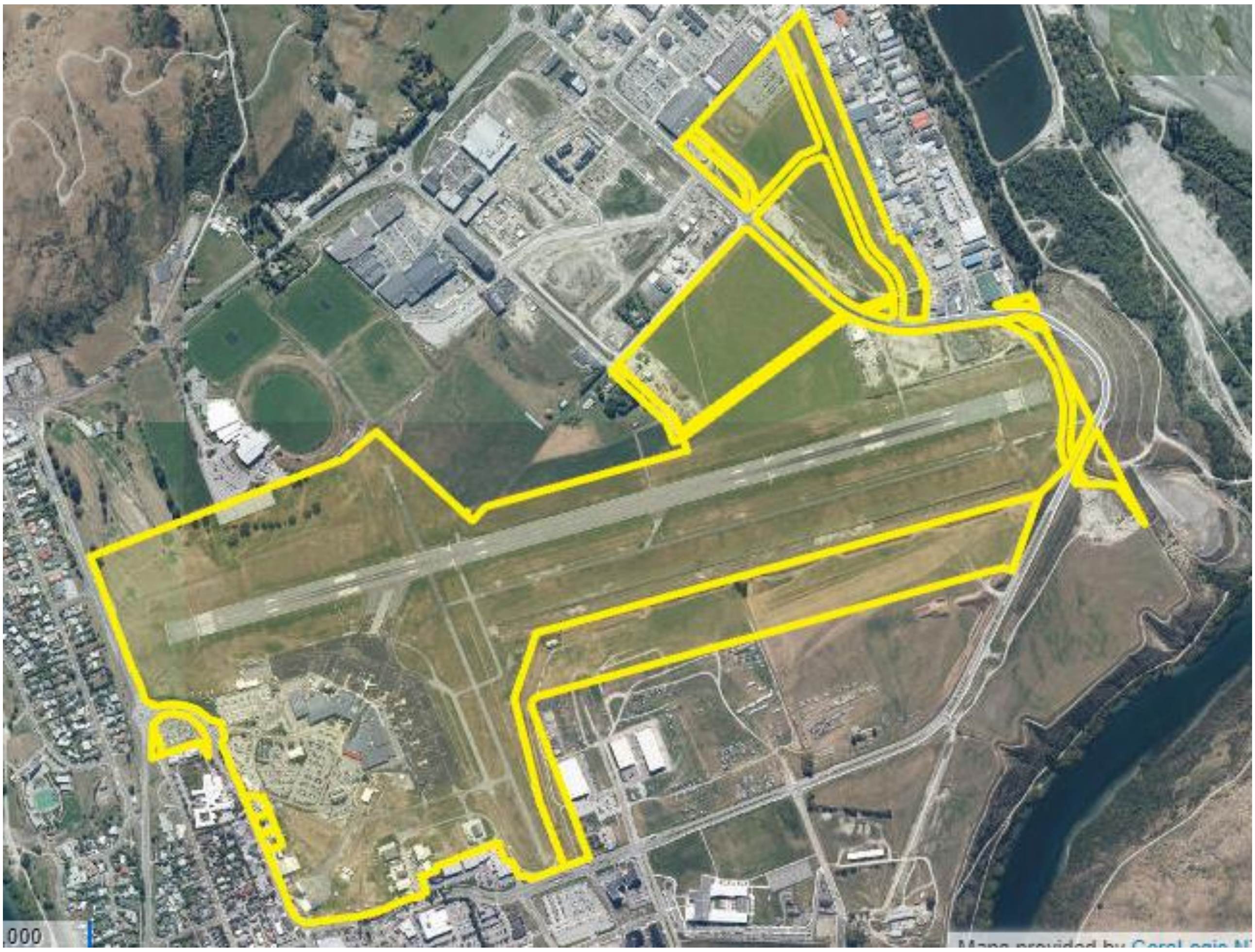

Table 39: Sites owned by Queenstown Airport Limited (Source: Core Logic)

A list of potential sites for further investigation is as follows:

Address	Area	Land Area	2021 Land Rating Valuation	Comments
105 – 121 Gorge Road	Gorge Road	1.1 ha	$11,500,000	Improved site
1 Bowen Street	Gorge Road	1.3 ha	$4,510,000	Undeveloped land
145 Frankton – Ladies Mile Highway	Frankton	4.0 ha	$24,200,000	Undeveloped land
495 Kingston Road	Jack's Point	41.3 ha	$4,320,000	Undeveloped land
Kingston Rd	Jack's Point	30.0 ha	$3,710,000	Undeveloped land
1 Hansen Rd	Frankton	3.4 ha	$25,500,000	Undeveloped land
27 Lucas Place (north)	Frankton	4.2 ha	$326,000,000	Owned by Queenstown Airport

Tex Smith Lane	Frankton	9.0 ha	$1,990,000	Owned by Queenstown Airport
27 Lucas Place (south)	Frankton	4.0ha	$326,000,000	Owned by Queenstown Airport

7 Conclusion

There are several types of infrastructure that are required to support the short-listed service pattern options which includes priority measures, intersection changes, modifications to Stanley Street and Frankton Hubs and a new bus depot.

There are several public transport priority measures including a Kawarau Falls bridge, bus lanes on State Highway 6 south and Lucas Place bus that have been documented for further consideration as part of the business case. Tracking of articulated and large buses through the network identified several intersections that would require modifications that will be included in the programme costs.

For the Stanley Street and Frankton bus hubs it was found that relatively simple design changes could be made in order to accommodate articulated buses whilst keeping the same general layout. For Five Mile and Remarkables Park an assessment of potential new on road bus hub locations was completed which identified preferred locations.

An assessment of the requirements for a new electric bus depot was completed which identified that the current depot site is not large enough to accommodate the future bus fleet. Alternative locations for a bus depot were then assessed at a high level which found that Frankton was the preferred location due to its central location and availability of large commercially zoned sites. An alternative location for a bus depot is Coneburn which is more peripheral in location and would rely on public transport priority measures in the southern corridor.

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Queenstown Public Transport Business Case

15/03/2024

CONFIDENTIAL

Service Patterns Advisory Paper

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1	Draft for comment
2	Updated from client feedback
3	Further updates from client feedback and review
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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Way To Go ('**Client**') in relation to the Service Patterns Paper which forms part of the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Consultant Agreement dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Executive Summary

Introduction

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This Service Patterns Advisory Paper is the third of the Project's advisory papers. It identifies the public transport network (routes, frequencies, and vehicles) to serve the forecast growth over the next 15 to 30 years.

The key opportunity for public transport is that the planned future development is largely linear along the southern and eastern corridors which is compatible with service by public transport. The bus lanes planned for State Highway 6 south and east of the BP intersection would result in faster and more reliable public transport journey times. Whereas the challenges identified at destinations within Frankton are dispersed around the Airport runway which makes serving these destinations with a direct route difficult. There are also high traffic volumes on State Highway 6A and a lack of available space makes widening the road corridor to provide bus priority costly and disruptive.

Forecast public transport demand in the short (5 years), medium (15 years), and long term (30 years) from the Forecast Demand Advisory Paper was considered. The key findings from this exercise were that current public transport demand is comparatively low (apart from route 1) but is forecast to increase rapidly in the medium to long term as Queenstown continues to develop. Demand from the southern corridor in particular is expected to increase rapidly and would require high-capacity public transport vehicles by approximately 2038. The current fleet of standard sized buses would be unable to meet the forecast demand even when running at a maximum frequency of 30 buses per hour (a bus every two minutes) along State Highway 6A.

Vehicle Capacity

A range of different types of public transport vehicles were considered as replacements for the current bus fleet including ferry, high-capacity bus and heavy rail. The capacity assessment found that articulated and bi-articulated buses provided more than enough capacity to meet the demand while operating at the optimal service frequency.

The most feasible public transport mode is articulated buses due to the relative ease of implementation (does not require rails or overhead power lines), the high capacity (around 110 passengers per vehicle with a high proportion of seated passengers), fast boarding/alighting from multiple doors and easier luggage accommodation. Articulated buses currently operate in numerous cities around the world and is a vehicle type recognised in the Vehicle Dimensions and Mass Rule (Figure A). There are several manufactures of battery electric articulated buses with the option being available to specify fast charging compatible vehicles which would provide options for en-route charging in addition to depot charging. The Decarbonisation Paper will explore the different propulsion technologies for public transport vehicles to achieve the zero emissions goal. The operation of articulated buses is different to a traditional bus due to having all-door boarding, the ability for level boarding at stations and fare collection independent of the driver.

Figure A. Example of articulated bus in operation from Pau, France (Source: Van Hool)

Service Options

A long list of 11 network options was considered which included different levels of transfers and different public transport modes. Various public transport modes were included in the long list to confirm whether the combination of two modes, such as ferry and bus, could provide sufficient capacity when operated together. This long list was narrowed down to four short list options through an assessment of capacity provided, customer needs and travel times.

The short-listed options are: Bus Max, Bus Max with Remarkables Park Bridge, Bus Max using Malaghans Road, Rapid Transit to Jacks Point.

Key features of Bus Max include:

- Three frequent core routes (Sunshine Bay and Fernhill to Shotover Country and Lake Hayes Estate; Arthurs Point to Arrowtown via Frankton and Ladies Mile; and Queenstown Town Centre to Hanley's Farm and Jack's Point via Frankton)
- Four individual services from Frankton Bus Hub to Jack's Point via Queenstown Airport and Hanley's Farm, Arrowtown via SH6 and Ladies Mile, Lake Hayes Estate via Shotover Country, and Kelvin Peninsula and Quail Rise;
- Two individual services to Fernhill and Sunshine Bay; and Arthurs Point

Key features of Rapid Transit to Jack's Point include:

- Single frequent spine service from Queenstown Town Centre to Jack's Point and Hanley's Farm via Frankton Bus Hub and Queenstown Airport
- This spine will connect to other services at Frankton Bus Hub: Kelvin Peninsula and Quail Rise via Frankton Flats, Arrowtown via SH6 and Ladies Mile, Lake Hayes Estate via Shotover Country
- This spine will connect to other services at the Stanley Street Bus Hub: Fernhill and Sunshine Bay and Arthurs Point via Gorge Road

It is recommended that a technical assessment on the feasibility of Remarkables Park Bridge and considering alternatives (bus lanes on SH6 south of Kawarau Falls) is conducted. It is also recommended the Bus Max and Rapid Transit to Jacks Point base options to be publicly consulted on, with Malaghans road offered as an add-on to both base options

2 Introduction

The scope of the service patterns paper is to develop a plan for how the public transport network should best meet future demand over the next 15 to 30-years.

The key outcomes sought from the service patterns paper are:

- Compare network design options which best meets the strategic objectives contained in the problem statements
- Identify the optimal service frequencies over the next 15 to 30 years to meet the forecast demand
- Recommend a public transport vehicle type which provides sufficient capacity and that is attractive for customers

To achieve these outcomes, the service patterns paper has the following structure, which first discusses the local context, then develops and compares network options:

- Section 3 and 4: Current and future land use and transport context of Queenstown
- Section 5 and 6: A summary of Advisory Paper 1 – Forecast Demand and the public transport network concept from the Queenstown Indicative Transport Business Case (previous business case)
- Section 7 and 8: Identifying opportunities and constraints for providing high-capacity public transport in Queenstown and developing a framework for understanding customer needs
- Section 9: A summary of the public transport network design principles that were applied to the development of the long list of service patterns
- Section 10: Determining the public transport modes that would provide sufficient capacity to meet the mode shift targets whilst operating at an optimal service frequency
- Section 11: Comparing the short-listed fleet options for the proposed public transport network
- Section 12: Documenting the long list service pattern options that were developed as part of this technical paper
- Section 13: Service patterns option assessment against capacity requirements; customer needs and travel time to identify the short list options
- Sections 14 to 21: Detailed consideration of link roads, a Frankton Loop service, ferry services, servicing Ladies Mile and Queenstown Airport and consideration of school services with recommendations
- Section 22: Discussion on the infrastructure required to enable the short listed service pattern options
- Section 23: Conclusion of this paper with short list recommendations and next steps

3 Current Land Use and Transport Context

3.1 Topography

Queenstown is located within the Wakatipu Basin which is surrounded by mountains and Lake Wakatipu (Figure 1). The two main activity centres are Queenstown and Frankton which are at either ends of the Frankton Arm of Lake Wakatipu. Queenstown and Frankton are connected by a single main road (State Highway 6A) which runs along a narrow corridor between Queenstown Hill and Frankton Arm. In addition, several rivers create natural barriers between residential suburbs and funnel traffic across strategically important bridges. These include Shotover River Bridge to Lake Hayes Estate, Kawarau Fall Bridge to Frankton and Jacks Point and Edith Cavell Bridge to Arthurs Point. Residential development had previously been focused on the Frankton Arm with suburbs including Kelvin Heights and Fernhill. With the continued growth of Queenstown more recent suburbs have emerged, including Lake Hayes Estate to the east and Jacks Point to the south. Other key areas which generate tourist trips are Arrowtown, Gibbston Valley, Glenorchy, Cromwell and Wanaka.

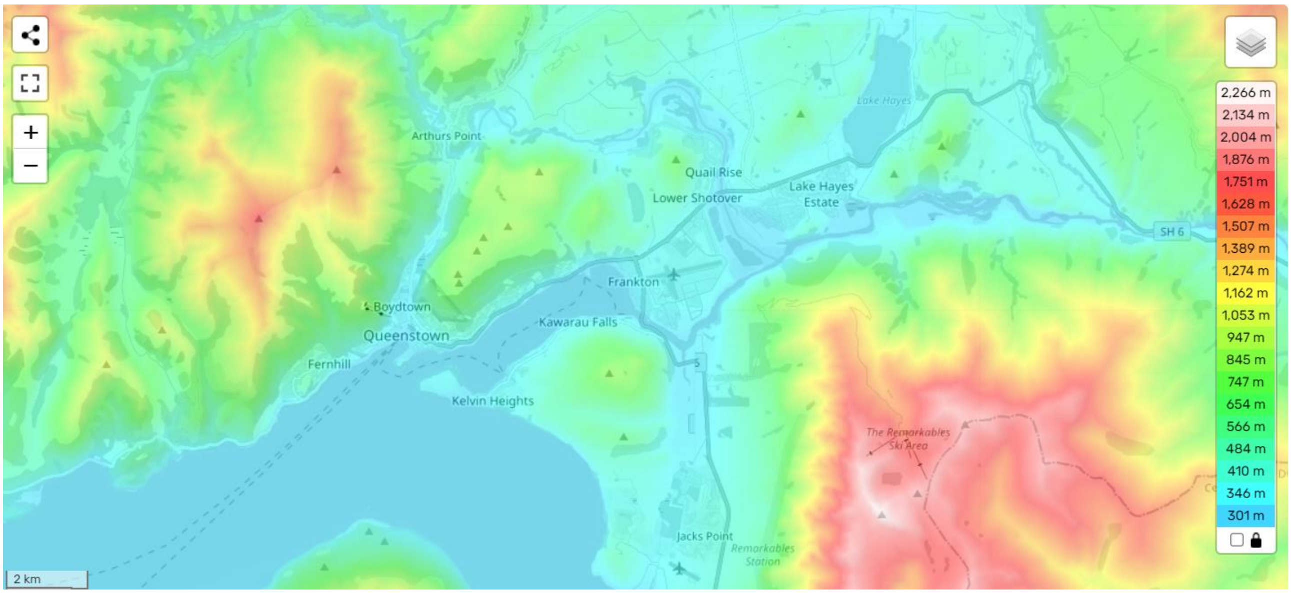


Figure 1. Queenstown-Lakes District topographic map. (Source: Topographic Map.com).

From a public transport planning perspective, the topography of Queenstown presents the opportunity to create a high-frequency and high-capacity service along the main residential corridors. These are the southern corridor (Jacks Point to Queenstown via Frankton) and eastern corridor (Lake Hayes Estate to Queenstown via Frankton). However, the challenge of having one main road between Queenstown and Frankton is that service duplication will need to be balanced against public transport access.

3.2 Land Use

Commercial activity within Queenstown is concentrated within the Queenstown Town Centre Zone, Remarkables Park Zone and Five Mile (Figure 2). Queenstown Airport divides Remarkables Park from Five Mile with all traffic needing to travel around either SH6 or Hawthorne Drive. The high-density residential zone is located around the town centre and along SH6A with low density residential zone covering the rest of the Frankton Arm. Pockets of residential land are located in Quail Rise, Shotover, Lake Hayes, Jacks Point and Arthurs Point.

The road layout of Quail Rise and Jacks Point presents a challenge from a public transport planning perspective. This is because Jacks Point and Hanley Farm do not currently have an internal road connection which means that buses must loop via SH6 rather than being able travel directly through the suburb. Similarly for Quail Rise there is one road into the suburb (Tucker Beach Rd) which means that buses must detour into the suburb and back out the same way.

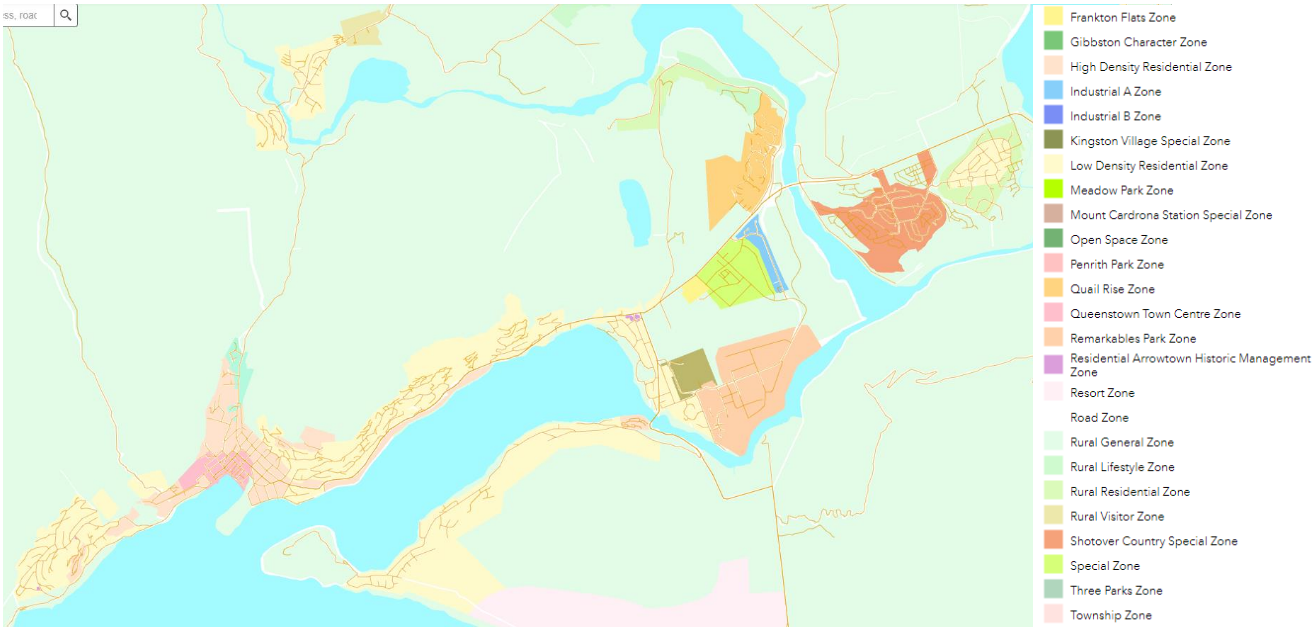


Figure 2. Queenstown Lakes District Council Operative District Plan. (Source: Queenstown Lakes District Council).

3.3 Public Transport Network Structure

The current public transport network in Queenstown has some services which run through to Queenstown town centre and others that terminate at Frankton Hub (Figure 3). Services from the west of Queenstown (Fernhill/ Sunshine Bay and Arthurs Point) are through run to destinations to the east (Remarkables Shopping Centre and Arrowtown). This reduces the number of buses which terminate at Stanley Street which is a central location that has road space constraints.

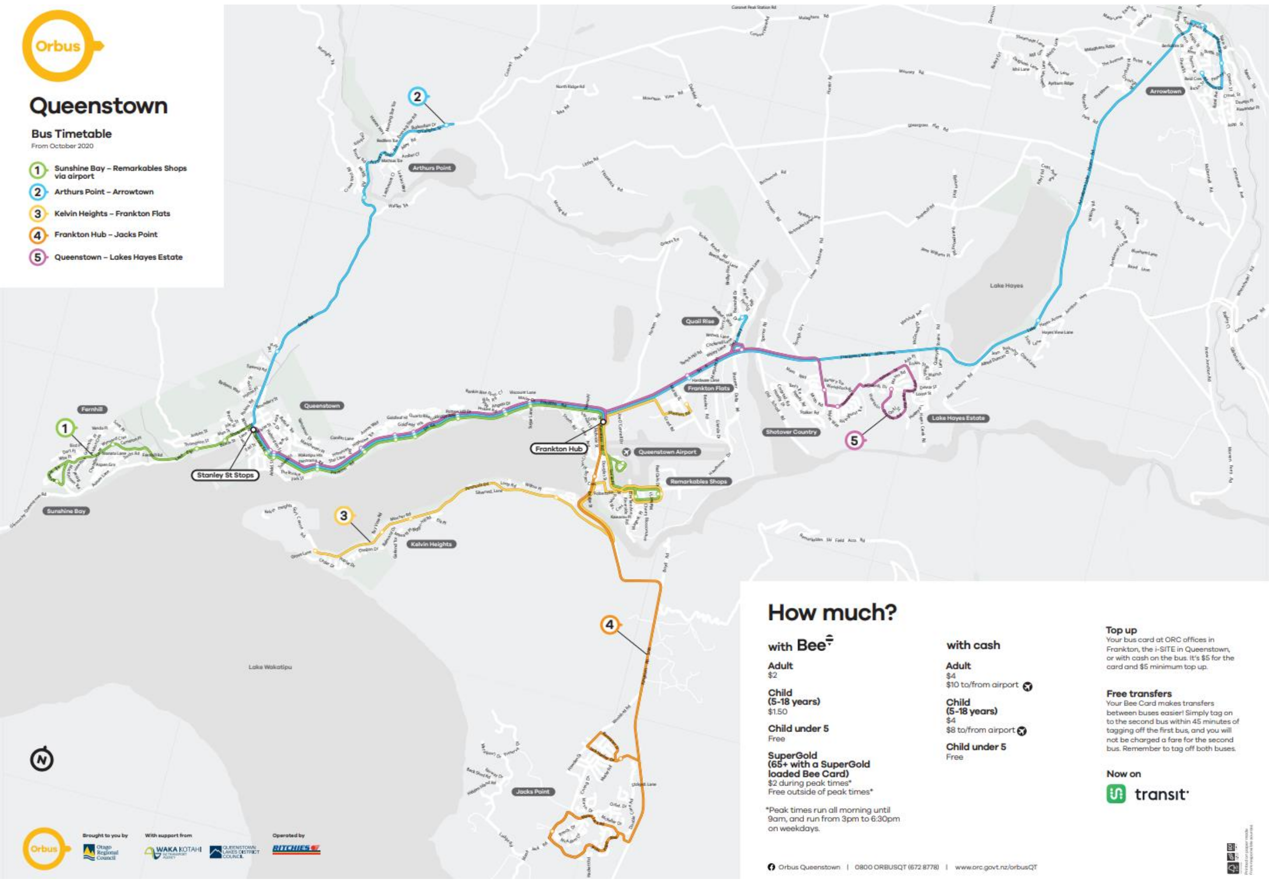


Figure 3. Orbus's Queenstown Bus Network (Source: Otago Regional Council).

Frankton Hub forms the key transfer point between services with passengers from Kelvin Heights and Jacks Point needing to transfer to routes 1, 2 or 5 for travel to central Queenstown. Bus services serve the destinations within Frankton to varying extents with route 1 serving the airport and Remarkables Shops, route 3 serving Remarkables Shops and Five Mile with route 4 going direct to Frankton Hub. Within the bus network there are two detours into residential areas which is the detour of route 2 into Quail Rise and the detour of route 4 into Hanley Farm.

In addition, there is a ferry service which picks commuters up at Bay View, Hilton, Frankton Marina and Queenstown.

3.4 Public Transport Service Levels

The frequency and span of service of the Queenstown public transport system effective from October 2020 are shown in the table below. Please note that the service levels are the planned services and not the reduced timetables from bus driver shortages.

Route 1 has the highest frequency with a 15-minute frequency throughout the day and is the only frequent bus route within the current network. Route 2 and route 5 have 30 min frequencies during the morning and afternoon peaks with 60 min frequencies during off peak times. Whereas routes 3 and 4 have 60 min frequencies throughout the whole day. All bus services have a long span of service with route 1 running from 6am to 12am and the other routes commencing at 6am and ending at 10pm.

Following the service classification contained in the Otago Regional Public Transport Plan 2021 rapid services are defined as having a 10-minute frequency all day, frequent as having a 15-minute peak and 30 minute off peak frequency and regular as 30 to 60 minute frequency. By this classification there is one frequent service and five regular services in Queenstown (Table 1).

Table 1. Destination and Frequencies of Orbus's Queenstown Bus Services.

Service	Destinations	Frequency	Span	Classification
1	Sunshine Bay, Fernhill, Queenstown, Frankton, Airport and Remarkables Shops	Every 15min until 7pm and every 30min until 12am	6am to 12am	Frequent
2	Arthurs Point, Queenstown, Frankton Hub, Arrowtown	Every 30min during the peaks and every 60min off peak	6am to 10pm	Regular
3	Kelvin Heights, Remarkables Shopping Centre, Frankton Hub and Frankton Flats	Every 60min	6am to 10pm	Regular
4	Jacks Point, Hanley's Farm and Frankton Hub	Every 60min	6am to 10pm	Regular
5	Lake Hayes Estate, Frankton Hub and Queenstown	Every 30min during the peaks and every 60min off peak	6am to 10pm	Regular
6	Frankton, Kelvin Heights and Queenstown	Every 60min	8am to 6am Mon-Thu and 8am to 10pm Fri-Sun	Regular

There is a total of eight trips per hour between Queenstown and Frankton during the peaks however some trips have the same timetabled departure times. For the Stanley to Frankton direction route 1 departs 10, 25, 40 and 55 minutes past the hour from Stanley St with routes 2 and 5 depart at 5 and 35 minutes past the hour. In the reverse direction route 1 departs at 5, 20, 35 and 50 minutes from the hour with both routes 2 departing at 20 and 50 minutes.

3.5 Transfers

The Queenstown bus network has a pulse timetable where most services are timed to arrive at Frankton Hub at the same time. Pulse timetables have the advantage of enabling easy transfers between services and reduced wait times for transferring passengers but can increase space requirements at terminals. Table 2 below shows the transfer times between services that terminate at the Frankton Hub. Zero-minute transfer time indicates that buses are timed to arrive and depart at the same time, in practice the feeder bus may arrive a few minutes before the timetabled time.

Table 2. Transfer times between terminating services at Frankton Hub.

From	To	Transfer wait time
Kelvin Heights	Queenstown	0
Queenstown	Kelvin Heights	0
Jacks Point	Queenstown	5
Queenstown	Jacks Point	5
Fernhill	Frankton Flats	10
Frankton Flats	Fernhill	0
Jacks Point	Frankton Flats	5
Frankton Flats	Jacks Point	5

3.6 Fares

With a Bee card, fares across the Queenstown bus network are a flat $2.00 for adults, free for children, $0.75 for youth (13-18 years), $1 for Youth Plus (19-24 years), $1 for Community Connect concession and $2 (peak) and free (off-peak) for SuperGold concession. Cash fares are $4 for adults, children, youth, Community Connect concession and SuperGold concession. Cash fares to and from the airport are $10 for adults, SuperGold (65+) and Youth Plus (19-24) concessions and $8 for youth (13-18 years) and children. SuperGold card holders have free off-peak travel and $2 fares during peak times.

3.7 Patronage

A review of the patronage data for the current bus network reveals that route 1 carries the highest number of passengers (Figure 4 & Figure 5). In the morning peak, 78 passengers per hour travel towards Sunshine Bay and 43 passengers per hour travel towards Remarkables Park. The route with the next highest patronage is route 5 in the To Queenstown direction with 29 passengers per hour, but not in the direction towards Lake Hayes which only has 5 passengers per hour. Route 2 has the third highest patronage with 19 passengers per hour travelling towards Arthur's Point and 25 travelling in the To Arrowtown direction. Route 3 has 10 passengers per hour travelling towards Frankton Flats and route 4 has 7 passengers per hour travelling towards Frankton Hub. As it can be expected, the routes with the highest frequency (route 1) and those that travel into Queenstown (routes 1, 2 and 5) have the highest patronage.

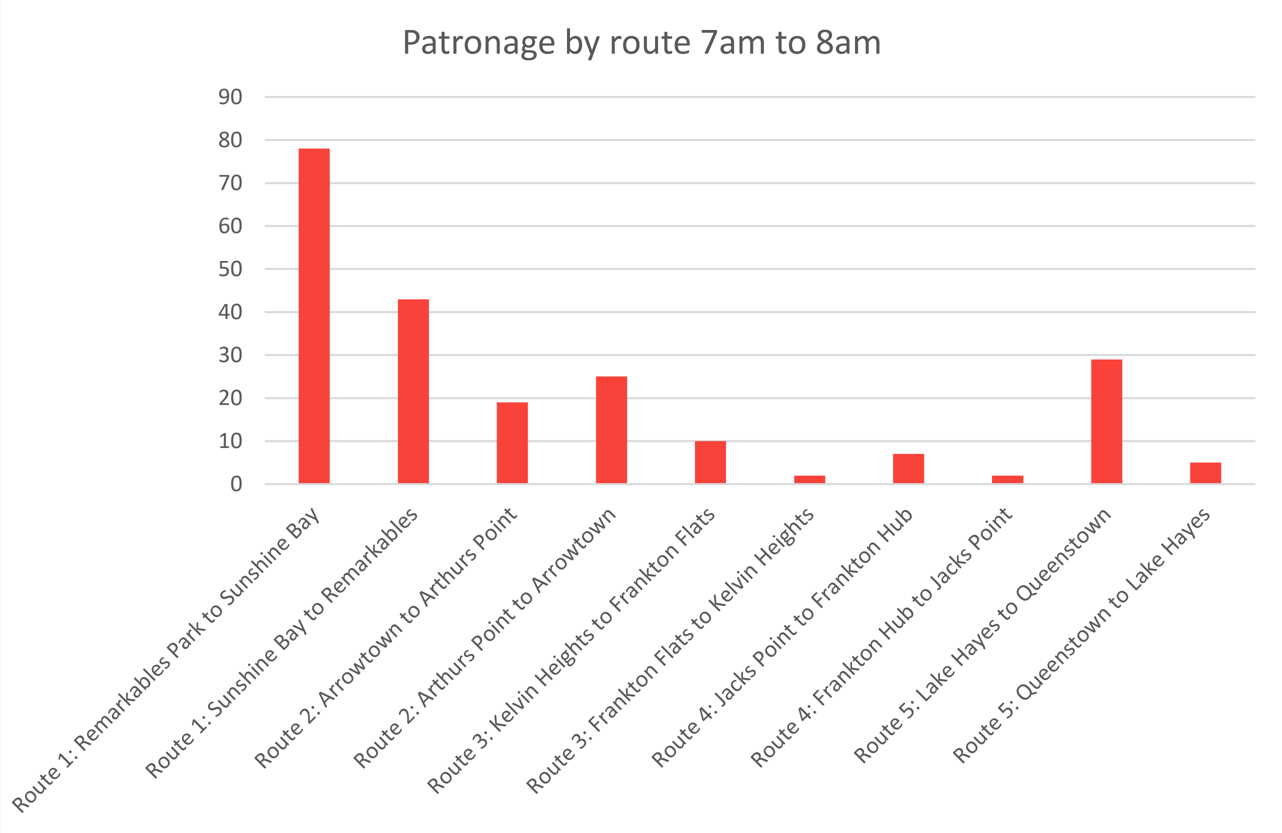


Figure 4. Patronage data for current bus network during morning peak (7 am - 8 am) in Term 4 2021 (Source: Otago Regional Council).

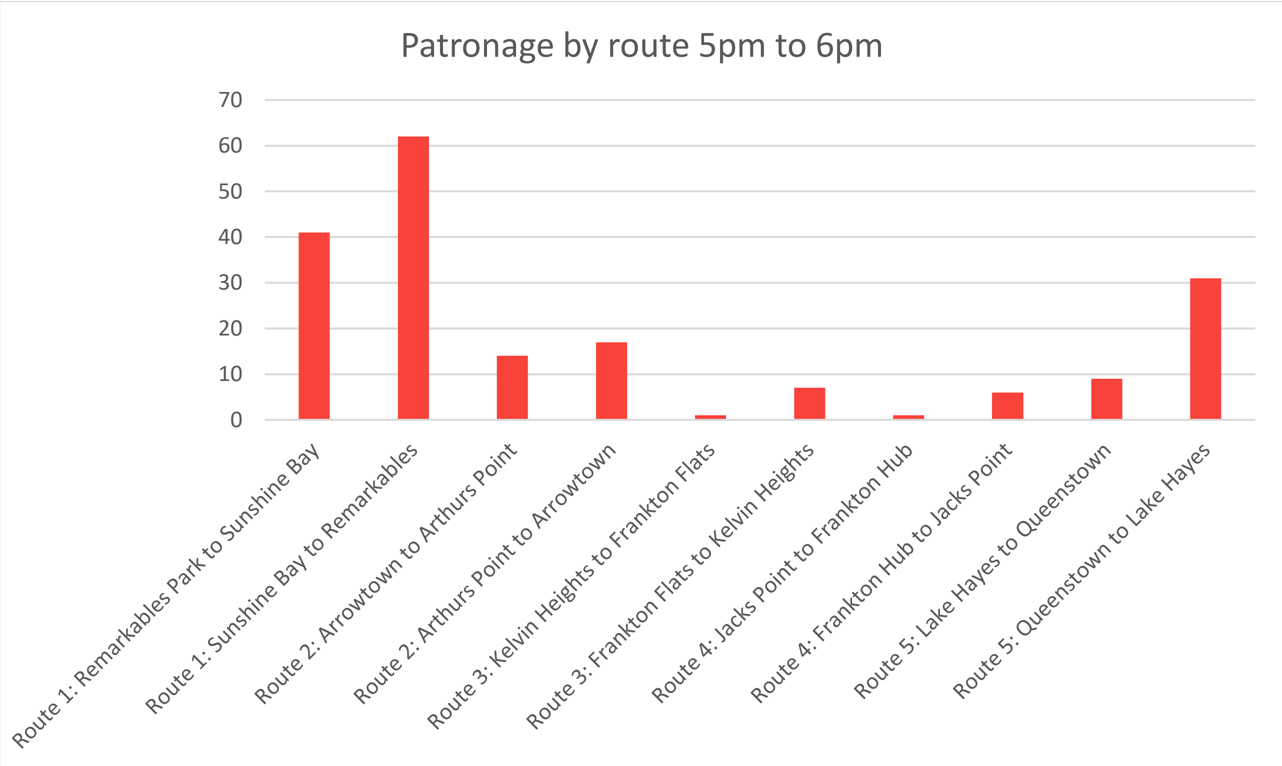


Figure 5. Patronage data for current bus network during morning peak (5pm - 6pm) in Term 4 2021 (Source: Otago Regional Council).

3.8 School trips

Within the wider Queenstown area there are seven full primary schools and one high school. Primary schools are spread across the main urban areas with students from Arthurs Point, Arrowtown, Fernhill, Quail Rise, Kelvin Heights and Jacks Point needing to travel further to access their local school. With Wakatipu High being the sole high school, this creates travel demand for trips going into Frankton from all areas of Queenstown. At the time of writing this report there are 18 Ministry of Education school bus routes which serve schools in both Queenstown and Frankton. These school bus routes carried a combined patronage of approximately 470 students which represents around 2/3rds of total public transport patronage in Queenstown.

3.9 Travel Time and Reliability

A strong influence on public transport patronage is the relative attractiveness of other modes. The table below compares the travel time of driving verses public transport, it is acknowledged that timetables are not necessarily the actual travel time (as traffic conditions on key routes can be variable) but provide a useful comparison. For the Frankton to Queenstown route the bus travel time is comparable to the drive time which is due to the bus routes following a direct route along SH6A and sharing road space with general traffic. From Lake Hayes the bus is approx. 10min slower than driving which could be due to time spent at bus stops. For Kelvin Heights the bus travel time is approx. 20min longer than driving due in part to route 3 making a detour to Remarkables Shops. For Jacks Point the bus travel time is along approx. 20min longer than driving due to the transfer time and detour into Hanley Farm.

Travel time reliability is a major factor in encouraging public transport patronage, and customers will accept longer travel times on public transport if the travel time is reliable enough to allow reasonable certainty of arrival time at the destination. The congested nature of SH6A; and the need for buses to share road space with general traffic, means that any travel time unreliability experienced by private vehicle travellers is also experienced by bus customers.

Table 3 below shows drive time is highly variable in percentage times on key routes in Queenstown, though as the data show, overall travel times are short in real terms.

Table 3. Travel time for driving versus public transport.

Route	Drive time (Google Maps)	Bus journey time (Timetables)
Frankton to Queenstown	9-14min	15min
Kelvin Heights to Queenstown	16-22min	40min
Jacks Point to Queenstown	16-22min	45min
Lake Hayes to Queenstown	16-22min	30min
Arrowtown to Queenstown	22-30min	40min

As seen from the Google Maps drive time, there is a 6 to 8min difference between the low end and high end of the travel time for each of the key routes. However, for a public transport service to be considered punctual it must arrive at each stop between -1min and +5min from the timetabled time[1]. Having large range in the of drive times will make it harder to provide a reliable public transport service considering that there is currently limited public transport priority. This is because trips which are caught in traffic will run late, while those services that experience an uncongested trip will need to dwell at bus stops to ensure compliance with the timetable (increasing passenger travel times).

3.10 Parking

Parking prices in Queenstown central are between $1 to $4 per hour for Queenstown Lakes District Council parking areas. Privately operating parking areas charge $4 to $5 per hour. In Frankton parking is free for people visiting retail premises with 12 hours off street parking costing $3. Compared to bus fares of $4 round trip public transport is price competitive with driving to Queenstown but less price competitive to driving to Frankton.

3.11 Walking and Cycling

Walking in Queenstown town centre is generally attractive due to frequently spaced pedestrian crossings and restrictions placed on the movement of vehicles such as limited access streets. Due to the high traffic volumes along SH6A (25,000-30,000 vehicles per day) it can be challenging for pedestrians to cross to bus stops despite pedestrian refuge islands being provided. Pedestrians being able to cross SH6A is important because half of the catchment area is up the side of Queenstown Hill. At the Frankton Hub there is a signalised pedestrian crossing which enables pedestrians to safely cross SH6. However, there is currently no direct path between the Frankton hub and Alpine Aqualand which limits the walking catchment.

Queenstown has an extensive network of cycling paths which can be used by both commuter and recreational cyclists (Figure 6). There are lakefront cycle trails that connect Queenstown, Frankton, Kelvin Heights and Lake Hayes. However, the trails are mostly unsealed, lack lighting and are shared with pedestrians which limits their attractiveness to commuter cyclists who are travelling longer distances. An integrated walking and cycling trail network will be delivered through the Whakatipu Active Travel Network project which will connect key suburbs and deliver new walking and cycling facilities.[2] Some routes in this project are estimated to be finished in 2023 and 2024.

[1] Punctuality definition from Otago Regional Public Transport Plan 2021
[2] Whakatipu Active Travel Network, Queenstown-Lakes District Council.

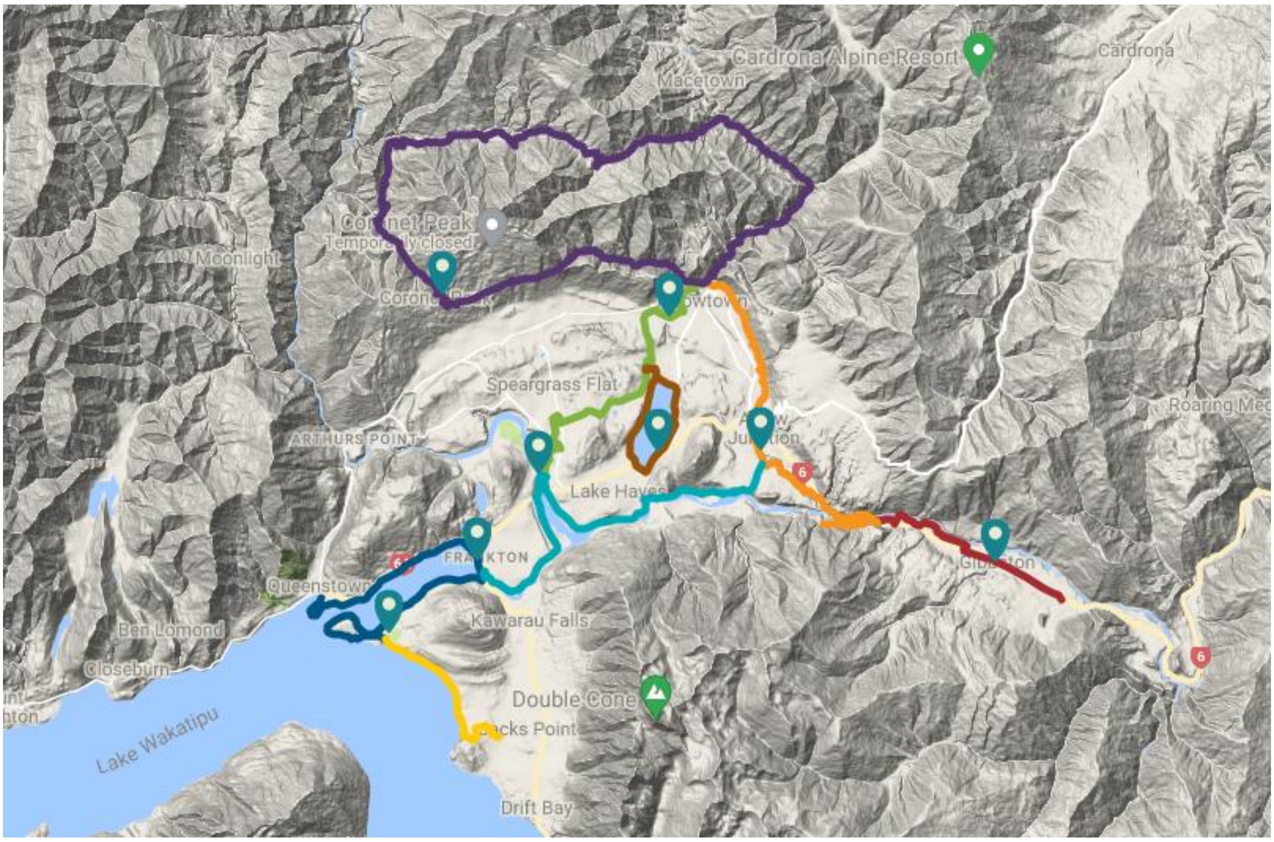


Figure 6. Queenstown Trails (Source: Queenstown Trails).

3.12 Tourist and Recreational Activities

Queenstown is a key tourism destination for both domestic and international visitors which offers a range of activities and accommodation options. Queenstown is also a gateway for visitors exploring Central Otago and the rest of the South Island as it hosts an international airport which has daily flights from New Zealand's main centres and east coast Australian airports.

Some activities that are located within the urban area of Queenstown are Skyline Queenstown, bars and restaurants, Queenstown Golf Club, walking and cycling trials and the TSS Earnslaw. Nearby destinations include resorts across Queenstown to Arrowtown (e.g. Millbrook and Hilton), The Remarkables Ski Area, Arrowtown (gold mining heritage), Coronet Peak ski area, Kawarau Gorge Suspension Bridge (bungy jumping attraction) and Gibbston Valley wineries. Queenstown is also a departure point for tours to Milford Sounds with tour buses departing multiple times per day. No information on the number of tourists using buses/coaches is publicly available for the various tours and activities that are offered in Queenstown.

Most outdoor tourist activities are situated in locations outside of Queenstown and companies will offer free transport from Queenstown if activities are booked. Tourists will typically have to travel into Queenstown (or Frankton for other outdoor activities) via their own transport (private vehicle or public transport) before transferring to the free buses offered by their tourist activity provider.

Having a well-connected and efficient bus network will improve connectivity for visitors staying in various parts of Queenstown to their recreational activities.

4 Future Land Use and Transport Context

4.1 Residential and Business Growth Areas

4.1.1 Queenstown Lakes Spatial Plan

The Queenstown Lakes Spatial Plan 2021 provides the long-term framework for managing growth within the district. The Spatial Plan promotes a consolidated and mixed-use approach to accommodating growth in the Queenstown Lakes. The approach focusses on locations that are already fully or partially urbanised. Within the existing Queenstown urban area, growth will be focused in locations with good access to facilities, jobs and public transport.

Three new future urban areas are identified for investigation, along the Eastern Corridor and northern/southern ends of the Southern Corridor (Figure 7). These locations integrate with existing development and are located on the proposed frequent public transport network. Frankton is of strategic importance to achieving the consolidated approach to growth in the Spatial Plan, due to its significant development potential and access to public transport.

The Spatial Plan forecasts significant growth for Queenstown Lakes:

- The average day population (residents and visitors) for the district is expected to increase from an estimated 51,000 people (41,000 residents and 10,000 visitors) in 2021 to an estimated 120,000 (78,000 residents and 42,000 visitors) in 2051. The resident population is approximately 81% on an average day; and
- The peak day population (residents and visitors) for the district is expected to increase from an estimated 103,000 people (41,000 residents and 62,000 visitors) in 2021 to an estimated 204,000 (78,000 residents and 126,000 visitors) in 2051. The resident population is approximately 38% on a peak day.

The main urban areas of Queenstown and Wanaka are intended to provide for approximately 80% of both the estimated growth in dwellings up to 2050 and the Spatial Plan capacity. The remaining 20% is distributed across the smaller settlements and rural areas of the Queenstown Lakes.

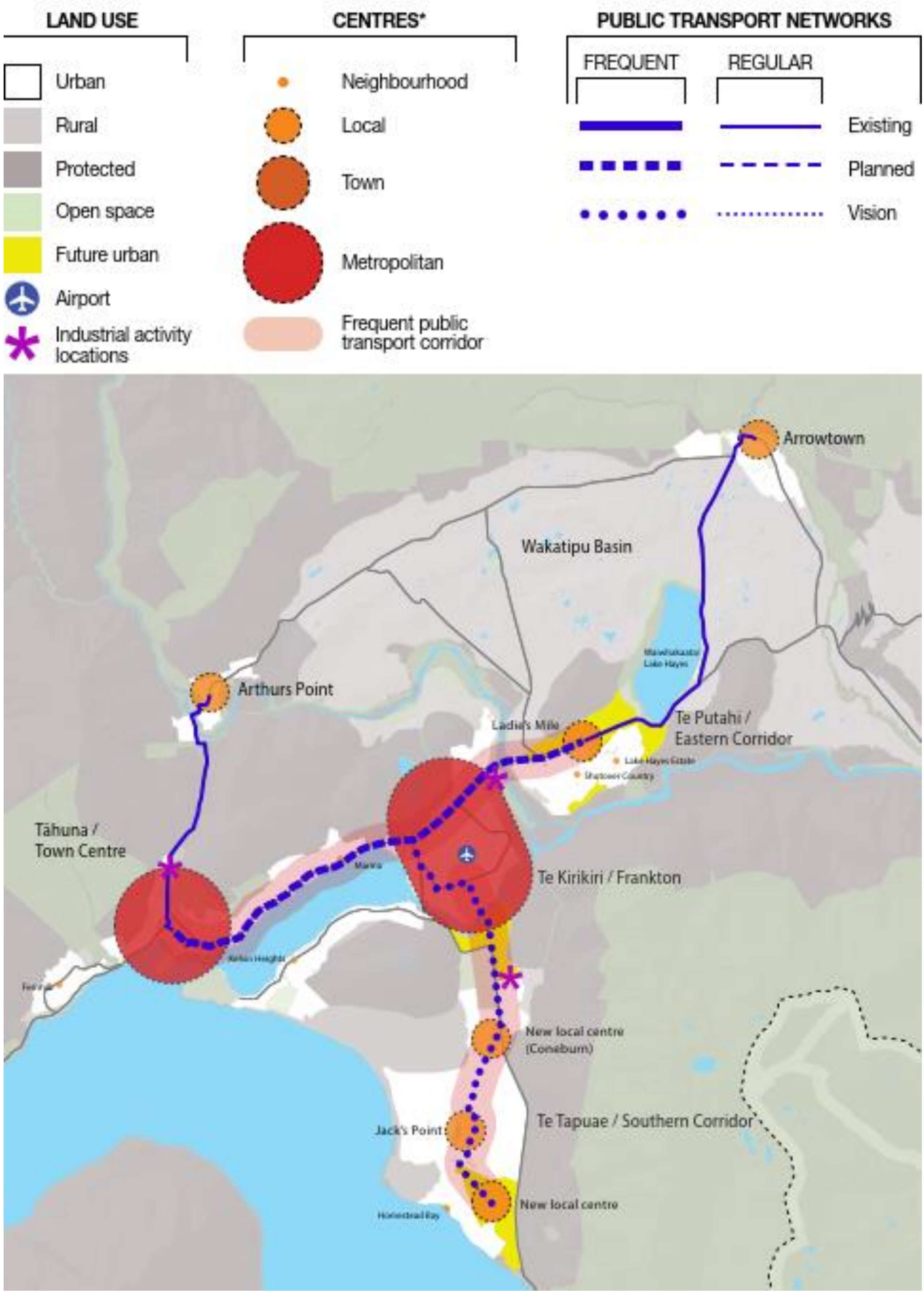


Figure 7. Spatial Plan map showing growth areas and public transport network

4.1.2 Southern Corridor

The southern corridor has been identified for further residential, commercial, and industrial development due to its relatively flat topography (with some rolling hills) and proximity to SH6. The southern growth area consists of areas which are currently under development including Jacks Point and Hanley's Farm and planned future development at Coneburn and Homestead Bay (Figure 8). Coneburn has been approved as a Special Housing Area with 650 dwellings planned to comprise of mostly three-to-four-bedroom houses. The Coneburn Industrial area is planned to the east of SH6 which compromises 260 industrial units that could attract freight and trade service businesses. Hanley's Farm has currently released approx. 500 titles and once complete could have 1,700 dwellings with a school and day care facilities. For Jack's Point, 600 dwellings are currently planned with approximately 30% of the homes having been completed to date. Lastly, Homestead Bay is a planned residential area which is to accommodate 900 dwellings subject to Environment Court proceedings.

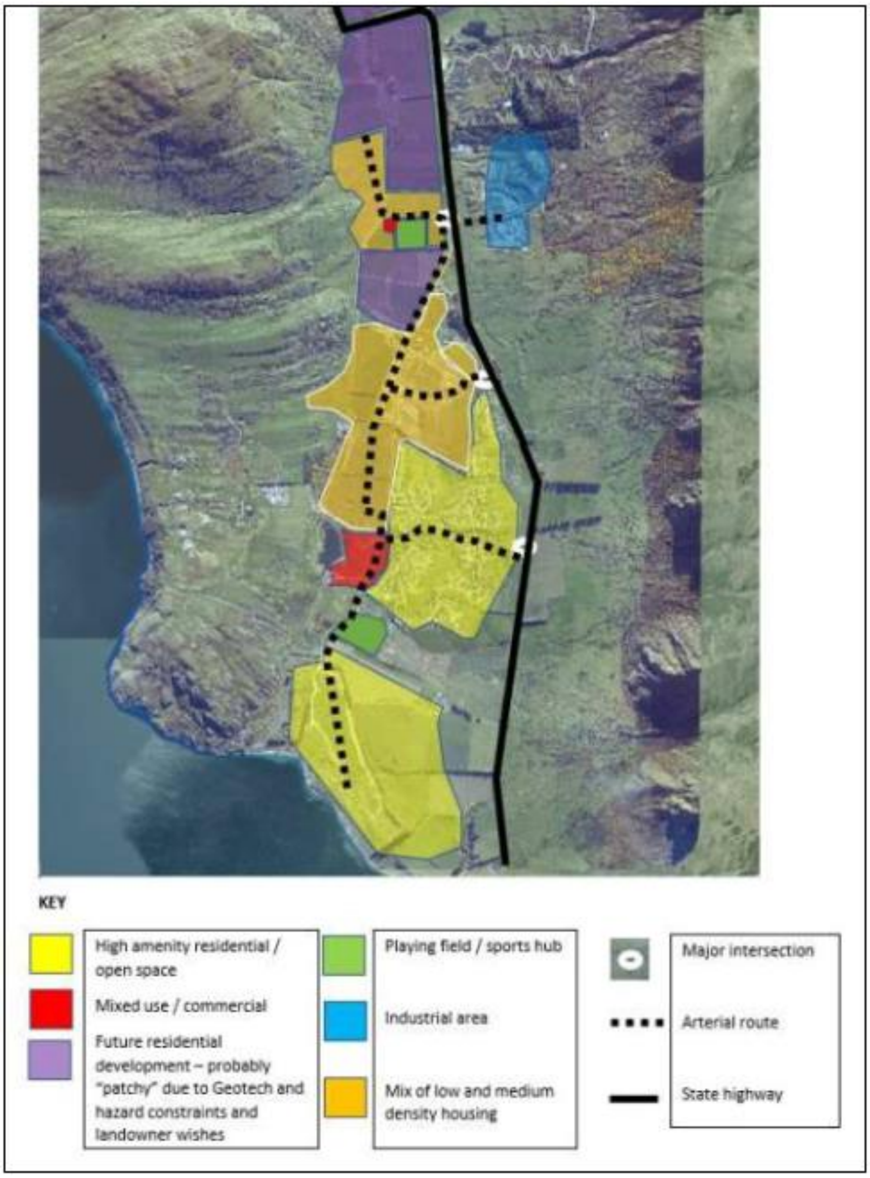


Figure 8. Southern corridor growth area.

4.1.3 Ladies Mile

Ladies Mile is a planned urban growth area that adjoins Lake Hayes and Shotover Country with SH6 to the south and Slope Hill to the north. The masterplan for Ladies Mile was approved from

Queenstown Lakes District Council in June 2022 after the initial application for rezoning was declined in April 2019. The masterplan includes a town centre, medium to high density development north of SH6, low density development and open space south of SH6 (Figure 9). The total number of dwellings across the Ladies Mile area is approximately 1,100.

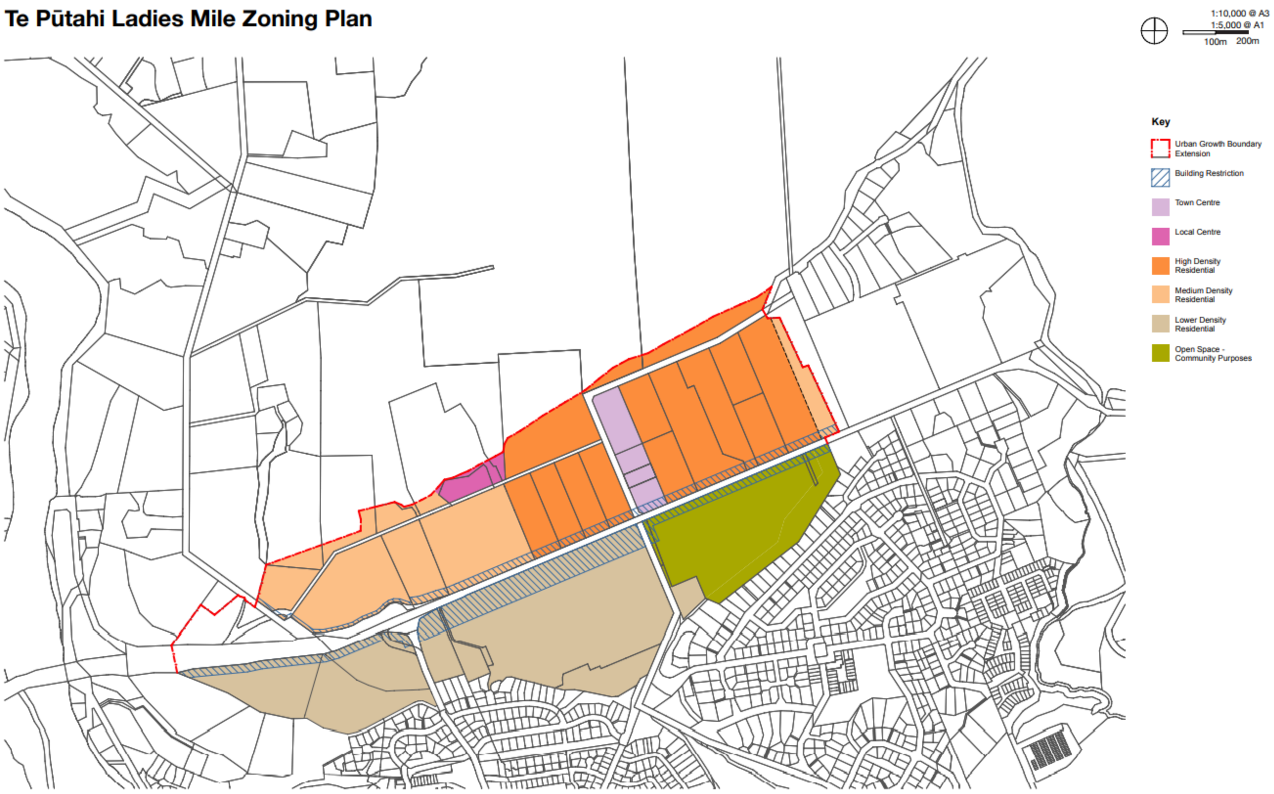


Figure 9. Ladies Mile Zoning Plan and urban growth area. (Source: Queenstown Lakes District Council).

4.1.4 Quail Rise South

Quail Rise South is a planned residential development that is located adjacent to Frankton Flats on the western side of SH6 (Figure 10). The area has the potential for approximately 1,100 new dwellings and could include a connection to SH6 at Hawthorne Drive linking to Ferry Hill Drive and walking and cycling connections to Five Mile. From a public transport planning perspective, the link road and additional houses would make it easier to serve Quail Rise with public transport.

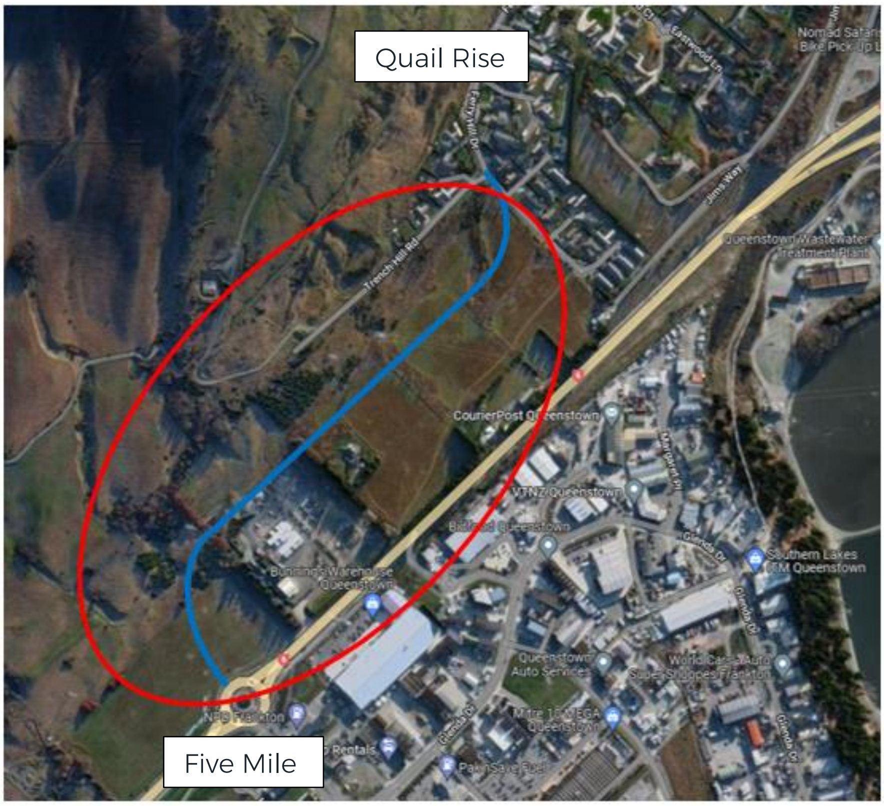


Figure 10. Quail Rise South, potential link road in blue and indicative development area shown with red circle.

4.2 Queenstown Airport

Queenstown Airport is the fourth busiest airport by passenger numbers in New Zealand and connects the Southern Lakes region to the rest of New Zealand and beyond. Drawing on the Queenstown Airport Strategic Plan 2023-2032 there were 2.3 million passenger movements in 2019 which dropped to 1.1 million in 2022 due to the impact of Covid-19. In 2022, passenger movements have returned to 2019 pre-Covid levels; from late June to July for domestic passengers and from November 2022 for international passengers.[3] The airport plans to accommodate passenger growth through extending the terminal building, relocating non-scheduled flights and by automating baggage handling. The Strategic Plan assumes no new international airport will be developed in the Lower South Island before 2032. From a public transport planning perspective, the continued growth in passenger numbers further strengthens the airport as a key destination to be served with high-capacity public transport.

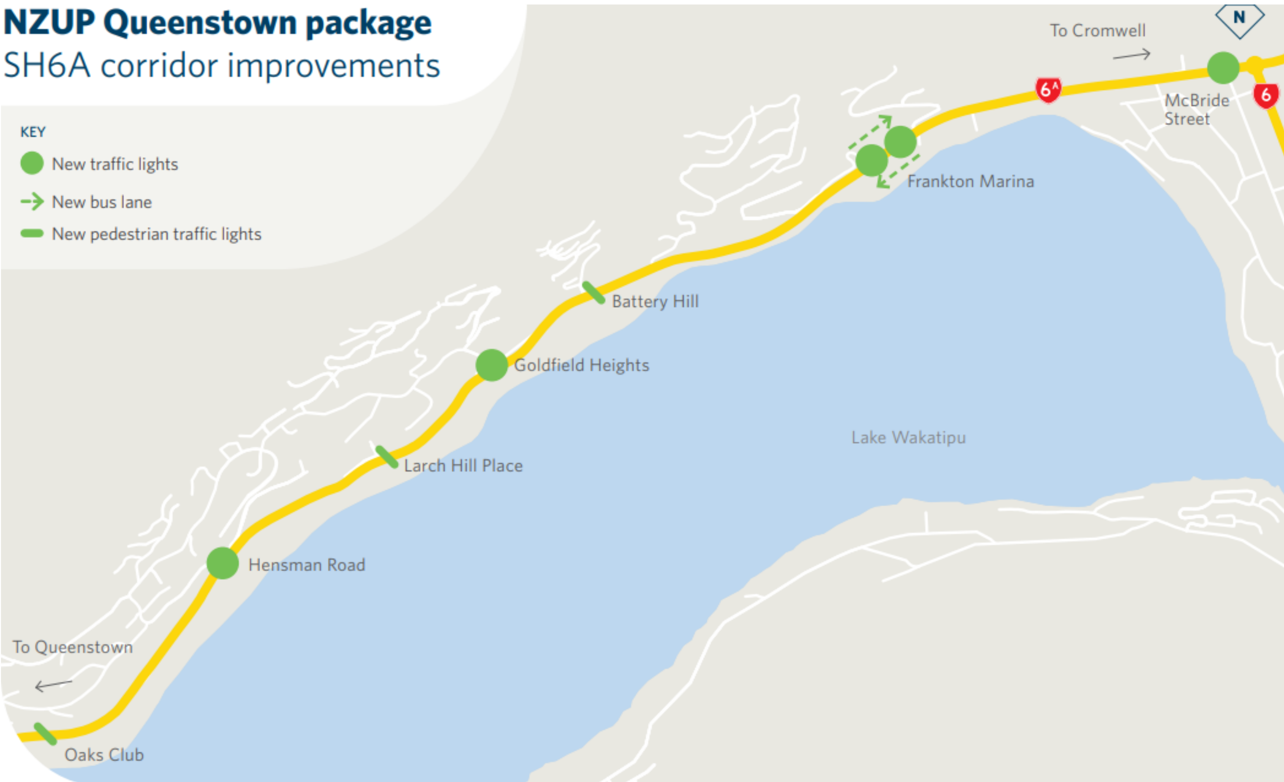
4.3 Planned and Committed Projects

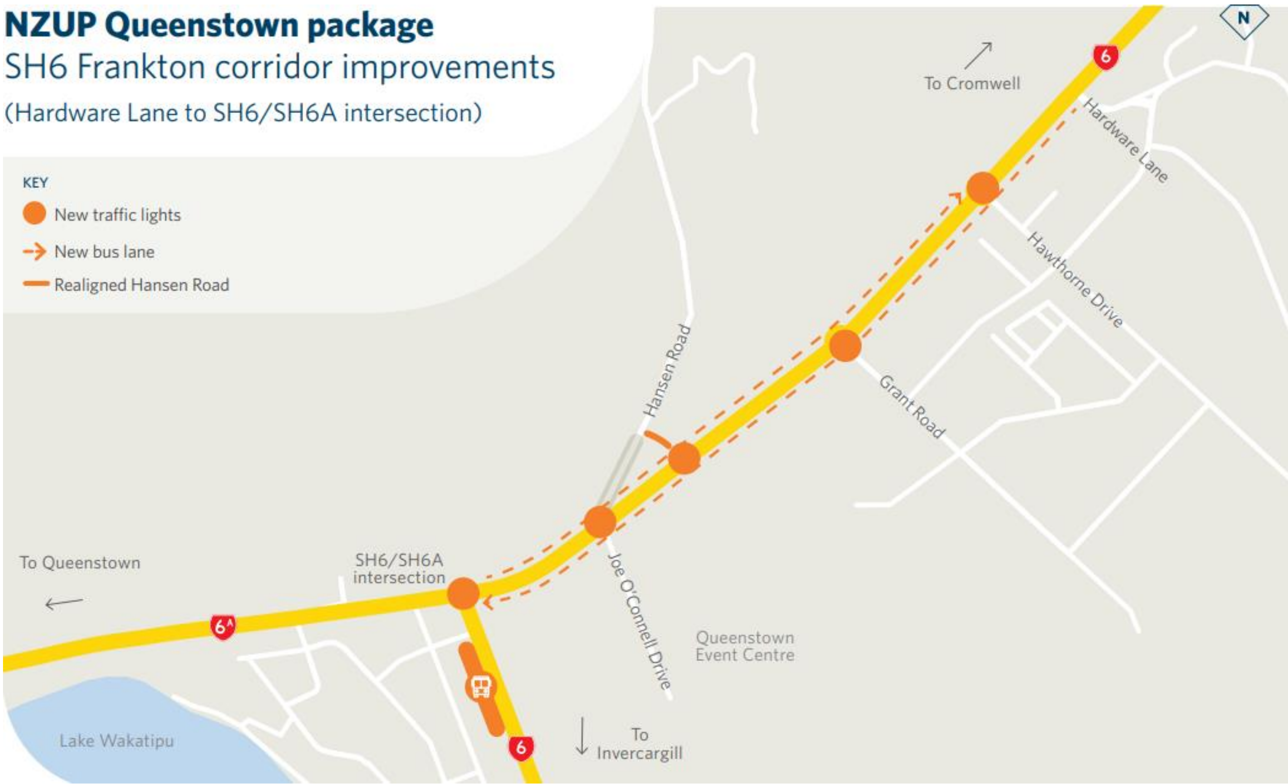
4.3.1 New Zealand Upgrade Programme

The Queenstown Package of the New Zealand Upgrade Programme (NZUP) will provide bus lanes on SH6, improvements to the existing Frankton hub, signalisation of intersections along SH6A/SH6 and pedestrian crossings across SH6A (Figure 11). The NZUP works will improve bus travel times and reliability, make it easier for passengers to access bus stops and improve the customer experience at the Frankton hub. However, due to property constraints there is only limited bus

[3] Airport Passenger Statistics - Facts & Figures, Queenstown Airport Corporation (n.d.).

lanes proposed for SH6A around the Frankton Marina and not full-length bus lanes to Queenstown.





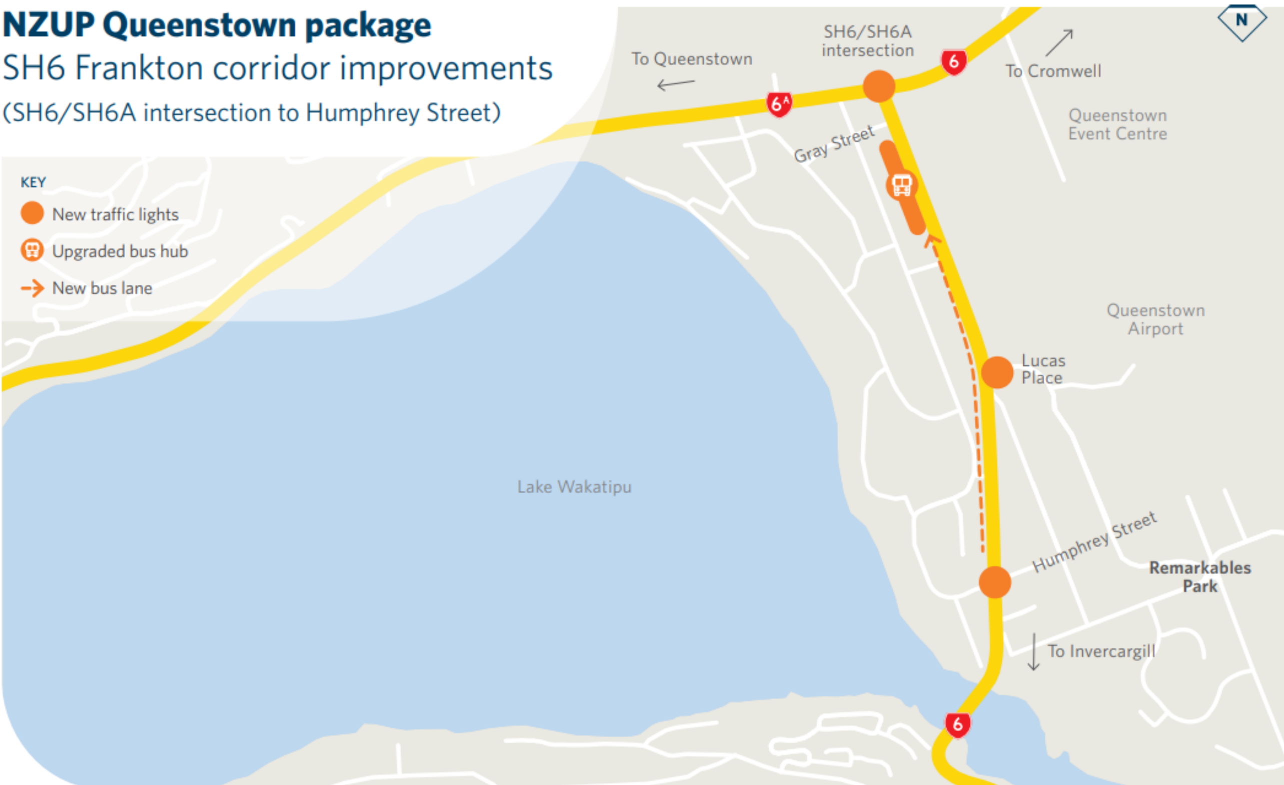


Figure 11. NZUP Queenstown package SH6A corridor and SH6 Frankton corridor improvements (Source: Waka Kotahi New Zealand Transport Agency).

4.3.2 Queenstown Arterial Road

The Queenstown Arterials project will divert general traffic away from the town centre by constructing new through roads around the perimeter of the town centre. This will be accompanied by pedestrian and placemaking improvements in the town centre that will enhance experience of Queenstown for locals and visitors. Arterials stage 1 is currently under construction and will create a new road along Melbourne St and Man St (Figure 12). The public transport hub at Stanley St will be retained in its current location with the volume of general traffic on Stanely Street expected to reduce once the road is built. Arterials stage 2 is Gorge Road to Hay Street and stage 3 is Hay Street to One Mile. Stages 2 and 3 will provide a second route to Fernhill and will enable better coverage of the western town centre including the Skyline Gondola.

Figure 12. Queenstown Arterials plan (Source: Queenstown Lakes District Council).

4.3.3 Arthurs Point Crossing

A single stage business case for the replacement of the Edith Cavell Bridge over the Shotover River in Arthurs Point has been endorsed. The recommended programme from this business case is a separate active modes bridge approximately 400m downstream from the existing bridge as stage 1. Stage 2 would be a new two-lane road bridge approximately 100m downstream from the existing bridge (Figure 13).

Figure 13. Recommended new pedestrian and road crossing locations.

4.3.4 Wakatipu Active Travel Network

The Wakatipu Active Travel Network is a single stage business case that contains improvements to the Queenstown walking and cycling network. The business case has been approved by Council with funding for the first package having been endorsed by NZTA. Stage 1 includes a connection to the existing Shotover Bridge, State Highway 6 to Frankton track, Jacks Point to Frankton (Figure 14). Stage 2 includes a connection from Fernhill to Frankton track, Queenstown to Arthurs Point and Lake Hayes Estate to Shotover River. Progress has been made on several trails in Stage 1 with the status of each of these projects being as follows:

- Route A2 – scope change and funding available for design through to construction.
- Route A3 – detailed design deferred.
- Route A7 – investigations underway to review several route options.
- Route A8 – detailed design completed, further work underway.
- Route C5 – Construction work finished for Matakauri Wetlands Trail, construction work to be finished in March 2024 for Gorge Road Cycleway.
- Route C7 – Detailed design complete, no funding available for construction.[4]

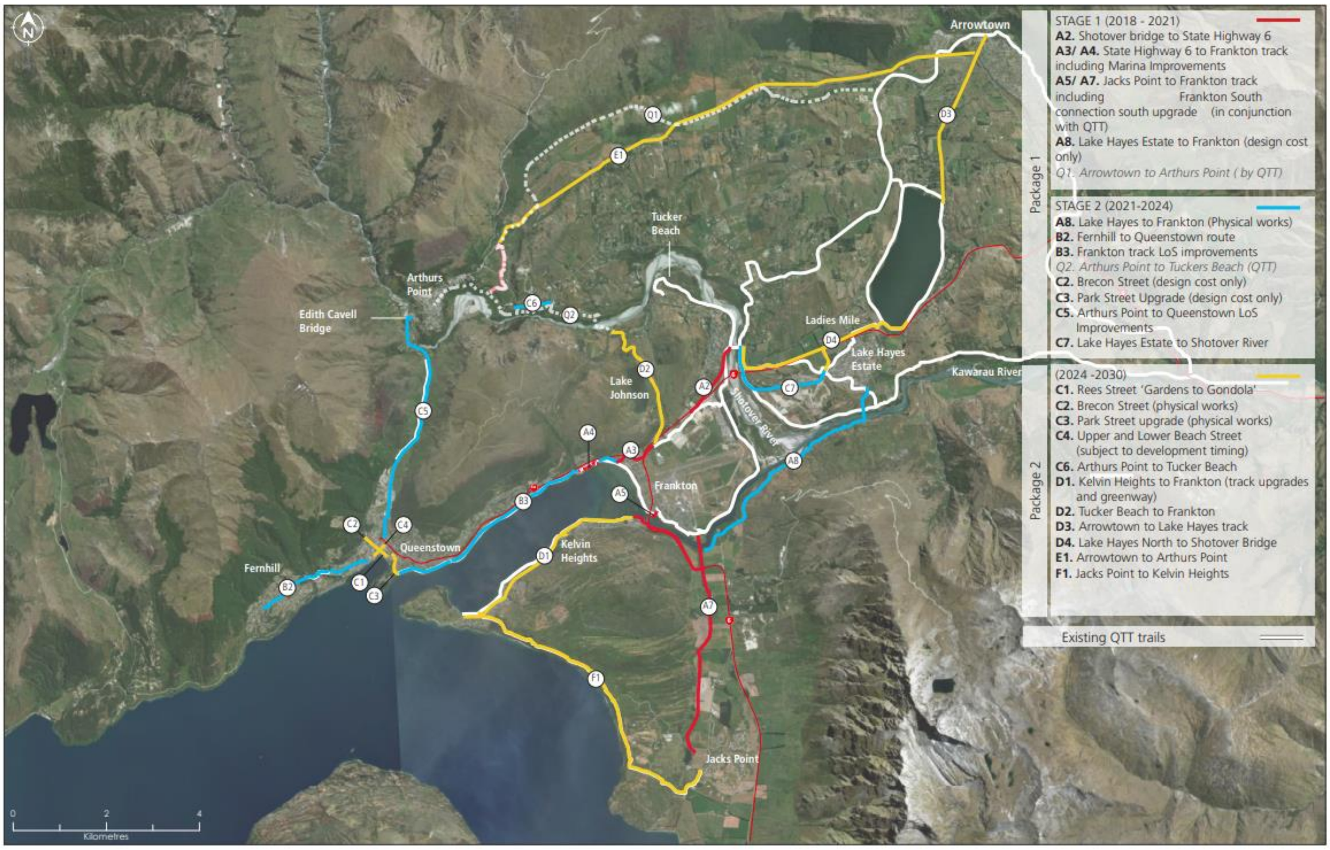


Figure 14. Wakatipu Active Travel Network recommend programme staging

[4] Whakatipu Active Travel Network, Queenstown Lakes District Council (n.d.).

5 Travel Demand

Public transport demand forecasts were made using the vehicle matrixes from the TRACKS 3-stage model and feeding these into a logic-based mode choice model. Details of the modelling methodology and results can be found in the Forecast Demand Advisory Paper, where optimum targets for key road links were set and modelling was then conducted to show the forecasted demand.

The key features of the public transport model are as follows:

- Base year 2018 with forecast years 2024, 2027, 2039 and 2054
- Model periods are 8am to 9am (morning peak), 12 noon to 1pm (interpeak) and 5pm to 6pm (evening peak)
- Applied a maximum volume over capacity ratio of 90% which is the generally accepted level at which significant congestion starts to occur
- Public transport crowding factors not applied, therefore the model is unconstrained
- The forecasts provide an indication of the volume of passengers required to be accommodated on public transport to maintain acceptable operation of the road network

Table 4 & Table 5 on the following pages show the public transport patronage required on each of the key road links to avoid significant congestion. Both for the previous business case (QITBC) and the current forecasts are shown. This gives an indication of the scale and volume of passengers required to be accommodated by public transport to maintain operation of the road network to an acceptable degree. The following insights have been provided by the demand forecasts:

- Several road network links would be over capacity without mode shift towards public transport which includes SH6A westbound, Shotover Bridge westbound, Kawarau Falls Bridge northbound and Arthurs Point Crossing southbound
- The public transport capacity required in 2053 is 1466 people per hour at SH6A, 772 people per hour at Shotover Bridge, 1687 people per hour at Kawarau Falls Bridge and 336 people per hour at Arthurs Point Crossing
- The current public transport can deliver capacity for around 260 passengers per hour along SH6A and therefore six times more public transport capacity is needed to accommodate the desired mode shift
- Counter peak trips e.g., those leaving Queenstown and Frankton do not have the same capacity constraints as trips travelling into town
- Capacity constraints are reached in 2027 for all key links which is expected due to the current congestion experienced on the road network
- The headline mode share for public transport in 2053 is 47% on SH6, 34% on Shotover Bridge and 53% on Kawarau Falls Bridge

			AM - Number of Passengers									
Location	Direction	Passengers	2027 Future		2028 QITBC		2039 Future		2048 QITBC		2053 Future	
SH6A (Suburb)	Eastbound	Car	1037	100%	1433	100%	1153	100%	1462	100%	1272	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	1037	100%	1433	100%	1153	100%	1462	100%	1272	100%
		DoS	50%		69%		55%		70%		61%	
	Westbound	Car	1638	73%	1638	68%	1638	60%	1638	54%	1638	53%
		PT	592	27%	775	32%	1082	40%	1388	46%	1466	47%
		Total	2230	100%	2413	100%	2720	100%	3026	100%	3104	100%
		DoS	90%		90%		90%		90%		90%	
SH6A (Marina)	Eastbound	Car	1107	100%	1521	97%	1206	100%	1491	100%	1216	100%
		PT	0	0%	51	3%	0	0%	0	0%	0	0%
		Total	1107	100%	1572	100%	1206	100%	1491	100%	1216	100%
		DoS	66%		90%		71%		88%		72%	
	Westbound	Car	1521	76%	1521	71%	1521	62%	1521	55%	1521	54%
		PT	480	24%	626	29%	938	38%	1236	45%	1283	46%
		Total	2001	100%	2147	100%	2459	100%	2757	100%	2804	100%
		DoS	90%		90%		90%		90%		90%	
Shotover Bridge	Eastbound	Car	867	100%	886	100%	1064	100%	1271	100%	1318	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	867	100%	886	100%	1064	100%	1271	100%	1318	100%
		DoS	48%		49%		58%		70%		72%	
	Westbound	Car	1521	82%	1521	68%	1521	75%	1521	61%	1521	66%
		PT	323	18%	709	32%	514	25%	957	39%	772	34%
		Total	1844	100%	2230	100%	2035	100%	2478	100%	2293	100%
		DoS	90%		90%		90%		90%		90%	
Kawarau Falls Bridge	Southbound	Car	580	100%	728	100%	740	100%	916	100%	691	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	580	100%	728	100%	740	100%	916	100%	691	100%
		DoS	34%		43%		44%		54%		41%	
	Northbound	Car	1521	89%	1521	96%	1521	60%	1521	60%	1521	47%
		PT	186	11%	64	4%	1033	40%	1018	40%	1687	53%
		Total	1707	100%	1585	100%	2554	100%	2539	100%	3208	100%
		DoS	90%		90%		90%		90%		90%	
Arthurs Point Crossing	Southbound	Car	761	94%	761	85%	761	80%	761	61%	761	69%
		PT	49	6%	130	15%	185	20%	487	39%	336	31%
		Total	810	100%	890	100%	945	100%	1248	100%	1096	100%
		DoS	90%		90%		90%		90%		90%	
	Northbound	Car	384	100%	476	100%	421	100%	532	100%	456	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	384	100%	476	100%	421	100%	532	100%	456	100%
		DoS	54%		67%		59%		74%		64%	

Table 4: Public transport demand forecasts - morning peak forecasts for the previous business case (QITBC) and the current forecasts (QPTBC) (Source: Queenstown Public Transport Business Case Forecast Demand Technical Note).

Location	Direction	Passengers	PM - Number of Passengers									
			2027 Future		2028 QITBC		2039 Future		2048 QITBC		2053 Future	
SH6A (Suburb)	Eastbound	Car	1872	79%	1872	68%	1872	66%	1872	53%	1872	56%
		PT	485	21%	884	32%	985	34%	1683	47%	1476	44%
		Total	2357	100%	2756	100%	2857	100%	3555	100%	3348	100%
		DoS	90%		90%		90%		90%		90%	
	Westbound	Car	1638	98%	1638	91%	1638	91%	1638	81%	1638	83%
		PT	36	2%	166	9%	170	9%	379	19%	329	17%
		Total	1674	100%	1804	100%	1808	100%	2017	100%	1967	100%
		DoS	90%		90%		90%		90%		90%	
SH6A (Marina)	Eastbound	Car	1521	72%	1521	61%	1521	60%	1521	48%	1521	52%
		PT	594	28%	980	39%	1028	40%	1642	52%	1384	48%
		Total	2115	100%	2501	100%	2549	100%	3163	100%	2905	100%
		DoS	90%		90%		90%		90%		90%	
	Westbound	Car	1521	81%	1521	80%	1521	77%	1521	77%	1521	74%
		PT	353	19%	392	20%	466	23%	453	23%	546	26%
		Total	1874	100%	1913	100%	1987	100%	1974	100%	2067	100%
		DoS	90%		90%		90%		90%		90%	
Shotover Bridge	Eastbound	Car	1638	82%	1638	69%	1638	71%	1638	58%	1638	65%
		PT	369	18%	748	31%	657	29%	1173	42%	869	35%
		Total	2007	100%	2386	100%	2295	100%	2811	100%	2507	100%
		DoS	90%		90%		90%		90%		90%	
	Westbound	Car	1276	100%	1521	95%	1485	100%	1521	71%	1521	90%
		PT	0	0%	75	5%	0	0%	610	29%	162	10%
		Total	1276	100%	1596	100%	1485	100%	2131	100%	1683	100%
		DoS	75%		90%		88%		90%		90%	
Kawarau Falls Bridge	Southbound	Car	1521	93%	1521	92%	1521	63%	1521	56%	1521	51%
		PT	123	7%	126	8%	909	37%	1211	44%	1489	49%
		Total	1644	100%	1647	100%	2430	100%	2732	100%	3010	100%
		DoS	90%		90%		90%		90%		90%	
	Northbound	Car	952	100%	937	100%	1267	100%	1310	100%	1381	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	952	100%	937	100%	1267	100%	1310	100%	1381	100%
		DoS	56%		55%		75%		78%		82%	
Arthurs Point Crossing	Southbound	Car	490	100%	544	100%	551	100%	673	100%	614	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	490	100%	544	100%	551	100%	673	100%	614	100%
		DoS	58%		64%		65%		80%		73%	
	Northbound	Car	644	82%	644	75%	644	74%	644	56%	644	69%
		PT	138	18%	216	25%	222	26%	508	44%	290	31%
		Total	782	100%	859	100%	866	100%	1151	100%	934	100%
		DoS	90%		90%		90%		90%		90%	

Table 5: Public transport demand forecasts - afternoon peak forecasts for the previous business case (QITBC) and the current forecasts (QPTBC) (Source: QPTBC Forecast Demand Technical Note).

6 Previous Business Case Work

6.1 Technical Note 30: High-Capacity Public Transport for Queenstown

Technical Note 30 from the Queenstown Indicative Transport Business Case outlines how the public transport network would need to develop to meet projected future demand and the forms of public transport best suited to meet this demand. The technical note was prepared at an Indicative Business Case level and therefore the concepts will be expanded on during this Detail Business Case phase.

The preferred public transport network is referred to as “Bus Max” which uses three high-capacity routes on SH6A heading to Jacks Point, Ladies Mile/ Lake Hayes and Arrowtown (Figure 15). The routes which make up the Bus Max Network are:

1 Sunshine Bay to Lake Hayes Estate/ Ladies Mile via Queenstown and Frankton
2 Arthurs Point to Arrowtown via Queenstown and Frankton
3 Queenstown to Jacks Point via Frankton, Queenstown Airport and Remarkables Park
4 Queenstown to Kelvin Heights Ferry
5 Kelvin Heights to Quail Rise via Frankton and Frankton Flats
6 Frankton Circular which links Frankton Hub, Airport, Remarkables Park and Frankton Flats

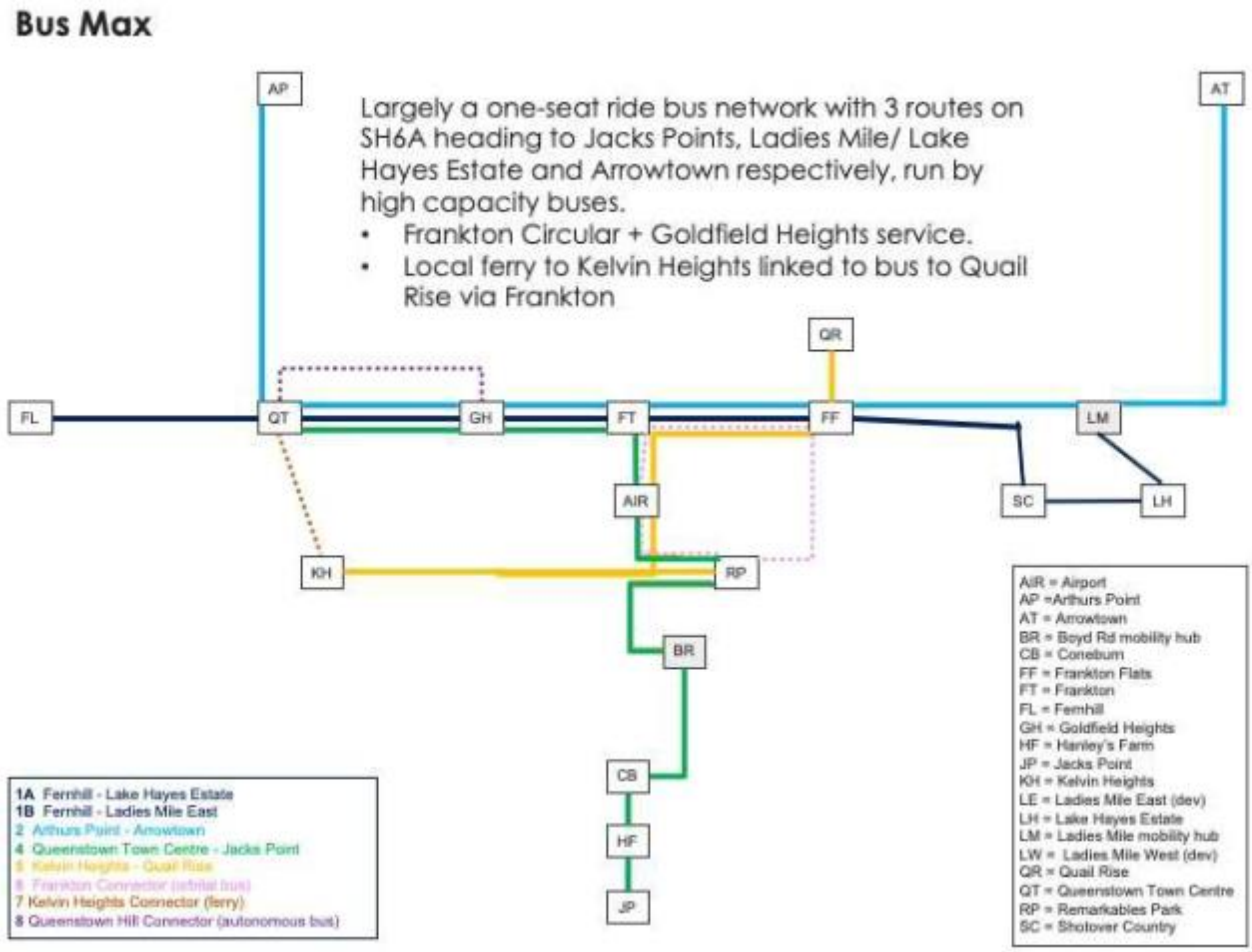


Figure 15. Preferred public transport network - Bus Max.

The key features of the Bus Max network concept are:

- Routes 1-3 inter-time on SH6A to provide a 3-4min peak and 5 min all day service between Queenstown and Frankton Hub
- There is largely a one-seat ride to minimise end-to-end journey times
- Frequent 6am to midnight on all routes
- Limit midnight to dawn service to provide 24/7 service
- High-capacity vehicles on routes 1, 2 and 3
- Public transport priority on SH6 East, SH6 South and SH6A

The proposed staging of the Bus Max network is:

- 2020-24: Current bus network with patronage recovering from the impact of Covid-19
- 2024-27: Upgrade to current route 1 (Sunshine Bay – Queenstown – Frankton – Airport – Remarkables) to a 10-minute frequency using larger buses (double decker or articulated)
- 2027-30: Introduction of the three core routes, the Frankton Loop service and the Queenstown to Kelvin Peninsula ferry. New fleet of either articulated or double decker buses for the core routes with single decker buses on Frankton Loop and Kelvin Heights to Quail Rise services.
- 2030-39: Upgrade to core routes to 10-minute frequency for peak and shoulder periods
- 2039-51: Change in fleet type to bi-articulated buses on core routes with capacity for 150-170 passengers to further increase service capacity (Figure 16).

Figure 16. Example of bi-articulated bus planned for Brisbane Metro.

6.2 Lakes Wakatipu Public Water Ferry Service

This Detailed Business Case was prepared in November 2019 and documents the case for investment in a Frankton Arm ferry service that is integrated into the public transport network. Six different route options were considered which are Frankton Arm, Kawarau River, wider Wakatipu and combinations of these (Figure 17). The Frankton Arm option provided a benefit cost ratio of 0.97 with the other options returning a BCR of below 1. The recommended programme is Frankton Arm ferry service with incentive payment to the ferry operator and capital costs for the wharf upgrades. The business case found that the Kawarau and Wakatipu ferry services would not be financially viable due to the lower forecast patronage (Table 6). Wharf upgrades and new facility at Frankton Beach are not progressed currently due to a lack of certainty on infrastructure requirements.

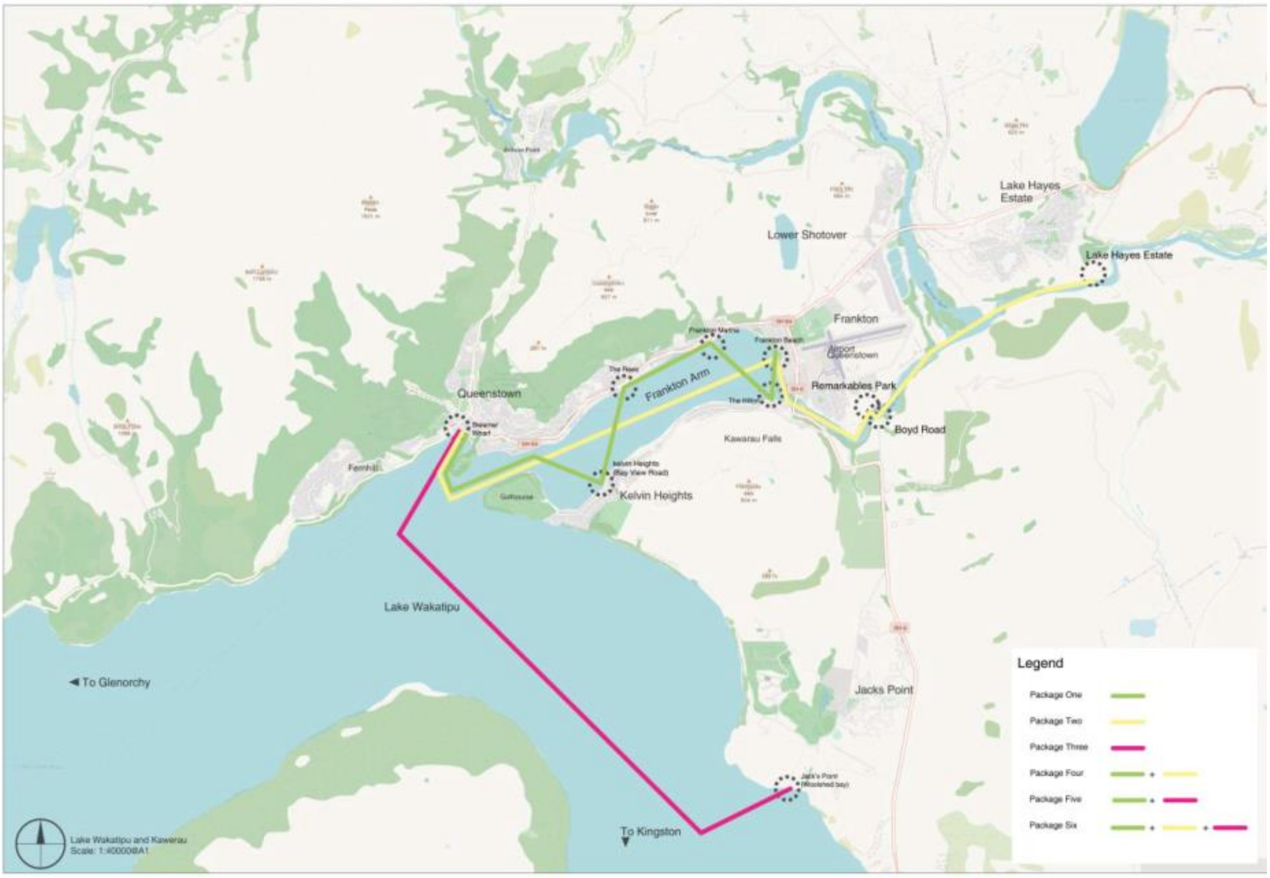


Figure 17: Six route options plotted (Source: Wakatipu Ferry Business Case).

Option	Financial results	Economic results	
	Annual incentive required for IRR @ 10%	**BCR**	**NPV**
1 – Frankton	$1.59m per annum	0.97	-$0.78m
2 – Kawarau	$7.77m per annum	0.20	- $81.3m
3 – Wakatipu	$1.56m per annum	0.07	- $22.9m
4 – Frankton + Kawarau	$9.36m per annum	0.43	- $72.1m
5 – Frankton + Wakatipu	$3.15m per annum	0.71	- $14.8m
6 – Frankton + Kawarau + Wakatipu	$10.99m per annum	0.38	- $91.4m

Table 6: Six route options and their economic results (Source: Wakatipu Ferry Business Case).

7 Opportunities and Constraints

The following opportunities and constraints have been identified for the provision of high-capacity public transport in Queenstown.

Constraints:

- Topographic barriers (Lake Wakatipu and Queenstown Hill) to connections between Queenstown and Frankton which means that all traffic including buses must funnel through a single corridor.
- That activity centres in Frankton are dispersed around the edges of the airport runway and that there is little current activity around the back of Hawthorn Drive. This makes it difficult to serve the destinations in Frankton whilst also providing a direct service to Queenstown.
- The high traffic volumes on State Highway 6A and the lack of public transport priority measures is likely to continue to cause unreliability issues for public transport.
- Last mile challenge for people living in Queenstown Hill who currently need to walk uphill from State Highway 6A when catching public transport.
- Tourist activities which are in rural areas are difficult to serve with public transport due to the limited catchment outside of urban areas.
- Long distances from Queenstown to outer areas including Arrowtown and Jacks Point (20km and 15km respectively) increases the potential for delays and disruptions along the routes.
- Current public transport network and bus fleet being unable to accommodate the volume of passengers needed to meet mode shift targets.
- Limited kerb space in Queenstown central to accommodate higher frequency public transport services all be it the situation will be greatly improved by the Queenstown Arterials Project.

Opportunities:

- Planned future development is largely linear along the southern and eastern corridors which is approximately 1km wide. This is ideal for public transport planning because most residents would be within a comfortable walking distance to a central public transport line.
- Potential for a walking, cycling and public transport bridge between Kawarau Falls and Remarkables Shops could enable Wakatipu High School, Remarkables Shops and the Airport to be served along the way to Frankton Hub. This would greatly simplify the public transport network and would result in public transport having more competitive journey times for people living in the southern corridor.
- Development of Quail Rise south and the planned link road to Hawthorne Drive would make it much easier to serve Quail Rise with a public transport route whilst avoiding the need for service loops.
- Planned Ladies Mile development which is adjacent to Shotover Country and Lake Hayes could support a higher frequency public transport route because of the increased number of residences within the catchment.

- The bus lanes planned for State Highway 6 south and east of the BP intersection would result in faster and more reliable public transport journey times which in turn makes public transport more attractive.
- The cost and difficulty of finding parking in Queenstown central is currently and could continue to encourage people to consider alternative modes of transport.
- Potential for public transport services (either fixed route or On Demand) to improve access to Queenstown and Frankton for people living in outer towns including Glenorchy, and Cromwell.
- Potential willingness for tourists and visitors to use public transport for general travel and/or arranged transport as part of tours when in Queenstown due to an unfamiliarity with driving on New Zealand roads.

8 Customer Needs

The Queenstown public transport network and services should serve the needs of people travelling for different purposes throughout Queenstown, such as commuting, shopping, recreation, and education trips. A network that meets the needs of many different customers will be more effective in reducing private vehicle use, which must be a key consideration in a space-constrained environment like Queenstown.

The use of customer personas is a robust way of understanding the travel needs of different customer groups. This enables an understanding of how alternative public transport travel options can improve their experience and address pain points they may experience with their current travel modes.

To better understand peoples' travel needs, customer personas have been developed which are generalisations of people who live in and visit Queenstown. These customer personas include both locals, seasonal workers, and short-stay visitors. Care has been taken when developing the customer personas to have personas for the different areas of Queenstown to have a good geographical spread (Figure 18). Furthermore, because Queenstown is a 24/7 destination the customer personas have been developed to represent trips which occur at different times of the day and on weekends (Table 7 to Table 14).

Figure 18. Customer personas and the geographic spread of their general trip origins.

Domestic Visitors (residing in other parts of NZ)

Profile	Behaviours	Needs/What's important	Pain Points
I love bringing my family to Queenstown during the holidays as the scenery is beautiful and there's always something for everyone.  Gareth 40-50 years old working professional Stays in hotel on SH6A	• Working professional who regularly brings his family to Queenstown during long weekends/holidays. • Tends to seek out convenient locations for food and amenities but will drive for harder-to-reach scenic locations and activities.	• Needs off-peak and peak services on the weekends to travel with his family around Queenstown. • Availability of real-time information to plan the day. • Needs clear and continuous signs to easily navigate with his family to the nearest bus stop. • Requires comfortable seating and facilities for his family. • Needs to carry luggage for some trips • Requires easy connection to airport • Needs legible system as travelling with family and has varying schedule	• Lack of bus routes available to tourist destinations that are harder to access • Irregular and infrequent bus services on the weekends. • Unable to find information on bus services. • Uncertain arrival time if driving • Have to find affordable parking

Table 7: Customer persona details (domestic visitors) - profile, behaviours, needs and pain points.

Local residents (working professionals, business owners, retail staff)

Profile	Behaviours	Needs/What's important	Pain Points
I run a popular outdoor gear store in Queenstown Town Centre from 9am to 6pm daily. I often need to make trips around town to meet suppliers.  Karina 30-40 year old business owner Lives in Arrowtown	• Retail owner running an outdoor gear business daily. Has to come into Queenstown early to prepare her store for open hours. • Usually drives as she has large items to transport to the store but finds it challenging during peak hours so likes having the bus as an option to get around. • Will use ridesharing service if car isn't available/practical and needs to get to places quickly.	• Off-peak bus services to get to her store early and to commute home after closing the store in the evening • Peak bus services if she has business meetings. • Needs good quality and comfortable bus stop and bus facilities as she may be transporting items. • Multiple bus stops in an area with convenient routes so that she can easily access a bus stop after a meeting. • Comfortable bus journey so she can work on her laptop • Safe crossing points, especially early/late.	• Having to walk long distances to access a bus stop when short on time. • Low frequency services that doesn't suit her varying schedule, especially on weekends. • Uncertain arrival time if driving • Have to find affordable parking • Doesn't like transferring too many times if using bus

Table 8: Customer persona details (local resident) – profile, behaviours, needs and pain points.

International Visitors (Backpackers, cruise, special interest, seasonal, luxury etc.)

Profile	Behaviours	Needs/What's important	Pain Points
I'm taking some time off work to travel. Queenstown is on my New Zealand itinerary and I want to explore as much of it as I can while I'm here.  Marissa 20-30 years old backpacker Stays in backpackers in Queenstown	• Adventurous backpacker taking a few months break from work to travel overseas; New Zealand being one of her stops. • She is visiting Queenstown to experience the iconic scenery, adventure activities and famous food hotspots. • On a time budget so will travel via any mode to get to a destination. • Might work casually in Queenstown to extend visit.	• Needs peak and off-peak services on weekdays and weekends to suit her varying travel schedule. • Requires signs and information to help with wayfinding around Queenstown. • Prefers comfortable seating facilities at bus stop and in buses as she is travelling daily. • Affordable fares as she can't afford ridesharing services.	• Lack of bus routes servicing destinations that are harder to access/not in areas of high demand. • Infrequent services making it difficult to fit multiple activities along a route resulting in time loss. • Not feeling safe due to facilities in poor condition.

Table 9: Customer persona details (international visitors) – profile, behaviours, needs and pain points.

Retirees

Profile	Behaviours	Needs/What's important	Pain Points
I love being active but due to age, I need to go for regular check-ups and physiotherapy in Frankton to monitor and maintain my health.  Marcus 60-70 years old retiree Lives in Kelvin Heights	• Retiree who enjoys going outside for walks. He loves spending time with his family and sometimes helps to care for grandchildren. • Goes to Frankton for monthly doctor appointments at the hospital and fortnightly appointments at the physiotherapy clinic.	• Needs regular and consistent services that will allow him to get from his suburb (Kelvin Heights) to the city centre and his daughter's suburb (Sunshine Bay) easily. • Requires convenient access and egress into the buses and bus stops. • Prefers comfortable bus stop and bus facilities, especially when during bad weather. • Needs convenient, legible, mobility-accessible and affordable public transport	• Availability and location of real time information for bus services. • Unable to easily access bus stops. • Not feeling safe at bus stops due to lack of lighting, poor visibility of vehicles and facilities in poor condition. • Too old to drive and can't walk for long distances • Difficulty using ridesharing application • Has to get lifts from family and friends

Table 10: Customer persona details (retirees) – profile, behaviours, needs and pain points.

Trades People

Profile	Behaviours	Needs/What's important	Pain Points
I work at various construction sites around Queenstown and need to be there by 7am on weekdays and weekends.  Faris 30-40 years old builder Lives in Lake Hayes	• Diligent builder who works eight-hour days and weekends occasionally. Enjoys going to the pub after work on Fridays to relax. • Sometimes drives a car to suit his varying schedule and work location. • Likes having public transport as another travel mode	• Flexible off peak services early in the morning and late at night, especially on weekends. • Reliable services with easily accessible arrival information so he can plan his routes and arrive on time. • Wayfinding information to help him navigate from bus stops to different work sites. • Needs sufficient space on bus for when carrying tools	• Service delays as it would affect route planning. • Infrequent services and inconsistent journey times, especially on weekends. • Congestion during peak times • Long commutes when getting home. • Due to his physically demanding job, he doesn't like standing on the bus, uncomfortable seats or lack of space especially when carrying tools

Table 11: Customer persona details (trades people) – profile, behaviours, needs and pain points.

Students (local)

Profile	Behaviours	Needs/What's important	Pain Points
I need to get to school by 8am in Frankton. On weekends, I need to be in Queenstown by 7am for my café job.  Natalie 18 years old student Lives in Jacks Point	• Energetic teenager in high school and is currently working a part-time job at a cafe on the weekends for some income. • Does not own a license or a car so she usually takes the bus to travel to and from school and to work on the weekends. Her parents occasionally drop and pick her up from school.	• Peak bus services to get to and from school on weekdays. • Off-peak bus services to travel to her café job in Queenstown. • Affordable fares due to limited income. • Lighting and feeling at safe when walking to bus stops and when waiting at bus stops.	• Infrequent and inconsistent bus services. • Insufficient shelter/seating facilities while waiting for the bus. • Dislikes long commutes. • Having to get lifts by parents • Feeling unsafe at bus stops and on bus • Having to travel early and late

Table 12: Customer persona details (local students) – profile, behaviours, needs and pain points.

Hospitality Workers (staff working in F&B, accommodation and customer service)

Profile	Behaviours	Needs/What's important	Pain Points
I work in a restaurant in Queenstown on various shifts so I take the bus at different times during the day from my home in Arthurs Point.  Rishi 20-30 years old waiter Rents in Arthurs Point	• Friendly and sociable waiter who works shift hours and enjoys hanging out with friends after work. Likes to explore and try out recreational activities during his off days. • Needs to walk from his accommodation to take the bus, then walks to his work place.	• Needs off peak services to suit his varying work shifts (early morning, mid-morning, afternoon and night). • Frequent bus services to ensure in case he misses the bus. • No bus delays/disruptions so that he can be on time for work. • Affordable fares to manage cost of living and recreational activities	• Inconsistent and unreliable bus services • Long commute times • Off-peak services means longer waits • Having to stand in the bus or uncomfortable seats after a long day at work • Insufficient information or notice of arrival information or delays • Not being able to take a bus to access certain recreational destinations/activities, requiring a car instead. • Considered cycling but worried about on and off-road safety

Table 13: Customer persona details (hospitality workers) – profile, behaviours, needs and pain points.

Tourism Operators (staff working in wineries, ski fields, hot pools etc.)

Profile	Behaviours	Needs//What's important	Pain Points
I travel from the Frankton to east of Lake Hayes early in the morning to start work as a winery supervisor.  Lilian 20-30 years old winery supervisor Rents in Frankton	• Easy-going and passionate about wine and looking to experience a new country while working during the seasonal grape intake. Works up to 12-hour days, 6 days a week. • Drives as work location is outside Queenstown and the bus network but prefers not to due to difficulty finding parking. • If taking bus, will get off at stop closest to winery, then carpools with others.	• Needs reliable off-peak AM and PM bus services that gets her from her accommodation to her area of work. • Needs reliable connection into the town centres for groceries and leisure activities. • Affordable fares to manage cost of living and recreational activities	• Dislikes having to switch to a car because the bus route doesn't serve her work location. • Long wait times between transferring buses • Infrequent services early morning and late at night. • Long commute times to get home. • Not being able to take a bus to access certain recreational destinations/activities, requiring a car instead

Table 14: Customer persona details (tourism operators) – profile, behaviours, needs and pain points.

Common needs for all personas are:

- requiring frequent off-peak and peak services
- sufficient real time-information
- clear signage; and wayfinding information
- comfortable and spacious bus stop, bus facilities and seating
- affordable fares
- good lighting
- accessible and legible system

Common pain points include:

- lack of bus routes to tourist/recreational/hard-to-access destinations
- infrequent/low frequency services
- poor facilities
- lack of lighting
- real time information and wayfinding information insufficient and not suitably located
- uncomfortable and insufficient bus stop and bus facilities
- feeling unsafe
- long commutes and wait times.

These needs and pain points of the customer personas are further support by the results from the recent Queenstown Lakes District Council's 2022 Quality of Life Survey Report, where residents in general have decreased satisfaction with public transport. The following results combine both the percentages of survey participants who agree and strongly agree, where 55% of residents deem public transport to be affordable and 40% felt that that it is easy to get to public transport from their house. Conversely, 27% found public transport to be accessible for their needs, 18% felt that it helps them get to and from destinations, 13% of respondents felt that public transport was reliable and 12% found it frequent enough. All characteristics of residents' experiences of public transport are shown to have decreased from 2018 to 2022 (Figure 19), particularly in reliability, frequency and the overall experience of public transport meeting the needs of residents.

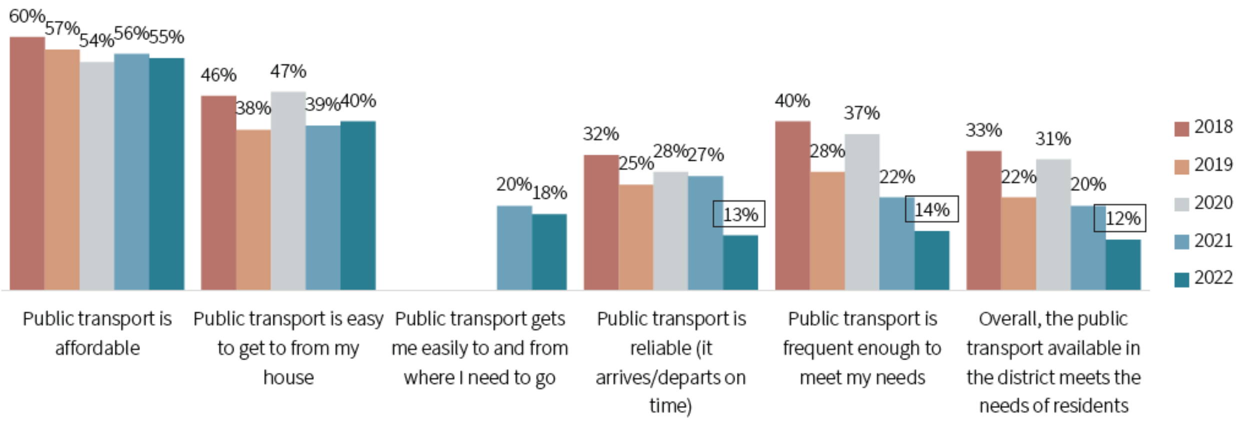


Figure 19. Survey results of residents experiences of various characteristics of public transport in Queenstown Lakes District 2018 - 2022 (Source: Quality of life Survey Results Report 2022)

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9 Service Design Principles

This section documents the service design principles that have been applied to the development of the long list of service pattern options for Queenstown. These service design principles draw on international best practice for network design with these general principles having been applied to Auckland, Wellington, and Christchurch public transport network reviews.

9.1 Ridership Versus Coverage

Ridership and coverage are two often competing goals for public transport service design. Ridership is the goal of attracting as many customers as possible to achieve mode shift, congestion relief or greenhouse gas reduction. Whereas coverage is the goal of making public transport accessible to as many people possible which is more focused on equity outcomes. Ridership is generally measured based on patronage per route or per service kilometre whereas coverage is generally measured from percentage of population that have access to employment, education, or healthcare via public transport.

The result for service design is that ridership-focused routes tend to be direct, high frequency and service main population and employment centres. Whereas coverage focused services tend to be indirect and low frequency to cover as much area as possible. In practice, most public transport networks are made up of a combination of ridership and coverage focused routes with different cities being more or less focused on one of these goals.

For Queenstown, the need to achieve much higher mode share for public transport to relieve congestion on the state highway network means that a greater number of direct, rapid, frequent and high-capacity bus routes will be needed. Areas which are not accessible to core bus routes would be able to be serviced with secondary bus routes, On Demand services, Park and Ride or total mobility. The combination of different types of public transport services will enable high ridership as well as high service coverage[5].

9.2 Frequency

Service frequency is the amount of time in between public transport departures which determines the amount of time that passengers need to wait for a service. A key success factor for public transport services which aim to attract high ridership is a “walk out and catch” frequency. A walk out and catch frequency is the point at which customers can forget the timetable because no matter when they make their trip, a bus will be not far away. A walk out and catch frequency is typically set at a minimum of a 15-minute frequency however a 10-minute frequency is preferred. High frequency services typically have much higher patronage than low frequency services because the service is more useful to a greater number of people.

Another key advantage of high frequency services is that it enables easy transfers between public transport services. This is because transfers between frequent services can occur without timetabled connection as there would only be a short wait between services. Furthermore, frequency can overcome service disruptions because the wait for the next service is comparatively short when connecting to a frequent service. Enabling transfers between services is critically important because the number of destinations that can be accessed using the network as a whole is much greater than those destinations served by a single route.

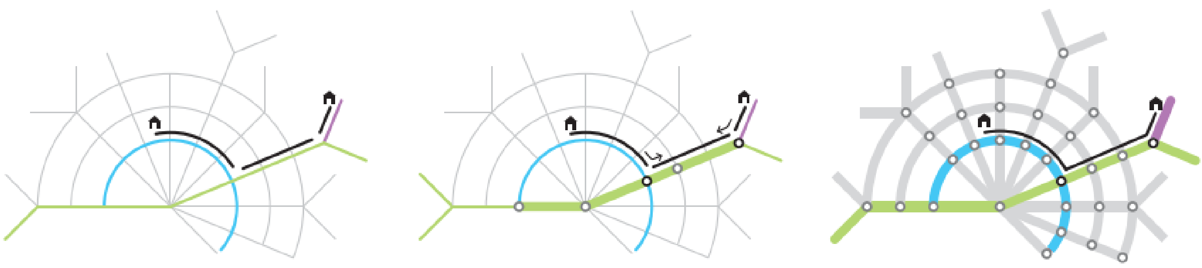
[5] The transit ridership recipe, Human Transit (n.d.).

9.3 Walking Catchments

Walking catchment is the distance from a bus stop or train station at which most people would no longer be willing to walk to access public transport. The walking catchment for low frequent bus services is typically considered to be 400m which is approximately a 5min walk. For high frequency bus services, this walking catchment can be increased to 800m or a 10 min walk because people are generally willing to walk further for a higher quality service. Furthermore, the walking catchment for train stations and bus stations is greater at 1,200m or 15 min walk because of the faster journeys provided by the public transport services which have a high degree of priority over general traffic. In Queenstown, bus routes are generally within a 400m walking distance, with some areas being outside comfortable walking distance to fixed bus routes. Some suburbs such as Fernhill, Queenstown Hill and Goldfield Heights/Lakeview have steep gradients due to the topography and road layout and are outside comfortable walking distance. Walking catchments in Queenstown are assessed in the accessibility assessment in Advisory Paper 4 – On Demand Services.

9.4 Transfers

In any city, it is not possible or desirable to serve all destinations with a single bus route and therefore some level of transferring between services is necessary. Accepting that some customers will need to transfer to access secondary destinations enables the development of a simple, direct, and high frequency network which better serves the majority of customers. Therefore, transfers need to be made as seamless as possible using real time information, high quality interchanges, reliable services, and high frequency services (Figure 20). However, customers should not need transfer to access primary destinations and instead a direct service should be provided whenever possible. The exception to this is when there is a net travel time saving from changing vehicles such as bus to rail connections. Considering the context of Queenstown, direct services should be provided from main suburbs to Queenstown town centre. These bus services should serve either Remarkables Park/Airport or Five Mile on their way to Queenstown town centre. Due to the geometry of Frankton, it will not be feasible to serve all destinations in Frankton with a bus bound for Queenstown and instead, a transfer onto cross town or circular services will be needed.



Low frequency network
A collection of lines that function separately if you are willing to plan your journey in detail. The area you can reach by a simple journey is restricted to those places that are within walking distance from the line that passes the place where you are. Change of lines where they cross each other is not very attractive. Waiting times will often be long, and you will need detailed information about more than one line. Transfering is perceived as a large barrier, and these crossing points are seen as being of little value. In reality, it is misleading to call this collection of lines a network.

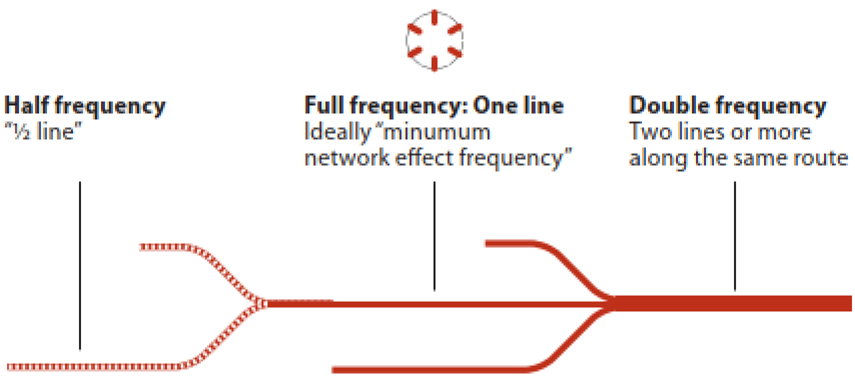
Network with some high frequency lines or sections
The service is good along the lines or sections with high frequency. Transfer is more attractive at places with such a service, but only in one direction, towards the high frequency section. The total number of origin-destination combinations that are given a better service is limited. Even very high frequencies on the best sections will not change this general picture.

High frequency network: Network effect
When all or many of the lines or sections have high frequency, the network effect is created. The network can be used by the public transport passengers in a similar manner to motorists' use of the road network. You may travel everywhere in the network, almost at the time of your own choice. Instead of being barriers to travel, transfers open up a large number of new travel opportunities. All lines and all modes of transport "feed" each other with traffic and increase each other's market share.

Figure 20: Diagram showing importance of service frequency for transfers (Source: Hi trans best practice guide 2).

9.5 Branching

Branching is the term for when a public transport route splits to serve multiple areas with each of the branches having different termini[6]. The advantage of branching compared to having two overlapping routes is that a single route is simpler and easier for customers along the trunk section of the route which is often holds majority of the customers. The disadvantage of branching services is that each split halves the service frequency and thereby reduces the attractiveness of the branched sections to customers (Figure 21). Therefore, branching is typically used for lower demand outer areas where greater service coverage is desired over service frequency.



Full frequency: approx. 6 departures per hour as the basic work day service, i.e. headways of 10 minutes. These frequencies are strengthened in peak hours according to demand, if required only on sections of the lines carrying heavy traffic. This will be experienced by the users as a "forget-the-timetable" service. The time loss for transfers between lines will also be limited at this level of service, at least in peak hours.
Half frequency: Approximately half the number of departures per hour, i.e. headways of some 20 minutes. For these lines the users will prefer to know the departure times, and there is a clear need for timetable co-ordination in order to facilitate transfers between lines.
Double frequency (or better): This frequency will occur on sections of the network where two or more lines follow the same route. On these sections the users can forget the timetable most of the service period, and transfers can be made without much waiting time.

Figure 21: Diagram explaining the trade-off for branching services (Source: Hi trans best practice guide 2).

9.6 Open Versus Closed Bus Rapid Transit

Bus rapid transit (BRT) is the term for when buses run on a dedicated corridor for all or part of their trip with the priority given to public transport resulting in a higher quality service. Open BRT systems are when buses can leave and join the priority corridor either at the ends of the corridor or

[6] Basics - should bus rapid transit be open or closed, Human Transit (2021)

part way along. Whereas for closed BRT system buses stay solely within the priority corridor with connecting buses for customers that want to travel further. The advantage of open BRT systems is that the priority corridor can be utilised by more services and there is less transferring required. The advantage of closed BRT systems is greater reliability because buses are not exposed to delays from mixed running sections. It is also possible to have a hybrid system where some services stay within the dedicated corridor and other extend beyond the dedicated corridor. The Auckland Northern Busway is an example of an open BRT system.

Considering the context of Queenstown, it is considered that elements of an open BRT system would be appropriate to apply to the new bus network. These elements are bus priority, wider stop spacing, high-capacity vehicles and high-quality interchanges. A closed BRT system is considered inappropriate for Queenstown due to the difficultly in having a dedicated priority corridor on SH6A and the dispersed nature of destinations in Frankton. None the less for completeness a closed BRT option has been included in the long list service patterns options.

9.7 Specialist Verses Generalist Services

Specialist public transport services such as peak time express buses and off-peak shopper services attempt to divide customers into market segments and design a service which appeals specifically to them. Whereas generalist services attempt to appeal to as many different types of customers as possible by providing a consistent all-day service. Public transport network design should start with all day services that will form the core of the public transport network[7]. If additional capacity is required at peak times and it is not inviable to increase the frequency of the core service, then express buses may be considered. Similarly, if additional coverage is required but an additional all-day service cannot be justified then shopper services may be considered as an addition to the network. The reason for prioritising all day services is that this recreates a simple and consistent network which is easy for customers to use for off peak trips (Figure 22). Furthermore, all day services tend to have higher ridership per in service kilometre as unlike express buses the same driver and bus is used for multiple trips throughout the day. Lastly having more off peak and evening services reduces the number of split shifts which are unattractive to bus drivers and thereby difficult to fill[8].

[7] The collapse of rush hour a deep dive, Human Transit (2020)
[8] Ibid.

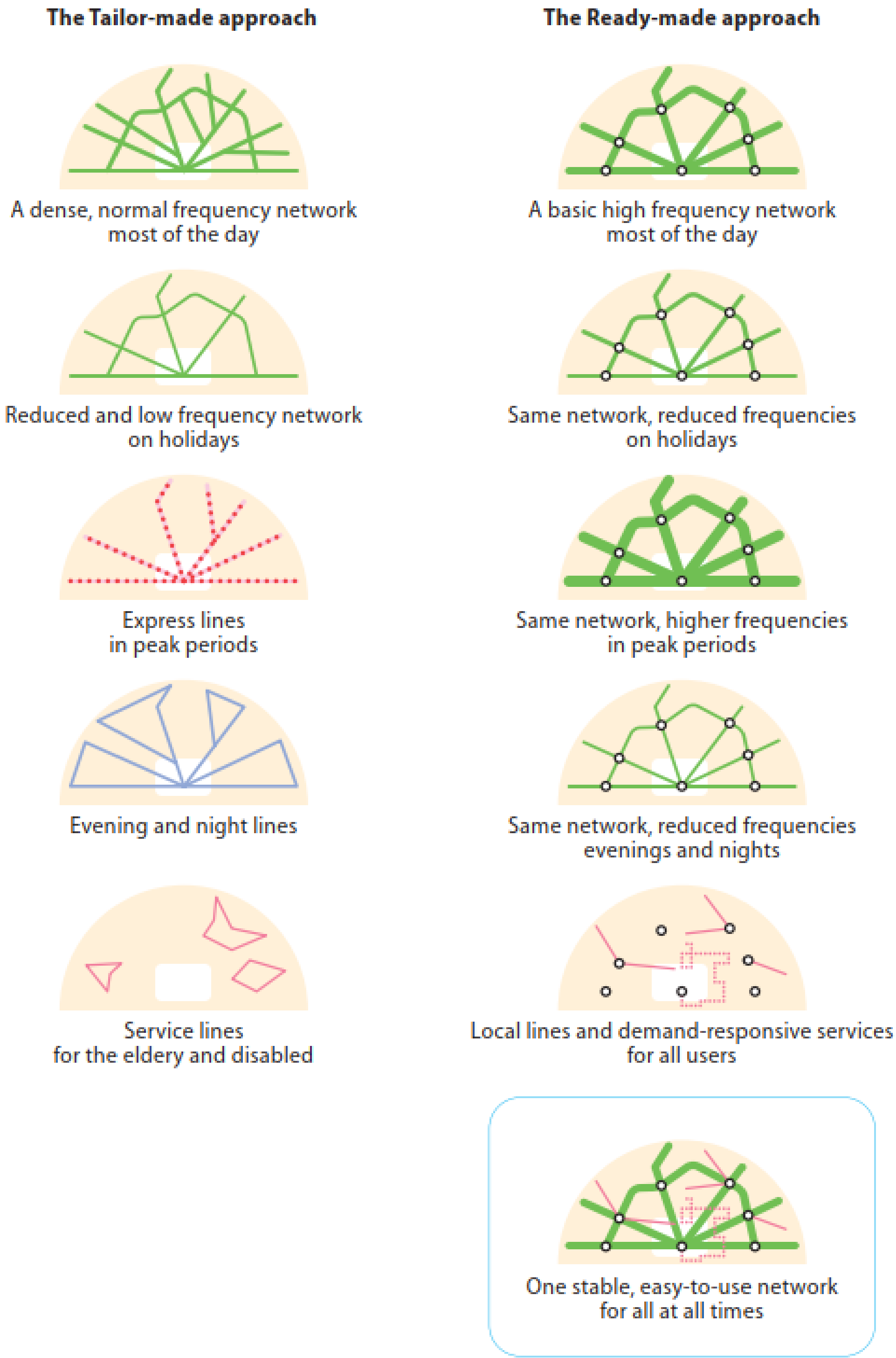


Figure 22: Diagram comparing the two different network design approaches (Source: Hi Trans best practice guide 2)

10 Capacity Requirements

The capacity of a public transport service is a product of the number of people that can be accommodated within each vehicle and the frequency of the service. The number of people that can be accommodated within each vehicle can be increased by having larger vehicles and/or by configuring the vehicle for standing passengers. A potential drawback of higher capacity public transport vehicles can be longer dwell times at stops, but this can be mitigated through additional doors or allowing all door boarding. For service frequency there is an upper limit to how many public transport vehicles can operate on a corridor before congestion starts to develop (Figure 23). In mixed running this threshold tends to be a 2-minute frequency which is due to delays experienced at traffic signals and boarding/ alighting passengers at stops. Where a high degree of public transport priority is provided it is possible to run even higher frequencies, but a 2-minute threshold is useful for planning purposes.

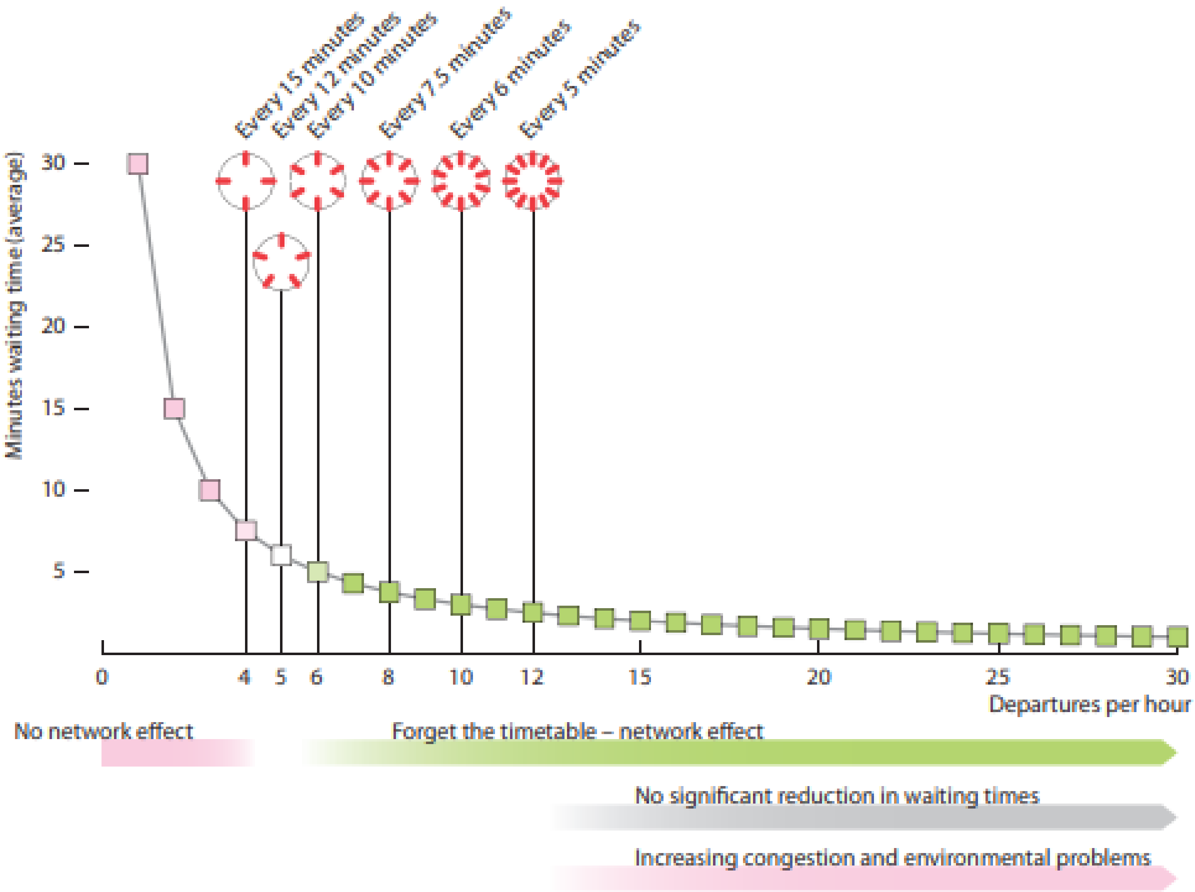


Figure 23: Capacity of public transport service based on number of people within each vehicle and frequency of the service (Source: HiTrans).

10.1 Case study: Wellington Golden Mile

An example of the service delivery problems that can be encountered when a public transport corridor becomes oversaturated with buses is the Golden Mile in Wellington. The Golden Mile is the collective term for Courtenay Place, Manners Street, Willis Street and Lambton Quay in Wellington CBD. The Golden Mile has bus priority along its length with bus lanes, b-lights and limited access roads however in some sections buses are mixed with general traffic. The bus fleet used in Wellington is a combination of double deck buses and large single deck buses with double deck buses being introduced in 2018. The majority of bus routes in Wellington City run along the Golden Mile which is the primary public transport corridor through the CBD.

It has been recognised in multiple studies that the Golden Mile is operating beyond capacity which causes reliability issues across the public transport network[9]. This is due to the high number of buses which use the corridor, the closely spaced signalised intersections and the lack of overtaking opportunities on Manners Street. The average speed of a bus travelling along the Golden Mile is 10 km/hr with the worst sections experiencing an average speed of 5 km/hr which is a same speed as an able-bodied person walking[10]. Investigations are under way for a second public transport corridor through the CBD and the use of higher capacity vehicles (light rail or articulated bus) for core bus routes.

10.2 2039 capacity assessment

The Table 16 shows the capacity per hour per direction for different combinations of public transport vehicles and frequencies. The target frequency for this analysis is 1,000 passengers which is the capacity required at the Kawarau Falls Bridge in 2039 to accommodate the desired mode shift. The maximum capacity is from manufacturers specifications, where possible specifications from vehicles which operate in New Zealand have been used. Whereas the planning capacity is 80% of the maximum capacity which is an allowance for uneven distribution of passengers between public transport vehicles. In practice routes which serve the airport may have lower effective capacity due to the need to accommodate luggage.

The options which provide sufficient capacity and which are within the optimal frequency range are shown in Table 15 and summarised below:

- Double deck buses with 15 departures per hour
- Articulated buses with 12 departures per hour
- Bi-articulated buses with 10 departures per hour

Although single deck buses provided sufficient capacity when operating at 30 departures per hour this would result in the too many buses on State Highway 6A. This is because buses from Lakes Hayes and Arrowtown also likely run along State Highway 6A which means that the 30 buses per hour threshold would be exceeded.

[9] Wellington Public Transport Spine Study, Greater Wellington Regional Council.
[10] Golden Mile Strategic Case 2020, Let's Get Wellington Moving.

			Departures per hour													
Vehicle type	Maximum capacity per vehicle	Planning capacity per vehicle	1	2	3	4	6	8	10	12	15	20	30	60	120	240
Gondola	10	8	8	16	24	32	48	64	80	96	120	160	240	480	960	1920
Jet boat	15	12	12	24	36	48	72	96	120	144	180	240	360	720	1440	2880
Single deck bus	55	44	44	88	132	176	264	352	440	528	660	880	1320	2640	5280	10560
Double deck bus	85	68	68	136	204	272	408	544	680	816	1020	1360	2040	4080	8160	16320
Articulated bus	110	88	88	176	264	352	528	704	880	1056	1320	1760	2640	5280	10560	21120
Bi-articulated bus	150	120	120	240	360	480	720	960	1200	1440	1800	2400	3600	7200	14400	28800
Commuter rail three car	380	304	304	608	912	1216	1824	2432	3040	3648	4560	6080	9120	18240	36480	72960
Ferry	400	320	320	640	960	1280	1920	2560	3200	3840	4800	6400	9600	19200	38400	76800
Commuter rail six car	760	608	608	1216	1824	2432	3648	4864	6080	7296	9120	12160	18240	36480	72960	145920
Commuter rail nine car	1140	912	912	1824	2736	3648	5472	7296	9120	10944	13680	18240	27360	54720	109440	218880
			Frequency too low				Optimal frequency							Frequency too high		
			Target capacity		1000											

Table 15: Capacity provided by difference combinations of fleet type and departures per hour using 2039 capacity targets

10.3 2053 capacity assessment

The same capacity assessment exercise was completed for the 2053 forecast year with the target being 1,700 passengers per hour at Kawarau Falls Bridge. The options which provide sufficient capacity, and which are within the optimal frequency range are shown in Table 16 and summarised below:

- Articulated buses with 20 departures per hour
- Bi-articulated buses with 15 departures per hour

Although double deck buses provided sufficient capacity when looking at the southern growth area in isolation when considering the wider network there is insufficient capacity provided. This is because it is likely that buses from Lake Hayes and Arrowtown would also run along State Highway 6A which means that the 30 buses per hour threshold would be exceeded.

Gondola can provide sufficient capacity but only when operating a very high frequencies (240 departures per hour or 15 sec headway). Both jetboat and single decker bus did not provide sufficient capacity due to the lower capacity per vehicle and being infeasible to run at very higher frequencies. Commuter rail more than provides sufficient capacity however is infeasible due to the need for a fully segregated corridor.

			Departures per hour													
Vehicle type	Maximum capacity per vehicle	Planning capacity per vehicle	1	2	3	4	6	8	10	12	15	20	30	60	120	240
Gondola	10	8	8	16	24	32	48	64	80	96	120	160	240	480	960	1920
Jet boat	15	12	12	24	36	48	72	96	120	144	180	240	360	720	1440	2880
Single deck bus	55	44	44	88	132	176	264	352	440	528	660	880	1320	2640	5280	10560
Double deck bus	85	68	68	136	204	272	408	544	680	816	1020	1360	2040	4080	8160	16320
Articulated bus	110	88	88	176	264	352	528	704	880	1056	1320	1760	2640	5280	10560	21120
Bi-articulated bus	150	120	120	240	360	480	720	960	1200	1440	1800	2400	3600	7200	14400	28800
Commuter rail three car	380	304	304	608	912	1216	1824	2432	3040	3648	4560	6080	9120	18240	36480	72960
Ferry	400	320	320	640	960	1280	1920	2560	3200	3840	4800	6400	9600	19200	38400	76800
Commuter rail six car	760	608	608	1216	1824	2432	3648	4864	6080	7296	9120	12160	18240	36480	72960	145920
Commuter rail nine car	1140	912	912	1824	2736	3648	5472	7296	9120	10944	13680	18240	27360	54720	109440	218880
				Frequency too low						Optimal frequency					Frequency too high	
			Target capacity		1700											

Table 16: Capacity per hour per direction for different combinations of public transport vehicles and frequencies for 2053

11 Fleet Option Assessment

The purpose of this section is to compare the short-listed fleet options for the proposed Queenstown public transport network which are double decker, articulated and bi-articulated buses.

11.1 Vehicle Characteristics

Below are the typical characteristics of different types of high-capacity buses, it should be noted that specifications vary between bus manufacturers and are subject to change.

Double deck bus

- Capacity: 80-100 passengers
- Length: 11-13m
- Height: 4.0-4.3m
- Number of doors: 2
- Number of axels: 2 or 3
- Examples: Alexander Dennis Limited Enviro 400EV and Wrightbus Streetdeck BEV
- Locations in service: Wellington, Singapore and London

Figure 24: Example of electric double deck bus which is in operation in Wellington (source: Stuff)

Articulated bus

- Capacity: 110-130 passengers
- Length: 18m
- Height: 3.3 to 3.4m
- Number of doors: 3 to 4
- Number of axels: 3
- Examples: Van Hool Exqui City 18 and Volvo 7900
- Locations in service: Singapore, Sydney and Oslo

Figure 25: Example of articulated bus in operation in Oslo, Norway (source: BYD)

Bi-articulated bus

- Capacity: 150 to 180 passengers
- Length: 24m
- Height: 3.3 to 3.4m
- Number of doors: 4 to 5
- Number of axels: 4
- Examples: Van Hool Exqui City 24 and Hess lightram
- Locations in service: Malmo, Brisbane (proposed), Barcelona

Figure 26: Bi-articulated bus in Brisbane during testing (source: Brisbane City Council)

11.2 Axle Weights

A key consideration when procuring high-capacity buses is the vehicle weight which is a particular constraint for battery electric buses because these are generally heavier than the equivalent diesel or trolley buses. In New Zealand all vehicles which use public roads must comply with the Vehicle Dimensions and Mass Rule (VDAM). VDAM sets maximum weight limits for all vehicles for the purpose of managing road surface degradation. For urban buses the maximum axle mass is shown in Table 17 below. Specialist vehicle permits typically require the bus routes which the vehicle would be used on to have a pavement strength that is greater than a typical New Zealand road.

Table 17: New Zealand axle weight limits from VDAM 2016

Type of axle set	Mass without a permit (kg)	Mass with a specialist vehicle permit (kg)
Single large-tyred axle	5,500	8,100
Twin-tyred axle in any axle set	9,000	12,000
Two axles in a tandem axle set comprising: • A twin-tyred axle with a single large-tyred axle and a 60/40 load share	14,500 14,500	16,000 18,000

• A twin-tyred axle with a single large-tyred axle and a 55/45 load share		
Two twin-tyred axles: • Spaced less than 1.3 metres from the first axle to the last axle • Spaced 1.3 metres or more from the first axle to the last axle	14,500 15,000	17,000 18,000

The maximum number of passengers which a bus is permitted to carry is determined by the lesser of two calculations which is:

- The number of standing passengers is calculated by dividing the standing area available by 0.17m2 per passenger (as contained in Land Transport Rule: Passenger Service Vehicles 1999). The standing area plus seating capacity gives a passenger limit; and
- Whether the gross vehicle weight exceeds the weight limit for the type of bus as specified in VDAM. The gross vehicle weight is calculated by multiplying the number of passengers by 80kg per passenger and adding this to the unladen vehicle weight (as contained in Land Transport Rule: Passenger Service Vehicles 1999)

Table 18 shows the maximum permitted number of passengers for different types of high-capacity buses based on New Zealand axle weight limits. This assessment uses battery electric buses that was the preferred propulsion type from the Fleet Decarbonisation Paper. For double deck buses the permitted number of passengers may be limited by the axle weight limit. This is due to the rear axles being located close together which means that the weight of the vehicle is loaded on a smaller surface area. This means that the effective capacity of double deck buses may be less than the manufacturer's specifications. Whereas for articulated and bi-articulated buses the gross vehicle weight typically does not exceed the axle weight limit. This is because the axles are more evenly spaced along the length of the bus and the additional axle set for bi-articulated bus. For articulated and bi-articulated buses the standing room is more often the limiter for the maximum permitted number of passengers rather than the axle weight limits.

Table 18: Assessment of typical capacity of different types considering NZ axle weight limits

	Double deck bus	Articulated bus	Bi-articulated bus
Number of axles	3	3	4
NZ weight limit without permit	20,000 kg	23,500 kg	29,000 kg
NZ weight limit with permit	26,100 kg	32,100 kg	40,200 kg
Seated and standing room	100 passengers	130 passengers	180 passengers
Unladen weight	19,000 kg	19,000 kg	22,500 kg
Gross vehicle weight	27,000 kg	29,400 kg	36,900 kg
Max permitted number of passengers	88 passengers	130 passengers	180 passengers

11.3 Turning Circle

Turning circle is the minimum radius which a vehicle needs to turn around which is a measure of how manoeuvrable a vehicle is. Turning circle is influenced by the length of the vehicle, the distance between axles, the amount of front and rear overhang and whether the bus has steerable rear axles. Table 19 below documents the turning circle for Transport for Brisbane fleet and the proposed Brisbane Metro system. The results show a small increase in turning circle between a 12.5m rigid bus and a 18m articulated bus with a 24m bi-articulated bus having the turning circle of a 18m articulated bus. This is because bi-articulated buses have a second articulation point and has the same distance between axles as an articulated bus.

Table 19: turning circle for buses in Transport for Brisbane fleet

Vehicle type	Outer turning diameter
12.5m rigid	23.2 m
18m articulated	23.9 m
24m bi-articulated	23.8m

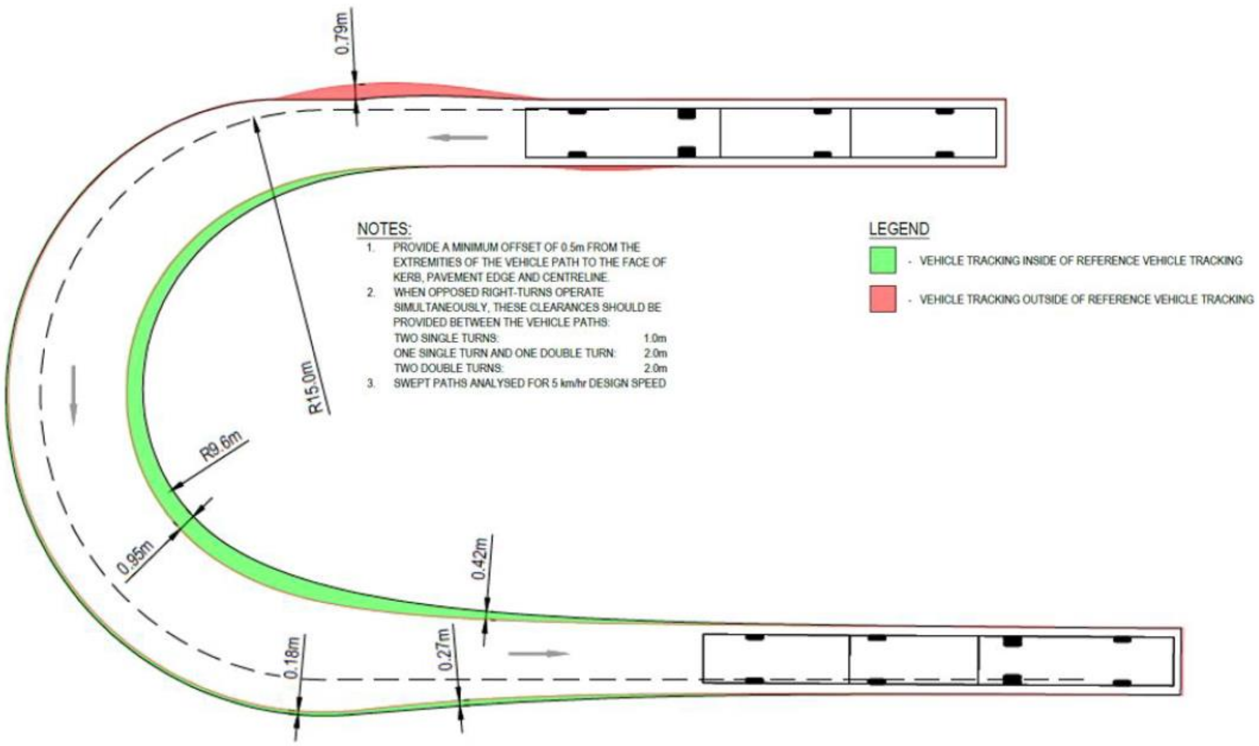


Figure 27: Swept path of bi-articulated bus from Brisbane Metro System

11.4 Vehicle Length

The length of articulated and bi-articulated buses is an important consideration for the interaction between these vehicles and general traffic. This is because a longer vehicle is more difficult to overtake, has larger blind spots and is more likely to obstruct intersections. In New Zealand the maximum permitted length of an articulated bus is 18m with the maximum length of a truck and trailer being 20m. Therefore, in order to operate in New Zealand bi-articulated buses would need an exception from the Vehicle Dimensions and Mass rule.

Articulated and bi-articulated buses would also require longer bus stops in order for the rear of the bus to be able to pull up in line with the kerb. However due to the higher capacity of articulated and bi-articulated buses the total number of buses that are needed to achieve the required capacity is lower. The reduced number of buses offsets the effect of a longer vehicle in terms of kerb space occupied when compared to standard buses. For interchange design the difficultly in reversing articulated and bi-articulated buses means that a drive in and reverse out type layout is not suitable.

11.5 Overhead Clearance

Overhead clearance is the space needed for a bus to safely pass under obstacles with the amount of space depending on the types of buses that will be used. For single deck buses the minimum clearance required is 3.65m to static objects such as verandas and 3.85m to changes objects such as trees. For double-deck buses the minimum vertical clearance increases to 4.6m for static objects and 4.8m for changeable obstacles. Therefore, should double-deck buses be implemented in Queenstown then the routes used by double deck buses and the dead runs would need to be cleared. From Auckland and Wellington experience the most common obstruction to clearance is trees with verandas, street light poles and power poles also being potential obstructions.

Figure 28: Overhead clearance requirement from NZ Public Transport Design Guidelines

11.6 Recommendation

Considering the advantages and disadvantages of different fleet types and the context of Queenstown the recommended fleet type for core bus routes is **articulated bus**. This is because a double deck bus would not be able to provide sufficient capacity to meet mode shift targets whilst providing a reliable service. This is due to lower capacity of this type of vehicle due to the space taken up by the stairs and close spacing of rear axles which reduces the maximum permitted passenger carrying capacity. For bi-articulated bus the current Vehicle Dimensions and Mass Rule prevents these vehicles from being used without a change in legislation. Bi-articulated buses operate in mixed traffic in Europe however these vehicles may be viewed as being suited to separated busways only due to safety concerns.

Articulated buses have several advantages over double-deck buses in urban settings which include faster boarding and alighting times from multiple doors and the lack of stairs. Being over a single level means that articulated buses provide more options for configuring the interior of the vehicle to increase standing space which could further increase capacity. Articulated buses are also easier for people with limited mobility to board and alight, this is because the aisles can be wider without the limitation of stairs found on double deck buses.

For secondary bus routes, the lower passenger demand means that standard single deck buses could be used. Therefore, articulated buses would be limited to main corridors where the higher capacity is needed. As part of the staging plan review, a slower rate of implementation of articulated/electric buses is being considered.

12 Long List Service Patterns

Service pattern concepts were developed for Queenstown which draw on the previous Queenstown Integrated Transport Business Case. Here some additional options have been developed for a potential public transport connection between Boyd Road and Remarkables Park. At this stage of the process, all public transport modes have been considered as well as networks which require transfers and those which maximise one seat rides.

The service pattern options are listed in Table 20 below with schematic network maps being provided in Figure 29 to Figure 39:

Table 20: Service pattern long list options

Service Pattern Option	Description
1. Bus Max	Same network as proposed in the Queenstown Integrated Transport Business Case with one seat rides from Jacks Point, Arrowtown and Lake Hayes to Queenstown using high-capacity bus routes
2. Bus Max with Remarkables Park bridge	Uses Bus Max as a starting point but routes the Jacks Point service via a new Remarkables Park bridge which removes the need for the Frankton loop service. This is because the Kelvin Heights to Quail Rise bus service can accommodate the cross Frankton transfers.
3. Bus Max using Malaghans Road	Runs Arrowtown to Queenstown bus via Malaghans Road instead of SH6A in order to free up space for more buses on SH6A. This option also provides the potential for a park n ride for Sparegrass Flat.
4. Rapid transit to Frankton	A closed network public transport corridor between Queenstown and Frankton with connecting buses to outer suburbs. This option reduces the number of buses on SH6A but increases the requirement for transfers.
5. Rapid transit to Lake Hayes	Extends the public transport priority corridor to Lake Hayes which reduces the number of transfers required compared to option 4.

6. Rapid transit to Remarkables Park	Similar as above but extending the public transport priority corridor to Remarkables Point via the Airport.
7. Rapid transit to Jacks Point	Rapid transit to Jacks Point via Remarkables Park bridge with buses from Lake Hayes and Arrowtown hubbing at Frankton
8. One seat ride	Similar to the current bus network but high frequency and extends the Jacks Point bus to Queenstown.
9. Ferry to Frankton Beach	High-capacity ferry service from Kelvin Heights and Frankton Beach. Jacks Point and Arrowtown buses continue into Queenstown.
10. Ferry to Lake Hayes	High frequency service using jet boats down the Kawarau River with a feeder bus service in Lake Hayes, Shotover Country and Ladies Mile
11. Ferry to Jacks Point	High-capacity ferry to Homestead Bay with supporting bus service from Jacks Point into Queenstown

12.1 Bus Max

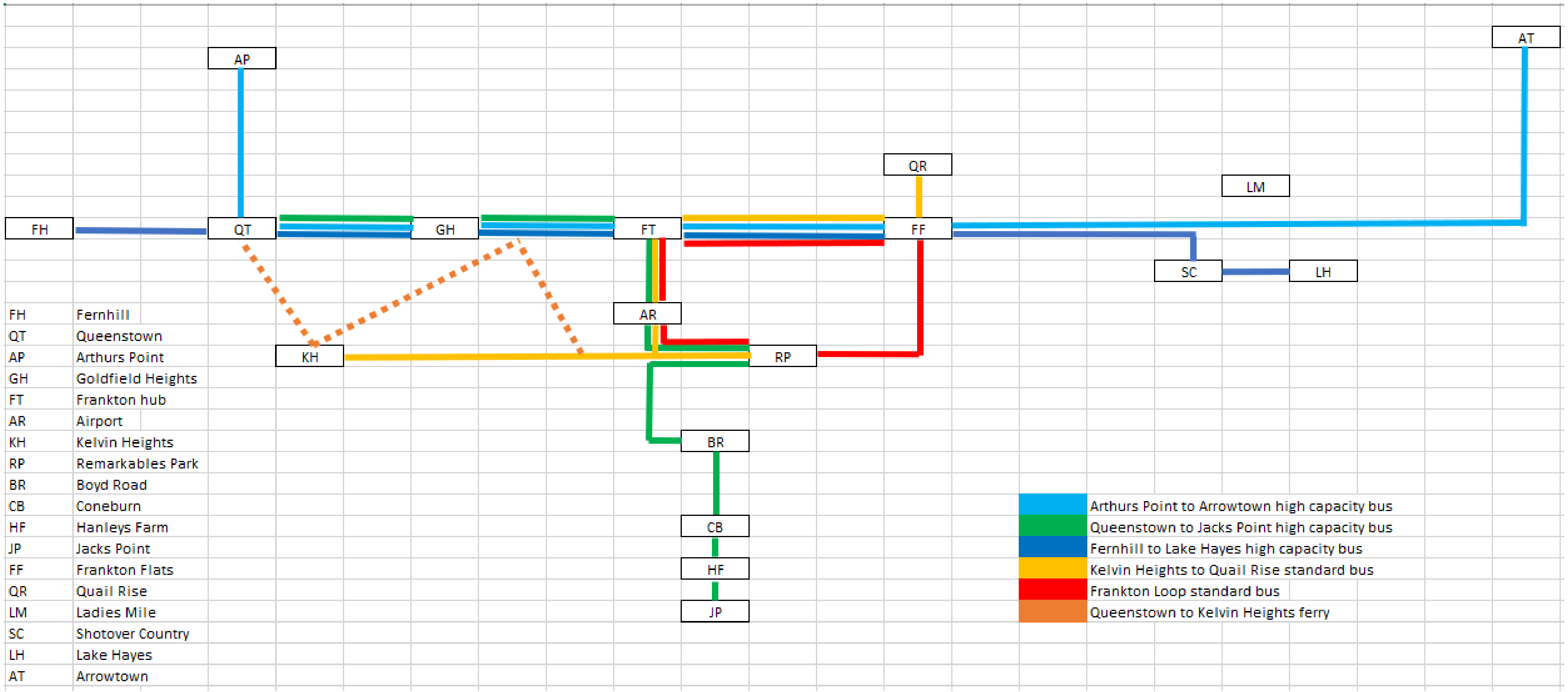


Figure 29: Long list option 1 - Bus Max.

12.2 Bus Max with Remarkables Park Bridge

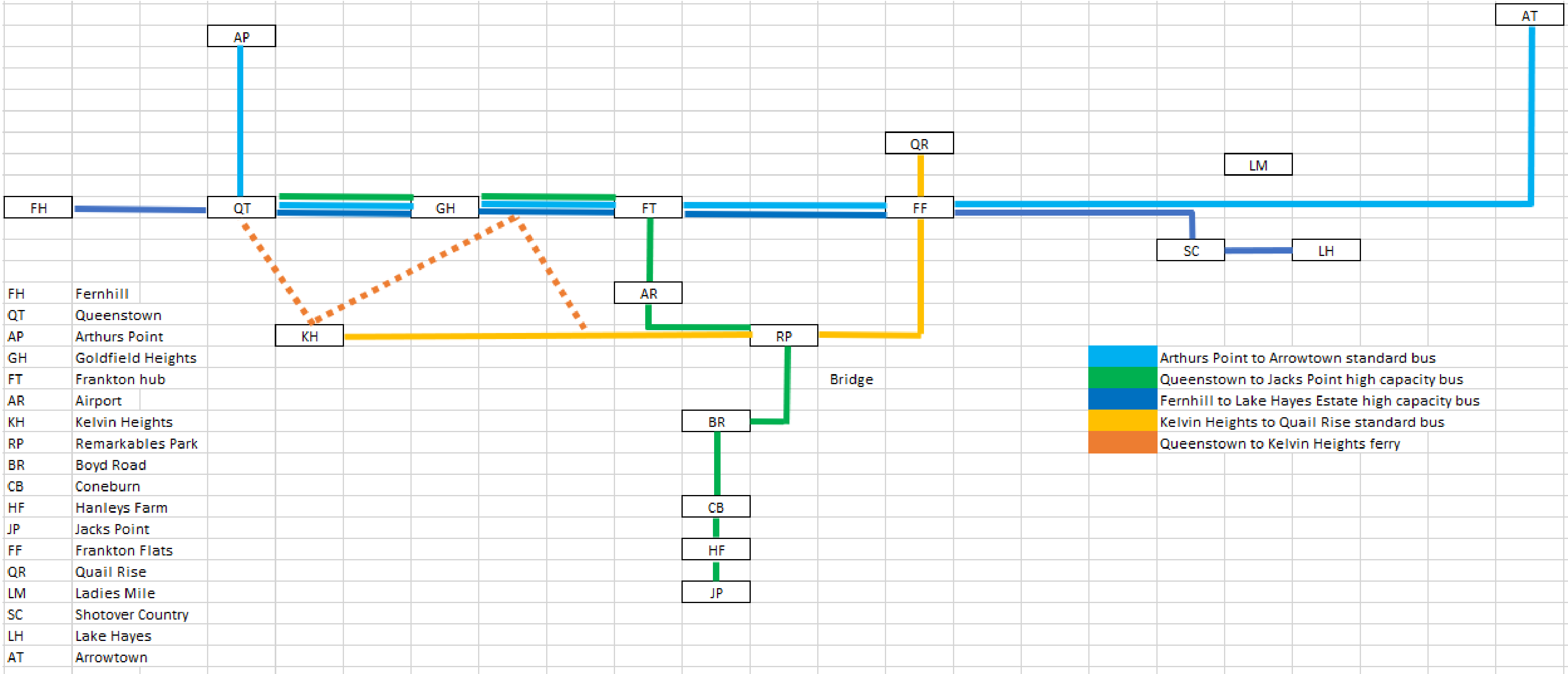


Figure 30: Long list option 2 - Bus Max with Remarkables Park bridge.

12.3 Bus Max Using Malaghans Road

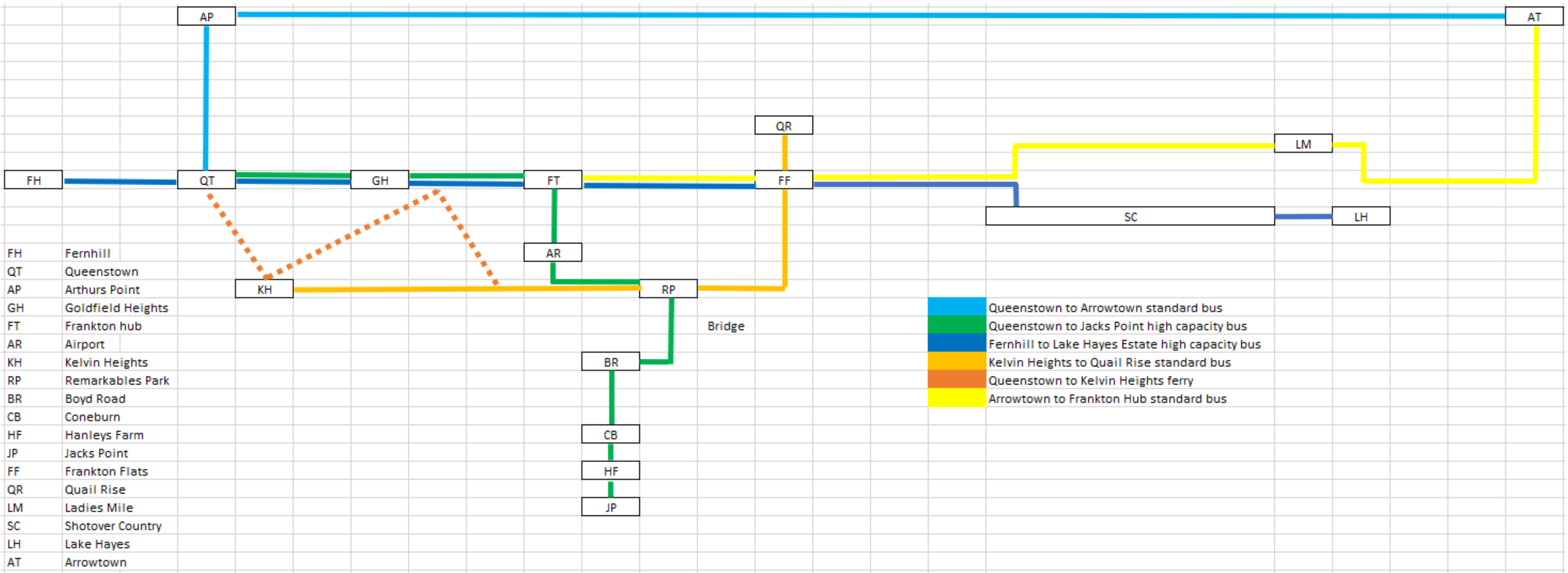


Figure 31: Long list option 3 – Bus Max using Malaghans Road.

12.4 Rapid Transit to Frankton Hub

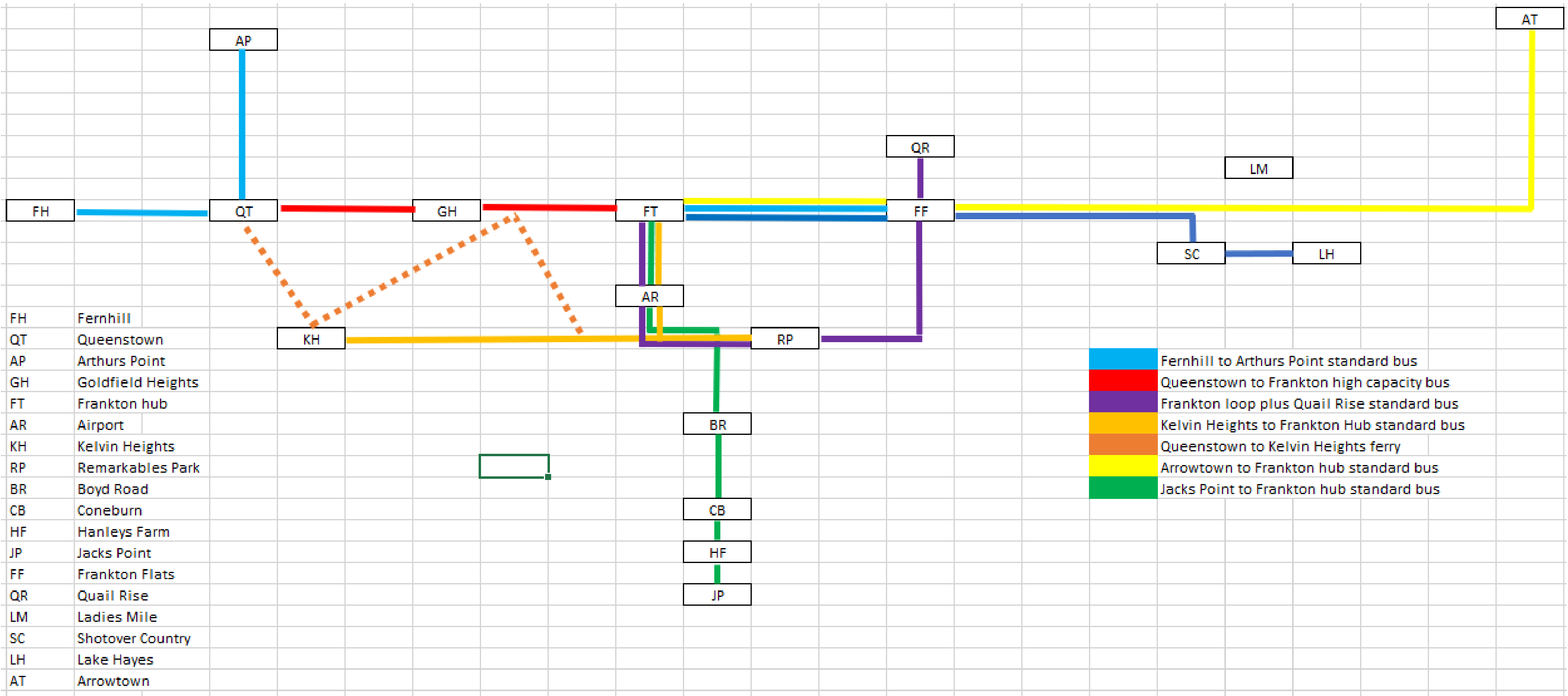


Figure 32: Long list option 4 – Rapid transit to Frankton Hub.

12.5 Rapid Transit to Lake Hayes

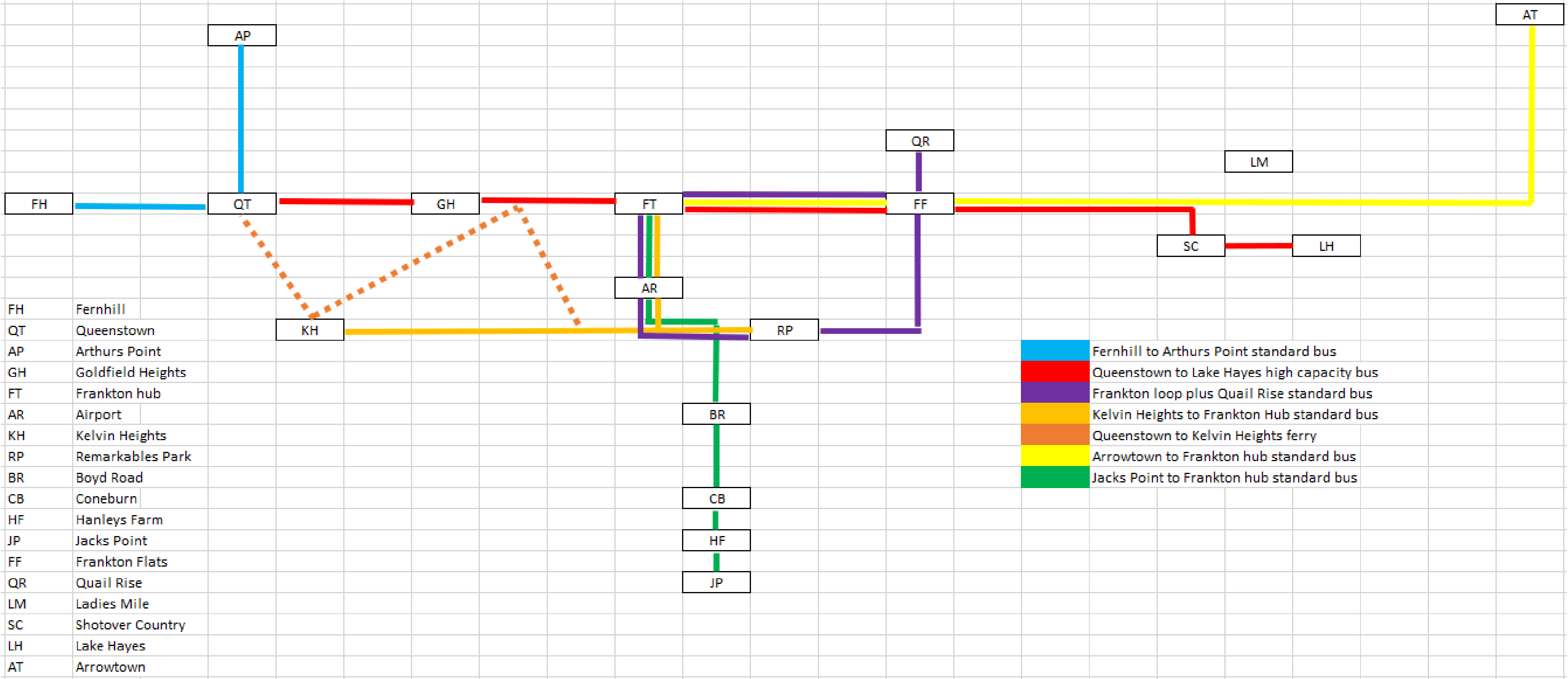


Figure 33: Long list option 5 – Rapid transit to Lake Hayes.

12.6 Rapid Transit to Remarkables Park

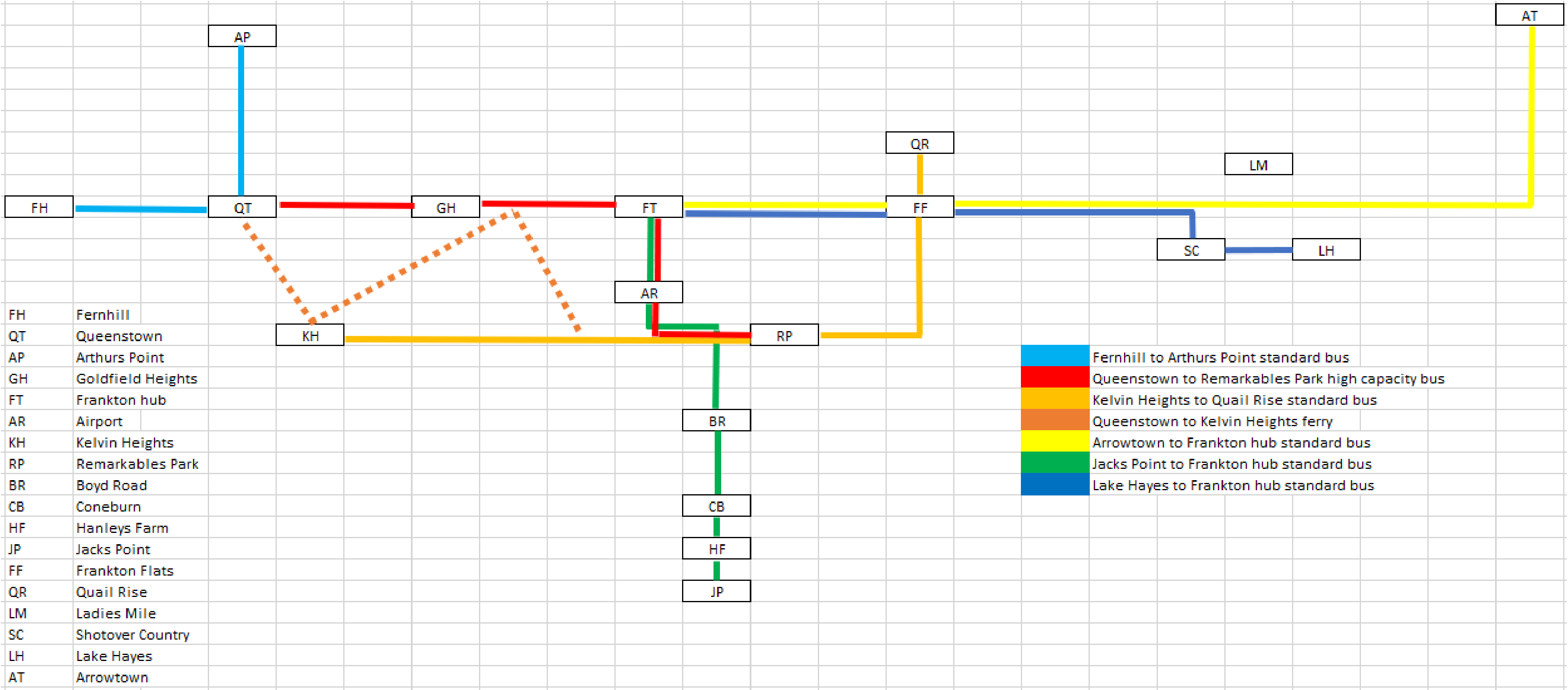


Figure 34: Long list option 6 – Rapid transit to Remarkables Park.

12.7 Rapid Transit to Jacks Point

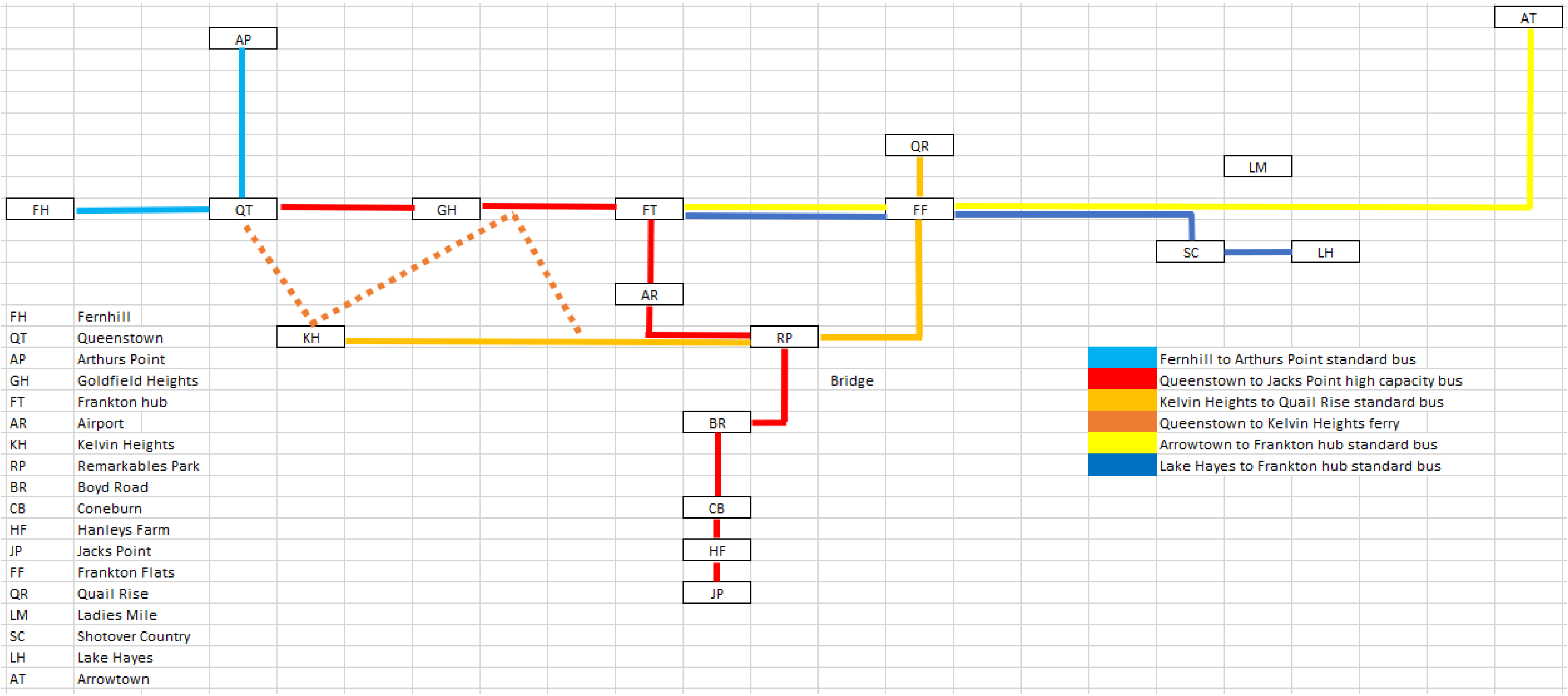


Figure 35: Long list option 7 – Rapid transit to Jacks Point.

12.8 One Seat Ride Network

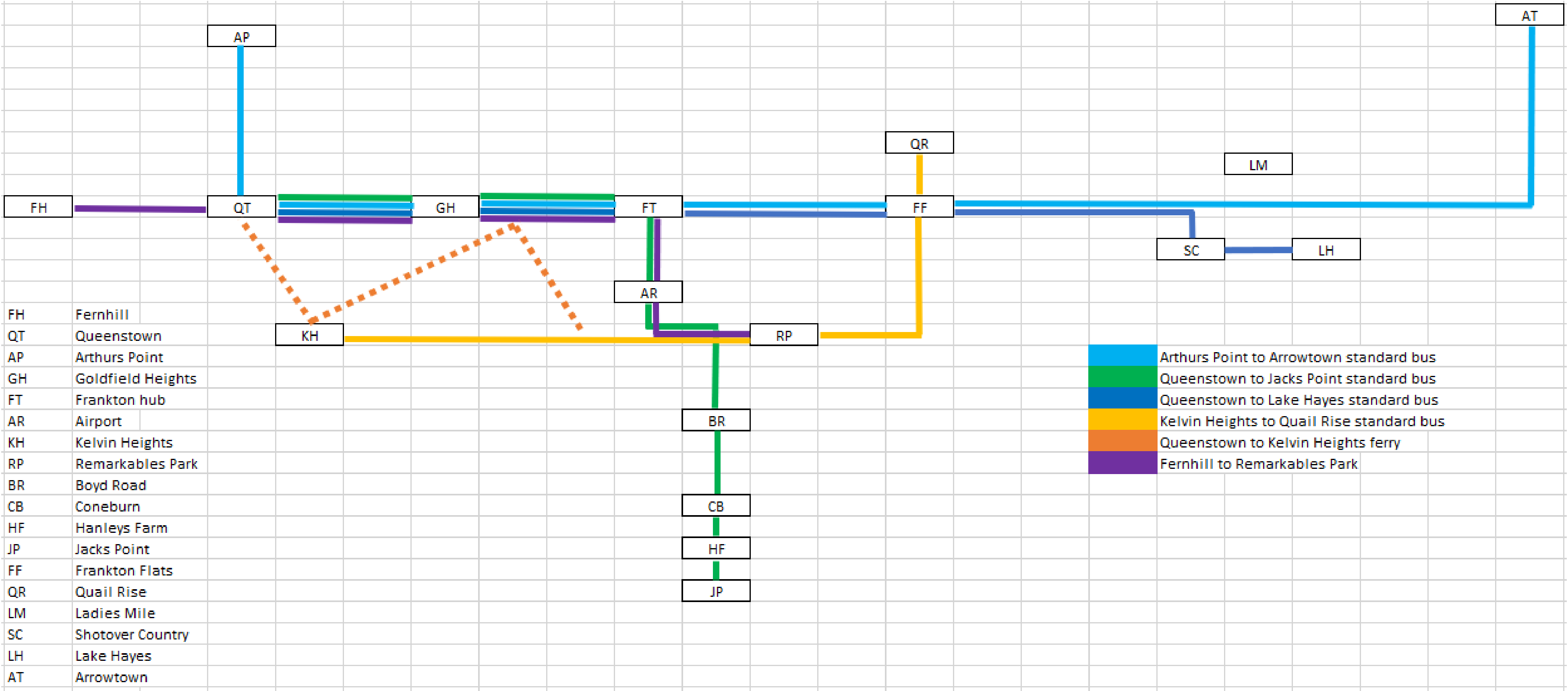


Figure 36: Long list option 8 – One seat ride network.

12.9 Ferry to Frankton Beach

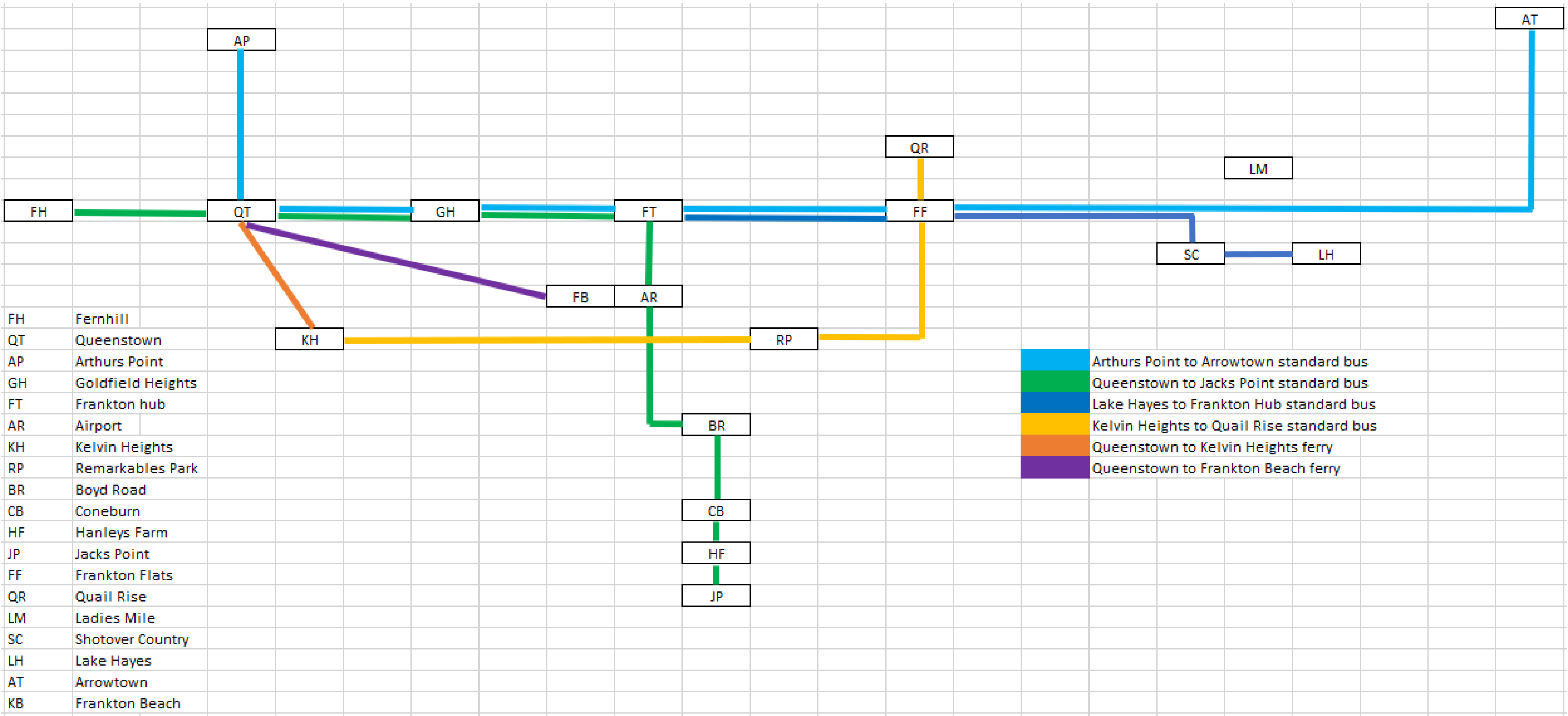


Figure 37: Long list option 9 – Ferry to Frankton Beach.

12.10 Jet Boat to Lake Hayes

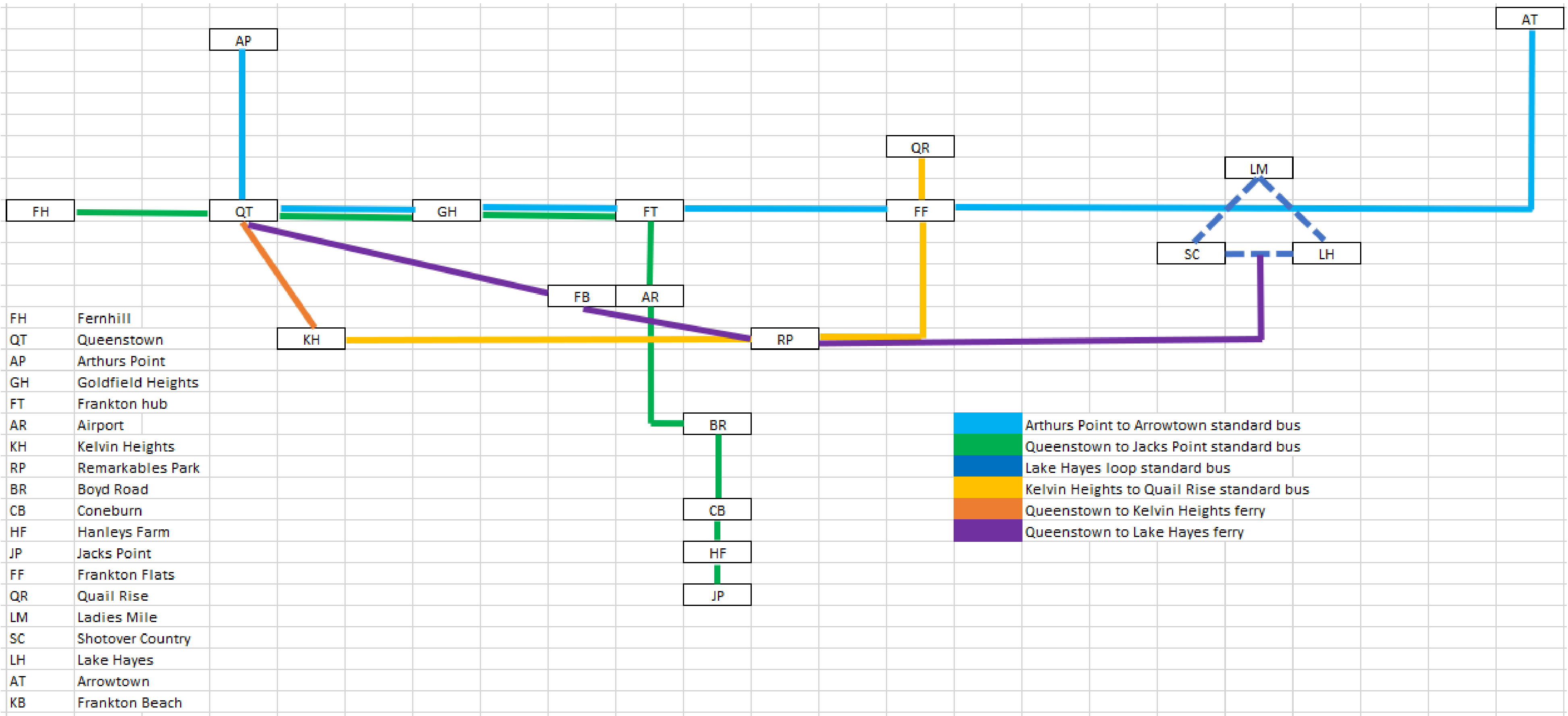


Figure 38: Long list option 10 – Jet boat to Lake Hayes.

12.11 Ferry to Jacks Point

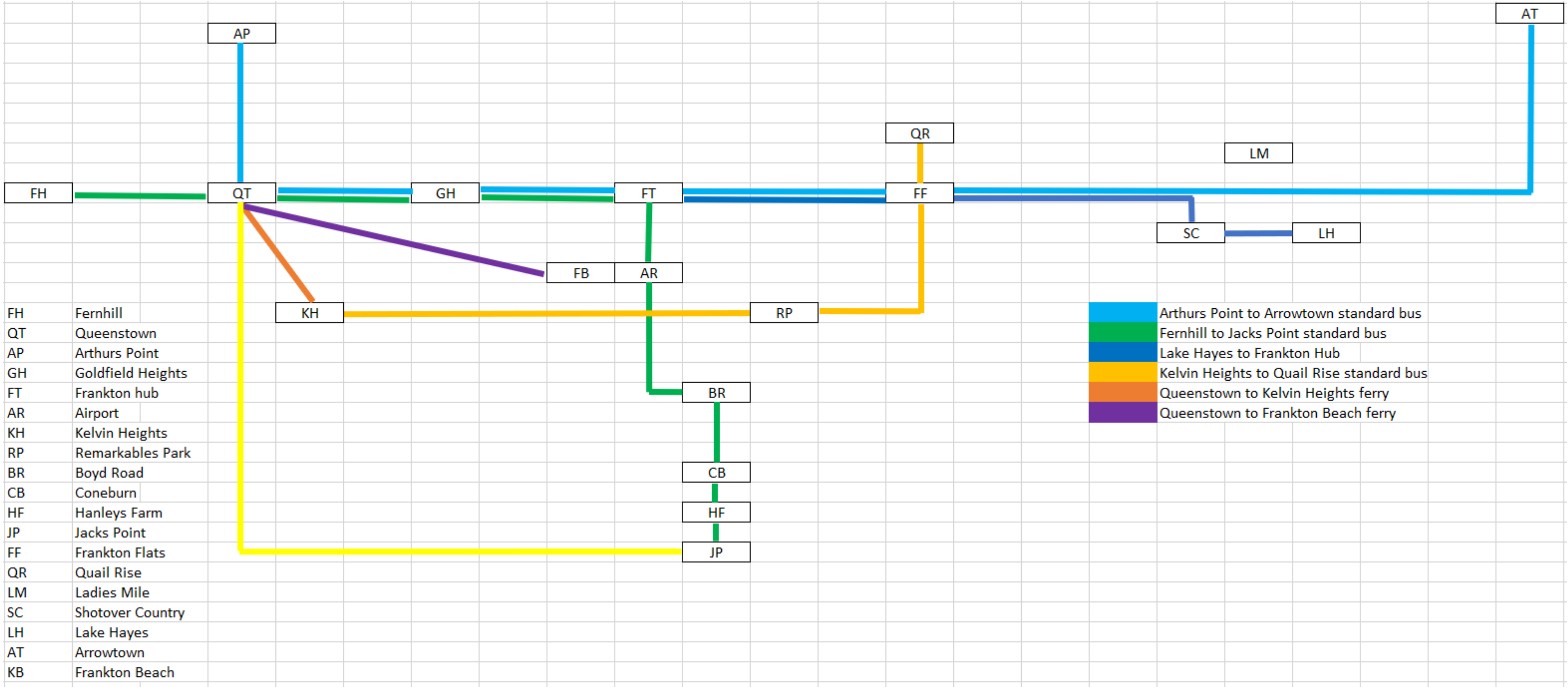


Figure 39: Long list option 11 – Ferry to Jacks Point.

13 Options Assessment

13.1 Capacity

The first measurement that the long list options have been assessed against is whether they could provide sufficient capacity to meet the mode shift required in 2054 (Table 21). The capacity assessment has been used to filter out poor performing options with only those that provide sufficient capacity been taken forward for further assessment.

The capacity requirement was taken from the travel demand modelling in 2054 for the morning peak at three key points in the network. The capacity provided was calculated by taking the planning capacity for each mode from Section 10 of this report and adding these together where multiple routes run in parallel. For standard buses, articulated buses, and jet boats, a cap of 30 departures per hour has been used and for ferries, the cap is 10 departures per hour. Where multiple road-based modes converge such as on SH6A the cap has been applied at the 'trunk' section with each of the 'branches' having half the number of departures.

The results of the capacity assessment are:

- Bus Max provides sufficient capacity to meet mode shift targets
- The demands from Jacks Point and Lake Hayes are unbalanced with more passengers coming from Jacks Point
- Options which do not provide high-capacity buses to Jacks Point fail to provide sufficient capacity to the southern growth corridor
- A one-seat ride network which uses standard buses do not provide sufficient capacity at any key point in the network
- Options which use ferry or jet boats do not provide sufficient capacity because they do not have the coverage to replace road based public transport modes

Table 21. Capacity assessment of long list options.

	State Highway 6A		Shotover bridge		Kawarau Falls bridge	
	Required capacity	Capacity provided	Required capacity	Capacity provided	Required capacity	Capacity provides
1. Bus Max	1,500	2,640	800	880	1,700	1,760
2. Bus Max with new Remarkables Park bridge	1,500	2,640	800	880	1,700	1,760
3. Bus Max using Malaghans Road	1,500	2,640	800	880	1,700	1,760
4. Rapid transit to Frankton Hub	1,500	2,640	800	2,640	1,700	1,320
5. Rapid transit to Lake Hayes	1,500	1,320	800	2,840	1,700	1,320
6. Rapid transit to Remarkables Park	1,500	2,640	800	1,320	1,700	1,320
7. Rapid transit to Jacks Point	1,500	2,640	800	1,320	1,700	2,640
8. One seat ride network	1,500	1,320	800	660	1,700	660
9. Ferry to Frankton Beach	1,500	3,240	800	1,320	1,700	660
10. Jet boat to Lake Hayes	1,500	1,680	800	1,020	1,700	660
11. Ferry to Jacks Point	1,500	2,280	800	1,320	1,700	1,620

13.2 Customer Needs

Table 22 below documents the customer journeys that would be better off and worse off for each network design option compared to the current bus network. A summary of the main findings is as follows:

- Providing a direct connection between Jacks Point and Queenstown would benefit many customers
- Options which require hubbing of bus services at either end of SH6A create customer disbenefits due to the need to transfer
- Customers in Fernhill have a good level of service under the current bus network with a frequent connection to the Airport and therefore can be disadvantaged in some options

Table 22: Customer journeys that would be better off and worse off for each network design option compared to the current bus network.

	Customers better off	Customers worse off
1. Bus Max	• Commuters from Jacks Point to Queenstown who no longer need to transfer • Customers in Arthurs Point, Quail Rise, Kelvin Heights, Jacks Point, Lake Hayes and Arrowtown who enjoy a frequent service • Customers travelling to Frankton who have more options to travel to Five Mile and Remarkables Park	• People in Fernhill who no long have direct route to Airport • People travelling from Quail Rise who now need to transfer
2. Bus Max with new Remarkables Park bridge	• Commuters from Jacks Point who no longer need to transfer and who have a direct journey • Customers in Arthurs Point, Quail Rise, Kelvin Heights, Jacks Point, Lake Hayes and Arrowtown who enjoy a frequent service	• People in Fernhill who no long have direct route to Airport • People travelling from Quail Rise who now need to transfer
3. Bus Max using Malaghans Road	• Commuters from Arrowtown who have the option to go via Malaghans Road and bypass any traffic on SH6 • Commuters from Jacks Point who no longer need to transfer and who have a direct journey • Customers in Arthurs Point, Quail Rise, Kelvin Heights, Jacks Point, Lake Hayes and Arrowtown who enjoy a frequent service	• People in Fernhill who no long have direct route to Airport • People travelling from Quail Rise who now need to transfer
7. Rapid transit to Jacks Point	• Commuters from Jacks Point who no longer need to transfer and who have a direct journey • Customers in Arthurs Point, Quail Rise, Kelvin Heights, Jacks Point, Lake Hayes and	• People travelling from Lake Hayes to Queenstown who need to transfer • People travelling from Arrowtown to Queenstown who need to transfer

	Arrowtown who enjoy a frequent service	• People travelling from Arthurs Point to Frankton who need to transfer • People travelling from Fernhill to Frankton who need to transfer

13.3 Travel Time

This section provides a comparison of the approximate in vehicle travel time from a selection of suburbs to key destinations for the different network options. The travel time was calculated using average speeds derived from Hi Trans Best Practice Guide for Public Transport (Figure 40).

Assumed average speeds and transfer times for different modes are listed below:

- 25km/hr for urban bus without priority
- 30km/hr for urban bus with priority
- 50km/hr for bus on rural highway
- 5min bus to bus transfer

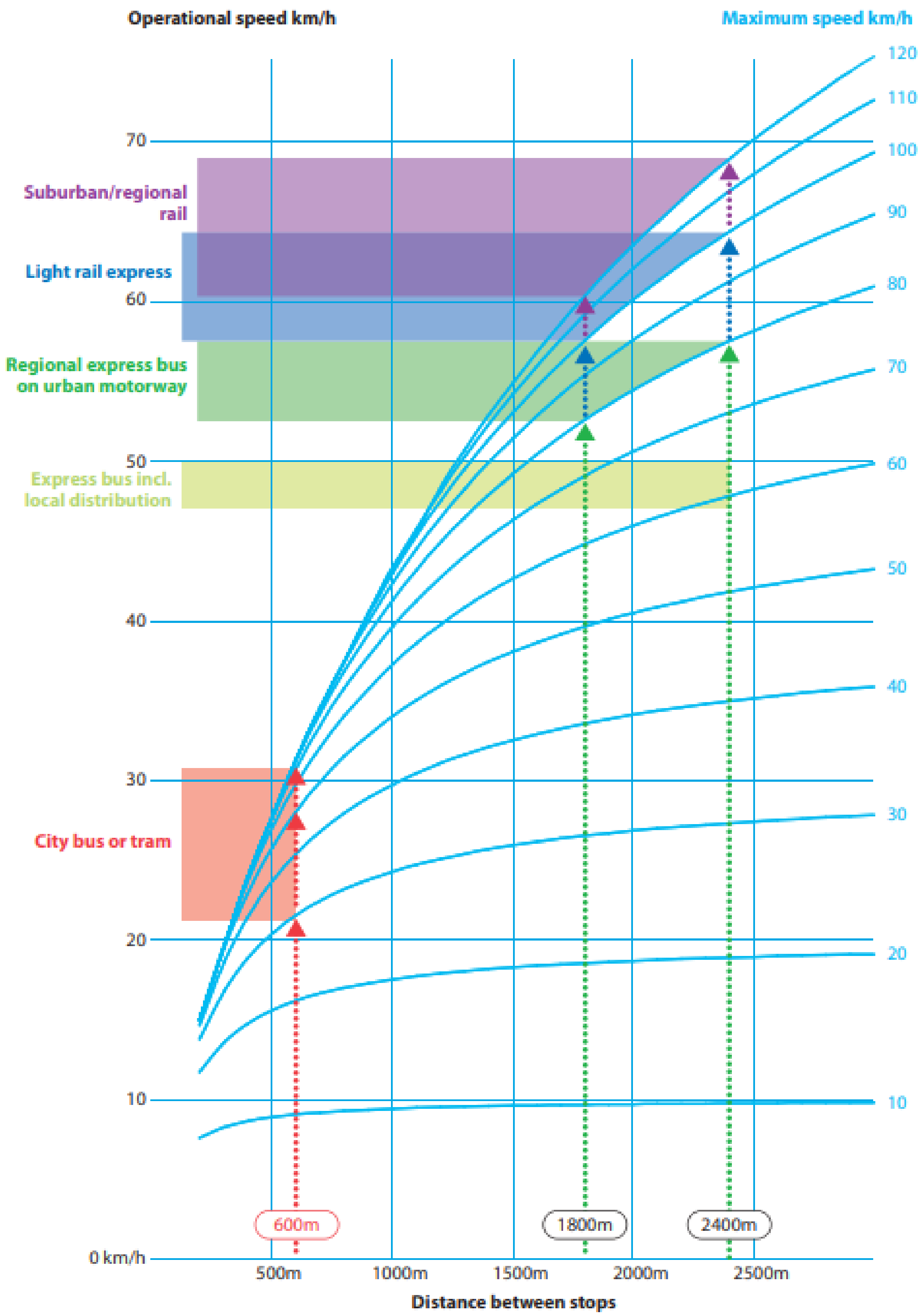


Figure 40. Average speeds of different transport modes relative to distance travelled between stops (Source: Hi Trans Practice Guide for Public Transport).

The travel time analysis is documented in Table 23 on the following page with a summary of the findings being listed below:

- Options with a new public transport bridge between Remarkables Park and Coneburn provide the fastest connection for the southern corridor
- Options which provide a direct bus between Queenstown and Lake Hayes offer the fastest way to serve the eastern corridor
- The Bus Max option using Malaghans Road offers the fastest travel time between Arrowtown and Queenstown due to the higher speed limit on Malaghans Road
- The rapid transit to Jacks Point option provides the worst travel time between Arthurs Point and Five Mile due to the double transfer

Table 23: Comparison of the approximate in vehicle travel time from a selection of suburbs to key destinations for the different network options. Green cells are faster options for each journey and red cells are the slowest options.

	Driving (Google Maps)	1. Bus Max	2. Bus Max with new bridge	3. Bus Max using Malaghans Road	7. Rapid transit to Jacks Point
Jacks Point to Queenstown	16-24 min	38 min	34 min	34 min	34 min
Jacks Point to Remarkables Park	8-12 min	19 min	15 min	15 min	15 min
Lake Hayes to Queenstown	16-26 min	29 min	29 min	29 min	34 min
Lake Hayes to Airport	10-16 min	33 min	33 min	33 min	33 min
Arrowtown to Queenstown	20-30 min	38 min	38 min	32 min	41 min
Arrowtown to Remarkables Park	14-20 min	30 min	30 min	30 min	30 min
Arthurs Point to Five Mile	18 min	31 min	31 min	36 min	41 min
Airport to Queenstown	12-18 min	18 min	18 min	18 min	18 min

13.4 Recommended short list options

The recommended short list service pattern options are:

1. Bus Max
2. Bus Max with new Remarkables Park bridge
3. Bus Max using Malaghans Road
4. Rapid transit to Jack's Point

The reasons for this recommendation are that these four options provide sufficient capacity to meet the mode shift targets. Each of these options provides a direct high-capacity service to the Southern Growth Corridor which is the location for the majority of the planned housing development in Queenstown. A one seat ride network is not preferred as it results in service duplication along SH6A which has limited capacity and higher operating costs from overlapping services. Options 4, 5 and 6 have the problem of resulting in high volumes of forced transfers which increases journey times and reduces the attractiveness of public transport. For options which include an additional ferry service (9, 10 and 11) it was found that the ferry offered limited additional capacity especially for a Kawarau River ferry and had limit catchment due to development patterns.

14 Link Roads

As noted in previous and current public transport planning work there are several potential link roads which could provide key public transport connections. These link roads are:

- Jacks Point to Hanley's Farm
- Boyd Road to Red Oaks Drive
- Southern airport link

14.1 Jacks Point to Hanley's Farm

There is currently no road connecting Jacks Point to Hanley's Farm, which are adjoining suburbs. This means that buses must loop into each suburb via SH6 which increases delays for passengers and operating costs (Figure 41). As Jacks Point and Hanley's Farm continue to grow in the future the number of passengers affected by the loop service will further increase. As a rough estimate a link road could save 2.5km or approximately five minutes per trip.

Figure 41: Current route 4 service.

14.2 Remarkables Park Bridge

The location of the Kawarau Falls bridge means that it is difficult to service Remarkables Shops, Wakatipu High School, and Queenstown Airport with bus services from the south. This is because bus services must either divert to Remarkables Shops which delays passengers travelling to Queenstown and Five Mile, or bypass Remarkables Shops. A public transport, walking and cycling bridge between Boyd Road and Red Oaks Drive would place Remarkables Park and the Airport on the way for buses from the southern growth corridor. As a rough estimate a Remarkables Park bridge could save 2km or approximately four minutes travel time per trip not taking into account traffic congestion (Figure 42).

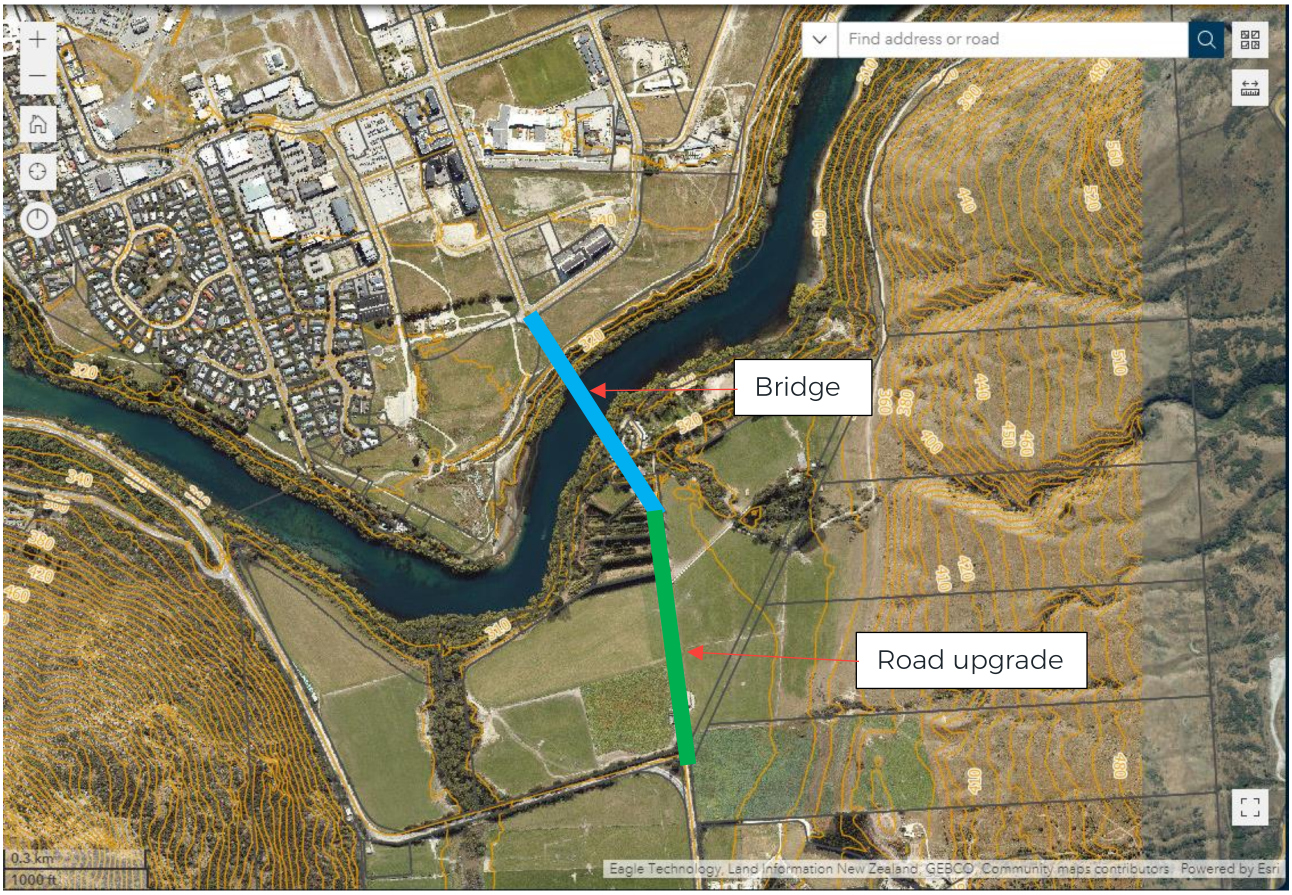


Figure 42. Suggested public transport only link road with a bridge connecting Boyd Road and Red Oaks Drive.

Figure 43. Example of public transport, cycling and walking only bridge, Tilikum Crossing Portland (Source: Archdaily).

14.3 Southern Airport Link

Due to the road network route 1 runs in a circuitous loop through the Airport and doubles back on the same route to exit the Airport. A bus-only link road from Lucas Place to Sir Henry Wigley Drive would provide a more direct route for buses from Remarkables Park (Figure 44). This would reduce travel time for bus passengers and would also reduce operating costs as trips lengths would be shortened. To enable this potential link road negotiations with landowners would need to take place.

Figure 44: Proposed bus only link from Lucas Place to Sir Henry Wigley Drive and connecting back out to Lucas Place.

15 Frankton Loop Service

The previous business case work contained a loop service from Frankton Hub, Five Mile, Queenstown Airport and Remarkables Park. The constraints of loop services are:

- Loop services tend to be unreliable because there is nowhere for buses to take a layover in between trips
- One-way loops create longer journeys because there will be customers who would need to take the long way round
- Loop services can be confusing for customers because the bus does not necessarily go in the direction that they want to travel in
- Running a Frankton loop service would duplicate other bus routes to Jacks Point and Lake Hayes which increases operating costs

A loop service is considered to be unsuitable for Frankton because the loop would take around 10 minutes and there are long sections of mixed running with traffic. This creates ample opportunities for buses to experience delays that is likely to result in the bunching of buses and unreliable services.

16 Ferry Service

The role of a ferry service within the recommended public transport networks is to provide a service from the Frankton Arm to Queenstown Town Centre which supports the bus services. The ferry service is envisaged to be similar to the current service with stops at Queenstown Bay, Bayview, Marina and Hilton (Figure 45). The reason for recommending a Frankton Arm focused ferry service is that the geography of Queenstown makes a ferry service from the Kelvin Peninsula competitive with land-based transport options. It was found that there is not a strong case for additional ferry services to Frankton Beach, Remarkables Park and Lake Hayes for the following reasons:

Frankton Beach

- Shallow water depth (approximately 1m) means that only a very small ferry can access the Willows Jetty. The current Frankton Arm ferry has difficultly accessing the Hilton Jetty which is in approximately 2m of water;
- Limited catchment area with Willows Jetty being a 15 minute walk from Queenstown Airport which is beyond a comfortable walking distance especially for people with luggage; and
- Higher operating costs than a bus service due to greater number of vessels and skippers being required as well as higher maintenance costs.

Remarkables Park

- Majority of trip generating activities are along Hathorne Drive which is 600m from the Kawarau River; and
- Shallow depth of the Kawarau Falls means that only a small vessel with a low displacement (such as a jet boat) could be used;
- Stops limited to Queenstown and potentially the Frankton Marina compared to a bus service that can stop at Queenstown Airport, Frankton golf course, along SH6A and Fernhill.

Lake Hayes

- Poor coverage of the residential area compared to a bus route as walking distance from far side of suburb to the river is 1.2kms;
- Inability to serve trips to nearest supermarket, school and pharmacy which reduces the types of trips that the ferry service would be useful for; and
- Slower journey times than a bus service as Lake Hayes to Queenstown ferry service is expected to take 50 minutes[11] compared to 35 minutes on the current route 5.

Figure 45: Current ferry service (Source: Otago Regional Council)

17 Ski fields

Skiing is a popular activity in Queenstown for both locals and tourists with there being high trip demand to the Remarkables Park and Coronet Peak ski fields during wintertime. Transport options for skiers to catch the ski bus from the town centre or Frankton, to park at the base of the mountain and catchup the ski bus to the chair lifts or to drive up the mountain road. However due to traffic congestion on SH6A only the early morning ski bus trips to Remarkables Park depart from the town centre with the mid-morning trips departing from the Frankton golf course. Both the Remarkables Park and Coronet Peak base parking areas are close to public transport routes. There is therefore the potential to provide a service to the base of the mountains where skiers could transfer onto a private shuttle. Further investigation would be required to develop suitable bus turns and passengers waiting areas to enable public transport to ski shuttle connection. Furthermore, the interior layout of the bus fleet would need to be designed to accommodate skis and snowboards in the luggage area.

[11] Based on application by Kawarau Jet Holdings

Figure 46: Network map for The Remarkables and Coronet Peak ski bus

18 Town centre expansion

As part of the Lakeview project the Queenstown town centre will be extended to the west with the addition of new hospitality, retail, office and hotel buildings. The Lakeview site is approximately a 10-minute walk from the Stanley Street bus hub which is outside of a comfortable walking distance. The Skyline Gondola is also located to the west of the current town centre and is a 8-minutes walk from the Stanley Street bus hub. The arterials stages 2 and 3 project provides the opportunity to expand the public transport coverage of the western town centre by using the new road. This would enable the Lake Hayes and/or Jack's Point bus routes to be extended to One Mile thus bring public transport closer to the new development area. Without arterials stages 2 and 3 it is not feasible to extend the bus routes due to lack of through roads and delays caused by traffic congestion.

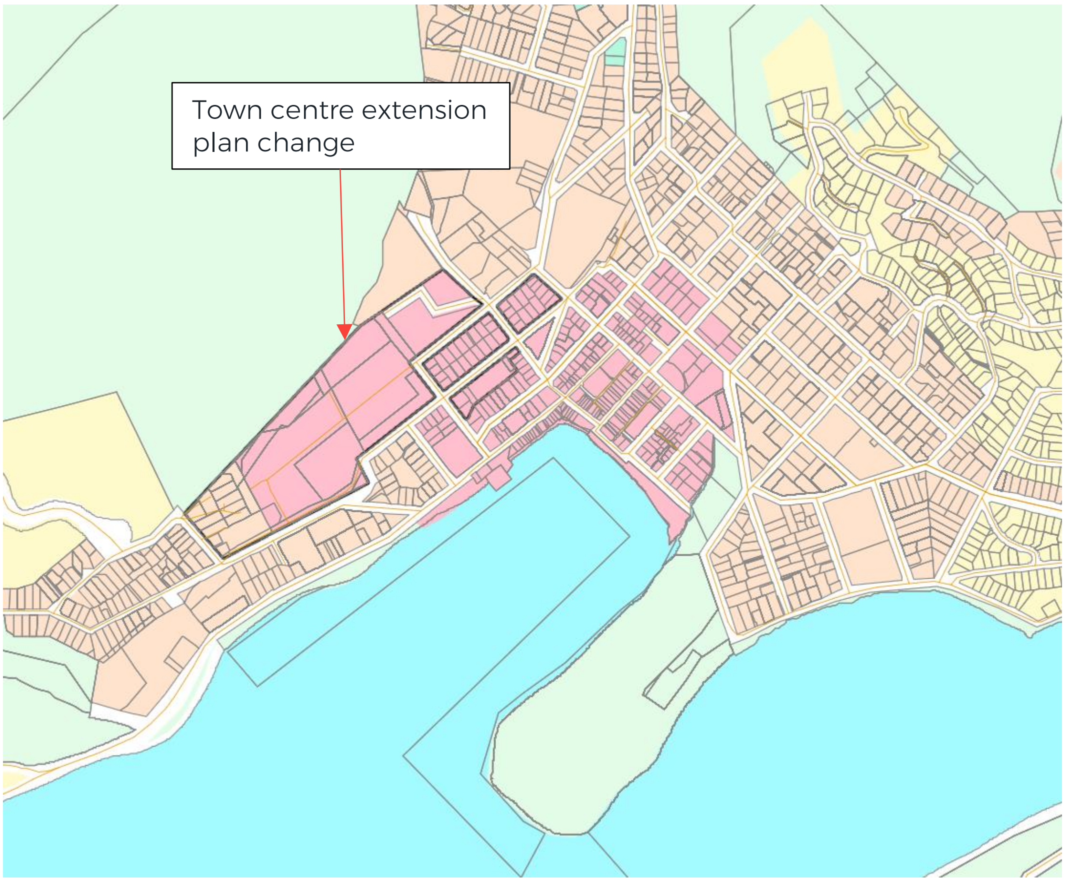


Figure 47: Zoning map showing town centre extension plan change (source: QLDC Operative Plan)

19 Ladies Mile

The suburbs of Shotover Country, Lake Hayes and Ladies Mile occupy a flat area of land between the Kawarau River, Shotover River, Slope Hill and Morven Hill (Figure 48). The combined area is 1.5km wide and 2.5m long with the state highway running off centre through the area. This geometry presents challenges from a public transport perspective because the area is too wide to serve with a single public transport route but not large enough to support two routes. The options considered with the potential to serve this area of Queenstown with public transport are:

- A branching route with one half into Shotover/ Lake Hayes and the other into Ladies Mile
- One route serving Shotover/ Lake Hayes with people in Ladies Mile walking out to the state highway to catch the Arrowtown route
- Diverting the Arrowtown route into Ladies Mile and keeping the Shotover/ Lake Hayes route unchanged

Figure 48: Geographical extent of Shotover Country, Lake Hayes and Ladies Mile (Source: Google Maps).

The preliminary recommended option for serving Ladies Mike is either to divert the Arrowtown route into the suburb or have people walk to state highway 6. The reasons for this are:

- Ladies Mile and Shotover/ Lake Hayes are different-sized suburbs and would having different travel times to the terminus. This would make timetabling a branching route difficult as the passenger loadings from each branch would be uneven
- Diverting the Arrowtown bus would add approximately 2km to the route whereas the route could be shortened by 7km by terminating at Queenstown instead of Arthurs Point
- Picking up the Ladies Mile catchment would support a higher frequency service to Arrowtown and offset the lack of urban catchment between Lake Hayes and Arrowtown
- The distance from the edge of Ladies Mile to SH6 is 400m which is a comfortable walking distance.

20 Queenstown Airport

Queenstown Airport is a key destination both for visitors but also for locals who work at the airport. The proposed public transport network includes a frequent, long span and high-capacity bus route to the airport. This service would serve both the airport, Remarkables Park, the southern growth corridor and connect with the wider network at Remarkables Park and Stanley Street. This is a similar approach to that used in Auckland with the AirportLink bus connecting the Airport to Manukau via Puhinui Station (Figure 49). A combined service is preferred over a separate airport bus service for the following reasons:

- A combined service would support a higher frequency service than if the services were separate because it is more efficient to have a single route rather than overlapping services
- A Queenstown- Airport- Remarkables Park- Jacks Point service connects customers to more destinations than a Queenstown to Airport service would. This is useful for locals who live in the southern growth area or visitors who have accommodation in Remarkables Park.

- A limited stop Airport to Queenstown Central service would not be significantly faster due to the short distance between the Airport and Queenstown Central (8km)
- A combined Queenstown- Airport- Remarkables Park- Jacks Point service reduces the number of buses on State Highway 6A and Stanley Street terminus combined to separate bus routes.

The additional capacity provided by articulated buses provides the opportunity to configure the buses to have a luggage area at the front of the bus.

Figure 49: Auckland public transport network map showing Airport Link service (source: Auckland Transport)

21 School Services

In New Zealand the provision of school services is the combined responsibility of the Ministry of Education and regional councils. Typically, the Ministry of Education provides school buses to rural areas whereas regional councils provide school buses within urban areas. Because Queenstown has rapidly urbanised over recent years the Ministry of Education is pass responsibility for some school buses to ORC. It is recommended that ORC completes a review of the school bus services in light of the proposed public transport network changes. The purpose of this would be to identify gaps in coverage where there is not a direct bus service to Wakatipu High School and there is sufficient demand to warrant a new school route. There may also be locations where a public bus route runs from a suburb and past Wakatipu High School and in that situation a separate school bus may not be required.

22 Infrastructure Requirements

The purpose of this section is to provide a summary of the infrastructure required to enable a new network to operate, regardless of the eventual chosen option.

22.1 Interchanges

Interchanges between services will likely be required. There are existing interchanges at Frankton Hub and on Stanley Street in Queenstown. Interchange requirements at Stanley Street Hub, Frankton Hub, Five Mile and Remarkables Park were identified to enable customers to transfer between bus services. This is particularly important for customers who are travelling from the south and going to Five Mile and customers travelling from the east who are going to Remarkables Park. Compared to relying solely on Frankton Hub, facilitating transfers at Remarkables Park and Five Mile provides more direct journeys for customers. The location options and design for the intersections would be considered further as part of the infrastructure technical papers however it is considered that an on-road interchange is likely to be appropriate. More information on the recommendations of the interchanges can be found in **Advisory Paper 5: Public Transport Hubs and Infrastructure**

Figure 50: Example of Kilbirnie bus interchange in Wellington (Source: Isthmus)

An upgrade to the Frankton Hub is part of the New Zealand upgrade programme. Plans include a saw tooth layout for part of the interchange. Implementing articulated buses may require a modification to this layout to straighten the platforms so that articulated buses can pull up inline with the kerb. Another option could be to allocate articulated buses to the linear platforms and have standard buses that would operate the connecting services use the saw tooth platforms. The operation of Frankton Hub with the proposed public transport network will be explored further in the Interchanges advisory paper.

The Stanley Street interchange is planned to be upgraded as part of the Queenstown Arterials project. The design of the upgraded interchange as six fully independent bus bays (Figure 51). Independent bus bays is the term for when buses can pull in and out of a bay without another bus needing to move. Articulated buses are longer than standard buses and therefore a modification to the interchange would likely be needed to facilitate the use of articulated buses. Options could include reducing the entry taper and thereby changing to four semi-dependent bays and two independent bays. Semi-dependent bays means that buses could depart freely but access to the first bus bay could be restricted if a bus is occupying the bay behind. The advantages of semi-dependent operation is that it reduces the length of kerb required, reduces walking distance between stops, and in-service buses typically dwell at stops for a short period (around 60 seconds). Examples of interchanges which have semi-dependent operation are the Auckland Northern Busway Stations and Otahuhu Station.

Figure 51: Design of Stanley Street interchange as part of Queenstown arterials project

22.2 Termini

At locations where buses begin and end their services, it is important that allowance is made for bus turn arounds, bus layover spaces and potentially driver facilities and electric bus chargers. As the frequency of public transport services increases, and as high-capacity buses are implemented, the infrastructure at termini will become more important because using existing bus stops becomes less viable.

22.3 Bus stops

In order to implement articulated buses the bus stops along the core routes would need to be lengthened. This is to enable the rear door of the bus to pull up in line with the footpath which enables passengers to board and alight more easily. The type of change required to lengthen bus stops depends on whether the stop is in-line or an indented bay. For in-line stops, a traffic resolution would be required to lengthen the bus box because of the change to parking restrictions. For indented bay type stops a section of kerbline may need to be rebuilt to lengthen the bay as the existing bay be too short to accommodate the longer vehicle. Assessment of bus stops are further detailed in Advisory Paper 5 – Public Transport Hubs and Infrastructure.

22.4 Priority Measures

Public transport priority is an important tool for ensure fast and reliable journey times which is a key driver of mode shift towards public transport. Committed public transport priority measures are SH6 south of BP roundabout and SH6 east of BP roundabout. Limited public transport priority measures at intersections are also planned for SH6A between Frankton and Queenstown. However, as Queenstown continues to grow, potential additional areas to investigate public transport priority are Hawthorne Drive and Lucas Place and SH6 along Ladies Mile. Lucas Place has an 11m wide grass verge which is road reserve space that could be used to provide bus lanes.

With continuous public transport priority on SH6A being difficult to achieve due to space constraints, maintaining traffic flow on SH6A becomes critically important for the reliability of the public transport network. This is because all the core public transport routes travel on SH6A. Therefore any delays will impact on the whole public transport network (this also means limited opportunities for buses to offer travel time or reliability advantages over private vehicles). Potential ways to maintain traffic flow include holding traffic back in Frankton with buses using the SH6 bus lanes to bypass the queues. Another method is comprehensive travel demand management through measures such as parking pricing, parking availability, and congestion charging to discourage driving into the town centre.

22.5 Guidance systems

A guidance system refers to the physical or computer system which aids the bus driver in steering the vehicle which can be along the whole route or just at bus stops. One type of guidance systems is guided busways such O-Bahn Busway in Adelaide which use guide-wheels of the side of a bus that follow a track. Another example is an optical guidance system in which a computer follows a painted line on the road. These types of systems are sometimes referred to as trackless trams (Figure 52). The advantages of a guidance system are that it enables buses to pull up closer to the platform and can contribute to a higher ride quality. The disadvantage of guidance systems is that they increase maintenance requirements for both the vehicles and the corridor.

Considering the Queenstown context, it is recommended that the articulated fleet is either un-guided (bus driver steers) or uses optical guidance at bus stops only. This is because of the following reasons:

- Physically guided busways require a dedicated corridor; there is insufficient road corridor space in Queenstown to achieve this
- Physically guided busways have low tolerances for the track alignment which increases construction costs compared to unguided systems
- During operation of optical guided busways in France it has proven difficult to keep the guidance line clear of dirt, leaves, and oil to have sufficient contrast for the guidance system[12]
- The most significant benefit of guidance systems is closer alignment with bus stop platforms which can be achieved through optical guidance at the entry and exit to bus stops
- The majority of public transport routes in Queenstown will be mixed running with traffic which increases the difficultly of maintaining guidance lines in between bus stops

[12] Yale Wong (2019), Debunking the myths around optically-guided bus.

Figure 52: Rouen bus rapid transit system which is optically guided at bus stops (Source: Mobilys)

23 Conclusion

The service patterns paper has developed public transport network design options for Queenstown to achieve the strategic objectives of the Queenstown public transport business case. The inputs that were used to develop the service pattern options are the travel demands from the Demand Forecasting technical note, the geographic content of Queenstown, current and future land use, customer needs, and best practice service design principles. Service pattern options were developed which use different public transport modes and different approaches to network design.

The long list of 11 network options were assessed and narrowed down to four short list options through an assessed against capacity provided, customer needs and travel time. The recommended short-listed options are bus max, bus max with Remarkables Park bridge, bus max with Malaghans Road and rapid transit to Jacks Point. The short-listed options provide a mix of high and low levels of infrastructure investment, different levels of transfers required and an option for a more direct service to Arrowtown. The recommended next steps for the network options as part of this business case is to consult with stakeholders and the public to receive feedback on the options. The options can then be refined based on the feedback and any hybrid options developed. The network options would then be combined with propulsion technology, on demand and park n ride options to form combined packages that would be assessed through an MCA.

An assessment was also completed the type of public transport vehicle that would balance the capacity provided with the wait times between services. It was found that articulated buses were the preferred vehicle type for the primary corridors as this vehicle type makes better use of the available capacity on SH6A and requires fewer bus drivers than standard buses. Articulated buses have a comparable turning circle to large buses with the main difference being the length of bus stop required to enable articulated buses to operate. As part of the infrastructure advisory paper an assessment of the feasibility of lengthening bus stops and amending the design of interchanges will be completed.

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Queenstown Public Transport Business Case

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System Management Advisory Paper

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Contents

Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the System Management Paper which forms part of the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Consultant Agreement dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Executive Summary

The purpose of this advisory paper is to investigate the management and labour requirements to deliver the recommended bus network from Advisory Paper 3 and the ownership model from Advisory Paper 7. The key elements of the recommended bus network are high frequency, long span bus services operated with electric articulated and standard buses. The recommended ownership model is that Otago Regional Council, or a third party, owns the bus depot and that bus operators continue to own the fleet and to deliver services. The reason for recommending public ownership of the bus depot is to protect the investment in high voltage power connection and to remove barriers to new operators in entering the Queenstown market.

Placing ownership of a new electric bus depot with Otago Regional Council will bring additional roles and responsibilities both for developing the bus depot and for the ongoing management of the depot. For the development phase there would be land procurement, design, consenting and construction management roles. During the management phase there would be property management, building maintenance and accounting roles. Much of the project specific roles can be outsourced to specialists in property, engineering and urban planning but there would be a project management role that would most likely sit within Council.

Due to the significant increase in service levels as part of the new public transport network there will be an increase in labour required including bus drivers, maintenance staff and ferry staff. There is currently a labour shortage in Queenstown across most industries which reflects a low unemployment rate, competition for limited labour and a high cost of living in Queenstown. It is expected that the labour shortage would lessen somewhat over time with increased immigration, reduced economic activity from higher interest rates and reskilling of staff which are new to the transport industry. However, due to high cost of housing it is expected that Queenstown will continue to find it challenging to hire and retain public transport workers when other centres offer a lower cost of living and comparable wages.

To ensure the availability of staff to operate the new public transport network, it is recommended that Otago Regional Council partners with Queenstown Lakes Community Housing Trust (or similar organisation) to fund affordable rental accommodation for public transport staff. This could take the form of an initial grant followed by ongoing grants funded from a small increase in public transport fares. Queenstown Lakes Community Housing Trust would use this revenue to construct affordable rental houses for public transport staff and would be the landlord. The advantage of partnering with Queenstown Lakes Community Housing Trust is to utilise the existing experience in constructing and managing rental accommodation.

Other support measures for hiring and retaining bus drivers is to minimise split shifts where a bus driver does a few hours work in the morning and a few hours work in the afternoon. The new Queenstown public transport network minimises the need for split shifts by utilising high-capacity buses with a consistent frequency instead of higher peak time frequencies. Another important measure would be to improve driver facilities at termini which are currently inconsistent and informal.

1 Introduction

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers have been produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This System Management Advisory Paper is part of the Project's suite of advisory papers. It outlines the resources and systems that would be required to implement the changes to public transport in Queenstown as proposed in the Queenstown Public Transport Business Case.

The Queenstown Public Transport Business Case proposes a large step change in service levels and could have a different ownership structure for the bus depot from existing. The increase in service levels and change to ownership models reflects the need to accommodate a far larger mode share on public transport and the transition to a zero-emission bus fleet.

The paper is structured as follows:

- An overview of the roles and responsibilities for the current bus and ferry network.
- A comparison between the resources required for the current public transport network compared to the proposed services.
- The additional roles and responsibilities for public ownership of a bus depot are then discussed as well as an assessment of bus driver availability in Queenstown.
- The potential tools available to council and operators to hire and retain more staff in Queenstown are outlined.

The recommendations of this paper will help shape the Commercial, Financial, and Management cases of the Business Case.

Glossary

CERF	Climate Emergency and Response Fund
FTE	Full time equivalents
NZTA	NZ Transport Agency Waka Kotahi
ORC	Otago Regional Council
QLDC	Queenstown Lakes District Council
QLCHT	Queenstown Lakes Community Housing Trust

2 Current Public Transport System Roles and Responsibilities

2.1 Otago Regional Council

Otago Regional Council (ORC) is responsible for the planning, management, and contracting of public transport services in Queenstown and Dunedin. The primary roles of public transport contracting authorities for non-exempt services are:

- Setting policies and fares.
- Writing and amending timetables.
- Tendering services and managing contracts.
- Monitoring services.
- Responding to customer queries.
- Branding and marketing.
- Funding partner.

Under the Sustainable Public Transport Framework, public transport contracting authorities potential roles and responsibilities have been expanded. These include the ability to own assets and deliver services in house.

2.2 Queenstown Lakes District Council

Queenstown Lakes District Council (QLDC) is responsible for owning, maintaining, and managing the local road network which is used by public transport services. QLDC is also responsible for the delivery of bus infrastructure on local roads. Specific roles and responsibilities for QLDC include:

- Providing bus stops and interchanges.
- Maintenance and cleaning of bus stops.
- Provision of bus priority on local roads.
- Enforcing parking, vehicle, and lane restrictions (except for moving offences).
- Provision of wharf and jetty assets.
- Funding partner.

2.3 NZ Transport Agency Waka Kotahi

The NZ Transport Agency Waka Kotahi (NZTA) is responsible for delivering on the government's desired land transport outcomes and investing the National Land Transport Programme's allocated funding into public transport and infrastructure. NZTA is also responsible for:

- Regulation and licensing bus operators.
- Providing public transport infrastructure on the state highway.
- Developing best practice guidance to transport practitioners e.g. Public Transport Design guidance.

- Setting national standards e.g. Vehicle Dimensions and Mass (VDM) and Requirement for Urban Buses.
- Funding partner.

2.4 Bus Operators

The main responsibility of bus operators is the day-to-day delivery of services in accordance with their contract with ORC. Other responsibilities of the bus operator are:

- Employing, training, and retaining staff to deliver on contracted services.
- Design of shifts and allocation of bus driver to shifts.
- Management of staff including leave and remuneration.
- Procuring, owning, and maintaining the bus fleet.
- Building, owning, and maintaining bus depots.
- Operational management and responding to disruptions.

2.5 Ferry Operator

The Queenstown ferry is currently an exempt service, which means that the operator delivers the service on a commercial basis without a public subsidy. Therefore, the ferry operator has additional roles above operating the service which are:

- Setting policies and fares.
- Writing and amending timetables.
- Responding to customer queries.
- Branding and marketing.

3 New Network Management Requirements

3.1 Proposed Ownership and Operating Model

In the Ownership and Operating Model Advisory Paper, the advantages and disadvantages of different roles and responsibilities for delivering the public transport network were explored. The recommendation was for private operators to retain the delivery function and ownership of fleet, with ORC being the preferred owner of the electric bus depot and retaining the network planning role. The roles of QLDC as infrastructure provider and NZTA as infrastructure provider and regulator would be unchanged by the Sustainable Public Transport Framework.

The reason for proposing public ownership of a new Queenstown bus depot is that it would protect the investment in electrical and charging infrastructure that is needed with a transition to a zero-emission fleet. Further, a publicly owned bus depot which is leased to bus operators may remove a barrier for new bus operators to enter the Queenstown market, and hence increase competition.

3.2 Status of Ferry Service

At the time of writing this advisory paper, the operator of the Frankton Arm ferry was looking for a buyer to take over operating the service. Therefore, it was unclear whether the service would continue in its current form. However, the current operator had committed to continue to run the service until a buyer had been found.

The proposed public transport network includes an increase in ferry frequency for the Frankton Arm service from hourly to 30 minutes. For the purposes of this paper, it has been assumed that the Frankton Arm service would be non-exempt. Therefore, ORC could assume more responsibilities for the planning and management of the ferry services.

3.3 Labour and Asset Requirements

The indicative bus and ferry fleet requirements for the proposed future services is shown in Table 1. These are based on the current timetables and typical bus and ferry operating speeds for the Preferred Option.

Comparing the current and Preferred Option networks shows that the Queenstown bus fleet would more than double in size by 2039. It has been assumed that all new buses would be battery electric, however the preferred decarbonisation pathway is yet to be determined. Electric buses available on the market have sufficient range to complete the expected block length with overnight depot charging. Therefore, the shift to zero emissions buses is not expected to impact the peak vehicle requirement and number of drivers required compared to diesel buses.

Table 1: Estimated Current and Bus Max 2039 Fleet Requirements

	Current Network	Preferred Option 2039
Bus fleet (including spares)	18 standard buses, all diesel	44 electric buses (8 articulated and 36 standard)
Ferry fleet (including spares)	One diesel ferry	Two electric ferries

The indicative number of drivers and captains for the current network and Preferred Option 2039 are shown in Table 2 as Full Time Equivalents (FTEs). These figures were calculated from taking the estimated peak vehicle requirement and multiplying it by two to account for drivers needed for evening shifts. The assessment shows that the number of bus drivers is expected to increase from 30 to 88 FTEs by 2039 due to the proposed increase in service levels.

Table 2: Estimated Current and Preferred Option Bus Driver Requirements (FTE)

	Current Network	Preferred Option 2039
Approximate bus drivers	30	88
Approximate ferry captains	2	4

4 Bus Depot Management

4.1 Development Phase

The development of a bus depot would be a complex project that would need to be managed and resourced accordingly. There would be multiple stages in completing the development that would require the following skills and experience:

- Site purchase and due diligence: Property and commercial advisory, concept level design and cost estimates
- Detailed design and consenting: Commercial architecture, transport engineering, electrical engineering, geotechnical engineering, structural engineering, and urban planning
- Construction: Procurement and construction management
- Contract development: Legal and commercial advisory

As discussed in Advisory Paper 7 – Ownership and Operating Model, ORC would only require these skills if the bus depot is publicly-owned. Many of the roles required for the development of the bus depot could be contracted out to engineering, legal, and procurement firms who have specialist knowledge. The role which is consistent across all stages of development would be project management that would likely be a council employee whether a permanent or fixed term role.

4.2 Operation Phase

Under the proposal for the bus depot to be publicly owned and leased to the bus operator, the arrangement between the council and bus company would be a commercial tenancy. The additional functions for council that this commercial tenancy would create include property management, maintenance, and property insurance. Many of these functions could be contracted out with it being common for a property management company to manage the tenancy, complete inspections, and organise repairs. Having a property management company as the go between would also help to separate the management of the bus depot from the management of services.

5 Labour Availability

5.1 Bus Drivers

5.1.1 Current Driver Salary

Bus drivers in Queenstown are paid approximately $32 per hour compared to $30 per hour in Wellington and $28 in Auckland. However, weekly median rent in Queenstown is higher than other parts of New Zealand at $775 compared to $620 for Lower Hutt and $500 for Christchurch. Table 3 compares the weekly median rent against the weekly take home income of a family earning a bus driver's wage. The hypothetical family would not be eligible for the government's accommodation supplement because the combined income is above the eligibility criteria threshold.

Table 3: Rent burden by selected towns and cities for couple on bus drivers' wages, assuming both work 40 hours per week.

Location	Weekly median rent	Weekly take home income	Rent as Percentage of income	Weekly income after tax and rent
Queenstown	$775	$2,020	38%	$1,245
Auckland	$620	$1,802	34%	$1,182
Napier	$470	$1,802	26%	$1,332
Palmerston North	$410	$1,802	23%	$1,392
Masterton	$500	$1,692	29%	$1,192
Wellington	$620	$1,912	32%	$1,292
Nelson	$540	$1,802	30%	$1,262
Christchurch	$500	$1,912	26%	$1,412
Dunedin	$440	$1,912	23%	$1,472

Weekly take home income assumed to be two drivers working full time, after taxes / ACC levy

Although bus driver salaries are higher in Queenstown than elsewhere in New Zealand this is offset by a higher cost of rent. As a result, rent takes up 38% of a bus driver's salary in Queenstown compared to 34% in Auckland and 26% in Christchurch. A rule of thumb is accommodation costs above 30% of income is typically considered to be rent burdened.[1] By this measure median rent would be unaffordable in Queenstown, Auckland, and Wellington with smaller centres and Christchurch being more affordable.

5.1.2 Current Labour Pool

New Zealand currently has an official unemployment rate of 3.6%[2] which is approximately half of the long-term average. The most recent unemployment data for Queenstown from the 2018 Census is an unemployment rate of 1.1% which is significantly below the unemployment rate for New Zealand as a whole. This contributes to businesses finding it difficult to find workers, with 78% saying it is hard to fill skilled roles and 57% saying that it is hard to fill unskilled roles.[3] There is evidence of upward pressure on wages with reports of $28 per hour starting wages for hospitality staff[4] and $27 per hour wages for housekeepers.

From Statistics New Zealand linked employer-employee data, bus service workers have the highest average age of any key industry at 54 years.[5] This is eight years older than the next highest industry of rental, hiring, and real estate. Bus services had a ten-year industry retention rate of 58.8% compared to 73.2% for healthcare and 24.6% for administrative support. This indicates that

[1] Ministry of Housing and Urban Development, Change in Housing Affordability Indicators Other ways to measure housing affordability - Te Tūāpapa Kura Kāinga - Ministry of Housing and Urban Development (hud.govt.nz)
[2] Statistics New Zealand indicator for June 2023 quarter
[3] Benje Patterson for QLDC Queenstown-Lakes' Labour Market snapshot – August 2022.
[4] McDonald's in Queenstown pays $28 an hour for new staff - no experience necessary | Stuff.co.nz
[5] Boomers bolster bus drivers' loyalty | Stats NZ

the bus service industry is reliant on older experienced workers with a low rate of younger new entrants into the industry. For Queenstown, a large proportion of the work force are people with overseas experience who are more likely to be attracted to tourism, retail, or hospitality roles than bus driving.

5.1.3 Current Immigration Settings

Bus drivers are included in Immigration New Zealand's skilled migrant category which means that if a person has enough points and meets other requirements then they may apply for a resident visa. They are also included under Immigration New Zealand's Transport Sector Agreement and have a two-year Work to Residence Green List pathway and may apply for a Work to Residence visa after fulfilling requirements.

These immigration settings enable bus drivers to migrate to New Zealand with some bus companies providing assistance for visas and relocation. Securing visas and a New Zealand driver's license can be a time-consuming process. Nonetheless, immigration is an important way to fill job gaps with the current bus operator prioritising Queenstown and Auckland for the placement of overseas applicants.

5.1.4 Wage and Rent Trends

The Government committed to improving bus driver wages and conditions through Climate Emergency and Response Fund (CERF) funding. This is delivered through a bus industry standard agreement for urban bus drivers that provides more favourable and nationally-consistent terms and conditions for bus drivers[6]. The CERF funding is available to Public Transport Authorities (PTAs) over four years and is subject to PTAs matching Crown funding and bus operators agreeing to adjust driver wages annually to pass on the full labour component of indexation payments[7]. The labour component of public transport indexes is based on Statistics New Zealand Labour Cost Index which is a quarterly survey of wages across different industries and occupations. The transport, postal and warehousing industry group which bus drivers are a part of had an index of 1401 in June 2023 with a base of 1000 in June 2009 when the index started. This provides an average annual wage movement of 2.9% per year over this period with a faster rate of increase over recent years due to general wage price inflation.

Trends for rent prices in Queenstown have been consistently increasing from 2003 to 2020. Rent prices for a 3-bedroom house was $327 per week in January 2003 and has grown up to a high of $807 per week in February 2020. Due to the COVID-19 pandemic, rent prices dropped significantly to $500 per week in April 2020 but have subsequently recovered to pre pandemic levels with the return of overseas tourism[8]. Rents in Queenstown have increased by an average of 14% per year between Jan 2003 and Jan 2020 which excludes the border closure period which can be seen as an outlier event.

From comparing previous trends, rents in Queenstown historically have increased faster than the national labour cost index. It is not possible to predict future changes in rents or wages. However, if these trends continue in the future, then affordability of rent in Queenstown for bus drivers is not expected to improve. This is partly due to the labour cost index being calculated nationally from reported wages so does not reflect the higher cost of living in Queenstown.

[6] Climate Emergency Response Fund, Wellbeing Budget 2022, Beehive.govt.nz (2022).
[7] Bus driver wages increased by Greater Wellington, Greater Wellington Regional Council (2023).
[8] Median rent in Queenstown-Lakes up by $110 a week, Auckland unchanged from a year ago, QV (2023).; The Cost of Living in Queenstown, Wise Move (2023).; Rental prices hit a new record high, Crux (2023).

5.2 Maintenance Staff

Maintenance staff for electric buses need to have a good understanding of the basic components of electric vehicles (e.g. charging ports, charging interfaces, power train parts, battery packs and battery monitoring system). A mix of electrical and mechanical skills will be needed within the mechanic industry as electric vehicles becoming increasingly widespread. There are some skills overlap between diesel, hybrid, and electric vehicles, where some fixing processes and components are similar.[9]

General servicing and maintenance tasks for electric buses are similar to those of diesel and compressed natural gas buses.[10] Electric buses will require less maintenance (electric motors are simpler than internal combustion engines) and more visual inspections and checks whereas diesel buses require replacing fluids and components during maintenance.[11]

It is important that original equipment manufacturers for electric buses provide a list of maintenance and repair tasks, skills required and estimated task duration. Some tasks may require licensed technicians, so it is important that operators are aware of the necessary requirements to facilitate effective maintenance. Maintenance manuals for charging infrastructure can help guide staff with preventative maintenance, troubleshooting and information on components needing regular upkeep and replacement.[12]

5.2.1 Shift in Auto Industry

Due to growing concerns about vehicle emissions and incentives put in place by governments, the automotive industry has seen a shift in the roll out of electric vehicles. As a result, there are growing concerns of a skills gap and a burgeoning need for technicians and mechanics with the knowledge and skills to repair and maintain electric vehicles. Currently in the United Kingdom only an estimated 16% of technicians are suitably qualified to work on electric vehicles. The Institute of Motor Industry forecasts that an estimated 77,000 qualified technicians will be needed to work on electric vehicles by 2030 in the United Kingdom.

Additionally, the increased demand for electric vehicles and associated maintenance can affect servicing costs and may even lead to unsafe maintenance practices if there are insufficient mechanics available. Hence it is important for governments to understand labour needs and work with the automotive industry to ensure that they will have sufficient qualified staff to be able to keep up with the growing electric vehicle demand.[13]

5.2.2 Reskilling

Mechanics who are trained for diesel buses are able to undertake some maintenance work on electric buses. However, they will need some reskilling if they are not trained in electrical operating systems and associated tasks due to safety risks with working with high voltage systems.[14] New Zealand has a local electric vehicle training and certification programme, EV Engineering Certification Programme (EVECP).[15] Bus companies will have the responsibility to reskill mechanics to be able to maintain and repair electric buses and charging stations but this issue will be transient as reskilling is a one-off procedure.

5.2.1 Labour Shortage

There is some evidence of a nationwide shortage of mechanics across New Zealand which mirrors the current general labour shortage. However, there is a lack of official reporting on whether there

[9] Understanding Zero-Emission Bus Maintenance Part 1 - Maintenance, C40 CItiies Finance Facility (n.d.); Preparing the maintenance workforce for electric trucks, Trucking Dive (2020).
[10] Training Technicians for an Electric Bus Fleet (presentation), American Public Transportation Association (2019).
[11] Understanding Zero-Emission Bus Maintenance Part 1 - Maintenance, C40 CItiies Finance Facility (n.d.)
[12] Understanding Zero-Emission Bus Maintenance Part 1 - Maintenance, C40 CItiies Finance Facility (n.d.)
[13] EVs are billed as the future. But a potential skills gap is sparking concerns about cost and safety, CNBC (2023).
[14] Training Technicians for an Electric Bus Fleet (presentation), American Public Transportation Association (2019).
[15] Repairing EVs in New Zealand, Drive Electric (2023).

is a labour shortage of mechanics specifically in Queenstown. Some anecdotes do indicate a shortage of mechanics in Queenstown, where workshops offering a good salary still struggled to find suitable staff. Additionally, the industry is not being seen as attractive to younger people compared to other trades, resulting in a lack of suitable workers willing to work in Queenstown where cost of living is high.

5.2.2 Pay and Conditions

Heavy vehicle mechanics (technicians) typically earn around $26 to $45 per hour, with the median salary being $34.20 ($66,664 per annum). Entry-level mechanics earn $58,500 per annum while experienced mechanics can earn up to $80,925 per year and are currently in high demand due to a shortage of workers across New Zealand. Mechanics work in well-lit and properly ventilated workshops that can also be dusty, dirty and loud and typically work business hours but may undertake shifts, weekends and be on call.[16]

5.2.3 Current Immigration Settings

Motor mechanics are included under the regional skill shortage list. They may apply for a resident visa through the Skilled Migrant Category and are also included under the two-year Work to Residence Green List pathway and may apply for a Work to Residence visa after fulfilling requirements. Mechanics are also better enabled by the new immigration settings to migrate to New Zealand to work with bus companies.

5.3 Ferry Staff

The proposed future public transport service will include an increase in ferry frequency to 30 minutes for the Frankton Arm service. It is estimated that the proposed Preferred Option network in 2039 will require two in-service ferries per hour (with one spare), as compared to the current one ferry per hour. The proposed increase in ferry services will result in an increase in ferry staff.

Common ferry staff roles are:

- boat captain
- ship's officer
- deckhand

For ferry terminals, common staff roles are:

- terminal manager
- customer service representatives
- operations manager
- security personnel
- maintenance personnel
- utility staff

The number of ferry and terminal staff needed will be dependent on the size of the ferries and ferry terminals. The number of captains is expected to increase from two to four FTEs in 2039 due to the proposed increase in service levels.

[16] Automotive Technician, careers.govt.nz (2023).; Mechanic average salary in New Zealand, 2023, NZ Talent (2023).

Ferry boat captains with one to three years of experience have an average salary of $78,918 per annum, where senior captains with more than eight years of experience are paid an average salary of $138,107 per annum.[17] Captains (ship's masters) and deck hands are also included under the skilled migrant category (where they must meet the pay rate thresholds) and the two-year Work to Residence Green List pathway. Experienced captains are in high demand and have high salaries so renting in Queenstown will be affordable. Other ferry staff are also in high demand but have lower salaries ($47,000 - $90,000 per annum)[18] than ferry captains. Renting in Queenstown will be more affordable for ferry staff on the middle to higher end of the industry pay range and unaffordable for those on the lower end of the range.

Hiring ferry staff is expected to be a constraint on the roll out of the new network as there is a lack of people with specialist skills to operate and maintain ferry services in Queenstown. The number of captains required under the proposed public transport networks is much lower than the number of bus drivers so there are fewer roles to fill. It may be easier to attract more young workers to the industry due to the variety of entry-level roles, higher pay in general and better conditions but it would take time for staff to be trained up for roles.

[17] Ferry boat captain salary, Salary Expert (2023).
[18] Deckhand salary, Careers.govt.nz (2023).

6 Potential Recruitment and Retention Tools

A range of tools have been considered to aid in recruiting and retaining public transport workers in Queenstown. The focus has been on supporting public transport workers with accommodation costs as housing affordability and availability is particularly acute in Queenstown. The measures considered are:

- Increase public transport workers wages further to reflect higher accommodation costs.
- Provide an accommodation allowance for rent payments.
- Pay transport workers their hourly wage for time spent commuting from other towns.
- Provide a grant to community housing provider to build affordable housing for public transport workers.
- Bus operators providing accommodation to public transport workers as part of their employment.
- ORC or QLDC building or purchasing housing for public transport workers to rent at below market rates.
- Providing driver accommodation at the bus depot

The recommended approach to recruiting more public transport workers is for ORC to partner with the Queenstown Lakes Community Housing Trust (QLCHT), or similar organisation. QLCHT is a community housing trust which is backed by QLDC and the Ministry of Housing and Urban Development.

As of 2023 QLCHT has a portfolio of 138 homes and 96 properties under construction with a wait list of 1,000 households. The primary sources of income for the trust are inclusionary zoning where developers are required to contribute towards affordable housing in the district as well as QLDC and central government grants.

Figure 1: QLCHT house in Lake Hayes Queenstown (source: QLCHT)

The proposed housing programme would be for ORC to provide grants to QLCHT to build affordable rentals with public transport workers being prioritised. QLCHT would use this revenue to purchase land in housing developments within Queenstown and construct houses. The finished houses would then be rented to public transport workers at below market rates with QLCHT being the landlord and collecting rent. This rent would be used to pay for the operational costs of the houses (maintenance, rates, insurance etc) with any remaining rent being put towards funding further worker housing.

It is proposed that the initial grant be funded through debt that would be repaid through an increase in bus fares in Queenstown. This would enable the programme to get off the ground and for some affordable rental houses to be constructed before the new bus network is implemented. As public transport patronage increases in the future the revenue above the debt repayments would be provided as an ongoing grant to QLCHT for further worker housing. Funding the programme through increases in bus fares would provide a stable long-term funding source for affordable housing. Using fares is also considered equitable because public transport users, who benefit the most from greater worker availability, would be contributing towards the cost of the scheme.

Using current land values and the budgets of community housing projects it costs approximately $1 million to build a house in Queenstown. The market price for the equivalent home is $1.3 - $1.5 million based on 2023 sales prices. A $0.5 increase in bus fares would generate an additional $0.5 million based on 2023 estimated patronage and $2 million per year from 2039 forecast patronage. It is recommended that the initial grant be set at a level that would enable the interest costs and loan principal to be repaid from current patronage. The most recent Local Government Funding Agency funding round has an interest rate of 3.5% for a 10-year bond. This would enable around $12 million to be borrowed by ORC for a 10-year term and be repaid by an increase in revenue. This would provide funding for 12 houses initially with a further 1-2 houses being funded per year as public transport patronage increases. By 2039 there would be funding for approximately 27 houses that would be sufficient to house 45% of the estimated number of bus drivers not including any additional revenue from rent.

The advantages of a workers accommodation programme are that it would leverage QLCHT's existing skills and experience in developing affordable housing and being a landlord. Without this programme it would be difficult for bus drivers to obtain a QLCHT house due to the long waiting list and the policy of prioritising people who have been on the waiting list the longest. Public transport workers in Queenstown are more likely to be on work visas and to have recently moved to Queenstown so could otherwise be waiting years for a home to become available.

In addition to affordable rental houses QLCHT also provides assistance for people to purchase their own homes through the Rent Saver and Secure Home programmes. Over several years public transport workers who have access to affordable rental housing may move through the housing continuum to market rental or independent ownership that would encourage workers to live in Queenstown long term (Figure 2).

Partnering with a community housing provider is preferred over providing direct financial support for public transport workers to rent on the open market because of the limited number of affordable houses in Queenstown. Although direct financial support would provide short-term relief, it would add further competition to the rental market without increasing housing supply thereby potentially pricing out other residents also in need of affordable rentals. Paying public transport workers to commute is also not preferred as bus driving involves long periods behind the wheel so additional time driving would not improve driver conditions. Having the bus operator provide accommodation for workers is not preferred as in competitive contract tendering process bus operators would be incentivised to reduce costs including any accommodation support. Because of this, bus contracts would have to be written in a prescriptive way in order to require worker accommodation of a suitable number, quality, and location which increases legal and administrative costs for council.

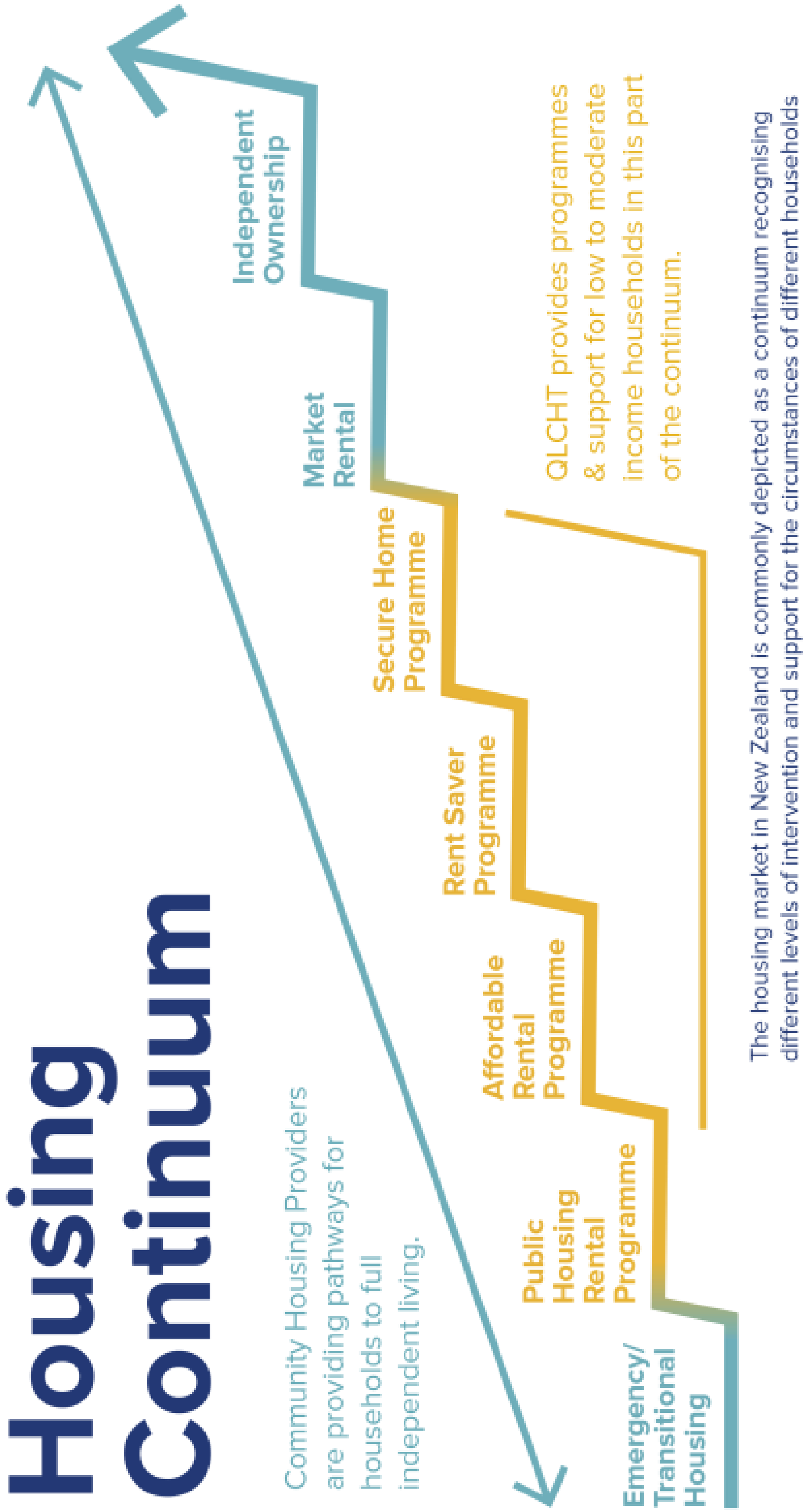


Figure 2: Housing continuum for moving from emergency and public housing to market rental and independent ownership with QLCHT providing support for the steps in between (source: QLCHT)

7 Supporting measures for retaining bus drivers

In addition to partnering with a community housing provider the following measures are considered necessary to improve bus driver working conditions. These measures are not expected to have a significant impact on the recruitment of bus drivers but should be included as a continuous programme.

7.1 Shift Design

There are typically three types of shifts for bus drivers:

- All day shifts when a driver would work continuously (apart from rest and meal breaks).
- Split shifts when a driver works the morning and afternoon but not the middle of the day.
- Part time shifts when a driver only works one period.

It is recommended that all day shifts are prioritised when scheduling drivers as these are more attractive than the other types of shifts. This is because split shifts involve the driver waking early and return home late with time off in the middle of the day. Part time shifts may appeal to some bus drivers such as those who are semi-retired, studying or working two jobs however part time shifts by themselves would be unlikely to provide sufficient income. The proposed public transport network utilises high-capacity buses which reduces the need to increase frequencies during the peaks which makes avoiding split shifts easier.

7.2 Driver Facilities

Currently the facilities available to bus drivers at termini are the Four Square in Arrowtown and toilets at Frankton Hub. Drivers can be on the road for several hours and only return to the depot at set times. Therefore, one way to improve driver conditions is to provide facilities at as many of the termini as possible. It is recognised that driver facilities can encounter consenting and community challenges. An approach to reduce this is to integrate driver facilities into other buildings such as the proposed wharf for Homestead Bay or to make commercial arrangements with existing businesses.

8 Conclusion

The current roles and responsibilities for the public transport system has ORC fulfilling a planning and contract management role, QLDC responsible for infrastructure, NZTA having a regulatory role, and bus operators being responsible for owning assets and the delivery of services. The proposed ownership model for the new Queenstown bus network would see ORC or a third party owning the bus depot with operators retaining responsibility for fleet and delivering services. Furthermore because of the significant increase in service levels planned for the new Queenstown bus network there would be an increase in labour requirements in the future.

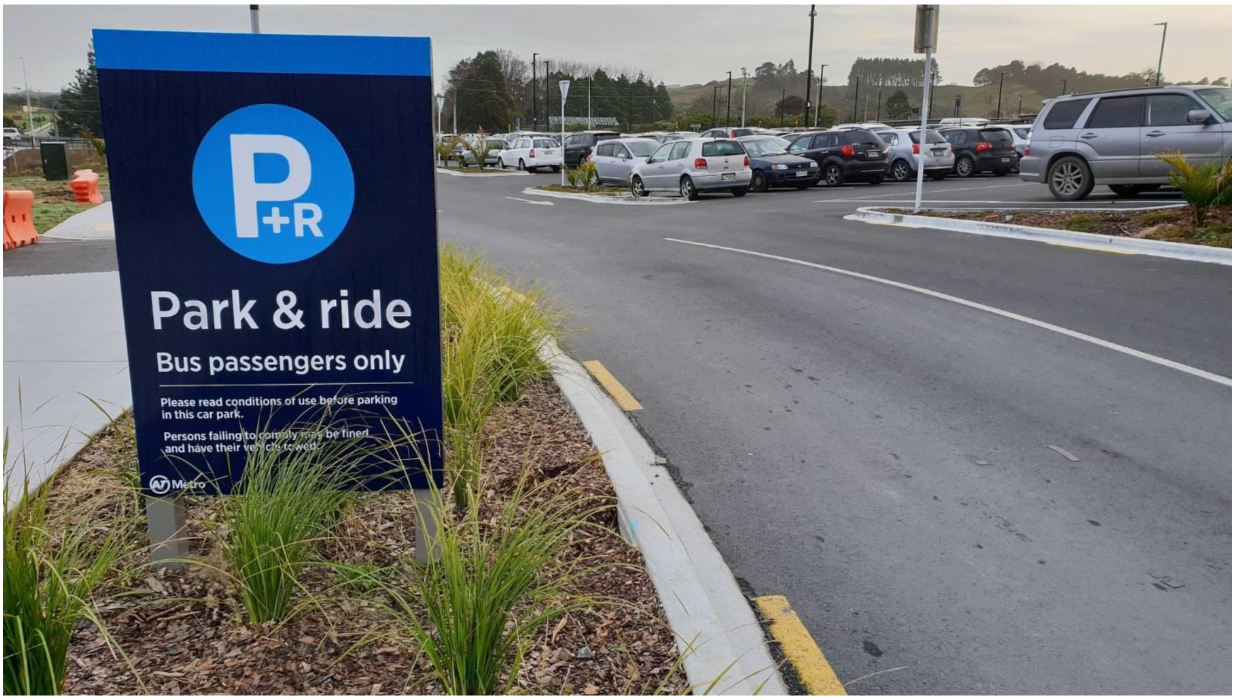
The additional roles and responsibilities placed on ORC should the bus depot be publicly owned are land acquisition, design, consenting, and construction during the depot development phase. Many of these roles can be outsourced to specialists in property, engineering, urban planning, and construction management however at a minimum there will be an important project management role for ORC staff. During the operation phase of the bus depot there will be additional property management, maintenance, and accounting roles for ORC. The property management and maintenance roles can be outsourced and the accounting role can be undertaken as part of business as usual practices.

Regarding labour availability there is a significant shortage of bus drivers, maintenance staff, and ferry staff in Queenstown which reflects the current national labour shortage and high cost of housing in Queenstown. To some extent the labour shortage may lessen as immigration to New Zealand increases, economic activity slows, and people new to the transport industry are trained. However due to the high cost of housing in Queenstown, which is not expected to improve, it is expected that Queenstown will continue to find it challenging to hire and retain public transport staff. Because of this it has been proposed that ORC works with QLCHT to fund affordable rental housing for public transport staff that would provide an incentive for workers to stay in Queenstown long term. The proposed funding model is an initial grant to QLCHT followed by ongoing smaller grants funded through a small increase in public transport fares.

Project Number: 6-XO014.00

Queenstown Public Transport Business Case

15 March 2024



Park & Ride Advisory Paper

wsp

150 YEARS IN AOTEAROA

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Revision	Details
1	Draft for comment
2	Updated draft based on ORC feedback
3	Minor update to align with business case
4	Final updated with partner feedback
4.1	Minor update based on QLDC feedback

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Consultant Agreement dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party. This advisory paper builds on work completed in earlier advisory papers namely the demand forecasting and service patterns papers which at the time of writing where in draft. Should the recommendations from these earlier advisory papers change then the recommendations from this park and ride paper may also be subject to change.

1 Executive Summary

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This Park and Ride Advisory Paper tests the requirements and options for park and ride as part of the future public transport network for Queenstown. If park n ride sites are included in the public transport package of services, then they would be further assessed as part of costings, land requirements, ownership and operating models and system management papers.

The key opportunities for park and ride in the content of Queenstown is the limited space for increased parking supply in the town centre and the lack of transport choice for rural areas. Another opportunity is to help address the constraint of the road network providing only two routes into Queenstown by intercepting car trips on the periphery of Queenstown and providing a more space-efficient transit option. Potential limitations on the use of park and ride were revealed from previous park ride proposals which includes the competing uses for suitable sites and the uncertainty on future growth patterns.

An accessibility mapping exercise was completed for the proposed public transport network to identify areas that are outside of a comfortable walking distance to bus stops. At the time of writing this advisory paper the proposed public transport network is draft for stakeholder comment. Changes to the proposed public transport may change the recommendations from this park and ride paper because park and ride sites need to be located on and integrated with public transport routes. The largest areas that do not have access to public transport are Speargrass Flat and Cromwell which is due to a lack of bus services. Speargrass Flat is a rural area with low density housing and Cromwell is a town situated almost an hour's drive from Queenstown. Other areas including Shotover Country and Jacks Point had some streets that were outside of walking distance to the nearest bus stop. However, for these areas, the preference was to amend the bus services to increase coverage rather than locating a park and ride in urban areas. This is because when not correctly sited, park and ride spaces can be taken up by people who are in walking distance to a bus stop and prevents people who live further away from using the park and ride spaces. The areas of Queenstown Hill and Goldfields also have limited walking catchment to public transport for topography however in the On-Demand Services Paper, an on-demand service was proposed for these suburbs.

The next stage of the analysis was to take the travel demands for each area and determine whether park and ride, fixed route or on-demand services would best meet this demand. The locations that were recommended for park and ride were Speargrass Flats and Cromwell. For Speargrass Flat, the purpose of park and ride would be to overcome the low population density and lack of walkability inherent in rural areas. Whereas for Cromwell the purpose of park and ride would be to maximise public transport usage thereby helping to make a Cromwell to Queenstown bus service more viable. For Jacks Point, a park and ride could be considered if the directness and coverage of the bus route could not be improved through new road connections. It was also found that a park and ride located in Ladies Mile was not required due to the proximity to existing bus routes and the high value of the land for other purposes. The park and ride in Speargrass will integrate into the proposed future network, by providing a connection to the subsequent Queenstown to Arrowtown bus route along Malaghans Road and the Cromwell park and ride option will feed into a bus service running from Queenstown to Cromwell.

In any case, a successful park and ride strategy for Queenstown will rely on much more than provision of parking spaces and a connecting transit service. The park and ride offer and experience must provide a real and perceived benefit compared with driving for the entire journey. This means that the transit solution must be faster and/or more reliable than driving to the final destination (primarily Queenstown centre), less costly and more convenient.

Supporting policies and strategies will be key, including a parking strategy that addresses cost and availability of parking for the different users of Queenstown, public transport priority and service provision that makes transit desirable. A park and ride service, if provided, is recommended as a supplemental add-on to the preferred service pattern option.

2 Introduction

This advisory paper considers how park and ride facilities could best support the wider public transport network that is proposed for Queenstown. The proposed public transport network is contained in the Service Patterns Advisory Paper and at the time of writing is draft for stakeholder comment.

The key outcomes sought by the paper area:

- Determine the role of park and ride and therefore the types of trips that park and ride would serve
- Identify the locations where park and ride sites should be considered for further detailed investigation
- Consider the case for park and rides in the areas identified in earlier work which are Jacks Point and Ladies Mile

The process that was followed to identify the recommended areas for park and ride is as follows:

- Consider the land use, transport and strategic content of Queenstown in particular the location of future development (sections 3 and 4)
- Map out walking access to the new public transport network to identify areas where residents could walk to the nearest bus stop and areas where other modes would be needed (section 5)
- Consider the role of park and ride within the context of Queenstown drawing on best practice guidance for public transport interchanges (section 6)
- Evaluate each of the areas within Queenstown as to whether fixed route, on-demand or park and ride would be the best way to meet travel demand (section 7)

Once the locations for park and ride are identified the next steps for a detailed assessment include estimate demand for park and ride, consider potential sites for park and ride and determine the appropriate level of facilities for each site.

2.1 Scope of this paper

The scope of this advisory paper is to consider the opportunities for park and ride to improve access to the public transport network. Because of the social good which public transport provides, park and rides are typically provided by local government for residents and visitors. Private companies may operate park and rides to encourage customers to park elsewhere and then catch a shuttle to their destination. Private park and rides tend to be found at destinations with limited land availability and high demand for parking such as ski fields and airports. Private park and rides are outside of the scope of this paper as the decision on whether to provide these facilities is solely a commercial decision by private companies.

3 Role of Park and Ride

3.1 Access to Public Transport

The role of park and ride within the public transport network is typically to provide access to public transport for those that do not have public transport close to where they live. These situations are where the public transport network in an area is underdeveloped or where an area is too low density to make a public transport route viable. The advantage of park and ride is that it concentrates passengers at stations which makes it easier to run a frequent and direct service. Another advantage of park and ride is that it can be a way of enticing people out of their cars by providing a convenient way to access public transport that does not require a transfer.

However, park and ride should be the lowest priority means of providing access to stations, because of the high cost of provision of car parking spaces; instead, walking, cycling, feeder buses and Kiss and Ride are in almost every instance, the preferred approach. This is because park and ride is the least space-efficient way of providing access to stations and in urban areas space is always at a premium. Although preferable to driving for the whole trip, park and ride does not align as well with strategic priorities around sustainability and vehicle kilometre reduction than walking, cycling and feeder bus services.

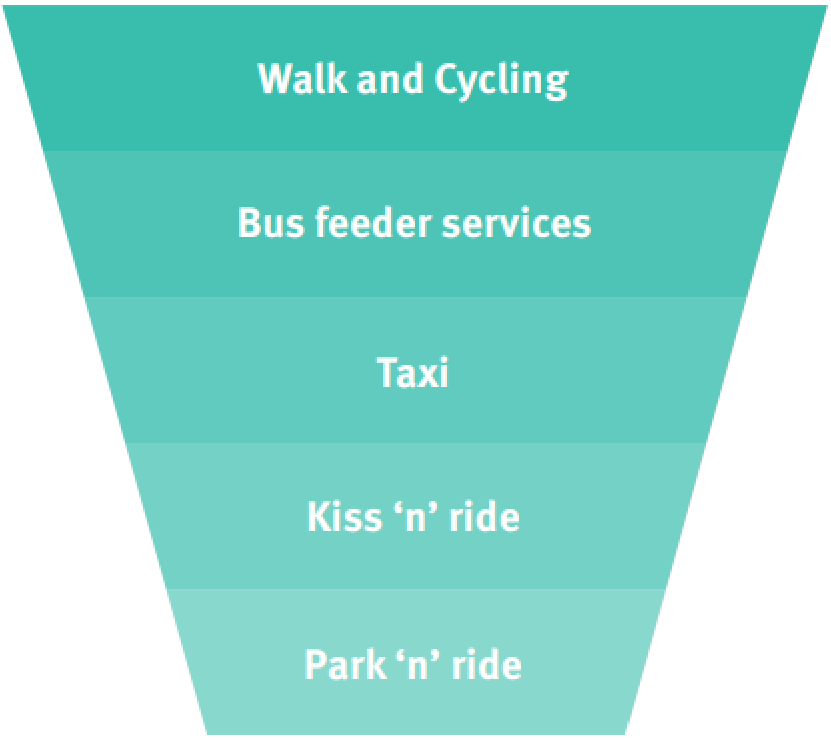

Figure 1. Typical access hierarchy for public transport stations. Source: (Queensland Government Department of Transport and Main Roads).

Lastly, it is also important to consider the other uses that the prime land surrounding public transport stations can be used for. Transit-oriented development where higher densities of residential, office or retail are located close to stations generates more public transport trips than park and ride. Furthermore, transit-oriented development tends to generate trips throughout the day and weekend when there is spare capacity on the public transport network. Whereas park and ride tend to generate peak time trips and is largely unused on the evening and weekend.

Finally, successful park and ride requires that it offers an advantage over continued use of private car. This advantage may be through convenience (reduced travel time and/or increased travel time reliability on transit, compared with private car) or cost (cost of parking and transit fare compared with cost of driving and parking), so the park and ride relies on other factors such as parking and fare policy, road pricing and the availability of transit priority.

In addition, in places like Queenstown, where access travel times to the centre are relatively short most of the time, the time penalty (real and perceived) of parking the car (considering ease of access to the car park and then from the car park to home again for the homebound trip), waiting for the transit service and then the transit trip travel time, must be beneficial to the potential user. As well, the real and perceived cost of park and ride (cost to park, transit fare) must be compared with cost to drive and park at the destination, and parking availability. Depending on the fare structure for transit, park and ride may even attract transit users away from transit-only trips, if the cost is less than the full transit journey.

Park and ride also involves a private vehicle trip which may be short or long. As traffic congestion on SH6A is variable, potential park and ride users may also make day to day judgements on the attractiveness of park and ride versus continuing their private car journey. Hence, park and ride (without other supporting policies and strategies) may not be very effective in changing travel behaviour and may instead increase car trips, particularly if there is an advantage to transit-only customers.

3.2 Pricing for Park and Ride

In New Zealand, park and ride spaces have traditionally been provided by councils free of charge to commuters. However, since park and ride is a limited resource, an unintended consequence of this policy is that park and ride spaces are often full by 7:30am in the morning. This is because people will change their travel plans to make use of something that is free by either departing earlier or by driving to stations instead of using alternative modes. As a result, park and ride spaces are not available during the day for people who have more fixed schedules, which reduces the ability of park and ride to improve access to public transport. This is particularly important for Queenstown which has a lot of casual/seasonal employment, meaning that park and ride options may not be available to some residents and visitors. This can result in calls for park and ride facilities to be expanded, however this is often an expensive undertaking. For example, the Albany Auckland Park and ride expansion costs about $10,000 per space.

In response to this, several cities in New Zealand including Auckland and Wellington have explored charging for park and ride spaces. In the case of Auckland, this was a proposal to introduce a fee once demand consistently exceeds 85 percent of the capacity. However, in both cases, the proposal to charge for park and ride was met with opposition which is in part because it is politically hard to charge for something that was previously free. In NSW, many park and ride facilities require a transit card for access, with parking being free if a transit trip is then made, or a charge is levied via the smart card ticket.

Free park and ride is often used by other non-transit users, including parking to access nearby activities by workers and visitors or even parking trailers, and this can both give a false impression of the level of park and ride use, and reduce availability for transit customers.

Some strategies to make it easier to introduce charging for park and ride spaces to manage demand are as follows:

- Charge for park and ride from day one, even if this is a nominal fee so that commuters become accustomed to paying their fair share. Set out a policy that the fee would be reviewed on a semi-regular basis to manage demand for the park and ride spaces.
- Enable people to reserve a space in a park and ride for a monthly charge and keep the remaining spaces free of charge. This gives people the choice to either travel early to get a free space or pay for the flexibility of a reserved space.

- Use the park and ride charge to improve services for commuters such as, security, lighting, cleaning etc. and inform commuters that this is what the charge is being spent on.
- Enable the private sector to own, operate and maintain the park and ride with the price being set by the market. In some stations in Auckland, additional parking spaces are provided by the private sector.

3.3 Future Ready

It is important for park and ride facilities to be adaptable to future needs, trends, technologies and land use changes. Access to mobility will be increasingly important to the transport sector and economic markets as people will seek more ways to travel and via modes that are convenient and efficient to suit their needs.

Transport sharing services are an example of mobility being provided as a service and has become increasingly popular in recent years; they are offered in the form of ridesharing/carsharing, bicycle-sharing (regular and electric bicycles), scooter-sharing etc. These services offer an alternative travel mode to single occupancy car travel and can complement park and ride facilities to promote public transport use and more seamless transit journeys. Hence it is important that park and rides evolve and ensure that there are opportunities for people travelling by other modes to also utilise the spaces, such as by providing bike and scooter racks.

Considering the rapidly changing land use in Queenstown to keep up with predicted future growth, it is important that park and rides are designed with the flexibility to be converted for other uses (e.g., residential and commercial developments) as social and economic needs evolve. This is so that as the area around public transport stations develop, and land values change over time, spaces from park and rides can be converted into developments to offer increased patronage benefits. In terms of emissions reductions targets, park and rides can contribute to them through mode shift however it should be noted that their impact is not as significant as commuters taking public transport directly at the origin of their journeys (i.e. from their front doors or the nearest stop/station within walking distance).

Park and ride stations also offer an opportunity to serve electric vehicle owners, ensuring that viable alternative (AC and DC-fast charging) charging infrastructure are provided when drivers are away from home. Since Queenstown's growth is widespread and some locations lack connections to the main public transport network, it is important to ensure that park and ride stations provided include charging infrastructure for electric vehicle owners to use before they transfer onto public transport or after they arrive from public transport. The availability of EV charging may help to attract transit users.

3.4 Park and Ride in Public Transport Guidance

Park and Rides are used to extend access to the public transport network by intercepting vehicle trips in advance, facilitate mode shift to reduce congestion and emissions and are typically offered as a premium service. The lifecycle of a Park and Ride should align with transport and land use at and around a public transport or Rapid Transit Network station[1]. Auckland Transport details the evolution of Park and Ride, as shown in Figure 2, in which as sites evolve to reflect changing needs, Park and Rides should evolve alongside it to help support access to public transport.

[1] Park and Ride Summary, Auckland Transport (2022)

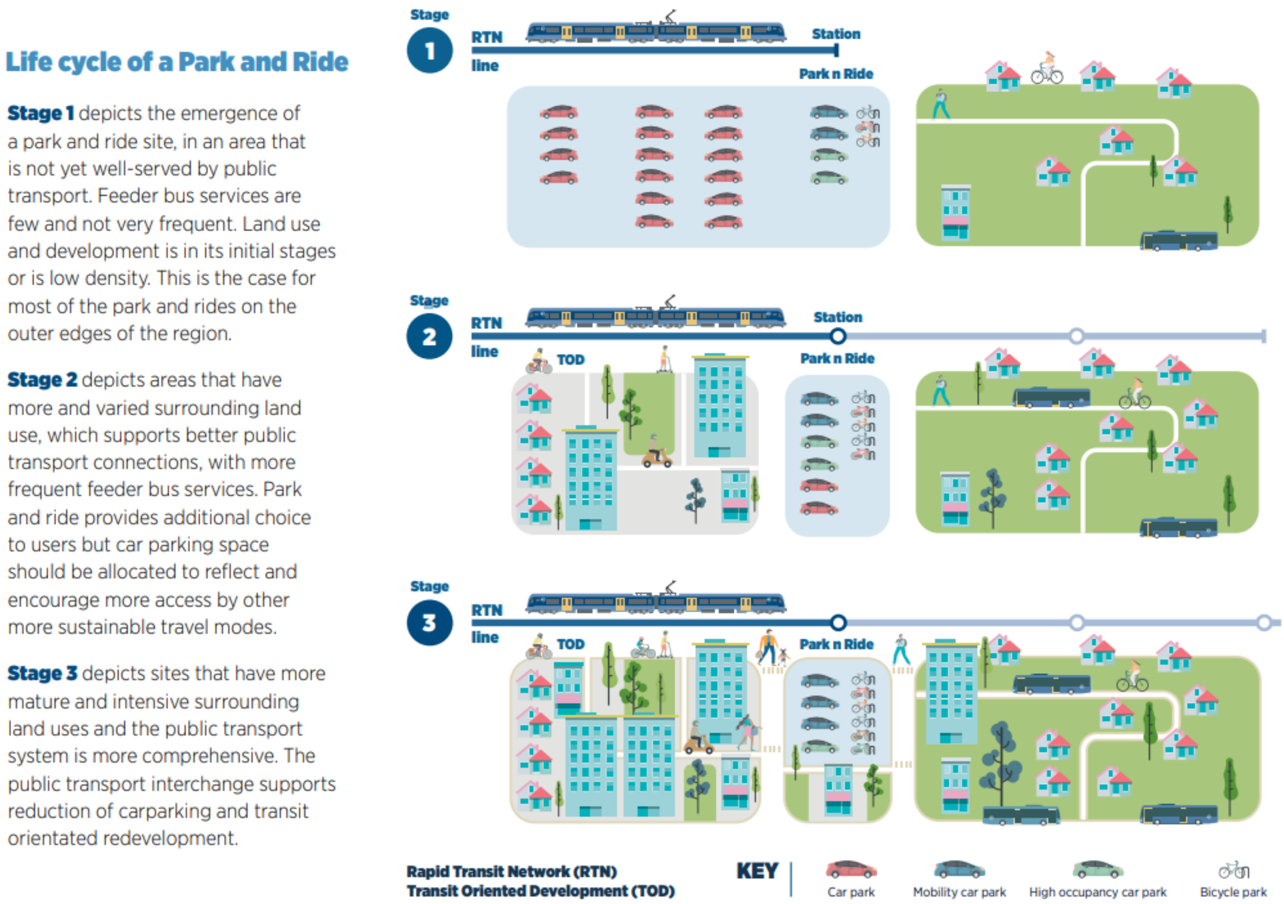

Figure 2. Stages in life cycle of a Park and Ride. (Source: Auckland Transport Park and Ride).

3.5 Recommended Approach to Park and Ride

Considering the role of park and ride within the public transport network and the context of Queenstown, the following is a general guide to the situations where park and ride may be appropriate:

- To serve rural areas such as Dalefield and Speargrass, where feeder buses services are not viable. Park and ride may be suitable for rural areas due to high car ownership and less competing uses for land compared to urban areas.
- To help get a new bus service off the ground, such as Cromwell to Queenstown or other new growth areas. This is because park and ride potentially reduces barriers to using public transport which is particularly important when people are forming new travel behaviours after moving houses.
- To intercept cars trips on the periphery of Queenstown by providing a location for drivers to change modes. However intercepting trips is considered to be most effective when park and ride is located a short distance from trip origins.
- However, the park and ride offered must provide a benefit to potential users, over driving for the entire trip, and this requires supporting strategies, services, infrastructure and policies for parking cost and availability, and transit priority or road space allocation.
- Smaller park n ride sites on the periphery would have lower land costs than larger park n ride sites in urban areas.

4 Land Use and Transport Context

4.1 Road Network and Location of Intercept Points

The State Highway network in Queenstown is a two-lane highway comprising of SH6A and SH6, where SH6A is an arterial road and SH6 is a regional road[2]. SH6A runs from the Queenstown Town Centre along the marina before splitting off into two SH6 branches at the BP roundabout in Frankton. One branch runs south through Frankton and Jacks Point to Kingston and beyond and the other branch runs east past Shotover Country and Lake Hayes to connect to Arrow Junction, Cromwell, Wanaka and beyond (Figure 3).

Figure 3. Queenstown road network structure comprising of state highways and other local roads – One Network Road Classification (Source: Waka Kotahi New Zealand Transport Agency).

Vehicle trips into and out of Queenstown experience congestion on SH6A, along SH6 past Frankton to the south and east along SH6 past Five Mile. Potential locations for park and ride are sites that will expand access to the public transport network and intercept vehicle commuters in advance of congested bottlenecks[3]. In the case of Queenstown, this would mean intercepting

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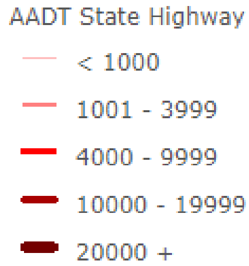
[2] One Network Road Classification, Waka Kotahi New Zealand Transport Agency
[3] Why invest in Park and Ride, Greater Wellington Regional Council

vehicle trips from outer areas on the periphery of Queenstown and encouraging these commuters



to transfer to buses. Potential interception points are shown in Figure 4 (circled in blue) on SH6A in Queenstown Town Centre, SH6 before Lake Hayes to the east, SH6 along the Southern Corridor. These are the areas where traffic congestion starts to build during peak periods and therefore a park and ride in these locations may encourage some private vehicle users to change modes in order to avoid traffic congestion. However, this will depend on public transport offering a real and perceived benefit compared to driving for the entire journey. The public transport solution must be faster and/or more reliable than driving to the final destination (primarily Queenstown centre) and/or less costly, more convenient and have parking availability. If congestion is perceived as less significant when drivers approach park and rides, it is likely that they will continue driving instead of changing modes. Park and rides will likely be more successful only where public transport shares SH6A, should parking supply and cost be the main factors, and if it offered a more direct route and bypasses congestion.

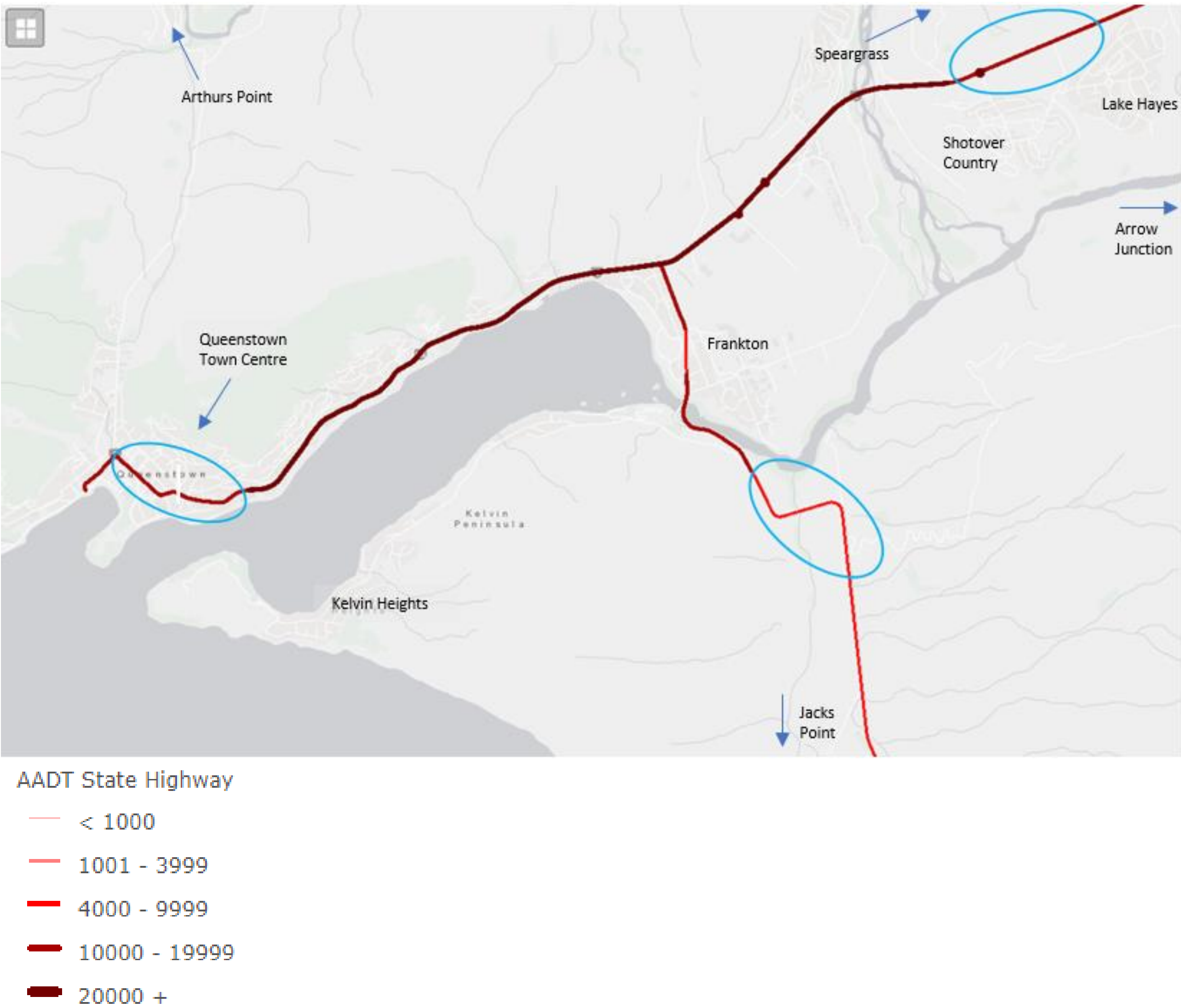


Figure 4. State highway traffic monitoring annual average daily traffic (source: Waka Kotahi New Zealand Transport Agency).

4.2 Parking Strategy

Queenstown Lakes District Council (QLDC) is undertaking community feedback and information gathering for a draft Parking Strategy which will feed into the district's parking strategy and management plans. The strategy and plans will explore the best use of the existing parking supply across the district and target known problems to ensure parking is available for those who need it most. It will also consider how Queenstown's transport network and people's movement patterns are changing in the short, medium and long term, in light of the investment of public transport and active travel. In particular, this includes competition for parking by various user groups, encroachment of parking into residential areas and increased need for parking. The strategy's draft objectives towards parking are:

- Balances availability against need
- Supports business and the safety and quality of our public spaces
- Provides a mix of paid and timed restrictions
- Maintains fair access for residents
- Protects and improves the safety of residential areas
- Supports travel choice and encourages mode-shift

Table 1 shows the various parking prices ($1 – $4 per hour) based on the locations around Queenstown Town Centre and the parking times allocated (1 – 10 hours maximum). Table 2 shows the parking prices of selected central city locations of other New Zealand cities to provide a comparison to Queenstown's parking prices.

Table 1. Pay and Display parking prices for locations around Queenstown Town Centre (Source: Queenstown Lakes District Council - Transport and Parking).

Location	Time	Price (from 17 July 2023)
Athol Street	8am-6pm, Mon - Sun, 4 Hour Max	$6/Hr
Ballarat (off-street)	8am-6pm, Mon - Sun, 10 Hour Max	$3/Hr
Ballarat Street	8am-6pm, Mon - Sun, 1 Hour Max	$3/Hr
Boundary St	8am-6pm, Mon - Sun, 10 Hour Max	$2/Hr
Camp Street	8am-6pm, Mon - Sun, 4 Hour Max	$6/Hr
Church Street	8am-6pm, Mon - Sun, 4 Hour Max	$6/Hr
Earl Street	8am-6pm, Mon - Sun, 4 Hour Max	$6/Hr
Marine Parade	8am-6pm, Mon - Sun, 4 Hour Max	$6/Hr
Memorial Street	8am-6pm, Mon - Sun, 1 Hour Max	$3/Hr
Stanley Street	8am-6pm, Mon - Sun, 1 Hour Max	$6/Hr
Coronation Drive	8am-6pm, Mon - Sun, 2 Hour Max	$2/Hr
Recreational Ground	8am-6pm, Mon - Sun, 10 Hour Max	$3/Hr
Lakeview	8am-6pm, Mon - Sun, 10 Hour Max	$2/Hr

Table 2. Parking prices for selected city centre locations in New Zealand.

Location					
Auckland – Victoria Street		*Wellington – Thorndon Quay*		*Christchurch – Lichfield Street*	
6am – 6pm, Mon – Fri, 0 – 1 hours,	*$4/Hr*	*8am – 6pm, Mon - Fri*	*$5/h*	*6am – 6pm, Mon – Sun*	*$4.10/Hr*
6am – 6pm, Mon – Fri, 1 – 2 hours	*$8/Hr*				
6am – 6pm, Mon – Fri, 2 – 3 hours	*$12/Hr*				
6am – 6pm, Mon – Fri, 3 – 4 hours	*$16/Hr*				
6am – 6pm, Mon – Fri, 4 – 5 hours	*$20/Hr*	*8am – 8pm, Sat and Sun*	*$3/Hr*	*6pm – 10am, Mon – Sun*	*$3.60/Hr*
6am – 6pm, Mon – Fri, 5 – 6 hours	*Maximum fee $24/Hr*				
After 6pm, Mon - Fri	*$2/Hr or maximum $10*			*All day*	*$15.30*
Weekend and public holidays	*$2/Hr or maximum $10*				

Queenstown's parking prices are similar to that of other city centres such as Auckland, Wellington and Christchurch, with some streets located further out being cheaper than the central streets.

Parking prices for Queenstown Airport are listed in Table 3, where prices are considerably more expensive for terminal parking than on Brookes Road and are more expensive than prices in the Town Centre.

Table 3. Parking prices for locations outside of Queenstown Town Centre (Source: Queenstown Airport).

Location	Time	Price
Queenstown Airport – Terminal Parking	0 – 10 mins	Free
	11 – 12 mins	$2
	21 – 40 mins	$4
	41 – 60 mins	$6
	61 – 80 mins	$8
	81 – 100 mins	$10
	101 – 120 mins	$12
	2 – 5 hours	$16
	5 – 12 hours	$20
	12 hours – 1 day	$25
	2 days	$50
	3 days	$75
	4 days	$95
	5 days	$115
	6 days	$135
	7 days	$155
	Days thereafter	$20
	Weekly thereafter	$140
Queenstown Airport – Brookes Road (open 24/7)	Up to 4 hours	$2
	Up to 12 hours	$4
	Every hour thereafter (up to 24 hours)	$1

The development and implementation of QLDC's Parking Strategy will be important in ensuring that parking is available for those who need it most, and for prices to be competitive to help commuters choose more sustainable travel modes through public transport and park and rides. Parking availability and charges will be key factors in the success of the public transport strategy including potential park and rides.

4.3 State Highway Volumes Outside of Queenstown

Figure 5 shows the state highway volumes outside of Queenstown Town Centre and Frankton as of 2021. The average annual daily traffic (AADT) is over 20,000+ AADT throughout the Queenstown to Frankton corridor and up to Ladies Mile. AADT for SH6A (arterial) and SH6 (regional), is at least four times and 1.5 times the recommended volumes respectively based on the One Network Road Classification[4].

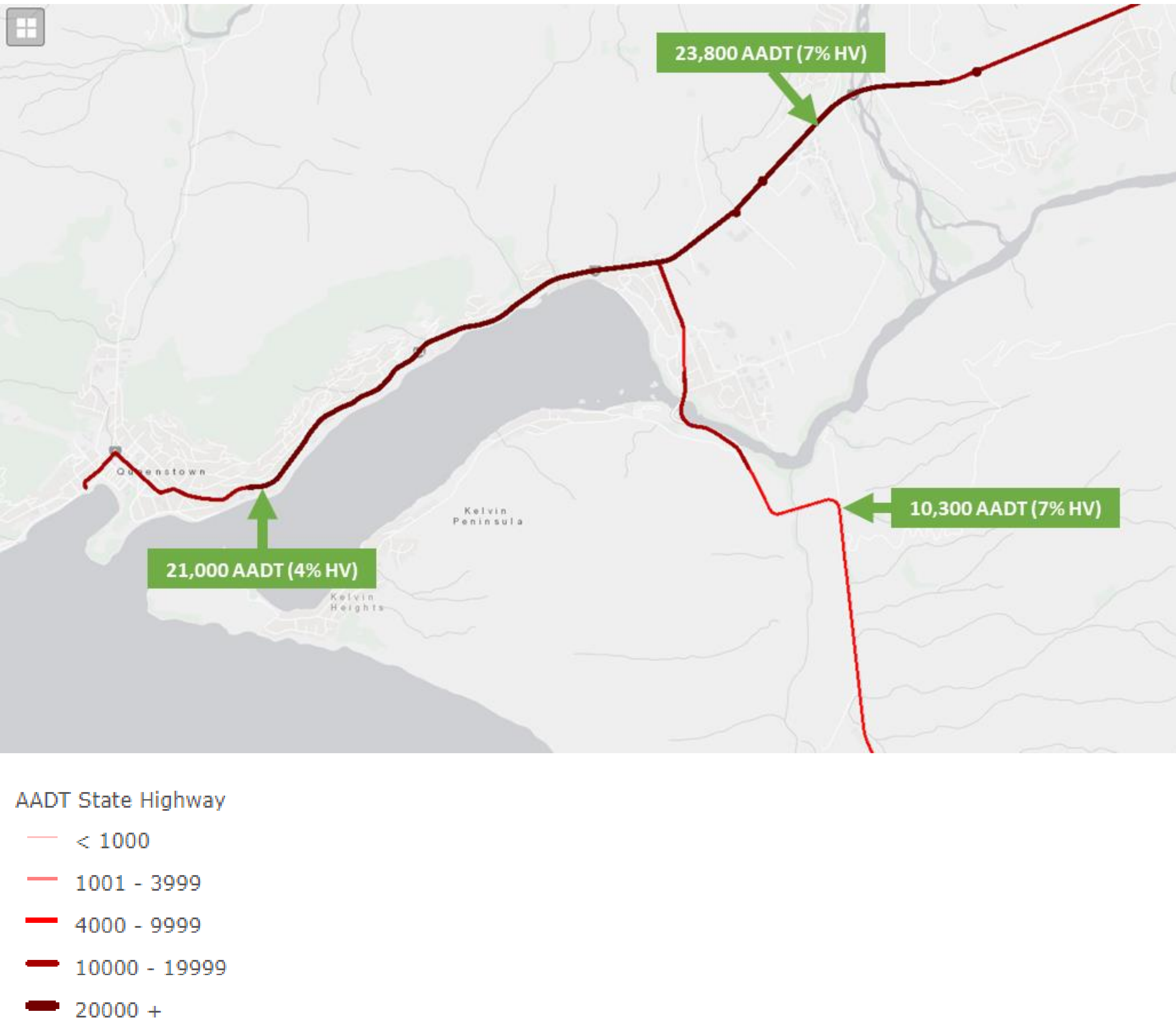


Figure 5. 2021 State highway volumes outside of Queenstown Town Centre and Frankton (Source: Mobile Roads).

[4] One Network Road Classification, Waka Kotahi New Zealand Transport Agency

4.4 Density Comparison of Areas in Queenstown

Population density
Queenstown and Outer Areas

N

0 1:550,000 @ A4 20 km

Aerial imagery and roads sourced from LINZ. Crown Copyright reserved. Population data (2018 census) and SA1 boundaries sourced from Stats NZ. State highways sourced from Waka Kotahi

Ref.	Suburb Name	Pop.	Pop. density (per km²)
1	Kingston	348	0.34
2	Wakatipu Basin	1356	23
3	Warren Park	1485	1586
4	Queenstown East	1416	1451
5	Lake Hayes	354	40
6	Shotover Country	2187	720
7	Cromwell (east and west)	5610	1560
8	Glenorchy	450	0.31
9	Wanaka (west, central, waterfront, north)	7521	995
10	Arthurs Point	1128	204
11	Queenstown Hill	6	0.39
12	Sunshine Bay-Fernhill	2931	2234
13	Arrowtown	2814	1191
14	Quail Rise	708	113
15	Queenstown Central	1017	1263
16	Frankton Arm	1917	1565
17	Frankton	2895	383
18	Kelvin Heights	1170	126
19	Lake Hayes Estate	2139	1106
20	Jacks Point	969	67

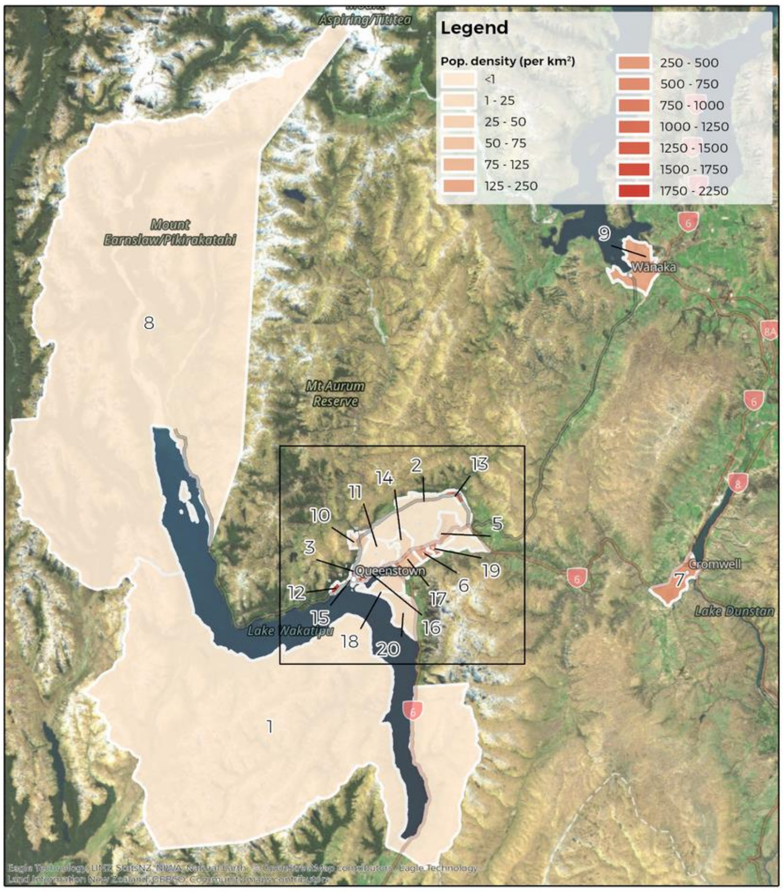


Figure 6. Population density map - Queenstown and relevant outer areas.

Based on the population density map of Queenstown and outer areas (Figure 6), the outer towns of Wanaka and Cromwell have a high to very high population density (995 and 1560 people per km² respectively) relative to similar outer areas of Glenorchy and Kingston which are more rural. Fixed route services are considered to be not suitable for outer towns close to Queenstown such as Glenorchy and Kingston as they have a low population density of less than 1 person per km². It should be noted that Wanaka and Cromwell are also facing growth pressures similar to Queenstown, where they're expecting their populations to double by 2050[5].

[5] Wanaka's building boom: Consents upsurge to counter forecasts, Otago Daily Times (2021); Cromwell 'Eye to the Future' Masterplan, Central Otago District Council (2019)

Population Density
Queenstown Centre and Outer Areas

Aerial imagery and roads sourced from LINZ. Crown Copyright reserved. Population data (2018 census) and SA1 boundaries sourced from Stats NZ. State highways sourced from Waka Kotahi

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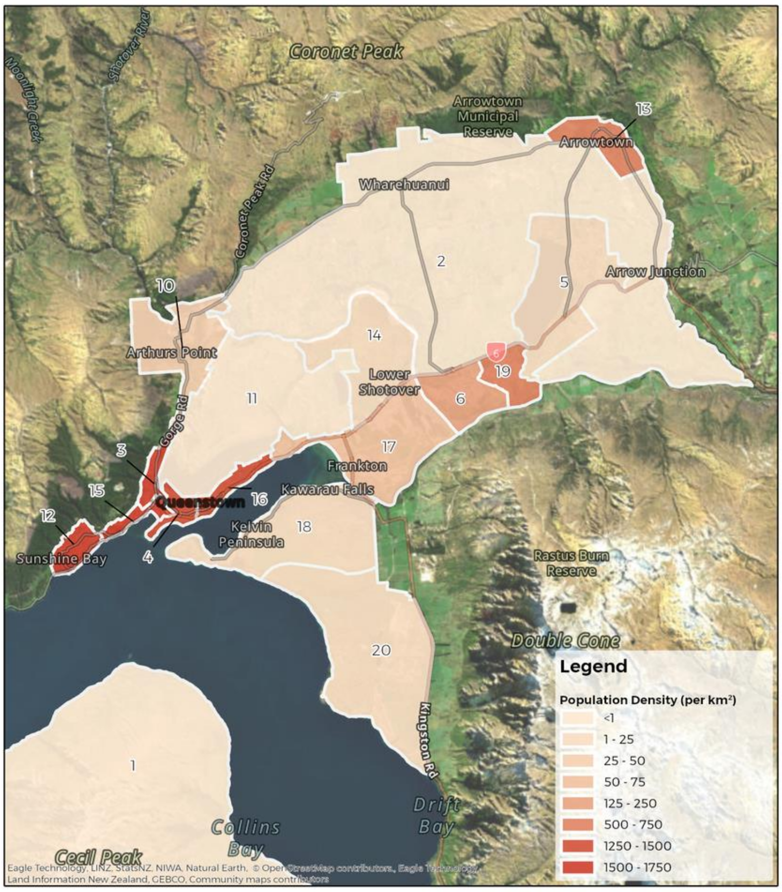

Figure 7. Population density map – Inner Queenstown suburbs.

Figure 7 shows that the central suburbs of Queenstown East, Queenstown Central, Warren Park and Sunshine Bay-Fernhill have the highest population density (from 1263 to 2234 people per km^2) relative to other Queenstown suburbs. Second highest population densities are Arrowtown and Lake Hayes Estate (1191 and 1106 people per km^2 respectively), followed by Shotover Country, Frankton and Arthurs Point (720, 383 and 204 people per km^2 respectively). Currently, fixed routes run through all major suburbs from Sunshine Bay-Fernhill and Arthurs Point on SH6/6A through the Town Centre and Frankton eastbound to Arrowtown and southbound through to Jacks Point. Fixed routes between the Queenstown's central suburbs (Queenstown Town Centre) and the other dispersed suburbs of Arrowtown, Lake Hayes Estate, Shotover Country, and Frankton are viable due to the high numbers of commuters living in and travelling to these areas for residential, social, employment purposes. Other suburbs have lower population densities however, where fixed public transport routes will be suitable for some suburbs that anticipate large future growth such as the Southern Corridor, and other suburbs may be better suited to on-demand services or park and ride facilities.

Overall, the large range of population densities across the various Queenstown suburbs and the outer towns makes it difficult to implement fixed-route bus services throughout Queenstown and its neighbouring outer towns. Some areas will have very low commuter numbers and other areas will have higher numbers, making it difficult to consistently meet the minimum number of passengers needed for fixed-route services to be viable and instead might suit having on-demand services or park and ride facilities.

5 Strategic Context

5.1 Wakatipu Park and Ride SSBC

The Wakatipu Park and Ride SSBC was developed to identify the options for the proposed Wakatipu Park and Ride facilities, proposed in three stages:

- Stage 1: Ladies Mile Council-owned land which would be integrated with Ladies Mile Masterplan.
- Stage 2: Facilities will be located on either side of Southern Corridor (between Hanley's Farm and Kawarau Falls Bridge) or further out on eastern corridor depending on anticipated growth and demand for 2030.
- Stage 3: Facilities and/or expansion of existing sites beyond 2030 depending on growth and demand.[6]

The recommendation was a 206-space facility at 516 Ladies Mile (concept plan is shown in Figure 8), where locals can park their car for the day and travel into town on the bus. The rationale for a park and ride facility in Ladies Mile was due to its location outside the town centre to help reduce pressure on central parking and to support Queenstown's transport system and to provide regional travellers with a cost-effective method to access public transport.

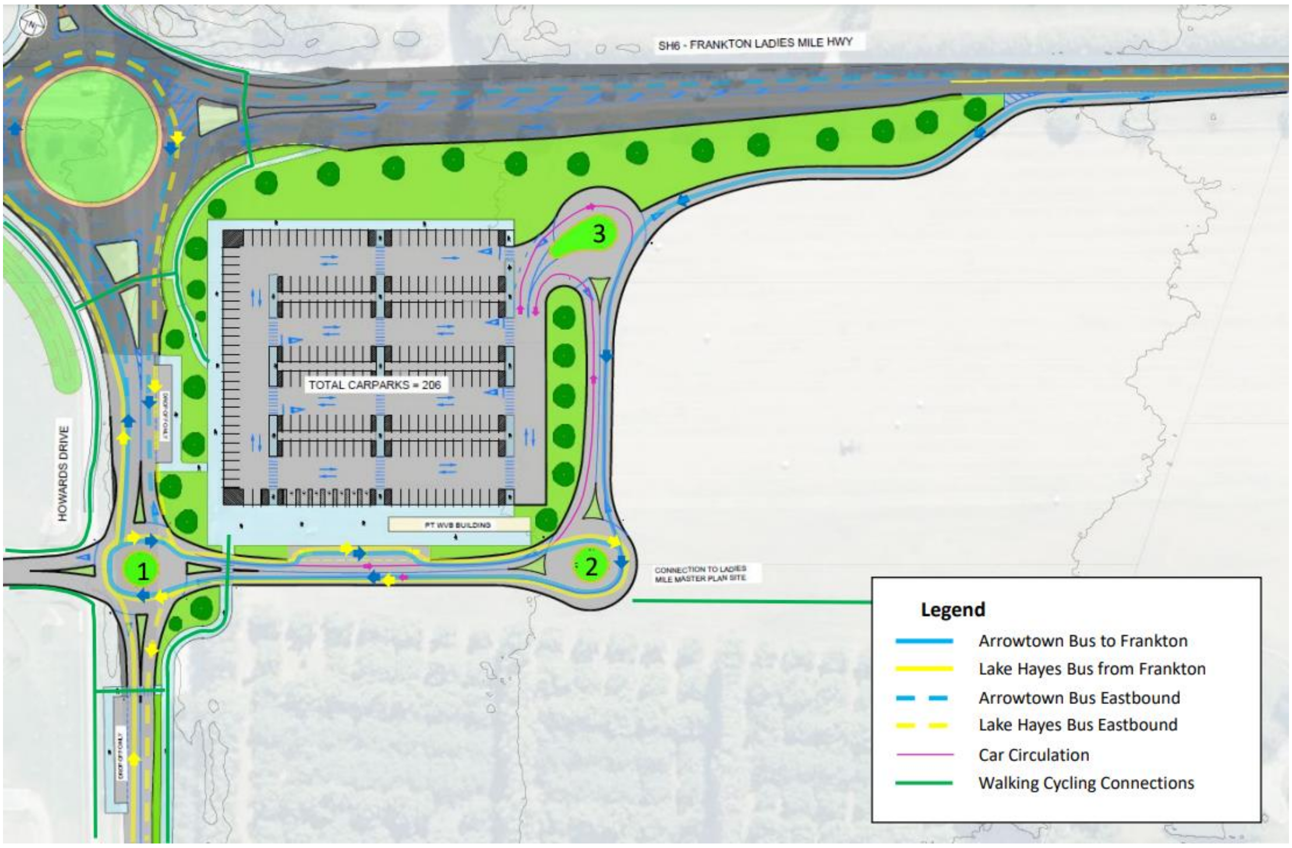

Figure 8. Concept plan for Park and Ride facility at Ladies Mile (Source: Queenstown Lakes District Council - Ladies Mile).

[6] Wakatipu Park and Ride Summary Booklet, Queenstown Lakes District Council.

5.2 Wakatipu Park and Ride SSBC Public Consultation

QLDC sought community consultation around the options for the park and ride facilities in August 2020 and February 2021. Following the feedback from the community consultation and the technical information, park and ride facilities were determined to be a beneficial addition to Queenstown's transport network however, project partners have decided to delay its implementation for the following reasons:

- Location – Park and ride perceived as of lower value than alternative uses of 516 ladies Mile. More support can be obtained if implementation suits community needs and after construction of bus lanes along Ladies Mile, implementation of priority bus measures on SH6A, improvements to Frankton BP roundabout intersection and returning of traffic growth and congestion to pre-COVID levels.
- Data – Detailed datasets needed to validate models for the specific target audience and a data improvement programme is implemented to better understand details of local and visitor travel.
- Timing – Facility cannot be implemented until completion of Howards Drive intersection upgrade and Ladies Mile bus lane (scheduled for mid-2024). A proposed travel demand management measures programme may enhance or negate need for park and ride.
- Ladies Mile uncertainty – QLDC is in the process of determining the Ladies Mile Masterplan. Scenarios may see either large or little increases in the number of households and competing land demands for 516 Ladies Mile, which will result in different outcomes for the preferred park and ride option.
- General growth uncertainty – Population, visitor and traffic growth were difficult to accurately project, with COVID-19 further complicating projections. Hence, the project is delayed to after COVID-19 recovery is better understood[7].

5.3 Ladies Mile Masterplan

The Ladies Mile Corridor between Shotover River and Lake Hayes is an area of significance for many locals and seen as a gateway into Queenstown. The Ladies Mile Masterplan was adopted by QLDC on 30 June 2022 to ensure a holistic planning approach for the growing Ladies Mile and a District Plan variation is expected to be notified soon to enable its implementation. The masterplan outcomes are:

- A land use solution is delivered in a timely, integrated, and organised manner, avoiding individual applications
- Increased liveability, wellbeing, and community cohesion for existing and future residents of the Ladies Mile area.
- Improved access to and from Ladies Mile with a transport network that can deliver its functions efficiently and effectively.
- Supporting enhanced public transport and active travel provision and utilisation through land-use solutions.

Critical to achieving objectives for Ladies Mile will be a very high mode share to public and active transport. Public transport networks for Ladies Mile are intended to be developed in stages to align with the progress of urban development. As seen in Figure 9, existing bus Route 5 will continue through SH6, other proposed bus routes will serve part of Ladies Mile and part of Shotover Country–Lake Hayes Estate and new bus stops will be situated on either side of SH6. These bus

[7] Wakatipu Park and Ride SSBC, Queenstown Lakes District Council.

routes interconnect with other existing and proposed walking and cycling trails to create a connected network for the area.

Figure 9. Fully developed public transport network proposed by the Ladies Mile Masterplan (Source: Queenstown Lakes District Council - Ladies Mile Masterplan).

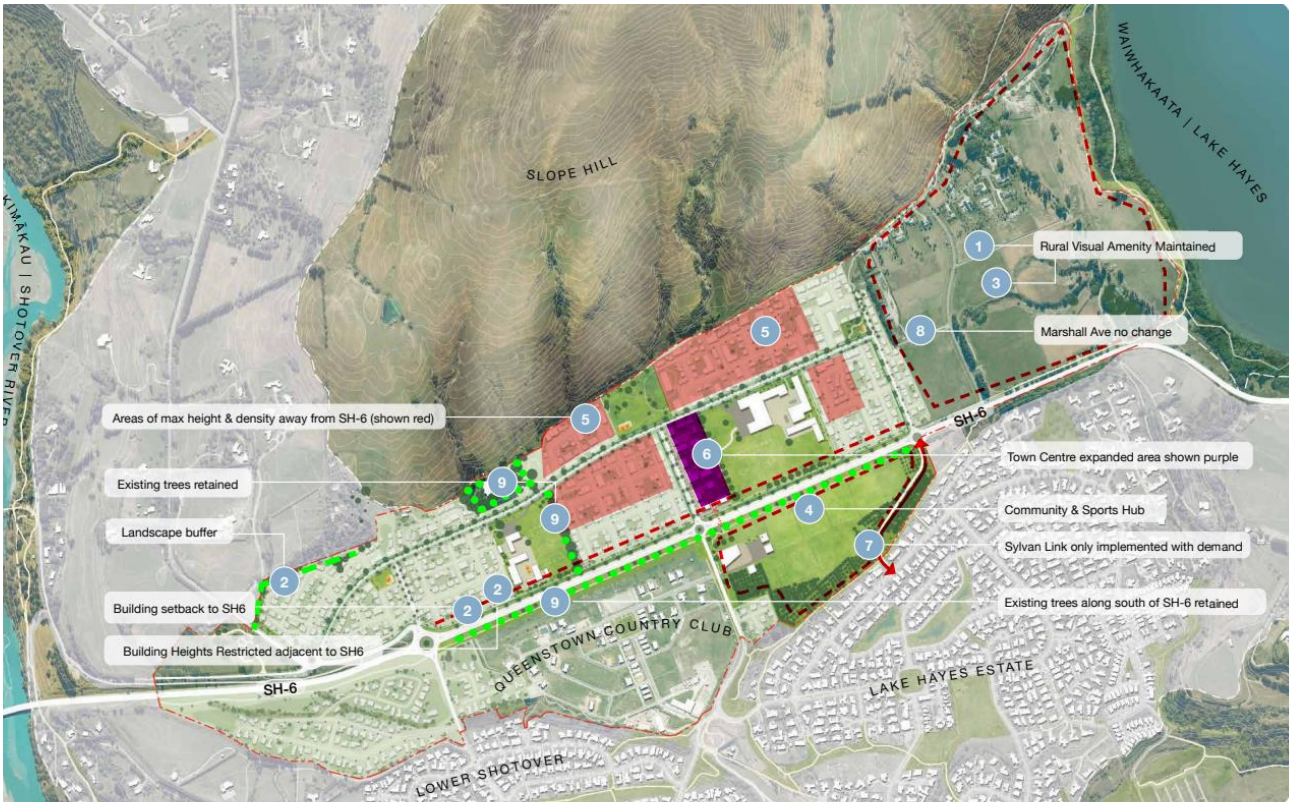

Figure 10. Key focus area for the Ladies Mile Masterplan (Source: Queenstown Lakes District Council - Ladies Mile Masterplan).

Figure 10 shows the geography and future development intentions for the Ladies Mile area. The land to the north of SH6 towards Slope Hill is flat and wide with existing communities with limited social infrastructure[8]. This area is intended to house the Town Centre and high school (circle 6) and areas of medium to higher density (circle 5). Land to the south of SH6 contains the Queenstown Country Club, where QLDC intends to expand the adjacent land to include Community and Sports Hubs. There is potential for a park and ride facility to be located in the rural land (circle 8) on the north side of SH6 slightly further east, which is not intended to have any planned developments, but will have to be accommodated in such a way that will not impact the proposed amenity function of that section of land.

5.4 Southern Corridor Network Operating Framework

The Southern Corridor Network Operating Framework issued in June 2020 provides a first principles approach for the Southern Corridor transport network to support current and future land uses as detailed in the Proposed District Plan and the Spatial Plan. Its outcomes are:

- Establishing a transport network that meets the medium and long-term needs of the Southern Corridor's population;
- Provide efficient connections between current and future settlements in Southern Corridor and major employment areas beyond;
- Improving safety perceptions for all users; and
- Promoting public transport, walking and cycling as preferred travel mode.

Future residential developments are planned for Hanley's Farm and Homestead Bay[9], plus an approved Special Housing Area at Coneburn[10]. Figure 11 shows the spatial extent of the new development areas planned in the Southern Corridor. By 2051, 5,460 dwellings are projected for the Jacks Point area[11]; while the Queenstown Lakes Spatial Plan aspires for up to 10,000 dwellings in the Southern Growth Area[12]. In addition to residential development, commercial and industrial growth is planned in Jacks Point Village and Homestead Bay which includes new hotels, restaurants, shopping and a marina[13]. A new industrial area on the eastern side of SH6 is also being proposed.

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[8] Ladies Mile Masterplan Part 1, Queenstown Lakes District Council.
[9] Homestead Bay Masterplan (2018)
[10] Coneburn Special Housing Area Resource Consent Approval (2020)
[11] Queenstown Lakes District Population Projections (March 2022)
[12] The Queenstown Lakes Spatial Plan (2021)
[13] Hundreds of new homes planned for Queenstown despite region's economic woes, Stuff New Zealand (2020); Jacks Point village to include 110 homes commercial properties and a five-star waterfront hotel, Stuff New Zealand (2020)

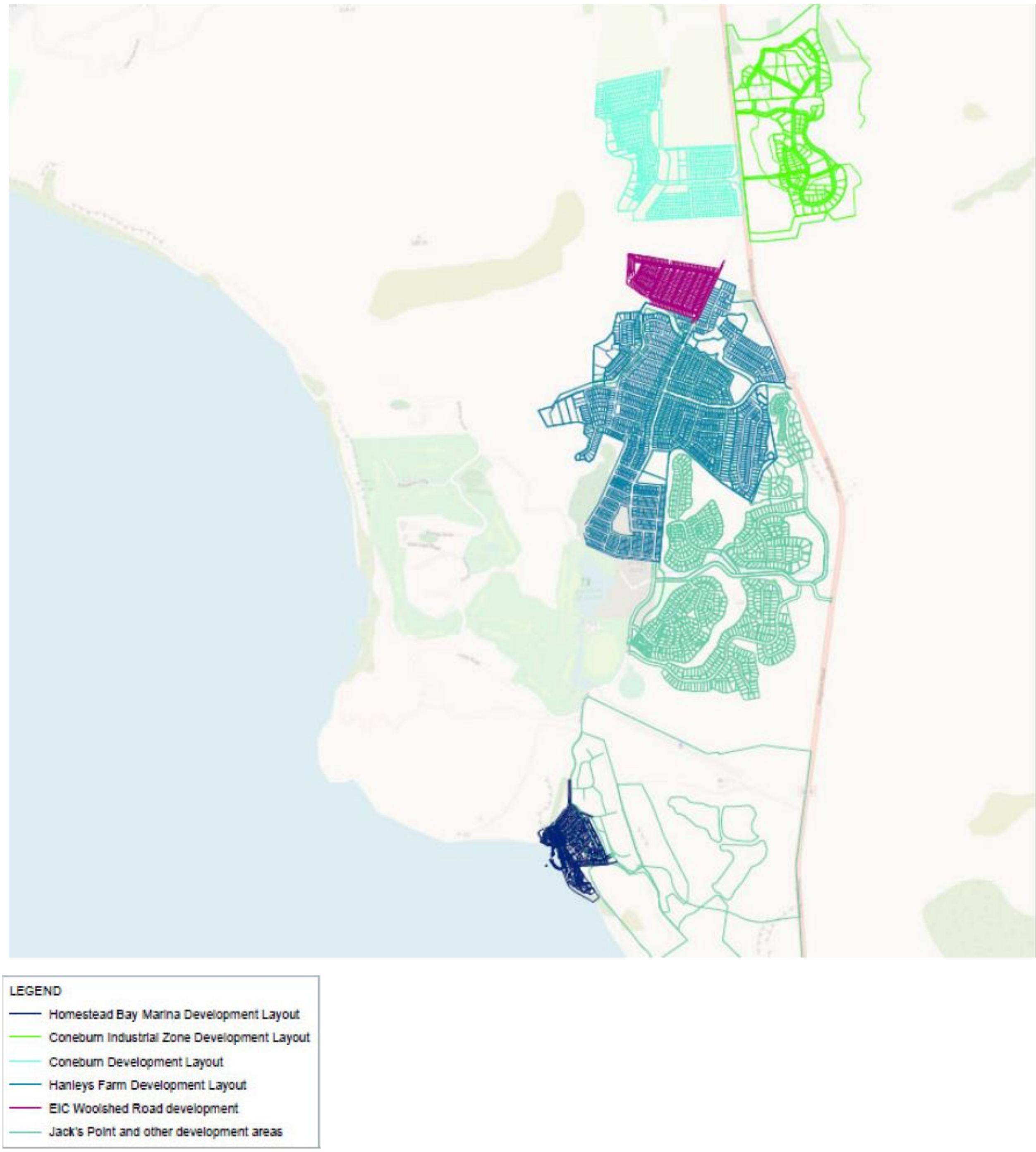


Figure 11. New development areas planned in Southern Corridor (Source: QLDC 2020).

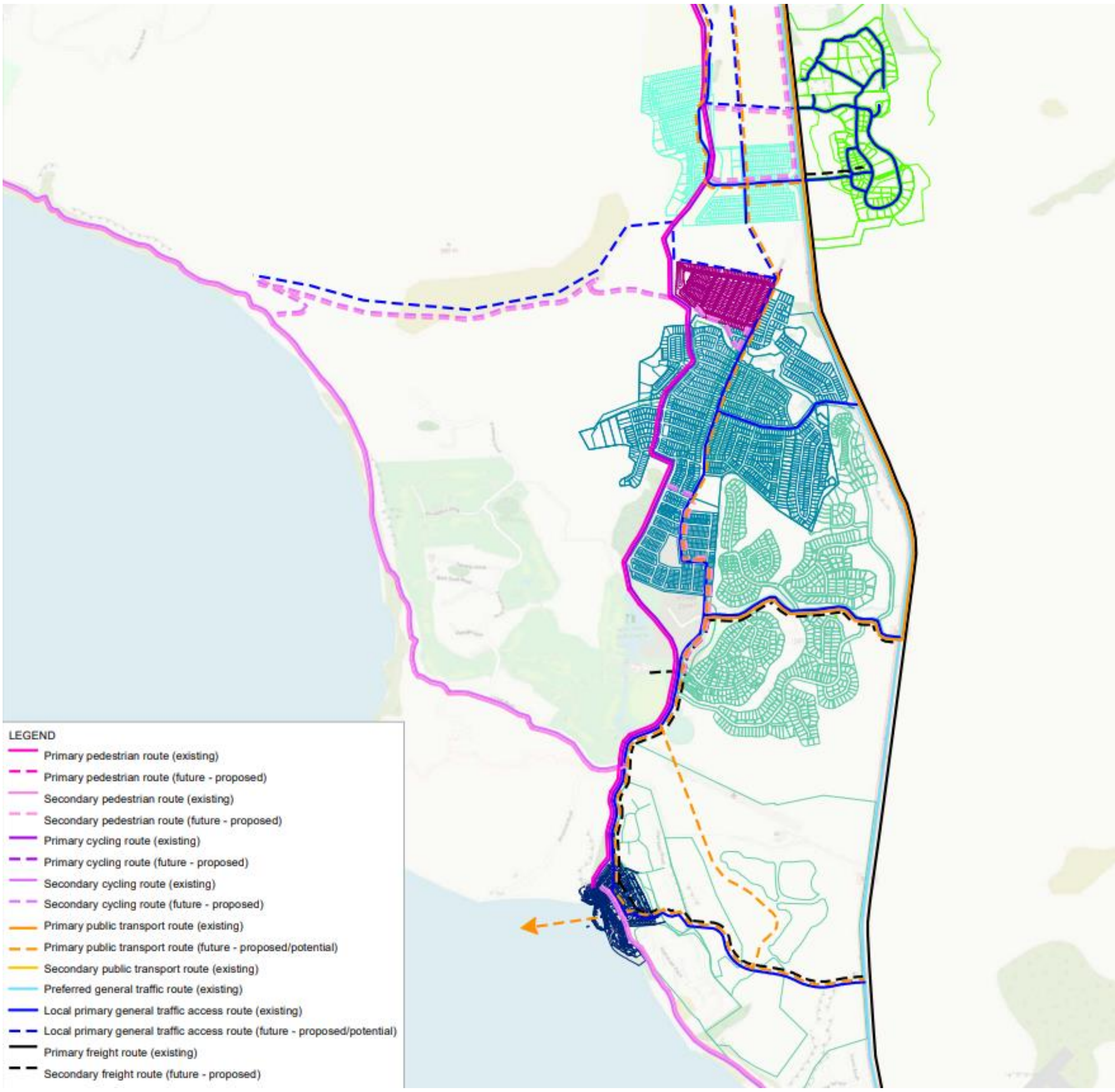


Figure 12. Southern Corridor Transport network Modal Map (Source: QLDC 2020).

Figure 12 shows the existing and proposed future modal connections in the Southern Corridor for pedestrians, cycling, public transport, general traffic and freight. Roads with the most modes using them as part of their routes are SH6 Kingston Road and Māori Jack Road, followed by North Zone Road and Drysdale Road connecting to SH6.

Considering the public transport routes (existing routes in orange and proposed future routes in orange dash), and the expansion of developments across the Southern Corridor, the most suitable location for a park and ride facility would be on the eastern side of SH6 closer to the south, opposite the existing Jacks Point suburbs. The proposed growth in the Southern Corridor could benefit from a park and ride facility that would help reduce general traffic volumes along SH6 and Māori Jack Road only if the public transport system provides real benefits in travel, reliability and cost compared to travelling by private car. Land is relatively flat and no developments are proposed in this area as of 2020 (Southern Corridor NOF).

6 Public Transport Network and Access

6.1 Current Public Transport Network

The current public transport network in Queenstown consists of five routes that run through Queenstown Town Centre and Frankton (Figure 13). These services extend to destinations in the north (Arthurs Point), west (Fernhill, Sunshine Bay), south (Kelvin Heights and Jacks Point) and east (Shotover Country, Lake Hayes and Arrowtown). Since services from the west of Queenstown run to destinations to the east, it reduces the number of buses which terminate at Stanley Street which is a central location that has road space constraints.

Frankton Hub forms the key transfer point between services for passengers from Kelvin Heights and Jacks Point, where they need to transfer to routes 1, 2 or 5 to travel to Queenstown Town Centre. Bus services serve the destinations within Frankton to varying extents with route 1 serving the airport and Remarkables Shops, route 3 serving Remarkables Shops and Five-Mile and route 4 going direct into Frankton Hub. Within the bus network, there are two detours into residential areas which is the detour of route 2 into Quail Rise and the detour of route 4 into Hanley's Farm (northern half of Jacks Point).

In addition, there is a ferry service which picks up commuters at Queenstown Bay, Bayview, Frankton Marina and Hilton (Figure 14).

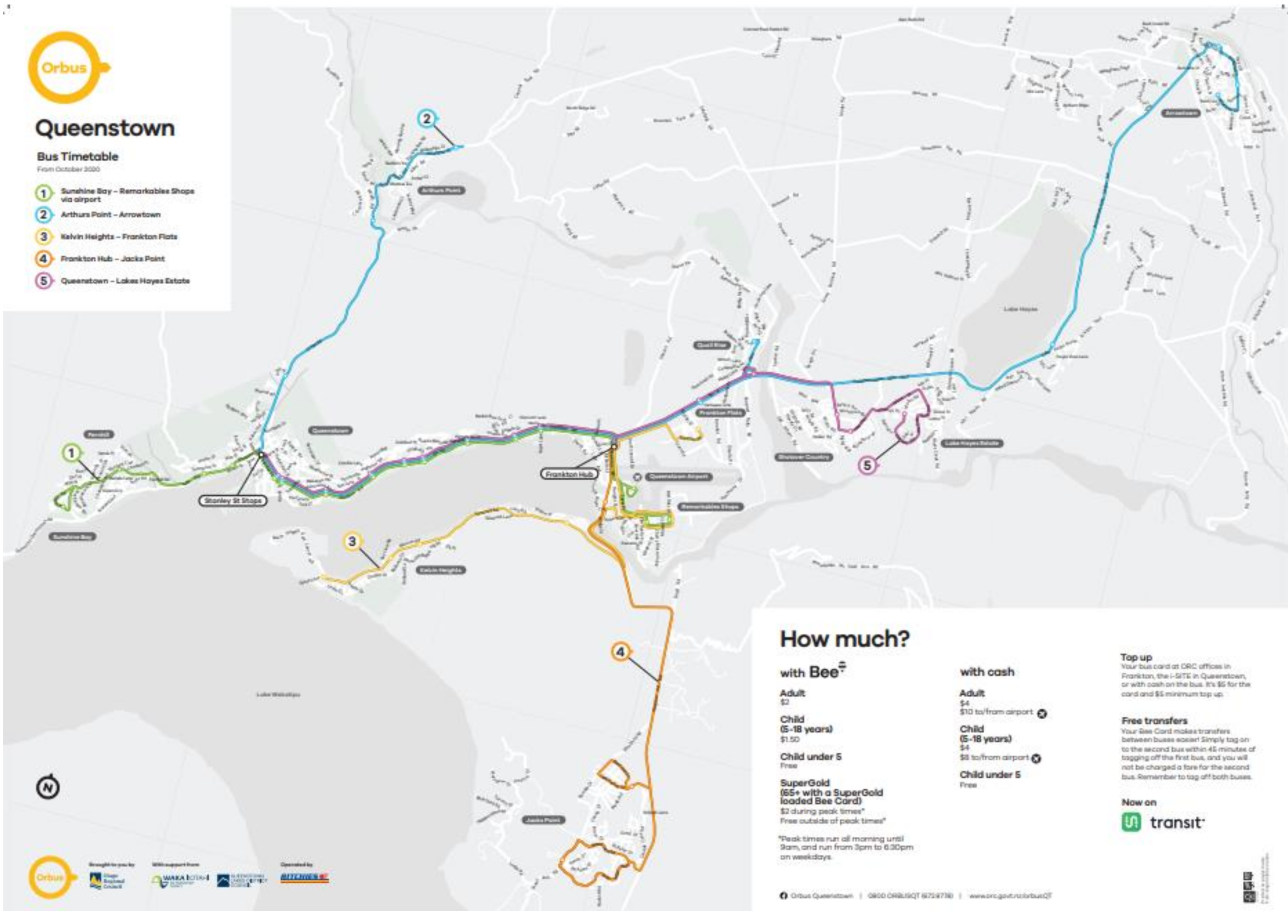


Figure 13. Current Orbus Network (Source: Otago Regional Council).

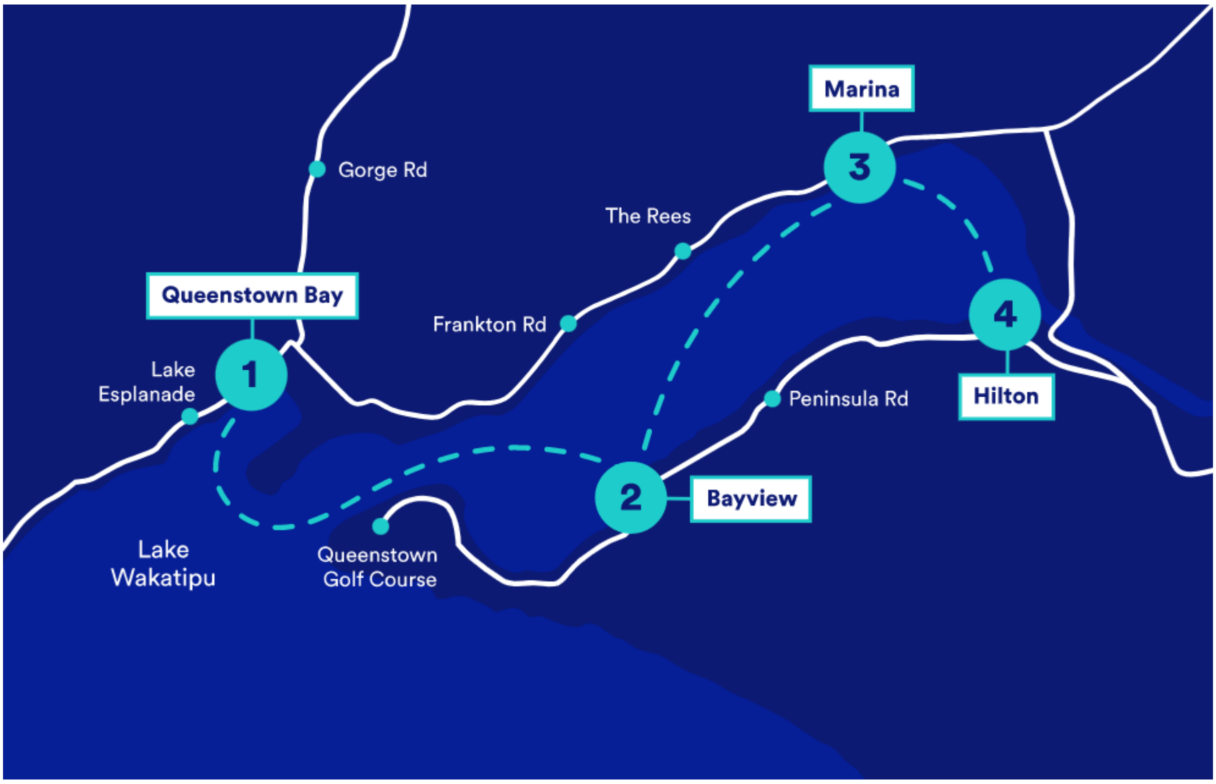


Figure 14. Queenstown ferry service route and stops (Source: Queenstown Ferries).

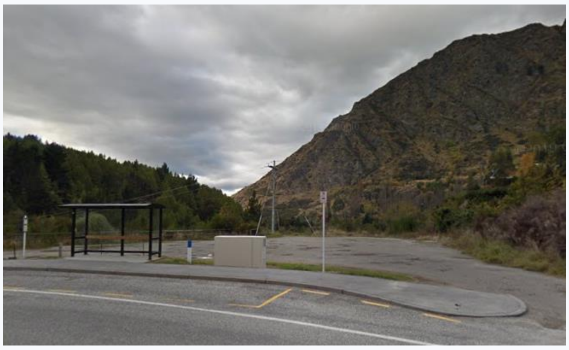
6.2 Existing Park and Rides

There are several parking areas, both paid and free, that are located throughout the suburbs of Queenstown. Although no surveys are available, some of these car parks are expected to be used as informal park and rides, considering their proximity to bus stops. Examples of car parks that may be used by commuters as park and rides are shown in Table 4.

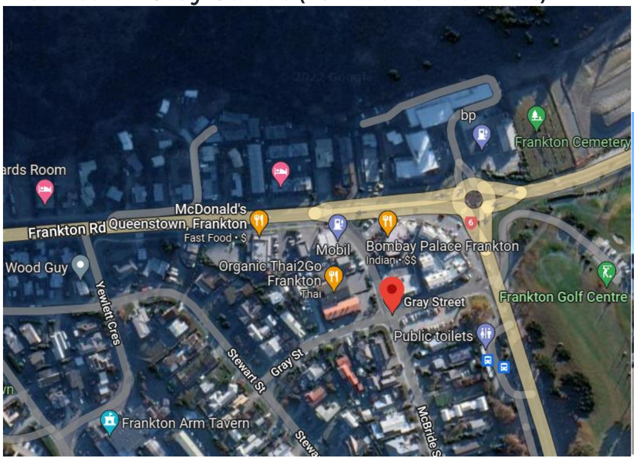
Table 4. Selected informal Park and Ride locations in Queenstown.

Informal Park and Rides

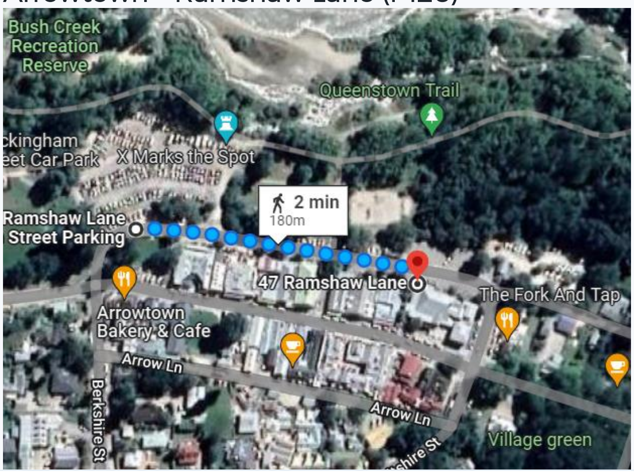
Arthurs Point – Gorge Road (free parking)



Frankton – Gray Street (10-hour time limit)



Arrowtown – Ramshaw Lane (P120)



The park and ride service at The Remarkables ski field is unavailable until further notice; people who intend to park at the base will need to purchase passes for the Express Ski Bus or take their own private transport. Schools in Queenstown will typically have their own car parks for parents who drive to drop their children off, alternatively, children travel by school buses.

For existing and future park and rides to be successful, it is also important to consider it in the context of measures that make public transport more competitive than driving. The New Zealand

Upgrade Programme's Queenstown Package (Figure 15) which is currently underway, includes bus priority measures on SH6/6A, bus lanes on SH6, improvements to Frankton bus hub and the SH6A/6 intersection (BP roundabout), pedestrian access improvements on SH6 and SH6A and a new roundabout at Howards Drive. Once implemented, these upgrades will help to facilitate improved public transport travel times, especially during peak periods. Combining park and rides with these infrastructure upgrades and travel demand management measures will increase the appeal and effectiveness of park and rides as they may offer more convenience and/or is cheaper than driving.

Figure 15. New Zealand Upgrade Programme Queenstown package overview.

6.3 Long-Term Network

The initial recommended public transport network options as detailed in the Service Patterns Advisory Paper are 'Bus Max with New Bridge' (Figure 16) and 'Bus Max using Malaghans Road' (Figure 17). At the time of writing further feedback was being sought on the public transport network options and therefore the routes shown are subject to change.

Figure 16. Option - Bus max with new bridge (Source: QPTBC Advisory Paper 3 Service Patterns)

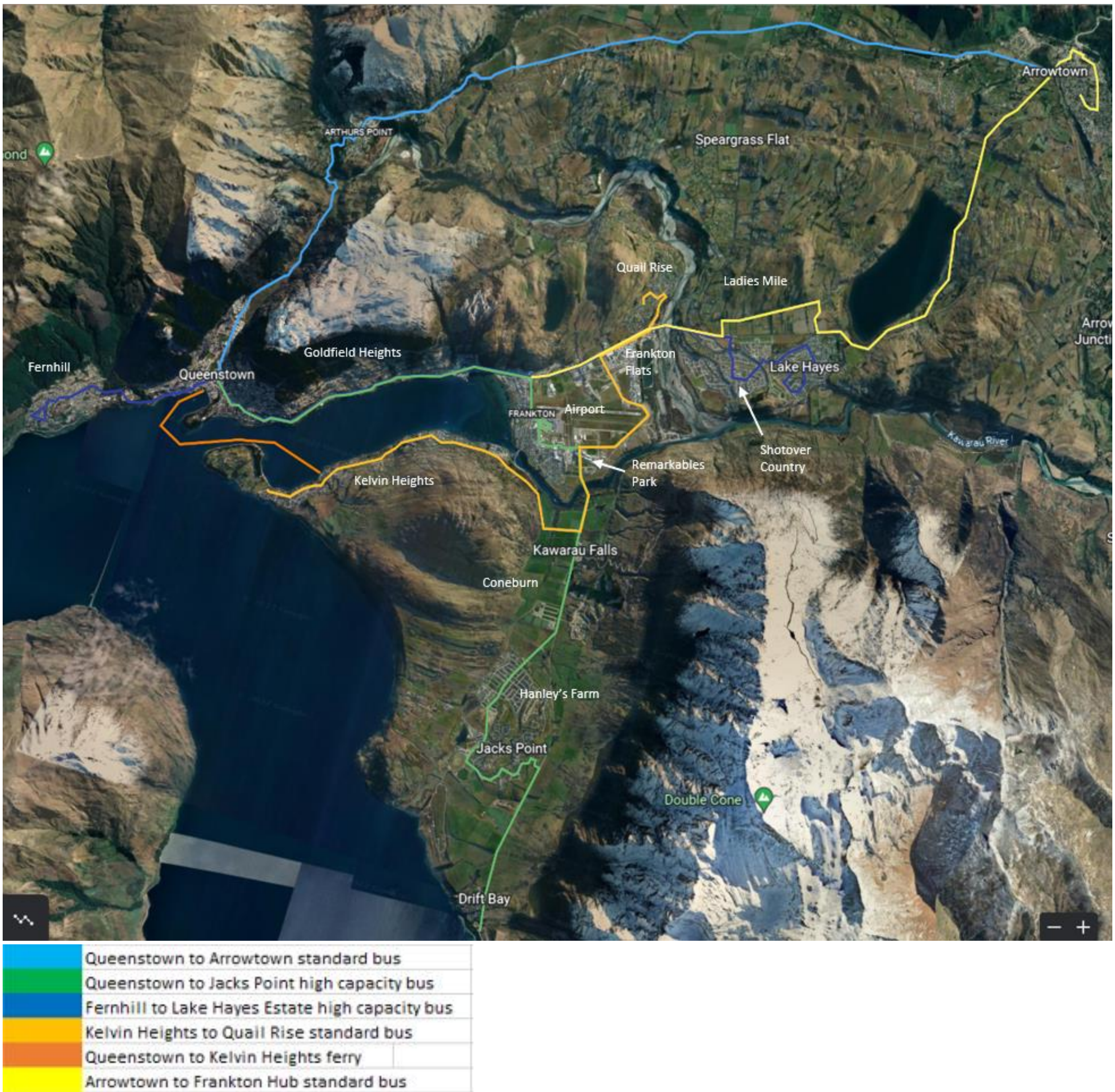


Figure 17. Option - Bus max using Malaghans Road (Source: QPTBC Advisory Paper 3 Service Patterns).

Both options provide high-capacity public transport to growth areas around Queenstown (such as the Southern Corridor) and meet customer expectations by providing commuter, visitor and local access trips with minimal transfers. Moreover, these options avoid transfers and minimise the size of interchanges needed at Stanley Street and Frankton by routing vehicles to outer termini. Additionally, 'Bus Max using Malaghans Road' has the advantage of freeing up capacity on SH6A which could be used to provide more capacity to Jacks Point or to decrease the number of buses on SH6A.

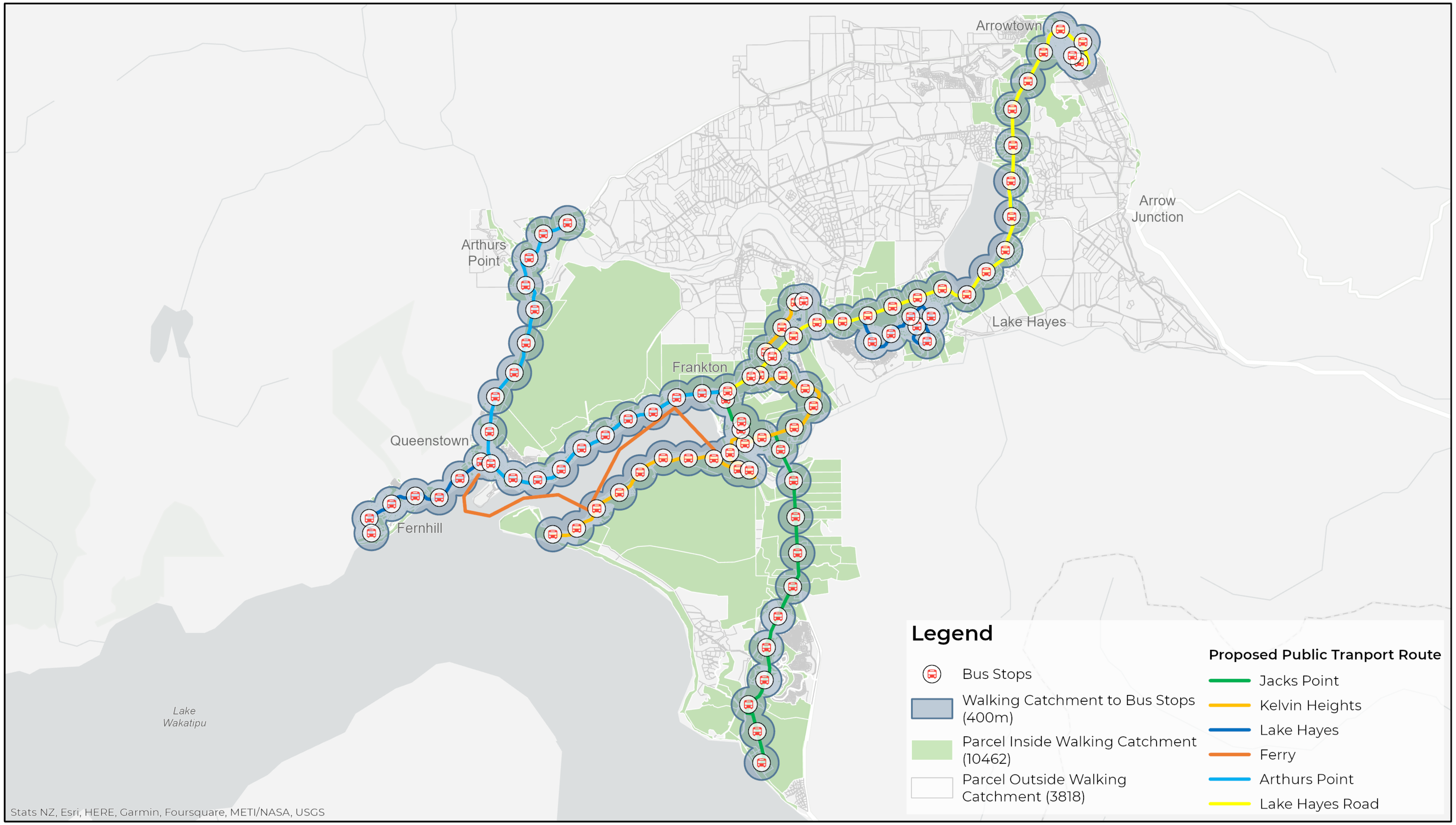
6.4 Mapping of Access to Public Transport

A walking catchment radius of 400m (an approximately 5-minute walk) has been applied to the bus routes using an indicative stop spacing of 600m (Figure 18). The purpose of mapping the walking catchment is that the role of park and rides is generally to provide access for residents who live beyond a comfortable walking distance to a bus stop. A 400m radius is widely used for planning purposes, research indicates that actual willingness to walk to larger 500-600m depending on quality of service with 400m used as an approximate to account for hills and the road network. In areas with challenging topography and road networks e.g. Queenstown Hill and

Goldfields, an on-demand service is proposed to increase coverage. The accessibility map is shown on the following page.

The accessibility assessment provides the following insights:

- The coverage of the public transport network in Queenstown is high, with 73% of parcels being within 400m of a bus route. This is because much of Queenstown's urban area is built near the lake front, or in pockets of housing, which are easy for public transport to serve.
- Speargrass Flat being a rural area does not have access to public transport with it being unviable to operate a new fixed route bus service in this area
- Parts of Jack's Point near the state highway are outside comfortable walking distance to the assumed bus route. Coverage of the fixed-route network could be improved by adjusting the route, or branching the service, with buses either terminating at Jack's Point or Homestead Bay.
- The planned Ladies Mile subdivision is within comfortable walking distance to SH6, which is the assumed route for fixed-route PT services.
- Lake Hayes has better coverage than Lower Shotover; some residents of Tonis Terrace are outside comfortable walking distance to the proposed fixed route. This could be addressed by either amending the bus route to divert via Tonis Terrace, or by branching the service when service frequency is increased.



Property boundaries and aerial imagery sourced from LINZ. Crown Copyright reserved. Property boundaries accuracy: +/- 1 m in urban areas, +/- 30 m in rural areas

Queenstown Proposed Public Transport Network
Accessibility to Walking Catchments

0 1:165,000 @ A4 5 km

C:\Users\jpa211\OneDrive - WSP O365\6-XO014.00_Queenstown_Transport_Network\

Figure 18: Walking Catchment to Service Patterns Paper Option 2 Fixed-Route Network

7 Public Transport Access Options

7.1 Service Delivery Thresholds

When planning for new or amended public transport services, there is a set of criteria that generally must be met in order to make the service viable. Park and ride, on-demand and fixed route services have different thresholds which reflect the different characteristics of these forms of public transport. The thresholds used will vary between jurisdictions, but the following Table 5 provides a general guide to the considerations when choosing between different forms of public transport.

Table 5. Service delivery thresholds general guide.

	Fixed route	On demand	Park and ride
Density	Above 15 dwellings per hectare	Below 15 dwellings per hectare	N/A
Population	Above 2500 people in catchment area	Below 2500 people in catchment area	N/A
Demand	Minimum of 20 passengers per hour	Minimum of 5 passengers per hour	Minimum 50 passengers per hour
Fare box recovery	At least 20%	At least 20%	At least 20%
CAPEX cost	NA	NA	$10,000 per parking space
Walking catchment	5-10 minutes' walk from bus stops	Set by on demand service zone	Unlimited catchment area
Social utility	Suitable for areas with low car ownership	Suitable for areas with low car ownership	Requires high car ownership
School access	Ability to provide travel to school	Separate school bus required	Ability to provide travel to school

One of the key differences between park and ride and other types of public transport is that park and ride has both CAPEX and OPEX costs. The CAPEX costs come from purchasing the land and constructing the parking spaces and station. The OPEX costs comes from maintaining the park and ride facility and from operating the bus service. For fixed route and on demand types of public transport, all of the costs are OPEX costs, assuming that the council does not own the buses or the depots.

7.2 Travel Demand Assessment

For each of the areas within Queenstown, the modelled travel demands from the Demand Forecasting Advisory Paper have been used to approximate potential public transport demand. A public transport mode share of 20% of trips was assumed, which is conservative considering that the overall public transport mode share target is 40%. For this exercise (Table 6), only the demand going to the Town Centre, Five Mile and Remarkables Park were included in the calculation. Using the demand thresholds contained in section 7.1, each of these areas was classified as suiting either fixed route, on-demand or park and ride public transport.

Table 6. Travel demand assessment for Queenstown.

Area	2027 demand assuming 20% mode share	2053 demand assuming 20% mode share	Viable public transport mode(s)
Cromwell	40 passengers per hour	40 passengers per hour	Park and ride
Speargrass	30 passengers per hour	50 passengers per hour	Park and ride
Queenstown Hill and Goldfields	110 passengers per hour	150 passengers per hour	Fixed route supported by on demand
Quail Rise	30 passengers per hour	70 passengers per hour	Fixed route or on demand
Kelvin Heights	30 passengers per hour	50 passengers per hour	Fixed route or on demand
Ladies Mile	20 passengers per hour	60 passengers per hour	Fixed route
Jacks Point	90 passengers per hour	170 passengers per hour	Fixed route
Fernhill	130 passengers per hour	150 passengers per hour	Fixed route
Frankton	50 passengers per hour	60 passengers per hour	Fixed route
Remarkables Park	40 passengers per hour	70 passengers per hour	Fixed route
Arrowtown	50 passengers per hour	70 passengers per hour	Fixed route
Lake Hayes Estate and Shotover Country	100 passengers per hour	110 passengers per hour	Fixed route
Arthurs Point	70 passengers per hour	90 passengers per hour	Fixed route
Wanaka	10 passengers per hour	20 passengers per hour	No service

The travel demand assessment provides the following insights:

- The majority of urban areas in Queenstown have sufficient demand to support fixed route public transport services, especially when a bus route serves multiple areas.
- Cromwell and Speargrass are the two areas which may suit park and ride. For Cromwell, a park and ride could suit commuters travelling into Queenstown if park and ride offered a benefit over driving. Whilst for Speargrass, a park and ride could help overcome a low population density and lack of walkability within the area and help to build transit demand.

- Kelvin Heights and Quail Rise could be served by on demand at least in the short term. However, since these areas currently have fixed routes and are expected to grow in the future it is recommended that a fixed route is retained. Furthermore, Kelvin Heights and Quail Rise could both be served by a cross Frankton bus service.
- For Wanaka, there was a low demand for trips into Queenstown, with the majority of these trips travelling to the Airport. It is considered that these trips would be better served by a private bus service which currently operates.

7.3 Speargrass and Dalefield

Speargrass and Dalefield are semi-rural areas that are bordered by Coronet Peak, Arrowtown, SH6 and Arthurs Point. The combined population is about 1,200 people from the 2013 census with the area expected to generate 750 trips in the morning peak by 2053. The most common destinations for people departing Speargrass are the Town Centre with 33% of trips, Arrowtown with 15% of trips and Five Mile with 10% of trips.

One of the recommended network design options from the Service Patterns Paper has a Arrowtown to Queenstown bus service via Malaghans Road and Arthurs Point. The purpose of routing the Arrowtown bus via Malaghans Road is to avoid SH6A and free up capacity that could be used by buses from other parts of Queenstown. A park in ride located along Malaghans Road would place the demand from Speargrass/ Dalefield on the way to Queenstown from Arrowtown. For people living in Speargrass/ Dalefield a park and ride would provide access to a direct and frequent public transport service to Queenstown which is more affordable than paying for parking in the town centre.

7.4 Cromwell

Cromwell is located 60km from Queenstown via the Kawarau Gorge and has a population of 5,600 people from the 2018 census. There is currently no public bus service between Cromwell and Queenstown with Ritchies and Intercity operating a limited private bus service. The modelled travel demand from Cromwell is 140 trips to Queenstown Town Centre and 80 trips to Five Mile in 2028 which is stay about the same in 2053.

The previous proposal for park and ride was located off SH6 near Ladies Mile with the purpose being to intercept car trips from Wanaka and Cromwell. However, considering the updated modelling a park and ride located near Cromwell could make more sense for the following reasons:

- The number of commuter trips over the Crown Range from Wanaka travelling into Queenstown is expected to be low (around 30 trips in the peak hour by 2053)
- People may be more willing to transfer to public transport if the park and ride is located closer to where they live because there is less temptation to complete their journey using a car
- A high mode share for trips from Cromwell to Queenstown would be needed to make a bus service viable and therefore park and ride could help to make public transport more attractive
- A park and ride could help pick up outer areas of Cromwell such as Mt Pisa, Bannockburn and Lowburn that would not otherwise have access to public transport
- There is greater availability of sites in Cromwell than Ladies Mile which includes undeveloped commercial and rural sites

7.5 Jacks Point

Jacks Point has more than enough demand to support a fixed route bus service especially considering the significant growth planned for this area. However, the development patterns present some challenges for serving the area with fixed route bus services. This is due to the current lack of road connection between Jacks Point and Hanley Farm as well as the lack of a central corridor through Jacks Point. The first preference would be a fixed route bus service with a road connection between Hanley Farm and Jacks Point. This would provide a frequent all day bus service to Frankton and Queenstown that is expected to generate the highest public transport mode share. The second preference would be a fixed route bus service with a supporting park and ride. This would improve access and potentially simply the bus route (avoiding the need for detours) but would encourage greater car use on SH6.

7.6 Ladies Mile

The Service Papers Paper recommended that Ladies Mile be served by a bus route along SH6. This is because of the short walking distance to SH6 for the planned development for Ladies Mile and flat topography. It is therefore considered that a park and ride would not be required for Ladies Mile as this would largely displace walking to local bus stops. With regards to the role of park and ride in intercepting car trips it is considered that a park and ride located closer to the origin of these trips would be more effective. This is because the closer that people driving get to their destinations the more likely they are to continue driving rather than changing modes. Therefore, a park and ride outside of Cromwell before the Kawarau Gorge is considered to be more effective in intercepting car trips.

8 Conclusion

This advisory paper considers the role of park and ride facilities within the wider public transport network which is planned for Queenstown. The role identified for park and ride is a limited one - to provide access to rural areas where feeder bus services are not viable. Another role is to support new bus services to get off the ground or to encourage public transport use for new growth areas. Note that this paper is a draft document with park and ride requirements and options to be consulted on. If these options are included in the final public transport package of services, then they would be further assessed as part of costings, land requirements, ownership and operating models and system management papers.

From the accessibility mapping that was completed for the proposed public transport network it was found that most urban areas would be within a comfortable walking distance of a bus stop. The main exceptions to this were areas that do not have a bus service which include Speargrass Flat and Cromwell. Queenstown Hill and Goldfields also have limited walking catchments due to topography however these areas were identified as having the highest potential for an on-demand transit service in the On-Demand Transit Advisory Paper. For Speargrass Flat the purpose of park and ride would be to overcome the low population density and lack of walkability inherent in rural areas. Whereas for Cromwell the purpose of park and ride would be to maximise demand thereby helping to make a Cromwell to Queenstown bus service more viable. For Jacks Point a park and ride could be considered if the directness and coverage of the bus route could not be improved through new road connections. It was also found that a park and ride located in Ladies Mile was not required due to the proximity to existing bus routes and the high value of the land for other purposes.

In any case, a successful park and ride strategy for Queenstown will rely on much more than provision of parking spaces and a connecting transit service. The park and ride offer and experience must provide a real and perceived benefit compared with driving for the entire journey. This means that the transit solution must be faster and/or more reliable than driving to the final destination (primarily Queenstown centre) and/or less costly and more convenient.

Supporting policies and strategies will be key, including a parking strategy that addresses cost and availability of parking for the different users of Queenstown, and transit priority and service provision that makes transit desirable. A park and ride service, if provided, is recommended as a supplemental add-on to the preferred service pattern option.

wsp.com/nz

Project Number: 6-XO014.00

Queenstown Public Transport Business Case

3 April 2024

CONFIDENTIAL

On-Demand Services Advisory Paper

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Revision	Details
1	Draft for comment
2	Minor updates
3	Final updated from project partner feedback
3.1	Minor update based on QLDC feedback

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the On-Demand Services Paper which forms part of the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Consultant Agreement dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Executive Summary

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This On-Demand Services Advisory Paper is the fourth of the Project's advisory papers. It identifies the potential for on-demand services to be included within the proposed public transport network for Queenstown.

The reason for considering on-demand transit is that this type of service offers a level of flexibility that is not feasible to provide with fixed route public transport. This flexibility means that on-demand could serve areas that are hard to reach with buses, shorten walking distance by providing a 'corner to corner' service and change the number of vehicles in service to better meet demand. It is envisaged that on-demand would complement and not completely replace a fixed route public transport network. This is due to the higher capacity provided by a fixed route service (50 to 100 seats per bus compared to around 10 seats for an on-demand van) which is needed to meet Queenstown's high mode shift targets.

A technical assessment of the potential for on-demand to serve different areas and types of trips within Queenstown was completed as part of this paper. It was identified that Queenstown Hill and Goldfields have the highest potential to be served by on-demand services. This is due to the limited walkability of these areas, the short distance to Queenstown and Frankton, the high housing density in the area and the potential to connect to fixed route services for longer trips.

Whereas other areas of Queenstown were found to be within a comfortable walking distance to proposed bus routes that are proposed to operate at a walk out and catch frequency under the Queenstown Public Transport Business Case. For people who have limited mobility there is the total mobility scheme which provides a door-to-door service that is wheelchair accessible. Lastly for school trips fixed route bus services are more appropriate due to the high demand which occurs within a short period before and after school.

It is recommended that an on-demand service for Queenstown Hill and Goldfields is considered for further investigation. This would include a more detailed assessment of patronage forecasts, fleet size, drop off/ pickup arrangements and depot requirements. The on-demand service, if provided, is recommended as a supplemental add-on to the preferred service pattern option.

2 Introduction

The purpose of this paper is to investigate the potential role for on-demand public transport within the wider public transport network for Queenstown. On-demand services differ from traditional public transport in that there is no fixed route or timetable. Rather, passengers book a trip in advance typically using a smart phone and the vehicle may detour to pick up or drop off other passengers along the way. The flexibility of on-demand is a key advantage for the service. Flexibility enables on-demand to reach customers where it is not possible or feasible to serve with fixed route services.

The on-demand services paper is one of the advisory papers that feeds into the Queenstown Public Transport Business Case. The on-demand paper has been developed following the service patterns paper which identified the preferred fixed route bus network. The recommendations from the on-demand services paper will help to inform the infrastructure advisory papers which includes interchanges, depots and electric vehicle charging facilities.

In order to answer the question on where on-demand services should be considered for detailed investigation, this advisory paper followed these steps:

1. Consider the context of the area in terms of the types of people who live in and visit Queenstown. It also considered how well different types of trips are served by other modes such as public transport, taxi and private shuttles.
2. Map out the accessibility of the proposed public transport network in terms of walking distance to fixed routes to identify any gaps
3. Consider the different potential roles for on-demand transit and the situations where on-demand is likely to be successful
4. Assess the potential for different locations within Queenstown to be served by on-demand and recommend locations for further assessment

3 Strategic Context

3.1 The District Plan

The strategic direction chapter of the Proposed District Plan sets the over-arching direction for managing growth, land use, and development. The aim is to ensure the sustainable management of compact and connected settlements that encourage public transport, biking, and walking [1].

Some relevant strategic objectives include:

- The Frankton urban area (including the Remarkables Park mixed use centre) functions primarily as a major commercial and industrial service centre, and provides community facilities, for the people of the Wakatipu Basin
- Public access to the natural environment is maintained or enhanced
- The accessibility needs of the district's residents and communities to places, services and facilities are met

Policies to achieve this objective that are relevant to on-demand transit include [2]:

- Require that transport networks, including active transport networks, are well connected, and specifically designed to enable an efficient public transport system
- Recognise the importance of expanded public water ferry services as a key part of the transport network and enable this by providing for park and ride, public transport facilities, and the operation of public water ferry services
- Acknowledge the potential need to establish new public transport corridors beyond existing roads in the future, particularly between Frankton and the Queenstown Town Centre
- Facilitate private coach transport as a form of large-scale shared transport through enabling the establishment of off-site or non-accessory coach parking in specified zones and allowing visitor accommodation activity to provide coach parking off-site
- Recognise that shared and commercially owned and operated transport services can complement active and public transport to achieve an efficient transport network.
- Acknowledge the benefits of drop-off and pickup areas for shared transport, public transport, and active transport, where appropriately located

On-demand transit could assist in achieving these objectives by being an extension of the public transport network into under served areas. An important consideration is the locations where on-demand passengers are picked up and dropped off which could potentially be shared with coach or taxi services.

3.2 The Spatial Plan

The Queenstown Lakes Spatial Plan's goal is based around the phrase *'Grow Well | Whaiora'*. The strategies contained within the Spatial Plan that are relevant to on-demand transit are:

- deliver responsive and cost-effective infrastructure
- ensure land use is concentrated, mixed, and integrated with transport
- coordinate a programme of travel demand initiatives
- prioritise investment in public transport and active mode networks
- promote a car free destination
- create well-connected neighbourhoods for healthy communities
- design to grow well

On-demand transit aligns with the Spatial Plan strategies because it could enable people to use a shared form of transport instead of private vehicles. This could contribute to reduced traffic congestion and less need for parking which in turn enables denser mixed-use development.

3.3 Commuter Patterns

Information attained in the 2018 census is used to provide insight into where people travel for work and education. The three main workplace destinations are Queenstown Central with 3,636 external arrivals, Frankton with 2844 arrivals, and Warren Park with 984 arrivals [3]. Driving is the predominant mode of travel for workers arriving in these zones. Of workers entering their zone of employment, 57% drive to Queenstown Central, 79% drive to Frankton, 73% drive to Warren Park.

This information shows that employment and education are concentrated in a few areas which increases the likelihood of people travelling in the same direction. This could increase the attractiveness of on-demand transit because it reduces the likelihood of long detours being needed to drop off passengers.

3.4 Current Alternative Transport Options

The current public transport network focuses on trips to Queenstown central. The only frequent bus route is Fernhill to Remarkables Shops via the Airport. Lower frequency routes (a bus every 30 to 60 minutes) also provide access to Five Mile and outer suburbs such as Jacks Point and Kelvin Heights.

Another option for visitors to Queenstown is Uber or a taxi with it costing around $45 for a trip into Queenstown Central. Some tourism operators such as AJ Hackett bungy jump provide shuttle services which pick tourists up from their accommodation. Lastly, Ritchies and Intercity operate buses to Cromwell and Wanaka with there being two or three departures per day.

There is therefore a potential market gap that on-demand services could fill. This is for customers who are willing to pay more for the convenience of a door-to-door service but cannot justify the expense of catching an Uber or taxi. This trade-off is particularly felt by independent visitors to Queenstown who need to choose whether to hire a car or to rely on public transport/ Uber/ taxis.

3.5 Demographics

Queenstown has a resident population of 29,800 people; 37% higher than that recorded in the 2006 census. Queenstown has a median age of 34 years. New Zealand's median age is 37. Queenstown has a high proportion of people aged 15 to 29 (24% of residents) and 30 to 64 (49% of residents). Another insight is that Queenstown has a higher proportion of managers (21.5% of people employed), trades people (16%), service works (12%) and sales workers (10.5%) than New Zealand as a whole.

Queenstown's demographic creates a potential challenge for traditional public transport planning due to the lower proportion of students, retirees, and professionals. Another limitation on transitional public transport is the high proportion of tourists, many of whom want to visit destinations outside of urban areas. Whereas on-demand transit could be more attractive to people who work in the service and sales sectors (25% of Queenstown permanent residents) as these people are more likely to travel at off-peak times. Furthermore on-demand could potentially travel to tourist destinations which are close to Queenstown which may replace some demand for hire cars.

3.6 Service Patterns Advisory Paper

The Service Patterns Advisory Paper evaluated fixed route network options required for the desired mode shift to public transport. The fixed route network is a starting point for the on-demand services paper with the details of the network being subject to refinement through stakeholder and community consultation. It is intended that the on-demand services paper and park n ride papers would consider the best ways to serve the areas that are not covered by fixed routes.

The Service Patterns paper evaluated 15 network options and identified two options as being preferred. The first of these options was called “Bus max using Remarkables Park Bridge” which is shown in Figure 1. The next preferred option was referred to as “Bus max via Malaghans Road” (Figure 2) which routes the Arrowtown to Queenstown service via Arthurs Point instead of State Highway 6A. The key features of both these networks are high frequency and high-capacity bus routes along the main development corridors which are State Highway 6A to Lake Hayes and to Jacks Point and secondary bus routes which serve Arthurs Point, Arrowtown, Quail Rise and Kelvin Heights. The proposed networks have good coverage of the existing and proposed residential areas none the less there are pockets of housing that are difficult to serve with core or secondary bus routes.

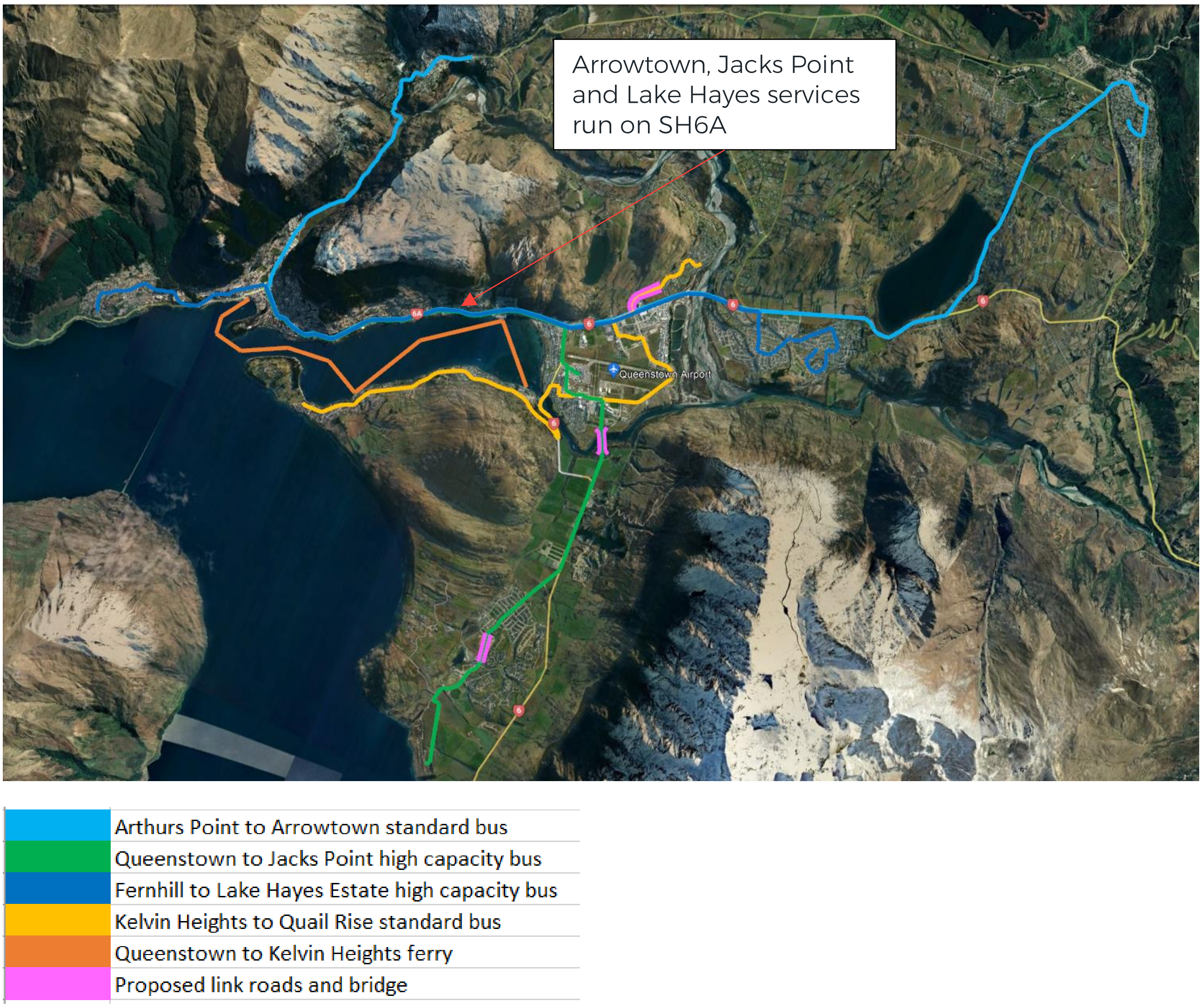
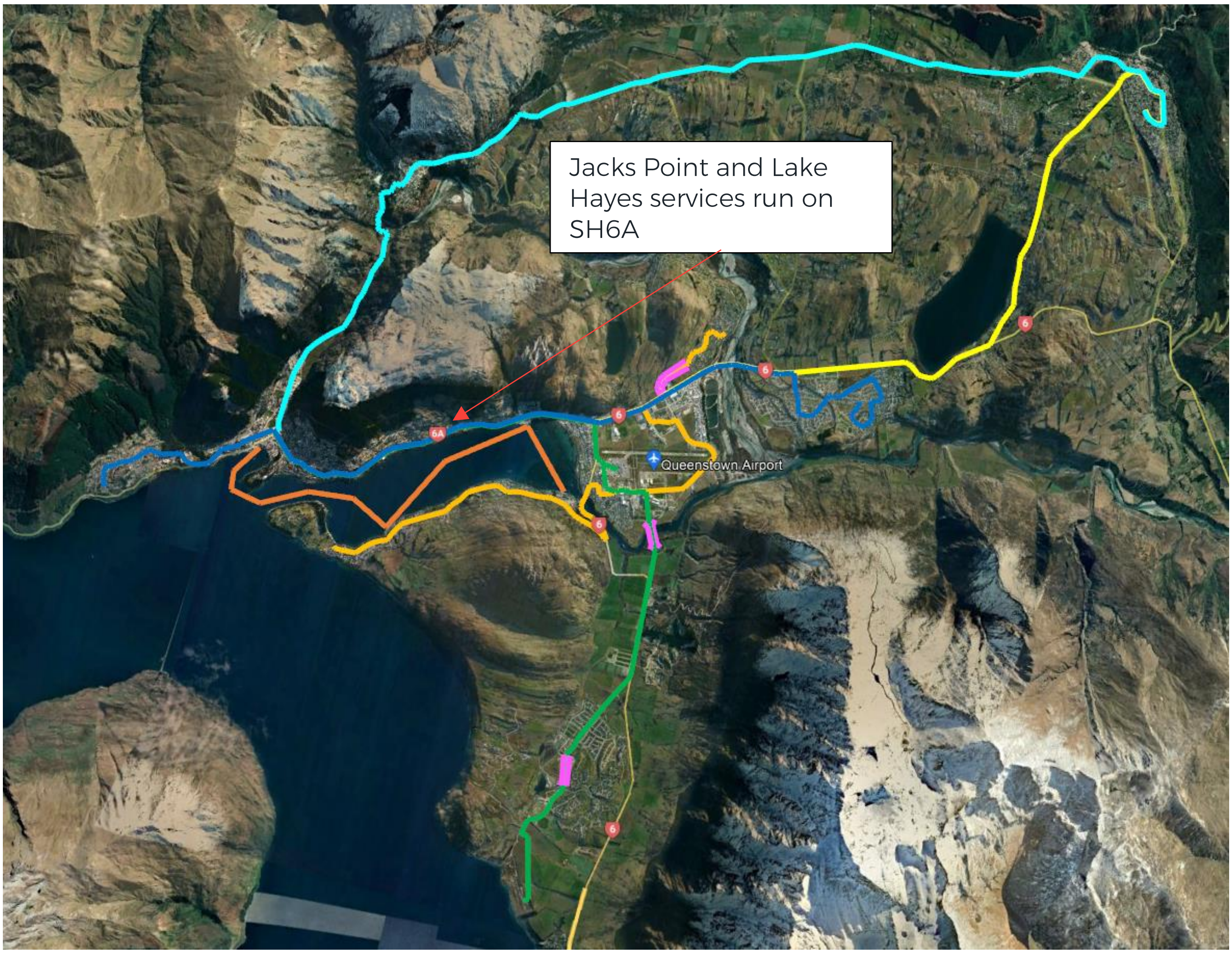


Figure 1: Service Patterns Paper Option 2: Bus Max using Remarkables Park Bridge



	Queenstown to Arrowtown standard bus
	Queenstown to Jacks Point high capacity bus
	Fernhill to Lake Hayes Estate high capacity bus
	Kelvin Heights to Quail Rise standard bus
	Queenstown to Kelvin Heights ferry
	Arrowtown to Frankton Hub standard bus
	Proposed link roads and bridge

Figure 2: Service Patterns Paper Option 3: Bus Max via. Malaghans Road

3.6.1 Accessibility to Proposed Fixed-Route Network

A key consideration for the role of on-demand transit in Queenstown is the accessibility to the proposed fixed route network. A walking catchment radius of 400m (an approximately 5-minute walk) has been applied to the bus routes using an indicative stop spacing of 600m. The accessibility map is show below.

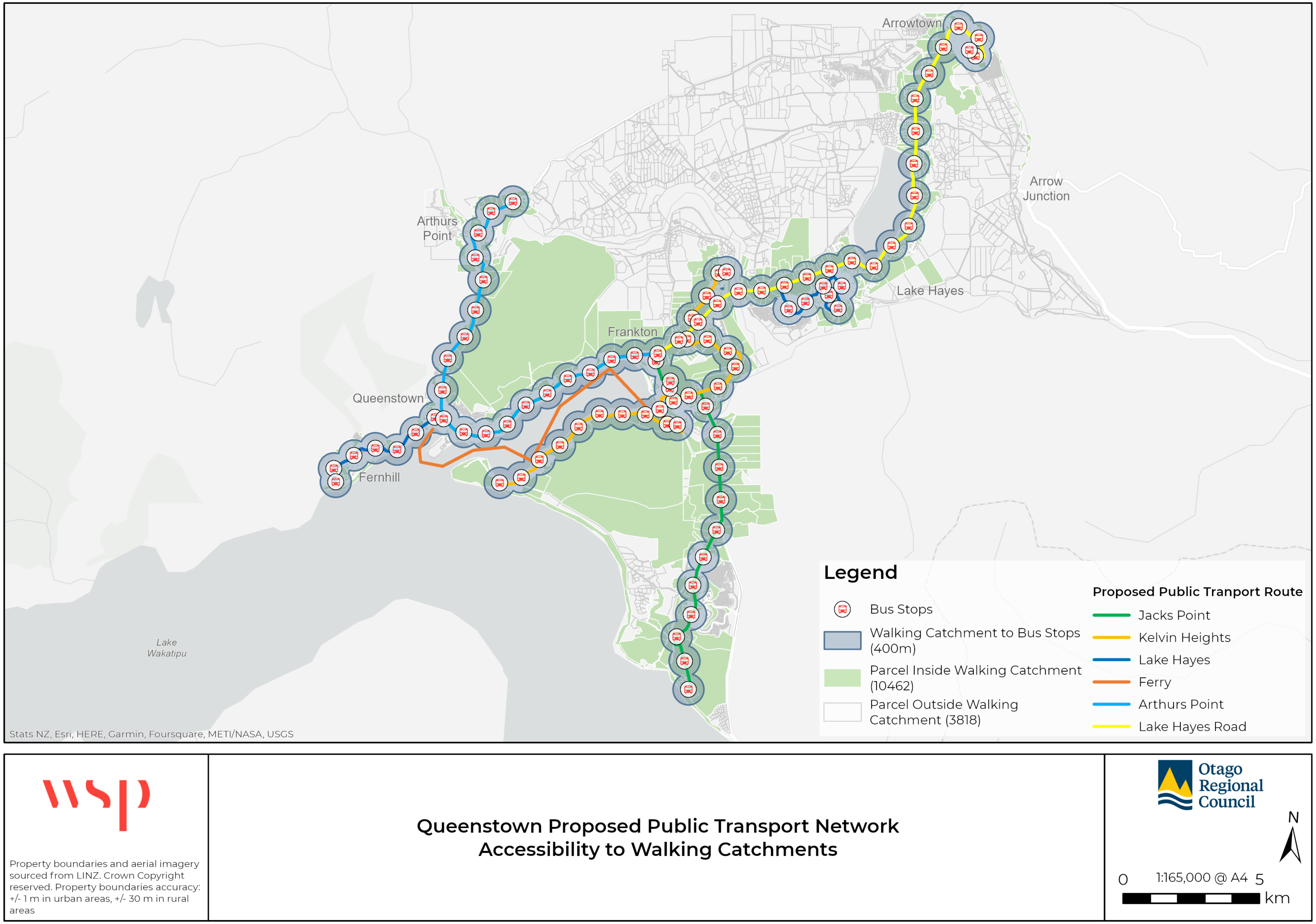


Figure 3: Walking Catchment to Service Patterns Paper Option 2 Fixed-Route Network

The accessibility assessment provides the following insights:

- The coverage of the public transport network in Queenstown is high, with 73% of parcels being within 400m of a bus route. This is because much of Queenstown's urban area is built near the lake front, or in pockets of housing, which are easy for public transport to serve.
- Areas of Jack's Point near the state highway are outside comfortable walking distance to the assumed bus route. Coverage of the fixed-route network could be improved by adjusting the route, or branching the service, with buses either terminating at Jack's Point or Homestead Bay.
- The planned Ladies Mile subdivision is within comfortable walking distance to SH6, which is the assumed route for fixed-route PT services.
- Lake Hayes has better coverage than Lower Shotover; some residents of Tonis Terrace are outside comfortable walking distance to the proposed fixed route. This could be addressed by either amending the bus route to divert via Tonis Terrace, or by branching the service when service frequency is increased.
- Parts of Goldfields and Queenstown Hill are outside comfortable walking distance from SH6A due to topography and road layout. For example, it takes 20 minutes to walk to the top of Goldfield Heights Road, despite being only 300m directly from the state highway.
- The new development area in Arrowtown south is outside of a comfortable walking distance to the nearest bus stop, however there is the potential to extend the bus route to serve this area

4 Role of On-Demand Services

4.1 Benefits

Within a community, on-demand transit can provide several benefits including:

- Reduce emissions: On-demand transit can be a more environmentally friendly transportation option, as it can be designed to use electric or hybrid vehicles and will optimise routes to reduce energy consumption.
- Improving access to economic or social destinations: On-demand transit can be used to provide access to jobs, retail, healthcare and recreation. This can either be through taking on-demand direct to destinations or by using on-demand to overcome the first and last mile barrier to accessing public transport
- Improved travel choice: By providing a more efficient transportation option, on-demand transit can help to reduce the number of cars on the road and alleviate traffic congestion.

4.2 Possible Applications

Drawing on both New Zealand and overseas practice, on-demand services are most applicable in the following situations:

- Rural townships: where there may be low utilisation of existing fixed route bus services and limited travel choices
- Areas with socioeconomic deprivation: provides the opportunity to improve access to jobs and services and reduce over-reliance on private cars
- Areas underserved by public transport: opportunity to reduce social isolation and improve access to jobs and services
- Business parks: many similar trips to one location. Particularly useful for employees that work non-standard hours.
- New housing areas: opportunity to put in place an on-demand service whilst an area is developing before shifting to a fixed route service as demand increases
- Areas with indirect bus services: On-demand services could replace a bus service in lower demand areas and thereby enable the bus service to focus on providing a frequent service along main corridors.

4.3 Limitations

Like all forms of transport, on-demand transit has some inherent draw backs so is not applicable in all situations. The situations where fixed route public transport services may be more appropriate include:

- When demand exceeds approximately 50 passengers per hour which assumes five on-demand vehicles operating with 10 passengers per vehicle. The successful Timaru on-demand service typically operates 4 to 5 vehicles during weekdays.
- For long distance trips because the benefit of on-demand services is to be able to shuttle passengers to a destination and then quickly pickup other passengers. The on-demand services implemented in New Zealand to date have an operating area equating to a 5-10min drive.
- Where the on-demand vehicle would need to make long detours to pick up each passenger such as rural areas. In these situations, a park and ride may be more appropriate because then passengers can be concentrated in a single point.
- When demand for the service would be too low to make the service financially viable from a subsidy per passenger point of view.

5 Area Assessment

An assessment of the potential for on-demand services to cater for different types of trips within Queenstown is shown in Table 1. Key considerations for the suitability of on-demand are the availability of fixed route public transport, the walkability of the area and peak time travel demands. This assessment has considered the public transport network as a whole as low demand areas may be feasible to serve with fixed route services if they are on the way to other destinations.

It is considered that Queenstown Hill and Goldfields have the most potential for on-demand public transport for the following reasons:

- Limited walking catchment to fixed route buses on State Highway 6A due to topography
- The short distance to destination (up to 10-minute drive) which enables on-demand vehicles to shuttle back-and-forth
- The steep and winding streets within Queenstown Hill and Goldfields which better suits a smaller vehicle
- The prevalence of hotels and rental homes in the area increases the proportion of trips made by tourists and people in the service sector
- The potential to take short car trips off State Highway 6A by enabling people to use a shared vehicle

Other areas within Queenstown were found to be better suited to the proposed fixed route public transport network or through the provision of park and ride. For example, in Quail Rise and Lower Shotover there are options to amend bus routes to increase coverage and thereby improve access to public transport without needing to create a new service. Increasing coverage of areas which are currently outside of a walking distance to public transport becomes easier as service levels increase as a result of increased housing development and as new road connections are built.

Table 1: Assessment of areas within Queenstown for suitability for on-demand services

Areas	Destination	Proposed fixed route network	Walkability	Recommendation
Queenstown Hill and Goldfields	Stanley St and Frankton Hub	Frequent bus routes along SH6A	Poor – 20 min walk to top of hill	Investigate on demand services due to limited walking catchment to SH6A
Quail Rise	Frankton	Frequent bus route to Frankton	Good – typically 5 min walk to Ferry Hill Dr	Increase frequency on fixed route service for both Quail Rise and cross Frankton trips
Kelvin Heights	Frankton	Frequent bus route to Frankton	Good – short walk to Peninsula Rd	Increase frequency on fixed route service for both Kelvin Heights and cross Frankton trips
Ladies Mile	State Highway 6	Frequent bus route along SH6	Good – flat 5 min walk	Serve Ladies Mile with bus route from Arrowtown
Lower Shotover	Frankton and Queenstown	Frequent bus route along Stalker Rd	Poor – up to 15min walk to nearest bus stop	Amend fixed route bus service to serve Tonis Terrace
Airport	Stanley St	Frequent bus route to Queenstown	Good – stop is 50m from station building	Service better suited to high capacity fixed route bus due to high demand
Jacks Point	Frankton and Queenstown	Frequent bus route to Queenstown	Depends on road links and routing	Investigate route options once clarity on internal road connections available
Queenstown	Tourist destinations such as ski fields	Not served	NA	Out of scope for public network as private transport operators provide a service to many tourist destinations
Speargrass Flats	Frankton and Queenstown	Option for bus route along Malaghans Rd	Poor as is rural area	Investigate park n ride which is better suited to serving a rural area which has levels of high car ownership
Arrowtown	Frankton and Queenstown	Frequent bus route to Queenstown	Good apart from area around Manse Rd	Increase frequency on fixed route service due to long trip distance

Fernhill	Queenstown	Frequent bus route to Queenstown	Good – mostly 5min walk to Fernhill Rd	Retain a fixed route service as is easy to serve as an extension of bus route from south or east
Queenstown late night	Suburban areas	Span of service up to mid night	Depends on area	Long span of fixed route service combined with availability of taxis/ uber potentially limits demand
Arthurs Point	Queenstown	Frequent bus route to Queenstown	Good – 5min walk to Arthurs Point Road	Retain a fixed route service as is easy to serve as an extension of bus route from south or east
All suburbs	Wakatipu High School	Frequent bus from Jacks Point, Quail Rise and Kelvin Heights	Depends on area	Demand too high for on-demand and school served by both public and school buses

6 Preferred Service Characteristics

The following section discusses the characteristics of the proposed Queenstown Hill and Goldfields on-demand service. These service characteristics should be considered as a starting point for further investigation should the proposal be taken forward.

6.1 Service Area

Potential boundaries for the service area are Lake Whakatipu, Queenstown Hill, Fernhill, Stanley Street and Frankton Hub. It is envisaged that passengers travelling to Queenstown central would be dropped off at Stanley St which avoids on-demand vehicles travelling through limited access roads. Frankton Hub was identified as the eastern boundary of the service because it would enable passengers to transfer to fixed route buses to the Airport, Five Mile and Remarkables Park. The service area is also proposed to cover Gorge Road as far as the Fresh Choice supermarket. Within the proposed service area there are 6,000 usual residents (from the 2018 census area). The service area has a high proportion of Airbnb and hotels so the number of people staying in the area would be large compared to the usual residential population.

Figure 4: Service area for proposed Queenstown Hill and Goldfields on-demand Service

6.2 Fares

Fares for the on-demand service would need to balance fare-box recovery with making the service attractive to a wide range of customers. Due to the short distance involved and the fact that bus fares in Queenstown are a flat $2 with Go-Card fares for on demand would likely be around the $2-$5. A more detailed assessment of fares would be undertaken at a later stage should the proposal be taken forward.

6.3 Span of Service

We recommend that the span of service reflects the vibrant night life and needs of Queenstown. Late night services are a potential market for on-demand transit as it is more attractive to catch a corner-to-corner service than walk home/ to accommodation in the dark. As a minimum the on-demand service should operate until midnight which is consistent with existing bus services.

6.4 Vehicles

It is envisaged that the Queenstown on-demand service would be operated with a van with 8-12 seats that would enable the vehicle to access the narrow roads on Queenstown Hill. Some on-demand vehicles need to be wheelchair and pram accessible, which may involve having an area at the front of the vehicle with fold up seats. Other recommended features are space to store luggage which could include bike/ ski/ snowboard racks. Some on-demand vehicles have LED route information display boards on the front of the vehicle. These are not considered to be essential as the vehicle location would be displayed through the on-demand app. At the time of writing there is some but limited options for electric vans in the New Zealand market. However, manufacturers are releasing an increasing number of electric commercial vehicles.

Figure 5: Vehicle used for Timaru on-demand service (Source: Environment Canterbury)

6.5 Advertising

Effective advertising is critical to informing people of the on-demand service. Advertising is potentially more important for on-demand services than for fixed route services because there are often no physical bus stops which serve as a reminder of the presence of public transport. General recommendations for the advertisement of on-demand are made below:

- The on-demand vehicles should be branded as being part of the public transport network instead of the branding of the operator
- Information about on-demand services should be available on the public transport website and ideally integrated into the journey planner

- Advertising of the service should be a combination of digital and physical to reach a wide range of potential customers
- Advertising is important both when establishing the service but also to maintain awareness of the service once it is up and running

6.6 Booking a Trip

Customers should be able to book a trip using an app or through a contact centre. Having more than one way to book a trip is important for some customers who may not have a smart phone or be confident using a smart phone. Ideally customers would be able to book a trip in advance (say the day before) to make it easier to arrive by a set time such as for an appointment. Payment for a trip could be through a credit/ debit card or through linking to a person's Go-Card account.

6.7 Pickup locations

To increase efficiency of an on-demand transit service, customers can be arranged to walk a short distance to a pick-up location. These pickup locations may be on a main road, or in a location where another rider will wait, which makes it easier for the on-demand service to quickly pick up customers. The walking distance to the pickup location should be short, ideally no more than 100m. For customers with mobility difficulties a door-to-door service should be an option which could be integrated into the total mobility scheme.

6.8 Journey Time

A customer's wait time varies depending on demand for the service at a given time, the number of vehicles in operation, and the proximity of the customer to the end point of another trip. If customers need to wait long periods of time (common target is 10 min or less) then the service becomes less attractive, and some customers may stop using it. Ways to minimise wait times include operating more vehicles, operating larger vehicles that can pick up more passengers, or allowing longer detours. It is important to strike the right balance between wait times, operating costs, and in vehicle journey times which may involve frequent monitoring of the service and making changes as needed. Learnings could be taken from the Timaru on-demand transit service to help with the initial setup of a Queenstown on-demand transit service.

6.9 Service Delivery

It is envisaged that the Queenstown on-demand service would follow the same delivery model as other public transport services. ORC would contract the delivery of the service to a private company such as a taxi company, bus company or company specialising in on-demand services. ORC would also partner with a technology provider to build and operate the mobile app, booking system and service optimiser. The council would be responsible for planning the service and would receive the fair revenue whilst the operator would be responsible for delivering the service, employing drivers, owning the vehicles and providing a depot.

7 Conclusion

On-demand transit has the potential role of improving access to public transport within Queenstown in particular for areas that are hard to serve with fixed routes. Therefore, a key consideration for planning on-demand transit is accessibility of the fixed route public transport network. The accessibility mapping exercise completed for this paper identified that overall, the proposed fixed route network has good coverage of urban areas. However, areas that are outside of a comfortable walking distance to public transport include parts of Queenstown Hill, Goldfields, Jacks Point, Lower Shotover and Arrowtown. A technical assessment on the potential of on-demand transit was completed which also considered demand levels, trip distance and potential amendments to the fixed route network. This assessment identified Queenstown Hill and Goldfields as the areas with the highest potential for on-demand transit. This is because of the limited walking catchment, the short distance to Queenstown and Frankton Hub and the potential to replace car trips to Queenstown Central. Therefore, it is recommended that an on-demand service for Queenstown Hill and Goldfields is considered for further investigation as a supplemental add-on to the preferred service pattern option. A potential trigger for implementing the on-demand service would be the completion of further development on Queenstown Hill such as the Silver Creek subdivision.

Appendix A: Case Studies

Savy, Queenstown

On-demand transit service Savy launched in Queenstown on 27 November 2017 [4]. It started with a $5 flat fare, increased to $7 on 4 January 2018, then changed its pricing structure to $1.50 per kilometre plus a $7 booking fee on 5 April 2018 [4]. On 24 April 2018, Savy promoted that an additional passenger per ride cost $4, regardless of journey length. The $4 per additional passenger remained throughout their pilot. Other promotions included 'Happy Hour' where rides were discounted during periods of lower demand, credit giveaways, ski pass giveaways, and a reduced $2 additional passenger fee.

By 10 July 2018, 225 days into operation, Savy had completed 25,000 rides. This equates to Savy providing 111 rides each day on average. The pilot was concluded on 31 October 2018 with the Savy team being involved in the Devonport and Timaru on-demand service trials.

MyWay by Metro, Timaru

Timaru is a port city in the southern Canterbury region and has a population of 28,700 people [5], almost double Queenstown's residential population of 15,800. Timaru's on-demand transit service, MyWay by Metro, commenced a 12-month trial on 21 April 2021 because the previous bus service was poorly used [6, 7]. The service trial was successful and is still operating [7]. On weekdays, the service runs 6:30am to 7pm, and on weekends or public holidays its operating hours are reduced 8am to 6pm [7]. Fares are $2.50 for adults but increase to $5 for a total mobility (driveway to driveway) journey [7]. The fleet will have nine operational vehicles as of February 2023 with three of these vehicles being low floor for improved accessibility.

Lessons learnt from the Timaru service include [8]:

- Fare structures should be thoroughly considered as part of on-demand service planning. A door-to-door on-demand service is costly compared to traditional fixed-route bus service. The flexibility and accessibility of on-demand transit does come at a price.
- On-demand transit does not cater to school children because of small vehicle size and the concentrated demand.
- Critical to the success of on-demand transit is partnership with transport operators, technology providers, and local authorities. On-demand transit requires higher levels of collaboration, time investment, and idea flexibility than traditional public transport.
- Drop-in sessions, focus groups, having a distinct brand, piloting an on-demand service, and responsiveness are critical elements of engaging the community.

Statistics about the MyWay service are shown in the table below:

	March 2022	November 2022
Total Requests	15,803	17,845
Met Demand	98.2%	94.3%
Completed Rides	13,278	13,839
Driver Hours (net)	1907	1813
Utilisation	7	7.6
Average ETA (mins)	15.1	17.7
Average walking distance (m)	57	60
Average Ride Distance (km)	4.2	4.5
Average Ride Time (mins)	8.8	9.8

Cooee Busways, Sydney

As the population grew in the outer-Sydney suburbs of Schofields, The Ponds, and Kellyville Ridge, parking pressure at public transport stations became unsustainable. Busways partnered with Via in 2019 to deliver an on-demand shared service for residents. It connects residents to local train stations and shopping.

The solution was to deploy six on-demand vehicles, operating between 6am and 9pm on weekdays. Over half of surveyed riders in July 2019 reported previously using private vehicles to complete the same trips. Convenience was the most liked feature of Cooee Busways.

The Cooee Busways service area has 24,000 residents [9]. As at March 2020, the application had more than 13,500 registered users [9]. Between June 2019 and February 2020, daily rides increased from 265 to 540, utilisation increased from 5.3% to 10.2%, and cost per ride before fare recovery decreased from $15 to $7.40 [9]. This cost is significantly lower than low-volume fixed bus route services, which can cost considerably more than $15 per passenger [9].

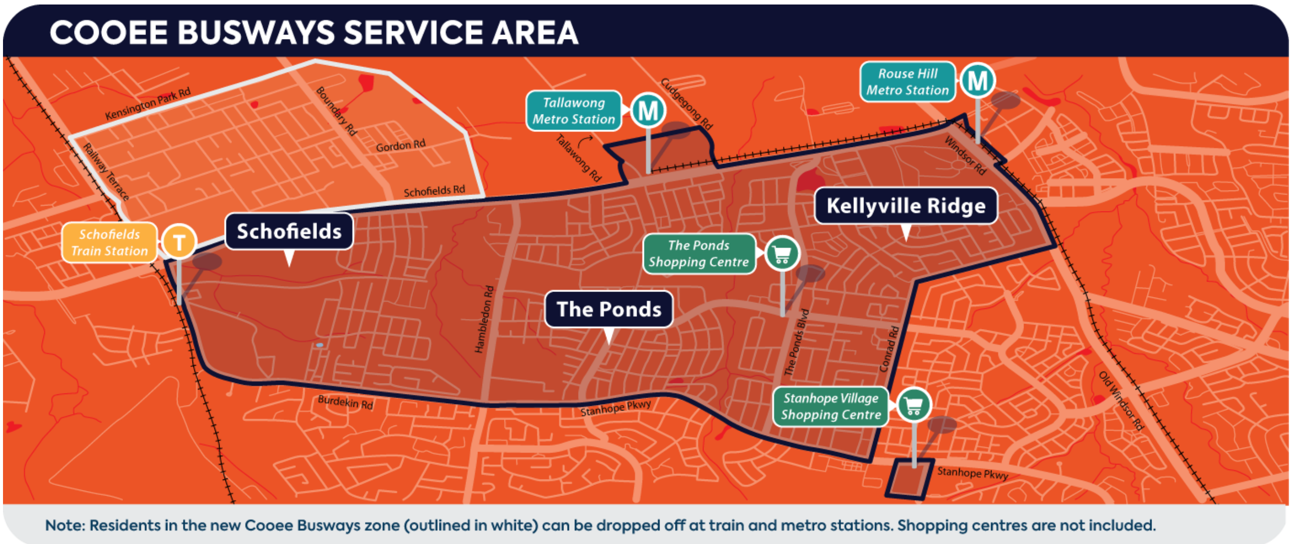


Figure 6: Cooee Busways Service Area

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Queenstown Public Transport Business Case

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Ownership and Operating Model Advisory Paper

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Revision Details

Revision	Details
1	Draft for initial comment
2	Updated from ORC comments
3	Draft updated with executive summary and conclusion
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Contents

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the Ownership and Operating Model Advisory Paper which forms part of the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Consultant Agreement dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Executive Summary

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This Ownership and Operating Model Advisory Paper discusses relevant factors affecting the choice of ownership and operating models including decarbonising the public transport system and recommends a model for future public transport services in Queenstown.

Government policy on public transport operations and decarbonisation have undergone significant changes through the introduction of Sustainable Public Transport Framework, emissions reduction targets in the Zero Carbon Amendment Act and the Emissions Reduction Plan. These policies influence the type of public transport fleet that would be procured for Queenstown in future.

Battery electric is the recommended technology from Advisory Paper 2 – Decarbonisation to achieve the decarbonisation objectives of this business case and to deliver on government policy. This paper considers the characteristics of battery electric buses and how these influence the choice of ownership models for the fleet and the bus depot. Key characteristics include higher upfront costs but lower operating costs of battery electric buses compared to diesel and the high CAPEX costs of upgrading the local electricity network to provide sufficient power for depot charging.

Currently public transport services in Queenstown are contracted out to private operators who operate the services, own the buses, employ drivers and own depots. The recommended ownership model for the bus depot is public ownership with the second preferred option being third party ownership (private investor). The reason for this is that public ownership would protect the investment in the local electricity network and electric bus chargers that would enable a faster transition to a battery electric bus fleet. For fleet ownership the recommended ownership model is the status quo of the operators continuing to own and maintain the bus fleet. This is because bus operators have the capacity to purchase battery electric buses which are now common in bus fleets across New Zealand. It is also recommended that bus operators continue to be responsible for delivering bus services as they have significant experience on running services, training bus drivers and managing fleet.

1 Introduction

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This Ownership and Operating Model Advisory Paper is part of the Project's suite of advisory papers. It discusses relevant factors affecting the choice of ownership and operating models including decarbonising the public transport system and recommends a model for future public transport services in Queenstown. The paper is structured as follows:

- Legislation and policy drivers
- Ownership considerations for transitioning to zero emission buses
- Discussion on the existing operating model in Queenstown
- Assessment of potential future ownership and operating models
- Recommendations for Queenstown

Advisory Paper 7 – Ownership and Operating Model forms Part A of the proposed model for Queenstown's future public transport services. Advisory Paper 8 – System Management, forms Part B which will cover required resources, systems, maintenance and assesses the feasibility of the proposed solutions. The recommendations of this paper will help shape the Commercial, Financial and Management cases of the Business Case.

2 Legislation and Policy Drivers

2.1 Introduction

This section discusses the current government policies on public transport operations and decarbonisation, the recent legislation changes and their influence on the future ownership and operating model for Queenstown.

These policy changes are:

- The Government announced in August 2022 that the Public Transport Operating Model, which governs how public transport in New Zealand is procured and delivered, was to be replaced by the Sustainable Public Transport Framework which has new objectives that support mode shift, improving workforce employment, reducing environmental impact and value for money.

- The Zero Carbon Amendment Act, as well as regional and local policies on climate change, that will influence the type of public transport fleet that would be procured for Queenstown in the future.

These policies are relevant to Queenstown as they provide the opportunity to use ownership and operating models that were not permitted under previous legislation. A zero emission public transport fleet also has different commercial characteristics than a diesel fleet which could also influence the choice of ownership and operating models.

2.2 Operating Model Context

2.2.1 Public Transport Operating Model

The Public Transport Operating Model (PTOM) was established in 2013. It prioritises operational efficiency through the delivery of public transport services mainly around the funding level relative to services delivered, incentives to invest in bus and ferry fleet and the appetite of new operators to enter markets. Additionally, PTOM focuses on collaboration across public transport authorities and aims to increase patronage while reducing dependence on public subsidies, thus improving value for money[1]. Improvements to operational efficiency were to be achieved through competitive tendering of public transport services as 'units' which are groupings of services typically by geographic area.

PTOM replaced a mixed commercial/ subsidised model that was closer to privatisation where bus operators would operate some trips or routes commercially and receive a subsidy to operate others. The problems encountered with this previous model include:

- Bus operators would engage in anti-competitive behaviour by temporarily designating services commercial before a tender and then revoking the commercial status of the services after the tender, thereby decreasing the attractiveness of the contract
- Customers on roads served by multiple bus companies would need to purchase multiple payment cards as ticketing was not compatible between bus operators
- Bus operators would have no or negative recovery time between trips to save on buses and drivers. This would contribute to service unreliability
- Some bus operators purchased buses smaller than the peak demand because the saving in road user chargers was worth more than the lost revenue from customers being left behind
- There was limited incentive to invest in new fleet as contracts were often rolled over on a short-term basis due to a lack of competition

A review into the impacts of PTOM initiated by Te Manatu Waka Ministry of Transport[2] found the following:

- PTOM has increased competition for contracts with operators with above average cost structures largely being unsuccessful in tendering
- There has been a major shift in the operator landscape with the dominant incumbent provider NZ Bus losing significant market share
- Service kilometres in Auckland and Wellington combined increased by 25% with only a 4% increase in contract costs
- The efficiency of the bus sector has improved substantially with contract costs per service kilometre falling by 17%
- Bus drivers have been impacted by a change in the operator landscape with some drivers needing to either leave incumbent operators or leave the sector
- The dominant incumbent operators typically have complex employment agreements where pay largely depends on seniority and penal rates for overtime work
- The newer operators typically have simple employment agreements with flat wage rates and no penal rates
- In Wellington, bus drivers with less than 5-10 years of service are mostly better off at new operators with the reverse being true for long service bus drivers
- In Auckland most bus drivers were worse off from moving from the incumbent operator to new operators
- In other regions there was limited impact as operators typically already used flat rate employment agreements

2.2.2 Sustainable Public Transport Framework

In August 2022, Government announced that PTOM was to be replaced by the Sustainable Public Transport Framework (SPTF). The SPTF sets out new objectives for the procurement of public transport services and provides public transport contracting authorities with more options for the

[1] Evaluation of the Public Transport Operating Model, KPMG and Mott McDonald, December 2020.

[2] PTOM Impacts on Bus Driver Employment Conditions and Wage Rates, 2018 PTOM-Research-Final-Report-26-June-2019_incl-exec-summary-marked-up_Redacted.pdf (transport.govt.nz)

delivery of services. The SPTF does not have a fixed implementation date but rather the legislation change will influence the next round of public transport contract tenders. The objectives of the framework are as follows[3]:

- Public transport services support mode-shift from private motor vehicles, by being integrated, reliable, frequent, accessible, affordable, and safe.
- Employment and engagement of the public transport workforce is fair and equitable, providing for a sustainable labour market and sustainable provision of public transport services.
- Well-used public transport services reduce the environmental and health impact of land transport, including by reducing reliance on single-occupancy vehicles and by using zero emission technology.
- Provision of services supports value for money and efficiency from public transport investment while achieving the first three objectives.

The establishment of the SPTF will see some amendments to the Land Transport Management Act 2003 (LTMA 2003) and development of operational policy, such as:

- Enable public transport authorities to own and operate public transport services
- Services are to be procured, contracted and delivered in a transparent manner
- Enable different asset ownership arrangements
- Promote more collaboration between regional and territorial authorities when preparing regional public transport plans
- Including on-demand public transport services in the SPTF

Compared to PTOM, SPTF has a more holistic approach, focusing on mode-shift, improving environment and health outcomes, and fair and equitable treatment of employees so that people will be attracted to working in public transport and workers will be supported and compensated well.[4] Local and regional authorities will have better management and flexibility over the planning, delivery and ownership of public transport assets and services.

2.3 Decarbonisation Context

2.3.1 Climate Change Response (Zero Carbon) Amendment Act

The Climate Change Response (Zero Carbon) Amendment Act 2019 introduced 2050 emissions reduction targets that are consistent with the Paris Agreement's commitment to limit warming to 1.5˚C above pre-industrial levels. The targets require gross emissions of biogenic methane to reduce to:

- at least 10% below 2017 levels by 2030
- at least 24 to 47% by 2050

Emissions of all other greenhouse gases (GHG) must reach net zero by 2050. In January 2021, the Government announced it was committed to decarbonising the public transport bus fleet. By 2025, the Government will only allow zero-emission public transport buses to be purchased. This commitment targets the complete decarbonisation of the public transport bus fleet by 2035[5].

2.3.2 Emissions Reduction Plan

In May 2022, the Ministry for the Environment released New Zealand's first Emissions Reduction Plan. The long-term vision is for New Zealand to have significantly reduced transport-related

[3] Public Transport Operating Model, Ministry of Transport
[4] Public Transport Operating Model, Ministry of Transport.
[5] https://www.transport.govt.nz/area-of-interest/environment-and-climate-change/public-transport-decarbonisation/

carbon emissions and have a more equitable and accessible transport system that supports wellbeing.

The Emissions Reduction Plan contains targets and actions to achieve a 41% reduction in transport emissions by 2035.

2.3.3 Otago Regional Public Transport Plan

The 2021-32 Otago Regional Public Transport Plan (RPTP) sets out policies and objectives related to public transport services and emissions. A key objective of the RPTP is to contribute to carbon emission reduction and improved air quality through increased public transport mode share and sustainable fleet options.

One RPTP policy is to ensure high vehicle quality standards on all contracted services through these actions:

- Require all operators to, at a minimum, adhere to the national standard Requirements for Urban Buses in New Zealand (RUB) published by Waka Kotahi NZ Transport Agency
- Incentivise higher vehicle quality, technology and lower emissions through contract procurement
- Ensure that, for each operator of contracted public transport units, the number of buses aged 0-10 years shall be equal or greater than 50% of their fleet

The second relevant RPTP policy is to transition to a lower-emission public transport network through these actions:

- Introduce non-CO2 emitting vehicles into the operational fleet in a phased approach based on the re-tendering of contract units
- Engage with operators to explore options to introduce ethically built non-CO2 emitting vehicles and/or alternative fuelled vehicles into the operational fleet earlier than the retendering of contract units through contract variations
- Trial new technologies and platforms that improve the efficiency and operation of the public transport network
- Assess alternative funding opportunities for the delivery of the necessary infrastructure (e.g. charging stations) to support the transition to electric and/or alternative fuelled vehicles
- Ensure that the procurement of contracted services results in greater fleet and operational efficiency.

The RPTP notes that central government requires that from 2025 no new fossil-fuelled buses can be introduced into service in New Zealand and by 2035, all fossil fuelled buses should be replaced.

2.3.4 Queenstown Lakes District Council Climate Action Plan

On 27 June 2019, Queenstown Lakes District Council declared a climate and ecological emergency. Council is on a programme of major organisational behaviour shift ensuring climate change considerations are reflected in decision making, policy setting, projects, and service delivery. In 2019, Council released the Climate Action Plan to help Council meet the challenge of the climate emergency.

A key outcome of the Climate Action Plan is for Queenstown Lakes to have a low-carbon transport system. To achieve this outcome, a key action is for QLDC to develop transformational options for net-zero emissions public transport, partnering with the Otago Regional Council to identify options for net-zero emissions public transport.

3 Decarbonisation Considerations

Current government policy is that only zero-emission public transport buses are to be purchased by 2025 with the target to decarbonise the public transport fleet by 2035. Therefore, all councils including ORC are transitioning towards a zero-emission bus fleet which apart from limited trials of hydrogen buses has meant battery electric buses. The key operational differences which battery electric buses present are higher capital costs but lower operating costs at present due to electricity being cheaper per kilometre travelled than diesel. If network demand increases significantly, then the operating costs may rise.

This section considers the characteristics and requirements of decarbonating the public transport system, moving to battery electric buses compared to diesel buses and how these may influence ownership and operating models. Key areas of consideration discussed include:

- Depot for battery electric buses
- Battery electric buses
- Intelligent transport system technology

At the time of writing this paper, a decision on future bus propulsion technology for Queenstown had not yet been made. However, battery electric is the most likely technology at least in the short and medium term.

3.1 Battery Electric Depot

Bus depots can present a barrier to entry for new operators especially in towns and cities with limited availability of commercial land such as Queenstown. This is because the incumbent operator may own the site(s) that are most suitable for bus depots leaving new operators with either smaller or less centrally located sites. The need for electric bus depots further increases the barrier to entry because of the additional capital expenditure needed before a contract commences. Whereas diesel bus depots require less improvements (especially if refuelling and maintenance occurs off site) it is easier for operators to either lease a site or to purchase a site for land banking.

The charging of electric buses tends to increase depot costs due to additional costs from the chargers and the electrical grid connections. The electrical grid connections in particular present a barrier to establishing a new depot or converting a diesel fleet to electric. This is due to the cost of high voltage connections, the timeframe involved in upgrading electric supply equipment and electrical grid constraints in some locations.

A preliminary, high-level estimate[6] for an electric depot of a size required to operate the 'Bus Max' service is in the range of $50-60M. Electric bus chargers and the high voltage power connection could be expected to be some 35% of the cost of the depot. The actual cost of chargers and power connection depends on the type and number of chargers selected, the length of trenching required for the power cable and how difficult it is to dig the trench.

The chargers and power connection would be a significant investment which is not easily transferrable to another site and would be unlikely to result in a proportional increase in the value of the site. This is because few other businesses require high voltage power connections with charging for heavy electric vehicles, with the possible exception of logistics centres with electric trucks.

It was recommended in **Advisory Paper 2 – Decarbonisation** that battery electric is the preferred technology to achieve the decarbonisation objectives of this business case and to deliver on the requirements of the Emissions Reduction Plan and other regional and local transport policies. Battery electric is recommended as the likely technology in the short and medium-term as the technology is ready, zero emission and enables a dramatic reduction in GHG and Critical Air Contaminant emissions by the public transport sector.

[6] This will be refined following evaluation of depot locations and discussion with ORC and W2G partners

3.2 Electric Buses

When establishing or expanding operations, bus companies will typically either place an order for new buses with a manufacturer, purchase buses from another operator or move buses from other parts of the country. Under the Requirements for Urban Buses in New Zealand, the maximum permitted vehicle age is 20 years with a midlife refurbishment of a bus being required around 10 years after the bus first entered service. Public transport procuring authorities may place lower vehicle age requirements or other standards in their contracts.

Another consideration for electric buses is the useful life of the batteries which typically degrades at a rate faster than the bus chassis and engine. The useful life of batteries depends on several factors including the battery chemistry, the charging regime, how heavily the bus is used and the minimum acceptable state of health. Typically, a battery will lose 30% of its capacity after 8 years in operation with some electric bus manufacturers guaranteeing their batteries for 10-12 years.

New buses are typically purchased by the operator using debt which is paid back using the revenue from the operating contracts. Some electric bus manufacturers (BYD and Proterra, amongst others) offer lease options for either the whole bus or for the batteries which reduces upfront costs for purchasing a new electric bus. These lease financing models are relatively new and typically marketed towards customers in North America.

The length of bus operating contracts varies between public transport contracting authorities with 7-12 years being a typical range. The PTOM bus operating contracts in Queenstown were awarded for nine years. Some authorities such as Transport for London, have a conditional extension of the contract based on the performance of the operator which in the case of London is five-year initial period plus two-year extension. The duration of contracts needs to provide incentives for good performance, enable competition between operators whilst also enabling efficient operators to return a profit.

The commercial calculation for electric and diesel buses is similar especially as the cost of batteries (which makes up a large proportion of the cost of an electric bus) has gradually decreased.

Considering the useful life of electric buses and the duration of operating contracts, the requirement to own buses is not considered a significant barrier for new operators to enter the Queenstown market. This is because all operators are currently needing to transition towards zero emission buses to meet government (SPTF and Zero Carbon Amendment Act) and council policies. Therefore, incumbent operators with large diesel bus fleets are at a disadvantage.

Because councils tend to require new or near new buses for urban services, there is limited resale value of second-hand buses especially those that require a refurbishment and/or battery replacement. Therefore, operators tend to price their tenders to recover the full costs of purchasing a bus and making a profit margin within the period of the contract. Furthermore, unlike depots which tend to increase in value (due to the underlying land), buses tend to decrease in value due to general wear on the vehicle and the fact that manufacturers tend to improve designs year on year.

3.3 Intelligent Transport Systems

The intelligent transport systems currently used in Queenstown include real time information, smart card ticketing and driver scheduling software. Real time information is provided by TrackABus via desktop and mobile devices, smart card ticketing is provided by Bee Card which is a part of the national ticketing solution and driver scheduling software is procured by operators.

The additional intelligent transport systems required to operate an electric bus network would be smart charging management software for the bus depot. Charging management software adjusts the rate of charging based on the cost of electricity, the capacity of the grid connection and the requirements for the next day's shift. The smoothing of demand reduces costs as it can avoid the need for electrical grid upgrades, avoids high usage tariffs and charges when electricity is cheapest which is typically overnight.

It is recommended that charging management software is provided by the asset owner as part of the new electric bus depot for Queenstown. This software would then be utilised by the bus operator to manage the charging of electric buses. The charging strategy (the parameters which the charging management software operates within) should be agreed between Aurora Energy, ORC and bus operators. Smart charging does involve some level of charging restrictions and therefore consideration should also be given to unforeseen events such as power outages.

4 Existing Operating Model

Otago Regional Council (ORC) currently contracts out the operation of the public transport services to private transport operators, in accordance with PTOM. There are three units (groups of services) within Queenstown which is as follows:

Table 4-1. Public Transport Operating contracts from Otago Regional Public Transport Plan

Unit	Description	Contract Start date	Contract End Date
6	Queenstown Airport to Fernhill; Jack's Point to Frankton	18 September 2017	19 November 2028
7	Arrowtown to Arthurs Point, Lake Hayes to Queenstown and Kelvin Heights to Frankton Flats	18 September 2017	19 November 2026
8	Trial Frankton Arm to Queenstown Bay Ferry Service	18 September 2017	30 June 2024

Units 6 and 7 were awarded to Ritchies which operate out of a depot on Glenda Drive in Frankton. Unit 8 is operated by Go Orange whose parent company is Real NZ, a tourism operator. At the time of writing this paper, Real NZ was looking to sell its Queenstown ferry business to a new owner. The current roles and functions for the provision of public transport services in Queenstown is shown in the following table:

Table 4-2. Current roles and functions for provision of public transport services in Queenstown

Organisation	Role	Functions
Otago Regional Council	Procuring organisation	• Planning the network • Procuring services • Funding partner • Monitoring services • Marketing the network
Queenstown Lakes District Council	Road controlling authority	• Provision of bus stops on local roads • Funding partner • Provision of bus priority on local roads
Waka Kotahi	Road controlling authority and regulator	• Provision of bus stops on the state highway network • Funding partner • Provision of bus priority on the state highway network • Regulation of vehicles including buses

Ritchies and Go Orange	Transport operators	• Provision of services • Employment of operational staff • Owners of fleet • Owners of depots

The roles and responsibilities of procuring organisations and transport operators are the same for both bus and ferry services. However, some ferry operators including the Queenstown Ferry have taken on more responsibility for marketing the service with their own branding, website and contact information. As a contracted service which is part of the public transport network it is expected that ORC would take on more responsibility for the marketing of the ferry service going forward.

Under the SPTF, there is no change to the function of road controlling authorities which is governed by the Land Transport Act. Therefore, QLDC would continue to be responsible for the provision of bus stops and bus priority on local roads with Waka Kotahi being responsible for the equivalent on state highways.

5 Future Ownership and Operating Model Options

5.1 Range of Options

Future ownership and operating model options available under the SPTF were discussed with Way to Go (W2G) partners at a workshop on 18 August and range from privatisation to establishing a Council controlled organisation to run public transport. It is noted however that neither the PTOM nor SPTF envisage the full privatisation of public transport services.

The table below shows the roles and functions under different ownership and operating models. The role of government increases from full privatisation to Council controlled organisation.

Table 5-1. Function of Roles of Organisations Under Different Ownership and Operating Models

Functions:	Privatisation	Status quo	Third party ownership of assets	Public ownership of assets	Council controlled organisation
Planning of network	Private operators	Regional council	Regional council	Regional council	Regional council
Branding/ marketing of services	Private operators	Regional council	Regional council	Regional council	Regional council
Provision of infrastructure	District council and Waka Kotahi	District council and Waka Kotahi	District council and Waka Kotahi	District council and Waka Kotahi	District council and Waka Kotahi
Collection of fare revenue*	Private operators	Regional council	Regional council	Regional council	Regional council
Ownership of assets	Private operators	Private operators	Investment company	Regional or district council	Regional or district council
Operation of services	Private operators	Private operators	Private operators	Private operators	Regional or district council
Relative Role of Government within Model					

**Fare revenue refers to ticket sales, the owner of bus stops typically collects any revenue from advertising at bus stops and operators tend to collect any revenue from advertising on buses.*

These options are discussed further below.

5.2 Third Party Ownership Model

With third-party ownership of assets, ORC would contract the provision of the bus depot separate to the operation of services. The bus depot would be built, owned and maintained by a private company who would charge ORC a fee to recover the cost of the investment and to make a profit. The contract with the bus depot owner would stipulate that the bus depot would be made available exclusively to the operator of urban bus services. The bus operator then enters into a commercial lease agreement with the depot owner for the duration of the contract with ORC.

This type of arrangement is currently found when a bus operator sells their depot to an investor with themselves becoming the tenant. For example, the Kaiwharawhara bus depot in Wellington was sold to an investor with NZ Bus (now Kinetic) being the sole tenant.

5.3 Public Ownership Model

Under the public ownership of assets model, ORC and/or QLDC would develop and own the depot and lease the site to the private operator for the duration of their contract. At the end of the lease, the depot would be made available to the next operator with the outgoing operator removing their property (such as maintenance equipment, furnishings and IT systems).

The relationship between ORC and the operator would be a commercial lease agreement with the landlord typically being responsible for maintenance, paying utilities and building insurance. Because bus operators typically run both urban buses, private charters, intertown trips and tourist services, the rent for the depot should be set at market levels. The lease agreement could stipulate the mechanism in which rents are reviewed to give the bus operator certainty of costs for the duration of their contract.

5.4 Council Controlled Organisation Model

Under the council-controlled organisation (CCO) model, ORC or QLDC could either start or purchase a bus operator. The bus operator would typically be held as a CCO with the council being responsible for establishing the governance and monitoring framework. Depending on the procurement policies of ORC, the CCO would then either tender for or negotiate for public transport service contracts. The CCO would purchase the assets (depots and buses) and employ staff in order to fulfil the contract with any profits being passed to council via dividends.

Council controlled bus companies were common before the privatisations of the 1980's and 1990's. As an example, Red Bus was one of the last CCO bus companies. It was sold in 2020 after losing contracts to operate urban services.

6 Evaluation of Ownership and Operating Models

The ownership and operating models were assessed against a range of criteria seen as important to enable to public transport service to meet the investment objectives. These are summarised in the table below. The models were assessed against these criteria, which including feedback from W2G partners at the 18 August workshop.

Table 6-1. Ownership and Operating Model Assessment Criteria

Assessment Criteria		Description
	Enabling a transition to zero emission bus fleet	Extent to which ownership and operating model enables or presents barriers to the adaption of zero emission buses
	Driver pay and conditions	Potential changes to driver pay and conditions including the ability to retain and attract staff which is related to the reliability of a service

	Quality of service for customers	Level of incentive for operators to provide a high-quality service in terms of maintenance, reliability and staffing
	Operational cost efficiency for councils	Level of subsidy required in order to financially sustain the network which is related to how competitive contract rates are
	Capital cost efficiency for councils	The level of upfront costs for councils in procuring the assets required to operate the new network
	Ability to respond to changes in customer needs	Ease to which services could be amended in order to respond to changes such as changes in travel patterns, new housing developments et
	Complexity of management regime for councils	The level of management required and complexity of legal agreements required to enable ownership model

Table 6-2 compares the ownership and operating models against the status quo (PTOM) scenario. The comparison considers whether there is considered to be a positive or negative movement against the status quo for each of these criteria.

Key findings from the comparison are:

- Privatisation is seen as the least desirable of the options because it would remove the ability for councils to plan the network as a whole and would result in worse levels of service for customers on secondary routes
- For the depot ownership model, public ownership would enable a smoother transition to zero emission buses and has a simpler management regime compared to third party ownership (See **Advisory Paper 9 – Sustainable Funding Model** for further discussion on the expected capital costs for an electric bus depot). However, if budget constraints would not allow council to invest in a depot then third party ownership of the depot separate to operating contracts should be explored.
- For ownership of the fleet, the status quo where operators own the fleet is seen as most desirable. This is because the need to own electric buses was not seen as a major barrier to entry for new operators into the Queenstown market. It is recommended that the leasing of buses from manufacturers be explored by council and operators in addition to a traditional ownership model.
- A Council-Controlled Organisation is not the recommended model for operating public transport services because it would reduce cost efficiency from removing competitive pressures[7]. There is also a risk with a CCO, that the operating model could change as different councils/ governments take office and reduce organisational stability and the ability for long term planning[8].

[7] On the buses: The benefits of private sector involvement in the delivery of bus services, L.E.K consulting, 2016. Retrieved from On the Buses: The benefits of private sector involvement in the delivery of bus services. Australian Bus Franchising. (lek.com)
[8] Good practice public transport concessions: the cases of London and Melbourne, G. Currie & N, Fournier, 2021. Retrieved from public-transport-concessions-london-melbourne.pdf (itf-oecd.org)

Table 6-2. Comparison of Ownership and Operating Models

Criteria	Privat-isation	Third Party Ownership		Public Ownership		CCO	Comments
		Depot	Fleet	Depot	Fleet		
Enabling a transition to zero emission bus fleet	∨	∧	∧	∧	∧	∧	Under privatisation, private operators have a limited financial incentive to operate electric buses without a government requirement due to the higher purchase price. The cost of providing high voltage power connection and chargers at depots is a large barrier to the adoption of electric buses. Options which guarantee the investment in depots (third party ownership and public ownership) are seen as beneficial.
Driver pay and conditions	∨	•••	•••	•••	•••	∧	Privationisation would remove the pay requirements in operating contracts and therefore driver pay would be set by the market. On the other hand, a CCO would enable government to directly control pay and conditions however improvements would be dependent on budget availability and political willingness.
Quality of service for customers	∨	•••	•••	•••	•••	•••	Privatisation is seen as negative as it would likely result in a significant reduction in level of services as operators would focus on profitable routes at the expense of lower demand routes. The incentives contained in operating contracts for on time performance and fleet condition are considered to provide a good quality of service for customer.
Operational cost efficiency for councils	∧	∧	•••	∧	•••	∨	Third party ownership and public ownership of depots are positive because it is expected to remove a barrier to entry for new operators thereby potentially increasing competition. A CCO is seen as negative, as with the removal of competitive pressures there is a risk that over time the operator could become less efficient in terms of labour and processes. Fleet are a deoreciating asset and therefore public ownership of fleet is not expected to result in cost savings.
Capital cost efficiency for councils	•••	•••	•••	∨	∨	∨	The capital cost challenge with public ownership and ownership models is the upfront cost to purchase the assets. Options which retain private ownership of assets do not require up front costs to councils but can have higher operating costs.
Ability to respond to changes in customer needs	∨	•••	•••	∧	∧	∧	Under privatisation, the council would have limited influence over private operators. With public ownership of depots and fleet, it would reduce the need to neigotiate with operators/ investors for service changes.
Complexity of management regime for councils	∧	∨	∨	∨	∨	∨	In terms of management complexity, third party ownership of depots would require a complex legal agreement to ensure the correct incentives are in place for investors in order to achieve the outcomes sought. Similarly, public ownership of the fleet would require a lease agreement with operators which covered maintenance and repairs of vehicles[9].

Key: ∧ Positive Comparison to status quo ∨ Negative Comparison to status quo ••• Neutral Comparison to status quo

[9] Transperth bus contracting model: Bus service franchising masterclass, Western Australia Public Transport Authority, 2017. Retrieved from Microsoft PowerPoint - Bus Franchising - Transperth Model UTG Publication (urbantransportgroup.org)

7 Conclusion

The policy and legal context of public transport operations has changed significantly with the introduction of the Sustainable Public Transport Framework and government policy on zero emission buses. These changes mean that there are more ownership and operating models available to regional councils and that there is a clearer pathway towards zero emission buses.

The commercial characteristics of battery electric buses that influence the choice of ownership models are the higher fleet costs, lower operating costs and significant cost of high voltage power connections for bus depots. Because of these factors public ownership of the bus depot is the recommended ownership model with third party ownership (private investor) being the second preferred option. The purpose of a change in ownership models is to protect the investment in the high voltage power connection and the battery electric bus charging infrastructure from changes in bus operators.

For fleet ownership the recommended ownership model is the status quo with bus operators continuing to own, maintain and manage the bus fleet. Procuring fleet is not a barrier to entry into the Queenstown market for new bus operators as incumbent operators would also need to purchase new fleet to replace their existing diesel fleet.

It is also recommended that the status quo of bus companies operating the services via performance based contracts is maintained. This is because bus operators have significant experience in scheduling services, managing staff and responding to service disruptions. Having contracts periodically be retendered provides an incentive for operators to deliver reliable and customer focused services that could diminish if the competitive pressure was removed through public ownership.

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Advisory Paper 2: Fleet Decarbonisation

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Contract TCTB1 dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1. Summary

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This Fleet Decarbonisation Advisory Paper is the second of the Project's advisory papers. It discusses relevant transport and emissions policies and how they relate to the Project, potential technologies for decarbonising the public transport system and a high-level discussion about procurement and ownership. This paper should be read in conjunction with the companion papers, and specifically Service Patterns and Forecast Demand papers.

In January 2021, the Government announced it was committed to decarbonising the public transport bus fleet. By 2025, the Government will only allow zero-emission public transport buses to be purchased. This commitment targets complete decarbonisation of the public transport bus fleet by 2035. In May 2022, the Ministry for the Environment released New Zealand's first Emissions Reduction Plan. The long-term vision is for New Zealand to have significantly reduced transport-related carbon emissions and have a more equitable and accessible transport system that supports wellbeing. Transport policy by Otago Regional Council and Queenstown Lakes District Council also require decarbonisation of the public transport system.

In this report, various bus technologies have been considered to decarbonise Queenstown's public transport service including battery electric, hydrogen fuel cell, biodiesel, hybrid, liquid natural gas and compressed natural gas. As noted in the service patterns and demand forecast, standard buses, double decker buses and high capacity (articulated buses) meet the anticipated fleet requirements (with ferries continuing to have a role).

The following are key conclusions of this assessment:

- Liquid natural gas and compressed natural gas have been discounted as NZ has currently stopped gas exploration and development. They do not meet the zero tailpipe emission criteria;
- Battery electric buses are considered most suitable as the technology is ready and zero tail pipe emission;
- Hydrogen fuel cell technology is also zero tail pipe emission. However, the technology is still being developed and is not likely to be ready for implementation within the required timeframes;
- Biodiesel and hybrid technologies are not considered suitable as they are not zero emission technologies;
- Battery electric buses and hydrogen fuel cell buses provide options that enable a dramatic reduction in the GHG and CACs emissions by the public transport sector. As the electrical energy sources and grids migrate even further to renewable and carbon-neutral options in NZ, this leads to the possibility of very minimal to zero upstream carbon emissions; and
- Hydrogen fuel cell buses are still an uncertain quantity with early trials only just beginning and upstream equipment and infrastructure proving to be expensive. Unless hydrogen infrastructure significantly improves and the costs come down considerably, it is considered that hydrogen fuel cell buses will not a viable option in the short-term

Based on the assessment in this report, it is recommended to further consider battery electric buses as the preferred technology to achieve the decarbonisation objectives of the Queenstown Public Transport Business Case and to address the requirements of the Emissions Reduction Plan and other regional and local transport policies.

In progressing battery electric buses in the short term, identifying existing electrical networks and planning power grid and generation reinforcements that meet the challenges of the increased

power demand is crucial, particularly as the capital deployment timelines for energy providers can be to two years or more if a site is selected that does not have suitable infrastructure in place. It should also be noted that if hydrogen is to be considered in the longer term, even more electrical energy is required due to the lower efficiency.

2. Introduction

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This Fleet Decarbonisation Advisory Paper is the second of the Project's advisory papers. It discusses relevant transport and emissions policies and how they relate to the Project, potential technologies for decarbonising the public transport system and a high-level discussion about procurement and ownership. The paper is structured as follows:

- Introduction
- Relevant policies related to transport and decarbonisation including the Emissions Reduction Plan
- Potential decarbonisation technologies

The technology options discussed in this paper will be used to inform public transport service and infrastructure option development.

3. Transport and Emissions Policy Context

These national, regional and local climate related transport policies are to be considered by the Queenstown Public Transport Business Case and options to decarbonise the public transport system.

3.1 Climate Change Response (Zero Carbon) Amendment Act

The Climate Change Response (Zero Carbon) Amendment Act 2019 introduced 2050 emissions reduction targets that are consistent with the Paris Agreement's commitment to limit warming to 1.5˚C above pre-industrial levels. The targets require gross emissions of biogenic methane to reduce to:

- at least 10% below 2017 levels by 2030
- at least 24 to 47% by 2050

Emissions of all other greenhouse gases (GHG) must reach net zero by 2050. This last target is the crucial date that applies to transport.

The Zero Carbon Act also put in place the institutional architecture to achieve the 2050 targets. This established the Climate Change Commission and included a system of emissions budgets that aim to achieve the reduction targets in a series of steps, and a requirement for governments to develop emissions reduction plans.

In January 2021, the Government announced it was committed to decarbonising the public transport bus fleet. By 2025, the Government will only allow zero-emission public transport buses to be purchased. This commitment targets complete decarbonisation of the public transport bus fleet by 2035[1].

3.2 Emissions Reduction Plan

In May 2022, the Ministry for the Environment released New Zealand's first Emissions Reduction Plan. The long-term vision is for New Zealand to have significantly reduced transport-related

[1] https://www.transport.govt.nz/area-of-interest/environment-and-climate-change/public-transport-decarbonisation/

carbon emissions and have a more equitable and accessible transport system that supports wellbeing.

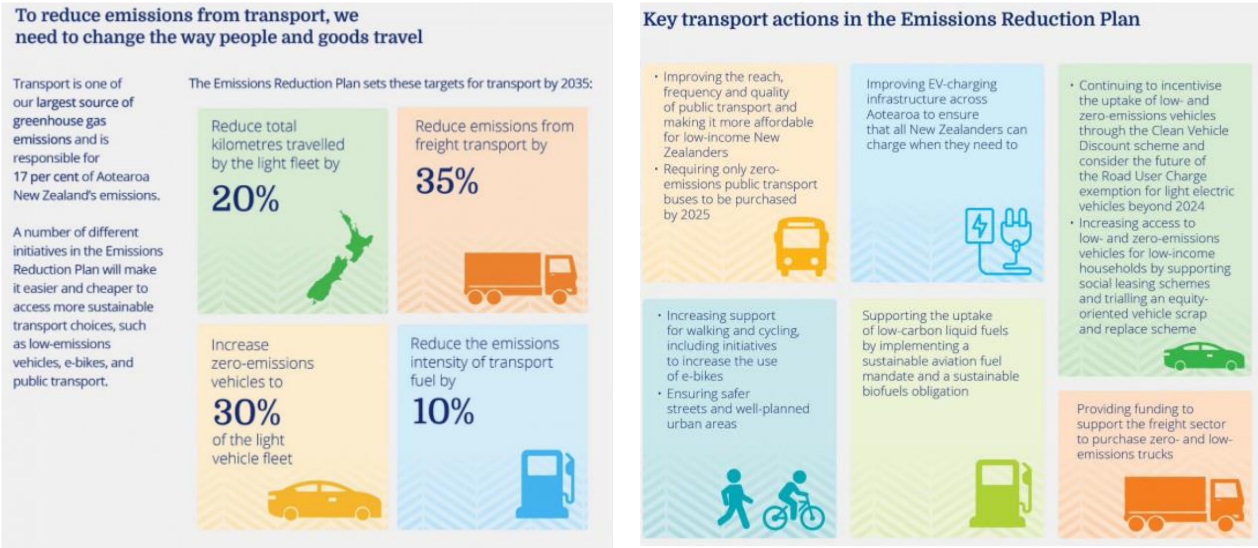

Figure 3-1 Emissions Reduction Plan (ERP) Actions Summary

The Emissions Reduction Plan contains targets and actions to achieve a 41% reduction in transport emissions by 2035. The Emissions Reduction Plan sets four transport targets that will support our vision and align with achieving a 41% reduction in transport emissions by 2035 from 2019 levels. Specific target dates include:

- Reduce total kilometres travelled by the light fleet by 20% by 2035 through improved urban form and providing better transport options, particularly in our largest cities
- Increase zero-emissions vehicles to 30% of the light fleet by 2035.
- Reduce emissions from freight transport by 35% by 2035.
- Reduce the emissions intensity of transport fuel by 10% by 2035.

The improvements to public transport considered by this report are under Target 1 above.

3.2.1 Funding for Transition

Whilst cabinet has agreed to the paper on Transport Emission Reduction, and has amended and iterated the emissions reduction plan, but the availability of funding has been limited.

- EECA low emission transport fund - $18 M for 2022/2023 (down on the $25 M originally proposed for this contestable fund) for on road, off-road and marine transport.
- New Zealand Green Investment Fund (NZGIF)
    - The NZGIF has contributed $20 million to UK fleet and battery storage specialist Zenobē for the production of 18 electric buses which have been allocated to Go Bus Transport in Christchurch.
    - NZGIF has co-financed a $20 million deal to help NZ Post transition its last mile delivery fleet to electric vans and low emissions vehicles. The finance was used for 06 E-Vans.
    - NZGIF has provided a credit line to CentrePort, Wellington which was used to purchase seven electrified tractor trailer units.

However, the current government has not provided clear guidelines for this funding process and many regions have selected their own timelines or processes to comply (or partly comply) with the zero emission goals. This has made decisions for investment difficult.

3.3 Otago Regional Public Transport Plan

The 2021-32 Otago Regional Public Transport Plan (RPTP) sets out policies and objectives related to public transport services and emissions. A key objective of the RTPT is to contribute to carbon emission reduction and improved air quality through increased public transport mode share and sustainable fleet options.

One RLTP policy is to ensure high vehicle quality standards on all contracted services through these actions:

- Require all operators to, at a minimum, adhere to the national standard 'Requirements for Urban Buses in New Zealand (RUB)' published by Waka Kotahi NZ Transport Agency
- Incentivise higher vehicle quality, technology and lower emissions through contract procurement
- Ensure that, for each operator of contracted public transport units, the number of buses aged 0-10 years shall be equal or greater than 50% of their fleet

The second relevant RLTP policy is to transition to a lower-emission public transport network through these actions:

- Introduce non-CO2 emitting vehicles into the operational fleet in a phased approach based on the re-tendering of contract units;
- Engage with operators to explore options to introduce ethically built non-CO2 emitting vehicles and/or alternative fuelled vehicles into the operational fleet earlier than the retendering of contract units through contract variations;
- Trial new technologies and platforms that improve the efficiency and operation of the public transport network;
- Assess alternative funding opportunities for the delivery of the necessary infrastructure (e.g. charging stations) to support the transition to electric and/or alternative fuelled vehicles; amd
- Ensure that the procurement of contracted services results in greater fleet and operational efficiency.

The RTPT notes that central government requires that from 2025 no new fossil-fuelled buses can be introduced into service in New Zealand and by 2035, all fossil fuelled buses must be replaced.

3.4 Queenstown Lakes District Council Climate Action Plan

On 27 June 2019, Queenstown Lakes District Council declared a climate and ecological emergency. Council is on a programme of major organisational behaviour shift ensuring climate change considerations are reflected in decision making, policy setting, projects, and service delivery. In 2019, Council released the Climate Action Plan to help Council meet the challenge of the climate emergency.

A key outcome of the Climate Action Plan is for Queenstown Lakes to have a low-carbon transport system. To achieve this outcome, a key action is for QLDC to develop transformational options for net-zero emissions public transport, partnering with the Otago Regional Council to identify options for net-zero emissions public transport.

4. Public Transport Trends and Developments

4.1 NZ Region Trends

In New Zealand, a number of central government and Council initiatives have accelerated the adoption of zero emission transport. As an example, Auckland has published their low emission roadmap, electrified the commuter train system, has commenced electrification of the buses and has embarked on an electric ferry process with electric ferries to be operating in 2024.

More locally, ORC has purchased electric buses to service Dunedin's public transport network following a trial in 2021. These buses will enter service in late 2023.

4.2 Australian Trends

Australia has increased their adoption of electric buses through 2022 and some Transit Systems fleets have now covered over 1,500,000 km with over 2 million passengers carried. Both the Sydney and Brisbane airports are now serviced by electric buses, with other Australian transit agencies now considering a full shift from diesel to electric in the near future.

5. Potential Decarbonisation Technologies

This section summarises various transport modes and fuels to be considered for decarbonisation of Queenstown's public transport service and makes a recommendation as to technologies for further consideration. The appendixes provides further detail on these technologies.

5.1 Passenger Loading and Bus Configurations

Please refer to the Service Patterns paper for the routes where demand requires alternative bus body and passenger capacity. For the purpose of this paper, the following have been considered:

- 10 passenger shuttle bus – on demand
- 65 passenger "standard" bus – standard routes
- 85 passenger double decker, 12m – increased demand
- 90 passenger articulated bus, 18m – higher demand
- 150 passenger bi-articulated bus 24m – heaviest demand.

Figure 5-1 Possible Fleet Configurations – Double Decker, Articulated and Bi-articulated buses

The size and layout of the bus may differ on routes that are expected to carry luggage extensively, such as to/from the airport. It should be also noted, that as with any energy source, the greater the length, weight and number of doors, the proportionately greater the power demand.

5.2 Bus Technology Options

The table below shows the options available, their readiness and a short summary of their characteristics.

Table 5-1 : Bus Technology Options Comparison

Technology System	Battery Electric (BEB)	Hydrogen Fuel Cell (HFCB)	Biodiesel	Hybrid
				
Readiness	🟢	🟠	🟢	🟡
Zero Emission/ Suitability	🟢	🟠	🔴	🔴
Overview	Electric motors powered by on board batteries Batteries are typically large, higher bus weight Current actual range to circa 350 km, planned range to 450 km per charge May require upstream infrastructure	Electric motors powered by batteries that are charged using on board hydrogen fuel cells Batteries are smaller, resulting in lighter buses Planned range up to c.350 km per tank Requires substantial upstream power & associated depot infrastructure	Combustion engine powered by sustainably sourced biofuels (biodiesel or biogas). Average range per tank up to c.850 km. Produces GHG from the tailpipe Requires biodiesel supply by others.	Electric motors, typically powered by batteries, operate at low speeds (under 20 km/h) with diesel engines used for higher speeds. Similar range to diesel c.850 km. Produces GHG from the tailpipe when the ICE is in use

- 🟢 Ready for implementation
- 🟠 Some parts of the technology and its supply chain are still in prototyping trials and costs may be high. Yet to be successfully delivered from a total cost of ownership perspective.
- 🟡 Technology exists and can be demonstrated, but low adoption and/or high cost/complexity/weight may preclude.
- 🔴 Does not meet the criteria / not suitable

As shown above, battery electric buses are considered most suitable as the technology is ready and zero emission. Hydrogen fuel cell technology is zero emission; however, the technology is still being developed and not likely to be ready for implementation within the required timeframes. Biodiesel and hybrid are not considered suitable as they are not zero emission technologies.

5.3 Ferry Options

Ferries can potentially use all the fuels noted above. They have been historically used diesel engines which require 360-degree access for maintenance and result in a broad hull. However, new technologies, such as electrical propulsion coupled with Hamilton jet systems allows shallow draft and removes the need for bow thrusters (without loss of manoeuvrability). Hybrid systems have been proposed and are under trial, but presently their increased complexity has resulted in few being commercially implemented. Electric systems are by far the greatest application and new battery systems and fast charging capability has accelerated this trend. A number of catamaran designs are being implemented in NZ and will comfortably cruise at 23 knots with 120 to 150 passengers covering both tourist and commuter needs.

It should be noted that the governments public transport fleet decarbonisation target only applies to buses and there is less directive policy on decarbonising ferries.

5.4 Assessment of Technologies

The table below provides a high-level assessment of how each energy and fuel technology performs against key selection criteria.

Table 5-2 : Technology Option Comparison

Technology / Category	Battery Electric (BE)	Hydrogen Fuel Cell (HFC)	Renewable Natural Gas (RNG)	Biodiesel	Hybrid
Environment sustainability	★ [green] No tailpipe emissions	★ [green] No tailpipe emissions	★ [orange] Tailpipe emissions	★ [red] Tailpipe emissions	★ [red] Tailpipe emissions
Operational readiness	★ [green] Available now	★ [orange] Trial only, Lease only	★ [red] Not in NZ	★ [orange] Limited availability	★ [green] Available, but not imported in NZ
Value for money	★ [green] Higher cost than diesel	★ [red] Much higher cost than diesel	★ [green] Similar to diesel costs	★ [orange] Similar to diesel costs	★ [orange] Similar to diesel costs
Resilience and future proofing	★ [green] Upgrades and recycling available	★ [orange] Uncertain	★ [orange] Uncertain future path	★ [orange] Uncertain future path	★ [orange] Uncertain future path
Skills, Deliverability and operational risk	★ [orange] Some new skills required	★ [red] Major new specialised skills and H&S/policy changes required.	★ [orange] Some new skills required	★ [green] No change	★ [red] New skills required, increased complexity & weight
Safety and change management	★ [orange] Well understood and manageable	★ [orange] Complex, Major changes, Hazardous substance approved handler required	★ [orange] Well understood	★ [orange] Well understood	★ [red] Complex
Overall Rating	★ [green]	★ [orange]	★ [red]	★ [red]	★ [red]

- ★ [green] A green score represents that the technology system 'achieves the objective'
- ★ [orange] An orange score represents that the technology system 'partially meets the objective'
- ★ [red] A red score represents that the technology system 'does not meet the objective'

Based on the assessment above, battery electric technology is considered the recommended technology to take forward for further consideration. Hydrogen fuel cell technology, while currently expensive and under development, could be considered in the longer term. Biodiesel and hybrid technology should be discounted as they are not zero emission technologies.

5.5 Bus Technology Comparison

The following table summarises the characteristics, advantages and disadvantages of battery-electric, hydrogen fuel cell and renewable natural gas buses as well as the required major system changes compared to business as usual with diesel buses. It should be noted that in most cases, a "retrofit" is not cost effective, although limited success has been achieved with custom retrofits of double decker buses in Wellington.

Table 5-3 : Comparison between the battery electric, fuel cell electric and CNG bus technology options

Technology*	Battery Electric Bus (BEB)	Fuel Cell Electric Bus (FCEB)	CNG Bus
Capital costs	Higher capital cost than diesel bus, mostly due to charging infrastructure and battery but can be lowered with battery leasing.	Much higher capital cost than diesel bus, mostly due to upstream costs of generation/storage/compression and depot refilling infrastructure	Increased capital cost premium compared to diesel buses, however comparatively lower than battery electric and fuel cell buses
Operational costs	Lower operational cost (dependant on electricity rate). Lower maintenance cost (unless overhaul is needed).	Potentially lower operational cost than diesel but dependant on electricity and hydrogen fuel rate. Upstream costs may outweigh vehicle savings. Potentially lower maintenance costs (unless new fuel cell required)	Lower fuel costs of CNG fuel, however this is depended on local fuel rates and the natural gas supply chain
Environmental impacts	Zero emission. Zero tailpipe emission (excluding any auxiliary diesel heater options). Low carbon (assuming power generated from sources such as wind, hydro and solar).	Zero emission. Zero tailpipe emission (excluding auxiliary diesel heater options). Low carbon (assuming hydrogen generated from electrolysis fed by renewable electricity).	Low emission. CNG Fuel burns more cleanly than diesel fuel with lower GHG emissions and CAC (Criteria Air Contaminants) emissions. RNG offers carbon neutral emissions impact through recycling and repurposing of landfill gases.
Social impacts	Potential NZ job creation to design, manufacture, operate and maintain fleet. Quieter performance than diesel with lower noise impact on the public.	Some limited potential for NZ job creation to manufacture (parts), operate and maintain (parts) fleet. Quieter performance than diesel with lower noise impact on the public.	Quieter performance than diesel with lower noise impact on the public.
Advantages	Quiet operation. High vehicle efficiency. Increasing range with larger battery capacity. Operational insight and experience from several trials and operations in several cities in NZ, Australia and worldwide.	Quiet operation. Similar range to diesel bus Similar refuelling time to diesel bus, although a morning "top-off" is required.	Minor infrastructure upgrades. Similar range to diesel bus Similar refuelling time to diesel bus.
Disadvantages	Longer charging time than refuelling of a diesel bus (except with fast charging options).	Limited supply of hydrogen fuel due to limited investment in hydrogen for NZ. Costs uncertain even with Government subsidies. Refuelling systems costly and uncertain reliability. Limited option of bus fleet.	Limited supply of CNG (proportion of renewable gas also unclear). Natural gas will be phased out by 2045 in ACT. Not 100% clean, still emits some emission.

BEBs and FCEBs could potentially complement each other as zero-emission bus options that satisfy different purposes and customers. BEBs work best with urban buses with shorter routes, while FCEBs can be used for routes that require long ranges but require access to a hydrogen refuelling station. In addition, it is important to note that running a fleet with two different fuels can be challenging from procurement, operation and maintenance perspectives.

In the short term, however, BEBs is a better option because the technology is more developed; the required electricity supply can be more easily sourced; the larger battery capacity can serve most urban bus routes.

FCEBs are still an uncertain quantity with early trials only just beginning and upstream equipment and infrastructure proving to be extremely expensive. At present, NZ has limited hydrogen-related skills, but this may grow in the future. Unless hydrogen infrastructure significantly improves and the costs come down considerably, it is considered that FCEBs will not a viable option in the short-term.

6. Electrical Power Network

6.1 Upstream Power Requirements

Successful transition to and fuel or power systems will require increased upstream power – and that is usually electricity delivered by the local electrical lines company. For Queenstown/Frankton and local areas, this would be Aurora Lines Company or PowerNet, depending on the specific location and high voltage cable ownership.

Both Battery Electric Buses and Fuel Cell Electric Buses (where fuel is generated at the depot site) require reliable access to secure, sustainable and cost-efficient power generation and distribution systems. Large-scale electrification for vehicle charging facilities or fuel generation facilities are likely to require upgrade of the electrical infrastructure and potentially construction of specialised on-site storage (of hydrogen or other fuel) infrastructure. The scale of generation and storage options can be assessed through power systems modelling.

In the short term, identifying existing electrical networks and planning power grid and generation reinforcements that meet the challenges of the increased power demand is crucial, particularly as the capital deployment timelines for energy providers can be to two years or more if a site is selected that does not have suitable infrastructure in place.

Long term considerations include a sustainable planning approach that will ensure that initial infrastructure will be adaptable to large-scale deployment. Fleet operators and transport network managers will benefit from ensuring that the power needs are understood by all parties. Strong partnerships with energy providers should be formed early, ensuring that the power needs are understood by all parties and are met prior to deployment.

6.2 Depot Infrastructure

It should be noted that to support both charging or hydrogen electrolysis equipment, the provision of increased electrical service may need on-site substations or transformers in the bus depot. This added equipment, as well as any backup power generation systems or on-site energy storage, can have a significant impact on space requirements at already space-constrained vehicle depots.

6.3 District Electrical Network

The Frankton network is supplied by one Transpower GXP at Frankton is supplied off a dual circuit 110 kV spur from Cromwell and supplies the Remarkables zone substation via two 33 kV feeders.

Frankton GXP also supplies the Aurora network (Queenstown, Arrowtown, and the remaining Frankton areas).

Sufficient power currently exists for a new bus depot and the required electrical infrastructure.

7. Timeline Critical Aspects

Irrespective of the technology or transport option selected, the issues that appear to delay projects of this nature moving forward are usually:

- Acquisition and zoning of suitable land for expanded depots, especially if this has to go through a Resource Management Act process or are in zones where flooding may occur and overland water paths require diversion.
- Access and upstream HV upgrades (due to long lead times on HV equipment, plus planning and consents/easements etc.). This can be 18 to 36 months in some areas.
- Procurement and contracts for selected, experienced HV and charger electrical contractors, especially where selected contractors have to be approved by the local lines distribution company.
- Specific to hydrogen technologies, new policy, process and health and safety procedures will be needed, including changes to embedded legislation. This in itself may take substantial time and there is the possibility that other technologies with better efficiency and higher specific energy density may surpass this in the interim. Battery technologies are less problematic as they can be upgraded and replaced in a modular fashion.

8. Emissions

This section presents a high-level discussion of public transport vehicle emissions. This will be expanded and refined as short list options are developed and assessed through the Queenstown Public Transport Business Case and once the preferred option (including service patterns and vehicles) is known, and staging and rate of adoption are defined.

As an average, transport is responsible for 17 to 21 percent of New Zealand's gross emissions[2] ,[3] and the majority generally being from light transport. However, in a congested urban setting the view becomes more complex as heavy vehicles (including public transport) may account for a considerably higher proportion of the particulate emissions. Some estimates put this at over 80%[4]

If the Queenstown public transport fleet were decarbonised, this would translate into an approximately 31 to 45% reduction in public transport related emissions[5] when compared to retaining diesel[6]. The typical relative emissions are provided for comparison below[7]

- Each light vehicle emits approximately 284 g of CO_2 (equivalent[8]) per kilometre driven, so for one passenger this is 284g CO2e/pkm.
- A typical diesel bus emits approximately 54.6 g of CO_2 (equivalent) per kilometre driven or 54.6g CO2e/pkm

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2 https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/transport/

3 https://www.eeca.govt.nz/strategic-focus-areas/efficient-and-low-emissions-transport/#:~:text=Over%2050%25%20of%20New%20Zealand%27s,that%20contribute%20to%20climate%20change.

4 https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/Documents/transport-emissions-reduction-pathway.pdf

5 https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/Documents/transport-emissions-reduction-pathway.pdf

6 In some cases, this could be higher if the bus fleets being replaced were below a Euro III or IV standard and traffic density was high (increased idling increases emissions per kilometre travelled.)

7 Case study of Bus Route No 2 in Tainan City, Tainan City, Taiwan. Department of Transportation and Communication Management Science, Chang, Chang & Liao, Science Direct, Vol 30, 2019

8 CO2e - Not all emissions are CO2. There is a formula that converts other emissions to an equivalent mass of CO2 in terms of its impact on our environment.

- A typical electric bus emits approximately 37.8 g of CO_2 (equivalent) per kilometre driven or 37.8g CO2e/pkm

Compared with driving alone in a light vehicle, taking public transportation reduces CO_2 e emissions by about 45%, decreasing pollutants in the atmosphere and improving air quality[9]. Thus, increasing the demand and usage of public transport in itself will decrease emissions, and decarbonising the vehicles will further this.

8.1.1 Air Quality

This emission reduction would also occur in the most densely populated areas (responding to transport demand) and is expected to improve air quality as there is a substantial reduction in engine-related particulate emission as well as equivalent tonnes of carbon dioxide.

8.1.2 Particulate Emission

For both diesel and electrified fleet, rubber particulates remain similar. However, electric fleets have been found to be considerably lighter on brake pad emissions (along with reduced wear and increased life) due to regenerative braking advantages.

8.1.3 Rate of Adoption, Impact on Emissions

The rate of achievement of these reductions will be related to the transition rate (replacement of diesel by electric). Bear in mind, historically a bus lifespan on NZ roads is typically 20 years. Both approaches below have to be balanced against funding and cashflow constraints and then tempered against depot availability.

8.1.3.1.1 Slower, Phased Approach

A "slower phased approach" based on replacement at end of life could possibly achieve about 15% of these emission savings by 2025[10]. The slower transition has an advantage in that the existing assets are better used and the increase in electrical demand is a slower transition, but it may also add risk that the existing available electrical capacity is used by other sectors and when depot upgrades are required the upstream infrastructure cost may be considerably higher.

The procurement of fleet vehicles is often price sensitive to volume, and purchasing in lower numbers may result in longer lead times and higher costs.

The availability of suitable land for bus depots will get more difficult as time progresses and leaving this necessary step too late may result in the depot being a substantial distance away from the bus routes. This will increase the non-revenue portion of the run.

The other aspect to consider is that some skills for older technologies are already difficult to source and retain (such as coal-fire boilers) and ongoing operating and spares costs for older vehicles (such as pre-Euro IV) may escalate as they may be unsupported by manufacturers who transition to Euro VII and electric vehicles.

8.1.3.1.2 Accelerated Transition

An accelerated transition will help to meet the emission targets sooner and may provide an opportunity to procure the fleet under better terms, where manufacturers are looking for volume.

The installation and operation of the fleet would use a portion of the available electrical capacity and at present, allows selection of depot locations.

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9 https://transportation.ucla.edu/blog/5-environmental-benefits-sustainable-transportation#:~:text=Compared%20with%20driving%20alone%2C%20taking,atmosphere%20and%20improving%20air%20quality.

10 The current fleet is shown in section **Error! Reference source not found.** and only 3 of the existing 22 buses are planned for replacement within the next 3 years. Thus, a slow phased approach would only achieve 3/22*100= 14% improvement. The balance of the vehicles are only due for replacement in 2034, thus further improvement would come from the added new vehicles based on route demand increase.

At present, land appears to be available in the Coneburn area to house a larger bus depot for the predicted growth. It is uncertain how rapidly this land will be occupied by other interested parties, or how rapidly the available power will be utilised.

9. Recommendations

In this report, various bus technologies have been considered to decarbonise Queenstown's public transport service including battery electric, hydrogen fuel cell, biodiesel, hybrid, liquid natural gas and compressed natural gas. The following are key conclusions of this assessment:

- Liquid natural gas and compressed natural gas have been discounted as NZ has stopped gas exploration and development. They do not meet the zero tailpipe emission criteria;
- Battery electric buses are considered most suitable as the technology is ready and zero emission. Hydrogen fuel cell technology is zero emission; however, the technology is still being developed and not likely to be ready for implementation within the required timeframes. Biodiesel and hybrid are not considered suitable as they are not zero emission technologies;
- Battery electric buses and hydrogen fuel cell buses provide options that enable a dramatic reduction in the GHG and CACs emissions by the public transport sector. As the electrical energy sources and grids migrate even further to renewable and carbon-neutral options in NZ, this leads to the possibility of very minimal to zero upstream carbon emissions;
- Hydrogen fuel cell buses are still an uncertain quantity with early trials only just beginning and upstream equipment and infrastructure proving to be expensive. At present, NZ has limited hydrogen-related skills, but this may grow in the future. Unless hydrogen infrastructure significantly improves and the costs come down considerably, it is considered that hydrogen fuel cell buses will not a viable option in the short-term

Based on the assessment in this report, it is recommended to further consider battery electric buses as the preferred technology to achieve the decarbonisation objectives of the Queenstown Public Transport Business Case and to address the requirements of the Emissions Reduction Plan and other regional and local transport policies.

In progressing battery electric buses in the short term, identifying existing electrical networks and planning power grid and generation reinforcements that meet the challenges of the increased power demand is crucial, particularly as the capital deployment timelines for energy providers can be to two years or more if a site is selected that does not have suitable infrastructure in place.

Appendixes

Bus and ferry decarbonisation technologies investigation

Appendix A

1 Battery Electric Bus Details

1.1 Technology Overview

The Battery electric bus (BEB or eBus)'s construction shares some similarities with a conventional diesel transit bus. However, there are several vehicle systems which are impacted through the use of an electrical power train and energy storage system, as outlined below.

Table A1-1: System changes from diesel bus to battery electric bus

System	Diesel	Change to Battery Electric
Propulsion	Internal combustion engine, transmission, fuel system and exhaust after treatment.	Electronic traction motor, battery with energy storage system.
Windows, Structure & Exterior Body	Chassis, roof & side structures, undercarriage, windows.	More robust structure to support battery weight, roof structure, low centre of gravity (floor-mounted battery packs).
Electrical & Auxiliary	Low voltage system to power components, interior lighting, hydraulic & headlights	Similar auxiliary at similar voltages, but battery pack (typical) at 800 VDC.
Steering	Hydraulic power steering	Electric power steering
Brakes, Pneumatic & ABS Sensors	Friction braking system with brake callipers.	Regenerative braking system, partially recharges battery during deceleration
Wheels, Axles, Suspension	Pneumatic suspension front & rear, rear differential, standard wheel & tire size.	Rear-axle to be compatible with regenerative braking, higher axle & suspension rating to support
Air-conditioner HVAC	Diesel-powered heater	Electric heating (to reach zero emission)
Farebox & ITS	Fare payment equipment, communications and destination signs.	No significant changes, varied design depending on model.
Doors & Ramps	Bifold doors front & rear, manual or powered	No significant changes, varied design depending on model.
Interior	Passenger seating, stanchions, stop request, signals, etc.	Optimised weight of interior components to compensate for additional battery weight (i.e. plastic seats, plastic trims, carpets etc.)

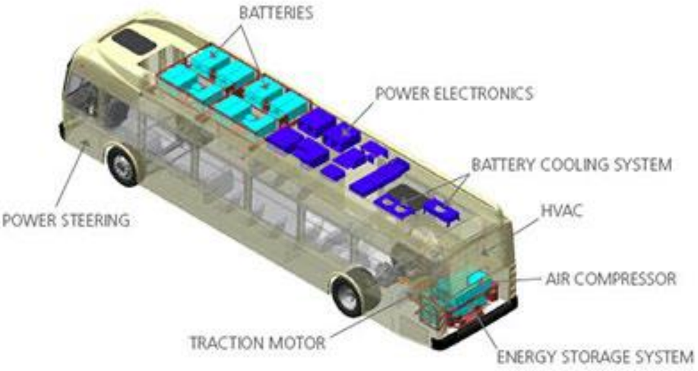

Figure A1-2 An example battery electric bus (BEB) components schematic

Note the battery packs may be stored in different locations depending on models, although they are typically located in the bus floor or roof.

BEBs adoption outside of China had been slow in the past due to the high acquisition cost, limited opportunities to aggregate demand for spare parts, required upgrade of electric grids and other relevant infrastructure. The acquisition cost, however, has decreased significantly in the last few years due to lower battery prices, which make up a large portion of BEB costs.

1.2 NZ Fleets

A number of NZ fleet owners have commenced transition of urban fleets to electric, including Transit NZ, NZBus and Howick & Eastern.

Bus suppliers include Yutong, BYD, CRRC and ADL amongst others. Fleet numbers are substantial and continuing to be added on a regular basis.

1.3 Australian Fleets

Similarly, a number of fleets have commenced transition, including Victoria (Transit[1]), Queensland (Kinetic[2])

2 Battery Types

2.1 Lithium-ion

The worldwide market for lithium-ion batteries (the most common battery type used in electric buses) is expected to continue growing. The market for lithium-ion batteries was estimated at USD $31.2 billion in 2016 and is forecasted to reach USD $67.7 billion by 2022 according to a 13.7 per cent compounded annual growth rate (CAGR)[3]. Some analysts are concerned that such large investment in lithium-ion batteries may crowd out other technological innovations (i.e. fuel cell technology)[4].

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1 https://www.greencarcongress.com/2022/06/20220606-vic.html

2 https://www.intelligenttransport.com/transport-news/134972/kinetic-electric-bus-depot/

3 Zion Market Research "$67.70 Billion for Global Lithium-Ion Battery Market at 13.70 per cent CAGR to 2022: Zion Market Research" Available at: https://globenewswire.com/news-release/2018/05/09/1499586/0/en/67-70-Billion-for-Global-Lithium-Ion-Battery-Market-at-13-70-CAGR-to- 2022-Zion-Market-Research.html

4 Brookings "Investment in lithium-ion batteries may crowd out future innovation" Available at:

The growth in this sector is being fuelled by a large spend in research and development to lower the price point and energy density (kWh/kg), which in turn will accelerate the adoption of battery electric vehicles/buses[5].

2.2 Other Chemistries

- Lithium Iron Phosphate (LFP): These batteries have a long life, are safer than other technologies (such as NMC), and are now very popular in the electric bus market. They are offered by manufacturers such as BYD , VDL , Volvo and EBusco . One of their disadvantages is their lower operating voltage (3.2 V/cell) and energy density (90-120 Wh/kg) which means that these batteries are heavier. In addition, their recharge speed is more limited than other technologies. These batteries have a charge rate limited to 1C , i.e. they can be charged at their rated discharge and hence it takes one hour to fully recharge them.

- Lithium nickel manganese cobalt oxide (NMC): These batteries are designed to have high energy density, or high power density. Nickel is known for its high specific energy but associated with low stability. Thus, by combining it with manganese, a denser spinel structure is formed which increases stability while offering low internal resistance. This chemistry is also popular with bus manufacturers, and used by New Flyer, and Nova Bus. The disadvantage of these batteries is that in the event of an accident, large quantities of toxic fumes are produced. In addition, this technology contains rare materials such as cobalt which have received a lot of attention in recent years due to the inhumane conditions in which they are mined (CBS News, 2018). Finally, this chemistry is generally more expensive than the LFP technology. One of the advantages of this technology over LFP is that it can be recharged faster, such as up to 1.5C .

- Lithium titanate (LTO): These batteries have been known since the 80s. Li-titanate replaces the graphite of the negative electrode. These batteries have the longest service life, as there are very few changes in their properties during operation. Thus, they can withstand high rates of charge and discharge. However, this technology also has a lower operating voltage at 2.4V/cell, so it is heavier. In addition, these technologies are expensive. They have been used by Proterra in the past.

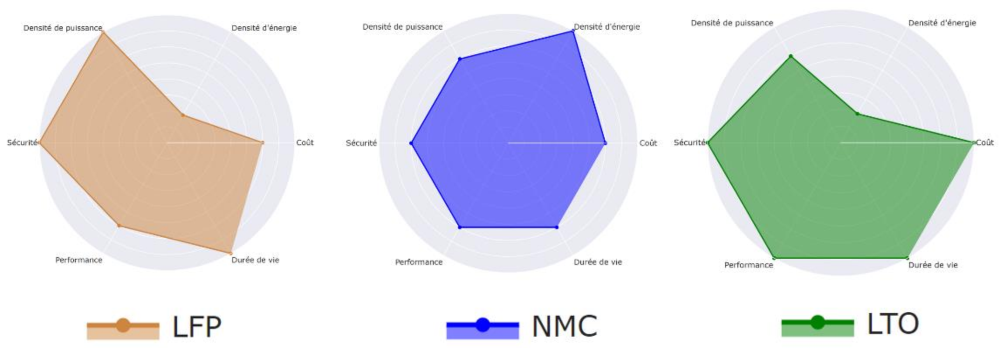

Figure A2-1 Illustrations of the types of chemistries and their characteristics available on the market for electric buses

2.3 Solid State Battery Advances

Battery technology is advancing rapidly with NASSA recently (2022) announcing their Solid-State Architecture Batteries for Enhanced Reliability (SABER) with discharge rates 10x higher factor and specific energy density at 500 watt-hours per kg[6] (Lithium batteries are typically around 35 wh/kg).

https://www.brookings.edu/blog/techtank/2016/10/04/investment-in-lithium-ion-batteries-may-crowd-out-future-innovation/

[5] https://www.brookings.edu/blog/techtank/2016/10/04/investment-in-lithium-ion-batteries-may-crowd-out-future-innovation

[6] https://www-independent-co-uk.cdn.ampproject.org/c/s/www.independent.co.uk/tech/nasa-battery-electric-planes-b2199312.html?amp

Another Lithium Metal Polymer (LMP) battery technology is also available and developed on the market, and used by Bluebus in France. Developed by Blue Solutions, a subsidiary of the Bolloré group, this battery is all-solid. For the moment, the deployment of these batteries in buses is limited, but they have a very strong potential due to their long life, high stability, safety, lower prices and high density. In addition, they do not contain nickel or cobalt, therefore no rare metals, and are therefore easily recyclable. By using a solid electrolyte, the use of liquid electrolyte which could leak, could be toxic and flammable could all be avoided. Cell production is also simplified[7] .

Similarly, Toyota has announced the launch of its new battery model which also uses all solid technology and promises a range of 500 km, safe operations for their new electric vehicles, and a recharge in ten minutes, or up to at 13.2 c[8] (Where "c" is the discharge rate of the battery).

2.4 Structural Batteries

These are batteries that can be used as structural elements in a vehicle and hence reduce weight. They are typically considered as solid-state batteries (see above) and are still in the development stage.

3 Battery Pricing

According to recent survey by Bloomberg New Energy Finance (BNEF), battery prices for automotive and light duty vehicles, which were above USD $1,100 per kilowatt-hour in 2010, have fallen 87 per cent in real terms to USD $156/kWh in 2019[9] (in the light duty commercial automotive sector). These reductions in 2019 were due to increased order size, growth in battery electric vehicle sales and the continued penetration of high energy density cathodes. The introduction of new pack designs and falling manufacturing costs are also expected to drive prices down in the near term. By 2023, average prices will be close to USD $100/kWh. As cumulative demand passes 2 TWh in 2024, the prices will fall below USD $100/kWh, making the energy cost and density of battery-electric on par with diesel and gasoline for conventional light-duty vehicles. The prices may be higher for transit fleets as they require more heavy-duty applications, although the same reducing cost trend is expected for these battery packs.

New chemistries, such as sodium-sulphur, are expected to reduce the dependence on lithium for industrial and grid-connected options in the short term[10], and as they increase in specific energy density, may also reduce lithium/cobalt reliance in the transport sector as well[11], [12].

[7] https://www.blue-solutions.com/app/assets-bluesolutions/uploads/2021/04/bsol_2102265_brochure_16_pages_fr_mel.pdf

[8] https://asia.nikkei.com/Spotlight/Most-read-in-2020/Toyota-s-game-changing-solid-state-battery-en-route-for-2021-debut

[9] https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/

[10] Elio, J.; Phelan, P.; Villalobos, R.; Milcarek, R.J. A review of energy storage technologies for demand-side management in industrialfacilities.J. Clean. Prod.2021,

[11] AL Shaqsi, A.Z.; Sopian, K.; Al-Hinai, A. Review of energy storage services, applications, limitations, and benefits. Energy Rep.2020,

[12] Wang, Y.; Pan, W.; Luo, S.; Zhao, X.; Kwok, H.Y.H.; Xu, X.; Leung, D.Y. High-performance solid-state metal-air batteries with an innovative dual-gel electrolyte .Int. J. Hydrogen Energy 2022

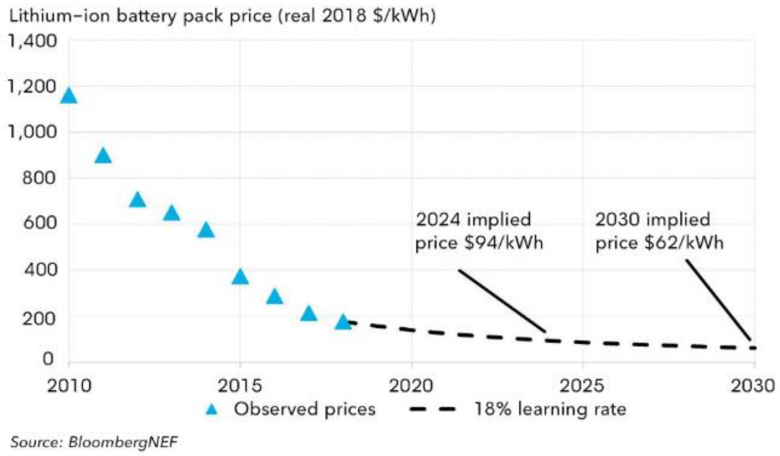

Figure A3-1 Lithium-ion battery price outlook

The energy density of batteries has also been improving at a quick pace of approximately 6–8 per cent per year following an exponential trend[13]. Solid-state electrolyte, often seen as one of the technologies with the most disruptive potential inside lithium-ion, is currently being explored to increase the energy density of a cell by over 40 per cent and improve battery safety[14].
Due to the falling battery prices and improved battery energy density, electric bus manufacturers are constantly improving the range on their buses. The trend is to focus on plug-in depot charging to eliminate the need for on-route charging in the near future as these on-route charging stations have a high capital cost (est. $1 million), which risks becoming obsolete infrastructure as battery technology improves in the future.

4 Battery Alternatives

4.1 Supercapacitors

Ultra-capacitors, also called supercapacitors, are electrochemical storage elements which make it possible to obtain a higher power output than batteries for a short period, but currently have a greater decay rate (so cannot store power for extended durations.) They also currently have a low specific energy density but can withstand higher voltages.
Supercapacitors can provide high power for a short period of time. Correspondingly, supercapacitors are postulated to be the potential replacement for batteries due to their excellent power density which reduces the charging period, longer cycle life than batteries, ability to sustain overuse and is environmentally friendly compared to batteries. However, supercapacitors lack in energy density compared to batteries; thus, it is often used as a short-term energy storage device[15].

4.2 Supercapacitor Application

Various projects and studies are underway (including Tesla/Maxwell) in the development and deployment of supercapacitors in hybrid electric vehicles, which would make it possible to improve the autonomy and charge rate of the vehicles. The “Hyheels” project (Hybrid High-Capacity Electric Energy Storage)[16] in Europe between aimed to create a system of ultra-capacitors for use on board hybrid battery and fuel cell vehicles. Development work included optimizing the capacitor's electrical properties, grouping it into modules that include integrated power balancing, power prediction, and powertrain communication interface. The results of this research, which also included a benefit-cost analysis and modelling, validated by tests, were conclusive, but no commercial adaptation seems to have been made following the finalization of the project.

13 The energy-storage frontier: Lithium-ion batteries and beyond (Crabtree, Kocs and Trahley)
14 https://www.adlittle.com/sites/default/files/viewpoints/adl_future_of_batteries-min.pdf
15 Brief review on construction and enhancements of supercapacitor, Peerhaana et al, 2022 https://www.sciencedirect.com/science/article/abs/pii/S2352152X22006156#!
16 https://cordis.europa.eu/project/id/518344/reporting/es

5 Electric Vehicle Trends

The recent expansion of electric vehicles into the 3 – 5 tonne trucks and further heavy goods vehicles is also expected to drive electronic and battery technology development and indirectly pricing and availability. This also has the advantage of improving the research into wheel hub motors, which whilst not currently widely used in transit vehicles shows promise for the near future. This in turn reduces weight by removing a transmission component.

6 Charging Infrastructure

Charging stations can be applied in various combinations to suit a route, a city and an operator's needs. The amount of charging needed also varies with route length, topography and weather conditions it operates in.

6.1 Charging Locations

Charging can either be done at end-point (in depots) or on-route (during stops or layovers). End-point or depot charging is the most common as it minimises and centralises the infrastructure upgrade to only the depot. BEBs with large battery capacities can generally operate with only requiring depot charging. Depot charging is the only type of charging currently being used in Australia for both BEB trial and regular operations due to its relatively lower upfront capital and planning cost and ease of implementation, as it is generally located on property already owned/leased by a transit operator.

Enroute or opportunity charging charges BEB while travelling to rapidly boost the charge of on-board batteries. This charging technique is used to extend the range of BEBs without additional energy storage burdens of battery weight and cost. Compared to depot charging, opportunity charging requires significant planning and approvals due to disparate locations of these charges. It has much higher capital costs for infrastructure and requires setting aside limited street space for chargers, as well as associated planning and approval requirements and electrical infrastructure upgrades. In addition, having bus fleets charging at random or during demand peak hours on the grid could be challenging to manage for grid operators.

6.2 Charger Types, Technology

6.2.1 AC slow charging, plugin

This technology uses an AC charger to recharge the Battery Electric Bus. As this technology uses Alternating Current the operator avoids voltage loses that are inherent in DC technology. This allows for more flexible on-depot cabling infrastructure as minimising distance from the transformer is not as important. However, AC charging does require the bus to have converter technology on board increasing the weight of the bus.

6.2.2 DC slow charging, plugin and pantograph enabled

This technology uses a DC charger to recharge the bus battery which has the advantage of not requiring an on-board converter and saving bus weight. The definition of slow charging in this context is a maximum of 150 kW charger with one dispenser.

6.2.3 DC fast charging compatible, plugin or pantograph

This option considers DC charging of 300-350kW to recharge. However, this also considers the use of 'ultrafast' charging up to a 600 kW charger with one dispenser as a means to quickly top up the fleet to maximise operational range over a day. Overnight charging can be in the "slow charge" range from the same charger to avoid excessive battery degradation from fast charging.

6.3 Megawatt Charging System (MCS)

In parallel with batteries that can be charged faster, the charging standards have evolved and the Megawatt Charging System (MCS)[17] allows charging of up to 1250 volts and 3,000 amp DC charging to ISO/IEC 15118-20 standards whilst still being a manually touch-safe process (UL2251). In effect, this focuses on Class 6, 7, & 8 commercial vehicles, buses, ferries, aircraft, or other large battery electric vehicles (BEVs) with huge battery packs and ability to accept a >1MW charge rate[18].

6.4 Swappable Batteries

This option considers the use of an emerging swappable battery technology. While the fleet is out in operation a series of extra batteries remains at the depot (and potentially at other strategic locations throughout the network) to be fully charged. As buses return to the depot, depleted batteries can be replaced quickly with fully charged batteries. The charging methodology (AC, DC, Fast, Slow) is not the main consideration as the assessment is for the platform overall.

The manual handling and chassis requirements for this can be accommodated in heavy goods vehicles, but is less favourable in a bus.

6.5 NZ Fleet Selection

Typically, in NZ, DC slow (overnight) charging has been selected by fleet owners as it is less capital intensive and can be used across a variety of public transport vehicles.

6.6 Charger Types, Connection

Three types of chargers are used by BEB fleets:

- Plug-in,
- Pantograph
- Inductive chargers (less common).

6.6.1 Plug In

Direct plug-in charger is the most broadly implemented and cost-effective charger type. They are considered safe, easy to use and efficient, requiring lower input voltages than rapid on-route chargers. Charging times vary based on the vehicle's power storage capacity, charger electrical parameters, and the distance covered by the bus since its last charge (current state of charge). Current manufacturers of plug-in charging stations include ABB and Siemens with input power on the charging station models ranging from 175 up to 460 kW[19].

6.6.2 Pantograph

Pantograph charging is a process by which electric vehicles are connected via automated pantograph to a high-voltage power source to reduce charging time, using charging stations with power supply ranging from 150 kW to 600 kW. The pantograph can be mounted onboard the bus (onboard pantograph) or on the charger (inverted pantograph). On-board pantograph simplifies charging stations but makes the bus chassis structure more rigid. The positioning accuracy can also impact the charging efficiency. Inverted pantograph, on the other hand, will simplify the bus, making it more compact for operations and maintenance and reducing the fleet price; this will, however, increase the charging infrastructure price. Some manufacturers and designers of on-route charging solutions currently exist including Siemens and ABB.

Currently, a standard for this charging technology is being developed by the Society of Automotive Engineers (SAE) to ensure interoperability across vehicle types (SAE J3105)[20]. In Australia, Brisbane

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17 https://www.charin.global/technology/mcs/
18 https://www.charin.global/news/mcs-launch-at-charin-na-conference-and-testival/
19 https://new.abb.com/ev-charging/products/car-charging/high-power-charging
20 https://www.sae.org/news/2020/02/sae-j3105-promotes-safe-charging-for-buses-and-heavy-duty-vehicles

Metro plans to use ABB's flash charging technology[21] (high power 600 kW on route charging for short bursts of time ~ 15 seconds) of time to charge its bi-articulated electric bus set for trial in 2020. ABB claims their technology can charge buses at the end of the route in under six minutes, although the range of each charging cycle is still unclear.

6.6.3 Inductive

Inductive charging uses induction power transmitters in the floor slab to communicate power to a vehicle parked over top of it, as shown in Figure 2.4. Buses are equipped with induction power receivers, allowing for power transmission without cables or an actuated contact surface such as a pantograph. Reported charging rates using inductive charging is akin to those achieved using wired connections. Inductive charging presents an appealing alternative due to the operational simplicity and low risk in connecting and disconnecting charging circuits. WAVE (Wireless Advanced Vehicle Electrification Inc.) is a manufacturer that develops high power wireless charging stations for electric vehicles, including transit and shuttle buses. WAVE charging systems rely on inductive charging and can transfer power at rates of 50 kW and 250 kW.

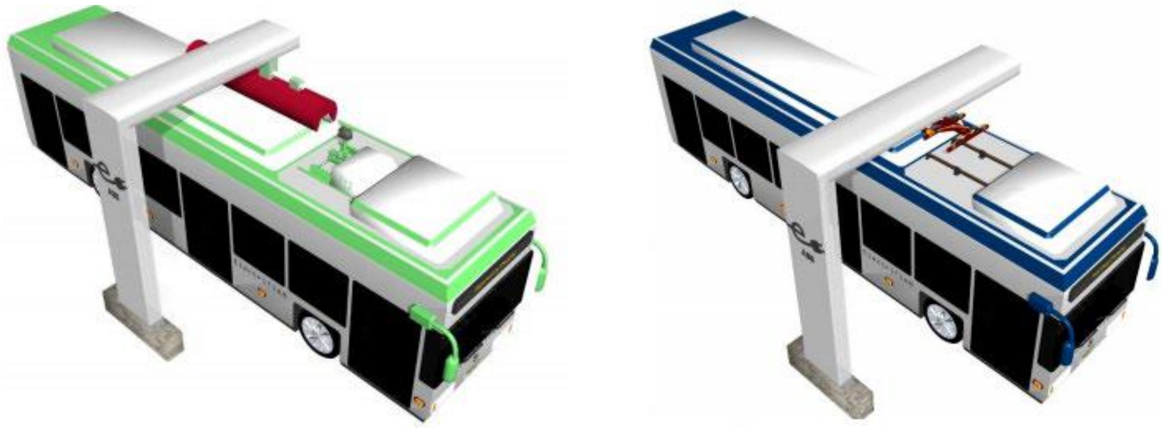


Figure A6-1 Onboard pantograph (left) and inverted pantograph (right) examples[22]

Currently, a standard for this charging technology is being developed by the Society of Automotive Engineers (SAE) to ensure interoperability for vehicles (SAE J2954/2[23]). In North America, Chinese manufacturer BYD plans to install the largest wireless vehicle charging network to date in partnership with Philadelphia-based Momentum Dynamics and Indianapolis' public transport system, Indygo. Three high-powered, wireless inductors will be installed to deliver 300 kW charging, allowing 24 hour-a-day, 7-day-a-week operation. Compared to other charging, however, inductive charging solutions are still in the early stages of commercial development and implementation. It also carries significant capital costs to retrofit applications.

[21] https://search.abb.com/library/Download.aspx?DocumentID=9AKK106713A9042&LanguageCode=en&DocumentPartId=&Action=Launch

[22] https://ecv-fi-bin.directo.fi/@Bin/66961f488c73b17986090df6cbfcdb77/1587938359/application/pdf/215749/19_16_NEBI2_Session5_M%c3% a4kinen_ABB.pdf

[23] https://www.sae.org/standards/content/j2954/2/

Figure A6-2 Concept design for inductive charging

6.7 NZ Fleet Charger & Plug Selection

Typically, in NZ, plug-in charging has been selected by fleet owners as it is less capital intensive and can be used across a variety of public transport vehicles. A standard plug-in connector has been used and is commonly a CCS type 2 (Amphenol or similar) and CHAdeMo DC for Japanese influenced systems.

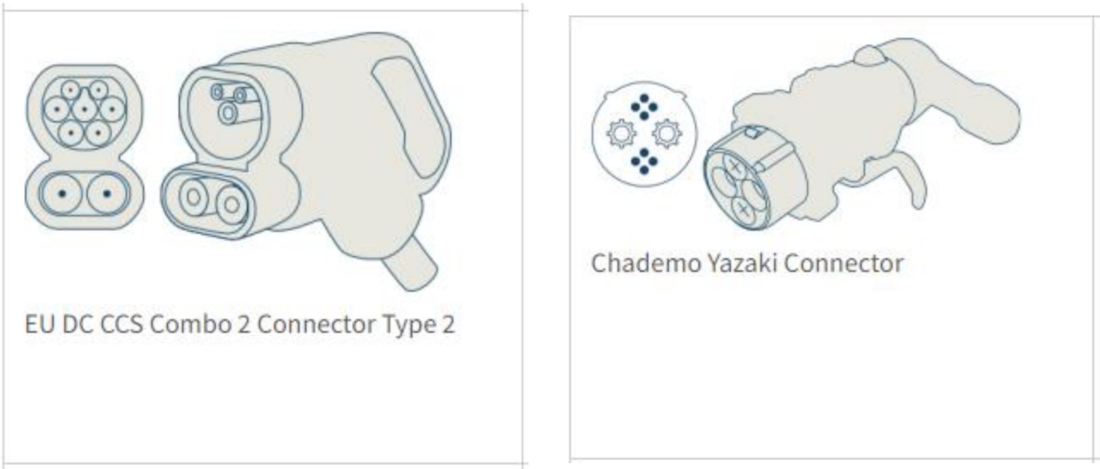


Figure A6-3 CCS Type 2 (Left) and CHAdeMO (Right) [24]

7 Depot Infrastructure

The depot infrastructure requirements to accommodate the BEB fleet will need to be considered, in particular existing depots' space constraints to accommodate the additional infrastructure associated with a BEB fleet. Depots will need to facilitate BEBs charging as well as maintenance operations.

[24] https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/charging-point-connectors-and-socket-outlets/

Depending on the fleet size, charging type and charging schedule, a large part of a depot may need to be dedicated to charging bays unless a separate charging station is available. To support the charging of BEBs, the electrical distribution system of existing depots will need to be upgraded such as transformers and switchboards. Additional electrical equipment will be required if electrical system redundancy is required to ensure reliability of power supply to charge the BEBs in the event of a grid outage. Companies such as The Mobility House offer charging and energy management system to manage loads and bill for BEB charging processes at the depot.

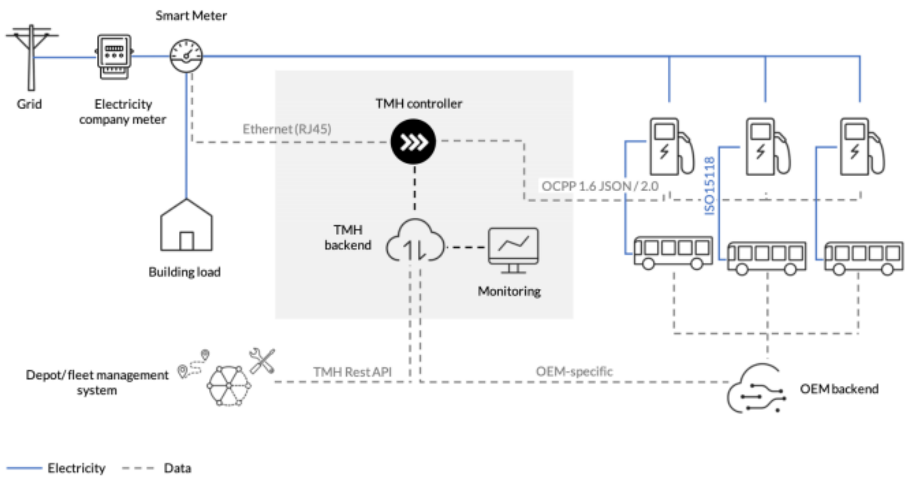


Figure A7-1 Systematic design of charging and energy management system by The Mobility House[25]

Maintenance needs of BEBs are also different from diesel bus. Although routine maintenance is expected to become less frequent, depots may need special tools to service BEBs, such as overhead platforms so that mechanics can reach components that are increasingly placed on the bus roof.

During the transition, operating and maintaining with multiple sets of fuelling or charging infrastructure may result in more space and planning requirements, which might impact the availability of space for other fleet types.

8 Maintenance And Operational Challenges

8.1 Operation

Given the varying ranges of BEBs, the deployment of this technology must consider many factors including route length, topography, average passenger load, weather and ambient temperature, etc. These calculations can be analysed using WSP's BOLT (Battery Optimization Lifecycle Tool) simulation platform, which will be discussed in the Scoping, system design and feasibility report. Compared to other battery electric vehicle types, buses have strict operation tasks, and their charging demand is rigid. The charging demand must be fulfilled at the time when needed, otherwise, bus operations will be disrupted.

Two charging strategies can be considered by the operator. The first strategy is charging BEBs as long as they are not in operation, even if the battery power is still high. The second, and more common, strategy is to charge BEBs when the power is low to minimise charging trips. The amount of charging needed, however, may vary depending on the weather and number of passengers the bus carried on a given day. Wherever the bus is charged, the facility will need to

[25] https://www.mobilityhouse.com/media/productattachments/files/White-paper_Smart-Charging-for-Electric-Buses.pdf

have a plan to deal with power outages. As the fleet becomes larger with multiple bus models operating at the same time, the charging system will require inter-operability of charging technology from their suppliers.

Once the routes to be electrified are decided, drivers need training to ensure optimal operation of the vehicles, which will result in increased efficiency, extended battery life and reduced maintenance.

In addition, consideration of on-route charging technology on the longer routes and blocks, can extend the operational range of the BEBs, and allow them to complete revenue trips over longer distances and durations. However, this would require the scheduling challenges of building sufficient layover time for the charging to occur (typically 5 to 15 minutes), which would impact overall service operations. As mentioned above, the range of an electric vehicle is greatly influenced by external factors, including weather conditions (extreme hot and cold weather), driver behaviour with braking and acceleration, passenger load and road conditions such as traffic and the quality of the road. The range of the vehicle is also impacted by the age and state of the battery. With every charging and discharging cycle, the battery ages and degrade. This phenomenon has three main impacts:

- The available capacity of the battery is reduced, which reduces the output power it can deliver
- The efficiency of the battery is reduced, which reduces the output power it can deliver
- The internal resistance of the battery increases, which increases charging time.

These can have an important impact on BEB operations, as the range is reduced, and the idled time required to charge the BEB is increasing. The impact of battery degradation is an important factor for consideration when planning operational requirements for route serviceability.

8.2 Maintenance

Bus electrification will require people in the bus industry to have new skills in procuring and maintaining the fleet as BEBs have a lower range, require longer refuelling time (assuming using plug-in chargers) and have different and fewer maintenance needs compared to their diesel counterparts.

Compared to diesel buses, BEBs are expected to have lower routine maintenance costs due to their fewer and less moving components (e.g. an absence of a large transmission system and direct transfer of power from traction motor to axles). Annual brake maintenance costs are also expected to be lower for electric buses, owing to the regenerative braking systems. Further bulk fluids such as transmission and engine oil are no longer needed in electric buses, along with exhaust and after treatment costs. This will result in reduced maintenance and part costs, although there is a risk of higher overall lifecycle costs if major systems fail and require an overhaul (e.g. the traction motor). These benefits may be further capitalised upon once more mechanics are familiar with the new electric systems, although this is still unproven as Australia has not seen an electric bus completing a lifecycle.

The major overhaul activities required for BEBs vary based on the adopted lifecycle of the buses and would typically entail a battery swap after the initial battery capacity has faded below the first life threshold (ex. 80 per cent initial capacity). Traction motors are typically not required for overhaul for shorter bus lifecycles.

Typically, bus OEMs provide maintenance training to their clients as part of the bus purchase price along with including all related operating and maintenance manuals. Training requirements can be specified in the RFP procurement process and contract negotiations. If additional training is necessary, it can be provided through a third-party institution.
Maintenance training shall focus primarily on the electrical systems of the bus, as most non-electrical components are similar to those on a diesel bus. While the amount of necessary training

will depend on the particular bus and OEM it should cover the basics of working with electric propulsion (traction motors), inverters and batteries. In the case of electric vehicles operating on a fuel cell (hydrogen), it should also cover the safe refuelling practices and maintenance around the fuel cell and storage tanks. Training should also include the required safety procedures for working with high voltage electrical components, correct usage of personal protective equipment (PPE) and specialised tools. Once a primary group of personnel have been trained, they can train additional mechanics and operators.

New standardised maintenance procedures will be needed regarding the lockout/tagout procedure for battery removal and other high voltage components along with putting a dedicated service line in place. Process flow maps need to be developed clearly illustrating the differences in maintenance practices between electric and diesel buses. In addition, similar standardised operating procedures and training need to be developed for charging infrastructure at depots an on- route working with respective OEMs.

Training should be provided for emergency responders and utility workers such that in the event of an accident involving an electric bus these personnel are aware of the potential high voltage and chemical hazards associated with electrical buses. They should have mitigation strategies and a safe response procedure in place.

As the electrical system on BEBs carries significant voltage and can supply enough current to injure or kill a person, OEMs may mandate that faults or concerns related to the high voltage side of the bus be reported directly to them for report, unless the depot maintenance team is equipped and well-trained to deal with high voltage system.

Maintenance of electrical buses can require specialized tools in order to service the more complex and high voltage electrical systems which are not present on a diesel bus. These systems included battery packs, inverters and electric motors (Traction motors) and require specialised tools and PPE.
Further detail can be made available as required.

8.3 Lessons Learnt from Other Trials

The following lessons learnt have been compiled from a number of pilot projects and implementations:

- Energy losses were significant (reactive power is close to 10%).
- Electric buses require less maintenance and were easier to maintain than initially expected.
- It is of the utmost importance to adhere to the manufacturer's specifications.
- The energy efficiency of the electric bus was as expected.
- Bus availability was over 80%. Outages were more often caused by non-electrical components, such as windscreens or doors.
- Charging management is a key element in optimizing operations and operating costs
- A one-for-one replacement (an e-bus replacing a diesel) does not work; the operation needs to be redefined.
- When scheduling on energy consumption a number of scheduling issues may be uncovered.
- Depot layouts had to be reviewed to enable consistent charging and avoid damage to charger leads.
- Interoperability between multiple bus brands was a key requirement for the charging infrastructure.
- Batteries are reliable. Manufacturers' technical specifications can be taken for granted.
- Some special technical specifications must be agreed on with manufacturers depending
- on charging operations, tank design, etc, for example, the location of the connector.

- Long routes (over 300 km depending on topology) may need opportunity charging or new technologies such as H2.

Appendix B

Hydrogen-Electric Bus Details

9 Technology Overview

A hydrogen fuel cell electric bus (FCEB) is powered by electricity that is produced from the reaction of pressurised hydrogen gas stored in a tank, with oxygen from the air, resulting in clean water vapour or steam as the by-product.
As compressed hydrogen has a higher energy content, FCEBs can achieve a greater operating range with energy per unit mass, resulting in vehicles with a greater operational range compared to BEBs.
Hydrogen fuel cell technology has been used in buses since the early 2000s. However, it has not gained as much popularity as battery-electric technology because hydrogen is relatively more complex and expensive to store, transport and create. However, recent advances show that the technology may become more efficient—already, hydrogen fuel cell can convert fuel into kinetic energy at roughly 60 per cent efficiency compared to traditional internal combustion engine's 25 per cent efficiency . The cost of hydrogen is also coming down globally due to improvements in water electrolysis and hydrogen fuel cell technology.

9.1 NZ Vehicle Availability

Currently fuel cell vehicles are not easily available for purchase – to our understanding, they can only be leased. At present there is one prototype hydrogen fuel cell bus under trail in Auckland.

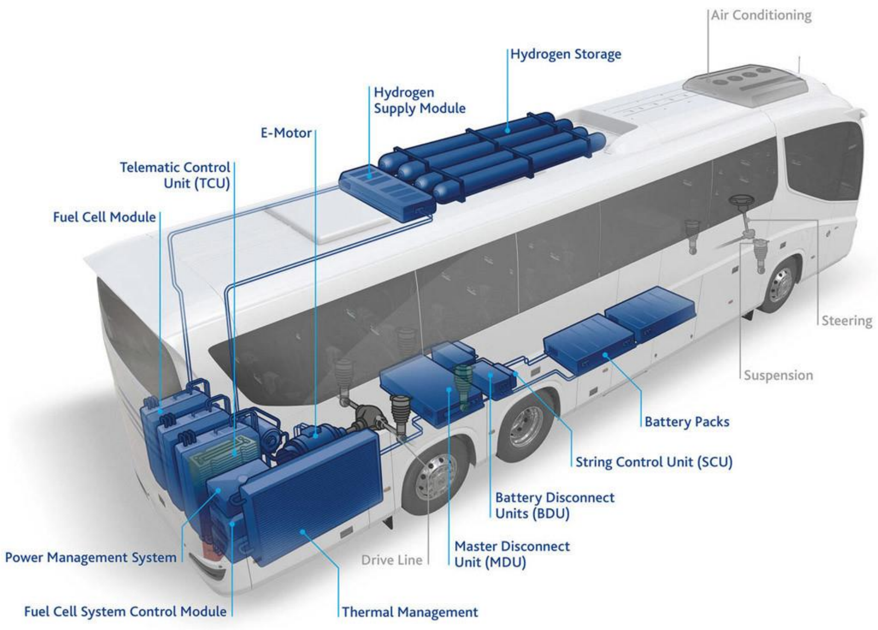


Figure B9-1 Concept design FCB [26]

The FCEB's construction shares some similarities with a conventional diesel transit bus.

[26] https://tomorrow.city/a/roads-with-less-fumes-hydrogen-fuel-cell-buses-for-long-distance-routes

Table B9-1 : System changes from diesel bus to hydrogen fuel cell bus

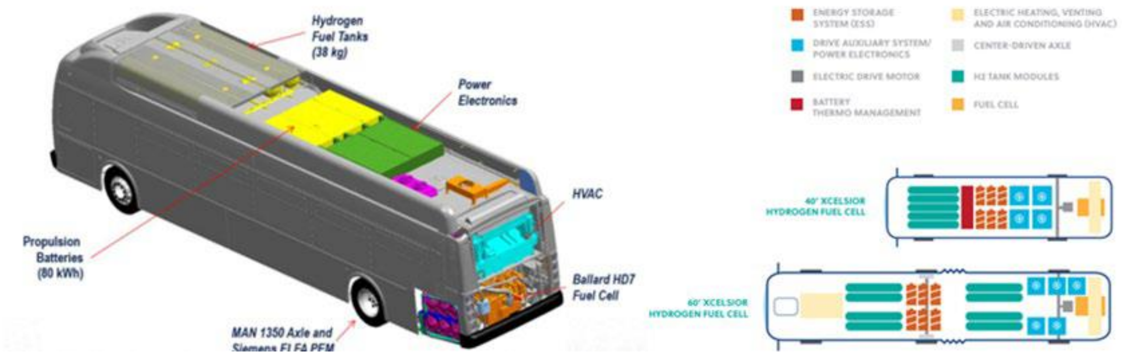
System	Diesel	Change to Hydrogen Fuel Cell
Propulsion	Diesel engine, gearbox, differential and axle.	Electronic traction motor, battery with energy storage system (ESS), fuel cell stack for reaction and electrical power output
Fuel Tank	Liquid fuel tank	Pressurised tank connected to regulated supply line into an on-board fuel cell
Windows, structure & Exterior Body	Standard coachworks	More robust structure to support battery weight, roof structure, pressurized fuel tanks, fuel cell stack and power electronics27
Electrical	Typically, 12 or 24 volt system for auxiliary services.	Additional high voltage power electronics to manage battery charging, regenerative braking, fuel cell stack electronics, and traction motor operation
Steering	Hydraulic power steering	Electrical power steering system.
Brakes, Pneumatic ABS sensors	Friction braking system with brake callipers	Regenerative braking system, partially recharges on board battery during deceleration
Wheels, axles, suspension & differential	Pneumatic suspension front & rear, rear differential, standard wheel & tire size	Rear-axle to be compatible with regenerative braking, higher axle & suspension rating to support battery weight and fuel cell systems
Airconditioning/HVAC	Diesel-powered heater.	Electric heater (to reach zero tailpipe emissions
Farebox & ITS	Fare payment equipment, communications and destination signs.	No significant changes, varied design depending on model
Doors & Ramps	Bifold doors front & rear, manual or powered ramp deployment.	No significant changes, varied design depending on model
Interior	Passenger seating, stanchions, stop request,	Optimised weight of interior components to compensate for additional battery weight and fuel cell systems weight (i.e. plastic seats, plastic stanchions).

Unlike traditional combustion technologies that burn fuel, fuel cells undergo a chemical process to convert hydrogen-rich fuel into electricity following these steps:

- Compressed hydrogen gas is stored on-board the vehicle in pressurised tanks as the fuel source of the bus.

[27] FCEB's curb weight is comparable to BEB curb weight

- Hydrogen gas travels from the storage tanks through a regulated supply line into an on-board fuel cell.
- Hydrogen gas released into the fuel cell undergoes reacts with oxygen (oxidation process) to generate an electrical current that power the powertrain, producing water vapour as a by-product.
- The electrical current is then either stored within a battery or energy storage system (ESS) or sent to the traction drive motor used to propel the vehicle. An FCEB can also function with regenerative braking similar to a BEB and store this energy in the on-



board batteries.

Figure B9-2 An example of hydrogen fuel cell electric bus (FCEB) components schematic

Hydrogen fuel cell is currently costlier to run than diesel and other alternative technologies, but estimates suggest that the technology will become comparable to other alternatives from a whole of life cost perspective in the long term where a separate entity has subsidised/built the upstream infrastructure.

Hydrogen can be sourced from natural gas, oil, coal and electrolysis of water. Transit agencies can choose to source the hydrogen in whichever way makes the most environmental and economic sense for them; however, to minimise carbon footprint and ensure renewable supply of hydrogen, electrolysis is the most preferred process as the hydrogen comes from water.

The production costs of hydrogen from electrolysis are influenced by various technical and economic factors such as capital requirements, conversion efficiency, electricity costs and annual operating hours. Currently, capital requirements are in the range of USD $500–1,800/kWe for alkaline and PEM (polymer electrolyte membrane) electrolysers. The electrolyser stack is responsible for over half of the capital costs with power electronics, gas-conditioning and plant components account for most of the rest of the costs. The future cost will be influenced by innovations in the technologies themselves (for example, the development of less costly materials for electrodes and membranes), and by economies of scale[28]. Larger electrolyser projects are still needed to demonstrate accelerated scale-up

Once hydrogen price decreases, the cost competitiveness of FCEB will depend on the cost of the fuel cell stack and the cost of onboard storage. The cost of FCEB is less dependent on battery prices because, although FCEB needs batteries to store electricity, they require significantly smaller battery capacity than BEB[29].

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[28] The Future of Hydrogen (IEA, 2019) https://webstore.iea.org/download/direct/2803

[29] http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhs-hydrogen-for-transport-report- 2019.pdf

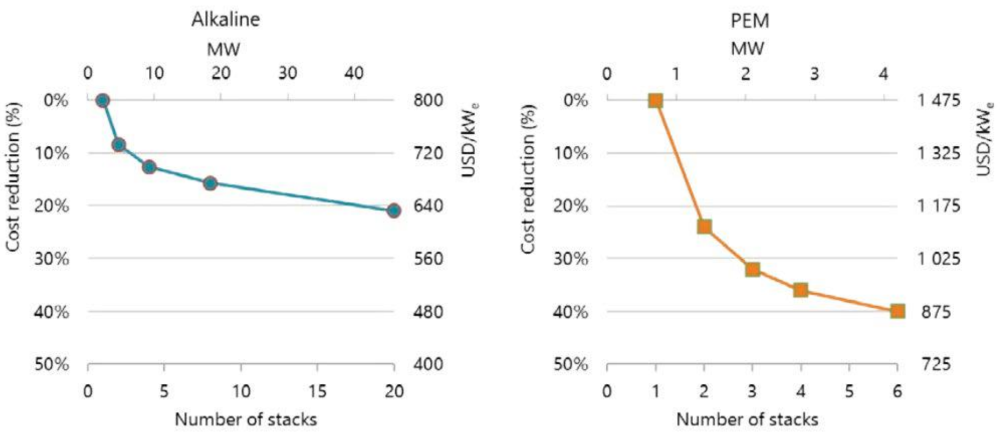

Figure B9-3 Expected reduction in electrolyser CAPEX* from the use of multi-stack systems.

*Based on a single stack size of 2 MW for alkaline electrolysis and 0.7 MW for PEM electrolysis[30]

10 NZ Hydrogen Production

In NZ, hydrogen production is in its infancy and will be aimed at heavy goods vehicles travelling in excess of about 550km per day, requiring two drivers to provide any advantage over an electric vehicle and a fast charger.

10.1 Hydrogen Cost Estimates

Hydrogen production cost is typically calculated using the concept of levelized cost[31]. A sensitivity analysis, cost reduction scenarios, and the implications for truck ownership costs should also undertaken, as proposed by Lazard.
The calculated levelized hydrogen cost is NZ$ 8.42/kg[32], but to be economically viable needed to be approximately below NZ$3.44/kg and ideally should be approximately NZ$2.00/kg to fully replace diesel. Electricity cost was found to be the most significant cost driver for green hydrogen production.

This can only be achieved with substantial upstream investment, both in generation of electricity and electrolysis to produce the hydrogen, followed by large infrastructure to store and distribute the hydrogen gas.

11 Hydrogen Use Case

Studies by various research companies, such as Roland Berger[33] indicate that the use case for hydrogen (assuming the infrastructure, generation and distribution is constructed and in place) would suite the following in order of priority:

1. Long-haul logistics (4x2 Tractor) running over 140,000 km per year and more than 570 km per day. The expected configuration would be a Sleeper cab with two drivers, hauling perishable high value items.
2. Wholesale trucking (6x2 rigid) running over 95,000 km per year and requiring high cargo carrying weight capacity.

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30 https://webstore.iea.org/download/direct/2803
31 https://www.lazard.com/media/451779/lazards-levelized-cost-of-hydrogen-analysis-vf.pdf
32 Analysis of the levelized cost of green hydrogen production for very heavy vehicles in New Zealand, Rapha Perez, Victoria University, Wellington
33 Fuel Cells Hydrogen Trucks, December 2020, EU and Roland Berger, Yvonne Ruf et al.

In most cases examined, the fuel cell vehicles (in spite of the assumed future improvements in efficiency and scale volume benefits) still shows a higher operation, energy and fuel cost when compared to battery electric vehicles[34].

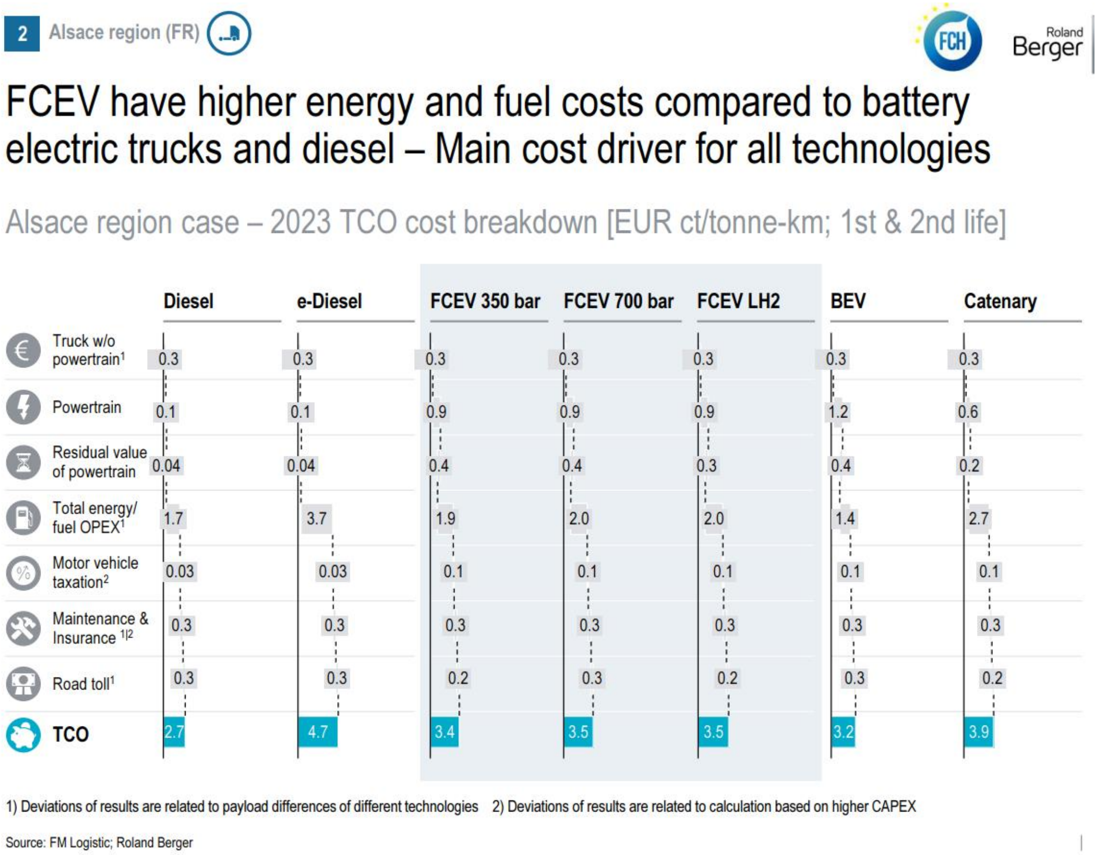

Figure B11-1 Sample Energy and Fuel costs by Fuel type [35]

12 Policies and Legislation

It should be noted that NZ does not currently have a complete set of policies or legislation in place to deal with bulk hydrogen. This is currently being worked on but has not been promulgated.

[34] https://www.hydrogeninsight.com/transport/opinion-battery-electric-trucks-will-be-three-times-cheaper-to-run-than-hydrogen-models-and-be-able-to-perform-all-the-same-tasks/2-1-1365662

[35] Fuel Cells Hydrogen Trucks, December 2020, EU and Roland Berger, Yvonne Ruf et al.

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A summary of relevant regulations at <u>Commonwealth</u> level is shown below.

Commonwealth	
Legislation and standards that are directly applicable to the development of the hydrogen industry	**Legislation and standards in respect of potential environmental impacts**
• *Australian Energy Market Act 2004* • *Fuel Quality Standards Act 2000* • *Greenhouse and Energy Minimum Standards (Registration Fees) Act 2012* • *Greenhouse and Energy Minimum Standards Act 2012* • *Greenhouse and Energy Minimum Standards Regulation 2012* • *Marine Order 17 (Chemical tankers and gas carriers) 2016* • *Marine Safety (Domestic Commercial Vessel National Law) Act 2012* • *National Construction Code 2019* • *Renewable Energy (Electricity) (Large-scale Generation Shortfall Charge) Act 2000* • *Renewable Energy (Electricity) Act* • *Renewable Energy (Small-scale Technology Shortfall Charge) Act 2010* • *Road Vehicle Standards Act 2018*	• *Building Energy Efficiency Disclosure Act 2010* • *Building Energy Efficiency Disclosure Regulation 2010* • *Environment Protection and Biodiversity Conservation Act 1999* • *Environment Protection and Biodiversity Conservation Regulations 2000* • *Navigation Act 2012* • *Navigation Regulation 2013* • *Offshore and Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* • *Product Emissions Standards Act 2017* • *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* • *Protection of the Sea (Prevention of Pollution from Ships) Regulations 1994*
Legislation and standards that are required to ensure the safety of the hydrogen industry	**Economic effects and access**
• *Australian Dangerous Goods Code* • *Carriage of Goods by Sea Act 1991* • *Industrial Chemicals (Notification and Assessment) Act 1989* • *National Greenhouse and Energy Reporting Act 2007* • *National Greenhouse and Energy Reporting Regulations 2008*	• *Australian Energy Market Act 2004* • *Australian Transport Assessment and Planning Guidelines* • *Competition and Consumer Act 2010* • *Excise Act 1901* • *Excise Tariff Act 1921* • *Fuel Tax Act 2006* • *Industry Research and Development Act 1986*

Figure B12-1 Legislation relevant to the hydrogen industry[36]

13 NZ Hydrogen Trials

In NZ, only Auckland Transport currently has a hydrogen bus under trial and the Ports of Auckland hydrogen trial was cut short after issues with hydrogen supply, hazardous regulations and compliance.

Hiringa Energy Ltd is planning to roll out a "triangle of hydrogen refuelling points," but focussed on heavy freight trucking. Public transport is seen as a secondary user and in some cases may not meet the required range demand to meet the business case pre-requisites to justify the costs.

36 Hydrogen Industry Legislation (Clayton Utz, 2019) http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhs-hydrogen-industry-legislation-
report-2019_0.pdf

13.1 Australian Trials

In Australia, investment in hydrogen is still relatively low with the Council of Australian Governments (COAG) Energy Council envisioning a "clean, innovative, safe and competitive hydrogen industry" in Australia by 2030 only. According to a consultant's study commissioned by the Department of Industry, Innovation and Science, key barriers to using hydrogen for transport is the limited supply of vehicles and refuelling infrastructure.

13.2 World Trials

WSP can provide results from the European Joint venture into hydrogen for public transport (JIVE I and JIVE II[37]) as well as results from USA (National (NREL) reports. In all cases reported, the trials were found to be currently uneconomic.

In summary some hydrogen fuel trucks are being trialled by start-ups, such as Nikola Motors (2021 US$163 million loss)[38] and Hyzon Motors[39] (both of whom are experiencing difficulties with Hydrogen roll outs) and to a limited extent Toyota Forklifts[40] and Hyundai[41].

14 Fuelling Infrastructure

Hydrogen fuel supply is replenished similarly as compressed natural gas. At refuelling stations, pressurised refuelling station nozzles engage with a receptacle on the FCEB to transfer hydrogen gas to the on-board tanks.

According to a study commissioned by Department of Industry, Innovation and Science, the location of refuelling sites, and their ability to be accessible, will be important for the initial pilots and trials in Australia[42].

As hydrogen fuel cell still has limited uses in public transport, the ability to refuel FCEB is key in ensuring reliability. The end-to-end supply chain for hydrogen is complex. The type of hydrogen used, the location of the refuelling site and security of overall fuel source must also be considered. Hydrogen refuelling stations are estimated can cost between USD $600,000 to $2 million for hydrogen at a pressure of 700 bar, and USD $150,000 to $1.6 million at 350 bar. The more utilised the refuelling infrastructure is the more competitive the FCEB will be. This can be achieved by concentrating or coupling demand with other uses of hydrogen, keeping in mind the need to develop hydrogen infrastructure development in step with hydrogen vehicle deployment. This will ensure that refuelling stations are commercially viable and help increase the possibility of receiving support from the Minister for Energy and Emissions Reduction[43].

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37 https://www.sustainable-bus.com/news/50-hydrogen-buses-in-operation-and-200-ordered-through-eu-backed-jive-and-jive-2-projects/

38 https://techcrunch.com/2022/02/24/nikola-earnings-report-ev-truck-progress-stiff-losses-2021/#:~:text=Financial%20results&text=So%20it%20closed%202021%20with,therefore%20just%20that%3A%20%24162.7%20million.

39 https://www.freightwaves.com/news/fuel-cell-maker-hyzon-motors-craters-after-disclosing-financial-troubles#:~:text=Hyzon%20Motors%20is%20the%20latest%20electrification%20startup%20to%20crash%20after,sending%20its%20shares%20down%2038%25.

40 https://fuelcellsworks.com/news/toyota-the-future-is-here-with-forklifts-powered-with-hydrogen/ NB at present Toyota hydrogen vehicles cannot be purchased, only leased in NZ. Only the Toyota Mirai model is offered.

41 https://carbuzz.com/cars/hydrogen-cars ; https://www.nzherald.co.nz/business/watch-wraps-come-off-nzs-first-hydrogen-powered-car-at-fieldays/S5DTCLJ3N2N7CS7EEBGAIWH4CY/#:~:text=Hyundai%20has%20unveiled%20New%20Zealand%27s%20first%20zero%20emissions%2C,an%20infrastructure%20is%20built%20to%20support%20the%20technology. No price available, no release date available. For HGV – Trial only (8 – 10 years) https://www.nztrucking.co.nz/hyundais-hydrogen-heavy-is-here/

42 http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhs-hydrogen-for-transport-report-2019.pdf

43 Australia's National Hydrogen Strategy (COAG, 2019) https://www.industry.gov.au/sites/default/files/2019-11/australias-national- hydrogen-strategy.pdf

Another important aspect to consider is generating partnership in hydrogen industry to bring together vehicle manufacturers, hydrogen producers and fuel suppliers to build up supply and demand at the same time and lower project risks. This approach for building refuelling infrastructure, with industry contributing to associated costs to promote long- term commercial viability, has been encouraged by the government

Governments agree if providing support for refuelling infrastructure, to promote open access wherever practical. This would encourage projects to unlock further investments, maximise public benefit and minimise barriers to scaling up the industry.

14.1 Hydrogen Fuel Depot Infrastructure

Most of the hydrogen fuel currently used in FCEB is generated at large scale production facilities, delivered to bus depots and stored as a liquid or compressed gas. Hydrogen can also be produced on-site using an electrolyser or natural gas reformer[44]. For the purpose of this study, only "green" hydrogen gas generated by an electrolyser fed by renewable energy would constitute zero emission.

14.2 Ammonia as an Alternative Energy Carrier

Hydrogen is typically stored onboard trucks in pressurized containers, which can be refilled at hydrogen refuelling stations, the fuel economy of hydrogen trucks is contingent on the form in which hydrogen is delivered. Hydrogen can be stored in a compressed or liquid state, or it can be supplied via a chemical hydrogen carrier such as ammonia.

Compared with compressed hydrogen (4.7 MJ/L at 690 bar and 15°C), liquid ammonia has a (volumetric) energy density (12.7 MJ/L) that is approximately 2.7 times greater, and it requires significantly less energy to store and transport safely. However, this adds an extra layer of handling and storage to the fuel system chain of supply[45].

Ammonia may benefit from existing supply infrastructure (such as fertilisers) and the ease of liquid-based transportation and storage[46]. Using ammonia as a hydrogen carrier combined with a compact and high efficiency cracker enables fuel cell trucks to achieve higher energy efficiency and comparable ranges to present-day diesel engines, but with added complexity and capital costs.

14.3 Refuelling times for Hydrogen tanks

Whilst the initial charge into a hydrogen fuel tank can be administered rapidly, the time taken to get the tank to 100% of its weight capacity is seldom fast (about 5 hours at 0 °C as shown in the trial[47] below (See Figure B14-2Hydrogen Tank refuelling, mass evaluation trails and correspondingly higher at higher ambient temperatures.) Hydrogen bus trials showed that the buses refuelled at the end of the day needed a "top-off" refuelling in the morning to achieve a full range – this is contrary to opinion that hydrogen refuelling is "as fast as liquid fuelling."

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44 https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming#:~:text=Natural%20gas%20reforming%20is%20an,reforming%20in%20large%20central%20plants.

45 https://amogy.s3.amazonaws.com/pdf/Amogy+White+Paper.pdf

46 AMOGY and (Ammonia powered trucks) NH3 https://wsp.smh.re/57-

47 Andujar, Segura, Rey and Vivas, Batteries and Hydrogen Storage: Technical Analysis and Commercial Revision to Select the Best Option. 2022

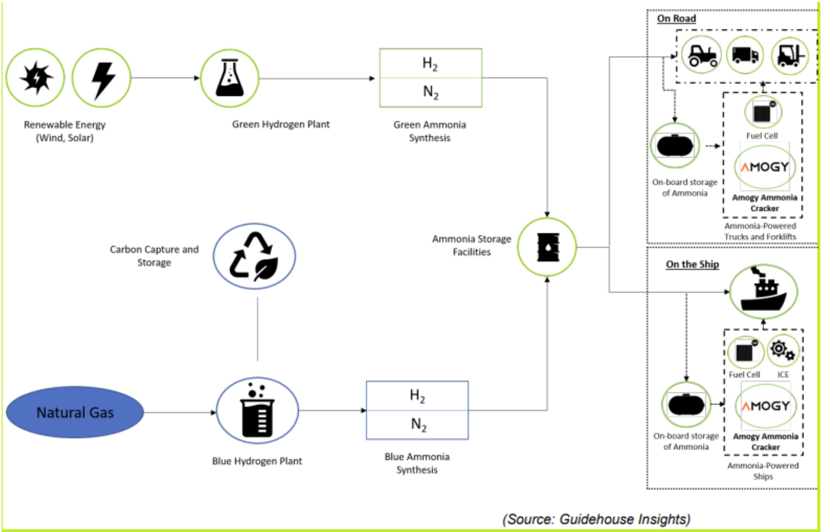

Figure B14-1 Indicative path for Ammonia Production[48]

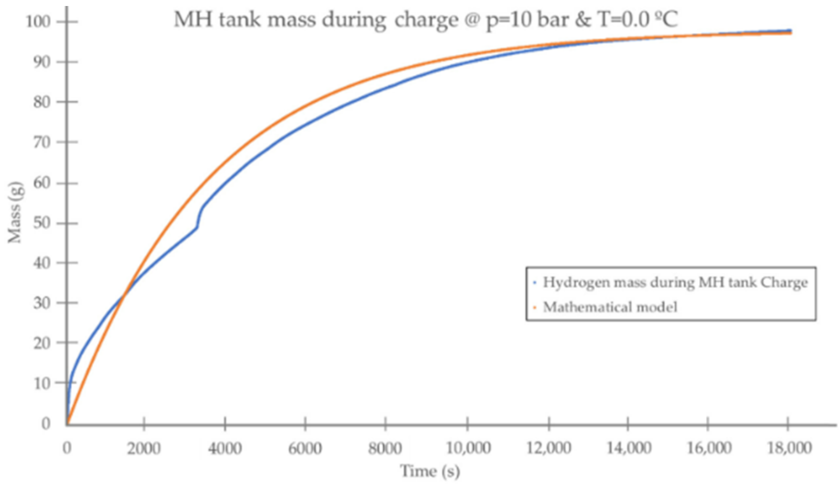

Figure B14-2 Hydrogen Tank refuelling, mass evaluation trails[49]

15 Hydrogen Fuel Stations in NZ

As of October 2022, there were no commercially available hydrogen fuel stations and only one private hydrogen fuel source. (Note industrial hydrogen is not suitable for a fuel cell as it is not pure enough). Hiringa has partnered with Waitomo Fuel[50] to roll out hydrogen fuel stations but are only planned for the South Island by 2030 (assuming no delays are incurred).

NZ's sole hydrogen producer, Hiringa Energy have made plans for a hydrogen triangle (Auckland – Tauranga – Hamilton)[51] on North Island, but have experienced some delays, including the financial woes of Hyzon[52], who was their prime hydrogen vehicle partner. Further refuelling stations are planned out to 2030 but only 4 sites are "under or planned for construction."

48 Guidehouse Insights
49 Andujar, Segura, Rey and Vivas, Batteries and Hydrogen Storage: Technical Analysis and Commercial Revision to Select the Best Option. 2022
50 https://www.waitomogroup.co.nz/stories-article/ground-to-be-broken-on-new-zealands-first-green-hydrogen-refuelling-site
51 https://www.hiringa.co.nz/hydrogen-refuelling-network
52 Fuel Cell Maker Hyzon Motors Craters After Disclosing Financial Troubles - Hydrogen Central (hydrogen-central.com)Z

It is noted that the Ports of Auckland hydrogen fuel cell refuelling project[53] has been closed in February 2022 and never passed the point of using imported hydrogen from a tube trailer.

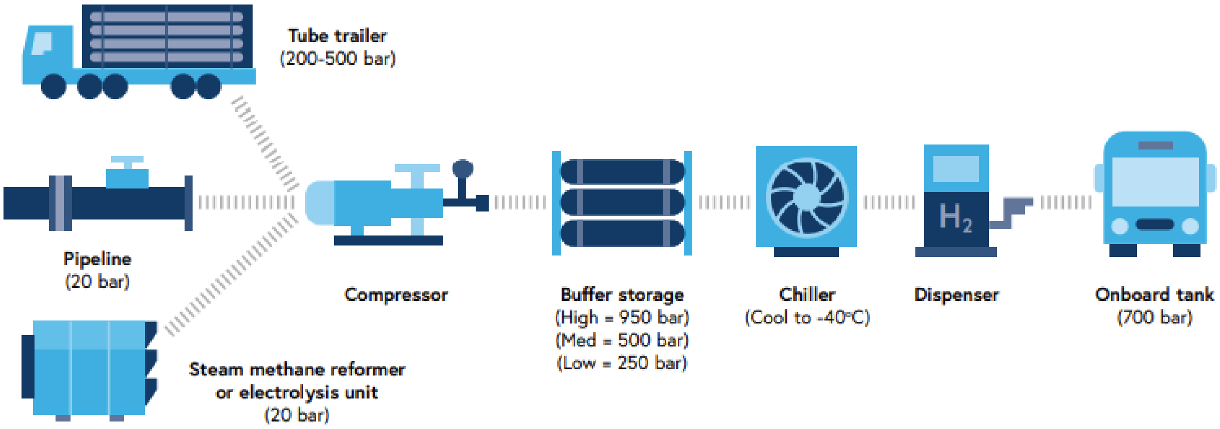

Figure B15-1 Hydrogen Tank refuelling stages[54]

15.1 Airport Collaboration

AirNZ is looking at the use of hydrogen for short haul aircraft, but at present pure electric aircraft appear to dominate this sector (in terms of actual orders placed by major airlines). Whilst an opportunity for other transport may arise at some stage in the future, this is extremely uncertain and even with a 15 year horizon may not be financially effective.

53 https://www.driven.co.nz/news/toyota-nz-obayashi-tuaropaki-trust-team-for-green-hydrogen/

54 Andujar, Segura, Rey and Vivas, Batteries and Hydrogen Storage: Technical Analysis and Commercial Revision to Select the Best Option. 2022

16 Technology Requirement

Unlike traditional combustion technologies that burn fuel, fuel cells undergo a chemical process to convert hydrogen-rich fuel into electricity. Fuel cells do not need to be periodically recharged like batteries, but instead, continue to produce electricity as long as a fuel source is provided.

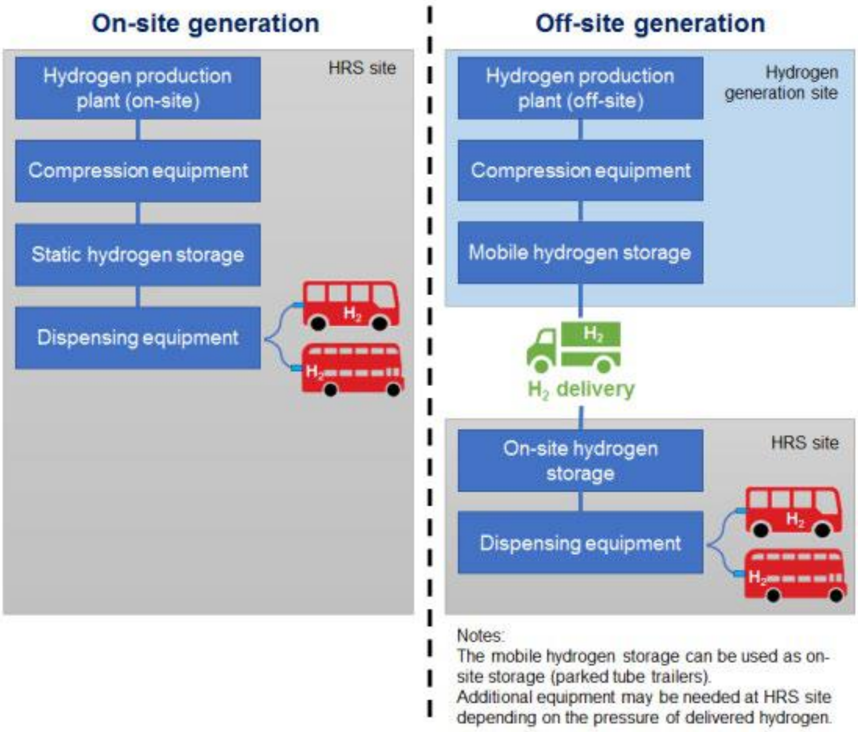

Figure B16-1 Schematic overview of hydrogen supplies for FCEB[55]

Hydrogen fuel is managed similarly to diesel and compressed natural gas (CNG) but new policies and procedures require update. The price is fixed over a period of time, and contracts are paid in dollars per kilogram. Budgeting fuel cost, in the long run, can be relatively accurate, assuming a typical urban bus will require 20 to 30 kilograms of hydrogen daily. Supply companies will compete

for the opportunity to supply the hydrogen and fuelling station for a fleet to keep the price of the fuel down, thus balancing the higher upfront price with lower operational costs[56].

16.1 Health and Safety

Although hydrogen is flammable, it is moderately safer than conventional fossil fuels such as diesel. As with any fuel, however, hydrogen must be treated with care. Compressed gases can also cause "cold" burns when expanding and the correct PPE is required for handling.

Hydrogen is non-toxic (as opposed to gasoline and diesel) and is also much lighter than air which results in rapidly dissipating when it is released, reducing risks in the event of a leak (gasoline and diesel pool on the ground). However, hydrogen has a lower ignition energy requirement compared to gasoline or natural gas, making it easier to ignite. Therefore, it is important to have flame detectors and to consider proper ventilation protocols and building code requirements when working with pressurised hydrogen fuel, as outlined in the National Construction Code 2019, NZ Land Transport NZS 5433:2012 and NZ Dangerous Goods Code, 2005.

55 https://www.theiet.org/media/10750/hydrogens-potential-as-a-fuel-for-road-transport.pdf

56 https://www.sustainable-bus.com/news/hydrogen-at-scale-for-transit-what-does-it-mean-to-operate-fuel-cell-buses

Training in safe hydrogen handling is a key step in the process of ensuring the safe use of hydrogen. Regular testing of hydrogen systems though tank leak testing, garage leak simulations, and hydrogen tank drop tests, can ensure that hydrogen can be produced, transported, stored and utilized safely. These compliance costs should not be underestimated.

16.2 Health and Safety Legislation and Conflicts

16.2.1 Certified Handler

The NZ requirement to have a tested and certified "Approved Handler" for hydrogen refuelling adds additional overhead costs and may complicate refuelling.

16.2.2 Added Odour

Added to this, NZ currently requires that all gases have a defined odour. The purity and composition of hydrogen suitable for fuel cells is such that adding an odour would detrimentally affect the fuel cell operation as this is not compatible with its purity requirements. This is problematic and yet to be resolved.

16.2.3 Added Colourant

NZ requires that all flammable gases have a colourant added to ensure that any flame can be seen, Hydrogen burns with an intense flame that is both clear and colourless, making it very difficult to see. At present, fuel cells cannot tolerate the added colourants. This is also problematic and yet to be resolved.

16.3 Depot Structure

To future-proof depot for FCEB, a significant amount of design work on the hydrogen refuelling station is required. It should consider how and where hydrogen will be made available at the refuelling station, access requirements for tube trailers (if delivered) as well as delivery timing (not to coincide with day-to-day operations).

Working on a fuel cell vehicle in enclosed spaces presents different risks from those associated with diesel buses due to hydrogen's characteristics. For example, any leak from the gas elements of the system will lead to hydrogen rising and potentially accumulating in the roof space, resulting in fire or explosion risk. This risk can be mitigated using measures such as the installation of hydrogen sensors, improved ventilation and installation of explosion-proof ATEX lighting. Similar to BEBs, high voltage systems on FCEBs also require special care. Risk assessments should be carried out by a suitably qualified expert.

Bus depot also needs to have all the equipment and tools required to service FCEB, including providing safe access to the roof (where the hydrogen tanks are typically placed on single deck buses) and underside of the vehicles. Some fall prevention systems and mobile platforms may be required.

17 Maintenance and Operational Challenges

17.1 Operation

FCEB is considered a like-for-like replacement for diesel vehicles in terms of range and refuelling time (with an added morning top-off). Assuming the refuelling system is reliable, FCEB day-to-day operation including route planning can follow an existing schedule for diesel buses with driver training on basic technical characteristics of FCEB, including the potential hazards of high voltage components and hydrogen systems. As FCEB is still currently under development, however, operations should be carefully collected and analysed to inform future implementations.

According to the EU Fuel Cells and Hydrogen Joint Undertaking's guide to FCEB implementation in Europe, experience in previous projects suggest the importance of a "run-in" period between the buses being delivered and the start of full operations. This implies a soft introduction of the vehicles into commercial service with an expectation that availability levels are likely to be lower during the period where technical issues are resolved and staff gain experience with operating the vehicles, diagnosing and rectifying issues, etc. Planning for such a phase from the outset, such as by securing a spare vehicle to continue services in the event of FCEB's unplanned downtime, is highly recommended. Sufficient support from the bus supplier (and component suppliers as necessary) should be made available.

17.2 Maintenance, Risks & Requirements

Similar to BEB, FCEB will require people in the bus industry to have new skills in procuring, operating and maintaining the fleet as FCEB uses a relatively new fuel and high-voltage components that require special attention.
Although there is a large degree of part commonality with a diesel bus and electrical bus, some specialized tools are required for the servicing and maintenance of a hydrogen bus. These tools are primarily related to the pressurized fuel system and hydrogen tanks. Some specialized tools include[57]:

- Gantry platforms/movable scaffold platforms for roof access, along with required fall arrest and protection equipment for maintenance workers working on hydrogen tanks commonly roof mounted on vehicles
- Gas leak detector worn by maintenance workers to monitor any gas leakage that could become a safety concern to workers and potential fire hazard.
- Tools for the removal and inspection of hydrogen tanks (gas extractor, torque wrenches and tensioner straps).

In addition, safety protocols and appropriate personal protective equipment (PPE) regarding Arc Flash and ignition safety risks must be considered during maintenance processes and procedures. An Arc Flash is a severe electrical hazard that is the result of a high voltage electrical discharge between conductors bridged by an air gap. This jump of electrical current at high voltage creates a large release of energy both thermal and as a light flash in the form of an electrical explosion which can be very dangerous to maintenance technicians if appropriate PPE and preventative measures are not used while working on high voltage equipment such as BEB battery packs and high voltage components including the ESS on a FCEB. Additional safety equipment that should be incorporated in the workplace around high voltage equipment include an insulated safety hook which can be used to pull someone safely away from an electrocution incident without putting the responder at risk of electrocution. Also, safety barriers should be used to close off the regulated work zone (arc flash boundary) that only high voltage qualified personnel wearing the appropriate PPE can enter. Furthermore, within this zone maintenance personnel should not wear metallic items due to the risk of thermal conduction from an Arc Flash. Warning labels should be put on the exterior encasement where access to high voltage components are located to provide the technician clear information on the electrical risk as well as the required PPE to work on the components. It is important for maintenance technicians working on these high voltage systems to undergo sufficient training for managing these risks and hazards. The added risk of ignition complicates this.

57 Guide to FCEB Implementation for Operators in Europe (EU Fuel Cells and Hydrogen Joint Undertaking, 2018)

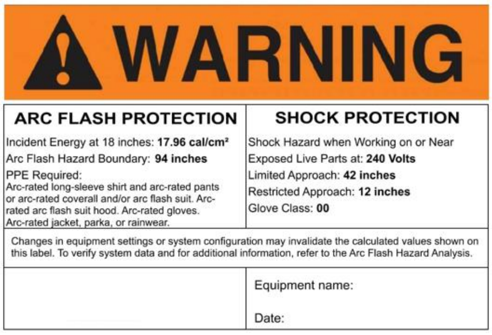

Figure B17-1 High Voltage Warning Label Illustration

18 Trends and Development

Few models of hydrogen FCEBs that are in production and available for purchase globally, even though hydrogen fuel cell technology has been in use on city transit buses since the early 2000s. One of the early adopters was Perth, Western Australia, which trialled the technology in 2007. The trial was funded by Western Australian State Government, Australian Greenhouse Office and BP. Combined, this cross-sector partnership invested approximately $16 million into three DaimlerChrysler EcoBuses and the required hydrogen supply chain and refuelling infrastructure. Path Transit operated the EcoBuses for three years, travelling more than 260,000 km and carried more than 330,000 passengers during that time. According to the state's Department for Planning and Infrastructure, the EcoBuses performed well with the buses being available 90 per cent of the time, travelling 250 km on average from a single refuel. The refuelling technology, however, did not match that performance with refuelling failures resulting in cancelled operations with nearly three months' worth of operation were lost during the three-year trial.

During the first two years of the trial, the buses spent a total of 1,077 hours in maintenance for a total operating time over 8,000 hours, which equalled to one hour of maintenance for every eight hours of operation. These figures may seem high, but it is important to consider that maintenance includes not only routine maintenance and repairs but also upgrades, testing and troubleshooting that were necessary due to the experimental nature of the buses. Routine maintenance made up a quarter of the total maintenance effort while repairs accounted for 56 per cent. The majority of repair was related to fuel cell repair (37 per cent) and the electrical system (2 per cent).

A cost-benefit analysis (CBA) following the trial found that diesel buses were less expensive to run due to their lower capital and fuel cost at the time[58]. The technology and reliability of FCEB have improved from those first buses tested. However, operating cost and infrastructure requirements still tend to be a concern.

The table below summarises the annual totals of key data from the Perth trial.

Table B18-1 : Key data from the Perth hydrogen fuel cell bus

	Year 1	Year 2	Year 3	Total
H2 consumed (kg)	12,861	17,478	16,613	49,593
Distance travelled (km)	75,887	98,280	85,378	259,545
Fuel efficiency (kg/100 km)	16.9	17.8	19.5	18.1
Drive train hours	3,617	4,212	3,874	11,704

58 https://www.eltis.org/sites/default/files/case-studies/documents/dpi_perth_fuel_cell_trial_summary_of_achievments_2004-2007_200806_4.pdf

Passengers carried	95,006	117,663	112,832	325,501

In recent years, hydrogen fuel cell has received more attention in Australia for both HFC vehicles and stationary applications. The Council of Australian Governments (COAG) Energy Council released Australia's National Hydrogen Strategy59. The goal was to identify actions that will support its vision of a "clean, innovative, safe and competitive hydrogen industry that benefits all Australians and is a major global player by 2030".

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has made significant breakthroughs in hydrogen production in 2018 which may prove to accelerate the future of hydrogen vehicles in the country. CSIRO developed and successfully tested a membrane technology which allows hydrogen to be transported in the form of liquid ammonia, making it possible to handle hydrogen in bulk using existing infrastructure, linking the production, distribution, and delivery processes.

Australia's first hydrogen test station at the Canberra Institute of Technology (CIT) Fyshwick in partnership with gas distributor Evoenergy is also expected to begin operation in 2020. Using renewable energy from the Hornsdale wind farm in South Australia to power the electrolysis process which generates the liquid hydrogen, the facility tests clean hydrogen on existing materials and equipment to prepare for the diffusion of hydrogen into the existing gas distribution network as well as trains plumbing students to work with hydrogen. Kawasaki Heavy Industries has also announced the construction of a liquefaction plant, storage facility and loading terminal for hydrogen export to Japan in Victoria as a pilot project for 2020-2021[60]. This may forge the path towards larger investment in hydrogen infrastructure in Australia.

19 Vehicle Market Scan

Limited options are currently available for 12-metre buses powered by hydrogen fuel cell technology as the broader market is primarily focused on the advancement of electric buses. IEA estimates approximately 500 hydrogen buses are in operation globally as of 2019 with several thousands more in China by the end of 2020.

Japan was slated to use 100 of its flagship FCEB Sora shuttling visitors of the summer 2020 Tokyo Olympic Games; however, the event was postponed due to the COVID-19 pandemic. By winter 2022 Beijing Olympic Games, 1000 buses using the same fuel cell technology will be built and operating through a partnership between Toyota and the Beiqi Foton Motor Company61.

South Korea plans to invest 2.6 trillion won (AUD$3.3 billion) in hydrogen car production facilities, hydrogen bus production, hydrogen storage containers for buses, and stack plant expansion by 2022. The national initiative will include a subsidy program and reduced acquisition tax for hydrogen FCEBs. Hyundai Motor will also set up the country's first hydrogen buses production plant in Jeonju[62]. In April 2021, Daimler Truck AG and the Volvo Group have signed a preliminary non-binding agreement to establish a new joint venture to develop, produce and commercialise fuel cell systems for heavy-duty vehicle applications and other use cases, including buses[63]. Mercedes-Benz is in the process of developing the eCitaro REX hydrogen-powered fuel cell buses (expected launch of 2022), which is based on the eCitaro BEB equipped with a fuel cell and a large traction battery[64].

59 https://www.industry.gov.au/sites/default/files/2019-11/australias-national-hydrogen-strategy.pdf
60 https://www.s-ge.com/en/article/global-opportunities/20201-c5-japan-hydrogen-market
61 https://www.canberratimes.com.au/story/6421121/why-canberra-is-jumping-on-board-the-hydrogen-bus/
62 http://www.businesskorea.co.kr/news/articleView.html?idxno=23248
63 https://www.daimler.com/company/news/planning-joint-venture-volvo.html
64 https://fuelcellsworks.com/news/mercedes-benz-sweg-launching-ecitaro-bus-with-fuel-cell-technology-in-2022/

19.1 NZ and Australian Hydrogen Trials

New Zealand-based manufacturer GBV combined with ADL (coachworks) is being trialled in Auckland (commenced 2020). The country's first FCEB was to be be supported by the first hydrogen production and refuelling facility built-in Ports of Auckland's Waitematā port[65] which discontinued operation.

A number of fleet owners are trailing BEB's but the FCEB trials have required government involvement. Central Coast, New South Wales Coast has a planned trail of 2 Foton FCEB, delivered in September 2022[66], [67]. These use a SinoHytec and Toyota fuel cell.

Table B19-1 : Market scan summary for hydrogen fuel cell bus in Australia & NZ

Manufacturer and Model	Operational Capability	NUse in Australia and **New Zealand**
GBV Hydrogen FCEB 	Integral bus, compliant with ADR (to be developed) Bus capacity: 43 seated Battery capacity and range: 60 kW fuel cell, 250 km per refuel Top speed: 80 km/h OEM expected life cycle: 20 years	Alexander-Dennison Auckland (1 bus, trial, 2020)

Although main bus and truck manufacturers such as Ford, Daimler, Van Hool, Nikola and Hyundai have started their FCEB supply in left-hand driving markets, very few are available for right-hand driving countries. Converting the driving side has been done in Australia for some specialist cars (costing up to 75 per cent of the original vehicle cost) but this may not be possible for buses.

19.2 NZ Conversion

Converting internal combustion engine buses into battery-electric BEB or even FCEB may be more effective to extend the life of existing assets, but will be expensive regardless[68], especially if done at fleet-level.

A freight firm, HW Richardson (HWR) plans to have 10 heavy goods vehicles on the roads in 2023 running on dual fuel[69]. The cost of diesel truck conversion was estimated at $80,000 to $130,000 and their Chief Executive admits this was not a commercial decision, with about $10M required for the 1.1MW electrolyser and associated infrastructure. In addition, they are seeking Waka Kotahi relief from road user chargers as hydrogen remains "significantly dearer" per kilometre tonne than diesel[70]

65 https://at.govt.nz/about-us/news-events/new-zealands-first-hydrogen-powered-bus-coming-to-auckland/
66 https://www.transport.nsw.gov.au/news-and-events/media-releases/states-first-hydrogen-bus-to-hit-central-coast-streets

67 https://www.busnews.com.au/industry-news/2208/foton-hydrogen-city-buses-arrive-for-transit-systems-australia
68 http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhs-hydrogen-for-transport-report- 2019.pdf
69 https://www.hwr.co.nz/hydrogen#:~:text=HWR%20plans%20to%20have%2010,in%20power%20or%20significant%20downsides.
70 https://businessdesk.co.nz/article/transport/hw-richardson-takes-uncommercial-plunge-into-hydrogen

19.3 NZ Hydrogen Prices

Currently, to obtain hydrogen in sufficient purity to operate in a fuel cell vehicle, the costs range from $14/kg to $40/kg with added distribution, storage and compression costs being incurred at the fuelling station.

19.4 Lessons Learnt from Other Trials

Total cost of ownership is extensively affected by the upstream cost of the technology chosen. So, for electrification, the upstream infrastructure is well understood and often funded in such a manner that both the direct cost and cashflow impacts can be ameliorated. However, with hydrogen the full cost must be carried by the fleet owner if they are the sole user.

Appendix C

20 Alternative Fuels and Gas

20.1 Types of Fuels

For the purpose of the NZ study, the following LPG , CNG and LNG are not considered suitable options for Zero-Emission transport[71].

- Liquid petroleum gas (LPG)
- Compressed natural gas (CNG)
- Liquefied natural gas (LNG)
- Bio-diesel and specifically Hydrogenated Vegetable Oil (HVO)

Thus only basic information is provided here[72].

20.2 Renewable Natural Gas

Renewable natural gas (RNG) is a low-carbon renewable fuel that is made from organic waste found in landfills, farms and other industries. It is the gaseous product of decomposition of organic matter that has been processed to purity standards and therefore does not require substantial exploration and drilling. RNG offers a carbon-neutral greenhouse gas emissions impact by recycling and re-purposing gas that would have been emitted into the atmosphere otherwise.

A portion of the international public transit authority's bus fleet has been switched to RNG because the biogas of decomposing organic material reduces the environmental footprint of the transit buses.

However, the supply of RNG may be limited by local conditions and infrastructure to collect and digest the organic material. In NZ, some trials have been undertaken in organic waste to electricity, as opposed to using the RNG for directly for transport[73].
The RNG uptake has been slow in Australia following some fire incidents and development in other zero-emission technology. In the ACT, the state government has aimed to phase out gas altogether by 2045.

20.3 Bio-Diesels

HVO has a similar chemical composition to fossil diesel fuel and can be used as a renewable fuel in existing diesel engine vehicles (pure or blended). HVO is considered a high-quality diesel substitute and is therefore often referred to as renewable diesel, but currently, comes with some downsides.

Biodiesel can be produced from different types of raw vegetable oils from energy crops, used frying oils or animal fats using the conventional transesterification technology. It presents many benefits, such as higher cetane number, good lubricity, higher flash point, and no sulphur or aromatics[74]. On the other hand, it has a series of negative effects on environment and urban air quality.

[71] https://www.otsi.nsw.gov.au/sites/default/files/otsi_assets/documents/reports/Bus%20Fires%20Summary%20Report%202019%20FINAL%20REPORT.pdf
[72] For further information, refer to https://alternative-fuels-observatory.ec.europa.eu/
[73] https://www.farmersweekly.co.nz/food-waste-to-energy-plant-opening-later-this-year/#:~:text=The%20facility%20at%20Reporoa%2C%20northeast,liquid%20fertiliser%20for%20primary%20production.
[74] Kousoulidou et al., 2009

- *It has been observed that FAME usage on light-duty diesel engines and vehicles increases NOx emissions during both steady-state and transient operating conditions*[75] .
- *Fuel consumption has also shown an increase due to FAME's lower energy content*[76].
- *Biodiesel usage on diesel engines leads to substantial reductions of particulate matter (PM)*[77]*, carbon monoxide (CO), and unburned hydrocarbons (HC)*[78].

As far as engine operation is concerned, biodiesel has been associated with a deterioration of engine cold operability due to its higher viscosity, and relatively high CP and CFPP, that may affect injection performance and cold-start properties.

Despite the several advantages, biodiesel has not met the expectations for green and environmentally friendly substitute for conventional diesel fuel. High feedstock cost and the competition with food sources, inferior storage and oxidation stability, lower calorific value, inferior low temperature operability and higher NOx emissions are some of the disadvantages that makes it less competitive fuel[79].

Some emission tracking work[80] has been undertaken on Euro 5 light duty diesel engines running on Hydrogenated Vegetable Oils (HVO).

20.4 Renewable Natural Gas (RNG)

RNG is considered as a clean, quiet and cheap alternative to diesel use in buses as it produces fewer emissions and has a lower carbon footprint. However, unlike battery electric bus and hydrogen fuel cell bus, RNG buses still produce tailpipe emissions albeit at a much lower rate than diesel buses.

RNG stored in this form operates on the same fundamental concepts as internal combustion engine (ICE) vehicle powered by petrol and is more commonly used for transit buses. It is interchangeable with conventional natural gas, it can be transported using the existing gas grid without significant upgrades.

RNG is chemically similar to conventional fossil-fuel natural gas, which is not renewable, as its supply cannot be replenished. RNG can be used as a transportation fuel in compressed (CNG) or liquefied (LNG) forms. The technologies for these two forms of RNG are vastly different with each having distinct refuelling equipment, fuel cost, pumps, tanks as well as hazards and capital costs profiles. One similarity is both forms of RNG need computer-controlled valves to control fuel mixtures inside the engine.

*20.5*Compressed Natural Gas

Compressed natural gas (CNG) is the common form of natural gas for use in buses in Europe and parts of America. The high-pressure natural gas is stored in a fuel tank, or cylinder, before transferred from the fuel tank to the engine's combustion chamber. In the combustion chamber, the gas is mixed with air then compressed and ignited by a spark plug.

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[75] George et al., 2007; Rakopoulos et al., 2008; Fontaras et al., 2009; Kousoulidou et al., 2010, 2012; Giakoumis et al., 2012
[76] Armas et al., 2013
[77] Graboski and McCormick, 1998
[78] Karavalakis et al., 2009; Giakoumis et al., 2012
[79] (Soo-Young, 2014
[80] https://www.frontiersin.org/articles/10.3389/fmech.2018.00007/full

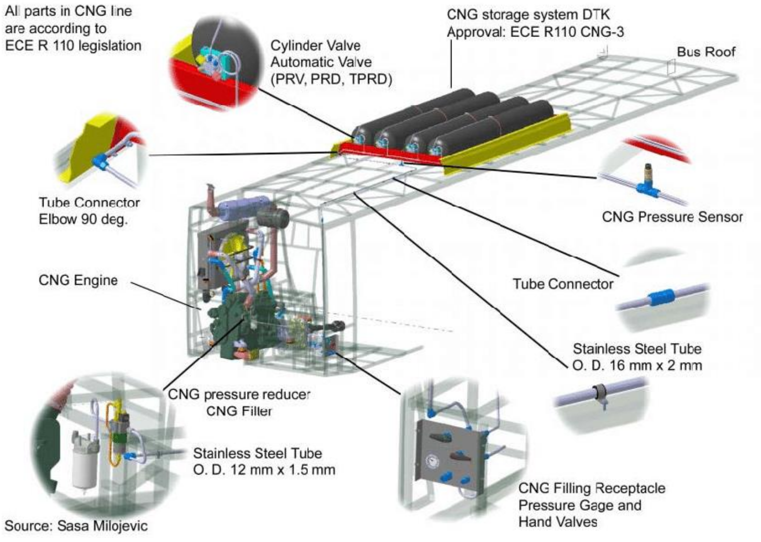

Figure C20-1 Sketch of CNG fuel line equipment installed on a bus[81]

20.6 Hydrogenated Vegetable Oil

HVO has a similar chemical composition to fossil diesel fuel and can be used as a renewable fuel in an existing diesel engine vehicles (pure or blended). HVO is considered a high-quality diesel substitute and may sometimes be referred to as "renewable diesel." HVO is a paraffinic diesel fuel and specified in the standard EN 15940:2016, which covers hydrotreated HVO and Fischer-Tropsch GTL products containing up to 7,0 % (V/V) of fatty acid methyl ester (FAME). Diesel fuel standards, such as EN 590 and ASTM D 975, are met with high blending ratios of HVO. However, note that Biodiesel (FAME) standards are not applicable to HVO. HVO is blended with fossil diesel and sold at fuel filling stations in some countries, just as bio-derived ethanol is added to petrol.
HVO is produced[82] by hydrogenation and hydrocracking of vegetable oils and animal fats using hydrogen and catalysts at high temperatures and pressures. In this hydrotreating process, oxygen is removed from the feedstocks consisting of triglycerides and/or fatty acids. The resulting products consist of straight-chained hydrocarbons (paraffins) with varying properties and molecular size depending on the feedstock characteristics and the process conditions. The conversion usually takes place in two stages:

- Hydrotreatment, followed by
- Hydrocracking/isomerization.

The hydrotreatment typically takes place between 300 – 390°C. For treatment of triglycerides, propane is a typical by-product.

[81] Benefit and Restrictions Related to the Application of Natural Gas as Engine Fuel for City Buses (S. Milojevic and R. Pesic, 2014)
[82] https://etipbioenergy.eu/images/ETIP_B_Factsheet_HVO_feb2020.pdf

Appendix D

21 Electric Ferry

21.1 Technology Overview

In essence the electric ferry (eFerry) has a large similarity to an eBus (BEB) and hence much of the applicable technology and comment from the prior sections apply.

Whilst some hybrid options have been considered, these are very early in their development and the majority of the ferries on order are pure electric.

NZ does have two advantages from local ingenuity – Composite construction (from competition sailing and the America's cup) and water-jet propulsion (from Hamilton jet boats) which have both been optimised to suite 25 knot "fast" displacement hull passenger ferries.

22 Battery Types and Sizes

22.1 Battery Types

These are similar to batteries in buses, although can be larger and may use air or water cooling.

22.2 Battery Sizes

A ferry is less efficient, in terms of propulsion to a bus, and experiences more drag from the water, and thus typically has a larger battery capacity. This in turn requires a larger physical volume and charger capacity.
Consequently, many Ferries rely on an overnight charge to start the day fully charged and then a number of smaller "fast charge" opportunities at the various terminus on the route.
By changing the size of the components and batteries, a battery-supported charger can be configured to suit the requirements of each installation.

22.3 Charging Infrastructure, Grid Connection & Battery

As noted above, due to the larger battery and greater demand when travelling, the charger infrastructure is also larger. The sample below considers a "home base" slow charger (overnight) coupled with a larger charger at each terminus to fast charge while collecting passengers.
To minimise the grid connected maximum demand, a grid connected battery can be added to reduce peak charges. In simplistic terms (for example only), a charger which was only required to charge a vessel for 5 minutes every 20 minutes at 2MW would have an average grid load of 500 kW. A direct connection from the grid installation would require a matched 2MW grid connection, transformer and inverter.
As shown in the table below, a battery supported charger for this example scenario could have as little as a 500 kW grid connection, transformer and inverter, plus a 1500 kW converter and a 250 kWh battery sized to discharge at 6C.

Table D22-1: Configuration options (2MW for 5 mins every 20, example only)

2MW, 5 mins every 20		Grid Direct	Battery Supported Configurations		
Output Capacity	kW	2000	2000	2000	2000
Energy Consumption	kWh/h	500	500	500	500
Connection Capacity	**kW**	**2000**	**1500**	**1000**	**500**
Transformer Capacity	kW	2000	1500	1000	500
Inverter Capacity	kW	2000	1500	1000	500
Converter Capacity	**kW**	-	**500**	**1000**	**1500**
Battery Load	kW	-	500	1000	1500

Battery Energy/charge	kWh	-	41	83	125
Battery Size[83]	**kWh**	-	**83**	**167**	**250**

23 Maintenance and Operation

23.1 Maintenance

23.1.1 Batteries

Replacement of batteries is likely to be the most significant replacement item in cost terms. The life of the batteries is very closely related to the specification and duty cycle of those batteries. Subject to the requirements, we would probably expect to plan for a supplier-warranted 8 to 10-year battery life for the first case.

23.1.2 Chargers & Plugs

Plugs are also likely to require regular maintenance and replacement, on account of their frequent use and exposure to the elements. It is not yet clear what life can be expected from heavy transport plugs in a marine environment.

23.1.3 Remote Monitoring

Maintenance requirements will largely be electrical, likely provided by the suppliers of the principal electronic equipment. Some routine mechanical service of cooling systems (liquid and/or air) can also be expected. The supplier would anticipate including charging stations in remote monitoring programs, such as Cloudlink electronic system monitoring programme, which would enable them to provide, respond-to and distribute real-time data and alerts, as well as to provide ongoing data summaries to maintain extended warranties (e.g. for batteries).

23.2 Operations

Operation (charging of vessels) is expected to become a standard crew task without particularly onerous training requirements. Vessel will arrive; crew will step onto dock, press a button on the charging post to engage "ready" cycle, open the sliding hatch on the side of the vessel, and plug the cables in to the sockets. No current will flow until the plugs are connected and internal automated safety checks are made between ship and shore.

23.3 Compliance

Maintenance will typically need to meet a different set of marine standards for the vessel, but onshore assets will have to meet land-based marina requirements.
At network level, the reinforcement requirements will be specific to each location and to the ferry size/capacity and demand. No survey of the wharves/jetties has been done to ascertain their suitability at this stage.
Compliance with Coastguard, NZ public and workplace health and safety would be an integral part of the engineering of any installation.
Compliance with EMC requirements and best practice would be an integral part of the engineering of any installation.

[83] Minimum battery size calculated based on LTO battery chemistry with 6C discharge rate and 64% DoD sweep

24 Market Scan

There are two main players in the NZ market – EV Maritime and GURIT. Both currently only offer customised vessels. Other suppliers include Damen, but they appear to have focussed on slower vessels.

Figure D24-1 Gurit (Above Left and Right) and EV Maritime (Below)

Appendix E

25 Electrical Grid Requirements

25.1 Transpower

The main feed to the entire geographic area is from Transpower backbone and feeds out at the Frankton Grid Exit Point (GXP) substation. Power is distributed from here at 66kV (PowerNet), 22kV (PowerNet) and 11kV (Aurora) into the various local areas noted below.

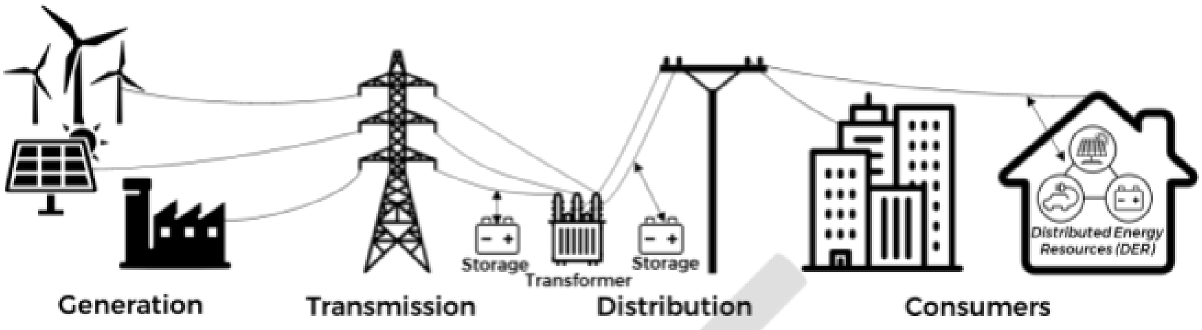

Figure D25-1 Simplified depiction – Generation, Transmission and Distribution System

25.2 Available Capacity, Frankton

Transpower GXP has approximately 8 MW of unallocated power capacity that can be used before further upstream GXP investment is required.

25.3 Security

The security of supply to a depot (resilience) is an indication of how the depot could be fed in the event of an outage, such as that caused by an extreme weather event. The security of the Frankton GXP is considered fairly good as it has dual feeders and can be fed from the North or the South, although some capacity constraints could be experienced if generation and a feeder line were compromised.

25.4 Queenstown - Aurora

This is typically an Aurora area and on an older 11kV network that requires upgrade. Also has serious space limitations and moving any public transport through Queenstown is restricted by the traffic flow and limited street paths.

From a new or expanded depot and energy perspective, our recommendation would be to stay out of this geographic area, even towards the North-west due to geographic and network constraints. The power supply aspects can be overcome but will be expensive and will not resolve the access issues.

25.5 Frankton & Remarkables Area - PowerNet

This area has some cross over between Aurora and PowerNet and has about 8MW of available power in the airport area, with option to run further cables in the near future (combined with road works.) This area would be good for fast charging at the "Shell Corner" bus terminus and could be used to supplement various routes that start and terminate at this location. This would require some standardisation between bus charging types.

An existing bus depot operates in Frankton, but an aerial overview indicates that this site may be space-constrained if the fleet expands and needs to transition from diesel to electric (or any other fuel.)

PowerNet indicate they have some capacity to feed power to the South-eastern aspect of the Remarkables suburb, but this may push a bus depot into a more difficult road access area that could as development progresses result in more traffic congestion.

25.6 Coneburn and Other

This is a development supported by PowerNet that is still fairly open and may have a number of industrial operations, which in turn may generate demand for public transport services.
The power to the area has potential to be increased if sufficient horizon is given and suitable land may be available for a well sized and laid out bus depot to facilitate the transition.

26 Depot Power Reliability and Security

The reliability of the power supply to the depot will depend on the method of feed. Outages could be caused by vegetation or weather events, but typically for cable fed networks – outages are caused either by upstream events (usually of broad impact and may switch off an entire region) or localised damage due to a traffic or construction accident. Consideration should be given to the frequency and duration of the outage – but typically these events are less frequent and the outage of short duration. The problem that then arises if this occurs during the re-charge period of the buses.

26.1 Mitigation of Outage

This can be accommodated by increasing the rate of charge so that charging can be completed in a shorter period of time (so that is the interruption was between 20:00 and 24:00, charging can still occur from `00:30 to 06:00).
Once a depot location is selected, a historic outage report can be run and mitigation planned.

26.2 Improvement of Security

The local depot power security could be improved by the following options:

- Install a second High Voltage feeder to the deport from a different substation. This is possible, but often constrained by available discrete geographic routes. This could be achieved for Frankton or Coneburn, but would be difficult to achieve for Queenstown due to the existing built environment.
- Install on-site generation using a suitably sized generator held as an emergency backup. This is currently a diesel generator and whilst seldom used, provides essential services back-up in the event of a complete power outage (keeps communication and essential services operating.) If sized sufficiently, it could also charge selected buses.
- Install on-site storage can be done by either using battery storage (typically suitable for 4 hours) or potentially generating hydrogen and storing that under compression (longer term but expensive and raises other risk aspects).
- Other region-specific contingency, such as a second depot off a different network where charging can be done.

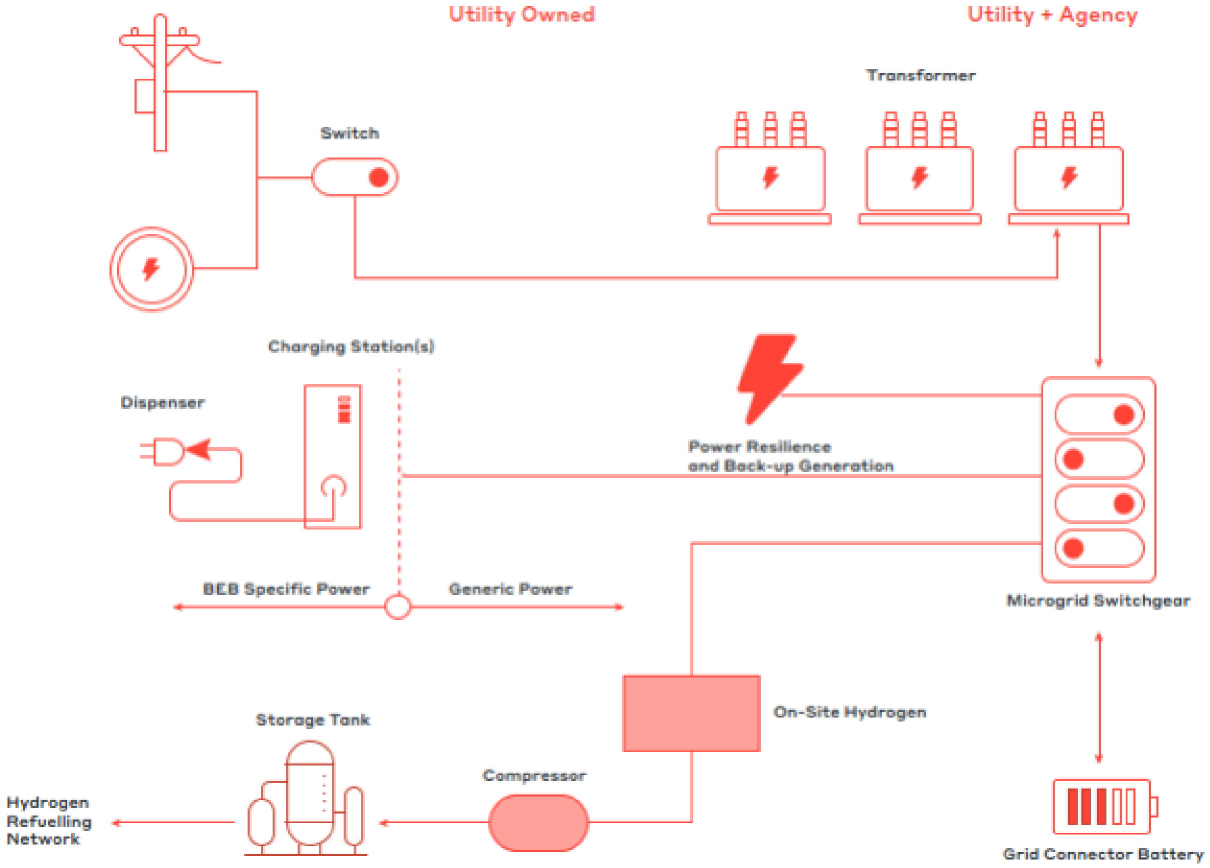

Figure D26-1 Simplified depiction – Transformers, Chargers and Storage Options

The fleet operator will need to assess its requirement for security of supply, considering the risk of an extended outage, redundancy in the bus fleet, and the cost of new infrastructure and the impact on operations. Consideration will need to be given to the benefits that will be gained from each option, and the cost of implementation on a case-by-case basis for each depot location.

26.3 Connection Costs

Each site drawing power will need a separate unique Installation Control Point number (ICP), which, depending on the site, the supply network, the voltage and metering/retailer selected may be at High or Low Voltage. The actual cost of this connection various by power network and by location, but typically the customer is required to pay (either upfront as a capital cost, or via a contract over an extended period for cost recovery) for the dedicated power and connection equipment, as well as the labour to install. Furthermore, the customer may be required to contribute to the development and costs incurred upstream to supply the connection and for large loads, may require a contribution to shared assets.

Design and construction of dedicated extensions to the distribution network, or alterations to an existing connection are arranged and funded by connection applicants who are also permitted their choice of approved contractors and energy retailers following the normal processes.

The fees for a Connection Application will be dependent on the chosen connection option and may vary based on the timing (first in first served). The fees are required to cover the reasonable costs of developing a Connection Offer and associated design. The connection fees are estimated in accordance with electricity network business connection policy.

27 Energy Grid Requirements

Apart from purchasing the bus, the following infrastructure needs to be upgraded for the large-scale adoption of BEB.

27.1 Grid Infrastructure

The roll out of BEB fleet will have a significant impact on the electricity grid as BEBs will most likely be charged via the electricity grid irrespective of charging locations (depot or on-route charging). Depot charging provides the benefit of a centralised power supply location and hence, centralisation of power supply upgrades to support BEB charging. This will simplify the planning and approvals as well as delivery of the power supply upgrades, particularly minimising negotiations and approvals. However, depot charging will place a higher demand on the electricity grid due to the centralisation of BEB charging and may require electricity network upgrades to meet this demand. Thus, the remainder of this section will focus on the grid impacts and opportunities for depot charging.

27.2 Impact on the grid

The capacity of the electricity grid to supply the depot is site specific dependent and depends on various factors such as the supplying substation capacity and forecast electricity demand on the substation. The grid capacity to supply the depot is to be determined in conjunction with the electricity distribution network company. Evoenergy, which is ACT electricity network company, publishes a planning report annually as part of their regulatory obligations. The annual planning report describes the capacities of all their substations and highlights any network constraints. An area of network constraints means the substation is reaching or have reached its maximum capacity.

As charging a BEB fleet will typically draw a significant amount of power (in the order of MW), an existing substation will unlikely have the capacity to supply this demand. Hence, the substation will need to be upgraded, which can be
costly and has a long lead time. Refer to the Baseline Report section 3 for further details on these upgrade cost and lead times.

27.3 Opportunities to reduce impact on the grid to avoid network upgrades

Opportunities to reduce the impact on the grid in the order of descending effectiveness are:

1. Selecting a depot site that can be supplied from a substation with available capacity.
    a. This will minimise network upgrades to minor upgrade works such as upgrade to the cable to the depot.

2. Demand management of electricity usage at the depot
    a. Demand management entails shifting the electricity usage at the depot to meet the grid needs. This can be achieved relatively easily by charging buses overnight when low demand for transport services coincides with low demand on the electricity grid. Electricity rates vary depending on the time of the day with the electricity rates being the cheapest at night between 10 pm to 7 am and on weekends. By shifting charging to the night, it will also provide the additional benefit of cost savings and could potentially even receive payment for charging at night.
3. On site electricity generation behind the meter such as solar PV, combined with storage
    a. Solar PV generation capacity is in the order of kW and the power demand of charging a BEB is in the order of MW, which is 1000 kW. This will only slightly reduce the electricity demand of the depot on the grid.

Using the bus batteries to provide ancillary services to the national electricity market will not avoid network upgrades as it does not address the demand required by the BEBs.
New depots can be future-proofed by configuring the electrical infrastructure to allow for growth in BEB fleet. In existing depots, however, location and capacity of the necessary electrical infrastructure (switchgear and transformers) may limit the number of BEBs a depot can accommodate.

As grid infrastructure is key enabler to the roll out of BEB fleet, it is crucial to have early discussion with the electricity network company to ensure any network upgrades meet the BEB fleet roll out timeframes in a cost-effective manner

27.4 Further Detail

Further information on Aurora and PowerNet networks and locations of available power can be obtained in further discovery, as required.

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Queenstown Public Transport Business Case

15 March 2024

CONFIDENTIAL

Sustainable Funding Model Advisory Paper

wsp

150 YEARS IN AOTEAROA

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Contents

Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the Sustainable Funding Model Paper which forms part of the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Consultant Agreement dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Executive Summary

The purpose of this advisory paper is to identify the appropriate funding mix for the proposed public transport services and infrastructure in Queenstown. The current public transport network is funded through passenger fares, targeted rates, fuel excise duty and parking charges. As part of this paper, the viability of alternative funding sources, including central government grants, developer contributions, and congestion charging, have been assessed.

At the time of initially drafting this paper the recommended service pattern had yet to be confirmed, therefore an affordability assessment was completed for the short-listed service pattern options. The operating cost estimates for the service pattern options in 2039 are in the range of $19.3M to $29.8M per annum with estimated fare revenue being $8.7M to $11.9M per annum. This provides a total subsidy amount of $8.5M to $18.9M with a split of 51% to central government and 49% to the regional council. The preferred option assessment has been appended to the short list assessment. The recommended service pattern is the Composite Option with Northbound Bus Lane and Malaghan's Road (Preferred Option). The operating cost estimates for the preferred service pattern option in 2039 are $25M per annum with estimated fare revenue being $8.7M p.a.

For the capital cost estimates, the funding split would be $29M for Otago Regional Council (ORC), $1.8M to $29.9M for Queenstown Lakes District Council (QLDC), and $24.8M to $54.0M for the New Zealand Transport Agency Waka Kotahi (NZTA). This assumes a 51% funding assistance ratio for the capital costs, that costs for works on the state highway network are borne by NZTA, that the depot cost is borne by ORC with NLTP contribution, and that local road improvements costs are borne by QLDC with NLTP contribution.

An affordability assessment was completed for the operating and capital costs for each of the project partners using long term plans and the National Land Transport Programme (NLTP). It was found that the subsidy for the operating costs are affordable for both ORC and NZTA pending confirmation from these organisations. For ORC the increased subsidy level could be met through an increase in targeted rates with the transport component of regional rates being comparable to other centres including Dunedin. For NZTA there appears to be sufficient uncommitted funding within the public transport services activity class to fund the central government portion of the subsidy.

For capital costs it was found that the majority of items are affordable with the exception of the Boyd Road bridge which is considered to be unaffordable for QLDC. For ORC the main capital cost incurred is for the electric bus depot which could be funded through debt with there being sufficient head room within debt and repayment limits to enable this. Debt funding is considered appropriate due to the upfront costs incurred and that a publicly owned bus depot would save in service contract costs from a more competitive bus operator market. For QLDC the options which do not have the Boyd Road bridge are affordable within the existing debt limits due to the lower capital costs. With regards to NZTA there appears to be sufficient funding available within the public transport infrastructure activity class to fund the options with the share of the fund used being in line with Queenstown population.

The last section of this advisory paper is an assessment of the feasibility of alternative funding sources to contribute towards the operating and capital costs of the options. It was found that congestion charging and developer contributions have the greatest potential as a funding source. A congestion charge would both manage demand for the road network and could provide funding for public transport but would require legislation change. Developer contributions would require amendment to QLDCs developer contribution policy with the developer of the Southern Growth Corridor having expressed a willingness to contribute to infrastructure which supports more housing. Other funding sources, including the Climate Emergency Fund and the Tourism Infrastructure, were fund to be unsuitable due to uncertainty in future funding and restrictive eligibility rules.

1 Introduction

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess, and develop service pattern and decarbonisation options, and explore funding and operational models.

This Sustainable Funding Model Advisory Paper is part of the Project's suite of advisory papers. It identifies the funding mix for the proposed service patterns and public transport infrastructure in Queenstown. The potential funding sources include the New Zealand Transport Agency Waka Kotahi (NZTA), Otago Regional Council (ORC), Queenstown Lakes District Council (QLDC), public transport users and third-party contributions. A key consideration of this paper is the affordability of funding for all parties including both operating and capital costs.

The paper is structured as follows:

- A high-level background on the current funding model for public transport services and the financial characteristics of Queenstown.
- The funding requirements (OPEX and CAPEX) for the short-listed service patterns options.
- An assessment of funding affordability from traditional sources using financial information contained in long term plans and the National Land Transport Programme.
- A high-level assessment of potential additional funding sources including parking charges, congestion charging and developer contributions.

The recommendations of this paper will help shape the Commercial, Financial and Management cases of the Business Case.

2 Current Funding Model

2.1 Funding Sources and Costs

Public transport services are typically funded from a combination of fare revenue paid by passengers, rates from regional councils and fuel excess duty from NZTA. The funding[1] mix for Queenstown and Dunedin services is 31% rates and charges, 41% fuel excess duty and 28% from fares. Some of the revenue from parking charges in Queenstown town centre are used to financially support the public transport.

Public transport infrastructure, such as bus stops and shelters, are typically funded through low cost low risk capital projects by the territorial authority. In Queenstown, $0.5M to $1M per year has been budgeted[2] for low-cost low risk public transport infrastructure improvements. The public transport capital works are typically funded through a 49% local share from rates and 51% from the National Land Transport Programme from fuel excess duty. In addition, the New Zealand Upgrade Programme package for Queenstown allocates $90M to bus lanes and bus priority on SH6A, a new bus hub on SH6, improvements to SH6A/SH6 intersection, and a new roundabout at Howards Drive.

2.2 Queenstown Public Transport Fare Structure

Public transport fares in Queenstown have a flat structure where trips are charged the same fare regardless of distance (based on the passenger category). The advantages of this compared to a zone structure is that it is simpler for customers to understand and makes taking longer distance trips on public transport better value for passengers. Another feature of the Queenstown fare structure is the significantly lower fares for passengers who pay using Bee Card compared to cash which helps to speed up boardings. There are concession fares for children, community card, and SuperGold card holders. Fares for the Queenstown Ferry are not eligible for concessions as the ferry is an exempt service and therefore the fares are set by the operator.

The fares for public transport are shown in Table 1.

[1] Otago Regional Council Long Term Plan 2021-2031

[2] Queenstown Lakes District Council 10 Year Plan

Table 1: Otago Regional Council public transport fare breakdown.[3]

Bus Fares		
Passenger Category	Cash Fare	Bee Card Fare
Infant (under 5 years)	Free	
Child (5 – 12 years)	Free when you tag on with your registered Bee Card	
Youth (13 – 18 years)	$4	75c
Youth Plus (19 – 24 years)	$4	$1
Adult (25+)	$4	$2
Community Connect	$4	$1
SuperGold (65+)	$4	$2 peak, free off-peak
Bus Fares – Queenstown Airport Only		
Child (5 – 12 years)	$8	Free when you tag on with your registered Bee Card
Youth (13 – 18 years)	$8	75c
Youth Plus (19 – 24 years)	$10	$1
Adult (25+)	$10	$2
Queenstown Ferry Only		
Infant (under 5 years)	Free	Free (no card required)
Child (5 – 12 years)	$14	$10 (no concessions on ferry)
Youth (13 – 18 years)		
Youth Plus (19 – 24 years)		
Adult (25+)		
Community Connect		
SuperGold (65+)		

[3] Public Transport Fares, Otago Regional Council (2023).

3 Proposed Services Funding Requirements

3.1 Operating Costs

Operating cost estimates have been completed for the short-listed service pattern options using the method contained in the NZTA Monetised Benefits and Costs Manual. This involved calculating the in-service kilometres, in-service hours, and peak vehicle requirements for each of the options.[4] These values were then multiplied by unit cost rates which have been updated to 2023 prices and to reflect the characteristics of electric buses and ferries.

Using the demand forecasts from the public transport model, an estimate of fare revenue was made assuming the current Bee Card adult bus fare of $2 and a $10 ferry fare. The costs and revenue were inflated at a rate of 2% per year which is the midpoint of the reserve banks inflation targets. Public transport fare structure and levels are not part of the scope of the business case. However, it has been assumed that fares would be increased in line with inflation.

The operating cost estimates for 2039 and 2053 are shown in Table 2 and Table 3, respectively.

Table 2: 2039 Operating cost estimates for short-listed service pattern options

Network Options	OPEX Cost Estimate	Revenue Estimate	Subsidy Estimate
Bus Max	$20,940,000	$11,830,000	$9,110,000
Bus Max plus PT Bridge	$19,250,000	$10,760,000	$8,490,000
Bus Max plus Malaghans Rd	$22,570,000	$11,860,000	$10,710,000
Bus Max plus Jacks Point Ferry	$29,830,000	$13,210,000	$16,620,000
Jacks Point Spine	$20,910,000	$9,490,000	$11,420,000
Jacks Point Spine plus PT bridge	$19,950,000	$10,560,000	$9,390,000
Jacks Point Spine plus Malaghans Rd	$23,270,000	$10,590,000	$12,680,000
Jacks Point Spine plus Jacks Point ferry	$29,810,000	$10,870,000	$18,940,000
Composite with Northbound Bus Lane plus Malaghan's Rd	$25,000,000	$8,730,000	$16,280,000

[4] See Appendix for further details of Opex estimates

Table 3: 2053 Operating cost estimates for short-listed service pattern options

Network Options (2053)	OPEX Cost Estimate	Revenue Estimate	Subsidy Estimate
Bus Max	$35,270,000	$18,970,000	$16,300,000
Bus Max plus PT Bridge	$32,610,000	$19,360,000	$13,250,000
Bus Max plus Malaghans Rd	$35,940,000	$18,910,000	$17,030,000
Bus Max plus Jacks Point ferry	$41,890,000	$25,170,000	$16,720,000
Jacks Point Spine	$33,090,000	$18,190,000	$14,900,000
Jacks Point Spine plus PT bridge	$30,880,000	$18,580,000	$12,200,000
Jacks Point Spine plus Malaghans Rd	$33,760,000	$18,140,000	$15,620,000
Jacks Point Spine plus Jacks Point Ferry	$39,700,000	$24,670,000	$15,030,000
Composite with Northbound Bus Lane plus Malaghan's Rd	$32,420,000	$12,820,000	$19,600,000

The forecast subsidy for the short-listed service patterns options in 2039 is in the range of $8.5 million to $18.9 million. The Preferred Option has a subsidy of $16.3M. Using fare box recovery as the metric, 35% to 56% of the operating costs are covered by fare revenue. The operating costs would be the responsibility of Otago Regional Council as an ongoing cost and would need to be covered by an increase in revenue.

With the focus of the business case being a 15-year plan, the 2039 figures will be used for the affordability assessment in this paper.

3.2 Capital Costs

High level cost estimates were completed for the component infrastructure items required to support the service pattern options as shown in Table 4.[5] The costs are indicative only. Infrastructure design is outside the scope of the business case. Therefore, there is a high degree of uncertainty in the estimates. An allowance for property acquisition was made using current rating values.

[5] See appendix for further detail of high level capex estimates

Table 4: High level cost estimates for public transport network infrastructure

Infrastructure Item	High Level Cost (p50)	Notes
Stanley Street hub	$890,000 (previous estimate $563,000)	Modification of proposed bus hub design
Frankton hub	$1,547,000	Modification of proposed bus hub design
Bus stop modifications	$1,134,000	Lengthening bus bays for articulated buses
Speargrass park n ride	$9,810,000	Park n ride on Malaghans Road
Intersection modifications	$511,000	Modifications to four intersections to enable bus movements
Remarkables Park on-street hub	$818,000	Bus shelters
Five Mile on-street hub	$393,000	Bus shelters
Jack's Point wharf	$3,370,000	Wharf and electric ferry charger. Excludes park n ride and ferry building
Electric bus depot	$58,400,000 (previous estimate $4,800,000)	Purchase of site, construction of buildings and bus chargers
Boyd Road bridge	$56,020,000	Two lane public transport bridge with walking and cycling facilities
Northbound bus lanes for composite option	$3,070,000	For composite option

Infrastructure on the local road network is assumed to be the responsibility of QLDC, with infrastructure on the state highway being the responsibility of NZTA.

For the bus depot, the benefits would fall to the regional council through potentially lower public transport operating contracts as it could remove a significant barrier to new bus operators entering the market. Therefore, the costs for the bus depot are assumed to be borne by Otago Regional Council and are common to all service pattern options.

Table 5 shows the sum of all infrastructure required to support each of the service pattern options. The bus depot has been excluded as this is required for all options.

Table 5: Infrastructure cost estimates by service pattern option

Service Pattern Option	High Level Infrastructure cost without depot (assumed QLDC)	Infrastructure Included
Bus Max	$3,755,000	Stanley St and Frankton Hubs, bus stop modifications and intersection modifications
Bus Max with Boyd Road Bridge	$60,986,000	Stanley St and Frankton Hubs, bus stop modifications, intersection modifications, Remarkables Park and Five Mile hubs and Boyd Road bridge
Bus Max with Malaghans Road	$13,565,000	Stanley St and Frankton Hubs, bus stop modifications, intersection modifications and Sparegrass park n ride
Bus Max with Jack's Point Ferry	$7,125,000	Stanley St and Frankton Hubs, bus stop modifications, intersection modifications and Jack's Point ferry
Jack's Point Spine	$3,755,000	Stanley St and Frankton Hubs, bus stop modifications and intersection modifications
Jack's Point spine with Boyd Road Bridge	$60,986,000	Stanley St and Frankton Hubs, bus stop modifications, intersection modifications, Remarkables Park and Five Mile hubs and Boyd Road bridge
Jack's Point Spine with Malaghans Road	$13,565,000	Stanley St and Frankton Hubs, bus stop modifications, intersection modifications and Sparegrass park n ride
Jack's Point Spine with Jack's Point Ferry	$7,125,000	Stanley St and Frankton Hubs, bus stop modifications, intersection modifications and Jack's Point ferry
Composite with Northbound Bus Lane plus Malaghan's Rd	$8,361,000	Stanley St and Frankton Hubs, bus stop modifications, intersection modifications, Remarkables Park and Five Mile hubs, Northbound bus lane

4 Affordability Assessment

4.1 Operating Costs

4.1.1 Otago Regional Council

The effect on rates from operating the Whakatipu Public Transport network in financial year 2023/24 is $2.1 million.[6] This is fully generated from targeted rates in areas where services are provided. The contribution towards operating public transport services from properties in Queenstown-Whakatipu Ward[7] would be around $104 on average. In practice, rates differ between residential/ non-residential properties and between properties of higher or lower value.

When considering the subsidy for the future public transport network it has been assumed that contributions would be based on the current funding assistance ratio for ORC of 51%[8]. Therefore, the share for Otago Regional Council for subsidising the public transport network in the year 2039 would be approximately $4.25 million to $9.47 million depending on the service pattern option.

If the number of rating units in the Queenstown-Whakatipu Ward[9] is assumed to be 27,443 in 2039, the average contribution from rates towards operating the future public transport network would be $154 to $345 on average. This increase would be staggered over the 15-year period as service levels were increased to encourage mode shift and accommodate growth.

For comparison, rate payers in Dunedin contribute $138 on average toward public transport for the financial year 2023/24.[10] The Dunedin bus network has services every 15 to 30min depending on the route and time of day compared to 10 to 15min service frequency proposed for Queenstown. Wellington regional rate payers contributed approximately $600 on average for 2023/24 for operating the extensive bus, ferry, and rail network.[11]

Queenstown's median personal incomes are $40,600 compared to $25,500 for Dunedin and $31,800 for New Zealand as a whole.[12] The rates contribution for the proposed Queenstown public network is in line with Dunedin on a per rating unit and personal incomes basis. Therefore, it is considered that the operating costs of the proposed Queenstown public transport network are affordable from increasing the targeted rates amount. The ultimate decision on affordability is a matter for elected representatives to determine based on consultation with the community. Potential alternative funding sources to lessen the rates burden will be explored later in this advisor paper.

4.1.2 Operating Costs – NZTA

Based on the NZTA 2021 – 2024 National Land Transport Programme, the total amount of funding committed each year within the NLTP period to public transport service operation is $407 million. From the Government Policy Statement on Land Transport the 2023/2024 funding range for Public Transport Services – Service Operation is $420 million (lower limit) to $700 million (upper limit).[13] This indicates an estimated underspend in 2023/2024 of $13 million to $293 million compared to the funding available.

The proposed public transport services in 2039 lie beyond the GPS 2024's provided forecast funding years. Hence, the 2033/2034 upper limit funding amount of $1.7 billion (from the GPS 2024)[14] will be assumed as the 2039 funding amount for the affordability assessment.

[6] Otago Long Term Plan 2021-2031
[7] The forecast number of rating units in the Queenstown-Whakatipu Ward is 19,664 for 2023/24 (from QLDC 10-year plan).
[8] NZTA 2021-24 NLTP Funding Assistance Ratios
[9] Assuming a linear extrapolation of the number of rating units forecast contained in the QLDC 10-year plan
[10] Otago Long Term Plan 2021-2031
[11] Wellington Regional Long Term Plan 2021-2031
[12] Stats New Zealand 2018 Census place summaries
[13] Government Policy Statement on Land Transport 2021/22 - 2030/31, Ministry of Transport (September 2020).
[14] Draft Government Policy Statement on land transport 2024/25 - 2033/34, Ministry of Transport (August 2023).

Applying the current funding assistance ratios policy, financial contributions would be shared 49% to Otago Regional Council and 51% to NZTA. Therefore, the share for NZTA subsidising the public transport network in the year 2039 would be approximately $4.2 million to $9.5 million, depending on the service pattern option. The Preferred Option would have $8.1 million NZTA subsidy.

It appears that there is sufficient funding within the public transport service operation activity class to cover the anticipated NZTA contribution for the Queenstown public transport service improvements. However, this would need to be confirmed with NZTA to account for any unconfirmed funding applications from other parts of New Zealand.

4.1.3 Funding Equity

It was also considered whether the required funding level for Queenstown would be equitable considering Queenstown's population relative to that of New Zealand. The latest figures from Statistics New Zealand on population size are shown in Table 6.

Table 6: Resident Population for Queenstown and New Zealand.

Categories	Population
Residents (2022)[15]	49,500
Whole of New Zealand (June 2023)[16]	5,223,000

Queenstown makes up approximately 0.95% of New Zealand's population not including the high volume of domestic and international tourists which visit Queenstown each year. Depending on the service pattern option chosen, the NZTA subsidy for public transport services in Queenstown would be 0.25% to 0.57% of the assumed funding available in 2039. Therefore, the proposed subsidy levels from the NLTP for the proposed Queenstown public transport services would be in line with Queenstown's population.

4.2 Capital Costs

4.2.1 Otago Regional Council

Public ownership of a new electric bus depot could remove barriers to new bus operators from entering the market. This is because Queenstown has limited commercially zoned land that is suitable for a bus depot and therefore incumbent operators can have an advantage over new operators. For the purposes of this paper, it has been assumed that the cost savings that private operators receive from public ownership of the bus depot would be passed back to the council via lower operating contract rates. This either requires the competitive tendering of the bus operating contract or 'open book' negotiations with the current operator.

Public ownership of a new bus depot would have an upfront cost from purchasing and developing the site with ongoing operating cost savings. For this assessment, it has been assumed that the new bus depot would be in place for the expiry of the current operating contracts. The contract expiry dates are 19 November 2028 for unit 6, 19 November 2026 for unit 7, and 30 June 2024 for the ferry. It is considered that this project would be well suited to debt funding rather than being funded from a one-off rates increase. This is because the debt would smooth out the funding and would be equitable as the cost savings from the bus depot would accrue mostly to future rate payers. The debt could be repaid through the targeted rate on properties within Whakatipu and could be offset by a reduction in operating costs relative to having the depot in private ownership.

Otago Regional Council has low debt levels of approximately 25% of total revenue[17] for the financial year 2023/24. From the ORC Long Term Plan 2021-31, borrowing limits on debt shall not exceed

[15] Queenstown Lakes District - Population, Infometrics.
[16] Population, Statistics New Zealand (2023).
[17] based on the Long Term Plan

175% of total revenue and interest expense shall not exceed 25% of total revenue. Assuming a 51% funding assistance ratio from the NLTF, the bus depot would increase debt by approximately $29 million. Total debt would go from approximately $33 million in 2023/24 to $62 million in approximately 2026. Debt servicing costs would be $1M[18] per annum. This would put debt servicing costs at approximately 0.9% of total revenue for 2023/24 well within the limit for affordability which is 10%.

4.2.2 Queenstown Lakes District Council

QLDC's potential share of capital costs involved in implementing the new network varies from $1.8 million to $29.9 million depending on the service pattern option. This assumes a normal funding assistance ratio of 51% from the NLTP.

Queenstown Lakes District Council has planned debt of $505.9 million,[19] which is 251% of total revenue. The debt limit set by the Local Government Funding Agency is 280% of total revenue. The interest expense from the debt is 5.9% in financial year 2023/24 with the affordability threshold being 20%. The current debt reflects the fact that Queenstown and Wanaka are high growth areas with large capital requirements for roading, three waters, and community facilities.

Activities contained in the Queenstown Integrated Transport Business are budgeted in the long-term plan including town centre street upgrades, Queenstown arterials, and public transport improvements. Due to changes in the proposed public transport network for Queenstown, some of the budgeted capital works may be able to be reallocated which is documented in the table below. The capital costs shown are the QLDC share assuming a normal funding assistance ratio from the NLTP.

Table 7: Selected activities from QLDC Ten Year Plan (2021-31)

Capital Works	Budget	Comments
Whakatipu Park & Ride Facility	$1,937,000 (approx. half in 2023 and other half is 2031)	This park and ride may not be required as it is not included in the service patterns options. Note: this facility is not in the draft LTP for 2024-2034.
Queenstown Public Transport Interchange	$12,203,000 (mostly in 2029)	Off road interchange not included in the service pattern options however could be required if offline public transport route is adopted

It is likely that the public transport infrastructure would be debt-funded. The affordability assessment for each of the short-listed service pattern options is shown in the table below. This assessment assumes that the infrastructure investment is made in 2026 to align with the expiry of the first bus operating contract (unit 6).

[18] assuming 10-year bonds at 3.5% coupon rate which is based on the results from the 9 August 2023 Local Government Funding Authorities bond tender
[19] QLDC 10-year plan

Table 8: Capital cost affordability assessment for service pattern options

Service Pattern Option	Approximate Debt Level (251% current and 280% limit)	Approximate Additional Debt Servicing Cost per year
Bus Max	248%	NA
Bus Max with Boyd Road bridge	260%	$500,000
Bus Max with Malaghans Road	250%	NA
Bus Max with Jack's Point Ferry	249%	NA
Jack's Point Spine	248%	NA
Jack's Point Spine with Boyd Road bridge	260%	$500,000
Jack's Point Spine with Malaghans Road	250%	NA
Jack's Point Spine with Jack's Point Ferry	249%	NA
Composite with Northbound Bus Lane plus Malaghan's Road	248%	NA

It is considered that QLDC capital contributions for the service pattern options, except for those that include the Boyd Road bridge, are affordable. This is because the debt levels and servicing are in line with the proposed levels in the 10-year plan. For the Boyd Road bridge, although the increase in debt required is within the limit set by the Local Government Funding Agency, it is considered not affordable as it does not leave an allowance for cost and funding risks. Therefore, the Boyd Road bridge would not be financially feasible until after Arterials Stage 3 is complete which is planned for financial year 2030/31.

Considering these funding constraints, a bus lane on State Highway 6 between Kawarau River bridge and Boyd Road should be investigated by NZTA as an alternative to the public transport bridge in the short term. This bus lane is included as a component of the Preferred Option. The bus lane would improve travel times for passengers travelling to Frankton and Queenstown from the Southern Growth Area and could potentially be implemented sooner. The bus lane would not solve the geographic challenge of Remarkables Park not being on the way from the Southern Growth Area, so does not reduce operating costs as much as the public transport bridge.

4.2.3 NZTA

The capital costs involved in implementing the new network for NZTA varies from $24.8 million to $54.0 million depending on the service pattern option. This assumes a normal funding assistance ratio of 51% from the NLTP. This assessment assumes that both the public transport bridge and the electric bus depot would be funded through the public transport infrastructure activity class.

Under the NLTP's Public Transport Infrastructure activity class, the level of committed funding is $604 million per year during the 2021-24 period. The funding range for Public Transport Infrastructure is $370 million - $660 million[20] for financial year 2023/24. This indicates an estimated underspend of approximately $56 million for 2023/2024 compared to the upper limit of funding available.

The indicative investment date for the additional public transport infrastructure is 2026 when the first bus operating contract expires and a ramp up in service levels could occur. In the financial year

[20] Government Policy Statement on Land Transport 2021/22 - 2030/31, Ministry of Transport (September 2020).

2026/27, the public transport infrastructure activity class has a lower limit of $620 million and an upper limit of $1,110 million.

Because of the planned increase in funding for public transport infrastructure in the future it is considered that the capital costs for NZTA are affordable. This is because the proposed capital costs would make up between 2.2% to 4.8% of the upper limit for the 2026/27 public transport infrastructure activity class.

5 Potential Alternative Funding Models

This section discusses alternative funding sources that are either currently available to QLDC and ORC or have been proposed for Queenstown. The focus of this investigation is to identify funding sources for the proposed public transport network and to not address general council funding pressures.

5.1 Parking Charging

There are 15 council administered paid parking areas in Queenstown town centre with a fee of $2 to $6 per hour, generating revenue[21] of $3.8 million. It is understood that a portion of the parking revenue is passed to ORC in order to financially support the Queenstown public transport network.

It is assumed that the maximum feasible revenue from parking charging is a 25% increase from current level that would involve increasing all parking chargers to $6 per hour. On this assumption, increasing parking fees could generate an additional $950,000. Since this is an existing funding source, no additional collection costs would be incurred. This is below the level of revenue estimated to be required to finance the Boyd Road Bridge capital costs which is $1.9 million per annum including debt interest costs.

5.2 Congestion Charging

Congestion charging would involve charging drivers a fee to use certain roads, with differing levels of fee being applied during peak and off-peak times. Congestion charging would require a change in legislation to enable councils to levy motorists. However, congestion charging has been suggested for Auckland, Wellington, and Tauranga. It is out of scope for this business case to consider demand management tools in detail (they will be investigated via the TDM programme), so this assessment will consider potential revenue levels from congestion charging at a high level.

From the 2039 Public Transport model, there are approximately 1,900 vehicles on Shotover Bridge, 900 vehicles on Arthur's Point Crossing, and 2,300 vehicles on Kawarau Falls Bridge in the morning peak. Assuming that these vehicles make two trips and that a $2 charge is placed on all peak time trips then approximately $20,400 per day or $5.1 million per year could be generated from a congestion charge. This does not take into account the likely mode shift away from driving and the administrative costs involved in collecting the charge. This revenue is likely to be sufficient to finance the public transport bridge assuming that debt repayments are made from the congestion charge.

It is considered that congestion charging cannot be relied upon to finance the operating or capital costs of the new public transport network. This is due to uncertainty of if, or when, congestion charging would be permitted through a change in legislation. Further, it is possible that there would be political pressure to make the congestion charging scheme revenue neutral or at least reduce rates as a result of introducing the charge.

5.3 Visitor Levy

The visitor levy would be a proposed levy on accommodation providers within the Queenstown Lakes District to contribute towards the cost of providing infrastructure. In 2019 a non-binding referendum was held in which 81% of voters supported the visitor levy with a 41% response rate. Work on drafting legislation to enable the visitor levy was progressed and political support from the government appeared to be forthcoming. However due to the Covid-19 pandemic work on the visitor levy was paused until tourism returned to normal levels. The QLDC 10-year plan includes a visitor levy from 2024 onwards that is expected to generate approximately $23 million in revenue

[21] 2023/ 24 Annual Plan

per year. The proposed levy is 5% of the accommodation cost (for example a $250 a night hotel room would equate to a $12.50 levy).

A visitor levy is included in the 10-year plan to fund general infrastructure needs, therefore this revenue stream would not be available to fund the additional public transport infrastructure costs. Because the visitor levy would be a new revenue stream it is assumed that increasing the visitor levy would not be feasible especially in the short term as accommodation providers adjust.

5.4 Tourism Infrastructure Fund

The Tourism Infrastructure Fund is a $25 million annual contestable fund to develop tourism-related infrastructure that supports regions facing pressure from tourism growth. Although the Queenstown public transport network is used extensively by tourists, neither the capital or operating costs would be eligible for tourism infrastructure funding. This is because eligibility criteria exclude projects that receive funding from NZTA.

5.5 Climate Emergency Response Fund[22]

In 2021, the Government announced the establishment of a new Climate Emergency Response Fund (CERF). The fund was set up with an initial $4.5 billion payment by the Government with proceeds from the Emissions Trading Scheme being planned to replenish the fund. The purpose of CERF is to provide a dedicated funding source for public investment in climate-related initiatives. To be eligible for CERF funding an initiative must either support emissions reductions or reduce vulnerability to the impacts of climate change. The activities contained in the 2023 CERF programme included research, international development, transport, social development, agriculture and forestry. The transport initiatives included subsidising public transport for community services card holders, decarbonising the public transport bus fleet, extending half price public transport fares, and recruiting bus drivers. The funds from CERF are distributed by the relevant government agency.

The initiatives contained in the CERF as of June 2023 that are of interest to this business case are summarised in Table 9.

Table 9: Funding for selected CERF initiatives (source: June 2023 Treasury reporting)

Initiative	Total Funding until 2025/26	Spend to Date
Decarbonising the public transport bus fleet	$36,000,000	$1,000
Retaining and recruiting bus drivers	$48,000,000	$0

Funding agreements for these initiatives are still being finalised, therefore, eligibility and timing of funding is unclear at the time of writing this report. Therefore, it is recommended that CERF funding is investigated to support the capital expenditure of the bus depot and the operating costs of the new network. However, due to the uncertainty at this early stage in the programme it is considered that CERF funding cannot be relied upon for this business case.

5.6 Developer Contributions

A developer contribution is a financial charge levied on new developments so that any party who creates additional demand on local infrastructure contributes to the extra cost they impose on the

[22] This paper was initially drafted in September 2023. At the time of finalising this paper in March 2024 New Zealand is in a transition period with government policies anticipated to change. This includes a planned redirection of CERF monies.

community. Developer contributions can be for council services relating to three waters, reserve, community facilities, and transportation. QLDC's Developer Contribution Policy sets out the contribution required per dwelling equivalent for each of the areas within Queenstown. The total cash contribution (excluding reserve land) for developments within Whakatipu are $15,255 to $24,037 per dwelling depending on the area, with a special contribution being made for properties within the Eastern Access Road area.

Transportation contributions for properties within the Southern Corridor are the same for the rest of Whakatipu at $3,389 excluding GST. However, it is considered that a higher contribution for the Southern Growth area could be warranted due to the high growth forecast in the area and the limited transport connections. Using the Public Transport model, SH6 at Kawarau Falls Bridge is forecast to be at 120% capacity (demand will exceed capacity) in 2039 and is the link with the highest demand in the transport network. Therefore, a significant increase in the level of service for public transport is needed for the Southern Growth area to enable a mode shift towards public transport.

The capital costs incurred by council for serving the Southern Growth area with public transport services of sufficient quality could include a ferry wharf and a public transport bridge. Funding the full local share of the Boyd Road bridge from developer contributions is considered infeasible as this would add $7,500 per planned dwelling. This would be approximately triple the transportation contributions and since developer contributions are passed on to home buyers this is considered too large an amount. However, funding the local share of the Homestead Bay wharf is considered feasible as it would add $900 per dwelling to developer contributions based on 3,650 new dwellings. Therefore, it is recommended that QLDC investigates amending the Developer Contribution Policy to include an allowance for the Homestead Bay wharf if a ferry service is recommended.

6 Conclusion

This Sustainable Funding Model Advisory Paper identifies the funding mix for the proposed service patterns and public transport infrastructure in Queenstown. The potential funding sources include NZTA, ORC, QLDC, public transport users and third-party contributions. A key consideration of this paper is the affordability of funding for all parties including both operating and capital costs. Indicative high level operating cost estimates were completed for the short-listed service pattern options in 2039 and 2053. Indicative high level capital cost estimates were also completed for the component infrastructure required to support the service patterns. The benefits for the bus depot are assumed to ORC through potentially lower public transport operating contracts, hence it is assumed that ORC would bear the bus depot costs.

Through affordability assessments, it is considered that the operating costs of the proposed Queenstown public transport network are affordable from increasing the targeted rate. The ultimate decision on affordability is a matter for elected representatives to determine based on consultation with the community. It is considered that there is sufficient funding available within the public transport service operation activity class to cover the anticipated NZTA contribution for the Queenstown public transport service improvements. However, this would need to be confirmed with NZTA to account for any unconfirmed funding applications from other parts of New Zealand. The proposed subsidy levels from the NLTP for the proposed Queenstown public transport services is also considered to be in line with Queenstown's population.

Through affordability assessments, for the capital costs for publicly-owned electric bus depot, it is considered that this project would be well suited to debt funding rather than being funded from a one-off rates increase. The debt could be repaid through the targeted rate on properties within Whakatipu and could be offset by a reduction in operating costs relative to having the depot in private ownership. It is considered that QLDC capital contributions for the service pattern options except for those that include the Boyd Road bridge are affordable. For NZTA, it is considered that the capital costs for NZTA are affordable because of the planned increase in funding for public transport infrastructure in the future. With regards to additional funding sources developer contributions and congestion charging were found to have the highest potential to contribute to the funding mix. It is recommended that the developer contributions policy is amended to account for public transport infrastructure for the Southern Growth Area. It is also recommended that congestion charging is investigated as both a demand management and funding stream for public transport services and infrastructure.

wsp.com/nz

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Queenstown Public Transport Business Case

15 March 2024

CONFIDENTIAL

Advisory Paper 1: Forecast Demand

150 YEARS IN AOTEAROA

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to the Queenstown Public Transport Business Case ('**Purpose**') and in accordance with the Contract TCTB1 dated 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Summary

This Forecast Demand Advisory Paper is the first of the advisory papers for the Queenstown Public Transport Business Case. It discusses the Queenstown Lakes Spatial Plan, how the plan will inform changes to land use and transport demand forecasting, briefly touches on the public transport forecasting and modelling methodology and discusses differences in forecast patronage to the previous Queenstown Transport Business Case.

The Queenstown Lakes Spatial Plan was adopted in July 2021. The Spatial Plan promotes a consolidated and mixed-use approach to accommodating growth in the Queenstown Lakes. The approach focusses housing and employment growth in locations that are already fully or partially urbanised. Within the existing Queenstown Lakes urban area, growth will be focused in locations with good access to facilities, jobs and public transport. This requires enabling higher density development and a greater mix of uses than currently provided. The Spatial Plan seeks to concentrate high density, mixed-use development along public transport corridors that will support high-frequency public transport services.

The Spatial Plan anticipates significant growth for Queenstown Lakes[1]:

- The average day population (residents and visitors) for the district is expected to more than double, from an estimated 51,000 people (41,000 residents and 10,000 visitors) in 2021 to an estimated 120,000 (78,000 residents and 42,000 visitors) in 2051. The resident population is approximately 81% on an average day
- The peak day population (residents and visitors) for the district is expected to increase from an estimated 103,000 people (41,000 residents and 62,000 visitors) in 2021 to an estimated 204,000 (78,000 residents and 126,000 visitors) in 2051. The resident population is approximately 38% on a peak day

Queenstown Lakes District Council (QLDC) provided new land use projections (from November 2022)[2] based on the Spatial Plan. The projections include:

- Fewer households (-9.4%), tourists (-12.1%) and jobs (-1.6%) in the district in the latest forecasts, comparing 2027 update to 2028 QITPBC
- Fewer households (-3.4%), tourists (-3.3%) and jobs (-10.0%) in the district in the latest forecasts, comparing 2053 update to 2048 QITPBC
- Halving of tourist accommodation in central Queenstown, comparing at both medium (2027/2028) and long term (2048/2053) time horizons, with accommodation units shifting to Frankton and further afield
- Also, there is a reduction in households within central Queenstown, at both medium- and long-term time horizons
- Increase in the population and associated job opportunities in Wanaka and Cromwell that could potentially result in less dependency on Frankton and Queenstown (resulting in a reduction in longer distance trips through Kawarau Gorge and over the Crown Range)[3].

These changes result in a drop in trip growth on the SH6A corridor, as less trips start or end in central Queenstown. The general drop in tourist numbers in the Queenstown Transport Business Case (QTBC 2020) did not account for the impact of COVID. The new land use projections also assume more "self-sufficiency" in employment within Wanaka and Cromwell which has led to reduced longer distance trips.

[1] Note that the population projects were completed after a period of significant uncertainty following the Covid-19 pandemic
[2] From the QLDC 2018 TRACKS Transportation Model Update and Futures by Abley
[3] Relative house price affordability could be a factor that continues to encourage commuting from Cromwell

The scale and volume of passengers required to be accommodated by public transport to maintain operation of the road network to an acceptable degree volume/capacity (v/c) ratio was then estimated[4]. Headline new target mode share and patronage numbers (one-way passengers per hour) in the critical direction are set out in the table on the following page.

Previously, the QTBC had headline targets of 40% PT mode share on SH6A by 2028, and 60% by 2048 – with associated targets on Shotover Bridge of 25% and 40% respectively. The latest forecasts suggest that the speed of mode shift does not need to be quite as quick as previous. However, the increased rate of residential growth on the Southern Corridor leads to significant public transport being required on this part of the network, similar to those predicted on SH6A by 2053.

		Morning peak hour		Afternoon peak hour	
		PT share	PT Pass/hour	PT share	PT Pass/hour
2027	SH6A	27%	592	28%	594
	Shotover Bridge	18%	323	18%	369
	Kawarau Falls	11%	186	7%	123
2039	SH6A	40%	1082	40%	1028
	Shotover Bridge	25%	514	29%	657
	Kawarau Falls	40%	1033	37%	909
2053	SH6A	47%	1466	48%	1384
	Shotover Bridge	34%	772	35%	869
	Kawarau Falls	53%	1687	49%	1489

These forecasts will be used to develop and assess public transport service options as part of the Service Patterns Advisory Paper. Sensitivity testing of the forecasts and assumptions will be undertaken as part of the advisory paper and business case development. The Service Patterns Advisory Paper will include describing the public transport network and frequencies to maximise public transport mode shift, over next 15-years, and 30-year period. It will describe areas where lead public transport services should go, and where better services can drive public transport, and inform when the investigation of an off-line public transport service is required

2 Introduction

WSP has been commissioned by Otago Regional Council (ORC) to undertake the Queenstown Public Transport Business Case (the 'Project'). As part of the Project, a series of advisory papers will be produced to assess the future public transport demand, assess and develop service pattern and decarbonisation options, and explore funding and operational models.

This Forecast Demand Advisory Paper is the first of the Project's advisory papers. It discusses the Queenstown Lakes Spatial Plan, how the plan will inform changes to land use and transport demand forecasting, briefly touches on the public transport forecasting and modelling

[4] Acceptable V/C ratio was set at 90% which is consistent with earlier business case stages

methodology and discusses differences in forecast patronage to the previous Queenstown Transport Business Case. The paper is structured as follows:

- Introduction
- Brief background from the previous Queenstown Transport Business Case (QTBC)
- Queenstown Lakes Spatial Plan
- Forecast Patronage Demand
- Summary

The forecasts summarised in this paper will be used to inform public transport service option development.

3 Background

Queenstown is one of New Zealand's fastest-growing regions which has been driven by population growth and tourism. In 2020, the QTBC was completed, which looked at options to address this growth and outlined the case for investment for a suite of multi-modal transport interventions covering the Wakatipu Basin over the next 30 years.

Prior to the Covid-19 pandemic, the Queenstown Lakes District experienced the fastest rate of resident and visitor growth in New Zealand. Over the past 30 years, the Queenstown Lakes District has grown from 15,000 residents to its current population of 41,000 along with significant growth in visitors to the area.

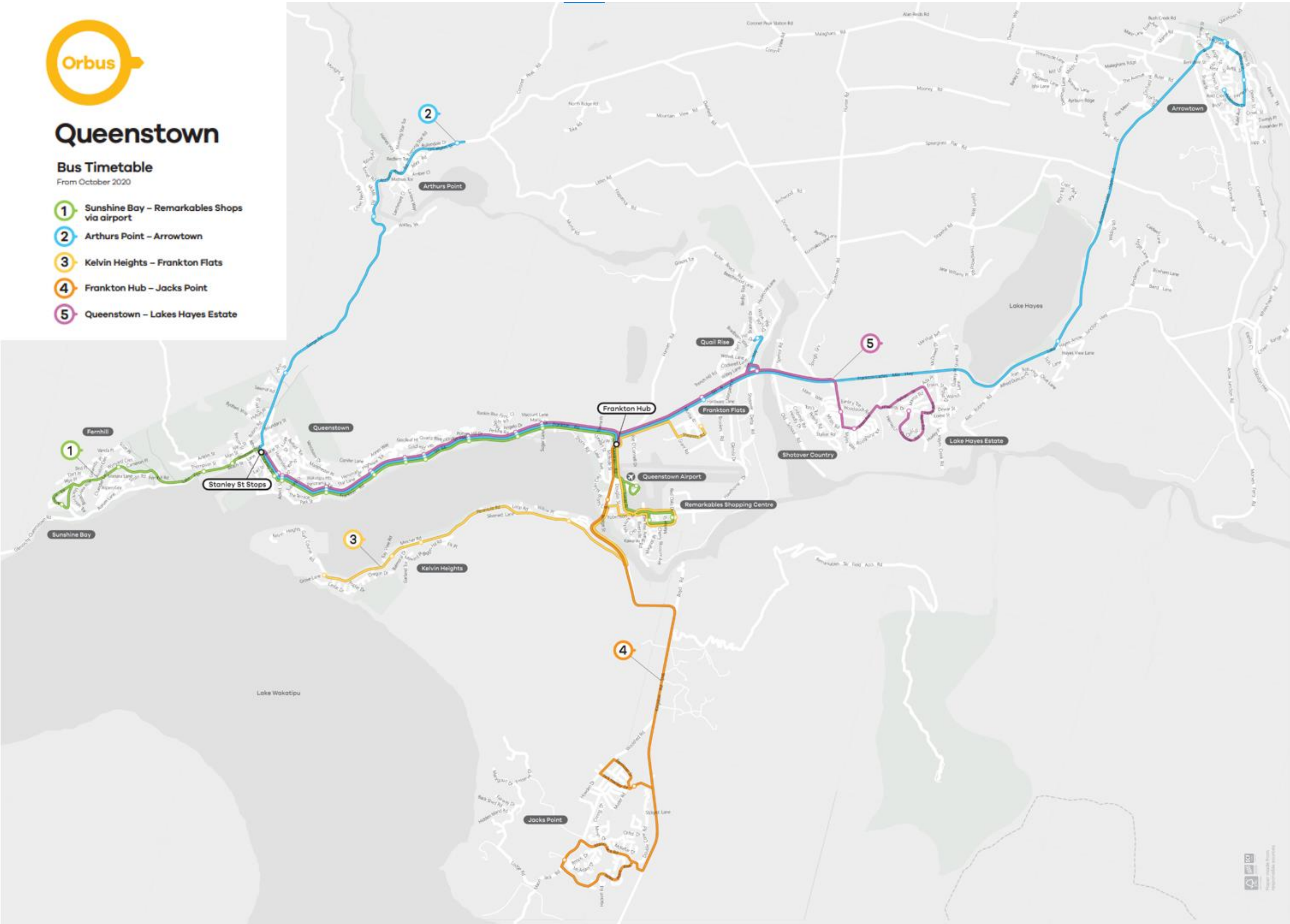
Queenstown has grown in a dispersed manner requiring infrastructure networks to be extended and upgraded. The transport system has not been able to keep up with growth in businesses, residents and visitors. The dispersed, low density development pattern means many people are reliant on private vehicles to access jobs, education and facilities. Significant tourism activities in Queenstown adds to congestion, emissions and safety issues.

The transport network in the Wakatipu Basin is constrained geographically and topographically, with many parts of served by one route (i.e. State Highway 6A between Frankton and Queenstown Town Centre), many of which are vulnerable to closure. This can be illustrated by the existing Queenstown Public Transport Network which is shown in **Figure 1**.

There is an alternative route between Arthurs Point and Arrowtown via Malaghans to Queenstown. There is a planned project to improve this route consisting of a new two-lane bridge adjacent to the existing Edith Cavell single lane bridge. The Wakatipu Basin includes the principal commercial centre of the district (of both Queenstown and Frankton), with the key road links bringing local and tourist traffic into and out of the area from other centres within the district (e.g. Wanaka) and adjacent districts (e.g. Cromwell), as well as longer distance trips from both directions of SH6.

Parts of the network are already at capacity. SH6A practical capacity was exceeded on 140 days in 2019 (QTBC). Without improvement, the level of service will further decline, peak spreading will occur, travel time reliability will deteriorate, and increasingly significant congestion will occur. Traffic is also coming from Wanaka and Cromwell, adding to the congestion in Wakatipu Basin. By 2028, QTBC modelling indicated that average conditions will be similar to current peak travel times and peak periods will experience regular gridlock with car and public transport travel times between Lake Hayes Estate and Queenstown regularly exceeding 60 minutes (compared to 15-20 min currently).

Figure 1: Existing Queenstown Public Transport Network



Transport modelling from the QTBC indicated that peak hour people trips are forecast to double on the geographically constrained SH6A, from approximately 1,500 (in 2028) to more than 3,000 (2048). Modelling further suggested that 40% of all trips between Frankton and Queenstown Town Centre at peak times will need to be on alternative modes to private vehicles by 2028 and 60% by 2048 if the high levels of congestion and major delays are to be avoided (noting the forecasting was done pre-Covid).

A multi-modal package of new transport initiatives was adopted including an improved walking and cycling network, enhanced ferry services and a frequent public transport system (Figure 2 and Figure 3). A key feature of the new system is a Frequent Public Transport Network, initially between the Queenstown Town Centre and Frankton, and eventually extending east to Ladies Mile, and south to Jacks Point via the Airport and Remarkables Park.

There are also several projects in various stages of planning or implementation which have transport initiatives to help drive mode shift. These include:

- Queenstown New Zealand Upgrade Programme (NZUP): proposed bus lanes on SH6A and bus priority measures (SH6) along with other improvements. Reduced to limited bus lanes along SH6A (near Marina Rd).
- Wakatipu Active Travel Network (WATN) Business Case: a programme of works to deliver new walking and cycling facilities to key destinations such as Arrowtown, Arthur's Point, Kelvin Heights, Jacks Point, Lake Hayes Estate and Shotover Country, Fernhill, Frankton and Queenstown.
- Wakatipu Ferry Services Detailed Business Case (DBC): investigates the utilisation of Lake Wakatipu as a public transport option.

Figure 2: QTBC Programme of Interventions

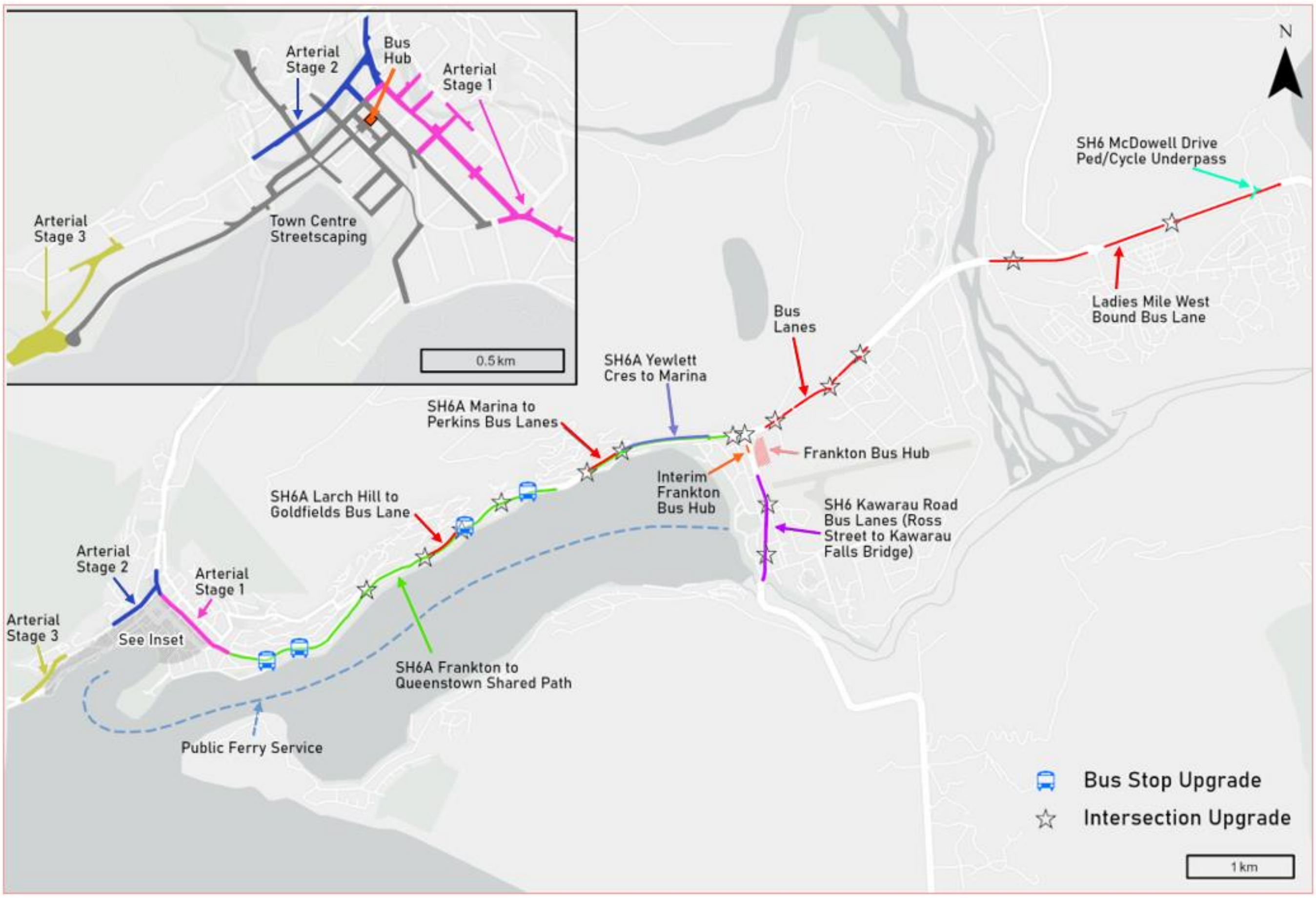
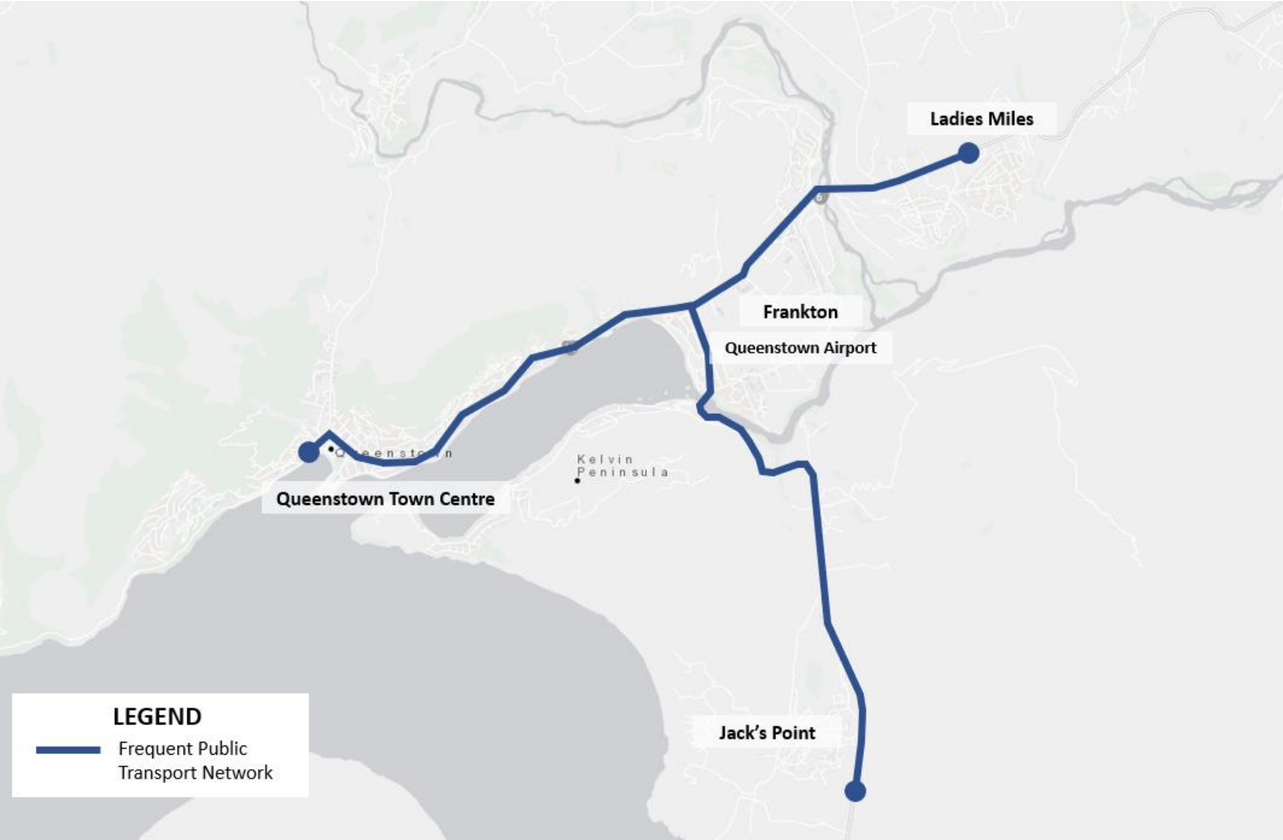


Figure 3: Proposed Frequent Public Transport Network From QTBC



At the time of the QTBC, the Spatial Plan was being developed to look at likely changes to where people will live and work within the Wakatipu Basin over the next 40 years and identifying a need to plan development sustainably to minimise traffic growth. The Spatial Plan is expected to lead to a major shift in planning policy in Queenstown Lakes, resulting in improved development control, where residential and other growth is located, and associated travel demand. The Queenstown Lakes Spatial Plan was adopted in 2021 and is discussed below.

4 Queenstown Lakes Spatial Plan

4.1 The Spatial Plan

The Queenstown Lakes Spatial Plan (July 2021) provides a long-term framework for managing growth. It directs growth in a way that will make positive changes to the environment, housing, access to jobs and opportunities, the wellbeing of the community and the experience of visitors.

The Spatial Plan seeks to achieve five outcomes:

- Consolidated growth and more housing choice
- Public transport, walking and cycling is the preferred option for daily travel
- A sustainable tourism system
- Well-designed neighbourhoods that provide for everyday needs
- A diverse economy where everyone can thrive.

The Spatial Plan promotes a consolidated and mixed-use approach to accommodating growth in the Queenstown Lakes. The approach focusses on locations that are already fully or partially urbanised. Within the existing Queenstown urban area, growth will be focused in locations with good access to facilities, jobs and public transport. This requires enabling higher density development and a greater mix of uses than currently provided.

Residential growth will increasingly move towards medium and higher density housing. Concentrating growth in the existing urban areas will mean more people live in areas where public transport, cycling and walking is easy and attractive. This is intended to support investment in improved public transport and active mode infrastructure, reduce the impact on the environment particularly through reducing emissions, and make the transport system safer and more resilient.

The Spatial Elements for Wakatipu are shown in Figure 4. Three new future urban areas are identified for investigation, along the Eastern Corridor and northern/southern ends of the Southern Corridor. These locations integrate with existing development and are located on the proposed frequent public transport network. Frankton is of strategic importance to achieving the consolidated approach to growth in the Spatial Plan, due to its significant development potential and access to public transport. Smaller local, transit-oriented and mixed-use centres are proposed along the frequent public transport network at Ladies Mile and in the Southern Corridor.

The Spatial Plan seeks to concentrate high density, mixed-use development along public transport corridors that will support high-frequency public transport services. A frequent public transport network is intended to service the main urban area of Queenstown, offering a 'turn up and go' service, forming the "backbone" of the urban area of Queenstown. The Spatial Plan seeks a transformational shift in public transport provision in Wakatipu centred on a new Frequent Transport Network. This will include a combination of physical improvements such as bus lanes, park and ride facilities, and more direct and frequent services that make public transport quicker than a car journey, particularly in the peak hours. High density development will be enabled in the frequent transport corridor and in new and established centres.

4.2 Anticipated Growth

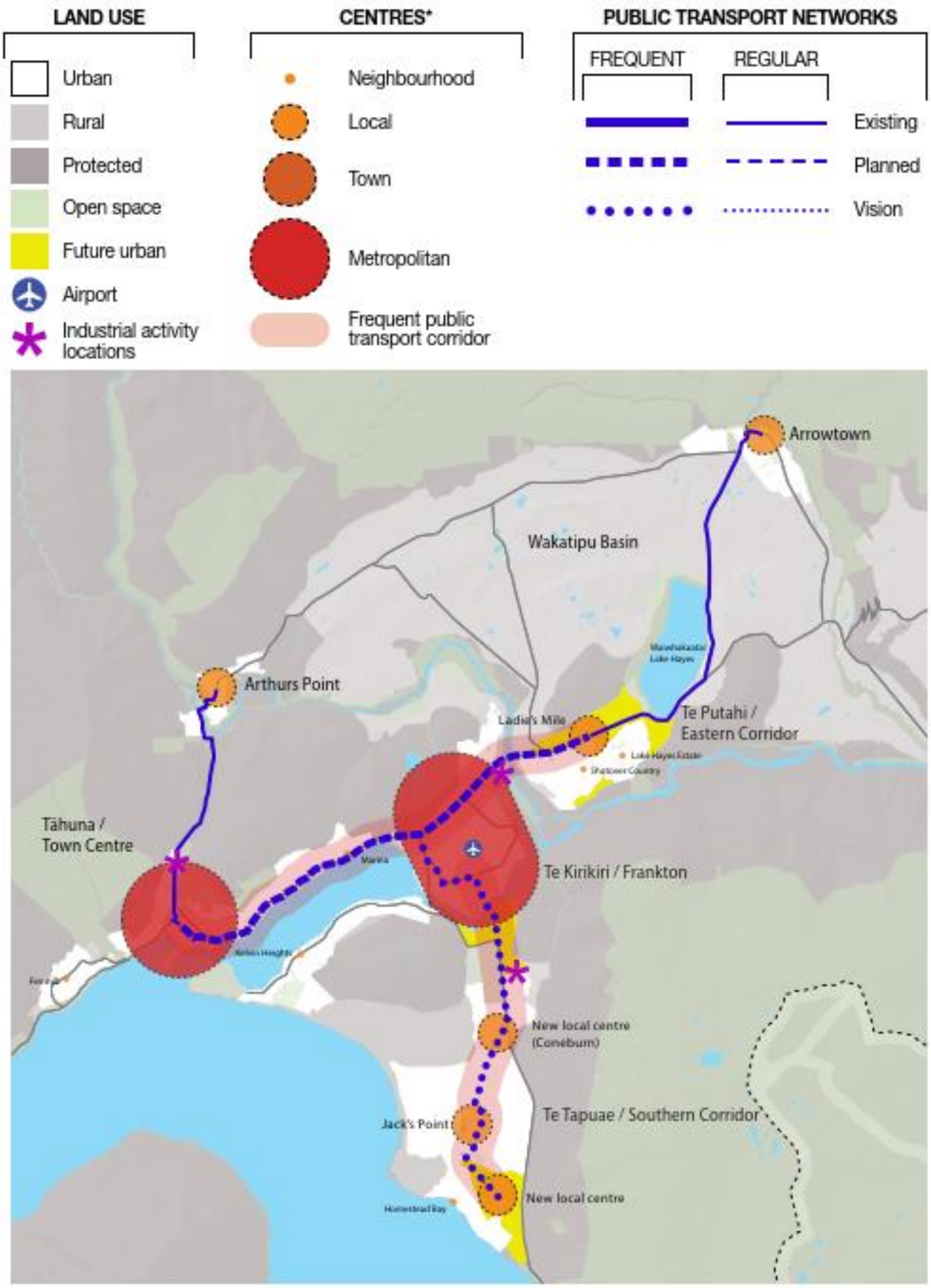
The Spatial Plan anticipates significant growth for Queenstown Lakes[5]:

- The average day population (residents and visitors) for the district is expected to increase from an estimated 51,000 people (41,000 residents and 10,000 visitors) in 2021 to an estimated 120,000 (78,000 residents and 42,000 visitors) in 2051. The resident population is approximately 81% on an average day; and
- The peak day population (residents and visitors) for the district is expected to increase from an estimated 103,000 people (41,000 residents and 62,000 visitors) in 2021 to an estimated 204,000 (78,000 residents and 126,000 visitors) in 2051. The resident population is approximately 38% on a peak day.

The main urban areas of Queenstown and Wanaka are intended to provide for approximately 80% of both the estimated growth in dwellings up to 2050 and the Spatial Plan capacity. The remaining 20% is distributed across the smaller settlements and rural areas of the Queenstown Lakes.

[5] Based on Statistics New Zealand population projections at the time of developing the Spatial Plan

Figure 4: Queenstown Lakes Spatial Plan – Wakatipu Spatial Elements



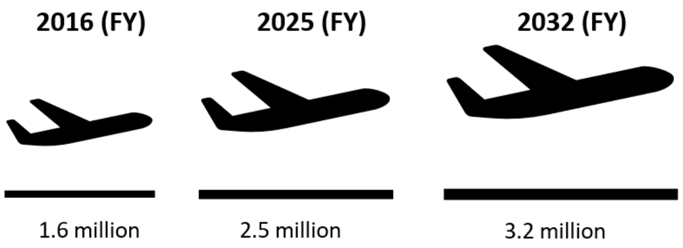
Queenstown Lakes District Council (QLDC) provided new land use projections upon which the regional TRACKS model update is based. Key changes in the latest projections based on the Spatial Plan include:

- Fewer households (-9.4%), tourists (-12.1%) and jobs (-1.6%) in the district in the latest forecasts, comparing 2027 update to 2028 QTBC;

- Fewer households (-3.4%), tourists (-3.3%) and jobs (-10.0%) in the district in the latest forecasts, comparing 2053 update to 2048 QTBC;
- Halving of tourist accommodation in central Queenstown, comparing at both medium (2027/2028) and long term (2048/2053) time horizons, with accommodation units shifting to Frankton and further afield;
- Also, there is a reduction in households within central Queenstown, at both medium- and long-term time horizons; and
- Increase in the population and associated job opportunities in Wanaka and Cromwell potentially resulting in less dependency on Frankton and Queenstown (i.e., a reduction in longer distance trips through Kawarau Gorge and over the Crown Range) .

The Queenstown Airport is also expected to see significant passenger demands in the future. Figure 5 shows the annual passenger demand at Queenstown Airport from 2016, 2025 and 2032 from Queenstown Airport 10-Year Strategic Plan (FY23 – FY32). These forecasts were developed considering COVID-19, with assumptions that both New Zealand and International markets will return to pre-COVID levels in FY 2025. Passenger demand growth at Queenstown Airport has been included in the Strategic TRACKs model[6] forecasts.

Figure 5: Queenstown Airport Annual Passenger Demand for 2016, 2026 and 2025



Queenstown Airport is constrained as it does not have enough capacity within the current airfield and terminal infrastructure to grow capacity in the long term. Additionally, the airport is subject to noise restrictions that limits the number of scheduled aircraft movements it can operate each year. Given the significant growth in annual passengers over the next 10+ years at Queenstown Airport, this has led to an investigation for a new regional airport in Central Otago (Tarras) by Christchurch Airport to meet the region's infrastructure need in 2050+. The Tarras Airport is a long-term vision for the region and has not been included in the strategic model. Sensitivity testing of projections could be undertaken if required.

5 Forecast Patronage Demand

5.1 Transport Models

The previous Queenstown Transport Business Case (QTBC) undertook traffic and public transport demand forecasting to ascertain future requirements for infrastructure and service improvements across the Wakatipu Basin network. This modelling work was based on:

- Strategic TRACKS model to determine traffic demand across the Queenstown Lakes District Council (QLDC) area
- A bespoke public transport model developed to estimate public transport mode share across the intended public transport network (including Park and Ride, water services and future mass transit options)

[6] QLDC 2018 Tracks Transportation Model Update and Futures, Abley

As the strategic model was traffic-based (i.e., a traditional 3-stage model), the public transport model therefore provided "the 4th stage" of mode choice.

5.2 TRACKS Model Update

For the QTBC, model scenarios were developed for the base year of 2018, and future years at 2028 and 2048. The Strategic TRACKS model was recently updated by Abley as a separate commission to ORC, to represent the recent land use forecasts for the district as supplied by QLDC. This has provided a number of future scenarios at the following years:

- 2018 (base year)
- 2024
- 2027
- 2039
- 2054

Abley provided WSP with origin/destination matrices from each of the above future years, for:

- Morning peak hour (0800-0900)
- Interpeak hour (1200-1300)
- Afternoon peak hour (1700-1800)

These matrices indicate the level of growth in demand on the transport network. Table 1 sets out the total matrix sizes, and linear growth between each modelled year. For context, the table also shows the future year matrices at 2028 and 2048 within the previous QTBC project.

Table 1: TRACKS Matrix Size (Total Vehicle Trips per hour)

	AM	IP	PM
2018	16092	15403	21291
2024	19890	18833	26102
Growth p.a. (2018-2024)	*3.9%*	*3.7%*	*3.8%*
2027	21575	20459	28320
Growth p.a. (2024-2027	*2.8%*	*2.9%*	*2.8%*
2028 QTBC	*22647*	*24274*	*27149*
2039	26754	25487	35194
Growth p.a. (2027-2039)	*2.0%*	*2.0%*	*2.0%*
2048 QTBC	*29469*	*34052*	*38383*
2053	32125	30799	42264
Growth p.a. (2039-2053)	*1.4%*	*1.3%*	*1.4%*

There is significant demand in future years, around a doubling from 2018 to 2053. This represents total demand within the whole model (QLDC boundary, plus Cromwell). These scenarios are independent (or not cognisant) of public transport provision – i.e., the demand is based on existing private car trip rates (as a function of low public transport share).

Compared to the previous QTBC, the total demand is forecast to have a similar trend in the morning peak, be lower in the interpeak, and higher in the afternoon peak period.

5.3 Public Transport Modelling Methodology

A public transport modelling methodology was developed for the Project and agreed with the peer reviewer and NZTA Quality Assurance team. The full memo outlining the methodology is included in Appendix A.

The QTBC public transport model will be simplified into a smaller zone structure and more indicative road (and public transport) network but one that will still allow for a wide range of possible interventions, which could include:

- Range of bus service frequencies
- Range of bus vehicle types (capacity)
- Range of infrastructure improvements (e.g. bus lanes)
- Range of park and ride site locations, service patterns and frequencies
- Range of mass transit options (i.e. gondola), which also have route, stop and capacity variations
- Range of sensitivities to other factors such as public transport fare, land use development, car park pricing, other travel demand management measures, behavioural change etc

The simplified public transport model will be used to develop the long list of options and assess the short list options. It is expected that initial runs will determine the likely service/ route/ frequency/ system requirements, from which sensitivities can be assessed (park and ride system versus no park and ride system; gondola versus no gondola; higher/lower residential growth sensitivities etc). A technical memo summarising the public transport model build and modelling is included in Appendix B.

5.4 Public Transport Forecasting

In order to determine the future needs for public transport in the Whakatipu Basin, the first stage was to determine the travel demand (as forecast by the strategic model) on parts of the network and establish when particular links begin to operate at or above capacity, noting that several parts of the network are already experiencing congestion in peak periods (especially afternoon peak period). The level of road network performance on key links was established, assuming zero public transport service. The level of public transport patronage that is required at these key links to enable at capacity operation was then calculated. This is irrespective of the actual public transport network, which will be part of the next stage of the project. The five key links explored in the Public Transport Model are listed below and are illustrated in Figure 6 and Figure 7:

- SH6A screenline, east of Suburb Street
- SH6A, east of Marina Drive
- Shotover Bridge
- Kawarau Falls Bridge
- Arthurs Point Crossing

Figure 6: Location of the key links explored in the Public Transport Model (Base Map Source: QLDC Operative and Proposed District Plan)[7]

Figure 7: Location of the Arthurs Point Crossing (key link) in the Public Transport Modal (Base Map Source: QLDC Operative and Proposed District Plan)[8]

[7] Aerial imagery of the Queenstown Lakes District, comprising multiple datasets (District-wide 2018/19, Wakatipu 2021, Wanaka 2018) from District Plan.
[8] Aerial imagery of the Queenstown Lakes District, comprising multiple datasets (District-wide 2018/19, Wakatipu 2021, Wanaka 2018) from District Plan.

5.4.1 Key Link Volumes (Vehicle Demand)

Figure 8 to Figure 12 shows the assigned vehicle demand in the public transport model for each of the five key links of the network in the morning and afternoon peaks, i.e., **with zero public transport patronage**:

Figure 8: SH6A (Suburb): AM Peak – Number of Vehicles

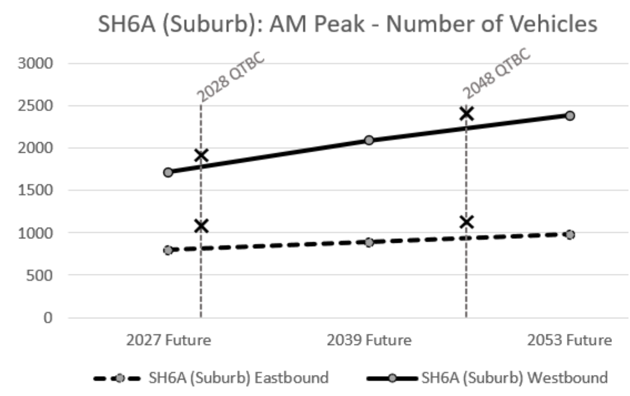


Figure 9: SH6A (Marina): AM Peak – Number of Vehicles

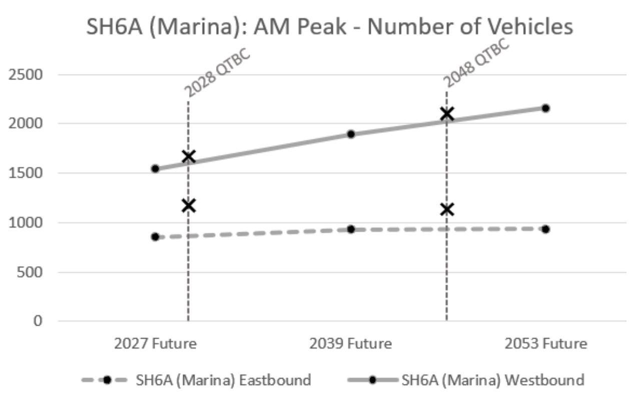


Figure 10: Shotover Bridge: AM Peak – Number of Vehicles

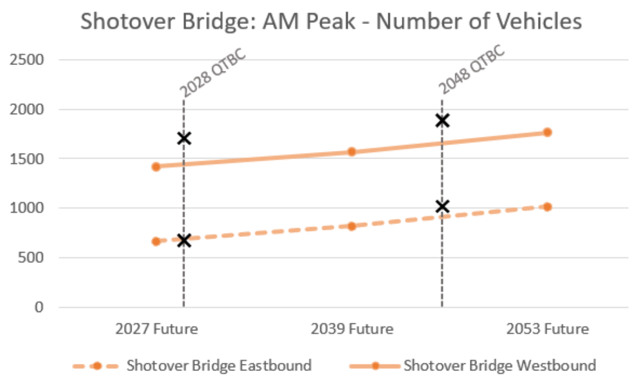


Figure 11: Kawarau Falls Bridge: AM Peak – Number of Vehicles

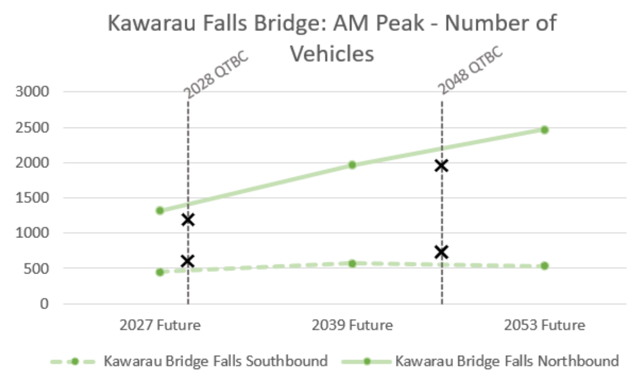


Figure 12: Arthurs Point: AM Peak – Number of Vehicles

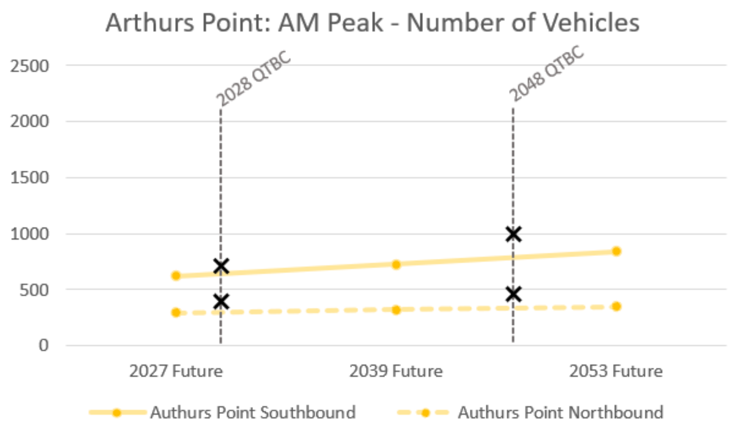


Figure 8 to Figure 12 shows:

- Volumes on SH6A and Shotover Bridge have generally dropped between the QTBC forecasts and the latest projections, particularly in the non-peak direction (eastbound)

- On Kawarau Falls Bridge, the latest projections of traffic volumes are higher than during the QTBC work

Figure 13: SH6A (Suburb): PM Peak – Number of Vehicles

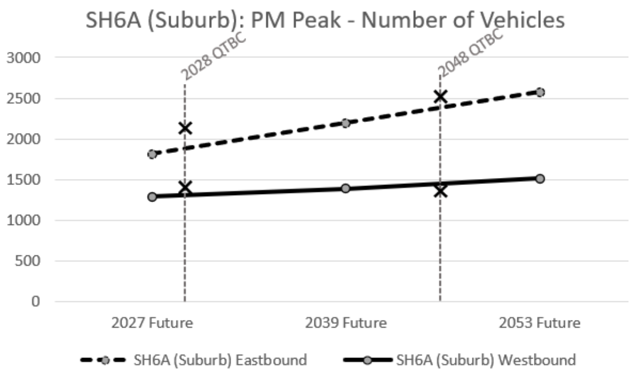


Figure 14: SH6A (Marina): PM Peak – Number of Vehicles

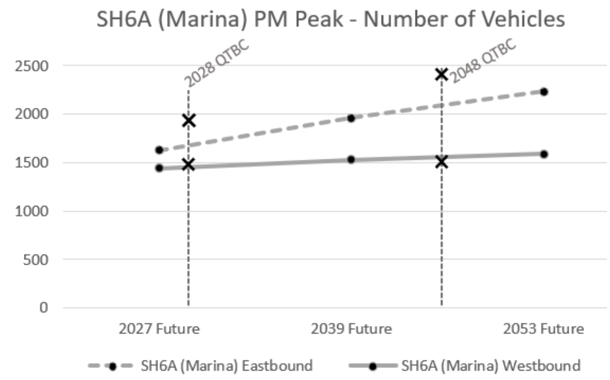


Figure 15: Shotover Bridge: PM Peak – Number of Vehicles

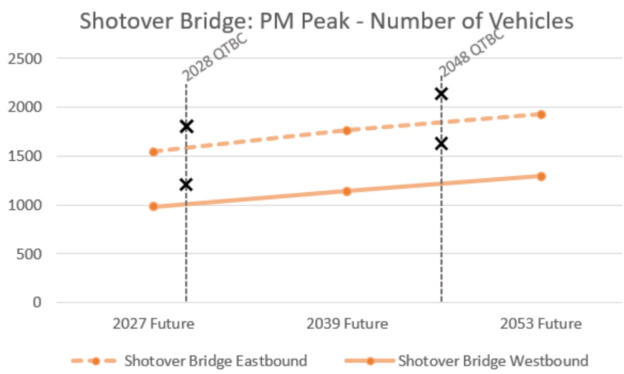


Figure 16: Kawarau Falls Bridge: PM Peak – Number of Vehicles

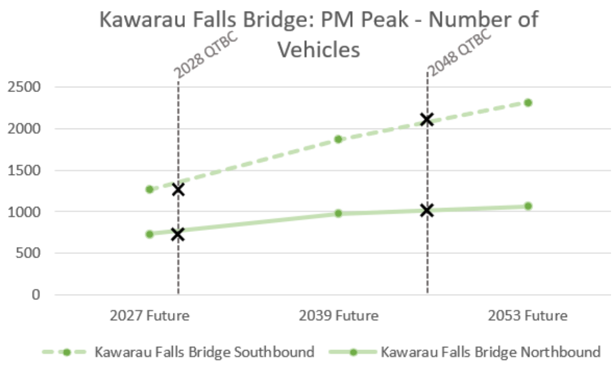


Figure 17: Arthurs Point: PM Peak – Number of Vehicles

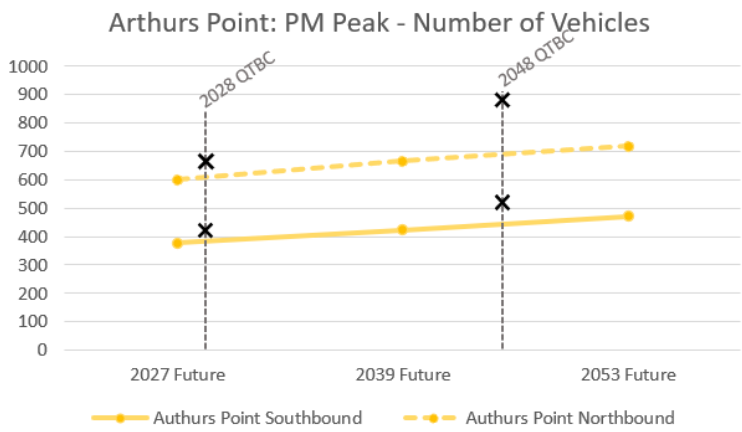


Figure 13 to Figure 17 shows:

- Volumes on SH6A and Shotover Bridge have significantly dropped between the QTBC forecasts and the latest projections

- On Kawarau Falls Bridge, the latest projections of traffic volumes are higher than during the QTBC work

The upshot of the above comparison is that in terms of likely public transport patronage, the (generally) slower growth in trips compared to the QTBC forecasts should mean that forecast patronage on public transport will likely be lower than previous forecasts. Assuming congestion is less than previously modelled there would be less incentive to shift from the private car mode. This is with the exception of the Southern Corridor, which sees higher growth, which may be assumed to result in the requirement to accelerate public transport improvements to and from this area.

5.4.2 Key Link Analysis (Public Transport Mode Share Needed)

A link analysis was undertaken to give an indication of the scale and volume of passengers required to be accommodated by public transport to maintain operation of the road network to an acceptable degree (Volume/Capacity Ratio at 90%). Headline new target mode share and patronage numbers (one-way passengers per hour) in the critical direction are set out below in Table 2. The detail and results of this modelling is included in **Appendix B**.

Table 2: Critical Public Transport Mode Share Targets

		AM peak hour		PM peak hour	
		PT share	PT Pass/hour	PT share	PT Pass/hour
2027	SH6A	27%	592	28%	594
	Shotover Bridge	18%	323	18%	369
	Kawarau Falls	11%	186	7%	123
2039	SH6A	40%	1082	40%	1028
	Shotover Bridge	25%	514	29%	657
	Kawarau Falls	40%	1033	37%	909
2053	SH6A	47%	1466	48%	1384
	Shotover Bridge	34%	772	35%	869
	Kawarau Falls	53%	1687	49%	1489

The results for the morning peak indicate:

- By 2027, SH6A requires approaching a 30% public transport mode share to operate satisfactory in the westbound direction. By 2053 this has increased to close to 50%, equivalent to carrying around 1,500 passengers per hour;
- By 2027, Shotover Bridge requires a 18% public transport mode share in the westbound direction, rising to 34% by 2053;
- On Kawarau Falls Bridge, at 2027 operation of the link is satisfactory with 11% public transport model share, but this quickly increases to 40% public transport mode share

required in the northbound direction by 2039, rising to over 53% by 2053 (around 1700 passengers/hour); and
- In terms of SH6A and Shotover Bridge, the public transport mode share is less in the latest forecasts compared to the QTBC projections. Albeit the same public transport model share is required at 2053 in the latest forecasts, that was required in the QTBC at 2048 – so a delay of 5 years of the same public transport requirement. For Kawarau Falls Bridge, the latest requirement of 40% mode share at 2039, was previously not required until 2048, moving forward the requirement to obtain a high mode share by more than 10 years.

The results for the afternoon peak indicate:

- By 2027, SH6A requires a 28% public transport mode share to operate satisfactory in the eastbound direction, increasing to 40% by 2039. By 2053 this has increased to close to 50%, equivalent to carrying around 1,400 passengers per hour;
- By 2027, Shotover Bridge requires a 20% public transport mode share in the westbound direction, rising to 35% by 2053;
- On Kawarau Falls Bridge, operation of the link at 2027 is satisfactory with less than 10% public transport model share. But this quickly increases to 37% public transport mode share required in the southbound direction by 2039, rising to 49% by 2053 (around 1500 passengers/hour);
- In terms of SH6A and Shotover Bridge, the public transport mode share is less in the latest forecasts compared to the QTBC projections, albeit the same public transport model share is required at 2039 in the latest forecasts, that was required in the QTBC at 2028. For Kawarau Falls Bridge, the latest requirement of 49% mode share at 2053, is generally in line with the 44% requirement in the 2048 QTBC analysis.

Previously, the QTBC had headline targets of 40% public transport mode share on SH6A by 2028, and 60% by 2048 – with associated targets on Shotover Bridge of 25% and 40% respectively. The latest forecasts suggest that the speed of mode shift does not need to be quite as quick as previous. However, the increased rate of residential growth on the Southern Corridor leads to significant public transport being required on this part of the network, similar to those predicted on SH6A by 2053.

5.5 Next Steps

These forecasts will be used to develop and assess public transport service options as part of the Service Patterns Advisory Paper. This will include describing the public transport network and frequencies to drive public transport mode shift over the next 15-years and 30-year period. Also describing areas where lead public transport services should go and where better services can drive public transport.

The next phase of public transport modelling will be to start to test public transport options at each of the future years to determine the optimal service. It is likely that the option testing will incorporate the following variations, which can all be tested within the public transport model:

- Fare changes
- Service frequency changes
- Service route changes
- Car parking supply constraints and fee changes (albeit a simplified model)
- Park and ride location and services
- Off-road corridors (e.g. gondola, ferry)
- Level of interface from tourism fleets on bus stops as this user groups grows
- Effects of lower speed limits
- Effects of multiple traffic signals
- Understand Queenstown's tourism plan to have a Zero Carbon Visitor Economy by 2030

Appendix A
PT Modelling Methodology

Queenstown Public Transport Business Case

Demand Forecasting – Methodology Statement (v3)

To	Project team, client team, peer review team
Copy	
From	Matthew Gatenby
Office	Dunedin
Date	14 October 2022
File/Ref	6-XO014.00
Subject	Demand Forecasting – Methodology Statement

Introduction

Public Transport (PT) modelling will be used to forecast PT demands, develop and assess a long list, and assess a short list of options for the Queenstown Public Transport Business Case (QPTBC) This methodology statement sets out the intended approach to public transport demand forecasting for the QPTBC.

The statement covers:

- Background and previous work
- Intended methodology for PT demand forecasting and economic case
- Modelling Output
- Next Steps

It is intended that this note is for discussion with the client group and peer reviewers for agreement on the way forward for the demand forecasting element.

Background and Previous Work

The previous Queenstown Transport Business Case (QTBC) undertook traffic and PT demand forecasting to ascertain future requirements for infrastructure and service improvements across the Whakatipu Basin network. This modelling work was based on:

- Strategic TRACKS model to determine traffic demand across the QLDC area
- A bespoke PT model developed to estimate PT mode share across the intended PT network (including Park and Ride, water services and future mass transit options)

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150 YEARS IN AOTEAROA

As the strategic model was traffic-based (i.e., a traditional 3-stage model), the PT model therefore provided "the 4th stage" of mode choice. This PT model was developed in Excel, as a "stop-gap" before the suite of modelling tools could be updated (at some future time) to a more sophisticated strategic model (or other modelling architecture) that could incorporate mode choice for PT, but also active mode share, and other sophisticated effects such as TDM, trip suppression and potentially the modelling of variable trip demand.

The PT model was essentially a logit-based mode choice model, using generalised cost of trips (via car or PT modes) to provide split by mode, assigned to the road and PT network. However, some sophistication was not included (for reasons of simplicity and time), such as PT crowding factors which could become significant as growth continues into the medium and long term.

Previously, model scenarios were developed for the base year of 2018, and future years at 2028 and 2048.

Recent Work - inputs to this project

The Strategic TRACKS model is in the process of being updated by Abley, to represent the recent land use forecasts for the district as supplied by QLDC (November 2022).

This will provide a number of future scenarios at the following years:

- 2024
- 2027
- 2039
- 2054

These scenarios are independent (or not cognisant) of PT provision – i.e., the demand is based on existing private car trip rates (as a function of low PT share).

It is expected that Abley will be able to provide the full trip matrices (by year, by period) to WSP in the same format as used in previous PT modelling work as part of the QTBC.

Also, it is understood that the MoE will no longer be providing school bus services in the area after 2024. We would require data on the current passenger volumes on these services at present (and forecast) so as to add this patronage into the public transport PT demand from 2025 onwards.

Intended Methodology

Due to the relatively short timescales, and the previous work undertaken under the QTBC projects, it is not intended to re-run the full PT model at this time for the above revised future years.

Instead, the PT model will be simplified into a smaller zone structure and more indicative road (and PT) network but one that will still allow for a wide range of possible interventions, which could include:

- Range of bus service frequencies
- Range of bus vehicle types (capacity)
- Range of infrastructure improvements (e.g. bus lanes)
- Range of Park and Ride site locations, service patterns and frequencies
- Range of mass transit options (i.e. gondola), which also have route, stop and capacity variations
- Range of sensitivities to other factors such as PT fare, land use development, car park pricing, other TDM measures, behavioural change etc

It is our intention to use the simplified PT model to develop and assess the long list of options and tune in on a short list. However, we do not expect to run the model for a limitless number of options – it is expected that initial runs will determine the likely service / route / frequency /

system requirements, from which sensitivities can be assessed (P&R system versus no P&R system; Gondola versus no Gondola; Higher/lower Residential growth sensitivities etc)

The process is proposed as below:

1. Tracks model updates to provide overall trip demand (by car, assuming a fixed occupancy)
2. Strip back the PT model to a simplified version to split the geographical area into a series of amalgamated zones (maximum of 25 zones), which can then be used to simply ascertain the total trip demand between these conglomerated zones (e.g. Frankton Flats to Jack's Point, Lake Hayes Estate)
3. Assign the demand to a simplified road/PT network (maximum 50 links)
4. Determine an initial input of service/route/frequency/system requirements for each future year, and apply to model
5. Model applies a logit model (as per the original PT model) to determine mode share across the network, based on generalised cost for each journey by mode
6. Model outputs the mode share across the network (both by link, and zone-to-zone)
7. Model inputs can then be tweaked (e.g. higher frequency on certain routes) and the model re-run
8. The spreadsheet model will principally look at the three main network constraints (SH6A Frankton Road, Kawarau Falls Bridge and Shotover Bridge) to set out key PT and traffic demand levels in each scenario – essentially the "3-point summary" used in the previous PT model – which is invaluable in determining the operational level of these three key network constraints
9. This output PT share can then be used to ascertain PT requirements across the network over various infrastructure, operational and land use scenarios at the future years (with potential for interpolation/extrapolation to other years). The simplicity of the approach could then be used to test the sensitivity of the demand forecasts to other external influences (such as demand suppression in a congested network, peak spreading etc)

Output

As above, the key outputs will be the total PT share (mode share and total passengers) between each amalgamated zone. The figure below shows a similar output provided by the previous PT model from QTBC 2020 (mode share by bus in this example).

BUS PASSENGERS (SHARE)	Airport	Arrowtown	Arthurs Point	Fernhill	Five Mile	Old Frankton	Frankton Rd	Glenda Dr	Gorge Road	Kelvin Heights	LHE/Shotover Country	Quail Rise	Town Centre	Jacks Point	South External	East External	Ladiers Mile	Remarkables Park	Frankton South East	**Total**
Airport	-	5%	3%	8%	7%	7%	9%	6%	6%	4%	11%	1%	33%	6%	-	-	0%	9%	7%	**12%**
Arrowtown	2%	-	7%	2%	4%	3%	4%	4%	3%	3%	4%	1%	9%	2%	-	-	0%	5%	2%	**4%**
Arthurs Point	4%	7%	-	4%	5%	5%	6%	5%	8%	3%	7%	1%	25%	3%	-	-	0%	6%	5%	**16%**
Fernhill	8%	2%	6%	-	6%	8%	7%	5%	6%	4%	8%	1%	30%	6%	-	-	0%	13%	10%	**22%**
Five Mile	9%	6%	7%	8%	-	10%	12%	7%	7%	6%	17%	1%	42%	9%	-	-	0%	10%	11%	**15%**
Old Frankton	8%	7%	7%	9%	9%	-	11%	9%	10%	5%	16%	2%	40%	8%	-	-	0%	12%	9%	**15%**
Frankton Rd	10%	7%	5%	6%	10%	11%	-	11%	7%	7%	16%	2%	34%	9%	-	-	0%	14%	11%	**20%**
Glenda Dr	5%	7%	6%	5%	7%	9%	11%	-	6%	12%	15%	1%	38%	6%	-	-	0%	8%	6%	**11%**
Gorge Road	6%	3%	7%	6%	6%	8%	7%	6%	-	4%	9%	1%	32%	4%	-	-	0%	10%	7%	**23%**
Kelvin Heights	2%	3%	2%	3%	4%	4%	4%	4%	3%	-	6%	2%	14%	2%	-	-	0%	4%	3%	**5%**
LHE/Shotover Country	4%	4%	4%	5%	8%	8%	9%	7%	6%	5%	-	1%	27%	5%	-	-	0%	9%	5%	**9%**
Quail Rise	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	0%	-	3%	1%	-	-	0%	1%	1%	**1%**
Town Centre	36%	11%	27%	31%	36%	38%	35%	37%	33%	23%	36%	10%	-	16%	-	-	0%	48%	40%	**30%**
Jacks Point	6%	2%	3%	5%	5%	7%	8%	5%	4%	3%	8%	1%	17%	-	-	-	0%	9%	7%	**8%**
South External	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0%**
East External	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0%**
Ladies Mile	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-	-	-	0%	0%	**0%**
Remarkables Park	10%	8%	7%	14%	13%	11%	15%	12%	11%	6%	18%	3%	49%	10%	-	-	0%	-	12%	**18%**
Frankton South East	6%	5%	4%	9%	8%	7%	10%	7%	7%	4%	12%	1%	36%	6%	-	-	0%	10%	-	**11%**
Total	**12%**	**6%**	**17%**	**24%**	**13%**	**14%**	**21%**	**10%**	**22%**	**9%**	**16%**	**2%**	**30%**	**8%**	**0%**	**0%**	**0%**	**16%**	**13%**	**16%**

From this output, other work packages within the project can be taken forward, principally WP2 Quality of Service and WP3 Public Transport Infrastructure in the first instance.

Additionally, the 3-point summary will provide a sense check and wider context for the predicted operation of the network under each scenario. The figure below shows a similar output provided by the previous PT model (mode split and total trips at Shotover Bridge in this example).

		AM				IP				PM			
Shotover		2028 NZUP BC		2028 NZUP NFr		2028 NZUP BC		2028 NZUP NFr		2028 NZUP BC		2028 NZUP NFr	
Eastbound	Car	1044	97%	1037	96%	1386	88%	1497	83%	2079	81%	2314	79%
	Bus	26	2%	43	4%	43	3%	155	9%	190	7%	294	10%
	P&R	4	0%	5	0%	149	9%	162	9%	298	12%	308	11%
	MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
	Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
	Total	1074	100%	1085	100%	1578	100%	1814	100%	2567	100%	2917	100%
	DoS	47%		47%		63%		68%		94%		105%	
Westbound	Car	1958	83%	2400	86%	1244	85%	1675	90%	1423	88%	1750	92%
	Bus	147	6%	181	6%	69	5%	94	5%	57	4%	66	3%
	P&R	267	11%	218	8%	146	10%	98	5%	135	8%	92	5%
	MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
	Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
	Total	2372	100%	2799	100%	1459	100%	1868	100%	1615	100%	1908	100%
	DoS	89%		109%		56%		76%		64%		79%	

Economic Case

As part of the economic case, it is expected that the programme of PT service improvements will need to be assessed in terms of economic value (i.e., BCR). If this is the case, then benefits such as reduced vehicle-kilometres and travel times for general traffic (versus a Do Minimum Case where non-car mode share will be higher) will need to be generated.

At this time, we would propose to use a similar process as used for the evaluation of QTBC, but using the simplified PT model, as per below:

- Simplified PT model is generated for the recommended programme and Do Minimum (at each model year), and the PT share is output as "PT skims"
- This PT skims are then provided to Abley (as operator of the QLDC strategic TRACKS model), to remove this skim from the full demand set, and re-run the remaining traffic demand for each scenario
- Output from the TRACKS model is then provided to WSP to feed into the economic case – for parameters such as VKT/VOC, VTT and road safety improvements

In terms of short list assessment, it is intended to use the simplified PT model, but to use previous relationships in the full model to re-disaggregate PT (and other mode) share across the individual zones. In this way, this gives a matrix of trips per mode across the TRACKS zone structure, which could then be used in TRACKS to produce economics (VKT, VOC, crash costs etc) in a similar way to the QTBC and establish a value for money assessment.

The number of scenarios/years that need to be run for the economic case will be determined once the options to be tested are known.

Next Steps

The following next steps are proposed to advance the PT modelling:

- Discuss / agree the intended PT modelling methodology with Otago Regional Council (ORC), Abley and modelling peer reviewer to align scope and timeframes
- It is also recommended to discuss and agree the modelling methodology with the ORC, Waka Kotahi Internal Quality Assurance (IQA) team and Queenstown Lakes District Council (QLDC) to align expectations from a business case review / funding perspective
- Once the methodology is agreed, WSP will prepare a scope/fee to undertake the PT modelling through the PT modelling provisional sum. This is likely be done in two stages: an initial scope to undertake the forecasting for the service of demand paper, followed by a subsequent scope/fee for economic case modelling once the options to be modelled are known.

Appendix B
PT Modelling Technical Note

Queenstown Public Transport Business Case

1 Technical Note – Forecast Demand

This note sets out the methodology and results of the public transport demand forecasting element of the Queenstown Public Transport Business Case.

The note covers:

- Model Inputs
- Public Transport Model Build
- Validation of 2018 Base Model
- Future Year Model demand

2 Model Inputs

2.1 Transport Models

The previous Queenstown Transport Business Case (QTBC) undertook traffic and public transport (PT) demand forecasting to ascertain future requirements for infrastructure and service improvements across the Whakatipu Basin network. This modelling work was based on:

- Strategic TRACKS model to determine traffic demand across the Queenstown Lakes District Council (QLDC) area
- A bespoke PT model developed to estimate PT mode share across the intended PT network (including Park and Ride, water services and future mass transit options)

As the strategic model was traffic-based (i.e., a traditional 3-stage model), the PT model therefore provided "the 4th stage" of mode choice. This PT model was developed in Excel, as a "stop-gap" before the suite of modelling tools could be updated (at some future time) to a more sophisticated strategic model (or other modelling architecture). The purpose of the PT model is to incorporate PT mode choice and other sophisticated effects such as travel demand management, trip suppression and potentially the modelling of variable trip demand.

The PT model was essentially a logit-based mode choice model, using generalised cost of trips (via car or PT modes) to provide split by mode, assigned to the road and PT network. However, some sophistication was not included (for reasons of simplicity and time), such as PT crowding factors which could become significant as growth continues into the medium and long term.

2.2 TRACKS Model Update

Previously, model scenarios were developed for the base year of 2018, and future years at 2028 and 2048. The Strategic TRACKS model has been updated by Abley as a separate commission to Otago Regional Council (ORC), to represent the recent land use forecasts for the district as supplied by Queenstown Lakes District Council (QLDC). This has provided a number of future scenarios at the following years:

- 2018 (base year)
- 2024
- 2027
- 2039
- 2054

These scenarios are independent (or not cognisant) of PT provision – i.e., the demand is based on existing private car trip rates (as a function of low PT share).

Abley has provided WSP with origin-demand matrices from each of the above future years, for:

- Morning peak hour (0800-0900)
- Interpeak hour (1200-1300)
- Afternoon peak hour (1700-1800)

The matrices are provided in a 300x300 zone format, as number of (vehicle) trips. Table 1 sets out the total matrix sizes, and linear growth between each modelled year. For context, the table also shows the future year matrices at 2028 and 2048 within the previous Queenstown Transport Business Case (QTBC) project.

Table 1: TRACKS Matrix Size (Total Vehicle Trips per hour)

	AM	IP	PM
2018	16092	15403	21291
2024	19890	18833	26102
Growth p.a. (2018-2024)	*3.9%*	*3.7%*	*3.8%*
2027	21575	20459	28320
Growth p.a. (2024-2027	*2.8%*	*2.9%*	*2.8%*
2028 QTBC	*22647*	*24274*	*27149*
2039	26754	25487	35194
Growth p.a. (2027-2039)	*2.0%*	*2.0%*	*2.0%*
2048 QTBC	*29469*	*34052*	*38383*
2053	32125	30799	42264
Growth p.a. (2039-2053)	*1.4%*	*1.3%*	*1.4%*

As would be expected, there is significant demand in future years, around a doubling from 2018 to 2053. This represents total demand within the whole model (QLDC boundary, plus Cromwell) – more specific demand changes per local area are reported within the section on future year model scenarios.

Compared to the previous QTBC, the total demand in the matrices is forecast to have a similar trend in the morning peak, be lower in the interpeak, and higher in the afternoon peak period. Further commentary on how demand trends have changed in the Whakatipu Basin study area is provided in subsequent sections of this report.

2.3 Land Use Update and Comparison with QTBC

As noted earlier, QLDC provided new land use forecasts upon which the TRACKS model update is based. Abley has provided some commentary around the key changes in the latest forecasts, summarised below:

- Fewer households (-9.4%), tourists (-12.1%) and jobs (-1.6%) in the district in the latest forecasts, comparing 2027 update to 2028 QTBC
- Fewer households (-3.4%), tourists (-3.3%) and jobs (-10.0%) in the district in the latest forecasts, comparing 2053 update to 2048 QTBC
- Halving of tourist accommodation in central Queenstown, comparing at both medium (2027/2028) and long term (2048/2053) time horizons, with accommodation units shifting to Frankton and further afield
- Also, there is a reduction in households within central Queenstown, at both medium- and long-term time horizons
- Increase in the population and associated job opportunities in Wanaka and Cromwell result in less dependency on Frankton and Queenstown (i.e., a reduction in longer distance trips through Kawarau Gorge and over the Crown Range).

2.4 PT Modelling Methodology

A PT modelling methodology was developed for the Project and agreed with the peer reviewer and Waka Kotahi Investment Quality Assurance team.

The QTBC PT model will be simplified into a smaller zone structure and more indicative road (and PT) network but one that will still allow for a wide range of possible interventions, which could include:

- Range of bus service frequencies
- Range of bus vehicle types (capacity)
- Range of infrastructure improvements (e.g. bus lanes)
- Range of Park and Ride site locations, service patterns and frequencies
- Range of mass transit options (i.e. gondola), which also have route, stop and capacity variations
- Range of sensitivities to other factors such as PT fare, land use development, car park pricing, other TDM measures, behavioural change etc

The simplified PT model will be used to develop the long list of options and assess the short list options. It is expected that initial runs will determine the likely service / route / frequency / system requirements, from which sensitivities can be assessed (P&R system versus no P&R system; Gondola versus no Gondola; Higher/lower Residential growth sensitivities etc).

The process is proposed as below:

- Tracks model updates to provide overall trip demand (by car, assuming a fixed occupancy)
- Strip back the PT model to a simplified version to split the geographical area into a series of amalgamated zones (maximum of 25 zones), which can then be used to simply ascertain the total trip demand between these conglomerated zones (e.g. Frankton Flats to Jack's Point, Lake Hayes Estate)
- Assign the demand to a simplified road/PT network (maximum 50 links)
- Determine an initial input of service/route/frequency/system requirements for each future year, and apply to model
- Model applies a logit model (as per the original PT model) to determine mode share across the network, based on generalised cost for each journey by mode

- Model outputs the mode share across the network (both by link, and zone-to-zone)
- Model inputs can then be tweaked (e.g. higher frequency on certain routes) and the model re-run
- The spreadsheet model will principally look at the three main network constraints (SH6A Frankton Road, Kawarau Falls Bridge and Shotover Bridge) to set out key PT and traffic demand levels in each scenario – essentially the "3-point summary" used in the previous PT model – which is invaluable in determining the operational level of these three key network constraints
- This output PT share can then be used to ascertain PT requirements across the network over various infrastructure, operational and land use scenarios at the future years (with potential for interpolation/extrapolation to other years). The simplicity of the approach could then be used to test the sensitivity of the demand forecasts to other external influences (such as demand suppression in a congested network, peak spreading etc)

3 PT Model Build

3.1 Model Form

The PT model is essentially a generalised cost and logit model built in Excel, comprising a demand and network element. It has been adapted from the original PT model developed as part of the QTBC project but simplified to make the process easier (both from a build, option testing and sense/error checking basis).

The network element of the model is a representation of the spatial nature of the actual road (and PT) network of the area of interest, which allows the demand matrix to be assigned onto the network, and travel time measures to be determined, as well as a shortcut to establish which origin-destination movements assign onto which part of the modelled network. The spreadsheet element of the model then takes these network-based inputs and carries out the allocation of generalised cost to each journey (by different modes), to output the mode share and PT usage within the network.

3.2 Demand

All base demand levels within the PT model are derived from the TRACKS model. It is worth noting at this point that the TRACKS model is a 3-stage assignment model and does not include the ability to calculate a PT mode share. This is important, as the demand from TRACKS is therefore the number of vehicle trips, rather than person-trips. Therefore, two further adjustments are made to this demand set:

- A vehicle occupancy value of 1.3 has been used as a fixed factor throughout the analysis. This has been developed from two earlier occupancy surveys carried out by Stantec (on Frankton Road, 2016) and WSP-Opus (on Frankton-Ladies Mile, 2017), and is generally in line with the baseline assumption within the Waka Kotahi MBCM. Clearly, the occupancy of vehicles will vary throughout the district, but these values have been used in the absence of any other data. In addition, the occupancy rate could also change in the future – however, for simplicity, this value has been retained in all future scenarios (although sensitivity testing using alternative values can be undertaken).

- There is existing bus use within the area. Patronage data for the existing service was obtained from ORC in 2018 and added to the vehicle matrix above. As this data is unable to be dis-aggregated beyond service number and direction (i.e. boarding and alighting volumes at individual bus stops or specific parts of the network are not able to be derived to any reasonable accuracy), a number of assumptions had to be made to spread the patronage levels across the matrix. This data is also used as a calibration set to ascertain that the model is (generally speaking, given the aggregated form of the data) re-allocating these trips back onto the PT mode once run

- There is also an existing water taxi service on Frankton arm. Patronage data was unable to be sourced from this (privately operated) service. However, a small number of observations were taken on this service, to ensure that base model patronage was of a suitable order of magnitude

The first stage of the model is to convert the TRACKS 300 x 300 demand set into a simplified zone structure for the revised PT model – this creates a 21 x 21 matrix. Figure 1 sets out the simplified zone structure, and network links included in the simplified PT model.

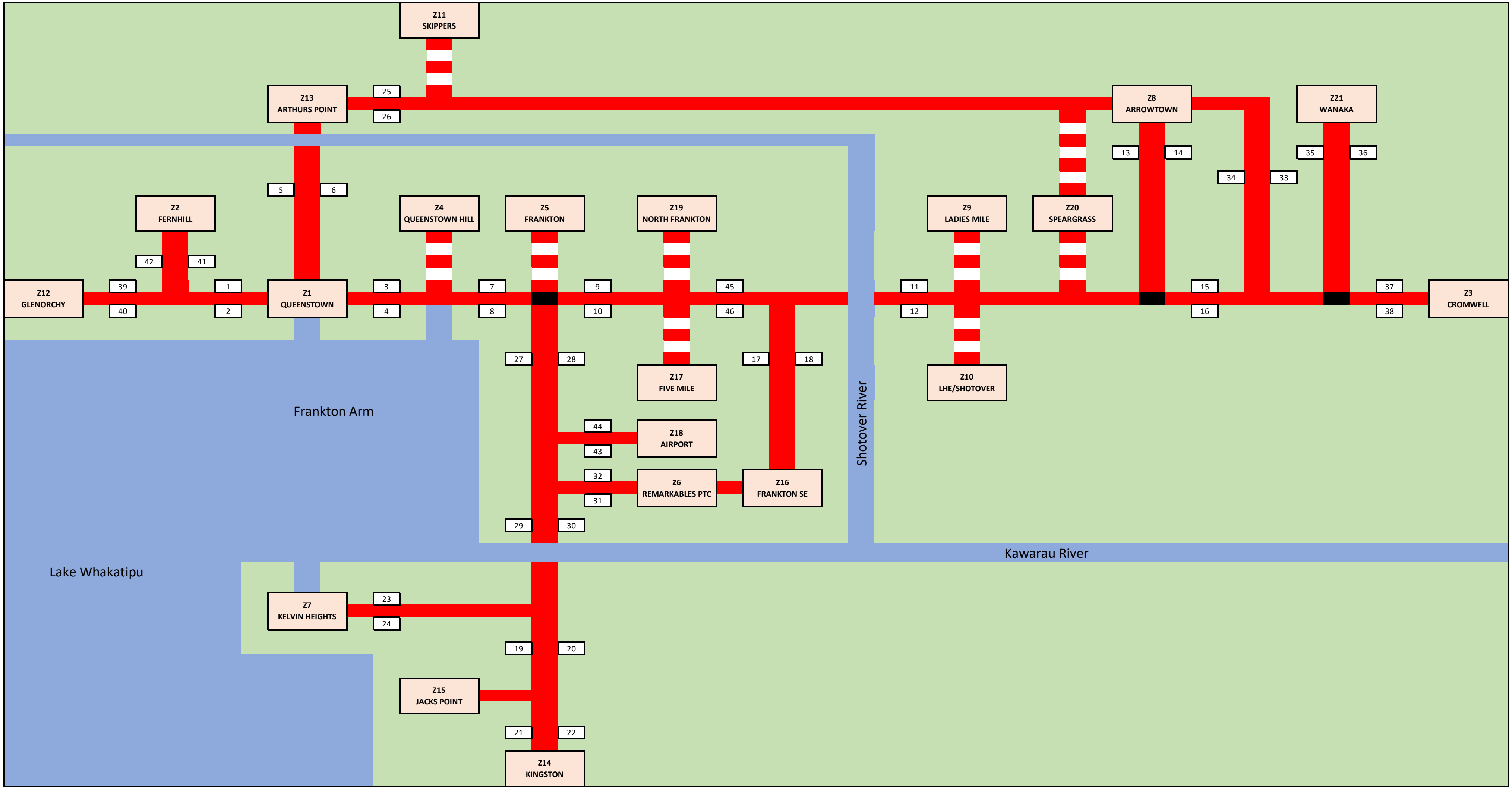
3.3 Network

The network element of the model is a representation of the spatial nature of the actual road (and PT) network of the area of interest. This has been simplified from the previous full PT model, which used GIS to calculate individual zone to zone distances – however, elements of the previous GIS work have provided various inputs to the simplified model:

- Zone structure – as above, conglomerated zones from the TRACKS zone structure
- PT stops – nearest PT stop allocated to each zone – as calculated by previous GIS work in full PT model
- Access times – walk times from zone centroid to the nearest PT stop as calculated by previous GIS work in full PT model
- Distances – crow flies and on-road distance between zones and PT stops as calculated by previous GIS work in full PT model
- Network characteristics – see below

The simplified PT model includes 46 road links that are applied to the network to allow the calculation of travel times.

Figure 1: Simplified PT Model: Zone and Road Link Structure



- Link free flow speed – each link within the network is allocated a free-flow speed based on the current posted speed limit but calibrated by an impedance factor (to represent general delays on a link due to minor interactions from side roads, intersections etc). In future scenario model, MRT (off-road corridor) and Ferry speeds can be assigned to 'links' directly on assumed alignments/routes.
- Additional bus delay – due to buses generally moving slower than general traffic through the network due to deceleration, alighting, boarding and acceleration activity at stops, an additional adjustable stop penalty is applied for each stop on the section of route
- Link capacity – each link is set with an operational capacity, with a default value of 1800v/h per lane. However, at certain key bottlenecks and intersections, this capacity is reduced to represent more realistic intersection approach capacities. In the case of future models, these values would be reviewed to represent changes in capacity (e.g. NZUP works, new Arthurs Point Crossing etc)
- Congestion – applied using an additional link delay factor based on step 3 of A3.18 in the NZ Transport Agency's Economic Evaluation Manual, using level terrain and 0% passing as per the table below – this increases the delay by between 0% and 32%. In addition, once a link assigned volume increases over the capacity of the link, an additional oversaturated delay is added, as a simple function of the unserved demand in relation to the hour period

Therefore, from the above calculations, the model calculates travel times from every origin zone to every destination zone, by the different modes. This is done in an iterative format, so that changes in mode share result in revised road travel time, and hence a change in mode share and so on until convergence. The same applies to the addition of extra bus stops and new PT service routes.

3.4 PT Modes

For PT modes, several inputs and factors are applied for each link and/or zone-to-zone movement, per mode:

- Travel time – as above, as sum of relevant link travel times, plus additional dwell times at stops
- Wait time – applied as a function of the frequency at the first boarding point
- Transfer – if a transfer is required, then a transfer penalty and additional second wait time is applied for the relevant OD movement. Similar assumptions are applied at Park and Ride sites
- Access time – taken as an average walk time from the zone to the nearest stop in the zone (or nearest zone, if there is no stop in the origin zone). This can be fine-tuned at future years to represent increased "fist/last mile" active mode share

For off-road PT (ferry and MRT), a similar calculation is applied, although travel times are fixed unaffected by road congestion).

Also note that in the future scenarios, the implementation of PT priority measures such as bus lanes, signal priority (and conversely the introduction of additional bottleneck points) will all be coded into the model based on engineering judgement (of the impact each measure will have on the travel time for each mode).

3.5 Generalised Cost and Multinomial Logit Model

The basis of the model is to calculate the generalised cost for any O-D trip for the transport modes available, and then allocate a proportion to each mode based on a logit model (see next section). This section sets out the form and assumptions of the generalised cost approach, for each mode choice.

3.5.1 Public Transport Based Trips

The cost for public transport trips (bus and water-based) is based on the following formula:

$$Gpt1\ (\$/h) = \left(\frac{d}{k}\right)^{x} \{(a * TTC) + (b * WT) + (c * AT1) + (e * AT2) + F + TP + MCpt1\}$$

Table 2 sets out the assumptions for each weighting and parameter.

Table 2: Public Transport Generalised Cost Inputs

Parameter	Description	Value	Source
TTC	Travel Time Cost (in mode)	15.13 $/h (AM peak) 17.95 $/h (Interpeak) 14.96 $/h (PM peak) All multiplied by EEM update factor of 1.47	EEM Table A4.3
WT	Wait Time	Set to Max (0.5*headway, 15 minutes)	Schedule based approach
F	Fare	$2 bus; $4.90 water	Existing fare
AT1 and AT2	Access Time (1=origin, 2=destination)	Walk time to/from stop	GIS network
TP	Transfer penalty	5 minutes	Applied only to transferred trips
MCpt1	Mode constant	$5 bus; $7.50 water	Value applied
a	Travel time weighting	1.0	-
b	Wait time weighting	2	-
c, e	Access time weighting	2.0 for origin, 1.5 for destination	-
d	Trip length	As calculated	Webtag Unit M2 to account for cost damping
k	Mean trip length	9.84	Webtag Unit M2 to account for cost damping
x	Calibration factor for cost damping	-0.5	Webtag Unit M2 to account for cost damping

** Original EEM referenced, rather than MBCM, as model originally built and calibrated in 2018*

3.5.2 Private Vehicle Based Trips

The cost for vehicle trips is based on the following formula:

$$Gv\ (\$/h) = \left(\frac{d}{k}\right)^{x} \{(a * TTC) + (b * VOC) + (c * PC) + (e * AT) + MCv\}$$

Table 3 sets out the assumptions for each weighting and parameter.

Table 3: Private Vehicle Generalised Cost Inputs

Parameter	Description	Value	Source*
TTC	Travel Time Cost (in mode)	15.13 $/h (AM peak) 17.95 $/h (Interpeak) 14.96 $/h (PM peak) All multiplied by EEM update factor of 1.47	EEM Table A4.3

VOC	Vehicle Operating Cost (shared amongst occupants)	21.8c/km for 50kph speeds; Multiplied by EEM update factor of 1.00	EEM Table A5.1
PC	Parking Charge (shared amongst occupants)	$6.10 (AM and PM peaks 2018) $3.43 (Interpeak 2018)	QLDC parking supply and charges; average parking cost for spaces available
AT	Access Time (walk)	15.13 $/h (AM peak) 17.95 $/h (Interpeak) 14.96 $/h (PM peak) All multiplied by EEM update factor of 1.47	EEM Table A4.3
MCv	Mode constant	0	No additional factor
a	Travel time weighting	1.0	No factor applied
b	Vehicle operating cost weighting	1.0	No factor applied
c	Parking cost weighting	0.5 x 2.0	Parking cost split equally by journey direction (0.5); additional weighting (2.0)
e	Access time weighting	1.0	Higher factor can be applied in future years when car parking assumed to be further from town centre
d	Trip length	As calculated	Webtag Unit M2 to account for cost damping
k	Mean model trip length	13km	Webtag Unit M2 to account for cost damping
x	Calibration factor for cost damping	-0.5	Webtag Unit M2 to account for cost damping

** Original EEM referenced, rather than MBCM, as model originally built and calibrated in 2018*

3.5.3 Additional Modes

In terms of potential future modes (MRT, Park and Ride etc), similar generalised cost equations have been generated, with weightings developed from engineering judgement and benchmarking against other studies.

3.5.4 Logit Model

We have used a multinomial logit model to estimate the proportion of users of each mode.

$$Pi = \frac{Exp(Gi)}{(Exp(Gi) + Exp(Gii) + \cdots + Exp(Gn))}$$

Where:

Pi = probability of choosing mode i

Gi = generalised cost of using mode i, Gii = generalised cost of using mode ii up to Gn = generalised cost of using mode n

The multinomial logit model includes an inherent assumption that the ratio of choice probabilities of any two alternatives is unaffected by the change in utility of an additional (or new) mode – commonly referred to as the red bus/blue bus paradox. Consideration was given to using a nested multinomial logit model but given the absence of both calibration data and detailed segmentation of the population, it was concluded that a more complex model could not be calibrated to any more certainty than the simpler multinomial logit model.

3.5.5 Non-inclusions

The model developed is intended as a higher-level public transport demand model to estimate the likely range of public transport demand into the future, and the required associated capacity interventions to supply such a demand. It is not intended as a replacement for a highly sophisticated traditional 4-stage transport model, either activity-based or trip-based.

Therefore, there are a number of elements and assumptions used in the model that are worth noting:

- Active modes are not included in the model. It is likely that these trip types will be relatively small even in the future, although potentially more significant for short trips. However, as the original TRACKS matrix does not include trips undertaken by active modes, the model is consistent in excluding these from the analysis. A future growth in the proportion of walk/cycle/active mode trips would need a factor to be applied to the overall trip matrix (either by flat assumption, weighted assumption by distance/convenience, or through calculation from an external model)
- Most other trip types are modelled (or are to be included in the future scenarios), including transfers dual-modes such as Park and Ride (car or walk as start/end mode), MRT (car or walk as start/end mode), and transfers across two bus services. In addition, transfers between PT modes are allowed (for example to allow an MRT to local bus service transfer). However, water-based to road-based public transport transfers are not included – such trips are likely to make up a negligible proportion of total trips, and in general transfer points between these modes are not convenient
- As noted previously, we have not discretely modelled car-passengers within the model. Therefore, a change in vehicle occupancy into the future cannot be discretely modelled (except for manually testing the sensitivity by changing the global car occupancy value). In addition, the increase in car sharing schemes or uptake of Kiss and Ride (for example) are also not included – but could be incorporated into a further increase in the car occupancy value
- All bus journeys are assumed to commence at the origin zone's nearest bus stop. That is, bus passengers are assumed to walk to the nearest bus stop regardless of their route, and transfer to their destination if required. 'Alternative' bus stops have not been coded as an option (for example, an Airport to Arrowtown trip would bus to Frankton Hub and transfer onto the Arrowtown service, rather than walk directly to the Hub). This may result in an underestimate of bus trips for some journeys, although these will generally be for low demand movements, and will be less of an issue in the future as service frequencies increase and route patterns improve
- All water-based journeys are assumed to be generated from walk-up from nearby zones – i.e. no car to water transfer is included in the model, given that in most jetty/wharf locations, land for parking is either unavailable or undesirable

Each PT service does not have an actual capacity defined in the model. Therefore, where demand exceeds capacity on a particular route or service, this would not result in a dampening of this demand – however, this performance would be flagged by the model as part of the output – and frequencies have been iterated (within reasonable bounds) so as to fit the associated demand.

3.6 Use of the Model

The process of running the model is summarised in the following steps (for the base model):

1 Apply demand matrix (TRACKS matrix) to PT model, and conglomerate demand in the simplified zone structure
2 Assigns trips to network, and outputs travel times (for all modes)
3 Generalised cost equation determines the mode share per origin-destination pair based on the travel times per mode, parameters and utility weightings
4 Tasks 2 and 3 re-run until mode share values converge between runs

4 Calibration/Validation of Base 2018 Model

The calibration of the base model has been undertaken against the following observed data:

- Link volumes
- Travel times
- PT patronage

In all cases the validation data used is the same as that observed data used in the calibration and validation of the Queenstown Business Cases Traffic Model work for consistency.

4.1 Link Volumes

Link volumes on key sections of the road network have been compared to the TRACKS traffic assignment to determine if the PT model is accurately reproducing the vehicular assignment. Table 4 shows a comparison of volumes (vph) in the AM and PM peak hour periods.

Table 4: Link Volume Comparison (vph)

Location	Direction	AM Peak Hour			PM Peak Hour		
		TRACKS	PT	Diff	TRACKS	PT	Diff
SH6 Shotover Bridge	Westbound	1263	1225	-38	877	854	-23
	Eastbound	570	555	-15	1345	1319	-26
SH6 Kawarau Falls Bridge	Northbound	619	614	-5	514	509	-5
	Southbound	334	332	-2	642	641	-1
SH6A, east of Marina Drive	Westbound	1124	1077	-47	1350	1358	8
	Eastbound	826	822	-4	1293	1268	-25
Edith Cavell Bridge	Northbound	204	233	29	420	463	43
	Southbound	430	468	38	277	298	21

The results show a good correlation with observed volumes. This suggests that the model is a reasonable representation of traffic volumes within the network, and that there is consistency between the TRACKS and PT model assignment. The application of appropriate levels of capacity constraints within the model should therefore enable a reasonable travel time validation to be achieved.

4.2 General Traffic Travel Times

Travel times on key sections of the road network have been compared to observed (Google) data to determine if the model is accurately reproducing the levels of delay and congestion in the network. Table 5 provides a summary of the results (minutes).

The results show good correlation against travel time observations. This suggests that the model is representing speeds and delays to an accurate degree, and therefore allows the parameters and weightings in the logit model element to be calibrated to produce a mode share consistent with current patronage data.

Table 5: General Traffic Travel Time Validation

Route	Direction	AM Peak Hour			PM Peak Hour		
		Google	Model	Diff	Google	Model	Diff
Arrowtown to QT (via Arthurs Point)	Westbound	22	24	2	22	22	0
	Eastbound	22	22	0	24	24	0
Fernhill to SH6/SH6A	Westbound	16	20	4	24	21	-3
	Eastbound	17	19	2	20	20	0
SH6/SH6A to Lake Hayes Estate	Westbound	10	10	0	9	10	1
	Eastbound	7	9	2	9	10	1
SH6/SH6A to Jacks Point	Northbound	12	12	0	15	12	-3
	Southbound	12	11	-1	12	12	0
Remarkables Town Centre to Arrowtown (via Hawthorne Drive)	Westbound	19	20	1	18	20	2
	Eastbound	18	20	2	22	21	-1
Remarkables Town Centre to Arrowtown (via SH6)	Westbound	22	24	2	20	23	3
	Eastbound	20	23	3	24	24	0
SH6/SH6A to Kelvin Heights	Westbound	10	10	0	10	10	0
	Eastbound	10	10	0	13	10	-3

4.3 Bus Travel Times

Travel times on key sections of the bus network have been compared to ORC timetable data to determine if the model is accurately reproducing the typical bus travel times in the network. It is appreciated that the timetable information does not represent actual journey times (either due to congestion and/or recovery periods at timing points), but it is nonetheless an interesting comparison to show that the model predictions line up with the published timetable. Table 6 provides a summary of the results (minutes).

The results show a reasonable correlation between model journey times and the published timetable. In general, the model travel times are quicker – this is to be expected as the timetable is likely to include some additional recovery time so as to avoid early running. This suggests that the model is representing speeds, delays and bus stop activity to a reasonably accurate degree, and therefore allows the parameters and weightings in the logit model element to be calibrated to produce a mode share consistent with current patronage data.

Table 6: Bus Travel Time Comparison

Route	Direction	Timetable	AM	IP	PM
Fernhill to QT (Route 1)	Westbound	12	10	10	10
	Eastbound	9	10	10	10
Arthurs Point to QT (Route 2)	Northbound	13	12	13	13
	Southbound	13	13	13	12
QT to Frankton (Route 1, 2, 5)	Westbound	15	18	17	18
	Eastbound	15	16	16	17
Frankton to Arrowtown (Route 2)	Westbound	22	23	22	22
	Eastbound	22	22	22	23
Frankton to Lake Hayes (Route 5)	Westbound	15	13	13	13
	Eastbound	15	12	13	13
Frankton to Remarkables Park (Route 1)	Northbound	15	13	13	13
	Southbound	15	13	13	13
Frankton to Jacks Point (Route 3)	Northbound	25	17	17	17
	Southbound	25	16	17	17
Frankton to Kelvin Heights (Route 4)	Northbound	28	24	24	24
	Southbound	28	23	24	24

4.4 Patronage Levels

The model output in terms of bus patronage has been compared to the data received by ORC. It should be noted that the data system in operation (in 2018) was somewhat unreliable, and although recordings of boarding and alighting points was made available, it was concluded that the recording of this data was not reliable enough to be used for calibration of the model. Consequently, the total patronage (per hour) has been compared together with a sense check of the patronage levels (from the model) on a few key sections of the PT network.

Table 7 shows the overall patronage in all three periods and also the patronage predicted by the model for water-based services. The results show excellent correlation against recorded patronage levels.

Table 7: Patronage prediction at 2018 versus observed

Test Description	Metric		AM	IP	PM
Base versus Observed (ORC Data)	Total Bus Passengers in Network	Base Model 2018	422	194	394
		Observed	409	188	395
		Difference	13	6	-1
	Total Water Service Passengers in Network	Base Model 2018	23	7	14
		Observed	-	-	-
		Difference	-	-	-

As a further sense check, Figure 2 and Figure 3 show the total bus passengers and total mode share per origin-destination trip in the morning peak hour. Figure 4 and Figure 5 show similar results for the PM peak hour. It is considered that the model is showing a satisfactory correlation against total recorded patronage levels, and a split of trips across the network that generally falls in line with observations. In two specific areas, however, the model is reporting trip levels that correspond less well with observations:

- Fernhill to Queenstown Town Centre – the model is likely to be overpredicting PT demand in this area, which is due to the total demand for the Fernhill zones being high compared to the actual demand (from the strategic model). However, the mode share percentage is considered reasonable
- Queenstown Town Centre to Frankton Road – again, the model is likely to be overestimating PT demand, although the mode share again seems reasonable

By reporting both absolute trips by mode and mode share (%), analysis can be carried out post-model output, to reflect any perceived or real inaccuracies in the background demand set – so that a more realistic PT patronage can be established.

Figure 2: AM Peak Bus Patronage (passengers per hour)

Bus Passengers	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables	Kelvin Height	Arrowtown	Ladies Mile	Lake Hayes/Sh	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton Sout	Five Mile	Airport	Frankton Nort	Speargrass	Wanaka	Total
Town Centre		15	0	15	12	6	1	2	0	1	0	0	5	0	1	1	4	11	0	0	0	**74**
Fernhill	73		0	2	2	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	**80**
Cromwell	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Frankton Rd	47	1	0		6	2	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	**62**
Frankton	27	1	0	4		4	1	1	0	1	0	0	0	0	2	1	6	3	1	0	0	**53**
Remarkables Park	10	0	0	1	4		1	0	0	1	0	0	0	0	0	2	2	3	0	0	0	**24**
Kelvin Heights	3	0	0	0	2	3		0	0	0	0	0	0	0	0	1	1	1	0	0	0	**12**
Arrowtown	6	0	0	1	2	0	0		1	1	0	0	0	0	0	0	3	1	0	0	0	**17**
Ladies Mile	1	0	0	0	1	0	0	1		1	0	0	0	0	0	0	1	0	0	0	0	**5**
Lake Hayes/Shotover Country	9	0	0	1	5	1	0	1	2		0	0	0	0	0	1	7	1	1	0	0	**30**
Skippers	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	**0**
Glenorchy	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	**0**
Arthurs Point	14	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	**16**
Kingston	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	**0**
Jacks Point	2	0	0	0	1	1	0	0	0	0	0	0	0	0		0	1	0	0	0	0	**6**
Frankton South East	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	**3**
Five Mile	3	0	0	1	2	1	0	1	0	1	0	0	0	0	0	0		1	0	0	0	**11**
Airport	14	1	0	1	2	2	0	1	0	0	0	0	0	0	0	0	1		0	0	0	**23**
Frankton North	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	**5**
Speargrass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	**0**
Wanaka	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		**0**
Total	**212**	**19**	**0**	**28**	**40**	**22**	**4**	**8**	**4**	**8**	**0**	**0**	**7**	**0**	**5**	**8**	**30**	**25**	**3**	**0**	**0**	422

Figure 3: AM Peak Bus Mode Share (percentage of person-trips)

Bus Mode Share	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables	Kelvin Height	Arrowtown	Ladies Mile	Lake Hayes/Sh	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton Sout	Five Mile	Airport	Frankton Nort	Speargrass	Wanaka	Total
Town Centre	0%	10%	0%	10%	14%	9%	2%	4%	2%	2%	0%	0%	5%	0%	3%	7%	4%	12%	4%	0%	0%	**3%**
Fernhill	12%	0%	0%	6%	9%	6%	1%	2%	3%	3%	0%	0%	3%	0%	2%	5%	3%	9%	3%	0%	0%	**8%**
Cromwell	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Frankton Rd	11%	5%	0%	0%	8%	5%	1%	3%	3%	1%	0%	0%	2%	0%	2%	4%	2%	7%	2%	0%	0%	**7%**
Frankton	18%	9%	0%	9%	0%	8%	4%	6%	6%	5%	0%	0%	4%	0%	14%	7%	8%	12%	8%	0%	0%	**9%**
Remarkables Park	10%	6%	0%	5%	8%	0%	2%	3%	3%	3%	0%	0%	2%	0%	3%	9%	4%	12%	4%	0%	0%	**5%**
Kelvin Heights	3%	1%	0%	2%	4%	6%	0%	1%	1%	1%	0%	0%	1%	0%	2%	5%	2%	4%	2%	0%	0%	**2%**
Arrowtown	4%	1%	0%	4%	6%	2%	1%	0%	7%	3%	0%	0%	1%	0%	1%	2%	4%	4%	4%	0%	0%	**2%**
Ladies Mile	4%	2%	0%	4%	6%	2%	1%	6%	0%	6%	0%	0%	1%	0%	3%	2%	3%	3%	3%	0%	0%	**3%**
Lake Hayes/Shotover Country	5%	2%	0%	2%	5%	2%	1%	3%	6%	0%	0%	0%	0%	0%	3%	1%	3%	3%	3%	0%	0%	**2%**
Skippers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Glenorchy	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Arthurs Point	5%	2%	0%	2%	4%	2%	0%	1%	1%	0%	0%	0%	0%	0%	1%	1%	2%	2%	2%	0%	0%	**3%**
Kingston	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Jacks Point	2%	1%	0%	1%	3%	2%	1%	1%	3%	3%	0%	0%	1%	0%	0%	1%	2%	2%	2%	0%	0%	**2%**
Frankton South East	9%	6%	0%	4%	7%	9%	2%	4%	2%	2%	0%	0%	2%	0%	2%	0%	3%	9%	3%	0%	0%	**5%**
Five Mile	4%	3%	0%	2%	7%	3%	2%	3%	3%	3%	0%	0%	2%	0%	2%	2%	0%	4%	0%	0%	0%	**2%**
Airport	17%	10%	0%	9%	13%	12%	3%	13%	5%	5%	0%	0%	4%	0%	4%	10%	5%	0%	5%	0%	0%	**7%**
Frankton North	4%	1%	0%	2%	7%	3%	2%	3%	3%	3%	0%	0%	2%	0%	2%	3%	0%	4%	0%	0%	0%	**2%**
Speargrass	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Wanaka	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Total	**5%**	**4%**	**0%**	**5%**	**6%**	**4%**	**1%**	**1%**	**3%**	**1%**	**0%**	**0%**	**2%**	**0%**	**2%**	**4%**	**3%**	**6%**	**2%**	**0%**	**0%**	

Figure 4: PM Peak Bus Patronage (passengers per hour)

Bus Passengers	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables	Kelvin Height	Arrowtown	Ladies Mile	Lake Hayes/Sh	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton Sout	Five Mile	Airport	Frankton Nort	Speargrass	Wanaka	**Total**
Town Centre		62	0	46	25	10	1	6	1	6	0	0	16	0	2	1	6	7	3	0	0	**191**
Fernhill	21		0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Cromwell	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Frankton Rd	15	1	0		3	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	**25**
Frankton	12	1	0	5		4	2	2	1	5	0	0	0	0	3	0	3	1	1	0	0	**40**
Remarkables Park	9	1	0	2	4		1	0	0	1	0	0	0	0	1	0	1	2	0	0	0	**22**
Kelvin Heights	1	0	0	0	1	3		0	0	0	0	0	0	0	0	0	1	0	0	0	0	**8**
Arrowtown	2	0	0	0	1	0	0		1	1	0	0	0	0	0	0	1	0	0	0	0	**7**
Ladies Mile	0	0	0	0	0	0	0	1		2	0	0	0	0	0	0	0	0	0	0	0	**4**
Lake Hayes/Shotover Country	2	0	0	1	2	1	0	1	1		0	0	0	0	0	0	3	0	0	0	0	**11**
Skippers	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	**0**
Glenorchy	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	**0**
Arthurs Point	7	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	**8**
Kingston	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	**0**
Jacks Point	0	0	0	0	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	**2**
Frankton South East	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	**2**
Five Mile	9	1	0	3	4	1	1	2	1	5	0	0	0	0	1	0		0	0	0	0	**29**
Airport	8	1	0	2	2	2	0	1	0	1	0	0	0	0	0	0	1		0	0	0	**19**
Frankton North	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0		0	0	**2**
Speargrass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	**0**
Wanaka	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		**0**
Total	89	66	0	61	46	24	6	13	4	22	0	0	17	0	7	2	18	13	5	0	0	394

Figure 5: PM Peak Bus Mode Share (percentage of person-trips)

Bus Mode Share	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables	Kelvin Height	Arrowtown	Ladies Mile	Lake Hayes/Sh	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton Sout	Five Mile	Airport	Frankton Nort	Speargrass	Wanaka	**Total**
Town Centre	0%	9%	0%	9%	14%	8%	1%	4%	2%	3%	0%	0%	6%	0%	2%	6%	5%	12%	5%	0%	0%	**3%**
Fernhill	6%	0%	0%	3%	5%	3%	0%	1%	1%	1%	0%	0%	1%	0%	1%	3%	2%	6%	2%	0%	0%	**3%**
Cromwell	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Frankton Rd	6%	3%	0%	0%	5%	3%	0%	3%	3%	1%	0%	0%	2%	0%	1%	2%	2%	4%	2%	0%	0%	**3%**
Frankton	11%	5%	0%	6%	0%	5%	3%	6%	5%	5%	0%	0%	4%	0%	9%	4%	5%	8%	5%	0%	0%	**5%**
Remarkables Park	5%	3%	0%	3%	5%	0%	1%	1%	1%	1%	0%	0%	1%	0%	1%	6%	1%	7%	1%	0%	0%	**2%**
Kelvin Heights	2%	1%	0%	1%	3%	5%	0%	1%	1%	1%	0%	0%	0%	0%	1%	4%	2%	3%	2%	0%	0%	**1%**
Arrowtown	3%	1%	0%	3%	6%	2%	0%	0%	6%	2%	0%	0%	1%	0%	1%	1%	3%	3%	3%	0%	0%	**1%**
Ladies Mile	3%	1%	0%	3%	5%	1%	0%	6%	0%	5%	0%	0%	1%	0%	2%	1%	3%	3%	3%	0%	0%	**3%**
Lake Hayes/Shotover Country	3%	1%	0%	2%	5%	1%	0%	2%	5%	0%	0%	0%	0%	0%	2%	1%	3%	3%	3%	0%	0%	**1%**
Skippers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Glenorchy	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Arthurs Point	4%	1%	0%	2%	3%	1%	0%	1%	1%	0%	0%	0%	0%	0%	0%	1%	2%	2%	2%	0%	0%	**2%**
Kingston	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Jacks Point	1%	1%	0%	1%	3%	1%	0%	1%	2%	2%	0%	0%	0%	0%	0%	1%	2%	2%	2%	0%	0%	**1%**
Frankton South East	4%	3%	0%	2%	4%	5%	1%	2%	1%	1%	0%	0%	1%	0%	1%	0%	1%	5%	1%	0%	0%	**2%**
Five Mile	3%	1%	0%	2%	4%	1%	1%	3%	2%	2%	0%	0%	2%	0%	1%	1%	0%	2%	0%	0%	0%	**2%**
Airport	9%	6%	0%	5%	8%	8%	1%	8%	3%	3%	0%	0%	2%	0%	2%	6%	3%	0%	3%	0%	0%	**4%**
Frankton North	3%	1%	0%	2%	4%	2%	2%	3%	2%	2%	0%	0%	2%	0%	1%	1%	0%	2%	0%	0%	0%	**1%**
Speargrass	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Wanaka	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Total	**2%**	**5%**	**0%**	**5%**	**6%**	**3%**	**1%**	**1%**	**2%**	**2%**	**0%**	**0%**	**3%**	**0%**	**2%**	**3%**	**2%**	**5%**	**2%**	**0%**	**0%**	

4.5 Sensibility Testing of Base Model

A number of tests have been carried out on the base model to demonstrate how the model reacts to changes in parameters. This allows the elasticity of changes of these parameters to be compared against the range of expected values (from other observed studies/data).

It should be noted that the use of elasticities are only really applicable for relatively small changes in parameters, as the current point on the demand curve will have an influence on the elasticity (and on the specific supply-demand relationship). In addition, elasticities are functions with several possible variables (time period, market segmentation, trip type etc) and so the values output in this section are only considered as a guide to the validity of the model.

Elasticity has been calculated as the arc elasticity (rather than the linear), as given as the calculation below:

$$Arc\ Elasticity\ (a) = \frac{\log(Q2) - \log\,(Q1)}{\log(P2) - \log(P1)}$$

$$Q2 = Q1\left(\frac{P2}{P1}\right)^{a}$$

Where Q1 and Q2 are the patronage before and after the change respectively, and P1 and P2 are the prices before and after the change respectively.

4.5.1 Car parking charge

In late February 2018, car parking charges were doubled in Queenstown town centre, allowing a check on the response of the model to such a change, compared to the observed impact on patronage. As the ORC data is not precise enough to be disaggregated (i.e. to only total trips to and from Queenstown Town Centre), a direct comparison is not possible, but given the majority of current PT trips are to and from Queenstown Town Centre, it is a reasonable approximation. Table 8 shows the results.

Table 8: Car parking sensitivity

Test Description	Metric		AM	IP	PM
50% Parking Charge Reduction	Total Bus Passengers in Network	Base Model 2018	422	194	394
		Model x0.5 Parking	399	184	369
		Model Elasticity	0.08	0.07	0.09
		Observed Elasticity	0.13	-	0.09

The results show that the model elasticity in the afternoon peak is similar to the observed elasticity. In the morning, the model is predicting that (although still inelastic), a change in parking charge has less of an impact in increasing patronage than observed. However, the elasticity is still relatively low, as might be expected given the relatively low level of parking charge currently in operation. Consequently, it is concluded that the model is reacting appropriately to car parking changes.

4.5.2 Fare reduction

At the end of November 2017, the new subsidised bus service was introduced, with a reduction in the standard fare of $5 to $2 if using a GoCard (available from the driver), with cash fares set at $5 ($10 to/from the Airport). This is a simplification as the old service included some multi-trip discount tickets, and both old and new services include a proportion of child and off-peak gold-card trips – however, the relative reduction in fare at the time of change is generally in line with the change in base fare. Table 9 shows the results.

Table 9: Fare reduction sensitivity

Test Description	Metric		AM	IP	PM
Fare increased to $5 Test	Total Bus Passengers in Network	Base Model 2018	422	194	394
		Model $5 Fare	301	129	260
		Model Elasticity	-0.37	-0.44	-0.45
		Observed Elasticity	-0.68	-	-0.83

The results show that in both the morning and afternoon peak hour periods, the actual patronage change was bigger than that predicted by the model. This is to be expected as the introduction of the subsidised service was also accompanied by some service improvements (increased frequencies) and some changes to car parking availability in the Queenstown Town Centre – which is not included in the model test. Consequently, it is considered that the model is reacting appropriately to fare changes.

4.5.3 Transfer Reduction

A further sensibility test has been carried out to show the model prediction if the required transfer from Lake Hayes Estate services was removed – i.e. direct services were provided between these areas to and from Queenstown Town Centre. ***Note that this service has since been introduced as a direct route to Queenstown town centre, although we do not have current data on the impact of this change***. This test resulted in the removal of the transfer penalty and transfer wait time from these journeys. Table 10 shows the results.

Table 10: Transfer reduction patronage

Test Description	Metric		AM	IP	PM
Lake Hayes Estate to Queenstown Direct Service	LHE/SC to QT (AM) and QT to LHE/SC (PM) Bus Passengers	Base Model 2018	11	-	7
		Model Direct Service	14	-	17
		Base Model 2018 (PT share)	6%	-	3%
		Model Direct Service (PT Share)	7%	-	8%

The results show that as would be expected, the model predicts an increase in trips when the transfer is removed from the journey. The impact is bigger in the afternoon peak, which is also to be expected – there is greater gain in the afternoon peak outbound direction due to a more significant transfer saving in that direction (the existing trip involves transfer from a high frequency service to a lower frequency one, whereas in the morning peak inbound journey, the trip involves a transfer from low to high frequency and therefore less wait time). Two further points to note:

- The absolute trips on the service are likely to be higher than observed (albeit observed data has not been collected to this level of detail), which is likely due to the underestimate of total (car) trips between the origin and destination points in the strategic model
- Consequently, the mode share proportion is likely to be a more realistic indicator of the impact of the transfer removal – i.e. patronage approximately doubles when the service becomes direct

In summary, it is considered that the model is predicting a reasonable level of increased trips due to the introduction of through trips.

4.5.4 Bus Travel Time Sensitivity

A sensitivity test has been carried out to show the model prediction if all bus travel times in the network were reduced by 20%. This test resulted in the factoring of original bus travel times by 0.8, and running the model to estimate the predicted additional switch to PT. It should be noted that only in-journey time was reduced and not wait or access times, so the test does not represent a total travel time saving for a particular trip. Table 11 shows the results.

Table 11: Bus travel time sensitivity

Test Description	Metric		AM	IP	PM
20% reduction in Bus Travel Times	Total Bus Passengers in Network	Base Model 2018	422	194	394
		Model 20% bus TT reduction	478	232	463
		Model Elasticity	-0.56	-0.80	-0.72

The results show that bus journey time savings have a significant impact on patronage, at around a 10-15% increase for a 20% saving in travel time. This seems reasonable as a forecast, whilst still being inelastic, and therefore it is considered that the model is providing reasonable forecasts.

4.5.5 Vehicle Operating Cost Sensitivity

An additional sensitivity test has been carried out to show the model prediction if general traffic vehicle operating costs (VOC) is decreased by 20%. This test resulted in the factoring of original general traffic VOC by 0.8, and running the model to estimate the predicted reduced switch to PT. Table 12 shows the results.

Table 12: VOC Sensitivity

Test Description	Metric		AM	IP	PM
20% reduction in General Traffic VOC	Total Bus Passengers in Network	Base Model 2018	422	194	394
		Model 20% lower VOC	413	190	385
		Model Elasticity	0.09	0.07	0.11

The results show that the change in vehicle operating cost has only a marginal impact on bus patronage – this might be expected as the vehicle operating cost is a minority proportion of the total generalised cost. In addition, particularly in the short term, a change in VOC (or fuel cost) will have little impact on travel behaviour as most essential trips will still be made. Consequently, it is considered that the model is providing a reasonable forecast in terms of cost sensitivity.

In summary, the sensibility tests show that the model is reacting appropriately to changes in a number of parameters.

5 Future Year Scenarios – Base Travel Demand

In order to determine the future needs for public transport in the Whakatipu Basin, the first stage is to determine the travel demand (as forecast by the strategic model) on parts of the network. Then establish when particular links begin to operate at or above capacity, noting that several parts of the network are already experiencing congestion in peak periods (especially afternoon peak period).

Consequently, this section concentrates on establishing the level of road network performance on key links, assuming zero public transport service. The subsequent calculation then determines the level of PT patronage that is required at these key links to enable at capacity operation – this is irrespective of the actual PT network, which will be part of the next stage of the project.

5.1 Key Link Analysis – Volumes

Firstly, assigned vehicle demand in the PT model is shown at five key links of the network, i.e., **with zero PT patronage**. These volumes will be similar to the assigned volumes in the TRACKS strategic model, but not exactly, given the simplified network within the PT model:

- SH6A screenline, east of Suburb Street
- SH6A, east of Marina Drive
- Shotover Bridge
- Kawarau Falls Bridge
- Arthurs Point Crossing

	AM Peak Hour - Number of Vehicles				
Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	798	1103	887	1124	979
SH6A (Suburb) Westbound	1716	1856	2092	2328	2388
SH6A (Marina) Eastbound	852	1209	927	1147	935
SH6A (Marina) Westbound	1540	1651	1891	2120	2157
Shotover Bridge Eastbound	667	682	818	978	1014
Shotover Bridge Westbound	1418	1716	1565	1906	1764
Kawarau Falls Bridge Southbound	446	560	569	705	531
Kawarau Falls Bridge Northbound	1313	1219	1965	1953	2467
Arthurs Point Crossing Southbound	623	685	727	960	843
Arthurs Point Crossing Northbound	295	366	324	409	351

Figure 6 to Figure 10 shows the same information in graphical form. It should be noted that whilst the 2027 latest forecasts and 2028 QTBC values can be directly compared, there is a 5-year difference between the long-term forecasts (2048 v 2053), which makes a direct comparison more difficult.

Table 13 sets out the traffic volumes at each of these key locations in the AM peak for the following scenarios:

- 2027 Queenstown Public Transport Business Case (“2027 Future”)
- 2028 QTBC
- 2039 Queenstown Public Transport Business Case (“2039 Future”)

- 2048 QTBC
- 2053 Queenstown Public Transport Business Case ("2039 Future")

	AM Peak Hour - Number of Vehicles				
Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	798	1103	887	1124	979
SH6A (Suburb) Westbound	1716	1856	2092	2328	2388
SH6A (Marina) Eastbound	852	1209	927	1147	935
SH6A (Marina) Westbound	1540	1651	1891	2120	2157
Shotover Bridge Eastbound	667	682	818	978	1014
Shotover Bridge Westbound	1418	1716	1565	1906	1764
Kawarau Falls Bridge Southbound	446	560	569	705	531
Kawarau Falls Bridge Northbound	1313	1219	1965	1953	2467
Arthurs Point Crossing Southbound	623	685	727	960	843
Arthurs Point Crossing Northbound	295	366	324	409	351

Figure 6 to Figure 10 shows the same information in graphical form. It should be noted that whilst the 2027 latest forecasts and 2028 QTBC values can be directly compared, there is a 5-year difference between the long-term forecasts (2048 v 2053), which makes a direct comparison more difficult.

Table 13: AM Peak Traffic Volumes

	AM Peak Hour - Number of Vehicles				
Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	798	1103	887	1124	979
SH6A (Suburb) Westbound	1716	1856	2092	2328	2388
SH6A (Marina) Eastbound	852	1209	927	1147	935
SH6A (Marina) Westbound	1540	1651	1891	2120	2157
Shotover Bridge Eastbound	667	682	818	978	1014
Shotover Bridge Westbound	1418	1716	1565	1906	1764
Kawarau Falls Bridge Southbound	446	560	569	705	531
Kawarau Falls Bridge Northbound	1313	1219	1965	1953	2467
Arthurs Point Crossing Southbound	623	685	727	960	843
Arthurs Point Crossing Northbound	295	366	324	409	351

Figure 6: SH6A (Suburb): AM Peak – Number of Vehicles

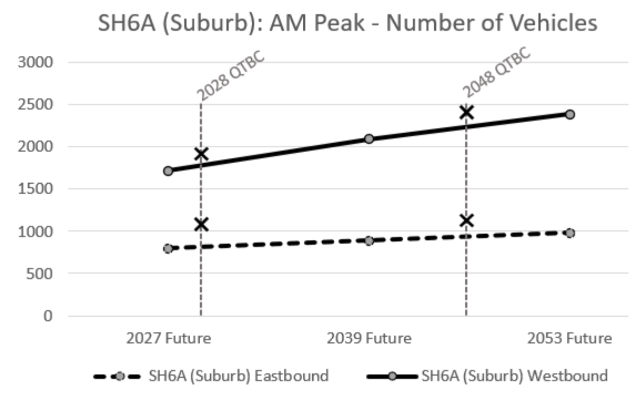


Figure 7: SH6A (Marina): AM Peak – Number of Vehicles

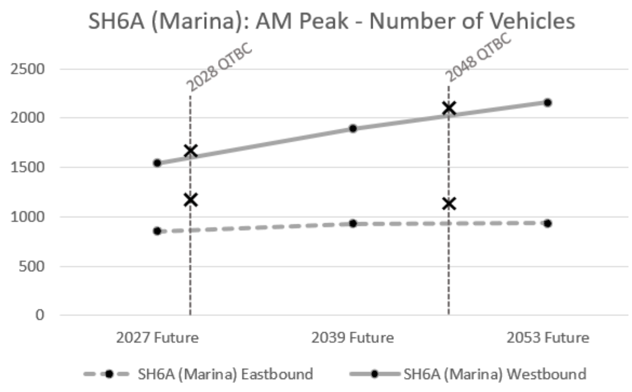


Figure 8: Shotover Bridge: AM Peak – Number of Vehicles

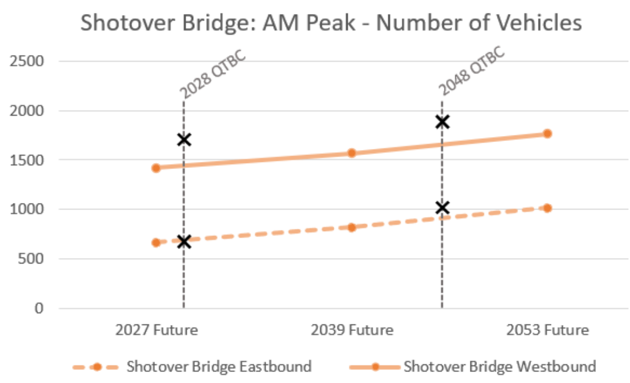


Figure 9: Kawarau Falls Bridge: AM Peak – Number of Vehicles

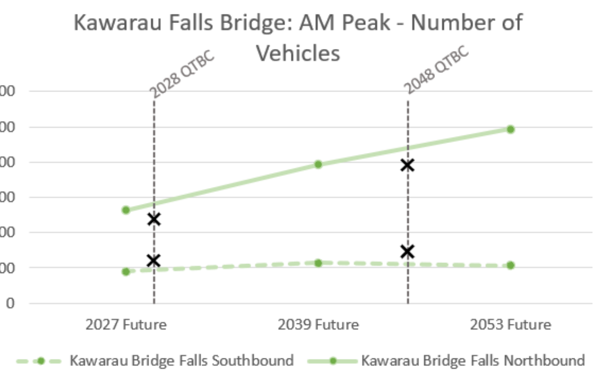


Figure 10: Arthurs Point: AM Peak – Number of Vehicles

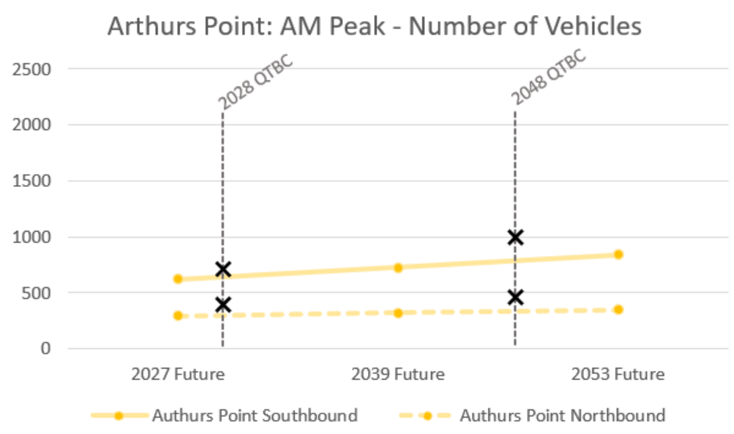


Table 13 and

Location - Direction	AM Peak Hour - Number of Vehicles				
	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	798	1103	887	1124	979
SH6A (Suburb) Westbound	1716	1856	2092	2328	2388
SH6A (Marina) Eastbound	852	1209	927	1147	935
SH6A (Marina) Westbound	1540	1651	1891	2120	2157
Shotover Bridge Eastbound	667	682	818	978	1014
Shotover Bridge Westbound	1418	1716	1565	1906	1764
Kawarau Falls Bridge Southbound	446	560	569	705	531
Kawarau Falls Bridge Northbound	1313	1219	1965	1953	2467
Arthurs Point Crossing Southbound	623	685	727	960	843
Arthurs Point Crossing Northbound	295	366	324	409	351

Figure *6* to **Figure** *10* show:

- Volumes on SH6A and Shotover Bridge have generally dropped between the QTBC forecasts and the latest projections, particularly in the non-peak direction (eastbound)
- On Kawarau Falls Bridge, the latest projections of traffic volumes are higher than during the QTBC work

Table 14 sets out the traffic volumes at the same key locations in the Interpeak period.

Table 14: Interpeak Traffic Volumes

Location - Direction	Interpeak Hour - Number of Vehicles				
	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	1290	1788	1568	2155	1784
SH6A (Suburb) Westbound	1318	1752	1597	2053	1820
SH6A (Marina) Eastbound	1245	1739	1516	2020	1717
SH6A (Marina) Westbound	1250	1679	1523	1942	1731
Shotover Bridge Eastbound	996	1116	1173	1510	1337
Shotover Bridge Westbound	990	1106	1153	1466	1294
Kawarau Falls Bridge Southbound	682	731	979	1199	1273
Kawarau Falls Bridge Northbound	756	729	1079	1200	1407
Arthurs Point Crossing Southbound	413	511	455	687	489
Arthurs Point Crossing Northbound	412	504	455	676	495

Table 14 shows that in the Interpeak period, there is a more significant drop in traffic growth in the latest forecast, compared to the QTBC, on SH6A, Shotover Bridge and Arthurs Point Crossing. On Kawarau Falls Bridge, the latest forecasts are generally in line with the previous projections.

Table 15 and **Figure** *11* to **Figure** *15* set out the traffic volumes at the same key locations in the afternoon peak period.

Table 15: PM Peak Traffic Volumes

	PM Peak Hour - Number of Vehicles				
Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	1813	2120	2198	2735	2576
SH6A (Suburb) Westbound	1288	1387	1391	1552	1513
SH6A (Marina) Eastbound	1627	1924	1960	2433	2235
SH6A (Marina) Westbound	1442	1471	1529	1518	1590
Shotover Bridge Eastbound	1544	1835	1766	2162	1928
Shotover Bridge Westbound	981	1228	1142	1639	1295
Kawarau Falls Bridge Southbound	1265	1267	1869	2101	2315
Kawarau Falls Bridge Northbound	732	721	974	1008	1062
Arthurs Point Crossing Southbound	377	418	424	518	472
Arthurs Point Crossing Northbound	601	661	666	886	718

Figure 11: SH6A (Suburb): PM Peak – Number of Vehicles

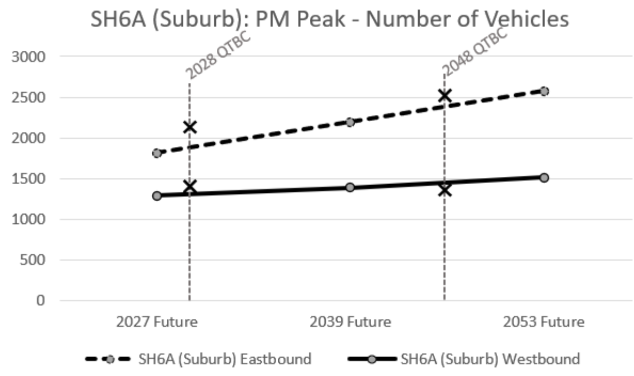


Figure 12: SH6A (Marina): PM Peak – Number of Vehicles

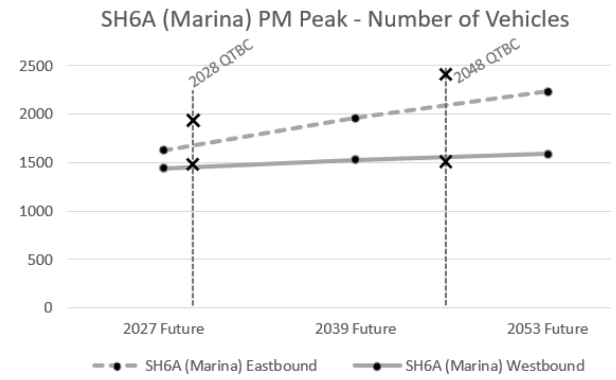


Figure 13: Shotover Bridge: PM Peak – Number of Vehicles

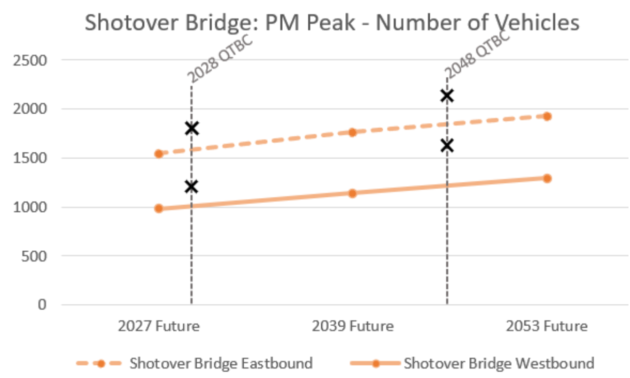


Figure 14: Kawarau Falls Bridge: PM Peak – Number of Vehicles

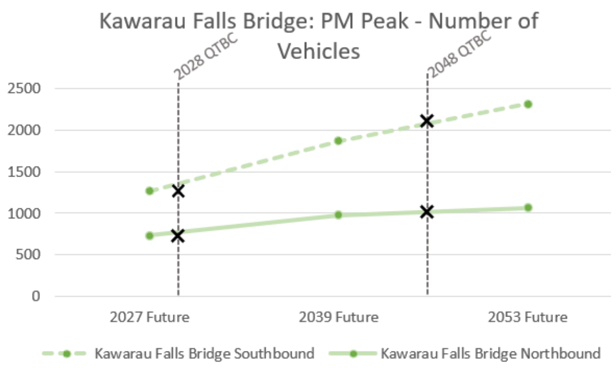


Figure 15: Arthurs Point: PM Peak – Number of Vehicles

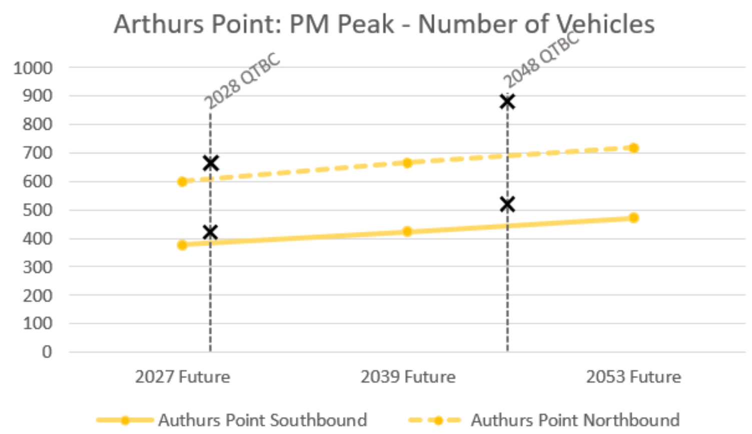


Table 15 and **Figure** *11* to **Figure** *15* show:

- Volumes on SH6A and Shotover Bridge have significantly dropped between the QTBC forecasts and the latest projections
- On Kawarau Falls Bridge, the latest projections of traffic volumes are higher than during the QTBC work

The upshot of the above comparison is that in terms of likely PT patronage, the (generally) slower growth in trips compared to the QTBC forecasts should mean that forecast patronage on PT will likely be lower than previous, assuming congestion is less than previous, and therefore there is less incentive to shift from the private car mode. This is with the exception of the Southern Corridor, which sees higher growth, which may be assumed to result in the requirement to accelerate PT improvements to and from this area.

In terms of underlying reasons for the changes between the QTBC and latest forecasts, Abley has provided some commentary around the key changes in the latest forecasts, summarised below:

- Fewer households (-9.4%), tourists (-12.1%) and jobs (-1.6%) in the district in the latest forecasts, comparing 2027 update to 2028 QTBC
- Fewer households (-3.4%), tourists (-3.3%) and jobs (-10.0%) in the district in the latest forecasts, comparing 2053 update to 2048 QTBC
- Halving of tourist accommodation in central Queenstown, comparing at both medium (2027/2028) and long term (2048/2053) time horizons, with accommodation units shifting to Frankton and further afield
- Also, there is a reduction in households within central Queenstown, at both medium- and long-term time horizons
- Increase in the population and associated job opportunities in Wanaka and Cromwell result in less dependency on Frankton and Queenstown (i.e., a reduction in longer distance trips through Kawarau Gorge and over the Crown Range

These changes result in a drop in trip growth on the SH6A corridor, as less trips start or end in central Queenstown. The general drop in tourist numbers (the 2028 and 20498 QTBC forecasts did not account for the impact of COVID), and more "self-sufficiency" in Wanaka and Cromwell has led to reduced longer distance trips, and associated drop in demand on Shotover Bridge.

5.2 Key Link Analysis – Volume/ Capacity

The following analysis sets out the operational level of the road network, initially assuming all trips are made by private car, as per the above section (i.e. with zero PT share).

Link capacity for each link is estimated from modelling work undertaken during the QTBC but should be treated as approximate values. In reality, link capacity at any fixed point will change for a number of reasons (such as side road activity, kerbside activity, weather conditions, pedestrian crossing movements etc), as well as being influenced by capacity and operation on adjacent links. However, as a simplified approach, this gives a scale of operational level that can be expected. In terms of the network, and he associated link capacity, it is assumed that:

- NZUP is implemented and in operation by 2027 and onwards
- Arthurs Crossing is not dualled (or improved from the existing Edith Cavell Bridge)
- No other significant road network improvements, including additional road bridges to/from Frankton Flats are provided

The analysis then fixes the maximum volume/capacity (v/c) ratio at **90%** (generally accepted as the practical maximum of v/c before unpredictable operation causes significant congestion). Then calculates the number of trips that need to shift to the PT mode (in whatever form) in order for the link v/c to operate at 100% or better (a fixed occupancy of 1.3 persons per vehicle is used for this calculation).

This gives an indication of the scale and volume of passengers required to be accommodated by PT to maintain operation of the road network to an acceptable degree. Note that this analysis assumes that all demand needs to be accommodated by either on-road private vehicle or PT, and therefore other behavioural elements are not accounted for (e.g., shift to active modes, suppressed trips, peak spreading etc).

Table 16 sets out the results for the morning peak hour period, with two smaller summary tables showing critical PT patronage to achieve 90% v/c road operation on the link, and associated PT mode share at that critical level. Note, where the PT share is zero, this indicates that the demand does not reach the critical v/c on any particular link (generally in the non-peak direction), so all trips could be accommodated by private road transport (in reality, there would be a level of PT share).

Table 16: Link Capacity and critical PT patronage in the AM peak hour period.

Location	Direction	Passengers	AM - Number of Passengers: 2027 Future		2028 QTBC		2039 Future		2048 QTBC		2053 Future	
SH6A (Suburb)	Eastbound	Car	1037	100%	1433	100%	1153	100%	1462	100%	1272	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	1037	100%	1433	100%	1153	100%	1462	100%	1272	100%
		DoS	50%		69%		55%		70%		61%	
	Westbound	Car	1638	73%	1638	68%	1638	60%	1638	54%	1638	53%
		PT	592	27%	775	32%	1082	40%	1388	46%	1466	47%
		Total	2230	100%	2413	100%	2720	100%	3026	100%	3104	100%
		DoS	90%		90%		90%		90%		90%	
SH6A (Marina)	Eastbound	Car	1107	100%	1521	97%	1206	100%	1491	100%	1216	100%
		PT	0	0%	51	3%	0	0%	0	0%	0	0%
		Total	1107	100%	1572	100%	1206	100%	1491	100%	1216	100%
		DoS	66%		90%		71%		88%		72%	
	Westbound	Car	1521	76%	1521	71%	1521	62%	1521	55%	1521	54%
		PT	480	24%	626	29%	938	38%	1236	45%	1283	46%
		Total	2001	100%	2147	100%	2459	100%	2757	100%	2804	100%
		DoS	90%		90%		90%		90%		90%	
Shotover Bridge	Eastbound	Car	867	100%	886	100%	1064	100%	1271	100%	1318	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	867	100%	886	100%	1064	100%	1271	100%	1318	100%
		DoS	48%		49%		58%		70%		72%	
	Westbound	Car	1521	82%	1521	68%	1521	75%	1521	61%	1521	66%
		PT	323	18%	709	32%	514	25%	957	39%	772	34%
		Total	1844	100%	2230	100%	2035	100%	2478	100%	2293	100%
		DoS	90%		90%		90%		90%		90%	
Kawarau Falls Bridge	Southbound	Car	580	100%	728	100%	740	100%	916	100%	691	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	580	100%	728	100%	740	100%	916	100%	691	100%
		DoS	30%		37%		38%		47%		35%	
	Northbound	Car	1707	100%	1585	100%	1638	64%	1638	65%	1638	51%
		PT	0	0%	0	0%	916	36%	901	35%	1570	49%
		Total	1707	100%	1585	100%	2554	100%	2539	100%	3208	100%
		DoS	88%		81%		90%		90%		90%	
Arthurs Point Crossing	Southbound	Car	761	94%	761	85%	945	100%	1170	94%	1096	100%
		PT	49	6%	130	15%	0	0%	78	6%	0	0%
		Total	810	100%	890	100%	945	100%	1248	100%	1096	100%
		DoS	90%		90%		73%		90%		84%	
	Northbound	Car	384	100%	476	100%	421	100%	532	100%	456	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	384	100%	476	100%	421	100%	532	100%	456	100%
		DoS	54%		67%		32%		41%		35%	

AM - Number of Passengers - Summary

Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	0	0	0	0	0
SH6A (Suburb) Westbound	592	775	1082	1388	1466
SH6A (Marina) Eastbound	0	51	0	0	0
SH6A (Marina) Westbound	480	626	938	1236	1283
Shotover Bridge Eastbound	0	0	0	0	0
Shotover Bridge Westbound	323	709	514	957	772
Kawarau Falls Bridge Southbound	0	0	0	0	0
Kawarau Falls Bridge Northbound	0	0	916	901	1570
Arthurs Point Crossing Southbound	49	130	0	78	0
Arthurs Point Crossing Northbound	0	0	0	0	0

AM - Required PT Mode Share

Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	0%	0%	0%	0%	0%
SH6A (Suburb) Westbound	27%	32%	40%	46%	47%
SH6A (Marina) Eastbound	0%	3%	0%	0%	0%
SH6A (Marina) Westbound	24%	29%	38%	45%	46%
Shotover Bridge Eastbound	0%	0%	0%	0%	0%
Shotover Bridge Westbound	18%	32%	25%	39%	34%
Kawarau Falls Bridge Southbound	0%	0%	0%	0%	0%
Kawarau Falls Bridge Northbound	0%	0%	36%	35%	49%
Arthurs Point Crossing Southbound	6%	15%	0%	6%	0%
Arthurs Point Crossing Northbound	0%	0%	0%	0%	0%

The results in Table 16 show a number of key conclusions:

- By 2027, SH6A requires approaching a 30% PT mode share to operate satisfactory in the westbound direction. By 2053 this has increased to close to 50%, equivalent to carrying around 1500 passengers per hour
- By 2027, Shotover Bridge requires a 18% PT mode share in the westbound direction, rising to 34% by 2053
- On Kawarau Falls Bridge, at 2027 operation of the link is satisfactory with 11% PT model share, but this quickly increases to 40% PT mode share required in the northbound direction by 2039, rising to over 53% by 2053 (around 1700 passengers/hour)
- In terms of SH6A and Shotover Bridge, the PT mode share is less in the latest forecasts compared to the QTBC projections, albeit the same PT model share is required at 2053 in the latest forecasts, that was required in the QTBC at 2048 – so a delay of 5 years of the same PT requirement. For Kawarau Falls Bridge, the latest requirement of 40% mode share at 2039, was previously not required until 2048, moving forward the requirement to obtain a high mode share by more than 10 years

Table 17 sets out similar results for the interpeak hour period for the summary tables showing critical PT patronage to achieve 90% v/c road operation on the link, and associated PT mode share at that critical level.

Table 17: Link Capacity and critical PT patronage in the Interpeak hour period

	IP - Number of Passengers - Summary				
Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	0	452	167	930	447
SH6A (Suburb) Westbound	76	640	438	1031	728
SH6A (Marina) Eastbound	98	739	450	1105	711
SH6A (Marina) Westbound	104	662	459	1003	729
Shotover Bridge Eastbound	0	0	0	325	101
Shotover Bridge Westbound	0	0	0	385	161
Kawarau Falls Bridge Southbound	0	0	0	0	0
Kawarau Falls Bridge Northbound	0	0	0	0	191
Arthurs Point Crossing Southbound	0	0	0	0	0
Arthurs Point Crossing Northbound	0	11	0	0	0

	IP - Required PT Mode Share				
Location - Direction	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	0%	19%	8%	33%	19%
SH6A (Suburb) Westbound	4%	28%	21%	39%	31%
SH6A (Marina) Eastbound	6%	33%	23%	42%	32%
SH6A (Marina) Westbound	6%	30%	23%	40%	32%
Shotover Bridge Eastbound	0%	0%	0%	17%	6%
Shotover Bridge Westbound	0%	0%	0%	20%	10%
Kawarau Falls Bridge Southbound	0%	0%	0%	0%	0%
Kawarau Falls Bridge Northbound	0%	0%	0%	0%	10%
Arthurs Point Crossing Southbound	0%	0%	0%	0%	0%
Arthurs Point Crossing Northbound	0%	2%	0%	0%	0%

The results for the interpeak period show less PT patronage is required (compared to the morning peak hour period) to maintain operation of the road network. However, the required PT mode share is still significant on SH6A, at above 20% in both directions at 2039, and over 30% in both directions at 2053 – the latter is equivalent to over 700 passengers in each direction. It should be noted that this critical level of PT patronage is significantly less than in the 2048 QTBC projections, where an extra 500 passengers in each direction was required, demonstrating the reduction in growth predicted in the interpeak period in the latest forecasts.

Table 18 sets out the results for the afternoon peak hour period, with two smaller summary tables showing critical PT patronage to achieve 90% v/c road operation on the link, and associated PT mode share at that critical level.

Table 18: Link Capacity and critical PT patronage in the PM peak hour period

Location	Direction	Passengers	PM - Number of Passengers									
			2027 Future		2028 QTBC		2039 Future		2048 QTBC		2053 Future	
SH6A (Suburb)	Eastbound	Car	1872	79%	1872	68%	1872	66%	1872	53%	1872	56%
		PT	485	21%	884	32%	985	34%	1683	47%	1476	44%
		Total	2357	100%	2756	100%	2857	100%	3555	100%	3348	100%
		DoS	90%		90%		90%		90%		90%	
	Westbound	Car	1638	98%	1638	91%	1638	91%	1638	81%	1638	83%
		PT	36	2%	166	9%	170	9%	379	19%	329	17%
		Total	1674	100%	1804	100%	1808	100%	2017	100%	1967	100%
		DoS	90%		90%		90%		90%		90%	
SH6A (Marina)	Eastbound	Car	1521	72%	1521	61%	1521	60%	1521	48%	1521	52%
		PT	594	28%	980	39%	1028	40%	1642	52%	1384	48%
		Total	2115	100%	2501	100%	2549	100%	3163	100%	2905	100%
		DoS	90%		90%		90%		90%		90%	
	Westbound	Car	1521	81%	1521	80%	1521	77%	1521	77%	1521	74%
		PT	353	19%	392	20%	466	23%	453	23%	546	26%
		Total	1874	100%	1913	100%	1987	100%	1974	100%	2067	100%
		DoS	90%		90%		90%		90%		90%	
Shotover Bridge	Eastbound	Car	1638	82%	1638	69%	1638	71%	1638	58%	1638	65%
		PT	369	18%	748	31%	657	29%	1173	42%	869	35%
		Total	2007	100%	2386	100%	2295	100%	2811	100%	2507	100%
		DoS	90%		90%		90%		90%		90%	
	Westbound	Car	1276	100%	1521	95%	1485	100%	1521	71%	1521	90%
		PT	0	0%	75	5%	0	0%	610	29%	162	10%
		Total	1276	100%	1596	100%	1485	100%	2131	100%	1683	100%
		DoS	75%		90%		88%		90%		90%	
Kawarau Falls Bridge	Southbound	Car	1644	100%	1647	100%	1755	72%	1755	64%	1755	58%
		PT	0	0%	0	0%	675	28%	977	36%	1255	42%
		Total	1644	100%	1647	100%	2430	100%	2732	100%	3010	100%
		DoS	84%		84%		90%		90%		90%	
	Northbound	Car	952	100%	937	100%	1267	100%	1310	100%	1381	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	952	100%	937	100%	1267	100%	1310	100%	1381	100%
		DoS	49%		48%		70%		72%		76%	
Arthurs Point Crossing	Southbound	Car	490	100%	544	100%	551	100%	673	100%	614	100%
		PT	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	490	100%	544	100%	551	100%	673	100%	614	100%
		DoS	58%		64%		42%		52%		47%	
	Northbound	Car	644	82%	644	75%	866	100%	1151	100%	934	100%
		PT	138	18%	216	25%	0	0%	0	0%	0	0%
		Total	782	100%	859	100%	866	100%	1151	100%	934	100%
		DoS	90%		90%		67%		89%		72%	

Location - Direction	PM - Number of Passengers - Summary				
	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	485	884	985	1683	1476
SH6A (Suburb) Westbound	36	166	170	379	329
SH6A (Marina) Eastbound	594	980	1028	1642	1384
SH6A (Marina) Westbound	353	392	466	453	546
Shotover Bridge Eastbound	369	748	657	1173	869
Shotover Bridge Westbound	0	75	0	610	162
Kawarau Falls Bridge Southbound	0	0	675	977	1255
Kawarau Falls Bridge Northbound	0	0	0	0	0
Arthurs Point Crossing Southbound	0	0	0	0	0
Arthurs Point Crossing Northbound	138	216	0	0	0

Location - Direction	PM - Required PT Mode Share				
	2027 Future	2028 QTBC	2039 Future	2048 QTBC	2053 Future
SH6A (Suburb) Eastbound	21%	32%	34%	47%	44%
SH6A (Suburb) Westbound	2%	9%	9%	19%	17%
SH6A (Marina) Eastbound	28%	39%	40%	52%	48%
SH6A (Marina) Westbound	19%	20%	23%	23%	26%
Shotover Bridge Eastbound	18%	31%	29%	42%	35%
Shotover Bridge Westbound	0%	5%	0%	29%	10%
Kawarau Falls Bridge Southbound	0%	0%	28%	36%	42%
Kawarau Falls Bridge Northbound	0%	0%	0%	0%	0%
Arthurs Point Crossing Southbound	0%	0%	0%	0%	0%
Arthurs Point Crossing Northbound	18%	25%	0%	0%	0%

Table 18 shows a number of key conclusions:

- By 2027, SH6A requires a 28% PT mode share to operate satisfactory in the eastbound direction, increasing to 40% by 2039. By 2053 this has increased to close to 50%, equivalent to carrying around 1,400 passengers per hour
- By 2027, Shotover Bridge requires a 20% PT mode share in the westbound direction, rising to 35% by 2053
- On Kawarau Falls Bridge, operation of the link at 2027 is satisfactory with less than 10% PT model share, but this quickly increases to 37% PT mode share required in the southbound direction by 2039. This rises further to 49% by 2053 (around 1500 passengers/hour), similar to the opposite direction in the morning peak hour period
- In terms of SH6A and Shotover Bridge, the PT mode share is less in the latest forecasts compared to the QTBC projections that was required in the QTBC at 2028. For Kawarau Falls Bridge, the latest requirement of 49% mode share at 2053, is generally in line with the 44% requirement in the 2048 QTBC analysis

Previously, the QTBC had headline targets of 40% PT mode share on SH6A by 2028, and 60% by 2048 – with associated targets on Shotover Bridge of 25% and 40% respectively. The latest forecasts suggest that the speed of mode shift does not need to be quite as quick as previous – however, the increased rate of residential growth on the Southern Corridor leads to significant PT being required on this part of the network, similar to those predicted on SH6A by 2053.

Headline new target mode share and patronage numbers (one-way passengers per hour) in the critical direction are set out below in Table 19.

Table 19: Critical PT mode share targets

		AM peak hour		PM peak hour	
		PT share	PT Pass/hour	PT share	PT Pass/hour
2027	SH6A	27%	592	28%	594
	Shotover Bridge	18%	323	18%	369
	Kawarau Falls	0%	0	0%	0
2039	SH6A	40%	1082	40%	1028
	Shotover Bridge	25%	514	29%	657
	Kawarau Falls	36%	916	28%	675
2053	SH6A	47%	1466	48%	1384
	Shotover Bridge	34%	772	35%	869
	Kawarau Falls	49%	1570	42%	1255

5.3 Forecast Matrices

Demand matrices (in person-trips) for the 2018, 2024, 2027, 2039 and 2053 have been compiled into the 21x21 matrices that form input into the simplified PT model. These matrices are presented in Appendices A to E respectively for information. The matrix totals will not match those set out in Table 1 as they include a number of conversions from the original strategic model demand sets:

- Vehicle-trips in strategic model matrix converted to person-trips, by multiplying by 1.3 occupancy factor
- Base observed (2018) public transport patronage added
- Intrazonal trips are set to zero – the PT model assumes zero PT trips internal to each zone. In reality there may be a small number of internal PT trips, but these will be negligible (and in future more likely to be undertaken by active modes than PT)

6 Future Year Scenarios – Forecast PT Demand

The next phase of PT modelling was to test PT options at each of the future years to determine the optimal service, and the associated PT capture. The option testing incorporated testing of some of the following variations, which can all be tested within the PT model:

- Fare changes
- Service frequency changes
- Service route changes
- Car parking supply constraints and fee changes (albeit a simplified model)
- Park and Ride location and services
- Off-road corridors (e.g. gondola, ferry)

The PT model does not currently include the ability to model the following:

- PT crowding – standing v seating generalised cost is not included in the model, although factors within the model can be applied to make PT congested routes less desirable (in effect, via input to the model, rather than an inbuilt function)
- Vehicle capacity – as above, this is not included within the model, but factors can be applied in the model to represent:
    - Different vehicle types by using a different mode penalty coefficient (e.g. LRT has lower mode penalty than conventional bus)
    - Additional PT crowding (as above) where lower capacity vehicles result in a higher generalised cost to a passenger – effectively an iteration within the model until the patronage converges to the vehicle/route capacity

6.1 Long List Testing

For purposes of brevity, the long-list results are not set out in detail here, as most long-list options were taken forward (at least in some respect) to the short-list testing.

However, the key outcomes of the long-list testing (in terms of PT forecasting) are:

- Cromwell Park and Ride service was rejected due to low patronage
- A direct Jacks Point to Ladies Mile/Lake Hayes Estate service (via the southern side of Frankton Flats was rejected due to ow patronage.

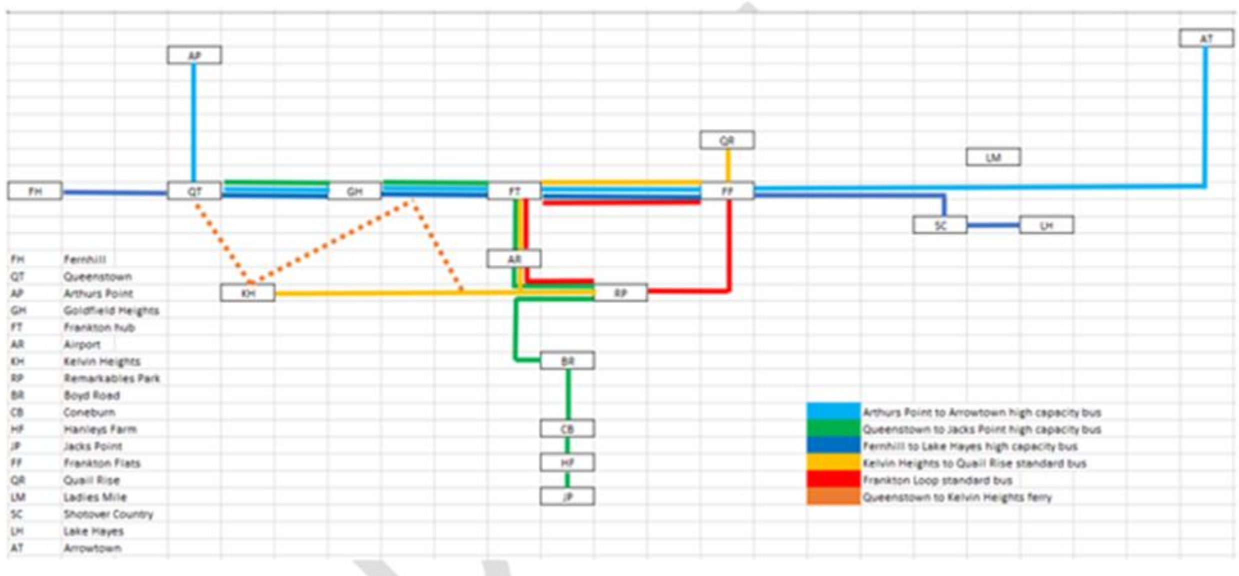
The majority of other options were taken through to the short-list testing process.

6.2 Short List Testing

A total of 13 options were investigated at the short-list stage, although most were relatively small variations on 4 main options as below:

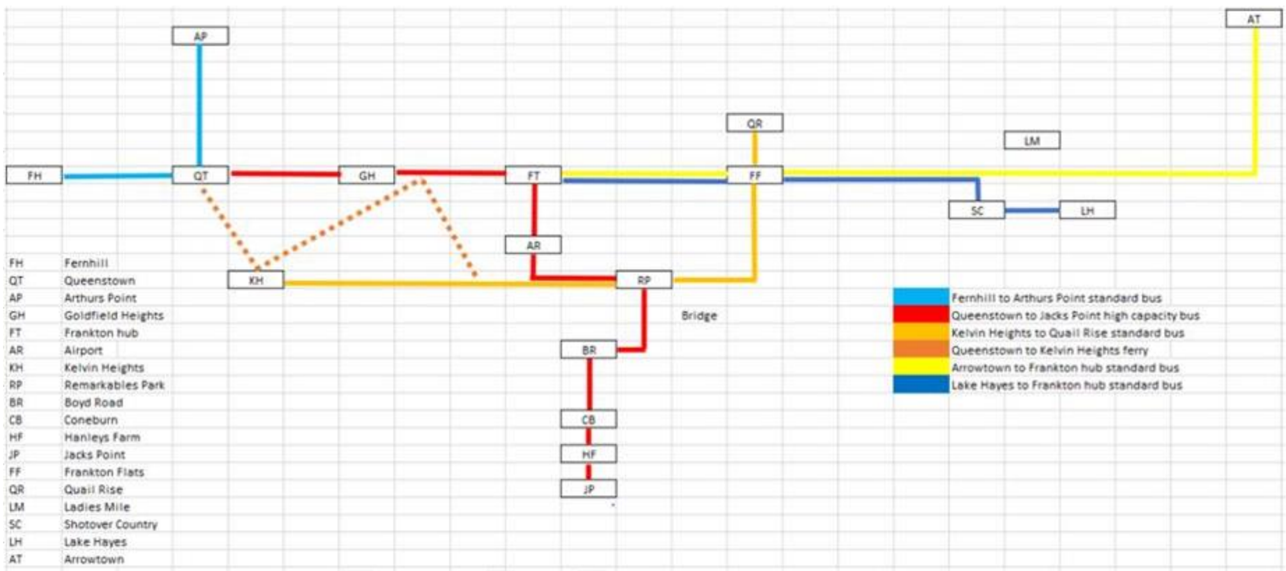
- Do Minimum (small changes to existing service)
- "Bus Max" – from the previous Queenstown Transport Business Case, providing a direct service to/from Frankton from both the south and east corridors

Figure 16: Bus Max PT system



- "Bus Max + JP/RP split" – As bus max but with split services to/from Queenstown to both Jacks Point and Remarkables Point (rather than a combined service)
- "JP Spine" – based on a main Spine from Queenstown to Jacks Point (Southern Corridor) with a new bridge over the Kawarau River, with services to/from the east connecting at Frankton hub

Figure 17: JP Spine PT system



Other variations were then added to these core options:

- Ferry from Homestead Bay to Steamer Wharf
- With new PT bridge over the Kawarau River
- With the Arrowtown service re-routed via Malaghans Road
- With northbound bus lane added from Park Ridge to Kawarau Falls bridge

This in combination resulted in the following combinations shown in **Table 20**.

Table 20: Short-list options tested in the PT model

Core Option	Sub-Options				Comment
	Jacks Point Ferry	Kawarau PT Bridge	Malaghans Route	With NB bus lanes	
Do Minimum	No	No	No	No	**Reference Case for full comparison aganst options**
Bus Max	No	No	No	No	Core option for Bus Max
	Yes	No	No	No	Impact of Jacks Point Ferry only
	No	Yes	No	No	Impact of Kawarau River PT bridge only
	No	No	Yes	Yes	Impact of Malaghans Route only
	Yes	Yes	Yes	Yes	All three above Variations
Bus Max with JP and RP routes split	No	No	No	No	As above with no PT bridge (as Remarkables Park Town Centre and Jacks Point routes split)
	No	No	No	Yes	
	Yes	No	No	Yes	
	No	No	Yes	Yes	
	Yes	No	Yes	Yes	
Southern Corrior Spine	No	Yes	No	No	Core option for JP Spine
	No	No	No	No	Without new PT bridge

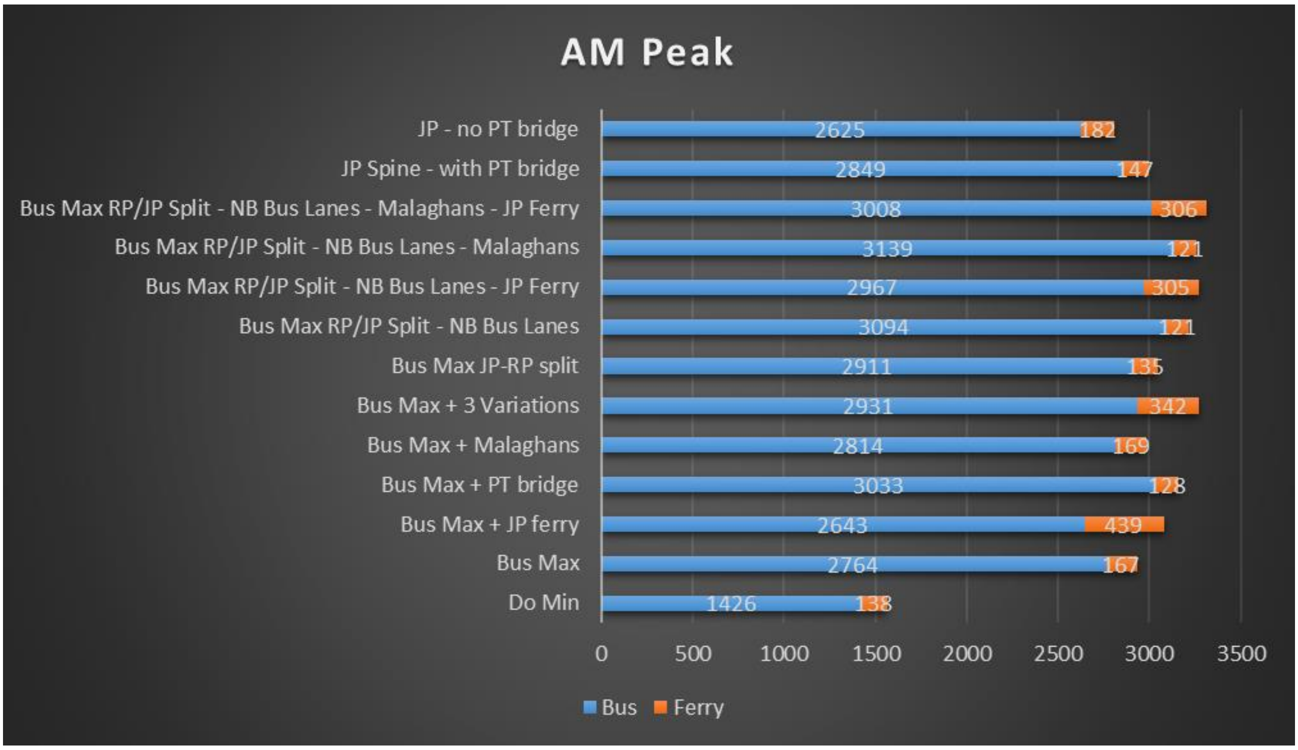
6.3 Short List Results

Appendix F contains the "5-point summary" results – the number of people per mode at 5 points in the network and the predicted degree of saturation of the road network at that point at 2053:

- SH6A, near Suburb Street
- SH6A, near Marina Drive
- SH6 Shotover Bridge
- SH6 Kawarau Falls Bridge
- Arthurs Point crossing (assuming the existing Edith Cavell bridge is replaced by a dual lane bridge by 2039)

Figure 18 below sets out the total PT passengers in the morning peak at 2053, within the 13 options tested.

Figure 18: Passenger forecasts in the AM peak at 2053

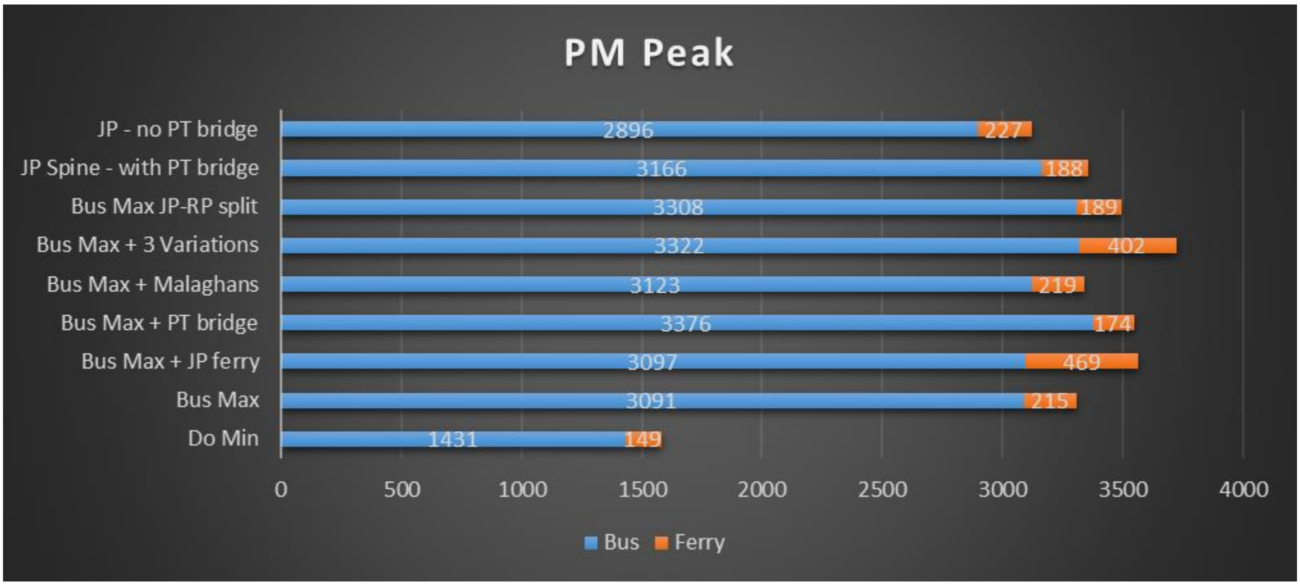


The results show that:

- The Do Minimum performs poorly against all options, which is expected given the low level of investment assumed in this option
- The Bus Max with the RP-JP split service achieves a higher level of patronage than the Bus Max and JP spine options
- The options with the new PT bridge offer little extra patronage over the other options. This is generally as the majority of bus passengers continue to travel to/from) Queenstown (rather than Frankton, where parking supply is less restrictive) – and therefore the extra routing via Remarkables Park Town Centre results in a longer journey than the route directly along SH6.
- The inclusion of the Jacks Point ferry provides the maximum level of PT patronage as a total, although much of the ferry patronage is captured from people who would otherwise use the bus service – and so there is little overall drop in non-car mode
- The addition of a northbound bus lane from the Southern corridor to Kawarau Falls bridge is generally as effective as both the PT bridge and JP ferry, and so likely presents a better value-for-money option to achieve increased PT share
- The routing of the Arrowtown service via Malaghans Road does marginally increase bus share on this route, albeit for additional operating cost. However, it does offer other benefits in moving that service off the key SH6A corridor, and therefore freeing up operating capacity to run additional SH6A services to more critical growth areas such the Southern Corridor

Figure 19 below sets out the total PT passengers in the PM peak at 2053, within 9 options tested (the northbound bus lanes from the south add little patronage in the PM peak so are omitted for brevity). The results show similar trends to the AM peak.

Figure 19: Passenger forecasts in the PM peak at 2053



Consequently, the PT modelling shows that the **Bus Max option, with a split Jacks Point/Remarkables Park Town Centre service, and Arrowtown service routed via Malaghans Road** as the likely optimum option in terms of passenger capture, without significant additional infrastructure investments such as a new ferry route and/or new river crossing).

6.4 Forecast versus Target PT share

As set out in Table 19, the target PT share required to retain at capacity (100% degree of saturation or better) is significant, particularly at 2053.

Table 21 sets out a comparison of the number of PT passengers required to be carried by PT (bus and water) at 2027, 2039 and 2053 to achieve at capacity road operation, versus the PT passengers forecast by the model of the preferred option – the latter is the full PT model calculation using the generalised cost for all origin-destination journeys, via all available modes, and proportioned using the multinomial logit model.

Table 21: AM Peak PT passengers and PT mode share (target v forecast)

	AM - Number of Passengers - Summary					
	2027 Future		2039 Future		2053 Future	
Location - Direction	2027 Target	2027 Predicted	2039 Target	2039 Predicted	2053 Target	2053 Predicted
SH6A (Suburb) Eastbound	0	123	0	139	0	159
SH6A (Suburb) Westbound	592	460	1082	844	1466	1281
SH6A (Marina) Eastbound	0	114	0	127	0	135
SH6A (Marina) Westbound	480	351	938	688	1283	1056
Shotover Bridge Eastbound	0	36	0	56	0	93
Shotover Bridge Westbound	323	145	514	209	772	358
Kawarau Falls Bridge Southbound	0	28	0	41	0	33
Kawarau Falls Bridge Northbound	0	130	916	443	1570	825
Arthurs Point Crossing Southbound	49	115	0	196	0	296
Arthurs Point Crossing Northbound	0	32	0	43	0	53

	AM - Required PT Mode Share					
	2027 Future		2039 Future		2053 Future	
Location - Direction	2027 Target	2027 Predicted	2039 Target	2039 Predicted	2053 Target	2053 Predicted
SH6A (Suburb) Eastbound	0%	12%	0%	12%	0%	13%
SH6A (Suburb) Westbound	27%	21%	40%	31%	47%	41%
SH6A (Marina) Eastbound	0%	10%	0%	11%	0%	11%
SH6A (Marina) Westbound	24%	17%	38%	28%	46%	37%
Shotover Bridge Eastbound	0%	4%	0%	5%	0%	7%
Shotover Bridge Westbound	18%	8%	25%	10%	34%	16%
Kawarau Falls Bridge Southbound	0%	5%	0%	5%	0%	5%
Kawarau Falls Bridge Northbound	0%	8%	36%	17%	49%	26%
Arthurs Point Crossing Southbound	6%	14%	0%	21%	0%	27%
Arthurs Point Crossing Northbound	0%	8%	0%	10%	0%	12%

The results of the morning peak show that there are significant shortfalls in the predicted passengers in the model:

- Westbound on SH6A, there is a shortfall in passengers of around 200 passengers per hour, albeit the mode share is still predicted to be high at around 40% in this period
- Westbound on Shotover Bridge, there is a larger discrepancy between target and forecast, with the PT share being less than half of the required target in all three future years. This is associated with a few factors, such as little capture of trips by PT to Frankton Flats (linked to abundant parking provision, and lack of PT infrastructure to bypass queues assumed in the model)
- Northbound on the Southern corridor, capture is higher than on the eastern corridor, largely due to the assumption of a bus lane providing reliable travel times on PT for much of the corridor.
- For Arthurs Point, the forecast PT capture is relatively high, despite the target being effectively zero, as the assumed improved crossing (after 2027) would remove the impending network constraint at this location

Table 22 and Table 23 show similar results for the PM peak and Interpeak hours respectively, again at the future years of 2027, 2039 and 2053.

Table 22: PM Peak PT passengers and PT mode share (target v forecast)

Location - Direction	PM - Number of Passengers - Summary					
	2027 Future		2039 Future		2053 Future	
	2027 Target	2027 Predicted	2039 Target	2039 Predicted	2053 Target	2053 Predicted
SH6A (Suburb) Eastbound	485	434	985	799	1476	1191
SH6A (Suburb) Westbound	36	219	170	335	329	424
SH6A (Marina) Eastbound	594	300	1028	581	1384	860
SH6A (Marina) Westbound	353	197	466	298	546	354
Shotover Bridge Eastbound	369	119	657	250	869	396
Shotover Bridge Westbound	0	39	0	73	162	104
Kawarau Falls Bridge Southbound	0	94	675	265	1255	394
Kawarau Falls Bridge Northbound	0	31	0	81	0	95
Arthurs Point Crossing Southbound	0	41	0	81	0	112
Arthurs Point Crossing Northbound	138	91	0	179	0	252

Location - Direction	PM - Required PT Mode Share					
	2027 Future		2039 Future		2053 Future	
	2027 Target	2027 Predicted	2039 Target	2039 Predicted	2053 Target	2053 Predicted
SH6A (Suburb) Eastbound	21%	18%	34%	28%	44%	36%
SH6A (Suburb) Westbound	2%	13%	9%	19%	17%	22%
SH6A (Marina) Eastbound	28%	14%	40%	23%	48%	29%
SH6A (Marina) Westbound	19%	10%	23%	15%	26%	17%
Shotover Bridge Eastbound	18%	6%	29%	11%	35%	16%
Shotover Bridge Westbound	0%	3%	0%	5%	10%	6%
Kawarau Falls Bridge Southbound	0%	6%	28%	11%	42%	13%
Kawarau Falls Bridge Northbound	0%	3%	0%	6%	0%	7%
Arthurs Point Crossing Southbound	0%	8%	0%	15%	0%	18%
Arthurs Point Crossing Northbound	18%	12%	0%	21%	0%	27%

Table 23: Interpeak PT passengers and PT mode share (target v forecast)

Location - Direction	IP - Number of Passengers - Summary					
	2027 Future		2039 Future		2053 Future	
	2027 Target	2027 Predicted	2039 Target	2039 Predicted	2053 Target	2053 Predicted
SH6A (Suburb) Eastbound	0	154	167	334	447	407
SH6A (Suburb) Westbound	76	142	438	329	728	438
SH6A (Marina) Eastbound	98	113	450	262	711	306
SH6A (Marina) Westbound	104	110	459	273	729	365
Shotover Bridge Eastbound	0	25	0	63	101	78
Shotover Bridge Westbound	0	24	0	61	161	72
Kawarau Falls Bridge Southbound	0	22	0	86	0	92
Kawarau Falls Bridge Northbound	0	21	0	93	191	125
Arthurs Point Crossing Southbound	0	22	0	49	0	61
Arthurs Point Crossing Northbound	0	23	0	52	0	65

Location - Direction	IP - Required PT Mode Share					
	2027 Future		2039 Future		2053 Future	
	2027 Target	2027 Predicted	2039 Target	2039 Predicted	2053 Target	2053 Predicted
SH6A (Suburb) Eastbound	0%	9%	8%	16%	19%	18%
SH6A (Suburb) Westbound	4%	9%	21%	16%	31%	19%
SH6A (Marina) Eastbound	6%	7%	23%	14%	32%	14%
SH6A (Marina) Westbound	6%	7%	23%	14%	32%	16%
Shotover Bridge Eastbound	0%	2%	0%	4%	6%	4%
Shotover Bridge Westbound	0%	2%	0%	4%	10%	4%
Kawarau Falls Bridge Southbound	0%	2%	0%	7%	0%	6%
Kawarau Falls Bridge Northbound	0%	2%	0%	7%	10%	7%
Arthurs Point Crossing Southbound	0%	4%	0%	9%	0%	10%
Arthurs Point Crossing Northbound	0%	4%	0%	9%	0%	10%

The results similar trends to the morning peak period, however:

- In the afternoon peak, the southbound PT share on Kawarau Falls Bridge is significantly lower than both the associated reverse direction in the morning peak, and the required PT southbound target. In some respects this is due to the independence of the three periods in the model – there is no link between someone taking the bus in the morning and then returning by bus in the evening, when in reality there would be a connection between many return trips. Consequently, it is expected that the model is underpredicting PT share in the commuter peak direction (away from Queenstown and Frankton) in the afternoon period. Albeit it is also noted that there is generally less planned PT infrastructure in the outbound direction, which will also impact on the projected PT patronage.

- Even in the interpeak, the network is predicted to operate in an oversaturated state by 2039 on SH6A in both directions, demonstrating that there is a need to achieve a relatively high PT share throughout moist of the day.

In summary, the model predicts a high PT share (by traditional NZ levels) would be achieved by 2053 – on SH6A, this is predicted to be over 1,000 passengers per hour in the dominant direction, equivalent to around 20-25 single decker services per hour. But this would be not sufficient to result in the road network operating within capacity.

To achieve this would likely take additional measures, both demand supply and more holistic behavioural measures:

- The target PT passengers on both SH6A and the Southern Corridor are higher than 1,500 passengers per hour. These levels could be accommodated by PT – either using higher-capacity buses (albeit this system will also reach a maximum practical capacity shortly after 2053), or by the addition of a new system (e.g. cable-based system)
- To achieve this would also require "nudging" of behaviour away from the private car, with measures such as:
  - Parking supply and cost management, both in Queenstown and Frankton
  - Extension of road user or congestion charging regimes to increase the cost on private car travel when other transport modes are available
  - Land use changes that encourage mixed development, which removes longer distance commuter/leisure/educational trips (and/or increases the number of these trips carried out by active modes or PT
  - Technological-related changes such as an increased level of home-working

Disclaimer

This report ('**Report**') has been prepared by WSP exclusively for Otago Regional Council ('**Client**') in relation to setting out the overall trip demand in the Whakatipu Basin and the calibration and validation of the simplified PT model ('**Purpose**') and in accordance with the Consultant Agreement of 22 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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Appendix A – 2018 Demand Matrices

2018 AM Peak Hour

People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		151	82	147	73	53	36	45	7	33	6	44	104	49	22	13	103	83	10	45	6	1111
Fernhill	2	549		9	29	17	10	5	5	1	5	1	20	18	6	4	5	22	11	2	8	1	728
Cromwell	3	103	9		22	22	13	11	71	9	36	1	4	16	0	7	7	54	27	6	58	251	727
Frankton Rd	4	380	21	16		58	36	17	13	5	19	1	6	15	7	12	15	73	25	7	16	1	741
Frankton	5	134	9	13	40		51	23	11	5	23	0	2	5	9	16	20	76	25	8	17	1	486
Remarkables Park	6	80	6	8	25	46		22	8	3	17	0	1	4	6	15	20	61	23	5	12	0	363
Kelvin Heights	7	97	6	10	25	47	42		10	3	12	0	2	5	6	22	19	52	23	5	12	1	399
Arrowtown	8	131	7	67	22	32	20	12		14	44	2	2	32	0	8	13	79	18	8	199	3	714
Ladies Mile	9	23	1	7	6	10	6	3	9		15	0	0	4	1	2	4	25	3	3	16	0	137
LHE/Shotover Country	10	194	10	36	48	88	55	21	51	31		1	2	20	2	16	38	225	28	24	91	2	981
Skippers	11	6	1	1	1	0	0	0	2	0	0		0	2	0	0	0	0	1	0	1	0	16
Glenorchy	12	95	20	4	8	3	2	2	1	0	1	0		4	3	1	1	3	9	0	2	0	161
Arthurs Point	13	247	15	13	17	8	5	4	20	3	8	3	4		1	3	2	15	9	2	26	1	406
Kingston	14	87	10	0	11	14	9	8	1	1	4	0	6	3		7	4	14	4	2	3	0	187
Jacks Point	15	69	4	6	17	34	30	22	7	2	8	0	1	3	5		14	37	15	3	8	1	288
Frankton South East	16	8	1	1	3	5	8	2	1	1	3	0	0	0	1	2		8	2	1	2	0	50
Five Mile	17	76	7	26	29	36	35	18	19	7	41	0	1	6	9	10	6		20	10	27	1	384
Airport	18	78	8	25	16	12	14	12	11	1	7	1	10	8	3	6	1	19		2	13	56	302
Frankton North	19	41	2	6	11	19	12	5	7	4	16	0	0	3	1	3	8	46	6		13	0	204
Speargrass	20	120	7	40	17	27	18	9	105	14	41	1	1	29	1	6	10	70	17	7		2	542
Wanaka	21	10	1	156	3	3	1	1	7	1	3	0	0	1	0	1	1	6	52	1	6		255
TOTAL		2527	294	527	494	554	423	232	403	115	337	19	106	284	111	160	201	990	401	105	574	326	9183

2018 Interpeak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	**Zone#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Town Centre	**1**		325	106	285	125	114	72	72	14	94	3	61	155	42	40	8	188	114	22	109	5	1954
Fernhill	**2**	386		13	25	13	12	6	5	1	6	0	16	13	8	3	1	19	12	2	9	0	552
Cromwell	**3**	73	8		18	17	16	9	49	7	36	0	3	10	0	4	2	51	31	6	56	200	594
Frankton Rd	**4**	319	30	23		48	41	21	14	4	25	0	6	15	8	12	3	69	26	7	22	1	696
Frankton	**5**	129	11	21	44		53	31	15	6	37	0	2	5	10	18	5	80	22	9	24	1	521
Remarkables Park	**6**	113	10	17	39	52		40	15	5	35	0	2	5	6	24	10	88	26	8	23	4	520
Kelvin Heights	**7**	76	6	11	23	32	41		8	3	14	0	2	3	8	18	4	47	20	4	13	1	334
Arrowtown	**8**	74	5	48	14	16	16	8		7	28	0	1	15	0	4	2	52	15	4	135	3	450
Ladies Mile	**9**	14	1	8	4	6	6	3	7		12	0	0	2	0	1	1	19	3	2	13	0	103
LHE/Shotover Country	**10**	100	6	38	26	40	37	14	27	13		0	1	9	3	7	6	127	17	10	51	1	534
Skippers	**11**	3	0	0	0	0	0	0	0	0	0		0	1	0	0	0	0	1	0	1	0	8
Glenorchy	**12**	72	18	5	6	2	2	1	1	0	1	0		3	4	1	0	4	11	0	2	0	134
Arthurs Point	**13**	163	13	12	14	5	5	3	14	2	9	1	3		1	2	0	13	10	1	26	0	298
Kingston	**14**	64	12	0	13	13	8	9	1	1	7	0	6	3		7	3	9	3	2	4	0	166
Jacks Point	**15**	42	3	4	12	18	24	18	4	1	7	0	1	2	7		3	27	11	2	7	0	194
Frankton South East	**16**	8	1	3	4	6	10	4	2	1	6	0	0	0	3	3		10	2	1	3	0	66
Five Mile	**17**	174	17	52	69	81	88	46	46	18	113	0	3	12	6	27	10		30	25	69	12	899
Airport	**18**	108	11	30	26	20	23	19	14	2	14	1	11	9	2	10	2	29		3	17	68	417
Frankton North	**19**	21	2	7	6	9	8	4	4	2	10	0	0	1	1	2	1	27	3		8	0	117
Speargrass	**20**	108	9	59	20	23	23	13	134	13	51	1	2	26	1	6	3	74	17	7		4	593
Wanaka	**21**	5	0	178	1	2	5	1	3	0	2	0	0	0	0	0	0	13	68	0	4		284
TOTAL		2055	488	636	647	528	531	322	437	103	506	8	121	293	110	188	63	947	440	116	594	302	**9434**

2018 PM Peak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		637	135	477	154	111	95	123	24	214	0	66	249	51	66	6	116	61	45	129	6	2766
Fernhill	2	324		16	32	11	14	6	7	1	12	0	21	16	9	4	0	19	6	3	8	0	509
Cromwell	3	81	11		22	18	31	7	70	11	57	0	4	14	0	3	1	89	16	8	63	192	700
Frankton Rd	4	258	31	27		63	48	33	19	7	58	0	3	15	9	20	2	67	17	14	20	1	713
Frankton	5	99	13	32	76		74	57	27	10	85	0	1	6	12	34	4	71	17	19	27	2	667
Remarkables Park	6	167	18	20	88	79		83	19	8	61	0	1	7	8	48	7	65	20	15	21	2	738
Kelvin Heights	7	46	5	10	29	41	49		9	3	26	0	1	2	9	29	2	38	14	6	10	1	331
Arrowtown	8	57	6	69	14	13	15	7		11	54	0	1	23	0	4	1	42	6	7	186	4	520
Ladies Mile	9	9	1	12	5	6	6	3	13		31	0	0	3	0	2	0	14	1	4	17	1	131
LHE/Shotover Country	10	67	6	52	30	38	37	18	45	18		0	1	11	3	10	2	108	10	18	61	2	536
Skippers	11	8	1	0	1	0	0	0	1	0	0		0	4	0	0	0	0	0	0	1	0	16
Glenorchy	12	67	40	7	5	2	4	1	1	0	2	0		3	4	1	0	5	5	0	1	0	146
Arthurs Point	13	172	22	15	18	5	6	3	26	4	22	0	2		1	2	0	12	4	3	34	1	354
Kingston	14	100	18	0	19	20	13	14	1	2	7	0	9	4		12	2	16	4	3	4	0	247
Jacks Point	15	27	3	4	15	21	26	27	5	2	15	0	0	1	9		1	20	6	4	5	0	191
Frankton South East	16	4	1	5	5	8	10	7	4	1	13	0	0	0	3	5		4	1	3	3	0	78
Five Mile	17	315	35	76	170	108	87	81	72	30	236	0	2	21	8	49	7		21	52	76	6	1455
Airport	18	89	11	29	31	31	31	28	15	4	31	0	7	6	3	16	2	24		7	19	53	435
Frankton North	19	15	2	10	9	11	10	6	8	3	26	0	0	2	1	4	1	24	2		10	1	146
Speargrass	20	59	7	77	18	20	20	11	259	20	103	0	1	31	1	7	1	52	11	14		5	718
Wanaka	21	2	0	278	0	4	32	0	2	0	1	0	0	0	0	0	0	80	35	0	2		438
TOTAL		1965	869	877	1065	654	622	487	726	160	1056	2	120	418	131	317	41	868	257	226	697	277	11834

Appendix B – 2024 Demand Matrices

2024 AM Peak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		190	79	180	80	81	41	57	10	39	1	50	141	60	38	20	127	96	14	57	2	1360
Fernhill	2	654		7	25	13	11	4	5	1	4	0	21	19	7	4	4	19	10	2	7	0	817
Cromwell	3	108	8		19	19	17	9	77	13	37	0	4	16	0	6	9	56	25	7	65	283	777
Frankton Rd	4	494	24	14		59	49	17	13	6	21	0	5	18	8	17	18	82	25	9	18	0	898
Frankton	5	162	9	11	41		60	22	11	6	25	0	2	6	9	24	24	78	23	8	17	0	537
Remarkables Park	6	125	7	10	33	50		28	10	6	24	0	1	5	10	31	34	84	27	8	17	0	509
Kelvin Heights	7	120	6	8	27	44	55		9	4	13	0	2	5	6	29	24	59	21	5	12	0	450
Arrowtown	8	164	8	69	21	26	24	10		19	45	1	2	34	0	8	14	77	15	9	213	4	761
Ladies Mile	9	46	2	10	10	14	13	4	16		25	0	0	7	1	4	8	43	5	5	31	0	245
LHE/Shotover Country	10	260	12	39	58	90	79	21	61	45		1	2	26	3	20	49	268	28	31	110	1	1204
Skippers	11	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	1
Glenorchy	12	114	21	4	6	2	2	1	2	0	1	0		4	4	1	1	3	9	0	2	0	178
Arthurs Point	13	329	17	12	18	7	6	4	19	4	9	1	4		2	3	2	16	7	2	28	0	490
Kingston	14	103	10	0	12	14	14	8	1	2	5	0	6	3		10	7	18	4	2	4	0	225
Jacks Point	15	252	12	8	55	98	117	57	13	9	25	0	2	8	9		59	125	36	12	22	0	917
Frankton South East	16	17	1	3	5	8	17	5	2	1	6	0	0	1	3	6		16	4	2	3	0	100
Five Mile	17	93	7	27	33	37	50	20	20	10	49	0	2	7	11	22	13		21	13	30	1	467
Airport	18	93	7	23	15	12	17	11	10	2	7	0	9	7	3	8	3	21		2	13	53	314
Frankton North	19	63	3	7	15	21	19	5	9	7	22	0	1	4	1	6	12	64	7		17	0	283
Speargrass	20	154	8	44	18	24	23	8	120	21	46	0	2	33	2	8	12	74	16	9		2	622
Wanaka	21	9	0	188	2	2	2	1	9	1	3	0	0	1	0	1	1	7	50	1	7		283
TOTAL		3358	352	563	592	621	657	274	463	168	406	4	116	343	139	243	315	1237	428	141	672	348	11439

2024 Interpeak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		369	99	331	128	137	80	82	24	116	1	66	187	49	102	23	214	123	31	131	6	2296
Fernhill	2	430		10	24	11	12	6	5	2	7	0	17	14	8	6	2	18	11	2	10	0	594
Cromwell	3	68	5		15	14	18	7	52	10	33	0	2	9	0	4	4	52	28	6	61	248	635
Frankton Rd	4	364	29	20		48	48	23	14	7	29	0	6	17	9	25	8	78	25	9	23	1	782
Frankton	5	133	9	17	43		59	29	13	7	36	0	2	5	9	35	12	83	20	10	23	2	547
Remarkables Park	6	137	10	18	46	57		47	16	9	42	0	2	5	8	58	26	115	29	11	27	5	670
Kelvin Heights	7	84	6	9	24	31	49		7	4	15	0	1	3	7	34	10	52	18	5	14	1	372
Arrowtown	8	86	5	50	14	14	17	8		11	31	0	1	17	0	5	4	53	14	5	154	4	494
Ladies Mile	9	24	2	11	6	8	10	4	11		19	0	0	4	1	4	2	30	3	3	22	1	163
LHE/Shotover Country	10	122	7	37	30	40	46	15	30	19		0	1	11	4	12	12	146	16	13	60	2	621
Skippers	11	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	2
Glenorchy	12	78	18	4	5	2	3	1	1	0	1	0		3	4	1	0	4	12	0	2	0	140
Arthurs Point	13	196	14	12	15	5	6	3	15	4	11	0	3		2	3	1	15	8	2	29	1	344
Kingston	14	71	12	0	13	12	10	8	2	2	10	0	6	5		12	5	13	2	3	5	0	193
Jacks Point	15	105	6	5	26	36	63	34	6	4	12	0	1	3	12		14	64	18	5	12	0	424
Frankton South East	16	22	2	5	9	12	26	10	4	2	12	0	0	1	4	14		26	5	3	6	0	164
Five Mile	17	200	16	54	79	84	115	51	47	28	131	0	3	14	8	62	26		31	34	77	13	1074
Airport	18	119	10	27	23	18	26	16	13	3	12	0	11	8	2	15	5	31		3	17	66	426
Frankton North	19	30	2	7	8	10	12	5	5	3	13	0	0	2	1	5	3	36	4		10	0	158
Speargrass	20	131	9	64	21	22	27	13	153	22	60	0	2	29	2	11	6	81	17	10		5	687
Wanaka	21	9	1	219	2	2	6	1	5	1	2	0	0	1	0	0	0	15	67	0	7		339
TOTAL		2408	531	667	735	554	690	360	483	162	593	2	125	338	131	409	162	1124	449	157	689	354	11124

2024 PM Peak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		771	137	581	183	147	113	146	47	277	0	87	321	52	259	19	126	63	73	153	7	3564
Fernhill	2	384		14	32	11	13	6	8	2	14	0	23	20	8	13	1	16	6	4	9	0	586
Cromwell	3	66	8		17	15	31	5	75	15	55	0	3	13	0	5	3	86	15	9	66	243	730
Frankton Rd	4	301	28	26		64	56	35	18	11	66	0	3	17	9	61	8	75	16	18	21	1	834
Frankton	5	113	13	26	76		75	54	23	14	91	0	2	5	10	90	11	73	15	21	24	2	740
Remarkables Park	6	200	20	25	102	92		91	24	16	90	0	2	7	11	133	28	88	23	23	27	3	1006
Kelvin Heights	7	52	4	8	29	38	55		7	5	26	0	1	2	9	77	8	41	13	8	10	1	394
Arrowtown	8	58	6	72	13	12	16	6		19	61	1	1	21	0	9	3	40	6	8	212	9	571
Ladies Mile	9	15	1	17	8	8	9	5	19		46	0	0	5	1	8	2	23	2	7	28	1	203
LHE/Shotover Country	10	81	6	54	34	39	46	18	49	30		0	1	13	2	25	9	126	9	25	71	3	642
Skippers	11	0	0	0	0	0	0	0	1	0	1		0	1	0	0	0	0	0	0	1	0	4
Glenorchy	12	52	30	6	5	2	4	1	1	0	2	0		3	4	2	0	5	5	0	1	0	123
Arthurs Point	13	209	24	16	21	6	6	3	29	8	28	1	3		1	7	1	13	3	4	40	1	426
Kingston	14	103	17	0	19	17	17	13	1	2	8	0	9	5		19	4	18	4	4	4	0	265
Jacks Point	15	75	6	5	30	39	63	50	6	5	22	0	1	3	16		9	54	11	7	10	0	413
Frankton South East	16	19	2	9	14	17	32	17	8	4	31	0	0	1	4	33		19	4	7	7	1	227
Five Mile	17	332	33	79	181	121	115	79	74	52	276	1	4	21	9	125	23		23	74	88	10	1719
Airport	18	91	9	26	27	26	33	24	12	5	28	0	7	5	2	40	5	26		7	17	52	445
Frankton North	19	26	3	12	12	12	13	7	9	6	34	0	0	2	1	12	2	33	2		13	1	202
Speargrass	20	68	8	83	19	19	22	11	285	38	123	0	1	34	1	20	4	56	10	18		6	825
Wanaka	21	2	0	298	1	4	34	0	3	0	2	0	0	0	0	0	0	85	35	0	2		467
TOTAL		2247	989	913	1221	725	787	539	797	282	1282	4	148	499	141	937	140	1005	264	318	805	341	14384

Appendix C – 2027 Demand Matrices

2027 AM Peak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		199	73	197	69	71	36	61	10	31	1	56	156	75	38	17	107	103	12	57	2	1373
Fernhill	2	674		6	22	9	8	3	5	1	3	0	23	19	8	3	3	12	9	1	7	0	816
Cromwell	3	90	6		18	17	18	9	86	16	39	0	3	18	0	7	9	59	29	8	69	320	822
Frankton Rd	4	550	23	14		55	45	15	13	6	18	0	6	19	10	17	17	75	24	9	16	0	932
Frankton	5	154	7	11	41		65	22	11	7	24	0	2	5	10	26	27	80	24	9	17	0	541
Remarkables Park	6	121	6	11	33	53		31	12	7	26	0	2	5	13	38	44	99	32	9	19	0	562
Kelvin Heights	7	121	5	9	28	46	61		10	4	12	0	2	5	7	35	27	60	22	6	12	0	473
Arrowtown	8	181	8	77	19	24	25	9		22	45	1	2	37	1	8	14	78	16	9	215	6	795
Ladies Mile	9	52	2	13	10	16	17	4	21		34	0	0	9	1	4	10	56	6	7	39	0	302
LHE/Shotover Country	10	225	10	42	52	86	85	18	66	56		1	2	29	3	18	52	287	28	35	118	1	1214
Skippers	11	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	1
Glenorchy	12	123	23	3	6	2	2	1	2	0	1	0		5	5	1	1	3	11	0	2	0	190
Arthurs Point	13	358	17	14	20	6	5	3	21	4	9	1	4		2	3	3	15	8	2	28	1	523
Kingston	14	122	12	0	14	16	17	9	1	2	6	0	7	4		12	8	22	4	3	4	0	265
Jacks Point	15	299	13	10	68	118	152	72	15	10	27	0	2	9	11		77	150	42	14	25	0	1115
Frankton South East	16	19	1	4	6	10	24	6	3	2	7	0	0	1	4	9		23	6	2	4	0	133
Five Mile	17	83	5	30	31	40	60	21	23	13	53	0	1	8	14	26	18		24	17	33	1	503
Airport	18	104	8	27	16	13	21	12	12	2	7	0	11	8	3	10	5	23		2	13	66	363
Frankton North	19	65	3	8	16	24	25	6	11	9	27	0	1	6	2	6	15	81	8		21	0	332
Speargrass	20	165	8	46	16	22	24	7	123	23	47	0	2	35	2	7	12	76	17	10		2	644
Wanaka	21	8	0	213	1	2	2	1	10	1	3	0	0	1	0	1	1	7	62	1	7		322
TOTAL		3514	358	613	615	628	728	285	506	196	418	4	126	378	172	268	360	1312	475	157	706	402	12222

2027 Interpeak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	**Zone#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Town Centre	**1**		387	93	366	118	126	75	88	25	101	1	70	204	60	119	24	190	133	31	136	5	2352
Fernhill	**2**	449		9	23	9	10	5	6	1	6	0	19	15	10	6	2	14	12	2	10	0	606
Cromwell	**3**	58	4		15	14	20	7	57	13	36	0	1	10	0	5	5	56	32	7	66	287	692
Frankton Rd	**4**	398	29	19		47	47	23	14	7	27	0	6	18	11	30	9	76	26	9	22	1	821
Frankton	**5**	123	8	16	42		66	30	13	8	35	0	2	5	11	42	15	86	22	11	22	2	556
Remarkables Park	**6**	131	9	20	47	61		52	17	11	45	0	2	5	11	73	35	130	33	14	29	5	729
Kelvin Heights	**7**	81	5	8	25	32	54		7	4	13	0	1	3	9	43	12	52	19	5	12	1	386
Arrowtown	**8**	92	5	55	12	14	18	7		14	33	0	1	18	1	6	5	55	16	6	159	4	521
Ladies Mile	**9**	26	1	14	7	9	12	4	13		24	0	0	5	1	4	3	37	4	4	26	1	195
LHE/Shotover Country	**10**	105	6	40	27	39	50	14	31	24		0	1	13	4	13	14	158	17	15	64	2	636
Skippers	**11**	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	3
Glenorchy	**12**	83	20	4	5	2	2	1	1	0	1	0		3	5	1	0	3	14	0	2	0	148
Arthurs Point	**13**	214	14	13	16	5	5	3	17	5	13	0	3		2	3	1	16	9	2	30	1	372
Kingston	**14**	83	13	0	15	13	12	9	2	3	11	0	7	5		15	6	15	3	4	6	0	225
Jacks Point	**15**	124	7	5	31	43	80	44	6	4	12	0	1	3	16		19	72	22	5	12	0	508
Frankton South East	**16**	25	2	6	10	14	35	12	5	3	14	0	0	2	5	19		34	7	4	8	0	207
Five Mile	**17**	170	13	60	74	88	135	52	49	35	143	0	3	14	9	72	35		36	43	82	14	1126
Airport	**18**	131	11	31	26	19	31	17	15	4	13	0	13	9	2	19	7	33		4	17	84	487
Frankton North	**19**	30	2	9	9	11	15	5	6	5	15	0	0	3	2	5	4	45	5		12	0	180
Speargrass	**20**	135	9	70	19	22	29	13	158	26	64	0	2	31	2	13	8	87	18	11		6	722
Wanaka	**21**	9	0	254	2	2	6	1	7	1	3	0	0	1	0	1	1	17	84	1	8		398
TOTAL		2466	544	727	771	564	753	374	511	193	608	3	134	366	159	490	206	1176	511	178	725	412	**11870**

2027 PM Peak Hour																							
People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		792	133	641	168	133	108	158	54	237	0	87	344	61	308	21	108	67	74	164	6	3663
Fernhill	2	394		15	31	9	11	5	7	2	11	0	25	19	9	14	1	13	6	3	9	0	585
Cromwell	3	63	7		18	15	33	5	83	22	64	1	3	16	0	6	4	92	18	11	75	292	827
Frankton Rd	4	327	27	25		62	51	33	15	12	60	0	3	18	10	74	9	73	16	20	18	1	853
Frankton	5	97	10	24	72		82	56	21	16	87	0	1	4	12	110	15	78	17	25	22	2	750
Remarkables Park	6	177	16	27	102	99		97	24	20	98	0	2	6	14	177	44	104	27	30	28	3	1094
Kelvin Heights	7	46	3	7	28	38	57		6	5	22	0	0	2	11	98	10	38	14	8	8	0	401
Arrowtown	8	71	6	75	12	12	17	6		24	66	1	1	25	0	10	3	42	6	10	222	12	621
Ladies Mile	9	15	1	20	7	9	11	5	22		57	0	0	5	1	9	2	30	2	9	33	1	240
LHE/Shotover Country	10	66	5	56	29	38	49	17	49	41		0	1	14	3	26	11	135	9	30	73	3	653
Skippers	11	0	0	0	0	0	0	0	1	0	1		0	1	0	0	0	0	0	0	1	0	4
Glenorchy	12	64	40	7	5	1	3	1	1	0	1	0		3	5	2	0	4	6	0	1	0	145
Arthurs Point	13	238	25	18	24	5	6	3	30	10	32	1	2		1	7	1	14	4	6	42	1	470
Kingston	14	126	20	0	22	19	21	15	1	2	8	0	10	5		25	6	21	4	5	4	0	316
Jacks Point	15	80	5	4	33	45	76	62	6	5	21	0	1	3	21		13	58	14	8	10	0	466
Frankton South East	16	18	2	10	13	21	44	20	8	6	35	0	0	1	5	45		26	6	9	8	1	279
Five Mile	17	287	26	81	182	126	144	82	72	67	301	1	2	21	10	156	38		25	95	90	11	1819
Airport	18	101	9	29	27	28	39	26	12	6	26	0	9	6	3	49	8	28		8	18	66	496
Frankton North	19	25	3	13	12	14	16	7	10	9	39	0	0	3	1	14	3	42	3		14	1	228
Speargrass	20	69	7	86	16	19	24	10	288	47	133	0	1	34	1	21	5	60	11	22		7	861
Wanaka	21	2	0	330	0	4	35	0	3	1	2	0	0	0	0	0	0	86	44	0	2		509
TOTAL		2266	1004	961	1276	733	852	558	817	349	1301	5	148	528	167	1150	194	1052	298	374	841	406	15280

Appendix D – 2039 Demand Matrices

2039 AM Peak Hour																							
People Movements / Hour	**TO**	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	**Zone#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Town Centre	**1**		229	72	224	70	75	32	64	15	28	1	66	172	121	48	19	112	116	18	57	3	1541
Fernhill	**2**	717		5	22	8	7	2	4	1	2	0	22	18	11	3	2	11	9	1	5	0	851
Cromwell	**3**	84	5		16	19	22	8	96	28	39	0	2	21	0	10	11	68	34	11	72	471	1019
Frankton Rd	**4**	646	25	14		55	46	11	13	9	16	0	7	20	15	18	17	77	26	13	15	0	1043
Frankton	**5**	169	7	12	46		83	20	12	12	25	0	2	6	17	35	34	100	31	17	19	0	647
Remarkables Park	**6**	150	6	14	41	75		33	15	15	30	0	2	7	23	55	69	143	46	19	23	1	767
Kelvin Heights	**7**	128	5	9	29	55	75		10	7	11	0	2	5	10	46	34	71	26	9	12	1	545
Arrowtown	**8**	220	9	81	17	23	26	8		33	40	1	2	40	1	10	14	79	17	12	201	8	841
Ladies Mile	**9**	88	3	23	16	27	30	5	32		57	0	1	15	3	7	18	100	10	16	58	1	510
LHE/Shotover Country	**10**	211	8	43	47	85	90	12	66	99		1	1	34	5	16	55	303	29	48	118	1	1271
Skippers	**11**	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	2
Glenorchy	**12**	147	23	3	8	2	2	1	2	0	1	0		5	7	2	1	3	12	1	2	0	221
Arthurs Point	**13**	405	19	16	21	6	5	3	21	5	8	0	5		4	4	3	15	9	3	25	1	577
Kingston	**14**	179	15	0	20	24	29	12	2	6	9	0	10	6		21	14	39	7	7	7	0	407
Jacks Point	**15**	462	17	15	101	198	262	110	23	27	37	0	4	14	19		136	253	73	34	38	1	1821
Frankton South East	**16**	35	1	5	10	19	46	9	5	5	10	0	1	2	8	16		46	12	6	7	0	243
Five Mile	**17**	90	5	36	34	54	87	23	27	26	58	0	2	11	27	39	30		33	33	39	2	655
Airport	**18**	118	8	32	19	17	30	12	13	4	8	0	13	9	5	15	8	31		4	14	81	444
Frankton North	**19**	102	4	11	25	43	46	7	14	21	33	0	1	8	5	10	28	142	14		27	0	540
Speargrass	**20**	204	9	48	14	22	26	5	117	34	43	0	2	38	3	8	13	79	17	13		2	697
Wanaka	**21**	8	0	287	1	2	2	1	13	2	3	0	0	2	0	1	1	8	76	1	7		417
TOTAL		4161	400	727	712	804	990	312	550	349	457	4	143	431	285	362	508	1680	596	267	745	574	**15058**

People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
		2039 Interpeak Hour																					
FROM	**Zone#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Town Centre	**1**		425	107	427	137	152	79	96	44	100	1	82	227	94	197	37	215	152	53	147	5	2778
Fernhill	**2**	484		10	25	10	10	4	6	2	5	0	17	15	13	9	2	14	13	3	10	0	651
Cromwell	**3**	62	4		14	16	24	7	61	24	38	0	1	12	0	8	7	67	38	10	70	422	885
Frankton Rd	**4**	453	30	21		53	55	22	13	11	26	0	6	19	16	45	14	85	29	15	22	1	937
Frankton	**5**	144	8	19	47		86	35	13	15	36	0	2	5	17	70	23	108	29	19	23	2	702
Remarkables Park	**6**	159	9	25	54	81		61	18	21	48	0	2	6	19	120	58	178	46	26	33	5	970
Kelvin Heights	**7**	88	4	8	24	37	63		6	6	12	0	1	3	12	61	17	58	22	7	11	1	441
Arrowtown	**8**	100	5	59	11	15	20	7		21	31	0	1	18	1	9	6	58	17	8	152	5	547
Ladies Mile	**9**	44	2	26	11	16	23	6	21		42	0	0	7	2	10	7	70	8	10	40	1	346
LHE/Shotover Country	**10**	105	5	44	25	40	53	12	30	42		0	1	13	5	16	17	167	17	21	61	2	677
Skippers	**11**	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	3
Glenorchy	**12**	96	18	4	6	2	2	1	1	0	1	0		3	7	2	1	4	15	1	2	0	167
Arthurs Point	**13**	237	15	16	18	5	6	3	17	7	13	0	3		2	5	2	17	11	3	30	1	413
Kingston	**14**	123	17	1	22	20	22	13	3	7	15	0	10	7		30	11	26	4	9	8	0	345
Jacks Point	**15**	207	9	8	46	71	129	61	8	9	15	0	2	5	31		36	117	39	12	17	0	825
Frankton South East	**16**	39	2	9	14	23	59	17	6	7	17	0	1	2	9	37		58	12	9	11	1	333
Five Mile	**17**	192	12	74	80	113	182	59	52	66	152	0	3	16	16	117	59		48	76	90	15	1424
Airport	**18**	150	12	37	29	26	45	20	16	6	13	0	15	11	4	33	12	45		7	18	103	604
Frankton North	**19**	51	3	13	14	20	28	8	8	10	20	0	1	3	5	13	9	79	9		15	1	308
Speargrass	**20**	147	9	75	18	23	33	12	152	40	61	0	2	31	2	17	11	94	19	15		6	768
Wanaka	**21**	11	1	367	2	3	7	1	8	2	3	0	0	2	0	1	1	19	104	1	9		540
TOTAL		2892	589	923	887	710	1001	427	537	343	649	2	152	407	257	797	331	1478	632	305	771	573	**14664**

2039 PM Peak Hour

People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		874	177	743	176	146	123	172	85	221	0	104	379	83	520	32	93	74	111	187	5	4305
Fernhill	2	447		18	33	8	10	5	8	4	9	0	24	21	10	21	1	10	6	5	10	0	650
Cromwell	3	72	7		22	18	37	5	89	43	74	1	3	20	0	10	7	108	21	18	83	456	1095
Frankton Rd	4	383	27	26		66	53	31	12	17	50	0	4	19	17	108	12	69	17	29	16	1	957
Frankton	5	98	8	28	76		109	59	20	27	86	0	1	4	20	178	27	100	23	44	22	2	931
Remarkables Park	6	154	11	33	103	130		107	24	37	107	0	1	7	26	302	83	152	40	56	29	3	1407
Kelvin Heights	7	44	3	5	25	40	60		4	6	15	0	0	2	16	134	14	39	15	10	6	0	438
Arrowtown	8	81	8	82	12	12	18	5		38	64	1	1	27	0	13	5	44	7	13	223	16	672
Ladies Mile	9	23	2	40	11	16	22	7	34		101	0	0	7	2	20	6	56	4	21	49	2	421
LHE/Shotover Country	10	59	4	63	25	38	53	13	45	71		0	1	13	4	31	16	146	9	39	69	3	701
Skippers	11	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	3
Glenorchy	12	91	44	10	6	1	3	1	1	1	1	0		3	6	3	0	4	6	1	1	0	182
Arthurs Point	13	267	28	22	28	5	7	3	31	15	33	1	3		2	12	2	16	4	7	45	1	531
Kingston	14	199	26	0	33	31	38	21	1	5	10	0	15	7		50	12	35	7	10	5	0	506
Jacks Point	15	120	7	4	43	66	110	87	6	9	20	0	1	4	41		24	82	22	15	11	0	671
Frankton South East	16	22	2	14	16	32	78	25	9	13	42	0	0	2	10	82		49	10	20	10	1	436
Five Mile	17	239	17	101	186	163	214	87	73	121	328	1	1	21	18	261	74		34	176	94	13	2222
Airport	18	113	9	34	29	37	58	29	12	9	26	0	9	7	5	83	15	37		14	17	81	625
Frankton North	19	35	3	21	18	26	33	11	12	20	52	0	0	3	4	30	10	83	6		18	1	385
Speargrass	20	72	7	93	14	19	27	9	280	70	128	0	1	33	2	27	8	67	11	28		7	902
Wanaka	21	1	0	497	0	4	35	0	3	1	2	0	0	0	0	0	0	90	54	0	2		691
TOTAL		2520	1084	1268	1422	890	1111	629	838	592	1370	5	169	579	265	1885	350	1279	371	617	898	593	18733

Appendix E – 2053 Demand Matrices

2053 AM Peak Hour

People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	**Zone#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Town Centre	**1**		244	80	289	69	73	22	66	18	25	1	74	184	159	35	19	107	128	21	54	4	1670
Fernhill	**2**	737		5	36	7	6	1	4	1	2	0	21	16	13	1	1	8	9	1	4	0	874
Cromwell	**3**	138	8		16	21	25	6	98	40	40	0	5	25	0	9	12	77	40	15	71	515	1163
Frankton Rd	**4**	751	28	15		54	42	6	12	11	14	0	8	21	19	10	15	73	27	15	14	0	1136
Frankton	**5**	160	6	16	52		111	14	15	20	28	0	2	8	24	26	46	133	42	27	22	1	754
Remarkables Park	**6**	152	6	19	48	109		25	20	26	35	0	2	10	33	41	102	205	67	32	29	1	963
Kelvin Heights	**7**	114	4	9	30	65	85		10	11	10	0	1	6	12	39	42	82	31	12	12	1	577
Arrowtown	**8**	267	11	86	21	22	25	5		39	35	1	3	43	1	7	13	74	17	14	183	10	877
Ladies Mile	**9**	143	5	35	21	38	42	3	43		77	0	1	21	5	4	25	141	14	28	75	1	722
LHE/Shotover Country	**10**	247	9	46	42	85	87	4	65	135		1	2	37	6	5	53	304	28	57	116	1	1329
Skippers	**11**	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	2
Glenorchy	**12**	170	25	3	12	2	2	1	2	1	1	0		5	9	2	1	3	13	1	1	1	255
Arthurs Point	**13**	449	19	18	29	5	6	2	21	6	7	0	5		4	3	2	14	10	3	22	2	630
Kingston	**14**	219	16	0	28	37	46	16	2	8	9	0	11	6		38	22	54	11	11	7	0	542
Jacks Point	**15**	509	17	18	128	280	350	150	28	46	42	0	4	20	31		192	353	107	52	48	1	2375
Frankton South East	**16**	41	2	8	13	32	75	7	8	10	13	0	1	4	11	14		77	19	12	10	0	357
Five Mile	**17**	80	4	47	35	74	119	18	33	41	63	0	2	14	38	31	44		45	53	45	2	789
Airport	**18**	130	8	40	21	25	45	12	15	6	9	0	14	10	8	16	13	43		7	15	98	533
Frankton North	**19**	114	4	17	33	66	70	4	21	40	44	0	1	14	7	6	42	221	22		38	1	765
Speargrass	**20**	253	10	50	19	21	25	3	112	42	40	0	2	39	4	4	13	77	17	15		2	746
Wanaka	**21**	12	0	411	1	2	3	0	16	4	3	0	1	3	0	0	2	9	92	1	8		568
TOTAL		4686	425	925	875	1017	1236	300	591	505	496	5	159	486	384	293	659	2054	739	377	774	640	**17627**

2053 Interpeak Hour

People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	**Zone#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Town Centre	**1**		444	118	506	150	160	79	102	58	92	1	91	249	122	270	43	216	167	69	158	5	3100
Fernhill	**2**	505		10	28	9	9	4	6	3	4	0	17	15	15	11	2	12	13	3	9	0	676
Cromwell	**3**	53	3		13	16	24	6	63	35	43	0	2	14	0	10	8	70	44	14	69	565	1053
Frankton Rd	**4**	517	35	24		61	61	23	14	16	26	0	8	24	22	65	16	93	34	21	22	1	1085
Frankton	**5**	158	7	21	54		112	40	14	23	38	0	2	6	25	102	32	136	38	30	25	2	865
Remarkables Park	**6**	173	8	28	59	104		69	19	33	51	0	2	8	30	168	82	229	64	39	35	6	1205
Kelvin Heights	**7**	92	4	7	26	43	71		6	7	10	0	1	3	16	74	20	63	27	10	10	1	491
Arrowtown	**8**	105	5	61	11	15	22	6		28	30	0	1	18	1	10	7	61	18	10	145	6	563
Ladies Mile	**9**	58	3	40	15	24	35	8	27		59	0	1	10	3	16	12	107	11	19	53	2	503
LHE/Shotover Country	**10**	96	4	49	24	42	56	11	29	59		0	1	14	6	18	19	178	18	27	60	2	712
Skippers	**11**	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	3
Glenorchy	**12**	107	19	6	7	2	2	1	1	1	1	0		4	10	2	1	3	17	1	2	0	184
Arthurs Point	**13**	256	15	19	21	6	8	3	17	10	14	0	3		3	7	3	20	12	5	31	1	454
Kingston	**14**	168	20	1	29	29	33	17	3	10	16	0	13	8		50	17	36	6	14	8	0	479
Jacks Point	**15**	289	11	9	66	104	178	79	10	15	17	0	3	7	53		52	157	59	20	20	1	1149
Frankton South East	**16**	47	2	12	17	32	83	21	7	12	19	0	1	3	15	55		81	18	14	12	1	450
Five Mile	**17**	193	10	82	83	141	236	65	54	101	162	0	3	18	23	160	83		62	117	95	16	1704
Airport	**18**	168	12	44	34	36	63	24	17	9	13	0	16	12	6	50	18	58		11	18	125	735
Frankton North	**19**	66	3	20	19	30	43	10	10	20	27	0	1	5	8	21	15	120	13		20	1	450
Speargrass	**20**	155	8	75	18	25	37	11	145	54	60	0	2	31	3	21	13	101	20	20		7	803
Wanaka	**21**	11	0	488	2	3	8	1	9	2	3	0	0	2	0	1	1	21	125	1	10		689
TOTAL		3218	614	1114	1031	873	1241	476	553	498	684	3	167	448	358	1110	446	1762	768	445	804	741	**17353**

2053 PM Peak Hour

People Movements / Hour	TO	Town Centre	Fernhill	Cromwell	Frankton Rd	Frankton	Remarkables Park	Kelvin Heights	Arrowtown	Ladies Mile	LHE/Shotover Country	Skippers	Glenorchy	Arthurs Point	Kingston	Jacks Point	Frankton South East	Five Mile	Airport	Frankton North	Speargrass	Wanaka	TOTAL
FROM	Zone#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Town Centre	1		920	229	865	187	156	136	182	117	216	0	117	411	77	716	42	81	80	146	208	5	4894
Fernhill	2	472		24	34	7	8	5	8	5	8	0	24	20	6	25	2	8	6	5	10	0	679
Cromwell	3	74	7		26	22	41	3	93	69	84	1	3	24	0	13	9	118	25	28	89	640	1370
Frankton Rd	4	472	28	22		64	47	26	10	21	43	0	4	22	26	129	12	57	16	34	15	1	1049
Frankton	5	105	7	24	84		141	53	19	40	90	0	1	4	33	231	40	130	33	67	23	2	1127
Remarkables Park	6	130	8	25	97	167		97	24	53	110	0	1	6	45	405	129	205	62	83	31	3	1681
Kelvin Heights	7	37	2	2	17	32	51		2	4	6	0	0	1	22	153	13	32	14	7	3	0	398
Arrowtown	8	92	8	74	13	14	20	3		51	64	1	1	31	1	14	7	46	7	18	225	22	711
Ladies Mile	9	30	2	52	13	24	35	6	44		142	0	0	9	4	28	12	85	6	40	65	3	599
LHE/Shotover Country	10	56	3	60	22	41	58	7	43	100		0	0	13	6	25	19	155	9	52	68	3	741
Skippers	11	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	4
Glenorchy	12	115	52	15	7	1	3	1	1	1	1	0		4	4	3	0	4	7	1	1	0	219
Arthurs Point	13	300	28	23	33	6	8	3	31	21	35	1	3		3	14	2	17	5	10	47	1	590
Kingston	14	272	31	0	45	44	57	27	1	8	11	0	20	8		83	20	52	11	16	6	0	713
Jacks Point	15	142	7	2	38	64	114	100	4	9	12	0	1	4	66		26	84	23	15	9	0	720
Frankton South East	16	24	2	11	16	43	116	25	9	20	44	0	0	2	20	111		72	17	32	11	1	577
Five Mile	17	199	12	86	190	210	294	77	72	177	346	1	1	19	37	345	114		46	270	96	13	2604
Airport	18	125	9	38	30	50	88	30	12	13	26	0	10	7	9	112	26	51		20	17	98	771
Frankton North	19	46	3	24	22	40	51	10	15	36	67	0	0	5	10	38	18	130	9		24	1	548
Speargrass	20	75	6	81	13	21	31	6	269	92	126	0	1	33	3	28	10	70	11	37		7	922
Wanaka	21	1	0	578	0	5	36	0	3	1	2	0	0	0	0	0	0	92	65	1	2		787
TOTAL		2767	1135	1370	1565	1046	1354	616	845	838	1434	5	188	625	370	2474	502	1488	452	880	950	801	21704

Appendix F – Short List 5-Point Summary at 2053 (AM, IP, PM)

Location	Direction	Passengers	2053 AM																									
			Do Minimum		Bus Max														RP + JP Split; With Northbound Bus Lanes								JP Spine	
					Bus Max		+ JP Ferry		+ PT Bridge		+ Malaghans		+ all 3 Variations		RP+ JP split		Base		+ JP Ferry		+ Malaghans		+JP Ferry + Malaghans		With PT bridge		No PT bridge	
SH6A (Suburb)	Eastbound	Car	1156	91%	1109	87%	1107	84%	1108	87%	1113	87%	1110	86%	1112	87%	1112	87%	1110	85%	1113	87%	1111	86%	1120	88%	1121	88%
		Bus	113	9%	160	13%	160	12%	161	13%	148	12%	149	11%	157	12%	157	12%	156	12%	148	12%	148	11%	146	11%	145	11%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	8	1%	11	1%	49	4%	11	1%	11	1%	39	3%	11	1%	11	1%	37	3%	11	1%	37	3%	9	1%	9	1%
		Total	1277	100%	1280	100%	1315	100%	1280	100%	1272	100%	1298	100%	1280	100%	1280	100%	1304	100%	1272	100%	1296	100%	1275	100%	1275	100%
		DoS	56%		53%		53%		53%		54%		53%		53%		53%		53%		54%		53%		54%		54%	
	Westbound	Car	2550	82%	1932	61%	1771	55%	1865	59%	1947	63%	1782	57%	1870	59%	1823	58%	1750	55%	1824	59%	1750	56%	1922	61%	1983	63%
		Bus	444	14%	1098	35%	1030	32%	1202	38%	1025	33%	1035	33%	1190	38%	1254	40%	1170	37%	1189	38%	1102	35%	1110	35%	1018	33%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	115	4%	129	4%	405	13%	99	3%	132	4%	313	10%	104	3%	92	3%	277	9%	92	3%	276	9%	104	3%	129	4%
		Total	3109	100%	3159	100%	3206	100%	3165	100%	3103	100%	3129	100%	3164	100%	3169	100%	3197	100%	3104	100%	3128	100%	3136	100%	3130	100%
		DoS	140%		106%		97%		102%		107%		98%		103%		100%		96%		100%		96%		106%		109%	
SH6A (Marina)	Eastbound	Car	1128	92%	1080	88%	1078	85%	1079	88%	1084	89%	1081	87%	1084	88%	1084	88%	1082	87%	1084	89%	1082	87%	1091	89%	1091	89%
		Bus	90	7%	135	11%	135	11%	136	11%	124	10%	125	10%	132	11%	132	11%	131	11%	123	10%	123	10%	122	10%	121	10%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	8	1%	11	1%	49	4%	11	1%	11	1%	39	3%	11	1%	11	1%	37	3%	11	1%	37	3%	9	1%	9	1%
		Total	1226	100%	1226	100%	1262	100%	1226	100%	1219	100%	1244	100%	1226	100%	1226	100%	1250	100%	1219	100%	1242	100%	1221	100%	1221	100%
		DoS	67%		64%		64%		64%		64%		64%		64%		64%		64%		64%		64%		65%		65%	
	Westbound	Car	2335	82%	1909	66%	1745	60%	1833	63%	1923	68%	1748	61%	1839	63%	1783	61%	1710	58%	1784	63%	1710	60%	1885	66%	1954	68%
		Bus	383	14%	856	30%	781	27%	969	33%	784	28%	798	28%	957	33%	1030	35%	941	32%	964	34%	872	31%	886	31%	785	27%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	115	4%	129	4%	405	14%	99	3%	132	5%	313	11%	104	4%	92	3%	277	9%	92	3%	276	10%	104	4%	129	4%
		Total	2833	100%	2894	100%	2931	100%	2901	100%	2839	100%	2859	100%	2900	100%	2904	100%	2927	100%	2840	100%	2858	100%	2875	100%	2868	100%
		DoS	138%		113%		103%		108%		114%		103%		109%		105%		101%		106%		101%		112%		116%	
Shotover Bridge	Eastbound	Car	1268	96%	1236	93%	1238	93%	1227	92%	1237	94%	1231	93%	1227	92%	1220	92%	1222	92%	1224	93%	1226	93%	1235	93%	1243	94%
		Bus	57	4%	92	7%	89	7%	101	8%	84	6%	89	7%	99	8%	106	8%	103	8%	93	7%	91	7%	90	7%	82	6%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	1325	100%	1328	100%	1327	100%	1328	100%	1320	100%	1320	100%	1326	100%	1325	100%	1325	100%	1317	100%	1317	100%	1325	100%	1325	100%
		DoS	70%		68%		68%		67%		68%		68%		67%		67%		67%		67%		67%		68%		68%	
	Westbound	Car	2092	91%	1922	82%	1921	81%	1920	82%	1926	84%	1925	84%	1925	82%	1925	82%	1925	81%	1936	84%	1936	84%	1963	84%	1963	84%
		Bus	208	9%	429	18%	440	19%	436	18%	368	16%	370	16%	430	18%	435	18%	438	19%	358	16%	358	16%	376	16%	371	16%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	2300	100%	2350	100%	2361	100%	2356	100%	2294	100%	2294	100%	2355	100%	2359	100%	2363	100%	2294	100%	2294	100%	2338	100%	2335	100%
		DoS	124%		114%		114%		114%		114%		114%		114%		114%		114%		115%		115%		116%		116%	
Kawarau Falls Bridge	Southbound	Car	679	98%	667	97%	665	96%	663	96%	667	97%	660	94%	658	95%	658	95%	655	95%	657	95%	655	95%	664	96%	668	97%
		Bus	10	1%	21	3%	21	3%	26	4%	21	3%	37	5%	31	5%	31	5%	31	4%	31	5%	31	4%	24	4%	21	3%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	2	0%	2	0%	6	1%	2	0%	2	0%	6	1%	2	0%	2	0%	5	1%	2	0%	5	1%	2	0%	2	0%
		Total	691	100%	691	100%	691	100%	691	100%	691	100%	702	100%	691	100%	691	100%	691	100%	691	100%	691	100%	691	100%	691	100%
		DoS	35%		34%		34%		34%		34%		34%		34%		34%		34%		34%		34%		34%		34%	
	Northbound	Car	2778	87%	2637	82%	2482	77%	2402	75%	2637	82%	2327	72%	2560	80%	2383	74%	2329	73%	2383	74%	2327	72%	2418	75%	2613	84%
		Bus	336	10%	491	15%	370	12%	759	24%	490	15%	633	20%	594	19%	782	24%	656	20%	782	24%	658	20%	730	23%	400	13%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	93	3%	80	2%	358	11%	46	1%	81	3%	261	8%	54	2%	42	1%	226	7%	43	1%	226	7%	60	2%	89	3%
		Total	3208	100%	3208	100%	3210	100%	3208	100%	3208	100%	3221	100%	3208	100%	3208	100%	3211	100%	3208	100%	3210	100%	3208	100%	3101	100%
		DoS	153%		145%		136%		132%		145%		128%		131%		131%		128%		131%		128%		133%		144%	
Arthurs Point Crossing	Southbound	Car	1037	95%	858	82%	847	82%	853	82%	800	73%	800	73%	853	82%	849	82%	846	82%	801	73%	801	73%	881	84%	885	84%
		Bus	53	5%	184	18%	184	18%	184	18%	296	27%	296	27%	184	18%	184	18%	184	18%	296	27%	296	27%	171	16%	171	16%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	1090	100%	1042	100%	1032	100%	1037	100%	1097	100%	1097	100%	1037	100%	1034	100%	1030	100%	1097	100%	1097	100%	1053	100%	1056	100%
		DoS	80%		66%		65%		66%		62%		62%		66%		65%		65%		62%		62%		68%		68%	
	Northbound	Car	427	95%	408	91%	409	91%	408	91%	403	88%	404	88%	408	91%	408	90%	408	91%	403	88%	404	88%	414	92%	415	92%
		Bus	24	5%	42	9%	42	9%	43	9%	53	12%	53	12%	42	9%	43	10%	43	9%	53	12%	53	12%	37	8%	37	8%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	451	100%	450	100%	451	100%	451	100%	456	100%	457	100%	450	100%	451	100%	451	100%	457	100%	457	100%	452	100%	451	100%
		DoS	33%		31%		31%		31%		31%		31%		31%		31%		31%		31%		31%		32%		32%	

Location	Direction	Passengers	2053 IP																									
			Do Minimum		Bus Max												RP + JP Split; With Northbound Bus Lanes								JP Spine			
					Bus Max		+ JP Ferry		+ PT Bridge		+ Malaghans		+ all 3 Variations		RP+ JP split		Base		+ JP Ferry		+ Malaghans		+JP Ferry + Malaghans		With PT bridge		No PT bridge	
SH6A (Suburb)	Eastbound	Car	2099	91%	1906	82%	1873	81%	1902	82%	1936	84%	1900	82%	1898	82%	1898	82%	1867	81%	1898	82%	1868	81%	1913	83%	1916	83%
		Bus	193	8%	372	16%	372	16%	376	16%	334	14%	336	15%	382	16%	381	16%	380	16%	373	16%	371	16%	363	16%	358	16%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	17	1%	35	2%	74	3%	35	2%	36	2%	75	3%	34	1%	34	1%	72	3%	34	1%	72	3%	29	1%	29	1%
		Total	2309	100%	2313	100%	2319	100%	2313	100%	2305	100%	2311	100%	2313	100%	2313	100%	2319	100%	2305	100%	2311	100%	2304	100%	2304	100%
		DoS	101%		92%		90%		91%		93%		91%		91%		91%		90%		91%		90%		92%		92%	
	Westbound	Car	2059	89%	1876	81%	1837	79%	1870	81%	1903	83%	1860	81%	1865	81%	1862	81%	1828	79%	1863	81%	1829	79%	1891	82%	1896	82%
		Bus	221	10%	395	17%	389	17%	402	17%	358	16%	358	16%	408	18%	410	18%	402	17%	402	17%	394	17%	377	16%	370	16%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	24	1%	38	2%	88	4%	37	2%	40	2%	89	4%	36	2%	36	2%	84	4%	36	2%	84	4%	34	1%	35	2%
		Total	2304	100%	2308	100%	2314	100%	2309	100%	2301	100%	2307	100%	2308	100%	2308	100%	2314	100%	2302	100%	2307	100%	2302	100%	2301	100%
		DoS	113%		103%		101%		103%		105%		102%		102%		102%		100%		102%		101%		104%		104%	
SH6A (Marina)	Eastbound	Car	2042	93%	1901	86%	1868	84%	1898	86%	1924	87%	1888	86%	1896	86%	1896	86%	1864	84%	1896	86%	1865	84%	1901	86%	1906	87%
		Bus	143	7%	274	12%	273	12%	278	13%	242	11%	245	11%	281	13%	280	13%	279	13%	272	12%	270	12%	271	12%	266	12%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	17	1%	35	2%	74	3%	35	2%	36	2%	75	3%	34	2%	34	2%	72	3%	34	2%	72	3%	29	1%	29	1%
		Total	2203	100%	2210	100%	2215	100%	2210	100%	2202	100%	2207	100%	2210	100%	2210	100%	2215	100%	2202	100%	2207	100%	2201	100%	2201	100%
		DoS	121%		113%		111%		112%		114%		112%		112%		112%		110%		112%		110%		113%		113%	
	Westbound	Car	2020	90%	1880	84%	1841	82%	1874	84%	1905	85%	1860	83%	1870	83%	1868	83%	1833	82%	1869	84%	1834	82%	1889	85%	1895	85%
		Bus	191	9%	322	14%	316	14%	330	15%	289	13%	289	13%	334	15%	336	15%	328	15%	328	15%	320	14%	311	14%	304	14%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	24	1%	38	2%	88	4%	37	2%	40	2%	89	4%	36	2%	36	2%	84	4%	36	2%	84	4%	34	2%	35	2%
		Total	2235	100%	2240	100%	2245	100%	2240	100%	2234	100%	2238	100%	2240	100%	2240	100%	2245	100%	2233	100%	2238	100%	2234	100%	2234	100%
		DoS	120%		111%		109%		111%		113%		110%		111%		111%		108%		111%		109%		112%		112%	
Shotover Bridge	Eastbound	Car	1693	97%	1668	95%	1668	95%	1668	95%	1671	96%	1671	96%	1663	95%	1663	95%	1663	95%	1666	96%	1666	96%	1669	95%	1669	95%
		Bus	55	3%	84	5%	84	5%	84	5%	73	4%	73	4%	89	5%	89	5%	89	5%	78	4%	78	4%	80	5%	80	5%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	1748	100%	1752	100%	1753	100%	1752	100%	1745	100%	1745	100%	1752	100%	1752	100%	1752	100%	1744	100%	1744	100%	1749	100%	1749	100%
		DoS	93%		92%		92%		92%		92%		92%		91%		91%		91%		92%		92%		92%		92%	
	Westbound	Car	1610	97%	1585	95%	1585	95%	1585	95%	1587	96%	1587	96%	1582	95%	1582	95%	1582	95%	1585	96%	1585	96%	1590	96%	1591	96%
		Bus	50	3%	79	5%	80	5%	79	5%	70	4%	70	4%	82	5%	83	5%	83	5%	72	4%	72	4%	72	4%	71	4%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	1659	100%	1664	100%	1664	100%	1664	100%	1657	100%	1657	100%	1664	100%	1664	100%	1665	100%	1657	100%	1657	100%	1662	100%	1662	100%
		DoS	95%		94%		94%		94%		94%		94%		94%		94%		94%		94%		94%		94%		94%	
Kawarau Falls Bridge	Southbound	Car	1621	98%	1587	96%	1552	94%	1576	95%	1587	96%	1540	93%	1562	94%	1562	94%	1530	92%	1562	94%	1530	92%	1569	95%	1580	96%
		Bus	24	1%	55	3%	54	3%	66	4%	55	3%	70	4%	81	5%	81	5%	79	5%	81	5%	79	5%	74	4%	62	4%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	10	1%	13	1%	49	3%	12	1%	13	1%	49	3%	11	1%	11	1%	47	3%	11	1%	47	3%	12	1%	13	1%
		Total	1655	100%	1655	100%	1655	100%	1655	100%	1655	100%	1659	100%	1655	100%	1655	100%	1655	100%	1655	100%	1655	100%	1655	100%	1655	100%
		DoS	83%		81%		80%		81%		81%		79%		80%		80%		78%		80%		78%		80%		81%	
	Northbound	Car	1742	96%	1715	95%	1672	92%	1699	94%	1715	95%	1656	91%	1695	93%	1690	93%	1652	91%	1690	93%	1652	91%	1694	93%	1710	95%
		Bus	57	3%	82	5%	77	4%	99	5%	81	4%	96	5%	104	6%	109	6%	102	6%	108	6%	102	6%	103	6%	73	4%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	16	1%	18	1%	66	4%	17	1%	18	1%	67	4%	16	1%	16	1%	62	3%	16	1%	62	3%	18	1%	19	1%
		Total	1815	100%	1815	100%	1815	100%	1815	100%	1815	100%	1819	100%	1815	100%	1815	100%	1815	100%	1815	100%	1815	100%	1815	100%	1801	100%
		DoS	96%		94%		92%		93%		94%		91%		87%		93%		91%		93%		91%		93%		94%	
Arthurs Point Crossing	Southbound	Car	592	97%	567	93%	566	93%	567	93%	555	90%	555	90%	567	93%	566	93%	566	93%	554	90%	554	90%	569	93%	569	93%
		Bus	21	3%	41	7%	41	7%	41	7%	60	10%	60	10%	42	7%	42	7%	42	7%	61	10%	61	10%	41	7%	41	7%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	612	100%	608	100%	608	100%	608	100%	615	100%	615	100%	608	100%	608	100%	608	100%	615	100%	615	100%	610	100%	610	100%
		DoS	46%		44%		44%		44%		43%		43%		44%		44%		44%		43%		43%		44%		44%	
	Northbound	Car	609	96%	581	93%	581	93%	581	93%	570	90%	570	90%	581	93%	581	93%	581	93%	570	90%	570	90%	584	93%	584	93%
		Bus	23	4%	46	7%	46	7%	46	7%	65	10%	65	10%	46	7%	46	7%	46	7%	65	10%	65	10%	46	7%	46	7%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	632	100%	627	100%	627	100%	627	100%	635	100%	635	100%	627	100%	627	100%	627	100%	635	100%	635	100%	630	100%	630	100%
		DoS	47%		45%		45%		45%		44%		44%		45%		45%		45%		44%		44%		45%		45%

			2053 PM																									
			Do Minimum		Bus Max												RP + JP Split; With Northbound Bus Lanes								JP Spine			
Location	Direction	Passengers			Bus Max		+ JP Ferry		+ PT Bridge		+ Malaghans		+ all 3 Variations		RP+ JP split		Base		+ JP Ferry		+ Malaghans		+JP Ferry + Malaghans		With PT bridge		No PT bridge	
SH6A (Suburb)	Eastbound	Car	2863	85%	2219	66%	2013	59%	2122	63%	2236	67%	2008	60%	2158	64%	2158	64%	1999	59%	2159	64%	1999	59%	2168	65%	2261	68%
		Bus	366	11%	1000	30%	1003	29%	1138	34%	948	28%	1032	31%	1087	32%	1087	32%	1070	31%	1052	31%	1029	31%	1066	32%	937	28%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	124	4%	161	5%	392	12%	125	4%	164	5%	327	10%	139	4%	139	4%	339	10%	139	4%	339	10%	118	4%	148	4%
		Total	3352	100%	3380	100%	3409	100%	3385	100%	3349	100%	3367	100%	3383	100%	3383	100%	3407	100%	3349	100%	3368	100%	3353	100%	3345	100%
		DoS	138%		107%		97%		102%		108%		97%		104%		104%		96%		104%		96%		104%		109%	
	Westbound	Car	1757	89%	1556	79%	1531	76%	1551	78%	1565	80%	1536	77%	1542	78%	1541	78%	1520	76%	1543	78%	1521	77%	1580	80%	1585	80%
		Bus	199	10%	394	20%	392	20%	400	20%	369	19%	371	19%	408	21%	409	21%	405	20%	393	20%	389	20%	365	19%	360	18%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	16	1%	32	2%	80	4%	31	2%	32	2%	77	4%	31	2%	31	2%	75	4%	31	2%	75	4%	27	1%	27	1%
		Total	1972	100%	1982	100%	2002	100%	1982	100%	1967	100%	1984	100%	1982	100%	1982	100%	2000	100%	1967	100%	1985	100%	1973	100%	1972	100%
		DoS	97%		85%		84%		85%		86%		84%		85%		85%		84%		85%		84%		87%		87%	
SH6A (Marina)	Eastbound	Car	2569	87%	2154	72%	1943	65%	2051	69%	2169	74%	1931	65%	2088	70%	2088	70%	1925	64%	2089	71%	1926	65%	2089	71%	2187	74%
		Bus	249	8%	665	22%	667	22%	808	27%	617	21%	704	24%	756	25%	756	25%	738	25%	721	24%	698	24%	747	25%	613	21%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	124	4%	161	5%	392	13%	125	4%	164	6%	327	11%	139	5%	139	5%	339	11%	139	5%	339	11%	118	4%	148	5%
		Total	2942	100%	2980	100%	3002	100%	2984	100%	2950	100%	2962	100%	2983	100%	2983	100%	3002	100%	2949	100%	2962	100%	2954	100%	2948	100%
		DoS	152%		127%		115%		121%		128%		114%		124%		124%		114%		124%		114%		124%		129%	
	Westbound	Car	1895	91%	1741	83%	1716	81%	1735	83%	1752	84%	1721	82%	1724	82%	1723	82%	1701	81%	1725	83%	1703	81%	1763	85%	1769	85%
		Bus	172	8%	321	15%	318	15%	327	16%	295	14%	297	14%	338	16%	339	16%	335	16%	323	16%	319	15%	294	14%	288	14%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	16	1%	32	2%	80	4%	31	1%	32	2%	77	4%	31	1%	31	1%	75	4%	31	1%	75	4%	27	1%	27	1%
		Total	2083	100%	2094	100%	2114	100%	2094	100%	2079	100%	2095	100%	2094	100%	2094	100%	2112	100%	2079	100%	2096	100%	2085	100%	2084	100%
		DoS	112%		103%		102%		103%		104%		102%		102%		102%		101%		102%		101%		104%		105%	
Shotover Bridge	Eastbound	Car	2260	90%	2103	83%	2103	83%	2102	83%	2110	84%	2109	84%	2104	83%	2104	83%	2103	83%	2112	84%	2111	84%	2133	84%	2134	84%
		Bus	252	10%	436	17%	444	17%	442	17%	398	16%	399	16%	438	17%	438	17%	444	17%	396	16%	397	16%	398	16%	394	16%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	2511	100%	2539	100%	2547	100%	2544	100%	2508	100%	2508	100%	2542	100%	2542	100%	2548	100%	2507	100%	2508	100%	2531	100%	2528	100%
		DoS	124%		116%		116%		115%		116%		116%		116%		116%		116%		116%		116%		117%		117%	
	Westbound	Car	1627	96%	1576	93%	1575	93%	1573	93%	1578	94%	1574	93%	1572	93%	1572	93%	1572	92%	1579	94%	1579	94%	1588	94%	1591	94%
		Bus	63	4%	123	7%	124	7%	126	7%	106	6%	110	7%	127	7%	127	7%	127	8%	104	6%	105	6%	107	6%	104	6%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	1689	100%	1699	100%	1699	100%	1699	100%	1684	100%	1684	100%	1699	100%	1699	100%	1699	100%	1684	100%	1684	100%	1695	100%	1695	100%
		DoS	96%		93%		93%		93%		93%		93%		93%		93%		93%		93%		93%		94%		94%	
Kawarau Falls Bridge	Southbound	Car	2860	95%	2736	91%	2514	83%	2515	84%	2736	91%	2393	79%	2616	87%	2616	87%	2444	81%	2616	87%	2444	81%	2523	84%	2737	91%
		Bus	63	2%	191	6%	178	6%	443	15%	190	6%	379	13%	331	11%	331	11%	302	10%	331	11%	302	10%	428	14%	186	6%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	87	3%	83	3%	321	11%	52	2%	84	3%	254	8%	63	2%	63	2%	266	9%	63	2%	266	9%	59	2%	87	3%
		Total	3010	100%	3010	100%	3012	100%	3010	100%	3010	100%	3026	100%	3010	100%	3010	100%	3012	100%	3010	100%	3012	100%	3010	100%	3009	100%
		DoS	147%		140%		129%		129%		140%		123%		134%		134%		125%		134%		125%		129%		140%	
	Northbound	Car	1336	97%	1311	95%	1283	93%	1300	94%	1311	95%	1273	91%	1289	93%	1286	93%	1262	91%	1286	93%	1262	91%	1307	95%	1317	96%
		Bus	40	3%	62	5%	60	4%	74	5%	62	5%	84	6%	85	6%	88	6%	84	6%	88	6%	84	6%	66	5%	44	3%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	5	0%	7	1%	39	3%	7	1%	7	1%	39	3%	6	0%	6	0%	36	3%	6	0%	36	3%	7	1%	8	1%
		Total	1381	100%	1381	100%	1383	100%	1381	100%	1381	100%	1396	100%	1381	100%	1381	100%	1383	100%	1381	100%	1383	100%	1381	100%	1368	100%
		DoS	73%		72%		70%		71%		72%		70%		66%		71%		69%		71%		69%		72%		72%	
Arthurs Point Crossing	Southbound	Car	574	94%	516	86%	515	86%	515	86%	503	82%	503	82%	515	86%	515	86%	515	86%	503	82%	503	82%	526	87%	526	87%
		Bus	35	6%	85	14%	86	14%	86	14%	112	18%	112	18%	86	14%	86	14%	86	14%	112	18%	112	18%	78	13%	77	13%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	609	100%	601	100%	601	100%	601	100%	615	100%	615	100%	601	100%	601	100%	601	100%	615	100%	615	100%	604	100%	604	100%
		DoS	44%		40%		40%		40%		39%		39%		40%		40%		40%		39%		39%		40%		40%	
	Northbound	Car	876	94%	723	80%	715	80%	719	80%	681	73%	681	73%	720	80%	720	80%	715	80%	681	73%	681	73%	742	81%	745	82%
		Bus	54	6%	181	20%	181	20%	181	20%	253	27%	253	27%	180	20%	180	20%	180	20%	252	27%	252	27%	169	19%	169	18%
		P&R	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		MRT	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Water	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
		Total	930	100%	903	100%	896	100%	899	100%	933	100%	933	100%	901	100%	901	100%	895	100%	933	100%	933	100%	911	100%	914	100%
		DoS	67%		56%		55%		55%		52%		52%		55%		55%		55%		52%		52%		57%		57%	