

TECHNICAL NOTE

Project	Byron Bay – Bus Bay Capacity Assessment		
Subject	Review of Scheduled Services and Capacity Assessment		
Date	8 April 2018	Note #	2.1
Prepared	D. Innis		

1 INTRODUCTION

1.1 Technical Note Purpose

The purpose of this technical note is to undertake a review of the existing scheduled timetable at the bus stop and high-level capacity assessment to identify the number of bays required for a proposed upgraded bus interchange facility. This technical note includes the following information:

- Review of scheduled timetable and identify pattern of bus use at the facility.
- Analyse capacity and utilisation demands of the bus facility.
- Identification of operational bus bays for the proposed bus facility.
- Review of existing concept design relating to operations, pedestrians and safety.

1.2 Assumptions

The following assumptions have been used in review the scheduled timetable of services:

- Buses and coaches will be stopping at a separate location to airport shuttles and local vans at the upgraded facility. Buses and coaches (referred to hereafter as buses) and airport shuttles and local vans (referred to hereafter as vans) will be analysed separately.
- Buses and vans commencing at the facility will arrive three minutes prior to their scheduled departure time. This allows sufficient time for passengers to board and purchase their required fare prior to departure.
- Buses and vans servicing Byron Bay mid-trip or passing through the town, will dwell at the stop for two minutes. This provides sufficient time for passengers to alight the service then allow passengers to board and purchase their fare before departing.
- Buses and vans terminating at Byron Bay and not continuing in-service from the facility will dwell at the stop for one minute. This provides sufficient time for passengers to alight the service.
- Buses and vans terminated at Byron Bay will not layover at the facility but return to depot or another location.
- Long distance services will dwell at the facility for ten minutes providing sufficient time for passengers to break from travel to refresh before continuing with their journey.
- No integration of timetables has been considered in the review. This allows for the worst-case scenario to be reviewed and the recommendations to be based on the highest possible number of buses and vans utilise the facility at the same time.

2 REVIEW OF SCHEDULED TIMETABLE

2.1 Service Providers

The analysis of the scheduled timetable for services at Byron Bay has included the follow bus operators and service providers:

- NSW TrainLink.

- Various airport shuttles:
 - Brisbane airport.
 - Gold Coast airport.
 - Ballina airport.
- Greyhound Coaches.
- Local hostels.
- Nimbin Buses.
- Northern Rivers Buslines.
- Premier Coaches.
- Blancs.
- Resort shuttles.
- Local tours.

These service providers offer 237 trips each week to various local and long distance locations. This is comprised of 147 trips using buses between 12m to 14.5m in length, and 90 trips using vans.

2.2 Bus Services

2.2.1 Weekday Schedule

Table 2-1 identifies the number of trips servicing the bus facility each weekday, by hour across the day, according to their status of a commencing trip (bus starts at Byron Bay), a passing trip (bus services Byron Bay mid-trip), or a terminating trip (bus finishes service at Byron Bay).

A Friday weekday for the school period has been assessed as this provides a higher volume of bus trips compared to the operational timetable on Monday to Thursday or during school holidays. This allows the bus facility to be assessed against the day when the highest volume of buses are scheduled.

Based on the current scheduled timetable, 121 buses are servicing the facility each weekday including 45 trips commencing, 29 trips passing through and 47 trips terminating at Byron Bay. The bus facility experiences the greatest number of buses using the stop between 5:00pm and 6:00pm with ten buses scheduled.

Table 2-1 Number of Weekday Trips - Buses

WEEKDAY				
Time Period	Commencing Trip	Passing Trip	Terminating Trip	Hour Total
4:00		1		1
5:00	1			1
6:00		1		1
7:00	3	2	1	6
8:00	2	1	4	7
9:00	3	1	2	6
10:00	4	2	2	8
11:00	2	4	3	9
12:00	1	3	2	6
13:00	3	1	3	7
14:00	4	1	2	7
15:00	1	3	4	8
16:00	4	1	4	9
17:00	3	4	3	10
18:00	3		4	7
19:00	3	1	4	8
20:00	3	3	3	9
21:00	1		2	3
22:00	3		3	6
23:00	1		1	2
Total	45	29	47	121

2.2.2 Saturday Schedule

Table 2-2 identifies the number of trips servicing the bus facility each Saturday, by hour across the day, according to their status. The number of bus trips operating on a Saturday is half as many as operating on weekdays.

Based on the current scheduled timetable, 60 buses are servicing the facility each Saturday with 16 trips commencing and terminating, and 28 trips passing through. The bus facility experiences the greatest number of buses using the stop between 8:00pm and 9:00pm, with nine buses scheduled.

Table 2-2 Number of Saturday Trips - Buses

SATURDAY				
Time Period	Commencing Trip	Passing Trip	Terminating Trip	Hour Total
4:00		1		1
5:00	1			1
6:00		1		1
7:00		2		2
8:00		2		2
9:00				0
10:00	1	3		4
11:00		2		2
12:00		3	1	4
13:00		2		2
14:00	1	1		2
15:00		2	1	3
16:00	1			1
17:00		5	1	6
18:00	1		1	2
19:00	3	1	3	7
20:00	3	3	3	9
21:00	1		2	3
22:00	3		3	6
23:00	1		1	2
Total	16	28	16	60

2.2.3 Sunday Schedule

Table 2-3 identifies the number of trips servicing the bus facility each Sunday, by hour across the day, according to their status. The number of bus trips operating on a Sunday is half as many as the number of trips operating on a Saturday and a quarter of trips compared to weekdays.

Based on the current scheduled timetable, 30 buses are servicing the facility each Sunday with 5 trips commencing, 21 trips passing, and 4 trips terminating at the bus facility. The bus facility experiences the greatest number of buses using the stop at the same time period as weekday's being between 5:00pm to 6:00pm with five buses scheduled.

Table 2-3 Number of Sunday Trips - Buses

SUNDAY				
Time Period	Commencing Trip	Passing Trip	Terminating Trip	Hour Total
4:00		1		1
5:00	1			1
6:00		1		1
7:00		1		1
8:00		2		2
9:00				0
10:00	1	2		3
11:00		1		1
12:00		3	1	4
13:00		2		2
14:00	1			1
15:00		1	1	2

SUNDAY				
Time Period	Commencing Trip	Passing Trip	Terminating Trip	Hour Total
16:00	1			1
17:00		4	1	5
18:00				0
19:00	1			1
20:00		3		3
21:00			1	1
22:00				0
23:00				0
Total	5	21	4	30

2.3 Van Services

2.3.1 Weekday Schedule

The number of services operating at Byron Bay using a van remains fairly consistent across the week. Overall 89 trips are operated by van each weekday, 83 each Saturday and 84 each Sunday.

Table 2-4 identifies the number of trips servicing the bus facility by van each weekday, by hour across the day, according to their status. Based on the current scheduled timetable, 34 trips commence and terminate with an additional 28 trips passing through the facility.

The highest number of vans accessing the bus facility during the same time period is between 1:00pm and 2:00pm with 11 vans servicing the facility.

Table 2-4 Number of Weekday Trips - Vans

WEEKDAY				
Time Period	Commencing Trip	Passing Trip	Terminating Trip	Hour Total
4:00				0
5:00	1			1
6:00	1			1
7:00	3			3
8:00	2	2		4
9:00	4	1	3	8
10:00	1	2	3	6
11:00	4	2	2	8
12:00	2	2	3	7
13:00	5	2	4	11
14:00	4	1	3	8
15:00	1	2	2	5
16:00	2	2	6	10
17:00	1	2	2	5
18:00	1	3	1	5
19:00	2		1	3
20:00			1	1
21:00			1	1
22:00			1	1
23:00			1	1
Total	34	21	34	89

2.3.2 Saturday Schedule

Table 2-5 identifies the number of trips servicing the bus facility by van each Saturday, by hour across the day, according to their status. Based on the current scheduled timetable, 32 trips commence from Byron Bay with an additional 20 trips passing through and 31 trips terminating.

The bus facility experiences the greatest number of vans using the stop between 1:00pm and 2:00pm, and again between 4:00pm and 5:00pm with ten vans scheduled.

Table 2-5 Number of Saturday Trips - Vans

SATURDAY				
Time Period	Commencing Trip	Passing Trip	Terminating Trip	Hour Total
4:00				0
5:00	1			1
6:00	1			1
7:00	3			3
8:00	2	2		4
9:00	4	1	3	8
10:00	1	2	3	6
11:00	4	2	2	8
12:00	2	2	3	7
13:00	5	2	3	10
14:00	3	1	3	7
15:00	1	2	2	5
16:00	2	2	6	10
17:00	1	1	2	4
18:00	1	3	1	5
19:00	1		1	2
20:00			1	1
21:00			1	1
22:00				0
23:00				0
Total	32	20	31	83

2.3.3 Sunday Schedule

Table 2-6 identifies the number of trips servicing the bus facility each Sunday, by hour across the day, according to their status. The current scheduled timetable is similar to Saturday's with the additional of an extra commencing trip.

The Sunday time period with the greatest number of vans servicing the facility at one time period is the same as Saturdays being between 1:00pm and 2:00pm, and again between 4:00pm and 5:00pm with ten vans scheduled

Table 2-6 Number of Sunday Trips - Vans

SUNDAY				
Time Period	Commencing Trip	Passing Trip	Terminating Trip	Hour Total
4:00				0
5:00	1			1
6:00	1			1
7:00	3			3
8:00	2	2		4
9:00	4	1	3	8
10:00	1	2	3	6
11:00	3	2	1	6
12:00	2	2	3	7
13:00	5	2	3	10
14:00	3	1	3	7
15:00	1	2	2	5
16:00	2	2	6	10
17:00	1	2	2	5
18:00		3	1	4
19:00	2		1	3
20:00			1	1
21:00			1	1
22:00			1	1
23:00			1	1
Total	31	21	32	84

3 CAPACITY ANALYSIS – EXISTING SERVICES

The scheduled arrival and departure times for bus and van services at Byron Bay, along with the assumed dwell times, has been assessed to provide a clear indication on the number of vehicles at the facility at a given time.

Section 3.1 will address bus services and the number of bays required to support current operations.

Section 3.2 will address van services and the number of bays required to support current operations.

The information provided in this assessment is based on scheduled timetable only and does not account for the early or late running of services which could impact operations of the bus facility.

The timetable of all routes scheduled to service Byron Bay is included as Attachment A, separated by bus and vans.

3.1 Bus Services

3.1.1 Weekday Service Conflicts

Figure 3-1 provides a breakdown of the volume of buses using the bus facility, taking into consideration dwell time, between 4:00am and 12:00am each weekday. From the scheduled timetable, there is one instance where four buses are identified at the facility at the same time. Furthermore, there are two instances where three buses are at the facility at the same time. The times of bus conflicts are:

- 10:05am to 10:07am.
- 5:00pm
- 7:22pm.

For all other times, no more than two buses are scheduled to be at the facility.

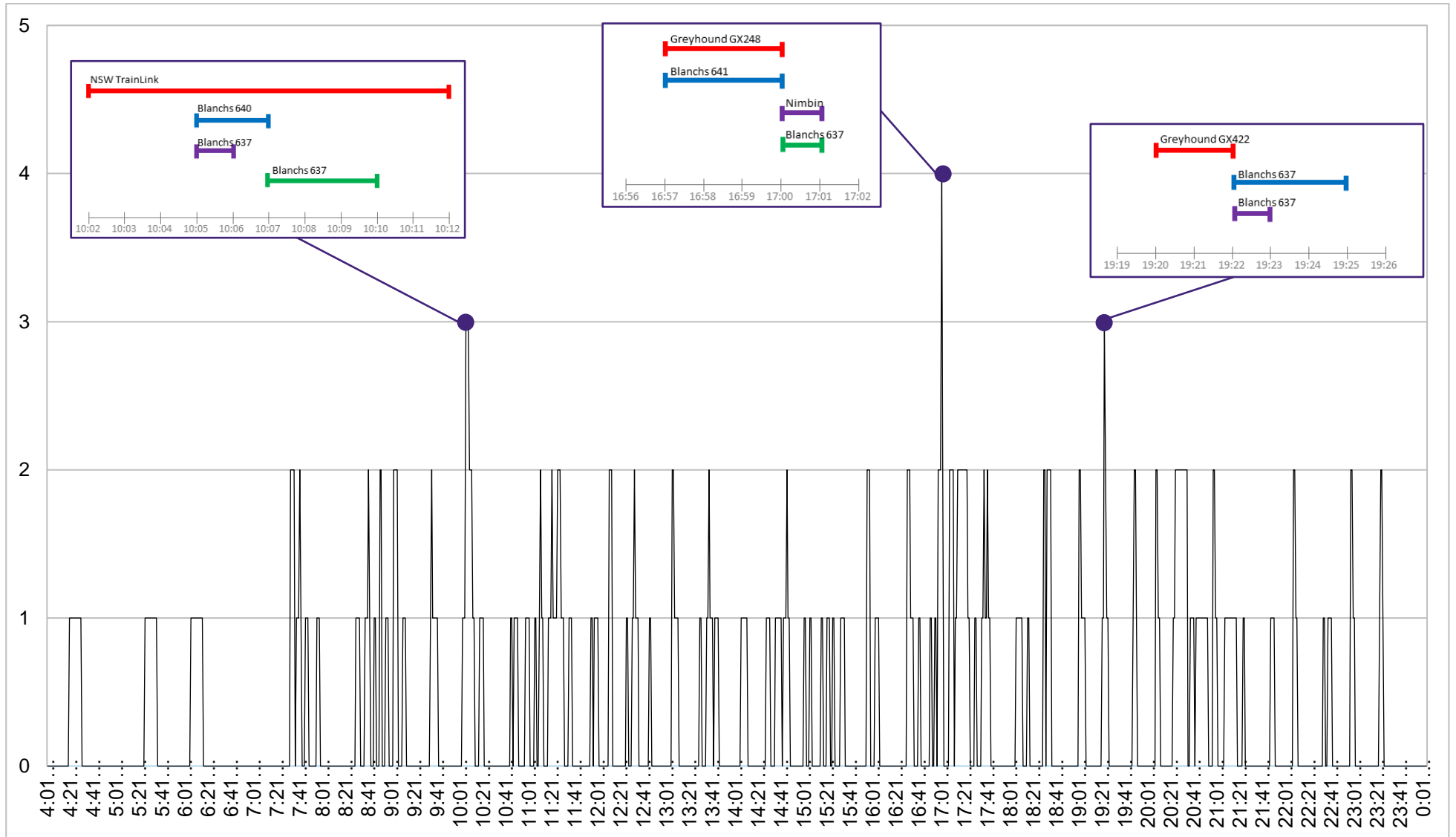
A review of the scheduled timetable at 10:05am to 10:07am shows that four services operated by NSW TrainLink and Blanches use the Byron Bay facility. In reviewing their, arrival, dwell and departure times, three buses are at the facility at the same time with two of those buses departed prior to the fourth bus arriving. The arrival and departure times of these four buses, and the period of time they remain at the bus facility are shown graphically in Figure 3-1 in the first inset.

In reviewing the buses scheduled around 5:00pm, four services operated by Greyhound, Blanchs and Nimbin Buses are using the facility. Two of these buses arrive and depart at the same time prior to the following two buses arriving. The second inset in Figure 3-1 graphically portrays the arrival, dwell and departure times of these buses.

In reviewing the buses scheduled at 7:22pm, three services operated by Greyhound and Blanchs utilise the facility. The single Greyhound bus departs as the two Blanchs buses are arriving. The third inset in Figure 3-1 graphically portrays these bus movements.

Overall according to the schedule timetable, weekday bus services can operate sufficiently with three dedicated bus bays at the proposed Byron Bay bus facility.

Figure 3-1 Breakdown of Weekday (Friday) Bus Trips



3.1.2 Saturday Service Conflicts

Figure 3-2 provides a breakdown of the volume of buses using the bus facility, taking into consideration dwell time, between 4:00am and 12:00am each Saturday. From the scheduled timetable, there are three instances where three buses are identified at the facility at the same time being:

- 10:07am.
- 5:00pm.
- 7:22pm.

These times match the same weekday periods where multiple vehicles arrive at the same time. For all other times, no more than two buses are scheduled to be at the facility.

A review of the scheduled timetable at 10:05am to 10:07am shows that three services operated by NSW TrainLink and Blanches use the Byron Bay facility. All three services are scheduled to be at the facility at the same time. The arrival and departure times of these three buses are shown graphically in Figure 3-2 in the first inset.

In reviewing the buses scheduled around 5:00pm, a Greyhound bus is scheduled to depart as a bus from Nimbin Buses and Blanches is scheduled to arrive. The second inset in Figure 3-2 graphically portrays the arrival, dwell and departure times of these buses.

The services scheduled at the facility at 7:22pm are the same as those identified on weekdays with one Greyhound bus departing as two Blanches buses arrive. This is shown in the third inset of Figure 3-2.

Overall according to the schedule timetable, Saturday bus services can operate sufficiently with three dedicated bus bays at the proposed Byron Bay bus facility.

3.1.3 Sunday Service Conflicts

Figure 3-3 provides a breakdown of the volume of buses using the bus facility, taking into consideration dwell time, between 4:00am and 12:00am each Sunday. From the scheduled timetable, there is one instance where three buses are identified at the facility at the same time, being 5pm.

The service scheduled at 5:00pm are the same as those identified on Saturdays with one Greyhound bus departing as a bus from Nimbin Buses and Blanches is scheduled to arrive. The inset shows the arrival and departure of these buses graphically in Figure 3-3.

For all other times, no more than two buses are scheduled to be at the facility.

Overall according to the schedule timetable, Sunday bus services can operate sufficiently with two dedicated bus bays at the proposed Byron Bay bus facility.

Figure 3-2 Breakdown of Saturday Bus Trips

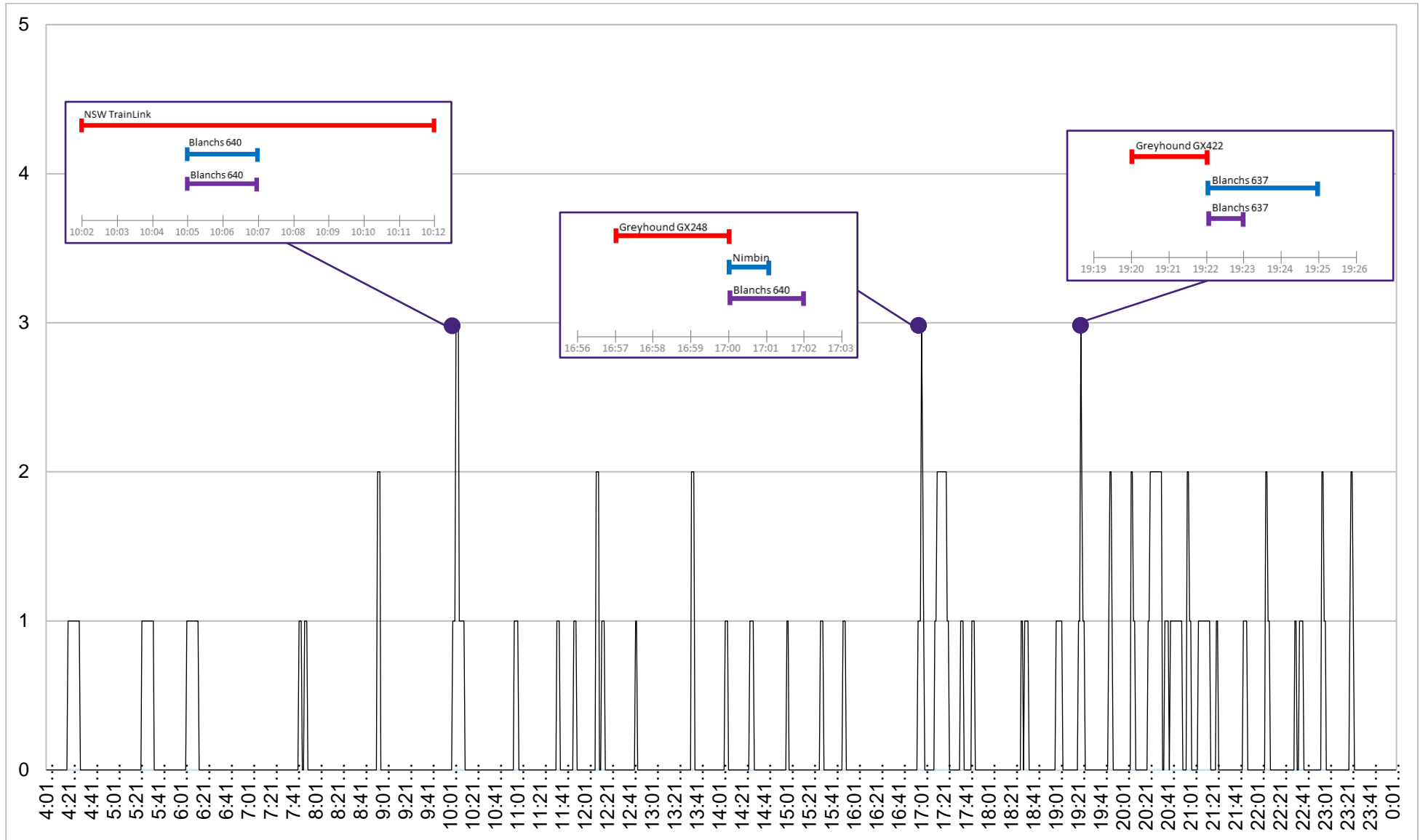
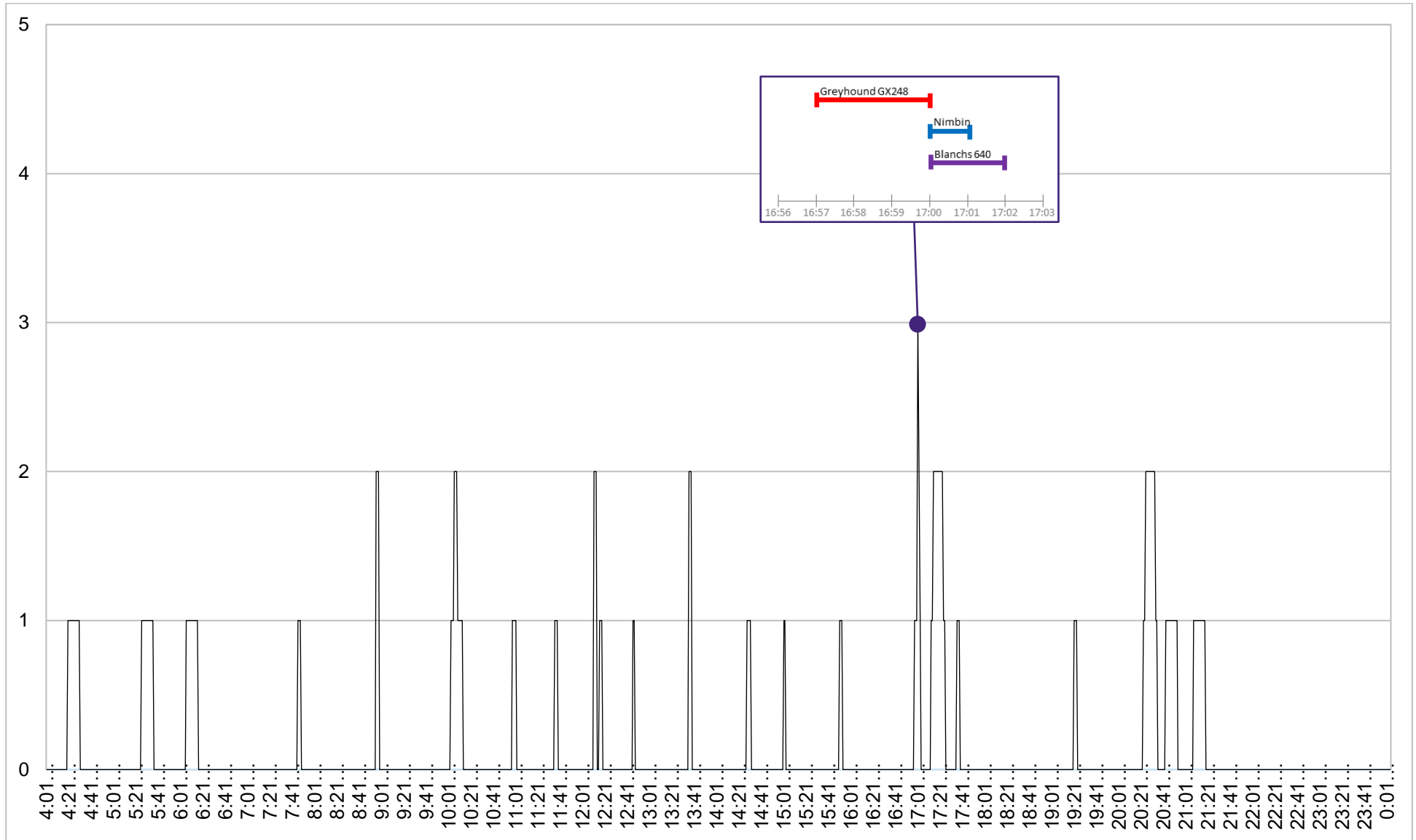


Figure 3-3 Breakdown of Sunday Bus Trips



3.2 Van Services

The capacity analysis for vans scheduled to service Byron Bus is fairly similar for all days of the week. All vans operate on weekdays with the following differences scheduled on Saturdays and Sundays when compared to weekdays:

- Saturday:
 - The 5:15pm, 7:12pm, 10:00pm and 11:45pm trips by Easybus do not operate.
 - The 1:00pm and 2:57pm trips by Bris2byr do not operate.
- Sunday:
 - The 11:00am, 11:57am, 1:00pm, 2:57pm and 6:27pm trips by Bris2byr do not operate.

Commentary on the conflict of services for Saturday and Sunday will not be included in this technical note as these conflicts are already covered in the weekday commentary. The removal of the trips identified above reduces the number of vans conflicting at the same time improving the outcome for the proposed Byron Bay bus facility.

The outcomes identified in Section 3.2.1 will apply to Saturday and Sunday, and overall van operations.

Figure 3-5 and Figure 3-6 shows the breakdown of buses accessing the facility each Saturday and Sunday respectively.

3.2.1 Weekday Service Conflicts

Figure 3-4 provides a breakdown of the volume of vans using the facility on weekdays. From the scheduled timetable for operators using vans, the following times indicated multiple vans using the facility at a similar time:

- 10:00am – four vans scheduled.
- 1:00pm – four vans scheduled.
- 2:00pm – five vans scheduled.

For all other times, no more than three vans are scheduled to be at the facility.

A review of the scheduled timetable at 10:00am indicates four vans operated by individual operators use the facility. One van is scheduled to depart at 10:00am with three other vans scheduled to arrive at that time. The arrival and departure of these vans is shown in Figure 3-4.

At 1:00pm, four vans are scheduled to arrive at the same time with two vans having Byron Bay as the last stop and the other two vans continuing beyond Byron Bay. Two of the vans are servicing local hostels and the other two are providing connectivity to airports and facilities at Brisbane and the Gold Coast. The arrival and departure of these vans is shown in Figure 3-4.

At 2:00pm, five vans are scheduled to utilise the facility. Three vans which arrived at 1:57pm are scheduled to depart at 2:00pm while two more vans are scheduled to arrive at 2:00pm. The arrival and departure of these vans is shown in Figure 3-4.

Overall according to the schedule timetable, weekday van services require four bays to support existing operations at the proposed Byron Bay bus facility.

Figure 3-4 Breakdown of Weekday (Friday) Van Trips

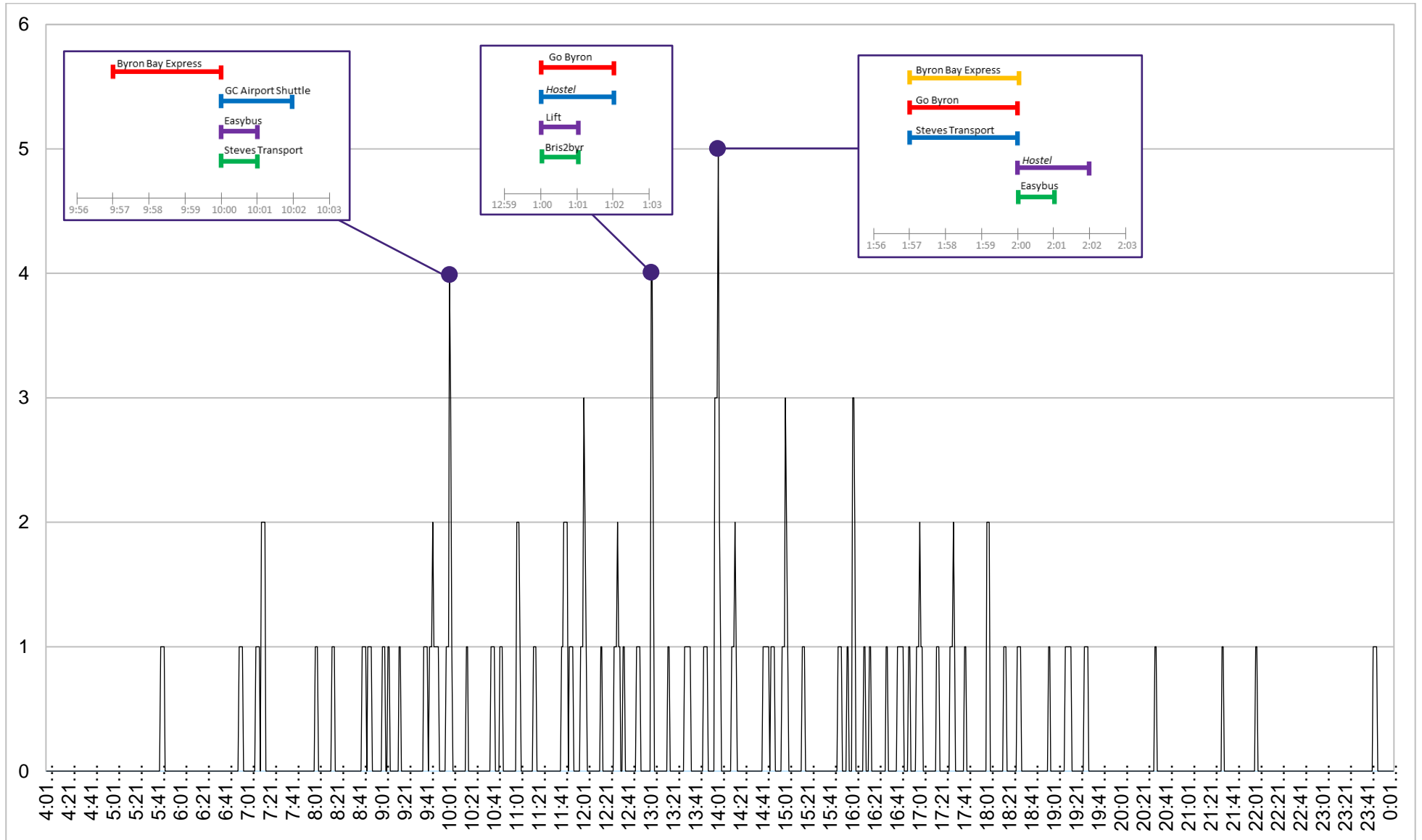


Figure 3-5 Breakdown of Saturday Van Trips

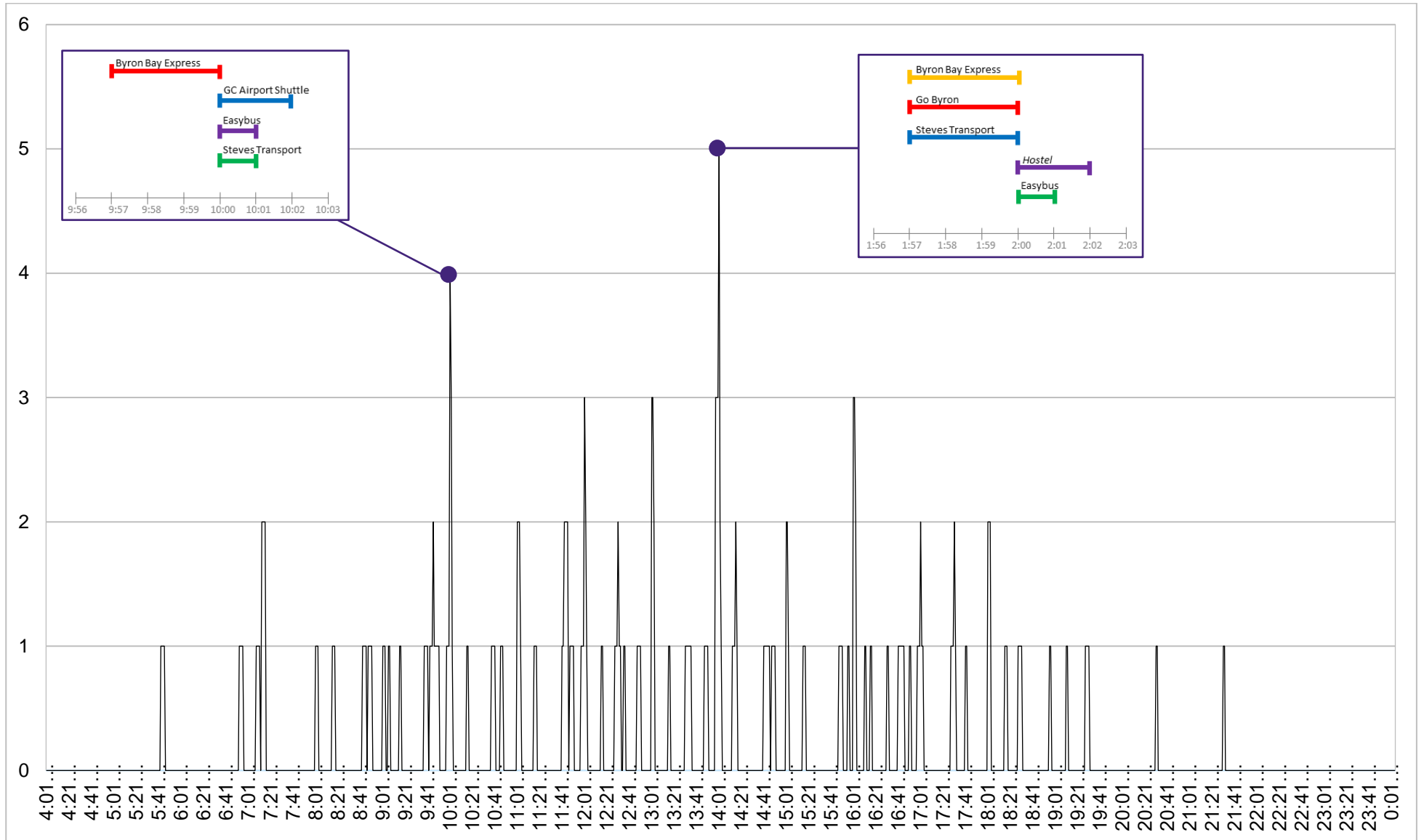
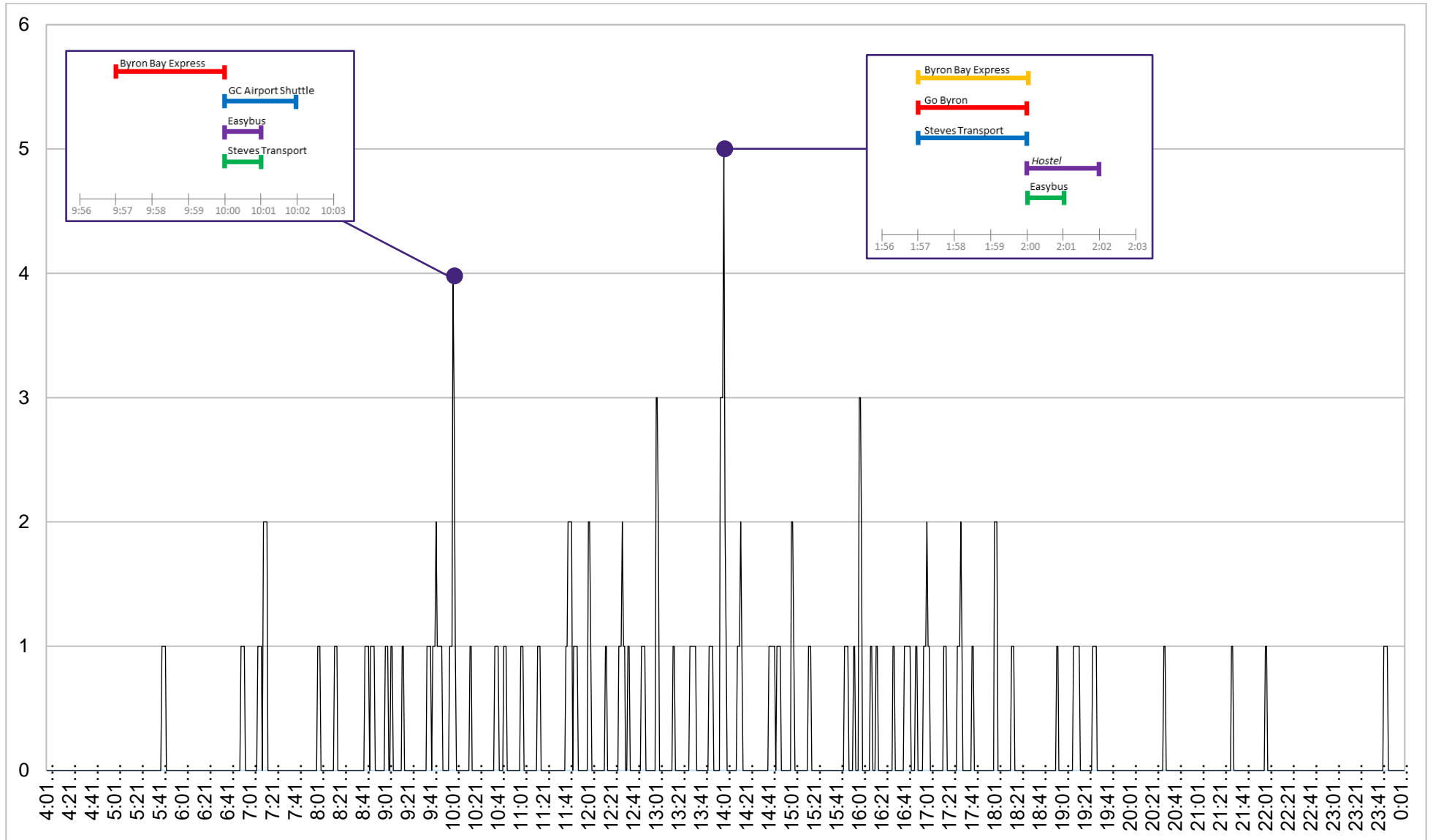


Figure 3-6 Breakdown of Sunday Van Trips



3.3 Required Capacity

3.3.1 Bus Service Requirements

Based on the existing timetable of services, there is a need for three dedicated bus bays in order for existing services to have sufficient space to support operations. Three bus bays accounts for the existing number of services arriving at the same time.

The provision of four bays is currently not required for operations as there are no scheduled occurrences of four buses servicing the facility at the same time.

3.3.2 Van Service Requirements

Based on the existing timetable of van services, there is a need for four dedicated van bays in order to cater for existing operations and not delay services waiting for a parking space.

However, as there is only once instance on weekdays only when four vans are scheduled to operate at the facility at the same time, providing a fourth bay will result in an inefficient use of resources as the bay would be empty the majority of the time.

The conflicts between the services at 1:00pm can be managed by encouraging the local hostel services to use the general parking, drop-off (kiss 'n' ride) or taxi areas if the dedicated facility and designated van bays are occupied. Providing vans with this option can minimise conflict and reduce the required space for vans from four to three.

4 CAPACITY ANALYSIS – FUTURE SERVICES

4.1 High Level Assessment

The Transportation Research Board (TRB) produces the *Transit Capacity and Quality of Service Manual*¹, which provides guidance on public transport services and the quantitative process for calculating transport capacity at bus stops and stations. The formula identified for calculating capacity is shown in Figure 4-1, and can be used as a provisional guide to identify the potential theoretical capacity of the Byron Bay bus facility.

This equation is useful in identifying the number of buses a facility can theoretically support per hour; however, this capacity figure depends on the timetabling and integrated nature of buses scheduled to service the facility. With numerous independent bus operators using the Byron Bay bus facility, there is the high chance of operators scheduling services to arrive at the same time, which has been demonstrated in Section 3. Therefore, this equation is used as a guide to identify the future number of services that could use the facility if timetables were integrated, revised and implemented to allow buses to arrive at different time.

¹ Transportation Research Board. 2014. *Transit Capacity and Quality of Service Manual, Third Edition*. Washington D.C.: Transportation Research Board.

Figure 4-1 Calculating Station Capacity

The capacity of a bus stop in buses per hour, B_s is:^(R36)

$$B_s = N_{el} B_l = \frac{3,600(g/C)}{t_c + t_d(g/C) + Zc_v t_d}$$

where:

- B_s = bus stop bus capacity (bus/h);
- B_l = individual loading area bus capacity (bus/h);
- N_{el} = number of effective loading areas, from Exhibit 4-12;
- 3,600 = number of seconds in 1 hour;
- g/C = green time ratio (the ratio of effective green time to total traffic signal cycle length, equals 1.0 for unsignalized streets and bus facilities);
- t_c = clearance time (s);
- t_d = average (mean) dwell time (s);
- Z = standard normal variable corresponding to a desired failure rate; and
- c_v = coefficient of variation of dwell times.

(Source: Transportation Research Board. 2014).

The assumptions used in this high-level assessment of the Byron Bay bus stop include:

- Using one to six operational bus bays at the new bus facility. This is to test the hourly capacity (buses per hour) a different of bus bays could support at Byron Bay given the varying service levels and service types.
- A green time ratio of one as the bus facility has all in-line stops, is not an on-road facility and is not influenced or affected by traffic signals.
- A clearance time of ten seconds to allow buses to close doors and depart the stop.
- An average dwell time of 280 seconds which is a combined average of ten minutes (600 seconds) dwell time for long distance coaches, three minutes (180 seconds) dwell time for shuttles, commencing and terminating services, and one minute (60 seconds) dwell time for passing buses. This is time estimated to drop-off and pick-up passengers.
- A failure rate of 15%, which represents collective delays of ten minutes per hour due to bus stop failure or queues forming behind stopped buses.
- A coefficient of variation of dwell times of 60% which is recommended by TRB for bus facilities.

Based on the assumptions above and using the TRB capacity formula, the realistic maximum capacity of the bus facility at Byron Bay, if one to six bays is implemented, is between seven and 46 buses per hour depending on the number of bays. Table 4-1 identifies the number of buses per hour that could be supported based on the number of bays used for the bus stop.

Table 4-1 Theoretical maximum capacity based on one to six operational bus bays

	Number of Operational Bays					
	1	2	3	4	5	6
Buses per hour	7	15	23	30	38	46

A review of the scheduled timetable from Section 2 indicates that the hour with the highest volume of buses operating at the facility is ten buses in total on a weekday, nine on a Saturday and five on a Sunday.

Referring to Table 4-1 and the current peak of buses per hour, the proposed bus facility with three bays has the ability to support an additional 13 buses per hour each weekday, 14 additional buses per hour on Saturdays and 18 additional buses per hour on Sundays.

The provision of three bus bays will provide for current bus operations as well as future proof the bus facility to support additional services that could be implemented as a result of development and growth in service demand.

5 BUS FACILITY CAPACITY RECOMMENDATIONS

The following are recommended as a result of the high level desk top capacity assessment for existing bus and van operations at the proposed bus facility in Byron Bay.

- Implement three bus bays to support existing operations.
 - Three bus bays would support the current instances where multiple buses are utilising the facility at the same time.
 - A lead stop or linear bus stop arrangement would reduce space requirements for buses to stop. Having independent bus bays requires additional space so all buses can enter and exit the bays. Implementing a lead stop arrangement means buses pull up directly behind the bus in front without stopping at a dedicated flag.
 - At times throughout the day when less buses are scheduled the redundant bays can be used as layover space for long distance coaches or urban services mealing or breaking prior to becoming in-service.

- Implement three to four bays for vans and shuttle services:
 - If space is not a constraint, four van bays should be provided to provide sufficient space for existing and future operations.
 - If space is a constraint, three van bays should be provided.
 - Non-scheduled or specialised vans, such as hotel/hostel and tour services, should be encouraged to use existing general parking spaces or kiss 'n' ride areas as these vans tend to be the size of a standard van and may not require a dedicated bay.
 - Bays for vans should be line-marked to ensure services are not utilising more space than required.
 - These bays could be modified in the future to provide additional bus bays for servicing passengers or for layover.

6 CONCEPT SKETCH COMMENTS

A review of Option 16 and the associated concept sketch was undertaken to identify aspects of the concept that could influence of impact bus operations.

Bus Operations

- Access to the facility is separated from general traffic which will reduce delays and conflicts.
- The road space between the roundabout and the end of the bus stopping area has the potential to be used as a holding area if buses are required to wait before entering the stop.
- Separating buses and vans improves legibility and reduces potential conflicts in the stopping area between services.

Pedestrian Movements

- A single plaza area provides a seamless connection between the bus facility, parking locations, proposed market square and surrounding land uses.
- A single platform improves legibility for passengers and provides a single waiting location for all service types.
- Consideration might be required for a wayfinding strategy to assist with pedestrians (and cyclists) in travelling between the facility and surrounding localities and destinations.

Safety

- Bus movements are completely independent with no obstruction from pathways or other conflicts to navigate.
- Buses have priority when it comes to exiting the facility with general traffic having to give way before proceeding to the exit.
- Pedestrians have minimal conflict with vehicles and no conflict with buses improving access and safety to bus stops and parking locations.
- Consideration may be required for a pedestrian crossing across Butler Street however this is dependent on the road environment e.g. speeds, lane widths etc.

DOCUMENT CONTROL

Project Details

Project Name	Byron Bay – Bus Bay Capacity Assessment
Project Number	17-001
Client	SMEC Australia Pty Ltd

Revision History

Revision	Date of Issue	Description	Prepared
1.1	29/10/2017	Preparation of technical note outlining findings from capacity assessment	D. Innis
2.1	08/04/2018	Update of information based on new proposed bus station site and separation of buses and vans	D. Innis

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