WAKA KOTAHI
NZ TRANSPORT AGENCY

ONE-LANE BRIDGE GUIDELINES

ITS Design Standard

29 NOVEMBER 2021
1.0

New Zealand Government

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1.2 Document owner

Role ITS Working Group

Organisation Waka Kotahi

1.3 Document approvers

This table shows a record of the approvers for this document.

Approval date	Approver	Role	Organisation
21/01/2021	Bruce Walton	Wellington Office and Transport Leader	Jacobs New Zealand Ltd
10/03/2021	Bruce Walton	Wellington Office and Transport Leader	Jacobs New Zealand Ltd
22/11/2021	Daniel Burgess	Programme Lead, Transport Services – Alignment and Strategy	Waka Kotahi
22/11/2021	ITS Working Group	ITS Standards and Specifications	Waka Kotahi

1.4 Version history – major changes

Document version control is the process of tracking and managing different versions (or drafts) of a document to easily identify the current iteration of a file.

This table shows a record of all major (published) versions of this document (for Waka Kotahi use only). To record minor versions (author updates, amendments etc), go to section 13 Full version history.

Version	Date	Author	Role and organisation	Reason
1.0	29/11/2021	ITS Working Group	Waka Kotahi	Document issued

2 TERMINOLOGY USED IN THIS DOCUMENT

Term	Definition
DRAFT	The document is being written and cannot be used outside of Waka Kotahi.
PENDING	The document has been finalised and is pending approval and ratification by Waka Kotahi. It can be used for procurement at this status.
RATIFIED	The document is an official Waka Kotahi document. Road controlling authorities are obliged to follow a document with this status.
RETIRED	The document is obsolete, and/or superseded.
CCTV	Closed-circuit television
ITS	Intelligent transport systems
NOC	Network outcomes contract
PTZ	Pan-tilt-zoom [camera]
RCA	Road controlling authority
SCATS	Sydney Coordinated Adaptive Traffic System
SH	State highway
SLA	Service level agreement
TMS	Traffic monitoring system, a telemetry collection platform for statistical traffic data on the road network.
TOC	Transport operations centre
UPS	Uninterruptable power supply
(m)	Minutes
(s)	Seconds
(vph)	Vehicles per hour

3 INTRODUCTION

These guidelines set out the best practice for the design and operation of signalised one-lane bridges in New Zealand. The goal of these guidelines is to achieve greater consistency in the design, equipment supplied and operation of one-lane bridge traffic signals.

It is intended that these guidelines will be used by Waka Kotahi transport operations centres (TOCs) and transport professionals designing or operating one-lane bridge signals.

These guidelines include the following sections.

- **Section 4** covers environments that warrant signalisation and key considerations regarding users, operation, security, resilience and safety.
- **Section 5** provides guidance on how to select equipment based on the environment and users. It also refers to other Waka Kotahi guidelines and New Zealand standards that may be needed in specific circumstances.
- **Section 6** covers the operation of the signalised one-lane bridge. This includes recommendations on how to model the signals in LinSig, Sydney Coordinated Adaptive Traffic System (SCATS) and fault management.
- **Section 7** covers the installation and maintenance of the one-lane bridge. It includes references to the latest version of ITS design standard: P43 Traffic signalling systems.
- **Section 8** provides examples of typical layouts for reference of what should be included for installation of one-lane bridge signals.
- **Section 9** provides typical operational set up for the controller information sheet and SCATS.
- **Section 10** highlights stakeholders that may need to be consulted prior to the design or implementation of one-lane bridge signals.

4 ENVIRONMENT

This section covers environments that warrant signalisation and key considerations regarding users, operation, security, resilience and safety.

4.1 Reason for signalising one-lane bridges

4.1.1 Lack of visibility

- If either side of the bridge approach is not visible from the limit line, or there are areas between where visibility is blocked.
- The approach visibility, particularly when road users are unable to obtain a satisfactory view of oncoming traffic, either within or on the far approach to the single lane section.

4.1.2 Difficulty passing

If the bridge is narrow: a single-lane situation exists when the trafficable width of a bridge or roadway is 5.0m or less, and there are limited passing points for the flow and opposing vehicles cannot pass each other without backing up.

4.1.3 Length of bridge

If the bridge is long: visibility will be impacted and it may be difficult to see all modes on the bridge or waiting at the limit line.

4.1.4 Priority control

Travel time across the bridge is a function of the length of the bridge. When operating under priority control the approach without priority may endure long wait times, especially if the traffic arrival frequency is less than the crossing time, ie as the travel time increases due to the bridge length or surface, the likelihood of additional vehicles arriving while there is a vehicle already crossing in the same direction increases. This causes a longer delay to the vehicles without priority as they need to wait for both, and the subsequent vehicle to cross. Refer to section 6.1.1 Flows, Table 9 for guidance on lengths and flows that require signalisation.

4.1.5 High speeds

If the operational speed environment surrounding the bridge is found to generally exceed the posted speed limit, signalisation can be used at one-lane bridges to help with speed management.

4.1.6 Volume of traffic

If the volume of traffic is causing differing delays on each approach, it may be caused by tidal flows or a seasonal flow variation. Signalisation can be used to ensure there is not excessive delay on one side of the bridge.

4.1.7 Bridge loading

If the bridge loading cannot cater for the potential maximum loading on the bridge, ie queued heavy vehicles.

4.1.8 Crash history

If there is a history of head-on crashes on the bridge or crashes with vulnerable road users.

4.1.9 Vulnerable road users

If the volume of vulnerable road users using the bridge is relatively high or if the bridge does not have a separated pedestrian and cycle lane. Vulnerable road users include pedestrians, cyclists, equestrian and motorcyclists, as they are less visible to oncoming vehicles.

4.2 Key considerations

4.2.1 Considerations for users

4.2.1.1 Wide loads

Wide loads will need to be considered when determining the location of any equipment. If a suitable location cannot be found, the type of equipment should be considered, eg hinged poles.

4.2.1.2 Slow vehicles

If the bridge is used by slow vehicles such as farm machinery, the phase time for clearance will need to be longer. Additional detectors may be necessary to implement the extended phase time.

4.2.1.3 Vulnerable road users

Pedestrians, cyclists and equestrian are slower than other road users and will require longer phasing to cross the bridge. Vulnerable road users may not activate loop or motion detectors, so the type of detectors will need to be considered, eg push buttons or infrared static detectors.

Consider an independent phase for cyclists, activated through a separate demand button.

4.2.2 Operational considerations

Approach gradients, winter icing of the roadway and any other factors that may affect the ability of road users to stop safely.

4.2.2.1 Power

Mains power to the site is essential. Fallback uninterruptable power supply (UPS) also needs to be considered in areas where the power supply may be unstable. To determine a suitable duration of battery life through a UPS, the design can generally be calculated so there is enough time to get maintenance personnel to the power supply and reconnect it.

4.2.2.2 Communications

Check the supplier zones for communication coverage. Where possible, a wired connection is preferred. For more remote areas where a wired connection is not available, mobile communications can be installed. Mobile communications sites need a specific login arrangement in this situation for security.

Sites with mobile communications should not provide a continuous video feed due to the data usage costs. Instead, these mobile communications sites should be set up so the video feed can be turned on if required via the login screen. For historical information, the camera should take a photograph every minute so that the time and cause of an issue can be easily identified. For these sites it is important to have the necessary alarms set up to inform operators if there is an issue at the bridge so they can dial into the camera.

4.2.2.3 Operator visibility and CCTV location(s)

Closed-circuit television (CCTV) cameras should be positioned so operators can see both limit lines and approaches. Cameras should not be installed on the signal pole as the camera should capture the aspects. Camera quality should be appropriately selected, consider if zoom is needed and the resolution required.

4.2.3 Security

There have been issues of equipment being stolen from signalised one-lane bridges due to the remoteness of the sites, particularly batteries and cameras. At a minimum, cages should be installed around the cabinets to provide additional security. Most of the expensive equipment is in the cabinets. In higher-risk areas, it may be sensible to install more cost-effective equipment if the replacement rate is high due to theft or vandalism.

Alternatively, controller boxes can also be installed to provide additional protection. Refer to the latest version of ITS design standard: P43 Traffic signalling systems.

4.2.4 Resilience

Most one-lane bridges cross rivers and may be located in valleys. Therefore, the flood and landslide risk will need to be assessed as it may impact the location of equipment. Poles should be positioned away from trees to reduce the likelihood of a falling tree or branch damaging equipment and to avoid vegetation from obstructing the equipment. This will also reduce ongoing vegetation maintenance.

4.2.5 Safety

Roadside barriers should be installed around equipment to reduce the roadside hazard if a vehicle loses control and crashes. These barriers will also protect maintenance crews, contractors and police, who may need to access the equipment, from vehicles.

5 EQUIPMENT

This section provides guidance on how to select equipment based on the environment and users. It also refers to other Waka Kotahi guidelines and New Zealand standards that may be needed in specific circumstances.

5.1 Signal poles

Standard 4.1m-tall signal poles generally should be utilised. However, alternative poles could be utilised to provide street lighting, additional height for camera mounting, or if a high-level aspect is required for greater visibility due to the vertical approach alignment. Poles should comply with the standards as set out in the latest version of ITS design standard: P43 Traffic signalling systems.

5.1.1 Wide/abnormal wide loads

On routes where wide loads are anticipated and so that the signals can be sited correctly, collapsible poles with hinges and padlocks are to be utilised. Care will need to be taken to ensure the poles can be laid down without damaging the aspects. A small support bracket can be added to the pole (see **Error! Reference source not found.** below) or a ground support can be included in the design. The resting area that a pole will be lowered to must be considered to ensure that it does not create a hazard or block access to users when lowered, and can be safely raised and lowered without placing the operator in any danger.

Figure 1. Typical bracket to support weight and enable pole to be lowered without resting on the signal aspects or equipment

5.1.2 Signal pole footings (bridge deck)

Where possible, alternative locations should be sought to avoid installing a pole in the bridge deck. However, where the pole is to be installed on a bridge deck, the use of suitable shallow-ground retention sockets should be considered. The pole should be cut down to ensure the aspects are positioned at the correct above-ground height. Consideration for crossing the expansion joint with any ducting needs to be considered.

5.2 Aspects

200mm full roundel aspects are recommended. Installing 300mm aspects should be considered if the additional light output is warranted at sites with poor visibility or where weather or environmental conditions reduce the prominence of the signals.

5.3 Civils

Any works done on the bridges will require approval from the asset owner's bridge engineers, so the structural integrity of the bridge is not compromised.

5.3.1 Ducting

Check if there is existing ducting across the bridge. Where new ducting is required, it is recommended that galvanised steel ducting is used for durability. Any ducting needs to be securely attached to the bridge and should be as discreet as possible. For guidance, refer to the latest version of ITS design standard: Ducts.

5.3.2 Cabinets

Refer to the latest version of ITS design standard: P43 Traffic signalling systems. In high-risk areas, an alternative cabinet may provide better security than those specified in P43, eg a concrete chamber or an inground chamber. See section 4.2.3 Security for further guidance.

5.3.3 Chambers

Refer to the latest version of ITS design standard: Jointing chambers and pull pits.

5.3.4 Street lighting

Refer to the Waka Kotahi Specification and guidelines for road lighting design (M30) and the relevant part(s) of AS/NZS 1158: Lighting for roads and public spaces, as listed below:

- AS/NZS 1158.0:2005 Part 0: Introduction
- AS/NZS 1158.1.1:2005 Part 1.1: Vehicular traffic (Category V) lighting – Performance and design requirements'
- AS/NZS 1158.1.2:2010 Part 1.2: Vehicular traffic (Category V) lighting – Guide to design, installation, operation and maintenance
- AS/NZS 1158.3.1:2020 Part 3.1: Pedestrian area (Category P) lighting – Performance and design requirements
- AS/NZS 1158.2:2020 Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting

Refer to the Waka Kotahi Bridge manual (SP/M/022) section titled Accommodation of signage and lighting columns, if lighting is required.

5.4 Detection

5.4.1 Advance detection loops

For advanced detectors, consider how far in advance the detector is needed and if any turnoffs between the advanced detector and the bridge will activate a phantom phase. Advanced detection can be used to extend or activate a green phase to reduce delay.

Note: If activating a phase, it is best to ensure that the approaching vehicle is brought to a stop prior to showing green. Crashes have been seen when providing a call in advance that permits drivers to enter the controlled zone without slowing, as this becomes the normal and results in failure to stop when necessary.

Activating a phase is often only necessary if timed clearance across the bridge is used rather than detected clearance, as additional time will likely be required to afford the approaching driver access into the controlled zone.

5.4.2 Limit line/SCATS detectors

Refer to the latest version of ITS design standard: P43 Traffic signalling systems. If the intention is to operate the bridge via SCATS, it is advisable to install a SCATS-compatible in-ground detector loop at the limit line. Whilst radar detection will provide a suitable alternative, a loop should be installed if possible due to the critical nature of the detection. Loops are noted as providing the highest level of reliability and cannot be put out of alignment in the same way as above-ground detection can.

5.4.3 All-red extension

Critical to the operational efficiency of the signals is the use of all-red extension detection. The placement and extension periods need to be carefully considered to guarantee that all the traffic is correctly accounted for, whilst either on the bridge or clearing the bridge. Suitably located above-ground detectors on the bridge are recommended as they provide continuous coverage, as compared to in-ground detector loops which only provide point coverage.

5.4.4 Above-ground detection

Detector types need to match the role required to ensure that all users are detected and catered for. It is likely that additional detection is required if intending to detect pedestrians, cyclists or equestrians, as well as vehicles. Above-ground detectors can provide advanced detection and provide a larger area of coverage as well as point detection. It is important to consider the detection areas carefully to avoid unwanted detections being placed.

5.4.5 Radar

Radars are becoming increasingly more affordable and reliable and can provide additional benefits to loop detection being adaptive in the form of coverage. If proposing to use a radar solution due to complex issues, discuss with the relevant TOC to determine suitability.

5.4.6 Push buttons

On narrow one-lane bridges without pedestrian and cyclist segregation, a push button could be used to activate a phase with a longer clearance time to protect vulnerable users from oncoming and following traffic. Additional detection may be desirable to either minimise excess waste time or to ensure that sufficient time is provided to enable vulnerable road users to clear the bridge.

5.4.7 Counting loops

Counting loops are likely unnecessary at one-lane bridges as limit-line loops or advance loops will suffice if connected to a suitable system and are correctly set up to monitor traffic.

5.5 Road markings

5.5.1 Centre lines

Continuous centre lines should be marked on the sealed roadway approaches to one-lane bridges. The centre line should be marked from the point where the width of the approach roadway is at least 5.1m to allow opposing traffic to pass. A centre line should not be marked where the roadway width is less than 5.1m, as noted in TCD Rule 54002, section 7.2(1) Centre-lines.

It may be necessary to widen the lanes and road to accommodate vehicles waiting on red to be passed by those exiting the bridge. An appropriate distance from the bridge will need to be widened and signal timings limited to minimise the possibility of traffic blocking each other should the approaches not be of suitable width over the predicted maximum queue length.

5.5.2 Edge lines

Sealed roadways forming the approaches to one-lane bridges should have reflectorised 100mm continuous edge lines marked.

The edge lines shall form a taper on the sealed roadway approach to one-lane bridges, from the edges of seal or edge lines to the bridge roadway width. Edge lines should normally terminate just clear of the kerbs at the end of one-lane bridges, but they may be continuous over bridges where there is sufficient width to effectively mark and maintain lines.

5.5.3 Limit lines

The limit line should be marked at the point where the width of the approach roadway is at least 5.1m, to allow opposing traffic to pass.

Limit lines on sharply curved bridge approaches should be located to allow for the swept path requirements of vehicles likely to be using the road, rather than the roadway minimum width requirements noted in TCD Rule 54002, section 7.2(1) Centre-lines.

It is recommended that in-ground loops are installed at the limit line because they are simple and reliable. However, in-ground loops will not always pick up cyclists and will not activate for pedestrian or equestrian

users. At sites with high volumes of cyclists, pedestrians and equestrians, static infrared detectors may be more suitable, or push-button demand units.

5.5.4 Keep-left reminder signs and road markings

A keep-left sign should be used on the departure side of one-lane bridges to remind road users that they should travel on the left. As per the Waka Kotahi Traffic control devices manual (TCD manual) part 5: Traffic control devices for general use – between intersections (part 5): Keep left reminders, a W14-11 keep-left sign should be installed where, in the opinion of the road controlling authority (RCA), there is a problem with drivers failing to keep left. The diamond-shaped warning sign and supplementary message sign must be installed together as a combination sign.

Figure 2. W14-11 kept-left sign with supplementary sign

Care must be taken when locating a keep-left reminder arrow near an intersection to ensure that the arrow does not mislead, hence a W14-11.1 drive on left sign should be installed at intersections or driveways where the RCA considers that drivers turning at the intersection or driveway need a reminder to drive on the left side of the road. The diamond-shaped warning sign and supplementary message sign must be installed together as a combination sign.

Figure 3. W14-11.1 drive on left sign with supplementary sign

The signs should be located where approaching drivers have an uninterrupted view of it over a distance of at least 120m in rural areas and at least 60m in urban areas.

The signs should be installed either in advance of the hazardous section of roadway or in advance of a particular hazard by at least the distance shown in Table 1 below.

Operating speed	Distance
50km/h	65m
70km/h	100m
80km/h	120m
90km/h	140m
100km/h	160m

Table 1. W14-11 and WD14-11-1 signs minimum distance to speed ratio

In some cases it may be appropriate to repeat W14-11 keep-left signs, and also include keep-left arrow markings on the road itself in each lane beyond the bridge to reinforce to road users that they should travel on the left.

Figure 4. Keep-left reminder arrows

Application	
Colour	Reflectorised white
Dimension	As shown in Figure 5 below
Proportion	Length dimensions can be increased by 50% if needed
Approach sight distance to arrows	Approximately 65m–100m in urban areas and 140m–160m in rural areas when used so that there is enough time for motorcycle riders to see them and avoiding riding over them

Table 2. Standard marking of keep-left reminder arrows

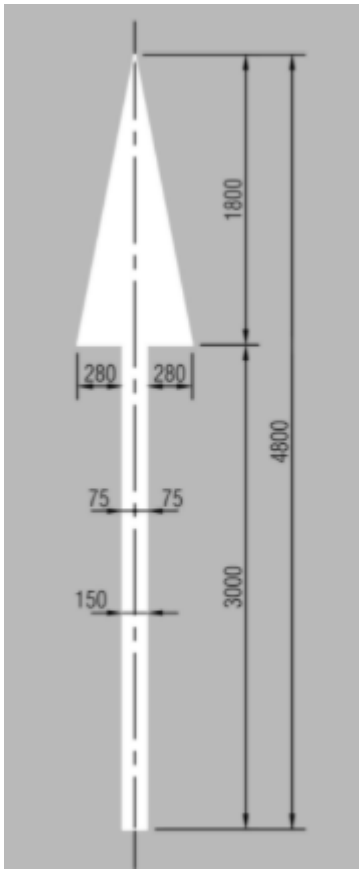


Figure 5. Keep-left reminder arrow marking dimensions

5.5.5 Temporary signage

Temporary signage shall be installed to notify users that the bridge priority has changed for a maximum period of six weeks. Signage W2-1.11A or W2-1.11B is to be used, refer to the TCD manual for sign specifications.

Figure 6. W2-1.11A sign new road layout supplementary

W2-1.11A	Hazard warning supplementary – new road layout		
Shape and size	Rectangle 900mm x 450mm (supplements W2-1)		
Background	Orange (RF)		
Border	Black 25mm		
Legend	**Description**	**Colour**	**Size**
	NEW ROAD	Black	120/16.8
	LAYOUT	Black	120/16.8

Table 3. W2-1.11A hazard warning supplementary – new road layout

Figure 7. W2.-1.11B sign new road layout supplementary for backing board

W2-1.11B	Hazard warning supplementary – new road layout		
Shape and size	Rectangle 1200mm x 600mm (supplements W2-1B)		
Background	Orange (RF)		
Border	Black 30mm		
Legend	**Description**	**Colour**	**Size**
	NEW ROAD	Black	160/22.4
	LAYOUT	Black	160/22.4

Table 4. W2-1.11B hazard warning supplementary – new road layout

5.5.6 Removal of all redundant markings and signs

All redundant markings and signs are to be erased or removed prior to commissioning the new signals.

5.6 Advanced warning signs

All sites will need to have permanent warning signage, as detailed below.

5.6.1 W10-4 sign traffic signals ahead

A W10-4 sign consists of a traffic signal symbol displayed on a standard diamond sign plate. Refer to the TCD manual part 5 Emergency vehicle – flashing signals/Signs.

Figure 8. W10-4 sign traffic signals ahead

The sign should be:

- located where approaching drivers have an uninterrupted view of it over a distance of at least 120m in rural areas and at least 60m in urban areas
- installed in advance of the entrance by at least the distance shown in the following table.

Operating speed	Distance
50km/h	65m
70km/h	100m
80km/h	120m
90km/h	140m
100km/h	160m

Table 5. W10-4 sign minimum distance to speed ratio

5.6.2 W10-5 sign with beacons

A W10-5 sign with beacons and a supplementary sign can be installed prior to the traffic signals to activate when a vehicle approaches or a queue is detected. It may be warranted where approach speeds are likely to be high or where the signals are not able to be seen easily at a suitable approach distance. Similarly, such a sign can be installed to warn drivers of queues where the back of the queue would be difficult to determine by approaching drivers.

Figure 9. W10-5 warning sign with supplementary signs

A sign combination consists of a W10-5 sign with the supplementary sign PREPARE TO STOP, QUEUED VEHICLES or HIDDEN QUENE and two alternately flashing yellow traffic signal lights. The lights should be activated by a suitable controller so that they flash at appropriate times to provide the necessary warning for approaching drivers, having regard to the likely length of queues or the presence of a red signal.

Signs may be installed in advance of an intersection controlled by traffic signals where in the opinion of the local RCA:

- the road alignment does not provide sufficient stopping sight distance to the end of the likely maximum length queue
- the existing road alignment cannot reasonably be altered to overcome the deficiency
- standard warning signs have proven insufficient to address a safety problem there.

No other sign may be attached to a W10-5 sign or its support. Minimum sizes are installed as per Table 7 below. The sign should be located where approaching drivers have an uninterrupted view of it over a distance of at least 120m in rural areas and at least 60m in urban areas (refer to Table 7 below).

The sign should normally be installed on the left-hand side of the road but where approaching drivers' sight distance is restricted, the sign may be installed on the right-hand side of the road. Where two approach lanes exist, signs should be gated, ie a sign on both sides of the road, with the lights arranged to flash in synchronisation top lights together then bottom lights together.

The sign should be installed in advance of the end of the likely maximum queue length by at least the distance shown in Table 6 below.

Posted speed	Distance
≤50km/h	65m
60km/h	80m
70km/h	100m
80km/h	120m

Table 6. W10-5 sign minimum distance to speed ratio

Signs should be at least the size shown in Table 7 below.

Area	Speed	Minimum size
Urban	Posted speed limit up to 70km/h	600mm x 600mm
	Divided roads with posted speed in excess of 50km/h	750mm x 750mm (or larger)
Rural	Posted speed limit over 70km/h	750mm x 750mm
	On motorways or divided roads and on other roads where operating speeds are higher than normal (ie the 85th percentile speed exceeds 100km/h)	900mm x 900mm (or larger)

Table 7. W10-5 minimum sign sizes

5.7 Bridge signage

5.7.1 Bridge end markers W20-5.1 and W20-5.2

Standard bridge signage including bridge end marker posts should be installed on the bridge end posts, road safety barriers, or other such width restrictions that come within the clear zone or trafficable approach width of the road.

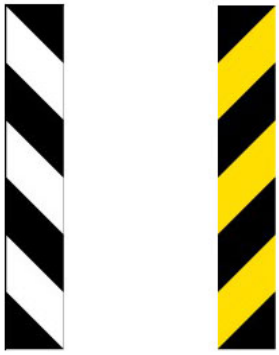


Figure 10. W20-5.1 and W20-5.2 bridge end markers

Bridge end markers are not to be installed on the signal poles, which are to be installed outside of the clear zone. The yellow pole could be confused for the yellow of an offside bridge end marker, as such every effort should be made to ensure that the offside signal poles are not mistaken for an offside yellow bridge end

marker post. Dimensions and further details regarding bridge end marker posts can be sourced from the TCD manual part 5: Bridge end marker posts at road safety barriers, bridges, and other width restrictions.

5.7.2 Other signage

In addition to the above, a W13-2 sign should be installed on each approach in advance of the single-lane section.

Figure 11. W13-2 sign

The sign should be:

- located where approaching drivers have an uninterrupted view of it over a distance of at least 120m in rural areas and at least 60m in urban areas.
- erected in advance of the nearest bridge abutment or approach guardrail end by at least 90m in rural areas and at least 45m in urban areas.

Additional information is available from the TCD manual part 5: Narrow bridges.

5.8 Active warning and time-to-green messaging

Active warning signs can be used to indicate queues ahead or to slow vehicles approaching the bridge. Countdown-to-green time or please-wait messaging will help reduce red-light running and crashes if drivers cannot see oncoming vehicles. This signage informs the driver that they have been detected and may reduce frustration. This responsive signage informs the driver that they have been detected and may reduce frustration.

5.9 Controller

5.9.1 Function

The traffic signal controller is to be a standard functioning traffic signal controller as set out in the latest version of ITS design standard: P43 Specification for Traffic Signals, including the Regional Special Conditions to P43 as produced by the local RCA in which the work is being undertaken.

Section 6 Operation of these guidelines sets out the details of specific functionality that is to be set up for each one-lane bridge. Typically, a four-signal group controller would be sufficient for one-lane bridges, however, depending on the configuration, the inclusion of pedestrians and cyclists as well as the use of dummy signal groups to manage clearance times, an eight-signal group controller may be required.

5.9.2 Location

All equipment is to be installed at a safe distance from the live lanes, for the controller this should be greater than 6.0m. If 6.0m cannot be achieved or where the posted speed is greater than 50km/h, a crash barrier must be installed to protect errant motorists, the controller cabinet and maintenance crew who may be working on it. Notwithstanding other requirements, the controller must not be located in the direct path of a vehicle's approach or the probable trajectory of a vehicle that has lost control.

Provision of a hardstanding area around the controller is required to provide good maintainability, when located remotely to ensure a suitable safe access route is also available. Where practicable also ensure that undergrowth is maintained.

5.10 Power considerations

5.10.1 UPS

Refer to the latest version of ITS design standard: P43 Traffic signalling systems when considering whether to install a UPS system. The design engineer should consider how the installation will operate under a failed state, taking into consideration the ability for drivers to see the opposing limit line as well as traffic volume, approach speed and vehicle classification. Other considerations such as use by vulnerable road users shall also be considered. These issues all need to be weighed up against the stability of the power supply, the ability for a technician to attend a site quickly and if necessary, connect in a generator, through to the additional security precautions required in providing a UPS.

Single-lane operation is often found in remote areas where power supplies may suffer from fluctuations as well as total failure. Whilst a UPS is often seen as a requirement for total power failure, it also provides more benefit from smoothing out poor-quality power supplied that would otherwise reduce the life of a traffic signal controller and/or cause it to fault and switch off.

Where provided, a UPS needs to be capable of providing sufficient backup power to enable the installation to operate until a technician is able to attend. The time for this response will depend on the contracted service level agreements (SLAs) for attendance to site.

In the event of power failure, a system will need to be in place to inform the maintenance contractor or operator, for remedial action to take place.

In the event of power failure, a system will need to be in place to inform the maintenance contractor or operator, for remedial action to take place.

5.10.2 Solar/wind power

Currently neither solar or wind power are deemed suitable to provide for the full-time demands of a signal installation, however either could be provided to complement a UPS solution, such as to charge batteries and extend operation in the event of a power failure.

5.11 CCTV

Every site shall require at least one pan-tilt-zoom (PTZ) camera where visibility can be gained of both limit lines and the extent of standard operational queues. It is beneficial to mount the camera away from the limit lines such that it is possible to see both limit lines without having to pan the camera.

At sites that have significant seasonal queuing, where operator intervention is anticipated or where topography limits visibility, additional cameras should be considered. This could take the form of a fixed camera to complement the PTZ and to enable operators to view both directions simultaneously, or a second PTZ, depending on circumstances.

A constant network connection such as ADSL is preferred for the CCTV camera feed. Cellular dial-up is an option but is only suitable for occasional use and should only be considered as a last resort.

5.12 Security

Security is always likely to be an issue with remote sites.

There are a few considerations that can assist in keeping the equipment safe. The simplest is the provision of a door switch that alarms on SCATS and additional security CCTV. If the camera is in a safe location, signs such as ‘CCTV surveillance in operation’ can be installed.

Other considerations include:

- additional steel strengthening and locks on controller cabinets
- construction of a fenced compound
- concrete cabinets
- location of the auxiliary equipment to ensure that it is within easy view of passing motorists, for security purposes.

5.13 Safety barrier

Where a safety barrier is required, it shall comply with the requirements of the Waka Kotahi Road safety barrier systems (NZTA M23).

Where the barrier is part of the bridge barrier, it must also comply with the requirements of SP/M/022.

5.14 Orientation monitors

Due to the remote location of many one-lane bridge installations, it is not possible for routine inspections to be undertaken. Orientation monitors enable the operator to know if an aspect has been knocked out of alignment. In some instances, this could indicate to opposing traffic that they have right of way. Orientation monitors should be considered on poles where the aspect is vulnerable to being knocked out of alignment.

6 OPERATION

This section covers the operation of the signalised one-lane bridge and includes recommendations on how to model the signals in LinSig, SCATS and fault management.

6.1 Modelling

Traffic assessment/modelling is required at all sites to assess the length of the queues and delay times that motorists are likely to encounter.

Modelling software used shall be either LinSig or SIDRA. Paramics can be utilised in addition to provide a more graphical output, should it be required.

6.1.1 Flows

Accurate traffic flow data will need to be collected to facilitate the final modelling assessment. However, initial flow data can be calculated through a 30-minute count onsite and factored up to provide an initial assessment using Table 9 below based on total flow and distance between hold lines. It is advisable to undertake several counts at various days and time periods and under various weather conditions to ensure that the highest flow period is being assessed.

Assuming an average speed across the bridge of 50km/h, the following maximum green times and all-red times have been developed, based off CoPTTM section J – Level 1 temporary traffic management handbook. These phase times and the maximum wait times displayed in Table 8 below are for design guidance and each location will require a specific set of timings.

Bridge length (m)	50	100	150	200	250	300	400	500	700	1000
Maximum green time (s)	35	40	45	50	50	50	50	50	50	50
All-red time (s)	10	15	20	25	30	35	45	55	75	105
Maximum wait time (s)	55	70	85	100	110	120	140	160	200	260

Table 8. Guidance for signal timings based on bridge length

Table 9 provides guidance for the expected vehicle queue length per cycle based on the arrival rate of the maximum hourly flow and the maximum wait time.

	Bridge length (m)									
Maximum hourly flow (vph)	**50**	**100**	**150**	**200**	**250**	**300**	**400**	**500**	**700**	**1000**
200	2	2	2	3	3	3	4	4	6	7
400	3	4	5	6	6	7	8	9	11	14
600	5	6	7	8	9	10	12	13	17	22
800	6	8	9	11	12	13	16	18	22	29
1000	8	10	12	14	15	17	19	22	28	36

Table 9. Guidance for the vehicle queue length per cycle

Note that when the initial figure falls into the amber zone, it will be necessary to include intelligent solutions to the design to minimise lost time and improve efficiency. If the calculations fall into the red zone, it is unlikely that a suitable signal design can be achieved without substantial delay to motorists. Any calculations falling into the blue zone indicate a need to consider the reason for signalising the bridge, as the flow is below what is considered necessary. This is likely to result in drivers failing to stop for the signals should they experience delays and are often not seeing opposing vehicles while they wait. Careful configuration will be required to ensure that drivers are not unduly delayed.

The road condition, surface, geometry, high proportion of heavy vehicles, cyclists, or walkers where facilities are not provided to separate modes, will likely affect travel times across the bridge, hence the overall capacity of the signals.

6.1.2 Scenario time periods

The modelled flow-data periods need to include:

- a standard weekday – morning and evening peak as well as off-peak
- a standard weekend peak – morning and evening only
- seasonal variation consideration
- public holiday peak.

Where the route can be demonstrated to have minor variation in the above periods and where there is little seasonal traffic-flow variation, these aspects can be discounted from the modelling.

6.1.3 Sensitivity testing

In addition to testing the scenario time periods shown in section 6.1.2 Scenario time periods above, sensitivity testing should be undertaken, taking into account annual growth within the area as well as to account for any district plan directives/plan changes that are likely to result in additional growth.

Where public holidays have not been accounted for, sensitivity testing should be undertaken to account for the higher flows. In addition, local events may create higher-than-anticipated traffic flows, known events should be considered.

Also assess whether the route is likely to act as the detour for high-flow highways or is part of a known detour route, undertake sensitivity testing to assess where necessary.

6.2 SCATS vs vehicle activated

Wherever possible, the bridge should be connected to SCATS as opposed to operating vehicle activated. This gives the ability for the bridge to be monitored, report faults, and for the cycle time to be adapted depending on the demand. Under SCATS, depending on the configuration, the operation will essentially be similar to vehicle activated.

6.3 Fault monitoring/dial-up

If SCATS is not available, the installation must be remotely monitored with a system that will report to the RCA that the signals are not operating in the event of a critical fault.

6.4 Rest in red, rest in last cycle, or cycle

Resting the signals in red is encouraged so the signals can control vehicles entering the controlled zone across the bridge. Best practice would be to stop an approaching vehicle prior to it receiving a green signal. The signals are left resting but are prepared to change upon detecting another approaching vehicle.

Advanced detection can be used to extend or activate a green phase to reduce delay.

Note: If activating a phase, it is best to ensure that the approaching vehicle is brought to a stop prior to showing green. Crashes have been seen when providing an advance call that permits drivers to enter the controlled zone without slowing as this becomes the normal and they fail to stop when necessary.

6.5 Phase diagrams

The Albert Town Bridge phase diagram indicates the typical phase sequence for a one-lane bridge, with a green time for each direction and a corresponding all-red phase for the bridge to clear:

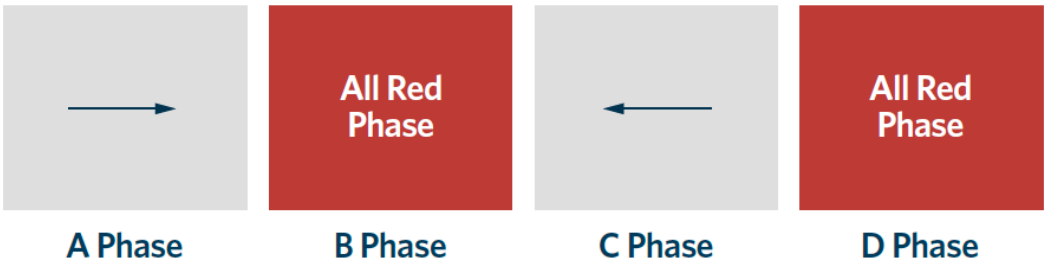


Figure 12. Phase diagram for Albert Town Bridge

The Maruia River Bridge phase diagram below shows a third green phase for a driveway or side road at one end of the bridge within the through movement control zone. The diagram below shows how this can be incorporated into the typical two-green sequence by adding an additional phase and separate all-red.

Other methods are available that would permit the side road to start prior to the traffic on the main approach at the same end. Special conditioning is required in both scenarios to ensure that the minimum inter-green and all-reds are not violated.

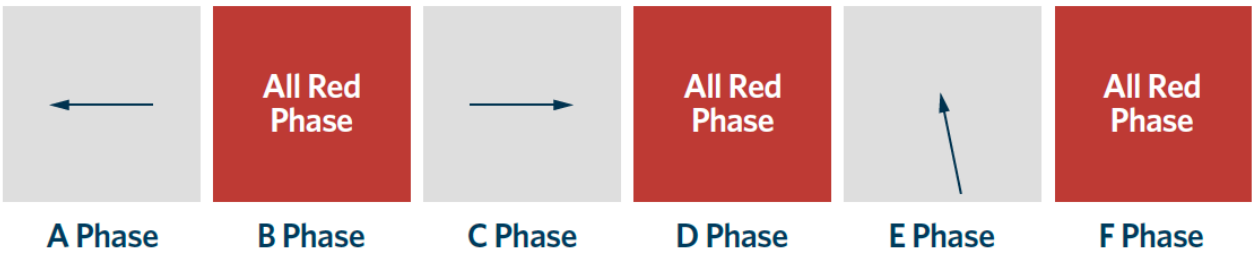


Figure 13. Phase diagram for Maruia River Bridge

6.6 Dimming

Dimming should be provided to reduce the glare of the signals at night.

6.7 Inter-green extension period

Sufficient inter-green and or extension periods with safeguards must be provided to avoid the creation of a situation of blind priority, whereby road users with inadequate visibility for safe stopping prior to the single-lane section might be encouraged by the green signal to press on and be unable to avoid a collision with an oncoming vehicle.

6.8 Typical timings

The typical timings will be determined by the bridge length and traffic flow. Refer to Table 8 and Table 9 in section 6.1.1 Flows, for typical timings and flows based on bridge length.

6.9 Backup detection and/or detector fault management

If there is a fault in the traffic signals, the signals should run the maximum phase times for the sequence or flash yellow to inform drivers to abide by give way rules. In a fault situation the controller should remotely monitor the bridge and follow an appropriate course of action.

6.10 Manual override

If both ends of the bridge are visible, a manual override with full inter-green extension period should be built into the system.

6.11 Detection set up

Detection needs to be adequate for the site and set up so all intended detection occurs correctly. Special consideration should be given to ensure ghost phases are not triggered, which would reduce the efficiency of the signals. Refer to section 5.4 Detection for more details.

7 INSTALLATION AND MAINTENANCE

This section covers the installation and maintenance of one-lane bridges. It includes references to the latest version of ITS design standard: P43 Traffic signalling systems.

7.1 Installation contractor

Installation works shall be carried out in accordance with the latest version of ITS design standard: P43 Traffic signalling systems, section titled Installation and commissioning of traffic signal equipment.

7.2 Maintenance contractor

All maintenance works shall be performed by the RCA's approved contractor or as per the network outcomes contract (NOC) where in place.

7.3 Safety in maintenance

All maintenance tasks shall be carried out to meet the RCA's requirements under the current traffic signal maintenance contract.

Maintenance vehicles should be parked so as not to become a safety issue to the users of the road and surrounding footpaths/cycleways.

8 TYPICAL LAYOUTS

This section provides guidance on typical layouts for signalised one-lane bridges.

The following are covered in this section:

- general signal layouts
- signage and markings to install and remove
- detection methods
- cycle markings (if required).

Each site will require a minimum of three display aspects for each approach:

- primary
- secondary or tertiary
- plus one other, being either primary or tertiary.

Best practice is to provide a nearside primary and both a secondary and tertiary, however sight constraints may dictate the aspects that can be provided. Consideration should be given to the location of the limit line if only a single secondary is provided, such that drivers are better located to see the primary while stopped. Where necessary, consideration of additional high-level aspects can be considered. Such aspects would be in addition to the above primary and secondary display combinations.

Ensure that the one-lane bridge signage and road lines are marked on the plan for removal and that new signal-ahead signs have been specified and meet the required visibility requirements.

For existing detection layouts, refer to section 11 Appendix A – Examples of one-lane bridge layouts, below.

9 TYPICAL SET UP

This section provides typical operational set up and information required for the controller information sheet and SCATS.

9.1 Controller information sheet

The controller information sheet should include the following information:

- layout plan
- install notes
- signal group information
- phase control
- detectors
- detector alarm categories
- time settings
- pedestrians
- special-purpose timers and notes (including any relevant logic notes)
- flexi and special flags
- conflict matrix
- all red.

Relevant logic notes could include phase sequencing or extensions and triggers for active/slow modes.

9.2 SCATS

The operation of the traffic signals should be set up in SCATS.

Examples of the SCATS set up for Albert Town Bridge and Maruia River Bridge are displayed in Figure 14 and Figure 15 below.

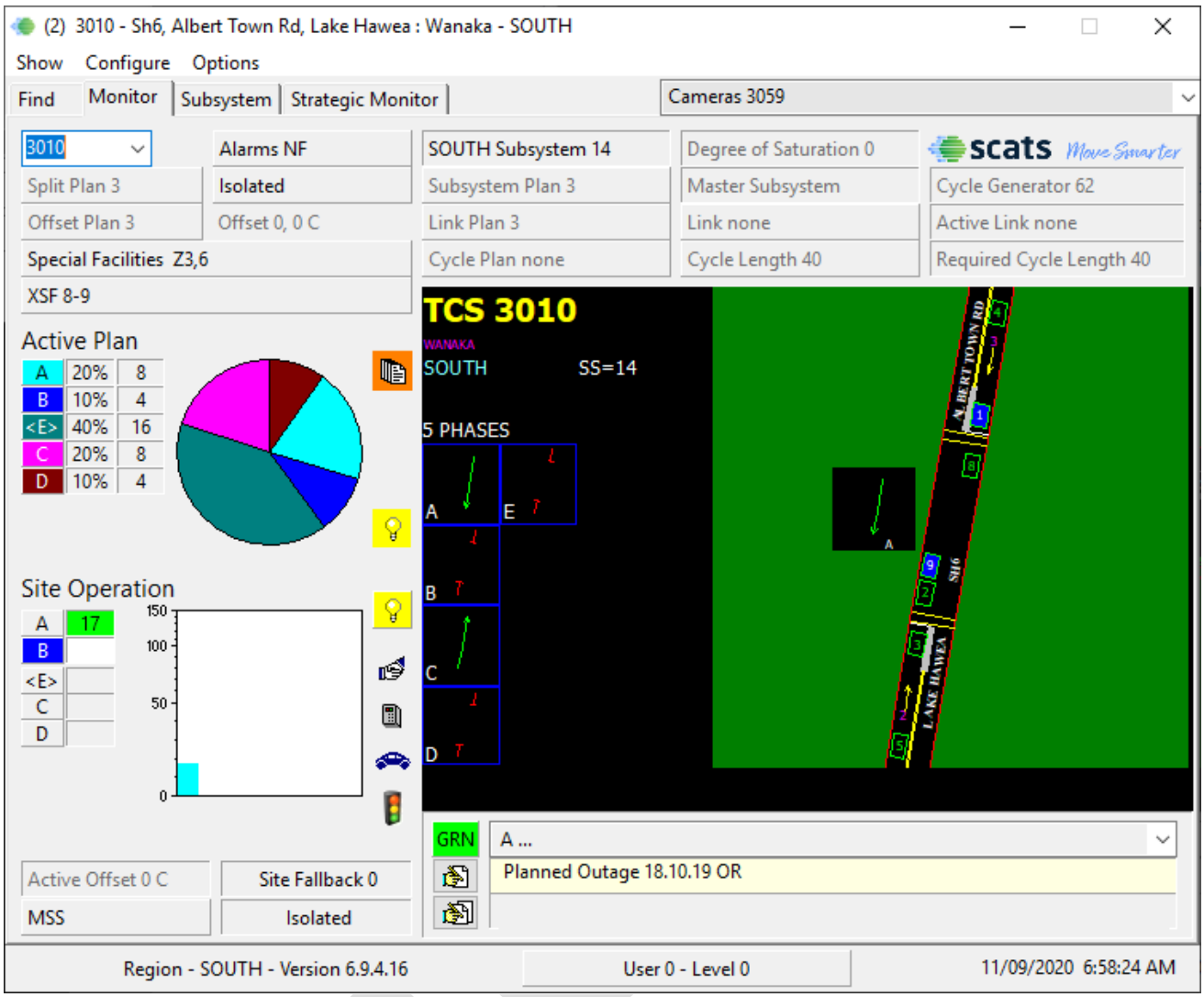


Figure 14. SCATS diagram for Albert Town Bridge

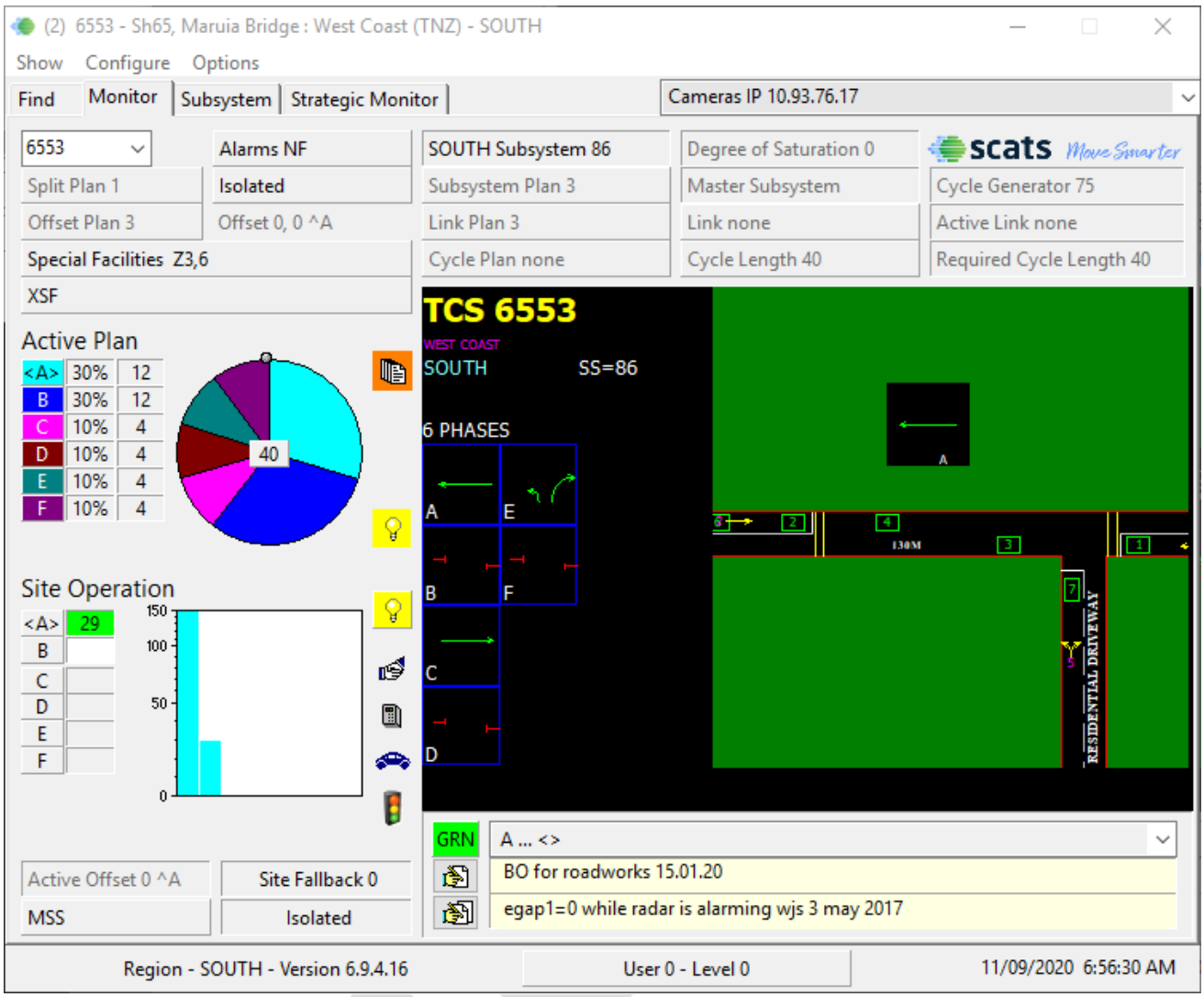


Figure 15. SCATS diagram for Maruia River Bridge

10 CONSULTATION

This section highlights stakeholders that may need to be consulted prior to the design or implementation of one-lane bridge signals.

10.1 Consultation with stakeholders

Stakeholders should be consulted before installing signals on a one-lane bridge. The stakeholders may be able to provide valuable information regarding the site.

10.1.1 Local RCA

The local RCA should be consulted as they may have information on the traffic volumes, if a traffic monitoring system (TMS) count is not available. They may also have insight if there are seasonal and tidal flows across the bridge.

10.1.2 Waka Kotahi transport operations centre

The Waka Kotahi TOC should be consulted as they will be responsible for the operation and maintenance of the signals. They will also receive any alerts if there is a fault with the signals.

10.1.3 Waka Kotahi Technology team

The Waka Kotahi Technology team should be consulted if the installation is a Waka Kotahi asset or going to be connected to a Waka Kotahi TOC as they can advise on the communication method, ITS specifications and integration requirements. Seek clarification from Waka Kotahi via email: itsspec@nzta.govt.nz

10.1.4 Heavy haulage

Heavy haulage should be consulted as the heavy vehicle usage will determine the:

- location and type of signal poles if the bridge is used by wide loads
- phase times as heavy vehicles will take longer to stop, start and cross the bridge
- location of any advanced detection and signage.

10.1.5 Cycle groups

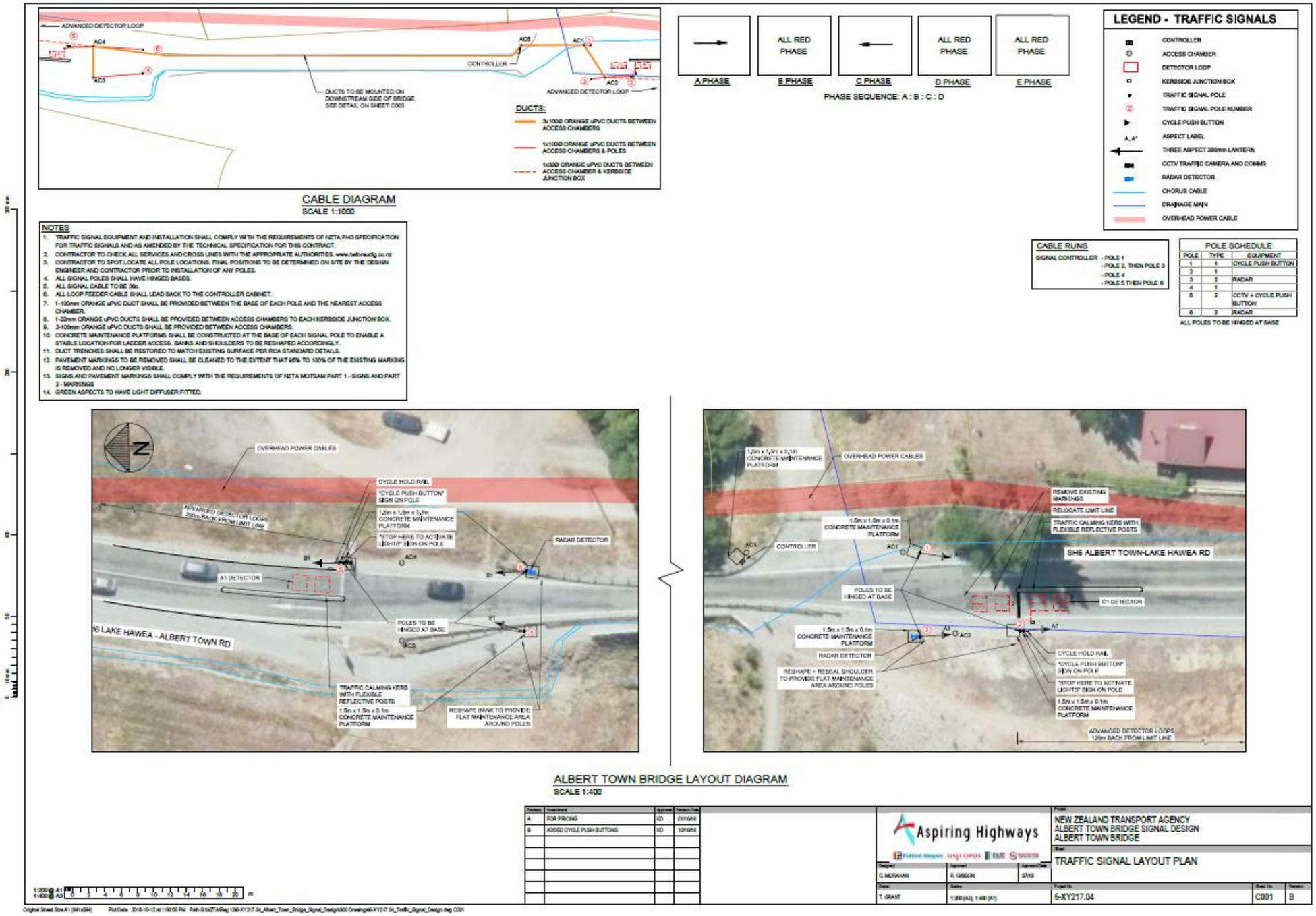
If the bridge has a high active-mode use, cycle groups will have interest as they will be concerned about the safety of cyclists on the bridge. They may also have an opinion on the detection type for cyclists.

10.1.6 Landowners

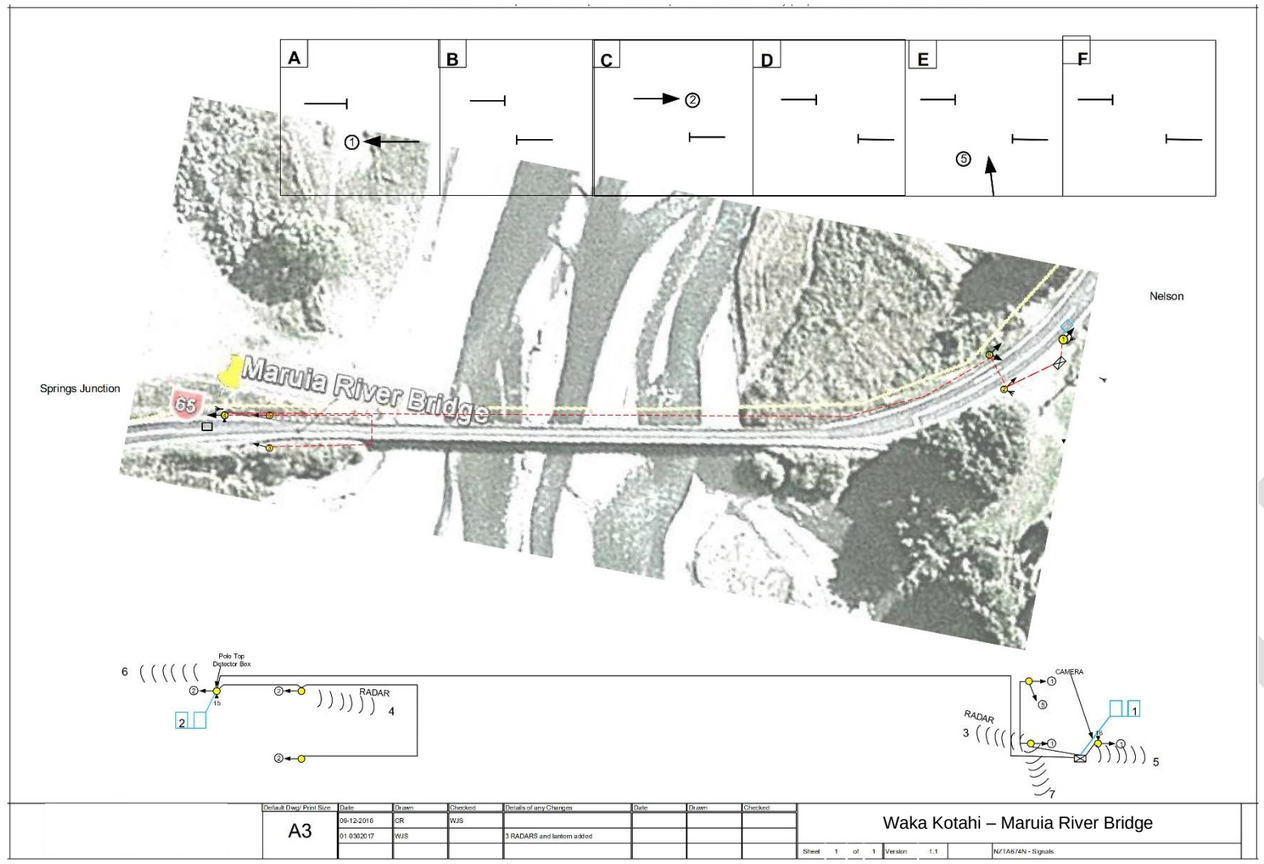
Landowners should be consulted as they will likely be using the bridge the most. They will also likely be using the bridge with slow modes, eg farm vehicles, equestrian or active modes.

11 APPENDIX A – EXAMPLES OF ONE-LANE BRIDGE LAYOUTS

The following examples of one-lane bridges display the information required on a typical layout to signalise a one-lane bridge. The first is of the Albert Town Bridge on SH6, which crosses the Clutha River. The signals are activated by loop detectors for vehicles and a push button for cyclists. There are also advanced detectors 120m–200m from the limit line to reduce delay on the bridge. Above-ground radar detectors are used to extend the red time if vehicles have not cleared the bridge in the typical red time. The drawings clearly label all the equipment, signage and road markings to install and remove.



The second example is of the Maruia River Bridge on SH65 north of Springs Junction. The signals are activated by above-ground radar detectors. Radars are also used to extend the red time if vehicles have not cleared the bridge in the typical red time. The bridge is more remote than the Albert Town Bridge and therefore does not have specific cyclist activation as the volume is likely very low.



12 REFERENCES

This section lists all external and Waka Kotahi references included in this document.

12.1 Industry standards

Standard number / name	Source	Licence type and conditions
AS/NZS 1158.0:2005 Part 0: Introduction	Standards NZ website	Available for purchase
AS/NZS 1158.1.1:2005 Part 1.1: Vehicular traffic (Category V) lighting – Performance and design requirements'	Standards NZ website	Available for purchase
AS/NZS 1158.1.2:2010 Part 1.2: Vehicular traffic (Category V) lighting – Guide to design, installation, operation and maintenance	Standards NZ website	Available for purchase
AS/NZS 1158.3.1:2020 Part 3.1: Pedestrian area (Category P) lighting – Performance and design requirements	Standards NZ website	Available for purchase
AS/NZS 1158.2:2020 Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting	Standards NZ website	Available for purchase

12.2 Waka Kotahi standards, specifications and resources

12.2.1 Standards and specifications

See the Waka Kotahi website for the latest versions of the ITS design standards, delivery specifications and core requirements listed below.

Document name
ITS design standard: Ducts
ITS design standard: Jointing chambers and pull pits
ITS design standard: P43 Traffic signalling systems

12.2.2 Resources

Document name / code	Waka Kotahi website link
Bridge manual (SP/M/022)	https://www.nzta.govt.nz/resources/bridge-manual
Code of practice for temporary traffic management (CoPTTM)	https://www.nzta.govt.nz/resources/code-temp-traffic-management

Document name / code	Waka Kotahi website link
Code of practice for temporary traffic management (CoPTTM) section J – Level 1 temporary traffic management handbook	https://www.nzta.govt.nz/roads-and-rail/code-of-practice-for-temporary-traffic-management/code-of-practice/copttm-document/sections/section-j-level-1-temporary-traffic-management-handbook
Land Transport Rule: Traffic Control Devices 2004, Rule 54002 (TCD Rule 54002), section 7.2(1) Centre-lines	https://www.nzta.govt.nz/resources/rules/traffic-control-devices-2004/#72
Specification and guidelines for road lighting design (M30)	https://www.nzta.govt.nz/resources/specification-and-guidelines-for-road-lighting-design
Road safety barrier systems (NZTA M23)	https://www.nzta.govt.nz/resources/road-safety-barrier-systems
Traffic control devices manual part 5: Traffic control devices for general use – between intersections | Keep left reminders	https://www.nzta.govt.nz/roads-and-rail/traffic-control-devices-manual/part-5-traffic-control-devices-for-general-use-between-intersections/keep-left-reminders/
Traffic control devices manual: Sign specifications	https://www.nzta.govt.nz/resources/traffic-control-devices-manual/sign-specifications/?category=&sortby=Default&term=W2-1.11
Traffic control devices manual part 5: Traffic control devices for general use – between intersections | Bridge end marker posts at road safety barriers, bridges, and other width restrictions	https://www.nzta.govt.nz/roads-and-rail/traffic-control-devices-manual/part-5-traffic-control-devices-for-general-use-between-intersections/features-structures-and-hazards-on-beside-or-above-the-roadway/markers-and-markings-for-hazards-on-or-near-roads/bridge-end-marker-posts-at-road-safety-barriers-bridges-and-other-width-restrictions/
Traffic control devices manual part 5: Traffic control devices for general use – between intersections | Narrow bridges	https://www.nzta.govt.nz/roads-and-rail/traffic-control-devices-manual/part-5-traffic-control-devices-for-general-use-between-intersections/features-structures-and-hazards-on-beside-or-above-the-roadway/height-and-width-constraints/narrow-bridges/
Traffic control devices manual part 5: Traffic control devices for general use – between intersections | Emergency vehicle – flashing signals | Signs	https://www.nzta.govt.nz/roads-and-rail/traffic-control-devices-manual/part-5-traffic-control-devices-for-general-use-between-intersections/emergency-vehicle-flashing-signals/signs/

13 FULL VERSION HISTORY

This table shows the full history of changes made to this document, both minor and major, in chronological order, since the document was first authored.

Minor versions are numbered 0.1, 0.2 etc until such point as the document is approved and published, then it becomes 1.0 (major version). Subsequent edited versions become 1.1, 1.2 etc, or if it's a major update 2.0, and so on.

Version	Date	Author	Role and organisation	Reason
0.1	21/01/2021	Jeff Greenough Marran Young	Principal ITS Engineer, Jacobs New Zealand Ltd Graduate Transport Engineer/Planner, Jacobs New Zealand Ltd	Draft for Waka Kotahi review
0.2	10/03/2021	Jeff Greenough Marran Young	Principal ITS Engineer, Jacobs New Zealand Ltd Graduate Transport Engineer/Planner, Jacobs New Zealand Ltd	Second draft for Waka Kotahi review
0.3	23/04/2021	Final Word	Editorial services	Transferring original client document to the latest Waka Kotahi ITS design standard template
0.4	03/05/2021	ITS Working Group	Waka Kotahi	Review of queries from editorial services
0.5	14/05/2021	ITS Working Group Jeff Greenough	Waka Kotahi Principal ITS Engineer, Jacobs New Zealand Ltd	Review of queries from editorial services and ITS Working Group review
0.6	08/11/2021	ITS Working Group	Waka Kotahi	Added section 5.5.4 Keep-left reminder signs and details as appropriate, reworded keep-left arrow information and included example, application and dimensions for this road marking Updated section 5.5.5 Temporary signage
0.7	22/11/2021	Final Word	Editorial services	Updated following review of queries, updated approvers
1.0	29/11/2021	ITS Working Group	Waka Kotahi	Document issued