# Appendix M – Traffic Signal Guidelines

(Normative)

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**Disclaimer**



Every attempt was made to ensure that the information in these documents was correct at the time of publication. Any errors should be reported as soon as possible so that corrections can be issued. Comments and suggestions for future editions are welcome and periodical reviews are undertaken on a regular basis. Users of these documents must ascertain themselves that they obtain the latest versions as valid references.

## Introduction

The Queenstown Lakes District Council (QLDC) is responsible for all traffic signals installed on Council roads in the Queenstown Lakes District. All QLDC traffic signals are operated by the Wellington Traffic Operations Centre (WTOC) and maintained by QLDC's agreed maintenance contractor.

This document is designed to assist all interested parties to understand the QLDC functions and the standards that have been adopted to ensure a consistent approach is maintained when designing and installing traffic signals and associated equipment.

## Glossary of Terms

| | |
|---|---|
| **AS / NZ** | Australian Standard / New Zealand Standard |
| Active Traffic Management System (**ATMS**) | Technology that provides information to road users by means of Variable Message Signage. |
| **Controller** | The equipment (including the housing) that switches power to signal lanterns and controls the duration and sequence of signal displays as defined by the controller personality. |
| Controller Information Sheets (**CIS**) | A hard copy of the information used to make a Controller Personality that is contained within the PROM. |
| Controller Personality | The unique program stored in the PROM, which configures the controller to the specific operational design of the intersection. |
| **CCTV** | Closed Circuit Television. |
| **CoP** | Code of Practice |
| **DP** Number | Distribution Point for telecommunications. |
| **FSL** | From Stop Line, measurement used for distance from start of detector loop. |
| **ICP** Number | Installation Connection Point Number (for electricity power meter). |
| Intelligent Transport Systems (**ITS**) | Refers to various systems like SCATS, CCTV, VMS and ATMS systems that provide and add information and communications technology to transport infrastructure. |
| **JUMA, JUSP** | **Joint Use Mast Arm, Joint Use Service Pole** |
| **KJB** | Kerbside Junction Box to access services. For example, detector loop feeders. |
| **NZTA** | New Zealand Transport Agency (now Waka Kotahi NZ Transport Agency) |
| **NGEN** | Software product developed by RMS to produce .SFT and .M68 files. |
| **PCMCIA** Card | A computer card containing the controller personality information housed in the TSC / AS 2578 compliant controller. |
| **PROM** | A computer chip containing the controller personality information housed in the TSC3 compliant controller. In this document PROM refers to either a PROM, a PCMCIA card or similar software storage device. |
| Road Asset and Maintenance Management (**RAMM**) | An Internet accessible system that stores the Traffic Signal assets. RAMM also records the activity of the Maintenance Contractors by the logging of faults as Dispatches and the updating by the Contractors following completion of the job. Contractors' claims are generated from the RAMM system each month end. |
| **RCA** | Road Controlling Authority. |
| Roads and Marine Services (**RMS**) of New South Wales (**NSW**) | The Authority accepted by Queenstown Lakes District Council as the basis for the QLDC standards and for product approval. RMS also develop and own SCATS traffic signal software and other products related to SCATS and their output files. |
| **SAT** | Site Acceptance Test, commissioning checklist. |
| **.SFT / .M68** | File formats for traffic signal software (TRAFF) |

| | |
|---|---|
| Sydney Coordinated Adaptive Traffic System (**SCATS**) | A fully adaptive area wide control system for traffic signals that is linked to the traffic signal controllers running TRAFF software via telecommunication lines. |
| **TRAFF** | Traffic signal base software inside traffic controllers on site running the signals. |
| **QLDC** | Queenstown Lakes District Council |
| Vehicle Activated Sign (**VAS**) | VAS is a generic term for a type of road traffic sign that displays a message conditional upon the presence or speed of a road vehicle. |
| Variable Message Sign (**VMS**) | An electronic traffic sign often used to display a message or picture.  The sign display is changeable and dynamic. |
| Wellington Transport Operations Centre (**WTOC**) | Organisation tasked with operating the traffic signals and the ITS systems for local roads and State Highways around the Queenstown Lakes District by monitoring SCATS and CCTV. |
| **Win Traff** | A software programme used to check the controller information by testing the software of the controller personality. |

# 1 REQUIREMENTS FOR TRAFFIC SIGNAL DESIGN

### Purpose

The purpose of this document is to give an understanding of the QLDC requirements when undertaking the design, installation or maintenance of traffic signal installations in the QLDC regions.

### Who Should Use This Document?

All consultants, contractors and project managers (we refer to as "applicant" in this document) involved in the design, installation and maintenance of traffic signals on behalf of Road Controlling Authorities (RCA) in the Queenstown Lakes District should use this document. Where for example, an upgrade is being carried out by an RCA the applicant shall be the assigned. In most situations this would be the traffic signal contractor (who would have most technical experience in providing the relevant information required).

QLDC has prepared this document to assist practitioners when designing traffic signal installations. Although this document has technical and specialist content, the applicant must read it in conjunction with the QLDC Land Development & Subdivision Code of Practice – 2020 (QLDC CoP). The QLDC CoP contains details on document management and describes processes. The intent is to show what is expected in the application.

This guideline has been created to ensure that the designs of all intersections are to the highest standard, with variations being the exception rather than the norm. It is important that the information submitted as part of new or modified traffic signal layouts are standardised as much as possible. This will enable any further changes that may result from changing traffic conditions to be implemented quickly and simply.

The applicant's project team members are expected to have the experience and knowledge required to provide the relevant details, particularly the production of software and, CIS and traffic signal design. QLDC are not responsible for providing training or resources for designers who are new to the industry as there are suitable courses and consultants who can provide training.

### Technical Criteria

The design of the traffic signals must be carried out in accordance with the standards and guidelines listed below and their revised / subsequent replacements:

- QLDC Land Development & Subdivision Code of Practice – 2022.
- QLDC CoP Appendix L – Traffic Signal Guidelines.
- NZTA P43 Specification for Traffic Signals.
- AUSTROADS Traffic Management Guides.
- Road Traffic Standards (RTS) 14.
- NZTA Pedestrian Planning and Design Guidelines.
- NZS1158 Public Lighting Standards.
- QLDC Southern Light Strategy.
- QLDC RAMM Database Operations Manual

The specification of traffic signals equipment shall comply with the current version of NZTA P43 Specification for Traffic Signals or, a written agreement with QLDC for the use of specific components shall be obtained.

The contractor is responsible for ensuring that all equipment that is installed meets the minimum standards. If there is any doubt, the contractor shall be required to provide evidence that the product meets QLDC requirements.

### Reference Material

Detailed below are recommended documents to assist in the processes required.

- NSW Roads & Maritime Services, Traffic Signal Design.
- Australian Road Research Board (ARRB), Traffic Signals: Capacity and Timing Analysis.
- Signals National User Group (SNUG).

## 1.1 TRAFFIC SIGNAL REPORT DOCUMENTATION

Prior to an applicant submitting a traffic signal report to QLDC, it is expected that the applicant liaise with QLDC and produce a Traffic Signal Feasibility Report prior to the Traffic Signal Detailed Design .

Any deviations from QLDC's Requirements and the reasons for the deviations must be summarised in a separate section in the report.

All documents to be supplied in electronic format. This is to ensure that the plans are clear and concise for reviewers, safety auditors and contractors.

### 1.1.1 Traffic Signal Feasibility Report

A brief traffic signal report with diagrams and maps that includes the following information:

> Site Location Plan.

> A brief description of the reason for proposing the installation of traffic signals.

> Intersection concept drawing/sketch showing proposed site including poles, lanterns, controller, accesses, bus stops and parking, vehicle and cycle lanes, with widths.

> Proposed and existing site layout detailing:
- Road and Footpath widths dimensioned
- Boundary, driveways, building lines and verandahs
- Traffic signal equipment including phasing
- Existing services, including manhole covers, boundary boxes, bus shelters etc.
- Trees, garden plots, berms etc.

> Risk Identification and assessment of existing services.

> Assessment of Network Operation Plan, road hierarchy, speed and usage including over-dimensioned vehicles.

> Assessment and map showing user desire lines and facilities that generate traffic and pedestrian movements. For example, Hospitals, Schools and associated safe routes, event venues/clubs, elderly housing areas etc. This data is to be included in the modelling, as is information about the expected use of the network surrounding the proposed site.

> List user hierarchy in priority order, time and day. For example:

AM Peak 07:00 – 09:00
1. Cycle
2. Freight
3. Vehicles
4. Pedestrians
5. Buses

> Existing crash data with a brief analysis of causes and commonalities.

> Modelling Report – refer to Section 2 of this Appendix.

> Movements Data. Examples of periods and types to be considered are:
- AM Peak turn counts (07:00 – 09:00) for cars, heavies, cycles and pedestrians.
- Inter Peak turn counts (11:00 – 13:00) for cars, heavies, cycles and pedestrians.
- PM Peak turn counts (15:00 – 18:00) for cars, heavies, cycles and pedestrians.
- School Travel turn counts for cars, heavies, cycles and pedestrians.
- Approach design speeds (posted and 85 percentile).

### 1.1.2 Traffic Signal Detailed Design

If a Traffic Signal Feasibility Report has been prepared, the detailed design scope can be defined clearly with the majority of risks and modelling assessments already identified. However, some of the requirements have been expanded with an emphasis on more detail.

All drawing plans submitted in electronic format, to show as a minimum:

- Legend corresponding to the symbols and hardware depicted on the drawing.
- North Point.
- Title Block.
- Revisions with comments on changes.
- Drawing type (i.e. construction, information, draft).

Detailed Design requirements in addition to the Traffic Signal Feasibility Report are to include the following drawings and documents:

- Cover Sheet and Site Location Plan.
- Existing Survey and Services.
- Proposed Construction and Set out.
- Proposed Signal and Phasing Layout.
- Proposed Ducting and Cable Diagram.
- Tactile Pavers and Pedestrian Layout.
- Proposed Road Marking and Signage.
- Vehicular Tracking Plan.
- Proposed Street Lighting.
- Standard Details (optional).
- Controller Information Sheet (CIS).

The detailed design should include detailed information for the proposed locations of poles, chambers, signs, lighting columns in relation each other and be drawn to scale.

Particular attention to detailing tactile pavers, pram crossings and pole locations, especially mast arms, should be made.

Further modelling work may be necessary during the detailed design process. The requirements are the same as detailed in the Traffic Signal Feasibility Report section, above.

### 1.1.3 Cover Sheet and Site Location Plan

This sheet will have the name of the project, a locality plan showing the location of the intersection, a brief and a drawing register.

### 1.1.4 Existing Survey and Services

This sheet is to show the location of all services plotted from the various service authorities services plans. In addition, the information collected by the topographical survey such as existing kerbs, driveways, trees, berms, local facilities such as manholes, valves, poles, streetlights and road marking and signs, must be shown.

We understand the accuracy of underground services plans can be minimal but it is expected that the designer has taken the steps to allow for inspections and trail holes to be investigated before the detailed design is approved.

### 1.1.5 Proposed Construction and Set Out

This sheet will show the extent of all new physical works to be undertaken such as kerb relocation, new islands, pole and chamber locations, pram crossings showing top and bottom of let-downs, tactile and directional pavers and, where services are being relocated to if applicable.

### 1.1.6 Proposed Signal and Phasing Layout

This sheet will show the proposed kerbs and road marking, the location and, the type of all signal hardware.

The plans shall be scaled appropriately to size of paper. Ideally, A1 size and include the following details:

- Lane configuration and assignment (arrows).
- Lane widths / carriageway widths (include cycle ways and advance cycle boxes where applicable).
- Detectors numbered (advance / queue loops to show distance from vehicle stop line).
- Signal Groups diagram, labelled and numbered.
- Signal phasing diagram, phase sequences and default sequence.
- Operation features e.g. 'Rest in A'; 'Z- allows filter'.
- Controller position and door opening.
- Poles with number and type (i.e. 5m outreach mast arm pole, JUMA, JUSP, CCTV).
- External Inputs (include type i.e. Detectors - Infrared, Doppler radar, Video, Thermal.).
- Aspects showing visor and type, and louvers (if used).
- Street Names.
- Property Boundaries.
- Kerb Lines.
- Vehicle Crossings.

### 1.1.7 Proposed Ducting and Cabling Diagram

A Ducting and Cabling Diagram shall be scaled appropriately to size of paper and include the following details:

- Kerb Lines.
- Access Chambers and Label.
- Kerbside Junction Boxes (KJB) and Tobies.
- Signal controller cabinet.
- Duct Lines, specifying the size and number of ducts.
- Poles and pole numbering.
- Detectors and detector numbering (including external inputs, overhead detection etc.).
- Cable runs.

#### 1.1.7.1 Tactile Pavers and Pedestrian Details

Tactile and directional pavers drawn to show actual proposed location. The design must consider location of services to minimise risk during construction. The relationship between:

- Pole location
- Push button with desired angle shown
- Slip and trip hazards, and
- Pedestrian access ramp and associated slope

is essential detail and the consideration given must be included.

The design should consider accessibility needs of disabled or aged users, such as orientation of the crossing to the target kerb ramp, wayfinding on approach and exit, wheelchair crossings of drains, etc.

The designer must consider relocating services or proposed pedestrian access locations to maintain a practical and operational site. Include additional drawings showing these details. For example:

> Staggered crossing to show fencing positions and method of quick removal for maintenance
> Drainage cross fall details showing within a Median Island, and
> Installation of poles on a staggered arrangement to be located behind the kerb to assist minimising trip hazard, footpath cleaning and drainage.

Specifications for type of tactile paver are defined in the QLDC CoP. Plastic tactile pavers maybe considered after consultation with QLDC. Furthermore, in ground pads are not to be used. Alternatives for call cancelling pedestrians can be considered, such as overhead detection. Refer NZTA P43 Specification for Traffic Signals.

#### 1.1.8 Proposed Road Marking and Signage

This sheet will show the proposed road-marking layout with dimensions including the tie-ins with the existing road marking at the extent of the physical works. Any proposed signage should also be included.

#### 1.1.9 Vehicle Tracking Plan

This sheet will show the tracking of the largest vehicles deemed appropriate for the site. Of particular note should be the left and right turning vehicles with respect to limit line location and kerb lines.

#### 1.1.10 Proposed Street Lighting

The street lighting designer shall provide a design that has assessed the proposed traffic signals design in relation to their industry standard documents and appropriate Road Controlling Authority (RCA) Code of Practice (CoP). QLDC shall comment on fit for purpose in relation to the proposed users and demographic environment. Examples by way of guide are:

> Suitable lighting to be installed for vehicle's, pedestrian access and crossing the road and also as part of the project site, and
> On the approaches to site, assist with crime prevention and CCTV operations.

The lighting design proposed for the intersection shall be peer reviewed by QLDC's nominated consultant.

All overhead traffic signal poles are to have a JUMA spigot fitted to facilitate future street lighting or CCTV equipment if required. A waterproof cap shall be fitted to all spigots not used for lighting or CCTV equipment.

The streetlight is to source its power separate from the traffic signals. This is to be discussed with QLDC prior to construction.

#### 1.1.11 Standard Details

Standard signal sheets will show the details particular to signal installations. NZTA P43 Specification for Traffic Signals shows some standard details however the designer may propose alternatives. For example:

> Staggered crossing to show fencing positions and the method of quick removal for maintenance.
> Drainage cross fall details (showing within a Median Island).

The applicant must ensure that all works meet the relevant RCA Development Codes and Standards. For example; ducting standards and depths, approved tactile pavers, waste management and drainage. Refer to the appropriate road controlling authority for relevant development code.

#### 1.1.12 Controller Information Sheet

Controller Software Specification is to be used to develop the Controller Information Sheet (CIS). The newest CIS sheet must show the revisions from the previous version and highlight each change in yellow.

The Controller Software Specification specifies the generic layout and operation of the site and includes any special requirements or logic in terms of detector or signal group operation.

These requirements are specific to each site / signal design. Refer to sections that follow for further details. At a glance, the requirements may include information such as:

> Train Operation.
> Pedestrian Protection (See Pedestrian Control section).

- Special Signal Group Overlaps.
- Bus, Tram or Cycle Logic.
- Conditional Phasing.
- Pedestrian Reintroduction.
- Special Time Setting Substitutions, and
- Special Detector Calling Functions.

MSS bits to be considered for all non-loop detectors such as push buttons, pedestrian overhead and underground detectors, Video, Infra-Red, Doppler Radar. This is so WTOC can monitor the devices and control functions under SCATS variations.

## 1.2 TRAFFIC SIGNAL EQUIPMENT

This section is referring to considerations during Feasibility and Design stages in relation to location and practical operations rather than equipment performance and specifications where these are defined in the QLDC CoP and NZTA P43.

### 1.2.1 Controller

The controller and its associated cable draw pit located within the road reserve with the back of the controller facing the intersection where practicable, with Door opening to be shown on drawing.

The controller should be located where it is:

- Close to the power supply and telecommunications.
- On reasonably level ground.
- Accessible to maintenance vehicles and personnel.
- Preferably near a property boundary and away from the edge of road.

The controller should be located where it:

- Can accommodate temporary external portable power supplies.
- Does not interfere with sight distance.
- Does not interfere with pedestrian and shared path facilities.
- Enables maintenance and operation personnel to have a clear view of traffic signals from the controller, if possible.

Where controllers are at risk of minor collision, e.g. with vehicles manoeuvring / parking on verges, protective bollards are to be installed.

### 1.2.2 Traffic Signal Post Locations

Traffic signal posts shall generally be located in accordance with AUSTROADS Guide to Traffic Management; however we have detailed the requirements for QLDC below.

In addition, an absolute minimum clearance of 600mm shall be maintained between any portion of the fittings, lanterns or accessories and the kerb face. Clearances must be increased where there is a probability of:

- Conflict with the 'overhang' of vehicles such as buses, or
- The 'cutting in' of the rear end of long vehicles or trailers, or
- Where the road has a significant camber which may cause high vehicles to 'lean in' towards the posts and attachments.

The requirements of clearances for over dimension vehicles (See NZTA website for routes) shall be met where applicable.

Where the lateral position is less than 1metre clear from the kerb face (e.g. on narrow medians) consideration shall be given to modifying the intersection geometry (e.g. widening the medians).

Where there are more than two (2) posts along a kerb (e.g. opposite the stem of a T-junction) they shall be laterally offset sufficiently to provide clear sight lines to all aspects from all relevant approaches; i.e. the lanterns and visors on one post do not restrict sight lines to lanterns on another.

Traffic signal posts shall be longitudinally located such that pedestrian push buttons are easily reached from the top of pedestrian ramps by all pedestrians including the disabled. Where this cannot be readily achieved, relocate traffic signal post or when not practical then separate pedestrian push button posts (stub posts) shall be provided.

Pole location and their relationship to tactile pavers and pedestrian access ramps must be carefully considered ensuring drainage and practical installation of poles can be achieved.

Where the requirements for clearances for over dimension vehicles apply, but the geometric layout and signal post location cannot be arranged to adequately cater for over dimension vehicles, hinged or removable traffic signal posts are to be used and placed near a termination pit so that the post can easily be removed.

#### 1.2.3 Use of Overhead Signal Faces (Mast Arms)

The use of overhead signal faces (mast arms) should be minimised and shall only be included with prior approval from QLDC. Where practicable the geometric layout should be modified to avoid the necessity to use mast-arms. As per AUSTROADS Guide to Traffic Management Part 10, mast arms are warranted where the:

- Stopping sight distance to the post-mounted signal face is inadequate, e.g. because of vertical or horizontal alignment, awnings, poles, trees or similar sight obstructions, and
- Roadway is too wide for kerb mounted signal faces to fall within the driver’s line of sight.

Care must also be taken to ensure signal lanterns do not conflict with airport lights. Alignment and louvres may need to be modified.

#### 1.2.4 Signal Display Location

In general, primary signal posts and signal displays should be located such that they are as close as practicable to the direct line of vision of approaching drivers, ideally at least 1m from the stop line, taking into account the alignment of the approaching lanes.

Secondary and tertiary signals posts and signal displays should be located such that they are as close as practicable to the direct line of vision of drivers when stationary at the stop line and when manoeuvring through the intersection, whilst taking into account the alignment of the individual lanes. For example; a dual secondary signal display may be out of direct line of vision when the driver is stationary at the stop line but may come into direct line of vision when moving forward and waiting to turn.

To assist in the potential conflict of displays the designer may consider use of aspect louvres and/or visors to maintain safe operations.

Multiple signal displays are used to ensure drivers on multilane roads can see at least one signal display for each movement on approach and on departure. This allows for masking of some of the signals by adjacent vehicles and also provides some redundancy in case of lamp failure.

Signal displays shall be arranged generally in accordance with AUSTROADS Guide to Traffic Management Part 10 with the following variations:

- Split tertiary signals shall not be used.
- Signalised left slip lanes shall have a primary and dual primary signal display located between the projection of the stop line and up to a distance of 3m downstream, consider use of arrows on green display to avoid confusion for Giveway / Stop slip lanes.
- Single-lane signalised left slip lanes shall have at least a secondary signal display located on the median of the cross road.
- Multi-lane signalised left slip lanes shall have a secondary and tertiary signal display, both located in the median of the cross road.
- Where parallel walks / no parallel walks are in place at sites without right turn arrows, there is no requirement for a Dual Far Right Secondary Display.

To assist in placing signals as close as practicable to the driver's direct line of vision, where medians are more than 6m wide consideration shall be given to mounting the dual secondary signals on the same post as the dual primary signals of the opposing direction, instead of the far right corner

Where the right hand turn lane approach is aligned towards the right and filtering is prohibited, splitting the 6-aspect secondary signal face and mounting the right turn arrows column on the same post as the dual primary signals of the opposing direction, and maintaining the dual secondary on the far right corner shall be considered.

### 1.2.5 Chamber Locations and Ducts

A chamber is generally required on each corner of an intersection. An additional chamber is to be installed immediately adjacent to a controller. This allows for easy installation of cables to the controller, provides more space for maintenance contractors to work and keeps cabling within the controller tidier.

Chamber locations should be placed so as not to cause a trip hazard and where practicable outside of any tactile paving. Furthermore, chambers are to be located where minimum traffic management is required. For example, not on the nose of an island.

All ducting should link back to a chamber location at each road crossing. To minimise carriageway work and disruption to traffic, it is best practice to only cross a main road once (i.e. road having the highest volumes). A minimum of two ducts shall be installed on all road crossings. Cables pull throughs to be installed on all ducts.

### 1.2.6 Detectors

All loop positions are to be determined early in the design.

All controlled lanes must have detector loops installed including for example left turn lanes under Give Way control to count vehicles only, if there are sufficient detector inputs available.

Advance loops may be required in some instances to optimise signal operation and enhance safety in high-speed environments. If controller capacity allows, detector loops are to be included in uncontrolled slip lanes for traffic counting purposes. Loops on bridge decks or approach slabs should be avoided where practical. Refer Section 3 of this Appendix.

Where there are a high number of cyclists the type and style of loops shall be clearly shown. Cycle lane design requires special attention and these shall be considered on a site by site basis.

Special care is required to ensure that the placement of the loop is in the correct position within the lane. Failure to confirm positions prior to sealing can mean that another loop may be required to be saw cut into the new seal. All loop locations to be accurately located and included on as-built drawings.

The ideal or preferred methodology of installing loops is to place them under the bedding of the pavement prior to sealing in order to avoid repeatedly cutting in a short period of time.

Consult with NZTA P43 Specification for Traffic Signals and the QLDC CoP for details on installation methods.

If the controller cabinet is relocated then the site must be renumbered to comply with the standard convention.

Configure virtual red light running loops in the CIS when there is spare capacity to allow, consult with QLDC as required.

#### 1.2.6.1 Vehicle Detectors

Detectors are numbered anticlockwise from the controller assuming that a line is drawn from the controller through the centroid of the intersection.

The first circuit is the stop line loops, departure loops and counting loops are numbered first, with the departure loop being numbered after the stop line loop it is associated with.

The second circuit is the dynamic loops, followed by the advance dynamic loops.

The reason detectors are numbered anticlockwise is so that an approach will read numerically correct left to right when viewed on a SCATS System Monitor display.

Where there is a secondary part to the signals such as at interchanges, the first circuit is around the part of the intersection closest to the controller, then around the second part of the intersection. Then back to the first part of the intersection for the second circuit. A line is drawn from the controller through the centroid of the second part of the intersection to give the starting point for each numbering circuit.

If a controller is relocated then the site must be renumbered to comply with the standard.

1.2.6.2 Detector Card Configurations for AS 2578 VC5/6 Compliant Controllers

When the new AS 2578 and VC5/6 compliant controllers were first introduced each Detector card had 16 Internal Detectors (Vehicles) and 16 External Detectors (Pedestrian). Since then the manufacturers have provided some flexibility to allow combinations to be used. It is important for the designer to understand and number the loops and pedestrian call detectors in the appropriate manner as this impacts directly on the preparation of the software. Furthermore, VC6 controllers have extended the capacity therefore check with the manufacturer on these specifications.

1.2.6.3 Pedestrian Detectors

Pedestrian detectors are numbered depending upon the card in use. First ascertain the number of detectors available at the controller if it is an existing site or determine the requirement if new. TSC3 Controller Detector cards come in groups of four ranging between 4 and 32.

The AS 2578 Compliant controllers come with a 16, 24 or 32 input Detector card. This consists of vehicle inputs and external inputs. Again, this will depend on the type of controller and the configuration applied.

The pedestrian detectors are numbered from the highest number down as follows and may include more than four pedestrian facilities:

| PEDESTRIAN / WALK NUMBER | 1 PED | 2 PEDS | 3 PEDS | 4 PEDS | 5 PEDS |
|---|---|---|---|---|---|
| W1 | 16 | 16 | 16 | 16 | 16 |
| W2 | | 15 | 15 | 15 | 15 |
| W3 | | | 14 | 14 | 14 |
| W4 | | | | 13 | 13 |
| W5 | | | | | 12 |

**Table 1-1: Pedestrian Detector Slot Numbering (16 Detector)**

A similar configuration will apply across the top end for 24 and 32 detector cards.

In ground and above ground pedestrian detection systems will need to be configured as a pedestrian input. Using Table 1-1 as an example, for four pedestrians we use inputs 13-16 and if we were to install above ground pedestrian detection for all the walks the detection would be numbered 11-4 leaving one unused before the pedestrians. MSS bits shall be used and numbered the same as the pedestrian detector number (where possible). Furthermore all non-loop detectors shall have an MSS assigned for each unit for additional SCATS variation options and monitoring options.

### 1.2.7 Pole Numbering

Poles are numbered in a clockwise direction from the controller assuming that a line in drawn from the controller to the centroid of the intersection.

Where there is a secondary part to the signals such as at interchanges, the intersection closest to the controller shall be numbered first then the additional part can be numbered in the same format assuming that a line is drawn from the controller to the centroid of the secondary part of the intersection. If a controller is relocated then the site must be renumbered to comply with the standard convention.

### 1.2.8 Signal Groups

With AS 2578 and VC5 compliant controllers, the number of signal groups can range from 4 to 32 in modules of four signal groups. The recent changes to VC6 controllers may change some of the content listed below, therefore discussions with the manufacturer is expected during the design phase.

Pedestrian signal groups in a sixteen group controller will be denoted as: W1=16, W2=15, W3=14, & W4=13. If there are only two Pedestrian groups then W1=16 and W2=15.

### 1.2.9 Phasing

The phasing diagram must show the following:

- Each phase in a separate box with the phase label inside the box corner A, F, F1, etc.
- Show only the movements that display green in each phase.
- Indicate movements by an arrow pointing in the direction that traffic will travel.
- Signal groups shown in a circle at the point of the movement arrow for vehicles and beside.
- Pedestrian movements.
- Any Special Flags inside the phase box Z, Z+, etc.
- Indicate if filter turn movements are permitted.
- Label phasing to lanterns.
- Default and Alternative phasing to be shown. Alternative phasing must show split phasing for each approach to assist in maintenance and operations.
- An all red phase to be added to all plans for operational requirements, no detector or input to be assigned to call/demand. Shall be operated only by SCATS Dwell.

The phase sequence must be shown on the plan adjacent to the phasing diagram.

In general, all traffic signals shall be consistent with the standard RMS configuration. Standard phasing configurations are detailed below. Where standard phasing configurations are not appropriate due to the site or traffic flow conditions, the phasing should be designed to:

- Minimise the number of phases
- Minimise cycle time
- Run as many compatible movements as possible in each phase
- Restrict each phase to non-conflicting movements
- Allow each movement to run in as many phases as possible (preferably allowing as many as possible to overlap from the previous phase or into the following phase), and
- Comply as closely as possible with the standard RMS configuration. Examples of a range of standard arrangements are found on the following pages of this document.

The phasing design should consider the use of filter right turn movements. The phasing design should provide the most flexible operation that will accommodate changes in traffic conditions without the need to reprogram the controller personality. This may result in a phasing sequence in which not all phases are used initially. An example of this is the inclusion of repeat right turn phases.

The phasing sequence (i.e. the order in which each phase runs) should be designed to provide the optimum coordinated flow along a corridor. This may change at different times of the day.

#### 1.2.9.1 Filtering Right Turn Movements

At most intersections right turning traffic that has opposing movements will be provided for by installing a separate signal display, giving the right turning motorist a protected turn at some time in the phasing sequence. However, under strict criteria filter turn movements may be permitted in order to improve intersection efficiency.

Whilst the provision of filter turns may improve efficiency, it reduces the potential safety as conflicting movements may now occur. The phasing design must consider a balance between safety and efficiency. When considering allowing filtering, safety must be given a higher weighting in the decision process.

The phasing design at adjacent intersections should also be considered to provide consistency along a corridor and preferably throughout the region.

The operation of such movement should be designed and implemented with prior consultations with QLDC.

1.2.9.2 Repeat Right Turn Phases

A repeat right turn is where the right turn movement is introduced for a second time within the same phase cycle. Repeat right turns can be provided at any site with a right turn phase. Generally the controller logic will have two phases with exactly the same movements (i.e. for a T-intersection B and D) with one phase only introduced when a special facility signal is activated (normally B using the Z+ flag).

Repeat right turn phasing can only be used under Masterlink or Flexilink control modes (not in isolated mode) and is generally provided at peak times. It is unusual to have a repeat right turn phase operating 24 hours a day.

Repeat right turn phasing is normally used where the single right turn phase does not provide sufficient capacity within a cycle for specific flow periods, or it is necessary for progression within a coordinated system.

A typical use is where a right turn bay is too short to cope with the number of right turning vehicles that can arrive within the cycle which results in the right turn queue extending into and blocking the through traffic lane. This reduces the capacity for the through movement and increases the risk of nose to tail type crashes occurring. The use of the repeat right turn is particularly important, under these circumstances, where there is only one through lane.

Repeat right turn phasing should only be considered under the above mentioned conditions. Generally, where vehicles may queue outside of the through lane (i.e. on a painted median), it is more efficient to provide a longer single right turn phase than two short phases. Installation of queue detection loops to be considered in the design.

### 1.2.10 Pedestrian Control

The hierarchy of signalised pedestrian control strategies range from providing full pedestrian protection through to partial protection during the early stages of the crossing movement. They fit broadly into the following range:

i. Exclusive pedestrian phase with full protection and all vehicle traffic stopped. Also known as Barnes Dance. This is only used where pedestrian numbers are high, in CBD.

ii. Full protection for the whole Walk and Clearance using red arrow.

iii. Partial protection for part of the Walk and Clearance using red arrow and individual push button inputs. Red arrow on a minimum of 6 seconds for one direction and the other direction to be calculated to the last crossing lane using 1.5m per second (this can be reduced on site as required).

iv. Full protected staggered or staged pedestrian movements.

The method of control adopted at any specific site is based on location, traffic volumes, pedestrian volumes and type (i.e. age or disability), intersection layout combined with the aim to provide safe, efficient movement for all users. However, when selecting control options, it is important to ensure, whenever possible, that a consistent approach is adopted within any given corridor. This may result in a more conservative approach being adopted at some intersections to maintain uniformity throughout that corridor.

At signalised intersections, near schools, where there is a high pedestrian demand at the same time each day, the signal operation should be adjusted to cater for the reoccurring demand. This will generally be achieved by increasing the Walk' and/or clearance times.

It is preferable to have all pedestrian push button inputs wired and configured in the CIS individually to enhance pedestrian protection.

MSS bits to be used for every push button to enhance the variation options in Scats. (All non-loop detectors shall have an MSS assigned for each unit for additional Scats variation options and monitoring options).

### 1.2.11 Cyclists

Cycle lanes are being progressively introduced along some of the main corridors. Cyclists are features managed as part of the 'traffic mix' and there are currently limited special facilities for them at signalised intersections. These facilities are generally in the form of advance boxes or hook turn boxes and do not require special traffic signal control. Where cyclists may be on a side road or one that is not reverted to during phase sequence then detectors may be required to demand the phase for the cyclist.

Cycle detector loops are numbered in sequential order as part of the first circuit of vehicle detectors. Cycle call buttons are external inputs and numbered in descending order after the pedestrian inputs, e.g. W1=32, W2=31, C1=30.

Special care and attention to the detector position, type and detector alarm to be used in the cycle lane and / or cycle box.

Where cycle boxes are used they shall always be behind the traffic signal primary pole. Consultation with QLDC is required at an early stage so we can consult the users groups.

#### 1.2.12 Bus Lanes

Bus priority is becoming more common and requires the allocation of a signal group to each approach using the same convention as above for individual sites. If the bus signal group is demanded then the controller puts in a pre-specified delay to the through movement signal group. Where bus loops are installed these are numbered as part of the first circuit of vehicle detectors in sequential order. Where a separate signal group is provided for bus movements, these are numbered last, after all other vehicle signal groups.

## 2 MODELLING GUIDELINES

### Purpose

This guideline is specifically designed to provide guidance without being prescriptive or limiting the modeller building the model. A proportion of the content of the document is designed to make the model scope, building, submission, review and approval as transparent as possible for all parties without inhibiting the practitioner in the technical construction of the model.

### Who Should Use This Document?

Modellers, on behalf of consultants and contractors, should use this document and project managers (we refer to as "applicant" in this document) involved in the design, installation and maintenance of traffic signals on behalf of Road Controlling Authorities (RCA) in the Queenstown Lakes District.

QLDC has prepared this document to assist practitioners when designing traffic signal installations. Although this document has technical and specialist content for modellers it must read in conjunction with the QLDC CoP and this Appendix.

### Technical Criteria

The design of the traffic signals must be carried out in accordance with the standards and guidelines listed below and their revised / subsequent replacements:

- QLDC Land Development & Subdivision Code of Practice – 2022.
- QLDC CoP Appendix L – Traffic Signal Guidelines.
- NZTA P43 Specification for Traffic Signals.
- AUSTROADS Traffic Management Guides.
- NZTA Pedestrian Planning and Design Guidelines.

### Reference Material

Recommended documents to assist in the processes required are as follows:

- NSW Roads & Maritime Services, Traffic Modelling Guidelines.
- NSW Roads & Maritime Services, Traffic Signal Design.
- Australian Road Research Board (ARRB), Traffic Signals: Capacity and Timing Analysis.
- Signals National User Group (SNUG).

## 2.1 MODELLING REPORT

The modelling report must show initiative and educated judgement rather than default parameter settings in modelling (e.g. analysis period profile in terms of peak hour factor, demand arriving at back of queue versus counts at stop-line on oversaturated approaches, adjustments to gap parameters, intergreen times, coordinated arrival types). The modelling report must also contain site observations including calculations.

Whichever traffic signal modelling software is used, the user should consult the SIDRA User Guide or SIDRA software Help menus for any model-specific guidance on reconciling the signal timing input and outputs with average SCATS operation for the peak periods. To facilitate more realistic modelling of existing traffic signal site upgrades, SCATS history files of typical peak hour timings can be provided to modellers upon request to WTOC (including signals in close proximity, refer Table 2-1).

Due to the nature of the models, traffic surveys must be undertaken at all intersections to be modelled. Other critical data collection includes signal operation, queue observation and saturation flow measurement (or estimation). Future traffic flows can be estimated using highway assignment models or by applying growth factors as appropriate. Highway assignment models should only be used to estimate traffic growth as they are generally too coarse to adequately produce detailed turn movements.

### 2.1.1 Modelling Outputs

The designer shall submit a detailed SIDRA report consisting (as a minimum):

> Introduction.

> Background.

> Traffic volumes including any adjustments made to modelled volumes noting in particular, the forecast years(s).

> Each Option should be modelled in Year 0 and Year 10. The land arrangement and phasing of each Option must be shown.

> Analysis Methodology (including details of calibration).

> Analysis Results Summary, including a table highlighting the following for each movement and the intersection as a whole:
- Degree of Saturation (DoS) (maximum 0.90).
- Average Delay (RMS NSW Method).
- Level of Service (LoS).
- 50% and 95% Back of Queue distance.
- Fuel Consumption, Emissions and Cost (total and rate).
- Flow Scale / Design Life Results based on a 10% increase in traffic volumes.
- Pedestrian Movements.

> Discussion on all observations of the analysis results and outcomes.

> Conclusions and Recommendations (e.g. length of extensions to turn lanes, etc.).

> A table indicating the proposed cycle length, phase splits and offsets (if coordinated) that the model suggests be adopted by SCATS for the morning peak, and, afternoon peak.

> Best Level of Service whilst fuel consumption and emission are not the highest rate compare to other level of services.

> The applicant must obtain all traffic data deemed necessary to complete the validation.

> For closely spaced signals, a decision needs to be made and justified on isolated versus coordinated system analysis. An initial isolated analysis should inform the design layout and phasing prior to a full coordinated system analysis, serving as a useful cross-check.

>

### 2.1.2 Modelling Inputs

The designer shall consider listed SIDRA input data when preparing a SIDRA report for traffic signals at grade and if required, as a network. The list below is a minimum requirement for outputs:

> Lane width
> Grade
> Median
> Approach Cruise Speed
> Vehicle Movements
> HV%
> Peak Flow Factor
> Peak Flow Period
> Signal Coordination
> Phasing

2.1.2.1 Signal Analysis Method:

*For intersections running under SCATS Coordinated or Master Isolated Control, use the Fixed-Time / Pretimed analysis option. Although SCATS is an adaptive control system, the Fixed-Time / Pretimed analysis method is recommended to emulate the SCATS control algorithms, especially due to the "equal degree of saturation method" used for determining green splits. SCATS green splits and cycle time may change cycle by cycle. The green splits and cycle time determined by SIDRA INTERSECTION should be considered to represent average timings under SCATS control for the analysis period. Use the Actuated analysis method for intersections operating under the traditional actuated control method. This control method uses maximum green and gap settings and does not implement an equal degree of saturation strategy for green splits.*

2.1.2.2 Intersection Dialogue

In the SIDRA intersection dialogue:

*Area Type Factor parameter for Signals is used as a saturation flow adjustment factor. It applies to all lanes of the approach. HCM recommends 0.9 for CBD area type. This parameter could also be used as a simple saturation flow calibration parameter which can be specified per approach.*

*Area Type Factor affects the SCATS MF estimates as well.*

2.1.2.3 Geometry Dialogue

Geometry should closely resemble actual alignment and orientation of the intersection.

The following is required as a minimum in the Geometry Dialogue:

> Approach and exit lane data are to be as per the existing geometry for constructed intersections and/or for Construction Plans for approved intersections.
> If slip lanes or continuous lanes already exist then the appropriate selection is required.
> Values for extra bunching should be used if there are upstream signals in close proximity. Extra bunching should only be applied to sign-controlled and roundabout intersections.

Maximum values to be used to simulate the effects of extra bunching should be as shown in Table 2-1.

| **Distance to upstream signals (m)** | <100 | 100-200 | 200-400 | 400-600 | 600-800 | >800 |
|---|---|---|---|---|---|---|
| **Extra bunching (%)** | 25 | 20 | 15 | 10 | 5 | 0 |

**Table 2-1 - Maximum values for extra bunching**

The maximum basic saturation flow should be 1950 tcu /hr (SIDRA Default). Any higher or lower values than default value should be supported by appropriate data. Saturation flow measurements should be undertaken whenever possible on approaches that are heavily congested or forecasted to be heavily congested:

*The following method is recommended to calibrate the saturation flow in SIDRA INTERSECTION:*

*(i) measure the lane saturation flow, s' (veh/h) using the HCM or ARR 123 method; this saturation flow will have effects of all road and traffic factors (heavy vehicles, turning vehicles, lane width, grade, and so on);*

*(ii) compare the measured lane saturation flow, s' with the lane saturation flow estimated by SIDRA INTERSECTION, s (veh/h) given in the Lane Flow and Capacity Information table in the Detailed Output report; if they are significantly different (given that all road and traffic factors have been specified as input to SIDRA INTERSECTION correctly), calculate a calibration factor s' / s;*

*(iii) adjust the basic saturation flow (tcu/h) to s'b = (s' / s) sb where sb is the basic saturation flow (tcu/h) specified as input for estimating saturation flow s (veh/h);*

*(iv) specify the adjusted basic saturation flow in the Lane Data tab of the Lane Geometry dialog and re-process SIDRA INTERSECTION to estimate saturation flow using the new basic saturation flow (s'b); repeat the process if necessary.*

*The calibration factor (s' / s) can be used for future design options if it is believed that it adjusts the SIDRA INTERSECTION default basic saturation flow for local driver behaviour adequately. This method is not recommended for short lanes, or for lanes with opposed (permitted) turns.*

- ***Saturation Speed:***

***Saturation Speed** is the steady speed value associated with queue discharge (saturation) flow rate. This parameter indicates that vehicles do not accelerate to the speed limit during queue discharge.*

*The **Program** option is selected by default and the data field is blocked. The Saturation Speed is estimated by the program in this case. To use an observed value to override the program calculations, select the **Input** option and enter the value in the data field. The program will use the value you specify. Select the **Program** option again for program to estimate the saturation speed (no need to delete the value in the data field).*

*The saturation speed can be observed easily while driving a car, e.g. when the car crosses the stop line after accelerating from the queued position at signals, while its position was more than about the fifth car in the queue.*

*In addition to estimating the driver response time, Saturation Speed is useful for determining parameters such as various SCATS parameters (occupancy and space time at saturation, DS, best loop length, etc), and parameters for microsimulation (average and maximum acceleration rate, acceleration time and distance during queue discharge).*

*Saturation Speed is determined by SIDRA INTERSECTION for each approach lane using the method described below. This parameter is applicable to all types of intersection. The Saturation Speed is subject to various constraints related to Approach Cruise Speed and the Negotiation Speed.*

*For through movements at signalised intersections, the saturation speed, vs is estimated from:*

*vs = 0.75 vac*

*where 0.75 is the saturation speed factor and vac is the approach cruise speed.*

*If the queue discharge behaviour is influenced by existence of signals at a nearby downstream location, then the user can specify a lower value than the program estimate (say 10 per cent lower).*

*For turning movements at signalised intersections, Exit Negotiation Speed estimated by the program or specified by the user is used as the saturation speed.*

*For all movements at roundabouts and sign-controlled intersections, Exit Negotiation Speed* *estimated by the program or specified by the user is used as the saturation speed.*

*The following should be noted in relation to the Saturation Speed parameter in SIDRA INTERSECTION:*

- *Movement Classes: the Saturation Speed is not adjusted for Movement Classes.*
- *Queue Move-up Speed: The Saturation Speed is used as an upper limit in determining the queue move-up speed. In previous versions, the Approach Cruise Speed was used for this purpose.*
- *Negotiation Speeds:*
  - *For Through Movements at signalised intersections, the Approach Cruise Speed is used as the Approach and Exit Negotiation Speed, van = ven = vac for unqueued vehicles. This is relevant for geometric delay calculations.*
  - *User-specified Saturation Speed values that exceed the Exit Negotiation Speed are ignored. If a user-specified Saturation Speed is less than the Exit Negotiation Speed, then the Exit Negotiation Speed is reduced to match the Saturation Speed value, ven = vs to ensure that there is no acceleration in the Exit Negotiation section.*

*The Driver Characteristics and SCATS Parameters tables in the Detailed Output report include the estimates of saturation speeds and other parameters derived using the Saturation Speed parameter, e.g. driver response times."*

Utilisation Ratio, Saturation Speed and Capacity Adjustment Data values should only be changed subject to appropriate intersection data being collected or provided. The Turning Movement Designation should be allocated as per the existing or proposed operation of the intersection.

For wider lane approaches the SIDRA Intersection model should show how the intersection is used rather than how it operates. A wide approach is where width of the lane allows two vehicles to stand next to each other at a Stop line or operate the road as two lane road even though the road is marked as one lane only.

For signalised intersections, the parameters for Buses Stopping, Parking Manoeuvres, Short Lane Green Constraints and free queue should only be inserted if the appropriate intersection data is available.

#### 2.1.2.4 Volumes Dialogue

The following is required as a minimum in volumes dialogue.

- Vehicle volumes are to be based on the most current data collected through an intersection survey/count. Turning Movement Demands are required, which in all cases can be collected by counting arrivals at the back of queue. If a lane or approach is over-saturated (i.e. Cycle failure), then departure counts at the stop-line (presence detectors) only represent capacity, which are likely to be less than the true demand, which the new signal design should accommodate. Thus, stop-line or detector counts are only acceptable if that movement is not over-saturated.
- SIDRA default Peak Flow Factor of 95% is acceptable. Analysis of intersection data collected may impact the Peak Flow Factor used. Supporting documentation is required to justify the factor used other than the default Peak Flow Factor of 95%.
- The appropriate Growth Rate parameter should be used in consultation with QLDC if completing a design life analysis on the intersection.
- Growth rates used for future volume estimation and/or the justification of the methods used to determine future volumes should be included in the final report.

Unit time for volumes and peak flow period should reflect data of the intersection counts where the:

- Maximum unit time for volumes is 60 minutes (unit used is dependent on actual flow data and any variation should be discussed with QLDC and documented).
- Maximum peak flow period is 30 minutes.

> Peak Flow Factor (volume dialogue box) should be carefully assessed to replicate actual Peak Period.

2.1.2.5 Path and Movement Data Dialogue

The Approach Cruise Speed and Exit Cruise Speed for existing intersections should reflect the present intersection conditions. The Approach Travel Distance should be changed to reflect the existing and/or proposed operation of the intersection. The Negotiation Speed and Negotiation Distance can be changed manually to indicate the physical parameters for intersections that have unusual geometry features. Justification should be given for the values used for the intersections of unusual nature. All other items in this dialogue should be the SIDRA default values.

In the Movement Data input dialogue some of the data items may not be available depending on the intersection type and the characteristics of the movement. The default values in the Movement Data Dialogue box should be used unless evidence is provided indicating a different set of values are appropriate. Data in the Pedestrian Effects section can be manually inserted with the appropriate justification provided.

2.1.2.6 Lane Data Dialogue

*In the Lane Data input dialogue, you can specify a lane utilisation ratio which is less than 100 per cent in order to allow for lane underutilisation observed in the field. The resulting lane flows estimated by SIDRA INTERSECTION can be compared with the observed lane flows and the lane utilisation ratio can be modified for the estimated lane flows to match the observed values. Where available, SCATS lane flow information is useful for this purpose. The sensitivity analysis facility (the Demand & Sensitivity input dialogue) allows for testing varied values of user-specified lane utilisation ratios.*

2.1.2.7 Gap-Acceptance Dialogue

Default values should be adjusted under different geometric arrangements. Therefore, gap-acceptance parameters applicable to particular intersection geometry and flow conditions should be selected by using good judgement and taking into account the local driver characteristics.

Appropriate judgement is required while selecting the critical gap and follow-up headway values to suit the circumstances considering grades, sight distance conditions, opposing movement speeds, number of lanes, and one-way or two-way conditions. Any changes to these values should be justified.

2.1.2.8 Pedestrians Dialogue

The volume of pedestrians and Peak Flow Factor can be altered to suit the intersection counts obtained. The growth rate used under Pedestrian Data should be justified and explained. Data for Crossing Distance, Approach Travel Distance, and Downstream Distance can be changed to reflect the geometry of the existing intersection if this data is available. Default values should be used for all other parameters in this dialogue.

SIDRA default for Pedestrian Walking Speed (Average) in the Pedestrian Data dialogue box is 1.3m/sec. A value of 1.5 m/sec should be used for pedestrian modelling.

Where partial pedestrian protection is proposed the calculation shall be measured ¾ across the full width of crossing.

2.1.2.9 Phasing and Timings Dialogue

The phasing and timing on signalised intersections can be altered to determine the most appropriate solution. However, when modelling the existing intersection, the phasing and timing should be representative of current Phasing and Timing of that intersection. Intersection surveys should be undertaken if the necessary data is not available. Default yellow time of four seconds and red time of two seconds should be used if the measured data is not available.

The maximum cycle time to be used is 120 seconds, consult with WTOC for advice. Cycle time is generally controlled by the SCATS master subsystem. Therefore the cycle time for all intersections linked with the master subsystem should use the same cycle time.

- ***Slip Lanes without detectors:***

  *Slip/bypass lane movements should be treated as Undetected under the SCATS control system where turning vehicles using slip/bypass lanes do not cross over stop-line detectors. This is not appropriate in control systems where turning vehicles using slip/bypass lanes cross over advanced detector loops, or with controllers using fixed-time signal plans where the plans are designed to accommodate all turning vehicles.*

- ***Detection Zone length:***

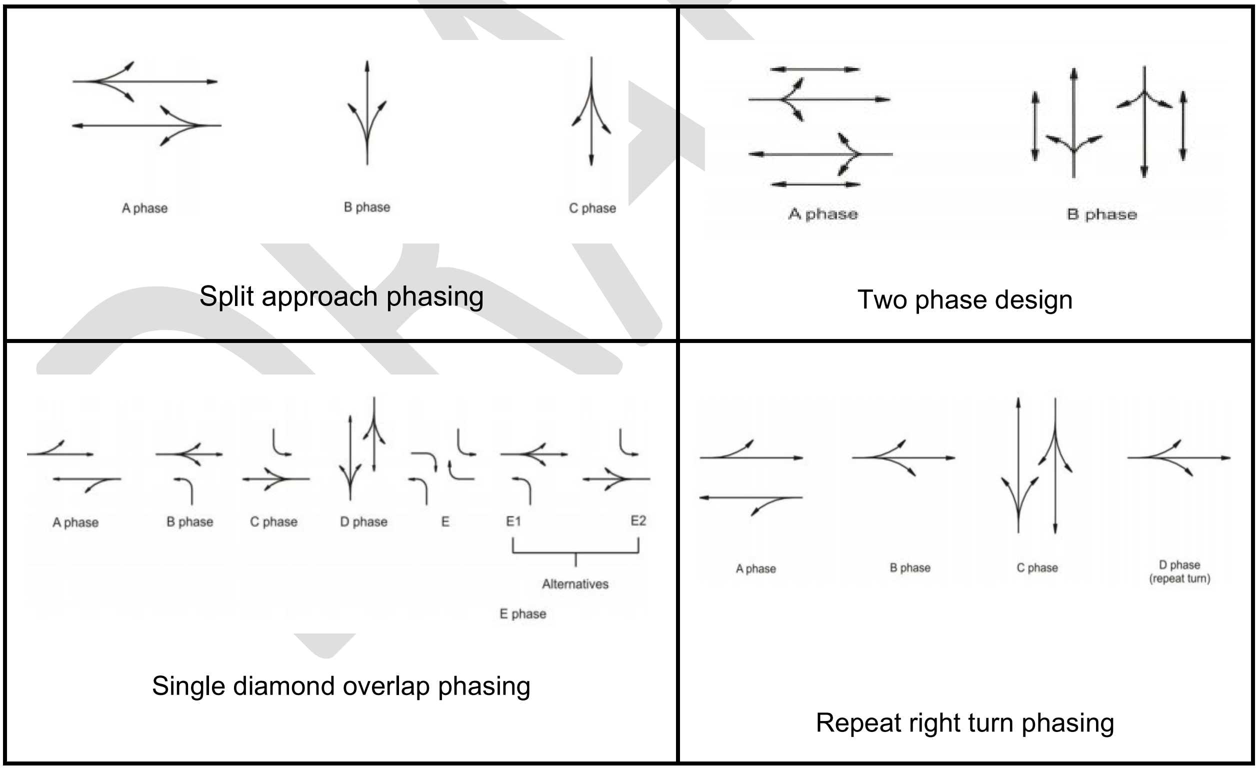
  *Effective Detection Zone Length can be specified at all signalised intersections regardless of whether the Analysis Method is specified as; Fixed Time/Pre-timed or Actuated. This is particularly relevant to modelling of intersections running under the SCATS system.*

### 2.1.3 SCATS Standard Traffic Signal Phasing Diagrams

QLDC has standard phasing arrangements in one of the following forms:

- Conventional phases.
- Conventional phases with turning leading, trailing or repeat right turn phases.
- Diamond phase.
- Split phases.

These phase arrangements should be used in intersection modelling. Refer to Table 2-2 for examples of phasing arrangements.



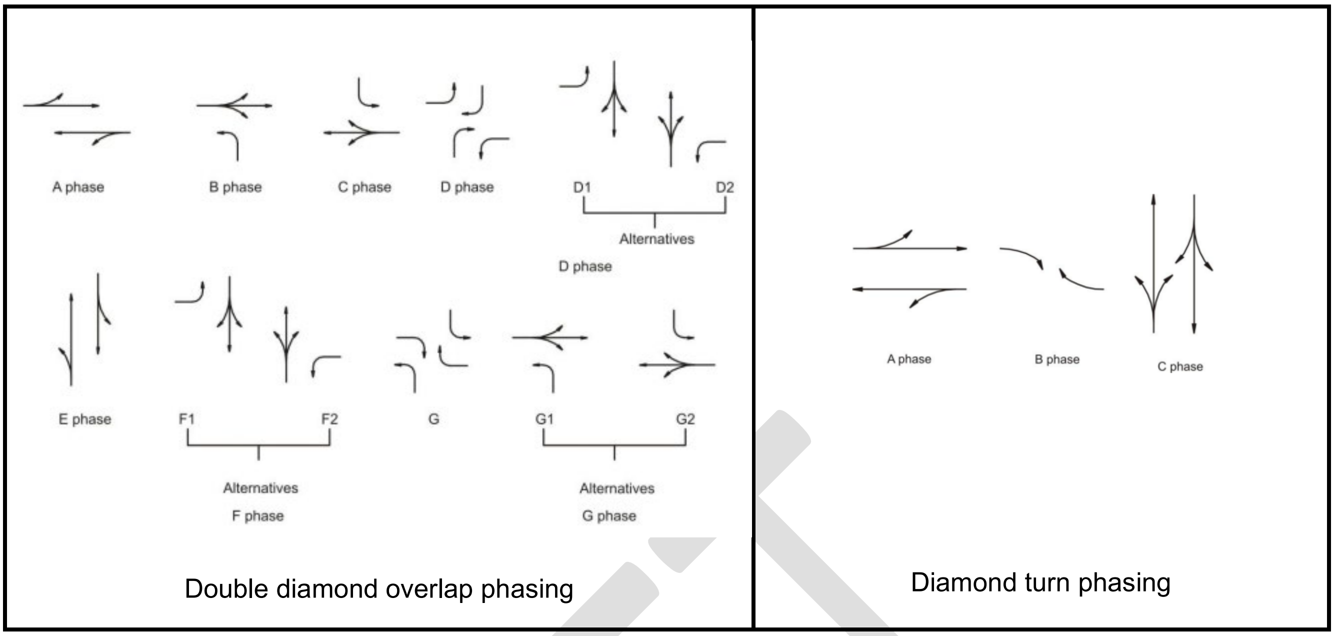



**Table 2-2 - Examples of phasing arrangements**

### 2.1.4 Calibration

The calibration process should be based on various traffic surveys and site observations. All changes required in order to calibrate the model should be fully documented with an explanation and justification of the change. SIDRA User Guidelines should be referred to for possible calibration methods.

In order to properly identify the effects of future network and/or demand changes on the existing operation of signalised intersections, the timings obtained from a calibrated model of existing conditions (based on observed signal times) should be compared with those obtained from the SIDRA optimised timings. In this way differences can be compared and an explanation provided as to why they may exist.

This comparison is useful in identifying:

- Incorrect model assumptions in respect of traffic behaviour (saturation flows, delays due to pedestrians, queue storage space etc.).
- Incorrect model assumptions in respect of signal operation assumptions (i.e. alternative phase calls, phase skipping, offset, cycle times, minimum greens, clearance times etc.).
- Incorrect SCATS setup.

In addition to the above, many model software packages have specific SCATS input/import and output/export features. The Help instructions regarding SCATS compatibility should be consulted and guidelines followed, to the extent possible. Specifically, SIDRA has a SCATS Parameters Table available in the Detailed Output report[i]:

*It provides the user with estimates of the Maximum Flow (MF) and the associated Headway at maximum Flow (HW), Occupancy Time at maximum Flow (KP) and Space Time parameters reported by the SCATS traffic signal control system.*

*SCATS parameter estimates can be used together with lane flow rates reported by SCATS for the purpose of calibrating SIDRA INTERSECTION against measured conditions. The basic saturation flow parameter can be adjusted so as to match the measures SCATS MF parameter.*

*The SCATS on-line feedback system determines the MF parameter using a complex set of filtering rules using traffic data collected cycle by cycle during the day. On the other hand, the SIDRA INTERSECTION estimate of the MF parameter is based on average conditions and derived on the basis of various assumptions regarding the factors that influence this parameter.*

*Therefore, a one to one correspondence should not be expected between a SCATS-reported MF value and the corresponding SIDRA INTERSECTION estimate. However, a comparison of the SCATS-reported value of MF and* *associated parameters and the SIDRA INTERSECTION estimates can be of valuable help when saturation flow rates from field surveys are not available.*

*The SIDRA INTERSECTION sensitivity analysis facility (Demand & Sensitivity dialog) can be used to vary the basic saturation flow parameter so as to match the SCATS-reported MF parameters.*

#### 2.1.5 Outputs

As outlined in the Introduction, the designer shall submit a detailed SIDRA report consisting (as a minimum) of the following:

> Introduction.

> Background.

> Traffic volumes including any adjustments made to modelled volumes noticing in particular the forecast years(s).

> Each Option should be modeled in Year 0 and Year 10. The land arrangement and phasing of each Option must be shown.

> Analysis Methodology (including details of calibration).

> Analysis Results Summary, including a table highlighting the following for each movement and, the intersection as a whole:

- Degree of Saturation (DoS) (maximum 0.90).
- Average Delay (RMS NSW Method).
- Level of Service (LoS).
- 50% and 95% Back of Queue distance.
- Fuel Consumption, Emissions and Cost (total and rate).
- Flow Scale / Design Life Results based on a 10% increase in traffic volumes.
- Pedestrian movements.

> Discussion on all observations of the analysis results and outcomes.

> Conclusions and Recommendations (e.g. length of extensions to turn lanes, etc.).

> A table indicating the proposed cycle length, phase splits and offsets (if coordinated) that the model suggests to be adopted by SCATS for the morning peak, and, afternoon peak (include SCATS Parameters Table from Detailed Output report).

> Best Level of Service whilst Fuel Consumption and Emission are not the highest rate compare to other level of services.

> The applicant must report all traffic data deemed necessary to complete the validation in an appendix. An electronic copy of the software input and output files for all options, showing the phasing and time settings used in the evaluation, must also be provided.

> For closely spaced signals, a decision needs to be made and justified on isolated versus coordinated system analysis. An initial isolated analysis should inform the design layout and phasing prior to a full coordinated system analysis, serving as a useful cross-check.

# 3 GUIDE FOR USE OF ADVANCE DETECTION

| | Yes | No | Maybe |
|---|---|---|---|
| **Main Road** | Runs in Isolated mode and has a combination of:<br>• Approach Speed 60km/hr or greater, or<br>• Multilane approach, or<br>• Sight lines to signal displays restricted due to vertical or horizontal alignment, or<br>• Has a steep approach gradient, or<br>• Significant volume of heavy vehicles. | Controlled by SCATS under continuous Masterlink mode and is the Stretch phase. | Controlled by SCATS but may operate in Master Isolated or Isolated mode during off peak periods and has a combination of:<br>• Approach Speed 60km/hr or greater, or<br>• Multilane approach, or<br>• Sight lines to signal displays restricted due to vertical or horizontal alignment, or<br>• Has a steep approach gradient where slow starting vehicles may cause the approach to terminate early, or<br>• Significant volume of heavy vehicles.<br>• High incidence of Red light running |
| **Minor Road** | May operate in Masterlink, Master Isolated or Isolated mode and has a combination of:<br>• Approach Speed 60km/hr or greater, or<br>• Multilane approach, or<br>• Sight lines to signal displays restricted due to vertical or horizontal alignment, or<br>• Has a steep approach gradient where slow starting vehicles may cause the approach to terminate early, or<br>• Significant volume of heavy vehicles. | • Low volumes with easy or flat approach gradient<br>• Low approach speeds<br>• Single lane approaches.<br>• Low volume of heavy vehicles | • Single lane, low speed, low volumes but may have a steep approach gradient where slow starting vehicles may cause the approach to terminate early<br>• High incidence of Red light running<br>• High incidence of Nose to tail type accidents. |
| **Pedestrian Crossing** | At all mid-block signalised pedestrian crossings | | |

The Table above is intended to provide guidance on where the use of advance detection may or may not be considered appropriate. Each site should be assessed based traffic flows and composition, site layout, safety and efficiency considering the above guide and notes below.

It is recognised that costs of installing and maintaining the additional loops for advance detection are not insignificant but we believe that benefits exist to offset the additional costs associated with advance detection. This is especially so at strategic state highway intersections. The following discussion covers these benefits.

These areas have been categorised into ***efficiency***, ***safety*** and ***traffic data***. Often efficiency can result in greater safety by reducing driver frustration.

## 3.1 EFFICIENCY

### 3.1.1 Phase Termination

Under isolated or master isolated vehicle actuated operation, signal phases predominantly terminate on gap identification. Typically a gap setting may be in the vicinity of 3-4 seconds. When a gap is identified at a limit line loop, the last vehicle in a 50km/h traffic stream is already some 50-60metres beyond the limit line. By the time the intergreen period (typically 5 seconds) has expired and the opposing flow commences, the last vehicle is 120-140beyond the intersection.

If the gap is located at an advance loop 40-50 metres ahead of the limit line, the intergreen period will introduce as the last vehicle passes through the intersection, thus eliminating 3-4 seconds of waste time at the end of every phase that is terminating on a gap. The last vehicle will still be 50-60 metres beyond the intersection when the opposing flow commences.

Under SCATS control, although the stretch phase length is predetermined, often the side road phases still utilise gap termination thus enjoying some of the benefits above.

The provision of advance loops allows the specifying of special logic within the controller which utilises the limit line loops to get traffic moving during the first 12 seconds or so, and then interrogates the advance loops only, for gap identification. The software in no way affects the SCATS algorithms and purely provides for more efficient phase termination in phases where gap termination is specified.

It is recognised that under low flows (during the first 12 seconds) or under high volumes where phases are terminating on maximum, the benefits above are not realised, but there are significant periods when this is not the case and overall, motorists would experience a far more responsive operation of the signals.

### 3.1.2 Phase Introduction

Under isolated or master isolated vehicle actuated operation, whenever a vehicle approaches a red display without an advance loop, the phase demand does not occur until the vehicle has almost stopped at the limit line. The vehicle then has to wait for the 5 second intergreen period before receiving a green display. With an advance loop the demand is lodged 40-50 metres before the limit line and if the vehicle begins slowing, the green display should come on as the vehicle reaches the limit line eliminating the unnecessary stop condition.

Advance loops were the universally recognised control system before the advent of SCATS, and still the preferred positioning in regions where SCATS, or other area control systems requiring alternative loop positioning, do not exist. There appears to be no evidence that phase introduction by advance loops is any less safe than the far less efficient phase call at the limit line.

### 3.1.3 Approach Priority

With advance loops at varying distances from limit lines on different approaches, a measure of priority can be afforded to a particular movement. On some major state highway intersections, we have provided advance loops 70m or more from the limit line on the priority approach whilst the advance loops on a side road of lesser importance may be positioned only 30m from the limit line. This provides priority to the main road approach both in terms of phase calling and extending the main road phase.

### 3.1.4 Loop Backup

The provision of advance and limit line loops also provides a level of backup in the event of a loop failure. A faulty loop can be switched out and the approach run with a satisfactory level of service utilising either the advance loops only or the limit line loops only until repairs can be effected.

## 3.2 SAFETY

### 3.2.1 Non-use of dynamic approach loops

Prior to SCATS, inductance loops were positioned about 40metres in advance of limit lines in 50km/h zones and further back in higher speed areas. This enabled identification of gaps before reaching the limit line and signals tended to change to yellow as the last approaching vehicle in a platoon reached the intersection. The control system was also aware of any vehicle within 40metres of the intersection and unless terminating on maximum, allowed a further increment of green time to progress the approaching vehicle up to the intersection.

Where advance loops are not used the control system is unaware of approaching vehicles and phases terminate regardless of positioning of vehicles approaching the limit line.

On a co-ordinated route under full SCATS control the dynamic approach loops are irrelevant. The termination of such approaches are controlled entirely by the SCATS algorithms designed to maintain the necessary offsets between intersections. If the intersection falls back to isolated or master isolated control, or for side roads under full SCATS control, the dynamic approach loops are far better positioned to safely and efficiently terminate the relevant approaches.

Using SCATS limit line loops, termination following a gap commences when a vehicle is already well clear of the intersection (thus introducing unnecessary waste time), and regardless of whether another vehicle is now approaching the limit line.

Both premature phase termination and inefficient phase termination encourage ***red light running***. We believe that a combination of SCATS and dynamic approach loops can provide a significant improvement in overall safety at an intersection especially where operational speeds of 60km/h or greater are experienced.

At intersections operating under higher speeds, studies have indicated that very significant safety benefits are obtained by protecting areas known as 'Dilemma Zones' with appropriately positioned dynamic approach loops. A 'Dilemma Zone' is a zone of indecision within which, if the yellow signal comes on, the decision of whether to stop or proceed is not clear and varies from driver to driver thus increasing the risk of rear-end collision. Protection of these zones requires advance loops up to 100metres in advance of the limit line on high speed approaches.

# 4 PROJECT CHECK SHEET FOR TRAFFIC SIGNALS

## Purpose

The purpose of this check list is to summarise what is expected when submitting approval to QLDC.

## Who Should Use This Document?

This document should be used by all consultants, contractors and project managers (referred to as "applicant" in this document) involved in the design of traffic signals within the Queenstown Lakes District. Where, for example, a traffic signals intersection is proposed the majority of this document will be filled out by the consultant since the design process is specialised.

Each section must be filled out with tick for submitted, any associated notes / comments; when left unticked please comment the reasons why.

### 4.1 TRAFFIC SIGNAL PROJECT CHECK LIST OF FILES SUBMITTED

| **Applicant / Consultant** | | | **QLDC** |
|---|---|---|---|
| Traffic Feasibility Report | ✓ | Notes / Comments | Approved |
| Site Location Plan | | | |
| | | | |
| Brief description | | | |
| | | | |
| Concept Drawing | | | |
| | | | |
| Services / Risks | | | |
| | | | |
| Road / User Assessment | | | |
| | | | |
| Crash Data / CAS | | | |
| | | | |
| Movement Data / Counts | | | |
| | | | |
| Traffic Modelling Report | | | |
| | | | |
| Modelling Data Files | | | |
| | | | |

| **Applicant / Consultant** | | | **QLDC** |
|---|---|---|---|
| Road Safety Audit | ✓ | Notes / Comments | Approved |
| Pre-Construction Audit | | | |
| | | | |
| Post-Construction Audit | | | |
| | | | |

| **Applicant / Consultant** | | | **QLDC** |
|---|---|---|---|
| Traffic Signal Detail Design | ✓ | Notes / Comments | Approved |
| Cover Sheet and Site Location Plan | | | |
| | | | |
| Existing Survey and Services. | | | |
| | | | |
| Proposed Construction and Set out. | | | |
| | | | |
| Proposed Signal and Phasing Layout. | | | |
| | | | |
| Proposed Ducting and Cable Diagram. | | | |
| | | | |
| Tactile Pavers and Pedestrian Layout. | | | |
| | | | |
| Proposed Road Marking and Signage. | | | |
| | | | |
| Vehicular Tracking Plan. | | | |
| | | | |
| Proposed Street Lighting. | | | |
| | | | |
| Standard Details (optional). | | | |
| | | | |
| Controller Information Sheet (CIS). | | | |
| | | | |

| Applicant / Consultant | | | QLDC |
|---|---|---|---|
| Software Development | ✓ | Notes / Comments | Approved |
| Controller Information Sheet | | | |
| | | | |
| .SFT Wintraff Test Report | | | |
| | | | |

# 5 TRAFFIC SIGNALS SOFTWARE GUIDELINES

## Purpose

The purpose of this document is to give an understanding of the QLDC requirements when undertaking the design, installation or maintenance of traffic signal installations in the Queenstown Lakes District.

## Who Should Use This Document?

All consultants, contractors, should use this document and project managers (we refer to as “applicant” in this document) involved in the design, installation and maintenance of traffic signals on behalf of Road Controlling Authorities (RCA) in the Queenstown Lakes District. Where for example an upgrade is being carried out by an RCA the applicant shall be the assigned. This would in most situations be the traffic signal contractor who would have most technical experience in providing the relevant information required.

QLDC has prepared this document to assist practitioners when designing traffic signal installations. Although this document has technical and specialist content, the applicant must read in conjunction with this document, the QLDC CoP. The QLDC CoP contains details on document management, flow charts and describes processes. The intent is to show what is expected in the application. The applicants should also refer to NZTA P43 Specification for Traffic Signals.

This guideline has been created to ensure that the designs of all intersections are to the highest standard, with variations being the exception rather than the norm. It is important that the information submitted as part of new or modified traffic signal layouts are standardised as much as possible. This will enable any further changes that may result from changing traffic conditions to be implemented quickly and simply.

This document lists the information that must be shown on the drawing for the traffic signal layout plan. The guideline information covers all the basic data required for a contractor to install the traffic signal equipment. The information will assist QLDC and WTOC to review the Controller Information Sheets (CIS) and the Controller personality as well as allow WTOC to set up the intersection on the SCATS network and provide good operational performance.

This document covers in some detail requirements that must be included in other plans. For example, requirements pertaining to any physical works such as; existing survey and services, proposed construction or road marking. These are essential to provide as complete a picture as possible. The applicant’s project team members are expected to have the experience and knowledge required to provide the relevant details, particularly the production of software and, CIS and traffic signal design. QLDC are not responsible for providing training or resources for designers who are new to the industry as there are suitable courses and consultants who can provide training.

### 5.1 TECHNICAL CRITERIA

The design of the traffic signals must be carried out in accordance with the standards and guidelines listed below and their revised / subsequent replacements:

> QLDC Land Development & Subdivision Code of Practice – 2022.

> QLDC CoP Appendix L – Traffic Signal Guidelines.

> NZTA P43 Specification for Traffic Signals.

> AUSTROADS Traffic Management Guides.

> Road Traffic Standards (RTS) 14.

> NZTA Pedestrian Planning and Design Guidelines.

> Other NZTA, TCC, RMS, AS / NZ standards as agreed from time to time.

The specification of traffic signals equipment shall comply with the current version of the QLDC CoP or a written agreement with QLDC for the use of specific components shall be obtained.

The contractor is responsible for ensuring that all equipment that is installed meets the minimum standards. If there is any doubt the contractor shall be required to provide evidence that the product meets the QLDC requirements.

### 5.1.1 Reference Material

The traffic signal is very specialist and partially in New Zealand where resources and training is minimal. There we have provided some recommended documents listed below to assist in the processes required.

> NSW Roads & Maritime Services, Traffic Modelling Guidelines.

> NSW Roads & Maritime Services, Traffic Signal Design.

> Australian Road Research Board (ARRB), Traffic Signals: Capacity and Timing Analysis.

> Signals National User Group (SNUG)

### 5.1.2 Detectors

All loop positions are to be determined early in the design.

All controlled lanes must have detector loops installed including for example left turn lanes under Give Way control to count vehicles only, if there are sufficient detector inputs available.

Advance loops may be required in some instances to optimise signal operation and enhance safety in high speed environments. If the controller capacity allows, detector loops are to be included in uncontrolled slip lanes for traffic counting purposes. Loops on bridge decks or approach slabs should be avoided where practical. Refer Section 3 of this Appendix.

Where there are a high number of cyclists the type and style of loops shall be clearly shown. Cycle lane design requires special attention and these shall be considered on a site by site basis.

Special care is required to ensure that the placement of the loop is in the correct position within the lane. Failure to confirm positions prior to sealing can mean that another loop may be required to be saw cut into the new seal. All loop locations to be accurately located and included on as-built drawings.

The ideal or preferred methodology of installing loops is to place them under the bedding of the pavement prior to sealing in order to avoid repeatedly cutting in a short period of time.

The requirements for the detector numbering convention are detailed in 1.2.6.1 of this Appendix. If the controller cabinet is relocated then the site must be renumbered to comply with the standard convention.

Configure virtual red light running loops in the CIS when there is spare capacity to allow, consult with QLDC as required.

#### 5.1.2.1 Vehicle Detectors

Detectors are numbered anticlockwise from the controller assuming that a line is drawn from the controller through the centroid of the intersection.

The first circuit is the stop line loops, departure loops and counting loops are numbered first, with the departure loop being numbered after the stop line loop it is associated with.

The second circuit is the dynamic loops, followed by the advance dynamic loops.

The reason detectors are numbered anticlockwise is so that an approach will read numerically correct left to right when viewed on a SCATS System Monitor display.

Where there is a secondary part to the signals such as at interchanges, the first circuit is around the part of the intersection closest to the controller, then around the second part of the intersection. Then back to the first part of the intersection for the second circuit. A line is drawn from the controller through the centroid of the second part of the intersection to give the starting point for each numbering circuit.

If a controller is relocated then the site must be renumbered to comply with the standard

#### 5.1.2.2 Detector Card Configurations for AS 2578 VC5/6 Compliant Controllers

When the new AS 2578 and VC5/6 compliant controllers were first introduced each Detector card had 16 Internal Detectors (Vehicles) and 16 External Detectors (Pedestrian). Since then the manufacturers have provided some flexibility to allow combinations to be used. It is important for the designer to understand and number the loops and pedestrian call detectors in the appropriate manner as this impacts directly on the preparation of the software. Furthermore, VC6 controllers have extended the capacity therefore check with the manufacturer on these specifications.

5.1.2.3 Pedestrian Detectors

Pedestrian detectors are numbered depending upon the card in use. First ascertain the number of detectors available at the controller if it is an existing site or determine the requirement if new. TSC3 Controller Detector cards come in groups of four ranging between 4 and 32.

The AS 2578 Compliant controllers come with a 16, 24 or 32 input Detector card. This consists of vehicle inputs and external inputs. Again, this will depend on the type of controller and the configuration applied.

The pedestrian detectors are numbered from the highest number down as follows and may include more than four pedestrian facilities:

| PEDESTRIAN / WALK NUMBER | 1 PED | 2 PEDS | 3 PEDS | 4 PEDS | 5 PEDS |
|---|---|---|---|---|---|
| W1 | 16 | 16 | 16 | 16 | 16 |
| W2 | | 15 | 15 | 15 | 15 |
| W3 | | | 14 | 14 | 14 |
| W4 | | | | 13 | 13 |
| W5 | | | | | 12 |

**Table 5-1: Pedestrian Detector Slot Numbering (16 Detector)**

A similar configuration will apply across the top end for 24 and 32 detector cards.

In ground and above ground pedestrian detection systems will need to be configured as a pedestrian input. Using Table 5-1 as an example, for four pedestrians we use inputs 13-16 and if we were to install above ground pedestrian detection for all the walks the detection would be numbered 11-4 leaving one unused before the pedestrians. MSS bits shall be used and numbered the same as the pedestrian detector number (where possible). Furthermore all non-loop detectors shall have an MSS assigned for each unit for additional SCATS variation options and monitoring options.

### 5.1.3 Pole Numbering

Poles are numbered in a clockwise direction from the controller assuming that a line in drawn from the controller to the centroid of the intersection.

Where there is a secondary part to the signals such as at interchanges, the intersection closest to the controller shall be numbered first then the additional part can be numbered in the same format assuming that a line is drawn from the controller to the centroid of the secondary part of the intersection.

If a controller is relocated then the site must be renumbered to comply with the standard convention.

### 5.1.4 Signal Groups

With AS 2578 and VC5 compliant controllers, the number of signal groups can range from 4 to 32 in modules of four signal groups. The recent changes to VC6 controllers may change some of the content listed below, therefore discussions with the manufacturer is expected during design.

Pedestrian signal groups in a sixteen group controller will be denoted as: W1=16, W2=15, W3=14, & W4=13). If there are only two Pedestrian groups then W1=16 and W2=15.

### 5.1.5 Phasing

The phasing diagram must show the following:

> Each phase in a separate box with the phase label inside the box corner A, F, F1, etc.

> Show only the movements that display green in each phase

> Indicate movements by an arrow pointing in the direction that traffic will travel

> Signal groups shown in a circle at the point of the movement arrow for vehicles and beside
> Pedestrian movements
> Any Special Flags inside the phase box Z, Z+, etc.
> Indicate if filter turn movements are permitted
> Label phasing to lanterns
> Default and Alternative phasing to be shown. Alternative phasing must show split phasing for each approach to assist in maintenance and operations.
> An all red phase to be added to all plans for operational requirements, no detector or input to be assigned to call/demand. Shall be operated only by SCATS Dwell.

The phase sequence must be shown on the plan adjacent to the phasing diagram.

In general, all traffic signals shall be consistent with the standard RMS configuration. Standard phasing configurations are detailed below. Where standard phasing configurations are not appropriate due to the site or traffic flow conditions, the phasing should be designed to:

> Minimise the number of phases
> Minimise cycle time
> Run as many compatible movements as possible in each phase
> Restrict each phase to non-conflicting movements
> Allow each movement to run in as many phases as possible (preferably allowing as many as possible to overlap from the previous phase or into the following phase), and
> Comply as closely as possible with the standard RMS configuration. Examples of a range of standard arrangements are found on the following pages of this document.

The phasing design should consider the use of filter right turn movements. The phasing design should provide the most flexible operation that will accommodate changes in traffic conditions without the need to reprogram the controller personality. This may result in a phasing sequence in which not all phases are used initially. An example of this is the inclusion of repeat right turn phases.

The phasing sequence (i.e. the order in which each phase runs) should be designed to provide the optimum coordinated flow along a corridor. This may change at different times of the day.

## 5.2 STANDARD TYPES

### 5.2.1 Midblock Pedestrian Crossing

#### 5.2.1.1 Required Signal Groups

##### *5.2.1.1.1 Vehicle*

> SG 1 Main road through movement clockwise from the controller
> SG 2 Main road through movement opposite to SG 1.

##### *5.2.1.1.2 Pedestrian*

The midblock crossing will normally have one pedestrian and can be catered for with a much smaller controller than would otherwise be required.

Pedestrian Movement 1 – At a right angle to the main vehicle flow (e.g. SG 4, 8, 12 or 16) but typically SG4.

***Note:***

Staggered / two stage pedestrian crossings require an additional signal group as the walk phases are normally split.

### 5.2.2 Staggered Pedestrian Crossing

The configuration of a staggered pedestrian crossing should be left to right. Although this may not be practical, this requirement is so pedestrians are walking towards the main traffic flow. Careful consideration for poles and access would be required in the design.

#### 5.2.2.1 Required Signal Groups

##### *5.2.2.1.1 Vehicle*

- SG 1 - Main road through movement clockwise from the controller
- SG 2 - Main road through movement opposite to SG1.

##### *5.2.2.1.2 Pedestrian*

- Pedestrian Movement 1 – At a right angle with SG1 (e.g. SG 4, 8, 12 or 16) but typically SG4
- Pedestrian Movement 2 – At a right angle with SG2 (e.g. SG 3, 7, 11 or 15) but typically SG3.

### 5.2.3 T-Intersections

#### 5.2.3.1 Required Signal Groups

##### *5.2.3.1.1 Vehicle*

- SG 1 - Main Road through movement adjacent to main road right turn
- SG 2 - Main Road through movement conflicting with main road right turn
- SG 3 – Right turn from main road
- SG 4 – Right turn or right and left turn from side road.

##### *5.2.3.1.2 Pedestrian*

- Pedestrian Movement 1 – across side road (i.e. parallel with SG2)
- Pedestrian Movement 2 – across main road and to the left of the side road.

#### 5.2.3.2 Optional Signal Groups

Where provided use next available signal group in order below.

##### *5.2.3.2.1 Vehicle*

- Left turn from main road into side road
- Left turn from side road into main road.

##### *5.2.3.2.2 Pedestrian*

If an existing controller has eight signal groups and more than four vehicle groups then it may be necessary to renumber the pedestrian signal groups.

- Pedestrian movement across controlled left turn slip lane from main road
- Pedestrian movement across controlled left turn slip lane from side road.

#### 5.2.3.3 Phasing

Normal Phase Sequence = A : C : D

Alternative phase sequence A : B : C : D

<u>A Phase</u> – SG's 1, 2 and Pedestrian Movement 1.

May also include left turn movement into side road from main road if controlled by a separate signal group.

Note : Where considered safe the right turn movement may be permitted to FILTER turn. Filtering will be controlled through the introduction of the Z- flag. Filtering enabled under Flexilink or Masterlink only. If filtering is enabled, the main road left turn signal group (if provided) shall be in the OFF state.

<u>B Phase</u> – SG's 1 and 3.

May also include left turn from side road into main road if controlled by a separate signal group.

Note : B Phase introduction is controlled through introduction of Z+ flag in Flexilink or Masterlink only.

C Phase – SG 4 and Pedestrian Movement 2.

May also include the left turns into and out of the side road, if controlled by separate signal groups.

D Phase – SG's 1 and 3.

May also include left turn from side road into main road if controlled by a separate signal group.

### 5.2.4 Split Side Road Phases

#### 5.2.4.1 Required Signal Groups

*5.2.4.1.1 Vehicle*

- SG 1 - Main road through movement clockwise from the controller
- SG 2 - Main road through movement opposite to SG 1.
- SG 3 - Right turn adjacent to SG 1
- SG 4 - Right turn adjacent to SG 2
- SG 5 - Side road movements to the left of SG 1 (clockwise from SG 1)
- SG 6 - Side road movements to the left of SG 2 (clockwise from SG 2).

*5.2.4.1.2 Pedestrian*

- Pedestrian Movement 1 – parallel to SG 1 (e.g. SG 16)
- Pedestrian Movement 2 – parallel to SG 2 (e.g. SG 15)
- Pedestrian Movement 3 – pedestrian on the left of the C phase side road (e.g. SG 14)
- Pedestrian Movement 4 – pedestrian on the left of the D phase side road (e.g. SG 13).

#### 5.2.4.2 Optional Signal Groups

Where provided use next available signal group in order below.

*5.2.4.2.1 Vehicle*

- Right turn adjacent to SG 5 (red arrow only for pedestrian protection)
- Right turn adjacent to SG 6 (red arrow only for pedestrian protection)
- Left turn adjacent to SG 1
- Left turn adjacent to SG 2
- Left turn from C phase side road
- Left turn from D phase side road.

*5.2.4.2.2 Pedestrian*

- Pedestrian across controlled left turn slip lane from main road and parallel to SG 1
- Pedestrian across controlled left turn slip lane from main road and parallel to SG 2
- Pedestrian across controlled left turn slip lane from D phase side road
- Pedestrian across controlled left turn slip lane from E phase side road.

#### 5.2.4.3 Phasing

Normal Phase Sequence = A : D : E : F

A Phase – SG's 1, 2, Pedestrian Movements 1 and 2.

May also include left turn movements into side road from main road if controlled by separate signal groups.

Note: Where considered safe the right turn movements may be permitted to filter turn. Filtering shall be permitted on the AB (SG1) approach under the following conditions:

- The mode of operation is Masterlink or Flexilink AND XSF 1 bit is set and there is Z- flag present
- Filtering shall be permitted on the AC (SG2) approach under the following conditions:
- The mode of operation is Masterlink or Flexilink AND XSF 2 bit is set and there is Z- flag present.

Note: If filtering is enabled, the main road left turn signal groups (if provided) shall be in the "OFF" state.

B Phase – SG's 1, 3, Pedestrian Movement 1.

May also include left turn parallel to SG1 and from D phase side road if controlled by separate signal groups

C Phase – SG5, Pedestrian Movement 3.

May also include left turn parallel to SG2 and from D phase side road if controlled by separate signal groups

D Phase (least busiest side road movement) –SG 6 and Pedestrian Movement 4.

May also include left turn from main road parallel to SG 1 if controlled by a separate signal group.

### 5.2.5 Single Diamond Overlap with Split Side Road Phases

#### 5.2.5.1 Required Signal Groups

##### *5.2.5.1.1 Vehicle*

- SG 1 Main road through movement clockwise from the controller
- SG 2 Main road through movement opposite to SG 1.
- SG 3 – Right turn adjacent to SG 1
- SG 4 – Right turn adjacent to SG 2
- SG 5 – Side road movements to the left of SG 1 (clockwise from SG 1)
- SG 6 – Side road movements to the left of SG 2 (clockwise from SG 2).

##### *5.2.5.1.2 Pedestrian*

- Pedestrian Movement 1 – parallel to SG 1 (e.g. SG 16)
- Pedestrian Movement 2 – parallel to SG 2 (e.g. SG 15)
- Pedestrian Movement 3 – pedestrian on the left of the D phase side road (e.g. SG 14)
- Pedestrian Movement 4 – pedestrian on the left of the E phase side road (e.g. SG 13).

#### 5.2.5.2 Optional Signal Groups

Where provided use next available signal group in order below.

##### *5.2.5.2.1 Vehicle*

- Left turn adjacent to SG 1
- Left turn adjacent to SG 2
- Left turn adjacent to SG 5 (red arrow only for pedestrian protection)
- Left turn adjacent to SG 6 (red arrow only for pedestrian protection).

##### *5.2.5.2.2 Pedestrian*

- Pedestrian across controlled left turn slip lane from main road and parallel to SG 1
- Pedestrian across controlled left turn slip lane from main road and parallel to SG 2
- Pedestrian across controlled left turn slip lane from D phase side road
- Pedestrian across controlled left turn slip lane from E phase side road.

#### 5.2.5.3 Phasing

Normal Phase Sequence = A : D : E : F

A Phase – SG's 1, 2, Pedestrian Movements 1 and 2.

May also include left turn movements into side road from main road if controlled by separate signal groups.

Note: Where considered safe the right turn movements may be permitted to filter turn. Filtering shall be permitted on the AB (SG 1) approach under the following condition:

- The mode of operation is Masterlink or Flexilink AND XSF 1 bit is set and there is no Z+ flag present (i.e. C phase is not permitted to run)

Filtering shall be permitted on the AC (SG 2) approach under the following condition:

> The mode of operation is Masterlink or Flexilink AND XSF 2 bit is set and there is no Z- flag present (i.e. B phase is not permitted to run)

Note: If filtering is enabled, the main road left turn signal groups (if provided) shall be in the OFF state i.e. filtering also.

B Phase – SG's 1, 3, Pedestrian Movement 1.

May also include left turn parallel to SG 1 and from E phase side road if controlled by separate signal groups

Note : Phase introduction controlled through introduction of Z- flag in Flexilink or Masterlink only.

C Phase – SG's 2, 4, Pedestrian Movement 2.

May also include left turn parallel to SG 2 and from D phase side road if controlled by separate signal groups

Note : Phase introduction controlled through introduction of Z+ flag in Flexilink or Masterlink only.

D Phase (least busy side road movement) – SG 5 or SG 6 and Pedestrian Movement 3 or 4.

May also include left turn from main road parallel to SG 1 if controlled by a separate signal group.

E Phase – SG 5 or SG 6 and Pedestrian Movement 3 or 4.

May also include left turn from main road parallel to SG 2 if controlled by a separate signal group.

F Phase – SG's 3 and 4.

May also include left turn movements from side roads, if controlled by separate signal groups.

F1 Phase – SG's 1, 3 and Pedestrian Movement 1.

May also include left turn parallel to SG 1 and from E phase side road if controlled by separate signal groups.

F2 Phase – SG's 2, 4 and Pedestrian Movement 2.

May also include left turn parallel to SG 2 and from D phase side road if controlled by separate signal groups.

### 5.2.6 Single Diamond Overlap with Combined Side Road Phase

#### 5.2.6.1 Required Signal Groups

##### *5.2.6.1.1 Vehicle*

> SG 1 - Main road through movement clockwise from the controller
> SG 2 - Main road through movement opposite to SG 1
> SG 3 - Right turn adjacent to SG 1
> SG 4 - Right turn adjacent to SG 2
> SG 5 - Side road to the left of SG1
> SG 6 - Side road to the left of SG2.

##### *5.2.6.1.2 Pedestrian*

> Pedestrian Movement 1 – parallel to SG 1 (e.g. SG 16)
> Pedestrian Movement 2 – parallel to SG 2 (e.g. SG 15)
> Pedestrian Movement 3 – parallel and to the left of SG 5 (e.g. SG 14)
> Pedestrian Movement 4 – parallel and to the left of SG 6 (e.g. SG 13)

#### 5.2.6.2 Optional Signal Groups

Where provided use next available signal group in order below.

##### *5.2.6.2.1 Vehicle*

- Right turn adjacent to SG 5 (red arrow only for pedestrian protection)
- Right turn adjacent to SG 6 (red arrow only for pedestrian protection)
- Left turn adjacent to SG 1
- Left turn adjacent to SG 2
- Left turn adjacent to SG 5 (red arrow only for pedestrian protection)
- Left turn adjacent to SG 6 (red arrow only for pedestrian protection).

*5.2.6.2.2 Pedestrian*

- Pedestrian across controlled left turn slip lane from main road and parallel to SG 1
- Pedestrian across controlled left turn slip lane from main road and parallel to SG .

5.2.6.3 Phasing

Normal Phase Sequence = A : D : E

A Phase – SG's 1, 2, Pedestrian Movements 1 and 2.

May also include left turn movements from main road if controlled by a separate signal group.

Note: Where considered safe the right turn movements may be permitted to filter turn. Filtering shall be permitted on the AB (SG 1) approach under the following condition:

- The mode of operation is Masterlink or Flexilink AND XSF 1 bit is set and there is no Z+ flag present (i.e. C phase is not permitted to run)

Filtering shall be permitted on the AC (SG 2) approach under the following condition:

- The mode of operation is Masterlink or Flexilink AND XSF 2 bit is set and there is no Z- flag present (i.e. B phase is not permitted to run).

Note: If filtering is enabled, the main road left turn signal groups (if provided) shall be in the OFF state.

B Phase – SG's 1, 3, Pedestrian Movement 1.

May also include left turn adjacent to SG 1 if controlled by a separate signal group.

Note : Phase introduction controlled through introduction of Z- flag in Flexilink or Masterlink only.

C Phase – SG's 2, 4, Pedestrian Movement 2.

May also include left turn adjacent to SG 2 if controlled by a separate signal group

Note : Phase introduction controlled through introduction of Z+ flag in Flexilink or Masterlink only.

D Phase – SG 5, 6, Pedestrian Movements 3 and 4.

E Phase – SG's 3 and 4.

E1 Phase – SG's 1, 3 and Pedestrian Movement 1.

May also include left turn adjacent to SG 1 if controlled by a separate signal group.

E2 Phase – SG's 2, 4 and Pedestrian Movement 2.

May also include left turn adjacent to SG 2 if controlled by a separate signal group.

### 5.2.7 Double Diamond Overlap

5.2.7.1 Required Signal Groups

*5.2.7.1.1 Vehicle*

- SG 1 Main road through movement with stretched phase, clockwise from the controller
- SG 2 Main road through movement opposite to SG 1
- SG 3 – Right turn adjacent to SG 1
- SG 4 – Right turn adjacent to SG 2
- SG 5 Side road through movement clockwise from SG 1
- SG 6 Side road through movement clockwise from SG 2

- SG 7 – Right turn adjacent to SG 5
- SG 8 – Right turn adjacent to SG 6.

*5.2.7.1.2 Pedestrian*

- Pedestrian Movement 1 – parallel to SG 1 (e.g. SG 16)
- Pedestrian Movement 2 – parallel to SG 2 (e.g. SG 15)
- Pedestrian Movement 3 – parallel to SG 5 (e.g. SG 14)
- Pedestrian Movement 4 – parallel to SG 6 (e.g. SG 13).

5.2.7.2 Optional Signal Groups

Where provided use next available Signal Group in order below.

*5.2.7.2.1 Vehicle*

- Left turn adjacent to SG 1
- Left turn adjacent to SG 2
- Left turn adjacent to SG 5
- Left turn adjacent to SG 6.

*5.2.7.2.2 Pedestrian*

- Pedestrian across controlled left turn slip lane from main road and adjacent to SG 1
- Pedestrian across controlled left turn slip lane from main road and adjacent to SG 2
- Pedestrian across controlled left turn slip lane from main road and adjacent to SG 5
- Pedestrian across controlled left turn slip lane from main road and adjacent to SG 6.

5.2.7.3 Phasing

Normal Phase Sequence = A : D : E : G.

<u>A Phase</u> – SG's 1, 2, Pedestrian Movements 1 and 2.

May also include left turn movements from main road if controlled by separate signal groups.

Note : Where considered safe the right turn movements may be permitted to FILTER turn. Filtering shall be permitted on the A-B (SG 1) approach under the following condition:

- The mode of operation is Masterlink or Flexilink AND XSF 1 bit is set and there is no Z+ flag present (i.e. C phase is not permitted to run)

Filtering shall be permitted on the AC (SG 2) approach under the following condition:

- The mode of operation is Masterlink or Flexilink AND XSF 2 bit is set and there is no Z- flag present (i.e. B phase is not permitted to run)

Note: If filtering is enabled, the main road left turn signal groups (if provided) shall be in the OFF state.

<u>B Phase</u> – SG's 1, 3, Pedestrian Movement 1.

May also include left turn parallel to SG 1 and left turn parallel to SG 6 if controlled by separate signal groups

Note : Phase introduction controlled through introduction of Z- flag in Flexilink or Masterlink only.

<u>C Phase</u> – SG's 2, 4, Pedestrian Movement 2.

May also include left turn parallel to SG 2 and left turn parallel to SG 5 if controlled by separate signal groups.

Note : Phase introduction controlled through introduction of Z+ flag in Flexilink or Masterlink only.

<u>D Phase</u> – SG's 7 and 8.

May also include left turn movements from main road, if controlled by separate signal groups.

<u>D1 Phase</u> – SG's 5, 7 and Pedestrian Movement 3.

May also include left turn parallel to SG 1 and left turn parallel to SG 5 if controlled by separate signal groups.

D2 Phase – SG's 6, 8 and Pedestrian Movement 4.

May also include left turn parallel to SG 2 and left turn parallel to SG 6 if controlled by separate signal groups.

E Phase – SG's 5, 6, Pedestrian Movements 3 and 4.

May also include left turn movements from side road to main road if controlled by separate signal groups.

Note: Where considered safe the right turn movements may be permitted to FILTER turn. Filtering shall be permitted on the D1-E-F1 (SG 5) approach under the following condition:

- The mode of operation is Masterlink or Flexilink AND XSF 3 bit is set and there is no XSF 6 bit present (i.e. F2 phase is not permitted to run)

Filtering shall be permitted on the D2-E-F2 (SG 6) approach under the following condition:

- The mode of operation is Masterlink or Flexilink AND XSF 3 bit is set and there is no XSF 5 bit present (i.e. F1 phase is not permitted to run).

Note: If filtering is enabled, the main road left turn signal groups (if provided) shall be in the OFF state.

F1 Phase – SG's 5, 7 and Pedestrian Movement 3.

May also include left turn parallel to SG 6 if controlled by a separate signal group.

Note: Phase introduction controlled through introduction of XSF 5 Bit in Flexilink or Masterlink only.

F2 Phase – SG's 6, 8 and Pedestrian Movement 4.

May also include left turn parallel to SG 5 if controlled by a separate signal group.

Note: Phase introduction controlled through introduction of XSF 6 Bit in Flexilink or Masterlink only.

G Phase – SG's 3 and 4.

May also include left turn movements from side roads, if controlled by a separate signal group.

G1 Phase – SG's 1, 3 and Pedestrian Movement 1.

May also include left turn parallel to SG 1 and left turn parallel to SG 6 if controlled by a separate signal groups.

G2 Phase – SG's 2, 4 and Pedestrian Movement 2.

May also include left turn parallel to SG 2 and left turn parallel to SG 5 if controlled by a separate signal groups

### 5.2.8 Filtering Right Turn Movements

At most intersections right turning traffic that has opposing movements will be provided for by installing a separate signal display, giving the right turning motorist a protected turn at some time in the phasing sequence. However, under strict criteria filter turn movements may be permitted in order to improve intersection efficiency.

Whilst the provision of filter turns may improve efficiency, it reduces the potential safety as conflicting movements may now occur. The phasing design must consider a balance between safety and efficiency. When considering allowing filtering, safety must be given a higher weighting in the decision process.

The phasing design at adjacent intersections should also be considered to provide consistency along a corridor and preferably throughout the region.

The operation of such movement should be designed and implemented with prior consultations with QLDC.

### 5.2.9 Repeat Right Turn Phases

A repeat right turn is where the right turn movement is introduced for a second time within the same phase cycle.

Repeat right turns can be provided at any site with a right turn phase. Generally the controller logic will have two phases with exactly the same movements (i.e. for a T-intersection B and D) with one phase only introduced when a special facility signal is activated (normally B using the Z+ flag).

Repeat right turn phasing can only be used under Masterlink or Flexilink control modes (not in isolated mode) and is generally provided at peak times. It is unusual to have a repeat right turn phase operating 24 hours a day.

Repeat right turn phasing is normally used where the single right turn phase does not provide sufficient capacity within a cycle for specific flow periods, or it is necessary for progression within a coordinated system.

A typical use is where a right turn bay is too short to cope with the number of right turning vehicles that can arrive within the cycle which results in the right turn queue extending into and blocking the through traffic lane. This reduces the capacity for the through movement and increases the risk of nose to tail type crashes occurring. The use of the repeat right turn is particularly important, under these circumstances, where there is only one through lane.

Repeat right turn phasing should only be considered under the above mentioned conditions. Generally, where vehicles may queue outside of the through lane (i.e. on a painted median), it is more efficient to provide a longer single right turn phase than two short phases. Installation of queue detection loops to be considered in the design.

### 5.2.10 Pedestrian Control

The hierarchy of signalised pedestrian control strategies range from providing full pedestrian protection through to partial protection during the early stages of the crossing movement. They fit broadly into the following range:

i. Exclusive pedestrian phase with full protection and all vehicle traffic stopped. Also known as Barnes Dance. This is only used where pedestrian numbers are high, in CBD.

ii. Full protection for the whole Walk and Clearance using red arrow.

iii. Partial protection for part of the Walk and Clearance using red arrow and individual push button inputs. Red arrow on a minimum of 6 seconds for one direction and the other direction to be calculated to the last crossing lane using 1.5m per second (this can be reduced on site as required)

iv. Full protected staggered or staged pedestrian movements.

The method of control adopted at any specific site is based on location, traffic volumes, pedestrian volumes and type (i.e. age or disability), intersection layout combined with the aim to provide safe, efficient movement for all users. However, when selecting control options, it is important to ensure, whenever possible, that a consistent approach is adopted within any given corridor. This may result in a more conservative approach being adopted at some intersections to maintain uniformity throughout that corridor.

At signalised intersections, near schools, where there is a high pedestrian demand at the same time each day, the signal operation should be adjusted to cater for the reoccurring demand. This will generally be achieved by increasing the Walk' and/or clearance times.

It is preferable to have all pedestrian push button inputs wired and configured in the CIS individually to enhance pedestrian protection.

MSS bits to be used for every push button to enhance the variation options in Scats. (All non-loop detectors shall have an MSS assigned for each unit for additional Scats variation options and monitoring options).

### 5.2.11 Cyclists

Cycle lanes are being progressively introduced along some of the main corridors. Cyclists are features managed as part of the 'traffic mix' and there are currently limited special facilities for them at signalised intersections. These facilities are generally in the form of advance boxes or hook turn boxes and do not require special traffic signal control. Where cyclists may be on a side road or one that is not reverted to during phase sequence then detectors may be required to demand the phase for the cyclist.

Cycle detector loops are numbered in sequential order as part of the first circuit of vehicle detectors. Cycle call buttons are external inputs and numbered in descending order after the pedestrian inputs, e.g. W1=32, W2=31, C1=30.

Special care and attention to the detector position, type and detector alarm to be used in the cycle lane and / or cycle box.

Where cycle boxes are used they shall always be behind the traffic signal primary pole.

Consultation with QLDC is required at an early stage so we can consult the users groups.

### 5.2.12 Bus Lanes

Bus priority is becoming more common and requires the allocation of a signal group to each approach using the same convention as above for individual sites. If the bus signal group is demanded then the controller puts in a pre-specified delay to the through movement signal group. Where bus loops are installed these are numbered as part of the first circuit of vehicle detectors in sequential order. Where a separate signal group is provided for bus movements, these are numbered last, after all other vehicle signal groups.